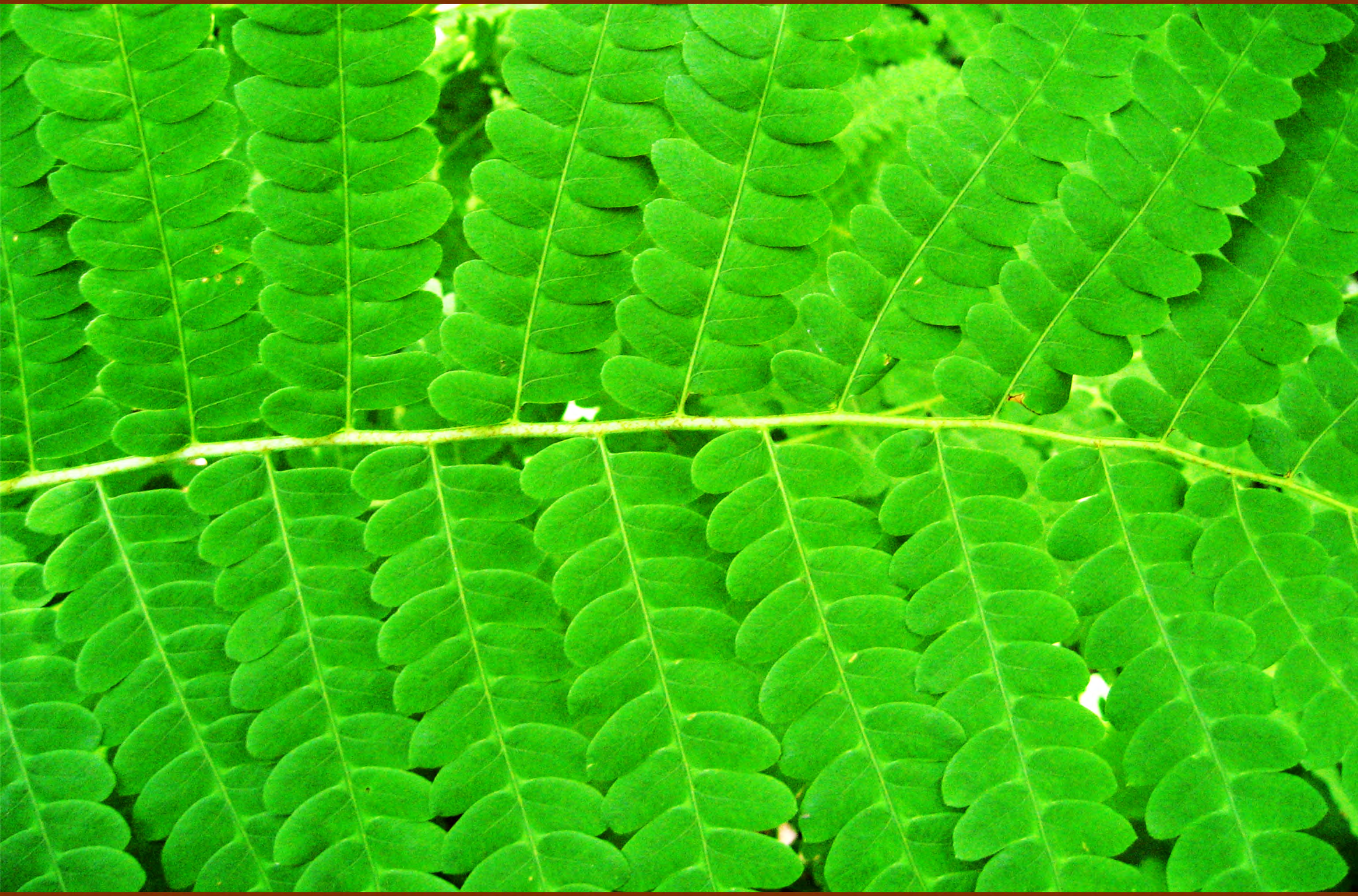
Ecological Assessment, Mapping, and Prioritization at the Huron-Clinton Metroparks

Case study: Lower Huron and Willow Metroparks

A Master's Project Completed for the Huron-Clinton Metropolitan Authority



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April 19, 2011

ECOLOGICAL ASSESSMENT, MAPPING, AND PRIORITIZATION AT THE HURON-CLINTON METROPARKS

CASE STUDY: LOWER HURON AND WILLOW METROPARKS

A MASTER'S PROJECT COMPLETED FOR THE HURON-CLINTON METROPOLITAN AUTHORITY

SCHOOL OF NATURAL RESOURCES AND ENVIRONMENT, UNIVERSITY OF MICHIGAN

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ABSTRACT

The Huron-Clinton Metropolitan Authority's Natural Resource Department (NRD) is responsible for the management and conservation of undeveloped areas within 13 southeastern Michigan's Metroparks- roughly 80% of the nearly 24,000 total acres. While their management decisions should ideally be based on consistent, current, and comprehensive ecological information, the data currently used by the NRD has been collected at different points in time, using different methods, and only in select undeveloped areas. This lack of consistent data inhibits the proper siting of municipal and recreational amenities and may lead to inefficient and unsound land management. Additionally, the NRD's current method for assessing ecological quality is difficult to implement, given the reality of time, funding, and staffing constraints. Our master's project sought to assist the NRD in the development of a practical, effective, and informed protocol for assessing ecological quality; thereby enabling the NRD to target management efforts towards natural areas of maximum conservation benefit.

Five ecological assessment protocols were examined through a case-study approach in Lower Huron and Willow Metroparks during the fall of 2010: a Floristic Quality Assessment (FQA), the NRD's current model, the Huron River Watershed Council's Bioreserve Rapid Assessment Method (BRAM), the Huron River Watershed Council's corresponding Bioreserve Desktop Analysis, and a GIS-based Multi-Criteria Evaluation. Each protocol was measured against a set of pre-determined evaluation criteria as a means to determine their advantages and disadvantages for implementation within HCMA. A recommended action plan was developed for HCMA based on the findings of our evaluation.

Our action plan recommends that the NRD generate preliminary data for all natural areas of all parks using a multi-criteria evaluation. Following this initial desktop analysis, HCMA's NRD should implement the BRAM to create a comprehensive baseline dataset, as it is a resource-efficient and holistic approach to field-based ecological assessments. Our results suggest that the BRAM is a relatively accurate and reliable assessment given its large statistical correlation with FQA and the HCMA's current model. We highly recommend NRD pursue partnerships with local conservation organizations in order to implement and expand the agency's management, conservation, and preservation activities.

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EXECUTIVE SUMMARY

INTRODUCTION

The Huron-Clinton Metropolitan Authority's Natural Resource Department (NRD) is responsible for the management and conservation of all natural areas within southeastern Michigan's Huron-Clinton Metroparks - roughly 80% of the nearly 24,000 acres. However, the baseline ecological data currently used by the NRD has been collected at different points in time, using different methods, and only in select undeveloped areas. As a result, the existing dataset contains large data "gaps" across the Metroparks (HCMA personal comm., February 2011). Additionally, the NRD's current method for assessing ecological quality is challenging to implement, given the department is primarily composed of just two full-time staff members, and has a limited budget.

Ideally, HCMA's conservation and management decisions would be able to use consistent, current, and comprehensive information regarding the total species richness and habitat diversity found within all natural areas. However, the HCMA's current resource constraints make this idealistic approach impractical. Nevertheless, having an incomplete and inconsistently collected dataset prevents the NRD from making the best possible management decisions and inhibits the proper siting of municipal and recreational amenities. Inefficient and unsound land management can contribute to habitat loss and the degradation of valuable natural features. Continued practice of poor land management may eventually lead to the extirpation of rare native species from the Huron-Clinton Metroparks.

The goal of this master's project was to assist HCMA's NRD in the development of a practical, effective, and informed protocol for assessing ecological quality. Such a protocol would allow the HCMA to efficiently prioritize natural areas for conservation and management within the Metroparks.

EVALUATION

Our team examined five ecological assessment protocols through a case-study approach in Lower Huron and Willow Metroparks (Appendix D, D.1) during the fall of 2010. Each protocol was measured against a set of pre-determined evaluation criteria to determine the advantages and disadvantages of implementing each method within HCMA. This evaluation is outlined in the following discussion.

FLORISTIC QUALITY ASSESSMENT

A Floristic Quality Assessment (FQA) allows ecological investigators to objectively evaluate an ecosystem by ranking an area's plant species based on the ranges of habitats in which they are able to live. An FQA is completed by calculating a Floristic Quality Index (FQI) using these rankings. This standardized method has been used worldwide as a substitute for subjective assessments (Rama

Bhat and Kaveriappa 2009; Tu et al. 2009; Mack 2009; Andreas et al. 1995; Andreas et al. 2004) and across a wide range of ecosystem types (Rama Bhat and Kaveriappa 2009; Tu et al., 2009; Mack 2009; Andreas et al. 2004; Hargiss et al. 2008; Matthews et al. 2009). Due to its wide usage, FQA can be considered the "gold standard" of ecological assessments.

A major advantage of implementing FQA is its high relative accuracy, which results from its direct use of field survey data and its use of ranking categories that are based on state-wide trends. The frequent use of FQA also allows for statewide comparisons of natural areas. Additionally, it provides results that are commonly understood and highly regarded by other professionals. Furthermore, its heavy emphasis on floristic communities reflects HCMA's past history of placing high value on vegetation, as demonstrated by the usage of FQA in their current ecological assessment protocol.

However, FQA considers only a single criterion (plant species presence), thus making this protocol less comprehensive than other methods. Additionally, our team found that the required field surveys are extremely time-intensive and necessitate a team of highly trained plant identifiers. Whether the team is composed of permanent staff or a group of consultants, the financial burden of this method is high. While it is possible that a hired volunteer coordinator could recruit and train volunteers to do the surveys, the time required to develop and implement such a training program would further delay results.

HCMA ECOLOGICAL QUALITY MODEL

HCMA's NRD staff developed an ecological assessment protocol that combines field surveyed data and spatial data using four criteria: the field-data based FQA, wetland occurrence according to the National Wetlands Inventory, elemental occurrences of rare plant species, and natural community type state rankings. Implementing this method as part of our project enables comparison of HCMA's business-as-usual approach to other methods of ecological assessment. Current staff members are already trained on using the method, and the model's inclusion of FQI indicates that it parallels the "gold standard" of FQA, while enriching the assessment with other criteria of ecological importance.

Within Lower Huron Metropark, HCMA's current ecological assessment method is strongly correlated with FQA (ρ-value=0.890), at $p<0.0001$. HCMA's current ecological assessment method relies heavily on the vegetation quality as defined by FQI, which likely explains the strong correlation observed between the two methods (Table V.1 and V.2). Despite the HCMA Model's obvious strengths, its use of FQA renders it impractical to implement at a landscape scale, particularly within the agency's current resource constraints. Additionally, the model may place a disproportionate weight on vegetation rather than overall habitat quality, ecosystem functioning, and the presence of wildlife. Furthermore, because the additional parameters used in this model are not accurate at a park scale, the time used to gather and input this information into the model reduces its overall efficiency and accuracy.

BIORESERVE RAPID ASSESSMENT METHOD (BRAM)

The Huron River Watershed Council's Bioreserve Project was developed to identify privately-owned lands within the Huron River catchment that are areas of highest ecological value, such that conservation and protection measures could be implemented. The Bioreserve Rapid Assessment

Method (BRAM) is another field-based ecological assessment and is adapted from the assessment methods used by professional ecologists at Michigan Natural Features Inventory. This assessment is "general enough that volunteers with a half-day training and a field guidebook will be able to complete, but detailed enough to glean meaningful information about the ecological quality of the site" (Project Details...[updated 2010]).

The BRAM protocol is tailored to the ecosystems in Southeast Michigan and has provided reliable ecological quality information for conservation purposes in the past (Project Details…[updated 2010]). Additionally, it incorporates factors such as vegetation composition, age structure, and soil type, which act as habitat indicators. Because these factors serve as proxies for the exhaustive species lists required by a FQA, the BRAM serves as a more holistic approach to ecological assessments. Furthermore, the BRAM is easily conducted by volunteers in a shorter time frame than required by FQA, lessening the burden on hired park personnel. The burden could be even further reduced through the resource expanding opportunity of partnering with HRWC to assist in the recruiting and training of volunteers. Finally, should HCMA want to understand the ranking of their areas relative to other natural areas in the region, the BRAM could allow for a direct comparison of the natural areas within park boundaries to lands owned by other entities. In Lower Huron, the BRAM is strongly correlated with both FQA (ρ-value = 0.87) at $p < 0.0001$. This is likely due to the fact that the BRAM incorporates direct field-survey data that is heavily reliant on vegetation quality, natural community type as defined by MNFI, and the presence of specific species. However, because the BRAM incorporates field data at a less detailed scale than FQI, the somewhat lower correlation is reasonable. A drawback of using a volunteer-based assessment protocol is that the quality of collected data is dependent upon the expertise of the volunteers. BRAM field worksheets are formatted such that reliable results are collected regardless of observer skill level. Nevertheless, varying levels of expertise could compromise the accompanying species list. Although this method is faster than FQA, completing the BRAM assessment across all parks will likely require multiple field seasons, depending on the availability and expertise of staff and volunteers.

BIORESERVE PROJECT DESKTOP ANALYSIS

A second component of HRWC's Bioreserve Project is the desktop analysis, in which publicly available aerial photographs of natural areas are examined for probable woodland, wetland, or open-field habitats (Project Details…[updated 2010]). A computerized model is used to rank the areas based on a set of ecological criteria, in which each criterion is assigned a point value that correlates to the presence/absence, or relative amount, of each ecological characteristic. We modified the analysis by narrowing the original 15 criteria (Appendix C.3) to nine that were both more appropriate for the natural area units within the Metroparks, which are much smaller than the watershed for which HRWC originally developed this method, and most tailored to HCMA's specific interests. We refer to the resulting approach as the Bioreserve Modified Desktop Analysis (BMDA).

Like the BRAM, an advantage to this method is that it was developed specifically for Southeast Michigan. Additionally, it uses publicly available spatial data and has already been shown to generate reliable and comparable results. The use of a desktop method potentially provides

HCMA with a cost-effective way to prioritize or narrow the scope of their field assessments to only "highly ranked" natural areas. Additionally, it can be employed at any point in the season. As a result, this method is highly feasible to implement across all 13 Metroparks. The BMDA considers landscape-scale elements, such as size, core size, and connectivity as well as habitat elements such as wetlands and waterways. Furthermore, it considers a rich set of data and many NGOs in the region are familiar with the criteria utilized in this method.

Despite these advantages, the BMDA relies entirely on spatial data, which may explain its moderate to weak correlation with FQA (ρ-value=0.37, $p<.0001$ in Lower Huron and ρ-value = 0.29, $p<0.014$ in Willow). These lower correlations with FQA suggest that the BMDA may be a less accurate assessment method than the field-based assessments. Furthermore, because BMDA uses historical data, it neglects to consider the importance of using more current land-cover data. It also appears that the BMDA has the potential to overestimate the quality of large areas due to its inclusion of criteria on size and core size. Additionally, implementation of this method without field data prevents the NRD from identifying current elemental occurrences and habitat characteristics. Though the criteria used in our modified desktop method are specific to NRD's objectives, our modifications to the HRWC's original desktop method make comparisons to areas outside of the parks more difficult.

Ecological quality assessments typically require some on-the-ground investigation to generate valid results. However, an examination completed by a single individual from an office setting can still work to prioritize areas for field examinations, and is preferable to no assessment at all.

MULTI-CRITERIA EVALUATION (MCE)

Multi-criteria evaluations (MCE) combine the information from several criteria to form a single evaluation in a geographical information system (Sahoo et al….[cited 2011 March 10]). Multi-criteria models are commonly used in ecological assessments because they are adaptable, where the natural-area manager and change the criteria and corresponding weights (Noss et al. 2002) based on his or her management goals and objectives. Using ArcGIS Model Builder as a platform to integrate several parameters, we developed a desktop analysis specifically for HCMA's purposes.

Relatively low correlation coefficients were observed between the MCE and FQA (ρ-value = 0.27 in Lower Huron and ρ-value = 0.26 in Willow) because the MCE includes characteristics, such as distance to water/wetland, soil conditions, etc., that were not considered in the FQA. Additionally, the MCE approach does not include the detailed field data that are central to the FQA approach.

MCE models, such as this one, are advantageous in that they can be easily tailored to HCMA's specific preferences through the flexibility of modifying the criteria utilized, their rankings, and their weightings. Similar to the BDMA approach, the MCE uses publicly available data, and model implementation requires only one trained individual; thus, this method would place low financial and temporal demands on the NRD. Additionally, this method could be quickly applied to all 13 parks, which would immediately alleviate the existing problem of data gaps.

However, there are several potential disadvantages to relying on this protocol. Although only one trained person is required, that person must have a solid understanding of the GIS methods. Additionally, the public datasets used in the analysis are not frequently updated and are measured at a larger scale than is ideal for the natural community units within the Metroparks. Therefore, an MCE may be less appropriate for prioritizing areas within a park and more appropriate for prioritizing management efforts across parks.

RECOMMENDATIONS

In the short term, our team recommends that the HCMA employ a multi-criteria evaluation desktop analysis to generate an initial rating for all natural areas within the Metroparks. This would immediately alleviate their issue of data gaps and would provide a "road map" for prioritizing field-based ecological assessments. Additionally, the adaptability of an MCE renders it suitable for long-term use within the agency. However, we strongly recommend augmenting the MCE approach we tested with additional assessment criteria in order to improve its correlation with FQA prior to implementation.

It is critical that management efforts prioritize areas both within and across the 13 Metroparks. Therefore, over the long-term, our team strongly recommends that the agency continue to pursue the compilation of a comprehensive baseline data set for all of the 13 Metroparks. A complete dataset that is rich in information has multiple strengths. First, it incorporates multiple ecologically based criteria and takes a holistic approach, which allows for the consideration of flora, fauna, and ecosystem factors over a broad scale. Second, it maximizes conservations efforts directed towards all aspects of ecosystem function.

Unfortunately, the creation of such a dataset is labor-intensive, making it a less feasible option given the current operating constraints faced by the NRD. Therefore, we also recommend HCMA employ a volunteer coordinator within the NRD to help expand agency resources through the facilitation of volunteers programs and the development of resource-cultivating partnerships.

Despite the data richness and higher accuracy associated with the FQA protocol, we find that this protocol requires too much time, effort, and expertise to be practical for HCMA purposes under their current resource constraints. Therefore, we recommend that HCMA's NRD implement the BRAM to compile their baseline field dataset, as it is a more resource efficient and holistic approach to conducting ecological assessments. Implementing this method in all natural areas will allow the NRD to consistently account for additional habitat characteristics, thereby creating a dataset comparable across all Metropark natural areas. Additionally, our experience suggests that natural areas can be assessed more quickly and efficiently using the BRAM, which offers clear advantages for the HCMA NRD given their current resource constraints. Furthermore, given the BRAM's strong statistical correlations with both the FQA and the HCMA Model, our results suggest that the BRAM is a relatively accurate and reliable proxy for those methods. Lastly, an added benefit of utilizing the BRAM is that it opens the possibility of forming a partnership with HRWC to assist in completing the remaining ecological assessments; a partnership effort that would benefit both organizations.

In addition to partnering with HRWC, we recommend that the NRD pursue partnerships with other local conservation organizations to assist in the implementation and expansion of the agency's management, conservation, and preservation activities. Similarly, we recommend continued investigation into the possibility of employing methods that use other living organisms as a means of assessing ecological quality such as a Bioblitz or the hiring of consultants as suggested by the NRD (Muelle, personal comm. February 2011).

The action plan below (Box 1) summarizes our recommendations for the HCMA. We believe the implementation of these recommendations would improve park planning, lead to a more effective and efficient use of park funds and personnel, and guide the NRD's management activities to achieve maximum conservation benefit.

Box 1 - Action Plan Summary

- Continue to pursue the compilation of a comprehensive baseline data set for all 13 Metroparks.
- Employ a MCE as a means of completing a desktop analysis across all 13 Metroparks with some criteria modifications, such as those utilized by the BMDA and HCMA Model, in order to provide a data set for decisions that need to be made in the near term and to assist in prioritizing areas for field-based assessment.
- Employ a volunteer coordinator to facilitate the utilization of volunteers to assist in executing the massive data collection effort required to create a comprehensive baseline data set.
- Pursue partnerships with HRWC, the Clinton River Watershed Council, the Michigan Botanical Club, and the Stewardship Network in order to expand the agency's resources for management, conservation, and preservation activities.
- Implement the BRAM in all Metropark natural areas, including those areas with existing FQA data, in order to provide a holistic data set, collected with consistent methodology.
- Continue investigating the possibility of assessing other organisms as a means of assessing ecological quality through implementation of a Bioblitz and the hiring of consultants as suggested by the NRD Chief (Muelle, personal comm, February 2011).

I. INTRODUCTION

1.1 AN INTRODUCTION TO THE HURON-CLINTON METROPOLITAN AUTHORITY

HISTORY OF THE METROPARKS

In the early 1930s, the Huron-Clinton Parks and Parkway Committee proposed a series of public green spaces and an associated parkway from Lake St. Clair to the Detroit River (Appendix C, Figure C.1, Reynolds 2006). The Committee aimed to (1) restore and conserve natural water levels, (2) improve lake shores and stream beds, (3) eliminate pollution and the degradation of natural land values, (4) develop lakes and channels, (5) preserve and develop scenic vistas, and (6) promote local parks and drives (Reynolds 2006). In 1939, Public Act 147 established the Huron-Clinton Metropolitan Authority (HCMA) with these goals in mind (Reynolds 2006) for the purpose of planning, promoting, developing, owning, maintaining and operating parks, and connecting drives and limited access highways across Wayne, Oakland, Macomb, Washtenaw and Livingston counties. Under this Authority, the Metroparks were designated as a specific regional park district, which now has jurisdiction over almost 24,000 acres across 13 parks (Metroparks History…[cited 2010 March]).

In addition to the creation of the HCMA, Public Act 147 also included the passing of a millage, in which local property taxes were allocated for parkway and park development. The nation was struggling with the adverse impacts from the Great Depression at this time, making the millage a notable achievement. Its passage was a reflection of the increased desire for recreational spaces and roadside stops, and closely parallels the rise of the American automobile (Reynolds 2006). However, construction of Interstate 94 interfered with the original parkway plan, and forced HCMA to modify the original vision of the park system in exchange for the current park plans that exist today (Reynolds 2006).

The basic principle of the commissioners was to only acquire and develop areas they were able to maintain (Reynolds 2006). It is with this idea in mind that patterns of land acquisition and maintenance of existing areas developed over time for the HCMA (Reynolds 2006). HCMA garnered land acquisitions through both purchase and donations. As funding opportunities increased for the HCMA, they found themselves able to manage larger areas. Though the HCMA has the right to force people to sell by eminent domain, it has adamantly opposed enforcing this right, favoring a more peaceable approach (Reynolds 2006). In 1946, the HCMA purchased the land that became Lower Huron Metropark, which opened in 1953 (Reynolds 2006). The HCMA acquired the land that became Willow Metropark in 1968, and opened the park in 1970 (Reynolds 2006). Through the end of the 1970's, the HCMA actively acquired land, shifting to a time of development beginning in the 1980s (Reynolds 2006).

CHANGES IN PARK MISSION

The Huron-Clinton Metroparks underlying mission has gradually changed over time. According to Paul Muelle, HCMA Chief of Natural Resources, the main goal of the parks system, since the inception of the Authority in 1939, has been to provide recreational opportunities for the general public in Metro Detroit (Muelle, personal comm. 2010). An informational plaque at Kensington Metropark reads, "…the primary purpose of the Huron-Clinton Metropolitan Authority is to plan, acquire, develop and operate regional recreational facilities." While these traditional views focused less attention on the impacts that such recreational activities had on the surrounding ecosystems, gradual changes in values led to the inclusion of natural resource and ecosystem management. As of 2000, in order to avoid the over-development of their lands, the HCMA shifted their focus to the preservation of natural resources and the maintenance of existing facilities (Reynolds 2006). In 2001, HCMA created a formal Natural Resources Department (NRD) when a partnership with the Michigan Natural Features Inventory (MNFI) highlighted the need for better understanding and management of natural areas within the parks. However, degradation from past large-scale changes, such as intensive land use, fire suppression, and exotic species introduction presents a difficult challenge for the NRD.

The changes in parkland management represent HCMA's recognition of the importance of maintaining and restoring Michigan's natural heritage for future generations. HCMA's current mission is to "[provide] excellent recreational and educational opportunities while serving as stewards of its natural resources. Our efforts are guided by the belief that the use of parks and exposure to natural environments enhance society's health and quality of life" (Semion 2010).

