Natural Features Inventory and Management Recommendations for Kensington and Oakwoods Metroparks

Prepared by:
Michael A. Kost and Ryan P. O'Connor

Michigan Natural Features Inventory
P.O. Box 30444
Lansing, MI 48909-7944

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Introduction

During the summer of 2002 Michigan Natural Features Inventory (MNFI) conducted surveys for exemplary natural communities and rare plants in two Huron-Clinton Metroparks, Kensington and Oakwoods. In addition, surveys were conducted to evaluate management needs on lands considered to have good potential for supporting high-quality natural communities with active land management and restoration. This report summarizes the findings of MNFI's surveys and evaluations of Kensington and Oakwoods Metroparks.

Landscape Context

Regional landscape ecosystems of Michigan have been classified and mapped at three hierarchical levels (section, subsection, and sub-subsection) based on an integration of climate, physiography (topographic form and geologic parent material), soil, and natural vegetation (Albert 1995). The regional classification provides a framework for understanding broad patterns of natural community and species occurrences and natural disturbance regimes across the state, which is useful in integrated resource management and planning, as well as for biological conservation. The classification is hierarchically structured with three levels in a nested series, from broad landscape regions called sections, down to smaller subsections and sub-subsections.

All of the Huron-Clinton Metroparks occur within the Washtenaw Subsection (VI.1) of southern Lower Michigan (Figure 1) (Albert 1995). The Washtenaw Subsection contains three sub-subsections that differ from each other in their soils, glacial landforms, climate, and vegetation. Kensington Metropark occurs within the Jackson Interlobate Sub-subsection (VI.1.3), and Oakwoods Metropark occurs on the Maumee Lake Plain Sub-subsection (VI.1.1) (Albert 1995). The local landforms within the metroparks reflect those typical of their regional landscape ecosystems and respective sub-subsections.

The Jackson Interlobate Sub-subsection contains broad expanses of glacial outwash sands that surround sandy and gravelly end moraines and ground moraines (Albert 1995). The soils on the moraines are typically well drained or excessively well drained and in the 1800s supported drought-tolerant, fire-dependent natural communities such as oak barrens, oak savanna, oak forest, and hillside prairie. The outwash soils vary from excessively well drained sands, which once supported oak barrens, oak forests, woodland prairies, and dry sand prairies, to poorly drained organic deposits that supported a variety of open and forested wetland types.

Kensington Metropark is located within the Jackson Sub-subsection, along the Huron River in southwestern Oakland County. Coarse-textured end moraine and ground moraine characterize the northern and central portions of the metropark (Figure 2). The Huron River flows through a narrow, steep-sided glacial outwash channel (too small to be mapped) that dissects a coarse-textured end moraine in the northern portion of the park. Here, groundwater seepage at the base of the end moraine supports a diverse wetland complex along the narrow floodplain of the Huron River. In the southern portion of the metropark, the river, which is now dammed to form Kent Lake, flows through an expansive glacial outwash plain that encompasses the entire southern portion of the park.

Like Kensington, Oakwoods also occurs along the Huron River, however, the glacial landforms at the two metroparks are very different (Figure 3). Oakwoods occurs within the Maumee Lake Plain Sub-subsection, which is comprised of a flat, clay lake plain, dissected by broad glacial drainageways of sandy soil (Albert 1995). Within the glacial drainageways, beach ridges and small sand dunes are common. Clay soils of the lake plain are generally wet with low permeability and poor drainage. In the past, these poorly drained soils supported broad expanses of lowland hardwood forest. In contrast, the soils on the upland beach ridges and dunes of the sandy glacial drainageways are excessively drained and once supported extensive bur oak and white oak savannas. The sandy glacial drainageways also supported vast wet prairies and marshes, which commonly occurred in depressions on poorly to very poorly drained soils (Comer et al. 1993). Oakwoods lies on a broad, flat expanse of lacustrine clay and silt, with intrusions of lacustrine sand and gravel occurring in the northwestern and central portions of the metropark. Small beach ridges and other local topographical variations in landforms also occur within the park, but are too small to be mapped. The Huron River forms the northern border of much of the metropark as it flows through the flat lake plain toward Lake Erie.

Vegetation *circa* 1800

By interpreting the General Land Office survey notes for Michigan recorded during the period of 1818-1856, MNFI ecologists were able to piece together a relatively accurate picture of the state's vegetation in the early 1800s (Comer et al. 1995). A digital map of

vegetation encountered by the land surveyors during this period reveals that Kensington Metropark was almost entirely occupied by fire-dependent community types such as black oak barrens, mixed oak savanna, oak-hickory forest, and wet prairie (Figure 4). Because the original land surveyors did not differentiate among the many different types of open, grass- and sedge-dominated wetlands, the areas designated as wet prairie on the *circa* 1800 vegetation map were likely to have also supported other types of open, fire-dependent wetlands such as wet-mesic prairie, prairie fen, and wet meadow. These wetland types once occupied over 856 acres (270 ha) along the Huron River and in the areas now occupied by Kent Lake and near the nature center. A large (137 acres or 56 ha) mixed conifer swamp (tamarack swamp) also occurred on the outwash plain near the Huron River in the area now flooded to form Kent Lake. A smaller pocket of mixed conifer swamp occurred in a narrow outwash channel of the Huron River in the northeastern portion of the park.

The digital map of vegetation *circa* 1800 for Oakwoods depicts the park as entirely forested, primarily by mesic southern forest, which is labeled as beech-sugar maple forest on Figure 5. On the lake plain, these mesic forests typically contained a diverse mix of tree species and in some places, like Oakwoods Metropark, were dominated by species other than American beech (*Fagus grandifolia*) and sugar maple (*Acer saccharum*). A close look at the original notes of General Land Office surveyors reveals that the area now occupied by Oakwoods was predominately forested with white oak (*Quercus alba*), white ash (*Fraxinus americana*), and American elm (*Ulmus americana*). Additional canopy associates included black oak (*Quercus velutina*), hickory (*Carya* spp.), and basswood (*Tilia americana*). The presence of black oak and white oak, which are highly dependent on open conditions, indicate that in the past some areas of the metropark likely supported fire-dependent, lakeplain oak openings (e.g., oak savanna). In addition, many of the very large oaks within the present woodlands at Oakwoods show evidence of having once grown in open conditions. Along the Huron River floodplain the surveyors noted several species typical of forested wetlands including black walnut (*Juglans nigra*), spicebush (*Lindera benzoin*), and red mulberry (*Morus rubra*), a species now listed as threatened in Michigan. Mixed hardwood swamp, dominated by red maple (*Acer rubrum*), silver maple (*Acer saccharinum*), and black ash (*Fraxinus nigra*) also occurred occasionally in small depressions and along a small tributary to the Huron River (Warner Drain). A small area of prairie was noted by the surveyors north of the river along the east-west township line (between sections 25 and 36), just south of where Huron River Drive occurs today. In the 1800s, the mesic southern forest at Oakwoods was bordered by a vast (39,102 acres or 15,824 ha) mixed hardwood swamp and floodplain forest to the east and an immense (16,117 acres or 6,522 ha) lakeplain prairie to the north.

Present Land Cover

The 1995 Land Cover maps (Figures 6 and 7) were produced by overlaying *circa* 1980 National Wetlands Inventory data over the Southeast Michigan Council of Governments (SEMCOG) 1995 land cover data set. The accuracy of land cover types within each metropark was further enhanced through photo interpretation and ground truthing.

Comparisons between *circa* 1800s vegetation and present land cover reveal drastic changes across the landscape (Figures 4 - 7). At Kensington, the Huron River was dammed to greatly enlarge Kent Lake in 1947 and much of the riparian corridor and surrounding wetlands in the southern portion of the park are now underwater. Small fragments of a formerly vast wetland complex persist within the Nature Study Area (Figure 6: A). Another wetland complex of note remains in the Group Camp Area along floodplain of the Huron River (Figure 6: B). At a larger scale, the areas adjacent to Kensington have been transformed to a semi-urbanized landscape, with the metropark and adjacent Island Lake Recreation Area providing some of the only remaining natural habitats. Nearly all of the black oak barrens and mixed oak savanna at Kensington (and in the remainder of the Midwest) have been converted to lawn and old field or have succeeded to closed-canopy oak forest in the absence of natural, periodic fires. The conversion of oak barrens and oak savanna to closed-canopy oak forest was rapid, typically taking place within 30 years following the onset of fire suppression (Curtis 1959). The mature oak forest that now occurs is highly fragmented, with many small, isolated blocks of forest surrounded by old fields and urbanized areas.

At Oakwoods, the pattern of forest fragmentation is also severe. Significant blocks of forest remain at Oakwoods along the floodplain of the Huron River and in the Nature Study Area (Figure 7). Smaller, isolated patches of mature forest also persist in the western portion of the park near the Horse Staging Area, along the railroad tracks north of the Huron River, and along the southern border of the park. Like Kensington, the area surrounding Oakwoods is rapidly converting to an urbanized landscape, thus raising the importance of remaining natural habitats within the metroparks to regional biodiversity.

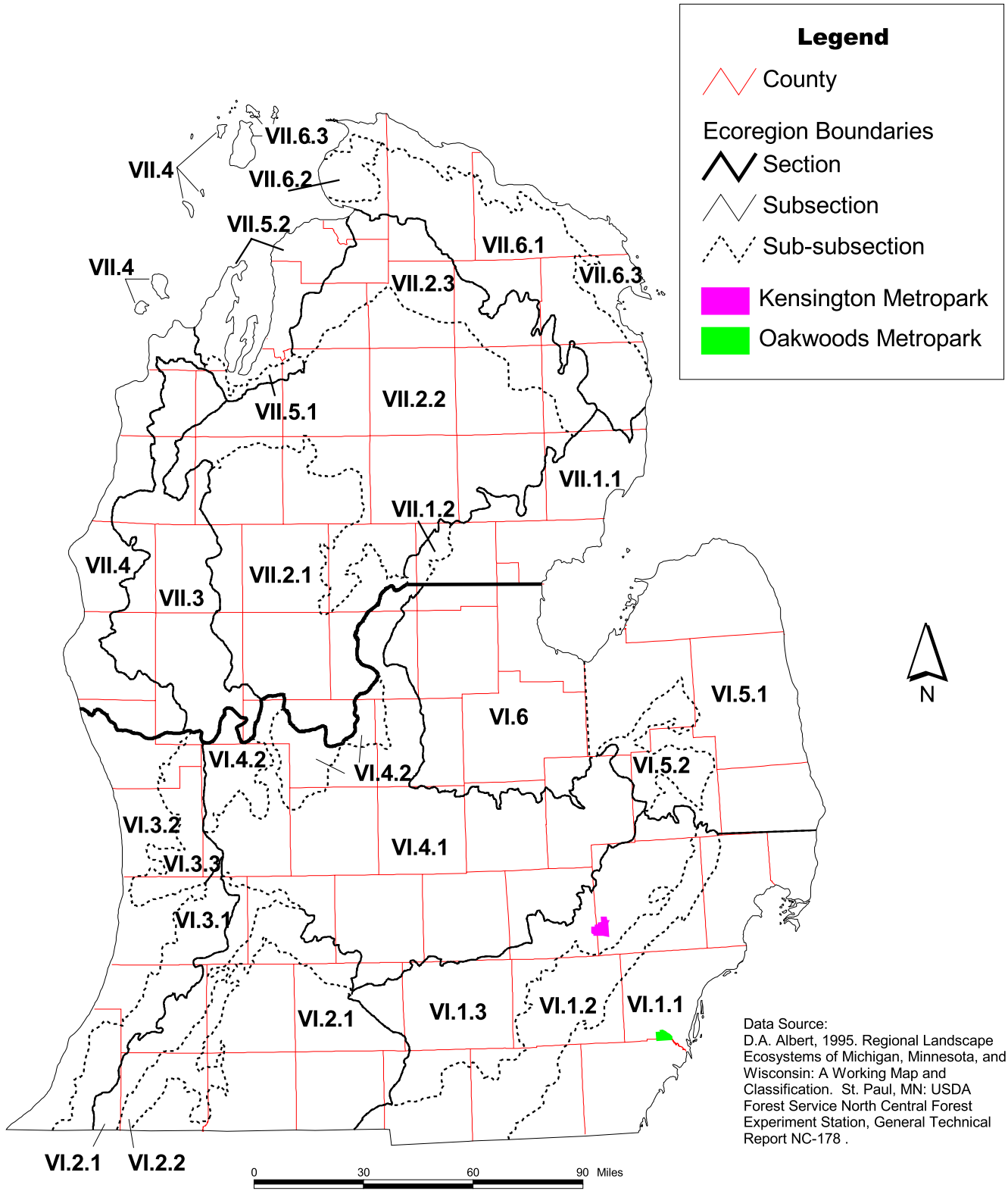


Figure 1. Ecoregions of Lower Michigan (Albert 1995).

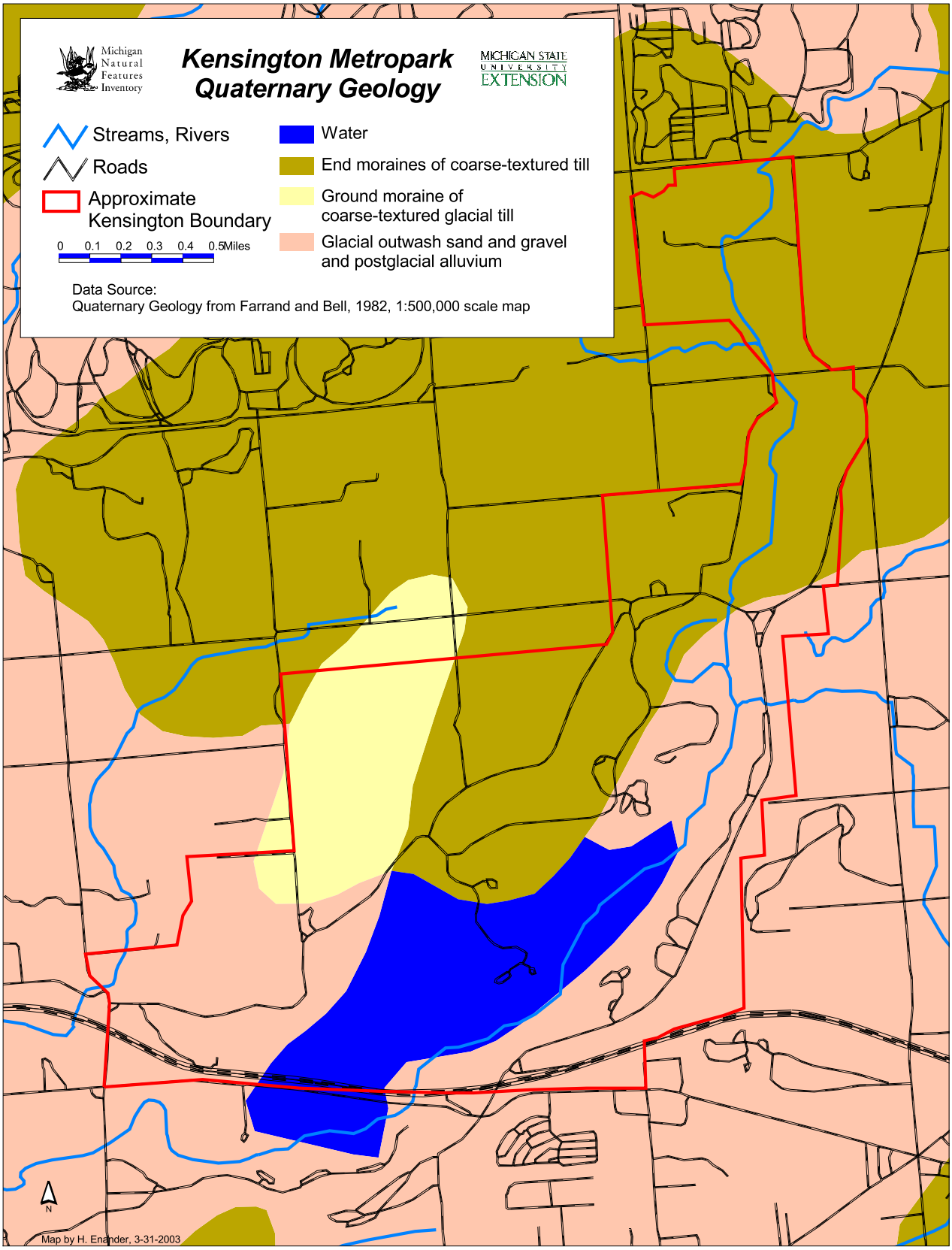


Figure 2. Surficial geology of Kensington Metropark (Farrand and Bell 1982).

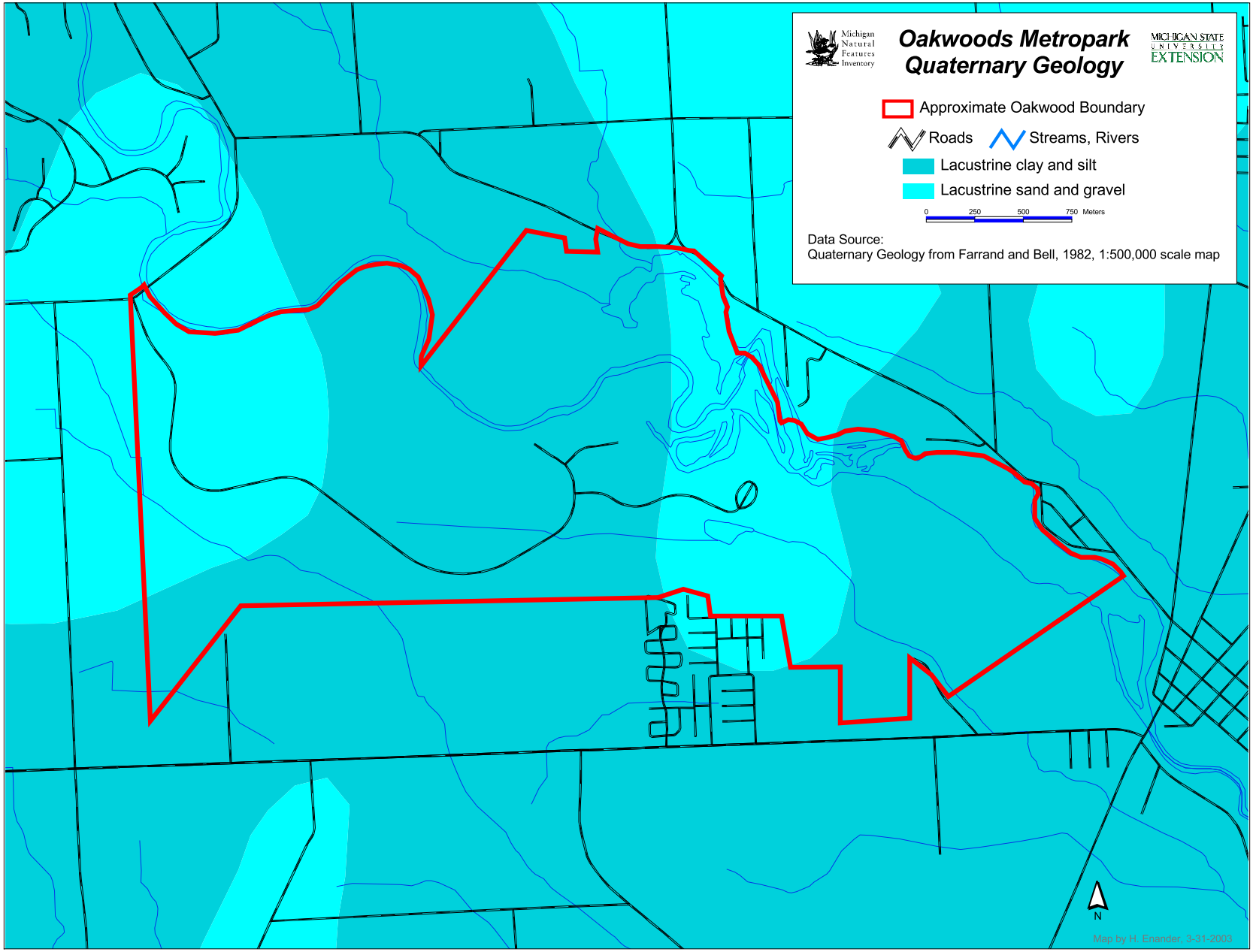


Figure 3. Surficial geology of Oakwoods Metropark (Farrand and Bell 1982).

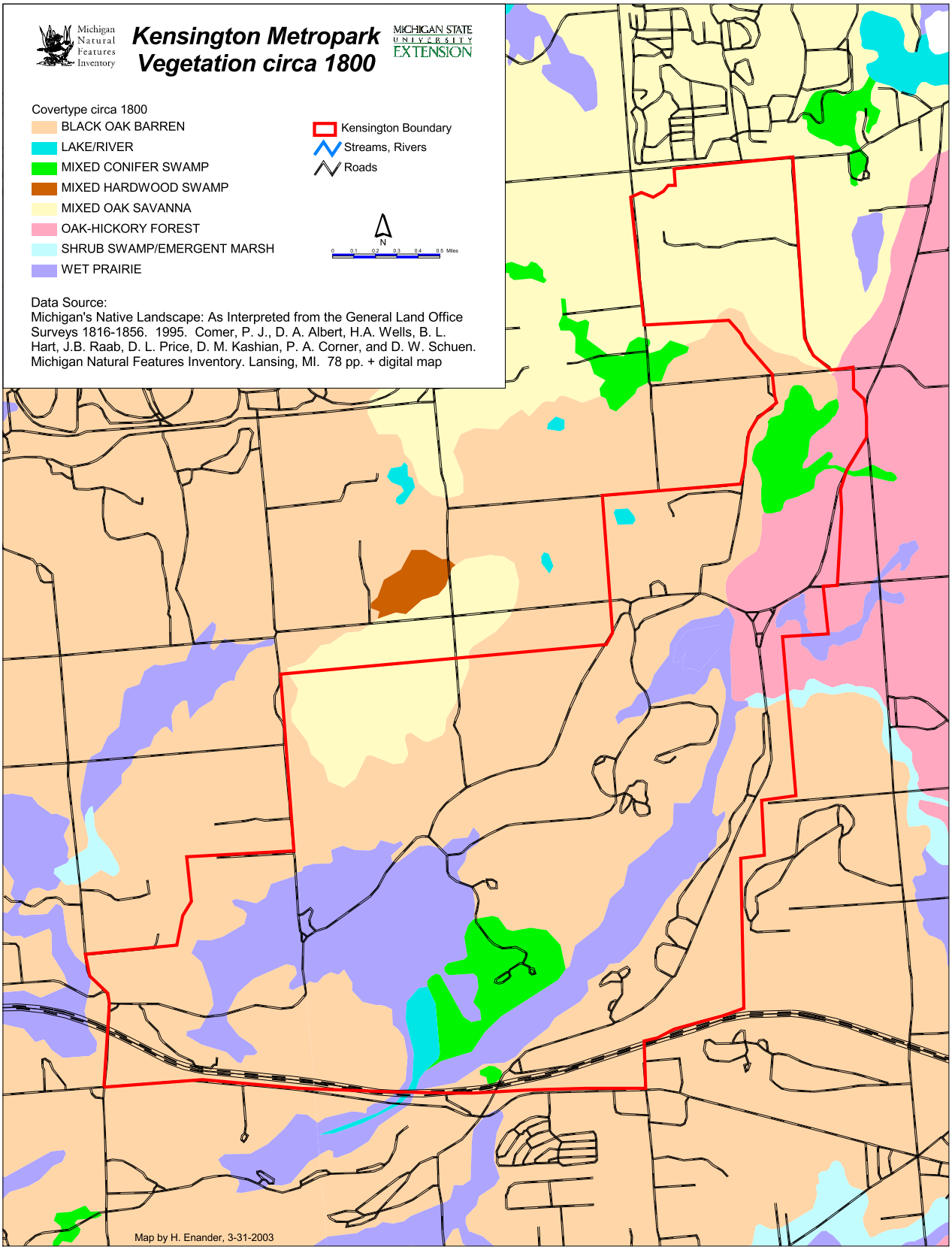


Figure 4. Kensington Metropark vegetation *circa* 1800.

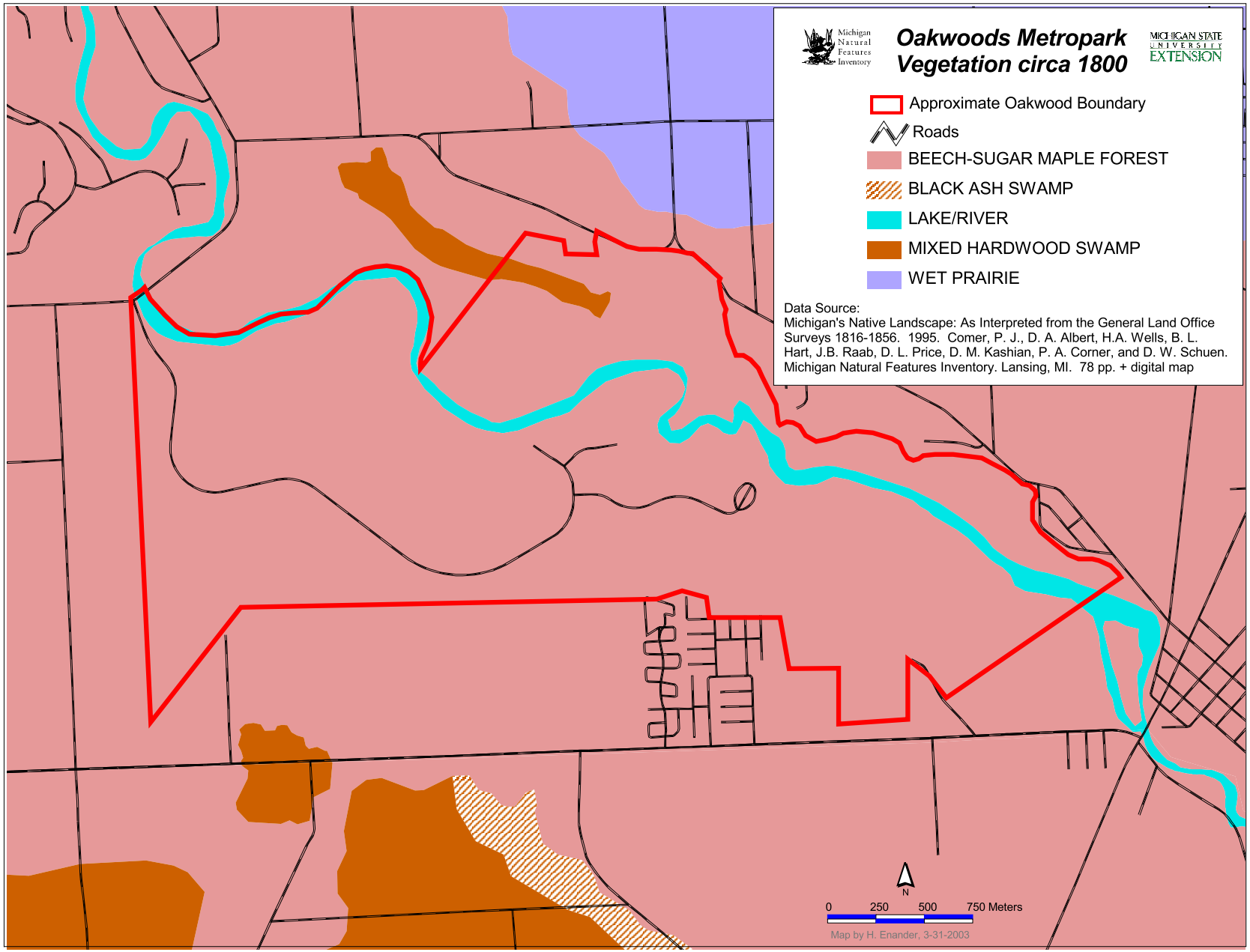


Figure 5. Oakwoods Metropark vegetation *circa* 1800.

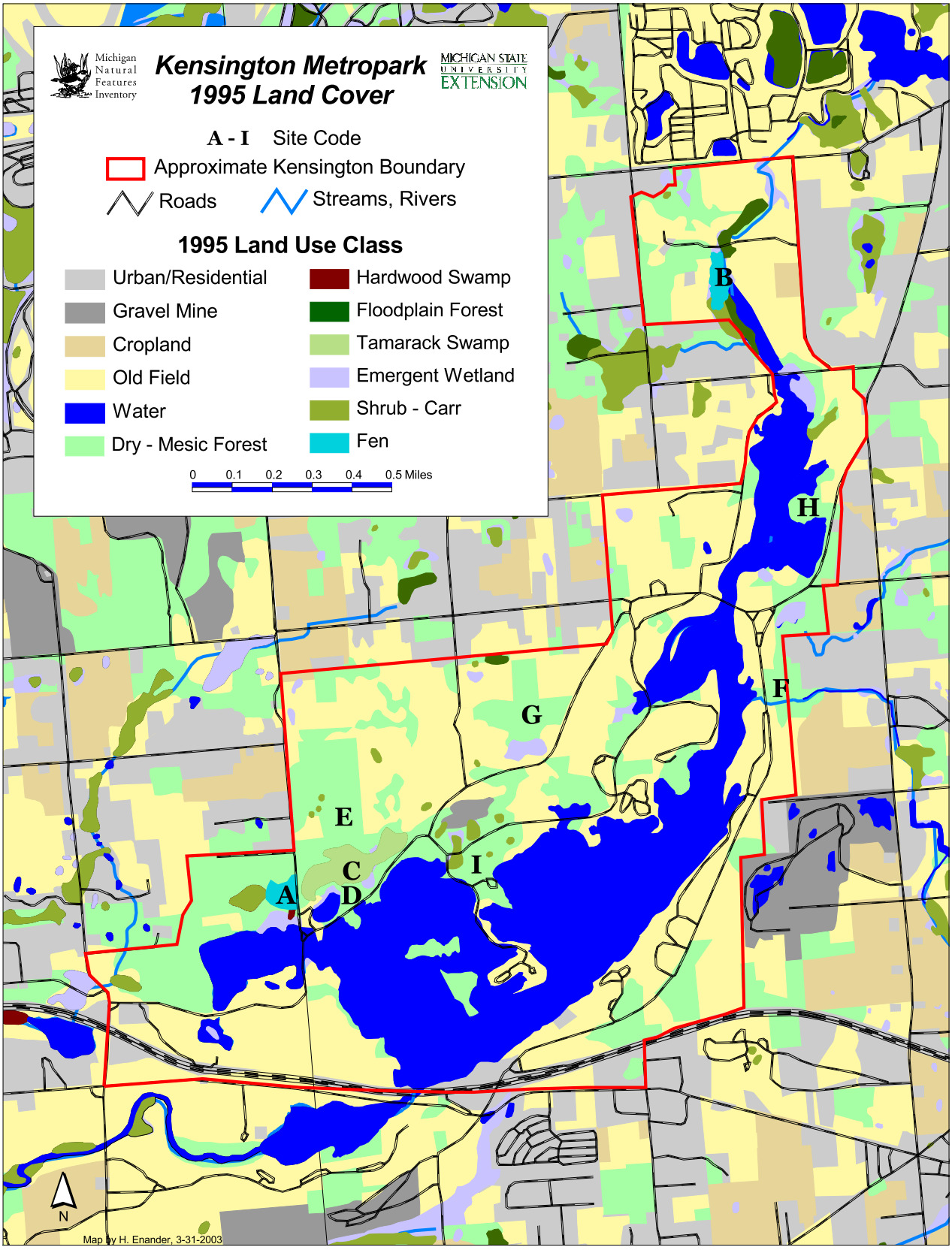


Figure 6. Kensington Metropark 1995 land cover.

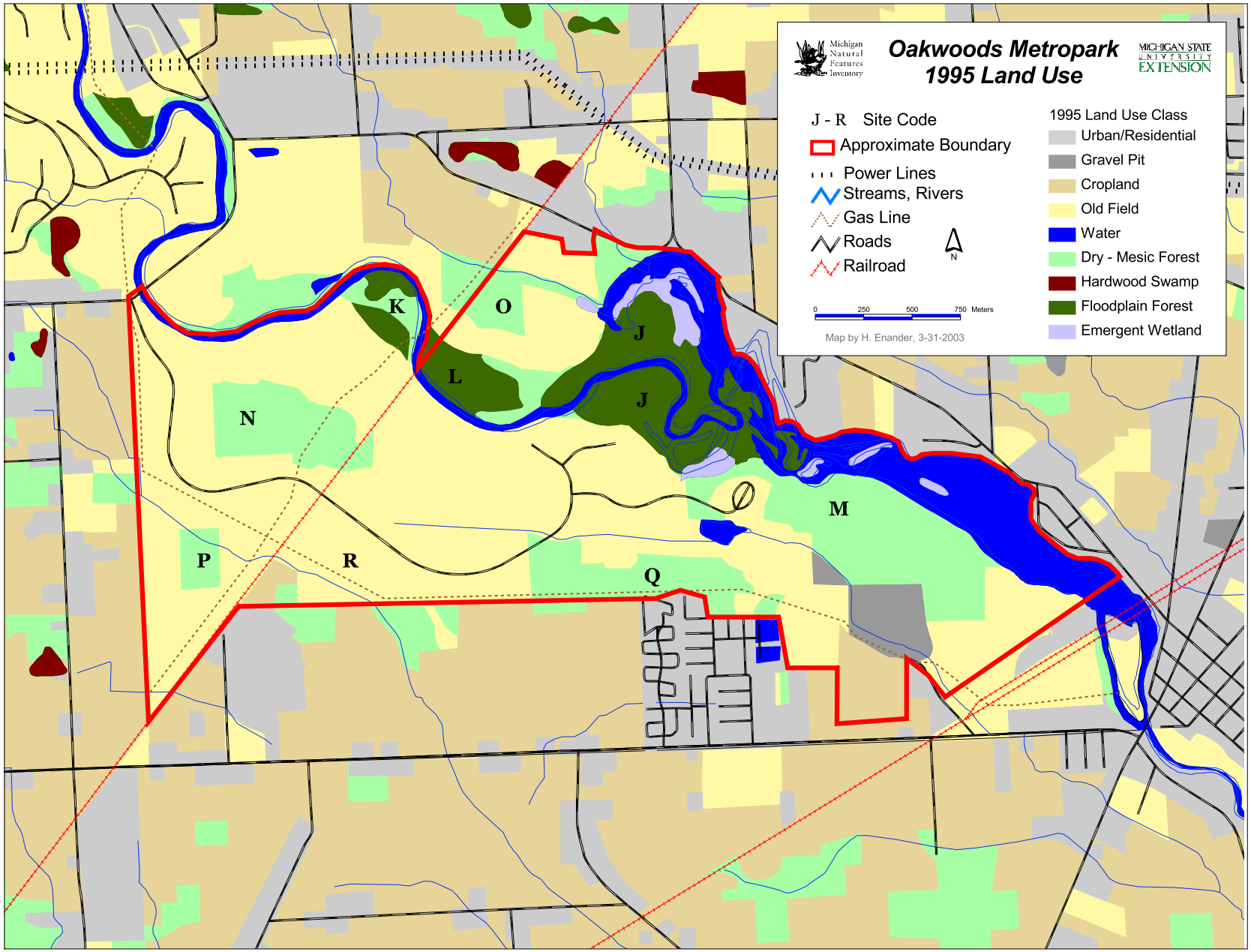


Figure 7. Oakwoods Metropark 1995 land cover.

Methods

Natural Communities

Natural community surveys were conducted in conjunction with rare plant surveys. Prior to surveys aerial photos were interpreted to determine the types of natural communities likely to be present within each of the metroparks. Field surveys concentrated on identifying high-quality natural areas and recording management concerns such as evidence of fire suppression, excessive deer herbivory, hydrologic manipulation, farming, logging, and invasive species. Species lists were compiled for high-quality sites and those deemed to have potential to significantly improve with restoration. Site names and site codes used in the accompanying metropark maps (Figures 6 and 7) are listed in Table 1. Partial species lists were recorded for most of the areas visited and are included as appendices for each metropark (Appendices 1 and 2). Site summaries were written for each site visited and for all high-quality natural communities and sites thought to have good potential for significant improvement with restoration and management. Species lists for this report were tabulated with the Florist Quality Assessment Program and species nomenclature follows Herman et al. (2001).

Table 1. Survey site names and associated site codes for accompanying maps (Figure 6 and 7).

