BOTANICAL ASSESSMENTS OF HIGH-QUALITY SOUTHERN SHRUB-CARR AND HARDWOOD SWAMP WETLANDS IN THE UNDEVELOPED LOWELL REGIONAL GREENSPACE, KENT COUNTY, MICHIGAN

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ABSTRACT

The 2019–2023 Masterplan for Kent County Parks includes the future development of acquired properties that have been designated as the Lowell Regional Greenspace (528 acres), occupying nearly the entirety of Section 22 of Lowell Charter Township in Kent County, Michigan. Four wetlands located in the same drainage basin along Karen Creek in the Lowell Regional Greenspace were inventoried for floristic quality assessments during the summers of 2016, 2018, 2019, and 2021. One of the wetlands was forested and determined to be a southern hardwood swamp community type. The other three wetlands are best classified as shrub-carr communities. In the southern hardwood swamp, we recorded 94 species, of which 87 (92%) are native. A total of 321 species were documented in the three shrub-carrs wetlands combined. The number of species in each shrub-carr site, ranging from 172 to 238, is roughly twice that for the southern hardwood swamp site. Two of the species documented are listed as Special Concern in Michigan, and two are new county records for Kent County, Michigan. A non-metric multidimensional scaling model (NMDS) was run to spatially compare similarities and differences among the sites. The Sørensen Index of Similarity, which was employed to further discern differences between pairs of individual sites, was also useful for assigning plant community types as described by the Michigan Natural Features Inventory (2016). The Floristic Quality Assessments indicate that all four of the wetlands are floristically important statewide; furthermore, the three shrub-carr communities have exceptional conservation value. We discovered that the three shrub-carr sites have a high degree of similarity in their species assemblages, whereas the southern hardwood swamp was markedly different. The high richness and significant floristic quality of the shrub-carr sites highlight the conservation value of these often-overlooked habitats. This study underscores the importance of preserving even small tracts of persisting remnant natural habitats. Our research should be of use to Kent County Parks as they approach development of the Lowell Regional Greenspace into a multiple-use recreational space, as well as to those interested in learning more about how to assess and compare habitat quality of remnant natural areas.

KEYWORDS: Michigan flora, biodiversity, shrub-carr, southern hardwood swamp, Floristic Quality Assessment, floristic inventory.

INTRODUCTION

A legal wetland definition provided by the U. S. Army Corps of Engineers (1987) states: “Those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in

saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas." Although formal definitions have been developed by scientists and federal agencies, Mitsch and Gosselink (2015) note that the ecotonal nature between terrestrial and aquatic systems renders wetlands not easily defined. Furthermore, the wetland delineation manual prepared by the U. S. Army Corps of Engineers (1987, 2012) states that the definition of the term "wetland" is, of necessity, a broad term and notes that the wetland delineation manual does not specifically function as a classification system of wetland communities.

Defining a specific wetland community can be challenging because wetlands encompass a variety of ecosystems that do not always segregate easily. In the Great Lakes Region, forested wetlands range from bottomland hardwood swamps to floodplain forests to conifer swamps. Open, non-forested wetlands are abundant and diverse, ranging from acidic bogs to wet meadows, marshes and calcareous fens. Ecologically positioned somewhere between these extremes are wetlands that are dominated by shrubs. The nomenclature itself for shrub-dominated wetlands can be confusing (Curtis 1959; Davis 1979; Jenik and Vetvicka 2002; Jenik et al. 2002). Of the 28 wetland communities listed by the Michigan Natural Features Inventory, three are shrubby wetlands, each of which is given a different habitat name: inundated shrub swamp, northern shrub thicket, and southern shrub-carr (Cohen et al. 2015). In this paper we use the term "shrub-carr" to refer to shrub-dominated wetlands, and we use the term "swamp" to refer to wetlands that are dominated by trees.

Another source of confusion is that species assemblages can vary widely even within a particular wetland community type (Jolman et al. 2019). This is certainly true of shrub-carrs, where the dominant woody species can differ between individual sites. In northern latitudes, shrub-carrs are often dominated by speckled alder (*Alnus incana*). Elsewhere shrub-carrs can support a shrub matrix dominated by species of *Salix* (including *Salix cinerea*, *S. discolor*, and/or others) or *Cornus* (including *Cornus amomum*, *C. racemosa*, and/or *C. sericea*), and some shrub-carrs are populated by a mixture of shrubby species without a clear dominant. Secondary woody species in shrub-carrs may include black chokeberry (*Aronia prunifolia*), bog birch (*Betula pumila*), spicebush (*Lindera benzoin*), wild black currant (*Ribes americanum*), American red raspberry (*Rubus strigosus*), elderberry (*Sambucus canadensis*), poison sumac (*Toxicodendron vernix*), highbush blueberry (*Vaccinium corymbosum*), nannyberry (*Viburnum lentago*), or the non-native glossy buckthorn (*Frangula alnus*) (Eggers and Reed 2015; Crum 1992; Davis 1979; Cohen et al. 2015; Květ et al. 2002).

Additionally, shrub-carrs are often habitats in flux, involved in the slow process of transitioning from more open sedge meadows or fens into shadier, woody-dominated habitats (Curtis 1959; Jeník and Větvická 2002; Jeník et al. 2002; White 1965). The successional stage of a site will influence the density of the shrub layer, the availability of light, and moisture conditions. These factors will in turn affect the richness and composition of the herbaceous matrix (Eggers and Reed 2015; White 1965). Typically, a combination of wetland ferns, forbs, vines, grasses, and sedges contribute to a shrub-carr groundcover. The wide variability of environmental conditions that are possible in even a single shrub-carr can contribute to high floristic richness in these communities, particularly in

shrub-carrs that have experienced minimal direct human disturbance (Curtis 1959; Eggers and Reed 2015; White 1965).

Although variability is inherent among shrub-carr communities, a general definition is that these are wetlands dominated by tall, deciduous shrubs reaching an average height of 1.5–3.0 meters (Eggers and Reed 2015; Cohen et al. 2015). They usually occur on either saturated or seasonally flooded soils and are impacted by fluctuating water levels (Cohen et al. 2015; Květ et al. 2002). Shrubs usually account for more than 50 percent of the cover in shrub-carrs, in some sites reaching as high as 95 percent (Curtis 1959; Cohen et al 2015). The herbaceous vegetation in shrub-carrs includes a combination of heliophytic wet meadow and shade-tolerant species (Curtis 1959).

Most shrub-carrs are ecosystems that have been subjected to and influenced by disturbance (Ruch et al. 2009). Authors have historically disagreed about the relative importance of disturbance in shrub-carrs and whether these communities are naturally occurring or if they appear only in the aftermath of disturbance. Indeed, fire suppression and wetland drainage have both been associated with advancing the presence of shrubs in otherwise herbaceous wetlands such as sedge meadows or fens (Warners 1989, 1997; Eggers and Reed 2015). Other studies have documented that repeated disturbances like grazing or mowing also promote shrub cover (Middleton 2002; Jeník and Větvická 2002; Jeník et al. 2002). And yet, whatever their origin, shrub-carrs are relatively common ecological features in the Great Lakes region and can serve as important refuges for native biodiversity.

The purpose of this paper is to document and compare four wetlands that occur in close proximity along Karen Creek in Lowell Township, Kent County, Michigan. Three of these wetlands fit the above definition of shrub-carr, and the fourth is clearly a southern hardwood swamp, dominated by silver maple (*Acer saccharinum*). The property containing three of these wetlands was recently acquired by the Kent County Parks Department as the Lowell Regional Greenspace, and the fourth is part of the Land Conservancy of West Michigan's B. D. White Preserve. All four wetlands are less than four hectares in size (Table 1). By conducting thorough floristic inventories of each wetland, assessing similarities and differences in their species assemblages, and calculating metrics of floristic quality for each wetland, we aim to contribute a better understanding of the shrub-carr association in Michigan. Additionally, we aim to demonstrate the contribution that these wetland types make to the state's native biodiversity and highlight the similarities and differences among shrub-carrs and between shrub-carrs and a southern hardwood swamp. Furthermore, this work will generate management considerations for the Kent County Parks Department and others who are tasked with managing shrub-carr habitats.

MATERIALS AND METHODS

General Site Description

The Kent County Parks Masterplan 2019–2023 (Kent County Parks 2021) includes development and further acquisition of properties occupying nearly the entirety of section 22 in Lowell Charter Township (Warners et al. 2021). This currently undeveloped land, referred to as the Lowell Regional

TABLE 1. Floristic Quality Assessment metrics for the four wetland sites. Data for the B. D. White Shrub-Carr from Stockdale et al. (2019) combined with unpublished data from J. Heslinga, Land Conservancy of West Michigan.

