DISCUSSION

QUALITATIVE ASSESSMENT

Plants

The comprehensive plant list in Appendix 1 represents a compilation of records from various sources, including private and faculty reports, and student projects. This method of gradually accumulating species lists from observers of various skill levels has a tendency to accumulate many erroneous reports as well as some valid reports not substantiated by a voucher specimen. By seeking to verify the presence or absence of each reported species, both in the herbarium and in the field, a list has been produced that more accurately represents the flora of the Asylum Lake Preserve. While many species have been verified and ruled out, many additional species have been added to the list that were not previously reported. Although highly degraded as a whole, there some areas of surprisingly high floristic quality.

Oak Woodlands

Some of the most exciting floristic finds include oak savanna species, remnants from a once prevalent natural community (Map 1, Table 1). Not only do individual savanna species occur at the Preserve as random relicts, but they are found in assemblages that suggest potential for restoration of oak savanna at the Preserve (Map 5). When combined with many of the historical reports of savanna species and the structure implied by older oak trees, the historical and potential oak savanna begins to take shape. Suppressed by shade, the impacts of human occupancy, and the ravages of deer browse, these species persist in assemblages as individuals or as small patches. Examples abound, and include a rough blazing star with a softball-sized corm, widely scattered prairie ragwort (*Senecio plattensis*), occasional Culver's root (*Veronicastrum virginicum*), and a small patch of northern bedstraw (*Galium boreale*).

There were 47 new reports of native species from the uplands, and 33 adventive. Many new reports likely represent re-identification of species reported in the past (Table 3). Others were probably overlooked in the past, such as spiderwort (*Tradescantia ohiensis*), early meadow rue, sedges (*Carex blanda, C. muehlenbergii, C. rosea*), alum root, northern bedstraw, rough blazing star, broad-leaved panic grass (*Panicum latifolium*), and shinleaf (*Pyrola elliptica*). Some represent changes in taxonomy, such as the hill's oak (*Quercus ellipsoidalis*), which has previously been considered within the *Quercus coccinea* species-complex (Voss 1985). There are also a few new reports of weedy, adventive species such as the widespread butter-and-eggs (*Linaria vulgaris*) and the infrequently encountered European corn-salad (*Valerianella locusta*).

Large-leaved shinleaf (*Pyrola elliptica*) in Forest I

Prairie and Savanna

Only 14 of the original 23 species planted during the prairie and savanna reconstruction were observed (Table 20). Seven additional species commonly included in Midwestern prairie restorations were observed (Table 20, pers. obs.). Species such as rosinweed and cup-plant (*Silphium integrifolium* and *S. perfoliatum*) occur in isolated clumps, while foxglove beardtongue (*Penstemon digitalis*) was observed uncommonly throughout. The composition of species planted in Prairie and Savanna I

would not likely be associated in a native Michigan prairie community. For example, heart-leaved golden Alexanders (*Zizia aptera*) and dotted mint (*Mondarda punctata*) are limited to dry and sandy prairies, while New England aster is generally in wetter prairies. They do, however, demonstrate the floral diversity of Michigan's prairies, and provide a valuable educational tool.

Wetlands

Wetlands are often a refuge of diversity in a landscape where uplands have been disproportionately disturbed through logging and farming, although hydrology is affected by upland disturbances. Invasive species often degrade habitat, crowding out conservative native species. As with upland species, some new reports were probably re-identifications. There are, however, many conservative species among the 35 native new reports of wetland species that are uncommon at the Preserve and have escaped detection in the past. Some of these were missed in meander surveys, but observed under the close examination of transect surveys. Some of the more notable observations include marsh St.-John's wort (*Triadenum fraseri*), bog buckbean (*Menyanthes trifoliata*), and black ash (*Fraxinus nigra*) in Wet Meadow. Many additions were made to the sedge flora of the Preserve, including: *Carex aquatilis, C. bebbii, C. lacustris, C. leptalea, C. pellita,* and *C. sterilis* (Appendix 1). Four adventive species are new reports which were no doubt observed in the past: peppermint (*Mentha piperita*), hairy willow herb (*Epilobium hirsutum*), reed canary grass, and common reed. All but the former are ecological invaders that occupy large areas (Table 2). Their spread has likely occurred since wetland studies at the Preserve in the 1970s that would have noted their presence (Scott 1976, Engemann 1977, Benson et al. 1978).