Site Name	Site Code
Kensington Metropark	
Wildwing Fen	A
Group Camp Fen	B
Tamarack Trail Swamp	C
Kingfisher Wet Meadow	D
Chickadee Loop Woodland	E
East Border Oak Barrens	F
Spring Hill Woodland	G
North Windfall Hill Woodland	H
Hickory Ridge Woodland	I
Oakwoods Metropark	
Oxbow Floodplain Forest	J
West Oxbow Floodplain Forest	K
Railroad Floodplain Forest	L
Nature Study Area Woodland	M
Salamander Woods	N
White Oak Woodland	O
Brandes Road Woodland	P
Borderline Woods	Q
Seedbox Swale	R

Rare Plant Inventories

Rare plant species were targeted for survey based on the natural communities determined to be present in the park through aerial photo review and known historical and current rare plant distribution patterns within the region. Table 2 lists the rare species by associated natural community that were focused on during the surveys. Rare plant inventories were performed by meander survey of appropriate habitat during periods when the plants are most recognizable (usually flowering or fruiting periods). When a rare plant was encountered, an MNFI special plant form was filled out, selected photos were taken, and when necessary a voucher specimen was collected for later determination.

Table 2. Rare plants sought by associated natural communities. State status abbreviations are as follows: E, endangered; T, threatened; SC, special concern.

Community	Scientific Name	Common Name	State Status
Mesic Southern Forest			
	Castanea dentata	American chestnut	E
	Aristolochia serpentaria	Virginia snakeroot	T
	Carex platyphylla	broad-leaved sedge	T
	Galearis spectabilis	showy orchis	T
	Hydrastis canadensis	goldenseal	T
	Mertensia virginica	Virginia bluebells	T
	Panax quinquefolius	ginseng	T
	Polymnia uvedalia	large-flowered leaf-cup	T
	Spiranthes ovalis	lesser ladies'-tresses	T
	Tipularia discolor	cranefly orchid	T
	Trillium recurvatum	prairie trillium	T
	Triphora trianthophora	three-birds orchid	T
	Adlumia fungosa	climbing fumitory	SC
	Jeffersonia diphylla	twinleaf	SC
	Liparis lilifolia	purple twayblade	SC
Southern Floodplain Forest			
	Chelone oblique	red turtlehead	E
	Arabis perstellata	rock-cress	T
	Camassia scilloides	wild hyacinth	T
	Carex conjuncta	sedge	T
	Carex lupuliformis	false hop sedge	T
	Corydalis flavula	yellow fumewort	T
	Diarrhena americana	beak grass	T
	Fraxinus profunda	pumpkin ash	T
	Justicia americana	water-willow	T
	Lycopus virginicus	Virginia water-horehound	T
	Morus rubra	red mulberry	T
	Nelumbo lutea	American lotus	T
	Polemonium reptans	Jacob's ladder	T
	Silphium perfoliatum	cup-plant	T
	Trillium recurvatum	prairie trillium	T
	Valerianella chenopodifolia	goosefoot corn-salad	T
	Wisteria frutescens	wisteria	T
	Euonymus atropurpurea	wahoo	SC
	Gymnocladus dioicus	Kentucky coffee tree	SC
	Hybanthus concolor	green violet	SC
	Viburnum prunifolium	black haw	SC
Lakeplain Wet-Mesic Prairie			
	Gentiana flavida	white gentian	E
	Rhyncospora globularis	globe beak-rush	E
	Scelaria pauciflora	few-flowered nut-rush	E
	Aristida longespica	three-awned grass	T

Asclepias sullivantii	Sullivant's milkweed	T
Bartonia paniculata	panicled screw-stem	T
Carex typhina	cat-tail sedge	T
Silphium laciniatum	compass plant	T
Sisyinchium atlanticum	Atlantic blue-eyed grass	T
Carex squarrosa	squarrose sedge	SC
Hypericum gentianoides	gentian-leaved St. John's-wort	SC
Ludwigia alternifolia	seedbox	SC
Scelaria triglomerata	tall nut-rush	SC

Prairie Fen

Berula erecta	cut-leaved water-parsnip	T
Cypripedium candidum	small white lady's slipper	T
Muhlenbergia richardsonis	mat muhly	T
Phlox maculata	spotted phlox	T
Sangiusorba canadensis	Canadian burnet	T
Valeriana edulis var. *ciliata*	edible valerian	T
Sporobolus heterolepis	prairie dropseed	SC

Dry-Mesic Southern Forest

Eupatorium sessilifolium	upland boneset	T
Angelica venenosa	hairy angelica	SC
Celtis tenuifolia	dwarf hackberry	SC
Quercus shumardii	Shumard's oak	SC

Results

The surveys identified five new element occurrences (EOs). (All state and federally listed rare species and high-quality natural communities are referred to as elements and their occurrence at a specific location is referred to as an element occurrence or EO.) In addition, the presence of four previously identified elements was reconfirmed. Natural community surveys identified two new high-quality community occurrences and revisited one previously identified exemplary natural community (Table 3). Surveys for rare plants resulted in three new element occurrences. Three existing plant records were also reconfirmed (Table 4). It is possible that additional rare species may be found in the future, especially with active restoration and management. All new natural community and rare plant occurrences have been entered into the statewide database (Biotics) managed by MNFI and all previously existing records have been updated.

Natural Community Inventories

Natural community surveys resulted in the identification of a prairie fen and relict conifer swamp at Kensington (Figure 6: B and C). Kensington also contains another prairie fen that was identified prior to 2002 (Figure 6: A). In addition to these exemplary natural communities, both parks also contain areas that have great potential of becoming high-quality natural communities with ecological restoration. The high-quality natural communities and sites with good potential for restoration are listed below along with their associated stewardship needs (Table 5). Detailed site descriptions and management recommendations for each area are included in the Site Summaries and Management Recommendations section (page 16).

Rare Plant Inventories

Rare plant surveys resulted in three new rare plant occurrences at Oakwoods including beak grass (*Diarrhena americana*), squarrose sedge (*Carex squarrosa*), and cup-plant (*Silphium perfoliatum*) (Table 4). In addition, three previously known rare plant records were reconfirmed including small white lady's slipper (*Cypripedium candidum*) from Kensington and seedbox (*Ludwigia alternifolia*) and water-willow (*Justicia americana*) from Oakwoods (Table 4). Previously known records of goldenseal (*Hydrastis canadensis*) from Kensington and American lotus (*Nelumbo lutea*) from Oakwoods were sought but could not be relocated.

At Oakwoods rare plants were found in several habitats including southern floodplain forest, dry-mesic southern forest, and old field. Beak grass, cup-plant, and water-willow are all located within the floodplain of the Huron River at Oakwoods. Beak grass occurs throughout the southern floodplain forest. Cup-plant was found growing in partially open meadows adjacent to the river. Water-willow was found thriving in emergent marshes within the river. Squarrose sedge occurs in shallow, wet depressions within dry-mesic southern forest at Oakwoods. Seedbox occurs in a sandy, wet depression of an old field near the southern border of the park.

At Kensington, small white lady's slipper was located in a prairie fen near the nature center. A thorough search was conducted for a previously documented population of goldenseal but failed to reconfirm its presence even though ample habitat exists within the metropark.

Table 3. Natural Community Occurrences.

Community	Site Name	Year First Observed	Year Last Observed	Metropark
prairie fen	Wildwing Fen	1986	2002	Kensington
prairie fen	Group Camp Fen	2002	2002	Kensington
relict conifer swamp	Tamarack Trail Swamp	2002	2002	Kensington

Table 4. Rare Plant Occurrences.

Species	Site Name	Status	Year First Observed	Year Last Observed	Metropark
Cypripedium candidum small white lady's slipper	Wildwing Fen	T	1986	2002	Kensington
Hydrastis canadensis goldenseal	Chickadee Loop Woodland	T	1986	1986	Kensington
Diarrhena americana beak grass	Oxbow Floodplain Forest and West Oxbow Floodplain Forest	T	2002	2002	Oakwoods
Justicia americana water-willow	Oxbow Floodplain Forest and Nature Study Area Woodland	T	1930	2002	Oakwoods
Nelumbo leutea American lotus	Huron River	T	1979	1979	Oakwoods
Silphium perfoliatum cup-plant	West Oxbow Floodplain Forest and Railroad Floodplain Forest	T	2002	2002	Oakwoods
Carex squarrosa squarrose sedge	Salamander Woods and White Oak Woodland	SC	2002	2002	Oakwoods
Ludwigia alternifolia seedbox	Seedbox Swale	SC	1991	2002	Oakwoods

Table 5. Management recommendations for high-quality natural communities and sites with good potential for improvement through restoration and management.

Site Name	Community Type	Metropark	Management Recommendations
Wildwing Fen	prairie fen	Kensington	- invasive and woody species control - prescribed fire - deer control
Group Camp Fen	prairie fen	Kensington	- invasive and woody species control - prescribed fire - deer control
Tamarack Trail Swamp	relict conifer swamp	Kensington	- red maple control - monitoring for glossy buckthorn - deer control
Kingfisher Wet Meadow	southern wet meadow	Kensington	- invasive and woody species control - prescribed fire - deer control
Chickadee Loop Woodland	dry-mesic southern forest	Kensington	- invasive species control - red maple control - prescribed fire - deer control
East Border Oak Barrens	oak barrens	Kensington	- invasive species control - tree and shrub removal - prescribed fire - deer control
Spring Hill Woodland	dry-mesic southern forest	Kensington	- invasive species control - prescribed fire - deer control
Hickory Ridge Woodland	dry-mesic southern forest and oak barrens	Kensington	- invasive species control - shrub removal (in oak barrens area) - prescribed fire - deer control
Oxbow Floodplain Forest	southern floodplain forest	Oakwoods	- invasive species control
West Oxbow Floodplain Forest	southern floodplain forest	Oakwoods	- invasive species control
Nature Study Area Woodland	dry-mesic southern forest	Oakwoods	- invasive species control - prescribed fire - deer control
Salamander Woods	dry-mesic southern forest	Oakwoods	- invasive species control - prescribed fire - deer control
White Oak Woodland	dry-mesic southern forest	Oakwoods	- invasive species control - prescribed fire - deer control
Borderline Woods	dry-mesic southern forest	Oakwoods	- invasive species control - prescribed fire - deer control

Wildwing Fen (Site Code: A)

A small but highly diverse prairie fen occurs along Aspen Trail just west of the nature center. This fen was previously identified by MNFI as an exemplary natural community (Figure 6). A prairie fen is a fire-dependent wetland community with highly alkaline soils, often composed of peat and marl, supporting vegetation characteristic of both fens and prairies (see natural community abstract in Appendix 3 for more information on prairie fens). The hydrology of Wildwing Fen is maintained by a steady seepage of calcareous groundwater from the base of the coarse-textured moraines to the north. The site is dominated by grasses such as big bluestem (*Andropogon gerardii*), Indian grass (*Sorghastrum nutans*), and sedges (*Carex* spp.). Occasional tamarack (*Larix laricina*) and native shrubs are also scattered throughout the fen (Appendix 1). A small but well-known population of small white lady's slipper has been observed at this site for many years (see rare plant abstract in Appendix 3 for more information on small white lady's slipper). This site is part of a much larger fen and tamarack swamp complex that once stretched over a kilometer from the northeast shore of Wildwing Lake to the northeast portion of the Nature Study Area. The wetland complex persists now as a series of smaller prairie fens and tamarack swamps (e.g., relict conifer swamp) bisected by numerous gravel trails. Fires were historically an important natural disturbance to prairie fens, and prescribed burning is recommended to set back woody shrub and tree encroachment, promote native prairie fen vegetation, and encourage regeneration of small white lady's slipper and other tiny-seeded species (Leach and Givnish 1996). The gravel paths that traverse the prairie fen provide excellent fire breaks and will enable the community to be easily divided into separate management units. Several invasive species occur within the prairie fen and along its margins including giant reed (*Phragmites australis*), garlic mustard (*Alliaria petiolata*), common buckthorn (*Rhamnus cathartica*), and autumn-olive (*Elaeagnus umbellata*). These species pose a direct threat to biodiversity because of their ability to quickly spread and out-compete surrounding vegetation. Garlic mustard was observed in the forested uplands along the western portions of the Aspen Trail. All garlic mustard plants should be removed before they set seed in late spring and the area should be monitored annually to detect recruitment from the seed bank. Giant reed was observed in several locations and should be controlled using herbicide, followed by annual monitoring. Both common buckthorn and autumn-olive should be cut and their stumps treated with herbicide to prevent resprouting.

Big bluestem grass, goldenrods, and blazing star abound at the Wildwing Fen in Kensington.

Group Camp Fen (Site Code: B)

A large wetland complex occurs along the west side of the Huron River within the Group Camp Area (Figure 6). The wetland complex is composed of several different types of natural communities including a prairie fen, relict conifer swamp, southern wet meadow, emergent marsh, and southern shrub-carr (see natural community abstract in Appendix 3 for more information on prairie fen, relict conifer swamp, and southern wet meadow). The wetland occurs in a narrow glacial outwash channel at the base of a steep moraine and its hydrology is maintained by a steady flow of calcareous groundwater that seeps from the base of the moraine. The site contains several springs that support narrow headwater streams, which flow through the wetland and into the Huron River. The moraine, which borders the wetland to the west, harbors many large white oak (*Quercus alba*) and bur oak (*Quercus macrocarpa*), with one bur oak measuring 134 cm (53 inches) in diameter.

The prairie fen, which is dominated by sedges (*Carex sterilis* and *Carex stricta*), big bluestem, shrubby cinquefoil (*Potentilla fruticosa*), poison sumac (*Toxicodendron vernix*), and tamarack, has been entered into the MNFI database as a natural community occurrence. At present, the prairie fen supports 107 native plant species including many that are found in few other natural communities types including star-grass (*Hypoxis hirsuta*), bog valerian (*Valeriana uliginosa*), hoary willow (*Salix candida*), slender wheat grass (*Agropyron trachycaulum*), bog birch (*Betula pumila*), grass-of-Parnassus (*Parnassia glauca*), large yellow lady's slipper (*Cypripedium calceolus var. pubescens*), golden alexanders (*Zizia aurea*), Riddell's goldenrod (*Solidago riddellii*), bog goldenrod (*Solidago uliginosa*), and alder-leaved buckthorn (*Rhamnus alnifolia*) (Appendix 1). The prairie fen was likely much larger in the past but has been reduced to only a small portion of the wetland complex as a result of tree and shrub invasion. In addition, glossy buckthorn (*Rhamnus frangula*), a highly invasive exotic shrub, is common throughout the wetland and threatens to significantly degrade the entire complex by out-competing other species and forming an impenetrable monoculture. Other highly invasive species occurring within the wetland complex include common buckthorn, multiflora rose (*Rosa multiflora*), Morrow honeysuckle (*Lonicera morrowii*), autumn-olive, marsh thistle (*Cirsium palustre*), Oriental bittersweet (*Celastrus orbiculata*), and Japanese barberry (*Berberis thunbergii*). Management of the prairie fen should include a significant reduction in shrub and tree cover with special emphasis on removal of glossy buckthorn and other invasive shrub species listed above. Shrubs should be cut and their stumps treated with herbicide to prevent resprouting (Reinartz 1997). Prescribed fire is also an important form of natural disturbance that should be implemented to help maintain species diversity and open conditions. The Huron River to the east provides an excellent fire break.

At the Group Camp Fen in Kensington, openings in tamarack are interspersed with native grasses and sedges.

Tamarack Trail Swamp (Site Code: C)

The tamarack swamp near the nature center has been entered into the MNFI database as an exemplary natural community of relict conifer swamp (see natural community abstract in Appendix 3 for more information on relict conifer swamps). Historically, most of the swamp was probably part of an extensive prairie fen, which has since been colonized by tamarack as a result of fire suppression (Figure 6). The relict conifer swamp borders prairie fen to the east and dry-mesic southern forest to the north, south and west. The hydrology of the wetland is maintained by calcareous groundwater seepage from the bases of adjacent coarse-textured moraines that border the swamp to the north and east. Gravel paths cut through and border the swamp in numerous places. The overstory is dominated by tamarack, with black ash (*Fraxinus nigra*) and basswood (*Tilia americana*) locally common. Other trees species present include yellow birch (*Betula alleghaniensis*), red maple (*Acer rubrum*), American elm (*Ulmus americana*), swamp white oak (*Quercus bicolor*), and quaking aspen (*Populus tremuloides*) (Appendix 1). Most relict conifer swamps are characterized by a thick shrub layer, however, this site has a very sparse shrub layer, suggesting that intense browsing pressure by white-tailed deer has significantly altered the community's structure and species composition. Common shrub species include poison sumac, smooth highbush blueberry (*Vaccinium corymbosum*), blue-beech (*Carpinus caroliniana*), tag alder (*Alnus rugosa*), Michigan holly (*Ilex verticillata*), common juniper (*Juniperus communis*), gray dogwood (*Cornus foemina*), and nannyberry (*Viburnum lentago*). The ground layer was diverse with some portions of the swamp supporting a dense mat of sphagnum moss. Common ground layer species include sedges (*Carex stricta*, *C. leptalea*, and *C. lacustris*), swamp goldenrod (*Solidago patula*), dwarf raspberry (*Rubus pubescens*), Canada mayflower (*Maianthemum canadense*), tall flat-top white aster (*Aster umbellatus*), and fringed brome (*Bromus ciliatus*). The only invasive

species observed of significance was giant reed. This species should be removed using herbicide and the area closely monitored to detect further recruitment from the seed bank. As hardwoods, especially red maple, become established within the swamp they will eventually create a closed canopy and cause significant reductions in the amount of light that reaches the understory and ground layer. Light-demanding species such as tamarack and many of the shrub and ground layer species will eventually be eliminated unless measures are taken to reduce dominance of hardwoods such as red maple. Important basking sites for reptile species are also eliminated when relict conifer swamps are invaded by red maple. In order to maintain biodiversity within the tamarack swamp, red maple should be cut and herbicide applied to the stumps to prevent resprouting.

Kingfisher Wet Meadow (Site Code: D)

A small southern wet meadow borders the north shore of Kingfisher Lagoon in the Nature Study Area (see natural community abstract in Appendix 3 for more information on southern wet meadows). It is bordered by dry-mesic southern forest and relict conifer swamp to the north and east. The wet meadow supports 41 species and is dominated by sedges (*Carex stricta, C. lasiocarpa, C. rostrata, C. pseudo-cyperus C. prairea C. hystericina,* and *C. comosa*) (Appendix 1). Other common species include broad-leaved cattail (*Typha latifolia*), softstem bulrush (*Schoenoplectus tabernaemontani*), joe-pye-weed (*Eupatorium maculatum*), common boneset (*Eupatorium perfoliatum*), fen willow-herb (*Epilobium leptophyllum*), spotted touch-me-not (*Impatiens capensis*), and marsh fern (*Thelypteris palustris*). Because the community is in an open condition (non-forested), it provides important basking sites for reptile and amphibian species. Management of the area should strive to maintain the community in an open condition through shrub and tree removal (e.g., cutting followed by herbicide application to cut stumps), periodic flooding, and prescribed fire. A small population of giant reed occurs within the meadow and should be controlled using herbicide. Annual monitoring to detect the further spread of giant reed and presence of invasive species like purple loosestrife (*Lythrum salicaria*) and glossy buckthorn will be an important part of any long-term protection strategy. If found, invasive species should be promptly removed before they detrimentally impact this small wet meadow.

At Kensington, a southern wet meadow on Kingfisher Lagoon borders a dry-mesic oak forest.

Chickadee Loop Woodland (Site Code: E)

A dry-mesic southern forest, approximately 80 acres in size, occurs in the Nature Study Area north of the prairie fen and relict conifer swamp (Figure 6). The woodland occurs on rolling, coarse-textured moraines and borders prairie fen and relict conifer swamp to the south. In the past, this area supported more open, fire-dependent natural community types like oak barrens and mixed oak savanna that were comprised of widely scattered black and white oaks with a prairie ground flora (see natural community abstract in Appendix 3 for more information on oak barrens). Today the site is occupied by closed-canopy forest, which is dominated by white oak, black oak, and red oak (*Quercus rubra*). The woodland contains a diverse assemblage of tree species, several of which include bur oak, pignut hickory (*Carya glabra*), shagbark hickory (*Carya ovata*), bitternut hickory (*Carya cordiformis*), American beech, basswood, white ash, black walnut (*Juglans nigra*), and sugar maple (Appendix 1). While no reproduction of white oak, bur oak, or black oak was observed, red maple is thriving in the understory. Additional species occupying the understory include ironwood (*Ostrya virginiana*), sassafras (*Sassafras albidum*), flowering dogwood (*Cornus florida*), and blue-beech. The forest contains an intermittent stream that runs through a swallow ravine towards the prairie fen and relict conifer swamp, and several areas of groundwater seepage (e.g., springs) occur along the woodland's southern edge where it abuts these wetlands. Numerous plants normally associated with mesic southern forests or wetlands occur near this edge and along the ravine including skunk-cabbage (*Symplocarpus foetidus*), false nettle (*Boehmeria cylindrica*), golden ragwort (*Senecio aureus*), blue cohosh (*Caulophyllum thalictroides*), jack-in-the-pulpit (*Arisaema triphyllum*), cinnamon fern

(*Osmunda cinnamomea*), maidenhair fern (*Adiantum pedatum*), and wood nettle (*Laportea canadensis*). Several invasive species occur within the forest including Oriental bittersweet, autumn-olive, and sweet cherry (*Prunus avium*). In order to prevent these species from negatively impacting biodiversity they should be cut and their stumps treated with herbicide to prevent resprouting. A small amount of garlic mustard was also observed on the southern margins of the forest, just west of the trailside deer exclosure. All garlic mustard plants should be removed before they set seed in late spring and the area should be monitored annually to detect recruitment from the seed bank. With an absence of flowering common trillium (*Trillium grandiflorum*) and numerous signs of deer browsing, the forest appears heavily impacted by an overabundance of white-tailed deer. In addition, deer herbivory may be responsible for the loss of a state-threatened plant, goldenseal, which had been observed here in the past but could not be relocated. Management of the forest should include a concerted effort to reduce the density of white-tailed deer. Because of the lack of oak regeneration, management methods that increase the amount of light reaching the understory and ground layer should be considered. These may include conducting prescribed burns to help reduce the density of fire-sensitive tree species like red maple, selective removal or girdling of individual shade-tolerant tree species (e.g., red maple), or active management of light gaps to favor oak regeneration.

East Border Oak Barrens (Site Code: F)

A small area of remnant oak barrens occurs near the Shorefishing Parking area (Figure 6). The area straddles both sides of Route 1, and stretches from the east shore of Kent Lake to the metropark's eastern border. Black oak and white pine (*Pinus strobus*) dominate the scattered overstory east of Route 1. West of the road, the area is mostly open. While several invasive species occupy much of the ground layer, a diverse group of native prairie and oak barrens species also occur here including lupine (*Lupinus perennis*), little bluestem grass (*Andropogon scoparius*), butterfly-weed (*Asclepias tuberosa*), clustered-leaved tick-trefoil (*Desmodium glutinosum*), woodland sunflower (*Helianthus divaricatus*), round-headed bush-clover (*Lespedeza capitata*), showy goldenrod (*Solidago speciosa*), flowering spurge (*Euphorbia corollata*), and Pennsylvania sedge (*Carex pensylvanica*) (Appendix 1). The area contains numerous woody and invasive species. The woody invasive species, which includes autumn-olive, Oriental bittersweet, and multiflora rose, should be cut and their stumps treated with herbicide to prevent resprouting. Prescribed fire should be used to control the invasive herbaceous species, which include spotted knapweed (*Centaurea maculosa*), smooth brome (*Bromus inermis*), Kentucky bluegrass (*Poa pratensis*), and red fescue (*Festuca rubra*). Because oak barrens were maintained in an open condition by frequent ground fires, the plants that were historically associated with this ecosystem are well adapted to fire and typically respond with increased growth, flowering, and seed production (see natural community abstract in Appendix 3 for more information on oak barrens).

Spring Hill Woodland (Site Code: G)

Spring Hill supports a dry-mesic southern forest that is dominated by a mixture of black oak, white oak, red oak, shagbark hickory, pignut hickory, and American beech. Most of the Spring Hill forest occupies the south-facing slope of a steep end moraine, however, approximately 20 acres of the forest lies on level land atop the moraine and is surrounded on three sides by old field (Figure 6). The western portion of the forest sits atop a moraine that rises over 40 meters (140 feet) above Spring Hill Pond and provides an excellent view of the surrounding landscape. A steep-sided ravine runs down the slope of the moraine through the center of the forest and carries a small stream that is fed by both groundwater seeps (e.g., springs) and a drain-tile outlet pipe emanating from the edge of an old field above the slope. The seepage areas within the ravine support a variety of wetland plants including skunk-cabbage, great water dock (*Rumex orbiculatus*), jack-in-the-pulpit, false nettle, spinulose woodfern (*Dryopteris carthusiana*), and great blue lobelia (*Lobelia siphilitica*) (Appendix 1). In addition to the spring-fed stream, the forest also supports a small vernal pool on the level terrain near the northern edge of the forest. This small, ephemeral pond provides important breeding habitat for amphibian species. The forest understory is dominated by red maple, black cherry (*Prunus serotina*), and sassafras. No oak reproduction was observed within the forest. Common ground-layer species include Pennsylvania sedge, bottlebrush grass (*Hystrix patula*), and wild geranium (*Geranium maculatum*). Numerous invasive species were observed including Oriental bittersweet, Japanese barberry, autumn-olive, and Amur honeysuckle (*Lonicera maackii*). These species should be controlled through cutting, accompanied by herbicide application to the cut stumps to prevent resprouting. Prescribed fire should be used to help reduce understory density and help control invasive species. Fire may also help create light gaps, which will facilitate oak reproduction. Removal or girdling of

selective, shade-tolerant trees like red maple may also help facilitate oak reproduction. The woodland should be monitored annually during the spring for garlic mustard, and if detected, all plants should be removed before setting seed.

North Windfall Hill Woodland (Site Code: H)

A small (20 acre, 8 ha) block of dry-mesic southern forest occurs adjacent to North Windfall Hill picnic area and is bordered by Kent Lake (Figure 6). The forest is located on a steep-sided end moraine and is dominated by white oak and black oak, with scattered shagbark hickory, black cherry, red maple, American beech, sugar maple, and white ash. The steep south-facing slope above Kent Lake supports a well developed shrub layer of sassafras, blueberry (*Vaccinium angustifolium*), and wild rose (*Rosa blanda* or *R. caroliniana*), indicating that the forest canopy was likely more open in the past. Other common native shrub species include witch-hazel (*Hamamelis virginiana*), hazelnut (*Corylus americana*), downy arrow-wood (*Viburnum rafinesquianum*), huckleberry (*Gaylussacia baccata*), flowering dogwood, juneberry (*Amelanchier arborea*), nannyberry, gray dogwood, and hawthorn (*Crataegus* sp.) (Appendix 1). The west edge of the forest adjacent to Kent Lake harbors a small wetland that supports a diverse set of hydrophilic species including marsh bellflower (*Campanula aparinoides*), tall flat-top white aster, monkey flower (*Mimulus ringens*), royal fern (*Osmunda regalis*), spinulose woodfern, common skullcap (*Scutellaria galericulata*), common boneset, sedges (*Carex stricta and Carex stipata*), ninebark (*Physocarpus opulifolius*), meadowsweet (*Spiraea alba*) and swamp rose (*Rosa palustris*). The forest contains several invasive species including Oriental bittersweet, autumn-olive, Morrow honeysuckle, and lily-of-the-valley (*Convallaria majalis*). To safeguard biodiversity within the forest and surrounding landscape these invasive species should be removed. Control measures should include the direct application of herbicide for herbaceous species (lily-of-the-valley) and cutting accompanied by herbicide application to the cut stumps to control resprouting for woody species. Prescribed fire should be implemented within the forest to help control invasive species, thin the understory, and create light gaps to stimulate oak reproduction, which is currently absent.

Hickory Ridge Woodland (Site Code: I)

A dry-mesic southern forest occurs along the northwest shore of Kent Lake near the Island Road, South Hickory Ridge, North Hickory Ridge, and Baywoods picnic areas (Figure 6). The forest contains some very open areas that support many species normally associated with prairie and oak barrens as well as closed-canopy forest and numerous forested wet depressions. The most open areas occur near the South Hickory Ridge picnic area where the south and west facing slopes of a coarse-textured end moraine meet Kent Lake. The black oak and white oak canopy is relatively open here, which allows a diverse remnant prairie flora to persist. An additional factor that may have aided the persistence of native prairie plants is the occasional addition of hot embers from the barbecue grills located atop the hillside. It appears that these hot ashes occasionally ignite the dried plant debris, which bolsters nutrient cycling and creates the open soil conditions required by prairie plants such as annual false foxglove (*Aureolaria pedicularia*). Other native prairie and oak barren species observed here include bush-clover (*Lespedeza intermedia*), wild lupine, butterfly-weed, clustered-leaved tick-trefoil, shrubby St. John's-wort (*Hypericum prolificum*), round-headed bush-clover, panicled tick-trefoil (*Desmodium paniculatum*), black-eyed susan (*Rudbeckia hirta*), and wild bergamot (*Monarda fistulosa*) (Appendix 1). Many of the black oaks in this area have double trunks, an indication they most likely grew from fire-suppressed oak grubs that were maintained in a shrub-like condition for hundreds of years by frequent fires when this area supported black oak barrens (Curtis 1959). Shrub species in this area include hazelnut, blueberry, gray dogwood, flowering dogwood, huckleberry, and common juniper. Several invasive species occur here including woody species such as Oriental bittersweet, autumn-olive, and Amur honeysuckle, and herbaceous species such as spotted knapweed, Canada bluegrass (*Poa compressa*), orchard grass (*Dactylis glomerata*), and bittersweet nightshade (*Solanum dulcamara*). Because the woody invasive species have the potential to rapidly spread and negatively impact biodiversity they should be cut and their stumps treated with herbicide to prevent resprouting. Of the herbaceous invasive species listed above, spotted knapweed poses the greatest threat to biodiversity. Management efforts should focus on removing this plant using a combination of herbicide application and prescribed fire. The area should be managed with prescribed fire to control the spread of woody and herbaceous invasive species, thin the understory, create canopy gaps, increase nutrient cycling, reduce leaf litter, stimulate the soil seed bank, and bolster flowering and seed production.

The remainder of the forest in this area is a mixture of closed-canopy, oak-dominated dry-mesic southern forest and wet depressions. The forest harbors numerous large white oaks, some measuring as large

as 97 cm, 78 cm, and 55 cm in diameter. Additional canopy trees include black oak, red oak, pignut hickory, sugar maple, basswood, red maple, American beech, white ash, ironwood, black cherry, sassafras, and American elm. Common shrub species include nannyberry, blue-beech, and prickly gooseberry (*Ribes cynosbati*). Common ground-layer species include wild geranium, Pennsylvania sedge, and bottlebrush grass. The wet swales support a large number of wetland plants including black ash, wood reedgrass (*Cinna arundinacea*), maidenhair fern, skunk-cabbage, jack-in-the-pulpit, spinulose woodfern, cinnamon fern, New York fern (*Thelypteris noveboracensis*), lady fern (*Athyrium filix-femina*), and sedges (*Carex rosea* and *C. stipata*).

Portions of the forest appear heavily impacted by white-tailed deer and have a distinct browse line. Invasive species observed within the forest include garlic mustard, Japanese barberry, and Dame's rocket (*Hesperis matronalis*). A small patch of garlic mustard and Dame's rocket occurs near the intersection of Park Routes 2 and 5, across the road from the Island Road picnic area. This small patch should be removed now, while it is easily manageable and before the plants set seed in late spring. In addition, the area should be monitored annually to detect further recruitment of these invasive species from the seed bank. Because seeds of garlic mustard and Dame's rocket are very easily spread, monitoring to detect new populations of these species should be conducted annually and all plants should be removed in the spring before they set seed. The population of Japanese barberry near the North Hickory Ridge picnic area may also be relatively easily controlled at this time by using a combination of cutting and herbicide application to the cut stump to prevent resprouting. Prescribed burning will facilitate invasive species control and help thin the understory. No oak reproduction was observed within the forest interior. Prescribed burning may also help create light gaps, which will stimulate oak reproduction.

Oakwoods Metropark

Oxbow Floodplain Forest (Site Code: J)

A southern floodplain forest of approximately 80 acres (32 ha) borders both sides of the Huron River just west of the nature center at Oakwoods Metropark. A natural terrace (e.g., embankment) separates the southern edge of the floodplain from adjacent picnic areas to the south. From there, the relatively flat terrain slopes gradually toward the Huron River. On the north side of the river, the flat to gently sloping terrain is broken by occasional drainage ditches cut through the forest long ago to drain adjacent upland agricultural fields. Throughout the floodplain, a complex microtopography of small, shallow depressions and gentle rises provide a diversity of habitats that support a wide variety of species.

The site is dominated by a closed-canopy forest of medium-sized silver maple, red ash (*Fraxinus pennsylvanica*), and cottonwood (*Populus deltoides*). The forest includes other tree species characteristic of floodplains such as hackberry (*Celtis occidentalis*), redbud (*Cercis canadensis*), hawthorn, swamp white oak, black walnut, shagbark hickory, and American elm. Structural diversity is added by a diverse shrub layer comprised of species such as bladdernut (*Staphylea trifolia*), buttonbush (*Cephalanthus occidentalis*), spicebush, hazelnut, hop-tree (*Ptelea trifolia*), nannyberry, elderberry (*Sambucus canadensis*), and silky dogwood (*Cornus amomum*) (Appendix 2). The ground flora is especially diverse with 58 native herbaceous species recorded, including numerous colonies of state-threatened beak grass. Other plants characteristic of floodplains present include green dragon (*Arisaema dracontium*), wood reedgrass, wood nettle, cut grass (*Leersia oryzoides*), cardinal flower (*Lobelia cardinalis*), sensitive fern (*Onoclea sensibilis*), cut-leaved coneflower (*Rudbeckia laciniata*), lizard's-tail (*Saururus cernuus*), and purple meadow-rue (*Thalictrum dasycarpum*). State-threatened water-willow was also found on the eastern portion of the site in slackwater areas of the river.

Stewardship priorities for this site should focus on removal of invasive shrubs scattered occasionally throughout the floodplain. These species include

A high water table and rich soil supports lush vegetation on the Huron River floodplain at Oakwoods.

Windthrow and flooding are important natural processes on the Huron River floodplain at Oakwoods.

common and glossy buckthorn, Amur and Morrow honeysuckle, and multiflora rose. Notably absent at this site was garlic mustard and Dame's rocket, two highly invasive herbaceous species that often invade floodplain habitats. Vigilant monitoring and quick eradication of any adventive colonies of these species is critical to the stewardship of this site. Because abundance of exotic species in this floodplain is relatively low, it presents an excellent opportunity to maintain a large, high-quality site by doing a minimal amount of stewardship activity.

West Oxbow Floodplain Forest (Site Code: K)

Another large block of southern floodplain forest is located west of the railroad, south of a wide bend in the Huron River. While similar to the Oxbow Floodplain Forest in its species composition, it differs topographically in that the riverbank rises much higher above the river and the southern portion of the woodlot contains large, seasonally wet depressions that remain inundated throughout spring and much of the summer. A dense canopy of silver maple, red ash, and black walnut dominates the floodplain, with swamp white oak and cottonwood abundant in the large, seasonally wet depressions. Native shrubs such as buttonbush, silky dogwood, spicebush, bladdernut, and nannyberry also add diversity to the site. The floodplain supports characteristic, native ground flora including wild garlic (*Allium canadense*), jack-in-the-pulpit, green dragon, wild ginger (*Asarum canadense*), purple joe-pye-weed (*Eupatorium purpureum*), white snakeroot (*Eupatorium rugosum*), and cut-leaved coneflower (Appendix 2).

The most notable species on the floodplain is beak grass, which occurs nearly continuously along a trail used for walking and riding horses. It is one of the largest known colonies in Michigan of this state-threatened grass, but it is imperiled by a locally dominant layer of invasive shrubs including multiflora rose, Japanese barberry, and Morrow honeysuckle. If possible, these shrubs should be aggressively controlled in a way that limits impact to beak grass, such as cutting and treating stumps with herbicide in the winter when beak grass is dormant (Reinartz 1997). Another rare species, cup-plant, is located in a meadow in a pipeline corridor adjacent to the southeast portion of the floodplain forest. This meadow is frequently mowed to keep it open, which is detrimental to cup-plant and other native species when conducted in the heart of the growing season. If possible, prescribed fire should be used to maintain the corridor and bolster native species or mowing should be conducted in late fall after fruiting and seed dispersal has been completed.

At Oakwoods, beak grass, a rare plant, lines a trail through the West Oxbow Floodplain Forest.

