BOTANICAL ASSESSMENT OF HIGH-QUALITY WOODLAND PARCELS IN THE UNDEVELOPED LOWELL REGIONAL GREENSPACE, KENT COUNTY, MICHIGAN

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ABSTRACT

The 2019–2023 Masterplan for the 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. As part of an on-going botanical inventory project of the greater Grand Rapids area, we have been assessing sites that Emma Cole described over 120 years ago, along with other high-quality remnant natural areas in the region. Nine wooded sites within the Lowell Regional Greenspace property that appear to be high-quality habitat were identified for floristic inventories and floristic quality assessments during the summers of 2018 and 2019. A total of 274 species are reported for the nine wooded sites, including 241 (88.0%) native species. Three of these species are designated in Michigan as rare (one of Threatened status, two of Special Concern status). A non-metric multidimensional scaling (NMDS) was run using presence/absence floristic data from the nine woodlots to spatially compare similarities and differences among the sites. Additionally, Sørensen Index of Similarity was employed to ascertain the similarity between pairs of individual sites, which was also useful for assigning plant community types in accordance with the classification system developed by the Michigan Natural Features Inventory. Six of the wooded sites were best classified as mesic southern forest (one of which has old growth characteristics), two as dry southern forest, and one as dry-mesic southern forest. Of the nine sites, the floristic quality assessment indicated that eight of the sites are floristically important statewide, whereas one, having numerous weedy native and non-native species, was deemed to be of low to moderate value. We discovered remarkable differences in species composition among the sites, even between wooded sites we classified as the same community type. Such high-diversity in a limited space underscores the importance of preserving persisting remnant habitats, even those small in extent. This study should be useful to the Kent County Parks as they begin to develop the greenspace into parkland, and to those interested in learning more about how to assess habitat quality and diversity of remnant natural areas.

KEYWORDS: Michigan flora, biodiversity, Floristic Quality Assessment, floristic inventory, Kent County Parks, Emma Cole's *Grand Rapids Flora*

INTRODUCTION

When European immigrants and their descendants began arriving in southern Michigan from places further to the east, their appreciation of forest ecosystems contrasted notably with that of the indigenous Anishinaabeg. Europeans viewed the wooded landscape as filled with resources that could be converted into capital (money), whereas the Ottawa and Potawatomi generally taught that the forest was filled with gifts that provided for the flourishing of all creatures, humans included (Cronon 1983; Cleland 1992; Kimmerer 2013). This contrast in under-

standing is illustrated by two quotes recorded just one year apart. In 1888, the Grand Rapids Board of Trade (1888) published *Grand Rapids As It Is*, with the intention of attracting immigrants, and wrote:

> It is known of all men that for many years this state has been the chief producer of pine lumber in the union; no other commonwealth has placed nearly so much nor so good pine lumber on the markets of the entire country for many years past. The gross product for 1887 was well toward five thousand million feet, valued at $65,000,000 and this annual total will not be very largely decreased for the next decade to come . . . . But yet, great as this wealth of pine has been and yet is . . . the hardwood wealth of the state, yet undeveloped, is greater than the pine wealth ever was. This hardwood wealth, consisting chiefly of beech, maple, oak, elm, ash, hickory, butternut, birch, basswood, and sycamore . . . is almost innumerable in quantity, and unsurpassed in quality. There is also a vast amount of hemlock, cedar, and other evergreen timber wealth in Western Michigan. Grand Rapids is admirably located to secure the very choicest of this forest wealth.

Just one year earlier, Andrew Blackbird (known by his people as Mackaw-de-be-nessy), a highly educated indigenous Ottawa who spent much of his childhood along the Grand River, authored *History of the Ottawa and Chippewa Indians*. In his fascinating account, Blackbird (1887) wrote:

> [T]he land the Great Spirit has given us in which to live, to roam, to hunt, and build our council fires, is no more to behold . . . . Our forests are gone, and our game is destroyed. Hills, groves and dales once clad in rich mantle of verdure are stripped. Where is this promised land which the Great Spirit had given to his red children as the perpetual inheritance of their posterity from generation to generation? Ah, the pale-faces who have left their fathers' land, far beyond the ocean, have now come and dispossessed us of our heritage with cruel deceit and force of arms . . . . O, my father, our happiest days are o'er, and never again shall we enjoy our forest home.

These two accounts show the sharply contrasting worldviews of European colonists and Indigeous Anishinaabeg and how these different worldviews valued the wealth of Michigan's forests. The colonists understood wealth as something to be secured through the *taking* of wood products from the land. A forest that was left standing was viewed as wasted; only by clearing the land and subsequent agricultural development could wealth be secured (Michigan DNR 2008). Michigan's Native Americans, however, valued forest wealth as an *existing* ecosystem, because through its flourishing, their lives were sustained, along with the lives of many other species. To the Anishinaabeg, a forest was filled with gifts, and once harvested, those gifts and their ability to support life were sacrificed (Kimmerer 2013).

Perhaps an exception to the European perspective that a forest's value came only through destructive harvesting was the preservation of family farm woodlots. In *History of the City of Grand Rapids*, Albert Baxter (1891) wrote:

> [E]ven the song birds whose music once enlivened the woods, and the wild honeybees that stored sweetness in the trees, and the wild berries, and many varieties of beautiful flowers of the forest and the openings, have dwindled away—almost gone, abashed, from the presence of the white man. And the grand natural parks and groves and thickets, of maple, and elm, and oak, and hickory, and black walnut, and linden, and pine—these have been cut away—utterly destroyed—except such occasional small patches as are needed for farm and family uses.

Woodlots were kept on most family farms because of their usefulness to the overall farming operation and because they directly provided the farm family with firewood and maple syrup (NIFA, USDA 2010). Forest patches also served as a refuge for wild game that could be hunted for meat or as a cool respite for livestock on hot summer days. Many farm families, unfortunately, also used their woodlots as long-term "storage" areas for extra fencing, old tractors, or broken machinery. Because of the high quality of soils in southern Michigan, around 80% of the forest lands were cleared for agriculture in the 1800s. The remaining 20% was mostly comprised of small and isolated forest islands, many of which were farm woodlots (Michigan Society of American Foresters 2021). In more urbanized areas where cities were expanding, the fate of forests was even worse. Trees were typically seen as obstacles to development and were clear-cut for roadways, neighborhoods, and business ventures (Belknap 1922).

These land-altering dynamics were in high gear in the late 1800s when Emma Cole was writing her flora of the Grand Rapids area (Cole 1901; Crow 2017). Cole's highly regarded *Flora* covered 16+ townships (some 585 square miles) centered on the city of Grand Rapids, including parts of Kent and Ottawa Counties. In her book Cole (1901) laments that:

> Since the district has become more thickly settled, it is undergoing rapid transformation. Much of the swampland is being drained, cleared, and utilized; forests are being deprived of their valuable timber, and uplands converted into farms. The woodlands at present consist mostly of the 'wood-lot' reserved by the farmer.

From Cole's writings came the inspiration for the Emma Cole Project, which is an effort supervised by the two lead authors of this paper and based at Calvin University's herbarium. Together with undergraduate summer research assistants, we have been inventorying and assessing sites that Emma Cole (1901) described over 120 years ago along with other high-quality remnant natural areas in the Grand Rapids region. Many of the sites we have visited have been former farm woodlots. Some of these have been of marginal natural quality, while others have proven to be exceptional representations of pre-settlement forest vegetation. As part of this project, we were asked by Kent County Parks (the department of County government established in 1924 that is tasked with establishing and maintaining parks and trails in Kent County) to evaluate the natural quality of a roughly one square mile parcel near Lowell, Michigan, that is allocated greenspace to become a future Kent County park. Although slightly outside the area that Emma Cole designated for her *Flora*, this opportunity allowed us to inventory and botanically assess nine distinct mature woodland parcels within a confined geographic area, the results of which can inform parkland development.

MATERIALS AND METHODS

Site

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 of Lowell Charter Township (see Figure 1). This currently undeveloped land, which is referred to as Lowell Regional

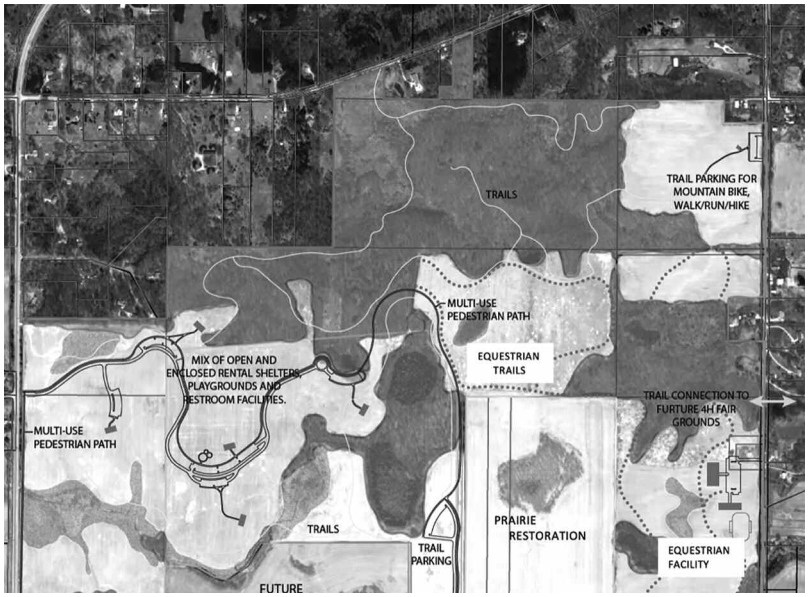

FIGURE 1. Map of present and future plans for Lowell Regional Greenspace. From Kent County Parks (2021).

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.

Initial land acquisition by Kent County Parks began in 1999 and the property currently covers an area of 528 acres. The greenspace property includes open fields, rolling wooded hills and ravines, two pristine open shrub-dominated wetlands, a Silver Maple swamp, and a large open old-field site. Some management has already begun, including a 30-acre prairie restoration project initiated in an old agricultural field (Figure 1), for which prescribed burns were conducted in 2010 and 2017. The Lowell Regional Greenspace will eventually host an equestrian facility and bridle trails, including a connecting trail to the new Kent County Youth Fair Grounds situated about 1.25 mi. eastward that now occupies the old Deer Run Golf Course on Cascade Road just north of Pratt Lake. To date, Kent County Parks has not yet begun construction of any of the facilities proposed in the master plan.