Site Name (Wetland Community Type)	Area hectares (acres)	Total FQI	Native FQI	Total Mean *C*	Native Mean C	Number of Species	Number of Native Species (percentage)	Number of Non-Native Species (percentage)
Silver Maple Swamp (Southern hardwood swamp)	1.33 ha (3.28)	36.8	38.2	3.8	4.1	94	87 (92.6%)	8 (7.4%)
East Wetland (Southern shrub-carr)	1.68 ha (4.15)	52.5	55.8	4.0	4.5	172	154 (89.5%)	18 (10.5%)
West Wetland (Southern shrub-carr)	3.71 ha (9.18)	63.3	65.4	4.1	4.4	238	221 (92.9%)	17 (7.1%)
B. D. White Shrub-Carr (Southern shrub-carr)	3.48 ha (8.59)	55.4	56.3	4.0	4.2	192	180 (93.8%)	12 (6.3%)

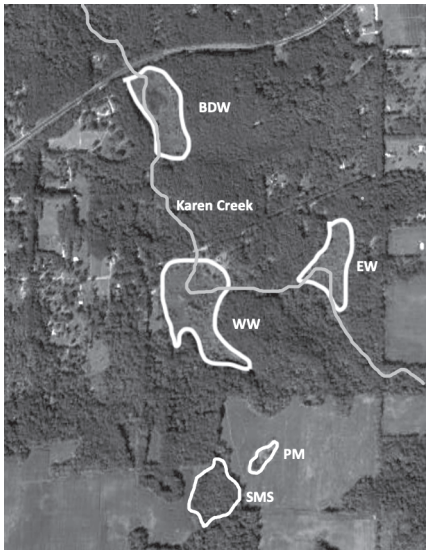

FIGURE 1. Lowell Regional Greenspace wetlands: EW = East Wetland (southern shrub-carr); WW = West Wetland (southern shrub-carr); SMS = Silver Maple Swamp (southern hardwood swamp forest); PM = Prairie Pond/Marsh. Bradford Dickinson White Preserve wetland: BDW = B. D. White Shrub-Carr (southern shrub-carr). (Image: 9/25/2014; source: Google Earth).

Greenspace, is bounded on the north by 36th Street, on the south by Cascade Road, on the east by Segwun Avenue, and on the west by Alden Nash Avenue. The property is contiguous to the B. D. White Preserve, located on the north side of 36th Street and owned and actively managed by the Land Conservancy of West Michigan. The B. D. White Preserve has an extensive southern shrub-carr (which we will refer to as the B. D. White Shrub-Carr; Figure 1: BDW), fed by the same stream, Karen Creek, that flows through the Lowell Regional Greenspace. This downstream shrub-carr was inventoried in 2016 and described and reported in our earlier study (Stockdale et al. 2019). It is included in the current assessment because it is part of the same drainage system as the wetlands in the Lowell Regional Greenspace. The other three wetlands included in this assessment are as follows.

The East Wetland (Figure 1: EW) lies toward the northeastern portion of the Lowell Regional Greenspace property. This wetland is situated in a broad basin and is fed by seepage as well as by Karen Creek, which flows into the basin from a steep-sided ravine after originating approximately 0.5 km upstream from springs and seeps. The creek meanders northward through the southern portion of East Wetland, then flows westward, exiting the wetland and flowing through a wooded parcel known as North Woods before entering West Wetland (Warners et al. 2021).

The West Wetland (Figure 1: WW) is bordered on its north end by 36th Street. This open shrubby wetland is fed by Karen Creek and by springs that emerge from the base of a steep slope that supports a track of old growth forest. There are also intermittent tributaries that flow off other surrounding wooded slopes, contributing surface flow to the wetland especially during rain events. Karen Creek enters West Wetland on the east side, and eventually meanders to the north. The creek then crosses under 36th Street via a culvert, flowing northward into the B. D. White Preserve. After passing through forested areas for about 0.5 km, the creek enters B. D. White Shrub-Carr (see Stockdale et al. 2019).

The Silver Maple Swamp (Figure 1: SMS), a southern hardwood swamp dominated by silver maple trees (*Acer saccharinum*), is curiously perched about 30 m higher in elevation than the Karen Creek lowlands. This swamp is located approximately 0.25 km due south of West Wetland and is situated between two mature upland hardwood forests. This ecosystem is likely underlain by an impervious clay lens or hardpan, above which has accumulated a relatively thin layer of muck (Cohen et al. 2015). On each of our visits (7 times in 2021 alone) this site had standing water. The large trees, both standing and fallen, together with a rich assemblage of ferns and mosses give it a primeval appearance. We included this wetland in our assessment both to offer a contrast to the nearby East Wet-

land and West Wetland and to provide a detailed description for Kent County Parks as they make plans to manage all of these natural areas.

Botanical Inventory

During the growing seasons of mid-March through mid-September of 2018, 2019, and 2021, botanical inventories were conducted to assess the wetlands in the Lowell Regional Greenspace. Sampling protocol for all sites was a meander-search throughout, conducted multiple times over the course of the three growing seasons. All species encountered were documented by voucher herbarium specimens or recorded as photo or sight records. During each visit all species in flower or fruit were identified primarily using Voss and Reznicek (2012), as well as Barnes and Wagner (2004), Crow and Hellquist (2000a, 2000b), and the Internet online sources MICHIGAN FLORA ONLINE (2011) and keys at Go Botany (Native Plant Trust 2019). Identifications and nomenclature follow that of MICHIGAN FLORA ONLINE (2011), as this source includes both seed plants, based on Voss and Reznicek (2012) and pteridophytes, based on Palmer (2019); the online source is periodically updated with taxonomic and nomenclatural changes. A total of 540 herbarium voucher specimens documenting the study were deposited in the Calvin University Herbarium (CALVIN), and duplicates are deposited in the herbaria of Michigan State University (MSC) and/or University of Michigan (MICH). A similar approach was used to inventory the B. D. White Shrub-Carr in 2016, with details described in Stockdale et al. (2019).

Floristic Quality Assessments

Floristic Quality Assessments provide useful metric-based measures to evaluate habitat conservation priorities and have become increasingly influential in North America over the past 20 years (Spyreas 2019). Floristic Quality Assessments are based on the *C*-value of each species in the area under investigation. Plants with *C*-values of 8–10 (high *C*-values) have a very strong affinity to a narrow range of undisturbed ecological conditions, whereas *C*-values of 0–2 are associated with more widespread, disturbance-tolerant species that can be found growing in a wide range of habitats. A Floristic Quality Index (FQI) provides a reliable estimate of the natural quality of an area and can be used to compare the ecological integrity of different landscapes (Bried et al. 2013). The Universal FQA Calculator (https://universalfqa.org/) (Freyman et al. 2015) generates both a Native FQI and a Total FQI, the former based only on the native species that are present and the latter based on both native and non-native species combined. Inclusion of non-native species (*C*-values = 0) results in a Total FQI which is lower than the Native FQI; the difference between the two indicates the relative impact of non-native species. Herman et al. (2001) have set FQA thresholds, suggesting that sites with Native FQI thresholds of 35 or higher are generally valued as floristically important statewide. FQI scores greater than 50 suggest exceptional sites that exhibit extremely high conservation value.

The Universal FQA Calculator (Freyman et al. 2015) also generates a Mean *C*-value, the average *C*-value for all species within the site assessed, including non-native species, and is then referred to as the Total Mean *C*. A Native Mean *C* is also calculated, reflective of the site's native species richness. These FQA metrics are used variously by state and federal agencies and conservation organizations to evaluate natural areas and inform land management strategies. The Native Mean *C* for the entire state of Michigan is 6.5, based on 1814 native species (2912 spp. total) (Reznicek et al., 2014). Matthews et al. (2005) and Slaughter et al. (2015), while recognizing that a site's FQI values are useful, feel that the Mean *C*-value represents a less biased indicator of relative conservation value. We have found both metrics to be helpful for practitioners involved in ecological integrity assessments, so we provide both in this report.

Non-metric Multidimensional Ordination (NMDS)

A non-metric multidimensional scaling model (NMDS) was run on presence/absence floristic data to spatially analyze similarities and differences among the four wetlands. Jaccard's dissimilarity metric is especially helpful in comparing binary data. To run the NMDS, R version 4.4.1 (R Core Team 2020) was used with the package's vegan (Oksanen et al. 2020) and MASS (Venable and Ripley 2002) options. The ordination was created using the ggplot2 (Wickham 2016) and cowplot (Wilke 2020) packages. A post-hoc test was not run because the data were binary (either present or absent) and there were no groupings except by sites.