Railroad Floodplain Forest (Site Code: L)

North of the river and immediately east of the railroad trestle lies a small, degraded southern floodplain forest. In comparison to the other floodplain forests at Oakwoods, this site has been more heavily impacted, with recent disturbances resulting from construction of a railroad trestle and maintenance of a powerline corridor. Exotic shrubs are also prevalent in portions of the site. Despite its overall lower site quality, the floodplain still supports small colonies of beak grass, and an additional colony of cup-plant was found along the river in a meadow beneath the power line (Appendix 2). Stewardship needs at this site include removing invasive shrubs and maintaining

openings for cup-plant. Ideally, these activities would take place before or after the growing season to minimize impacts to rare species. Long-term conservation planning and restoration should focus on allowing areas adjacent to the river to reforest in order to connect fragmented blocks of floodplain forest and create a contiguous forested riparian corridor.

Nature Study Area Woodland (Site Code: M)

A large, impressive forest of approximately 80 acres (32 ha) is located in the nature study area immediately east of the nature center. It is a mosaic of fire-dependent, dry-mesic forest interspersed with shallow mesic ravines and seasonally wet depressions that support mesic and wet-mesic species. The forest is bordered to the north by a steep bank leading down to the Huron River. To the south, it is bordered by younger forests and open fields. The forest is dominated by bur oak, white oak, black oak, and pin oak (*Quercus palustris*), often of very large size (80 to 130 cm in diameter) and old age (up to an estimated 300 years old). Many of the large oaks are severely shade-pruned with numerous, large lower branch scars and barren lower limbs. These ancient trees likely once grew in more open conditions such as those associated with lakeplain oak openings (for more information on lakeplain oak openings see appendix 3). Red maple, basswood, American elm, shagbark hickory, and pignut hickory are also common in the forest subcanopy. Sapling or understory oak regeneration is completely absent from the forest. Small shrubs are scattered throughout the forest; these include gray dogwood, hazelnut, witch-hazel, maple-leaved arrow-wood (*Viburnum acerifolium*), smooth arrow-wood (*Viburnum dentatum*), and prickly-ash (*Zanthoxylum americanum*) (Appendix 2). Ground flora in the forest is diverse, with the dry-mesic uplands supporting wild geranium, may-apple (*Podophyllum peltatum*), false spikenard (*Smilacina racemosa*) and numerous other species. Shallow ravines with intermittent streams running down to the river bisect the forest and provide habitat for mesic species like doll's-eyes (*Actaea pachypoda*), jack-in-the-pulpit, and wild ginger. The steep embankment that rises up from the river is drier than the forest interior and supports native species such as prairie alum-root (*Heuchera richardsonii*), Pennsylvania sedge, blue-stemmed goldenrod (*Solidago caesia*) and broad-leaved goldenrod (*Solidago flexicaulis*). Below the embankment, large colonies of state-threatened water-willow thrive in shallow water on the margins of the Huron River.

This forest, as with much of the forested uplands of Oakwoods Metropark, is undergoing a slow but profound change in species composition. The age and growth form of many of the oaks in the forest suggest the site was once much more open, and may have been maintained by periodic wildfires and the activity of Native Americans known to inhabit the area in the mid-eighteenth and early nineteenth centuries. As a result of fire suppression, red maple has succeeded in colonizing the understory and is now subdominant within the forest overstory. Currently, the shaded conditions of the ground layer created by the predominance of red maple preclude oak regeneration, and over time, aging oaks will be lost from the canopy. Management to maintain oak dominance includes physically removing a portion of the red maple subcanopy, prescribed burning, and hand planting acorns or small oak seedlings in areas with large light gaps and on forest edges. Any management for oak regeneration must also include reducing densities of white-tailed deer and protecting seedlings from browsing. Numerous invasive woody plants occur within the forest including Oriental bittersweet, Japanese barberry, Morrow honeysuckle, common buckthorn, glossy buckthorn, multiflora rose, winged wahoo (*Euonymus alata*), common privet (*Ligustrum vulgare*), and black locust (*Robinia pseudoacacia*). Stewardship activities should focus on first monitoring for and removing invasive species from areas not yet heavily infested and still harboring a diverse ground flora. Following this containment strategy, larger epicenters of invasive species should be removed. To prevent woody invasives from resprouting and creating even more serious stewardship and ecological problems, it is critically important that herbicide be applied to all stumps immediately after cutting.

Salamander Woods (Site Code: N)

One of several seasonally wet, dry-mesic southern forests occurs just west of the railroad tracks and north of the park drive (Figure 7). The site is dominated by very large red oak, white oak, bur oak, swamp white oak, and shellbark hickory (*Carya laciniosa*). Shagbark hickory, bitternut hickory, and red maple also occupy a significant portion of the subcanopy. This woodland has numerous seasonally wet, shallow depressions, a feature common to lake plain where heavy clay soils and flat topography prevent drainage. The seasonally wet depressions provide critical habitat for the rare squarrose sedge and amphibians. Other tree species common in this seasonally wet forest include blue-beech, ironwood (*Ostrya virginiana*), sassafras, and American elm. The ground flora is very sparse in mid summer, with the vast majority of ground covered only by decaying leaves or mineral soil. The species that are present are often more characteristic of mesic to wet-mesic environments,

such as round-lobed hepatica (*Hepatica americana*), downy solomon-seal (*Polygonatum pubescens*), lady fern, spinulose woodfern, fowl manna grass (*Glyceria striata*) and sedges (*Carex grayi*, *C. lacustris*, *C. lupulina*, and *C. pensylvanica*) (Appendix 2).

Despite being bisected by a natural gas corridor, the majority of this site is relatively high-quality with few invasive species. Glossy buckthorn and Japanese barberry occur occasionally throughout the ground layer and at the margins of the forest and should be eradicated where found. If sufficient leaf litter is present, a prescribed burn may also be effective in reducing small glossy buckthorn stems, which are numerous in places. As in most of the oak forests within the park, a dense layer of red maple in the subcanopy is severely limiting oak regeneration. Measures such as prescribed burning, girdling red maple, and managing natural light gaps may be employed to foster oak regeneration and maintain oak dominance.

Large white oak and bur oak are common at Salamander Woods.

White Oak Woodland (Site Code: O)

Another seasonally wet, dry-mesic southern forest is located north of the Railroad Floodplain Forest and east of the railroad tracks (Figure 7). Similar to Salamander Woods, small seasonally wet depressions are scattered through this forest. The hydrologic regime along the woodland's northern edge is somewhat disturbed by the channelization of a small stream (Warner Drain), which likely had a strong influence on the ecology of this portion of the forest in the past. White oak dominates the canopy of this woodlot. Other locally common overstory species include black oak, red oak, bur oak, pin oak, red ash, white ash, shagbark hickory, pignut hickory, red maple, and American elm. The shrub layer is sparse but includes species such as rough-leaved dogwood (*Cornus drummondii*), gray dogwood, and prickly-ash. A series of long, narrow vernal pools surrounded by pin oak and sedge (*Carex muskingumensis*) occurs along the southern border of the site. A small colony of the state special concern species, squarrose sedge, grows within small, shallow, wet depressions along the woodland's western border. Other herbaceous plants found in this forest include clustered-leaved tick-trefoil, wild geranium, sneezeweed (*Helenium autumnale*), southern blue flag (*Iris virginica*), Virginia wild-rye (*Elymus virginica*), white grass (*Leersia virginicus*), wood reedgrass, and sedges (*Carex hirtifolia*, *C. pensylvanica*, and *C. radiata*) (Appendix 2). Oaks were once again conspicuously absent from the sapling and ground layers of this forest.

Two invasive species, glossy buckthorn and multiflora rose, were found at this site and should be removed through cutting and herbiciding stumps. This site would benefit from prescribed fire, which can help thin the understory and improve nutrient cycling. The railroad tracks to the west and stream channel to the north provide excellent fire breaks. The woodlot may also support additional populations of amphibians and should be surveyed in spring to document their presence prior to conducting other management activities.

Brandes Road Woodland (Site Code: P)

South of Salamander Woods, adjacent to Brandes Road and west of the railroad tracks lies a small woodlot dominated by red oak, basswood, and shellbark hickory (Figure 7). Other common species include black cherry, prickly-ash, prickly gooseberry, and jumpseed (*Polygonum virginianum*) (Appendix 2). Portions of the interior support significant amounts of oak and hickory regeneration, which was likely facilitated by an event that opened the canopy in the past. A similar management approach that encourages oak regeneration can be applied on the northern margins of the woodlot, which are currently dominated by a dense stand of hawthorn and other shrubs. Invasive shrubs such as common buckthorn and glossy buckthorn also occur within the woodland and along its edges and should be removed. Long-term management at this and other similar upland sites should focus on allowing portions of adjacent meadows to reforest with oaks and hickories, thus connecting fragmented woodlots and creating larger blocks of mature forest.

Borderline Woods (Site Code: Q)

Another small, oak-dominated woodlot with shallow wet depressions occurs along the southern

border of the metropark, just south of the park drive and west of the nature center (Figure 7). This site is dominated by very large red oak, bur oak, and pin oak (up to 114 cm in diameter), but like other forests in the park, oak regeneration is limited by a dense layer of red maple and black cherry in the subcanopy. Other species commonly found at this site include tulip-tree (*Liriodendron tulipifera*), riverbank grape (*Vitis riparia*), hairy sweet cicely (*Osmorhiza claytonia*), and lopseed (*Phryma leptostachya*) (Appendix 2). Several exotic shrubs (common buckthorn, Japanese barberry, and multiflora rose) were also found at this site. Although no rare species were found in the woodlot, it has the potential to harbor populations of rare amphibians. Surveys for salamanders should be conducted before beginning the recommended stewardship activities, which include invasive shrub removal accompanied by herbicide application to cut stumps, and prescribed burning.

Seedbox Swale (Site Code: R)

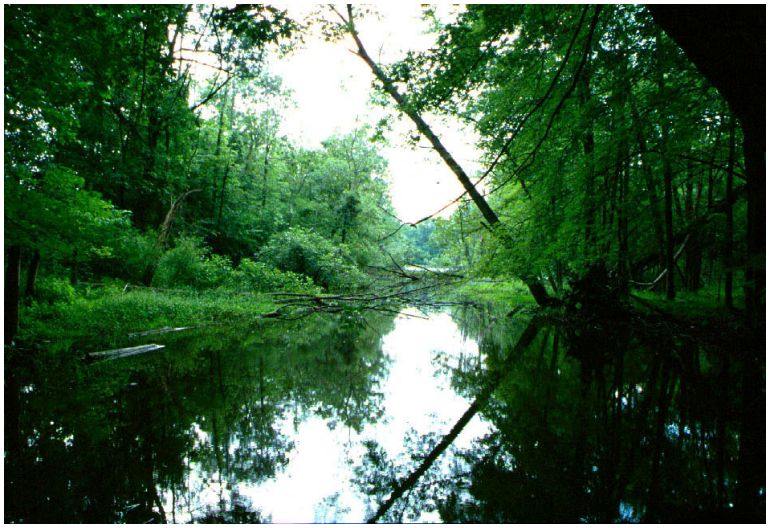
A shallow, wet, sandy swale containing several species typically associated with lakeplain prairie occurs in the southwest portion of the metropark (Figure 7). Positioned immediately north of the biking trail and gas line corridor, the swale was likely influenced or possibly created by their construction. The site is highly degraded, with numerous exotic species, but contains a sizable, localized colony of the rare plant, seedbox. Purple loosestrife threatens to overwhelm the site along with glossy buckthorn and other native woody species such as red maple and rough-leaved dogwood (Appendix 2). Because seedbox is a light-demanding species, woody plants and exotics will soon shade it out if they are left unchecked. Although the site is quite degraded, it is sufficiently small that a minimal amount of restoration will significantly improve conditions for seedbox and other native remnant prairie species.

Dissucussion

Rare Plants

Small white lady's slipper is a state-threatened plant and is known from 81 locations in Michigan (10 in Livingston County), mostly in the southern three tiers of counties in Lower Michigan. This species inhabits high-quality prairie fens, and can be reliably recognized only while flowering in mid-May to early June. It is threatened by habitat loss from development and encroachment of woody species into its grass- and sedge-dominated habitat. When first documented in 1986, the colony of white lady's slipper at Kensington contained 30-40 plants. In 2001 and 2002, park naturalists observed only two plants. The dramatic declines in the abundance of small white lady's slipper observed at Wildwing Fen at Kensington Metropark are very likely the result of overbrowsing by deer. Declines may also be due to a lack of fire, which strongly stimulate lady's slipper. Protection of the population of white lady's slipper should include reducing deer densities, maintaining the fen's hydrology, and using prescribed fire to reduce competition from larger perennials and stimulate flowering and seed germination.

Water-willow is a state-threatened plant and has been recorded at 11 sites in Michigan. It is found primarily in southeast Michigan along the Huron River where it inhabits muddy riverbanks and slackwater areas that support emergent marsh. It has also been found occasionally along the Raisin River and on shallow, muddy margins of inland lakes and historically along Lake Erie. The species usually grows in shallow water in emergent marshes with common associates such as arrow-arum (*Peltandra virginica*) and bur-reed (*Sparganium* sp.). This perennial forms dense clones, which can reach many square meters in size, and spreads by rhizomes and leafy stolons. It is best surveyed for while flowering from mid-July to late August, but is recognizable throughout the latter part of the growing season. Alterations to river hydrology and impoundments can be detrimental to this species. Protecting the hydrology and water quality of the Huron River as well as preventing the spread of invasive plant species such as purple loosestrife are critical conservation strategies that must be employed



Slackwater area of the Huron River support colonies of water-willow, a state-threatened plant.

to protect this species. In addition, a significant portion of its known populations in Michigan occurs at Oakwoods and other metroparks, making it a high conservation priority. It is recommended that its distribution within the parks be closely mapped and monitored to detect changes in the population over time.

Beak grass is a state-threatened species found primarily in southern floodplain forests. Previous to this study, it was known from only 13 locations in Michigan, including several sites in southeast Michigan along the Huron and Raisin rivers (2 in Wayne County). Where it is found, beak grass is usually sparsely distributed, mostly occurring only in scattered clumps. The new occurrence discovered in the floodplains of Oakwoods Metropark is unusually large, and as one of the largest populations known in the state, it is also a high conservation priority. This species can be recognized throughout the growing season but is most easily identified in August and September by its characteristic inflated spikelets. Longer-term conservation strategies to protect beak grass include removing invasive species, protecting the hydrology of river systems and corresponding cyclical flooding regimes, maintaining healthy, intact, mature floodplain forests, and using conservation planning and restoration to connect previously fragmented floodplain forests to create contiguous riparian corridors.

Beak grass, a state-threatened plant, is abundant along the Huron River floodplain at Oakwoods.

Cup-plant is listed as a state-threatened species. Prior to this study, it was known from 19 sites in Michigan, mostly in southern Michigan (11 in Wayne and Monroe Counties combined). Cup-plant commonly occurs in openings of floodplain forests and in adjacent meadows, and is easily recognized during the latter part of the growing season (July – October) by its characteristic yellow flower and perfoliate leaves. Threats to cup-plant include loss of its floodplain forest and meadow habitat, competition from invasive species, and mowing of meadows during the growing season. These threats are especially severe at Oakwoods where the population is mowed during the summer and the surrounding floodplain forest supports large numbers of invasive woody plants such as Morrow honeysuckle and common and glossy buckthorn. Conservation strategies for this species include maintaining natural forest openings and meadows, preventing mowing of its habitat during the growing season, protecting southern floodplain forests, controlling invasive species, and maintaining or restoring historical flooding regimes of rivers.

Squarrose sedge is listed as a species of special concern. Plants are given the status of special concern when the status of the species in unknown. A species remains on the special concern list until it is determined whether the species should be elevated to threatened or endangered status or is common enough to be untracked. Prior to this study squarrose sedge was known from only 10 locations in Michigan, mostly in southeast Michigan (4 in Wayne and Monroe Counties combined). This sedge inhabits wet meadows and seasonally wet depressions within oak-hickory forests. Threats to squarrose sedge include habitat loss, competition from invasive species, mowing during the growing season, and forest fragmentation. At Oakwoods Metropark, very small populations of squarrose sedge were observed near the edges of two isolated blocks of forest. Long-term conservation strategies to protect squarrose sedge include maintaining healthy, intact, mature forests, controlling invasive species, and using conservation planning and restoration to connect previously fragmented blocks of forest.

Squarrose sedge inhabits seasonally wet depressions in the woodlands at Oakwoods.

Seedbox is listed as a species of special concern. Seedbox is currently known from 29 locations in Michigan, mostly in the southern two tiers of counties (11 in Wayne and Monroe Counties combined). It occurs in disturbed sandy depressions and remnants of lakeplain prairie. Threats to the species include habitat loss, tree and shrub encroachment, and competition from invasive species. The small population of seedbox at Oakwoods Metropark is currently overrun with purple loosestrife, reed, glossy buckthorn, rough-leaved dogwood, and red maple. Conservation strategies to protect seedbox include woody plant removal, invasive species control, and prescribed burning to enhance seed production and stimulate seed germination.

Two known records for state-threatened plants were not reconfirmed. Goldenseal was last observed in Kensington Metropark in 1986, and a thorough survey of potential habitat failed to locate this species. It is likely that the plants were either illegally poached for their medicinal roots or were excessively browsed by deer. There is a chance that the species persists within the seed bank and may again be found when deer densities have been significantly reduced. American lotus was last observed at Oakwoods Metropark in 1979 in slackwater areas of the Huron River. Although some of this habitat has been invaded by purple loosestrife, large portions of suitable habitat remain intact. Future surveys for this species should be conducted by boat along the edges of islands and in backwater areas as our foot surveys of the river banks failed to relocate this species. If the species has been extirpated, it is possible that it may reappear following changes in water levels.

Fire as an Ecological Process

Many of the areas within the metroparks we surveyed once supported fire-dependent ecosystems such as wet prairie, wet meadow, prairie fen, oak barrens, and oak forest. In the past, lightning- and human-induced fires frequently spread over large areas of southern Michigan and other Midwestern states (Curtis 1959, Grimm 1984, Dorney 1981). In the absence of frequent fires, open oak barrens convert to forested communities such as oak-hickory forest or mixed oak forest (see oak barrens abstract, Appendix 3). The reduction of wildfires in Midwestern states following the loss of indigenous cultures in the early 1800s is well documented and resulted in a loss of fire-dependent natural communities through both active conversion for farming and succession from open barrens and prairie to forest (Curtis 1959).

The conversion of open barrens and prairie to forested communities continues today and often results in a loss of species and habitat diversity (Curtis 1959, McCune and Cottam 1985, McClain et al. 1993). This was evident at many of the sites we surveyed in each of the metroparks. At Kensington Metropark the open character of prairie fen, oak barrens, and openings within dry-mesic southern forest are being lost as the communities actively succeed to closed-canopy shrub- and tree-dominated communities. As shade-tolerant woody species and canopy closure increases, light levels are reduced and light-demanding species such as prairie forbs and grasses are unable to remain viable. As a result, both species diversity and habitat heterogeneity are being reduced.

Some of the biggest changes as a result of canopy closure may be taking place within the oak forests. At present, oaks dominate the canopies of dry-mesic forests at both Kensington and Oakwoods. However, oak regeneration within these forests is absent and suppression of the historic fire regime has allowed thin-barked, shade-tolerant species such as red maple dominate the subcanopy and forest understory (Abrams 1998). As aging oaks slowly reach senescence and the dense shade created by the predominance of red maple precludes further oak recruitment, the structure and species composition of these forests will undergo significant changes. Because the historic fire regime that maintained oak forests is now drastically disrupted, active forest management is necessary to maintain oak dominance within the metroparks.

The proliferation of red maple within the oak forests also results in significant changes in adjacent wetland communities. For example, at Kensington fire suppression has enabled red maple to establish within a dry-mesic forest and the species is now beginning to colonize an adjacent relict conifer swamp (Chickadee Loop Woodland and Tamarack Trail Swamp, Figure 6: E and C). Species loss following invasion of relict conifer swamp by red maple can be significant. The shift from conifer-dominance to hardwood-dominance also results in a drastic reduction in shrub cover (Kost 2001). The reduction of shrub cover that results from red maple invasion can adversely impact a wide range of both animal and plant species. In particular, many bird species rely heavily on the fruit of these wetland shrubs during fall migration and winter. While fire is not a frequent form of natural disturbance for relict conifer swamp its absence in the broader landscape has significantly altered wetland successional pathways to the detriment of light-demanding species like tamarack. Thus, actively cutting or girdling shade-tolerant hardwoods such as red maple from relict conifer swamps is needed if this important natural community type is to be maintained.

Plant communities, whether upland or lowland, benefit from prescribed fire in several ways. Depending on the season and intensity of a burn, prescribed fire may be used to decrease the cover of exotic, cool-season grasses and woody species, and increase the cover of native warm-season grasses and forbs (White 1983, Abrams and Hulbert 1987, Tester 1989, Anderson and Schwegman 1991, Collins and Gibson 1990, Glenn-Lewin et al. 1990). Prescribed fire helps reduce litter levels, allowing sunlight to reach the soil surface and stimulate seed germination and enhance seedling establishment (Daubenmire 1968, Hulbert 1969, Knapp 1984, Tester 1989, Anderson and Schwegman 1991, Warners 1997). Important plant nutrients (e.g., N, P, K, Ca, and Mg) are elevated following prescribed fire (Daubenmire 1968, Viro 1974, Reich et al. 1990, Schmalzer and Hinkle 1992). Prescribed fire has been shown to result in increased plant biomass, flowering, and seed production (Laubhan 1995, Abrams et al. 1986, Warners 1997, Kost and De Steven 2000). Prescribed fire can also help express and rejuvenate seed banks, which may be especially important for maintaining species diversity (Leach and Givnish 1996, Kost and De Steven 2000).

Impacts to faunal communities should also be strongly considered when planning a prescribed burn. Dividing a large area into smaller burn units that can be burned in alternate years or seasons can protect populations of many species. This allows unburned units to serve as refugia for immobile invertebrates and slow moving amphibian and reptile species. When burning larger areas it may be desirable to strive for patchy burns by igniting during times of high relative humidity. As mentioned above, the unburned patches may then serve as refugia, which facilitate recolonization of burned patches by fire-sensitive species. Burning under overcast skies and when air temperatures are cool (<55°F) can help protect reptiles, since they are less likely to be found basking above the surface when conditions are cloudy and cool. Lastly, conducting burns during the dormant season (late October through March) may also help minimize impacts to reptiles.

Implications for Forest Management

In the absence of natural fires, the oak-dominated, upland forests at Kensington and Oakwoods are likely to continue to undergo significant changes in structure and species composition as the oaks are replaced by more shade-tolerant tree species. Management of the upland forests at Kensington and Oakwoods should focus on creating conditions suitable for oak regeneration, that is, an open canopy with high light levels. In commercial forest management, these open conditions are typically created through a seedtree cut, which significantly reduces tree cover but retains scattered oaks to produce mast. While this approach can be very effective when deer densities are low, its application within the heavily visited portions of the metroparks may not be practical. Other less drastic options include cutting or girdling shade-tolerant species like red maple, prescription burning, and managing ecological succession within canopy gaps. By removing competitors and planting acorns or oak seedlings within large light gaps such as those created by recent tree-falls, metropark staff can direct the ecological succession of some portions of the forest. Prescription burning will help thin the understory and shrub layer and will favor retention and establishment of fire-tolerant species such as bur oak, black oak, and white oak. Any management for oak recruitment must also include reducing densities of white-tailed deer and protecting seedlings from browsing.

Another important forest management goal at Kensington and Oakwoods will be to reduce forest fragmentation. At present, a hard edge is maintained along many of the forest stands within the metroparks. Allowing oaks and hickories to establish within the old fields between blocks of forest and then directing the succession of these fields towards oak savanna or oak forest will enable isolated blocks of forest to be enlarged and connected. The formation of larger blocks of forest will help improve nesting success for raptors, neotropical migrant songbirds, and ground-nesting species because their nests are less likely to be parasitised and predated in larger blocks of forest (Wilcove et al. 1986). In addition, invasions by exotic species are reduced in larger blocks of contiguous habitat, since the ratio of interior habitat to edge typically increases with size.

At Kensington, where the upland soils are well drained and oak barrens once occupied much of the metropark, large blocks of oak barrens can be restored by allowing oaks to establish in old fields and reducing canopy cover in adjacent oak-dominated forests through burning and selective removal of shade-tolerant trees like red maple. Because young oaks resprout vigorously following burning, prescribed fire can be used along with mowing to direct succession of old fields towards oak barrens and savanna. The old fields and narrow peninsula of oak forest above Spring Hill (G) may provide an ideal setting for this type of restoration (Figure 6). Ideally, the land between Spring Hill Woodland (G) and Chickadee Loop Woodland (E) would also be managed for oak barrens, as would the area between Hickory Ridge (I), Spring Hill and the Orchard Picnic Area (Figure 6).

Conversely, at Oakwoods, where poorly drained soils once supported contiguous forest, directing the ecological succession of old fields towards oak-dominated forests will help reduce fragmentation by consolidating small, isolated woodlots into larger blocks of mature forest. The old fields that separate Salamander Woods (N) and West Oxbow Floodplain Forest (K) provide an excellent opportunity to reduce fragmentation by directing their succession towards oak-dominated forest (Figure 7). Additionally, the old fields that separate White Oak Woodland (O), Oxbow Floodplain Forest (J), and Railroad Floodplain Forest (L) may also provide an opportunity to reduce forest fragmentation and restore upland forest (Figure 7). Other opportunities to reduce forest fragmentation may be found by connecting the Borderline Woods (Q) with the Nature Study Area Woodland (M) and allowing old fields adjacent to these woodlands to succeed to oak forest (Figure 7).

Invasive Species

Invasive species also pose a major threat to species and habitat diversity within the metroparks. By outcompeting and replacing native species, invasives change species composition, alter vegetation structure, and reduce native species diversity, often causing local or even complete extinction of native species (Harty 1986). Invasive exotic species can also upset delicately balanced ecological processes such as trophic relationships, interspecific competition, nutrient cycling, soil erosion, hydrologic balance, and solar insolation (Bratton 1982). Lastly, exotic invasive species often have no natural predators and spread aggressively through rapid sexual and asexual reproduction.

While numerous invasive species occur within the metroparks, garlic mustard, glossy buckthorn, and purple loosestrife are likely to pose the greatest threat because of their ability to invade intact communities and quickly dominate an area. Garlic mustard, in particular, is of serious concern even in very small numbers because it is self-fertile, thus a single plant can establish an entire population and quickly result in a large infestation. While it invades all types of forested habitats, it is especially aggressive in mesic and wet-mesic sites (Meekins and McCarthy 2001). Garlic mustard should be removed prior to seedset wherever it is encountered. Glossy buckthorn can also severely reduce species diversity, especially in alkaline, wetland habitats like prairie fen and relict conifer swamp. Left untreated, it can form large, impenetrable, monotypic stands in place of open, species diverse wetlands. Purple loosestrife is another pernicious invader of wetland habitats, often completely replacing native emergent marsh communities. Some success in controlling purple loosestrife has recently occurred with the application of biological control agents, *Galerucella* beetles, which are native to purple loosestrife's European habitat (Hight and Drea 1991, Blossey 1992). More information on detailed methods of controlling specific invasive species can be obtained at http://tncweeds.ucdavis.edu/.

Several invasive species also threaten upland dry-mesic forests. Among the most problematic of these are Oriental bittersweet, common buckthorn, and Amur and Morrow honeysuckle. By invading the shrub layer of semi-open forest communities, these species severely reduce the amount of light available to the ground layer, causing the elimination of many ground-layer species and preventing the reproduction of overstory dominants. Oriental bittersweet is especially problematic. A twining vine, it can literally strangle large trees by tightly wrapping around the trunk and preventing new growth of cambium tissue, effectively girdling the stem. These woody species can be effectively controlled by stem removal, but cutting without immediate herbicide application should be strictly avoided, since resprouting typically results in the proliferation of multiple stems, thus making it even more difficult to eliminate these problematic species. Invasive species abstracts, which include detailed management guidelines, can be obtained at http://tncweeds.ucdavis.edu/.

Setting Stewardship Priorities

While invasive species occur in nearly all natural communities surveyed in this study, management priority should be given to the highest quality sites. By concentrating effort on a few high-quality sites, limited resources of time, personnel, volunteer effort, and money can be directed to make a significant impact on biodiversity. How should metropark managers and naturalists determine which sites to manage? That decision is one best made by metropark resource professionals, but evaluation criteria should include the following:

1) A preference toward high-quality sites with minimal infestations of invasive species. Biodiversity is most easily and effectively protected by preventing high-quality sites from degrading, and invasives are much easier to eradicate when they are not yet well established.
2) A focus on sites that harbor high levels of native species diversity or unique elements of biodiversity (e.g., prairie fens, tamarack swamps, floodplain forests, springs, rare species, etc.). Wetlands in particular, harbor a

disproportionate number of rare species and provide critical habitat to many species.

3) Sites that enhance core areas of high-quality habitat or act as critical corridors for wildlife. Reducing forest fragmentation at Oakwoods or restoring oak barrens at Kensington will enhance many of the existing high-quality sites.
4) High profile sites that are viewed by many visitors such as well used trails or sites with scenic overlooks or picturesque views. Opportunities to educate the public on biodiversity and stewardship are maximized by actively working to restore frequently visited sites. Restoring sites that provide scenic vistas will promote an appreciation of the park's natural resources.

A brief summary of sites with high restoration potential in each park follows below. Detailed site descriptions and management recommendations are included in the Site Summaries and Management section (page 16).

High Priority Sites at Kensington

At Kensington, we identified several sites with high restoration potential. Located near the Nature Center, **Wildwing Fen** is of high quality with a small rare plant population (Figure 6: A). It is highly visible, easily accessible, and would greatly benefit from shrub and tree removal and prescribed burning. Portions of the **Group Camp Fen**, while less visible and difficult to access, are also high in quality and would benefit from similar restoration activities (Figure 6: B). Another wetland community, the **Tamarack Trail Swamp**, can be maintained in a high-quality state by the periodic removal of successional hardwoods like red maple (Figure 6: C). The **Chickadee Loop Woodland** currently contains some of the fewest numbers of invasive plants in the upland areas of the metropark, and is easily accessible by staff and visitors (Figure 6: E). A minimal amount of time spent patrolling for and removing garlic mustard and invasive shrubs would keep this site in good condition. **Spring Hill Woodland**, though heavily infested with exotics and requiring significantly more restoration effort, could be transformed into a very scenic location with excellent vistas of the surrounding landscape through a semi-open forested canopy (Figure 6: G). The hillside spring also represents a unique element of biodiversity and is worthy of protection. The oak barrens component of the **Hickory Ridge Woodland** also represents a unique feature, as many of the prairie and oak barrens species found here occur nowhere else in the park (Figure 6: I). Shrub removal and prescribed fire will benefit these species tremendously. Finally, managing adjacent old fields for oak barrens will further protect the core areas of many of these sites. Other sites at Kensington may also merit attention and should be evaluated for work based on available resources.

High Priority Sites at Oakwoods

Oakwoods also contains several high-quality, prominent areas that can be easily maintained and improved with minimal restoration efforts. The **Nature Study Area Woodland** is in relatively good condition and receives a great deal of visitor attention (Figure 7: M). Work here should focus on first removing single, isolated exotic shrubs from the higher quality portions of the site and secondly, on tackling epicenters of large infestations. The **Oxbow Floodplain Forest** is also relatively high in quality, provides habitat for the rare beak grass, and could be greatly improved by the removal of scattered buckthorn, honeysuckle, and barberry before they become more dominant (Figure 7: J). The **West Oxbow Floodplain Forest** also contains a large population of beak grass, and while it would greatly benefit from restoration work, the infestation level of honeysuckle, barberry, and buckthorn is much higher, access is slightly more difficult, and visitor prominence is somewhat lower (Figure 7: K). **Salamander Woods** provides unique habitat for several rare species, and should be closely monitored for outbreaks of glossy buckthorn and barberry within the interior, followed by removal of buckthorn from the forested edges (Figure: N). While not easily accessed or often visited, **White Oak Woodland** is in very good condition and could be protected through invasive shrub removal within the interior and along its edges and by prescribed fire to reduce understory density (Figure 7: O). Lastly, the core areas of the sites mentioned above could be greatly enhanced by directing the ecological succession of their adjacent old fields towards oak savanna or oak forest. Other sites at Oakwoods may also merit attention, and should be evaluated for work based on available resources.

Deer Densities

Many studies have shown that high deer densities adversely impact local ecosystems and vegetation (Alverson et al. 1988, Balgooyen and Waller 1995, Waller and Alverson 1997, Horsely et al. 2003). Heavy deer browse was evident throughout both metroparks. At Kensington, excessive deer herbivory has likely contributed to a sharp decline in abundance of small white lady's slipper and the extirpation of goldenseal. Deer herbivory may also be contributing to the lack of oak regeneration within the oak forests (Strole and

Anderson 1992). Through preferential grazing of native species, high deer densities are also thought to contribute to the spread of invasive, exotic species such as garlic mustard (Victoria Nuzzo pers. comm. 1998). It is recommended that the Huron-Clinton Metropolitan Authority work cooperatively with the Michigan Department of Natural Resources to assess metropark deer densities and reduce deer densities if determined to be higher than recommended by the DNR.

Conclusion

The Huron-Clinton Metropolitan Authority has the considerable responsibility of stewarding numerous populations of rare species and ecologically significant natural communities. As the region becomes more developed, the prominence of natural features harbored by the metroparks is substantially heightened. Both rare and common native species are threatened by the rapid pace of development in southeast Michigan. In addition, changes taking place outside the metropark boundaries are having significant repercussions within their borders. For example, as new roads, subdivisions, shopping centers, and industries are built outside the park, invasive plants used in landscaping quickly find their way into the park and cause severe degradation to natural communities and their associated complement of native species. Historic wildlife corridors are disrupted, and cosmopolitan edge species such as white-tailed increasingly seek refuge within the confines of the metroparks. The increased deer density within the metroparks result in extirpation of numerous plant and animal species as their effects on ecosystems reverberate at multiple trophic levels (McShea and Rappole 1992, Waller and Alverson 1997). As rare plants and high-quality natural communities are lost due to development, the regional significance of safeguarding these natural features within the metroparks becomes even more important.

Conservation scientists and practitioners are more aware today than ever before that protecting rare species and ecologically significant natural communities requires far more than simply building preserves to prevent their outright destruction (Janzen 1986). Because changes occurring outside the metropark boundaries result in significant impacts within the park, protection of rare species and natural communities today requires the active participation by metropark staff in stewarding the land for ecological integrity. This formidable task requires metropark staff to identify significant natural features, develop conservation strategies, and apply their considerable expertise in resource management to the active stewardship of ecological integrity.

Both Kensington and Oakwoods support significant natural features that are threatened by events taking place within the parks as well outside their boundaries. The metroparks have lost a considerable amount of their biodiversity as a result of fire suppression, infestation of pernicious invasive species, and extraordinarily high white-tail deer populations. Restoring the ecological process of fire to the ecosystems at Kensington and Oakwoods will profoundly enhance their ecological integrity. The loss of biodiversity caused by infestations of invasive plants can be reversed by developing monitoring and eradication programs that are focused on protecting the centers of biodiversity, namely the prairie fens, tamarack swamp, wet meadows, floodplain forests, oak woodlands, and oak barrens. Finally, active management of the local deer herd is likely to result in the recovery of many plants and ground- and shrub-nesting animal species over time.

Tremendous ecological benefits can also be gained by directing the ecological succession of old fields towards oak barrens, lakeplain oak openings, oak woodlands, or floodplain forest. Connecting isolated forest patches, enlarging current woodlands, and creating a more natural transition between open field and forest edge will help increase nesting success rates of ground-nesting birds and mammals, forest raptors, and neotropical migrant songbirds, many of which are experiencing sharp declines in their populations. The ecological benefits of reducing fragmentation will be especially great when this approach is applied to important wildlife corridors like the Huron River floodplain in Oakwoods.

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Appendix 1. Plant species observed at Kensington Metropark. "X" indicates the species occurred within the site. "-" indicates species was not observed at the site. Capitalized scientific and common names indicate non-native species. Life form acronyms are as follows: Nt, native; P, perennial; Ad, adventive; B, biannual; A, annual. "C" is the Coefficient of Conservation for each species (Herman et al. 2001).