The property is contiguous to the Bradford Dickinson White Nature Preserve which is located on the north side of 36th Street and is owned and actively managed by the Land Conservancy of West Michigan. The B. D. White Preserve has similar woodland ecosystems and an extensive southern shrub-carr wetland habitat that is fed by a stream emerging from the two high quality shrub-dominated wetland areas in the Lowell Regional Greenspace site (Stockdale et al. 2019). Together Lowell Regional Greenspace and B. D. White Preserve parcels offer a significant area of preserved woodland and wetland habitat that will only increase in value from a conservation standpoint as development progresses in the vicinity.

Botanical Inventory

Botanical inventories were conducted mid-March through September 2018 and 2019 within the Lowell Regional Greenspace for nine distinct wooded research sites, selected because they appeared to retain significant elements of pre-settlement habitat (Figure 2). Two rather pristine shrub-dominated wetlands (Figure 2, EW and WW) and a Silver Maple swamp (SMS) also occur within the greenspace; inventories of these sites will be reported in a subsequent paper.

Our sampling protocol in each of these inventoried sites was a meander-search through the entire

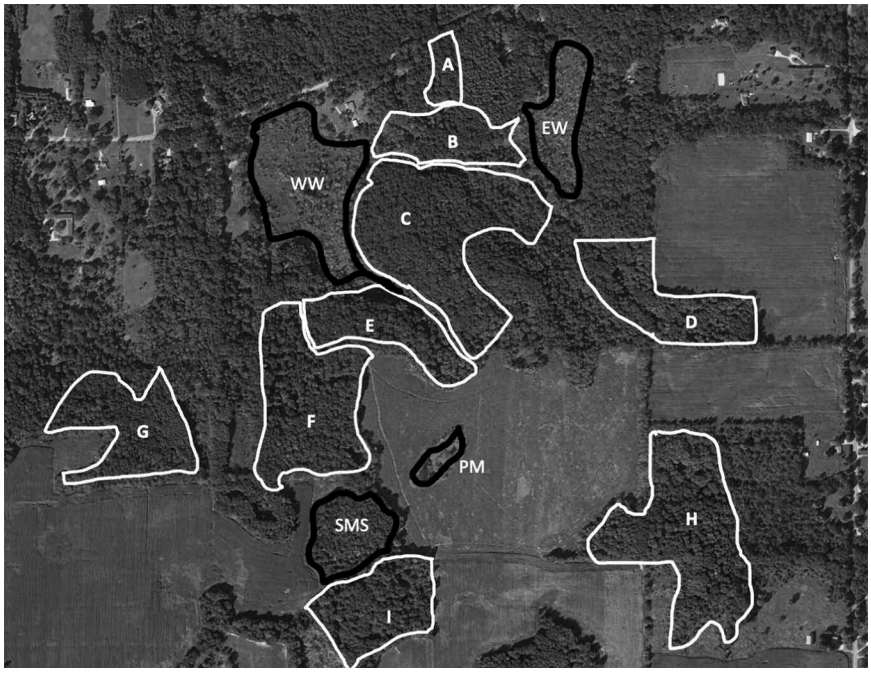

FIGURE 2. Locations of the nine Lowell Regional Greenspace woodland study sites, outlined in white. These are: A = Gateway Woods; B = North Woods; C = Dry Woods; D = Ravine Woods; E = Old Growth Woods; F = Middle Woods; G. West Woods; H = East Woods; I = South Woods. Wetlands mentioned in the text are outlined in black. These are: EW = East Wetland; WW = West Wetland; SMS = Silver Maple Swamp; PM = Prairie Marsh and Pond. (Image: 9/25/2014; source: Google).

site multiple times over the course of the growing season, keeping a sharp eye out for any microhabitats within. Particular attention was paid to areas within these sites that appeared to support high diversity. During site visits all plant species encountered were recorded as sight records and/or documented by specimens. A total of 449 herbarium specimens were collected to document the flora, especially if they had flowering or fruiting material. The first set of voucher specimens documenting the study were deposited in the Calvin University Herbarium (CALVIN), with duplicate specimens deposited in the herbaria of Michigan State University (MSC) and/or University of Michigan (MICH). Identifications were made primarily using Voss and Reznicek (2012) for seed plants and Palmer (2018) for pteridophytes. We also accessed various online resources such as MICHIGAN FLORA ONLINE (2011) and Go Botany (Native Plant Trust 2019). Nomenclature follows that of MICHIGAN FLORA ONLINE (2011), as this source includes both seed plants and pteridophytes and is frequently updated with taxonomic and nomenclatural changes.

Floristic Quality Assessments

Floristic Quality Assessment (FQA) values were obtained for each woodland site following the methodology described by Freyman et al. (2016) and Reznicek et al. (2014) using the online Universal FQA Calculator (Freyman 2016). Floristic Quality Assessments provide an extremely practical and useful metric-based measure to evaluate habitat conservation values, and have become increasingly influential in North America within the last 20 years (Spyreas 2019). The Floristic Quality Assessment tool assigns each native Michigan species a Coefficient of Conservatism (C) ranging from

0 to 10 (Reznicek et al. 2014). The C-value reflects a given species' fidelity to undisturbed habitats. Plants with C-values of 8–10 indicate 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. After calculating the Mean *C* ($\overline{C}$) for each site inventoried, which is the average of the C-values of the species in that site, a Native Floristic Quality Index (FQI) for the entire site is calculated as follows:

$$\text{FQI} = \overline{C} \times \sqrt{n}$$

where *n* is the number of native species at the site. Hence, the Floristic Quality Index provides a reliable indication 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 generates a Native FQI and a Total FQI, the former based only on the native species present at the locality inventoried (as described above) and the latter on both native and non-native species. Inclusion of non-native species (C-value = 0) (to obtain a Total Mean *C*) for the calculation of a Total FQI results in a lowered overall FQI, which gives a comparative indication of the impact of non-native species on the site's floristic quality.

The online Universal FQA Calculator also generates an Adjusted FQI score, which was first introduced in a study conducted within forested wetlands of central Pennsylvania (Miller and Wardrop 2006). One fundamental problem with the Total FQI calculation is the strong influence of species richness (which often reflects within-site habitat diversity). The Adjusted FQI corrects the index downwards for habitats with high native species richness but a low Mean *C* value. The Adjusted FQI also shifts the index upwards for habitats that have a lower native species richness but a high Mean *C* value. The Adjusted FQI formula is as follows:

$$\left(\frac{\overline{C}}{10} \times \frac{\sqrt{N}}{\sqrt{N+A}}\right)$$

where *C* is the Mean *C* value, N is the number of native species, and A is the number of non-native species.

Non-metric Multidimensional Ordination (NMDS)

A non-metric multidimensional scaling (NMDS) was run on presence/absence floristic data from the nine woodlots as a spatial way to compare similarities and differences among the sites (Figure 3). Jaccard's dissimilarity metric is especially helpful in comparing binary data. To run the NMDS, R (R Core Team 2020) version 4.4.1 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 are binary (either present or absent) and there were no groupings except by sites.

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 among each of the woodland sites studied. This approach allowed us to evaluate whether these floristic lists effectively describe the same woodland habitat type. The Sørensen Index 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 each of the two sites, 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).

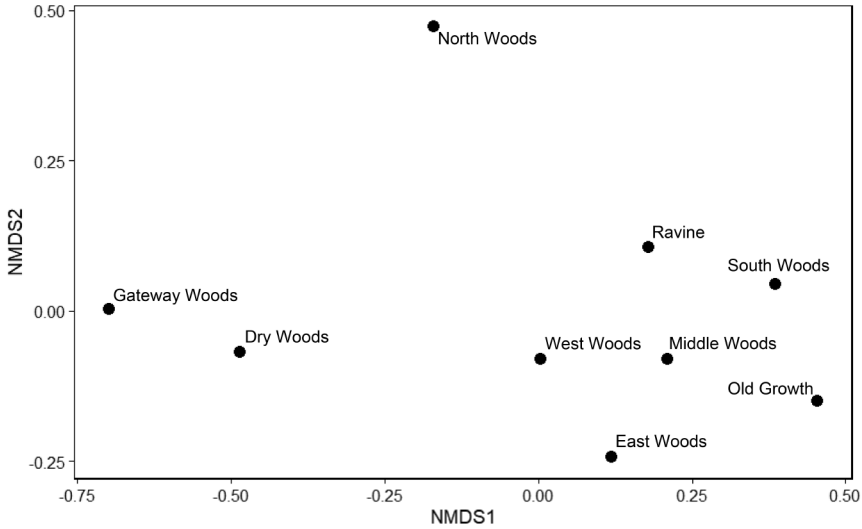

FIGURE 3. NMDS ordination demonstrating the relative similarity of the nine sites using a Jaccard distance metric. Points are labeled with the name of each site. Stress = 0.0455.

RESULTS AND DISCUSSION

Floristic Quality Assessments (FQA) Overview

As a consequence of logging, agricultural development, and urban growth, large sectors of the Michigan landscape have been significantly altered from their pre-settlement condition. Much of our native biota has become severely restricted to small, isolated tracts of natural landscapes, which have themselves been impacted by growth and development, and, according to Herman et al. (2001), principal elements of our natural ecosystems are poorly represented in the state's present landscape. Thus, any site with a Native FQI score of 35 or higher is valued as floristically important statewide. FQI scores greater than 50 indicate exceptional sites with extremely high conservation value. Matthews et al. (2005) and Slaughter et al. (2015), while recognizing that the FQI values are useful, feel that the Mean *C* values represent a less biased indicator of relative site conservation value. We consider both metrics to be helpful for practitioners involved in ecological integrity assessments.

Individual Site Assessments

Among the nine wooded sites inventoried in 2018 and 2019 (identified as A through I in Figure 2), the Total Floristic Quality Index (Total FQI) values (see Table 1) ranged from a low of 26.9 (Total Mean *C* = 2.7) at Gateway Woods, which is the site with the highest percentage of non-native species (18.2%), to a

TABLE 1. Floristic Quality Assessment metrics for the nine woodland sites.