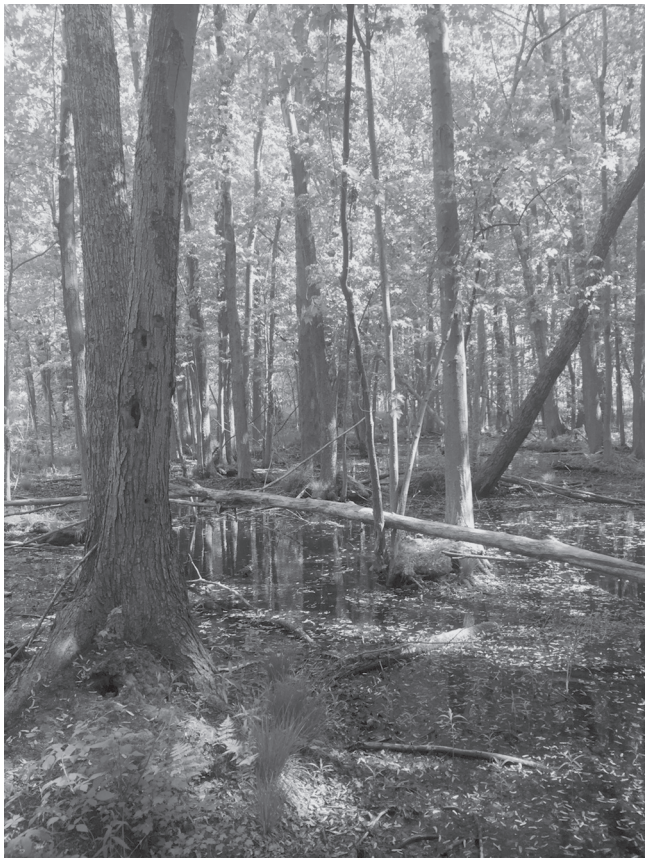

FIGURE 2. Silver Maple Swamp showing pool with hummocks and wet margins. Photo by Garrett E. Crow.

Similarity Index

In addition to the Jaccard's dissimilarity ordination described above, we used the Sørensen Index of Similarity (Mueller-Dombois and Ellenberg 1974) to quantitatively compare the floristic lists of each pair among the four wetland sites. This assessment allowed us to evaluate whether these floristic lists effectively describe the same wetland habitat type, especially with respect to the three shrub-dominated wetlands. The Sørensen Index between two sites is calculated as follows:

$$\text{Sørensen Index} = [2C \div (A+B)] \times 100\%,$$

where C is the number of shared species between the two sites, and A and B are the numbers of species in the first and second site, respectively. An Index value of 50% or more indicates that the two sites are likely the same plant community type (Curtis 1959; Bradley and Crow 2010).

RESULTS AND DISCUSSION

Individual Site Assessments

Silver Maple Swamp (42°53.595′N, 85°21.483′W):

This site (Figure 2) is different from the other three sites in being a forested wetland (1.33 ha or 3.28 acres), best fitting the classification of southern hardwood swamp (Cohen et al. 2015). It is dominated by silver maple (*Acer saccharinum*) along with a lesser presence of red maple (*Acer rubrum*) as well as scattered individuals of American ash (*Fraxinus americana*) and red ash (*F. pennsylvanica*). Virginia creeper (*Parthenocissus quinquefolia*) and poison-ivy (*Toxicodendron radicans*) were in abundance, covering many of the hummocks, while the intermittent pools were well-populated by the sedge, *Carex bromoides* (Figure 3).

FIGURE 3. Silver Maple Swamp showing dominant sedge tussocks of *Carex bromoides* on border of swamp pool. Photo by Garrett E. Crow.

TABLE 2. Species of the Silver Maple Swamp (southern hardwood swamp).

Acer rubrum	*Fagus grandifolia*	*Prunus serotina*
Acer saccharinum	*Floerkea proserpinacoides*	*Prunus virginiana*
Agrimonia gryposepala	*Fraxinus americana*	*Ranunculus recurvatus*
Alliaria petiolata	*Fraxinus pennsylvanica*	*Ribes americanum*
Amelanchier laevis	*Galium aparine*	*Ribes cynosbati*
Amphicarpaea bracteata	*Galium tinctorium*	*Rosa multiflora*
Arisaema triphyllum	*Geranium maculatum*	*Rosa palustris*
Bidens connata	*Geum canadense*	*Rubus allegheniensis*
Boehmeria cylindrica	*Glyceria striata*	*Rubus occidentalis*
Cardamine bulbosa	*Impatiens capensis*	*Rubus pubescens*
Carex blanda	*Iris virginica*	*Rubus setosus*
Carex bromoides	*Leersia virginica*	*Salix alba*
Carex cristatella	*Lemna minor*	*Salix exigua*
Carex disperma	*Lindera benzoin*	*Sambucus canadensis*
Carex echinata	*Liriodendron tulipifera*	*Sassafras albidum*
Carex gracillima	*Lycopus americanus*	*Scirpus atrovirens*
Carex interior	*Lysimachia thyrsiflora*	*Scutellaria lateriflora*
Carex leptalea	*Maianthemum canadense*	*Sium suave*
Carex lupulina	*Maianthemum stellatum*	*Solanum dulcamara*
Carex stipata	*Mitella diphylla*	*Solidago caesia*
Carpinus caroliniana	*Nyssa sylvatica*	*Symphyotrichum lanceolatum*
Carya ovata	*Onoclea sensibilis*	*Symplocarpus foetidus*
Cephalanthus occidentalis	*Osmunda regalis*	*Taraxacum officinale*
Cinna arundinacea	*Osmundastrum cinnamomeum*	*Tilia americana*
Circaea canadensis	*Parthenocissus quinquefolia*	*Toxicodendron radicans*
Cornus florida	*Persicaria virginiana*	*Urtica dioica*
Dioscorea villosa	*Phalaris arundinacea*	*Vaccinium corymbosum*
Dryopteris carthusiana	*Platanthera clavellata*	*Viola sororia*
Dryopteris intermedia	*Poa compressa*	*Vitis riparia*
Elaeagnus umbellata	*Podophyllum peltatum*	*Zanthoxylum americanum*
Epilobium coloratum	*Prenanthes altissima*	
Erythronium americanum	*Prunella vulgaris*	

A total of 94 species (Table 2), 87 (92.6%) of which are native, were found in this wetland. The Floristic Quality Assessment (Table 1) yielded a Total FQI of 36.8, a Native FQI of 38.2, and a Total Mean *C* of 3.8. These metrics indicate that this relatively small wetland is floristically important statewide—an important component of Michigan's native biodiversity. Yet only five species had high *C*-values of 8-10 (Table 3).

As is typical with this type of swamp, there was an abundance of royal fern (*Osmunda regalis*) and cinnamon fern (*Osmundastrum cinnamomeum*), especially on hummocks and along water edges in the swamp. Southern blue flag (*Iris virginica*), tufted loosestrife (*Lysimachia thyrsiflora*), and skunk-cabbage (*Symplocarpus foetidus*) were also present and locally abundant, as were false nettle (*Boehmeria cylindrica*), wood reedgrass (*Cinna arundinacea*), fowl manna grass (*Glyceria striata*), white grass (*Leersia virginica*), common water horehound (*Lycopus americanus*), reed canary grass (*Phalaris arundinacea*), and water-parsnip (*Sium suave*). Wetland sedges, besides the dominant *Carex bromoides*, included *C. cristatella*, *C. echinata*, *C. gracillima*, *C. interior*, *C. leptalea*, *C. lupulina*, and *C. stipata*. Scattered shrubs of buttonbush (*Cephalan-*

TABLE 3. Species having a C-value of 8–10, indicating a high level of fidelity to a narrow range of undisturbed ecological conditions. An X indicates the presence of a species in that site.

