A Floristic Quality Assessment of Forest Tracts in the Little Traverse Conservancy's Offield Family Nature Preserve, Emmet County, Michigan

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EEB 556 Field Botany of Northern Michigan

14 August 2009

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Abstract

Proper land management is dependent on understanding the composition of plant communities. Floristic Quality Assessment (FQA) is a useful method that places a numeric value, or Floristic Quality Index (FQI), on vegetation in a given area. We conducted a FQA of two adjacent mesic, hardwood forest tracts at the Little Traverse Conservancy's Offield Family Nature Preserve in Emmet County, Michigan. We compared species richness, floristic quality indices, and tree species dominance of both tracts in order to evaluate the difference in plant community composition between the two forest tracts. We recorded 86 total species in the forest (83% native, 17% non-native). Plant species richness, the total number of different plant species present in a given area, was not significantly different between the East and West forest tracts ($p=0.42$). However, the FQI was significantly different between the two tracts ($p=0.01$). This

pattern is due to different species composition between the two sites, including high quality *Platanthera orbiculata* (Round leafed orchid) and non-native *Berberis thunbergii* (Japanese barberry) in the East that were absent in the West. The mean diameter at breast height (dbh) of the dominant overstory species *Acer saccharum* was significantly greater in the West than the East. These differences could be indicative of different age of stands, disturbance history, or productivity. We also examined a nascent invasion of *B. thunbergii* in our East tract sampling plots in order to provide the Little Traverse Conservancy with baseline data for understanding *B. thunbergii* population dynamics at OFNP. *Berberis thunbergii* was distributed throughout the East forest tract, with a large concentration southwest of our sampling plots. We recommend that *B. thunbergii* be pulled by hand as opposed to herbicide or fire control options to minimize negative ecological impact of removal, and to prevent the spread of this noxious invader.

Introduction

At the start of the 19th century, northern Michigan was covered with more than 1.9 million ha (4.7 million acres) of mixed hardwood forests composed of *Betula alleghaniensis* (yellow birch), *Acer saccharum* (sugar maple), *Tsuga canadensis* (hemlock), *Ulmus americana* (American elm), *Tilia americana* (basswood), and *Fagus grandifolia* (beech) (Karamanski 1989). However, the area was logged extensively beginning in the 1840s. From 1847 to 1872, the Michigan lumber industry was particularly prosperous, and clear-cutting increased in intensity throughout this period (Karamanski 1989). The rate of deforestation in northern Michigan paralleled that of the technological advances taking place in the southern part of the state, particularly as the advance of the railroads allowed for year round logging and thus accelerated the destruction of forests (Karamanski 1989). By the time selective logging and forest fires had subsided, northern Michigan was left with half of its original 9 million acres (3,642,000 ha) of pine and hardwood forests (Karamanski 1989). Over more than 99% of the mature oak and beech-maple forests were destroyed (Noss et. al 1995).

Before logging brought about the destruction of the hardwoods in the northern part of Michigan, wind was the primary disturbance of northern mesic forests (Cohen 2000). However, by 1880 the removal of forests and the abundance of slash left on the forest floor after logging led to constant wildfires, which favored aspen (*Populus*) species and suppressed regeneration of small pines and hemlocks (Kilburn 1957). Frequent forest fires plagued the northern lower peninsula of Michigan until the 1940s but by examining fire scars Kilburn (1957) noted only five major fires had occurred in Cheboygan County during the lifetime of the trees present in 1957. While logging and fires in Cheboygan and Emmet Counties have decreased in importance in

recent decades, recreational and housing development near Great Lakes coastlines has fragmented the landscape, leaving remnant forests vulnerable to disturbance (Hansen 2005).

One consequence of disturbance is the opening of niches for exotic species to colonize. Wilcove et al. (1998) describe habitat destruction and its correlation with the introduction of non-native species as a major, and possibly the largest, threat to native plant species. In forests, the negative effects of non-native species on recruitment of native seeds (Hartman and McCarthy 2004) over long term invasions can impede forest regeneration and alter community composition (Collier et al. 2002). Invasive plants in the Midwest and northeast tend thrive in mesic landscapes (Mehrhoff et al. 2003). Furthermore, Huebner and Tobin (2006) found a positive correlation between invasive species and elevation. It is difficult to predict the spread of an invasive species within any community (Ibanez et al. 2009) and the most efficient way to maintain current diversity and promote further colonization of native plants is to prevent colonization, monitor for new invasions, and to optimize control efforts (Ibanez et al. 2009).

The Little Traverse Conservancy's (LTC) Offield Family Nature Preserve (OFNP) located in Emmet County, MI, includes a relatively large area of nutrient rich mesic hardwood forest characterized by *Acer saccharum* (Sugar maple) and *Fagus grandifolia* (American beech) of which the eastern tract has a lower elevation. Within the OFNP indicators of disturbance, such as charred stumps and winding understory trails, show possible evidence of past logging activity. According to Sakai et al. (1984) northern Michigan illustrates a history of early successional species such as *Populus grandidentata* (Big tooth aspen), *Populus tremuloides* (Trembling aspen) and *Betula papyrifera* (Paper birch) establishing immediately after logging and fire disturbances. However, at OFNP the canopy consists mainly of *Acer saccharum* and *Fagus grandifolia,* illustrating their rapid growth following presumed logging at the site

(Karamanski 1989). *Berberis thunbergii* (Japanese barberry), a non-native shade tolerant deciduous shrub (Silander and Klepeis 1999) has begun to invade the OFNP forest, creating dense thickets in some areas that threaten to out compete native understory plants and change the vegetation structure of the understory.