1.2. DESCRIPTION OF HCMA'S NATURAL RESOURCES DEPARTMENT

HCMA's NRD manages roughly 80% of the 25,000 acres of parkland that remain undeveloped across the 13 Metroparks (Metroparks History… [cited 2010 April]). Their mission is, "to protect and restore significant elements of natural diversity while balancing ecological stewardship with compatible recreational uses" (Huron-Clinton Metroparks...[accessed March 2010]). In order to enact these goals, the NRD provides recommendations for management plans, restores and preserves habitat for rare plant and animal species, removes and monitors invasive species in the parks, and educates park employees and the public (Muelle and Gajewski, 2010, personal comm.).

The Chief of Natural Resources, Paul Muelle, works under the director and the deputy director of HCMA (Appendix C, Figure C.2). In 2007, the addition of one full-time position for a Natural Resource Technician, along with the capacity for the department to hire part-time and seasonal staff, greatly expanded the NRD's capabilities (HCMA, personal comm. March 2011). The summer of 2010 saw the largest staff size of the Department thus far: three full-time employees and three summer interns (Muelle, personal comm. 2011).

In an effort to more effectively promote and protect natural resources within the parks, the HCMA's NRD recently developed a protocol for assessing ecological quality (Heslinga 2010), which is described in detail in section III of this report. This protocol prioritizes the natural areas for conservation management efforts, including such techniques as prescribed burns, invasive species removal, native species re-establishment, and animal culling (Natural Resource Volunteer Opportunities… [cited 2011 March 4]).

Management initiatives generally focus on a few specific priority areas across all parks, rather than a predetermined number of areas within each individual park, allowing the NRD to maximize their conservation efforts. These high-priority areas were initially identified through MNFI's surveys in the early 2000s, and have since been investigated for elemental occurrences of plants, animals, wetlands, and other notable features. Area species lists developed during the MNFI surveys are augmented after routine site visits, and a floristic quality index (FQI) was developed for each unit, allowing for the comparison of its ecological significance with areas found throughout Michigan. The NRD defined additional ecological communities as secondary management areas, and protects natural areas that (1) act as important buffers to development, or are (2) rare or declining ecological communities according to statewide rankings,

Additionally, the NRD holds two volunteer workdays each year. One workday is held in the spring to pull garlic mustard, a highly invasive herbaceous plant, and the other day is in the fall, where volunteers collect native prairies seeds for the expansion of natural areas. Additional volunteer land stewardship opportunities are available when other management projects are implemented (Natural Resource Volunteer Opportunities… [cited 2011 March 4]).

1.3. PROBLEM STATEMENT

While the creation of a formal NRD and the development of an ecological assessment protocol represent a significant leap forward towards the protection and conservation of natural resources within the Huron-Clinton Metroparks, a number of areas of opportunity still exist. One area of opportunity lies in the improvement of the existing ecological dataset. The data currently used by the NRD were gathered at different points in time, using different methods, and only in select undeveloped areas (HCMA personal comm., February 2011). MNFI initially collected the vegetation related data in the early 2000s, and HCMA staff has augmented those species lists over time. Existing wildlife data are based on sightings reported over many years by park patrons, HCMA Nature Center staff, and NRD staff. As a result, wildlife data are prolific in areas where additional data were generated by individuals or professional organizations doing studies or surveys within the parks, while areas rarely visited by park patrons have limited information. Additionally, MNFI surveyed and mapped select natural communities within the parks, but the majority of HCMA land lacks baseline information on ecological quality. Large data “gaps” exist in each of the 13 Metroparks, which has confounded the NRD’s efforts to analyze ecological quality. For example, it is noted in their ecological quality model that in areas with incomplete or absent species lists, floristic quality needed to be estimated (Heslinga 2010).

A second major area of opportunity for HCMA’s ecological assessment protocol is feasibility of implementation. The existing HCMA Model is challenging to implement under the NRD’s current resource constraints, given that it requires the time- and personnel-intensive protocol of developing a FQI for each natural area. With a department primarily staffed by just two full-time members, such a resource intensive ecological assessment protocol may not be practical, as evidenced by the fact that as of February 2010, this model had only been completed for Huron Meadows and Oakwoods Metroparks (Heslinga 2010). Adding more staff is a logical solution, however this does not appear likely in the near future given current funding constraints. The NRD, along with the rest of HCMA, operates from funds through a property tax levy limited to one-quarter of one mill, and by revenues from vehicle entry fees and other user fees. The 2011 budget for all of HCMA is $73.5 million, with an 11% drop in tax revenue predicted for this year, and further reductions predicted for 2012 and 2013 (Miller 2010).

These areas of opportunity must be addressed in the near future. Comprehensive knowledge of the ecological status of the parks is necessary for long-term planning. The existence of an incomplete and inconsistently collected dataset is insufficient given the NRD's need to accurately identify and prioritize natural areas for conservation and management activities. Inefficient and unsound management can contribute to habitat loss and degradation, which may eventually lead to the extirpation of rare native species from the Huron-Clinton Metroparks. This lack of comprehensive ecological knowledge on the parks also inhibits the proper siting of municipal and recreational amenities. HCMA's NRD needs an ecological assessment method that will be feasible to implement within their current resource constraints, can be consistently applied across all parks, and will enable them to target their management efforts towards natural areas of maximum conservation benefit.

1.4. GOALS AND OBJECTIVES

The goal of this master's project is to assist HCMA's NRD in the development of a practical, effective, and informed method for assessing ecological quality and prioritizing natural areas for conservation and management within their Metroparks.

Our objectives were to:

- identify ecological assessment methods that are available and applicable for use by the HCMA NRD;
- implement the identified ecological assessment protocols through a case-study approach within the Lower Huron and Willow Metroparks;
- identify gaps in HCMA's existing dataset for Lower Huron and Willow;
- conduct field surveys of the natural areas within Lower Huron and Willow Metroparks to identify vegetation and other natural features indicating ecological quality;
- evaluate the possibility for using herpetofauna presence and their associated habitats as an indicator of ecological integrity and a criterion for conservation and management prioritization, through a case-study survey in Lower Huron and Willow Metroparks;
- create a series of maps that illustrate levels of ecological quality for Lower Huron and Willow Metroparks utilizing the identified ecological assessment protocols;
- develop a set of criteria on which to evaluate and compare the usefulness of each protocol for implementation by HCMA's NRD;
- identify the advantages and disadvantages of each of the identified ecological assessment protocols using the above evaluation criteria;
- provide HCMA's NRD with ecological quality data for Lower Huron and Willow Metroparks, a series of ecological quality maps, and a written report recommending a course of action for implementing ecological assessments across the Metroparks.

II. LOWER HURON AND WILLOW METROPARKS AS A CASE STUDY

2.1. REASONING AND JUSTIFICATION

Our team chose to take a case study approach with this project by utilizing Lower Huron and Willow Metroparks as test sites for our identified ecological assessment methods. We found Lower Huron, Willow, and Oakwoods Metroparks to be attractive locations for our study because they form a riparian corridor, spanning a long stretch of the Huron River (Appendix D, D.1). Lower Huron, Willow, and Oakwoods together form a potential corridor for wildlife in an otherwise fragmented and inhospitable matrix making the collection of baseline data in these parks very important. Unfortunately, because the timeframe of our project did not permit the collection of data from all three of these parks, the final study was limited to Lower Huron and Willow Metroparks. These parks are representative of the Metroparks' mission of maintaining recreational use while preserving natural areas. Furthermore, because the parks are located close to one another, management plans can be developed and implemented on both a small scale and a landscape scale. These parks are run by one park office (Appendix C, Figure C.2), so jurisdiction disagreements will be minimal when implementing ecological assessment plans across both parks.

2.2. SITE DESCRIPTIONS

HISTORICAL LAND USE AND NATURAL HISTORY

In 1946, the HCMA purchased the land that became Lower Huron Metropark, which was opened in 1953 (Reynolds 2006). The HCMA acquired the land that became Willow Metropark in 1968, and opened the park in 1970 (Reynolds 2006). The HCMA continued actively acquiring land through the end of the 1970's, followed by the extensive development of recreational amenities in the 1980s (Reynolds 2006).

PRE-SETTLEMENT VEGETATION

Lower Huron and Willow Metroparks had very similar vegetation in the 1800s (pre-settlement vegetation covers). Pre-settlement vegetation in both Lower Huron and Willow Metroparks consisted of the following natural communities, defined in Appendix F.

Mixed hardwood swamp	Mixed oak savanna	Oak-hickory forest
Wet prairie	Mixed conifer swamp	Muskeg/bog
Black ash swamp	Shrub swamp	Black oak barren
Lake/river	Emergent marsh	Mixed oak forest
Beech/sugar maple forest		

Maps displaying the distributions of the pre-settlement vegetation cover within Lower Huron and Willow Metroparks are provided in Appendix D, D.2 and D.3.

DISTURBANCES AND ALTERATIONS TO THE LANDSCAPE

The land in both parks was historically farmland, except where conditions were too wet. In most cases, these wet areas were either dammed or converted into mills (Reynolds 2006). Settlements along the Huron River were established, and later grew into towns (Reynolds 2006). Eventually, the transportation needs of these businesses outgrew the capabilities of the river (Reynolds 2006); businesses relocated, leaving behind severely altered ecosystems.

The Huron River was severely polluted from industrial and residential wastes, fertilizers, and sewage, rendering many stretches of the river unusable (Reynolds 2006). Large-scale removal of vegetation led to increased erosion and the accumulation of muck and marl at the bottom of many lakes. Drainage projects led to decreased water levels, drying up lakes and leaving behind mud flats, marshes, and bogs (Reynolds 2006). In order to account for these activities within our project, we recorded evidence of human disturbance, defined as: residential development, bulldozing, dirt roads, ATV trials, drains, ruts, abandoned homestead, abandoned agricultural fields, rock piles, fences, soil buildup, cut stumps, footpaths, and evidence of plowing. All of these serve as indicators of past human activity in natural communities.

PRESENT STATUS

The current vegetation in Lower Huron and Willow Metroparks is different in important ways from pre-settlement vegetation. Present-day vegetation classifications are based on classifications developed by the MNFI. Additionally, the HCMA developed some classifications to represent communities that are successionally transitional.

LOWER HURON METROPARK

Lower Huron's present vegetation and natural communities are displayed in Appendix D, D.4 and defined in Appendix F. Man-made waterways such as ponds, and streams have been constructed for recreational uses. Large swaths of land have been converted to picnic areas, parking lots, and a group camping area, while smaller portions include a paved hike-bike trail, baseball diamonds, tennis courts, basketball courts, a water park, and a golf course. South Metropolitan Parkway bisects the parkland. Natural communities in Lower Huron include:

Dry-mesic forest (DMF)
Floodplain forest (FF)
Old field (OF)
Mesic forest (MF)
Wet-mesic forest (WMF)
Wet-mesic prairie (WMP)
Shrub land (SH)
Shrub-carr (SC)

WILLOW METROPARK

Willow Metropark's present vegetation and natural communities are displayed in Appendix D, D.5 and defined in Appendix F. Man-made waterways such as Washago Lake, ponds, and streams have been constructed for recreational purposes. The northern-most region of the park largely consists of a golf course and driving range, while the southern region includes a paved hike-bike trail, sledding hills, picnic areas, playgrounds, parking lots, a disc golf course, softball diamonds, basketball courts, a skatepark, and a waterpark. The southern portion of the park also contains interloping roads that circle the core area. Natural communities found in Willow include

- Old field (OF)
- Floodplain forest (FF)
- Hardwood swamp (HS)
- Wet-mesic prairie (WMP)
- Dry-mesic forest (DMF)
- Lowland conifer (LC)
- Emergent wetland (EW)

CURRENT NATURAL RESOURCE MANAGEMENT

Prior to this report, five exemplary areas had been identified in Lower Huron for management activities, along with pockets of mesic forest and wet-mesic prairie. Willow does not contain any high-priority management areas due to the high percentage of developed recreational lands. However, Willow's floodplain forests are noted as containing significant populations of the state-threatened beak grass *(Diarrhena obovata)*, and serve as important riparian buffers for the Huron River (Huron-Clinton Metropolitan Authority 2010).

The general management plans for the recognized priority natural areas were written in 2010 as a part of a natural features summary and broad management plan for Lower Huron, Willow, and Oakwoods. Each management plan includes a statement of the plan's objectives, a list and description of the principals guiding the ecological management, a description of the historical and current vegetation, and the approximate locations of species of concern. The community's current threats and stressors have been identified, and the management goals, objectives, and strategies for ameliorating these stressors are explained. However, this report was based on limited observational data, reflecting the previously mentioned gaps in the existing datasets. Furthermore, it does not include an explanation of why the identified areas were classified as "high priority," relative to other areas of the parks.

In Lower Huron, past and present management activities in the high-priority areas have focused on invasive species removal by seasonal staff and during volunteer workdays. Rare species are mapped and monitored by the natural resource technician to track their response to this management. The management plans also call for deer culling to reduce browse effects, and for long-term coordination with HRWC to reduce the erosive effects of stormwater runoff. To date, these last two management initiatives have yet to be undertaken.

III. OVERVIEW OF OUR APPROACH

3.1. ECOLOGICAL ASSESSMENT PROTOCOLS IDENTIFIED

Our team identified five ecological assessment protocols that could be applied by HCMA's NRD through a literature review and personal communication with NRD staff. These protocols include: Floristic Quality Assessment (FQA), the HCMA Ecological Quality Model (HCMA Model), the Bioreserve Rapid Assessment Method (BRAM), and two geographic information system (GIS) desktop analyses, including the Bioreserve Desktop Analysis and a Multi-Criteria Evaluation (MCE). Detailed explanations of these protocols are provided in the following sections along with our justifications for considering their use by HCMA.

FLORISTIC QUALITY ASSESSMENT

EXPLANATION

Floristic Quality Assessments allow ecological investigators to assess the overall quality of an ecosystem by ranking the plant species living in an area based on the ranges of habitats, in which they are able to live. These rankings are termed floristic quality indices (FQIs). FQIs and other indices of biological integrity (IBIs) are widely implemented in ecological assessments (Andreas et al. 2004; Hargiss et al. 2008; Matthews et al. 2009; Mack 2009; Rama Bhat and Kaveriappa 2009).

REASONING AND JUSTIFICATION FOR USE

We decided to consider FQA as a potential ecological assessment model for HCMA because it has been so widely tested and implemented. FQA is used worldwide (Rama Bhat and Kaveriappa 2009; Tu et al. 2009; Mack 2009; Andreas et al. 1995; Andreas et al. 2004) and across a wide range of ecosystem types (Rama Bhat and Kaveriapp 2009; Tu et al., 2009; Mack 2009; Andreas et al. 2004; Hargiss et al. 2008; Matthews et al. 2009). Furthermore, it is a method that can be combined with other parameters to fully assess ecological quality based on the needs of the organization completing the assessment. This strength is seen in the case of HCMA, which is currently employing FQI as a criterion in their current model of ecological assessment. Additionally, because FQA is such a widely tested and broadly implemented method, we considered it a gold standard in ecological assessment against which to measure other methods of ecological quality assessment.

HCMA ECOLOGICAL QUALITY MODEL

EXPLANATION

Prior to the start of this project, HCMA's NRD staff developed a model for conducting ecological assessments within the Metroparks. The HCMA Model combines field surveyed data and spatial data using four criteria: FQI, wetland occurrence, elemental occurrences, and community ranking. HCMA's FQI criteria are based on species lists developed from surveys conducted by MNFI and HCMA staff utilizing the formula described in the above section on FQA. However, in areas with incomplete or absent species lists, an estimate of FQI is used in their model. Wetland occurrence has been defined by the agency using a combination of NWI spatial data and on-the-ground observations of wetlands. Elemental occurrences are defined by HCMA as high quality natural communities or state-listed plant species that have been entered into the Michigan Natural Features Database. The agency also includes verified reports of state-listed animal species. Community Ranks are rankings of natural communities defined by the State of Michigan based on the community's rarity and/or decline. These rankings can be identified in Appendix F.

REASONING AND JUSTIFICATION FOR USE

We decided to employ this model of ecological assessment in our study based on its prior use by HCMA. Implementing this method as part of our project enables comparison of HCMA's business-as-usual approach to other methods of ecological assessment. Furthermore, our use of this protocol would provide HCMA with a baseline dataset in Lower Huron and Willow consistent with what they have previously compiled for Huron Meadows and Oakwoods.

BIORESERVE RAPID ASSESSMENT METHOD

EXPLANATION

In researching potential ecological assessment methods for our team to test in our study, we identified the Huron River Watershed Council's (HRWC) Bioreserve Project as an applicable method of assessing natural areas. The HRWC is a non-profit organization begun by a recommendation from the State Water Resources Commission. Based in Ann Arbor, Michigan, HRWC provides water resource information and research services related to the Huron River (History of HRWC…[updated 2010]), and acts as a consultative unit to help resolve mutual water use and pollution problems along the Huron River. In 1965, the Huron River Watershed Intergovernmental Committee successfully petitioned the Water Resources Commission to form the HRWC. Today, HRWC's nine-person staff coordinates hundreds of volunteers in programs that generate scientific reports, educate citizens on pollution prevention and abatement, and inform stakeholders about water resource policy and legislation (History of HRWC…[updated 2010]).

The largest threat to the Huron River comes from the development of natural areas. Suburban and commercial development outside Detroit has increased impervious surface area, and reduced diversity and quantity of natural areas, disrupting ecosystem services essential to maintaining the integrity of the Huron River (Project Details...[updated 2010]). In an effort to identify the remaining areas of highest ecological value for conservation and protection, the Bioreserve Project was developed.

There are two major components of the Bioreserve Project: first, a desktop analysis employing aerial photo-interpretation to identify natural areas, followed by the use of spatial data to rank the natural areas based on a set of criteria indicating ecological quality (further explanation can be found in the Bioreserve Project Desktop Analysis section of this report). Areas of highest priority are investigated for potential ecological quality during a roadside survey, in which volunteers complete a roadside questionnaire. Results from the roadside questionnaire are then used to further prioritize sites for an on-the-ground field assessment, the BRAM, also completed by volunteers.

The BRAM was adapted from the assessment methods used by professional ecologists at MNFI, such that it is "general enough that volunteers with a half-day training and a field guidebook will be able to complete, but detailed enough to glean meaningful information about the ecological quality of the site" (Project Details...[updated 2010]). The BRAM considers eight criteria of a site within three major categories: (1) its landscape ecosystem, which includes land form, soils, and hydrology; (2) its vegetation, including community, structure, and composition; and (3) its disturbance including natural and anthropogenic (human-caused) sources. Checkbox worksheets developed for different ecosystem types are used while in the field. Information from the worksheets is entered into a Microsoft Access database, which generates two scores for a site: a biointegrity score and a disturbance score (Appendix H, H.2). These scores provide field-level detail to supplement HRWC's desktop based ranking of priority conservation areas, and the data can be referenced for HRWC's work with municipalities, conservancies, and natural area property landowners (Project Details … [updated 2010]).

REASONING AND JUSTIFICATION FOR USE

In our search for applicable and appropriate ecosystem evaluation models, the BRAM represented a logical alternative to the HCMA method for several reasons. The project's rapid assessment method is based primarily on the professional MNFI ecosystem assessments, and as such, has provided reliable ecological quality information for conservation purposes in the past (Project Details…[updated 2010]). The method takes a more holistic approach to ecological assessments by incorporating focused species-specific data with other habitat indicators, including vegetation composition, age structure, and soil type, which can potentially act as proxies for exhaustive species lists required by FQI calculations. It also exists in a format that can be easily implemented by volunteers, rather than hired park personnel, should HCMA's time and financial constraints render other methods infeasible. Additionally, should HCMA want to understand the ranking of their areas relative to other natural areas in the region, the BRAM allows for a direct comparison of the natural areas within park boundaries to lands owned by other entities. Furthermore, the method is tailored to the ecosystems in Southeast Michigan, specifically those along the Huron River, where our designated case-study parks are located.

It should be noted that this logical partnership between HCMA and HRWC had not gone unrecognized prior to this effort. HRWC's coordinator of the Bioreserve Project, Kris Olsson, and HCMA's Chief of Natural Resources Paul Muelle have previously discussed the possibility of utilizing HRWC's volunteer base in some of HCMA parks, such that the interests of both organizations would be met. Even so, at the time this report written, this option had not been actively pursued, partly because HRWC's "highest priority areas" are typically privately owned lands, which are subject to extensive development as they do not carry the inherent protection afforded to parklands.

GEOGRAPHIC INFORMATION SYSTEM DESKTOP ANALYSES

In addition to testing ecological assessments based on field surveys, our team decided to consider if desktop analyses, performed with GIS software and using publicly available spatial data, could be a useful form of ecological assessment for HCMA. Since 1996, researchers have recognized and advocated the use of GIS as a powerful descriptive and qualitative tool for ecological assessments (Byron et al. 2000). Recently, a fast development of technologies has extended the analytical capacity of GIS. These developments have triggered the acceptance of the broad use of GIS as an environmental modeling tool for research and contemporary ecological assessments (Goodchild 2002). Land managers can use GIS to prioritize areas for conservation and management by analyzing spatial data describing the physical and biological characteristics of the landscape. A 2002 thesis proposed a GIS modeling method based on ecosystem rarity that allowed land managers to introduce criteria for the protection and preservation of nature (Geneletti 2002). Additionally, biodiversity indices developed from such criteria as the number of species, the spatial distribution of species, species sensitivity to disturbance, and land-cover classes can be shown in ecological assessment maps. Integration of ecological tools and GIS software in the ecological assessment processes is critical to the development and implementation of sustainable ecological management. Our team tested two different types of desktop analysis: HRWC's Bioreserve Project desktop analysis and a MCE.

BIORESERVE PROJECT DESKTOP ANALYSIS

EXPLANATION

As previously mentioned, prior to HRWC's implementation of the BRAM, natural areas are initially identified and examined by the Council's Bioreserve Project Coordinator from an office using a desktop analysis. Our team identified the desktop analysis as another potential method of ecological assessment, which could be adopted for use by HCMA. In HRWC's desktop analysis, publicly available aerial photographs taken over land within the watershed area are examined for probable woodland, wetland, or open field habitats, and these areas are digitized using ArcGIS. Then, a computerized model was developed during a previous partnership with faculty and students from the University of Michigan School of Natural Resources and Environment (Project Details...[updated 2010]). It is used to rank the areas based on a set of ecological criteria, in which each criterion is assigned a point value that correlates to the presence/absence, or relative amount, of each ecological characteristic. Fifteen criteria are measured in HRWC's desktop analysis: (1) total size, (2) core size, (3) presence of a waterway, (4) presence of wetlands, (5) potential for groundwater recharge, (6) presence of specific communities in the 1800s, such as a conifer swamp, lowland hardwood forest, oak opening, central hardwood forest, or an emergent wetland, (7) glacial variation, (8) topographical variation, (9-10) connectedness to other natural areas through percentage and number, (11-12) potentially unchanged variation by percentage and by area, (13) the restorability of surrounding land, (14) area of MNFI "special" communities, and (15) the biorarity of observed species (Appendix C, Figure C.3) . HRWC analyzes these criteria in a GIS to develop a "Bioreserve Map" of all natural areas within the Huron River Watershed. The map ranks areas as lower, medium and highest priority for preservation (Project Details...[updated 2010]) on a watershed scale. Due to the smaller scale of units within the Metroparks, we found that only 9 of the 15 criteria were appropriate and relevant for HCMA's purposes, and modified this desktop analysis in this way, creating our Biorserve Modified Desktop Analysis (BMDA).

REASONING AND JUSTIFICATION FOR USE

Ecological quality assessments typically require some on-the-ground investigation to generate valid results. However, time and resource constraints might render a detailed field analysis of all park areas impractical. In this case, an assessment completed by a single individual from an office setting is preferable to no assessment at all. Furthermore, some of the landscape-level criteria utilized in this desktop method, such as size, core size, and connectedness, which may potentially be useful for prioritizing areas for conservation and management within the Metroparks, are easier to assess from spatial data. An additional consideration is that this method was developed specifically for use in Southeast Michigan, and given that the Bioreserve Project's desktop analysis is already in use across the Huron River Watershed, it has already been shown to generate reliable and comparable results using publically available spatial data. Additionally, the use of a desktop method potentially provides HCMA with a way to narrow the scope of their field assessments to only "highly ranked" natural areas. For these reasons, the Bioreserve Project's desktop analysis was considered as a potential ecological assessment method, independent of other assessment methods, but with the possibility of being paired with its rapid field assessment if used by HCMA.