Species	C-value	West Wetland	East Wetland	B. D. White Shrub-Carr	Silver Maple Swamp
Carex disperma	10				X
Carex formosa	10		X		
Carex prairea	10	X	X	X	
Carex prasina	10	X			
Conioselinum chinense	10		X		
Cuscuta campestris	10	X			
Lysimachia quadriflora	10	X			
Micranthes pensylvanica	10	X	X	X	
Muhlenbergia glomerata	10	X			
Pedicularis canadensis	10	X		X	
Valeriana uliginosa	10	X			
Carex tetanica	9	X	X		
Cypripedium reginae	9	X	X	X	
Deschampsia cespitosa	9				
Liriodendron tulipifera	9				X
Nyssa sylvatica	9				X
Poa alsodes	9	X		X	
Rudbeckia fulgida	9	X	X		
Rumex orbiculatus	9	X	X	X	
Salix myricoides	9	X	X	X	
Carex cryptolepis	8	X	X		
Carex lasiocarpa	8	X			
Chimaphila umbellata	8			X	
Cornus florida	8				X
Dasiphora fruticosa	8	X	X	X	
Dryopteris clintoniana	8		X		
Elymus riparius	8	X	X		
Elymus trachycaulus	8	X			
Hypericum ascyron	8	X			
Lysimachia quadrifolia	8	X	X		
Milium effusum	8	X	X		X
Mitella diphylla	8	X			
Pedicularis lanceolata	8	X	X	X	
Quercus bicolor	8			X	
Quercus palustris	8			X	
Rhamnus alnifolia	8	X	X	X	
Salix serissima	8	X		X	
Veronicastrum virginicum	8	X			
Viola nephrophylla	8				
Totals		26	18	14	5

thus occidentalis), spicebush (*Lindera benzoin*), swamp rose (*Rosa palustris*), and sandbar willow (*Salix exigua*) were present as well. Late summer plants included tall white lettuce (*Prenanthes altissima*), bulrush (*Scirpus atrovirens*), bluestem goldenrod (*Solidago caesia*), and panicled aster (*Symphyotrichum lanceolatum*).

Because this swamp lies between two mesic southern forests (Figure 1) (Warners et al. 2021), we encountered a spring flora in May that occurs along

FIGURE 4. East Wetland, southern shrub-carr habitat, with David Warners and Lucas Walker. Photo by Haley R. Weesies.

parts of the outer margin and on some hummocks in the swamp interior, including tall agrimony (*Agrimonia gryposepala*), yellow trout lily (*Erythronium americanum*), false mermaid (*Floerkea proserpinacoides*), wild geranium (*Geranium maculatum*), Canada mayflower (*Maianthemum canadensis*), starry false Solomon-seal (*Maianthemum stellatum*), Bishop's-cap (*Mitella diphylla*), hooked crowfoot (*Ranunculus recurvatus*), and common blue violet (*Viola sororia*).

East Wetland (42°54.055′N, 85°21.180′W):

This open, shrubby wetland (Figure 4) of 1.68 ha (4.15 acres), with its saturated mucky substrate and dominance of dogwoods (*Cornus* spp.) and willows (*Salix* spp.), best fits the Michigan Natural Features Inventory's southern shrub-carr community type (Cohen et al. 2015). A total of 172 species (Table 4), 154

TABLE 4. Comparison of species occurring in the three southern shrub-carr wetlands. Data for the B. D. White Shrub-Carr is from Stockdale et al. 2019 combined with unpublished data from J. Heslinga, Land Conservancy of West Michigan.

Species	East Wetland	West Wetland	B. D. White Shrub-Carr
Acer rubrum L. red maple	X	X	X
Achillea millefolium L. yarrow		X	
Actaea rubra (Aiton) Willd. red baneberry	X	X	
Adiantum pedatum L. maidenhair fern	X		
Agrimonia gryposepala Wallr. tall agrimony	X	X	
Agrostis stolonifera L. creeping bent		X	
Alliaria petiolata (M. Bieb.) Cavara & Grande garlic mustard	X		
Amphicarpaea bracteata (L.) Fernald hog peanut	X	X	X
Anemone canadensis L. Canada anemone	X	X	X
Anemone virginiana L. thimbleweed	X		
Angelica atropurpurea L. purplestem angelica	X	X	X
Apios americana Medik. Indian-potato	X	X	X
Apocynum cannabinum L. Indian-hemp	X	X	
Aquilegia canadensis L. wild columbine		X	
Arisaema triphyllum (L.) Schott Jack-in-the-pulpit	X	X	X
Asarum canadense L. wild ginger	X		
Asclepias incarnata L. swamp milkweed	X	X	X
Asclepias syriaca L. common milkweed	X	X	X
Athyrium filix-femina (L.) Roth lady fern	X	X	X
Barbarea vulgaris R. Br. yellow rocket		X	
Berberis thunbergii DC. Japanese barberry			X
Bidens cernua L. nodding beggar-ticks			X
Boehmeria cylindrica (L.) Sw. false nettle		X	X
Bromus ciliatus L. fringed brome	X	X	X
Bromus pubescens Willd. Canada brome	X		

(*Continued on next page*)

TABLE 4. (*Continued*).

Species	East Wetland	West Wetland	B. D. White Shrub-Carr
Calamagrostis canadensis (Michx.) P. Beauv. blue-joint	X	X	X
Caltha palustris L. marsh marigold	X	X	X
Campanula aparinoides Pursh marsh bellflower		X	X
Cardamine bulbosa Muhl.) Britton, Sterns & Poggenb. spring cress	X	X	X
Cardamine concatenata Michx.) O. Schwarz cut-leaved toothwort		X	
Cardamine pensylvanica Willd. Pennsylvania bitter cress			X
Carex annectens (E. P. Bicknell) E. P. Bicknell sedge		X	
Carex aquatilis Wahlenb. sedge			X
Carex bebbii (L. H. Bailey) Fernald sedge		X	X
Carex blanda Dewey sedge		X	
Carex bromoides Willd. sedge	X	X	X
Carex cephalophora Willd. sedge			X
Carex comosa Boott sedge	X		
Carex crinita Lam. sedge	X	X	X
Carex cristatella Britton sedge		X	X
Carex cryptolepis Mack. sedge	X	X	
Carex davisii Schwein. & Torr. **Special Concern** Davis' sedge	X		
Carex gracillima Schwein. sedge	X	X	X
Carex grayi J. Carey sedge	X	X	
Carex grisea Wahlenb. sedge	X	X	
Carex hirtifolia Mack. sedge	X	X	
Carex hystericina Willd. sedge	X	X	X
Carex interior L. H. Bailey sedge	X	X	
Carex lacustris Willd. sedge	X	X	X
Carex leptalea Wahlenb. sedge	X	X	X
Carex lupulina Willd. sedge	X		

(*Continued on next page*)

TABLE 4. (*Continued*).

Species	East Wetland	West Wetland	B. D. White Shrub-Carr
Carex lurida Wahlenb. sedge		X	
Carex normalis Mack. sedge	X		
Carex pellita Willd. sedge	X	X	X
Carex prairea Dewey sedge	X	X	X
Carex prasina Wahlenb. sedge		X	
Carex stipata Willd. sedge	X	X	X
Carex stricta Lam. sedge	X	X	X
Carex tetanica Schkuhr sedge	X	X	
Carex vulpinoidea Michx. sedge	X		X
Carpinus caroliniana Walter blue-beech	X	X	
Celastrus orbiculatus Thunb. oriental bittersweet	X		
Chelone glabra L. turtlehead		X	X
Chimaphila umbellata (L.) Nutt. pipsissewa			X
Cicuta bulbifera L. water hemlock	X		X
Cicuta maculata L. water hemlock	X	X	X
Cinna arundinacea L. wood reedgrass		X	X
Circaea canadensis (L.) Hill enchanter's nightshade	X	X	X
Cirsium muticum Michx. swamp thistle	X	X	X
Claytonia virginica L. spring beauty		X	X
Clematis virginiana L. virgin's bower	X	X	X
Conioselinum chinense (L.) Britton, Sterns & Poggenb. hemlock-parsley	X		
Conium maculatum L. poison hemlock	X		
Cornus amomum Mill. silky dogwood	X	X	X
Cornus foemina Mill. gray dogwood	X	X	X
Cornus sericea L. red-osier	X	X	X
Corylus americana Walter hazelnut	X	X	X

(*Continued on next page*)

TABLE 4. (*Continued*).

Species	East Wetland	West Wetland	B. D. White Shrub-Carr
Cryptotaenia canadensis (L.) DC. honewort	X	X	X
Cuscuta campestris Yuncker **Special Concern** field dodder		X	
Cuscuta gronovii Roem. & Schult. common dodder			X
Cypripedium reginae Walter showy lady slipper	X	X	
Dactylis glomerata L. orchard grass		X	
Dasiphora fruticosa (L.) Rydb. shrubby cinquefoil	X	X	X
Dichanthelium clandestinum L.) Gould panic grass	X		
Deschampsia cespitosa (L.) P. Beauv. hair grass			X
Desmodium canadense (L.) DC. showy tick-trefoil		X	
Diervilla lonicera Mill. bush honeysuckle		X	
Dioscorea villosa L. wild yam	X	X	X
Doellingeria umbellata (Mill.) Nees flat-topped white aster	X	X	
Dryopteris clintoniana (D. C. Eaton) Dowell Clinton's woodfern	X		
Dryopteris cristata (L.) A. Gray crested shield fern	X	X	X
Dryopteris intermedia (Willd.) A. Gray evergreen woodfern	X		
Elaeagnus umbellata Thunb. autumn olive	X	X	
Eleocharis erythropoda Steud. spike-rush		X	X
Eleocharis intermedia Schult. spike-rush			X
Elymus canadensis L. Canada wild rye	X		
Elymus hystrix L. bottlebrush grass	X	X	X
Elymus repens (L.) Gould quack grass	X		
Elymus riparius Wiegand riverbank wild rye	X	X	
Elymus trachycaulus (Link) Gould slender wheatgrass		X	
Elymus villosus Willd. silky wild rye	X	X	
Elymus virginicus L. Virginia wild rye		X	X
Epilobium ciliatum Raf. willow herb		X	

(*Continued on next page*)

TABLE 4. (*Continued*).