Site Name (Forest Community)	Area	Total FQI	Native FQI	Adjusted FQI	Total Mean C	Number of Species	Number of Native Species (percentage)	Number of Non-native Species (percentage)
Gateway Woods (Dry Southern Forest)	0.49 ha 1.20 acres	26.9	29.7	29.8	2.7	99	81 (81.8%)	18 (18.2%)
North Woods (Dry-Mesic Southern Forest)	2.56 ha 6.33 acres	43.8	45.4	40.5	3.9	126	117 (92.9%)	9 (7.1%)
Dry Woods (Dry Southern Forest)	5.64 ha 13.95 acres	34.1	36.5	39.5	3.7	85	75 (88.2%)	10 (11.8%)
Ravine Woods (Mesic Southern Forest)	7.46 ha 18.43 acres	39.3	41.0	42.8	4.1	92	87 (94.6%)	5 (5.4%)
Old Growth Woods (Mesic Southern Forest)	2.56 ha 6.25 acres	33.2	34.3	47.6	4.6	52	49 (94.2%)	3 (5.8%)
Middle Woods (Mesic Southern Forest)	5.27 ha 13.01 acres	29.2	31.0	38.1	3.6	66	60 (90.9%)	6 (9.1%)
West Woods (Mesic Southern Forest)	6.20 ha 15.31 acres	30.8	32.2	37.7	3.6	73	65 (89.0%)	8 (11.0%)
East Woods (Mesic Southern Forest)	7.65 ha 18.92 acres	34.2	35.5	37.5	3.6	90	83 (92.2%)	7 (7.8%)
South Woods (Mesic Southern Forest)	2.57 ha 6.36 acres	30.5	31.3	41.1	4.0	58	53 (91.4%)	5 (8.6%)

high of 43.8 (Total Mean *C* = 3.9) at North Woods, where the percentage of non-native species is only 7.1%. Descriptions of these nine wooded sites, all within close proximity to each other, bring to light many resemblances. However, we found it noteworthy that each parcel held its own distinctness as well, an observation we address more fully below in the Conclusion. The Floristic Quality Assessment metrics for each of these nine sites are given in Table 1, and the species recorded from each site are listed in Table 2. The forest community classification follows that of the Michigan Natural Features Inventory (Cohen et al. 2015).

Gateway Woods (42° 54.065'N, 85° 21.363'W)

Gateway Woods (A in Figure 2) is a narrow parcel that gives access from 36th Street to the Lowell Regional Greenspace property. This open woodland parcel seems to best fit a dry southern forest community type. A total of 99 species, of which 81.8% (81 species) are native, were cataloged here. Among all the woodland sites inventoried, this site had the lowest Total FQI value (26.9) and likewise the lowest Total Mean *C* value (2.7); since these values are indicative of disturbance, it is a site of relatively low conservation value.

Gateway Woods can be subdivided into two areas: the northernmost wooded area adjacent to 36th Street and the more southerly, somewhat open, hillside sloping down toward a creek and its floodplain. The wooded area is dominated by *Quercus velutina*, *Pinus strobus*, and *Sassafras albidum* with an understory characterized by *Cornus alternifolia*, *Chimaphila maculata*, *Diphasiastrum digitatum*, *Carex pensylvanica*, *Dichanthelium depauperatum*, *D. commonsianum*, *D. oligosanthes*, and *Osmorhiza longistylis*.

The southern somewhat open, dry sandy hillside has little canopy cover with only *Quercus velutina* saplings, a small stand of *Populus grandidentata*, scattered *Juniperus virginiana*, and the shrubs *Rubus occidentalis*, *R. allegheniensis*, *R. flagellaris*, *R. pensilvanicus*, and *Corylus americana*. There are several other species typical of open dry sites that are present in the area, including *Monarda punctata*, *Euphorbia corollata*, *Apocynum cannabinum*, *Rudbeckia hirta*, *Vicia villosa*, *Fragaria virginiana*, *Oenothera biennis*, *Dichanthelium* spp., and *Solidago canadensis.*

Overall, there is a high diversity of both native and non-native plants in the small-sized Gateway Woods. The relatively high proportion of non-native weedy species (18 species or 18.2%) attests to a moderate degree of disturbance: *Achillea millefolium*, *Berteroa incana*, *Bromus inermis*, *Verbascum thapsus*, and the rather despised *Alliaria petiolata*, as well as a recently spreading invasive vine, *Vincetoxicum nigrum*. The location of this woods immediately alongside 36th Street likely accounts for the high number of weedy natives and non-native species. There also seems to be routine human disturbance as is evident by a deer hunting blind that overlooks the open slope. The southern portion of the parcel grades down to an abrupt change in vegetation (North Woods) and is bounded on the east side by a two-track separating it from a strip of planted Red Pine (*Pinus resinosa*) on private land.

North Woods (42° 54.000'N, 85° 21.341'W)

We classified the North Woods (B in Figure 2) as dry-mesic southern forest.

TABLE 2. Floristic composition of each of the nine woodland study sites at Lowell Regional Greenspace. An X indicates the presence of a species at a given site. The right-hand column gives the number of sites from which each species was recorded. State-listed species are indicated in boldface as follows: T = Threatened; SC = Special Concern.

Species	Gateway Woods	North Woods	South Woods	East Woods	West Woods	Middle Woods	Growth Woods	Ravine Woods	Dry Woods	Species of sites
Acer negundo L.										
Box Elder	X	X		X						3
Acer nigrum F. Michx.										
Black Maple			X	X		X	X	X		5
Acer rubrum L.										
Red Maple	X	X		X	X	X	X	X	X	8
Acer saccharinum L.										
Silver Maple				X		X				2
Acer saccharum Marshall										
Sugar Maple			X	X	X	X	X	X		6
Achillea millefolium L.										
Yarrow	X									1
Actaea pachypoda Elliott										
White Baneberry, Doll's Eyes		X	X			X	X	X	X	6
Adiantum pedatum L.										
Maidenhair Fern							X			1
Agrimonia gryposepala Wallr.										
Tall Agrimony	X	X	X	X	X				X	6
Agrostis gigantea Roth										
Redtop		X								1
Agrostis perennans (Walter) Tuck.										
Autumn Bent, Upland Bent									X	1
Alliaria petiolata (M. Bieb.) Cavara & Grande										
Garlic Mustard	X			X	X	X	X	X	X	7
Allium burdickii (Hanes) A. G. Jones										
Wild Leek							X			1
Allium tricoccum Aiton										
Ramps, Wild Leek						X	X			2

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TABLE 2. (*Continued*)

Species	Gateway Woods	North Woods	South Woods	East Woods	West Woods	Middle Woods	Growth Woods	Ravine Woods	Dry Woods	Species of sites
Amelanchier laevis Wiegand										
Smooth Shadbush			X							1
Amphicarpaea bracteata (L.) Fernald										
Hog-peanut		X			X			X		3
Anemone virginiana L.										
Thimbleweed		X								1
Apios americana Medik.										
Groundnut, Indian-potato	X	X								2
Apocynum androsaemifolium L.										
Spreading Dogbane									X	1
Apocynum cannabinum L.										
Indian-hemp	X									1
Arctium minus Bernh.										
Common Burdock					X	X		X		3
Arisaema triphyllum (L.) Schott										
Jack-in-the-pulpit, Indian-turnip		X	X	X		X	X	X		6
Asarum canadense L.										
Wild-ginger		X						X		2
Asclepias incarnata L.										
Swamp Milkweed				X						1
Asclepias syriaca L.										
Common Milkweed	X									1
Asplenium platyneuron (L.) D. C. Eaton										
Ebony Spleenwort	X				X				X	3
Athyrium filix-femina (L.) Roth										
Lady Fern		X								1
Barbarea vulgaris R. Br.										
Yellow Rocket				X						1
Berberis thunbergii DC.										
Japanese Barberry		X	X					X		3

Berteroa incana (L.) DC.										
Hoary Alyssum	X									1
Boehmeria cylindrica (L.) Sw.										
False Nettle		X								1
Botrypus virginianus (L.) Michx.										
Rattlesnake Fern	X									1
Brachyelytrum aristosum (Michx.) Branner & Coville										
Northern Shorthusk		X						X	X	3
Brachyelytrum erectum (Roth) P. Beauv.										
Long-awned Wood Grass			X		X	X				3
Bromus inermis Leyss.										
Smooth Brome	X									1
Campanulastrum americanum (L.) Small										
Tall Bellflower, American Bellflower					X					1
Cardamine bulbosa (Muhl.) Britton, Sterns & Poggenb.										
Spring Cress			X							1
Cardamine concatenata (Michx.) O. Schwarz										
Cut-leaved Toothwort			X					X		2
Cardamine diphylla (Michx.) Alph. Wood										
Two-leaved Toothwort								X		1
Cardamine douglassii Britton										
Pink Spring Cress							X			1
Cardamine pensylvanica Willd.										
Pennsylvania Bitter Cress	X									1
Carex albursina E. Sheld.										
Sedge		X	X	X	X		X	X		6
Carex blanda Dewey										
Sedge	X				X	X			X	4
Carex bromoides Willd.										
Sedge		X						X	X	3
Carex cephalophora Willd.										
Sedge	X									1
Carex crinita Lam.										
Sedge		X		X						2

(*Continued on next page*)

TABLE 2. (*Continued*)

Species	Gateway Woods	North Woods	South Woods	East Woods	West Woods	Middle Woods	Growth Woods	Ravine Woods	Dry Woods	Species of sites
Carex davisii Schwein. & Torr. (SC) Davis' Sedge				X						1
Carex gracillima Schwein. Sedge		X	X			X	X	X	X	6
Carex granularis Willd. Sedge									X	1
Carex grayi J. Carey Sedge				X		X		X		3
Carex grisea Wahlenb. Sedge				X				X		2
Carex hirtifolia Mack. Sedge				X						1
Carex hitchcockiana Dewey Sedge				X				X		2
Carex intumescens Rudge Sedge		X								1
Carex jamesii Schwein. James' Sedge			X	X			X			3
Carex laxiflora Lam. Sedge			X				X	X		3
Carex lupulina Willd. Sedge				X						1
Carex pedunculata Willd. Sedge								X		1
Carex pensylvanica Lam. Pennsylvania Sedge	X	X	X		X			X	X	6
Carex prasina Wahlenb. Sedge								X		1
Carex radiata (Wahlenb.) Small Straight-styled Wood Sedge						X				1