The mesic forest section of the OFNP consists of two tracts ("East" and "West", hereafter) with different ownership history, which may have caused differences in vegetation. In order to evaluate the differences in vegetation of the two tracts, we studied the floristic quality, species composition, and species richness of the tracts. With plans to open OFNP to the public the need for baseline data to assess the floristic quality of the forest prior to greater activity in the preserve is essential. We surveyed the two forest tracts in order to provide a Floristic Quality Assessment (FQA; Herman et. al. 2001), a comparison of the community and age structure of the tracts, and to assess the status of colonization of the tracts by *B. thunbergii*. As part of this baseline, one of the objectives was to assess the abundance and distribution of *B. thunbergii* within OFNP and to suggest *B. thunbergii* management options.

We hypothesized that the two tracts will have similar species richness and diversity in both canopy and understory with very few differences in species richness. We predicted a difference in age structure of overstory trees with the West plot being older and thus having a larger diameter trees. Our preliminary observation suggested that the East tract contains an emerging invasion of *Berberis thunbergii* with density increasing further to the East.

Methods

The Little Traverse Conservancy (LTC) is a non-profit land trust organization that manages over 164 preserves in Northern Michigan in the public trust (Little Traverse Conservancy 2009). One such preserve is the Offield Family Nature Preserve (Figure 1) which is a 158 ha (ca. 390 acres) former farm- and timber land located in Emmet County, Michigan (T35N R5W S9; 45°25′54″ N; 84°59′31″ W). The parcel is a mosaic of plant communities, including a small peatland and a larger mesic hardwood forest with two distinct tracts (defined by an old property line and possibly different logging histories) each dominated by *Acer saccharum* as well as red pine plantations and an old orchard. The East forest tract is flat and lower in elevation than the West tract which has greater topographic relief and may be a possible glacial moraine or ancient shoreline feature.

We established a 100 m^2 study area in a stand representative of each tract, first setting a baseline in the East-West direction and then running five transects North at randomly generated points along the baseline (see Figure 1 for study area locations). We used five randomly generated points along each transect for both a Point-centered quarter (PCQ) sampling of the over-story and a quadrat-based understory assessment.

The PCQ method that we used follows that of Cottam and Curtis (1956), using each sample point along the transects as the origin of four quadrants. At each sample point we measured the distance to and diameter at breast height (dbh) of the closest over-story tree with a dbh no less than 9.1 cm. We calculated the BA of the overstory cover using the equation provided by Albert (2009).

$$BA\ (m^2) = \sum (dbh)^2 \times (7.854 \times 10^{-5}) \qquad \text{Eqn. 1}$$

We calculated relative dominance of overstory species for each tract as a percentage of the total basal area for each species. We used the Braun-Blanquet cover scale (Causton 1988) to quantify cover of herbs and shrubs in the understory (Table 1).

We also noted scattered but abundant *B. thunbergii* patches in the understory. To quantify the extent of invasion by *B. thunbergii*, we applied the methods of Ehrenfeld (1999) to measure density (plants per unit area), size class (under 50 cm, 50-100 cm, and over 100 cm long), and two age categories, new growth (defined as a green stem originating this year) or old growth (woody stems) in 11 of our study plots in the East tract. We did not sample the West tract for *B. thunbergii* because we found only a single small individual there. All *B. thunbergii* encountered within sample plots were removed.

We studied the two forest tracts between July and August of 2009 and created an annotated list of plant species using Voss (1972, 1985, 1996) and Gleason and Cronquist (1991 see Appendix 1). We then performed a Floristic Quality Assessment (FQA) by calculating the mean coefficient of conservatism (CC) and Floristic Quality Index (FQI) (Swink and Wilhelm 1994). FQI is a method used to evaluate a tract of land based on the significance that native flora has on overall composition. This is achieved by assigning every species a CC ranging from 0-10, which is representative of the likeliness of that species to occur in unaltered pre-European settlement conditions. We used CC for Michigan species established by MDNR and calculated the FQI using the equation $FQI = CC \sqrt{n}$, where CC is the mean coefficient of conservatism of an inventory of plants and n is the total number of species (Herman et al. 2001).

We performed statistical analysis using *GraphPad Prism* (GraphPad Software, Inc., La Jolla, CA) using two tailed t-tests to compare the mean values of the basal area of the canopy, the mean species richness of understory plots, and the mean FQI of understory plots.