Site Name	Site Abbreviation	Site Code
Wildwing Fen	WWF	A
Group Camp Fen	GCF	B
Tamarack Trail Swamp	TTS	C
Kingfisher Wet Meadow	KWM	D
Chickadee Loop Woodland	CLW	E
East Border Oak Barrens	EOB	F
Spring Hill Woodland	SHW	G
North Windfall Hill Woodland	NWW	H
Hickory Ridge Woodland	HRW	I

		Site Name		WWF	GCF	TTS	KWM	CLW	EOB	SHW	NWW	HRW
		Site Code		A	B	C	D	E	F	G	H	I
Scientific Name	**Common name**	**Life Form**	**C**									
Acer nigrum	black maple	Nt Tree	4	-	-	-	-	x	-	-	-	-
Acer rubrum	red maple	Nt Tree	1	-	x	x	-	x	-	x	x	x
Acer saccharum	sugar maple	Nt Tree	5	-	-	-	-	x	-	-	x	x
Achillea millefolium	yarrow	Nt P-Forb	1	-	-	-	-	-	x	-	-	-
Actaea pachypoda	doll's-eyes	Nt P-Forb	7	-	-	-	-	x	-	-	-	-
Actaea rubra	red baneberry	Nt P-Forb	7	x	-	-	-	-	-	-	-	-
Adiantum pedatum	maidenhair fern	Nt Fern	6	-	-	-	-	x	-	-	-	x
Agropyron trachycaulum	slender wheat grass	Nt P-Grass	8	-	x	-	-	-	-	-	-	-
AGROSTIS SP.	BENTGRASS	Ad P-Grass	0	-	x	-	-	-	-	-	-	-
ALLIARIA PETIOLATA	GARLIC MUSTARD	Ad B-Forb	0	-	-	-	-	x	-	-	-	x
Alnus rugosa	tag alder	Nt Shrub	5	-	-	x	-	-	-	-	-	-
Amelanchier arborea	juneberry	Nt Tree	4	-	-	-	-	x	x	x	x	-
Amphicarpaea bracteata	hog-peanut	Nt A-Forb	5	-	-	x	-	-	-	-	-	-
Andropogon gerardii	big bluestem	Nt P-Grass	5	x	x	-	-	-	-	-	-	-
Andropogon scoparius	little bluestem grass	Nt P-Grass	5	x	-	-	-	-	x	-	-	-
Anemonella thalictroides	rue anemone	Nt P-Forb	8	-	-	-	-	x	-	-	-	-
Apios americana	groundnut	Nt P-Forb	3	-	-	x	-	x	-	-	x	-
Apocynum androsaemifolium	spreading dogbane	Nt P-Forb	3	-	-	-	-	x	-	-	-	-
Apocynum cannabinum	Indian-hemp	Nt P-Forb	3	-	x	-	-	-	-	-	x	-

Appendix 1. Plant species observed at Kensington Metropark continued.

		Site Name	WWF	GCF	TTS	KWM	CLW	EOB	SHW	NWW	HRW
		Site Code	A	B	C	D	E	F	G	H	I
Scientific Name	**Common name**	**Life Form**	**C**								
Aquilegia canadensis	wild columbine	Nt P-Forb	5	-	x	-	-	-	-	-	-
Arisaema triphyllum	jack-in-the-pulpit	Nt P-Forb	5	x	x	x	-	x	-	x	-	x
Aronia prunifolia	black chokeberry	Nt Shrub	5	-	x	-	-	-	-	-	-	-
Asclepias incarnata	swamp milkweed	Nt P-Forb	6	-	x	x	-	-	-	-	-	-
Asclepias syriaca	common milkweed	Nt P-Forb	1	-	-	-	-	-	x	-	-	-
Asclepias tuberosa	butterfly-weed	Nt P-Forb	5	-	-	-	-	-	x	-	-	-
Aster firmus	smooth swamp aster	Nt P-Forb	4	-	-	-	x	-	-	-	-	-
Aster laevis	smooth aster	Nt P-Forb	5	-	x	-	-	-	-	-	-	-
Aster lateriflorus	side flowering aster	Nt P-Forb	2	-	x	x	-	-	x	x	-	-
Aster macrophyllus	big-leaved aster	Nt P-Forb	4	-	-	-	-	-	x	-	x	-
Aster novae-angliae	New England aster	Nt P-Forb	3	-	x	-	-	-	-	-	-	-
Aster pilosus	hairy aster	Nt P-Forb	1	-	-	-	-	-	x	-	-	-
Aster puniceus	swamp aster	Nt P-Forb	5	-	x	-	x	-	-	-	-	-
Aster umbellatus	tall flat-top white aster	Nt P-Forb	5	x	x	x	-	-	-	-	x	-
Athyrium filix-femina	lady fern	Nt Fern	4	-	x	-	-	x	-	-	-	x
Aureolaria pedicularia	annual false foxglove	Nt A-Forb	10	-	-	-	-	-	x	-	-	-
BERBERIS THUNBERGII	JAPANESE BARBERRY	Ad Shrub	0	-	x	-	-	-	-	x	-	x
Betula alleghaniensis	yellow birch	Nt Tree	7	-	-	x	-	-	-	-	-	-
Betula papyrifera	paper birch	Nt Tree	2	-	x	-	-	-	-	-	-	-
Betula pumila	bog birch	Nt Shrub	8	x	x	-	-	-	-	-	-	-
Bidens cernuus	nodding bur marigold	Nt A-Forb	3	-	-	-	-	-	-	-	x	-
Bidens coronatus	tall swamp marigold	Nt A-Forb	7	-	-	x	x	-	-	-	-	-
Boehmeria cylindrica	false nettle	Nt P-Forb	5	-	-	x	x	x	-	x	-	-
Bromus ciliatus	fringed brome	Nt P-Grass	6	x	x	x	-	-	-	-	-	-
BROMUS INERMIS	smooth brome	Ad P-Grass	0	-	-	-	-	-	x	-	-	-
Calamagrostis canadensis	blue-joint grass	Nt P-Grass	3	-	x	x	-	-	-	-	-	-
Caltha palustris	marsh marigold	Nt P-Forb	6	x	x	x	-	-	-	-	-	-
Campanula aparinoides	marsh bellflower	Nt P-Forb	7	-	-	-	-	-	-	-	x	-
Cardamine bulbosa	spring cress	Nt P-Forb	4	-	x	-	-	-	-	-	-	-
Carex aurea	sedge	Nt P-Sedge	3	x	-	-	-	-	-	-	-	-
Carex comosa	sedge	Nt P-Sedge	5	-	-	-	x	-	-	-	-	-
Carex diandra	sedge	Nt P-Sedge	8	x	-	-	-	-	-	-	-	-
Carex flava	sedge	Nt P-Sedge	4	x	x	-	-	-	-	-	-	-
Carex gracillima	sedge	Nt P-Sedge	4	x	-	-	-	x	-	-	-	-

Appendix 1. Plant species observed at Kensington Metropark continued.

		Site Name	WWF	GCF	TTS	KWM	CLW	EOB	SHW	NWW	HRW
		Site Code	A	B	C	D	E	F	G	H	I
Scientific Name	**Common name**	**Life Form**	**C**								
Carex hirtifolia	sedge	Nt P-Sedge	5	-	-	-	-	x	-	-	-	-
Carex hitchcockiana	sedge	Nt P-Sedge	5	x	-	-	-	x	-	-	-	-
Carex hystericina	sedge	Nt P-Sedge	2	x	x	-	x	-	-	-	-	-
Carex lacustris	sedge	Nt P-Sedge	6	x	-	x	-	-	-	-	x	-
Carex lasiocarpa	sedge	Nt P-Sedge	8	-	-	-	x	-	-	-	-	-
Carex leptalea	sedge	Nt P-Sedge	5	x	x	x	-	-	-	-	-	-
Carex pensylvanica	Pennsylvania sedge	Nt P-Sedge	4	-	-	-	-	x	x	x	x	x
Carex plantaginea	sedge	Nt P-Sedge	8	-	-	-	-	x	-	-	-	-
Carex prairea	sedge	Nt P-Sedge	10	x	-	-	x	-	-	-	-	-
Carex pseudo-cyperus	sedge	Nt P-Sedge	5	-	-	-	x	-	-	-	-	-
Carex radiata	straight-styled wood sedge	Nt P-Sedge	2	-	-	x	-	-	-	-	-	-
Carex rosea	curly-styled wood sedge	Nt P-Sedge	2	-	-	-	-	-	-	-	-	x
Carex rostrata	sedge	Nt P-Sedge	10	x	-	-	x	-	-	-	-	-
Carex sterilis	sedge	Nt P-Sedge	10	x	x	-	-	-	-	-	-	-
Carex stipata	sedge	Nt P-Sedge	1	x	x	-	-	-	-	x	x	x
Carex stricta	sedge	Nt P-Sedge	4	x	x	x	x	-	-	-	x	-
Carex tetanica	sedge	Nt P-Sedge	9	x	x	-	-	-	-	-	-	-
Carex vulpinoidea	sedge	Nt P-Sedge	1	-	-	-	-	-	-	x	-	-
Carpinus caroliniana	blue-beech	Nt Tree	6	x	-	x	-	x	-	-	-	x
Carya cordiformis	bitternut hickory	Nt Tree	5	-	-	-	-	x	-	-	-	-
Carya glabra	pignut hickory	Nt Tree	5	-	-	-	-	x	x	x	-	x
Carya ovata	shagbark hickory	Nt Tree	5	-	-	-	-	x	-	x	x	-
Caulophyllum thalictroides	blue cohosh	Nt P-Forb	5	-	-	-	-	x	-	-	-	-
CELASTRUS ORBICULATA	ORIENTAL BITTERSWEET	Ad W-Vine	0	-	x	-	-	x	x	x	x	-
CENTAUREA MACULOSA	SPOTTED KNAPWEED	Ad B-Forb	0	-	-	-	-	-	x	-	-	-
Chelone glabra	turtlehead	Nt P-Forb	7	-	x	-	-	-	-	-	-	-
CICHORIUM INTYBUS	CHICORY	Ad P-Forb	0	-	-	-	-	-	-	x	-	-
Cicuta bulbifera	water-hemlock	Nt P-Forb	5	-	-	-	x	-	-	-	-	-
Cicuta maculata	water-hemlock	Nt B-Forb	4	x	x	-	-	-	-	-	-	-
Cinna arundinacea	wood reedgrass	Nt P-Grass	7	-	-	-	-	-	-	-	-	x
Circaea lutetiana	enchanter's nightshade	Nt P-Forb	2	-	-	-	-	x	-	x	x	x
CIRSIUM ARVENSE	CANADIAN THISTLE	Ad P-Forb	0	x	-	-	-	-	-	x	-	-
Cirsium muticum	swamp thistle	Nt B-Forb	6	x	x	x	-	-	-	-	-	-
CIRSIUM PALUSTRE	MARSH THISTLE	Ad B-Forb	0	-	x	-	-	-	-	-	-	-

Appendix 1. Plant species observed at Kensington Metropark continued.

		Site Name	WWF	GCF	TTS	KWM	CLW	EOB	SHW	NWW	HRW
		Site Code	A	B	C	D	E	F	G	H	I
Scientific Name	**Common name**	**Life Form**	**C**								
CONVALLARIA MAJALIS	LILY-OF-THE-VALLEY	Ad P-Forb	0	-	-	-	-	-	-	-	x	-
Cornus amomum	silky dogwood	Nt Shrub	2	-	x	-	-	-	-	-	-	-
Cornus florida	flowering dogwood	Nt Tree	8	-	-	-	-	x	x	-	x	-
Cornus foemina	gray dogwood	Nt Shrub	1	x	x	x	x	x	x	-	x	-
Cornus stolonifera	red-osier dogwood	Nt Shrub	2	-	x	-	-	-	-	-	-	-
Corylus americana	hazelnut	Nt Shrub	5	-	x	-	-	-	x	-	x	-
Crataegus sp.	hawthorn	Nt Tree		-	-	-	-	-	x	-	x	-
Cryptotaenia canadensis	honewort	Nt P-Forb	2	-	-	-	-	-	-	x	-	-
Cypripedium calceolus var. pubescens	large yellow lady's slipper	Nt P-Forb	5	-	x	-	-	-	-	-	-	-
Cypripedium candidum	small white lady's slipper	Nt P-Forb	10	x	-	-	-	-	-	-	-	-
DACTYLIS GLOMERATA	ORCHARD GRASS	Ad P-Grass	0	-	-	-	-	-	x	-	-	-
DAUCUS CAROTA	QUEEN-ANNE'S-LACE	Ad B-Forb	0	x	-	-	-	-	-	x	-	-
Desmodium glutinosum	clustered-leaved tick-trefoil	Nt P-Forb	5	-	-	-	-	-	x	-	x	-
Desmodium paniculatum	panicled tick-trefoil	Nt P-Forb	4	-	-	-	-	-	x	-	-	-
Desmodium sp.	tick-trefoil	Nt P-Forb		-	-	-	-	-	-	-	x	-
Dioscorea villosa	wild yam	Nt P-Forb	4	-	-	-	-	-	-	-	-	x
Dryopteris carthusiana	spinulose woodfern	Nt Fern	5	-	-	-	-	-	-	x	x	x
Dryopteris cristata	crested shield fern	Nt Fern	6	-	x	x	-	-	-	-	-	-
Dryopteris intermedia	evergreen woodfern	Nt Fern	5	-	-	-	-	x	-	-	-	-
ELAEAGNUS UMBELLATA	AUTUMN-OLIVE	Ad Shrub	0	x	x	-	-	x	x	x	x	-
Eleocharis erythropoda	spike rush	Nt P-Sedge	4	-	-	-	x	-	-	-	-	-
Elymus canadensis	Canada wild-rye	Nt P-Grass	7	x	-	-	-	x	-	-	-	-
Elymus virginicus	Virginia wild-rye	Nt P-Grass	4	x	-	x	-	-	-	-	-	-
Epilobium coloratum	cinnamon willow-herb	Nt P-Forb	3	-	-	-	x	-	-	-	-	-
Epilobium leptophyllum	fen willow-herb	Nt P-Forb	6	-	-	-	x	-	-	-	-	-
Epilobium sp.	willow-herb	P-Forb		-	-	x	-	-	-	-	-	-
Equisetum arvense	common horsetail	Nt Fern Ally	0	-	-	-	-	-	-	-	x	-
Equisetum fluviatile	water horsetail	Nt Fern Ally	7	x	x	x	-	-	-	-	-	-
Equisetum hyemale	scouring-rush	Nt Fern Ally	2	-	x	-	-	-	-	-	-	-
Eragrostis hypnoides	creeping love grass	Nt A-Grass	8	-	-	-	-	-	x	-	-	-
Erigeron philadelphicus	marsh fleabane	Nt P-Forb	2	x	x	-	-	-	-	-	-	-
Erigeron strigosus	daisy fleabane	Nt P-Forb	4	-	-	-	-	-	x	x	-	-
Erythronium americanum	yellow trout lily	Nt P-Forb	5	-	-	-	-	x	-	-	-	-

Appendix 1. Plant species observed at Kensington Metropark continued.

		Site Name	WWF	GCF	TTS	KWM	CLW	EOB	SHW	NWW	HRW
		Site Code	A	B	C	D	E	F	G	H	I
Scientific Name	**Common name**	**Life Form**	**C**								
Eupatorium maculatum	joe-pye-weed	Nt P-Forb	4	x	x	x	x	-	-	-	-
Eupatorium perfoliatum	common boneset	Nt P-Forb	4	x	x	-	x	-	-	x	x	-
Eupatorium rugosum	white snakeroot	Nt P-Forb	4	-	-	x	-	-	-	-	-	-
Euphorbia corollata	flowering spurge	Nt P-Forb	4	-	-	-	-	-	x	-	x	x
Euthamia graminifolia	grass-leaved goldenrod	Nt P-Forb	3	-	x	-	-	-	-	-	-	-
Fagus grandifolia	American beech	Nt Tree	6	-	-	-	-	x	-	-	x	x
FESTUCA RUBRA	RED FESCUE	Ad P-Grass	0	-	-	-	-	-	x	-	-	-
Fragaria virginiana	wild strawberry	Nt P-Forb	2	x	x	x	-	x	x	-	-	-
Fraxinus americana	white ash	Nt Tree	5	-	x	-	-	x	x	-	x	x
Fraxinus nigra	black ash	Nt Tree	6	x	-	x	x	-	-	-	-	x
Fraxinus pennsylvanica	red ash	Nt Tree	2	x	x	-	-	-	-	-	-	-
Galium aparine	annual bedstraw	Nt A-Forb	0	-	x	x	-	x	-	-	-	-
Galium boreale	northern bedstraw	Nt P-Forb	3	x	x	-	-	-	-	-	-	-
Galium circaezans	white wild-licorice	Nt P-Forb	4	-	-	-	-	-	x	x	x	-
Gaylussacia baccata	huckleberry	Nt Shrub	7	-	-	-	-	-	x	-	x	-
Geranium maculatum	wild geranium	Nt P-Forb	4	x	-	-	-	x	-	x	x	x
Geum canadense	white avens	Nt P-Forb	1	-	-	-	-	x	x	-	x	-
Glyceria striata	fowl manna grass	Nt P-Grass	4	x	x	x	-	-	-	-	x	-
Hamamelis virginiana	witch-hazel	Nt Shrub	5	-	-	-	-	-	-	-	x	-
Helianthus divaricatus	woodland sunflower	Nt P-Forb	5	-	-	-	-	-	x	-	-	-
Helianthus giganteus	tall sunflower	Nt P-Forb	5	x	-	-	-	-	-	-	x	-
Hepatica acutiloba	sharp-lobed hepatica	Nt P-Forb	8	-	-	-	-	x	-	-	-	-
Hepatica americana	round-lobed hepatica	Nt P-Forb	6	-	-	-	-	-	x	-	-	-
HESPERIS MATRONALIS	DAME'S ROCKET	Ad P-Forb	0	-	-	-	-	-	-	-	-	x
Hierochloe odorata	sweet grass	Nt P-Grass	9	-	x	-	-	-	-	-	-	-
Hypericum prolificum	shrubby St. John's-wort	Nt Shrub	5	-	-	-	-	-	x	-	-	-
Hypoxis hirsuta	star-grass	Nt P-Forb	10	x	x	-	-	-	-	-	-	-
Hystrix patula	bottlebrush grass	Nt P-Grass	5	-	-	x	-	x	-	x	-	x
Ilex verticillata	Michigan holly	Nt Shrub	5	-	-	x	-	-	-	-	-	-
Impatiens capensis	spotted touch-me-not	Nt A-Forb	2	x	x	x	x	-	-	x	x	-
Iris virginica	southern blue flag	Nt P-Forb	5	-	x	-	-	-	-	-	-	-
Juglans nigra	black walnut	Nt Tree	5	-	-	-	-	x	-	-	-	-
Juncus brachycephalus	rush	Nt P-Forb	7	-	x	-	-	-	-	-	-	-
Juniperus communis	common or ground juniper	Nt Shrub	4	x	x	x	-	-	x	-	x	-

Appendix 1. Plant species observed at Kensington Metropark continued.

		Site Name	WWF	GCF	TTS	KWM	CLW	EOB	SHW	NWW	HRW
		Site Code	A	B	C	D	E	F	G	H	I
Scientific Name	**Common name**	**Life Form**	**C**								
Juniperus virginiana	red-cedar	Nt Tree	3	x	x	-	-	-	x	-	-	-
Laportea canadensis	wood nettle	Nt P-Forb	4	-	-	-	-	x	-	-	-	-
Larix laricina	tamarack	Nt Tree	5	x	x	x	-	-	-	-	-	-
Lathyrus palustris	marsh pea	Nt P-Forb	7	-	x	-	-	-	-	-	-	-
Leersia oryzoides	cut grass	Nt P-Grass	3	-	-	x	-	-	-	-	x	-
Leersia virginica	white grass	Nt P-Grass	5	-	-	-	-	-	-	x	-	x
Lemna minor	small duckweed	Nt A-Forb	5	-	-	-	-	-	-	x	-	-
LEONURUS CARDIACA	MOTHERWORT	Ad P-Forb	0	-	-	-	-	-	-	x	-	-
Lespedeza capitata	round-headed bush-clover	Nt P-Forb	5	-	-	-	-	-	x	-	-	-
Lespedeza intermedia	bush-clover	Nt P-Forb	7	-	-	-	-	-	x	-	-	-
Liatris spicata	marsh blazing-star	Nt P-Forb	8	x	-	-	-	-	-	-	-	-
Lindera benzoin	spicebush	Nt Shrub	7	-	x	x	-	-	-	-	-	-
Lobelia siphilitica	great blue lobelia	Nt P-Forb	4	-	x	-	-	-	-	x	-	-
LONICERA MAACKII	AMUR HONEYSUCKLE	Ad Shrub	0	-	-	-	-	-	x	x	-	-
LONICERA MORROWII	MORROW HONEYSUCKLE	Ad Shrub	0	-	x	-	-	-	-	-	x	-
Lupinus perennis	wild lupine	Nt P-Forb	7	-	-	-	-	-	x	-	-	-
Lycopus americanus	common water-horehound	Nt P-Forb	2	x	x	-	-	-	-	-	-	-
Lycopus uniflorus	northern bugleweed	Nt P-Forb	2	-	x	x	x	-	-	-	-	-
Lysimachia quadrifolia	four-leaved loosestrife	Nt P-Forb	8	-	x	-	-	-	-	-	-	-
Lysimachia thyrsiflora	tufted loosestrife	Nt P-Forb	6	-	-	-	x	-	-	-	-	-
Maianthemum canadense	Canada mayflower	Nt P-Forb	4	x	-	x	-	-	-	-	x	-
Malus sp.	apple	Tree		-	x	-	-	-	-	-	-	-
Mentha arvensis	wild mint	Nt P-Forb	3	x	x	-	-	-	-	-	x	-
Mimulus ringens	monkey flower	Nt P-Forb	5	-	-	-	-	-	-	-	x	-
Mitella diphylla	bishop's cap	Nt P-Forb	8	-	-	x	-	-	-	-	-	-
Monarda fistulosa	wild bergamot	Nt P-Forb	2	x	x	-	-	-	x	-	-	-
Muhlenbergia glomerata	marsh wild-timothy	Nt P-Grass	10	-	x	-	-	-	-	-	-	-
Muhlenbergia mexicana	leafy satin grass	Nt P-Grass	3	-	-	x	-	-	-	-	-	-
MYOSOTIS SCORPIOIDES	FORGET-ME-NOT	Ad P-Forb	0	-	x	-	-	-	-	-	-	-
NASTURTIUM OFFICINALE	WATERCRESS	Ad P-Grass	0	x	x	x	-	-	-	x	-	-
Nuphar variegata	yellow pond lily	Nt P-Forb	7	-	-	-	x	-	-	-	-	-
Onoclea sensibilis	sensitive fern	Nt Fern	2	x	x	x	x	-	-	x	x	x
Osmunda cinnamomea	cinnamon fern	Nt Fern	5	-	-	x	-	x	-	-	-	x
Osmunda regalis	royal fern	Nt Fern	5	-	-	-	-	-	-	-	x	-

Appendix 1. Plant species observed at Kensington Metropark continued.

		Site Name	WWF	GCF	TTS	KWM	CLW	EOB	SHW	NWW	HRW
		Site Code	A	B	C	D	E	F	G	H	I
Scientific Name	**Common name**	**Life Form**	**C**								
Ostrya virginiana	ironwood; hop-hornbeam	Nt Tree	5	-	-	-	-	x	-	-	-	x
Parnassia glauca	grass-of-Parnassus	Nt P-Forb	8	-	x	-	-	-	-	-	-	-
Parthenocissus quinquefolia	Virginia creeper	Nt W-Vine	5	x	x	x	-	x	x	x	-	-
Pedicularis lanceolata	swamp betony	Nt P-Forb	8	x	x	-	-	-	-	-	-	-
Phalaris arundinacea	reed canary grass	Nt P-Grass	0	-	-	x	-	-	-	-	-	-
Phlox pilosa	prairie phlox	Nt P-Forb	7	x	-	-	-	-	-	-	-	-
Phragmites australis	reed	Nt P-Grass	0	x	-	x	x	-	-	-	-	-
Physocarpus opulifolius	ninebark	Nt Shrub	4	-	x	-	-	-	-	-	x	-
Pilea pumila	clearweed	Nt A-Forb	5	-	-	x	-	-	-	x	x	x
Pinus strobus	white pine	Nt Tree	3	-	-	-	-	-	x	-	-	-
POA COMPRESSA	CANADA BLUEGRASS	Ad P-Grass	0	-	x	-	-	x	x	-	-	-
POA PRATENSIS	KENTUCKY BLUEGRASS	Ad P-Grass	0	-	x	-	-	-	x	-	-	-
Podophyllum peltatum	may-apple	Nt P-Forb	3	-	-	-	-	x	-	-	-	-
Polygonatum pubescens	downy solomon-seal	Nt P-Forb	5	x	-	-	-	x	x	x	-	-
Polygonum hydropiper	water-pepper	Nt A-Forb	1	-	-	-	x	-	-	x	x	-
Polygonum virginianum	jumpseed	Nt P-Forb	4	-	-	x	-	x	x	x	-	-
Populus grandidentata	big-toothed aspen	Nt Tree	4	-	-	-	-	x	-	-	-	-
Populus tremuloides	quaking aspen	Nt Tree	1	x	x	x	-	-	-	x	x	-
Potentilla fruticosa	shrubby cinquefoil	Nt Shrub	10	x	x	-	-	-	-	-	-	-
Potentilla simplex	old field cinquefoil	Nt P-Forb	2	-	-	-	-	x	x	-	-	-
Prenanthes alba	white lettuce	Nt P-Forb	5	-	-	-	-	x	-	-	-	x
PRUNELLA VULGARIS	LAWN PRUNELLA	Nt P-Forb	0	-	x	x	-	-	-	-	-	-
PRUNUS AVIUM	SWEET CHERRY	Ad Tree	0	-	-	-	-	x	-	-	-	-
Prunus serotina	wild black cherry	Nt Tree	2	-	-	-	-	x	x	x	x	x
Prunus virginiana	choke cherry	Nt Shrub	2	-	x	-	-	-	-	-	-	-
Pteridium aquilinum	bracken fern	Nt Fern	0	-	-	-	-	-	x	-	x	-
Pycnanthemum virginianum	common mountain mint	Nt P-Forb	5	x	x	x	-	-	-	-	-	-
Quercus alba	white oak	Nt Tree	5	-	-	-	x	x	x	x	x	x
Quercus bicolor	swamp white oak	Nt Tree	8	x	x	x	-	-	-	-	-	-
Quercus macrocarpa	bur oak	Nt Tree	5	-	x	-	-	x	-	-	-	-
Quercus rubra	red oak	Nt Tree	5	-	-	-	-	x	-	x	-	x
Quercus velutina	black oak	Nt Tree	6	-	-	-	-	x	x	x	-	-
Ranunculus abortivus	small-flowered buttercup	Nt A-Forb	0	-	-	-	-	x	-	x	-	-
Ranunculus recurvatus	hooked crowfoot	Nt A-Forb	5	-	x	-	-	-	-	-	-	-

Appendix 1. Plant species observed at Kensington Metropark continued.

		Site Name	WWF	GCF	TTS	KWM	CLW	EOB	SHW	NWW	HRW
		Site Code	A	B	C	D	E	F	G	H	I
Scientific Name	**Common name**	**Life Form**	**C**								
Rhamnus alnifolia	alder-leaved buckthorn	Nt Shrub	8	x	x	-	-	-	-	-	-
RHAMNUS CATHARTICA	COMMON BUCKTHORN	Ad Tree	0	x	x	-	-	-	-	-	-
RHAMNUS FRANGULA	GLOSSY BUCKTHORN	Ad Shrub	0	-	x	-	-	-	-	-	-
Rhynchospora alba	beak-rush	Nt P-Sedge	6	x	-	-	-	-	-	-	-
Ribes americanum	wild black currant	Nt Shrub	6	-	-	-	x	-	-	-	-
Ribes cynosbati	prickly or wild gooseberry	Nt Shrub	4	-	-	-	-	x	-	x	-	x
Ribes hirtellum	swamp gooseberry	Nt Shrub	6	-	x	-	-	-	-	-	-	-
ROSA MULTIFLORA	MULTIFLORA ROSE	Ad Shrub	0	-	x	-	-	-	x	-	-	-
Rosa palustris	swamp rose	Nt Shrub	5	-	-	-	-	-	-	-	x	-
Rosa sp.	rose	Nt Shrub		-	-	-	-	-	x	-	x	-
Rubus allegheniensis	common blackberry	Nt Shrub	1	-	-	-	-	-	x	-	-	-
Rubus flagellaris	northern dewberry	Nt Shrub	1	-	-	-	-	-	x	-	-	-
Rubus occidentalis	black raspberry	Nt Shrub	1	x	x	-	-	x	x	-	-	-
Rubus pubescens	dwarf raspberry	Nt P-Forb	4	x	-	x	-	-	-	-	x	-
Rubus strigosus	wild red raspberry	Nt Shrub	2	-	x	x	-	-	x	x	x	-
Rudbeckia hirta	black-eyed susan	Nt P-Forb	1	x	x	-	-	-	x	-	-	-
Rudbeckia laciniata	cut-leaved coneflower	Nt P-Forb	6	-	-	x	-	-	-	-	-	-
Rumex orbiculatus	great water dock	Nt P-Forb	9	-	x	-	x	-	-	x	-	-
Sagittaria latifolia	common arrowhead	Nt P-Forb	1	-	-	-	x	-	-	-	x	-
Salix bebbiana	bebb's willow	Nt Shrub	1	-	x	-	x	-	-	-	-	-
Salix candida	hoary willow	Nt Shrub	9	-	x	-	-	-	-	-	-	-
Salix discolor	pussy willow	Nt Shrub	1	x	x	-	x	-	-	-	-	-
Salix serissima	autumn willow	Nt Shrub	8	x	-	-	-	-	-	-	-	-
Sambucus canadensis	elderberry	Nt Shrub	3	-	x	-	-	-	-	-	-	-
Sanguinaria canadensis	bloodroot	Nt P-Forb	5	-	-	-	-	x	-	-	-	-
Sassafras albidum	sassafras	Nt Tree	5	-	-	-	-	x	-	x	x	x
Saxifraga virginiensis	early saxifrage	Nt P-Forb	10	-	-	x	-	-	-	-	-	-
Schoenoplectus tabernaemontani	softstem bulrush	Nt P-Sedge	4	-	-	-	x	-	-	-	-	-
Scirpus atrovirens	bulrush	Nt P-Sedge	3	x	-	x	-	-	-	-	-	-
Scirpus cyperinus	wool-grass	Nt P-Sedge	5	-	-	-	-	-	-	-	x	-
Scutellaria galericulata	common skullcap	Nt P-Forb	5	-	-	-	-	-	-	-	x	-
Scutellaria lateriflora	mad dog skullcap	Nt P-Forb	5	-	-	x	x	-	-	x	-	x
Senecio aureus	golden ragwort	Nt P-Forb	5	x	x	x	-	x	-	-	-	-
Smilacina racemosa	false spikenard	Nt P-Forb	5	-	x	-	-	-	-	-	-	-

Appendix 1. Plant species observed at Kensington Metropark continued.

		Site Name	WWF	GCF	TTS	KWM	CLW	EOB	SHW	NWW	HRW
		Site Code	A	B	C	D	E	F	G	H	I
Scientific Name	**Common name**	**Life Form**	**C**								
Smilacina stellata	starry false solomon-seal	Nt P-Forb	5	x	x	-	-	-	-	-	-
Smilax tamnoides	bristly greenbrier	Nt W-Vine	5	-	-	-	-	x	-	-	-
SOLANUM DULCAMARA	BITTERSWEET NIGHTSHADE	Ad P-Forb	0	-	x	-	-	-	x	-	-
Solidago altissima	tall goldenrod	Nt P-Forb	1	-	x	-	-	-	-	-	-
Solidago caesia	blue-stemmed goldenrod	Nt P-Forb	7	-	-	-	-	-	x	-	x
Solidago canadensis	Canada goldenrod	Nt P-Forb	1	-	x	-	x	-	-	-	-
Solidago gigantea	late goldenrod	Nt P-Forb	3	x	-	x	-	-	-	-	-
Solidago juncea	early goldenrod	Nt P-Forb	3	-	-	-	-	-	x	-	x
Solidago ohioensis	Ohio goldenrod	Nt P-Forb	8	x	-	-	-	-	-	-	-
Solidago patula	swamp goldenrod	Nt P-Forb	6	x	x	x	-	-	-	-	-
Solidago riddellii	Riddell's goldenrod	Nt P-Forb	6	-	x	-	-	-	-	-	-
Solidago rugosa	rough goldenrod	Nt P-Forb	3	-	x	x	-	-	-	-	-
Solidago speciosa	showy goldenrod	Nt P-Forb	5	-	-	-	-	-	x	-	-
Solidago uliginosa	bog goldenrod	Nt P-Forb	4	-	x	-	-	-	-	-	-
Sorghastrum nutans	Indian grass	Nt P-Grass	6	x	-	-	-	-	-	-	-
Spiraea alba	meadowsweet	Nt Shrub	4	-	x	-	-	-	-	x	-
Symplocarpus foetidus	skunk-cabbage	Nt P-Forb	6	x	x	x	-	x	-	x	-	x
Thalictrum dasycarpum	purple meadow-rue	Nt P-Forb	3	x	x	-	-	-	-	-	-	-
Thalictrum dioicum	early meadow-rue	Nt P-Forb	6	-	-	-	-	x	-	-	-	x
Thelypteris noveboracensis	New York fern	Nt Fern	5	-	-	-	-	-	-	-	-	x
Thelypteris palustris	marsh fern	Nt Fern	2	x	x	x	x	-	-	-	x	-
Tilia americana	basswood	Nt Tree	5	x	x	x	-	x	-	-	-	x
Toxicodendron radicans	poison ivy	Nt W-Vine	2	x	x	x	-	x	x	-	x	-
Toxicodendron vernix	poison sumac	Nt Shrub	6	x	x	x	x	-	-	-	-	-
Trillium grandiflorum	common trillium	Nt P-Forb	5	-	-	-	-	x	-	-	-	-
TYPHA ANGUSTIFOLIA	NARROW-LEAVED CATTAIL	Ad P-Forb	0	-	-	-	-	-	-	-	x	-
Typha latifolia	broad-leaved cattail	Nt P-Forb	1	x	x	x	x	-	-	-	-	-
Ulmus americana	American elm	Nt Tree	1	x	x	x	x	x	-	x	-	x
Vaccinium angustifolium	blueberry	Nt Shrub	4	-	-	-	-	x	x	-	x	-
Vaccinium corymbosum	smooth highbush blueberry	Nt Shrub	6	-	-	x	-	-	-	-	-	-
Valeriana uliginosa	bog valerian	Nt P-Forb	10	x	x	-	-	-	-	-	-	-
VERBASCUM THAPSUS	COMMON MULLEIN	Ad B-Forb	0	-	-	-	-	-	-	x	-	-
Verbena hastata	blue vervain	Nt P-Forb	4	-	-	-	x	-	-	-	-	-
Verbena urticifolia	white vervain	Nt P-Forb	4	-	-	-	-	-	x	x	-	-

Appendix 1. Plant species observed at Kensington Metropark continued.

		Site Name	WWF	GCF	TTS	KWM	CLW	EOB	SHW	NWW	HRW
		Site Code	A	B	C	D	E	F	G	H	I
Scientific Name	**Common name**	**Life Form**	**C**								
Viburnum lentago	nannyberry	Nt Shrub	4	x	x	x	x	x	-	-	x	x
Viburnum opulus var. americanum	highbush-cranberry	Nt Shrub	5	-	x	-	-	-	-	-	-	-
Viburnum rafinesquianum	downy arrow-wood	Nt Shrub	5	-	-	-	-	-	-	-	x	-
Viola nephrophylla	northern bog violet	Nt P-Forb	8	x	x	-	-	-	-	-	-	-
Viola sp.	violet	Nt P-Forb		-	-	x	-	-	x	-	x	x
Vitis aestivalis	summer grape	Nt W-Vine	6	-	-	-	-	-	x	-	-	-
Vitis riparia	riverbank grape	Nt W-Vine	3	-	x	x	-	x	x	-	-	-
Zanthoxylum americanum	prickly-ash	Nt Shrub	3	-	-	-	-	x	-	-	-	-
Zizia aurea	golden alexanders	Nt P-Forb	6	x	x	-	-	-	-	-	-	-
Total number of species observed in survey site				90	127	75	41	74	69	52	71	42
Total number of species observed in Kensington Metropark: 299												

Appendix 2. Plant species observed at Oakwoods Metropark. "X" indicates the species occurred within the site. "-" indicates species was not observed at the site. Capitalized scientific and common names indicate non-native species. Life form acronyms are as follows: Nt, native; P, perennial; Ad, adventive; B, biannual; A, annual. "C" is the Coefficient of Conservation for each species (Herman et al. 2001).