Species	East Wetland	West Wetland	B. D. White Shrub-Carr
Epilobium coloratum Biehler cinnamon willow herb			X
Epilobium parviflorum Schreb. willow herb		X	X
Epilobium hirsutum L. great hairy willow herb	X		
Epipactis helleborine (L.) Crantz helleborine	X		
Equisetum arvense L. common horsetail	X	X	X
Erigeron annuus (L.) Pers. daisy fleabane		X	X
Erigeron philadelphicus L. Philadephia fleabane		X	
Euonymus obovatus Nutt. running strawberry bush		X	
Eupatorium perfoliatum L. boneset	X	X	X
Eutrochium maculatum (L.) E. E. Lamont joe-pye weed	X	X	X
Festuca subverticillata (Pers.) E. B. Alexeev nodding fescue		X	
Fragaria virginiana Mill. wild strawberry		X	
Frangula alnus Mill. glossy buckthorn	X		X
Fraxinus nigra Marshall black ash		X	
Fraxinus pennsylvanica Marshall green ash		X	X
Galium aparine L. annual bedstraw	X	X	X
Galium asprellum Michx. rough bedstraw		X	X
Galium boreale L. northern bedstraw	X	X	
Galium obtusum Bigelow wild madder		X	
Galium tinctorium L. stiff bedstraw			X
Gaylussacia baccata (Wangenh.) K. Koch huckleberry			X
Geranium maculatum L. wild geranium	X	X	X
Geum aleppicum Jacq. yellow avens		X	X
Geum canadense Jacq. white avens	X		
Geum rivale L. purple avens	X	X	X
Glyceria grandis S. Watson reed manna grass		X	X

(*Continued on next page*)

TABLE 4. (*Continued*).

Species	East Wetland	West Wetland	B. D. White Shrub-Carr
Glyceria striata (Lam.) Hitchc. fowl manna grass	X	X	X
Hackelia virginiana (L.) I. M. Johnst. beggar's lice			X
Hamamelis virginiana L. witch-hazel			X
Helianthus decapetalus L. pale sunflower		X	
Helianthus giganteus L. tall sunflower	X	X	
Hypericum ascyron L. giant St. John's-wort		X	
Hypericum boreale (Britt.) E. P. Bicknell northern St. John's-wort			X
Hypericum prolificum L. shrubby St. John's-wort		X	
Hypericum punctatum Lam. spotted St. John's-wort	X	X	X
Ilex verticillata (L.) A. Gray Michigan holly	X	X	X
Impatiens capensis Meerb. spotted touch-me-not	X	X	X
Iris virginica L. southern blue flag	X	X	X
Juglans cinerea L. butternut	X		
Juglans nigra L. black walnut			X
Juncus dudleyi Wiegand Dudley's rush	X	X	
Juncus nodosus L. joint rush		X	
Juncus pylaei Laharpe Pylaie's soft rush		X	
Juncus tenuis Willd. path rush			X
Juniperus virginiana L. red cedar		X	
Laportea canadensis (L.) Wedd. wood nettle	X	X	
Lathyrus palustris L. marsh pea	X	X	X
Leersia oryzoides (L.) Sw. white grass			X
Lemna minor L. common duckweed	X	X	X
Lemna turionifera Landolt red duckweed		X	
Leonurus cardiaca L. motherwort	X		
Lilium michiganense Farw. Michigan lily	X	X	

(*Continued on next page*)

TABLE 4. (*Continued*).

Species	East Wetland	West Wetland	B. D. White Shrub-Carr
Liparis loeselii (L.) Rich. green twayblade, fen orchid		X	
Lindera benzoin (L.) Blume spicebush	X	X	
Lobelia siphilitica L. great blue lobelia	X	X	
Lonicera dioica L. glaucous honeysuckle		X	
Lonicera maackii (Rupr.) Herder amur honeysuckle			X
Lonicera morrowii A. Gray morrow honeysuckle			X
Luzula multiflora (Ehrh.) Lej. common wood rush		X	
Ludwigia palustris (L.) Elliott water-purslane	X		
Lycopus americanus Muhl. common water horehound	X	X	X
Lysimachia ciliata L. fringed loosestrife	X	X	X
Lysimachia quadriflora Sims four-flowered loosestrife		X	
Lysimachia quadrifolia L. whorled loosestrife		X	
Lysimachia thyrsiflora L. tufted loosestrife		X	X
Maianthemum racemosum (L.) Link false spikenard			X
Maianthemum stellatum (L.) Link starry false Solomon-seal	X	X	
Matteuccia struthiopteris (L.) Todaro ostrich fern		X	
Menispermum canadense L. moonseed			X
Mentha canadensis L. wild mint	X	X	
Micranthes pensylvanica (L.) Haw. swamp saxifrage	X	X	X
Milium effusum L. wood millet	X	X	
Mitella diphylla L. bishop's cap		X	
Monarda fistulosa L. wild bergamot	X	X	X
Muhlenbergia glomerata (Willd.) Trin. marsh wild timothy		X	
Muhlenbergia mexicana (L.) Trin. leafy satin grass		X	
Nasturtium microphyllum Rchb. watercress	X	X	X
Onoclea sensibilis L. sensitive fern	X	X	X

(*Continued on next page*)

TABLE 4. (*Continued*).

Species	East Wetland	West Wetland	B. D. White Shrub-Carr
Osmorhiza longistylis (Torr.) DC. smooth sweet cicely		X	
Osmundastrum cinnamomeum (L.) C. Presl cinnamon fern	X	X	X
Osmunda claytoniana L. interrupted fern		X	
Osmunda regalis L. royal fern		X	X
Oxalis stricta L. yellow wood-sorrel			X
Oxypolis rigidior (L.) Raf. cowbane	X	X	
Packera aurea (L.) Á. Löve & D. Löve golden ragwort	X	X	X
Parthenocissus quinquefolia (L.) Planch. Virginia creeper			X
Pedicularis canadensis L. wood betony		X	X
Pedicularis lanceolata Michx. swamp betony	X	X	X
Persicaria amphibia (L.) Delabare water smartweed			X
Persicaria hydropiper (L.) Delabare water-pepper			X
Persicaria pensylvanica (L.) M. Gómez pinkweed		X	X
Persicaria punctata (Elliott) Small smartweed		X	X
Persicaria sagittata (L.) H. Gross arrow-leaved tear-thumb	X	X	X
Persicaria virginiana (L.) Gaertn. jumpseed	X	X	X
Phalaris arundinacea L. reed canary grass	X	X	X
Phlox divaricata L. wild blue phlox		X	
Physocarpus opulifolius (L.) Maxim. ninebark	X	X	X
Pilea pumila (L.) A. Gray clearweed			X
Platanthera psycodes (L.) Lindl. purple fringed orchid	X	X	X
Poa alsodes A. Gray bluegrass		X	X
Poa compressa L. Canada bluegrass		X	
Poa palustris L. fowl meadow grass	X	X	X
Poa pratensis L. Kentucky bluegrass	X	X	
Poa trivialis L. bluegrass	X	X	

(*Continued on next page*)

TABLE 4. (*Continued*).

