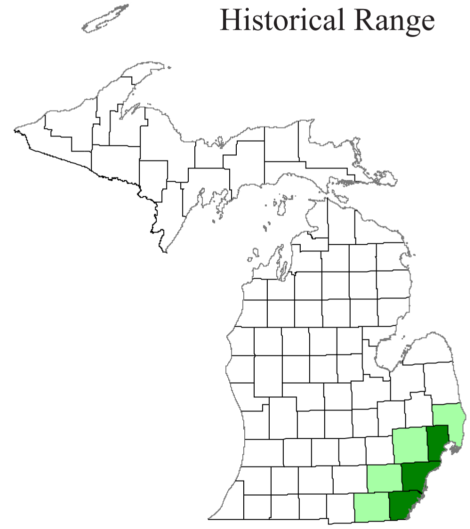
Wet-mesic Flatwoods Community Abstract

Photo by Suzan L. Campbell



Overview: Wet-mesic flatwoods is a somewhat poorly drained to poorly drained forest on mineral soils dominated by a mixture of lowland and upland hardwoods. The community occurs exclusively on glacial lakeplain in southeastern Lower Michigan, where an impermeable clay layer in the soil profile contributes to poor internal drainage. Seasonal hydrologic fluctuations and windthrow are important natural disturbances that influence community structure, species composition, and successional trajectory of wet-mesic flatwoods.

Global and State Rank: G2G3/S2

Range: Flatwoods communities characterized by relatively flat topography, slowly permeable to impermeable subsurface soil layers, and seasonal hydrologic fluctuation occur scattered throughout the eastern United States (NatureServe 2009). In the Great Lakes region, flatwoods communities on poorly drained glacial lakeplains and flat to undulating till plains are distributed in Michigan, Ohio, Indiana, Illinois, Pennsylvania, and Ontario, Canada (Fike 1999, Faber-Langendoen 2001, NatureServe 2009). In Michigan, wet-mesic flatwoods is restricted to relatively flat glacial lakeplain in southeastern Lower Michigan in the Maumee Lake Plain ecological Sub-subsection (Albert 1995, Kost et al. 2007, Albert et al. 2008).

Rank Justification: The acreage of wet-mesic flatwoods present in Michigan circa 1800 is difficult to determine because the community type has characteristics that overlap those of several of the forest types mapped based on General Land Office (GLO) survey notes, primarily hardwood swamp and beech-sugar maple forest (Comer et al. 1995a, Kost et al. 2007). Analysis of GLO survey notes reveals that lowland forest dominated by hardwoods covered approximately 570,000 ha (1,400,000 ac) of southern Lower Michigan circa 1800 (Comer et al. 1995a). These stands were characterized by mixed hardwoods (490,000 ha or 1,200,000 ac), black ash (77,000 ha or 190,000 ac), elm (5,300 ha or 13,000 ac), and silver maple-red maple (4,000 ha or 10,000 ac). The majority of lowland forest acreage in southern Lower Michigan was associated with stream and river floodplains, and is classified as floodplain forest (Tepley et al. 2004, Kost et al. 2007). Extensive stands of lowland hardwoods not associated with stream floodplains were concentrated on poorly drained lakeplain in Wayne, Lenawee, Saginaw, St. Clair, Huron, Monroe, Sanilac, and Macomb Counties (Comer et al. 1995a). These stands were characterized by southern hardwood swamp on very poorly drained soils, and wet-mesic flatwoods on somewhat poorly to poorly drained soils. Wet-mesic flatwoods also likely occupied portions of the lakeplain characterized as mesic southern forest (i.e., beech-sugar maple forest) on the circa 1800 vegetation map (Comer et al. 1995a). Forests classified as hardwood swamp

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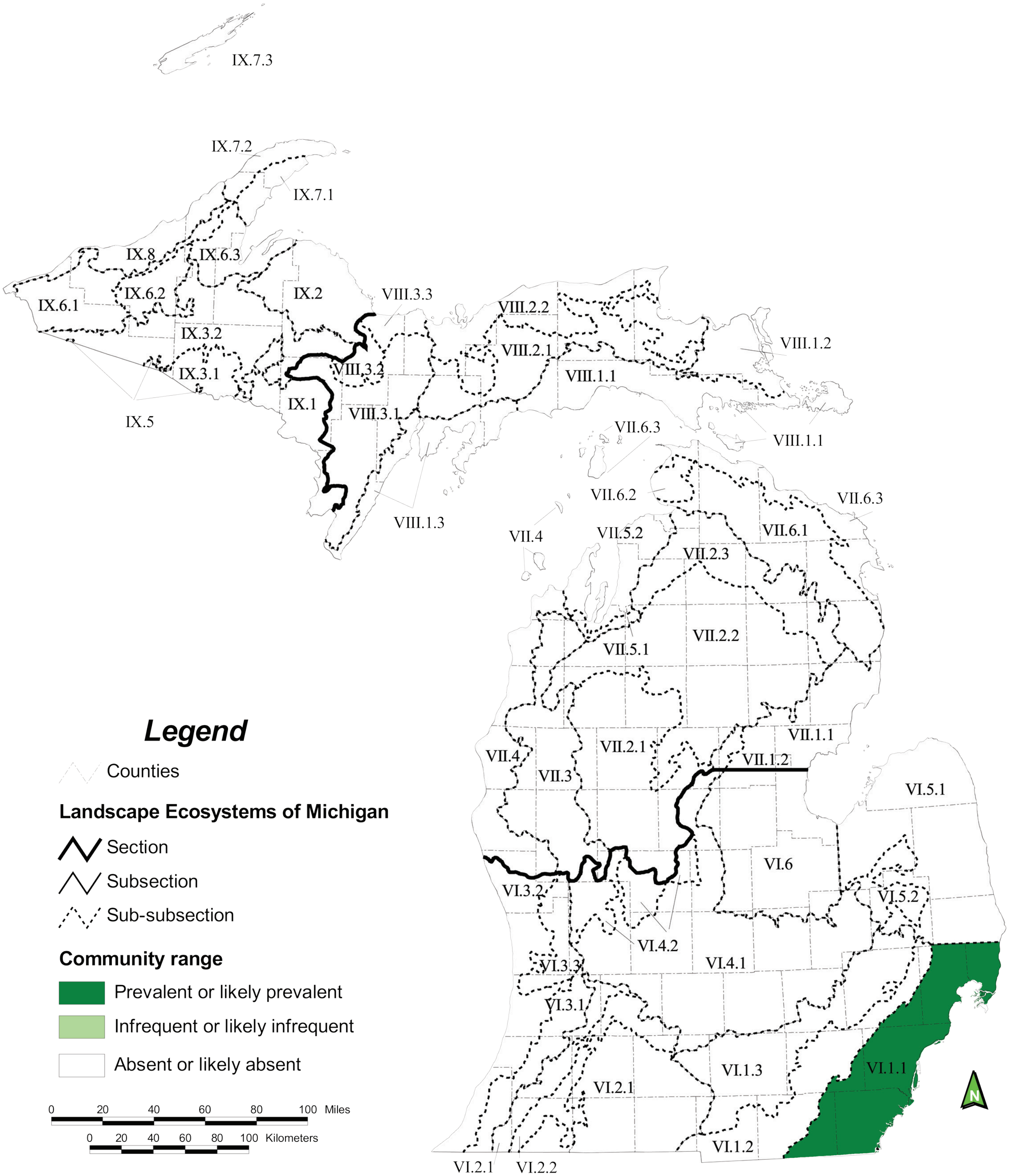