Site Name	Site Abbreviation	Site Code
Oxbow Floodplain Forest	OFF	J
West Oxbow Floodplain Forest	WFF	K
Railroad Floodplain Forest	RFF	L
Nature Study Area Woodland	NSW	M
Salamander Woods	SMW	N
White Oak Woodland	WOW	O
Brandes Road Woodland	BRW	P
Borderline Woods	BDW	Q
Seedbox Swale	SBS	R

		Site Name		OFF	WFF	RFF	NSW	SMW	WOW	BRW	BDW	SBS
		Site Code		J	K	L	M	N	O	P	Q	R
Scientific Name	**Common name**	**Life Form**	**C**									
Acer negundo	box elder	Nt Tree	0	x	x	x	-	-	-	-	x	-
Acer nigrum	black maple	Nt Tree	4	-	-	-	-	-	-	x	-	-
Acer rubrum	red maple	Nt Tree	1	-	-	-	x	x	x	-	x	x
Acer saccharinum	silver maple	Nt Tree	2	x	x	x	x	-	-	-	-	-
Actaea pachypoda	doll's-eyes	Nt P-Forb	7	-	-	-	x	x	-	-	x	-
Agrimonia gryposepala	tall agrimony	Nt P-Forb	2	x	-	-	x	x	x	-	x	-
Agrimonia pubescens	soft agrimony	Nt P-Forb	5	x	-	-	x	x	x	-	-	-
Alisma plantago-aquatica	water-plantain	Nt P-Forb	1	-	-	-	-	-	-	-	-	x
Allium canadense	wild garlic	Nt P-Forb	4	-	x	-	-	-	-	-	-	-
Amelanchier arborea	juneberry	Nt Tree	4	-	-	-	x	-	-	x	-	-
Amphicarpaea bracteata	hog-peanut	Nt A-Forb	5	-	-	-	-	x	-	-	-	-
Andropogon virginicus	broom sedge	Nt P-Grass	4	-	-	-	-	-	-	-	-	x
Anemone virginiana	thimbleweed	Nt P-Forb	3	x	-	-	x	-	-	-	-	-
Apocynum cannabinum	Indian-hemp	Nt P-Forb	3	-	x	-	-	-	-	-	-	x
ARCTIUM MINUS	COMMON BURDOCK	Ad B-Forb	0	x	-	-	-	-	-	-	-	-
Arisaema dracontium	green dragon	Nt P-Forb	8	x	x	-	-	-	-	-	-	-
Arisaema triphyllum	jack-in-the-pulpit	Nt P-Forb	5	-	x	-	x	x	-	-	x	-
Asarum canadense	wild ginger	Nt P-Forb	5	x	x	x	x	-	-	-	-	-
Asclepias incarnata	swamp milkweed	Nt P-Forb	6	x	-	-	-	-	-	-	-	-

Appendix 2. Plant species observed at Oakwoods Metropark continued.

		Site Name	OFF	WFF	RFF	NSW	SMW	WOW	BRW	BDW	SBS
		Site Code	J	K	L	M	N	O	P	Q	R
Scientific Name	**Common name**	**Life Form**	**C**								
Aster lanceolatus	eastern lined aster	Nt P-Forb	2	-	-	-	-	-	-	-	x
Aster lateriflorus	side-flowering aster	Nt P-Forb	2	x	x	-	x	x	x	-	x	x
Aster novae-angliae	New England aster	Nt P-Forb	3	-	-	-	-	-	-	-	-	x
Aster sagittifolius	arrow leaved aster	Nt P-Forb	2	-	-	-	x	-	-	-	-	-
Athyrium filix-femina	lady fern	Nt Fern	4	-	-	-	x	x	-	-	x	-
BERBERIS THUNBERGII	JAPANESE BARBERRY	Ad Shrub	0	x	x	x	x	x	-	-	x	-
Bidens coronatus	tall swamp marigold	Nt A-Forb	7	-	-	-	-	-	-	-	-	x
Boehmeria cylindrica	false nettle	Nt P-Forb	5	x	x	-	-	x	-	x	-	-
Botrichium sp.	fern	Nt Fern		-	-	-	-	x	-	-	-	-
Carex amphibola	sedge	Nt P-Sedge	8	x	-	-	-	-	-	-	-	-
Carex bebbii	sedge	Nt P-Sedge	4	x	-	-	-	-	-	-	-	-
Carex crinita	sedge	Nt P-Sedge	4	-	-	-	-	-	-	-	x	-
Carex gracillima	sedge	Nt P-Sedge	4	-	-	-	-	x	-	-	x	-
Carex grayi	sedge	Nt P-Sedge	6	x	x	x	-	x	-	-	-	-
Carex hirtifolia	sedge	Nt P-Sedge	5	-	-	-	-	-	x	-	-	-
Carex intumescens	sedge	Nt P-Sedge	3	x	-	-	-	-	-	-	-	-
Carex lacustris	sedge	Nt P-Sedge	6	-	-	-	-	x	-	-	-	-
Carex lupulina	sedge	Nt P-Sedge	4	x	x	-	-	x	-	-	-	-
Carex muskingumensis	sedge	Nt P-Sedge	6	-	-	-	-	-	x	-	-	-
Carex pensylvanica	Pennslyvania sedge	Nt P-Sedge	4	-	-	-	x	x	x	x	x	-
Carex pseudo-cyperus	sedge	Nt P-Sedge	5	x	-	-	-	-	-	-	-	-
Carex radiata	straight-styled wood sedge	Nt P-Sedge	2	-	-	-	-	-	x	-	-	-
Carex rosea	curly-styled wood sedge	Nt P-Sedge	2	x	-	-	-	-	-	-	-	-
Carex squarrosa	squarrose sedge	Nt P-Sedge	9	-	-	-	-	x	x	-	-	-
Carex stipata	sedge	Nt P-Sedge	1	x	-	-	-	-	-	-	-	-
Carex vulpinoidea	sedge	Nt P-Sedge	1	-	-	-	-	-	-	-	-	x
Carpinus caroliniana	blue-beech	Nt Tree	6	-	-	-	x	x	-	-	x	-
Carya cordiformis	bitternut hickory	Nt Tree	5	-	x	-	x	x	-	x	-	-
Carya glabra	pignut hickory	Nt Tree	5	-	-	-	x	-	x	-	x	-
Carya laciniosa	shellbark hickory	Nt Tree	9	-	-	-	-	-	-	x	-	-
Carya ovata	shagbark hickory	Nt Tree	5	x	-	-	x	x	x	-	x	-
CATALPA SPECIOSA	NORTHERN CATALPA	Ad Tree	0	x	-	-	-	-	-	-	-	-
CELASTRUS ORBICULATA	ORIENTAL BITTERSWEET	Ad W-Vine	0	-	x	-	x	x	-	-	-	-
Celastrus scandens	American bittersweet	Nt W-Vine	3	x	-	-	-	-	-	-	-	-

Appendix 2. Plant species observed at Oakwoods Metropark continued.

		Site Name	OFF	WFF	RFF	NSW	SMW	WOW	BRW	BDW	SBS
		Site Code	J	K	L	M	N	O	P	Q	R
Scientific Name	**Common name**	**Life Form**	**C**								
Celtis occidentalis	hackberry	Nt Tree	5	x	x	-	-	-	-	-	-
Cephalanthus occidentalis	buttonbush	Nt Shrub	7	x	x	-	-	-	-	-	-
Cercis canadensis	redbud	Nt Tree	8	x	x	x	x	-	-	-	-
Cicuta maculata	water-hemlock	Nt B-Forb	4	x	-	-	-	-	-	-	-
Cinna arundinacea	wood reedgrass	Nt P-Grass	7	x	x	-	-	x	x	-	x	-
Circaea lutetiana	enchanter's nightshade	Nt P-Forb	2	x	x	-	x	x	x	x	x	-
Conopholis americana	squawroot	Nt P-Forb	10	-	-	-	-	-	-	x	-	-
Cornus amomum	silky dogwood	Nt Shrub	2	x	x	-	-	-	-	-	-	-
Cornus drummondii	rough-leaved dogwood	Nt Shrub	6	-	x	x	-	-	x	-	-	x
Cornus florida	flowering dogwood	Nt Tree	8	-	-	-	x	x	-	-	x	-
Cornus foemina	gray dogwood	Nt Shrub	1	-	-	-	x	-	x	x	-	-
Corylus americana	hazelnut	Nt Shrub	5	x	-	-	x	-	-	-	-	x
Crataegus sp.	hawthorn	Nt Tree		x	x	x	x	x	x	-	-	x
Cryptotaenia canadensis	honewort	Nt P-Forb	2	-	-	-	-	x	-	-	-	-
Desmodium glutinosum	clustered-leaved tick-trefoil	Nt P-Forb	5	x	-	-	x	x	x	-	-	-
Desmodium sessilifolium	sessile-leaved tick-trefoil	Nt P-Forb	8	-	-	-	-	-	-	-	-	x
Diarrhena americana	beak grass	Nt P-Grass	9	x	x	x	-	-	-	-	-	-
Dioscorea villosa	wild yam	Nt P-Forb	4	-	-	-	-	-	x	-	x	-
Dryopteris carthusiana	spinulose woodfern	Nt Fern	5	-	-	-	x	x	-	-	x	-
Echinocystis lobata	wild-cucumber	Nt A-Forb	2	-	x	-	-	-	-	-	-	-
ELAEAGNUS UMBELLATA	AUTUMN-OLIVE	Ad Shrub	0	x	x	x	-	x	-	x	-	-
Elymus virginicus	Virginia wild-rye	Nt P-Grass	4	-	-	-	-	-	x	-	-	-
Equisetum hyemale	scouring-rush	Nt Fern Ally	2	-	x	-	-	x	-	-	x	x
Erigeron strigosus	daisy fleabane	Nt P-Forb	4	x	-	-	-	-	-	-	-	-
EUONYMUS ALATA	WINGED WAHOO	Ad Shrub	0	-	-	-	x	-	-	-	-	-
Euonymus obovata	running strawberry-bush	Nt Shrub	5	-	-	-	x	-	-	-	-	-
Eupatorium purpureum	purple joe-pye-weed	Nt P-Forb	5	-	x	-	-	-	-	-	-	-
Eupatorium rugosum	white snakeroot	Nt P-Forb	4	-	x	x	x	x	x	-	-	-
Euthamia graminifolia	grass-leaved goldenrod	Nt P-Forb	3	-	-	-	-	-	-	-	-	x
Fragaria virginiana	wild strawberry	Nt P-Forb	2	-	-	-	x	-	-	-	-	-
Fraxinus americana	white ash	Nt Tree	5	-	-	-	-	x	x	-	x	-
Fraxinus nigra	black ash	Nt Tree	6	-	x	-	-	-	-	-	x	-
Fraxinus pennsylvanica	red ash	Nt Tree	2	-	x	x	x	x	x	x	x	x
Galium aparine	annual bedstraw	Nt A-Forb	0	-	-	-	-	x	-	-	x	-

Appendix 2. Plant species observed at Oakwoods Metropark continued.

		Site Name	OFF	WFF	RFF	NSW	SMW	WOW	BRW	BDW	SBS
		Site Code	J	K	L	M	N	O	P	Q	R
Scientific Name	**Common name**	**Life Form**	**C**								
Galium circaezans	white wild licorice	Nt P-Forb	4	-	-	-	-	x	-	-	-	-
Galium sp.	bedstraw	Nt P-Forb		x	-	-	x	-	x	-	-	-
Geranium maculatum	wild geranium	Nt P-Forb	4	-	-	-	x	x	x	-	x	-
Geum canadense	white avens	Nt P-Forb	1	-	x	x	x	x	x	x	x	-
Glyceria striata	fowl manna grass	Nt P-Grass	4	-	x	-	x	x	-	-	x	-
Hackelia virginiana	beggar's-lice	Nt P-Forb	1	-	x	x	x	-	-	-	x	-
Hamamelis virginiana	witch-hazel	Nt Shrub	5	-	-	-	x	x	-	-	-	-
Helenium autumnale	sneezeweed	Nt P-Forb	5	-	x	x	x	-	x	-	-	-
Hepatica americana	round-lobed hepatica	Nt P-Forb	6	-	-	-	-	x	-	-	-	-
Heuchera richardsonii	prairie alum-root	Nt P-Forb	8	-	-	-	x	-	-	-	-	-
Impatiens capensis	spotted touch-me-not	Nt A-Forb	2	-	x	-	-	x	-	-	-	-
Iris virginica	southern blue flag	Nt P-Forb	5	x	x	-	-	-	x	-	-	-
Juglans nigra	black walnut	Nt Tree	5	x	x	-	x	-	x	-	x	-
Juncus tenuis	path rush	Nt P-Forb	1	-	-	-	x	-	-	-	-	-
Justicia americana	water willow	Nt P-Forb	9	x	-	-	-	-	-	-	-	-
Laportea canadensis	wood nettle	Nt P-Forb	4	x	x	x	-	x	-	-	x	-
Leersia oryzoides	cut grass	Nt P-Grass	3	x	-	-	-	-	-	-	-	-
Leersia virginica	white grass	Nt P-Grass	5	x	x	-	x	x	x	-	-	-
LEONURUS CARDIACA	MOTHERWORT	Ad P-Forb	0	-	-	-	x	-	-	-	-	-
LIGUSTRUM VULGARE	COMMON PRIVET	Ad Shrub	0	x	x	x	x	-	-	-	-	-
Lindera benzoin	spicebush	Nt Shrub	7	x	x	-	x	x	-	-	x	-
Liriodendron tulipifera	tulip-tree	Nt Tree	9	-	-	-	x	-	-	-	x	-
Lobelia cardinalis	cardinal flower	Nt P-Forb	7	x	-	-	-	-	-	-	-	-
LONICERA MAACKII	AMUR HONEYSUCKLE	Ad Shrub	0	x	-	-	-	-	-	-	-	-
LONICERA MORROWII	MORROW HONEYSUCKLE	Ad Shrub	0	x	x	x	x	x	-	-	-	-
Ludwigia alternifolia	seedbox	Nt P-Forb	8	-	-	-	-	-	-	-	-	x
Lycopus uniflorus	northern bugleweed	Nt P-Forb	2	x	-	-	-	-	-	-	-	-
Lysimachia ciliata	fringed loosestrife	Nt P-Forb	4	x	-	-	-	-	-	-	-	-
LYSIMACHIA NUMMULARIA	MONEYWORT	Ad P-Forb	0	x	x	-	x	-	-	x	-	-
LYTHRUM SALICARIA	PURPLE LOOSESTRIFE	Ad P-Forb	0	-	-	-	-	-	-	-	-	x
Medeola virginiana	Indian cucumber-root	Nt P-Forb	10	-	-	-	-	x	-	-	-	-
Menispermum canadense	moonseed	Nt W-Vine	5	x	x	-	-	-	-	-	-	-
Mentha arvensis	wild mint	Nt P-Forb	3	-	-	-	-	-	-	-	-	x
MORUS ALBA	WHITE MULBERRY	Ad Tree	0	x	-	-	-	-	-	-	-	-

Appendix 2. Plant species observed at Oakwoods Metropark continued.

		Site Name	OFF	WFF	RFF	NSW	SMW	WOW	BRW	BDW	SBS
		Site Code	J	K	L	M	N	O	P	Q	R
Scientific Name	**Common name**	**Life Form**	**C**								
MYOSOTIS SCORPIOIDES	FORGET-ME-NOT	Ad P-Forb	0	x	-	-	-	-	-	-	-
Nuphar variagatum	yellow pond lily	Nt P-Forb	7	x	-	-	-	-	-	-	-
Onoclea sensibilis	sensitive fern	Nt Fern	2	x	x	-	x	x	-	-	x	-
Osmorhiza claytonii	hairy sweet cicely	Nt P-Forb	4	-	-	-	-	x	-	-	x	-
Osmorhiza longistylis	smooth sweet cicely	Nt P-Forb	3	x	-	-	-	-	-	-	-	-
Osmunda regalis	royal fern	Nt Fern	5	-	-	-	x	x	-	-	-	-
Ostrya virginiana	ironwood; hop-hornbeam	Nt Tree	5	-	x	-	x	x	-	x	x	-
Oxalis stricta	common yellow wood sorrel	Nt P-Forb	0	-	x	-	-	x	-	-	-	-
Panicum sp.	grass	Nt Grass		-	-	-	x	-	-	-	-	-
Parthenocissus quinquefolia	Virginia creeper	Nt W-Vine	5	x	x	-	x	x	-	x	x	-
Pedicularis lanceolata	swamp betony	Nt P-Forb	8	-	-	-	-	-	-	-	-	x
Phalaris arundinacea	reed canary grass	Nt P-Grass	0	x	-	-	-	-	-	-	-	-
Phragmites australis	giant reed	Nt P-Grass	0	-	-	-	-	-	-	-	-	x
Phryma leptostachya	lopseed	Nt P-Forb	4	-	-	-	-	x	-	-	x	-
Pilea pumila	clearweed	Nt A-Forb	5	x	-	-	-	-	-	-	-	-
Platanus occidentalis	sycamore	Nt Tree	7	-	x	x	x	-	-	x	-	-
POA COMPRESSA	CANADA BLUEGRASS	Ad P-Grass	0	-	-	-	x	-	-	-	-	-
Podophyllum peltatum	may-apple	Nt P-Forb	3	-	x	-	x	x	x	-	x	-
Polygonatum pubescens	downy solomon-seal	Nt P-Forb	5	-	-	-	-	x	-	-	x	-
Polygonum sp.	smartweed	Nt P-Forb		x	x	-	-	-	-	-	-	-
Polygonum virginianum	jumpseed	Nt P-Forb	4	x	x	x	x	x	x	x	x	-
Populus deltoides	cottonwood	Nt Tree	1	x	x	x	-	x	-	-	-	x
Populus grandidentata	big-toothed aspen	Nt Tree	4	-	-	-	x	-	-	-	-	-
Prenanthes alba	white lettuce	Nt P-Forb	5	-	-	-	-	x	x	-	x	-
Prunus serotina	wild black cherry	Nt Tree	2	x	-	x	x	x	x	x	x	-
Prunus virginiana	choke cherry	Nt Shrub	2	x	x	-	x	-	-	x	x	-
Ptelea trifoliata	hop-tree	Nt Shrub	4	x	x	-	-	-	-	-	-	-
Quercus alba	white oak	Nt Tree	5	-	x	-	x	x	x	-	x	-
Quercus bicolor	swamp white oak	Nt Tree	8	x	x	-	-	x	-	-	x	-
Quercus macrocarpa	bur oak	Nt Tree	5	-	x	-	x	x	x	-	x	-
Quercus palustris	pin oak	Nt Tree	8	-	-	-	x	x	x	x	x	-
Quercus rubra	red oak	Nt Tree	5	x	-	-	-	x	x	x	x	-
Quercus velutina	black oak	Nt Tree	6	-	-	-	x	-	x	-	-	x
Ranunculus recurvatus	hooked crowfoot	Nt A-Forb	5	-	-	-	-	-	-	x	-	-

Appendix 2. Plant species observed at Oakwoods Metropark continued.

		Site Name	OFF	WFF	RFF	NSW	SMW	WOW	BRW	BDW	SBS
		Site Code	J	K	L	M	N	O	P	Q	R
Scientific Name	**Common name**	**Life Form**	**C**								
RHAMNUS CATHARTICA	COMMON BUCKTHORN	Ad Tree	0	x	x	x	x	x	-	x	x	-
RHAMNUS FRANGULA	GLOSSY BUCKTHORN	Ad Shrub	0	x	x	x	x	x	x	x	-	x
Rhus glabra	smooth sumac	Nt Tree	2	-	-	x	x	-	-	-	-	-
Ribes americanum	wild black currant	Nt Shrub	6	x	-	-	-	-	-	-	-	-
Ribes cynosbati	prickly or wild gooseberry	Nt Shrub	4	-	-	-	x	x	x	x	-	-
ROBINIA PSEUDOACACIA	BLACK LOCUST	Ad Tree	0	-	x	-	x	-	-	-	-	-
ROSA MULTIFLORA	MULTIFLORA ROSE	Ad Shrub	0	x	x	x	x	x	x	-	x	-
Rosa sp.	rose	Nt Shrub		-	-	-	x	-	-	-	-	-
Rubus allegheniensis	common blackberry	Nt Shrub	1	-	-	x	-	x	-	-	-	-
Rubus occidentalis	black raspberry	Nt Shrub	1	x	x	-	x	-	-	x	-	-
Rubus sp.	raspberry	Nt Shrub		-	-	-	x	-	x	-	x	-
Rudbeckia hirta	black-eyed susan	Nt P-Forb	1	-	-	-	-	-	-	-	-	x
Rudbeckia laciniata	cut-leaved coneflower	Nt P-Forb	6	x	x	-	-	-	-	-	-	-
RUMEX CRISPUS	CURLY DOCK	Ad P-Forb	0	x	-	-	-	-	-	-	-	-
Rumex orbiculatus	great water dock	Nt P-Forb	9	x	-	-	-	-	-	-	-	-
Sagittaria latifolia	common arrowhead	Nt P-Forb	1	x	-	-	-	-	-	-	-	-
Salix nigra	black willow	Nt Tree	5	x	x	-	-	-	-	-	-	-
Sambucus canadensis	elderberry	Nt Shrub	3	x	-	-	-	-	-	-	-	-
Sanicula gregaria	black snakeroot	Nt P-Forb	2	x	-	-	-	x	-	-	x	-
Sassafras albidum	sassafras	Nt Tree	5	-	-	-	x	x	x	-	x	-
Saururus cernuus	lizard's-tail	Nt P-Forb	9	x	-	-	-	-	-	-	-	-
Scirpus atrovirens	bulrush	Nt P-Sedge	3	x	-	-	-	-	-	-	-	-
Scirpus cyperinus	wool-grass	Nt P-Sedge	5	-	-	-	-	-	-	-	-	x
Scirpus sp.	bulrush	Nt P-Sedge		-	-	-	-	-	x	-	-	x
Scrophularia marilandica	late figwort	Nt P-Forb	5	-	-	-	x	-	-	-	-	-
Scutellaria lateriflora	mad-dog skullcap	Nt P-Forb	5	x	-	-	-	-	-	-	-	-
Silphium perfoliatum	cup-plant	Nt P-Forb	10	-	x	x	-	-	-	-	-	-
Smilacina racemosa	false spikenard	Nt P-Forb	5	-	-	-	x	x	-	-	x	-
Smilax rotundifloia	common greenbrier	Nt W-Vine	6	-	-	-	x	-	-	-	-	-
Smilax tamnoides	bristly greenbrier	Nt W-Vine	5	x	-	-	-	x	-	-	-	-
Solidago altissima	tall goldenrod	Nt P-Forb	1	-	-	-	-	-	-	-	-	x
Solidago caesia	blue-stemmed goldenrod	Nt P-Forb	7	-	-	-	x	x	-	-	-	-
Solidago canadensis	Canada goldenrod	Nt P-Forb	1	-	-	x	-	-	-	-	-	-
Solidago flexicaulis	broad-leaved goldenrod	Nt P-Forb	6	-	-	-	x	-	-	-	-	-

Appendix 2. Plant species observed at Oakwoods Metropark continued.

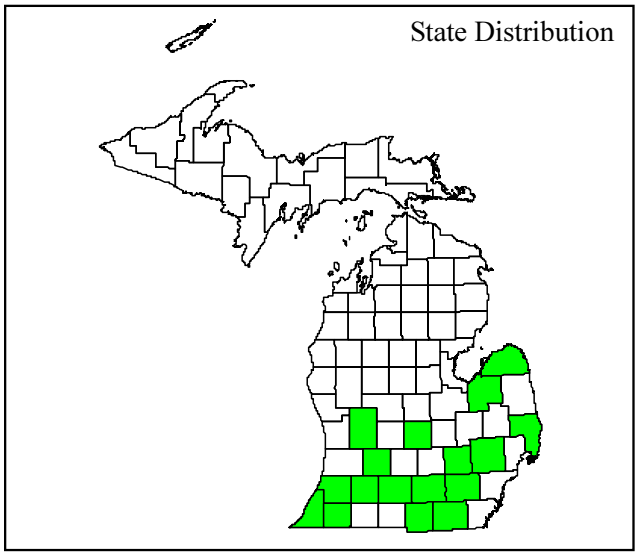
		Site Name	OFF	WFF	RFF	NSW	SMW	WOW	BRW	BDW	SBS
		Site Code	J	K	L	M	N	O	P	Q	R
Scientific Name	**Common name**	**Life Form**	**C**								
Solidago gigantea	late goldenrod	Nt P-Forb	3	x	-	-	-	-	-	-	-
Solidago rugosa	rough goldenrod	Nt P-Forb	3	-	-	-	-	-	x	-	x	x
Sparganium sp.	bur-reed	Nt P-Forb		x	-	-	-	-	-	-	-	-
Spiraea alba	meadowsweet	Nt Shrub	4	-	-	-	-	-	-	-	-	x
Staphylea trifolia	bladdernut	Nt Shrub	9	x	x	x	x	-	-	-	-	-
Teucrium canadense	wood-sage	Nt P-Forb	4	-	x	x	x	-	-	-	-	-
Thalictrum dasycarpum	purple meadow-rue	Nt P-Forb	3	x	-	-	-	-	-	-	-	-
Thalictrum dioicum	early meadow-rue	Nt P-Forb	6	-	x	-	x	-	x	-	-	-
Thelypteris palustris	marsh fern	Nt Fern	2	-	-	-	x	-	-	-	-	-
Tilia americana	basswood	Nt Tree	5	x	x	-	x	x	-	x	x	-
Toxicodendron radicans	poison ivy	Nt W-Vine	2	x	x	x	x	x	x	x	x	x
Trillium grandiflorum	common trillium	Nt P-Forb	5	-	-	-	-	x	-	-	-	-
Triosteum perfoliatum	horse-gentian	Nt P-Forb	5	-	-	-	x	-	x	-	-	-
Ulmus americana	American elm	Nt Tree	1	x	x	x	x	x	x	x	x	-
Verbena hastata	blue vervain	Nt P-Forb	4	x	-	-	-	-	-	-	-	-
Verbena urticifolia	white vervain	Nt P-Forb	4	-	-	x	x	-	-	-	-	-
Vernonia missurica	Missouri ironweed	Nt P-Forb	4	x	x	-	-	-	-	-	-	x
Veronica sp.	speedwell	P-Forb		x	-	-	-	-	-	-	-	-
Veronicastrum virginicum	culver's-root	Nt P-Forb	8	-	x	-	-	-	-	-	-	-
Viburnum acerifolium	maple-leaved arrow-wood	Nt Shrub	6	-	-	-	x	x	-	-	-	-
Viburnum dentatum	smooth arrow-wood	Nt Shrub	6	-	-	-	x	-	-	-	-	-
Viburnum lentago	nannyberry	Nt Shrub	4	x	x	-	x	x	-	-	-	-
VIBURNUM OPULUS	EUROPEAN HIGHBUSH-CRANBERRY	Ad Shrub	0	x	x	-	-	-	-	-	-	-
Viola sp.	violet	Nt P-Forb		x	-	x	-	-	-	-	x	-
Vitis riparia	riverbank grape	Nt W-Vine	3	x	x	x	x	x	x	x	x	x
Zanthoxylum americanum	prickly-ash	Nt Shrub	3	-	-	-	x	x	x	x	x	-
Total number of species observed in survey site				98	77	36	94	82	51	31	61	33
Total number of species observed in Oakwoods Metropark: 215												

Appendix 3. Rare Plant and Natural Community Abstracts for:

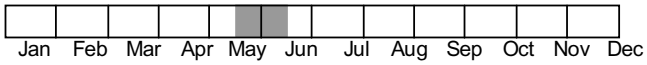
- small white lady's slipper
- goldenseal
- prairie fen
- relict conifer swamp
- southern wet meadow
- oak barrens
- lakeplain oak openings

For additional rare species and natural community abstracts go to:
http://web4.msue.msu.edu/mnfi/pub/abstracts.cfm

Cypripedium candidum Muhl. ex Willd. — small white lady's-slipper



Best Survey Period



Status: state threatened

Global and state rank: G4/S2

Other common names: white lady-slipper

Family: Orchidaceae

Total range: This principally upper Midwestern species ranges eastward to New Jersey and New York, extending west through southern Michigan to Minnesota, the eastern Dakotas, and southern Manitoba and Saskatchewan. To the south it ranges to Nebraska, Missouri, and Kentucky. It is considered rare in Iowa (S1), Illinois (S3), Indiana (S2), Kentucky (S1), Michigan (S2), Minnesota (S3), North Dakota (S2S3), New York (S1), Ohio (S1), South Dakota (S1), Wisconsin, and Manitoba. In Pennsylvania and Saskatchewan, it is considered extirpated and is known only from historical records in Missouri and New Jersey.

State distribution: Small white lady's-slipper is restricted to southern Michigan, occurring primarily within a narrow band from Berrien and Kalamazoo counties in the southwest to southeastern Michigan, were it is concentrated in Livingston, Oakland, Washtenaw, and Jackson counties. Two localities in the thumb region constitute the northernmost occurrences in the state. About one-third of approx. 81 recorded occurrences have succumbed to ecological succession or loss of habitat due to development pressures. Of the remaining extant populations, several are quite large, consisting of over 100-200 individuals.

Recognition: Although *Cypripedium candidum* produces solitary stems, mature plants commonly form small, dense, clonal clumps. This relatively small lady's-slipper averages about 20 cm in height, each stem producing **several strongly-ribbed, sheathing leaves that are densely short-hairy**. Stems are usually terminated by **a single flower (occasionally there may be two) characterized by its ivory-white pouch** (the lip or lower petal) which may be **faintly streaked with purple veins** toward the bottom and slightly purple-spotted around the pouch opening. The **lateral petals**, which are similar to the sepals, are **pale yellow-green and spirally twisted**. *Cypripedium candidum* is known to hybridize with two well-known varieties of yellow lady's-slipper, *C. calceolus* var. *pubescens* and *C. calceolus* var. *parviflora*, producing *C.* X*favillianum* and *C.* X*andrewsii*, respectively. These hybrids are the only taxa that small white lady-slipper is likely to be confused with. However, *Cypripedium* X*favillianum* can be distinguished by its larger size and very pale yellow pouch, and *C.* X*andrewsii*, which produces a white pouch like *C. candidum* can be distinguished by the dark, strongly spiralling petals and sepals more characteristic of var. *parviflorum*.

Best survey time/phenology: Surveys for this species should be conducted from late May to early June, when it typically flowers. It is fairly difficult to confirm the identity of non-flowering specimens.

Habitat: In Michigan, small white lady's-slipper occurs primarily in prairie fens and other marly, alkaline sites with groundwater seepage. These graminoid-dominated peatlands are commonly found adjacent to lake and stream systems. It also occurs in wet prairie communities of the

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clay lakeplain regions of southwestern Michigan and the thumb. These wet prairies are similar to tallgrass prairies, the typical habitat of this species outside of Michigan. Case (1987) also reports that it has been found in damp depressions in limestone barrens in Kentucky. Typical prairie fen soils in Michigan are Houghton mucks, often forming deep organic deposits. Common associates of white lady's-slipper include *Andropogon gerardii* (big bluestem), *Sorghastrum nutans* (Indian grass), *Potentilla fruticosa* (shrubby cinquefoil), *Carex stricta* (sedge), *Betula pumila* (bog birch), *Thelypteris palustris* (marsh fern), *Valeriana uliginosa* (valerian) and *V. edulis* var. *ciliata* (edible valerian, state threatened), *Sporobolus heterolepis* (prairie dropseed, state special concern), *Muhlenbergia richardsonis* (mat muhly, state threatened), *Solidago ohioensis* (Ohio goldenrod), *S. riddellii* (Riddell's goldenrod), *Pycnanthemum virginianum* (mountain mint), *Rhamnus alnifolia* (alder-leaved buckthorn), *Hierochloe odorata* (sweet grass), and numerous other species typical of southern Michigan fens, including several additional listed taxa.

Biology: Flowering occurs in late May to early June. Case (1987) and Luer (1975) both report that this perennial species develops rapidly, often blooming before the leaves have fully flushed and unwrapped the stems. Curtis (1943) estimated that at least 12 years or more are necessary for maturation following germination, and observed that clones are formed through the production of small plants from adventitious buds on 2 to 3-year-old roots. Curtis (1954) also documented the marked variation in flower and fruit production from year to year, and found no correlation between avg. flower and fruit production and the relative abundance of this species in the vegetation in comparison to other lady-slipper species. In a pollination study in southern Ontario, Catling and Knerer (1980) found small halictine and andrenid bees to be the principal pollinators. These bees were dependent on the availability of nectar from a variety of other flowering species whose blooming period coincided with *C. candidum.*

Conservation/management: Exemplary occurrences are protected and managed by several conservation organizations, including The Nature Conservancy and the Michigan Nature Association. However, many sites have been severely disturbed or destroyed through agricultural activities, peat or marl mining, land drainage, and other human activities. Others have succumbed to the invasion of woody shrubs due to ecological succession, while still others are threatened by the invasion of exotic species, the most notable pests being *Rhamnus frangula* (glossy-leaved buckthorn) and *Lythrum salicaria* (purple loosestrife). Prevention of hydrological changes and maintenance of a farily open condition are necessary for maintaining viable fen habitat. Careful fire management has been recommended for both shrub control and the healthy maintenance of populations (Bowles 1983). Kohring (1981) observed the favorable response of a population following a planned burn in a railroad right-of-way, noting that the number of blooming plants tripled and plant vigor increased. The use of prescribed burns should be carefully studied before, during and after their use in order to determine if and how burning can best be employed to maintain and/or enhance small white lady's-slipper populations. Since at least one Federal and State threatened insect species, (Mitchell's satyr), is known to inhabit prairie fens in southwest Michigan, any burn strategy employed should consider the presence of rare insects, mollusks, and herptiles.

Research needs: Due to the significant development pressure in southern Michigan where this species is most common, research regarding compatible development activities is of highest priority. Specific precautions that must be taken in order to maintain fen hydrology should be determined and proposed as policy. The role of fire as a management tool to minimize succession or the invasion of exotic species should also be investigated. Research on the breeding biology and genetic diversity of this species will provide a sounder basis for making management decisions.

Related abstracts: wet prairie, wet-mesic prairie, edible valerian, English sundew, mat muhly, prairie dropseed, prairie Indian-plantain, Mitchell's satyr

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Catling, P.M. and G. Knerer. 1980. Pollination of the small white lady's-slipper (*Cypripedium candidum*) in Lambton County, southern Ontario. Can. Field-Nat. 94:435-438.

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Abstract citation

Michigan Natural Features Inventory. 1998. Special plant absract for *Cypripedium candidum* (small white lady's-slipper). Lansing, MI. 3 pp.

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7-99/pjh

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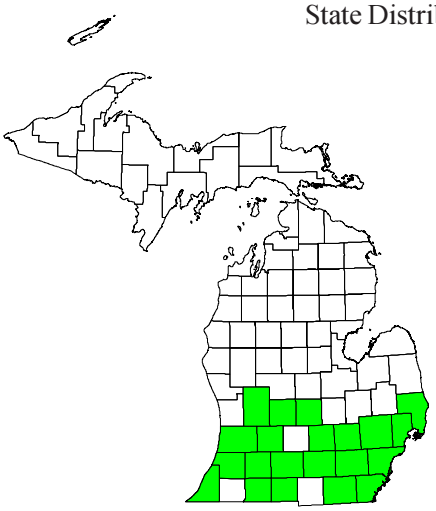
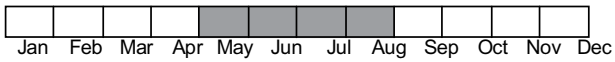
Hydrastis canadensis L. goldenseal

State Distribution



Best Survey Period



Legal status: State threatened

Global and state rank: G4/S2

Family: Ranunculaceae (buttercup family)

Total range: Goldenseal occurs throughout the eastern half of North America, occurring from Vermont to Minnesota and ranging south to Nebraska, Kansas, Arkansas, Georgia, and Alabama. It is considered rare over several portions of its range, including Connecticut, Delaware, Iowa, Massachusetts, Maryland, Minnesota, Mississippi, Vermont, North Carolina, New York, Virginia, Alabama, Indiana, Tennessee, Wisconsin, and Ontario.