Bog buckbean (*Menyanthes trifoliata*) in Wet Meadow.

Property	Former Oak Savanna	FQI	Acres	# Spp.
Lime Lake	North Uplands	54.7	39.6	136
	South Uplands	34.5	57.8	166
	Oak Island	29.3	4.2	49
PVH	Shores Woods	27.6		65
	Blackberry	24.8		69
	Katydid	24.1		69
	Cherry Creek Woods	23.3		80
	Songbird	18		49
	Cricket	11.1		13

Property	Sedge Meadow/Shrub Carr	FQI	Acres	# Spp.
Lime Lake	Western Swamp	40.8	12.6	84
	Eastern Swamp	39.4	30.1	92
PVH	Prairie Fen	45.3		128
	Shores Wetlands	32.6		123
	Willow Creek Wetlands	32.2		116
	Lime Kiln Wetlands	14.5		37
	Cherry Creek Wetlands	9.7		18
KNC	Source Marsh West	47.1	20.21	95
	East Fen	41.7	2.95	115
	Source Marsh East	37.4	11.89	63
	West Fen	35.3	3.21	79
	S2	33.5	0.8	51
	E5	21.1	3	48
	E3	17.5	1.53	30
	E4	13.4	4.02	32

Table 21. Floristic quality indices and species richness from other survey sites. PVH= Parkview Hills; KNC= Kalamazoo Nature Center. Values in red are greater than at least one comparable survey area during the current study.

Floristic Quality Assessment

The FQA is useful in affirming the subjectively apparent quality of a habitat. Wet Meadow had the highest FQI (Table 5), and not surprisingly has the highest FQI among groundlayer plots (Appendix 3), as well as a unique flora as revealed in the Jaccard similarity test (Figure 5a). The quality

of the oak woodlands on the property is less apparent. Despite significant disturbed areas lacking conservative species, the FQI is markedly increased by concentrations of conservative species in small patches, especially in Forest II. In such an instance, the FQI suggests the potential of the entire compartment to support an exemplary community in which the conservative species are more prevalent or dominant. This is often supported by removal of exotic species from the FQI calculation, yielding a *native* FQI (Table 5). In the most dramatic example, a jump in compartment A from an FQI of 30.7 to a native FQI of 39.1 (a 27% increase) suggests a significant increase in floristic and habitat quality with the removal of invasive exotic species. Similarly, an increase from 39.1 to 47.3 (21%) in Forest II supercedes the native FQI of Wet Meadow.

Parkview Hills (PVH) directly to the south of the Preserve and Lime Lake (LL) in eastern Van Buren County are in a similar landscape (historical oak savanna, headwaters, glacial outwash and ice-contact topography); the Kalamazoo Nature Center (KNC) is along the Kalamazoo moraine that divides the two and also contains wetlands that form headwaters to a small stream. Among them, they are found in a diversity of contexts: urban (PVH, ALP), rural residential/agriculture (LL), and natural land cover/agriculture (KNC). Comparisons of FQIs from similar habitats (sedge meadow/shrub carr; closed-in oak savanna) with various levels of disturbance at these sites places a valuable perspective on the floristic quality of the Preserve (Table 21).

Birds

The woodland, grassland and wetland habitats on the Preserve have attracted an impressive list of bird species over the years. Historical species lists were compiled by Adams et al. (2002). Numerous species reported from the Preserve in the past were observed during the current study but there were also several species that were reported in the past that were not reported in the current study (Appendix 2). The absence of a species does not necessarily indicate the species was absent from the site. Several species of migratory birds, in particular, undoubtedly were missed. Also, species that are secretive, less conspicuous and/or nocturnal are underrepresented because they would have been missed during normal surveys. Owls, woodcocks and some sparrows (e.g., Vesper Sparrow) are likely more abundant than numbers reported.

Differences between the years can be attributed to the amount of effort involved, the length of time the lakes are frozen during the winter, and general annual variation of bird distribution and abundance. It is difficult to suggest meaningful trends between the 1999/2000 study (Adams et al. 2002) and the 2008/2009 study because of differences in survey frequency. The compiled records in Appendix 2, however, provide an indication of the fluctuations in diversity from 1976 to 2009.

The most notable changes have occurred since the prairie and savanna plantings. Prairie and Savanna I & II have attracted several species of grassland birds and the grasslands are critical habitat for this group of birds that are declining due to loss of habitat.