Results

There were 86 plant species in 42 different families present in the East and West tracts of the Offield Family Nature Preserve (Appendix A, B, and C). Native species accounted for 83% of the total flora and non-native species made up 17%. Notable native species such as *Platanthera orbiculata*, *Actaea rubra*, *Actaea pachypoda*, *Milium effusum*, *Hepatica americana* and *Carex plantaginea* were present in the OFNP and illustrated high coefficients of conservatism (CC), adding to the overall floristic quality of the forest. *Plantanthera orbiculata* (CC=10) had the highest coefficient of conservatism in the forest. *Milium effusum*, *Hepatica americana* and *Carex plantaginea* had a CC=8. *Actaea rubra* and *Actaea pachypoda* have a CC= 7. Non-native species *Berberis thunbergii* and *Lonicera morrowii* were also present within the forest. These two invasive species have a CC of 0, therefore reducing the overall floristic quality of the Offield Family Nature Preserve.

The overstory of both forest tracts were strongly dominated by *Acer saccharum.* Although the mean basal area of *Acer saccharum* was lower in the East tract (5.64 m^2/ha; mean dbh= 25.59 cm) than in the West (7.01 m^2/ha; mean dbh=29.85 cm) (Figure 2) the mean dbh of *A. saccharum* was significantly greater in the East tract (t-test, $p = 0.02$). Overstory species richness was also greater in the east plot (7 species) than in the west (5 species). Numerous tree species including *Ostrya virginiana*, *Betula papyifera*, *Acer rubrum,* and *Prunus serotina* appeared in plots in the East tract, but not the West. Meanwhile, *Fraxinus americana* and *Tsuga canadensis* were present in West tract plots, but not the East. *Acer saccharum, Tilia americana,* and *Fagus grandifolia* were found in both sampling areas.

The overstory dominance based on calculated basal area, differed between the two tracts, as did species frequency (Figure 3). Relative dominance of *A. saccharum* was less in the West (81.78%) than the East (88.35%). *Fagus grandifolia* contributed more area to the overstory in the West (16.29%) than in the East (5.71%) and individuals in the West had dbh measurements ranging from 44.7 – 74.9 cm, while only a single *F. grandifolia* appeared in sampling plots in the East.

For the combined forest tracts, including tree species, the mean CC was 3.43 and FQI was 31.81. The understory herbaceous and shrubby species of the East tract had a mean CC value of 3.57 and an FQI of 19.54, while the West tract had a mean CC of 4.56 and an FQI of 23.67. Plots in the East tract had a mean FQI of 9.2 when overstory species were considered, and 5.6 when only understory species were included (Appendix B). Plots in the West tract had a mean FQI of 10.9 with overstory species included and 7.6 with only understory considered (Table 2; Appendix C). Although mean species richness did not differ significantly between the East and West tracts (t-test, $p = 0.42$), the mean FQI was significantly different (t-test, $p = 0.01$) (Figure 4).

Berberis thunbergii invasion was prevalent in the East tract where 91 individuals were noted, while the West tract only contained a few scattered individuals that did not fall within sample plots. New growth accounted for 27% of the total *B. thunbergii* observed and old growth was present in 73% of the samples. 86% of *B. thunbergii* was in the under 50 cm size class while 14% fell within the 50 cm to 100 cm size class. *Berberis thunbergii* was concentrated in a single area of the East tract study area, with number and age of plants decreasing with distance from this “epicenter”. Aproximately 380 cubic meters of *B. thunbergii* was noted and removed from the site in trash bags. The population of *B. thunbergii* extended into an area with

approximately 36 individulas of the mesic forest orchid, *Platanthera orbiculata*. Of the 36 individuals of *Platanthera orbiculata* 20 were flowing and 16 consisted of only basal leaves.

Discussion

Michigan's forests have been shaped by a history of successional change caused by glaciation, logging, and wildfires (Jolls 1983, Dickmann and Leefers 2003). Prior to logging, Cheboygan County was characterized by red and white pine dominated forests. These were succeeded by hardwood forests characterized by *Acer saccharum*, *Tilia americana*, *Betula allegheniensis* and *Ulmus* spp. after the frequent wildfires of 1880-1920 (Jolls 1983).

The difference in mean dbh of *A. saccharum* between the East and West forest tracts at the OFNP suggest dissimilarity in stand age which can be attributed to either distinct disturbance history or soil characteristics (Tarrant 1961). The two tracts also differed in canopy composition. Greater numbers of large *Fagus grandifolia,* a long-lived slow growing species (Barnes and Wagner 1981), in the West tract indicate that this is the older tract. This difference may be the result of differing histories of human impact. Beech trees are very fire intolerant (Barnes and Wagner 1981), indicating that recent widespread fire is unlikely. Further research into the detailed history of the site is required to determine the nature of disturbances that have influenced the modern vegetation of OFNP.

The tracts are also significantly different in understory species composition. We noted 34 species in the understory of the East tract and 32 species in the West tract. Most species represent an overlap between both sites, but the different species provided a significant difference in floristic quality. Different species composition may be indicative of different soil conditions or

management history between the two tracts. Further research into the soil types of the two tracts will elucidate possible differences in canopy overstory.

The LTC is planning on opening public access trails on the preserve property. Trail construction or enhancement within OFNP will make it susceptible to the invasion of ruderal species (Godefroid and Koedam 2004). We noted several non-native species that were not the focus of our study but were located along paths or in habitats adjoining the forest tracts. *Centauria maculosa* (Spotted knapweed), a noxious weed common throughout northern Michigan, is present in the field entering the property. *Veronica officinalis* (Common speedwell), a non-native creeping groundcover, is scattered throughout the forest. *Lonicera morrowii* (Morrow honeysuckle) is present in fields near the property entrance and within the forest. Forest disturbances can open niches for early-successional and non-native species propagation, such as *Berberis thunbergii*, by increasing open canopy and thus light levels that reach the understory (Parendes and Jones 2000).