Carex rosea Willd.										
Curley-styled Wood Sedge		X	X	X	X	X	X	X	X	8
Carex sparganioides Willd.										
Sedge	X	X	X					X		4
Carex stricta Lam.										
Sedge				X						1
Carex swanii (Fernald) Mack.										
Sedge	X				X	X			X	4
Carex tribuloides Wahlenb.										
Sedge						X				1
Carex vulpinoidea Michx.										
Sedge				X						1
Carpinus caroliniana Walter										
Hornbeam, Blue-beech, Muscle-wood		X		X		X				3
Carya cordiformis (Wang.) K. Koch										
Bitternut Hickory		X	X	X		X	X	X		6
Carya glabra (Mill.) Sweet										
Pignut Hickory		X		X					X	3
Carya ovata (Mill.) K. Koch										
Shagbark Hickory	X			X	X	X			X	5
Caulophyllum thalictroides (L.) Michx.										
Blue Cohosh							X	X		2
Celtis occidentalis L.										
Hackberry					X	X		X	X	4
Centaurea stoebe L.										
Spotted Knapweed	X									1
Cephalanthus occidentalis L.										
Buttonbush				X						1
Chimaphila maculata (L.) Pursh										
Spotted Wintergreen	X								X	2
Chimaphila umbellata (L.) Nutt.										
Pipsissewa, Prince's-pine									X	1
Cinna arundinacea L.										
Wood Reedgrass				X						1

(*Continued on next page*)

TABLE 2. (*Continued*)

Species	Gateway Woods	North Woods	South Woods	East Woods	West Woods	Middle Woods	Growth Woods	Ravine Woods	Dry Woods	Species of sites
Circaea canadensis (L.) Hill										
Enchanter's-nightshade	X	X	X	X	X	X	X	X	X	9
Claytonia virginica L.										
Spring-beauty		X	X							2
Clematis virginiana L.										
Virgin's Bower		X			X					2
Collinsonia canadensis L.										
Horse-balm, Stoneroot, Richweed					X		X			2
Conopholis americana (L.) Wallr.										
Squaw-root							X		X	2
Cornus alternifolia L. f.										
Alternate-leaved Dogwood, Pagoda Dogwood	X									1
Cornus foemina Mill.										
Gray Dogwood		X		X						2
Cornus florida L.										
Flowering Dogwood	X	X							X	3
Cornus rugosa Lam.										
Round-leaved Dogwood	X									1
Cornus sericea L.										
Red-osier				X						1
Corylus americana Walter										
Hazelnut	X	X								2
Cryptotaenia canadensis (L.) DC.										
Honewort								X		1
Cyperus lupulinus (Spreng.) Marcks										
Slender Sand Sedge	X									1
Cystopteris tenuis (Michx.) Desv.										
Fragile Fern								X		1
Dactylis glomerata L.										
Orchard Grass									X	1

Danthonia spicata (L.) Roem. & Schult. Poverty Grass, Oatgrass									X	1
Desmodium paniculatum (L.) DC. Panicled Tick-trefoil	X	X								2
Dicentra cucullaria (L.) Bernh. Dutchman's-breeches			X							1
Dichanthelium clandestinum (L.) Gould Panic Grass	X									1
Dichanthelium columbianum (Schribn.) Freckmann Panic Grass									X	1
Dichanthelium commonsianum (Ashe) Freckmann Panic Grass	X									1
Dichanthelium depauperatum (Muhl.) Gould	X								X	2
Dichanthelium implicatum (Scribn.) Kerguélen Panic Grass	X								X	2
Dichanthelium oligosanthes (Schult.) Gould Panic Grass	X									1
Dioscorea villosa L. Wild Yam		X		X	X					3
Diphasiastrum digitatum (A. Braun) Holub Ground-cedar	X									1
Dryopteris intermedia (Willd.) A. Gray Evergreen Woodfern					X		X			2
Dryopteris carthusiana (Vill.) H. P. Fuchs Spinulose Woodfern				X		X	X	X	X	5
Dryopteris clintoniana (D. C. Eaton) Dowell Clinton's Woodfern		X								1
Elaeagnus umbellata Thunb. Autumn-olive	X	X			X			X	X	5
Elymus hystrix L. Bottlebrush Grass		X	X	X	X	X		X	X	7
Elymus villosus Willd. Silky Wild-rye		X			X	X		X		4

(*Continued on next page*)

TABLE 2. (*Continued*)

Species	Gateway Woods	North Woods	South Woods	East Woods	West Woods	Middle Woods	Growth Woods	Ravine Woods	Dry Woods	Species of sites
Elymus virginicus L.										
Virginia Wild-rye				X						1
Epifagus virginiana (L.) Bart.										
Beech-drops							X			1
Epipactis helleborine (L.) Crantz										
Helleborine			X			X	X			3
Equisetum arvense L.										
Common Horsetail	X	X				X		X		4
Erigeron annuus (L.) Pers.										
Daisy Fleabane	X	X		X						3
Euonymus obovatus Nutt.										
Running Strawberry-bush		X					X	X		1
Eupatorium perfoliatum L.										
Boneset		X								1
Euphorbia corollata L.										
Flowering Spurge	X									1
Eurybia macrophylla (L.) Cass.										
Large-leaved Aster, Big-leaved Aster	X	X		X	X			X	X	6
Eutrochium maculatum (L.) E. E. Lamont										
Joe-Pye-weed	X	X								2
Fagus grandifolia Ehrh.										
American Beech		X	X	X	X	X	X	X	X	8
Festuca subverticillata (Pers.) E. B. Alexeev										
Nodding Fescue		X			X			X	X	4
Floerkea proserpinacoides Willd.										
False Mermaid			X							1
Fragaria virginiana Mill.										
Wild Strawberry	X									1
Fraxinus americana L.										
White Ash				X						1

Fraxinus nigra Marshall										
Black Ash								X		1
Fraxinus pennsylvanica Marshall										
Green Ash, Red Ash	X	X	X	X	X	X	X	X		8
Galium aparine L.										
Cleavers, Annual Bedstraw	X	X	X	X	X	X		X	X	8
Galium circaezans Michx.										
White Wild Licorice	X								X	2
Galium lanceolatum Torr.										
Yellow Wild Licorice	X								X	2
Galium tinctorium L.										
Stiff Bedstraw				X						1
Geranium maculatum L.										
Wild Geranium		X	X	X	X	X		X		6
Geum canadense Jacq.										
White Avens	X	X	X	X	X	X	X	X	X	9
Glechoma hederacea L.										
Creeping Charlie, Gill-over-the-ground	X									1
Glyceria striata (Lam.) Hitchc.										
Fowl Manna Grass		X	X	X	X	X	X	X		7
Hackelia virginiana (L.) I. M. Johnst.										
Beggar's Lice		X	X				X		X	4
Hamamelis virginiana L.										
Witch-Hazel					X		X	X	X	4
Hepatica americana (DC.) Ker Gawl.										
Round-lobed Hepatica		X			X					2
Hesperis matronalis L.										
Dame's Rocket					X					1
Hieracium caespitosum Dumort.										
King Devil, Yellow Hawkweed	X								X	2
Hydrastis canadensis L. (T)										
Goldenseal										1
Hydrophyllum appendiculatum Michx.										
Great Waterleaf						X	X	X		3

(*Continued on next page*)

TABLE 2. (*Continued*)

Species	Gateway Woods	North Woods	South Woods	East Woods	West Woods	Middle Woods	Growth Woods	Ravine Woods	Dry Woods	Species of sites
Hydrophyllum canadense L.										
Broadleaved Waterleaf, Canada Waterleaf				X			X	X		3
Hydrophyllum virginianum L.										
Virginia Waterleaf								X		1
Hylodesmum glutinosum (Willd.) H. Ohashi & R. R. Mill										
Clustered-leaved Tick-trefoil					X					1
Hylodesmum nudiflorum (L.) H. Ohashi & R. R. Mill										
Naked Tick-trefoil	X	X							X	3
Hypericum perforatum L.										
Klamath Weed, Common St. John's-wort		X							X	2
Impatiens capensis Meerb.										
Spotted Touch-me-not		X		X	X	X	X	X		6
Iris virginica L.										
Southern Blue Flag		X								1
Juglans cinerea L.										
Butternut	X			X	X				X	4
Juglans nigra L.										
Black Walnut		X	X	X		X			X	5
Juncus effusus L.										
Soft-stemmed Rush		X								1
Juniperus virginiana L.										
Red Cedar	X								X	2
Laportea canadensis (L.) Wedd.										
Wood Nettle		X	X			X	X	X		5
Leersia oryzoides (L.) Sw.										
Cut Grass				X						1
Leersia virginica Willd.										
White Grass		X		X					X	3
Leucanthemum vulgare Lam.										
Ox-eyed Daisy	X									1

Lilium michiganense Farw.										
Michigan Lily		X								1
Lindera benzoin (L.) Blume										
Spicebush	X	X		X	X	X	X		X	7
Liriodendron tulipifera L.										
Tulip Tree		X		X	X	X	X	X	X	7
Lithospermum latifolium Michx. (SC)										
American Gromwell, Broad-leaved Puccoon									X	1
Lysimachia ciliata L.										
Fringed Loosestrife		X		X						2
Lysimachia lanceolata Walter										
Lance-leaved Loosestrife		X								1
Maianthemum racemosum (L.) Link										
False Spikenard	X	X	X		X	X		X	X	7
Matteuccia struthiopteris (L.) Todaro										
Ostrich Fern				X						1
Mentha canadensis L.										
Wild Mint		X								1
Micranthes pensylvanica (L.) Haw.										
Swamp Saxifrage		X								1
Milium effusum L.										
Wood Millet		X								1
Monarda fistulosa L.										
Wild-bergamot	X	X						X	X	4
Monarda punctata L.										
Dotted Mint, Horse Mint	X									1
Monotropa uniflora L.										
Indian-pipe	X	X			X				X	4
Nasturtium microphyllum Rchb.										
Watercress		X								1
Oenothera biennis L.										
Common Evening-primrose	X									1
Onoclea sensibilis L.										
Sensitive Fern	X	X	X	X	X	X		X		7