Woodland Birds

Based on Kalamazoo Breeding Bird Survey and Breeding Bird Atlas data (Kalamazoo Nature Center, unpublished data), there have been increasing population trends for several woodland species including robins, doves, crows, cardinals, goldfinch, titmice, chickadees and some woodpeckers because they are habitat generalists and have adapted well to human-altered environments. Some

neotropical migrants appear to not have been limited by increasing forest fragmentation including Eastern Wood Pewee, Red-eyed Vireo, Scarlet Tanager, and Rose-breasted Grosbeak and are well represented at Asylum Lake Preserve (Table 7).

Threats to woodland species include predation, parasitism and forest fragmentation. Many avian species breed more successfully when over 100 meters from the forest edge (Herkert et al. 1993). Efforts should be made to limit further fragmentation and avoid or reduce activity during the nesting season (mid-May through mid-July).

Grassland Birds

Data from Breeding Bird Surveys and the Breeding Bird Atlas clearly illustrate an overwhelming decline in grassland species (60-90%) in Michigan and throughout the Great Lakes Plains over the past 30 years (Kalamazoo Nature Center, unpublished data). Noteworthy declines in the state and region include the American Woodcock, Red-headed Woodpecker, Brown Thrasher, Eastern Towhee, Field Sparrow, Henslow's Sparrow, Grasshopper Sparrow, Bobolink and Eastern Meadowlark.

Savanna II and Prairie supported many grassland bird species, with the exception of the switchgrass patch (Prairie Unit 1 on Map 4). The grasslands support a healthy number of Song and Savanna Sparrows, Eastern Meadowlark and numerous Red-winged Blackbirds (Table 7). Henslow's Sparrows have shown a 96% population drop in Kalamazoo since the 1970s, based on Kalamazoo Breeding Bird Surveys and is considered to be a species that needs immediate attention. It is encouraging to see two pairs of Henslow's Sparrows utilizing the grasslands at the Preserve.

Robertson (unpublished data) surveyed the ten acre switchgrass patch and observed only six species: American Crow, American Goldfinch, Mourning Dove, Song Sparrow, Red-winged Blackbird, and a single Tree Swallow (Appendix 2). This is an indication that a monoculture of plant species does not support as many bird species as a more diversified planting.

Species that may be attracted to the site in future years include Horned Lark, Sedge Wren, and Dickcissel, as well as increasing numbers of Grasshopper, Henslow's, Vesper and other Sparrow species. It will remain valuable to continue surveys at the Preserve and maintain historical records, especially with the maturing grasslands. Surveys will also continue to be important if as management efforts increase.

Loss of habitat is the primary threat to grassland birds. Recommended conservation and management efforts include increasing the size and quality of habitat, reducing fragmentation, controlling woody vegetation. Burning, grazing or mowing can be beneficial, but should be avoided during the nesting season (April – July).

Wetland Birds

Wetlands incur significant loss and degradation. Wetland protection is essential for the survival of breeding wetland species and migratory birds that are dependent on wetlands for stopover sites. Declining wetland species seen during the study include Pied-billed Grebe, Great Blue and Green Herons, and Blue-winged Teal among others. Other highlights include Common Loon, Virginia Rail, and Sora.

In general, fewer species and individuals were observed during the current study most likely due to the lakes being frozen well into March. However, during the breeding season, comparable species and numbers were seen in previous years (Appendix 2).

Canada goose on nest in Asyum Lake.

Threats to wetland birds include pesticides and other contaminants, fishing, loss or degradation of habitat, collisions with objects, declining food base for herons (amphibians are declining too), low water levels, and predation. Wetland birds need plenty of emergent vegetation, safe breeding sites, plentiful food supplies and vegetated buffers adjacent to lakes. Preservation of wetlands that are greater than 25 acres are most valuable to wetland birds (Adams et al. 2005). Asylum Lake Preserve consists of over 63 acres of open water and surrounding wetlands and therefore is an important body of water for our resident and migrant waterfowl and other wetland birds. Efforts should be made to increase the quality of the water and adjacent habitats.

NATURAL COMMUNITIES

A detailed summary of the ideal state of the natural communities of the Preserve is found in Appendix 1. The following discussion places these communities in a historical and management perpective.