Berberis thunbergii is a significant invader of OFNP. *Berberis thunbergii* can affect nitrogen cycles, soil structure and function (Huebner and Tobin 2006, Ward et al. 2008). Ehrenfeld et al. (2001) discovered that soils underneath patches of *B. thunbergii* had higher pH, nitrification, and nitrogen mineralization rates. Kourtev et al. (2002) found significant differences in bacterial and fungal microbe communities in soils supporting *B. thunbergii* compared to soils supporting native species in New Jersey. In Maine, large patches of *B. thunbergii* were resistant to deer browse and were correlated with increased black-legged ticks (*Ixodes scapularis*; Elias et al. 2006). Black-legged ticks are a vector for Lyme Disease, a threat to public health, and thus the presence of *Berberis* may provide habitat that is conducive to higher occurrences of ticks and tick-borne illnesses.

Unrestricted spread of *Berberis thunbergii* will alter the habitat structure and ecological interactions in the mesic forest tracts of the preserve. It is highly likely that coalescing thickets of *Berberis thunbergii* will have detrimental impacts on populations of a variety of native flora and fauna. One species that is concentrated within the area that *Berberis thunbergii* is currently spreading is the round-leaved orchid, *Habenaria orbiculata*. Orchids are rarely strong competitors, and *Habenaria orbiculata* populations are unlikely to respond well to a dense canopy of *Berberis thunbergii*.

Berberis thunbergii at OFNP can be classified as a nascent invasion. It is important to implement a management plan before it becomes more widely established. At the moment there is a single large focus of invasion, with numerous smaller foci in close proximity. These smaller "satellite" foci should not be ignored, as they will rapidly grow and radiate further outward and will soon cover more area than the original large focus (Moody and Mack 1988). *Berberis thunbergii* seedlings germinate in early spring (Ehrenfeld 1999). Fall may be a good time to pull *B. thunbergii*, because seedlings will be big enough to notice, and sensitive native species may have died back and trampling can be minimized. We recommend that annual fall volunteer work days be initiated to slow the spread and hopefully eradicate *B. thunbergii* in OFNP. Herbicides and fire also have been used to manage invasions (Ward et al. 2009). However, because the invasion is in a nascent stage and most individuals are of a manageable size, we recommend manual removal to minimize negative ecological impacts of other methods.

Regardless of the control strategy, removal of *Berberis thunbergii* from OFNP is essential for maintaining the pre-invasion ecological function of the forest understory. Ehrenfeld (1999) made a series of recommendations for *Berberis thunbergii* control. First, all life stages should be removed since large individuals produce copious seeds and small individuals

contribute heavily to its spread across the forest floor. Once an individual of *B. thunbergii* has approximately three stems, its mortality is very low making manual or herbicide control essential (Ehrenfeld 1999). The low mortality of young *B. thunbergii* individuals also contributes to the rapid spread of *B. thunbergii* across a site. Ehrenfeld (1999) states that all size classes of individuals should be controlled when financial resources allow. However, when resources are minimal, large individuals should be the focus of control efforts.

With the baseline data obtained from this comparison of the two forest tracts, the LTC will be able to assess management options and better document the arrival and disappearance of plant species within the Offield Family Nature Preserve. As management plans for the Offield Family Nature Preserve are considered, control of the nascent *Berberis thunbergii* invasion should be a priority.

Acknowledgments

We appreciate the assistance of Eric Hellquist and Elizabeth Haber as well as other members of the UMBS faculty and staff who helped us in various ways throughout the project. We also thank the Little Traverse Conservancy, especially Cindy Mom, for supporting and encouraging our work at the Offield Family Nature Preserve.

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Table 1. Braun-Blanquet cover scale of understory herbs and shrubs.

Rating	Description
+	Sparsely, or very sparsely present
1	Plentiful, but of small cover frequency
2	Numerous, of cover 5-20%
3	Any number of individuals, of cover 25-50%
4	Any number of individuals, of cover 50-75%
5	Any number of individuals, of cover >75%

Table 2. Mean C and mean FQI for East and West Tracts, a) including and b) excluding overstory species

a.

East Tract		**West Tract**	
Mean C	4.2	Mean C	4.6
Mean FQI	9.2	Mean FQI	10.9

b.