State distribution: Goldenseal is currently known from 53 sites in 21 counties, where it is concentrated in the southern three tiers. Nine counties are represented by only a single locality. The species has been discovered or confirmed extant since 1980 at twenty-five localities; eight sites are based on records from 1930 or earlier, many in areas now with widespread development, and where the status of these historical records is largely unknown. Nine occurrences are reported to support more than 100 shoots and only two of those occurrences comprise populations with more than 1000 shoots.

Recognition: Goldenseal has an unbranched, hairy stem reaching 20-50 cm in height. Each stem produces one or two leaves near the top. These leaves are **palmately divided (maple-like)** into **five to nine sharply-pointed lobes with toothed margins**. Young leaves are small (3-10 cm wide), **shiny**, and **wrinkled**. When fully flushed, the leaves become dull green, the veins appear deeply impressed on the upper leaf surface, and they expand up to about 25 cm wide. A solitary flower about 15 mm in width terminates the stem. Below the flower is a very reduced bract-like leaf similar in shape to the other leaves. The flower of goldenseal has no petals, although there are **three pale, greenish-white sepals** at the base. These sepals are very ephemeral and **drop as soon as the flower opens**, revealing a **dense spray of conspicuous showy stamens with white, expanded filaments.** The berry-like fruit (8-18 mm) is green when immature, ripening to a **bright red color** and somewhat resembling a large raspberry in appearance. Goldenseal has a thick, knotty rhizome (4-7 cm long, 0.5-2cm wide) that is brown on the surface, with a bright yellow pigment inside, from which the common name is presumably derived.

Best survey time/phenology: Goldenseal is most easily identified when in flower or in fruit, but sterile plants can also be reliably determined by those experienced with this clone-forming, rich woodland

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species. The distinctive flowers are visible from approximately late April through early May. The fruits, first appearing green and then ripening to form a bright red aggregate of achenes, are visible from mid to late-season, about June to early August and perhaps later in some localities.

Habitat: Goldenseal typically inhabits shady, rich, mesic southern forests, usually under a canopy of beech-sugar maple or red oak-sugar maple. It frequently occurs in moist microhabitats near vernal pools, along forested streams, and also in southern floodplain forests, often in moist sandy loam, clay loam, or even organic (muck) soils. Overstory species include *Acer saccharum* (sugar maple), *Fagus grandifolia* (American beech), *Quercus rubra* (red oak), *Betula alleghaniensis* (yellow birch), *Acer saccharinum* (silver maple), *Tilia americana* (American basswood), *Juglans nigra* (black walnut), *Juglans cinerea* (butternut), *Celtis occidentalis* (hackberry), and *Fraxinus pennsylvanica* and *F. nigra* (red and black ash). Common mesic woodland herbs that are associated with goldenseal include *Arisaema triphyllum* (jack-in-the-pulpit), *Asarum canadense* (wild ginger), *Carex hirtifolia* (sedge), *Carex plantaginea* (plantain-leaved sedge), *Claytonia virginica* (spring beauty), *Erythronium americanum* (trout-lily), *Caulophyllum thalictroides* (blue cohosh), *Geranium maculatum* (wild geranium), *Uvularia perfoliata* (wild-oats), *Trillium grandiflorum* (common trillium), and *Hepatica acutiloba* (hepatica), among many other forbs typical of the ground layer in mesic forests.

Biology: Goldenseal is a perennial which, in Michigan, flowers in early May and produces fruits through September (Albert and Penskar 1984). Colonies of up to several hundred shoots can occur, with the smallest or late-flowering ones on the edges and the taller plants more central, suggesting that colonies expand by vegetative propagation. Colonies may be long-lived, slowly increasing in size through the years (Charette 1964).

Conservation/management: The knotty root (actually a rhizome) of this species is considered to have great medicinal value, and a large part of the great reduction in goldenseal populations can be attributed to exploitation by commercial harvesters (Swink and Wilhelm 1994). Protection from over-harvesting is a necessary first step to insure this species' survival. Habitat protection is also essential. At least three Michigan populations are in nature preserves under protective ownership of The Nature Conservancy, Michigan Nature Association, and Michigan Audubon Society. Two others are within University designated natural areas, one in a county park natural area, three in city parks, two in metropolitan parks, one in a state park, and one within a university woodlot. Other populations are on various tracts of private land. In addition to exploitation, this plant is vulnerable to removal of the forest canopy and probably to drainage or extended flooding of its habitat. The species is reportedly difficult to cultivate (Mitchell and Dean 1982).

Comments: Although goldenseal populations have been severely diminished and fragmented through over-harvesting and habitat destruction, it is also a species that can be easily overlooked when obscured by the typical lush vegetation of its forest habitat. Since more than one-half of the populations known to be extant have been discovered in the last several years, it is likely that others have yet to be discovered. Observations of a large population within a Nature Conservancy preserve (Albert and Penskar 1984) indicate that the fruit is highly palatable to animals, who appear to readily seek out this species as soon as the fleshy achenes are ripened.

Research needs: Investigation of the biology and ecology of goldenseal would assist in the management and protection of this species. Status inventories are also needed to provide better data on known populations, as well as to determine the condition of any existing historically documented localities.

Related abstracts: Ginseng, large toothwort, showy orchis, cerulean warbler, northern goshawk, red-shouldered hawk

Selected references:

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Abstract citation:

M.R. Penskar, E.G. Choberka, and P.J. Higman 2001. Special Plant Abstract for *Hydrastis canadensis* (goldenseal). Michigan Natural Features Inventory. Lansing, MI. 3 pp.

Funding for abstract provided by Michigan Department of Natural Resources-Forest Management Division and Wildlife Division.

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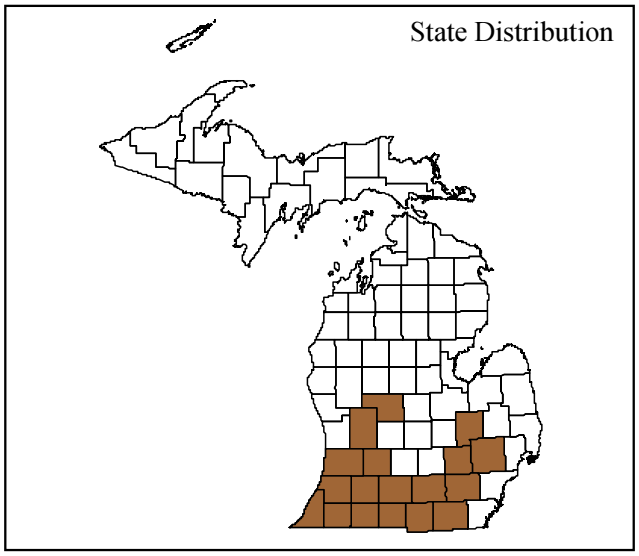
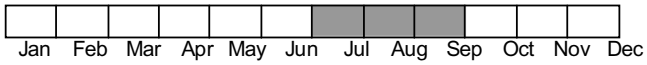
Prairie fen — Community Abstract


Photo by Dennis A. Albert.





Global and state rank: G4/S4

Total range: Prairie fens are geologically and biologically unique wetlands found only in the glaciated Midwest. They are distinguished from other calcareous fens by a tallgrass prairie flora and fauna component. They currently are known in Illinois, Indiana, Iowa, Ohio, Michigan, Minnesota, North Dakota, Wisconsin and southern Ontario. Similar communities are also known in unglaciated Missouri (Orzell & Kurz 1984). In Michigan, prairie fens occur in the southern three to four tiers of counties, primarily in the glacial interlobate region.

Rank justification: With the exception of Missouri, prairie fens are restricted to glaciated portions of the Midwest with specific geologic features, and are a regionally common natural community. Prior to European settlement, prairie fens were undoubtedly more numerous than they are today. Agriculture and urban development in Michigan have disrupted groundwater flow and destroyed wetlands, including prairie fens. In addition, lack of fire has likely caused prairie fens to succeed into shrub carr communities (Moran 1981). Currently, about 85 prairie fens are identified in Michigan totalling about 2,000 acres (810 hectares).

Landscape context: Prairie fens occur in the glacial interlobate region of Michigan's southern Lower Peninsula. This region contains a broad outwash plain scattered with "islands" of coarse-textured end and ground moraine, and ice contact ridges (Albert 1995). Prairie fens are typically located along the junction of outwash plain and moraine or ice contact ridge. They occur on lower slopes of the moraine or ridge, where coarse-textured glacial deposits provide high hydraulic conductivity, forcing groundwater to the surface (Moran 1981). Prairie fens are often associated with and drain into a small lake or pond, or, less often, a river or stream. Sapric peat, one foot to greater than 36 feet (.5 to >12 meters) deep (Moore et al. 1993), is typical prairie fen substrate, which is saturated with a constant supply of groundwater. Groundwater is calcareous, or rich in both calcium and magnesium bicarbonates; resulting from flow through limestone bedrock and/or coarse textured calcareous glacial deposits (Curtis 1959, Moran 1981, White & Chapman 1988). The high concentrations of bicarbonates often precipitate as marl at the soil surface. Soils are circumneutral with a typical pH range from 6.8 to 8.2. (White & Chapman 1988, Aaseng et al. 1993).

Natural processes: Hydrological processes are very important in prairie fen vegetative structure.

Saturated peat is maintained by a constant inflow of groundwater rich in calcium and magnesium from surrounding glacial deposits. Calcium and magnesium-rich groundwater often upwells through the peat and forms broad seeps or local springs. Once groundwater enters the prairie fen, drainage continues through the peat either in diffuse surface flow or in stream flow (Almendinger et al. 1994).

In the early 1800s, prairie fens were part of an ecosystem complex maintained by fire (Chapman 1988).

Prior to European settlement, dry, open upland communities such as mixed oak barrens or white oak

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savannas were often adjacent to prairie fens (Comer et al. 1995). Native American or lightning strike fires burned uplands and likely spread into adjacent prairie fens (Vogl 1969). These fires burned surface vegetation, inhibited shrub invasion, and maintained the open prairie fen community structure (Curtis 1959).

Vegetation description: Historically, prairie fen vegetation was adapted to the natural processes described above. Fire is supressed in most landscapes today, and therefore the vegetative structure in existing prairie fens is largely a result of the unique hydrology. Vegetation of this community consists of obligate wetland and calcicolous species mixed with tallgrass prairie and sedge meadow species.

Three (or four) vegetation zones are often present in prairie fens (Chapman 1988). Inundated flats or depressions are located around lake or stream margins. This zone can be expansive around lakes, or localized along small ponds, streams, or springs. It is the wettest portion of the prairie fen, with up to a foot (.3 meter) of standing water in the spring and early summer. Dominant species include *Scirpus acutus* (hardstem bulrush), *Scirpus americanus* (three-square), *Cladium mariscoides* (twig-rush), *Juncus brachycephalus* (rush), *Eleocharis elliptica* (golden-seeded spike-rush), and *E. rostellata* (spike-rush).

Sedge meadow is the largest and most characteristic vegetative zone of a prairie fen. This zone is saturated but not inundated and slightly sloping with stable peat. Any number or combination of three general associations of dominance can be found in the sedge meadow zone. The sedge-shrub association is a combination of sedges and low growing shrubs, often dominated by *Potentilla fruiticosa* (shrubby cinquefoil), *Carex stricta* (meadow sedge), and *C. aquatilis* (sedge). The sedge-composite association is often dominated by *C. stricta* (meadow sedge), *Eupatorium maculatum* (joe-pye weed), *E. perfoliatum* (common boneset), and *Aster* spp. (asters). The grass-sedge association is often dominated by *C. stricta*, *C. sterilis*, *C. aquatilis* (sedges), *Andropogon scoparius* (little bluestem), *A. gerardii* (big bluestem), and *Sorghastrum nutans* (Indian grass). Other species common in all associations of the sedge meadow zone include *Bromus ciliatus* (fringed brome), *Calamagrostis canadensis* (blue-joint grass), *Lysimachia qaudriflora* (whorled loosestrife), *Muhlenbergia glomerata* (marsh wild-timothy), *Pycnanthemum virginianum* (Virginia mountain mint), *Rudbeckia hirta* (black-eyed Susan), *Solidago ohioensis* (Ohio goldenrod), and *Thelypteris palustris* (marsh fern). Other shrubs in this zone include *Betula pumila* (bog birch), and *Cornus spp*. (dogwoods). Lack of fire and disruptions in groundwater flow often result in the colonization of these and other shrub and tree species including *Salix spp*. (willows), *Populus tremuloides* (quaking aspen), *Rhamnus alnifolia* (alder-leaved buckthorn), and *Ulmus americana* (American elm). Diversity and herbaceous cover are greatest in the sedge meadow zone, which distinguishes prairie fen from other calcareous fen communities in Michigan.

A wooded fen zone dominated by shrubs and trees is often located around upland edges of prairie fen.

The zone usually occurs on higher and slightly sloping surfaces where upland grades to wetland.

However, lower and wetter wooded fen zones also occur. *Larix laricina* (tamarack) is often a major component and sometimes dominant in the wooded fen zone. Occasionally, these zones resemble deciduous swamp dominated by *Acer rubrum* (red maple) and *Ulmus americana* (American elm). Shrub species, such as *Cornus stolonifera* (red-osier dogwood), *C. foemina* (gray dogwood), *Physocarpus opulifolius* (ninebark), *Salix candida* (sage willow), *Spiraea alba* (meadowsweet), and *Toxicodendron vernix* (poison sumac) are common in both types of wooded fen.

Another vegetative zone is sometimes distinct in areas of calcareous groundwater seepage. These areas are either broad and flat or small and broken and sparsely vegetated with marl precipitate at the surface.

The high concentration of calcium and magnesium in these areas results in vegetation dominated by calcicolous species including *Carex flava* (sedge), *Lobelia kalmii* (bog lobelia), *Parnassia glauca* (grass-of-parnassus), *Rhynchospora alba* (beak-rush), and *Triglochin maritimum* (bog arrow-grass). Carnivorous *Drosera rotundifolia* (round-leaved sundew), *Sarracenia purpurea* (pitcher plant), and *Utricularia intermedia* (flat-leaved bladderwort) are also found in this zone.

Strata	Most abundant
Tree canopy	*Larix laricina* (tamarack)
Short shrub	*Potentilla fruiticosa* (shrubby cinquefoil), *Betula pumila* (bog birch)
Herbaceous	*Carex stricta*, *C. aquatilis* (sedges), *Eleocharis rostellata* (spike-rush), *Cladium mariscoides* (twig rush), *Scirpus acutus* (bulrush)


Photo by William W. Brodowicz.

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Michigan indicator species: *Larix laricina* (tamarack), *Parnassia glauca* (grass-of-parnassus), *Potentilla fruiticosa* (shrubby cinquefoil), *Pycnanthemum virginianum* (Virginia mountain mint), *Solidago ohioensis* (Ohio goldenrod), *S. riddellii* (Riddell's goldenrod), and *Sorghastrum nutans* (Indian grass).

Other noteworthy species: Several rare animals are associated with prairie fen. *Oecanthus laricis* (tamarack tree cricket) is associated with the wooded fen zone often fringing a prairie fen. *Neonympha mitchellii mitchellii* (Mitchell's satyr) is also associated with more open edges of wooded fen zone where tamarack trees and poison sumac are scattered within a meadow of tall sedges. *Oarisma poweshiek* (poweshiek skipper) is found associated with spike and bulrushes in the inundated flat/ depression zone.

Celephelis muticum (swamp metalmark) is found associated with its host plants *Circium muticum* (swamp thistle) primarily and *C. altissimum* (tall thistle). *Lepyronia angulifera* (angualr spittlebug) has been collected from marly flats. Food plants for the adults include *Sporobolus indicus* (smut-grass), *Cyperus sweinitzii* (umbrella sedge), and other sedges. Adults of this species feed on *Gossypium hirsutum* (cotton) as well as a variety of monocots. Although not restricted to fens, *Sistrurus catenatus catenatus* (massasauga) is often found in the sedge meadow zone.

Rare plants associated with prairie fen include *Cacalia plantaginea* (tuberous Indian plantain), *Carex richardsonii* (Richardson's sedge), *Cypripedium candidum* (white ladies-slipper), *Muhlenbergia richardsonis* (mat muhly), *Rudbeckia sullivantii* (black-eyed Susan), *Sporobolus heterolepis* (prairie dropseed), and *Valeriana ciliata* (common valerian).

Invasive, non-native species such as *Rhamnus frangula* (glossy buckthorn) establish monocultures along wooded fen edges and often extend into the sedge meadow zone. *Lythrum salicaria* (purple loosestrife) can also invade the inundated flat/depression zone.

Conservation/management: Protecting hydrology is most important in the maintenance of vegetative structure in prairie fens. Groundwater flow into the prairie fen is altered by agricultural and residential drains and wells. The underlying groundwater table is lowered because of groundwater extraction and lack of recharge due to drained surface water. A lower groundwater table cannot supply the calcareous seepage which underlies prairie fen communities. Land use planning to protect the aquifer recharge area to the prairie fen is necessary to retain the unique hydrology. Many of the existing prairie fens already have disrupted aquifer recharge areas and portions of these communities are slowly changing to shrub-carr.

Healthy woodlands, savanna, and prairies in uplands adjacent to fens allow infiltration of precipitation into the groundwater. Whereas lawns, agricultural fields, and impervious surfaces contribute warm, nutrient & sediment-laden surface water runoff into fens.

Nutrient addition from leaking septic tanks and drain fields is suspected of contributing to the dominance of invasives such as *Typha angustifolia* (narrow-leaved cat-tail), and *Phragmites australis* (reed) and purple loosestrife in portions of several prairie fens (Panno, S.V et al. 1999).

Control of invasive and woody species invasion is necessary in these prairie fens to restore natural vegetative patterns of diversity. Fire and manual removal have proven effective in controlling exotics and native woody invasives (Kohring 1982, Zimmeran 1983). Bowles et al. (1996) determined that although fire did not significantly decrease woody species frequency it increased graminoid dominance.

Research needs: Quantify vegetational differences of structure and species diversity in prairie fens across the regional distribution. Investigate historical fire frequency within prairie fens. Determine how varying degrees of hydrological disruption effect patterns of praire fen vegetative structure. Investigate the association of rare species with prairie fens (i.e. Mitchell's satyr). Further identify the most effective management techniques in restoring native prairie fen flora and fauna.

Similar communities: wet prairie, wet-mesic prairie, southern wet meadow, shrub carr, lakeplain prairie, northern fen, poor fen, interdunal wetland, bog

Other classifications

Michigan Natural Features Inventory (MNFI) Presettlement Vegetation: not specifically noted, likely associated with 6227-wet prairie, 6122-marsh.

Michigan Department of Natural Resources (MDNR): L-lowland brush, N-marsh, T-tamarack.

Michigan Resource Information Systems (MIRIS): 612-shrub/scrub, 623-non-forested flats.

National Wetland Inventory (NWI): not specifically mentioned.

The Nature Conservancy National Classification: CODE: (V.A.7.N.p).

Alliance: *Potentilla fruiticosa*/*Carex* (*flava*, *interior*, *sterilis*, *lasiocarpa*) (saturated shrub herbaceous).

Association: *Potentilla fruiticosa*/*Carex sterilis-Carex flava-Eleocharis rostellata-Cacalia plantaginea* (shrub herbaceous vegetation).

Related abstracts: Mitchell's satyr, poweshiek skipper, white lady's-slipper, prairie dropseed

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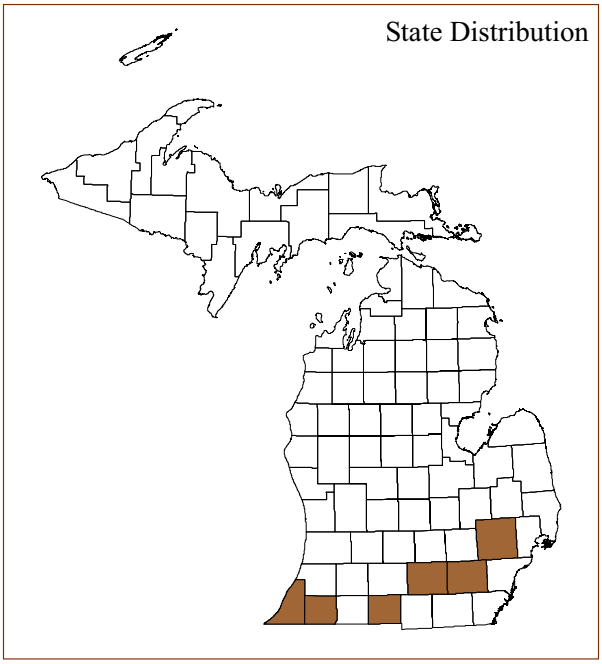
Relict conifer swamp — Community Abstract

Photo by David Cuthrell



Overview: Relict conifer swamp is a groundwater-influenced, or minerotrophic, forested wetland community that is typically dominated by tamarack (*Larix laricina*) and occurs on deep organic soils (e.g., peat and muck) in southern Michigan.

Global and State Rank: G2G3/S3

Range: Relict conifer swamp occurs in Minnesota, Wisconsin, Indiana, Michigan and Ontario. In Michigan, relict conifer swamp is thought to be restricted to the southern Lower Peninsula, although no statewide survey for the community has been conducted. Relict conifer swamp represents a type of rich conifer swamp, a more widespread, minerotrophic, forested wetland that is usually dominated by northern white cedar (see abtract for rich conifer swamp). Throughout northern Michigan and near the tension zone in Mid Michigan, northern white cedar (*Thuja occidentalis*) replaces tamarack as the dominant tree species in groundwater-influenced, forested wetlands. Acidic, rainwater-influenced (ombrotrophic) tamarack and black spruce swamps also occur in southern Michigan and are classified as poor conifer swamp (Chapman 1986). Many large wetland complexes contain zones of both minerotrophic tamarack swamp (e.g. relict conifer swamp) near the upland edge where groundwater seeps occur, as well as ombrotrophic tamarack swamp (e.g., poor conifer swamp) near the center of the complex. In the ombrotrophic zone, deep peat separates the vegetation from the influence of groundwater and sphagnum mosses acidify the surface water and peat.

Rank Justification: Analysis of the General Land Office (GLO) survey notes reveals that tamarack-dominated wetlands were common throughout southern Lower Michigan during the mid 1800s (Comer et al. 1995). In fact, tamarack swamps were the most common type of conifer swamp in all sub-subsections (Albert 1995) of southern Lower Michigan expect for those occupying the thumb region (e.g., Huron Lapeer, Sanilac and Tuscola Counties), where mixed conifer swamps were more abundant (Comer et al. 1995). While information is not readily available for deciphering the type of tamarack swamp (e.g., relict conifer swamp or poor conifer swamp) from the GLO data, tamarack-dominated wetlands overall occupied 196,526 ha (485,624 acres) of southern Lower Michigan. Comparisons between the GLO and 1978 MIRIS land cover data reveal that less than 1% or 1,149 ha (2,839 acres) of tamarack swamp remain in southern Lower Michigan (Albert 2001). Tamarack swamps were frequently drained and logged and subsequently used for agriculture, mined for peat, or abandoned and converted to wet meadow, shrub-carr or hardwood

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swamp. Tamarack logs were commonly utilized for fence posts, house and barn beams, and the early auto industry used tamarack for wheel spokes.

Landscape and Abiotic Context: Relict conifer swamp occurs in outwash channels, outwash plains, and kettle depressions throughout southern Lower Michigan. The community typically occurs in association with headwater streams and/or adjacent to inland lakes. Relict conifer swamps are often found where groundwater seeps occur at the base of moraines. The organic soils underlying relict conifer swamp are typically composed of a thin layer of muck overlying 2 – 5 m of fibric and woody peat (Kost 2001). Underlying the peat there is usually a layer of marl, a calcium carbonate precipitate that accumulates as sediment on lake bottoms.

Natural Processes: Relict conifer swamp is a groundwater-dependent, tamarack-dominated, wetland community. Its hydrology is maintained by calcareous groundwater that permeates the muck and peat soils. Because glacial till in southern Michigan is typically high in calcium and magnesium, the groundwater that reaches the surface has high levels of alkalinity and dissolved nutrients. The pH values of the muck and peat soils underlying relict conifer swamp are typically near 8.0, with surface water alkalinity measuring near 300 mg CaCO3/L and conductivity values near 600 uS (Kost 2001, Merkey 2001).

Because of the strong influence of groundwater on the community, water levels in relict conifer swamps tend to fluctuate less than in many other wetland types (Merkey 2001). However, seasonal water fluctuations are common and may be related to the varied microtopography of tamarack swamps. The tamarack roots form large hummocks that stand elevated above adjacent mudflats. During winter and spring, water typically fills the spaces between tamarack root-hummocks, while in summer and fall, exposed mud flats occupy these areas.

Windthrow, insect outbreak, beaver flooding, and fire are all important forms of natural disturbance for relict conifer swamp. Because tamarack is shade-intolerant (Curtis 1959), disturbance events that result in increased light to the understory and ground layer are especially important for maintaining the tamarack component of the community.

Trees growing in the anaerobic conditions associated with a high water table and muck and peat soils tend to be shallowly rooted and are thus, especially prone to windthrow. The light gaps created by windthrow help to regenerate tamarack and maintain the community's dense shrub layer. In addition, the coarse woody debris that results from windthrow also adds to the community's complex structure and microtopography.

Periodic outbreaks of larch sawfly (*Pristophora erichsonii*) and eastern larch beetle (*Dendroctonus simplex*), both native insect species, and the introduced tamarack casebarer (*Coleophora laricella*) can cause significant tamarack mortality. The defoliation associated with an insect outbreak results in increased light reaching the understory and ground layer, and like windthrow, may promote tamarack regeneration and shrub-layer density. However, in relict conifer swamps where red maple is widely distributed, these defoliation events may alter community structure by promoting the growth of red maple. Once red maple reaches the overstory its broad canopy effectively reduces the amount of light available to the understory and results in a significant reduction in shrub-layer cover and species richness as well as a loss of many shade-intolerant ground flora species (Kost 2001).

Long-term flooding resulting from beaver dams or other forms of blocked drainage such as road construction through a wetland can cause mass tamarack mortality and a conversion of relict conifer swamp or other forested wetlands to wet meadow or marsh. However, beaver may have also contributed to the establishment of relict conifer swamp when sources of tamarack seeds were accessible for colonization of abandoned beaver floodings. Tamarack may have also colonized sites where beaver flooding destroyed a hardwood-dominated swamp forest community.

Like long-term flooding, fire may cause extensive tamarack mortality (Curtis 1959) and create new opportunities for seedling establishment on freshly exposed organic soils. While fire is not a frequent form of disturbance directly within relict conifer swamps, its influence on the surrounding landscape is very important to the long-term viability of the community.

The role of fire in maintaining relict conifer swamp is especially important in the interlobate region of southern Michigan where fire was responsible for maintaining the open condition of many of the region's natural

communities including oak barrens, prairies, wet meadows, and prairie fens. With the widespread absence of fire in southern Michigan, tamarack, a common prairie fen species, has completely colonized many sites that were previously occupied by prairie fen, thus forming many of the relict conifer swamps we see today. The photo on the first page shows relict conifer swamp encroaching on prairie fen in the foreground. In addition to maintaining many community types in an open condition, fire also severely restricted the distribution of thin-barked, fire-intolerant tree species such as red maple. Aided by fire suppression, red maple has come to assume a leading role in the understory of many southern Michigan oak forests and frequently occurs in the canopy as well. In the past, the lack of red maple in the surrounding uplands meant disturbance events such as windthrow and insect outbreaks, which create light gaps, helped facilitate tamarack regeneration and the long-term viability of relict conifer swamp. With red maple now abundant in the surrounding uplands and widely distributed in many relict conifer swamps, these disturbance events may not be enough to maintain the tamarack component of the ecosystem and many former conifer swamps are now dominated by hardwoods. As evidence of this conversion, it is common to find dead, standing and downed tamarack in hardwood swamps that occur on deep, organic soils in southern Michigan. The conversion of these conifer swamps to hardwood swamps also results in a severe reduction in shrub-layer cover and the loss of many species (Kost 2001). Because many of the dominant shrub species are prolific fall, fruit producers, migrating and over-wintering songbirds as well as small mammals that rely on the fruit may be adversely impacted by the conversion to hardwood swamp.

Photo by Michael Kost

Poison sumac is one of several dominant shrub species in relict conifer swamp that provide critical food resources to wildlife during the fall migration and winter.

Vegetation Description: The structure of the community is largely shaped by tamarack, the dominant tree species. The roots of tamarack often form extensive mats that stand elevated above pools of water or mudflats and provide a substrate for a diverse wetland ground flora. In addition, the tamarack root mats form a varied microtopography, adding to the biocomplexity and high species richness of the community. Tamarack windthrows also add to the heterogeneous structure of the ground and shrub layers. Because of the open branching and spire-shape of tamarack, the shrub layer of relict conifer swamp receives a high level of light and is typically both very dense and diverse. In fact, the shrub layer may contain as many as 28 species, with multiple species intertwined and over topping one another so that total shrub-layer cover may reach 90 – 130% (Kost 2001). In addition to tamarack, other common tree species include: black ash (*Fraxinus nigra*), yellow birch (*Betula alleghaniensis*), American elm (*Ulmus americana*), red maple, swamp white oak (*Quercus bicolor*), quaking aspen (*Populus tremuloides*), red cedar (*Juniperus virginiana*), and in some locations white pine (*Pinus strobus*), and northern white cedar.

Common tall shrub species include: poison sumac (*Toxicodendron vernix*), winterberry (*Ilex verticillata*), smooth highbush blueberry (*Vaccinium corymbosum*), grey dogwood (*Cornus foemina*), silky dogwood (*Cornus amomum*), swamp rose (*Rosa palustris*), hazelnut (*Corylus americana*), nannyberry (*Viburnum lentago*), juneberry (*Amelanchier arborea*), black chokeberry (*Aronia prunifolia*), and pussy willow (*Salix discolor*). Other large shrubs that may occasionally occur in relict conifer swamp include spice bush (*Lindera benzoin*),

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mountain holly (*Nemopanthus mucronata*), hornbeam (*Carpinus caroliniana*), alternate-leaved dogwood (*Cornus alternifolia*), Bebb's willow (*Salix bebbiana*), and elderberry (*Sambucus canadensis*).

Low shrub species common to relict conifer swamp include: swamp gooseberry (*Ribes hirtellum*), dwarf raspberry (*Rubus pubescens*), bog birch (*Betula pumila*), wild raspberry (*Rubus* spp.), sage willow (*Salix candida*), swamp fly honeysuckle (*Lonicera oblongifolia*), alder-leaved buckthorn (*Rhamnus alnifolia*), common juniper (*Juniper communis*), shrubby cinquefoil (*Potentilla fruticosa*), and bog willow (*Salix pedicellaris*).

Common woody vines include: poison ivy (*Toxicodendron radicans*), Virginia creeper (*Parthenocissus quinquefolia*), and riverbank grape (*Vitis riparia*).

Because of the high frequency of canopy disturbance and open structure of tamarack, the ground flora is composed of a heterogeneous mixture of shade-tolerant and -intolerant wetland plants. In addition, the stark difference in moisture levels between the elevated root hummocks and saturated mudflats also significantly increases the diversity of wetland species found in the ground flora. While mosses are prevalent throughout the ground layer, sphagnum mosses (*Sphagnum* spp.) are usually only locally distributed. The following list contains common ground flora species occurring in relict conifer swamp:

SCIENTIFIC NAME	COMMON NAME
Aster puniceus (*A. firmus*)	smooth swamp aster
Aster lanceolatus	eastern lined aster
Bidens cernuus	nodding bur-marigold
Bidens coronatus	tall swamp-marigold
Boehmeria cylindrica	false nettle
Calamagrostis canadensis	blue-joint grass
Caltha palustris	marsh-marigold
Campanula aparinoides	marsh bellflower
Cardamine pensylvanica	Pennsylvania bitter cress
Carex alata	winged sedge
Carex comosa	sedge
Carex hystericina	sedge
Carex lacustris	sedge
Carex leptalea	sedge
Carex stricta	sedge
Cicuta bulbifera	water hemlock
Dryopteris carthusiana	spinulose woodfern
Equisetum fluviatile	water horsetail
Galium asprellum	rough bedstraw
Galium labradoricum	bog bedstraw
Galium tinctorium	stiff bedstraw
Glyceria striata	fowl manna grass
Impatiens capensis	spotted touch-me-not
Leersia oryzoides	cut grass
Lemna minor	small duckweed
Lycopus uniflorus	northern bugle weed
Lysimachia thyrsiflora	tufted loosestrife
Maianthemum canadense	Canada mayflower
Onoclea sensibilis	sensitive fern
Osmunda regalis	royal fern
Pilea pumila	clearweed
Rubus pubescens	dwarf raspberry
Sagittaria latifolia	common arrowhead
Scutellaria lateriflora	mad-dog skullcap
Senecio aureus	golden ragwort
Solidago patula	swamp goldenrod
Solidago rugosa	rough goldenrod
Symplocarpus foetidus	skunk-cabbage
Thelypteris palustris	marsh fern
Trientalis borealis	starflower
Viola spp.	violet

Michigan indicator species: Tamarack, poison sumac, smooth highbush blueberry, winterberry, black chokeberry, alder-leaved buckthorn, black ash, yellow birch, and sedge (*Carex leptalea*).

Other noteworthy species: Many of the rare plants associated with relict conifer swamp include species that are more commonly found in open prairie fen. These shade-intolerant species may occur on the edges of relict conifer swamp or within light gaps that have remained in an open condition. Species that fit this group include water parsnip (*Berula erecta*), tuberous Indian plantain (*Cacalia plantaginea*), narrow leaved reedgrass (*Calamagrostis stricta*), white lady's lipper (*Cypripedium candidum*), English sundew (*Drosera anglica*), queen-of-the-prairie (*Filipendula rubra*), mat muhly (*Muhlenbergia richardsonis*), sweet william phlox (*Phlox maculata*), Jacob's ladder (*Polemonium reptans*), prairie dropseed (*Sporobolus heterolepis*), and edible valerian (*Valeriana edulis* var. *ciliata*). Bog bluegrass (*Poa paludigena*), a rare species most commonly found in hardwood-dominated swamps and floodplains, may also occur in relict conifer swamp.

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Rare animal species associated with relict conifer swamp include: tamarack tree cricket (*Oecanthus laricis*), Mitchell's satyr butterfly (*Neonympha mitchellii*), eastern massasauga (*Sistrurus catenatus*), Blanding's turtle (*Emydoidea blandingii*), and spotted turtle (*Clemmys guttata*).

Conservation/management: The presence of conifer-dominated wetlands in southern Michigan contributes significantly to the region's overall biodiversity. The relict conifer swamps in southern Michigan represent the southern range of the minerotrophic conifer swamps in the Midwest. Because they are dominated by tamarack and not by northern white cedar like their more widespread, northern counterpart, the relict conifer swamps in southern Michigan represent a unique type of minerotrophic conifer swamp.

Protection of relict conifer swamp includes protecting the site's hydrology. This may include avoiding surface water inputs to the community from drainage ditches and agricultural fields, and protecting groundwater recharge areas by maintaining native vegetation types in the uplands around relict conifer swamps. Long-term flooding from road construction through the center of a relict conifer swamp or clogged road culverts can result in mass tamarack mortality. Because relict conifer swamp is a groundwater-dependent community, protecting the quantity and quality of the groundwater is critical.

Invasion by red maple can cause a relict conifer swamp to shift to hardwood domination. This shift begins to occur as red maple reaches the overstory. The broad canopy of red maple prevents direct sunlight from reaching smaller tamaracks and results in a rapid loss of tamarack and other shade-intolerant species. The dense shrub layer, which is characteristic of relict conifer swamp, is significantly reduced under a hardwood canopy and thus, species that rely on fruit during the fall migration and winter are adversely impacted.

Reducing red-maple cover in relict conifer swamps by girdling red maple in conjunction with herbicide application may be effective in preventing the loss of the shrub layer and shade-intolerant species such as tamarack. Ideally, this type of management would accompany the use of prescribed fire in the upland forests adjacent to the swamp and hydrologic restoration where necessary. Significantly reducing red maple cover in both the upland and lowland forests will help ensure that characteristic natural disturbance events, such as windthrow and insect outbreaks, result in tamarack regeneration.