Historical vs. Current Natural Communities

Though fragmented, aspects of the historical natural communities (see "Natural History" above) were observed in all survey areas, including the reconstructed prairie and savanna (Table 1). Many grassland bird species presumed to be historical residents of oak savanna have returned to the Preserve after the reconstruction of the prairie and savanna ecosystems, and the Preserve's habitats still support a diversity of herptiles. The historical character of the property is preserved in remnant oak-dominated uplands and sedge-dominated wetlands by the presence of native indicator species. Many modifications to the surrounding and immediate landscape have altered the species composition and community structure, but the basic biotic and abiotic components of especially the wetland communities persist. Descriptions of historical community composition and structure provide important blueprints for natural lands management (e.g., Kost 2007). However, climate change and habitat fragmentation will continue to necessitate adaptively managing for changing conditions.

Oak Systems

The oak-dominated uplands of the Preserve historically supported oak savanna, presumably dominated by white oak (Hodler et al. 1981, Comer et al. 1995). Since that time, due to fire suppression and other human activities, the upper canopy of white oak and other trees has closed in to form a forest. Groundlayer plant species with savanna affinities still persist, however, suggesting that the forest may respond to management and be restored to savanna.

Species Compostion and Community Structure

Dominance of the canopy by white and other oak species is common across the historical range of Midwestern oak savanna, with an understory dominated by opportunistic species such as elm, ash, cherry, hazelnut (*Corylus americana*), and sumac (Brewer and Vankat 2006, Karnitz and Asbjornsen 2006, Stan et al 2006, Peterson et al. 2007, Chapman and Brewer 2008). American elm and especially wild black cherry are well-represented in the understory at the Preserve, with wild black cherry dominating in all size classes (Table 11, Figure 3a). Oaks and hickories as a whole dominate both the 2.5-10 cm DBH and the > 10 cm DBH size classes, and white oak has the highest RIV of all oaks in the canopy (Table 10, Figure 2). White oak also has the highest average DBH, suggesting historical dominance (i.e., older trees). Lack of disturbance (i.e., management such as fire) in oak savanna typically leads to increases in small woody stems, especially natives like gray dogwood and invasives like glossy buckthorn (Laatsch and Anderson 2000, Peterson et al 2007). Consistent with these findings, adventive shrubs dominate in the 2.5-10 cm DBH size class (glossy buckthorn, bush honeysuckle) at the Preserve and gray dogwood is the overwhelming dominant in the 1-2.5 cm DBH size class (Table 11, Figure 4a). There are many snags (dead standing woody stems) in the 1-2.5 cm DBH category (722.2 stems/ha; Figure 3a). Many of these may represent shaded oak saplings crowded out by the dense understory, although undoubtedly include other species.

Forbs often dominate the groundlayer of savannas, especially in the shadier end of the continuum, which also favors C^3 (cool-season) grasses and sedges (Leach and Givnish 1999, Bacone et al. 2007). Historically the oak savanna landscape of southern Michigan was characterized by an open understory, maintained by regular anthropogenic fires, that allowed for ease of passage (Chapman and Brewer 2008). In the absence of fire, monocultures often occur in the herbaceous layer, dominated by species such as Virginia creeper (Laatsch and Anderson 2000, Table 12). The groundlayer in Forest I and Forest II is dominated by adventive forbs and shrubs (bush honeysuckle, Kentucky bluegrass, garlic mustard, glossy and common buckthorn) and weedy natives (Canada goldenrod, Virginia creeper, poison ivy [*Toxicodenron radicans*], gray dogwood, white avens [*Geum canadense*], wild black cherry, and enchanter's nightshade [*Circaea lutetiana*]) (Table 12). Only a few typical oak savanna or forest species had reasonably high cover in modified-Whittaker plots: Pennsylvania sedge, sedge (*Carex cephalophora*), white and black oak, pignut hickory, wild strawberry (*Fragaria virginiana*), downy Solomon-seal (*Polygonatum pubescens*), fragrant sumac (*Rhus aromatica*), mayapple (*Podophyllum peltatum*), false Solomon-seal (*Smilacina racemosa*), and heart-leaved aster (*Aster cordifolius*).