East Tract		**West Tract**	
Mean C	3.3	Mean C	3.2
Mean FQI	5.6	Mean FQI	7.6

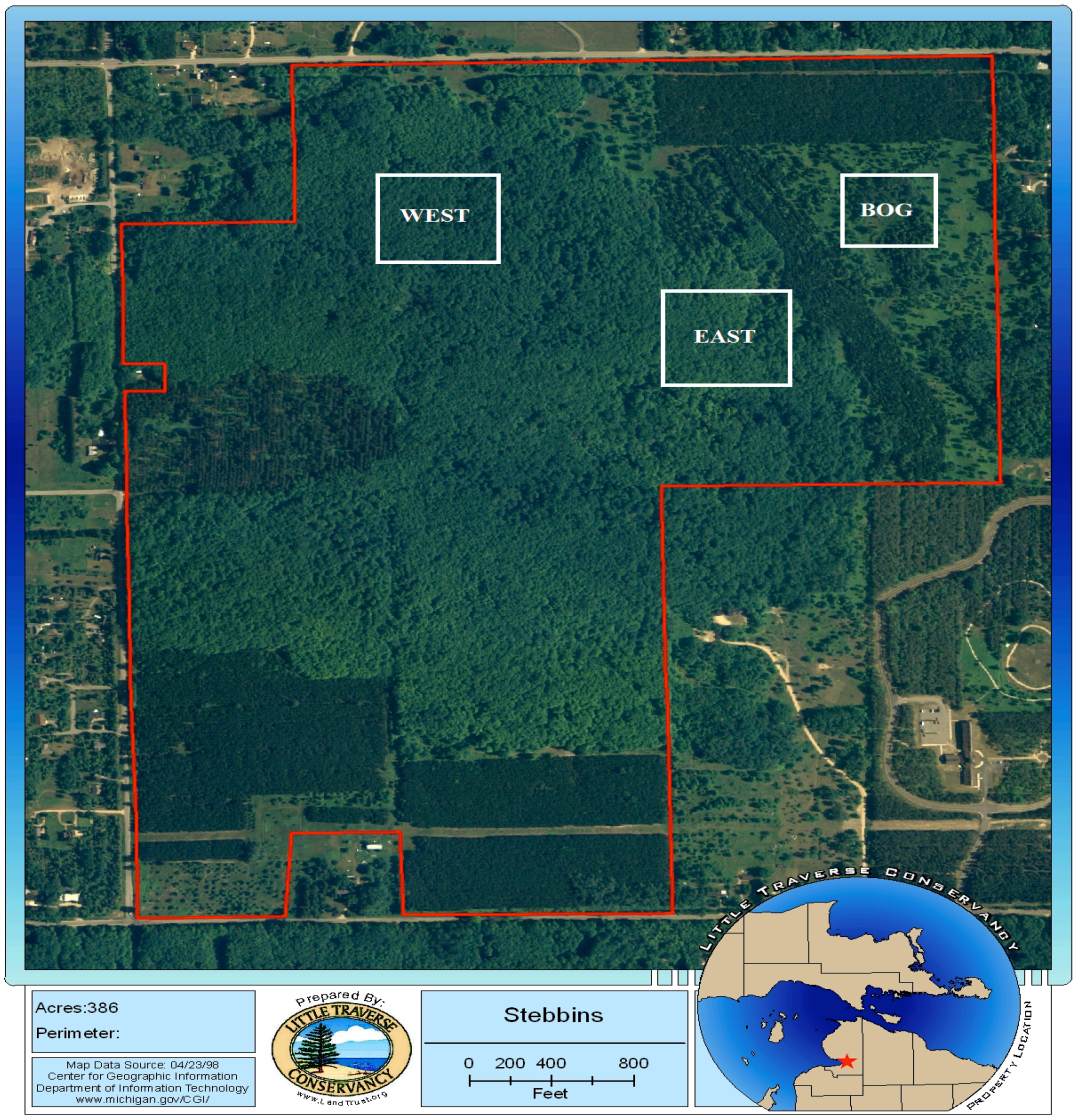

Figure 1. Aerial view of the Offield Family Nature Preserve (formerly called the Stebbins Preserve), showing the locations of East and West study plots. Photo courtesy of the Little Traverse Nature Conservancy.

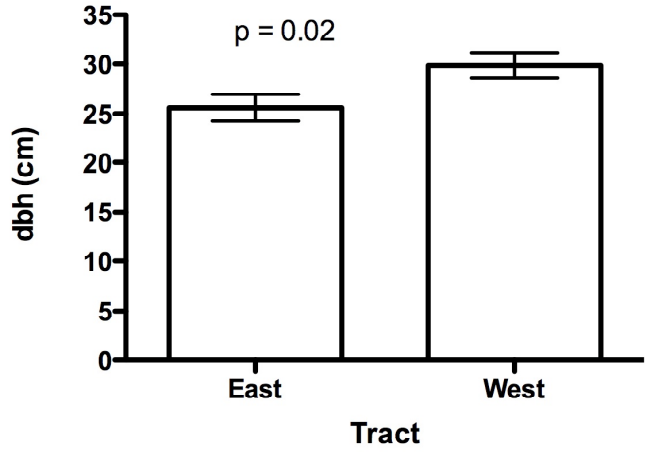

Figure 2: Mean dbh of *Acer saccharum* in the east and west tracts of the Offield Family Nature Preserve, Harbor Springs, MI