Invasive species that occur in relict conifer swamp include: glossy buckthorn (*Rhamnus frangula*), purple loosestrife (*Lythrum salicaria*), reed canary grass (*Phalaris arundinacea*), reed (*Phragmites australis*), and bittersweet nightshade (*Solanum dulcamara*). While bittersweet nightshade is not typically a threat to a site's overall species richness, each of the other invasive species listed above can negatively influence species richness and alter community structure. Glossy buckthorn, in particular, is probably the greatest threat to species diversity and community structure in relict conifer swamp. This species has colonized similar habitats throughout the Midwest and can completely dominate the shrub and ground layers. Treatment for removing glossy buckthorn can be accomplished with cutting, accompanied by herbicide application (Reinartz 1997) and by using spot-burning to eliminate seedlings (Jack McGowan-Stinski 1999 pers. comm.).

Research needs: Because tamarack plays a critical role in structuring relict conifer swamp, studies aimed at better understanding the factors that influence its ability to regenerate will help managers maintain the long-term viability of this community type. The role of red maple and other hardwoods in altering community structure is also an important research topic. An historical study, using GLO notes, of the distribution of red maple in relation to tamarack-dominated swamps as well as other types of conifer swamp would help managers to better understand the differences between past successional processes and those observed today. Gaining an understanding of the effects of fire and other forms of natural disturbance on relict conifer swamp will also help managers better understand the ecosystem. Little attention has been given to the importance of relict conifer swamp for maintaining certain rare plant and animal species. In addition, the role of relict conifer swamp in providing both thermal cover and important food reserves during fall migration and winter will be useful for understanding the significance of this community type in maintaining regional biodiversity.

Similar communities: Rich conifer swamp, conifer-hardwood swamp, southern swamp, poor conifer swamp,

prairie fen, and southern wet meadow.

Other Classifications:

Michigan Natural Features Inventory Pre-settlement Vegetation (MNFI):
Lowland Conifer – Tamarack

Michigan Department of Natural Resources (MDNR): T-Tamarack.

Michigan Resource Information Systems (MIRIS): 4233 (Tamarack).

The Nature Conservancy National Classification (Faber-Langendoen 2001, Natureserve 2001):

CODE; ALLIANCE; ASSOCIATION; COMMON NAME

I.B.2.N.g.3; *Larix laricina* Saturated Forest Alliance; *Larix laricina – Acer rubrum* / (*Rhamnus alnifolia*, *Vaccinium corymbosum*) Forest; Tamarack – Red Maple / (Alderleaf Buckthorn, Highbush Blueberry) Forest; Central Tamarack – Red Maple Rich Swamp.

Related Abstracts: rich conifer swamp, prairie fen, southern wet meadow, prairie-Indian-plantain, white lady-slipper, English sundew, mat muhly, prairie dropseed, tamarack tree cricket, eastern massasauga, Mitchell's satyr butterfly, Blanding's turtle, spotted turtle.

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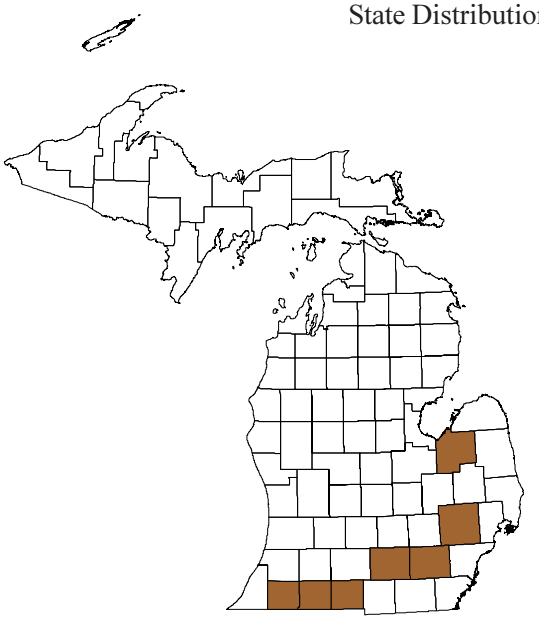
Southern wet meadow — Community Abstract

Photo by Diane De Steven

State Distribution



Overview: Southern wet meadow is an open, groundwater-influenced (minerotrophic), sedge-dominated wetland that occurs in mid and southern Lower Michigan. Sedges in the genus *Carex*, in particular *Carex stricta*, dominate the community.

Global and State Rank: G4?/S3?

Range: Southern wet meadow, which is commonly referred to as sedge meadow, occurs in Iowa, Illinois, Indiana, Michigan, Minnesota, North Dakota, Wisconsin and Ontario. In Michigan, southern wet meadow is thought to be restricted to the southern Lower Peninsula and to differ from sedge meadows in northern Michigan (see northern wet meadow, MNFI 1990). However, no detailed study of the differences between northern and southern types has been undertaken. Curtis (1959) studied sedge meadows in northern and southern Wisconsin and found them to be floristically similar but concluded that northern meadows had consistently lower soil pH values and were frequently wetter and smaller than many southern wet meadows. Another sedge-dominated natural community, poor fen, also occurs in Michigan but differs markedly from southern wet meadow because of its strongly acidic, organic soils and the prevalence of *Carex oligosperma* and other open bog species (MNFI 1990).

Rank Justification: Because southern wet meadow often occurs as a zone within large wetland complexes, information on its presettlement extent and present acreage is not readily available. However, in Wisconsin, where 459,000 ha (1,130,000 acres) of sedge meadow are thought to have existed prior to settlement (Curtis 1959), it is estimated that less than 1 percent remain intact (Reuter 1986). It is likely southern wet meadow acreage has declined similarly in other Midwest states, such as Michigan, where similar agricultural methods have been practiced.

Southern wet meadows have been extensively utilized for agriculture. Prior to the 1950s mowing for marsh hay was widely practiced (Stout 1914, Curtis 1959). Wet meadows were frequently tiled, ditched, drained, and converted to pasture, row crops or mined for peat (Costello 1936, Curtis 1959, Reuter 1986). In addition, fire suppression has facilitated shrub encroachment with many southern wet meadows converting to shrub-carr (Curtis 1959, Davis 1979). This is especially evident where the water table has been lowered though tiling or ditching and the practice of mowing for marsh hay has been abandoned (White 1965).

Landscape and Abiotic Context: Southern wet meadow occurs on glacial lakebeds, and in depressions on glacial outwash and moraines (Curtis 1959). The community

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frequently occurs along the margins of lakes and streams where seasonal flooding or beaver-induced flooding is common.

Southern wet meadow typically occurs on organic soils such as muck and peat (Curtis 1959) but saturated mineral soil may also support the community (Costello 1936). Because of the calcareous nature of the glacial drift in the regions occupied by southern wet meadow, its wet soils contain high levels of dissolved minerals such as calcium and magnesium. Southern wet meadow soil pH values range between 7.0 to 7.8 in southeastern Michigan and 7.2 to 8.5 in southern Wisconsin and indicate that the community typically occurs on neutral to strongly alkaline soils (Costello 1939, Curtis 1959, Warners 1993).

Southern wet meadow typically occurs adjacent to other wetland communities in large wetland complexes. In southern Michigan's interlobate region where ground water seeps occur at the base of moraines, southern wet meadow often borders prairie fen. In depressions on ground moraine or lakeplain, southern wet meadow may grade into wet prairie or lakeplain wet prairie up slope and emergent marsh in lower areas. On the edges of inland lakes, southern wet meadow often borders emergent marsh. It may also occur along the Great Lakes shoreline within extensive areas of Great Lakes marsh. In all of these landscape settings, southern wet meadow may border shrub-carr and swamp forest.

Natural Processes: Southern wet meadow is a groundwater-dependent, *Carex stricta*-dominated, wetland community. Water levels in southern wet meadow fluctuate seasonally, reaching their peak in spring and lows in late summer (Costello 1936, Warners 1993). However, water levels typically remain at or near the soil's surface throughout the year (Costello 1936, Curtis 1959, Warners 1993). The community's structure may depend on maintaining a consistently high water table. Costello (1936) states that the *Carex stricta* tussocks disappeared within 10 years from a meadow where the water levels were reduced to 2 to 4 feet below the surface as a result of tiling.

In addition to seasonal flooding, beaver-induced flooding may also play an important role in maintaining the community by occasionally raising water levels and killing encroaching trees and shrubs. Beaver may also help create new southern wet meadows by flooding swamp forests and shrub-carr and thus creating suitable habitat for the growth of shade-intolerant wet meadow species such as *Carex stricta*.

Evidence from wetland peat cores and presettlement maps indicate that southern wet meadow is a fire-dependent natural community (Curtis 1959, Davis 1979). Analysis of wetland peat cores shows that charcoal fragments are consistently associated with sedge and grass pollen (Davis 1979). Conversely, charcoal fragments are lacking from sections of peat cores dominated by shrub pollen. Additional evidence for the role of fire in maintaining sedge meadows in an open condition comes from presettlement maps. In southern Wisconsin, where prevailing westerly winds carry fires eastward, sedge meadow frequently occurred adjacent to fire-dependent natural communities such as oak savannas and prairies on the west side (i.e., windward) of large rivers. While directly east (i.e., leeward) of these same rivers, similar topography supported fire-intolerant tamarack swamps and mesic forests (Zicker 1955 in Curtis 1959).

By reducing leaf litter and allowing light to reach the soil surface and stimulate seed germination, fire can play an important role in maintaining southern wet meadow seed banks (Warners 1997, Kost and De Steven 2000). Fire also plays a critical role in preventing declines in species richness in many community types by creating micro-niches for small species (Leach and Givnish 1996). Another critically important attribute of fire for maintaining open sedge meadow is its ability to temporarily reduce shrub cover (Reuter 1986).

In the absence of fire or flooding, all but the wettest sedge meadows typically convert to shrub-car and eventually swamp forest (Curtis 1959). Because many of the species that inhabit southern wet meadow are shade-intolerant, species richness usually declines following shrub and tree invasion (Curtis 1959, White 1965).

Vegetation Description: Southern wet meadow is typically dominated by *Carex stricta* (Stout 1914, Costello 1936, Curtis 1959, Warners 1997, Kost and De Steven 2000). Because the roots of *Carex stricta* form large hummocks or tussocks, the species is responsible for the community's hummock and hollow structure. Individual culms of *Carex stricta* grow from the tussocks, which may reach more than 1 m in height and .5 m in diameter and live for more than 50 years (Costello 1936). The

Early spring photo of *Carex stricta* tussocks and encroaching shrubs. A prescribed fire removed the litter from tussocks in the background, while a thick layer of litter remains on unburned tussocks in the foreground.

Carex stricta tussocks can occur at very high densities (1 to 4 per m^2) and occupy more than 40% of a meadow's area (Costello 1936). Because the shaded areas between tussocks are often covered with standing water and leaf litter, many of the shorter species inhabiting sedge meadows grow almost exclusively from the sides or tops of *Carex stricta* tussocks.

Other sedges that commonly occur in southern wet meadow include: *Carex aquatilis*, *C. comosa*, C. *bebbii*, *C. hystericina*, *C. lacustris*, *C. lanuginosa*, *C. lasiocarpa*, *C. prairea*, *C. rostrata*, *C. sartwellii*, *C. stipata* and *C. vulpinoidea*. Although most of the associated sedge species tend to be randomly interspersed, *Carex lacustris* often occurs in dense patches.

The most dominant grass species in southern wet meadow is blue joint grass (*Calamagrostis canadensis*) (Stout 1914, Kost and De Steven 2000). Other common grasses include: fringed brome (*Bromus ciliatus*), fowl mana grass (*Glyceria striata*), marsh wild timothy (*Muhlenbergia glomerata*), leafy satin grass (*Muhlenbergia mexicana*), and fowl meadow grass (*Poa palustris*).

A wide variety of wetland forbs occur in southern wet meadow. The following table contains many of the more commonly occurring southern wet meadow species.

SCIENTIFIC NAME	COMMON NAME
Asclepias incarnata	swamp milkweed
Aster puniceus (*A. firmus*)	swamp aster
Aster lanceolatus	eastern lined aster
Aster lateriflorus	side flowering aster
Calamagrostis canadensis	blue joint grass
Campanula aparinoides	marsh bellflower
Carex aquatilis	sedge
Carex hystericina	sedge
Carex lacustris	sedge
Carex lanuginosa	sedge
Carex lasiocarpa	sedge
Carex prairea	sedge
Carex sartwellii	sedge
Carex stipata	sedge
Carex stricta	sedge
Cicuta bulbifera	water hemlock
Cirsium muticum	swamp thistle
Eleocharis erythropoda	spike rush
Equisetum fluviatile	water horsetail
Eupatorium maculatum	joe pye weed
Eupatorium perfoliatum	common boneset
Galium asprellum	rough bedstraw
Glyceria striata	fowl manna grass
Impatiens capensis	jewelweed
Iris virginica	southern blue flag
Lathyrus palustris	marsh pea
Lycopus uniflorus	northern bugle weed
Lysimachia thyrsiflora	tufted loosestrife
Mentha arvensis	wild mint
Muhlenbergia glomerata	marsh wild timothy
Muhlenbergia mexicana	leafy satin grass
Onoclea sensibilis	sensitive fern
Pilea pumila	clearweed
Polygonum amphibium	water smartweed
Pycnanthemum virginianum	mountain mint
Rumex orbiculatus	great water dock
Sagittaria latifolia	common arrowhead
Scutellaria galericulata	common skullcap
Solidago canadensis	canada goldenrod
Solidago gigantea	late goldenrod
Solidago patula	swamp goldenrod
Thalictrum dasycarpum	purple meadow rue
Thelypteris palustris	marsh fern
Triadenum fraseri	marsh st. john's wort
Typha latifolia	broad leaved cattail
Viola cucullata	marsh violet

Michigan indicator species: *Carex stricta*, *Carex lacustris*, blue joint grass, swamp aster, joe pye weed, common boneset, northern bugleweed, great water dock, marsh bellflower, and tufted loosestrife.

Other noteworthy species: The small white lady's slipper (*Cypripedium candidum*) may occur in southern wet meadow. Rare animal species associated with southern wet meadow include: swamp metalmark (*Calephelis mutica*), Mitchell's satyr butterfly (*Neonympha mitchellii*), eastern massasauga (*Sistrurus catenatus*), Blanding's turtle (*Emydoidea blandingii*), spotted turtle (*Clemmys guttata*), marsh wren (*Cistothorus palustris*), northern harrier (*Circus cyaneus*), short eared owl (*Asio flammeus*), and American bittern (*Botaurus lentiginosus*).

Conservation/management:
Southern wet meadows contribute significantly to the overall biodiversity of southern Michigan by providing habitat to a wide variety of plant and animal species including many rare species.

Protecting the hydrology of southern wet meadow is imperative for the community's continued existence. This may include avoiding surface water inputs to the meadow from drainage ditches and agricultural fields, and protecting groundwater recharge areas by maintaining native vegetation types in the uplands around the community.

Management for southern wet meadow should include the use of prescribed fire (Curtis 1959). Prescribed fire can help reduce litter, stimulate seed germination, promote seedling establishment, and bolster grass, sedge, and perennial and annual forb cover (Bowles et al. 1996, Warners 1997, Kost and De Steven 2000). While prescribed fire can be an important tool for rejuvenating southern wet meadow seed banks, it can also help ensure that the community remains in an open condition by temporarily setting back invading woody species (Reuter 1986). Using prescribed fire to control shrub invasion in sedge meadows has also been shown to be 85% less expensive to implement than manual cutting (Reuter 1986). The use of prescribed fire should be avoided during periods of drought to avoid igniting the community's organic soils (Curtis 1959, Vogl 1969).

Invasive species that can occur in southern wet meadow include purple loosestrife (*Lythrum salicaria*), reed canary grass (*Phalaris arundinacea*), reed (*Phragmites australis*), and glossy buckthorn (*Rhamnus frangula*). Each of these species is capable of significantly altering community structure and dramatically reducing species richness. Management should strive to prevent the further spread of these invasive species and implement control measures when possible.

Restoration of degraded southern wet meadows depends on the occurrence of water-saturated peat and muck soils, maintaining waters levels very near the soil surface throughout the year, providing protection from shrub encroachment and invasive species, and the availability of appropriate seed stock (Reuter 1986). Finding viable seed for *Carex stricta*, the species responsible for the overall structure of southern wet meadow, may be a difficult task. Costello (1936) reports that in more than six years of studying *Carex stricta*-dominated sedge meadows he did not find a single seedling of the species. Because of the difficulty of restoring southern wet meadow in the absence of favorable hydrology and intact organic soils, conservation efforts should focus on protecting the remaining community occurrences (Reuter 1986).

Research needs: Research on methods for establishing and maintaining *Carex stricta* in wetland mitigation or degraded sites will facilitate restoration efforts for southern wet meadow. Further work on community classification is needed to elucidate differences among sedge meadow types both within and among ecoregions. Research is needed on plant and animal community responses to the frequency and seasonal timing of prescribed burning. Research on the importance of the community for maintaining certain rare species will help stimulate southern wet meadow conservation and management.

Similar communities: emergent marsh, northern wet meadow, poor fen, prairie fen, wet prairie, lakeplain wet prairie, Great Lakes marsh and southern shrub-carr.

Other Classifications:

Michigan Natural Features Inventory Pre-settlement Vegetation (MNFI):
wet meadow (6224)

Michigan Department of Natural Resources (MDNR): L, lowland brush; N, marsh; V, bog or muskeg.

Michigan Resource Information Systems (MIRIS): 622 (emergent wetland).

The Nature Conservancy National Classification (Faber-Langendoen 2001, Natureserve 2001)**:**

CODE; ALLIANCE; ASSOCIATION; COMMON NAME

V.A.5.N.k; Carex stricta Seasonally Flooded Herbaceous Alliance; *Carex stricta – Carex* spp. Herbaceous Vegetation; Tussock Sedge – Sedge Species Herbaceous Vegetation; Tussock Sedge Wet Meadow.

Related Abstracts: small white lady's slipper, mat muhly, prairie dropseed, short-eared owl, northern harrier, spotted turtle, Blanding's turtle, Mitchell's satyr butterfly, eastern massasauga, lakeplain wet prairie, prairie fen, Great Lakes marsh, and relict conifer swamp.

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P.O. Box 30444 - Lansing, MI 48909-7944
Phone: 517-373-1552

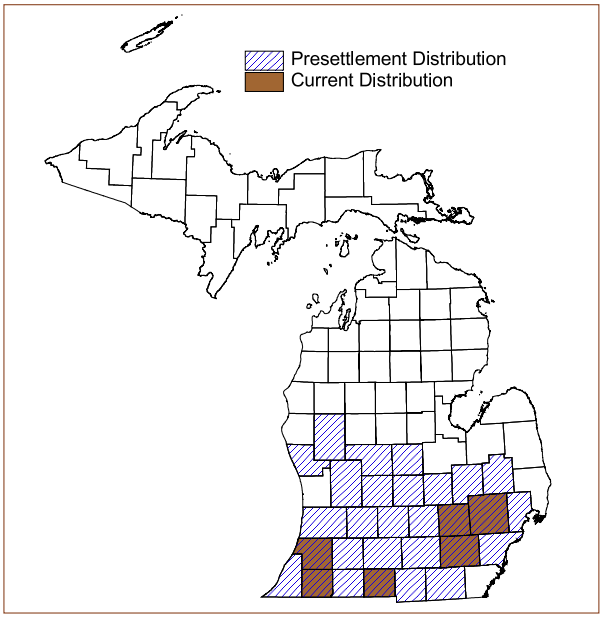
Oak Barrens — Community Abstract

Photo by: Susan R. Crispin

Overview: Oak barrens is a fire-dependent, savanna type dominated by oaks, having between 5 and 60 percent canopy, with or without a shrub layer. The predominantly graminoid ground layer is composed of species associated with both prairie and forest communities. Oak barrens are found on droughty soils and occur typically on nearly level to slightly undulating sandy glacial outwash, and less often on sandy moraines or ice contact features.

Global and State Rank: G2?/S2

Range: Barrens and prairie communities reached their maximum coverage in Michigan approximately 4,000-6,000 years before present, when postglacial climatic conditions were comparatively warm and dry. During this time, xerothermic conditions allowed for the invasion of fire-dependent, xeric vegetation types into a large portion of the Lower Peninsula and into sections of the Upper Peninsula. With the subsequent shift of more mesic climatic conditions southward, there has been a recolonization of mesic vegetation throughout Michigan. The distribution of fire-dominated communities, such as oak barrens, has been reduced typically to isolated patches concentrated along the climatic tension zone. In the 1800s, oak barrens were located in the interior of the southeastern Lower Peninsula on sandy glacial outwash and coarse-textured, moraines (Comer et al. 1995). Presently the distribution of this community has been reduced to degraded remnants throughout its original range. In addition to southern Michigan, oak barrens remnants occur south of the tension zone through Wisconsin and southeastern Minnesota, and in the glaciated portions of Ohio, Indiana, Illinois, Iowa, Missouri, Kansas, and Nebraska (Chapman et al. 1995, NatureServe 2001).



Rank Justification: At the time of European settlement, oak savanna communities covered some 11-13 million hectares of the Midwest. Presently oak savanna remnants occur on just 0.02% of their presettlement extent (Nuzzo 1986). The notes of the original land surveyors of Michigan

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Phone: 517-373-1552

reveal that in the 1800s, oak barrens covered approximately 719,042 acres or 1.9% of the state, distributed patchily across the four lower tiers of counties. In Allegan and Ottawa Counties, savanna communities where typically oak-pine barrens, while lakeplain oak openings were prevalent in the thumb region (Huron, Bay, and Tuscola Counties). Oak openings shared the same range as oak barrens but occurred on dry-mesic to mesic soils as opposed to droughty sites. Surveyors' notes indicate that high concentrations of oak barrens occurred in the following counties: Oakland County (28% or 200,557 acres), Jackson County (12% or 84,204 acres), Livingston County (11% or 81,176), and Washtenaw County (9% or 62,966 acres). Today merely a few hundred acres of oak barrens remain in Michigan with small, restorable remnants occurring in Cass, Branch, Livingston, Jackson, Washtenaw, and Van Buren Counties. This rare community constitutes less than 0.0005% of the present vegetation of Michigan.

Oak barrens have been cleared for sand mining, agriculture, and residential and urban development (Chapman et al. 1995). Alteration of historic fire regimes has shifted most barrens types into woodlands and forest (Curtis 1959, Faber-Langendoen 1993). Wildfire suppression policies instituted in the 1920s in concert with road construction, expansion of towns, and increased agriculture caused a dramatic decrease in fire frequency and intensity (Abrams 1992). The reduction of fire in the landscape resulted in the succession of open oak barrens to closed-canopy forests dominated by black and white oaks with little advanced regeneration of oaks and a vanishing graminoid component (Chapman et al. 1995). In addition, timber exploitation of oaks in the 1920s destroyed or degraded oak barrens across Michigan (Michigan Natural Features Inventory 1995). Many oak barrens fragments are currently completely dominated by black oak as the result of selective harvest of canopy white oak (Minc and Albert 1990). In addition to simplified overstory structure, these communities are often depauperate in floristic diversity as the result of fire suppression and subsequent woody encroachment, livestock grazing, off-road vehicle activity, and the invasion of exotic species (Michigan Natural Features Inventory 1995).

Landscape and Abiotic Context: Oak barrens occur on well-drained, nearly level to slightly undulating sandy glacial outwash, and less often on sandy moraines or ice contact features. Oak barrens typically occur in the driest landscape positions, such as ridge tops, steep slopes, south and west facing slopes, and flat sand plains. This xeric, fire-prone community is characterized by soils that are infertile, coarse-textured, well-drained sand or loamy sand with medium to slightly acid pH and low water retaining capacity. Soils contain low organic matter and lack the fine-textured illuvial horizon associated with soils of the oak openings and are thus droughtier. Oak barrens and oak-pine barrens typically occur in bands surrounding prairie (Michigan Natural Features Inventory 1990, Chapman et al. 1995).

Oak barrens are distributed in Michigan's Region I, Southern Lower Michigan (Albert et al. 1986). This region has a warm, temperate, rainy to cool, snow-forest climate with hot summers and no dry season. The daily maximum temperature in July ranges from 29° to 32° C (85° to 90° F) and the daily minimum temperature in January ranges from -9° to -4° C (15° to 25° F). The number of freeze-free days is between 120 and 220, and the average number of days per year with snow cover of 2.5 cm or more is between 10 and 60. The mean annual total precipitation for Region I is 820 mm (Albert et al. 1986, Barnes 1991).

Natural Processes: Curtis (1959) suggested that oak barrens originated when prairie fires spread into surrounding closed oak forest with enough intensity to create open barrens. Repeated low intensity fires working in concert with drought then maintain these barrens (Curtis 1959, Faber-Langendoen and Tester 1993). Oak barrens persist when fire disturbance and/or drought prevents canopy closure and the dominance of woody vegetation. Presently, the prevalent catalyst of fires is lighting strike but historically, Native Americans played an integral role in the fire regime, accidentally and/or intentionally setting fire to prairie ecosystems (Day 1953, Chapman 1984). Where large-scale herbivores are abundant, grazing may help inhibit the succession of grass-dominated oak barrens to woodland (Ritchie et al. 1998).

The character of oak barrens can differ dramatically, primarily as the result of varying fire intensity and frequency, which are influenced by climatic conditions, soil texture, topography, and landscape context (i.e., proximity to water bodies and fire-resistant and fire-conducing plant communities) (Bowles et al. 1994, Chapman et al. 1995). Infrequent, high-intensity fires kill mature oaks and produce barrens covered by abundant scrubby oak sprouts. Park-like barrens with widely spaced trees and an open grass understory are maintained by frequent low-intensity fires, which occur often enough to restrict maturation of oak seedlings (Chapman et al. 1995, Faber-Langendoen and

Davis 1995, Peterson and Reich 2001). Canopy oaks within these barrens rarely burn because of low fuel loads beneath their crowns, which shade out light-demanding vegetation (Anderson and Brown 1983). Frequent low-intensity fires also maintain high levels of grass and forb diversity by deterring the encroachment of woody vegetation and limiting single species dominance. Absence of fire in oak barrens causes increased litter layer and fuel loads, decreased herb layer diversity, increased canopy and subcanopy cover, invasion of fire-intolerant species, and ultimately the formation of a closed-canopy oak community, often within 20-40 years (Curtis 1959, Chapman et al. 1995, Faber-Langendoen and Davis 1995).

Vegetation Description: The oak barrens community is a heterogeneous savanna vegetation type with variable physiognomy in time and space. Structurally, oak barrens range from dense thickets of brush and understory scrub oak within a matrix of grassland to park-like open woods of widely spaced mature oak with virtually no shrub or sub-canopy layer above the open forb and graminoid understory (Michigan Natural Features Inventory 1990, Bowles and McBride 1994, Chapman et al. 1995). The physiognomic variations, which occur along a continuum, are the function of the complex interplay between fire frequency and intensity (Chapman et al. 1995). Typically, oak barrens grade into prairie on one edge and dry forest on the other. As noted by Bray (1958) and Curtis (1959), the flora of this community is a mixture of prairie and forest species, with prairie forbs and grasses more abundant in high light areas and forest forbs and woody species in the areas of low light.

Photo by: Gary Reese

Canopy closure and woody encroachment in a fire suppressed oak barrens.

The canopy layer generally varies from 5 to 60 percent cover (Chapman et al. 1989) and is dominated or co-dominated by *Quercus velutina* (black oak) and *Quercus alba* (white oak). These species of oak are also prevalent in the sub-canopy in shrubby clumps, especially where fire intensity is high. In addition, *Acer rubra* (red maple), *Prunus serotina* (black cherry), *Populus grandidentata* (bigtooth aspen), *Populus tremuloides* (trembling aspen), and *Quercus ellipsoidalis* (pin oak) are often found in the overstory and sub-canopy of this community. Pin oak is especially common on excessively well-drained sites. Prevalent species of the subcanopy layer include: *Carya* spp. (hickory species), *Cornus* spp. (dogwood species), *Corylus americana* (American hazelnut), *Prunus* spp. (cherry species), and *Sassafras albidum* (sassafras).

Characteristic shrubs include: *Amelanchier* spp. (serviceberry), *Arctostaphylos uva-ursi* (bearberry), *Ceanothus americanus* (New Jersey tea), *Comptonia peregrina* (sweetfern), *Corylus americana*, *Cornus* spp., *Corylus cornuta* (beaked hazelnut), *Crataegus* spp. (hawthorn species), *Gaultheria procumbens* (wintergreen), *Gaylussacia baccata* (huckleberry), *Prunus americana* (wild plum), *Prunus virginiana* (choke cherry), *Prunus pumila* (sand cherry), *Quercus prinoides* (dwarf chestnut or dwarf chinkapin oak), *Rhus copalina* (shining sumac), *Rosa carolina* (pasture rose), *Rubus flagellaris* (northern dewberry), *Salix humilis* (prairie or upland willow), and *Vaccinium angustifolium* (low sweet blueberry).

The ground layer is dominated by graminoids and forbs. Common species include: *Scizhachyrium scoparium* (little bluestem), *Andropogon gerardii* (big bluestem), and *Carex pensylvanica* (Pennsylvania sedge), with Pennsylvania sedge often replacing the bluestems in shaded areas and fire-suppressed communities. Other prevalent herbs of the oak barrens include: *Aster oolentangiensis* (sky-blue aster), *Aureolaria* spp. (false foxglove), *Coreopsis lanceolata* (tickseed), *Cyperus filiculmis* (nut grass), *Danthonia spicata* (poverty oats), *Deschampsia flexuosa* (hair grass), *Euphorbia corollata* (flowering spurge), *Helianthus divaricatus* (tall sunflower), *Hypericum perforatum* (St. John's-wort), *Koeleria macrantha* (June grass), *Krigia biflora* (dwarf dandelion), *Lathyrus ochroleucus* (white pea), *Lespedeza hirta* (hairy lespedeza), *Liatris aspera* (blazing star), *Liatris cylindrica* (dwarf blazing star), *Lupinus perennis* (wild lupine), *Monarda fistulosa* (wild bergamot), *Panicum implicatum* (grass panicum), *Pedicularis canadensis* (wood betony), *Stipa avenacea* (needle grass), *Stipa spartea* (needle grass), *Tephrosia virginiana* (goats-rue), and *Viola pedata* (birdfoot violet).

In the absence of fire and with the prevalence of anthropogenic disturbance such as logging, off-road vehicle recreation, and livestock grazing, the following exotic species may be dominant components of the herbaceous layer of oak barrens: *Agropyron repens* (quack grass), *Agrostis stolonifera* (creeping bent), *Asparagus officinalis* (wild asparagus), *Centaurea maculosa* (spotted knapweed), *Hieracium* spp. (hawkweeds), *Poa compressa* (Canada bluegrass), *Poa pratensis* (Kentucky bluegrass), *Rumex acetosella* (sheep sorrel), and *Tragopogon dubius* (goat's beard).

Michigan indicator species:

Spring/Early Summer
Comandra umbellata (bastard toadflax), *Coreopsis lanceolata* (lanceolate coreopsis), *Geum triflorum* (prairie smoke, state threatened), *Lithospermum canescens* (hoary puccon), *Lupinus perennis*, *Krigia biflora*, *Pedicularis canadensis*, *Potentilla simplex* (common cinquefoil), *Senecio plattensis* (prairie ragwort), *Stipa spartea*, and *Viola pedata*.

Summer
Anenome cylindrica (thimbleweed), *Asclepias tuberosa* (butterfly weed), *Asclepias verticillata* (whorled milkweed), *Ceanothus americanus*, *Helianthus occidentalis* (woodland sunflower), *Helianthus divaricatus*, *Linum sulcatum* (furrowed flax, state special concern), *Monarda punctata* (horsemint), *Monarda fistulosa*, *Opuntia humifusa* (prickly pear), and *Trichostema dichotomum* (blue curls, state threatened).

Fall
Andropogon gerardii, *Aristida purpurascens* (three awn grass), *Aster oolentangiensis*, *Aster ericoides* (many flowered aster), *Aster sericeus* (silky aster, state threatened), *Aureolaria flava* (false foxglove), *Aureolaria pedicularia* (false foxglove), *Aureolaria virginica* (false foxglove), *Bouteloua curtipendula* (side oats gramma, state threatened), *Liatris aspera* (rough blazing star), *Liatris cylindrica* (dwarf blazing star), *Scizhachyrium scoparium*, *Silphium terebinthinaceum* (prairie dock), *Solidago speciosa* (showy goldenrod), *Solidago rigida* (stiff goldenrod), and *Stipa avenacea*.

Other noteworthy species: Rare plants associated with oak barrens include: *Aster sericeus* (silky aster, state threatened), *Bouteloua curtipendula* (side-oats gramma grass, state threatened), *Cirsium hillii* (Hill's thistle, state special concern), *Geum triflorum* (prairie-smoke, state threatened), *Linum sulcatum* (furrowed flax, state special concern), *Prunus alleghaniensis var davisii* (alleghany or sloe plum, state special concern), and *Sisyrinchium strictum* (blue-eyed grass, state special concern).

Oak barrens frequently support numerous lichens and mosses. Oak trunks provide substrate for foliose lichens (i.e., *Punctelia rudecta, Physcia millegrana,* and *Candelaria concolor*) and crutose lichens (i.e., *Candelariella xanthostigma* and *Rinodina papillata*). In addition to the cryptogamus communities thriving on tree boles, oak barrens often contain patches of microbiotic soil crust composed of lichens, mosses, and cyanobacteria (Will-Wolf and Stearns 1999).

The oak barrens and surrounding prairie habitat share a rich diversity of invertebrates including numerous butterflies, skippers, grasshoppers, and locusts. However, the fragmented and degraded status of midwestern oak barrens/savannas and prairies has resulted in the drastic decline of numerous insect species associated with dry, open habitats or obligates of barrens and prairie host plants (Chapman et al. 1995). Rare butterflies, skippers, and moths include: *Atrytonopsis hianna* (dusted skipper, state threatened), *Catocala amestris* (three-staff underwing, state endangered), *Erynnis p. persius* (persius duskywing, state threatened), *Hesperia ottoe* (ottoe skipper, state threatened), *Incisalia henrici* (Henry's elfin, state special concern), *Incisalia irus* (frosted elfin, state threatened), *Lycaeides melissa samuelis* (Karner blue, state threatened/federal endangered), *Papaipema sciata* (Culver's root borer, state special concern), *Pygarctia spraguei* (Sprague's pygarctia, state special concern), *Pyrgus centaureae wyandot* (grizzled skipper, state special concern), *Schinia indiana* (phlox moth, state endangered), *Schinia lucens* (leadplant flower moth, state endangered), *Spartiniphaga inops* (Spartina moth, state special concern), and *Speyeria idalia* (regal fritillary, state endangered).

Other rare invertebrates include *Lepyronia gibbosa* (Great Plains spittlebug, state threatened), *Oecanthus pini* (Pinetree cricket, state special concern), *Orphulella p. pelidna* (barrens locust, state special concern), *Prosapia ignipectus* (red-legged spittlebug, state special concern), and *Scudderia fasciata* (pine katydid, state special concern).

Numerous songbirds utilize oak barrens. Rare species include *Ammodramus savannarum* (grasshopper sparrow, state special concern) and *Dendroica discolor* (prairie

warbler, state endangered). Typical songbirds include: *Melospiza lincolnii* (Lincoln's sparrow), *Passerina cyanea* (indigo bunting), *Pooecetes gramineus* (vesper sparrow), *Sial sialis* (eastern bluebird), *Spizella passerina* (chipping sparrow), *Spizella pusilla* (field sparrow), *Toxostoma rufum* (brown thrasher), *Vermivora pinus* (blue-winged warbler) and *Vermivora ruficapilla* (Nashville warbler). Additional avian species that utilize this habitat include: *Accipter striatus* (sharp-shinned hawk), *Bartamia longicauda* (upland sandpiper), *Bonasa umbellus* (ruffed grouse), *Buteo jamaicensis* (red-tailed hawk), *Carduelis tristis* (American goldfinch), *Charadrius vociferus* (killdeer), *Chondestes grammacus* (lark sparrow), *Falco sparverius* (American kestrel), *Icterus galbula* (Baltimore oriole), *Melanerpes erythrocephalus* (red-headed woodpecker), *Meleagris gallopavo* (wild turkey), *Otus asio* (Eastern screech-owl), *Tyrannus tyrannus* (eastern kingbird), and *Zenaida macroura* (mourning dove). Savanna restoration with prescribed fire in Minnesota resulted in the increase in the abundance of open- country bird species, including many species that have been declining in central and eastern North America (Davis et al. 2000).