It is important to note that in addition to the changes associated with human occupation and fire-suppression, other factors have certainly contributed to changes in the plant communities. For example, prolonged or periodic drought and herbivory (whether native herbivores such as deer or domesticated grazers) can have a profound effect on the species composition in a natural community (Bacone et al., 2007). The effects of overabundant deer on forest and forest edge ecosystems are numerous, and especially apparent in communities with a diverse herbaceous component. Waller and Alverson (1997) found that herbaceous plants may constitute up to 87% of a deer's summer diet. The detrimental effects of deer browse on herbaceous plants are varied and include gender modification of hermaphroditic species (Ruhren and Handel 2000), reduced flowering (Webster et al. 2001), and reduced overall abundance of forest herbs (Fletcher et al. 2001). Perhaps no other species is more prone to deer predation than common trillium. This widespread forest herb, known from as recently as 2000 (Adams et al. 2002), was not observed during the study.

Wolf Trees: Savanna or Woodland?

Due to their diminished presence in the current landscape (Nuzzo 1986), the structure and species composition of historical prairies and savannas in the Midwest is poorly understood. Through knowledge of each plant species' habitat requirements and careful analysis of historical descriptions of habitats, inferences can be made. The prairie and savanna landscape of southwestern Michigan has often been described as a "mosaic" in which open prairies graded into savannas which graded into closed-canopy forests (O'Connor 2006). As fires spread across the landscape, areas that were once savannas or forests may have become prairies or savannas, while former patches of prairie were spared fires for long enough to support trees at some density. Certainly there were gradients in between these ecosystems as they are now defined. Birds appear to utilize both savannas and woodlands as ecotones rather than exhibiting a consistent fidelity to these transitional habitats (the apparent exception is Red-headed Woodpecker), taking advantage of the diversity of plants, insects, and cover types they provide (Grundel and Pavlovic 2007). Because bird diversity is proportional to structural diversity, however, bird species richness in savannas and woodlands is often higher than in adjacents grasslands or forests (Grundel and Pavlovic 2007, Au et al. 2008).

The nature of wolf trees in concert with the presence of indicative herbaceous species provides information suggesting the specific character of the oak-dominated community on the property. While the slope north of Asylum Lake (Forest II) supports more species indicative of a savanna, the forest south of Asylum Lake (Forest I) supports many species believed to have prairie or savanna affinities alongside those typically believed to occur most often in forests. Furthermore, many of the larger (and presumably older) oak trees on the property display branching characteristics of maturing neither in wide open spaces nor in a dense forest, but in some "in-between state". Some ecologists recognize this as a distinct community, and in the Midwest it is typically classified as an "oak woodland" (MNDNR 2003, WDNR 2009). It is typified in its natural state by canopy closure of 50-95% and an open understory. These conditions allow more light to reach the groundlayer and create a "filtered shade". The open understory of oak woodland also supports many declining bird species such as Red-headed Woodpecker, Blue-wing Warbler, and Golden-wing Warbler (Au et al. 2008).

Cooler, moister conditions of a north-facing slope often support a mesic forest (i.e., beech-maple), but in a landscape where fire is prevalent a canopy of fire-tolerant oaks is maintained with a corresponding fire-tolerant open understory and herb layer (Nowacki and Abrams 2008). Amidst dense stands of periwinkle, lily-of-the-valley, and glossy buckthorn, one small pocket of oak woodland in Forest I has a canopy of white oak and the more shade-tolerant red oak (Map 5). The herb layer contains species such as prairie alum root, Culver's root, northern bedstraw, false Solomon's seal, poverty oatgrass, and sedges (*Carex muehlenbergii, C. cephalophora*). Other oak woodland species found at the Preserve include elm-leaved goldenrod (*Solidago*

Shaded oak woodland along slope south of Asylum Lake. See Map 5.

ulmifolia), broad-leaved panic grass, prairie ragwort, and starry campion. These somewhat shade-tolerant species have a wide environmental tolerance, most thriving in full sun and others also often found in wetlands (e.g., northern bedstraw in fens, Culver's root in wet prairies).