(*Continued on next page*)

TABLE 2. (*Continued*)

Species	Gateway Woods	North Woods	South Woods	East Woods	West Woods	Middle Woods	Growth Woods	Ravine Woods	Dry Woods	Species of sites
Osmorhiza claytonii (Michx.) C. B. Clarke										
Hairy Sweet-cicely	X	X								2
Osmorhiza longistylis (Torr.) DC.										
Smooth Sweet-cicely	X				X				X	3
Osmunda regalis L.										
Royal Fern		X								1
Osmundastrum cinnamomeum (L.) C. Presl										
Cinnamon Fern		X								1
Ostrya virginiana (Mill.) K. Koch										
Ironwood, Hop-hornbeam			X	X		X		X		4
Oxalis stricta L.										
Yellow Wood-sorrel	X									1
Packera aurea (L.) Á. Löve & D. Löve										
Golden Ragwort		X								1
Packera glabella (Poir.) C. Jeffrey										
Butterweed, Yellowtop				X						1
Parthenocissus quinquefolia (L.) Planch.										
Virginia Creeper	X	X	X	X	X	X	X	X	X	9
Penstemon hirsutus (L.) Willd.										
Hairy Beard-tongue	X									1
Persicaria amphibia (L.) Delabare										
Water Smartweed				X						1
Persicaria virginiana (L.) Gaertn.										
Jumpseed	X	X	X	X	X	X	X	X	X	9
Phalaris arundinacea L.										
Reed Canary Grass		X								1
Phlox divaricata L.										
Wild Blue Phlox			X					X		2
Phryma leptostachya L.										
Lopseed	X	X							X	3

Physocarpus opulifolius (L.) Maxim.										
Ninebark		X								1
Phytolacca americana L.										
Pokeweed, Poke	X				X			X		3
Picea abies (L.) H. Karst.										
Norway Spruce	X									1
Pilea pumila (L.) A. Gray										
Clearweed				X						1
Plantago major L.										
Common Plantain		X								1
Pinus strobus L.										
White Pine	X	X								2
Pinus sylvestris L.										
Scots Pine, Scotch Pine	X								X	2
Poa alsodes A. Gray										
Bluegrass									X	1
Poa annua L.										
Annual Bluegrass				X						1
Poa palustris L.										
Fowl Meadow Grass				X						1
Poa sylvestris A. Gray										
Woodland Bluegrass				X						1
Poa saltuensis Fernald & Wiegand										
Bluegrass	X									1
Podophyllum peltatum L.										
May-apple, Mandrake		X	X	X	X	X	X	X	X	8
Polystichum acrostichoides (Michx.) Schott.										
Christmas Fern			X			X	X	X	X	5
Populus deltoides Marshall										
Cottonwood					X	X		X		3
Populus grandidentata Michx.										
Large-toothed Aspen, Big-toothed Aspen	X	X							X	3
Potentilla simplex Michx.										
Old-field Cinquefoil, Common Cinquefoil	X	X							X	3

(*Continued on next page*)

TABLE 2. (*Continued*)

Species	Gateway Woods	North Woods	South Woods	East Woods	West Woods	Middle Woods	Growth Woods	Ravine Woods	Dry Woods	Species of sites
Prenanthes altissima L.										
Tall White Lettuce		X	X		X	X		X		5
Prunella vulgaris L.										
Self-heal, Heal-all		X								1
Prunus cerasus L.										
Pie Cherry, Sour Cherry			X							1
Prunus serotina Ehrh.										
Wild Black Cherry	X	X	X	X		X	X	X	X	8
Prunus virginiana L.										
Choke Cherry					X	X			X	3
Pteridium aquilinum (L.) Kuhn										
Bracken Fern		X							X	2
Pyrola elliptica Nutt.										
Large-leaved Shinleaf		X								1
Quercus alba L.										
White Oak	X	X		X	X			X	X	6
Quercus bicolor Willd.										
Swamp White Oak								X		1
Quercus macrocarpa Michx.										
Bur Oak		X								1
Quercus rubra L.										
Red Oak		X		X	X	X	X	X	X	7
Quercus velutina Lam.										
Black Oak	X			X					X	3
Ranunculus abortivus L.										
Small-flowered Buttercup				X				X	X	3
Ranunculus hispidus Michx.										
Swamp Buttercup		X								1
Ranunculus recurvatus Poir.										
Hooked Crowfoot								X		1

Rhamnus cathartica L.										
Common Buckthorn					X					1
Ribes americanum Mill.										
Wild Black Currant		X								1
Ribes cynosbati L.										
Prickly Gooseberry, Wild Gooseberry	X	X	X	X	X	X	X	X	X	9
Rosa multiflora Murry										
Multiflora Rose, Japanese Rose	X	X	X	X	X	X	X	X		8
Rubus allegheniensis Porter										
Common Blackberry	X	X	X	X	X	X		X	X	8
Rubus flagellaris Willd.										
Northern Dewberry	X	X							X	3
Rubus occidentalis L.										
Black Raspberry	X	X		X		X			X	5
Rubus pensilvanicus Poir.										
Dewberry	X									1
Rudbeckia fulgida Aiton										
Black-eyed Susan, Orange Coneflower		X								1
Rudbeckia laciniata L.										
Tall Coneflower, Cut-leaf Coneflower		X								1
Rudbeckia hirta L.										
Black-eyed Susan	X								X	2
Rumex acetosella L.										
Red Sorrel, Sheep Sorrel	X								X	2
Rumex crispus L.										
Curly Dock, Sour Dock		X				X			X	3
Rumex obtusifolius L.										
Bitter Dock				X						1
Sambucus canadensis L.										
Common Elder, Elderberry		X								1
Sanguinaria canadensis L.										
Bloodroot			X	X	X		X	X		5
Sanicula odorata (Raf.) Pryer & Phillippe										
Black Snakeroot		X			X			X		3

(*Continued on next page*)

TABLE 2. (*Continued*)

Species	Gateway Woods	North Woods	South Woods	East Woods	West Woods	Middle Woods	Growth Woods	Ravine Woods	Dry Woods	Species of sites
Sassafras albidum (Nutt.) Nees										
Sassafras	X	X	X		X	X		X	X	7
Scirpus atrovirens Willd.										
Bulrush		X								1
Scutellaria lateriflora L.										
Mad-dog Skullcap		X								1
Smilax ecirrata (Kunth) S. Watson										
Upright Carrion-flower								X		1
Smilax illinoensis Mangaly										
Carrion-flower	X	X								2
Solidago caesia L.										
Bluestem Goldenrod		X	X	X	X	X		X	X	7
Solidago canadensis L.										
Canada Goldenrod	X	X		X	X		X			5
Solidago flexicaulis L.										
ZigZag Goldenrod								X		1
Solidago uliginosa Nutt.										
Bog Goldenrod		X								1
Sphenopholis intermedia (Rydb.) Rydb.										
Slender Wedgegrass					X			X		2
Spiraea alba Du Roi										
Meadowsweet		X								1
Staphylea trifolia L.										
Bladdernut			X	X						2
Stellaria longifolia Willd.										
Long-leaved Chickweed	X								X	2
Symphyotrichum lateriflorum (L.) Á. Löve & D. Löve										
Calico Aster				X						1
Symplocarpus foetidus (L.) Nutt.										
Skunk-cabbage		X				X		X		3

Thalictrum dasycarpum Fisch. & Avé-Lall.										
Purple Meadow-rue		X								1
Thalictrum dioicum L.										
Early Meadow-rue		X			X		X	X		4
Tilia americana L.										
Basswood, Linden			X	X	X	X	X	X		6
Torilis japonica (Houtt.) DC.										
Hedge-parsley	X	X	X		X				X	5
Toxicodendron radicans (L.) Kuntze										
Poison Ivy	X	X	X	X	X	X	X	X	X	9
Trillium grandiflorum (Michx.) Salisb.										
Common Trillium		X	X		X			X		4
Turritis glabra L.										
Tower Mustard	X								X	2
Ulmus americana L.										
American Elm, White Elm				X						1
Ulmus rubra Muhl.										
Slippery Elm, Red Elm	X		X	X	X			X		5
Urtica dioica L.										
Stinging Nettle				X				X		2
Verbascum densiflorum Bertol.										
Mullein	X	X		X						3
Verbascum thapsus L.										
Commom Mullein, Flannel Plant	X									1
Veronica officinalis L.										
Common Speedwell	X					X			X	3
Veronicastrum virginicum (L.) Farw.										
Culver's-root		X								1
Viburnum acerifolium L.										
Maple-leaved Viburnum								X		1
Viburnum lentago L.										
Nannyberry						X				1
Vincetoxicum nigrum (L.) Pers.										
Black Swallow-wort	X				X					2

(*Continued on next page*)

TABLE 2. (Continued).

Species	Gateway Woods	North Woods	South Woods	East Woods	West Woods	Middle Woods	Growth Woods	Ravine Woods	Dry Woods	Species of sites
Vicia villosa Roth										
Hairy Vetch	X									1
Viola canadensis L.										
Canada Violet		X	X		X	.	X			5
Viola rostrata Pursh										
Long-spurred Violet								X		1
Vitis riparia Michx.										
River-bank Grape	X	X		X	X	X	X	X	X	8
Zanthoxylum americanum Mill.										
Prickly-ash	X		X	X	X	X		X		6
TOTALS	99	126	58	90	73	66	52	92	85	-

A total of 126 species, of which 92.9% (117 species) are native, were found in this relatively small parcel. It is the most diverse and species-rich of all the woodland sites inventoried. The Total FQI of North Woods is 43.8, and the Native FQI is 45.4, giving it the highest FQA of our forested parcels and ranking the woods as having high conservation quality (Table 1); its Mean *C* value is 3.9. North Woods consists of undisturbed forest on relatively flat terrain at the base of the disturbed southern slope of Gateway Woods (A in Figure 2) and the adjacent privately owned red pine plantation. It is bordered on the south by the north-facing slope of a very dry hillside in Dry Woods (C in Figure 2). A stream flows westward through this section of forest from one area of southern shrub-carr wetland (East Wetland; EW in Figure 2) into West Wetland (WW).