Species	East Wetland	West Wetland	B. D. White Shrub-Carr
Podophyllum peltatum L. May-apple	X	X	
Polygonatum biflorum (Walter) Elliott Solomon-seal	X		
Polygonatum pubescens (Willd.) Pursh downy Solomon-seal		X	
Populus deltoides Marshall cottonwood	X		X
Populus tremuloides Michx. quaking aspen	X	X	X
Potentilla simplex Michx. common cinquefoil		X	
Prenanthes alba L. white lettuce	X		
Prunella vulgaris L. self-heal	X	X	X
Prunus serotina Ehrh. wild black cherry			X
Prunus virginiana L. choke cherry		X	
Pycnanthemum virginianum (L.) Durand & Jackson common mountain mint	X	X	X
Pyrola elliptica Nutt. large-leaved shinleaf		X	
Quercus bicolor Willd. swamp white oak			X
Quercus macrocarpa Michx. bur oak	X	X	X
Quercus palustris Munchh. pin oak			X
Quercus velutina Lam. black oak		X	
Ranunculus abortivus L. small-flowered buttercup			X
Ranunculus hispidus Michx. swamp buttercup	X	X	X
Ranunculus recurvatus Poir. hooked crowfoot	X	X	X
Ranunculus sceleratus L. cursed crowfoot		X	
Rhamnus alnifolia L'Her. alder-leaved buckthorn	X	X	X
Rhus glabra L. smooth sumac		X	X
Ribes americanum Mill. wild black currant	X	X	X
Ribes cynosbati L. prickly gooseberry		X	X
Ribes hirtellum Michx. swamp gooseberry		X	X
Rosa multiflora Murray multiflora rose	X	X	X

(*Continued on next page*)

TABLE 4. (*Continued*).

Species	East Wetland	West Wetland	B. D. White Shrub-Carr
Rosa palustris Marshall swamp rose	X	X	X
Rubus allegheniensis Porter common blackberry		X	
Rubus hispidus L. swamp dewberry		X	X
Rubus occidentalis L. black raspberry	X	X	X
Rubus pubescens Raf. dwarf raspberry	X	X	X
Rubus strigosus Michx. wild red raspberry			X
Rudbeckia fulgida Aiton showy coneflower	X	X	
Rudbeckia hirta L. black-eyed Susan	X	X	
Rudbeckia laciniata L. cut-leaf coneflower	X	X	X
Rumex crispus L. curly dock		X	X
Rumex obtusifolius L. bitter dock	X	X	X
Rumex orbiculatus A. Gray great water dock	X	X	
Sagittaria latifolia Willd. common arrowhead			X
Salix bebbiana Sarg. beaked willow		X	X
Salix discolor Muhl. pussy willow		X	
Salix eriocephala Michx. willow	X	X	X
Salix exigua Nutt. sandbar willow		X	X
Salix lucida Muhl. shining willow			X
Salix myricoides Muhl. blueleaf willow	X	X	X
Salix nigra Marshall black willow		X	
Salix petiolaris Sm. slender willow	X	X	X
Salix sericea Marshall silky willow			X
Salix serissima (L. H. Bailey) Fernald autumn willow		X	X
Sambucus canadensis L. elderberry	X	X	X
Sanicula odorata (Raf.) Pryer & Phillippe black snakeroot	X	X	
Saponaria officinalis L. soapwort		X	

(*Continued on next page*)

TABLE 4. (*Continued*).

Species	East Wetland	West Wetland	B. D. White Shrub-Carr
Schoenoplectus tabernaemontani (C. C. Gmel.) Palla softstem bulrush	X	X	X
Scirpus atrovirens Willd. bulrush	X	X	X
Scirpus cyperinus (L.) Kunth wool-grass		X	X
Scirpus expansus Fernald bulrush			X
Scirpus pendulus Muhl. bulrush		X	
Scrophularia marilandica L. late figwort			X
Scutellaria galericulata L. marsh skullcap			X
Scutellaria lateriflora L. mad-dog skullcap			X
Sium suave Walter water parsnip			X
Smilax hispida Raf. bristly greenbrier	X		X
Solanum dulcamara L. bittersweet nightshade	X	X	X
Solidago altissima L. tall goldenrod		X	
Solidago canadensis L. Canada goldenrod		X	
Solidago gigantea Aiton late goldenrod		X	X
Solidago patula Muhl. swamp goldenrod	X	X	X
Solidago riddellii Frank Riddell's goldenrod		X	
Solidago rugosa Mill. rough-leaved goldenrod	X	X	X
Solidago uliginosa Nutt. bog goldenrod		X	
Sphenopholis intermedia (Rydb.) Rydb. slender wedgegrass	X		X
Spiraea alba Du Roi meadowsweet	X	X	X
Stellaria longifolia Willd. long-leaved chickweed	X	X	X
Symphyotrichum firmum (Nees) G. L. Nesom smooth swamp aster	X	X	X
Symphyotrichum laeve (L.) G. L. Nesom smooth aster		X	
Symphyotrichum lanceolatum (Willd.) G. L. Nesom panicled aster	X		
Symphyotrichum lateriflorum (L.) Á. Löve & D. Löve calico aster		X	X
Symphyotrichum ontarionis (Wiegand) G. L. Nesom Lake Ontario aster			X

(*Continued on next page*)

TABLE 4. (*Continued*).

Species	East Wetland	West Wetland	B. D. White Shrub-Carr
Symphyotrichum pilosum (Willd.) G. L. Nesom frost aster		X	
Symphyotrichum puniceum (L.) Á. Löve & D. Löve purple-stemmed aster	X	X	X
Symplocarpus foetidus (L.) Nutt. skunk-cabbage	X	X	X
Taraxacum officinale F. H. Wigg. common dandelion		X	X
Thalictrum dasycarpum Fisch. & Avé-Lall. purple meadow-rue	X	X	X
Thelypteris noveboracensis (L.) Nieuwl. New York fern	X		X
Thelypteris palustris Schott marsh fern	X	X	X
Tilia americana L. basswood	X	X	
Torilis japonica (Houtt.) DC. hedge parsley		X	
Toxicodendron radicans (L.) Kuntze poison ivy	X	X	X
Toxicodendron vernix (L.) Kuntze poison sumac	X	X	X
Trillium grandiflorum (Michx.) Salisb. common trillium	X	X	
Typha angustifolia L. narrow-leaved cattail	X		
Typha latifolia L. broad-leaved cattail			X
Ulmus americana L. American elm		X	X
Ulmus rubra Muhl. red elm		X	
Urtica dioica L. stinging nettle	X	X	X
Vaccinium corymbosum L. highbush blueberry			X
Vaccinium myrtilloides Michx. velvetleaf blueberry			X
Valeriana officinalis L. common valerian	X		
Valeriana uliginosa (Torr. & A. Gray) Rydb. swamp valerian		X	
Verbena hastata L. blue vervain		X	X
Veronicastrum virginicum (L.) Farw. Culver's root		X	
Viburnum cassinoides L. wild raisin			X
Viburnum lentago L. nannyberry	X	X	X
Viburnum opulus L. European highbush cranberry	X		X

(*Continued on next page*)

TABLE 4. (*Continued*).

Species	East Wetland	West Wetland	B. D. White Shrub-Carr
Viburnum rafinesquianum Schult. downy arrowhead		X	X
Vincetoxicum nigrum (L.) Pers. black swallow-wort		X	
Viola cucullata Aiton marsh violet	X	X	X
Viola labradorica Schrank dog violet			X
Viola macloskeyi F. E. Lloyd smooth white violet			X
Viola sororia Willd. common blue violet		X	
Viola striata Aiton cream violet		X	
Vitis riparia Michx. riverbank grape	X	X	X
Zanthoxylum americanum Mill. prickly ash		X	X
Zizia aurea (L.) W. D. J. Koch golden Alexanders	X	X	X
Total species	**172**	**238**	**192**
Native species	154 (89.5%)	221 (92.9%)	180 (93.8%)
Non-native species	18 (10.5%)	17 (7.1%)	12 (6.3%)

(89.5%) of which are native, were found in this wetland. The Floristic Quality Assessment metrics of this site (Table 1) are quite high: a Total FQI of 52.5, a Native FQI of 55.8, and a Total Mean *C* of 4.4.

Common shrub species in the East Wetland shrub-carr are: dogwoods (*Cornus sericea*, *C. foemina*, *C. amomum*), buckthorns (*Frangula alnus*, *Rhamnus alnifolia*), willows (*Salix eriocephala*, *S. myricoides*, *S. petiolaris*, *S. bebbiana*), poison sumac (*Toxicodendron vernix*), and viburnums (*Viburnum lentago*, *V. opulus*). The presence of occasional calciphiles suggests a fen-like quality in certain zones. These include prairie sedge (*Carex prairea*), tussock sedge (*Carex stricta*), another smaller sedge (*Carex tetanica*), shrubby cinquefoil (*Dasiphora fruticosa*), swamp saxifrage (*Micranthes pensylvanica*), swamp-betony (*Pedicularis lanceolata*), Virginia mountain mint (*Pycnanthemum virginianum*), black-eyed Susan (*Rudbeckia fulgida*), blueleaf willow (*Salix myricoides*), and swamp valerian (*Valeriana uliginosa*). Additional common herbaceous species include bluejoint grass (*Calamagrostis canadensis*), flat-topped white aster (*Doellingeria umbellata*), Clinton's woodfern (*Dryopteris clintoniana*), common boneset (*Eupatorium perfoliatum*), joe-pye-weed (*Eutrochium maculatum*), including an albino form, golden ragwort (*Packera aurea*), smooth swamp aster (*Symphyotrichum firmum*), side-flowering aster (*S. lateriflorum*), swamp aster (*S. puniceum*), and marsh fern (*Thelypteris palustris*). The genus *Carex* is well rep-

resented with 21 species in this small wetland. Three viny species, hog-peanut (*Amphicarpaea bracteata*), groundnut (*Apios americana*), and wild yam (*Dioscorea villosa*) are also common.