Ecoregional map of Michigan (Albert 1995) depicting historical distribution of wet-mesic flatwoods (Albert et al. 2008) and beech-sugar maple forest comprised a significant proportion of the lakeplain in the early 1800s, covering > 60% of the land surface in Lenawee, Macomb, Monroe, St. Clair, and Wayne counties (Comer et al. 1995a). An additional natural community that may be successionally related to wet-mesic flatwoods, lakeplain oak openings, covered significant acreage in Monroe (13%) and Wayne (5%) counties on sand lakeplain prone to frequent fires (Comer et al. 1995a, Kost et al. 2007). The historic prevalence of hardwood swamp, beech-sugar maple forest, and lakeplain oak openings in southeastern Lower Michigan suggests wet-mesic flatwoods was common at the time of the GLO surveys.

Conversion of the southeastern Michigan glacial lakeplain for agricultural production accelerated in the early 1800s and resulted in the loss and degradation of wet-mesic flatwoods. Extensive drainage networks created to expand agriculture lowered regional water tables and reduced wet-mesic flatwoods to small, isolated woodlots (Comer et al. 1995b, Knopp 1999). This development led to the reduction of wetland acreage in southeastern Lower Michigan by 80-90%, the highest percentage loss of wetlands among all regions of the state (Comer et al. 1995b). Despite the significant loss of wetlands statewide and in southeastern Lower Michigan, MIRIS data (MDNR 1978) indicate that approximately 500,000 ha (1,200,000 ac) of lowland hardwood forest occurred in southern Lower Michigan in the 1970s. This figure includes 28,000 ha (69,000 ac) in the Maumee Lake Plain ecological Sub-subsection. The portion of this acreage represented by wet-mesic flatwoods cannot be determined because wet-mesic flatwoods does not correspond closely to any of the MIRIS cover type classifications. More recent data indicate 340,000 ha (840,000 ac) of lowland deciduous forest exists at present in the southern Lower Peninsula, including 17,000 ha (42,000 ac) in the Maumee Lake Plain (MDNR 2001). Again, the portion of this acreage characterized by wet-mesic flatwoods cannot be determined with precision due to broad cover type classification and resolution of the spectral data. However, the majority of lowland forest in the ecoregion is comprised of fragmented, degraded woodlots that do not closely approximate undisturbed conditions. Some areas of wet-mesic flatwoods may be classified as upland deciduous forest in the MIRIS and IFMAP land cover classifications due to the community's naturally variable canopy composition (MDNR 1978, MDNR 2001).

Currently, six occurrences of wet-mesic flatwoods are documented from Michigan, located in Macomb, Wayne, and Monroe counties. These occurrences range in size from 3 ha (7 ac) to 35 ac (87 ac), totaling approximately 96 ha (240 ac) (MNFI 2010). Only two occurrences are estimated to be of good to fair viability (BC-rank), with the remaining occurrences estimated to be of fair or fair to poor viability (C- to CD-rank). All of these sites are isolated woodlots in agricultural or urban landscapes, degraded by landscape-scale fragmentation and hydrologic alteration (MNFI 2010). Additional disturbances that have reduced viability of remnant wet-mesic flatwoods over the past century include the introduction of non-native pests and pathogens (e.g., elm blight and emerald ash borer), invasive plants, and excessive deer herbivory, which have significantly altered community structure, species composition, and successional trajectory (Barnes 1976, Rooney and Waller 2003, McCullough and Katovich 2004). For these reasons, the community is considered imperiled in the state (Kost et al. 2007).