Many historical oak trees at the Preserve were likely logged. Thus the current canopy may be composed of trees that matured since European settlement and are not representative of historical character of the property (Karnitz and Asbjornsen 2006). A significant propagule source (e.g., many oak trees) clearly remained on site for the recolonization of oak and hickory species (Copenheaver and Abrams 2002). Understanding the disturbance history of a site, combined with an understanding of historical vegetation and environmental characteristics, can offer the best insight on the current vegetation (Corbett and Corbett 2004). Thus the ground flora may not only represent the relicts of an oak woodland but simply the more shade tolerant components of an oak savanna or prairie (i.e., Culver's root and prairie alum root) (Chapman and Brewer 2008). Pavlovic et al. (2006) investigated differences in species composition in sand savanna in northern Indiana, from the base of oak trees to open canopy gaps. They found that a few forbs preferred the environmental conditions under oak trees to the canopy gaps, while C^4 grasses (warm-season grasses such as big and little bluestem) peaked in cover at the edge of oak canopy and gaps. While species composition differed from oak canopy to gap, soil characteristics (pH, nutrient availability, moisture) appear to be more important drivers (Pavlovic 2006). In pockets of sun on the more sandy and dry north side of Asylum Lake, heliophytic (sun-loving) species persist (rough blazing star, showy goldenrod, stiff goldenrod, early buttercup, and tower mustard); and many heliophytes have disappeared (kitten tails, dwarf dandelion, sand cress, hoary puccoon) as canopy cover has presumably increased. Human disturbance certainly aided their disappearance, and perhaps they are less tolerant of disturbance than the species that persist.

Selection of "Savanna Pockets"

Given the lack of information on the historical species composition and community structure at the Preserve, a number of qualitative criteria were used to identify remnant patches of oak savanna or woodland, herein termed "Savanna Pockets" (Map 5). Most of the following criteria are present in all such areas. Many areas outside of the identified "pockets" support mostly native vegetation, but have 80-100% canopy and a dense understory.

1) Concentrations of typical **savanna/prairie indicator species** (Table 1, Kost 2007, Chapman and Brewer 2008).
2) **Relatively open or patchy canopy** of 60-80% of large more or less open-grown oaks and hickories (see discussion under "Wolf Trees" in the Results section).
3) **Open understory**, especially when compared to surrounding forest.
4) If present, **understory is thin and composed of native species** such as wild black cherry, gray dogwood, hazelnut, and hawthorn, and NOT bush honeysuckle or glossy buckthorn.
5) **Steep slopes**, between 1:1 and 4:1, allowing for angled, filtered light to penetrate to the groundlayer.
6) Presence of **oak trees in the understory** or as saplings.
7) **Diverse microhabitat**, from oak canopy to sunnier canopy gaps, that typify savannas.

Oak Regeneration

With the settlement of Europeans in the eastern United States in the 1800s, the Central Hardwood Forest was reduced in area from 140 million hectares to 4 million hectares and resulted in forests dominated primarily by oaks, hickories and chestnut to the south (McClain et al. 2006, Pierce et al. 2006). In the 1900s, the trend shifted from frequent, low-intensity fires (primarily for land clearing) to a policy of fire suppression and a loss of regular disturbance. Area burned annually in the eastern United States decreased from more than 10 million ha in 1940 to less than 1 million hectare by 1955 (Nowacki and Abrams 2008). Massive reductions in the fire-frequency in oak systems in the eastern United States have resulted in replacement of "pyrogenic" (fire-tolerant) oaks and hickories by shade-tolerant and fire-sensitive tree species. This trend has been termed "mesophication" by Nowacki and Abrams (2008), and is accompanied by an increase in understory shade and moister conditions. Historically, the southern lower peninsula of Michigan burned frequently due to dense combustible fuels and many fires were severe enough to top-kill 75-100% of trees in a forest or savanna stand; fire frequency and severity have shifted from among the highest in the eastern United States to the lowest (Chapman and Brewer 2008, Nowacki and Abrams 2008). In sites formerly dominated by white and black oak, red maple (*Acer rubrum*) now dominates in many drier sites and sugar maple (*Acer saccharum*) in more mesic sites (McClain et al. 2006, Pierce et al. 2006, McEwan et al 2007, Hutchinson et al. 2008, Nowacki and Abrams 2008). While both species are present at the Preserve, neither appears to be expanding rapidly. Plot data support this, showing relatively low RIVs for either maple species, although the adventive Norway maple (*Acer platanoides*) is locally common (Table 10). Mesophytic species may have been controlled historically at the Preserve, not by fire, but by selection by managers maintaining an open understory. Due to the Preserve's isolation from other natural areas, maples may have been slow to establish in the absence of a propagule source, or a "seed tree" (R. Brewer, pers. comm., Tyrell 2003).