The woody species that characterize this site are *Acer rubrum*, *A. negundo*, *Quercus alba*, *Q. rubra*, *Carpinus caroliniana*, *Sassafras albidum*, and *Cornus florida*, along with scattered individuals of *Quercus macrocarpa*, *Prunus serotina*, *Juglans nigra*, *Hamamelis virginiana*, *Cornus foemina*, *Sambucus canadensis*, *Ribes americanum*, and *R. cynosbati*. The forest ground cover is comprised of species such as *Carex gracillima*, *Festuca subverticillata*, *Milium effusum*, *Hylodesmum nudiflorum*, *Toxicodendron radicans*, and *Lysimachia lanceolata.* However, along the streambank there is a higher concentration of wet woodland species, including *Lindera benzoin*, *Angelica atropurpurea*, *Symplocarpus foetidus*, *Iris virginica*, *Packera aurea*, *Onoclea sensibilis*, *Osmundastrum cinnamomeum*, and nine species of *Carex.* The higher proportion of wetland species is understandable when one considers that the stream, with its floodplain, connects two larger wetland ecosystems.

Dry Woods (42° 53.930'N, 85° 21.379'W)

Dry Woods (C in Figure 2) best fits the dry southern forest community type. A total of 85 species, 88.2% (75 species) of which are native, were found at this site. The Total FQI is 34.1, and the Native FQI is 36.5; when the Adjusted FQI of 39.5 is taken into account, this site can be ranked as a high-quality site, of floristic importance to the state. Interestingly, the dry southern forest located in the B. D. White Preserve just on the north side of 36th Street ca. 0.5 miles away has similar FQA metrics, with 109 species (89.0% native), with a Total FQI of 37.6, a Native FQI of 40.4 and an Adjusted FQI of 38.7 (Stockdale et al. 2019).

The dry hillside habitat of Dry Woods is dominated by *Quercus velutina*, *Q. alba*, and *Q. rubra*, with scattered individuals of S*assafras albidum*, *Hamamelis virginiana*, *Juglans nigra*, *Juglans cinerea*, *Juniperus virginiana*, *Acer rubrum*, and *Elaeagnus umbellata*. The understory is very open; sandy soils contribute to sparse ground cover (likely exacerbated by deer browsing), with only scattered species such as *Hypericum perforatum*, *Hylodesmum nudiflorum*, *Galium aparine*, *Eurybia macrophylla*, and *Dryopteris carthusiana.* A number of scattered graminoids also occur, including several grasses: *Brachyelytrum aristosum*, *Dichanthelium depauperatum*, *D. implicatum*, *D. columbianum*, *Elymus hystrix*, *Festuca subverticillata*, and several sedges, among which are: *Carex pensylvanica*, *C. blanda*, *C. gracillima*, *C. granularis*, *C. rosea*, and *C. swanii*. There is also a somewhat moist depression here where *Apocynum androsaemifolium*, *Phryma leptostachya*, and other species are found. Among the more notable

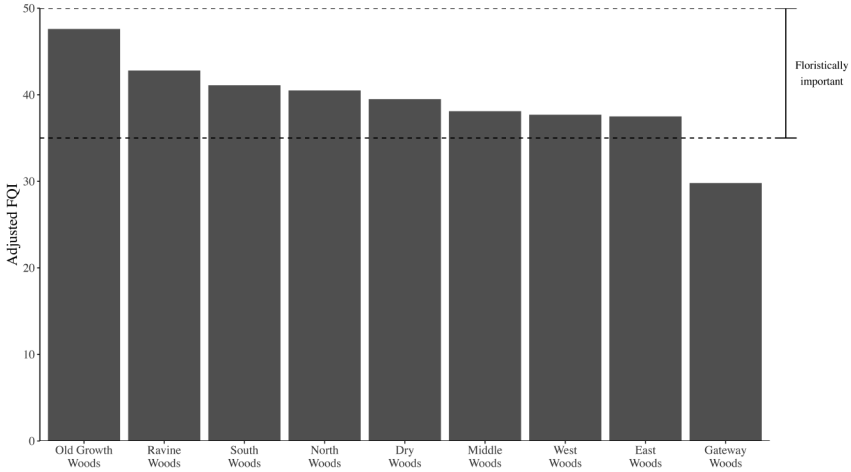

FIGURE 4. Comparison of the nine woodland study sites based on the Adjusted Floristic Quality Index (Adjusted FQI), indicating those of statewide floristic significance.

plants found in Dry Woods are *Chimaphila umbellata* and *Conopholis americana.* Two deer stands were also observed, and a herd of about 15 deer were seen at this site in spring 2019.

The outline of the Dry Woods site forms a "C" shape on a sandy hillside around a disturbed young forest on the east side of the hill (which was not inventoried). The north side of this parcel abuts North Woods, a dry-mesic southern forest that follows the stream at the bottom of the incline. The western side slopes steeply down to the large wetland of southern shrub-carr in West Wetland (WW in Figure 2). Southward is a fairly large, young, highly-disturbed secondary forest, which was not inventoried.

Ravine Woods (42° 53.821'N, 85° 21.047'W)

Ravine Woods (D in Figure 2) is wetter than most of the other wooded sites and was classified as mesic southern forest. A total of 92 species, 87 (94.6%) of which are native, were cataloged. It has the second highest Total FQI (39.3) among the nine sites, a Native FQI of 41.0, and an Adjusted FQI of 42.8 (Figure 4). It's Mean *C* value of 4.1 was the second highest of the wooded sites studied. Thus, this high-quality site is also floristically important on a state-wide basis.

Ravine Woods consists of a steep-sided stream that flows west, then northwest, into East Wetland. There are several seeps and flat areas along the top of the slope. This wooded area is characterized by *Acer saccharum*, *A. rubrum*, *Fagus grandifolia*, and *Tilia americana*, with notable scattered individuals of *Liriodendron tulipifera*, *Quercus bicolor*, *Celtis occidentalis*, *Ostrya virginiana*, and *Acer nigrum*. Three viny species, *Toxicodendron radicans*, *Vitis riparia*, *and Parthenocissus quinquefolia*, are also present. The herbaceous ground cover of the woods is indicative of a rich, moist forest and is characterized by *Geranium*

maculatum, *Podophyllum peltatum*, *Carex pedunculata*, *Solidago flexicaulis*, *S. caesia*, *Phlox divaricata*, *Hydrophyllum appendiculatum*, *H. canadense*, *H. virginianum*, *Ranunculus recurvatus*, *R. abortivus*, *Trillium grandiflorum*, *Cryptotaenia canadensis*, *Geum canadense*, and *Polystichum acrostichoides.* Along the stream bank there are species such as *Laportea canadensis* and *Asarum canadense*. In the seep areas there are additional species such as *Symplocarpus foetidus* and, notably, *Carex prasina*, along with several other more common species of *Carex*. This ravine site is bounded by agricultural lands on the northeast, east and south, and on the west by immature disturbed forest.

Old Growth Woods (42° 53.805'N, 85° 21.405'W)

Old Growth Woods (E in Figure 2) best fits a mesic southern forest plant community type. A relatively low total of 52 species was identified here, but with a very high percentage of native species, 94.2% (49 species). The aspect of this forest is impressive, with many stately trees located on a very steep north-facing slope descending into the upper reaches of the large West Wetland. On a class field trip, D. Warners had students randomly measure 80 trees in this parcel. More than half were larger than 2 feet dbh, six were greater than 3 feet dbh, and the three largest trees were a 40-inch dbh *Fagus grandifolia* (American Beech), a 46-inch dbh *Liriodendron tulipifera* (Tulip Tree), and a 48-inch dbh *Quercus rubra* (Red Oak). The Total FQI is 33.2, and the Native FQI is 34.3. Since the number of species in this wooded slope is low, the Adjusted FQI of 47.6 is the most reliable measure to affirm its value as a high-quality site, worthy of floristic recognition at the state level (Figure 4). This is further confirmed by having the highest Mean *C* value (4.6) of all the wooded sites.

As a community, this forest is dominated by *Acer saccharum*, *Fagus grandifolia*, and *Liriodendron tulipifera*, with scattered trees of *Acer nigrum*, *A. rubrum*, *Fraxinus pennsylvanica*, *Hamamelis virginiana*, *Prunus serotina*, *Tilia americana*, and *Quercus rubra*. The understory is patchy, with a species assemblage indicative of a rich woodland, with *Actaea pachypoda*, *Adiantum pedatum*, *Polystichum acrostichoides*, *Cardamine douglassii*, *Caulophyllum thalictroides*, *Collinsonia canadensis*, *Circaea canadensis*, *Euonymus obovatus*, *Hydrophyllum canadense*, *H. virginianum*, *Podophyllum peltatum*, *Sanguinaria canadensis*, *Laportea canadensis*, *Viola canadensis*, *Conopholis americana*, *Allium tricoccum*, and *A. burdickii*. Several sedges that are found here are also indicative of high-quality rich woods, including *Carex albursina*, *C. gracillima*, *C. jamesii*, *C. laxiflora*, *and C. rosea*. It is suspected that this is a remnant of old growth forest that was never logged due to its location on such a steeply sloped contour.

To the south and southeast is a successional old agricultural field shifting to meadow, part of which has been managed for prairie restoration. The east boundary is a ravine that channels runoff from the meadow. The north boundary is the large shrub-dominated wetland (West Wetland), and a large seep dominated by *Laportea canadensis* and *Symplocarpus foetidus*. Toward the west boundary there is a shift in ground cover vegetation from spring ephemerals and ferns to soils dominated by *Parthenocissus quinquefolia*; the trees are mature in this area but do not have the distinctive appearance of old growth.