MULTI-CRITERIA EVALUATION

EXPLANATION

We chose to use the ArcGIS Model Builder as a platform to develop our own version of desktop analysis as it would allows us to integrate several parameters relevant to an ecological assessment. MCE is a GIS based approach that combines the information from several criteria to form a single evaluation (Sahoo et al….[cited 2011 March 10]). This approach uses a different set of criteria from the BMDA and represents a general framework and weighting system that can be modified in the future. For example, criteria we used in our MCE approach which included distance to river, distance to wetland, distance to road, slope, soil type, pre-settlement vegetation type, and MNFI's biological rarity index, could be combined with the criteria from the Bioreserve Project Desktop

Analysis to create a combined desktop assessment. Weighted linear combination is a common technique to create a single index from several different criteria. All the criteria must be standardized and transformed to the same scale for the final suitability analysis. A pair-wise comparison matrix is often used to establish the criteria weights (Pairwise Comparison…[updated 2005]). MCEs are commonly used in ecological assessments because they are adaptable and the criteria and their corresponding weights can be chosen by the natural area manager (Noss et al. 2002) based on his or her management goals and objectives. Ultimately, we chose eight criteria for our MCE based on either traditional usage or their usage in other ecological assessments.

REASONING AND JUSTIFICATION FOR USE

A multi-criteria model, such as the MCE that we outlined above, could potentially be useful for HCMA's NRD on a few different levels. This MCE is a way to assess ecological quality on multiple parameters, something that the NRD clearly has an interest in as seen in their current ecological quality model. Additionally, MCEs, such as this one, can be easily tailored to the agency's specific preferences through the flexibility offered in the model's criteria choices and ranking and weighting scoring system. Therefore, in the event that HCMA's management goals change in the future, a GIS model such as this could easily be adapted to compensate for shifts in priority as they occur. Additionally, as addressed in our problem statement, resource constraints are an important consideration in choosing a method of ecological assessment for HCMA. Implementing an MCE would be a resource minimal approach since it makes use of publicly available special data, which are free to download from the internet.

3.2. WILDLIFE AS POTENTIAL CRITERIA FOR AN ECOLOGICAL ASSESSMENT

During the development stages of this study, the HCMA NRD expressed an interest in gaining information about wildlife presence, habitat, and elemental occurrences of any rare or threatened species in the Metroparks. We investigated the possibility of incorporating this kind of field data as ecological assessment criteria, which could be combined with other datasets for prioritizing conservation and management efforts. The NRD expressed that they would rather craft management policies and long-term plans for areas based on their actual observed existence of different flora and fauna, rather than the likelihood that they could or could not potentially exist in areas, as would be defined by other criteria typical of ecological assessment protocols (HCMA personal comm. March 2010). With this preference in mind, we investigated the possibility of wildlife presence as a criterion to be utilized in our ecological assessment.

We began to examine the known presence of rare animal species in the Metroparks and across the region that could be useful to survey as part of our ecological assessment. We discovered that Oakwoods, a park just south of Lower Huron and Willow, has recorded observations of a breeding population of the smallmouth salamander (*Ambystoma texanum*) a state-endangered species that has only been observed in four of Michigan's counties, all of which are in the southeastern corner of the state (*Ambystoma texanum,* smallmouth salamander…[accessed 2011 Mar 4]). This salamander inhabits forested bottomlands, the associated wetlands and adjoining uplands, and occasionally prairies and farm fields. As with most salamander species, water bodies that are seasonal, shallow, and free of fish are required for successful breeding. An examination of aerial photos of the parks, along with data provided by NWI, suggested that these habitat requirements could potentially be fulfilled by Willow and Lower Huron, but the NRD's current datasets were lacking detailed habitat information. To the best of our knowledge, surveys for the smallmouth salamander had never been conducted in Lower Huron and Willow. In the event that an additional population of smallmouth salamanders was located, there would be sufficient evidence to prioritize conservation efforts to support the habitat area of that population and to support land management activities that focus on increasing connectivity between the three parks, thus forming an ecological corridor of expanded available habitat.

In addition to concern for this particular endangered salamander species, baseline knowledge of the amphibian and reptile species present within Lower Huron and Willow was lacking. Our team identified this missing information as a data "gap," which could be ameliorated through a herpetofauna survey. The NRD indicated that data showing herpetofauna presence would likely affect management decisions, since the department aims to employ management practices that "incorporate all organisms within an ecosystem, rather than focusing on an individual species" (Ecosystem Management…[accessed April 2010]). For example, the timing of brush cutting and herbicide application under transmission lines that run through the park could be adjusted to accommodate the breeding period for tree frogs, if it was known that tree frogs utilized an area and were negatively impacted by those management activities (HCMA, personal comm. May 2010). In the interest of gaining site and species-specific information on commonly used ecological indicators and the potential of locating additional populations of a state-endangered species within the Metroparks, we chose to investigate the presence of herpetofauna (reptiles and amphibians) as a potential indicator of ecological quality.

REASONING AND JUSTIFICATION FOR CONSIDERATION OF HERPETOFAUNA PRESENCE AS A CRITERION

Our decision to focus on a survey of herpetofauna as a criterion for wildlife-related ecological assessment within the Metroparks is supported by a body of literature on herpetofauna as indicators of ecological quality. While it would be ideal to monitor the total species richness (alpha richness) for all natural areas of concern, time, funding, and resource constraints make this approach impractical. The use of indicator species thus provides land managers and conservationists an efficient way to assess the impacts of environmental disturbances on an ecosystem (Carigan and Villard 2001).

Reptiles and amphibians have been used as indicators of ecosystem health in numerous past studies (Paggetti et al. 2006, Welsh and Droege 2001). Amphibians in particular have been heralded as proxies for environmental integrity (Welsh and Droege 2001, Keddy et al. 1993). Their life cycle typically requires both aquatic and terrestrial habitats, and their thin skin and subcutaneous respiration renders them vulnerable to environmental contaminants and slight changes in microhabitat conditions (Keddy et al. 1993). Additionally, amphibians are often an important source of food for higher trophic levels in wetlands, and also act as key consumers of invertebrates themselves. These characteristics suggest that they are closely related to the maintenance of essential environmental processes and ecosystem functions. Thus, their presence can be indicative of these functions having been maintained (Keddy et al. 1993). Moreover, the use of herpetofauna as indicators, instead of other animal classes, is particularly efficient; they require relatively little survey time using standard methodologies, and species-level identification is relatively simple (Paggetti et al. 2006).

In a recent assessment of the biological integrity of the coastal wetlands along the Great Lakes, marsh bird and amphibian assemblages were used to indicate wetland integrity (Crewe and Timmermans 2005). The connectivity and proximity of upland forest areas with lowland wetland areas has also been shown to impact amphibian richness, because the loss of forests in the upland areas connecting different wetland clusters can cause population declines (Blaustein et al. 1994, Lehtinen et al. 1999). Thus, herpetofauna are potentially good indicators of biological integrity in areas that exhibit forested habitats interspersed with wetland complexes.

IV. METHODS

4.1. DATA COLLECTION

We surveyed Lower Huron and Willow Metroparks during the growing season of 2010. We excluded areas of turf grass, designated picnic areas with or without over-story trees, and buffers along roadsides, parking lots, and paved-paths from all surveys due to their inherently low habitat quality (Marsh 2007, Piper and Catterall 2005, Kissling et al. 2009). In areas with prairie-type systems maintained through mowing and/or herbicide application (i.e. areas beneath transmission lines, utility right-of-ways), we only completed surveys if the area appeared un-mowed within the previous month, or with sufficient vegetation of ecological value at the time of the survey. In all other cases, natural areas were surveyed regardless of the initial on-the-ground impressions of ecological quality.

HERPETOFAUNA SURVEYS

Visual and auditory surveys for reptiles and amphibians were conducted during the months of March, April and May, following the spring migration from winter hibernation. Within each park, wetland areas identified by the NWI were investigated on foot, and selected as survey areas for our team's focused monitoring (Appendix E, E.4 and E.5). Vernal pools and forested wetlands were selected based on a visual evaluation of the presence of amphibians and standing water not connected to the Huron River or its tributaries.

During March and April, we placed 40 coverboards throughout Lower Huron, and 24 throughout Willow. Artificial cover objects used for surveys of amphibians and reptiles have been successful in past studies (Houze and Chandler 2002, Hampton 2007) and were recommended to us (Mifsud personal comm. 2010). The placement of uniform, wooden boards at each study site allows for a standardized, quick, unbiased sampling method (Houze and Chandler 2002). Sheets of untreated plywood 23/32-inch were cut into squares measuring 2 foot by 2 foot. One to three boards were placed at each site, at roughly equal intervals along the margin of vernal pools and wetlands. Contact information and an alphanumeric code designating the survey site and individual cover board was written on the exposed side. Flagging tape was attached to a nearby tree to aid in locating the boards during future visits, and to provide a reference for initial board placement in the event they had moved. Locations of the coverboards were also recorded with a GPS receiver (Appendix E, E.4 and E.5).The boards were overturned to check for herpetofaunal presence during dipnet surveys in May.

Dipnet surveys are a proven method for making quantitative estimates of amphibian larvae populations (Shaffer et al. 1994). In this study, we chose to utilize them as a method to confirm the presence of breeding species. Dipnet surveys were conducted in May, once amphibian larvae had reached an identifiable life stage, prior to metamorphosis. D-frame nets with wooden handles, canvas sides, and fine grain mesh netting were used. Standing at the edge of the water, we took three one-meter long swipes, dragging the frame of the net along the bottom of the pool towards the edge of the pool, checking the net's contents between each swipe. Larvae were removed and placed in a plastic container filled with the pool's water for identification. Where possible, larvae were identified to species level with the aid of a hand lens and a key (Parmelee et al. 2002). Following identification, the presence and age class of each species was recorded for each wetland area surveyed. Observations of fish, potential herpetofauna predators, in the surveyed areas were also recorded.

Pools less than 4 feet in diameter were surveyed by one observer, while 2 observers surveyed pools 4-8 feet in diameter. Pools containing fish, or those connected to a stream or river at the time of survey were not investigated with dipnets. Each wetland or vernal pool was surveyed once during the first full week of May, and again in the latter half of the month (Table IV.1). All coverboards were overturned during dipnet surveys, regardless of fish presence or connection to the river. Auditory observations were also recorded during the time of the dipnet surveys.

During the herpetofauna survey, we found that dip netting distracted us from visual encounters of reptiles. We determined that two separate days should be dedicated to visual encounter surveys, May 14-15. This timeframe is considered by MNFI to be an appropriate time for observing several reptile species of concern (Michigan's Special Animals… [updated 2009]). Teams of 2-3 observers scanned habitats using binoculars to look for turtles swimming in the water or basking along the wetland edges. We then slowly walked the wetland perimeter to search for turtles basking on woody debris or in vegetation. We continued by walking the land surrounding the wetland to make additional terrestrial visual encounters of individuals on land or under cover objects. Coverboards were also monitored during visual encounter surveys.

Table IV.1. - Survey dates and types for each park. Wetlands were examined in order from North to South at the beginning of the month, and South to North at the end of the month. Surveys were conducted in 2010 by Jessica Gorchow, Elizabeth Straus, Elizabeth Hood, and Yi Hou.

Park	Date Surveyed	Time of Day	Survey Type
Lower Huron	May 2	Daylight hours	Dipnet; North to South
	May 15	Daylight hours	Visual encounter ; South to North
	May 17	Daylight hours	Dipnet; South to North
	May 20	After dusk	Auditory
Willow	May 5	Daylight hours	Dipnet; North to South
	May 14	Daylight hours	Visual encounter; North to South
	May 20	Daylight hours	Dipnet; South to North
		After Dusk	Auditory

Auditory surveys for male frog calls were conducted in both parks after dusk on May 20. For safety reasons, auditory surveys were conducted from the road, or, in the case of the Willow golf course, from the paved golf cart paths. Species were identified based on prior knowledge of frog calls and confirmed using the audio CD from Tekliela (2004). Frog calls could not be attributed to one individual vernal pool or wetland, because spring floods had caused many pools to expand and merge. Calls were attributed to each series of connected pools that were distinct from other series of pools (e.g. calls along the Bobwhite Nature Trail were easily distinguished from those from the Paw Paw Nature Trail).

During the herpetofauna survey effort, precautions were taken to avoid the possible introduction and/or spread of the parasitic fungus *Bactrachochytrium dendrobatidis* (chytrid) to amphibian populations within the parks. Chytrid has emerged in recent years as a major threat to pond- and stream-breeding amphibian populations (Kriger 2007). To kill fungus zoosporangia (Johnson et al. 2003), surveyor's nets, larvae-holding containers, and boots were sanitized by spraying with 1% bleach solution and air drying between wetland areas within and across the two parks during all visits.

PREPARATION FOR FLORISTIC QUALITY ASSESSMENT AND BIORESERVE RAPID ASSESSMENT FIELD SURVEYS

We created maps of the natural areas within the parks for field use prior to field surveys. Each individual natural area was given an alpha-numeric code based on the order observed from the park's northern edge and historical vegetation community. For example, the fourth dry-mesic forest from the north boundary of Lower Huron would be coded as LH_DMF4. Using ArcGIS, the coded MNFI units were overlaid on an aerial photograph of the parks to provide a visual context for surveyors. During field surveys, natural areas were located based on landmarks visible on the map.

PLANT SURVEYS FOR FLORISTIC QUALITY INDICES

Natural areas were surveyed for plant species between August 31, 2010 and October 24, 2010. Individual natural areas were differentiated from one another based on distinct vegetation communities, as defined by MNFI. A single species list was created for each individual area, based on the plants observed at the time of the survey.

Line transects were implemented as a standard method for examining each natural area (Appendix D, D.6 and D.7). Transects were chosen such that the widest part of each natural community unit was crossed, to ensure a representative sample was taken. Each transect began from one edge of the area, where edge effects or transitional zones occur (Matlak 1994, Honnay et al. 1999), extended through the core of the community, where habitat and microclimate conditions are more ideal for sensitive species (Matlak 1994, Spyreas and Matthews 2006, Berglund and Jonsson 2003), and ended at the opposite edge of the unit. We implemented a transect survey method to capture a unit's entire species distribution, which commonly occurs along a gradient from habitat edge to core (Patterson 1990, Honnay et al. 1999). In the event that an area was impassible due to thick brush, several transects into the core of the area were taken using multiple entrance points.

We crossed each transect on foot in a 2-4 person group. Herbaceous and woody plants were identified and recorded by either the common or scientific name. In some cases, the absence of flowers on individual plants prevented identification beyond the genus level, in which case, only the genus was noted. Field guides for flowers, ferns, trees, and shrubs were carried at all times, and were used as needed (Barnes and Wagner 2004; Clemants and Gracie 2006; Cobb et al 2005; Kalfsbeek and Riggs 2009; Little 1980; Niering et al. 2001; Peterson and McKenny 1996; Petrides and Wehr 1988; Soper and Heimburger 1982). In the event that a plant could not be identified in the field, detailed pictures and notes were taken, and the plant was later identified by the full group using additional resources, such as USDA PLANTS database ([updated 2011 April 12]) and Voss (1972, 1985, 1996). Plants that remained unidentifiable from pictures were recorded as "Unknown" and were not included in floristic quality calculations. With a few exceptions for invasive or rare native species, grasses and non-vascular plants were generally excluded from the surveys due to the difficulty of identification.

BIORESERVE RAPID ASSESSMENT METHOD FIELD SURVEYS

As stated earlier, the HRWC developed the Bioreserve Project as a way of prioritizing areas within the watershed for preservation. However, our team implemented the desktop-analysis component of the project as if it were a separate protocol available to HCMA. Therefore, the relative rankings of this analysis were not considered prior to field assessments. Additionally, roadside surveys were deemed to be unnecessary since all un-mowed natural areas were examined equally. Our team conducted the HRWC BRAM data sheets concurrently with the recording of species lists for FQA as we walked each transect. Notable features and summary remarks were written on the "Site Summary Worksheet" upon concluding an area's transect (Appendix H, H.1, p 82).

Data sheets for forest, grassland, shrubland, and wetland ecosystems were adapted from the original BRAM protocol for use within the Metroparks for this study (Appendix H, H.1). Due to the inclusion of an extended site summary, the "Site Overview" worksheets appeared redundant and were omitted from our surveys. The question regarding notes on invasive species in the "Site Summary" worksheets was replaced with question "II.5." from the original overview worksheet, which characterizes the presence of invasive species. We also removed questions asking for notes on property owner's comments or intentions from the Site Summary sheet, as this was not applicable at all sites. All other questions asking for notes on rare species, diversity of the site, and overall impressions of ecological quality of the site were condensed into one prompt at the top of the Site Summary Worksheet to minimize space. The "Additional Species or Other Notes" sheet was substituted with a more extensive species list form that we developed for floristic quality analysis. The Creek/River Worksheet was omitted from this study, due to the known presence of the Huron River and its tributaries, and because the current management priorities of HCMA center on ecological quality of terrestrial habitats. In all cases, adaptations were made to reduce redundancy and improve clarity as we were implementing both the BRAM and generating a species list for FQI, though we did not remove questions that were associated with scores. Because the questions associated with score were not removed, the quantity and quality of information gathered would not have differed from what is typically collected by the Bioreserve project. The scoring and subsequent ranking of areas within the Microsoft Access database was no different than if implemented using the unedited worksheets.

In areas that had features of more than one ecosystem type (e.g., a floodplain forest with wetland characteristics, wet meadow habitat) all applicable worksheets were completed for the area. All worksheet questions were addressed and noted on the worksheet as the surveyors traversed the natural area. In order to consider edge effects of a habitat, the interior of the natural area was selected for observations of soil and general vegetation structure.

In cases where it was known that HCMA had a pre-existing species list, a "rapid-fire" list of species readily recognizable to the present surveyors was generated with the intent that the previously existing list would be utilized to form a more comprehensive species list for that area. In cases where the existing community type did not correlate to that identified by MNFI, a note was made in the Bioreserve data sheets. Maps of natural communities were updated to reflect our ground-truthed observations (Appendix D, D.4 and D.5).

4.2. DATA ENTRY

PLANT SPECIES LISTS

Following the field surveys, species lists including the common and scientific names of observed plants were compiled into Microsoft Excel spreadsheets for each natural community unit. For several units in each park, the HCMA NRD provided plant species lists of areas that had been previously surveyed by MNFI. In order to provide the most complete data possible, MNFI species lists were combined with data collected by our team. These lists were seasonally standardized to better reflect the point in the growing season in which our project's surveys were taken. All spring ephemerals and species that were listed in Peterson wildflower field guides (Peterson and McKenny 1996) as blooming prior to July were removed from the MNFI lists, as it was unlikely that they could be identified during the time of our field surveys. Additionally, because the MNFI lists differed from our lists in their level of detail, rushes, sedges, and grasses that were not found on our master species list were also removed.

FLORISTIC QUALITY INDEX CALCULATIONS

To calculate FQI used in the FQA, we assigned a Coefficient of Conservancy (C value) to each plant species, based on Herman et al. (2001). In cases where Herman et al. (2001) had not defined a C value for a particular plant species, the USDA PLANTS database was consulted (PLANTS…[updated 2011 April 12]). C values were assigned to plants defined as native by the USDA Plants database and were based on the number of counties inhabited by the plants as defined by USDA PLANTS database maps of Michigan counties. In cases where that information was unavailable in the USDA Plants database, maps in Voss (1972, 1985, 1996) were consulted. Values indicating a species native/non-native status and its corresponding C value were included in the species list spreadsheets. To obtain the FQI variable used in our analysis, we then calculated two variables: richness, defined as the number of species in the natural area, and average C, defined as the sum of the C values divided by the total number species. The FQI was calculated by multiplying the average C value by the square root of the richness. This method for calculating FQI is described in Taft et al. (1997) and has been utilized in the HCMA Model in the past (Heslinga 2010).

We also calculated FQI as described in Andreas et al. (2004) because it is a common method for calculating FQI, it is included in pre-existing HCMA species lists, and its calculation is recommended by Taft et al. (1997). To obtain this FQI variable, not used in our analysis, we calculated two variables: native richness, defined as the number of native species in a natural area, and average native C, defined as the sum of the C values divided by the number of native species. The FQI was calculated by multiplying the average native C by the square root of native richness.

We chose to include the Taft method for calculating FQI because it is what HCMA has used in the past and because it is a richer and more conservative method for calculating FQI. By including adventives species, it uses more than one parameter of vegetation composition to calculate FQI and thus tells us more about the overall quality of the site (Taft et al. 1997).

BIORESERVE RAPID ASSESSMENT METHOD

The HRWC's rapid ecological assessment method utilizes a series of ecosystem worksheets designed to best match the observed vegetation with natural community type. Ecosystem worksheets were completed in the field and entered at a later date into a Microsoft Access Database obtained from HRWC. The database automatically calculated final assessment scores after the completion of data entry. Within the final assessment score was both an ecosystem integrity score and a disturbance score. The ecosystem integrity score describes the overall quality of the area while the disturbance score describes the overall disturbance in an area. Many of the survey areas exhibited characteristics of more than one ecosystem type (e.g. hardwood swamps). Therefore, a worksheet for each ecosystem type observed was completed for the area, entered into the database, and scored. In these cases, the highest ecological integrity score was used during the data analysis process.

We regularly used three worksheets: wetland, grassland, and forest. The survey team determined which worksheet should be used based on the MNFI classification of the area and the observed vegetation structure. The breakdown of each worksheet follows.

WETLAND WORKSHEET

Hydrological conditions: Wetlands are areas that have standing water periodically for at least some part of the year, contain plants with adaptations to wet conditions, and have rganic (muck or peat) soils. Surveyors identify if the site is a wetland based on the following criteria: evidence of standing water, occasional flooding, and proximity of site a body of water.

Appearance of soil: Includes physical characteristics of the soil and disturbance characteristics such as tree tip-up mounds, evidence of animal digging and evidence of human activities.

Vegetation structure: Characterizes patterns of vegetation as well as zoning of vegetation and open water status.

Vegetation type: Includes presence of invasive and notable native species as defined by HRWC, such as emergent and floating-leaved plants, grasses and grass-like plants (sedges and rushes), forbs, shrubs, trees, plants indicative of bogs and fens. Additionally, includes the total number of species found within the units.

Vegetation cover: An estimate of percent coverage divided into five categories (none, a little, common, abundant and dominant) for native emergent plants, grasses, forbs, shrubs, trees, bog and invasive species.

Invasive species distribution: Identifies the primary locations of invasive species within the area with descriptions such as: primarily along trails, along wetland edges, within wetland interior, etc.

Human disturbances: Identifies common human disturbances found in natural areas such as bulldozed clearings, ditches, channels, tiling, drainpipes, erosion control etc.

Extent of the disturbances: Estimates the total disturbance to the area using the following six descriptions: extensive, partial, moderate, mild, uncertain and none apparent.

FOREST WORKSHEET

General forest structure and appearance

Appearance of soil: Includes physical characteristics of the soil and disturbance characteristics such as tree tip-up mounds, evidence of animal digging and evidence of human activities.

Vegetation Structure (trees and shrub canopy): Categorizes the distribution trees and shrubs in the unit.

Vegetation structure (tree size distribution): Estimates the area covered by different age classes broken into five categories: very large, large, medium, small, and sapling.

Vegetation type: Includes native and invasive tree species according to their age class. Additionally, includes some specific species of native shrub and woody vines, native herbaceous ground cover, spring flora, and invasive species. Includes total number of species observed.

Vegetation cover: An estimate of percent coverage in one of five categories (none, a little, common, abundant and dominant) for native trees, shrubs, ground covers and invasive species.

Human disturbances: Identifies common human disturbances found in natural areas such as bulldozed clearings, ditches, channels, tiling, drainpipes, erosion control etc.

Extent of the disturbances: Estimates the total disturbance to the area using the following six descriptions: extensive, partial, moderate, mild, uncertain and none apparent.

GRASSLAND WORKSHEET

Appearance of soil: Includes physical characteristics of the soil and disturbance characteristics such as tree tip-up mounds, evidence of animal digging and evidence of human activities.

Vegetation Structure (trees and shrub canopy): Categorizes the distribution trees and shrubs in the unit.

Vegetation structure (tree size distribution): Estimates the area covered by different age classes broken into five categories: very large, large, medium, small, and sapling.

Vegetation type: Includes native and invasive tree species according to their age class. Additionally, includes some specific species of native grasses, forbs and invasive species as well as total number of species observed.

Vegetation cover: An estimate of percent coverage in one of five categories (none, a little, common, abundant and dominant) for native and invasive grasses, forbs shrubs and trees.

Invasive species distribution: Identifies the primary locations of invasive species in the area with descriptions such as: primarily along trails, along wetland edges, within wetland interior, etc.