Yet, it is unclear if oaks are regenerating. Maples are not important in any size class, but wild black cherry (as fire-sensitive and shade-tolerant as maple species, and even faster growing) is dominant in every class. The dominance of oaks and hickories in the canopy is predominantly of white and black oak, but in the 2.5-10 cm DBH size class it is black oak and pignut hickory that are more important (Table 11). White oak, clearly the historical canopy dominant, is among the least common in that class. If anything, the trajectory is shifting from white to black oak. Oaks as a whole, however, are absent from the smallest size class in modified-Whittaker plots (although oaks are weakly represented in 1-m^2 plots) (Table 11,12). Both white and black oak, due to the diversity of caterpillars and other insects they support, provide important foraging for many birds (Hartung and Brown 2005, Tallamy 2007).

The disturbance regime has been altered from fire to anthropogenic alteration of both canopy and understory vegetation. The most profound shift is the proliferation of invasive shrubs, which is also supported by previous data collected at the Preserve (Adams et al. 2002). Glossy and common buckthorn, bush honeysuckle, and gray dogwood occupy a high density in the understory (Table 11, Figure 4a,b). This density suppresses the regeneration of oaks, both through shade and perhaps through allelopathy (Seltzner and Eddy 2003). Managed systems, whether for timber production (Lee and Kost 2008) or restoration (Laatsch and Anderson 2000) have higher oak regeneration and reductions in these shrub species. A valuable perspective may be gained by comparing the oak forests of northern Michigan with those in the south. Oak systems in southern Michigan are more productive, leading to greater competition and less regeneration (Lee and Kost 2008). They suffer more deer browse, which is negatively correlated with oak regeneration (Lee and Kost 2008), and

suffer from greater stand isolation and therefore are more separated from new propagules (acorns). Because of the higher population density in southern Michigan, the proximity to the nearest stand of oak trees is replaced by a proximity to invasive species such as glossy and common buckthorn, bush honeysuckle, Oriental bittersweet and common privet (*Ligustrum vulgare*) that proliferate the urban and suburban landscape.

Wetlands

Wetland hydrology at the Preserve is influenced by numerous seeps and springs (Map 9). These have been impacted by alterations to the surrounding landscape (e.g., reduced groundwater recharge from impervious surfaces) and within the Preserve (e.g., raising the level of Asylum Lake) (Keiser and Associates 2008). Larger sedge meadows and a diversity of species still persist, though only in pockets (Map 9).

Sedge (*Carex pellita*) in sedge meadow (Coastal)

The shores of Asylum Lake grade slowly toward adjacent slopes. The moist sand in this intermediate zone may have once supported a wet-mesic prairie before the lake level was raised and shrubs such as glossy buckthorn, willow, and dogwood invaded. Some indicator species include sedge (*Carex pellita*), tall thimbleweed (*Anemone virginiana*), and blue-joint grass. Shrubs and trees dominate in these intermediate areas as well as in the wetlands themselves. A small band of hardwood swamp occurs along the south shore of Asylum Lake on wet silty clay loam, supporting black willow, walnut, and red oak. Willow, dogwood, glossy buckthorn, poison sumac, and common elderberry (*Sambucus canadensis*) form dense thickets in the muck soils that support pockets of sedge meadow. The spread of shrubs in sedge meadow is a product of natural succession, but can be exacerbated by modified hydrology and/or fire suppression (Kost and DeSteven 2000). Shrub canopy cover in transects averaged 26.5% (range 0-80%) (Table 16a), but the shading effects of cattails should not be underestimated.

Pockets of Sedge Meadow

Sedge (*Carex prairea*) in sedge meadow (Coastal)

Wet Meadow and Marsh are physiognomically dominated by native perennial forbs, mostly less conservative species such as Canada goldenrod, smooth swamp aster, Joe-pye weed, and cinnamon willow herb. The most dominant species is the sedge meadow dominant, tussock sedge, although purple loosestrife and cattails are also dominant (Table 16a) and a large nearly monospecific patch of common reed on the west end of Marsh is steadily expanding (P. MacNellis, WMU Landscape Services, pers. comm.). Tussock sedge is an important structural component of sedge meadows. Its tussocks provide surface area for the establishment of other species whereas invasive species such as reed canary grass do not (Werner and Zedler 2002). Other species typically co-dominant in sedge meadows are also prevalent, including blue-joint grass, smooth swamp aster, sedge (*Carex aquatilis*) and marsh fern (Kost 2007). Additional species typical of sedge meadow are present, though at lower cover, such as Virginia mountain mint (*Pycnanthemum virginianaum*), bog buckbean, spike rush,

purple gerardia, and at least ten additional sedge species (*Carex longii, C. prairea, C. leptalea, C. bebbii, C. comosa, C. hystericina, C. lacustris, C. pellita, C. sterilis* and *C. sartwellii*) (Appendix 1)