Middle Woods (42° 53.705'N, 85° 21.522'W)

Middle Woods (F in Figure 2) best fits the mesic southern forest category. A total of 66 species, 90.9% (60 species) of which are native, were documented here. While the Total FQI (29.2) and Native FQI (31.0) might suggest this to be a more average quality site, the Adjusted FQI (38.1) which corrects for low species richness, is substantially higher. The Mean *C* value of 3.6 also indicates that this woods should be regarded as a high-quality mesic southern forest (Figure 4).

This parcel is dominated by *Acer saccharum* and *Tilia americana*, with less abundant woody species including *Quercus rubra*, *Carya cordiformis*, *Carya glabra*, *Celtis occidentalis*, *Fagus grandifolia*, *Fraxinus pennsylvanica*, *Juglans nigra*, *Liriodendron tulipifera*, *Acer nigrum*, *A. rubrum*, *Prunus serotina*, *P. virginiana*, *Zanthoxylum americanum*, *Carpinus caroliniana*, and *Ostrya virginiana.* The understory is heavily populated by the vines *Parthenocissus quinquefolia*, *Toxicodendron radicans*, and *Vitis riparia*, interspersed with several large colonies of *Podophyllum peltatum*. Many of herbaceous species indicative of high-quality mesic woods are found here, including *Actaea pachypoda*, *Allium tricoccum*, *Arisaema triphyllum*, *Circaea canadensis*, *Geranium maculatum*, *Hydrophyllum appendiculatum*, and *Solidago caesia.*

A small open pool habitat occurs at the interface with the prairie restoration site, dominated by an almost solid growth of *Cephalanthus occidentalis* (Buttonbush) with sparse presence of *Acer saccharinum* (Silver Maple). Because of its edge location and small size, this microhabitat was not included in the inventory.

West Woods (42° 53.732'N, 85° 21.777'W)

We classified the West Woods (G in Figure 2) as mesic southern forest. A total of 73 species, 89.0% (65 species) of which are native, were found in this ravine-dominated parcel. Once again, although the Total FQI (30.8) and Native FQI (32.2), might suggest this to be a site of only moderate conservation value, the Adjusted FQI (37.7), along with a relatively high Mean *C* value of 3.6 boosts this woods to rank with the other mesic southern forest woods as a high-quality natural area (Figure 4).

The ravine running from the cultivated field to the south delineates the woods into a southwest side and a northeast side. The southwest side is dominated by *Acer saccharum*. The northeast side is more diverse and appears to be less disturbed. It is comprised of a relatively even mix of canopy species that include *Acer saccharum*, *A. rubrum*, *Tilia americana*, *Celtis occidentalis*, *Quercus alba*, *Q. rubra*, and scattered *Fagus grandifolia*, *Fraxinus pennsylvanica*, *Juglans cinerea*, *Prunus serotina*, *Ulmus rubra*, and *Liriodendron tulipifera.* Among the more abundant herbaceous species present in the open understory are *Trillium grandiflorum*, *Hepatica americana*, *Geranium maculatum*, *Maianthemum racemosum*, *Podophyllum peltatum*, *Monotropa uniflora*, *Osmorhiza longistylis*, *Hylodesmum glutinosum*, *Dioscorea villosa*, *Onoclea sensibilis*, *Asplenium platyneuron*, and *Lindera benzoin.* Two woodland species, *Solidago caesia* and *Eurybia macrophylla*, add to the fall-flowering flora. Graminoids in this wooded site include: *Carex swanii*, *C. albursina*, *C. blanda*, *C. rosea*, *C. pensylvanica*,

Brachyelytrum erectum, *Elymus hystrix*, *and E. villosus.*

Although much of the woods is populated by native vines such as *Vitis riparia*, *Toxicodendron radicans*, and *Parthenocissus quinquefolia*, the flora along the northwest side on a little wooded peninsula has a distinctly increased presence of weedy plants (both non-native species and adventive natives) that are usually associated with more disturbed sites, including *Rosa multiflora*, *Rubus allegheniensis*, *Phytolacca americana*, *Solidago canadensis*, and *Hesperis matronalis*, as well as a species that has recently been spreading aggressively in Michigan, *Vincetoxicum nigrum.* This rather abrupt change in flora likely indicates some type of past direct disturbance in this portion of the forest. A native species of note in this disturbed area, though, is *Campanulastrum americanum*, which occurs only occasionally in Kent County, and is never abundant.

East Woods (42° 53.600'N, 85° 21.000'W)

East Woods (H in Figure 2), which is somewhat disjunct from the other wooded sites, also best fits a mesic southern forest designation. A total of 90 species, 92.2% (83 species) of which are native, were found in this parcel. Similar to West Woods described above, the somewhat modest Total FQI of 31.4 and Native FQI of 32.4 suggest a floristically average site, However, as seen with other woods in this study, when the Total Mean *C* value (3.6) is considered with the Adjusted FQI (37.5) this parcel also ranks with the other mesic southern forest tracts as a high-quality woodland (Figure 4).

A small ravine system characterizes this forest, with a notable streamlet and floodplain, flowing northeast toward a *Cornus* thicket not considered part of this wooded site. The parcel is dominated by *Acer saccharum* and *Tilia americana*, with scattered individuals of *Acer nigrum*, *A. rubrum*, *A. saccharinum*, *Fraxinus pennsylvanica*, *Juglans cinerea*, *J. nigra*, *Liriodendron tulipifera*, *Prunus serotina*, *Quercus alba*, *Q. velutina*, *Ulmus rubra*, and *Ostrya virginiana.* The understory is characterized by the woody vines *Toxicodendron radicans* and *Parthenocissus quinquefolia*, and an herbaceous ground cover flora including such species as *Impatiens capensis*, *Arisaema triphyllum*, *Circaea canadensis*, *Dicentra cucullaria*, *Eurybia macrophylla*, *Geranium maculatum*, *Hydrophyllum canadense*, *Podophyllum peltatum*, *Symphyotrichum lateriflorum* and *Solidago caesia.* This site is also particularly rich in woodland sedges: *Carex albursina*, *C. crinita*, *C. grisea*, *C. hirtifolia*, *C. hitchcockiana*, *C. jamesii*, and *C. rosea*, as well as others that are more characteristic of wetlands such as *C. lupulina*, *C. stricta*, and *C. vulpinoidea.* The floodplain also has a population of the rare *Carex davisii*, which is listed in Michigan as Special Concern status (Michigan Natural Features Inventory 2009).

On the northwestern side of the woodland, we encountered a small vernal pool near the interface with the prairie restoration site. This transitional wet woods added 15 species to the overall flora, but these were not incorporated into the Sørensen Index of Similarity assessment because they are not typical of mesic southern forests. The pool was dominated by the amphibious *Persicaria amphibia*, with localized patches of *Matteuccia struthiopteris, Pilea pumila,* and *Leersia oryzoides* around the margin. A nice population of the rare *Carex davisii*

(Special Concern status) was located here, as well as elsewhere in the East Woods.

This wooded site has a notable open understory with few shrubby species and is rather isolated from the rest of the wooded areas in the Lowell Regional Greenspace. However, use of this tract historically as a dumping ground is evidenced by the presence of waste items and trash.

South Woods (42° 53.523'N, 85° 21.450'W)

South Woods (I in Figure 2) was classified as mesic southern forest. A total of 58 species, 91.4% (53 species) of which are native, were found in this site. The Total FQI of 30.5 and Native FQI of 31.3 suggest that the floristic value of this site is average, but the Adjusted FQI of 41.1 increases its rank to be comparable with the other mesic southern forest sites as a floristically high-quality site (Figure 4); this is further supported by the rather high Mean *C* value of 4.0.

This is a rather homogeneous woods dominated by *Fagus grandifolia* and *Acer saccharum* with scattered individuals of *Carya cordiformis*, *Fraxinus pennsylvanica*, *Juglans nigra*, *Prunus serotina*, *Sassafras albidum*, *Tilia americana*, *Ulmus rubra*, and the understory trees *Amelanchier laevis*, *Zanthoxylum americanum*, *Staphylea trifolia*, and *Ostrya virginiana*. The nearly ubiquitous vines *Parthenocissus quinquefolia* and *Toxicodendron radicans* are present as well. The understory herbaceous layer is rich in spring flora, characterized by *Erythronium americanum*, *Agrimonia gryposepala*, *Arisaema triphyllum*, *Sanguinaria canadensis*, *Cardamine bulbosa*, *Cardamine concatenata*, *Claytonia virginiana*, *Floerkea proserpinacoides*, *Dicentra cucullaria*, *Phlox divaricata*, *Trillium grandiflorum*, and *Podophyllum peltatum*, as well as the fern *Polystichum acrostichoides.* The sedge flora is well represented by *Carex albursina*, *C. gracillima*, *Carex jamesii*, *C. laxiflora*, *C. pensylvanica*, *C. rosea*, and *C. sparganioides. Solidago caesia* is notable as well. There is a surprising lack of mature maple trees found in this woodland parcel. There are, though, some remnant stumps which give evidence that selective logging likely occurred in these woods sometime in the past.

Non-metric Multidimensional Ordination (NMDS)

The NMDS ordination (Figure 3) shows that six of the woodlots (not including North Woods, Dry Woods, and Gateway Woods) cluster together and therefore, based on presence/absence data, are most similar to each other. The Gateway Woods and Dry Woods are positioned relatively close to one another in similarity as well, but distanced from the rest. The North Woods is set apart in this analysis, indicating that it is clearly the most dissimilar of the wooded parcels, exhibiting an assemblage of vegetation with the least amount of overlap to the other patches. The stress value of this ordination is 0.0455, indicating a very good fit.