One state-listed species, Davis' sedge (*Carex davisii*) (Special Concern status) was encountered in this wetland. Additionally, two orchids of interest were discovered: the showy lady-slipper (*Cypripedium reginae*) and purple fringed orchid (*Platanthera psycodes*). A total of 18 species from this site have high *C*-values (Table 3).

West Wetland (42°53.976′N, 85°21.583′W):

The West Wetland (Figure 5) is the largest of the four wetlands surveyed in this study, at 3.71 ha (9.18 acres). This wetland is also best classified as a southern shrub-carr community (Cohen et al. 2015). A total of 238 species (Table 4), 221 (92.9%) of which are native, were found in this wetland (Table 1). The Floristic Quality Assessment metrics of this site (Table 1) are remarkably high: a Total FQI of 63.3, a Native FQI of 65.4, and a Total Mean *C* of 4.1. This wetland is clearly an important refuge for native biodiversity and has significant conservation value at a statewide level, extremely worthy of protection and conservation by Kent County Parks.

The border of this wetland is shaded by nearby trees and dense shrubs. The substrate is mucky, difficult to traverse, and dominated by skunk-cabbage (*Symplocarpus foetidus*) and sensitive fern (*Onoclea sensibilis*). Towards the interior, shrubby growth occurs in patches, interrupted by an open mosaic of microhabitats populated by herbaceous species typical of southern sedge meadows or fens. Some of the most common shrubs are hazelnut (*Corylus americana*), dogwoods (*Cornus amomum, C. foemina,* and *C. sericea*), willows (*Salix bebbiana, S. myricoides*, and *S. serissima*), poison sumac (*Toxicodendron vernix*), and viburnums (*Viburnum lentago* and *V. rafinesquianum*). The open areas are marked by several calciphiles, including prairie sedge (*Carex prairea*), another smaller sedge (*Carex tetanica*), shrubby cinquefoil (*Dasiphora fruticosa*), marsh wild timothy (*Muhlenbergia glomerata*), alder-leaved buckthorn (*Rhamnus alnifolia*), black-eyed Susan (*Rudbeckia fulgida*), blueleaf willow (*Salix myricoides*), swamp valerian (*Valeriana uliginosa*), and golden Alexanders (*Zizia aurea*). *Carex stricta* is the dominant species in other open zones, where it is joined by swamp milkweed (*Asclepias incarnata*), golden ragwort (*Packera aurea*), green bulrush (*Scirpus atrovirens*), and other less dominant graminoids (*Bromus ciliatus*, *Calamagrostis canadensis, Carex interior*, *C. pellita*, *C. stipata*, and *Glyceria striata*). One tall forb, giant St. John's-wort (*Hypericum ascyron*), is well-represented in one of the *Carex stricta* areas, and our documentation of this species is the first for Kent County since Emma Cole collected it in 1893 (MICHIGAN FLORA ONLINE 2011). Isolated clones of quaking aspen trees (*Populus tremuloides*) are scattered throughout this wetland.

One species in the West Wetland shrub-carr is listed in Michigan as Special Concern— the parasitic field dodder (*Cuscuta campestris*); this species also constitutes a new county record (it was previously known from only five other counties in Michigan). Additionally, three fairly rare orchids were encountered:

FIGURE 5. West Wetland, southern shrub-carr habitat. Photo by DeAnna Clum.

showy lady slipper (*Cypripedium reginae*); purple fringed orchid (*Platanthera psycodes*); and the fen orchid or green twayblade (*Liparis loesellii*), which had previously been documented in Kent County only in 1940, 1946, and 1969 (MICHIGAN FLORA ONLINE 2011).

Only 7.2% of the flora in this wetland consists of non-native species, a few of which are considered aggressive. While they have not yet become problematic, these non-natives include autumn olive (*Elaeagnus umbellata*), Canada and Kentucky bluegrass (*Poa compressa*, *P. pratensis*), multiflora rose (*Rosa multiflora*), and curly and bitter dock (*Rumex crispus*, *R. obtusifolius*). The inventory of this southern shrub-carr wetland included a large number of species (26) with *C*-values ranging from 8 to 10, indicating a high concentration of species with preference for undisturbed habitats (Table 3).

B. D. White Shrub-Carr (42° 54.313′N, 85°21.631′W):

This wetland (Figure 6) is similar in size to the upstream shrub-carr wetlands (3.48 ha or 8.6 acres) and in the same drainage system. Karen Creek flows into this shrub-carr, dissipates across its broad basin, then collects again and ultimately winds its way to the north, emptying into the Grand River at Grand River Riverfront Park in the city of Lowell. For this assessment we combined inventory data from a previous report on the B. D. White Shrub-Carr (Stockdale et al. 2019) with unpublished data provided by J. Heslinga (Stewardship Director,

FIGURE 6. B. D. White Shrub-Carr, southern shrub-carr habitat, with tall *Angelica atropurpurea*. Photo by Garrett E. Crow.

Land Conservancy of West Michigan). This combined dataset resulted in 192 species (Table 4), 180 (93.8%) of which are native. The Floristic Quality Assessment calculations (Table 1) yielded a Total FQI of 55.4, a Native FQI of 56.3, and a Total Mean *C* of 4.0. These results are slightly lower than those of the West Wetland, but marginally higher than those of East Wetland.

Prairie Pond/Marsh (42°53.678′N, 85°21.348′W):

One additional wetland occurs within the Lowell Regional Greenspace, the Prairie Pond/Marsh site (Figure 1: PM). This site is an old farm pond of ca. 0.68 ha (1.67 acres) that lies within an open old-field portion of the Greenspace that Kent County Parks has begun managing as a 30-acre prairie restoration. Prior to agricultural development, this wetland likely supported a southern hardwood swamp similar to the Silver Maple Swamp site. Since the site represents a for-

mer farm pond and shows a high degree of disturbance, we did not conduct a full botanical inventory, nor did we include this site in our comparisons. However, we offer a brief description here for the benefit of Kent County Parks.

Today this wetland is an open marsh surrounding the pond with a few young and widely scattered trees of silver maple (*Acer saccharinum*), American ash (*Fraxinus americana*), willow (*Salix* cf. *alba*), and American elm (*Ulmus americana*). The margins and shallow zones are populated with reed canary grass (*Phalaris arundinacea*), sandbar willow (*Salix exigua*), softstem bulrush (*Schoenoplectus tabernaemontani*), bulrush (*Scirpus atrovirens*) and Canada goldenrod (*Solidago canadensis*). Also present are scattered individuals of northern water-plantain (*Alisma triviale*), swamp milkweed (*Asclepias incarnata*), false nettle (*Boehmeria cylindrica*), the sedges *Carex crinita*, *C. tribuloides, C. vulpinoidea*, willow-herb (*Epilobium ciliatum*), spotted touch-me-not (*Impatiens capensis*), Pylaei's soft rush (*Juncus pylaei*), common water horehound (*Lycopus americanus*), multiflora rose (*Rosa multiflora*), curly dock (*Rumex crispus*), mad-dog skullcap (*Scutellaria lateriflora*), stinging nettle (*Urtica dioica*), and white vervain (*Verbena urticifolia*).

Non-metric Multidimensional Ordination (NMDS)

The NMDS ordination (Figure 7) shows that the tree-dominated Silver Maple Swamp is distantly set apart from the three shrub-carrs, indicating that it is clearly the most dissimilar among the four wetlands. The East Wetland and the West Wetland cluster close together and are positioned relatively close to the B. D. White Shrub-Carr. However, the cluster is not sufficiently tight to permit the conclusion from this analysis alone that they are necessarily the same community type.