Evidence of Plowing: Identifies evidence of plowing activity such as spongy soils, soil buildup, etc.

Human disturbances: Identifies common human disturbances such as bulldozed clearings, ditches, and plowed or abandoned agricultural fields.

Extent of the disturbances: Estimates the total disturbance to the area using the following six descriptions: extensive, partial, moderate, mild, uncertain and none apparent.

HERPETOFAUNA

At the end of each day in which amphibian and reptile surveys were completed, observations were compiled from data sheets and entered into a Microsoft Excel spreadsheet. These spreadsheets were later imported into ArcGIS as attribute tables for polygons representing the surveyed wetland areas within the two parks. Using an ArcGIS platform allows the NRD to examine and map park areas for specific species presence, breeding areas, and overall herpetofaunal diversity. However, these surveys only included one field season of data, thus reducing the significance of their findings. Additionally, park areas were only considered for examination if recognized as a wetland by NWI. Of those areas, it was only possible for us to survey a few given our team's resources (Appendix E, E.4 and E.5). Due to the fact that our herpetofauna data were limited in scope and were not gathered for all natural areas, these data could not be incorporated as a criterion for our ecological assessments. However, the data may prove useful for future park management decisions. Therefore the results, discussion, and map creation of this study are provided in Appendix E, E.1, E.2, and E.3.

4.3. DATA ANALYSIS

ECOLOGICAL QUALITY MAPS

We compared five different methods of rating natural communities in the two parks. This section describes the process of delineating those communities spatially, and then each method for rating them.

CREATING A GROUND-TRUTHED NATURAL COMMUNITY LAYER

As we conducted our field surveys in the parks, we found that in some cases the MNFI natural community GIS layer, provided by HCMA's NRD, was not necessarily an accurate reflection of what currently exists in the field. Therefore, in order to create our series of maps delineating ecological quality, a new GIS layer had to be created to reflect the natural communities for which we collected data. This process entailed recoding some of the MNFI natural community units, digitizing new units that had not previously existed in the layer, and modifying the shapes of certain units. For example, several Old Fields (originally coded as OF) were recoded to reflect that they were actually mowed lawns (MA for mowed areas) and were therefore not surveyed. Additional examples of changes include the creation of some wetland and shrub-carr natural community units that were not originally included in the MNFI layer.

FQA

In order to create maps delineating ecological quality based on an FQA, we compiled FQI scores for all surveyed units into a single Excel spreadsheet and created a new field for the FQI scores in the attribute tables of the modified Natural Community GIS layers for Lower Huron and Willow. We then imported the FQI scores into this new field. These scores were manually broken into four categories representing patterns that have been found in tests of the FQA system in the State of Michigan: vegetation of "minimal significance from a natural quality perspective," "potentially significant vegetation," "floristically important from a statewide perspective," and "extremely rare and represent a significant component of Michigan's native biodiversity and natural landscapes" (Herman et al. 2001). The resulting maps (Appendix D, D.8 and D.9) display these categories using their corresponding score ranges defined by Herman et al. (2001) as rankings of low, moderate, high, and exceptional ecological quality (Table IV.2). We chose to use these rankings because they are currently used by HCMA's NRD in their model for assessing ecological quality. By using these same categories we are able to consistently compare the resulting maps of the varying protocols of ecological quality.

Table IV.2 – Description and explanation of the breaks in scores used in FQA Maps (Appendix D, D.8 and D.9). Descriptions of significance adapted from Herman et al. 2001.

FQI Score	Michigan DNR Description of Significance	Ecological Quality Label in FQA Map Legend
< = 19.9	"minimal significance from a natural quality perspective"	Low
20-34.9	potentially significant	Moderate
35-49.9	"floristically important from a statewide perspective"	High
>= 50.0	"Extremely rare and represent a significant component of Michigan's native biodiversity and natural landscapes"	Exceptional

HCMA ECOLOGICAL QUALITY MODEL

In order to create maps delineating ecological quality using HCMA's current model of ecological quality, we followed their current protocol for ecological quality ranking (Heslinga 2010). We used the FQI scores obtained through the results of our vegetation surveys to assign points to each unit. Units with the highest FQI scores received 5 points and those with the lowest scores received 0 points (Table IV.3).

In the past, HCMA's NRD has based their elemental-occurrences criterion on, "high quality natural communities or state-listed plant species entered into the Michigan Natural Features Database. Also included are verified reports of state-listed animal species occurring in the area" (Heslinga 2010). In order to prevent some units from being unfairly favored by using data collected in a different season, through different survey methods or with different levels of expertise, we used only data collected in our field surveys for the elemental occurrences criterion. Since we did not collect data regarding fauna in all of our surveyed units, the elemental occurrences in our resulting maps are based on our sightings of rare vegetation species only. Any flora listed as state threatened, special concern or endangered, as defined by Herman et al. (2001), was counted as an elemental occurrence. The number of elemental occurrences was summed for each survey unit and points were assigned according to the four categories currently utilized by HCMA (Table IV.3).

Wetland occurrence was recorded as a combination of our observations made while conducting the BRAM as well as through use of the NWI GIS layer. The NWI layer was overlayed on the modified natural community layers for Lower Huron and Willow. These overlays were visually inspected to determine whether a NWI polygon overlaid a natural community unit. Units that overlapped with a NWI layer were considered as having wetland "presence." However, during our visual inspection we observed that some NWI polygons overlapped the Huron River and roads. We concluded that the positional accuracy of the NWI layer may not be suitable for the scale we are observing within the Metroparks. Therefore, those NWI polygons slightly overlapping into an adjacent unit with no field notes indicating wetland presence were recorded as being absent of wetlands. We also examined our field notes for recorded observations of seasonal flooding, wetland vegetation, or presence of a wetland, all of which were considered to be an indication of wetland presence regardless of whether or not an NWI polygon overlapped that unit. These determinations of wetland presence or absence were compiled into a spreadsheet listing all of our surveyed units for each park. Each unit was scored according to HCMA's model (Table IV.3).

For the community rank criterion, each of our surveyed units was assigned a state rank based on the unit's designated natural community type (Appendix D, D.4 and D.5) in our modified version of the MNFI natural community GIS layer. These state ranking assignments were made according to MNFI (Kost et al. 2010). Accordingly, the community ranks in HCMA's model were divided into three categories: "critically imperiled" and "imperiled" communities in the state (S1 and S2, respectively), "vulnerable" in the state (S3), and "uncommon, but not rare" and "common and widespread communities" (S4 and S5, respectively). Following the HCMA Model, we assigned the most imperiled and rare communities a score of two points and the more common, communities a score of zero points (IV.3).

Table IV.3 - HCMA Model criteria, observations, and corresponding point values used to develop ecological quality rankings.

Criteria	Observations	Points
FQI Scores	<19.9	0
	20-29.9	1
	30-39.9	2
	40-44.9	3
	45-49.9	4
	>50.0	5
Elemental Occurrences	0	0
	1	1
	2	2
	3+	3
Wetland Occurrence	Absent	0
	Present	1
State Community Rank	S5-S4	1
	S3	2
	S2-S1	3

Table IV.4 - Priority rankings based on total point values in the HCMA Model.

Points	Rank	Ecological Quality Label
0-1	0	Low
2-3	3	Moderate
4-6	2	High
7-11	1	Exceptional

Total points were broken into four categories and assigned a priority ranking (Table IV.4). We assigned a priority ranking to each surveyed natural community unit based on its total points and created a new field for the assigned ranks (Field: Rank) in the attribute tables of the modified Natural Community GIS layers. The rank field was used to create maps that delineate low, moderate, high and exceptional ecological quality in the Lower Huron and Willow based on the current HCMA Model (Appendix D, D.10 and D.11).

BIORESERVE RAPID ASSESSMENT METHOD

We joined the final scores generated by the Microsoft Access Database directly to the GIS-based natural community units. As previously mentioned, for those areas with multiple scored sheets, we only used the highest of the scores for that particular unit. Please refer to Appendix H, H.2 for more detailed information regarding the BRAM scoring system.

Although the Access database generated both a biointegrity score and a disturbance score for each natural community unit, we chose to use only the biointegrity score for the analysis to avoid negative ecological quality scores. Furthermore, using a combination of the biointegrity and disturbance scores occasionally skewed the results, for example by making high-quality areas with small portions of highly disturbed areas seem of lower quality than they actually were Because the biointegrity score includes information pertaining to general ecosystem structure, soil appearance, vegetation age class, and types of native and invasive species present, it is likely an accurate reflection of the site's overall ecological condition.

The maximum total number of species observed in a single natural community unit was 188, leaving the potential for a maximum biointegrity score of 251.8. Since the results of this method suggest that Lower Huron is of overall higher ecological quality than Willow

(Appendix D, D.12 and D.13), it was important to use a system of breaks that would allow comparison between the two parks. Additionally, because the actual scores for the natural community units did not exceed 146, four categories of manual breaks were used: low ecological quality (0-30), moderate ecological quality (31-60), high ecological quality (61-100), and exceptional ecological quality (>100).

BIORESERVE DESKTOP ANALYSIS

The original Bioreserve desktop analysis uses 15 different criteria to evaluate natural areas at a watershed scale (Appendix C, C.3). Due to data availability limitations, differences in scale (individual park scale versus watershed scale), and the land-management interests of the NRD, we chose to omit several of the original desktop analysis criteria from our analysis. The removed criteria included: potential for groundwater recharge, glacial variation, connectedness using a ¼ mile buffer, unchanged vegetation by area, unchanged vegetation by percentage, and restorability. Additionally, because MNFI defined the survey areas, the "area of MNFI community" variable was modified to indicate the presence or absence of a MNFI community. The final criteria and scores used in our analysis remained unchanged from the original Bioreserve project methods, and can be seen as Table IV.5.

Each natural community unit was assigned a value between 0 and 100 for each of the nine criteria used in our analysis. The criteria scores were summed to produce a final score for each unit. Maps delineating ecological quality (Appendix D, D.14 and D.15) were made by manually dividing the scores into four categories: low quality (0-200), moderate quality (201-400), high quality (401-600), and exceptional quality (601-900).

Table IV.5 - BMDA criteria and scoring method

Category and units	Highest Lowest ranking ranking	Breaks	Method
Size Acres	100 75 50 25 0 Highest acreage Lowest acreage	5	Natural Breaks
Core Size Acres	100 75 50 25 0 Highest acreage Lowest acreage	5	Natural Breaks
Waterways	100 0 Rivers present Rivers absent	2	Presence Absence
Wetlands	100 0 Wetlands present Wetlands absent	2	Presence Absence
Remnant ecosystems Number of rare presettlement vegetation types	100 75 50 25 0 4 3 2 1 0	5	Numeric
Topographic variation TINs	100 75 50 25 0 Max. Number of TINs Min. number of TINs	5	Natural Breaks
Connectedness Number of natural areas within 100 ft. buffer	100 66 33 0 8 – 11 4 – 7 2 – 3 1	4	Numeric
MNFI Community	100 0 MNFI Comm. present MNFI Comm. absent	2	Presence Absence
Biorarity Average biorarity score for site	100 75 50 25 0 Highest score Lowest score	5	Natural Breaks

MULTI-CRITERIA EVALUATION

The following eight criteria were used in the MCE: distance to river, distance to wetland, distance to road, slope, soil type, pre-settlement vegetation type, and MNFI's biological rarity index and probability value. A description of the data and methods for each factor is provided below.

DISTANCE TO RIVERINE/ LACUSTRINE AND PALUSTRINE

The wetland data were downloaded from the SEMCOG Environment and Land Use GIS data catalog. Included in this catalog are digital data files including USFWS defined wetland locations and classifications as provided by NWI. The NWI data layers were created through manual digitization or scanning from stable-base copies of the 1:24,000 scale wetland overlays registered to the standard USGS 7.5 minute quadrangles into topologically correct data files using Wetlands Analytical Mapping System (WAMS) software. Because the wetland data was created using photo interpretation techniques, larger wetlands are more easily identified.

The hierarchical system for classifying wetlands and deepwater habitats is divided into five major systems at the broadest level, three of which are found in Southeast Michigan: Riverine (rivers, creeks, and streams), Lacustrine (lakes and deep ponds), and Palustrine (shallow ponds, marshes, swamps, sloughs). The distance to these water features was calculated assuming a straight-line distance, and all criteria scores were standardized on a common measurement scale with a range 0-100, where 0 is farthest from the river features and 100 is nearest to these features.

DISTANCE TO ROAD

The roads dataset, containing information on both roads and railroads at a 1:24,000 scale was obtained from the Michigan Geographic Framework. Distance to both major and minor roads was calculated and standardized to the measurement scale 0-100, where 0 is nearest to roads and 100 is furthest.

SLOPE

A digital elevation model (DEM) was downloaded from USGS. Slope was calculated based on the DEM and standardized to a range from 0-100, where 0 is the lowest slope and 100 is the highest.

SOIL TYPE

Soil data were obtained from the Soil Survey Geographic Database (SSURGO). Non-hydric soils often contain high concentrations of mineral soil and are well-drained, aerated, and typically have a low water-holding capacity. Partially hydric soils often have a good balance between organic and mineral content and thus have a moderate water-holding capacity. Hydric soils contain high levels of organic matter and can hold large amounts of water. Areas of unknown soil type or where soil type was not mapped were assigned a value of 0, water was assigned a value of 10, non-hydric soils were assigned a value of 80, partially hydric soils were assigned a value of 60, and hydric soils were assigned a value of 40.

VEGETATION TYPE

The vegetation-type data were downloaded from the SEMCOG 1800s vegetation dataset, which shows estimations of vegetation community types for Michigan circa 1800. Of the 19 land-cover categories interpreted by MNFI, there were 12 vegetation types found in the study area (Appendix D, D.2 and D.3). A short description of important vegetation types is below:

Beech-Sugar maple forests contain extremely important species contributing to ecological function. Sugar maples engage in hydraulic lift, drawing water from lower soil layers and exuding it into upper, drier soil layers, benefiting many organisms.

Hardwood-conifer swamps are minerotrophic forested wetlands dominated by a mixture of lowland hardwoods and conifers. These ecosystems typically occur on organic soils and poorly drained mineral soils throughout Michigan.

Black ash swamps are associated with groundwater seepage and are relatively wet with seasonal inundation. Black ash is a food source for the larvae of several species of Lepidoptera.

Wet prairies are native lowland grasslands occurring on level, saturated and/or seasonally inundated stream and river floodplains, lake margins, and isolated depressions in southern Lower Michigan. They are typically found on outwash plains and channels near moraines.

Oak savannas are lightly forested grasslands where oaks are the dominant tree species. These areas were historically maintained through wildfires , grazing, low precipitation, and poor soil.

Oak-hickory forests have a high density of trees with many animal, fungal, and plant species.

Oak barrens occur on well-drained, nearly level to slightly undulating sandy glacial outwash, and less often on sandy moraines or ice-contact features. These areas are very similar to oak savannas and were historically maintained by the same disturbances.

Mixed oak forests are dominated by black and white oak. They are predominantly found on sandy soils and ridge areas. These areas serve as good refuge habitat for scarlet tanagers, cerulean warblers and other bird species.

Based on the vegetation 1800 data and HRWC's definition of remnant ecosystems defined in Section III of this report, the ecological importance of historical ecosystem types was described by assigning values of 100 for mixed hardwood swamp, black ash swamp, wet prairie, mixed oak savanna and black oak barren, and a value of 0 for all other types.

BIOLOGICAL RARITY INDEX AND PROBABILITY VALUE

A biological rarity index (BRI) and a probability model have been created by MNFI from known sightings of threatened, endangered, or special concern species and high-quality natural communities. This model was created on a 1:24,000 scale.

The BRI was designed to prioritize areas with known rare species occurrences for the purpose of conservation. To create the rarity index map, three values describing species global status, species state status, and occurrence quality ranks were assigned to each occurrence. The BRI value of each occurrence was then calculated by adding the values for the global status, state status, and the quality ranking, and then multiplying the sum by the probability value, described below. The BRI scores were broken into nine classes. Each class had a range of 12.56.

The biological rarity probability value is designed to highlight sites with known occurrences of rare species and/or high quality natural communities. The species are grouped into general habitat classes using land-cover data, stream lines, and rail corridors. An occurrence value is assigned for each of the rare species observations based on the age of the record. For example, a value of 1 is assigned for occurrences observed from 1982-present, 0.5 for the occurrences observed between 1970 and 1982, and 0.25 for the occurrences observed prior to 1972. To create the probability map, the records in the species database with the lowest probability of still existing (value = 0.25) are assigned a value of 40. The records with a moderate likelihood of still existing are (value = 0.5) are assigned a value of 60. The records in the species database with the highest probability of continued existence (value = 1) are assigned a value of 80.

WEIGHTING SYSTEM

Scores were assigned to each survey area using a ranking and weighting system. The final assessment scores calculated range from 0 to 100.

The MCE allows for some discretion as to which factors are considered to be most influential through the ranking of criteria. In our analysis, the ranking for the weighting system was determined the by the NRD (Table IV.6 and IV.7).

Saaty's analytical hierarchy process (AHP) was used to determine the weights for the different criteria (Saaty 2005). The weights are shown in Table IV.7 and the Consistency Index (CI) value for the weights is 0.026494. The Maximum Eigen Value is 8.18546. Because the CI value is less than 0.1, the weights are considered to be reasonable.

Table IV.6 - MCE Ranking System

Criteria	Rank
Biological Rarity Index	1
Probability Value	2
Distance to Wetland	3
Distance to River	4
Soil	5
Vegetation Type	6
Slope	7
Distance to Road	8

Table IV.7.- MCE Criteria Weights.

Criteria	Weights (Eigen Vector)
Distance to River	0.154254
Distance to Wetland	0.160175
Distance to Road	0.0484607
Slope	0.0671229
Soil	0.125442
Vegetation Type	0.0985967
Biological Rarity Index	0.177575
Probability Value	0.168375

The average ecological quality value was calculated within each of the natural community units. The results are displayed in the (Appendix D, D.16 and D.17). The maximum possible score for the GIS multi-criteria evaluation was 100. Because Lower Huron is of higher ecological quality that Willow, we used a consistent system of breaks as it allowed us to make comparisons across the two parks. Four categories of manual breaks were used: low ecological quality (0-20), moderate ecological quality (21-40), high ecological quality (41-60), and exceptional ecological quality (>60). Actual scores in both parks did not exceed 85.

4.4. EVALUATION METHODS

To determine our recommended action plan for the NRD, our team developed a list of evaluation criteria upon which to judge the overall suitability of our identified assessment methods (Table IV.8).

Table IV.8 – Evaluation Criteria for judging suitability of the identified ecological assessment models for implementation by HCMA's Natural Resource Department.

Evaluation Criteria	Aspects of the Criteria Considered	Definition
Relative Accuracy	Statistical correlation with FQA	How well do the ecological assessment method's results correlate with the results of the FQI, which is considered to be a "gold standard" in ecological assessments?
	Statistical correlation with the other methods	How well does the ecological assessment method correlate with the other potential methods of ecological assessment?
	Visual delineation of ecological quality	How well does the method represent a delineation of ecological quality on a map?
Comprehensiveness of Model's Data	Source of Data	What is the source of the data collected/ provided to HCMA's Natural Resource Department through the implementation of this method?
	Relative Richness of Information	What is the relative richness of the information considered in this method compared to other methods of ecological assessment?
Feasibility of Implementation	Financial Cost	What are the budgetary considerations required for implementing this method of ecological assessment?
	Personnel Required	How many people are required to implement this assessment method?
	Time Required	How much time is required to implement the ecological assessment method?
Match to HCMA's Goals/ Management Priorities		To what extent does this method of ecological assessment suit HCMA's Natural Resources Department goals? What aspects specifically of the ecological assessment method are good matches or poor matches for the agency and/or for the department?

ASSESSING THE RELATIVE ACCURACY OF AN ECOLOGICAL ASSESSMENT METHOD

Accuracy of a model is a crucial piece of information to consider when recommending an assessment method to the HCMA. Whichever method the NRD chooses to implement must be reliable if they are to base important conservation and management decisions on the results.

CORRELATION COEFFICIENT ANALYSIS OF MODELS TO FQA

In order to determine the degree of correlation between models, we conducted a Spearman's Correlation Coefficient Analysis. We were interested in the correlation of each assessment methods' results with one another, as well as their correlation to that which is considered to be accurate representations of ecological quality. Ecologists typically regard FQA as the "gold standard" for ecological quality analyses. Therefore, our team is using a correlation to FQA to assess the accuracy of each method.

Spearman's rank correlation was used to test the correlation between the different ecological quality assessment methods at the natural community unit scale. We computed a matrix of Spearman's rank correlation coefficients for all possible pairs of columns in a matrix. Spearman's rho is a non-parametric measure of statistical dependence between two ranked variables. It assesses the extent to which the relationship between two variables is positive, meaning the rankings are similar, or the relationship is negative, meaning the rankings are in reverse order. In the event that rankings of landscape units in two methods are correlated with one another with a rho value of 1, the methods produce exactly the same rankings and can be used interchangeably. However, where the results do not all correlate well with one another the different methods will produce different rankings of landscape units. For the purpose of this analysis, we opted to follow common statistical convention in interpreting Pearson's correlations (Cohen 1988): a rho value of 0.5 was interpreted as a strong correlation, 0.3 as a moderate correlation, and 0.1 as a weak correlation.

Ecological quality ratings were categorized as exceptional, high, moderate and low for each natural community unit, based on rankings. Differences in delineations are also important to consider when choosing an ecological assessment method because they are ultimately the major tool used by the NRD when determining management priorities. The department typically does not manage areas of low quality, but focuses most of its activities within and around areas of exceptional or high ecological quality to reduce threats (Gajewski, personal comm. 2010).

ADDITIONAL CRITERIA TO CONSIDER IN CHOOSING AN ECOLOGICAL ASSESSMENT METHOD

Other criteria to consider in evaluating a method of ecological assessment are the comprehensiveness of a model, the feasibility of its implementation, and its match to the goals of the NRD. The comprehensiveness of a model could provide important explanations for the results of a method's accuracy. It also relates to how well a method matches the goals and priorities of the HCMA. For example, a method may emphasize criteria that are not relevant or may be deficient in considering criteria of great importance to the agency. Feasibility of implementing a method is also critical to considering in formulating a recommendation for ecological assessment method. It would not make sense to recommend a highly accurate method to the agency if it is impractical to implement within the agency's resource constraints. Full definitions for each of our evaluation criteria can be found in Table IV.8.

V. RESULTS

5.1. RELATIVE ACCURACY - SPEARMAN CORRELATION COEFFICIENT RESULTS

Relative accuracy can be interpreted both from the results of calculating Spearman's correlation coefficients (Table V.1 and V.2) as well as from the visual delineation of ecological quality depicted in the maps (Appendix D, D.8-D.17).

LOWER HURON

As seen in Table V.1, nearly all of the p-values resulting from our Spearman's rank correlation in Lower Huron had a p-value of $p< 0.05$ and, therefore, statistical significance for all of the correlation coefficients (ρ-values), except for the relationship between the BRAM and MCE (p-value = 0.1078). The strongest correlation between the various methods can be found between the FQI method and the HCMA with a strong correlation (ρ-value) of 0.890. Also strongly correlated were the FQA and the BRAM, with a correlation (ρ-value) of 0.870, as well as the BRAM and the HCMA ($\rho = 0.850$).

The lowest correlations were found between FQA and the two desktop analyses. The MCE has a correlation (ρ-value) of 0.2600 with FQA and the BMDA has a correlation (ρ-value) of 0.2900 with FQA.

Table V.1 – ρ-values (and their associated p-values) for the comparison of different ecological assessment methods tested in Lower Huron, calculated using Spearman's correlation coefficient method.

Ecological Assessment Method	FQA	HCMA	BRAM	BMDA	MCE
FQA		0.89 (<0.0001)	0.87 (<0.0001)	0.37 (<0.0001)	0.27 (0.0102)
HCMA			0.85 (<0.0001)	0.45 (<0.0001)	0.29 (0.0064)
BRAM				0.43 (<0.0001)	0.17 (0.1078)
BMDA					0.3 (0.0046)
MCE					

WILLOW

In Willow, all of the values obtained from the Spearman rank correlation analysis exhibited statistical significance $p < 0.05$ (Table V.2). The results of the Spearman rank correlation followed a similar pattern as that observed in Lower Huron, with the exception that the strongest correlation was seen between the HCMA Model and the BRAM (ρ=0.700) (Table V.2). Overall, the strongest correlations were seen between the FQA and HCMA (ρ=0.650) and between the BMDA and the MCE (ρ=0.620). The weakest correlations in Willow were seen between FQA and both the HRWC and MCE (ρ=0.290 and ρ=0.260, respectively).