The results of the NMDS confirm that the dry areas (Gateway Woods and Dry Woods) form similar communities while the other mesic woods form a different community type. The uniqueness that the North Woods experiences as a low riparian forest between East Wetland and West Wetland, both fitting the shrub-carr

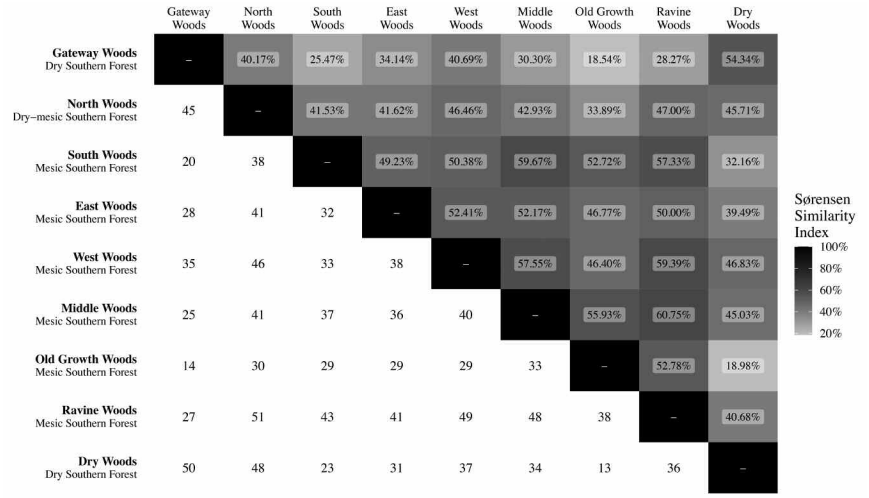

FIGURE 5. Sørensen Index of Similarity for each pair of the nine woodland sites. Values in the shaded boxes to the upper right of the diagonal are the percentage similarity of each pair; values to the lower left of the diagonal are the number of species shared between pairs of woodland sites. The forest classification of each site is indicated in the left column under the name of that site.

community type, is evident in its high species richness and the uniqueness of the species present. Also notable is the distance between the Old Growth Forest and Gateway Woods, the two sites lying furthest from each other on the ordination. Gateway Woods, which shows evidence of significant historical disturbance, is the most different from the nearly pristine Old Growth Woods, compared to all other possibilities.

Similarity Index

Initially, the collection of woodland sites at the Lowell Regional Greenspace appeared to be rather similar, and, in attempting to apply the Michigan Natural Features Inventory's (MNFI) natural communities classification system (Cohen et al. 2015), we were inclined to assign them to a single habitat type. The non-metric multidimensional ordination confirmed that several of the wooded sites cluster rather close. Recognizing that plant communities often exhibit a continuum of variability, we also employed the Sørensen Index of Similarity to assess how similar these various woodlots are floristically. Two sites can be considered to be essentially the same type of plant community, in the sense of Curtis (1959), when they exhibit a Similarity Index score greater than 50% (Curtis 1959; Bradley and Crow 2010).

Four of the sites—East Woods, West Woods, Middle Woods, and Ravine Woods—had a Sørensen Index score in the 50.0–60.75% range for all pairwise comparisons (Figure 5). Additionally, South Woods showed a very strong affinity with these tracts, only slightly below the 50% threshold in its comparison

with East Woods (49.23%). Old Growth Woods showed a strong similarity with three of these sites: Middle Woods (55.93%), Ravine Woods (52.78%) and South Woods (52.72%). These results led us to conclude that all six of these woodland sites best fit the MNFI's mesic southern forest habitat type (Cohen et al. 2015).

On the other hand, two forest sites, Gateway Woods and Dry Woods, were strongly correlated with each other at 54.34%, but had low Sørensen Index scores when compared to each of the other parcels. We considered both of these tracts fit best the dry southern forest community type. North Woods alone had no comparisons with any of the other sites that met the 50% threshold, and we therefore treated this parcel as a separate forest type—dry-mesic southern forest.

Rare Plants

Three species with rarity status in the State of Michigan (Michigan Natural Features Inventory 2009) were discovered in the Lowell Regional Greenspace, but because of the sensitivity of any Threatened or Endangered state-listed plants, we have withheld specific locality data.

Hydrastis canadensis: Threatened status. MICHIGAN FLORA ONLINE (2011) indicates that this rare species is a plant of rich deciduous forests. Although this database documents 81 specimens from 19 counties in southern Michigan, many of them are old collections. Emma Cole (1901) regarded this species as "scarce," with only a few plants at any station, but otherwise well-distributed within the greater Grand Rapids area. Our site fits Cole's description of local, with few plants. This appears to be the first specimen documenting *Hydrastis canadensis* from Kent County since the late 1890s. Voucher: *Walt & Hartwig EC-19-4347* (CALVIN, MICH).

Carex davisii: Special Concern status. This is a handsome cespitose sedge typically of floodplain forests, which in Michigan occurs only in 11 counties, all in the southern portion of the state. This sedge was found to be locally abundant only in East Woods, nearby to where the creek flows into a small floodplain-like site dominated by Silver Maple (*Acer saccharinum*) and Buttonbush (*Cephalanthus occidentalis*). Voucher: *Walt & Hartwig EC-19-3922* (CALVIN, MICH). *Carex davisii* was earlier reported from Kent County at one of Emma Cole's favorite collecting sites (Cole 1901), the Lamberton Creek mouth at Soldier's Home Woods (Stockdale et al. 2019). We have also collected vouchers of this species at Grand Ravines Park, Ottawa County, *Antuma & Murphy EC-17-1744* (CALVIN, MICH); *Antuma & Van Donselaar* EC-17-1914 (CALVIN, MSC); and Grand River Park, Ottawa County, *Van Donselaar, Antuma & Quakenbush EC-17-2187* (CALVIN, MICH).

Lithospermum latifolium: Special Concern status. This rather unassuming herb was found in Dry Woods, growing in a small depression; only two plants were present. Voucher: *Walt & Hartwig EC-19-4304* (CALVIN). We have also collected vouchers of this species at Ken-o-Sha Park, City of Grand Rapids, *Leisman, Van Staalduinen, & Warners EC-15-379* (CALVIN), at Mr. Lowes' Woods, Ball-Perkins Park, City of Grand Rapids, *Crow 11190* (CALVIN, MICH) (Stockdale et al. 2019), and at Hilbrands Property, Cascade Township, Kent Co., *Antuma & Quakenbush EC-17-1623* (CALVIN, MICH, MSC).

CONCLUSION

This study evaluated nine mature forest parcels that co-exist within a limited geographic area and are all relatively similar in size (ranging from 2.56–7.65 ha; with Gateway Woods much smaller at 0.49 ha) (Table 1). In viewing the proposed Lowell Regional Greenspace via Google Earth (Figure 2), the forest community at this location appears to be fairly expansive, but field-based observations reveal that much of the wooded landscape consists of young, early- to mid-successional woodlands rather than mature forest. Given the size of the trees, multi-aged forest composition, and overall community structure, the parcels that we determined to be high-value woodland tracts are likely vestiges of the old farm woodlot type. Although floristically dynamic over time, these remnant habitats have retained much of their presettlement forest character.

In an analysis of change over a period of 40 years in a high-quality Michigan woods, Kolp et al. (2021) documented a net loss of native species while gaining in overall diversity by the addition of non-native species, an overall change in diversity of 3%. Yet, interestingly, they also documented a total of 28 native species (five with high C-values of 8–10) that were newly recruited within this 40-year period. It is noteworthy that a lack of connectivity with other natural areas is an important factor that can hinder the recruitment of native species migrating into other woodlands (Brudvig et al. 2009). We propose that after clear-cutting at the Lowell site for agricultural purposes that occurred in the mid-19th century, these high-quality woodland parcels have been functioning as refugia, providing propagule sources for many native woodland plants to spread as the process of change from agricultural land toward successional woodlands has more recently been occurring. This process is no doubt continuing today, albeit possibly hindered by the counteracting influence of non-native invasive plants and a preponderance of deer.

We found remarkable differences among the nine woodlots situated within this Lowell Regional Greenspace. Old Growth Woods (E in Figure 2) has the highest natural quality with an Adjusted FQI of 47.6 (Figure 4) and highest Mean *C* (4.6). When visited, this forest displays an exceptional visual impression with its high canopy, carpet of spring wildflowers, diversity of large trees, and overall open aspect. This site has a look and feel that is unique among these nine parcels, owing to the minimal amount of disturbance that has occurred here over time because of its steeply sloped aspect. Ravine Woods, South Woods, and North Woods are similarly noteworthy for their conservation value with an Adjusted FQI for each that is over 40 (Figure 4). Yet these parcels appear to have experienced more disturbance over the years than Old Growth Woods. We strongly recommend to Kent County Parks that only passive recreational activities be permitted in these four woodlots as they continue plans toward developing the Greenspace. Additionally, we encourage vigilant monitoring and management for encroaching invasive species in these locations.

A close assessment of species composition across all nine sites (Table 1) further illuminates the variability among these parcels, even among those that scored high on the Sørensen Index of Similarity. In fact, of the 241 total native

woodland species identified in this study, 90 of them (37% of the total) occur in only one of the nine woodlots. This distribution highlights the differences between the remnant forest patches, and also suggests that these native species are vulnerable to local extinction. The dedicated effort of Kent County Parks to secure this land for preservation and public use is a welcome and hopeful step forward in stemming the tide of native species loss that has paralleled the expanding land development patterns in West Michigan.

The two forest sites exhibiting greatest dissimilarity according to the Sørensen Index were Old Growth Woods and Dry Woods (Figure 5). These two tracts were only found to be 19% similar even though they are located directly across from each other, separated only by a narrow lobe of the West Wetland (Figure 2). Having two mature forest stands located so close to each other, yet sharing only 13 species in common illustrates how markedly forest composition can shift within a small spatial scale. Such high-diversity in a limited space underscores the importance of preserving as many remaining remnant habitats as possible (Whittaker 1960; Tuomisto 2010).

Even though the forest parcels in this study are relatively small, they retain significant native plant diversity, collectively harboring a total of 274 species, with 241 (88%) being native. While conservation efforts across North America tend to prioritize large patches of land for protection, this study shows that small parcels such as farm family woodlots should not be overlooked. E. O. Wilson has emphasized that, ". . . every scrap of biological diversity is priceless, to be learned and cherished, and never to be surrendered without a struggle" (Wilson 1992). In some ways these former farm woodlots are examples of Wilson's "scraps" of biodiversity. And by preserving them, we allow possible connections to emerge, both physically—by offering dispersal opportunities into regenerating secondary forests—and genetically—through shared pollination and seed dispersal activities. In these ways, old leftover farm woodlots can serve as inoculation sources for expanding native Michigan forest communities into the future.

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