Physiographic Context: The Michigan range of wet-mesic flatwoods is in southeastern Lower Michigan, in the Maumee Lake Plain Sub-subsection within the Washtenaw Subsection (Albert 1995). This region has the longest growing season in the state, ranging from 160 to 170 days, averaging 163 days (Comer et al. 1995b, Barnes and Wagner 2004). The daily maximum temperature in July ranges from 28° to 29° C (82° to 85° F), the daily minimum temperature in January ranges from -10° to -7° C (14° to 19° F), and the annual average temperature is 9.3° C (48.7° F). Mean annual total precipitation is 820 mm (32 in), with average seasonal snowfall less than 100 cm (40 in) (Eichenlaub et al. 1990, Albert 1995, Barnes and Wagner 2004, MSU Climatology Office 2008).

Wet-mesic flatwoods occurs exclusively in the Maumee Lake Plain Sub-subsection in southeastern Lower Michigan (Kost et al. 2007, MNFI 2010). This Sub-subsection is characterized by a broad, flat clay lakeplain containing broad channels of lacustrine sand that support low beach ridges and small dunes (Albert 1995). Portions of the lakeplain with thick clay deposits near the surface are characterized by nearly level topography. In these areas, differences in elevation of as little as 30 cm separate "upland flats" from low, wet areas and depressions, and vernal pools were historically common (Knopp 1999). Areas of the lakeplain characterized by deep sand deposits are better-drained and more topographically diverse, with development of beach ridges and low dunes on the otherwise level surface. Areas of the lakeplain characterized by a relatively thin sand veneer over clay are distributed throughout the clay plain, and exhibit variable topography with level plains and low ridges (Knopp 1999). Wet-mesic flatwoods is concentrated on the clay and sand/clay lakeplain, where impermeable subsurface layers and low stream density impedes drainage and causes seasonal ponding (Albert et al. 1986, Comer et al. 1995b). In these areas, wet-mesic flatwoods occupies a topographic position between very poorly drained southern hardwood swamp in the wettest depressions and mesic southern forest where slope and stream density permit favorable drainage. The community may also occur scattered within sand lakeplain, where seasonal desiccation, fire, and beaver activity historically favored the development of prairie and savanna (i.e., lakeplain oak openings, lakeplain wet-mesic prairie, lakeplain wet prairie, and mesic sand prairie) rather than forest communities. On the wettest sites, wet-mesic flatwoods may also be associated with emergent marsh and Great Lakes marsh (Kost et al. 2007).

Photo by Steve A. Thomas

Slight changes in elevation are associated with significant differences in soil surface moisture and plant species composition.

Wet-mesic flatwoods occurs on seasonally wet, poorly aerated mineral soils on clay and sand/clay lakeplain that become desiccated during the late growing season and fall (Knopp 1999, Lee 2005). The water table seasonally or periodically drops well below the ground surface, permitting decomposition of organic matter on the forest floor. Seasonal water level fluctuations lead to mottling of the mineral soil layers. Soils on clay and sand/clay lakeplain contain a significant sand fraction in the upper layers, and tend to be medium acid (pH= 5.6-6.0) to slightly acid (pH= 6.1-6.5) at the surface, although pH may be greater in sites with high clay content in the upper layers. Clay fraction and alkalinity increase with depth; soils are typically mildly alkaline (pH= 7.4-7.8) to moderately alkaline (pH= 7.9-8.4) 1 m below the surface (Knopp 1999). Soils on the sand lakeplain are characterized by very high sand fractions at all depths and pH ranging from strongly acid (pH= 5.1-5.5) at the surface to neutral (pH= 6.6-7.3) at greater depth. The neutral to alkaline subsurface layers across the lakeplain are derived from calcareous Mississippian, Devonian, and Silurian marine and near-shore bedrock parent material (Comer et al. 1995b).

Natural Processes: The primary natural processes affecting development, structure, and successional trajectory of wet-mesic flatwoods are seasonal hydrologic fluctuations and small-scale windthrow. Wet-mesic flatwoods occupies seasonally wet depressions or mosaics of upland rises and depressions that are characterized by an impervious subsurface clay layer that causes seasonal inundation and ponding (Novitzki 1979, Brinson 1993, NatureServe 2009). The community receives most of its water from overland flow and precipitation (rain and snow) and loses water through evapotranspiration. Species composition in wet-mesic flatwoods is regulated by winter and spring inundation followed by soil desiccation in late summer and fall, when the water level drops well below the soil surface (Bryant 1963, Knopp 1999, Lee 2005). Several tree species adapted to flood-drought cycles are characteristic of wet-mesic flatwoods, including silver maple (*Acer saccharinum*), green ash (*Fraxinus pennsylvanica*), American elm (*Ulmus americana*), and eastern cottonwood (*Populus deltoides*) (Barnes and Wagner 2004). These and other flood-tolerant species exhibit a number of adaptations to inundation, rapid changes in water level, and low oxygen availability during the growing season, including hypertrophied lenticels (gas-exchanging pores), shallow roots, adventitious roots, absence of seed dormancy, rapid growth, and stomatal closure during periods of root submergence (Hosner 1960, Hosner and Boyce 1962, Kozlowski and Pallardy 2002, Barnes and Wagner 2004, Lee 2005, Weber et al. 2007). Species that are less tolerant of flood-drought cycles, such as black ash (*Fraxinus nigra*) and conifers, are rare or absent in wet-mesic flatwoods (Lee 2005). Shrub and ground layer species richness and cover is relatively low due to regular flood-drought cycles and canopy closure (Hall and Harcombe 1998, NatureServe 2009). Many shrub and ground layer species occur on hummocks above the zone of inundation.