Table V.2 – ρ-values (and their associated p-values) for the comparison of different ecological assessment methods used in Willow, calculated using Spearman's correlation coefficient method.

Ecological Assessment Method	FQA	HCMA	BRAM	BMDA	MCE
FQA		0.65 (<0.0001)	0.51 (<0.0001)	0.29 (0.014)	0.26 (0.0313)
HCMA			0.70 (<0.0001)	0.58 (<0.0001)	0.47 (<0.0001)
BRAM				0.50 (<0.0001)	0.53 (<0.0001)
BMDA					0.62 (<0.0001)
MCE					

5.2. RELATIVE ACCURACY - VISUAL DELINIATION OF ECOLOGICAL QUALITY

FLORISTIC QUALITY ASSESSMENT

LOWER HURON

FQI data were analyzed for 93 natural community units in Lower Huron (Appendix C, Table C.4). The average FQI score was 25.6 and the median was 23.1, both of which rank as moderate ecological quality. The range of scores stretched from 9.1 to 47.1, indicating that there were no natural community units in the exceptional quality category. Of the 93 units, 34.4% were of low quality, 45.2% were of moderate quality, and 20.4% were of high quality. With the exception of units MF2 and HS1, the majority of the high quality units appear to be floodplain forests located along the Huron River (Appendix D, D.8).

WILLOW

FQI data were analyzed for 72 natural community units in Willow (Appendix C, Table C.4). The average FQI score was 20.8 and the median was 21.3, both of which rank within the low end of the moderate quality category. The range of scores was 7.3 to 33.9, indicating that there were no natural community units in either the high or exceptional quality categories. Of the 72 units, 45.8% were of low quality and 54.2% were of moderate quality. Though there was a nearly even distribution among low and moderate quality, the areas of lower quality appeared to be located in the northern region of the park and along the south-eastern most edge (Appendix D, D.9). Additionally, there was a linear strip of low quality units located just south of Washago Pond (Appendix D, D.9).

HCMA ECOLOGICAL QUALITY MODEL

LOWER HURON

The average HCMA Model score for the 93 surveyed units in Lower Huron was 3.0 with a median score of 2.0, both of which fell within the moderate quality category (Appendix C, Table C.4). The range of scores for the HCMA Model was 0 to 9, indicating that all categories of ecological quality were represented within the park. Of the 93 units, 36.6% were of low quality, 30.1% were of moderate quality, 18.3% were of high quality, and 15% were of exceptional quality. Similar to FQA, the HCMA Model shows a very clear trend of floodplain forests adjacent to the Huron River as the predominant exceptional quality areas (Appendix D, D.10).

WILLOW

The average HCMA Model score for the 72 surveyed units in Willow was 2.4 and the median was just slightly higher with a score of 2.5, both ranking in the moderate quality category (Appendix C, Table C.4). The range of the scores for the HCMA Model was 0 to 6.0, indicating that there were no units in the exceptional quality category within Willow. Of the 72 units, 31.9% were of low quality, 43.1% were of moderate quality, and 25% were of high quality. In contrast to the FQA results, there were two units of high quality found within the northern most region of the park (Appendix D, D.11). The majority of the remaining high quality units were located along the Huron River and its tributaries, with the exception of a few high quality units in the south-western most corner of the park.

BIORESERVE RAPID ASSESSMENT METHOD

LOWER HURON

The BRAM analysis for Lower Huron yielded an average score of 75.0 and a similar median score of 72.4 (Appendix C, Table C.4). The range of scores was quite large, stretching from 16.8 to 145.9. Of the 91 units, only 5% were of low quality, 30.8% were of moderate quality, 38.5% were of high quality, and 25.3% were of exceptional quality.[1] Similar to our FQA and HCMA Model analyses, areas of exceptional quality were located along the Huron River, with additional units of exceptional quality located nearby (Appendix D, D.12). The units of lowest quality were located in the north-western corner of the park and were primarily old fields and shrub lands.

WILLOW

The BRAM results yielded an average score of 56.0 and a very close median score of 56.8 in Willow (Appendix C, Table C.4). The range of scores was 12.0 to 98.2, indicating that no units ranked within the exceptional quality category in Willow. Of the 71 units, 10% were of low quality, 52% were of moderate quality, and 38% were of high quality. Unlike the FQA

[1] Percentages do not sum to 100% due to rounding bias.

and HCMA Model analyses, the majority of the units in the northern region were of moderate quality instead of low quality (Appendix D, D.13). The high quality units remained adjacent to the Huron River, although they were primarily scattered throughout the interior of the park, with the moderate quality units along the exterior.

BIORESERVE MODIFIED DESKTOP ANALYSIS

LOWER HURON

The average BMDA score for Lower Huron was 383.2 and its median score was 358.0, both of which fall towards the upper end of the moderate quality category (Appendix C, Table C.4). The range of scores was 108.0 to 825.0, indicating that all ecological quality categories were represented within Lower Huron. Of the 93 units, 14% were of low quality, 46.2% were of moderate quality, 29% were of high quality, and 10.8% were of exceptional quality. With the exception of DMF13, the majority of exceptional quality areas are located adjacent to the Huron River, closely surrounded by areas of high quality (Appendix D, D.14).

WILLOW

The BMDA yielded an average score of 336.5 in Willow with a median score of 291.0, both of which fall towards the middle of the moderate quality category (Appendix C, Table C.4). The range of scores was 75.0 to 816.0, indicating that, similar to Lower Huron, all ecological quality categories were represented in the park. Of the 72 units, 19.4% were of low quality, 48.6% were of moderate quality, 23.6% were of high quality, and 8.3% were of exceptional quality.[2] Of particular interest as DMF30, which had previously been categorized by our FQA and HCMA Model analyses as moderate and high quality, respectively, and now ranked as exceptional quality according to the BMDA. The majority of Willow's exceptional quality areas were located adjacent to the Huron River except for those units adjacent to the river in the southernmost third of the park, which ranked as high quality (Appendix D, D.15).

MULTI-CRITERIA EVALUATION

LOWER HURON

Using the MCE approach, the average score for Lower Huron was 28.6 and the median was 30.3, both of which fall into the middle of the moderate quality category (Appendix C, Table C.4). The range of scores was 0 to 81.0, indicating that all ecological quality categories were represented within the park. Of the 91 units, 47.3% were of low quality, 11% were of moderate quality, 23% were of high quality, and 18.7% were of exceptional quality. Using the MCE, exceptional quality areas spread outward from the Huron River in both the northern and southern portions of the park with the middle region being of high to moderate quality (Appendix D, D.16).

[2] Percentages do not sum to 100% due to rounding bias.

The average score for Willow using the MCE was 22.0, although the median score was 0 (Appendix C, Table C.4). The range of scores was 0 to 72.0, indicating that all ecological quality categories were represented within the park. Of the 71 units, 53.5% were of low quality, 8.5% were of moderate quality, 31% were of high quality, and 7% were of exceptional quality. Using the MCE, the exceptional areas were isolated to a small group of units located near or adjacent to the Huron River in the northwestern region of the park (Appendix D, D.17). Additionally, almost the entire southern 2/3 of Willow were indicated as high quality with the exception of the same linear strip of low quality areas seen in the FQA map.

VI. DISCUSSION

6.1. RELATIVE ACCURACY

FLORISTIC QUALITY ASSESSMENT

SPEARMAN CORRELATION COEFFICIENTS

An ecological assessment analysis based on FQA strongly correlates to both the HCMA Model (ρ = 0.890 in Lower Huron and ρ = 0.65 In Willow) and to the BRAM (ρ = 0.870 in Lower Huron and ρ = 0.51 In Willow) (Table V.1 and V.2). On the other hand, desktop analysis methods are poorly correlated to the FQA analysis. There are a few possible explanations for these results, namely that FQA, the HCMA Model, and the BRAM use criteria heavily based on vegetation and current field surveys. In fact, the HCMA Model uses a FQI as one of its criteria, and would logically have the highest correlation coefficient to FQA out of all the methods. Similarly, the weak correlations between FQA and the desktop analyses are likely due to their use of different types of data on different scales. Other characteristics, such as the distance to a road, presence of a wetland, distance to a body of water, size of the area, core size, and connectivity are not at all considered in the FQA, and do not directly measure vegetation quality; thus, a low level of correlation is expected.

VISUAL DELINEATION OF ECOLOGICAL QUALITY

At first glance, the visual delineation of ecological quality provided in the FQA maps (Appendix D, D.8 and D.9) appears drastically different from the delineations provided in the other methods (Appendix D, D.10-D.17) given that no units are of exceptional ecological quality. However, FQA's rankings are based on statewide trends of flora presence (Herman et al. 2001), while the other ecological assessment methods show rankings based on the quality of the land relative only to areas within Lower Huron and Willow. FQA units only qualified as "exceptional" ecological quality with the presence of the state's most rare and significant native plant species (Herman et al. 2001). This stringent definition explains why there are no "exceptional" areas of ecological quality depicted in either Metropark. Thus, the undeveloped areas found within the parks are of low to high ecological quality when considering vegetation significance of natural areas found across the entire state.

Furthermore, other models utilized a variety of criteria to assess ecological quality that may have affected relative rankings, whereas the FQA was based on vegetation alone. For instance, the presence of a wetland was heavily weighted in the HCMA Model and BMDA, such that areas depicted as high quality in the FQA map attain an "exceptional" ranking in others. This point is well illustrated when looking at Lower Huron's southern floodplain forests (Appendix D, D.8, D.10, D.12, D.14, and D.16). The FQA model only ranked these areas as "high" ecological quality. However, these are areas of exceptional quality according to other methods, due to the inclusion of other criteria.

HURON-CLINTON METROPOLITAN AUTHORITY'S MODEL

SPEARMAN CORRELATION COEFFICIENTS

Within Lower Huron, HCMA's current ecological assessment method is strongly correlated with the BRAM (ρ-value=0.850) and FQA (ρ-value=0.890). As mentioned above, these close correlations are likely due to the fact that all three of these methods incorporate direct field-survey data, rely on vegetation quality and the presence of specific species, while both the HCMA method and BRAM consider a unit's natural community type,. These criteria are assessed differently when undergoing the ranking process during analysis resulting in ranking differences, but the similarities in the underlying data provide a strong basis for correlation. Similarly, the moderate correlation to the BMDA (ρ-value=0.450), and the weak correlation with the MCE (ρ-value= 0.290) is likely due to the differences in scales and types of data.

HCMA's method combines direct vegetation observations with the wetland presence data from NWI and the state rankings of natural communities, the latter two being broader datasets on a larger scale. The use of these "broad-scale" data in both HCMA and the BMDA most likely result in slightly decreased correlation between the two analyses. The weak correlation to the MCE is most likely caused by the MCE's inclusion of other weighted factors, such as soil type, slope, and the distance of a natural area to a road or waterway, which appear to have a drastic effect on the relative ranking of natural areas.

VISUAL DELINEATION OF ECOLOGICAL QUALITY

When examining maps of Lower Huron's ecological quality, the HCMA Model and the BRAM maps have visual differences for certain areas (Appendix D, D.10 and D.12). The BRAM's scoring of biological integrity considers criteria not measured by HCMA's model, such as hydrological conditions, soil permeability based on soil appearance, vegetation composition, and forest structure. Likewise, a side-by-side comparison of the HCMA Model's rankings with the desktop analyses (i.e. BMDA and MCE) shows substantial differences in some areas, which are likely attributable to the differences in source data and criteria weightings. The HCMA Model's use of field-gathered data allows it to show the low vegetation quality observed in the old fields and shrublands, while desktop methods rely on criteria serving as proxies for these observations.

For example, HCMA rankings seen in northwest corner of Lower Huron are well correlated to the other on-the-ground assessment methods, but strongly contrasts the categorizations provided by the desktop methods (Appendix D, D.14 and D.16). Similarly, maps created from Willow's rankings display differences between the HCMA Model and the FQA, particularly in the floodplain forests. These areas are ranked as moderate quality using FQA, but as high quality using the HCMA Model. The HCMA Model uses a FQI in combination with other measures of ecological quality, including the presence of a waterway, wetland presence and MNFI community ranking, which has favored the hardwood swamp areas adjacent to the river.

BIORESERVE RAPID ASSESSMENT MODEL

SPEARMAN CORRELATION COEFFICIENTS

The BRAM was moderately correlated with the BMDA in Lower Huron (ρ= 0.430). Because the BRAM incorporates field data at a less detailed scale than FQA or HCMA, this observed result is reasonable. The BRAM would logically confirm the rankings set out by the BMDA, but in this case, BRAM's inclusion of field data considerably refines BMDA's rankings. The strong correlation between the HCMA and BRAM methods in both parks is unsurprising, given that both of these methods place a strong emphasis on vegetation quality, wetland presence, and natural community type. Conversely, the lower correlation to FQA is probably a reflection of the BRAM's considerations given to vegetation composition and structure, whereas FQA relies only on species diversity.

VISUAL DELINEATION OF ECOLOGICAL QUALITY

The maps of the results of the BRAM in Lower Huron and Willow differ from other assessment models. For example, Lower Huron's DMF 14 is of "exceptional" quality according to the BRAM, but in other maps this area is only ranked as "moderate" to "high" (Appendix D, D.8, D.10, D.12, D.14, D.16). Where FQA acknowledges species presence, the BRAM considers the age-class of forest structure, the presence of rare species, and the vegetative composition of the forest, which were predominantly native trees within DMF 14. In other methods, the presence of a single native sapling would impart the same score as a stand of mixed-aged trees. The additional factors considered by the BRAM additional factors are given considerable weight when determining biological integrity. Other methods neglect these factors in favor of other criteria, thus explaining the differences in relative rankings.

Similarly, in Willow, the floodplain forests are high quality as defined by the BRAM and only of medium quality by the FQA (Appendix D, D.13 and D.9). This difference is due to the BRAM awarding points for the presence of rare plants and for the presence of a waterway, and a negative scoring for invasive species. This method accounts for quality ecosystems in different ways than FQA.

BIORESERVE MODIFIED DESKTOP ASSESSMENT

SPEARMAN CORRELATION COEFFICIENT

Ecological assessment analysis of Lower Huron and Willow based on the BMDA correlated strongly with the HCMA Model and the BRAM. The HCMA's Model is the most closely correlated with BMDA because it incorporates both field data and desktop analysis. And, as previously mentioned, the BMDA's reliance on large-scale spatial datasets contrasts the BRAM and FQA's use of field data. Correlation coefficients were much higher with the MCE in Willow (ρ=0.62), but surprisingly, only moderate in Lower Huron (ρ=0.3). While both the BMDA and the MCE utilize low resolution spatial data in a desktop analysis, which would explain a high correlation, the BMDA's consideration of size, core size, and connectivity likely reduced the similarities within Lower Huron, where natural area units were generally smaller and less contiguous.

VISUAL DELINEATION OF ECOLOGICAL QUALITY

The BMDA's criteria of size, core size, connectivity, and topographical variation are not measured in any of other tested protocols. The inclusion of these data may have favored large tracts of land surrounded by other natural areas, in which elevation changes from floodplains to uplands occur within a unit. A discrepancy in ranking is observed in Lower Huron's DMF 13, which was categorized as being "exceptional" in using both the BMDA model and the MCE model (Appendix D, D.14 and D.16). The assessments conducted using directly observed field data all categorize this unit as only "moderate" to "high" ecological quality. This difference may be a result of BMDA's use of size and core size, and the use of historical vegetation, which may be of higher quality than the ecosystem type currently found in the unit.

Likewise, very small areas of high vegetation quality would have ranked lower in the BMDA than in the field-data based assessments. Willow's SH3, for instance, is ranked as "high" quality using the BRAM, "moderate" quality using FQA and "low" quality using the BMDA (Appendix D, D.9, D.13, D.15).The differences in this unit's ranking between methods displays the impacts that size, observed vegetation, and digital data can have on an area's final score. Moreover, the inclusion of points in the BMDA for both wetland presence and river adjacency ranked floodplains with wetlands higher than areas with only one of these features, whereas other models awarded points once for having a wetland or being near the river. This is exemplified by Willow's FF8*, which is adjacent to the river and contains a wetland, is ranked by the BMDA as "exceptional" quality, while the BRAM ranks it as only high quality (Appendix D, D.13, D.15).

The BMDA also took into consideration MNFI's biorarity of plant species observed over time, whereas our implementation of the HCMA Model only used "elemental occurrences" of rare plant species observed during the single season in which we sampled. The differences in the number of rare species observed in an area may have differed over time, both over multiple growing seasons and within the same growing season.

MULTI-CRITERIA EVALUATION MODEL

SPEARMAN CORRELATION COEFFICIENT

Our ecological assessment analysis of Lower Huron based on the MCE was not strongly correlated to any other models (Table V.1, Table V.2), but had a weak-moderate correlation with the BMDA and the HCMA method. There are a few possible explanations for these results. The MCE correlates with the BMDA because these two methods used some of the same data sources, such as the NWI and the BRI. Also, the criteria used in the MCE were drawn from the BMDA, such as soil type, vegetation structure and cover, rare species, and hydrologic conditions. The moderate correlation between the MCE and the HCMA Model could result from the fact that both methods used the NWI wetlands and state-wide natural community type data. Lower correlation coefficients were observed between the MCE and FQA because FQA only considers vegetation data. The MCE likely had a low correlation with the BRAM because the MCE considered the distance to roads, an indicator of human disturbance, not considered in the BRAM. Our analysis used the BRAM's biointegrity score of an area, but excluded the human disturbance score. Finally, the BRAM factored the total number of species in a unit into the score, while the BMDA and the MCE did not include this field-collected data.

VISUAL DELINEATION OF ECOLOGICAL QUALITY

Lower Huron's wetland-containing units HS1, MF2, WMP1, and SC2 were either moderate or high quality in other models, but low quality in the MCE (Appendix D, D.8, D.10, D.12, D.14, and D.16). These areas are geographically closer to the South Metro Parkway than to the Huron River. Given that the MCE considers an area's distance to roads and rivers, their particular location likely explains their lower ranking in the MCE. This is also seen in Willow's DMF43, which had a low ranking using FQA (Appendix D, D.9), but a high ranking using MCE (Appendix D, D.17), which relied more on the positional and contextual characteristics relative to the surrounding landscape. Additionally, the inclusion of soil permeability in the MCE may also cause differences withthe BMDA. In the case of Lower Huron's HS1, the "low" quality ranking in the MCE (Appendix D, D.16) might partially be explained by the area's low soil permeability, in addition to other factors.

6.2. EVALUATION

FLORISTIC QUALITY ASSESSMENT

ADVANTAGES

FQA's reliance on objective field-based observations and its use of delineation breaks based on state-wide occurring patterns give this method a high level of accuracy. Based on past successful implementation, and widespread employment at state and global levels (Herman et al 2001; Rama Bhat and Kaveriappa, Tu et al. 2009, Mack 2009, Andreas et al 1995; Andreas et al 2004), we consider FQA to be the "gold standard" of ecological assessments within our study. The frequent use of FQA throughout the state renders it a powerful tool for statewide comparisons of natural areas, and its implementation in the Metroparks would provide the NRD with results commonly understood by other professionals. Finally, its heavy emphasis on floristic communities reflects HCMA's past history of placing high value on vegetation, as demonstrated by the inclusion of FQA in their current ecological quality assessment protocol.

DISADVANTAGES

The FQA's disadvantages stem from its sole emphasis on a single criterion (i.e. plants only) as well as its low feasibility of implementation. As an ecological assessment, FQA's focus on floral presence neglects other important features and indicators of habitat quality and ecosystem functioning, yielding an incomprehensive dataset. While having species of floristic importance on a state-wide level ideally acts as a proxy for other aspects of ecological quality, it does not necessarily render precise results. For example, FQA does not consider the extent and frequency of disturbance, nor the composition and age structure of a natural community. It also does not account for the presence of fauna, or faunal habitat.

Additionally, implementation of a FQA requires extensive, time intensive field surveys. that are most effectively and efficiently executed by a team of highly trained plant identifiers. Whether the team is composed of permanent staff or a group of consultants, the financial burden and time investments required to complete FQA field surveys are high. Furthermore, the extensive data entry required for FQI calculations places an additional time demand on staff. These costs could potentially be reduced if a volunteer coordinator was hired to recruit and train volunteers to do the surveys. However, such training would further delay results. Creating complete species lists for FQA would likely take many years to accomplish for all of the natural community units in each of the 13 Metroparks, and would require frequent updates thereafter. A more practical approach would target areas of interest to conduct these field surveys. However, large amounts of baseline data may never be collected in some areas, thus making no improvement upon their current problem of data gaps. Therefore, implementing and maintaining FQA surveys in every natural community unit is not feasible with the NRD's current budgetary, time, and staff constraints.

A final consideration taken into account is the need to match the ecological assessment method to the goals of the NRD. The Department Chief expressed interest in collecting and incorporating more fauna-related data into their future ecological assessments (Muelle, personal comm. March 2010). Because an FQA lacks this information, an appropriate ecological assessment method must incorporate other criteria in addition to the FQI, which would further reduce the feasibility of the method.

HCMA ECOLOGICAL QUALITY MODEL

ADVANTAGES

This model follows the protocol currently in use by the HCMA NRD. The current staff members have already received training on how to use the model, allowing business as usual to continue, eliminating the learning curve associated with implementing a new protocol. Additionally, the HCMA Model showed a strong correlation to FQA, indicating that it closely models the "gold standard" of ecological assessments, while incorporating other, more comprehensive criteria of ecological importance.

DISADVANTAGES

"Business as usual" has caused some of the issues addressed in our problem statement, such as large data gaps in the parks and time inefficient techniques for collecting baseline data and in implementing management plans. The use of FQA is impractical at a landscape scale, and may place a disproportionate weighting on vegetation relative to overall habitat quality, wildlife presence, and ecosystem functioning. Furthermore, some of the additional parameters are not accurate at the park scale, reducing the overall accuracy of the model while increasing the total amount of time and labor required.

Bioreserve Rapid Assessment Method

ADVANTAGES

The BRAM generates results comparable to FQA and HCMA's current protocol. Therefore we consider it relatively accurate, while being less resource intensive and more feasible for volunteers to accomplish. As mentioned above, this method is also more comprehensive than FQA, and records the distribution of invasive species, which is especially useful for park management. Partnering with other organizations to implement a volunteer program may improve public or non-governmental organizations' (NGOs) perceptions of the HCMA (Muelle, personal comm. 2011). HRWC has expressed an interest and willingness in partnering with HCMA, which could potentially provide the HCMA with additional resources, such as an active volunteer base, volunteer training and recruiting, and data entry workload sharing (Olsson, personal comm. March 2011). The BRAM is currently being conducted by the HRWC throughout the Huron River Watershed, allowing for comparison to nearby lands outside the parks, and could ultimately provide a consistently collected data set across the region. Furthermore, NGOs in the region are familiar with the BRAM as an ecological quality assessment. Because a species list is collected for each unit, a baseline FQA could potentially be calculated, provided that volunteers can reliably identify plants. However, since volunteers simply need to count the number of species in order to complete the protocol, comprehensive species lists are not required for the assessment and less skilled volunteers could be recruited to implement the protocol. Furthermore, Microsoft Access is used to compile data and calculate scores, which facilitates data entry and shortens the data analysis process.

DISADVANTAGES

Using a volunteer-based assessment method means that the collection of data is dependent upon the expertise of the volunteers. BRAM worksheets are formatted so that reliable results are collected regardless of the skill level of the observers, but species lists require volunteers with well developed plant species identifiers. The NRD could require volunteers with plant identification skills, or could provide volunteers with identification materials such as field guides or other books. Although this method is faster than FQA, completing this assessment across all parks will still likely be a multiple year process. Therefore, HCMA may need to seek partnerships with the Stewardship Network, Michigan Botanical Society, or the Clinton River Watershed Council in addition to HRWC. The HRWC will commit to working in parks within the Huron River watershed (Olsson, personal comm. March 2011).

A couple additional issues in need of modification may include duplication of effort that can occur, when a wetland and a forest worksheet is completed for an area and the lack of consideration for elemental occurrences. Because some units require two different ecosystem worksheets to be completed, some modification is needed to incorporate both sets of observations into one. While the method considers several indicator species and rare species as part of the check boxes and scoring it does not specifically consider state-listed species, a criterion of particular interest to HCMA.