Cryptotis parva (least shrew, state threatened) and *Microtus ochrogaster* (prairie vole, state endangered) are rare mammals that may be found in oak-pine barrens. Additional mammals commonly associated with the oak barrens community include: *Canis latrans* (coyote), *Microtus pennsylvanicus* (meadow vole), *Odocoileus virginianus* (white-tailed deer), *Scirus niger* (fox squirrel), *Spermophilus tridecemlineatus* (thirteen-lined ground squirrel), *Taxidea taxus* (badger), *Vulpes vulpes* (red fox), and *Zapus hudsonia* (jumping meadow mouse).

Several rare reptiles are known from this community type. They include: *Elaphe o. obsoleta* (black rat snake, state special concern), *Sistrurus c. catenatus* (eastern massasauga, state special concern, federal candidate species), and *Terrapene c. carolina* (eastern box turtle, state special concern). Some of the more common amphibians and reptiles that frequent the oak barrens include: *Bufo a. americanus* (eastern American toad), *Bufo fowleri* (Fowler's toad), *Heterodon platirhinos* (eastern hog-nosed snake), and *Opheodrys vernalis* (smooth green snake).

Conservation/management: Fire is the single most significant factor in preserving the oak barrens landscapes. Where remnants of oak barrens persist, the use of prescribed fire is an imperative management tool for maintaining an open canopy, promoting high levels of grass and forb diversity, deterring the encroachment of woody vegetation and invasive exotics, and limiting the success of dominants. Numerous studies have indicated that fire intervals of 1-3 years bolster graminoid dominance, increase overall grass and forb diversity, and remove woody cover of saplings and shrubs (White 1983, Tester 1989). Burning at longer time intervals will allow for seedling establishment and the persistence of woody plants. Where rare invertebrates are a management concern, burning strategies should allow for ample refugia to facilitate effective postburn recolonization (Michigan Natural Features Inventory 1995, Siemann et al. 1997).

Though most of the historical oak barrens have been degraded by selective logging, livestock grazing, and fire suppression or destroyed by development, agricultural clearing, sand mining, and extensive timber harvest, there is much opportunity for restoration of this community type. Plant species of oak barrens can persist through cycles of canopy closure and removal (Chapman et al. 1995). The occurrence of oak barrens indicator species in closed-canopy forests reveals the presence of a native seedbank and highlights that area as a target for restorative management. Also indicative of a site's potential for restoration is the prevalence of oak "wolf trees." "Wolf trees" are large open-grown trees with wide-spreading limbs that are often associated with oak barrens' plants or seedbank (Michigan Natural Features Inventory 1995).

Photo by: Kim Chapman

Prescribed fire in remnant oak barrens maintains open canopy conditions, promotes high levels of grass and forb diversity and deters the encroachment of woody vegetation and exotics.

Where canopy closure has degraded the savanna character, one can restore the oak barrens community by selectively

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cutting the majority of trees (White 1986), leaving an average of 4 trees/acre. Degraded barrens that have been long deprived of fire often contain a heavy overstory component of shade tolerant species, which can be removed by mechanical thinning (Peterson and Reich 2001). Reconstructed sites will need to be maintained by periodic prescribed fire and may require investment in native plant seeding where seed and plant banks are inadequate (Packard 1988). Depending on the physiognomic target of the management, one can manipulate the intensity, seasonality, and frequency of the prescribed burns: low-intensity and high-frequency burns for the park-like end of the barrens continuum and low-frequency and high-intensity burns for shrubby oak barrens. Fall burns typically are slow moving, low-intensity fires due to high relative humidity and slow wind speed, while late spring and summer burns are often more intense due to higher wind speeds and lower relative humidity (King 2000). Summer burning can be employed to simulate naturally occurring lightning season burns. Early spring burns often carry irregularly through barrens influenced by high spring water tables. Such patchy burns can be useful tool for establishing refugia for fire-sensitive species and may permit oak seedling establishment (Chapman et al. 1995). Patchy burns are often the result of frequent low-intensity fires, which carry sporadically through areas with low fuel loads. In contrast, infrequent fires are often more uniform in coverage, spreading evenly through areas of high fuel accumulation (Ladd 1991).

In many circumstances the effective use of prescribed fire is precluded due to monetary constraints or safety concerns. In areas where fire is undesirable or unfeasible, mowing or selective cutting can be utilized and should be carried forth in late fall or winter to minimize detrimental impact to herbaceous species and rare invertebrates (Chapman et al. 1995, Michigan Natural Features Inventory 1995, King 2000). Management of oak barrens communities should be orchestrated in conjunction with the management of adjacent communities such as dry sand prairie, dry southern forest, and coastal plain marsh.

Research needs: As noted by Nuzzo (1986), Minc and Albert (1990), Faber-Langendoen (1993), and Bowles and McBride (1994), no single definition of Midwest oak savanna or oak barrens is universally accepted, and numerous distinct community types have been lumped under the phrase "Midwest oak savanna." Misunderstanding and misuse of the term can be alleviated by the continued refinement of regional classifications that correlate species composition, site productivity, ecological process, and landscape context. Understanding spatial and temporal variability of oak barrens is also crucial for determining the direction of management.

Management of oak barrens remnants can be determined by site-specific research of site characteristics and presettlement composition and structure (Minc and Albert 1990, Bowles et al. 1994, Bowles and McBride 1998). Investigation into the frequency, periodicity (seasonality), and intensity of fires in oak barrens is needed to guide restoration and management activities. In addition, because limitations imposed by safety concerns can hamper the effectiveness of prescribed fire as a management tool, maintaining the ecological integrity of oak barrens requires experimentation with different disturbance combinations (King 2000). Effects of management need to be monitored to allow for assessment and refinement.

Since all of Michigan's oak barrens are degraded, it is essential to determine what role seedbanks, vegetative reproduction, and external seed sources play in restoration of remnant barrens. Numerous rare Lepidoptera have host plants occurring on oak barrens. The effects of fire and alternative management techniques on rare faunal populations and their host vegetation need to be studied (Chapman et al. 1995, Siemann et al. 1997). In addition, because of the daunting problem of exotic species encroachment, research needs to examine management strategies that minimize invasive species introduction and dominance.

Similar communities: Bur oak plains, dry sand prairie, dry southern forest, lakeplain oak openings, oak openings, oak-pine barrens, and pine barrens.

Other Classifications:

Michigan Natural Features Inventory Pre-settlement Vegetation (MNFI):
Black Oak Barren and Mixed Oak Savanna

Michigan Department of Natural Resources (MDNR): G-grass and O0(zero)-oak with <100 trees per acre.

Michigan Resource Information Systems (MIRIS): 33 (Pine or Oak Opening), 412 (Central Hardwood), 4122 (White Oak), 4123 (Black Oak), 4129 (Other Oak).

The Nature Conservancy National Classification:

CODE; ALLIANCE; ASSOCIATION; COMMON NAME

II.B.2.N.a.12; *Quercus alba - (Quercus velutina)* Woodland Alliance; *Quercus velutina - (Quercus ellipsoidalis) - Quercus alba/Deschampsia flexuosa* Woodland; Black Oak- Northern Pin Oak / Common Hairgrass Woodland

V.A.6.N.c.3; *Quercus velutina - (Quercus ellipsoidalis)* Wooded Herbaceous Alliance; *Quercus velutina - (Quercus alba) - Quercus ellipsoidalis/Schizachyrium scoparium - Lupinus perennis* Wooded Herbaceous Vegetation; Black Oak/Lupine Barrens

Related Abstracts: Alleghany plum, Culver's root borer, Hill's thistle, karner blue butterfly, oak-pine barrens, pine barrens, prairie smoke, and red-legged spittlebug.

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P.O. Box 30444 - Lansing, MI 48909-7944
Phone: 517-373-1552

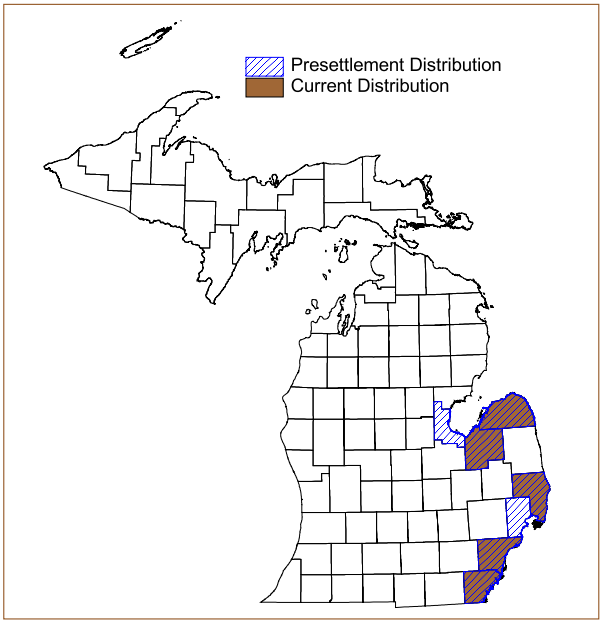
Lakeplain Oak Opening — Community Abstract

Photo by Kim Herman

Overview: Lakeplain oak openings occur within glacial lakeplains on sand ridges, level sandplains, or adjacent depressions. This fire-dependent savanna type is dominated by oaks and has a graminoid-dominated ground layer of species associated with both lakeplain prairie and forest communities.

Global and State Rank: G1?G2/S1

Range: Barrens and prairie plant communities reached their maximum coverage in Michigan approximately 4,000-6,000 years before present, when postglacial climatic conditions were warmer and drier than now. At this time, xerothermic conditions allowed for the invasion of fire-dependent, xeric vegetation types into large portions of the Lower Peninsula and some sections of the Upper Peninsula. With the subsequent shift of more mesic climatic conditions southward, there has been a recolonization of mesic vegetation throughout Michigan. The distribution of fire-dominated communities, such as lakeplain oak openings, has been reduced typically to isolated patches concentrated south of the climatic tension zone. Lakeplain oak openings occur on the lakeplain of the southern Great Lakes, in southeastern Michigan, southwestern Ontario, Canada, and possibly in southeastern Wisconsin (Faber-Langendoen 2001, NatureServe 2001). In the 1800s, Michigan's lakeplain oak openings were located on the glacial lakeplain along the shoreline of Lake Huron in



Saginaw Bay, within the St. Clair River Delta, and near Lake Erie (Comer et al. 1995). Presently the distribution of this community has been reduced to degraded remnants throughout the original range.

Rank Justification: At the time of European settlement, oak savanna communities covered some 27-32 million

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acres of the Midwest. Presently oak savanna remnants occur on just 0.02% of their presettlement extent (Nuzzo 1986). The notes of the original land surveyors of Michigan reveal that prior to European settlement in the 1800s, lakeplain oak openings covered approximately 76,411 acres or 0.20% of the state. This acreage was distributed patchily across the thumb region (Huron, Bay, and Tuscola Counties) and in several lakeplain counties (Macomb, Monroe, Oakland, St. Clair, and Wayne). Surveyors' notes indicate that high concentrations of lakeplain oak openings occurred in Monroe County (63% or 47,766 acres) and Wayne County (26% or 19,707 acres). Today just over a thousand acres of lakeplain oak openings remain in Michigan, with sizable, restorable remnants in Monroe, St. Clair, and Wayne Counties. A total of 10 lakeplain oak openings have been identified in Michigan, ranging in size from 3 to 600 acres and totaling 1,072 acres or less than 0.003% of the surface area of Michigan. The largest concentration of lakeplain oak opening remnants occur in southwest Wayne County and on and near the St. Clair River Delta in St. Clair County. Because of their proximity to the Detroit metropolitan area, these lakeplain oak openings and associated lakeplain prairie remnants are experiencing extreme development pressure.

Remaining occurrences have been degraded by alterations of the groundwater hydrology and fire suppression, both resulting in increased encroachment by woody species and succession to shrub and forest communities. Most lakeplain oak openings were cleared for agriculture, and either residential or industrial development (Chapman et al. 1995). Lakeplain oak openings occurring in wet depressions were frequently drained along with surrounding lakeplain prairie. The construction of extensive drainage networks to promote agriculture and residential development has lowered the water table in most of the historical range of lakeplain prairies and lakeplain oak openings. Wildfire suppression policies instituted in the 1920s in concert with hydrologic manipulation, road construction, expansion of towns, and increased agriculture caused a dramatic decrease in fire frequency and intensity (Abrams 1992). Alteration of the historical fire and hydrologic regime has shifted much of the lakeplain oak openings into woodlands and forest (Faber-Langendoen 1993), characterized by increased shrub dominance, scant oak advanced regeneration, and a vanishing graminoid component (Chapman et al. 1995, Michigan Natural Features Inventory 1995). In addition, timber exploitation of oaks in the 1920s further destroyed or degraded lakeplain oak openings across Michigan. In addition to simplified overstory structure, these communities are often depauperate in floristic diversity as the result of fire suppression and hydrologic alteration and subsequent woody encroachment, livestock grazing, off-road vehicle activity, and the invasion of exotic species (Michigan Natural Features Inventory 1995).

Landscape and Abiotic Context: Michigan's glacial lakeplains formed at the margins of melting lobes of the Wisconsin ice sheet. In southeast Lower Michigan, glacial lake deposits of clay are up to 100 meters thick over Paleozoic bedrock, with deposits thickest at their inland extremes and thinnest along the Lake St. Clair and Lake Erie shorelines (Albert 1995). Poorly drained mineral soils characterize most of the clay plain. These clay plains extend inland 30 to 40 miles (50 to 66 km) along the margins of Lake Erie, Lake Michigan, Lake St. Clair, and Lake Huron's Saginaw Bay. Within the clay lakeplains, several broad sand channels formed where glacial meltwater streams carried sand into the shallow proglacial lakes. These sand channels can be several miles wide but the sand in them is typically only one to three meters thick. A series of excessively drained sand beach ridges and dunes are found throughout these lakeplains. Adjacent swales have poorly drained soils. A large delta with both clay and sand deposits is located at the mouth of the St. Clair River.

Lakeplain oak openings typically occur on these dune features, with a wet variant occurring in the swales. Soils are typically mildly alkaline (pH 7.4-7.8), very fine sandy loams, loamy sands, or sands with moderate water-retaining capacity. Lakeplain oak openings occur less commonly on silty/clayey glacial lakeplains with seasonally high water tables. Historically, lakeplain oak openings occurred in complex mosaics with sand flatwoods (pin oak-swamp white oak), elm-ash-maple swamps, lakeplain wet prairie, lakeplain wet-mesic prairie, and lakeplain mesic prairie, all typical plant communities of poorly drained lakeplain.

Lakeplain oak openings are distributed in Michigan's Region I, Southern Lower Michigan (Albert et al. 1986). This region has a warm, temperate, rainy to cool, snow-forest climate with hot summers and no dry season. The daily maximum temperature in July ranges from 29° to 32° C (85° to 90° F), and the daily minimum temperature in January ranges from -9° to -4° C (15° to 25° F). The number of freeze-free days is between 120 and 220, and the average number of days per year with snow cover of 2.5 cm or more is between 10

and 60. The mean annual total precipitation for Region I is 820 mm (Albert et al. 1986, Barnes 1991).

Natural Processes: Lakeplain oak openings persist when fire, hydrology, and/or drought prevent canopy closure. The character of lakeplain oak openings can differ dramatically, primarily as the result of varying fire intensity and frequency, which are influenced by climatic conditions, soil texture, topography, and landscape context (i.e., proximity to water bodies and fire-resistant and fire-conducing plant communities) (Bowles et al. 1994, Chapman et al. 1995). Infrequent, high-intensity fires kill mature oaks and produce barrens with abundant scrubby oak sprouts. Park-like barrens, with widely spaced trees and an open grass understory, are maintained by frequent, low-intensity fires, which occur often enough to restrict maturation of oak seedlings (Chapman et al. 1995, Faber-Langendoen and Davis 1995, Peterson and Reich 2001). Frequent, low-intensity fires also maintain high grass and forb diversity by deterring the encroachment of woody vegetation and limiting single species dominance. Absence of fire in lakeplain oak openings causes increased litter layer and fuel loads, decreased herb diversity, increased canopy and subcanopy cover, invasion of fire-intolerant species, and ultimately the formation of a closed-canopy oak community, often within 20-40 years (Curtis 1959, Chapman et al. 1995, Faber-Langendoen and Davis 1995). Presently, the prevalent catalyst of fires is lighting strike, but historically Native Americans played an integral role in the fire regime, accidentally and/or intentionally setting fire to prairie ecosystems (Day 1953, Chapman 1984). It remains unclear whether lightning strikes or Native American activities had a more significant role in the historical maintenance of lakeplain oak openings(Hayes 1964, Faber-Langendoen and Maycock 1987). Native Americans utilized dune ridges on the lakeplain for settlements and trails (Jones and Knapp 1972, Comer et al. 1995), and it is quite likely that fires periodically resulted from this use, spreading to adjacent oak openings and grassland. One indication of the significance of fire on the lakeplain is the fact that many of the historical oak openings located along the beach ridges have become closed-canopy oak forests during the last century of fire suppression; large-diameter, open-grown oaks persist in these forests, surrounded by smaller, younger trees.

While the hydrological interactions of lakeplain oak openings and surrounding lakeplain prairie are not well understood, seasonally high water plays an important role in maintaining those lakeplain oak openings growing in lower areas

Photo by Dennis Albert

Suppression of fire and flooding in lakeplain oak openings results in woody species encroachment and eventually canopy closure.

(Chapman et al. 1995). High seasonal water table of lakeplains was a significant factor on the presettlement landscape. However, the hydrologic regime of the Michigan lakeplain has been drastically altered. Many lakeplain landscapes are artificially ditched and drained. In addition, beaver activity has been eliminated for well over 100 years. Before settlement, beaver were abundant on first through fourth order streams where they could impound flowing water (Naiman et al. 1988). The fur trade had decimated beaver populations in the Midwest by the mid-1800s. Hubbard (1888) was told by Indians that beaver, formerly abundant in the southeast Michigan lakeplain, created wet praries by damming streams. On lakeplains and outwash plains with streams, beaver would have dramatically influenced the landscape by expanding wetland area, preventing the encroachment of woody species in seasonally flooded areas, and creating barriers to fire.

Vegetation Description: Within glacial lakeplains there are two prominent forms of lakeplain oak openings that occur interspersed through ridge and swale topography. In both types, *Quercus* spp. dominate the tree canopy layer, and grasses and sedges make up the majority of the ground layer. The dry-mesic type occurs on droughty beach ridges and is typically dominated by *Quercus velutina* (black oak) and *Quercus alba* (white oak). The wet-mesic type, found on flat, poorly drained areas, is dominated by *Quercus macrocarpa* (bur oak), *Quercus palaustris* (pin oak), and *Quercus bicolor* (swamp white oak) with a ground layer

similar to lakeplain wet prairie and lakeplain wet-mesic prairie. The canopy often contains *Acer rubrum* (red maple), *Acer saccharinum* (silver maple), *Fraxinus pennsylvanica* (green ash), and/or *Populus deltoides* (cottonwood). The canopy of this community can be very open. In southwestern Ontario, Bakowsky (1988) described the average canopy as 33% cover and average density of trees greater than 6 cm dbh as 92 trees/ha (Faber-Langendoen 2001, NatureServe 2001). Prevalent species of the subcanopy include: *Carya* spp. (hickory species), *Cornus* spp. (dogwood species), *Corylus americana* (American hazelnut), *Fraxinus pennsylvanica* (especially where fire is suppressed), *Prunus* spp. (cherry species), and *Sassafras albidum* (sassafras).

Characteristic shrubs of the sandy ridges include: *Amelanchier* spp. (serviceberry), *Arctostaphylos uva-ursi* (bearberry), *Ceanothus americanus* (New Jersey tea), *Comptonia peregrina* (sweetfern), *Cornus foemina* (gray dogwood), *Corylus americana*, *Corylus cornuta* (beaked hazelnut), *Cratageus* spp. (hawthorn species), *Gaultheria procumbens* (wintergreen), *Gaylussacia baccata* (huckleberry), *Prunus americana* (wild plum), *Prunus virginiana* (choke cherry), *Prunus pumila* (sand cherry), *Rhus copalina* (shining sumac), *Rhus typhina* (staghorn sumac), *Rosa carolina* (pasture rose), *Rubus flagellaris* (northern dewberry), *Salix humilis* (prairie or upland willow), *Vaccinium angustifolium* (low sweet blueberry),

Photo by Kim Herman

and *Vaccinium myrtilloides* (Canada blueberry). Prevalent shrubs in moist swale lakeplain oak openings include: *Aronia melanocarpa* (chokeberry), *Cephalanthus occidentalis* (buttonbush), *Cornus amomum* (pale dogwood), *Cornus stolonifera* (red-osier dogwood), *Ilex verticillata* (Michigan holly), *Salix eriocephala* (willow), and *Salix myricoides* (bluelead willow).

The ground layer is dominated by graminoids and forbs. Common species include: *Andropogon gerardii* (big bluestem), *Calamagrostis canadensis* (blue joint grass), *Carex pensylvanica* (Pennsylvania sedge), *Scizhachyrium scoparium* (little bluestem), and *Sorghastrum nutans* (Indian grass). Prevalent herbs of the droughty beach ridges include: *Aster oolentangiensis* (sky-blue aster), *Aureolaria* spp. (false foxglove), *Coreopsis lanceolata* (tickseed), *Cyperus filiculmis* (nut grass), *Danthonia spicata* (poverty oats), *Deschampsia flexuosa* (hair grass), *Euphorbia corollata* (flowering spurge), *Helianthus divaricatus* (tall sunflower), *Hypericum perforatum* (St. John's-wort), *Koeleria macrantha* (June grass), *Krigia biflora* (dwarf dandelion), *Lathyrus ochroleucus* (white pea), *Lespedeza hirta* (hairy lespedeza), *Liatris aspera* (blazing star), *Liatris cylindrica* (dwarf blazing star), *Lupinus perennis* (wild lupine), *Monarda fistulosa* (wild bergamot), *Panicum implicatum* (grass panicum), *Pedicularis canadensis* (wood betony), and *Stipa spartea* (needle grass). Lakeplain oak openings occurring in flat, poorly drained areas can support a wide range of herbaceous species characteristic of lakeplain prairies, for example: *Andropogon gerardii*, *Calamagrostis canadensis*, *Carex stricta* (sedge), *Carex aquatilis* (sedge), *Cladium mariscoides* (twig-rush), *Juncus balticus* (rush), *Panicum virgatum* (switch grass), *Pedicularis lanceolata* (swamp-betony), *Potentilla fruticosa* (shrubby cinquefoil), *Pycnanthemum virginianum* (common mountain mint), *Scizhachyrium scoparium*, *Spartina pectinata* (cordgrass), *Solidago ohioensis* (Ohio goldenrod), *Solidago riddellii* (Riddell's goldenrod), *Sorghastrum nutans*, and *Vernonia* spp. (ironweed species).

In the absence of fire and with the prevalence of anthropogenic disturbance such as logging, ditching and draining, off-road vehicle recreation, and livestock grazing, the following exotic species may be dominant components of the herbaceous layer of lakeplain oak openings: *Agropyron repens* (quack grass), *Agrostis stolonifera* (creeping bent), *Asparagus officinalis* (wild asparagus), *Centaurea maculosa* (spotted knapweed), *Hieracium* spp. (hawkweeds), *Poa compressa* (Canada bluegrass), *Poa pratensis* (Kentucky bluegrass), *Rumex acetosella* (sheep sorrel), and *Tragopogon dubius* (goat's beard).

Michigan indicator species:

Spring/Early Summer

Dry: *Comandra umbellata* (bastard toadflax), *Coreopsis*

lanceolata (lanceolate coreopsis), *Lithospermum canescens* (hoary puccon), *Lupinus perennis*, *Krigia biflora*, *Pedicularis canadensis*, *Potentilla simplex* (common cinquefoil), *Senecio plattensis* (prairie ragwort), and *Stipa spartea*.
Wet: *Carex aquatilis, Carex pellita* (sedge), and *Carex stricta*.

Summer
Dry: *Anenome cylindrica* (thimbleweed*), Asclepias tuberosa* (butterfly weed), *Asclepias verticillata* (whorled milkweed), *Ceanothus americanus*, *Helianthus occidentalis* (woodland sunflower), *Helianthus divaricatus*, *Linum sulcatum* (furrowed flax, state special concern*), Monarda punctata* (horsemint), *Monarda fistulosa*.
Wet: *Aletris farinosa* (colic root*), Calamagrostis canadensis, Cladium mariscoides, Juncus balticus,* and *Potentilla fruticosa*.

Fall
Dry: *Andropogon gerardii*, *Aristida purpurascens* (three awn grass), *Aster oolentangiensis*, *Aster ericoides* (many flowered aster), *Aureolaria flava* (false foxglove*), Aureolaria pedicularia* (false foxglove), *Aureolaria virginica* (false foxglove), *Coreopsis tripteris* (tall coreopsis), *Liatris aspera* (rough blazing star), *Liatris spicata* (marsh blazing star), *Scizhachyrium scoparium, Solidago speciosa* (showy goldenrod), *Solidago rigida* (stiff goldenrod), and *Sorghastrum nutans*.
Wet: *Asclepias incarnata* (swamp milkweed), *Liatris cylindrica* (dwarf blazing star), *Silphium terebinthinaceum* (prairie dock), and *Spartina pectinata*.

Other noteworthy species: Rare plants associated with lakeplain oak openings include: *Agalinis gattingeri* (Gattinger's gerardia), *Agalinis skinneriana* (Skinner's gerardia), *Angelica venenosa* (hairy angelica), *Arabis missouriensis* var *deamii* (Missouri rock-cress), *Aristida longispica* (three-awned grass), *Asclepias purpurascens* (purple milkweed), *Astragalus neglectus* (Cooper's milk-vetch), *Carex richardsonii* (Richardson's sedge), *Leucospora multifida* (conobea), *Eupatorium sessilifolium* (upland boneset), *Euphorbia commutata* (tinted spurge), *Gentiana puberulenta* (downy gentian), *Helianthus hirsutus* (whiskered sunflower), *Helianthus mollis* (downy sunflower), *Hieracium paniculatum* (panicled hawkweed), *Hypericum gentianoides* (gentian-leaved St. John's-wort), *Lechea minor* (least pinweed), *Linum sulcatum* (furrowed flax), *Polygala cruciata* (cross-leaved milkwort), *Scirpus clintonii* (Clinton's bulrush), *Scleria pauciflora* (few-flowered nut-rush), *Scleria triglomerata* (tall nut-rush), *Spiranthes ochroleuca* (yellow ladies'-tresses), *Sporobolus clandestinus* (dropseed), and *Tradescantia virginiana* (Virginia spiderwort).

Lakeplain oak openings and surrounding lakeplain prairie habitat share a rich diversity of invertebrates including numerous butterflies, skippers, grasshoppers, and locusts. However, the fragmented and degraded status of midwestern oak openings/savannas and prairies has resulted in the drastic decline of numerous insect species associated with dry, open habitats or obligates of savanna and prairie host plants (Chapman et al. 1995). Rare butterflies, skippers, and moths include: *Atrytonopsis hianna* (dusted skipper), *Erynnis baptisiae* (wild indigo dusky wing), *Erynnis p. persius* (persius duskywing), *Euphyes dukesi* (Duke's skipper), *Lycaeides melissa samuelis* (Karner blue), *Papaipema maritima* (maritime sunflower borer), *Papaipema sciata* (Culver's root borer), and *Papaipema silphii* (Silphium borer moth). Other rare invertebrates include *Lepyronia gibbosa* (Great Plains spittlebug), and *Prosapia ignipectus* (red-legged spittlebug).

Numerous songbirds utilize lakeplain oak openings. Rare species include *Ammodramus savannarum* (grasshopper sparrow, state special concern) and *Dendroica discolor* (prairie warbler, state endangered). Typical songbirds include: *Melospiza lincolnii* (Lincoln's sparrow), *Passerina cyanea* (indigo bunting), *Pooecetes gramineus* (vesper sparrow), *Sial sialis* (eastern bluebird), *Spizella passerina* (chipping sparrow), *Spizella pusilla* (field sparrow), *Toxostoma rufum* (brown thrasher), *Vermivora pinus* (blue-winged warbler), and *Vermivora ruficapilla* (Nashville warbler). Additional avian species that utilize this habitat include: *Accipter striatus* (sharp-shinned hawk), *Bartamia longicauda* (upland sandpiper), *Bonasa umbellus* (ruffed grouse), *Buteo jamaicensis* (red-tailed hawk), *Carduelis tristis* (American goldfinch), *Charadrius vociferus* (killdeer), *Falco sparverius* (American kestrel), *Icterus galbula* (Baltimore oriole), *Melanerpes erythrocephalus* (red-headed woodpecker), *Meleagris gallopavo* (wild turkey), *Otus asio* (Eastern screech-owl), *Tyrannus tyrannus* (Eastern kingbird), and *Zenaida macroura* (mourning dove). Savanna restoration with prescribed fire in Minnesota resulted in the increase in the abundance of open-country bird species, including many species that have been declining in central and eastern North America (Davis et al. 2000).

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Cryptotis parva (least shrew, state threatened) and *Microtus ochrogaster* (prairie vole, state endangered) are rare mammals that may be found in lakeplain oak openings. Additional mammals commonly associated with this community include: *Canis latrans* (coyote), *Microtus pennsylvanicus* (meadow vole), *Odocoileus virginianus* (white-tailed deer), *Scirus niger* (fox squirrel), *Spermophilus tridecemlineatus* (thirteen-lined ground squirrel), *Taxidea taxus* (badger), *Vulpes vulpes* (red fox), and *Zapus hudsonia* (jumping meadow mouse).

Several rare reptiles are known from this community type. They include: *Elaphe o. obsoleta* (black rat snake, state special concern), *Elaphe vulpina gloydi* (eastern fox snake, state threatened), *Sistrurus c. catenatus* (eastern massasauga, state special concern, federal candidate species), and *Terrapene c. carolina* (eastern box turtle, state special concern). Some common amphibians and reptiles include: *Bufo a. americanus* (eastern American toad), *Bufo fowleri* (Fowler's toad), *Heterodon platirhinos* (eastern hog-nosed snake), and *Opheodrys vernalis* (smooth green snake).

Conservation/management: Where remnants of lakeplain oak openings persist, the use of prescribed fire and restoration of hydrologic processes is imperative for maintaining an open canopy, promoting high levels of grass and forb diversity, and deterring the encroachment of woody vegetation and invasive exotics. In areas where seasonal flooding has been diminished by extensive drainage networks, the filling of ditches can contribute to the restoration of hydrologic processes. The hydrological interactions of lakeplain oak openings and surrounding lakeplain prairie are not well understood, so restoration management will need to be experimental. Numerous studies in oak savanna systems have indicated that fire intervals of 1-3 years bolster graminoid dominance, increase overall grass and forb diversity, and remove woody cover of saplings and shrubs (White 1983, Tester 1989). Burning at longer time intervals will allow for woody plant seedling establishment and persistence. Where rare invertebrates are a management concern, burning strategies should allow for ample refugia to facilitate effective postburn recolonization (Michigan Natural Features Inventory 1995, Siemann et al. 1997).

Though most of the historical lakeplain oak openings have been degraded, there is opportunity for restoration of this community type. Plant species of lakeplain oak openings can persist through cycles of canopy closure and removal (Chapman et al. 1995). The occurrence of oak savanna indicator species in closed-canopy forests reveals the presence of a native seedbank and highlights that area as a target for restorative management. Also indicative of a site's potential for restoration is the prevalence of oak "wolf trees." "Wolf trees" are large open-grown trees with wide-spreading limbs that are often associated with lakeplain oak opening plants or seedbank (Michigan Natural Features Inventory 1995).

Where canopy closure has degraded the savanna character, one can restore lakeplain oak openings by selectively cutting the majority of trees (White 1986), leaving an average of 4 trees/acre. Degraded lakeplain oak openings that have been long deprived of fire often contain a heavy overstory and understory component of shade tolerant species such as *Acer rubrum* (red maple) and *Fraxinus pennsylvanica* (green ash), which can be removed by mechanical thinning, herbiciding, or girdling (Michigan Natural Heritage Program 2000, Peterson and Reich 2001). Restored sites will need to be maintained by periodic prescribed fire and may require investment in native plant seeding where seed and plant banks are inadequate (Packard 1988). Depending on the physiognomic target of the management, one can manipulate the intensity, seasonality, and frequency of the prescribed burns: low-intensity and high-frequency burns for the park-like end of the opening continuum, and low-frequency and high-intensity burns for shrubby lakeplain oak openings. Fall burns typically are slow moving, low-intensity fires due to high relative humidity and slow wind speed, while late spring and summer burns are often more intense due to higher wind speeds and lower relative humidity (King 2000). Summer burning can be employed to simulate naturally occurring lightning season burns. Early spring burns often carry irregularly through lakeplain oak openings influenced by high spring water tables. Such patchy burns can be useful for establishing refugia for fire-sensitive species and may permit oak seedling establishment (Chapman et al. 1995). Patchy burns are often the result of frequent low-intensity fires, which carry sporadically through areas with low fuel loads. In contrast, infrequent fires are often more uniform in coverage, spreading evenly through areas of high fuel accumulation (Ladd 1991).

In areas where fire is undesirable or unfeasible, mowing or selective cutting can be utilized and should be conducted in late fall or winter to minimize detrimental impact to herbaceous species and rare invertebrates (Chapman et al.

1995, Michigan Natural Features Inventory 1995, King 2000). Management of lakeplain oak openings should be orchestrated in conjunction with management of adjacent communities such as lakeplain wet prairie or lakeplain wet-mesic prairie.

Research needs: As noted by Nuzzo (1986), Minc and Albert (1990), Faber-Langendoen (1993), and Bowles and McBride (1994), no single definition of Midwest oak savanna or oak openings is universally accepted, and numerous distinct community types have been lumped under the phrase "Midwest oak savanna." Misunderstanding and misuse of the term can be alleviated by the continued refinement of regional classifications that correlate species composition, site productivity, ecological process, and landscape context. Understanding spatial and temporal variability of lakeplain oak openings is also crucial for determining the direction of management.

Management of lakeplain oak opening remnants can be determined by site-specific research of site characteristics and presettlement composition and structure (Minc and Albert 1990, Bowles et al. 1994, Bowles and McBride 1998). Investigation into the frequency, periodicity (seasonality), and intensity of fire and flooding events in lakeplain oak openings is needed to guide restoration and management activities. In addition, because limitations imposed by safety concerns can hamper the effectiveness of prescribed fire, maintaining the ecological integrity of lakeplain oak openings requires experimentation with different disturbance combinations (King 2000). Effects of management need to be monitored to allow for assessment and refinement.

Since all of Michigan's lakeplain oak openings are degraded, it is essential to determine what role seedbanks, vegetative reproduction, and external seed sources play in restoration of remnant barrens. Numerous rare insects have host plants occurring on lakeplain oak openings. The effects of fire, flooding, and alternative management techniques on rare faunal populations and their host vegetation need to be studied (Chapman et al. 1995, Siemann et al. 1997). In addition, because of the daunting problem of exotic species encroachment, research needs to identify strategies to minimize invasive species introduction and dominance.

Similar communities: Lakeplain wet prairie, lakeplain wet-mesic prairie, bur oak plains, dry sand prairie, dry southern forest, oak barrens, oak openings, oak-pine barrens, and pine barrens.

Other Classifications:

Michigan Natural Features Inventory Pre-settlement Vegetation (MNFI):
Black Oak Barren and Mixed Oak Savanna

Michigan Department of Natural Resources (MDNR): G-grass and O0(zero)-oak with <100 trees per acre.

Michigan Resource Information Systems (MIRIS): 33 (Pine or Oak Opening), 412 (Central Hardwood), 4122 (White Oak), 4123 (Black Oak), 4129 (Other Oak).

The Nature Conservancy National Classification:

CODE; ALLIANCE; ASSOCIATION; COMMON NAME

V.A.6.N.c.2.; *Quercus macrocarpa - (Quercus alba)* Wooded Herbaceous Alliance; *Quercus macrocarpa - Quercus palustris – Quercus bicolor / Calamagrostis canadensis* Wooded Herbaceous Vegetation; Lakeplain Wet-Mesic Oak Openings

II.B.2.N.a.12.; *Quercus alba - (Quercus velutina)* Woodland Alliance; *Quercus alba – Quercus velutina - Quercus palustris / Carex pennsylvaniva* Woodland; Lakeplain Mesic Oak Woodland

Related Abstracts: Culver's root borer, Hill's thistle, karner blue butterfly, lakeplain wet-mesic prairie, lakeplain wet prairie, oak barrens, oak-pine barrens, pine barrens, prairie smoke, and red-legged spittlebug.

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P.O. Box 30444 - Lansing, MI 48909-7944
Phone: 517-373-1552