Small-scale windthrow is a characteristic disturbance in wet-mesic flatwoods that influences community composition and structure by creating canopy gaps that are suitable for the colonization and growth of light-dependent tree seedlings and saplings, shrubs, and herbs. Windthrow also tips and uproots trees, creating pit-and-mound topography that provides suitable microhabitats for a diversity of plant species (Christensen et al. 1959, Paratley and Fahey 1986, Vivian-Smith 1997). Some species preferentially colonize hummocks and decaying logs, whereas other species colonize depressions between root hummocks and other low, wet areas within the forest (Paratley and Fahey 1986, Anderson and Leopold 2002). The historic frequency of extensive windthrows and their influence on successional turnover of wet-mesic flatwoods is less well understood. Large-scale windthrows in the Maumee Lake Plain were noted by the GLO surveyors only in the extreme northern portion of the sub-subsection, where lowland forests occurred on flat clay plains (Comer et al. 1995b). Fire, thunderstorms, ice events, and other natural disturbances likely influenced the frequency and severity of historic windthrows in wet-mesic flatwoods.

The importance of oaks (*Quercus* spp.) and other disturbance-dependent tree species in wet-mesic flatwoods suggests a role for historic wildfires in the development and persistence of the community. However, the role of fire in wet-mesic flatwoods is unclear. GLO surveyors made few references to fire in the Maumee Lake Plain, and the domination of the clay lakeplain by closed-canopy forests suggests fires were infrequent and/or of low severity (Comer et al. 1995b). Wet-mesic flatwoods associated with fire-dependent systems (e.g., lakeplain oak openings) likely burned more frequently than occurrences adjacent to or surrounded by fire-resistant systems (e.g., mesic southern forest). Historically, where wet-mesic flatwoods bordered lakeplain prairies and lakeplain oak openings, surface fire likely spread through portions of the community when standing water was absent.

Beaver (*Castor canadensis*) activity in the lakeplain was likely concentrated in wetland systems in the lowest topographic positions, such as emergent marsh, lakeplain wet prairie, lakeplain oak openings, and southern hardwood swamp. Although wet-mesic flatwoods occupies a higher topographic position than these wetland communities, the community historically occurred in large wetland complexes that were significantly influenced by this ecosystem engineer. Occurrences of wet-mesic flatwoods in the immediate vicinity of streams and large marsh and wet prairie complexes were likely susceptible to beaver-induced successional turnover. Beaver increase plant species richness at the landscape scale by creating novel habitat patches with variability in light availability, soil moisture, and nutrient availability (Wright et al. 2002).

Vegetation Description: Wet-mesic flatwoods is a closed-canopy deciduous forest characterized by a canopy layer consisting of several lowland and upland tree species and variable species composition within the understory, shrub, and ground layers. Conifers are absent. The species listed below are derived from NatureServe (2009), Kost and O'Connor (2003), Kost et al. (2006), Knopp (1999), Waldron (1997), Farwell (1901), and occurrences of the community tracked by MNFI (2010). Agricultural and urban development and widespread hydrologic disruption on the Maumee Lake Plain have reduced wet-mesic flatwoods to small, isolated remnants that likely do not represent the range of natural variation exhibited by the community circa 1800. Therefore, vegetative composition and dominance should be considered in the context of disturbance history and site-specific edaphic and hydrologic characteristics.

Tree species composition in any particular stand is regulated by topographic position, hydroperiod, soil characteristics, and other site-specific factors. Characteristic species include red oak (*Quercus rubra*), basswood (*Tilia americana*), beech (*Fagus grandifolia*), white oak (*Q. alba*), bur oak (*Q. macrocarpa*), chinquapin oak (*Q. muehlenbergii*), Shumard's oak (*Q. shumardii*, state special concern), black maple (*Acer nigrum*), bitternut hickory (*Carya cordiformis*), shellbark hickory (*C. laciniosa*), shagbark hickory (*C. ovata*), and white ash (*Fraxinus americana*). Wet-mesic flatwoods lacks the dominance of beech and sugar maple (*Acer saccharum*) that characterizes mesic southern forest, although both species may occur scattered in the canopy. Elevated, sandy beach ridges on the otherwise relatively level lakeplain support black oak (*Quercus velutina*), black cherry (*Prunus serotina*), sassafras (*Sassafras albidum*), black gum (*Nyssa sylvatica*), and other species characteristic of coarse-textured, well-drained soils. Historically, American chestnut (*Castanea dentata*) may have been a component of these beach ridges and other relatively well-drained, acidic portions of the lakeplain (Barnes and Wagner 2004). Seasonally wet depressions support several lowland hardwoods, including pin oak (*Quercus palustris*), swamp white oak (*Q. bicolor*), American elm (*Ulmus americana*), silver maple (*Acer saccharinum*), green ash (*Fraxinus pennsylvanica*), pumpkin ash (*F. profunda*, state threatened), red maple (*Acer rubrum*), cottonwood (*Populus deltoides*), sycamore (*Platanus occidentalis*), and tulip poplar (*Liriodendron tulipifera*). American elm was an important canopy tree prior to the introduction and spread of elm blight, but now primarily occurs in the understory, where it may be the dominant tree species (Barnes 1976, Knopp 1999). Other characteristic understory trees include saplings of canopy tree species, musclewood (*Carpinus caroliniana*), choke cherry (*Prunus virginiana*), and ironwood (*Ostrya virginiana*). Wet-mesic flatwoods often occurs as a mosaic of upland rises and low depressions, resulting in mixed canopy composition (Comer et al. 1995b, Waldron 1997, Knopp 1999, NatureServe 2009).

Shrub cover varies by landform and site-specific conditions. The tall shrub layer is characterized by buttonbush (*Cephalanthus occidentalis*), rough-leaved dogwood (*Cornus drummondii*), gray dogwood (*C. foemina*), Michigan holly (*Ilex verticillata*), spicebush (*Lindera benzoin*), wild black currant (*Ribes americanum*), elderberry (*Sambucus canadensis*), maple-leaved arrow-wood (*V. acerifolium*), nannyberry (*V. lentago*), downy arrow-wood (*V. rafinesquianum*), and prickly-ash (*Zanthoxylum americanum*). Low shrubs are sparse except on relatively well-drained beach ridges and dunes, which may support black chokeberry (*Aronia prunifolia*), wintergreen (*Gaultheria procumbens*), low sweet blueberry (*Vaccinium angustifolium*), and blueberry (*V. pallidum*) (Knopp 1999).