Similarity Index

The Sørensen Index of Similarity defines two sites as the same plant community type when they exhibit a Similarity Index greater than 50% (Curtis 1959; Bradley and Crow 2010). Figure 8 reports pairwise comparisons of all four wetlands. East Wetland and West Wetland, with a Sørensen Index score of 66.34%, showed the strongest affinity. This assessment also reports a range in Index scores of 59.89–66.34% (109–138 shared species) for all three pairwise comparisons of the shrub-carrs, thereby giving us confidence to conclude that these three wetlands belong to the same community type—southern shrub-carr. The Silver Maple Swamp differed considerably from the three shrub-carrs with a Sørensen Index ranging from 35.05 to 35.79% for all pairwise comparisons. Additionally, species richness was much lower in the swamp (94 species) than in the shrub carrs, and the number of species shared between the swamp and shrub carr sites was also low, ranging from 47 to 51. These results affirmed our impression that this is a very different habitat and that it belongs to a different community type, in this case a southern hardwood swamp (Cohen et al. 2015).

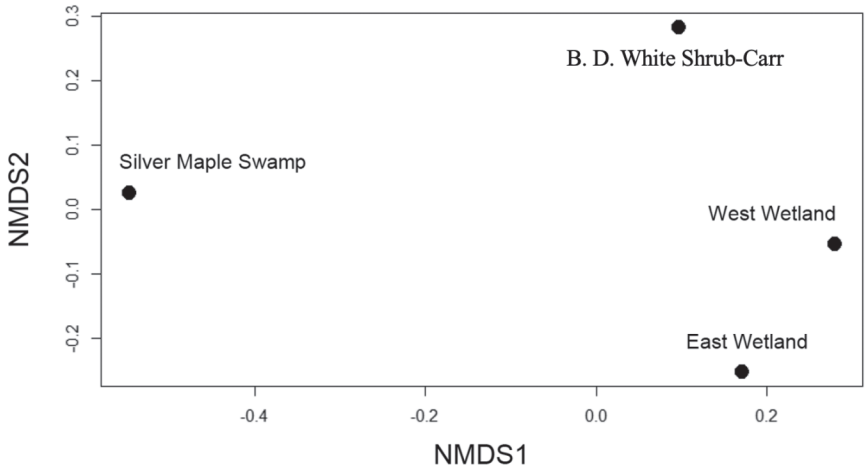

FIGURE 7. NMDS ordination demonstrating the relative similarity of the four wetland sites using a Jaccard distance metric. Points are labeled with the name of each site. Stress = 0.

CONCLUSION

As a consequence of agricultural and urban development, logging, and hydrological alterations, large sectors of the Michigan landscape have been significantly degraded from their pre-settlement condition. One outcome of these intense human activities is that much of Michigan's native biota has become severely restricted to small, isolated tracts of natural landscapes, which have themselves been impacted by surrounding growth and development (Zipperer 1993; Hartley and Hunter 1998). According to Herman et al. (2001), many of the principal floristic elements of our natural ecosystems are poorly represented in Michigan's present human-dominated landscape.

This paper is part of an ongoing botanical inventory project of the greater Grand Rapids area in which we have been assessing sites that Emma Cole described in her *Flora of Grand Rapids* (Cole 1901; Crow 2017) over 120 years ago, along with other high-quality remnant natural areas in the region. As a teacher of botany at Central High School, and as the curator of the herbarium of the Kent Scientific Institute, Cole saw the need for an up-to-date account of the plants of the area to involve her students in the study of systematic botany. She engaged in intensive botanical collecting during the years 1892 to 1899 by horse and buggy, and, with the help and encouragement of various high school students of botany, former teachers, and some local botanical enthusiasts, she was able to compile a thorough record of the plant species growing without cultivation within 16 townships, comprising 585 square miles, centered on Grand Rapids (Stivers and Crow 2018).

Enormous changes have taken place within and around the Grand Rapids area that have impacted the botanical richness of the region, both as a direct consequence of urbanization and as a result of expanded agricultural and suburban de-

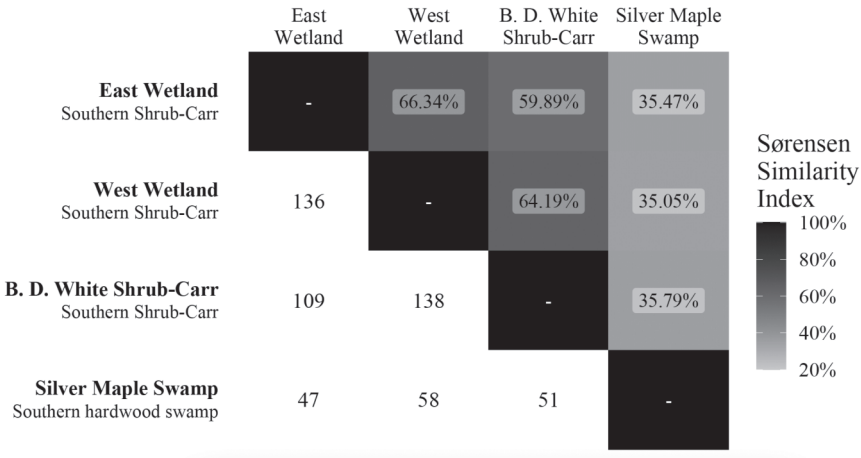

FIGURE 8. Sørensen Index of Similarity pairwise comparisons for the four wetland sites. Values in the shaded boxes to the upper right of the diagonal are the percentage similarity of each pair; values to the lower left of the diagonal are the number of species shared between pairs of wetland sites. The community classification of each site is indicated in the left column under the name of that site.

velopment. While it has been disheartening to discover the loss of many of Cole's collecting sites, we have also been encouraged to find some of her sites as well as other natural remnants that still retain high levels of ecological integrity and biodiversity.

In this paper, which is a companion study to an earlier assessment of the woodlands on this Kent County Parks property (see Warners et al. 2021), we inventoried and compared three natural wetlands within the Lowell Regional Greenspace together with a fourth wetland just downstream in the Karen Creek drainage. While the southern hardwood swamp was quite distinct from the three shrub-carrs, both in physiognomy and in floristic similarity (Figures 7 and 8), the shrub-carrs themselves exhibit a remarkable degree of similarity in Floristic Quality Assessment values (Table 1). Their Total FQIs of 52.5 (EW), 55.4 (BDW) and 63.3 (WW) all indicate unusually high natural quality, worthy of protection and long-term preservation by Kent County Parks. While the southern hardwood swamp detailed in this study appeared largely undisturbed and of high natural quality, it supported a far lower species richness than any of the shrub-carr sites. The lower species richness and FQI in swamps, compared to shrub-carrs, is likely related to less environmental variation (light in particular). By contrast, shrub-carrs host a diversity of microhabitats, due to their undulating topography and variable light levels, and therefore can support higher species richness. In fact, this research shows that even relatively small shrub-carrs (all < 4 ha in size) can serve as refuges for significant amounts of native biodiversity.

This study also underscores the importance of vigilantly monitoring and managing shrub-carr communities. Monitoring and removal of non-native invasive species will enhance the rich native character of these sites. In the shrub-carrs we

surveyed the most problematic invasive species were autumn olive (*Elaeagnus umbellata*) and multiflora rose (*Rosa multiflora*). The use of fire to discourage invasive species and promote native species is especially encouraged, particularly for enhancing the heliophytic herbaceous species in the shrub-carrs (Reuter 1985; Warners 1989, 1997). Preservation of the Lowell Regional Greenspace wetlands, in concert with the B. D. White Shrub-Carr, allows for connections by offering cross-pollination as well as shared seed dispersal opportunities toward maintaining the genetic health of these outstanding wetland habitats.

ACKNOWLEDGMENTS

We would like to thank the Hanes Trust, the Michigan Botanical Foundation, and the Calvin University Science Division Summer Research Program for financial support. The Calvin University Herbarium (CALVIN) and the Michigan State University Herbarium (MSC) provided access to their collections to confirm identifications of challenging specimens and serve as repositories for voucher specimens. Critical specimens, including those documenting new county records and rare species, have also been deposited at the University of Michigan Herbarium (MICH). We are grateful to Justin Heslinga, ecologist, botanist, and Stewardship Director at the Land Conservancy of West Michigan, for sharing his data and insights from the B. D. White Preserve shrub-carr to complement our data collected in 2017. The Land Conservancy financially supported our field work in the B. D. White Preserve in 2016. In addition to the coauthors of this study who carried out the inventory work, we are appreciative of the efforts of several additional people who participated in the field work, including Alan Stockdale and Lydia Abma in 2016 (B. D. White Preserve), DeAnna Clum and Jenna Van Donselaar in 2018 (Lowell Regional Greenspace), and Lucas Walker and Natalie Vredevoogd in 2021 (Lowell Regional Greenspace). We thank Roger Sabine and Brian Mulligan of Kent County Parks for granting access to the Lowell Regional Greenspace to carry out this field study. We are also appreciative of the comments and corrections provided by Michael Huft, Editor-in-Chief, as well as anonymous reviewers, who greatly improved the manuscript.

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