BIORESERVE MODIFIED DESKTOP ANALYSIS

ADVANTAGES

One trained person, using publicly available data, can employ this method at any point in the season. This low demand on time and budget makes it highly feasible to implement across all 13 Metroparks, ameliorating the issue of having gaps in the baseline dataset. Similar to the case with the BRAM, the HRWC has enacted a non-modified version of this method in other natural areas across the Huron River Watershed, allowing for comparison of surrounding lands. The BMDA considers landscape-scale elements, such as size and core size, as well as habitat elements such as wetlands and waterways that likely influence the local biodiversity. Furthermore, many NGOs in the region are highly familiar with the criteria utilized in this method, making the results transferrable and understandable by potentially partnering organizations.

Our BMDA results' moderate to strong correlation with other methods indicates that this method can serve as a relatively strong proxy for other ecological assessment protocols. A more comprehensive assessment implements this method in conjunction with more time-intensive methods by specifying high priority areas for further field investigation.

DISADVANTAGES

A desktop-based ecological assessment such as the BMDA is possibly less accurate than other assessment methods, because it uses less detailed data. Furthermore, because the modified HRWC assessment uses historical data, it neglects to consider the importance of using more current land-cover data. The moderate to weak correlation with FQA indicates that this method does not closely approximate field data. The data used may be of an inappropriate scale for Metropark use, or may not have been recently updated. Furthermore, the BMDA sometimes overestimates the quality of large areas, which, when combined with a lack of field data may lead to inaccuracies. Implementation of this protocol without field-validated data prevents the NRD from identifying current elemental occurrences and habitat characteristics. Since the criteria used in the BMDA are specific to NRD's objectives, our modifications to the HRWC's original desktop method make comparisons to areas outside of the parks more difficult.

Multi-criteria Evaluation

ADVANTAGES

One of the biggest advantages of the MCE lies in its relatively low costs of money and time. Like the BMDA, only one trained person is required for implementation, which can occur during any season, and data for the model is available via free online downloads. For these reasons, this method can be easily applied to all 13 parks, alleviating data gaps in a resource efficient way. Equally important is the adaptability of this model, where the criteria evaluated can be easily changed or weighted differently based on the needs of the NRD.

DISADVANTAGES

Though this model requires only one person, that person must have a solid understanding of the GIS and the GIS model builder. Additionally, because our tested MCE is weakly correlated with FQA in both parks, it may not accurately reflect data on the ground. Correlations with other methods were highly variable between the two parks, suggesting that this method might not be generalizable across parks. Additionally, the necessary revisions to the final model may require several days to complete. Execution of this method without the addition of field-based data prevents the NRD from identifying current elemental occurrences. Finally, because the MCE is more appropriate for a large, landscape-scale assessment across all 13 parks, it may not be useful to develop focused management plans.

6.3. HCMA ECOLOGICAL ASSESSMENT OPTIONS

Based on our evaluation, summarized in Table VI.1, we consider three reasonable options for going forward and their various characteristics, before offering our recommendations.

OPTION A: FLORISTIC QUALITY ASSESSMENT OR HCMA ECOLOGICAL QUALITY MODEL

Implementing further ecological assessments of the Huron-Clinton Metroparks utilizing FQA or HCMA Model would be appropriate if the following conditions are considered to be true by the agency:

- Interested in implementing a method traditionally highly regarded as a method of assessing ecological quality (in the case of FQA) and which employs state-tested categorizations of FQI.
- Specifically interested in prioritizing land based on vegetation significance and rarity (pursue a FQA).
- Interested in FQA, but also desire to expand the scope of the assessment to include habitat elements such as wetlands, natural communities, and elemental occurrences of fauna and flora (continue to pursue HCMA Model).
- Consider development of a comprehensive baseline data set for every natural area of all 13 Metroparks to be a low priority or unnecessary.
- Satisfied with a minimal field data set, representative of only targeted areas of interest that have been selected from desktop data.
- More resources become available to the NRD than currently exist in 2011; e.g. a permanently staffed volunteer coordinator to recruit and train already very well qualified volunteers to do comprehensive vegetation surveys and/or a larger staff of natural resource technicians.

OPTION B: BIORESERVE RAPID ASSESSMENT

Implementing further ecological assessments of the Huron-Clinton Metroparks utilizing BRAM would be appropriate if the following conditions are considered to be true by the agency:

- Using an ecological assessment method that has high statistical correlations with both FQA and HCMA Model is a satisfactory substitute for those methods
- Implementing a method based largely on MNFI's ecological assessment methods is considered to be valuable
- Implementing a method more easily done by volunteers and with greater potential accuracy of results is desirable

- The resources to work with volunteers and/or partner with HRWC and other NGOs become available; e.g. employment of a volunteer coordinator
- Prefer to implement partnerships with other organizations and utilize volunteers as a means to expand agency resources
- Consider implementing partnerships with other organizations and utilizing volunteers as beneficial to communication and positive community perceptions
- Consider collecting comprehensive baseline data on all natural areas within all the Metroparks a priority objective
- Desire to collect data in a resource efficient way
- Consider collecting data on a variety of ecological quality aspects beyond just a species list, such as disturbance levels and distributions of invasive species, to be an important objective.
- Satisfied by potentially collecting data with varying levels of expertise, which could potentially compromise the comprehensiveness of species data. (However, enforcing certain eligibility requirements of volunteer teams could amend this situation; e.g. having at least one or two expert plant identifiers in a group along with the provision of well-respected and up-to-date field guides.)

OPTION C: A DESKTOP ANALYSIS METHOD COMBINED WITH A FIELD ASSESSMENT METHOD

Implementing further ecological assessments of the Huron-Clinton Metroparks utilizing a combination of desktop analysis and field assessments would be appropriate if the following conditions are considered to be true by the agency:

- Continue to consider a desktop analysis alone to be an insufficient and non-viable option for conducting ecological assessments, as acknowledged in a personal communication with HCMA NRD (Muelle, personal comm. February 2011) and that management without field validation is inappropriate
- Consider collecting and visualizing data in the Metropark's natural areas in the most time and resource efficient way, as provided by a desktop analysis (coupled with rapid site validation), to be a useful tool for assisting in prioritization when time-sensitive decisions must be made
- Consider completing a comprehensive, field-validated baseline dataset to be a priority long-term objective for making larger long-term planning decisions
- Satisfied by using a data set that has weak to moderate correlations with FQA for making rapid, time-sensitive decisions when it is also coupled with rapid ground-truthing
- Desire a system for prioritizing locations for on-the-ground ecological assessments

Table VI.1 – Brief summary of our evaluation of each of the tested ecological assessment methods.

Evaluation Criteria	Aspects of Criteria Considered	FQA	HCMA Model	BRAM	BMDA	MCE
Relative Accuracy	**Statistical correlation with FQA results**	"Gold Standard" assuming quality data is collected	Lower Huron: Strong Willow: Strong	Lower Huron: Strong Willow: Strong	Lower Huron: Moderate Willow: Weak	Lower Huron: Weak Willow: Weak
	Strong Statistical correlations	HCMA and BRAM	FQA and BRAM	FQA and HCMA Model (BMDA in Willow only)	HCMA Model and BRAM - in Willow only	BRAM in Willow only
	Visual Delineation of Ecological Quality	Shows no areas of exceptional quality. High quality areas generally found along river.	May over-represent areas of low and moderate quality	May under-represent areas of low quality	May over-estimate the quality of large areas	May underestimate scores for areas near roads, far from rivers, or with low soil permeability
Comprehensiveness of Model's Data	**Source of Data**	Field-Collected data	Field-Collected and Spatial Data	Field-Collected Data	Spatial Data	Spatial Data
	Relative Richness of Information	Low; 1 criterion	Moderate; 4 criteria	Rich; 8 criteria (6 for biointegrity score)	Very Rich; 9 criteria	Rich; 8 criteria
Feasibility of Implementation	**Financial Cost**	High	High	NRD staff: High Volunteers: Low	Low	Low
	Personnel Required	Many	Many	Few	One	One
	Time Required	Very Intensive	Very Intensive	Moderate	Low	Low
	Feasibility for NRD	Low	Low	High	Very High	Very High
Match to HCMA's Goals and Management Priorities	**Quality of Match**	Medium to Low	Medium	Medium to High	Medium	Medium
	Explanation of matches and mismatches	Reflects NRD's previous emphasis on vegetation quality. Lack of habitat criteria may not reflect the agency's future assessment plans	Currently used protocol, so learning curve is reduced. Does not address current problems of large "data gaps" or overemphasis on vegetation quality.	Reflects NRD's past emphasis on vegetation and current interest in habitat quality. Lacks detailed information regarding elemental occurrences, but that is modifiable	Rich set of criteria considered, but lack of field-data validation prevents the NRD from identifying elemental occurrences and specific habitat characteristics	Adaptable criteria and weighting system increases suitability for long-term use. Lack of field-data prevents identification of current elemental occurrences

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6.4. RECOMMENDED COURSE OF ACTION FOR HCMA

Based on the results of our study's evaluation of the various tested ecological assessment methods, as well as our team's knowledge of HCMA NRD resources as of 2011, we recommend the agency adopt Option C, as described above and summarized below in Box 2. In the short-term, our team recommends that the agency employ a desktop analysis to generate an initial data set for all natural areas of all parks. This will immediately alleviate the issue of having "gaps in the data set." Despite the deficiencies that are inherent in desktop analyses, we recognize that some decisions will have to be made quickly by the Authority, and a desktop analysis provides a general idea of ecological quality from which to base such decisions. Furthermore, it can provide a "road map" for prioritizing parks and areas within parks for the implementation of on-the-ground ecological assessments. Based on our evaluation of the desktop analysis models that we tested, we recommend the agency use a MCE. The adaptability of a MCE is a highly advantageous feature, rendering it suitable for long-term use within the agency. However, given that our tested MCE had weak to moderate correlations with FQA and the other assessment methods, we suggest that the agency use the adaptability feature to incorporate additional assessment criteria. For example, the model could be augmented and/or modified by using some of the BMDA or the HCMA Model's criteria, or as the NRD sees fit relative to their management priorities, either within individual parks or across the HCMA. In addition, we recommend that the rankings of natural communities always be validated with field data before management decisions are made.

Over the long-term, we strongly recommend that the agency continue to pursue the compilation of a comprehensive baseline data set for all of the 13 Metroparks. A comprehensive baseline dataset, collected through implementation of a consistent data-collection method for all natural areas of the Metroparks allows for equitable comparisons and prioritizing of natural areas when developing management plans. Because there are 13 Metroparks to manage and resources are limited, prioritization of management efforts is critical both within and across parks. Prioritizing areas with the existence of large data gaps is not appropriate given that important natural areas could be overlooked. Furthermore, a dataset that is comprehensive, considers multiple criteria, and takes a holistic approach allowing for the consideration of flora, fauna, and ecosystem functioning broadly, and may maximize conservation efforts for all aspects of ecosystem function and organism community makeup. However, the intensive resources required to collect, enter, and analyze the above recommended baseline dataset are not feasible within the NRD current resources and Natural Resource Technician duties. Therefore, we also recommend the employment of a volunteer coordinator within the HCMA NRD to facilitate the utilization of volunteers to expand agency resources.

Additionally, despite the high regard and accuracy of FQA, we do not support the continued implementation of FQA based on our evaluation of the method. Based on our experience, we find that FQA requires too much time, effort, and expertise, thus, potentially increasing the financial cost of implementation. While volunteers could potentially be utilized to create the extensive species lists required for FQA, the use of volunteers may compromise data and expert volunteers would be required. Also, complicating an FQA executed by volunteers is the lack of field guides made specifically for the State of Michigan, which confounds identification of plants in the field. There is also a lack of up-to-date grass, sedge, and rush resources, which creates the need for consultants to identify these types of vegetation in order to include them in FQA.

Therefore, in order to develop the comprehensive baseline dataset, we recommend that HCMA's NRD implement the BRAM, a more resource efficient and holistic approach to conducting ecological assessments. Additionally, we recommend that HCMA implement the BRAM in both those natural areas lacking baseline data and in those areas where FQA has already been assessed. Implementing this method in all natural areas will allow the NRD to consistently account for additional habitat characteristics therefore creating a dataset that is comparable across all Metropark natural areas. Our correlation results suggest that the BRAM is a relatively accurate and reliable assessment given its large statistical correlation with FQI and the HCMA Model. Although the visual depiction of ecological quality in our results for Lower Huron suggest that this method may be less conservative than other methods in its categorization of exceptional and high quality areas, this could potentially be ameliorated, if desired, by simply adjusting the categories of breaks used to create maps of this data set. In addition to its relative accuracy and reliability, the BRAM will provide HCMA with a richly comprehensive data set; including an assessment of biointegrity along with observations of disturbance level, invasive distribution, and a list of observed species.

Furthermore, because we found that natural areas can be assessed quickly and efficiently utilizing BRAM, we view this as very advantageous for the HCMA NRD given their current resources. Past implementation by the HRWC shows that this method is user-friendly by volunteers and does not require plant identification experts. A comprehensive species list is not required, as in FQA, but rather just an estimated number of species, allowing morphological identification of plant and the identification of selected rare, indicator, invasive, and native species. Various elements of ecological quality are made easy to assess through the use of checkboxes on user-friendly worksheets. The process of data entry and analysis is sped up by the use of an already established Microsoft Access database, previously set up by HRWC. An additional benefit of utilizing the BRAM is that it opens the possibility of forming a partnership with HRWC to complete the remaining ecological assessments and train volunteers, a partnership effort that our team fully supports.

We recommend that the NRD pursue resource cultivating partnerships with organizations such as HRWC, the Clinton River Watershed, the Michigan Botanical Club, and the Stewardship Network in order to implement and expand the agency's management, conservation, and preservation activities. Similarly, we recommend continued investigation into the possibility of using methods that use other living organisms as a means of assessing ecological quality such as a Bioblitz and the hiring of consultants as suggested by the NRD (Muelle, personal comm. February 2011) to further strengthen the taking of a more holistic approach to ecological assessment and the expansion of department resources.

Box 2 - Action Plan Summary

- Continue to pursue the compilation of a comprehensive baseline data set for all 13 Metroparks.
- Employ a MCE as a means of completing a desktop analysis across all 13 Metroparks with some criteria modifications, such as those utilized by the BMDA and HCMA Model, in order to provide a data set for decisions that need to be made in the near term and to assist in prioritizing areas for field-based assessment.
- Employ a volunteer coordinator to facilitate the utilization of volunteers to assist in executing the massive data collection effort required to create a comprehensive baseline data set.
- Pursue partnerships with HRWC, the Clinton River Watershed Council, the Michigan Botanical Club, and the Stewardship Network in order to expand the agency's resources for management, conservation, and preservation activities.
- Implement the BRAM in all Metropark natural areas, including those areas with existing FQA data, in order to provide a holistic data set, collected with consistent methodology.
- Continue investigating the possibility of assessing other organisms as a means of assessing ecological quality through implementation of a Bioblitz and the hiring of consultants as suggested by the NRD Chief (Muelle, personal comm, February 2011).

In conclusion, HCMA NRD ecosystem management decisions should be based on consistent, current information of the alpha richness and habitat diversity found within and across all 13 Metroparks. However, the reality of time, funding, and staffing constraints make this idealistic approach impractical. The action plan provided by our Master's project team represents a strong start in the ecological assessment and prioritization of the Metroparks using appropriate proxies and indicators of ecosystem health, which should continue to be built upon and strengthened long into the future.

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APPENDIX CONTENTS

Appendix A: Glossary

Animal Culling: The controlled hunting of animals for the purposes of population management.

Baseline Data: An original data set

Biointegrity: A measure of overall biological quality of a natural area.

Biological Rarity: Generally refers to a species that meets the following conditions: occupies a limited geographical range, lives in specialized habitats, and/ or is only found in small populations.

Community Ranking: A ranking assigned by Michigan Natural Features Inventory to indicate the status of a particular natural community type's rarity and/or decline in the state of Michigan.

Connectedness: The degree of closeness between natural areas. Natural areas in close proximity to other natural areas allow them to serve as a natural corridor for wildlife.

Corridor: A connected component of the landscape that allows organisms to disperse and migrate between habitat patches.

Desktop Analysis: A framework designed to evaluate the quality of an area based solely on spatial data.

Dipnet Survey: A sampling technique in which a net with a D-shaped frame and fine-mesh netting is used to capture small wildlife from aquatic ecosystems.

Ecological Assessment Model: A framework designed to evaluate the ecological quality and degree of ecosystem functionality of a natural area.

Ecological Community: A group of organisms that interact with one another in a defined area.

Elemental Occurrence: Documented and/or verified observation of a state-listed plant or animal species occurring within a defined location.

Euclidean Distance: The relationship between a cell in a raster grid and a source or set of sources.

Extirpation: Local extinction of a population that may continue to persist elsewhere.

Floristic Quality Index: A measure of the quality of a natural area based on the vegetation community composition.

Floristic Quality Assessment: The method used to determine the floristic quality of a natural area.

Glacial Variation: Patterns of glacial landforms.

Ground-Truthing: The physical verification of data in a given location through the use of field surveys.

Groundwater Recharge: Hydrologic process in which surface water percolates downward into aquifers.

Herpetofauna: Amphibians and reptiles.

Hydric Soil: Water-saturated soils experiencing reduced conditions that affect plant growth.

Impervious: Impenetrable or impassible, often with regards to water.

Kettle Depression: A basin created by a block of glacial ice surrounded or buried by glacial deposits.

Kettle Lake: A kettle depression that remains filled with water.

Line Transect: A linear path from which all individuals observed in a fixed distance perpendicular to the path are included in a survey.

Marl: Soft calcium carbonate often mixed with impurities.

Matrix: The predominant landscape of an area, in which distinct habitat corridors and/or patches are embedded.

Millage: A property tax levy.

Minerotrophic: Groundwater-influenced ecosystems or soils.

MNFI Special Community: An area that has been entered into the Michigan Natural Features Inventory database as a high quality plant community.

Moraine: An accumulation of glacial drift that was deposited directly from the glacier.

Muck Soil: Soils composed of 20-50% muck.

Muck: Highly decomposed organic material. Differs from peat in its darker color and larger mineral content.

Natural Community: A distinct assemblage of interacting organisms that repeatedly occur across the landscape under similar environmental conditions and is predominantly mediated by natural processes.

Outwash Plain: Glacial till deposited by melt water flowing from receding glaciers.

Peat: Hydric soils consisting of slightly decomposed to decomposed organic matter.

p-Value: The probability of obtaining a test statistic at least as extreme as the one that was actually observed, assuming that the null hypothesis is true. The assumption is significantly true when p is less than 0.05 or 0.01

Rail Corridor: Area within a specified distance from a railroad.

Rho value: It assesses how well the relationship between two variables can be described using a monotonic function, which is the function that preserves the given order.

Riparian Buffer: The vegetated region of stream- or riverbanks.

Riparian Corridor: A linear natural area, immediately adjacent to a river or lake, which facilitates the movement of wildlife between significant habitats.

Sand: Soil particles with diameters between 0.005 and 2.0 mm.

Silt: Soil particles between 0.002 and 0.05 mm in diameter.

Spatial Data: Data that provides information regarding the spatial location and extent of a physical object.

Spearman's Correlation Coefficient: Also called Spearman's rho, see the glossary for Rho

Spearman's Rank Correlation: It is used to test the correlation between different ecological quality assessment methods based on the natural community unit scale.

Stream Line: Area within a specified distance from a stream water's edge.

Suitability Modeling: A model to help pick up the most suitability places, usually used in the land management for the best land prioritization

Topographic Variation: Differences in the shape and elevation of features on the earth's surface.

Weighted Liner Combination: Multiplying the importance weight assigned for each attribute and summing the products over all attributes to get the overall values.

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Appendix B - Acronyms

AHP: Saaty's analytical hierarchy process

BMDA: Bioreserve Modified Desktop Analysis

BRAM: Bioreserve Rapid Assessment Method

BRI: Biological Rarity Index

CI: Consistency Index

C of C: Coefficient of Conservancy

DEM: Digital Elevation Model

DMF: Dry Mesic Forest

ESRI: Environmental Systems Research Institute

EW Emergent Wetland

FF: Floodplain Forest

FQA: Floristic Quality Assessment

FQI: Floristic Quality Index

GIS: Geographic Information System

GPS: Global Positioning System

HCMA: Huron-Clinton Metropolitan Authority

HRWC: Huron River Watershed Council

HS: Hardwood Swamp

IBI: Index of Biological Integrity

LC: Lowland Conifer

MA: Mowed Area

MCE: Multi-Criteria Evaluation

MF: Mesic Forest

MNFI: Michigan Natural Features Inventory

NGO: Non-Governmental Organization

NRD: Natural Resources Department

NWI: National Wetlands Inventory

OF: Old Field

SC: Shrub-Carr

SEMCOG: Southeast Michigan Council of Government

SH: Shrubland

SSURGO: Soil Survey Geographic Database

USDA: United States Department of Agriculture

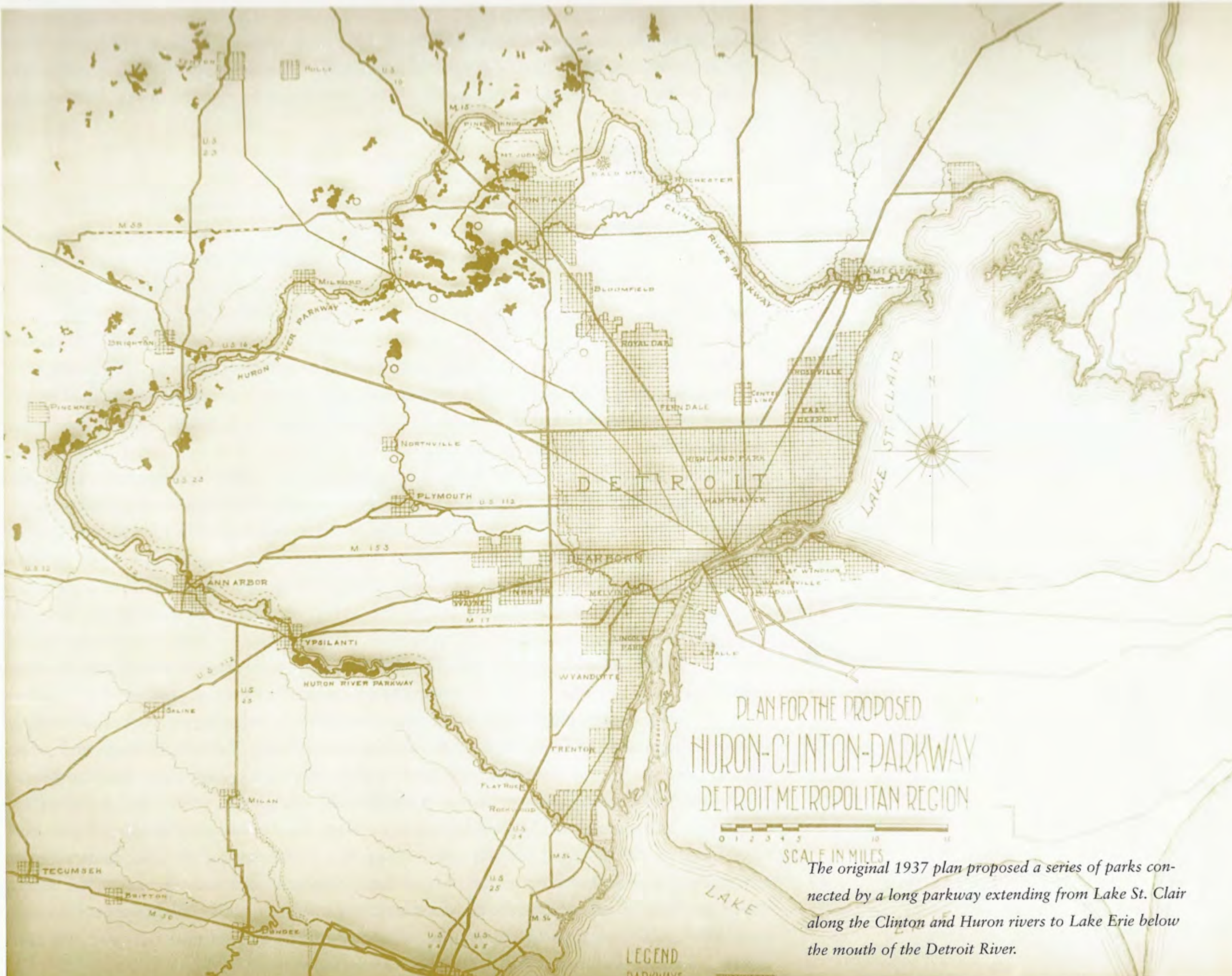
USGS: United States Geological Survey

WAMS: Wetland Analytical Mapping System

WMF: Wet-Mesic Forest

WMP: Wet-Mesic Prairie

Figure C.1. Historical Metroparks Plan



The original 1937 plan proposed a series of parks connected by a long parkway extending from Lake St. Clair along the Clinton and Huron rivers to Lake Erie below the mouth of the Detroit River.