Seasonal inundation results in patchy cover of ground layer species; ground cover may be low in sites that experience frequent flooding. The woody vines Virginia creeper (*Parthenocissus quinquefolia*), poison-ivy (*Toxicodendron radicans*), and riverbank grape (*Vitis riparia*) may dominate this layer. Seedlings of canopy trees, particularly maples and ashes, may carpet the ground layer. Characteristic herbs include hog-peanut (*Amphicarpaea bracteata*), jack-in-the-pulpit (*Arisaema triphyllum*), false nettle (*Boehmeria cylindrica*), pink spring cress (*Cardamine douglassii*), sedges (*Carex grayi*, *C. intumescens*, *C. lacustris*, *C. lupulina*, *C. muskingumensis*, *C. radiata*), water hemlock (*Cicuta maculata*), enchanter's nightshade (*Circaea lutetiana*), cut-leaved toothwort (*Dentaria laciniata*), wild yam (*Dioscorea villosa*), spinulose woodfern (*Dryopteris carthusiana*), white trout lily (*Erythronium albidum*), yellow trout lily (*E. americanum*), wild geranium (*Geranium maculatum*), fowl manna grass (*Glyceria striata*), round-lobed hepatica (*Hepatica americana*), southern blue flag (*Iris virginica*), white grass (*Leersia virginica*), common water horehound (*Lycopus americanus*), ostrich fern (*Matteuccia struthiopteris*), moon seed (*Menispermum canadense*), sensitive fern (*Onoclea sensibilis*), clearweed (*Pilea pumila*), mayapple (*Podophyllum peltatum*), Solomon-seal

Photo by Suzan L. Campbell

Better-drained portions of wet-mesic flatwoods may support a luxuriant spring flora.

(*Polygonatum biflorum*), downy Solomon seal (*P. pubescens*), jumpseed (*Polygonum virginianum*), Christmas fern (*Polystichum acrostichoides*), bloodroot (*Sanguinaria canadensis*), blue-stemmed goldenrod (*Solidago caesia*), broad-leaved goldenrod (*S. flexicaulis*), false spikenard (*Smilacina racemosa*), starry false Solomon-seal (*S. stellata*), and common trillium (*Trillium grandiflorum*).

Rare Plants Associated with Wet-mesic Flatwoods (E, Endangered; T, Threatened; SC, species of special concern).

Scientific Name	Common Name	State Status
Aristolochia serpentaria	Virginia snakeroot	T
Carex lupuliformis	false hop sedge	T
Carex seorsa	sedge	T
Carex squarrosa	squarrose sedge	SC
Castanea dentata	American chestnut	E
Cuscuta polygonorum	knotweed dodder	SC
Euonymus atropurpurea	wahoo	SC
Euphorbia commutata	tinted spurge	T
Fraxinus profunda	pumpkin ash	T
Galearis spectabilis	showy orchis	T
Hydrastis canadensis	goldenseal	T
Jeffersonia diphylla	twinleaf	SC
Lactuca floridana	woodland lettuce	T
Lactuca pulchella	blue lettuce	X
Lycopus virginicus	Virginia water-horehound	T
Morus rubra	red mulberry	T
Panax quinquefolius	ginseng	T
Plantago cordata	heart-leaved plantain	E
Populus heterophylla	swamp or black cottonwood	E
Quercus shumardii	Shumard's oak	SC
Smilax herbacea	smooth carrion-flower	SC
Valerianella umbilicata	corn salad	T
Viburnum prunifolium	black haw	SC

Rare Animals Associated with Wet-mesic Flatwoods (E, Endangered; T, Threatened; SC, species of special concern; LE, Federally Endangered; LT, Federally Threatened).

Scientific Name	Common Name	State Status
Acronicta falcula	corylus dagger moth	SC
Ambystoma opacum	marbled salamander	E
Ambystoma texanum	smallmouth salamander	E
Basilodes pepita	gold moth	SC
Buteo lineatus	red-shouldered hawk	T
Catocala illecta	Magdalen underwing	SC
Clemmys guttata	spotted turtle	T
Clonophis kirtlandii	Kirtland's snake	E
Emydoidea blandingii	Blanding's turtle	SC
Euphyes dukesi	Dukes' skipper	T
Gomphus quadricolor	rapids clubtail	SC
Haliaeetus leucocephalus	bald eagle	SC
Heterocampa subrotata	small heterocampa	SC
Heteropacha rileyana	Riley's lappet moth	SC
Incisalia henrici	Henry's elfin	T
Myotis sodalis	Indiana bat	E; LE
Nerodia erythrogaster neglecta	copperbelly watersnake	E; LT
Nycticorax nycticorax	black-crowned night-heron	SC
Pandion haliaetus	osprey	SC
Papaipema cerina	golden borer	SC
Papaipema speciosissima	regal fern borer	SC
Protonotaria citrea	prothonotary warbler	SC
Seiurus motacilla	Louisiana waterthrush	T
Sistrurus c. catenatus	eastern massasauga	SC
Terrapene c. carolina	eastern box turtle	SC


Photo by Joshua G. Cohen

Shumard's oak (*Quercus shumardii*; foreground) is associated with several other deciduous trees in the canopy of a remnant wet-mesic flatwoods in Macomb County.