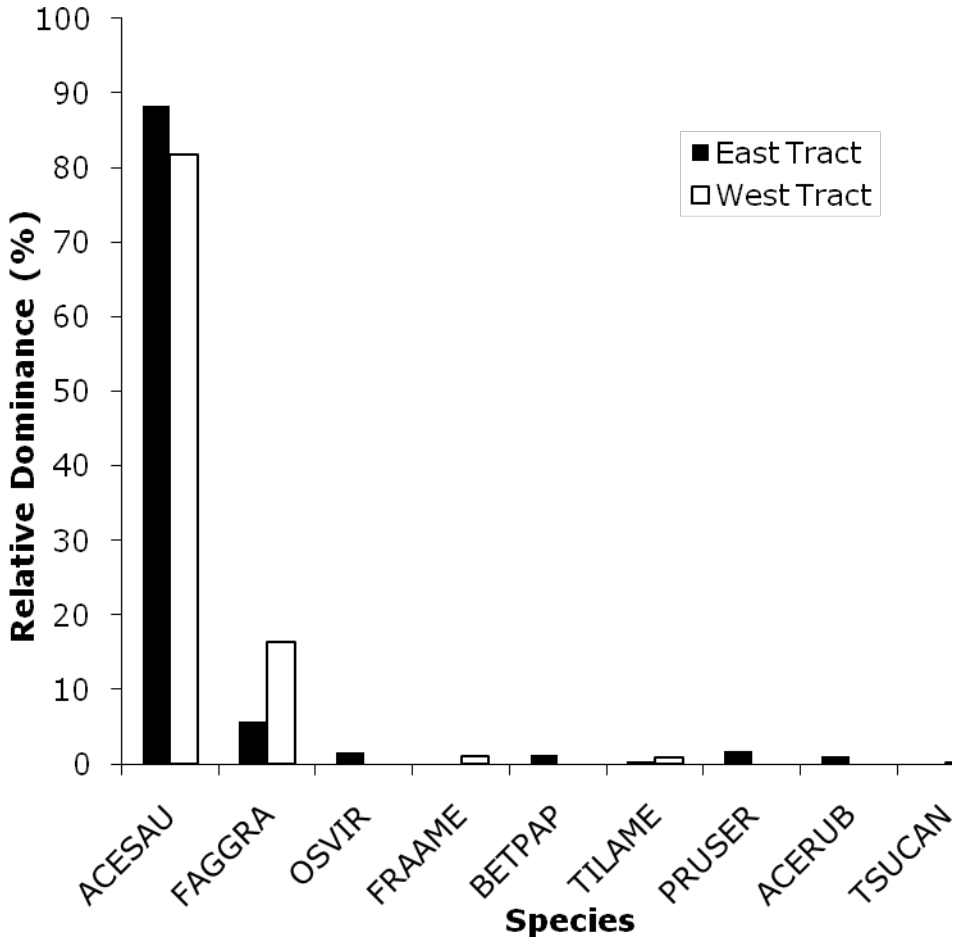

Figure 3. Comparison of relative dominance of overstory trees in the East and West forest tracts of the Offield Family Nature Preserve (Emmet County, MI). Arbbreviations are: ACESAU = *Acer saccharum*, FAGGRA = *Fagus grandifolia*, OSVIR = *Ostrya virginiana*, BETPAP = *Betula papyrifera*, TILAME = *Tilia americana*, PRUSER = *Prunus serotina*, ACERUB = *Acer rubrum*, TSUCAN = *Tsuga canadensis*.

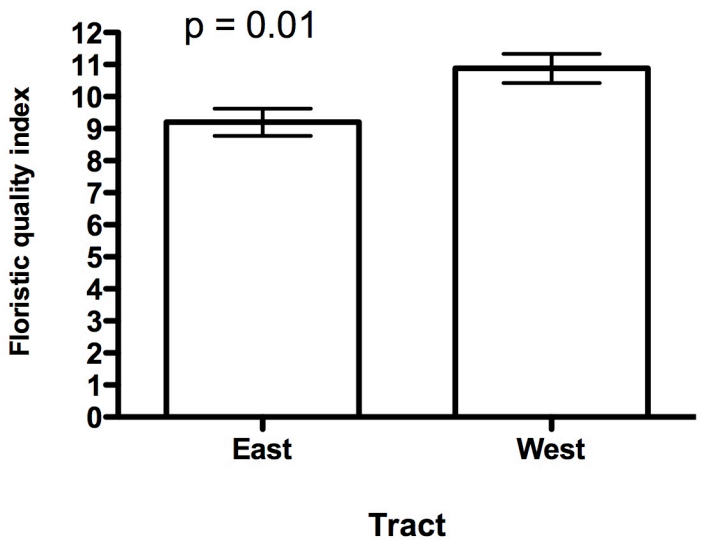

Figure 4. Mean floristic quality index (n=25) for East and West forest tracts for combined herb, shrub, and overstory of the Offield Family Nature Preserve, Emmet County, MI.

Appendix A Preliminary Species List of the East and West Forest Tracts of the Offield Family Nature Preserve, Emmet County, MI. CC: coefficient of conservatism; FQI: floristic quality index.