The diversity of the wetlands is largely extant, but is threatened by invasive species and hydrological modifications. While reversal of the various hydrological modifications is unlikely, and resultant effects of siltation and nutrient enrichment will continue to encourage invasive species (cattails and common reed) and upset the nutrient balance in the wetlands, action can be taken to reduce the current cover of invasive species. This is especially important in areas adjacent to extant sedge meadow pockets. Areas of strong groundwater discharge, or seeps, often serve to maintain species composition and community structure despite these perturbations. Seeps saturate the soil with bicarbonate salts producing an alkaline environment, and they support populations of many conservative species such as purple gerardia, bog buckbean, and whorled loosestrife.

Between the two large wetlands at the Preserve, Wet Meadow comprises the most exemplary native wetland community. It has the highest native species richness, FQI, and mean C, not only between wetlands, but at the Preserve as a whole (Appendix 3, Table 15).

Prairie/Savanna Reconstruction

Floristic quality in planted prairies generally increases with age (Taft et al. 2006). The reconstruction already supports many grassland birds, but the plant species distribution is very uneven and is dominated overwhelmingly by adventive species in many areas (Tables 13, 14b).

Dominance and Structure

Dominance in Prairie and Savanna I is either by adventive species or by dense prairie grasses (primarily big bluestem) (Table 14b). Remnant prairies are typically dominated more evenly by forbs and grasses (Leach and Givnish 1999, Bacone et al. 2007). Forbs and shorter grasses such as prairie dropseed provide a diversity of structure and less dense cover, which increases the habitat heterogeneity and thus the diversity of grassland bird species. For example, Henslow's Sparrow and Sedge Wren prefer the dense cover of tall grasses and Horned Lark prefer the sparse cover of short grasses (Vickery et al. 2009). Some birds prefer moderate shrub cover and others require stout forb stems for foraging and singing perches (Swanson 1996). A diversity of forbs support a diversity of insect species, which provides more food for birds, especially in rearing young (Tallamy 2007). The stand of switchgrass, in Prairie Unit 1 (Map 4), low in forb diversity and very dense, is a testament to this effect. Alone, it only supported six bird species, all of which are habitat generalists.

The floristic quality of the reconstructions are low, in part due to low species diversity despite the presence of conservative native species with high C-values. Additionally, numerous weedy adventive species were introduced during many years of cultivation and still persist.

Native vs. Adventive Species

Dominance by natives is patchy and percent of native species is only 54.0% in Prairie and 58.6% in Savanna I (Table 5). Therefore, a goal should be to shift this dominance toward a higher native species richness. The history of disturbance suggests that there is a seedbank of weedy adventive species which will continue to flourish. Red clover and quackgrass are especially challenging, and occupy large areas within the reconstructions (Table 14a). Overall, the trajectory of the development of the

reconstruction is at best stable, but will likely trend toward an increase in adventive species cover without a drastic management intervention.

ACKNOWLEDGEMENTS

We would like to thank Cari DeLong, Paul MacNellis, Dan List and the rest of the WMU's Landscape Services staff for providing GIS assistance and historical information about the Preserve. Mark Miller provided invaluable statistical support in planning and analyzing the vegetation monitoring. The level of analysis found in this report would not have been possible without him. Ray Adams, John Brenneman, and Torrey Moss of the Kalamazoo Nature Center graciously provided data and insights on regional avian population trends. Mark Hoffman and Richard Brewer provided documents and insights regarding the cultural and biological history of the Preserve. Adam Lenz assisted with the fieldwork. Of Native Connections, we thank Betsy Skare for help with bird surveys and suggestions on this report, and Jerry Stewart for recommendations on the management of the Preserve. Finally, we thank the Asylum Lake Policy and Management Council for their support and wish them good luck managing to the Preserve.