Noteworthy Animal Species: The emerald ash borer (EAB, *Agrilus planipennis*), an invasive beetle native to eastern Asia, was first noted in North America in 2002 in southeastern Lower Michigan and has since been discovered elsewhere in Michigan and the Midwestern and eastern United States and adjacent Canadian provinces (Haack et al. 2002, USDA APHIS 2010). The larvae of this species feed on cambial tissue in the inner bark of ash trees, causing mortality of the host tree within three years (Haack et al. 2002). All species of ash in Michigan are considered hosts or potential hosts, and EAB has caused mortality of millions of ash trees since its introduction to southeastern Lower Michigan (McCullough and Katovich 2004, MacFarlane and Meyer 2005). This invasive beetle is likely to have a significant impact on wet-mesic flatwoods, as black ash, green ash, pumpkin ash, and white ash all occur in this community. Wet-mesic flatwoods structure has already been altered by the near-elimination of American chestnut and mature American elms by non-native fungal pathogens (Barnes 1976, Barnes and Wagner 2004).

Vernal pools are abundant in wet-mesic flatwoods and serve as breeding ponds for aquatic invertebrates and amphibians. Today, these isolated forest stands are often completely surrounded by agriculture, old fields, and urban developments, and therefore provide critical habitat for cavity nesters (e.g., owls), canopy-dwelling species, and interior forest obligates, including neotropical migrant birds such as black-throated green warbler (*Dendroica virens*), scarlet tanager (*Piranga olivacea*), and ovenbird (*Seiurus aurocapillus*).

Conservation and Biodiversity Management: Wet-mesic flatwoods has been reduced to small, disturbed remnant woodlots throughout the Maumee Lake Plain. The Maumee Lake Plain is the most developed ecological Sub-subsection in Michigan, and extensive drainage networks have altered hydrology at the landscape scale (Comer et al. 1995b). Conservation and management of wet-mesic flatwoods is hindered by landscape alteration and fragmentation, site-specific land-use history, and private ownership (Knopp 1999). A few occurrences of wet-mesic flatwoods are located in the Huron-Clinton Metroparks System (Kost and O'Connor 2003, Kost et al. 2006). Conservation and management of these and other remnants should focus on protection and/or restoration of the hydrological regime, reduction of landscape fragmentation, detection, control, and monitoring of invasive plants, animals, and pathogens, protection of downed and decomposing wood, reduction of deer browse pressure, and promotion of oak regeneration.

Protection of hydrology is critical to maintaining the integrity of wet-mesic flatwoods. Although drainage networks have altered hydrology at the landscape scale, much of the Maumee Lake Plain remains poorly drained or saturated from January to May (Knopp 1999). Protection from further hydrologic degradation is essential for the maintenance of processes that support persistence of wet-mesic flatwoods remnants. Several measures can be taken to protect the integrity of wet-mesic flatwoods hydrology. A relatively wide upland buffer zone can be established in developed areas to prevent run-off of polluted surface water. Within remnant stands, construction of new drainage ditches should be avoided, as should new road construction and stream maintenance projects (e.g., dredging, straightening, and removal of fallen wood). Hydrologic restoration projects can focus on removal of drain tiles and prevention of erosion along ditches. Although the drainage network in the Maumee Lake Plain has irreversibly altered hydrologic processes at the landscape scale, the characteristic natural processes of seasonal pooling of water followed by summer desiccation still occurs away from the immediate vicinity of ditches and drainage tiles.

Landscape fragmentation has reduced wet-mesic flatwoods occurrences to isolated stands surrounded by agriculture or urban development (Knopp 1999, Lee 2005, MNFI 2010). Fragmentation has a number of detrimental effects on biodiversity conservation, including the introduction of non-native predators, competitors, diseases, and parasites, reduction or elimination of dispersal corridors, disruption of ecosystem processes, and removal of key resources (Marzluff and Ewing 2001). The impacts of fragmentation can be reduced by establishing habitat linkages among remnant stands and management of the surrounding landscape to more closely approximate the conditions within the isolated stands (Marzluff and Ewing 2001). Research on wetland birds suggests that many species favor wetland tracts in a matrix of upland forest, rather than isolated wetland tracts, regardless of size (Riffell et al. 2006). Though restoration of these conditions is not possible in particularly urbanized landscapes, conservation efforts for isolated wet-mesic flatwoods tracts in agricultural landscapes should focus on improving the suitability of adjacent land for native species. Restoring connectivity between isolated forest patches by either replanting forest, especially oak species, or allowing old fields to succeed to forest will aid species dispersal and reduce edge effects.

Invasive plant species are a significant threat to wet-mesic flatwoods. Invasive species monitoring and removal efforts should be implemented in existing remnants of wet-mesic flatwoods. Species of particular concern include garlic mustard (*Alliaria petiolata*), Japanese barberry (*Berberis thunbergii*), ground ivy (*Glechoma hederacea*), Dame's rocket (*Hesperis matronalis*), common privet (*Ligustrum vulgare*), honeysuckles (i.e., *Lonicera japonica*, *L. maackii*, *L. morrowii*, and *L.* x *bella*), moneywort (*Lysimachia nummularia*), white mulberry (*Morus alba*), reed canary grass (*Phalaris arundinacea*), reed (*Phragmites australis*), common buckthorn (*Rhamnus cathartica*), glossy buckthorn (*R. frangula*), and multiflora rose (*Rosa multiflora*) (Kost et al. 2007). Fragmentation and isolation of wet-mesic flatwoods occurrences by residential, commercial, and industrial development threatens this natural community type by restricting dispersal of native species and increasing the propagule pressure of commonly planted non-native trees, shrubs, and herbs. Monitoring and removal of invasive species should focus on those species that threaten to alter community composition, structure, and function (e.g., glossy buckthorn and multiflora rose). Management activities should avoid disturbances to soil and hydrology, which often leads to the establishment and spread of invasive plant species, especially in urban settings where invasive plants are well established.