Family	Genus and species		Common name	CC
Adoxaceae	Viburnum	acerifolium	Maple-Leaved Arrow Wood	6
Apiaceae	Aralia	nudicaulis	Wild Sarsaparilla	5
	Osmorhiza	claytonii	Hairy Sweet Cicely	4
Araceae	Arisaema	triphyllum	Jack-in-the-pulpit	5
Asclepiadaceae	Asclepias	syriaca	Common Milkweed	1
Asteraceae	Centaurea	maculosa	Spotted Knapweed	0
	Chrysanthemum	leucanthemum	Ox-Eye Daisy	0
	Cirsium	arvense	Canadian Thistle	0
	Erigeron	strigosus	Daisy Fleabane	4
	Lactuca	muralis	Wall-lettuce	0
	Tragopogon	dubius	Goat's Beard	0
Berberidaceae	Berberis	thunbergii	Japanese Barberry	0
	Caulophyllum	thalictroides	Blue Cohosh	5
Betulaceae	Betula	papyrifera	Paper Birch	2
	Ostrya	virginiana	Ironwood / Hop Hornbeam	5
Caprifoliaceae	Lonicera	morrowii	Morrow Honeysuckle	0
Clussiaceae	Hypericum	perforatum	St. John's Wort	0
Cupressaceae	Juniperus	communis	Common Juniper	4
Cyperaceae	Carex	intumescens	Sedge	3
	Carex	pensylvanica	Pennsylvania Sedge	4
	Carex	plantaginea	Sedge	8
Dennstaedtiaceae	Pteridium	aquilinum	Bracken Fern	0
Dryopteridaceae	Athyrium	filix-femina	Lady Fern	4
	Cystopteris	bulbifera	Bulblet Fern	5
Equisetaceae	Equisetum	arvense	Common Horsetail	0
	Equisetum	laevigatum	Smooth scouring rush	2
Ericaceae	Gaultheria	procumbens	Wintergreen	5
	Monotropa	hypopitys	Pinesap	6
	Monotropa	uniflora	Indian Pipe	5
Euphorbiaceae	Euphorbia	cyparissias	Cypress Spurge	0
Fagaceae	Fagus	grandifolia	American Beech	6
Geraniaceae	Geranium	robertianum	Herb Robert	3
Grossulariaceae	Ribes	cynosbati	Wild Gooseberry	4
Lamiaceae	Monarda	fistulosa	Bergamot	2
	Prunella	vulgaris	Selfheal / Lawn Prunella	0
	Clinopodium	vulgare	Wild Basil	3
Liliaceae	Allium	tricoccum	Wild Leek	5
	Maianthemum	canadense	Canada Mayflower	4
	Maianthemum	racemosum	False Spikenard	5
	Polygonatum	pubescens	Downy Solomon's Seal	5
	Streptopus	roseus	Rose Twisted-Stalk	5
	Trilium	grandiflorum	Common Trillium	5

Lycopodiaceae	Dendrolycopodium	dendroideum	Tree Clubmoss	5
	Diphasiastrum	tristrachyum	Ground Cedar	7
	Lycopodium	annotinum	Stiff Clubmoss	5
	Lycopodium	clavatum	Running Ground-Pine	4
Malvaceae	Tilia	americana	Basswood	5
Myrsinaceae	Triantalis	borealis	Starflower	5
Oleaceae	Fraxinus	americana	White Ash	5
Onocleaceae	Onoclea	sensibilis	Sensitive Fern	2
Onograceae	Circaea	lutetiana	Enchanter's-Nightshade	2
Ophioglossaceae	Botrychium	virginianum	Rattlesnake Fern	5
Orchidaceae	Epipactis	helleborine	Helleborine	0
	Platanthera	orbiculata	Large Round-Leafed Orchid	10
Oxalidaceae	Oxalis	stricta	Common Yellow Wood-Sorrel	0
Pinaceae	Pinus	resinosa	Red Pine	6
	Pinus	strobus	White Pine	3
	Tsuga	canadensis	Hemlock	5
Plantaginaceae	Plantago	major	Common Plantain	0
Poaceae	Milium	effusum	Wood Millet	8
	Phleum	pratense	Timothy	0
Polyganaceae	Polygonum	cilinode	Fringed False Buckwheat	3
	Rumex	crispis	Curly Dock	0
Pteridaceae	Adiantum	pedatum	Maidenhair Fern	6
Ranunculaceae	Actaea	pachypoda	Doll's eyes	7
	Actaea	rubra	Red Baneberry	7
	Anemone	canadensis	Canada Anemone	4
	Aquilegia	canadensis	Wild Columbine	5
	Hepatica	acutiloba	Sharp-Lobed Hepatica	8
Rosaceae	Amelanchier	arborea	Juneberry	4
	Fragaria	vesca	Woodland Strawberry	2
	Geum	rivale	Purple Avens	7
	Potentilla	norvegica	Rough Cinquefoil	0
	Prunus	serotina	Wild Black Cherry	2
	Prunus	virginiana	Chokecherry	2
	Rubus	allegheniensis	Common Blackberry	1
Rubiaceae	Galium	triflorum	Fragrant Bedstraw	4
	Mitchella	repens	Partridge Berry	5
Sapindaceae	Acer	pensylvanica	Striped Maple	5
	Acer	rubrum	Red Maple	1
	Acer	saccharum	Sugar Maple	5
Scrophulariaceae	Verbascum	thapsus	Common Mullen	0
	Veronica	officinalis	Common Speedwell	0
Ulmaceae	Ulmus	americana	American Elm	1
Violaceae	Viola	canadensis	Canada Violet	5
	Viola	pubescens	Yellow Violet	4