Figure C.2. HCMA Organizational Structure 1

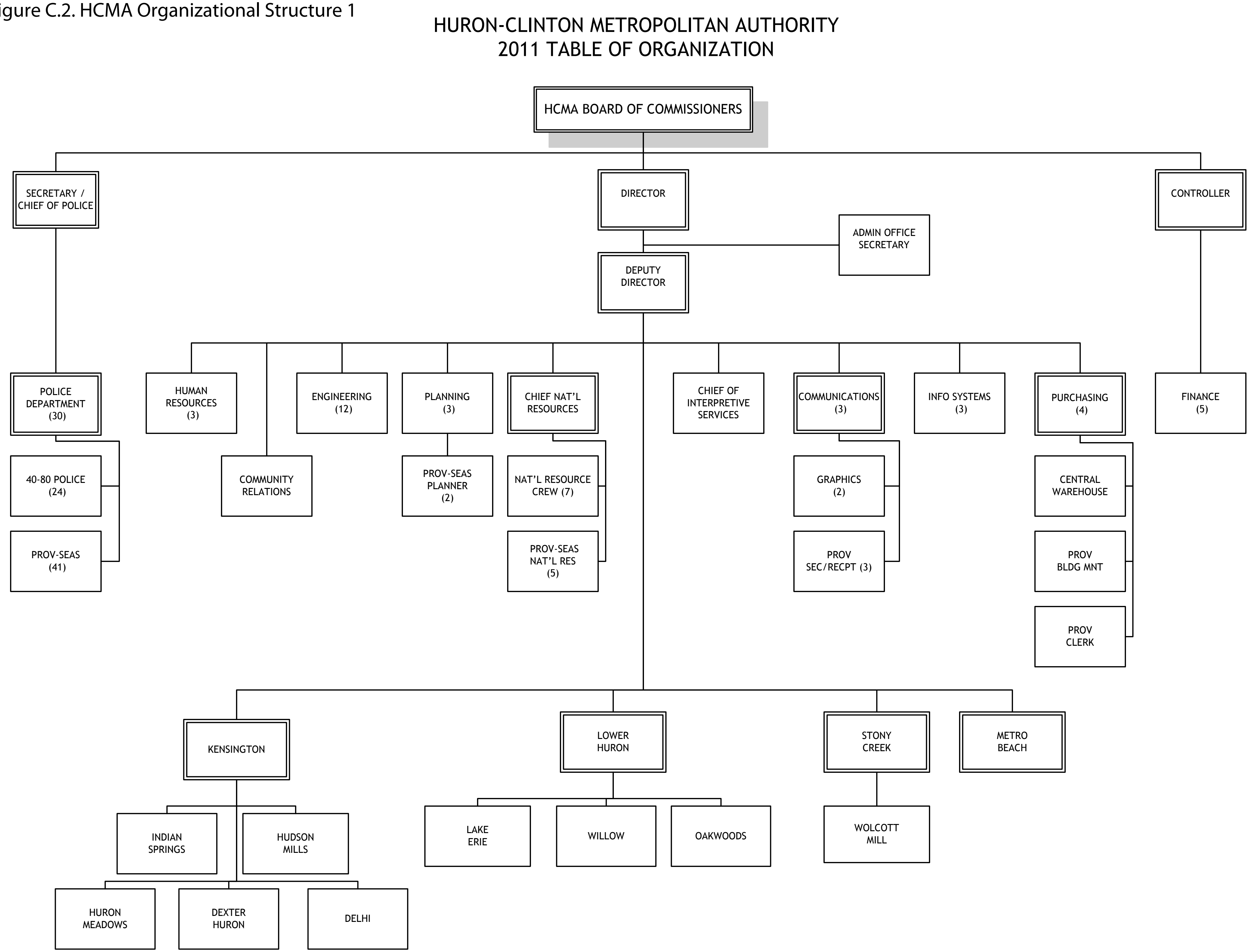


Figure C.2. HCMA Organizational Structure 2

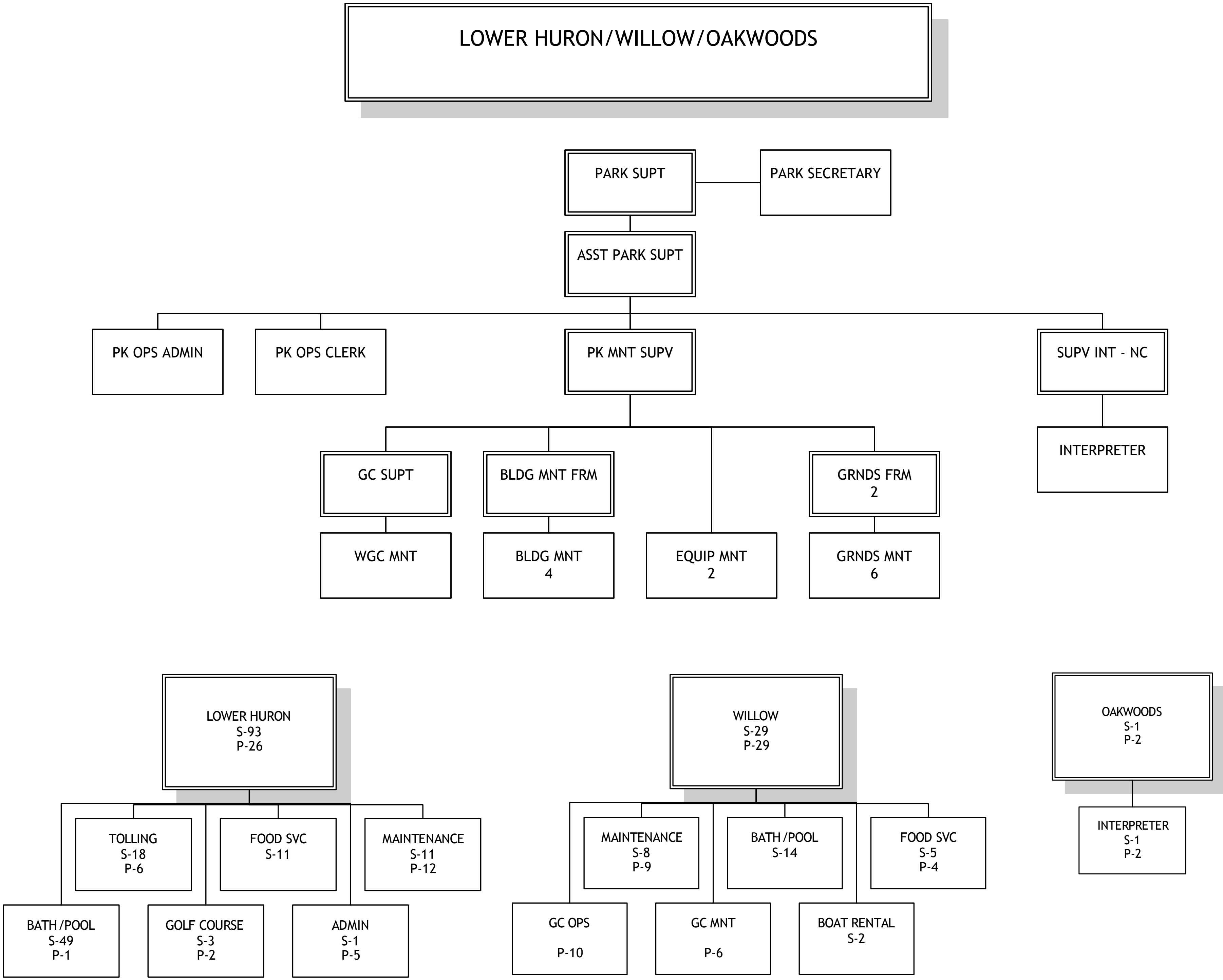


Figure C.3 BMDA Explained

Huron River Watershed Council

Protecting the river since 1965

1100 N. Main Street Suite 210
Ann Arbor, MI 48104
(734) 769-5123
www.hrwc.org

Bioreserve Method

Following is a breakdown of the scoring for each criterion:

- **Size**. Natural areas were sorted according to their size and divided into five categories using natural breaks. The largest areas received 100 points and the smallest parcels received zero. Field: “Acres.”
- **Core size.** Core area is defined as “size” (see above) minus a 300-foot wide buffer measured inward from the edge of the site. Core area is different from total area of the site because it takes into account the shape of the site. Typically, round shapes contain a larger core area relative to the total site than long narrow shapes. The largest core areas received 100 points and the smallest parcels received zero. Field: “Core Size.”
- **Presence of waterway or lake.** Natural areas containing rivers or streams received 100 points, natural areas without waterways received zero. Field: “WATER.”
- **Areas containing wetlands and uplands.** Natural areas containing any wetlands present received 100 points while natural areas without wetlands received 0. Field: “WETLANDS.”
- **Potential for groundwater recharge.** The movement of groundwater through soils and into surface waters can be illuminated by applying Darcy's Law, an equation that describes water flow in soils. A map illustrating how Darcy’s law applies to groundwater flow has been created for the entire lower peninsula of Michigan (Baker, M.E., M. J. Wiley, and P.W. Seelbach. 2001). It indicates areas where soil types are more likely to allow infiltration leading to groundwater discharge. Natural areas were converted from vector to raster format to match the data of the Darcy map, and Darcy values within each natural area were averaged. The average Darcy value for all the cells in a natural area was generated. These averages were ranked into five classes using natural breaks. Natural areas with a higher potential for groundwater infiltration received 100 points while areas with the lowest potential received zero. Field: “Groundwater.”
- **Presence in the 1800’s of conifer swamp, lowland hardwood, oak opening, central hardwood, or emergent wetland.** Natural areas were analyzed to see if they had formerly contained any of these presettlement vegetation types. The number of types of presettlement ecosystems present in each natural area was tallied, and natural areas that intersected areas where any of the presettlement vegetation occurred were ranked higher than those without. Sites with the highest number of these (“remnant”) ecosystems received 100 points while areas with none received zero. Field: “Remnant Ecosystems Count.”

- **Glacial variation.** Natural areas were intersected with glacial variation data to determine the number of glacial landforms within each natural area. A higher diversity of glacial landforms in a particular natural area resulted in that area scoring higher points. Sites with the highest number of glacial landscapes received 100 points while areas with only one received zero. Field: "Glacial_co."
- **Topographical variation.** The number of slopes and aspects in a natural area is an indicator of ecosystem diversity. For instance, northeast slopes tend to be cooler and moister, while southwest aspects tend to be warmer and drier. Slope and aspect were identified using a digital elevation model (DEM) of the Watershed to create a triangulated irregular network (TIN) for the Huron River Watershed. A TIN identifies slope and direction between centroid points of the raster DEM data, creating a triangle for each piece of land with consistent slope and aspect. The number of triangles within each natural area was summarized, providing an indication of the roughness or topographic diversity of the site. The number of TINs was divided into five categories using natural breaks. Those sites with highest topographical diversity received 100 points, those with the least received zero. Field: "Topographic Count."
- **Connectedness**. Natural areas closer to other natural areas have the potential to be corridors for wildlife and provide for more contiguous natural areas. The proximity of the site to other bioreserve sites was measured by building a 100 foot buffer around each site and counting the other bioreserve sites in that buffer. Sites with the highest number of bioreserve sites within their buffers received 100 points while areas with only one received zero. Field: "Connectedness Count."
- **Connectedness**. Another measure of connectedness is the percent of a ¼ mile buffer around the natural area that remains undeveloped. The sites with the largest percentages of undeveloped area in their buffers received 100 points and those with the smallest percentages received zero. Field: % of Buffer Bioreserve
- **Unchanged Vegetation: by Percentage**. A vegetation change map comparing the 2000 vegetation to the circa 1800 vegetation was created. The resulting potential unchanged vegetation can then act as an indicator of vegetation quality. Calculating the percentage of the site that contains potentially unchanged vegetation allows small sites with a high percentage of potentially unchanged vegetation to score points. Sites with the highest percentage of unchanged vegetation received 100 points; those with the lower received zero. Field: "%Potentially Unchanged."
- **Unchanged Vegetation**: **by Area**. Calculating the area of potentially unchanged vegetation that falls within each bioreserve site balances the bias of small sites with high percentage of potentially unchanged vegetation by awarding points based on actual area covered. Sites with the largest area of unchanged vegetation received 100 points; those with lower areas received zero. Field: "Area Potentially Unchanged."
- **Restorability**. We measured the percentage of undeveloped l ands within a ¼ mile buffer area. Sites with the largest percentage of undeveloped lands within their buffer received 100 points; those with lower percentages received zero. Field: "% of Buffer Undeveloped."

- **Area of MNFI Community**. The Michigan Natural Features Inventory has a database of known boundaries of high quality plant communities. Sites with larger areas of "MNFI Communities" received 100 points; those with no areas received zero. Field: "Area of MNFI Community"
- **Biorarity**. MNFI has created a grid by section of what it calls "biorarity," a score reflecting their database of high quality plant communities, occurrences of threatened and endangered plants and animals, and other measures of potential ecological quality. This grid was overlaid onto the Bioreserve Site layer. Sites with a higher average biorarity score received 100 points; those with a lower score received zero. Field: "Average Biorarity."

Ranking breakdown by category

Category and units	*Highest ranking*				*Lowest ranking*	*Breaks*	*Method*
Size	100	75	50	25	0	5	Natural Breaks
Acres	Highest acreage		Lowest acreage				
Core Size	100	75	50	25	0	5	Natural Breaks
Acres	Highest acreage		Lowest acreage				
Waterways	100				0	2	Presence Absence
	Rivers present		Rivers absent				
Wetlands	100				0	2	Presence Absence
	Wetlands present		Wetlands absent				
Groundwater recharge	100	75	50	25	0	5	Natural Breaks
Average of standard deviations per unit	Highest infiltration		Lowest infiltration				
Remnant ecosystems	100	75	50	25	0	5	Numeric
Number of rare presettlement vegetation types	4	3	2	1	0		
Glacial variation	100	66	33		0	4	Numeric
Number of different landforms	4	3	2		1		
Topographic variation	100	75	50	25	0	5	Natural Breaks
TINs	Max. Number of TINs		Min. number of TINs				
Connectedness	100	66	33		0	4	Numeric
Number of bioreserve sites w/in 100 ft. buffer	8 – 11	4 – 7	2 – 3		1	4	
Connectedness	100	7550	25		0	5	Natural Breaks
Percent of ¼ mile buffer that is a Bioreserve Site	Highest percentage		Lowest percentage				

Unchanged Vegetation	100 7550 25 0	5	Natural
Percent of Bioreserve Site that remain unchanged	Highest percentage Lowest percentage		Breaks
Unchanged Vegetation	100 7550 25 0	5	Natural
Area of Bioreserve Site that remains unchanged	Highest area Lowest area		Breaks
Restorability	100 7550 25 0	5	Natural
Percent of buffer that is undeveloped	Highest percentage Lowest percentage		Breaks
Area of MNFI Community	100 75 50 25 0	5	Natural
Area of Site that is MNFI Community	Highest acreage Lowest acreage		Breaks
Biorarity	100 75 50 25 0	5	Natural
Average Biorarity score for Site	Highest score Lowest score		Breaks

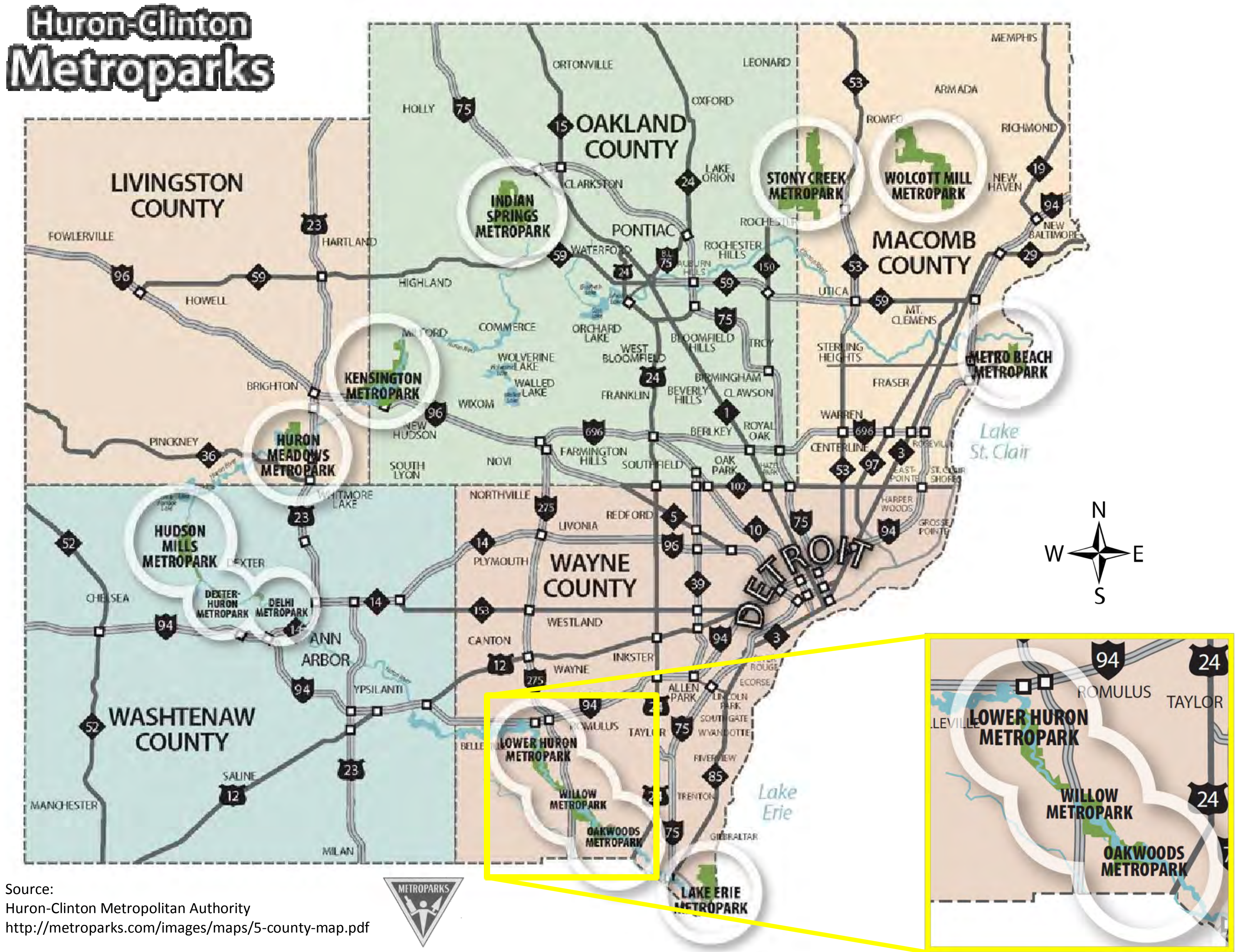
To obtain final rank, create the field “final rank,” and calculate it as the sum of all the ranks.

We have displayed the final ranking with three classes from lowest to highest priority, with the final ranking classified in 3 categories with natural breaks. 0 – 158, 158 – 591, and 591 – 1224.

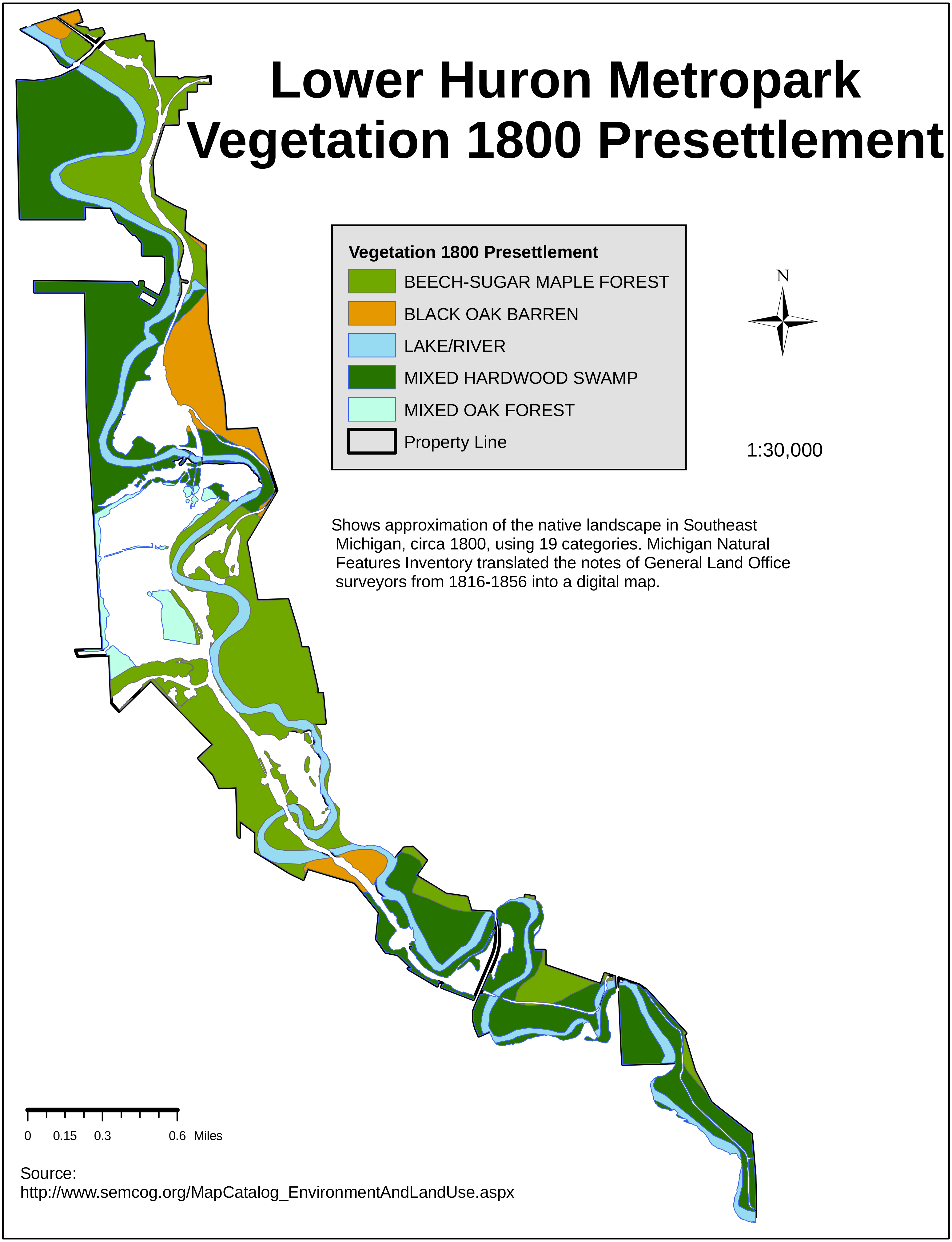
Table C.4 – Ecological quality scores for each of the five tested ecological assessment methods in Lower Huron and Willow Metroparks