Control of emerald ash borer is currently limited to prevention of human introduction of this species to new locations through banning transport of infected firewood or living trees. Research on parasitoids and fungal pathogens that may serve as potential biological controls of this species in North America is ongoing (Liu et al. 2003, Liu and Bauer 2006). Forest stands throughout the entire range of wet-mesic flatwoods are vulnerable to invasion by EAB, and the lack of a successful control strategy at this time emphasizes the importance of preventing its introduction to new sites. Evidence from the previous die-off of American elm suggests that shrub density may increase following the mortality of canopy ash trees (Dunn 1986). Invasive species, including reed, may also establish in the canopy gaps created by ash-kill (Cohen 2009).

Protection of large-diameter rotting logs and dead standing wood is important for the preservation of structural diversity and suitable substrate for the germination and establishment of several plant species (Paratley and Fahey 1986, McGee 2001, Anderson and Leopold 2002). Downed and standing dead wood also provides habitat for decomposers, invertebrates, birds, and small mammals (Marzluff and Ewing 2001). In addition to protection of the existing downed and dead wood in wet-mesic flatwoods stands, maintenance of mature and over-mature canopy trees ensures continued recruitment of large-diameter coarse woody debris.

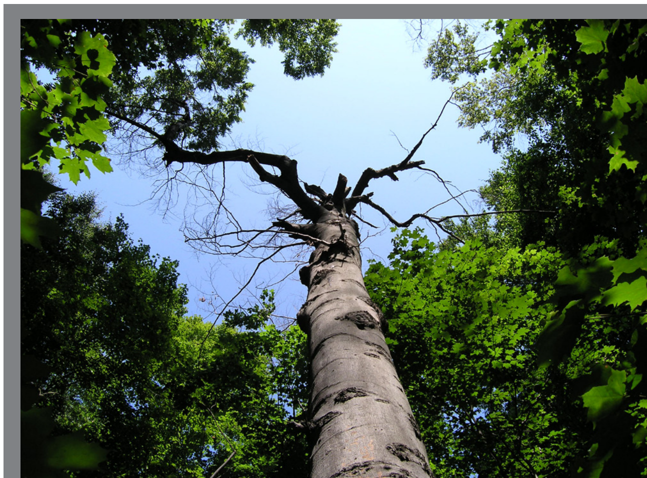
Photo by Joshua G. Cohen

Dead, standing wood provides important habitat for decomposers, invertebrates, birds, and small mammals. In addition, the canopy gaps created by dead trees create microhabitats suitable for the colonization and growth of light-dependent tree seedlings and saplings, shrubs, and herbs.

High density of white-tailed deer (*Odocoileus virginianus*) has led to significant browse pressure on tree seedlings, shrubs, and herbs throughout much of the eastern United States and adjacent Canadian provinces, altering structure and composition of all strata and producing a cascade of effects (e.g., detrimental impacts to pollinators of affected plant species) (McShea and Rappole 1992, Balgooyen and Waller 1995, Waller and Alverson 1997, Augustine and Frelich 1998, Rooney and Waller 2003, Kraft et al. 2004). Reduction of deer densities at the landscape scale will promote recovery of tree seedling, shrub, and herb populations. In areas where reducing the number of deer is not feasible, or in small, isolated stands of high-quality wet-mesic flatwoods, deer exclosures should be considered in order to promote tree regeneration and recruitment, in addition to recovery of impacted shrub and ground layer species.

Oak regeneration in wet-mesic flatwoods remnants appears to be poor (Kost and O'Connor 2003, Kost et al. 2006). Fire suppression, landscape fragmentation and development, deer browse, and mesophytic invasion may be contributing to the lack of oak regeneration in these stands (see Lee and Kost [2008] for a review of the ecological factors associated with oak regeneration in Lower Michigan). Historically, fire may have interacted with large-scale windthrow to create suitable conditions for the regeneration of oak species across the Maumee Lake Plain. In order to maintain a significant oak component in remnant wet-mesic flatwoods, a variety of management techniques should be considered, including the reduction of deer densities, construction and placement of deer exclosures, application of prescribed fire, and planting acorns and oak seedlings in suitable open areas adjacent to remnant forests that are suitable for colonization by oak species. Management for oak regeneration on mesic and wet-mesic soils may be especially difficult due to the lack of fuels for conducting prescribed fires and interspecific competition from germinating tree seedlings, resprouts, and shrubs (Iverson et al. 2008).

Research Needs: The distribution of wet-mesic flatwoods in the heavily developed Maumee Lake Plain as isolated, disturbed fragments limits our understanding of its original vegetative composition, structure, edaphic characteristics, and spatial configuration. Past disturbances and the relative scarcity of land in public ownership may be responsible for the lack of ecological studies of the system (Knopp 1999). A systematic survey for wet-mesic flatwoods in Michigan, including the collection of plot data, is necessary to assess the statewide conservation status of this natural community type.

Relatively undisturbed wet-mesic flatwoods remnants provide an opportunity to study the impacts of microtopography and soil texture on the distribution of plant species and vegetative associations. This research will inform and improve classification of wet-mesic flatwoods, and allow for better differentiation of the community type from similar hardwood-dominated communities that occur on slightly higher, better-drained soils (e.g., mesic southern forest), and lower, more poorly drained soils (e.g., southern hardwood swamp). An improved understanding of the spatial distribution of wet-mesic flatwoods will also aid classification, and will facilitate more accurate mapping of remnant occurrences.