Species richness = 86
Mean CC: 3.4
FQI: 31.8

Appendix B Preliminary Species List of the East Forest Tract of the Offield Family Nature Preserve, Emmet County, MI. CC: coefficient of conservatism

Family	Genus and species		Common name	CC
Apiaceae	Osmorhiza	claytonii	Hairy Sweet Cicely	4
Araceae	Arisaema	triphyllum	Jack-in-the-pulpit	5
Asclepiadaceae	Asclepias	syriaca	Common Milkweed	1
Berberidaceae	Berberis	thunbergii	Japanese Barberry	0
Berberidaceae	Caulophyllum	thalictroides	Blue Cohosh	5
Betulaceae	Ostrya	virginiana	Ironwood / Hop Hornbeam	5
Cyperaceae	Carex	intumescens	Sedge	3
Cyperaceae	Carex	pensylvanica	Pennsylvania Sedge	4
Cyperaceae	Carex	plantaginea	Sedge	8
Dennstaedtiaceae	Pteridium	aquilinum	Bracken Fern	0
Equisetaceae	Equisetum	arvense	Common Horsetail	0
Fagaceae	Fagus	grandifolia	American Beech	6
Geraniaceae	Geranium	robertianum	Herb Robert	3
Lamiaceae	Clinopodium	vulgare	Wild Basil	3
Liliaceae	Allium	tricoccum	Wild Leek	5
Liliaceae	Maianthemum	canadense	Canada Mayflower	4
Liliaceae	Trilium	grandiflorum	Common Trillium	5
Malvaceae	Tilia	americana	Basswood	5
Myrsinaceae	Triantalis	borealis	Starflower	5
Oleaceae	Fraxinus	americana	White Ash	5
Ophioglossaceae	Botrychium	virginianum	Rattlesnake Fern	5
Orchidaceae	Epipactis	helleborine	Helleborine	0
Orchidaceae	Platanthera	orbiculata	Large Round-Leafed Orchid	10
Rosaceae	Amelanchier	arborea	Juneberry	4
Rosaceae	Fragaria	vesca	Woodland Strawberry	2
Rosaceae	Prunus	serotina	Wild Black Cherry	2
Rosaceae	Prunus	virginiana	Chokecherry	2
Rosaceae	Rubus	allegheniensis	Common Blackberry	1
Rubiaceae	Galium	triflorum	Fragrant Bedstraw	4
Sapindaceae	Acer	saccharum	Sugar Maple	5
Scrophulariacae	Veronica	officinalis	Common Speedwell	0
Ulmaceae	Ulmus	americana	American Elm	1
Violaceae	Viola	canadensis	Canada Violet	5
Violaceae	Viola	pubescens	Yellow Violet	4

Species richness: 34

Appendix C Preliminary Species List of the West Forest Tract of the Offield Family Nature Preserve, Emmet County, MI. CC: coefficient of conservatism

Family	Genus and species		Common name	CC
Adoxaceae	Viburnum	acerifolium	Maple-Leaved Arrow Wood	6
Apiaceae	Aralia	nudicaulis	Wild Sarsaparilla	5
Apiaceae	Osmorhiza	claytonii	Hairy Sweet Cicely	4
Araceae	Arisaema	triphyllum	Jack-in-the-pulpit	5
Asclepiadaceae	Asclepias	syriaca	Common Milkweed	1
Asteraceae	Tragopogon	dubius	Goat's Beard	0
Berberidaceae	Caulophyllum	thalictroides	Blue Cohosh	5
Caprifoliaceae	Lonicera	morrowii	Morrow Honeysuckle	0
Cyperaceae	Carex	intumescens	Sedge	3
Cyperaceae	Carex	plantaginea	Sedge	8
Dennstaedtiaceae	Pteridium	aquilinum	Bracken Fern	0
Dryopteridaceae	Athyrium	filix-femina	Lady Fern	4
Fagaceae	Fagus	grandifolia	American Beech	6
Geraniaceae	Geranium	robertianum	Herb Robert	3
Lamiaceae	Clinopodium	vulgare	Wild Basil	3
Liliaceae	Allium	tricoccum	Wild Leek	5
Liliaceae	Maianthemum	canadense	Canada Mayflower	4
Liliaceae	Maianthemum	racemosum	False Spikenard	5
Liliaceae	Polygonatum	pubescens	Downy Solomon's Seal	5
Liliaceae	Streptopus	roseus	Rose Twisted-Stalk	5
Liliaceae	Trilium	grandiflorum	Common Trillium	5
Malvaceae	Tilia	americana	Basswood	5
Oleaceae	Fraxinus	americana	White Ash	5
Pinaceae	Tsuga	canadensis	Hemlock	5
Poaceae	Milium	effusum	Wood Millet	8
Ranunculaceae	Actaea	pachypoda	Doll's eyes	7
Ranunculaceae	Actaea	rubra	Red Baneberry	7
Rosaceae	Prunus	virginiana	Chokecherry	2
Rosaceae	Rubus	allegheniensis	Common Blackberry	1
Rubiaceae	Galium	triflorum	Fragrant Bedstraw	4
Sapindaceae	Acer	saccharum	Sugar Maple	5
Violaceae	Viola	canadensis	Canada Violet	5

Species richness: 32