Research on the distribution of wet-mesic flatwoods in Michigan is necessary to determine if the community or a similar community occurs elsewhere in Michigan, chiefly in the Sandusky Lake Plain, Saginaw Bay Lake Plain, and/or Southern Lake Michigan Lake Plain Ecological Sub-subsections (Albert 1995). The Sandusky and Saginaw Bay Lake Plains were historically characterized by extensive tracts of upland and lowland forest dominated by a mixture of hardwoods and conifers (Comer et al. 1995a). No occurrences of wet-mesic flatwoods have been documented in the Southern Lake Michigan Lake Plain Sub-subsection, but flatwoods communities are documented in the Indiana and Illinois portions of the Lake Michigan lakeplain (NatureServe 2009), and may potentially occur in Berrien County or elsewhere in southwestern Lower Michigan. Surveys are also needed to determine if the community occurs on other landforms where the impervious subsurface clay layers and level topography characteristics of glacial lakeplain are more locally distributed.

The natural disturbance regime that influences community structure, species composition, and successional trajectory of wet-mesic flatwoods is incompletely understood. For example, the natural fire regime of the community is poorly understood. At the time of the GLO surveys in the early 1800s, closed-canopy forests dominated the clay and sand/clay lakeplain, and fires were infrequently recorded (Comer et al. 1995b). However, some occurrences of wet-mesic flatwoods may represent fire-suppressed lakeplain oak openings, particularly on sandy soils that historically supported savanna and prairie communities (Comer et al. 1995b, Kost et al. 2007, NatureServe 2009). The ecological factors associated with successful oak regeneration in wet-mesic flatwoods merit further study and elucidation. The role and importance of beaver in shaping succession of wet-mesic flatwoods also warrants further research. Systematic inventory and long-term studies of wet-mesic flatwoods may result in a better understanding of these and other disturbance factors influencing the vegetation and structure of the community.

Photo by Joshua G. Cohen

The historic frequency and intensity of fires set by lightning (above) and humans in landscapes dominated by wet-mesic flatwoods warrants investigation.

Similar Communities: *Southern hardwood swamp* is an ash- or maple-dominated lowland forest on poorly drained to very poorly drained mineral or organic soils (Kost et al. 2007, Slaughter 2009). *Northern hardwood swamp* is an ash- or maple-dominated lowland forest that occurs north of the climatic tension zone (Weber et al. 2007). *Mesic southern forest* is a beech- and sugar maple–dominated upland forest that occupies a higher topographic position than wet-mesic flatwoods (Cohen 2004). *Lakeplain oak openings* is a fire-dependent savanna community on xeric or hydric soils, concentrated on sand lakeplain (Cohen 2001). *Floodplain forest* is a lowland forest impacted by over-the-bank flooding and cycles of erosion and deposition associated with streams of third order or greater (Tepley et al. 2004).

Other Classifications:

Michigan Natural Features Inventory Land Cover Mapping Code: 4148 (Oak [Pin oak, Swamp white oak] [Pin Oak Depression]); 4121 (Mesic Southern Forest); 414 (Hardwood Swamp [Lowland Hardwoods])

MNFI circa 1800 Vegetation: Beech – Sugar Maple Forest; Mixed Hardwood Swamp

Michigan Resource Information Systems (MIRIS): 414 (Lowland Hardwood); 412 (Central Hardwood)

Michigan Department of Natural Resources (MDNR): E – Swamp Hardwoods; M – Northern Hardwoods

MDNR IFMAP (MDNR 2001): Lowland Deciduous Forest; Northern Hardwood Association; Mixed Upland Deciduous

NatureServe U.S. National Vegetation Classification and International Classification of Ecological Communities (Faber-Langendoen 2001, NatureServe 2009):

CODE; ALLIANCE; ASSOCIATION; COMMON NAME

I.B.2.N.e; *Quercus palustris – (Quercus bicolor)* Seasonally Flooded Forest Alliance; *Quercus palustris – Quercus bicolor – Acer rubrum* Flatwoods Forest; Northern (Great Lakes) Flatwoods

I.B.2.N.e; *Quercus palustris – (Quercus bicolor)* Seasonally Flooded Forest Alliance; *Quercus palustris – Quercus bicolor – Nyssa sylvatica – Acer rubrum* Sand Flatwoods Forest; Pin Oak – Swamp White Oak Sand Flatwoods

I.B.2.N.a; *Fagus grandifolia – Quercus* spp. – *Acer* spp. Forest Alliance; *Fagus grandifolia – Acer saccharum – Quercus bicolor – Acer rubrum* Flatwoods Forest; Beech – Hardwoods Till Plain Flatwoods

Other states and Canadian provinces (natural community types with the strongest similarity to Michigan wet-mesic flatwoods indicated in *italics*)**:**

IL: *Northern flatwoods* (White and Madany 1978)
IN: *Boreal flatwoods* (Jacquart et al. 2002)
ON: *Fresh – moist oak – maple – hickory deciduous forest ecosite*; *Oak mineral deciduous swamp ecosite*; Fresh – moist sugar maple deciduous forest ecosite; Fresh – moist lowland deciduous forest ecosite (Lee et al. 1998)
OH: *Maple – ash – oak swamp* (Schneider and Cochrane 1998)
PA: *Great Lakes region lakeplain palustrine forest* (Fike 1999)

Related Abstracts: floodplain forest, lakeplain oak openings, mesic southern forest, northern hardwood swamp, southern hardwood swamp, red-shouldered hawk, spotted turtle, Blanding's turtle, Dukes' skipper, rapids clubtail, bald eagle, black-crowned night-heron, osprey, regal fern borer, prothonotary warbler, Louisiana waterthrush, eastern massasauga, eastern box turtle, pumpkin ash, showy orchis, goldenseal, ginseng.

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