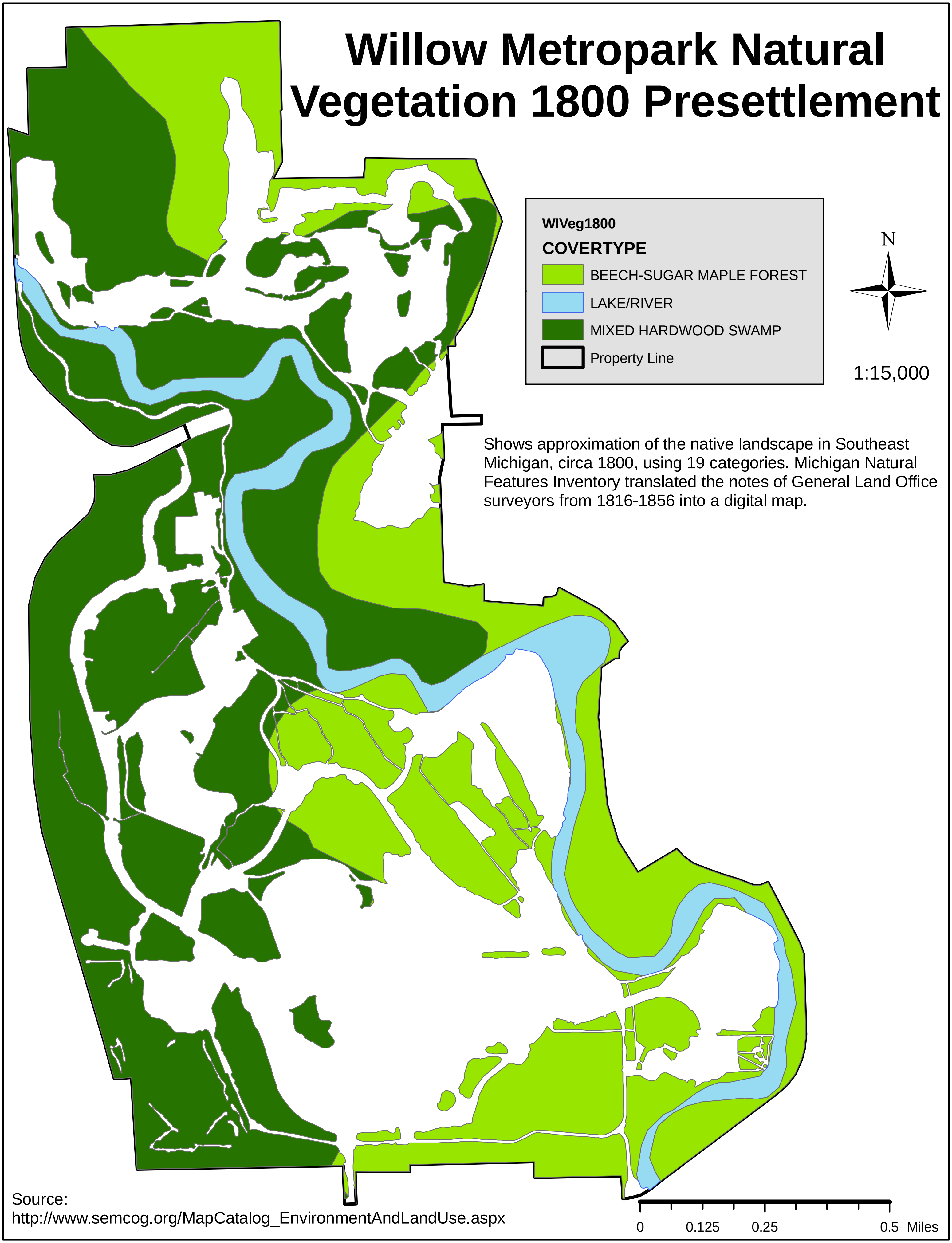
	Lower Huron				
	FQA	**HCMA**	**BRAM**	**BMDA**	**MCE**
Mean	25.6	3.0	75.0	383.2	28.6
Median	23.1	2.0	72.4	358.0	30.3
Range	9.1 – 47.1	0 – 9.0	16.8 – 145.9	108.0 – 825.0	0 – 81.0
	Total Number of Units				
Exceptional	0	14	23	10	17
High	19	17	35	27	21
Moderate	42	28	28	43	10
Low	32	34	5	13	43
Total	93	93	91	93	91
	Willow				
Mean	20.8	2.4	56.0	336.5	22.0
Median	21.3	2.5	56.8	291.0	0
Range	7.3 – 33.9	0 – 6.0	12.0 – 98.2	75.0 – 816.0	0 – 72.0
	Total Number of Units				
Exceptional	0	0	0	6	5
High	0	18	27	17	22
Moderate	39	31	37	35	6
Low	33	23	7	14	38
Total	72	72	71	72	71

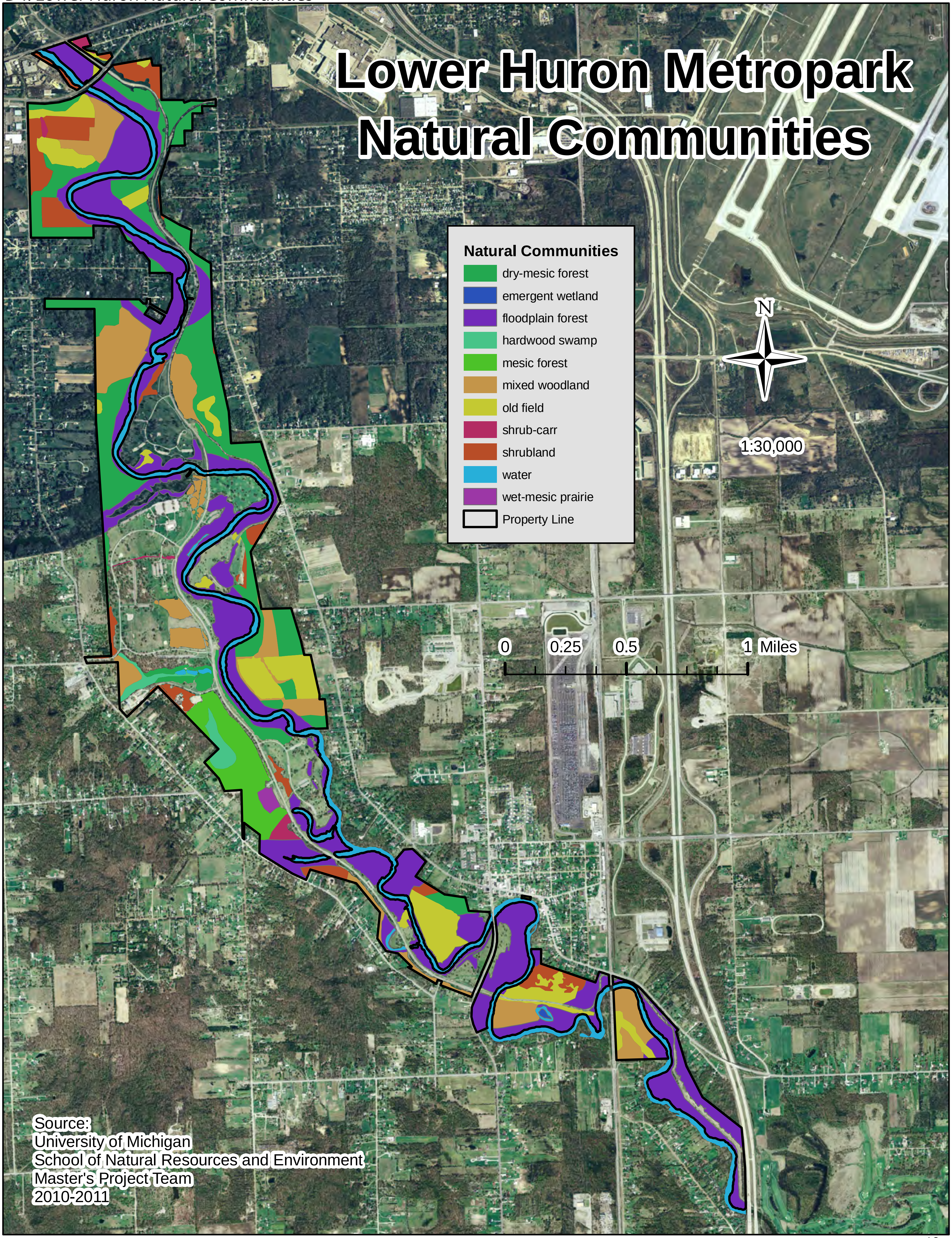
D.1. Survey Areas

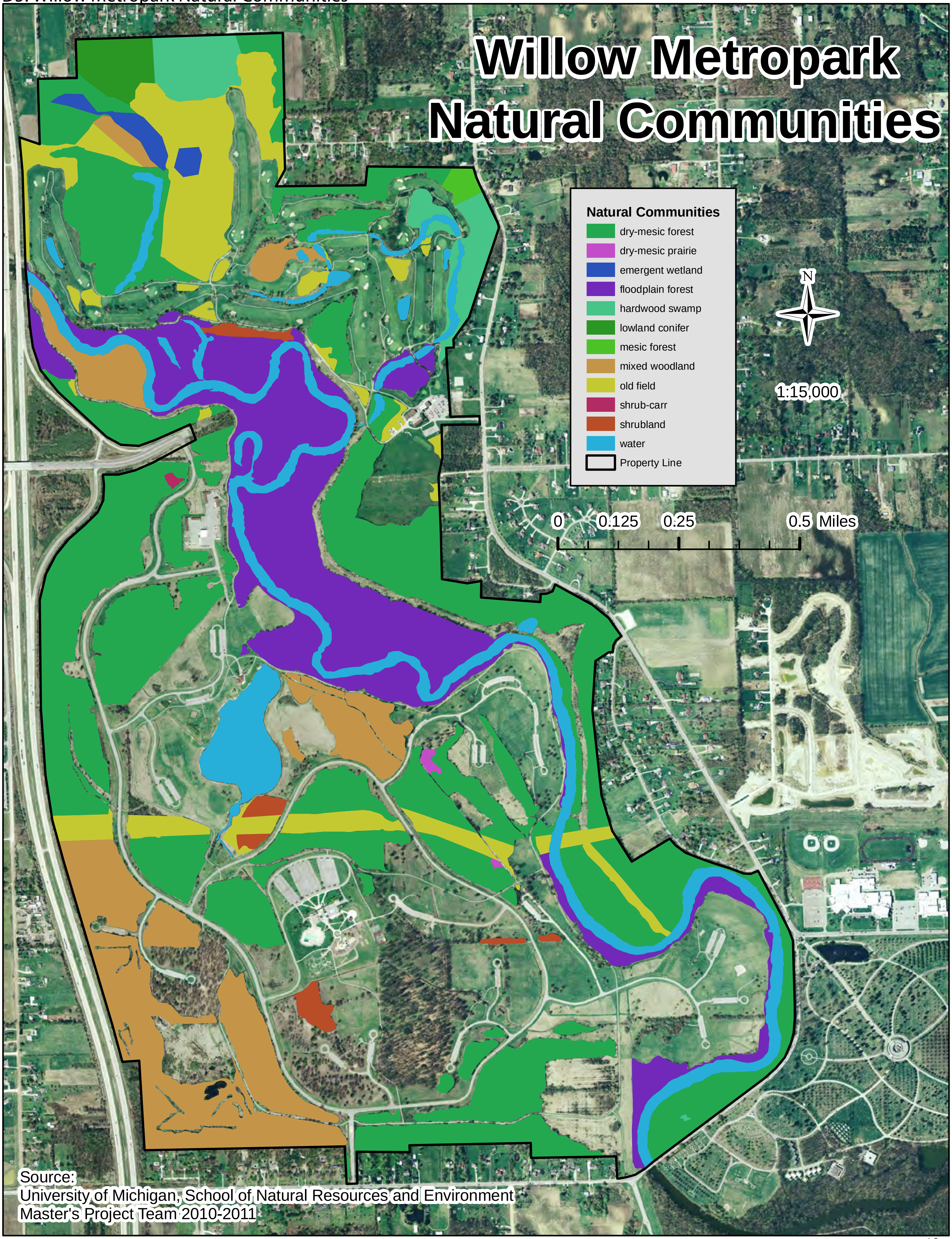


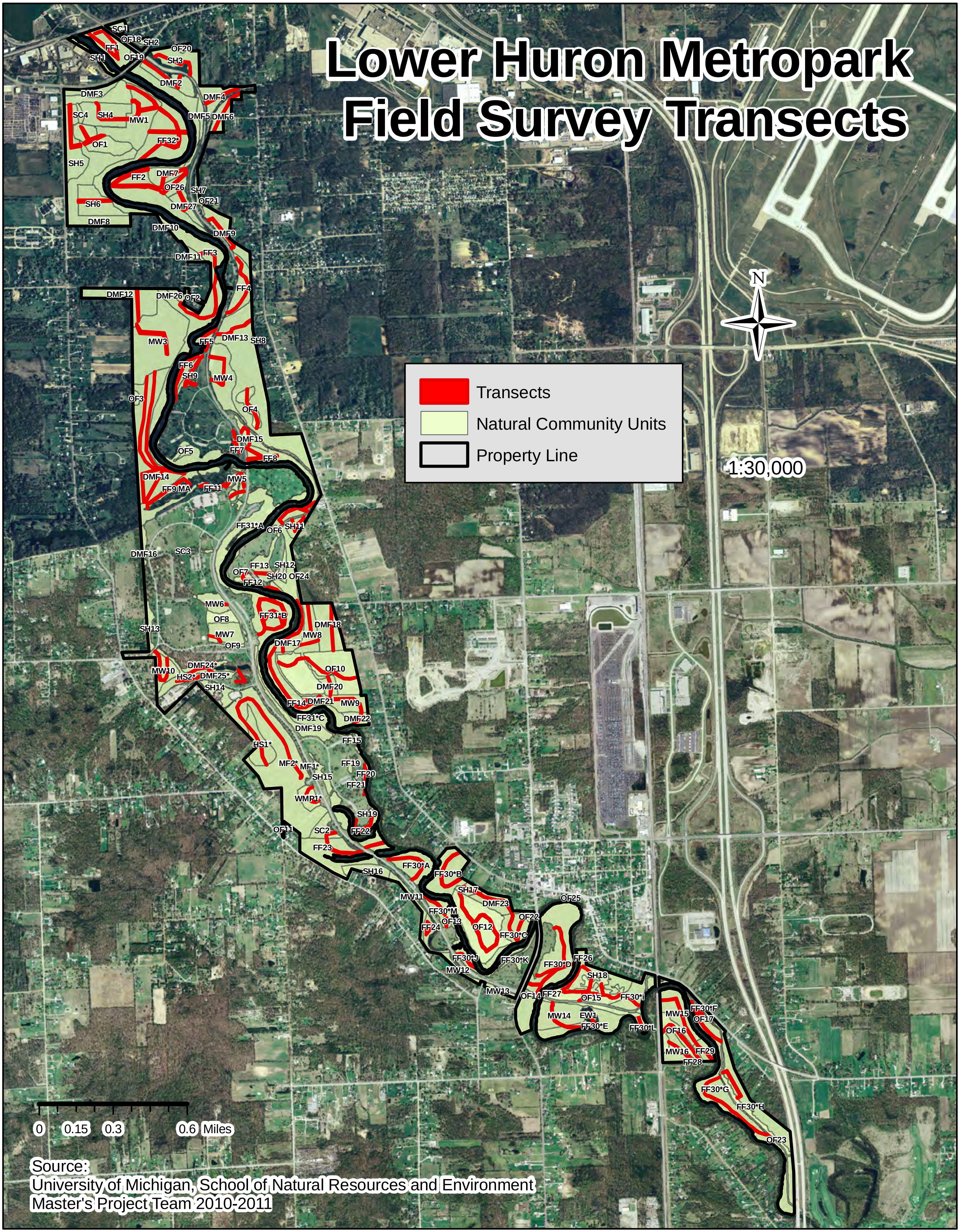
Source:
Huron-Clinton Metropolitan Authority
http://metroparks.com/images/maps/5-county-map.pdf


Lower Huron Metropark
Vegetation 1800 Presettlement
Vegetation 1800 Presettlement
BEECH-SUGAR MAPLE FOREST
BLACK OAK BARREN
LAKE/RIVER
MIXED HARDWOOD SWAMP
MIXED OAK FOREST
Property Line
N
1:30,000
Shows approximation of the native landscape in Southeast Michigan, circa 1800, using 19 categories. Michigan Natural Features Inventory translated the notes of General Land Office surveyors from 1816-1856 into a digital map.
0 0.15 0.3 0.6 Miles
Source:
http://www.semcog.org/MapCatalog_EnvironmentAndLandUse.aspx


Willow Metropark Natural Vegetation 1800 Presettlement
WIVeg1800
COVERTYPE
BEECH-SUGAR MAPLE FOREST
LAKE/RIVER
MIXED HARDWOOD SWAMP
Property Line
N
1:15,000
Shows approximation of the native landscape in Southeast Michigan, circa 1800, using 19 categories. Michigan Natural Features Inventory translated the notes of General Land Office surveyors from 1816-1856 into a digital map.
0
0.125
0.25
0.5 Miles
Source:
http://www.semcog.org/MapCatalog_EnvironmentAndLandUse.aspx


Lower Huron Metropark
Natural Communities
Natural Communities
dry-mesic forest
emergent wetland
floodplain forest
hardwood swamp
mesic forest
mixed woodland
old field
shrub-carr
shrubland
water
wet-mesic prairie
Property Line
N
1:30,000
0
0.25
0.5
1 Miles
Source:
University of Michigan
School of Natural Resources and Environment
Master's Project Team
2010-2011


Willow Metropark
Natural Communities
Natural Communities
dry-mesic forest
dry-mesic prairie
emergent wetland
floodplain forest
hardwood swamp
lowland conifer
mesic forest
mixed woodland
old field
shrub-carr
shrubland
water
Property Line
N
1:15,000
0 0.125 0.25 0.5 Miles
Source:
University of Michigan, School of Natural Resources and Environment
Master's Project Team 2010-2011


Lower Huron Metropark
Field Survey Transects
N
Transects
Natural Community Units
Property Line
1:30,000
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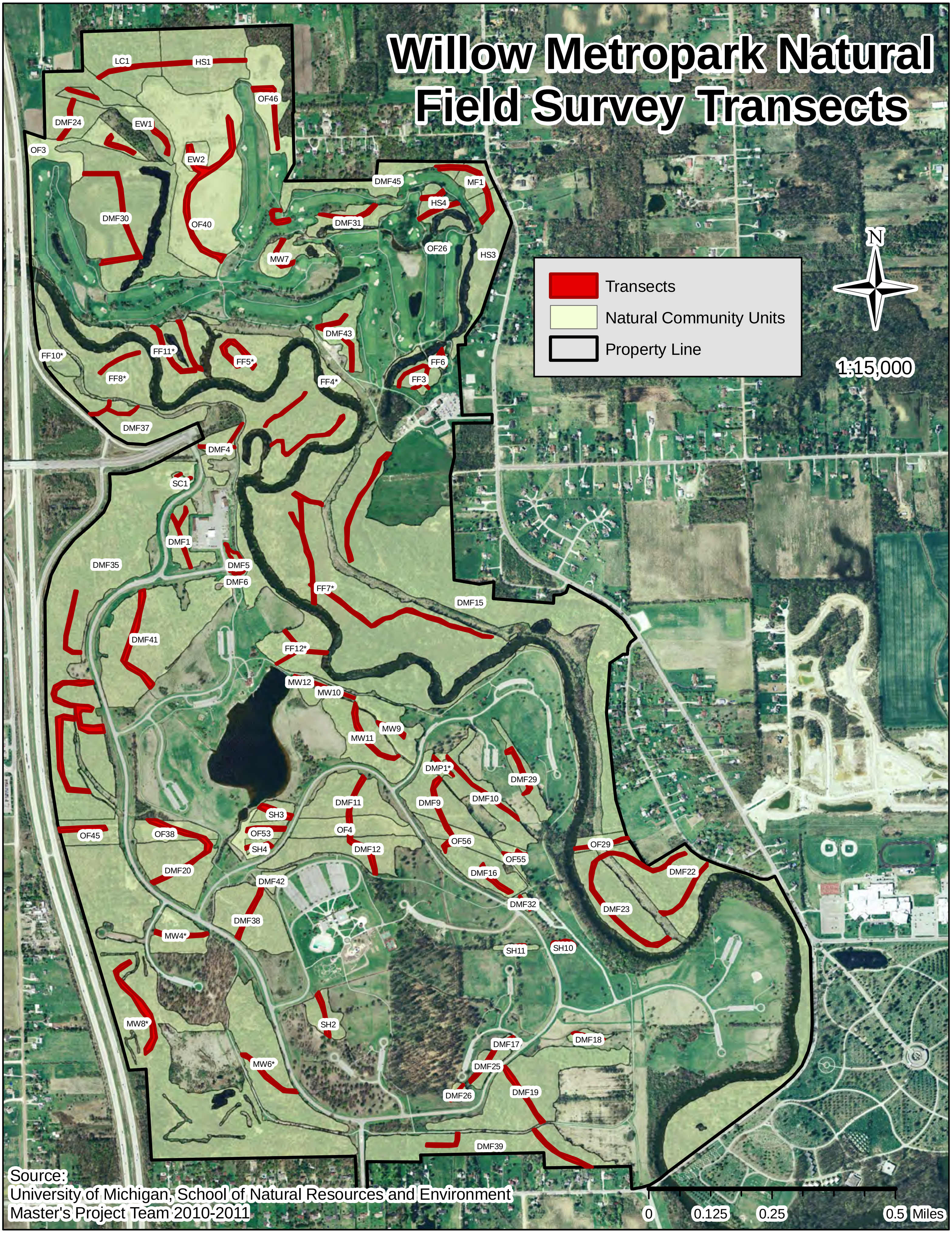
Master's Project Team 2010-2011


Willow Metropark Natural Field Survey Transects
Transects
Natural Community Units
Property Line
1:15,000
N
0
0.125
0.25
0.5 Miles
Source:
University of Michigan, School of Natural Resources and Environment
Master's Project Team 2010-2011
LC1
HS1
OF46
DMF24
EW1
OF3
EW2
DMF30
OF40
DMF45
MF1
HS4
DMF31
MW7
OF26
HS3
DMF43
FF10*
FF11*
FF5*
FF6
FF8*
FF4*
FF3
DMF37
DMF4
SC1
DMF1
DMF35
DMF5
DMF6
FF7*
DMF15
DMF41
FF12*
MW12
MW10
MW9
MW11
DMP1*
DMF29
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DMF9
DMF10
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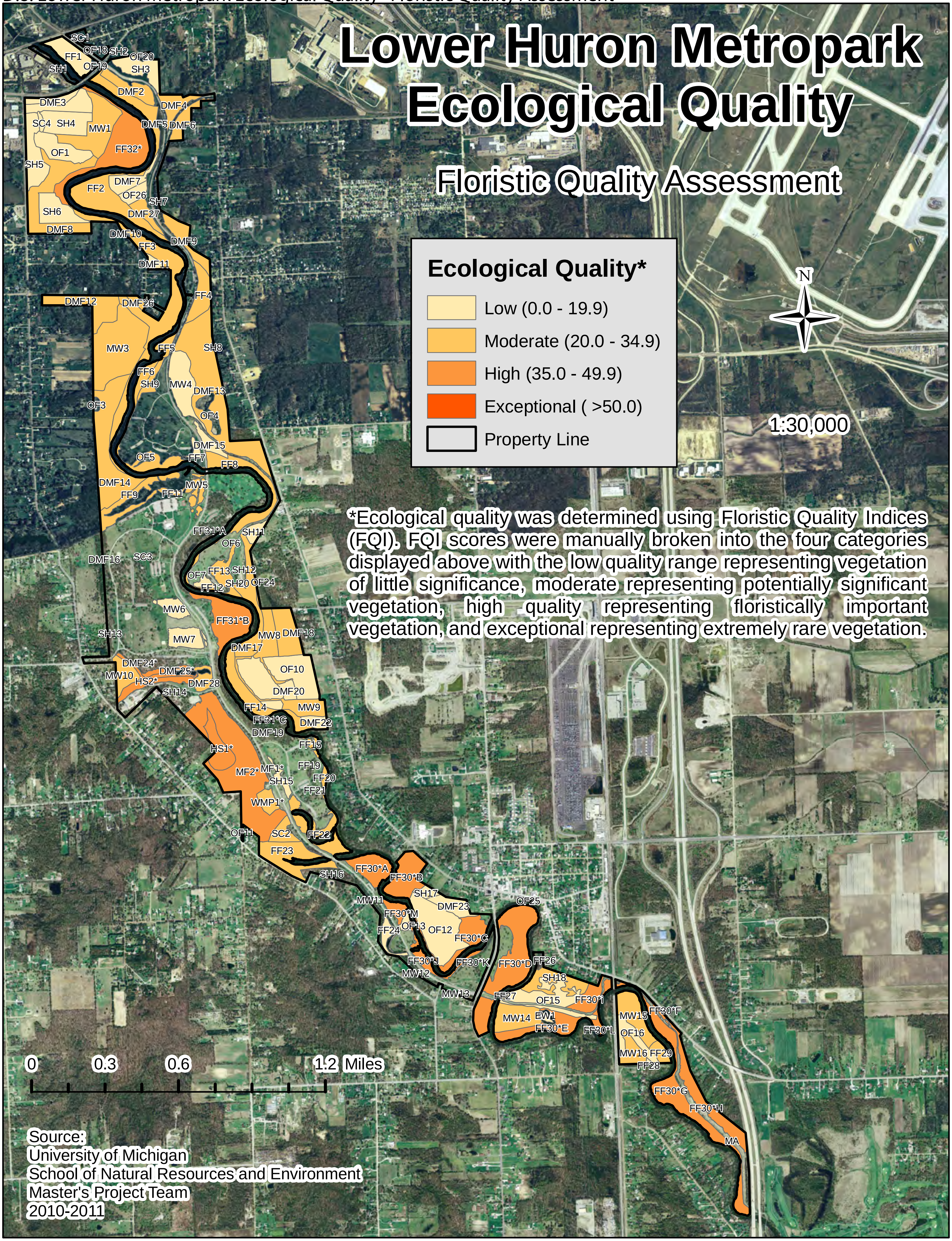
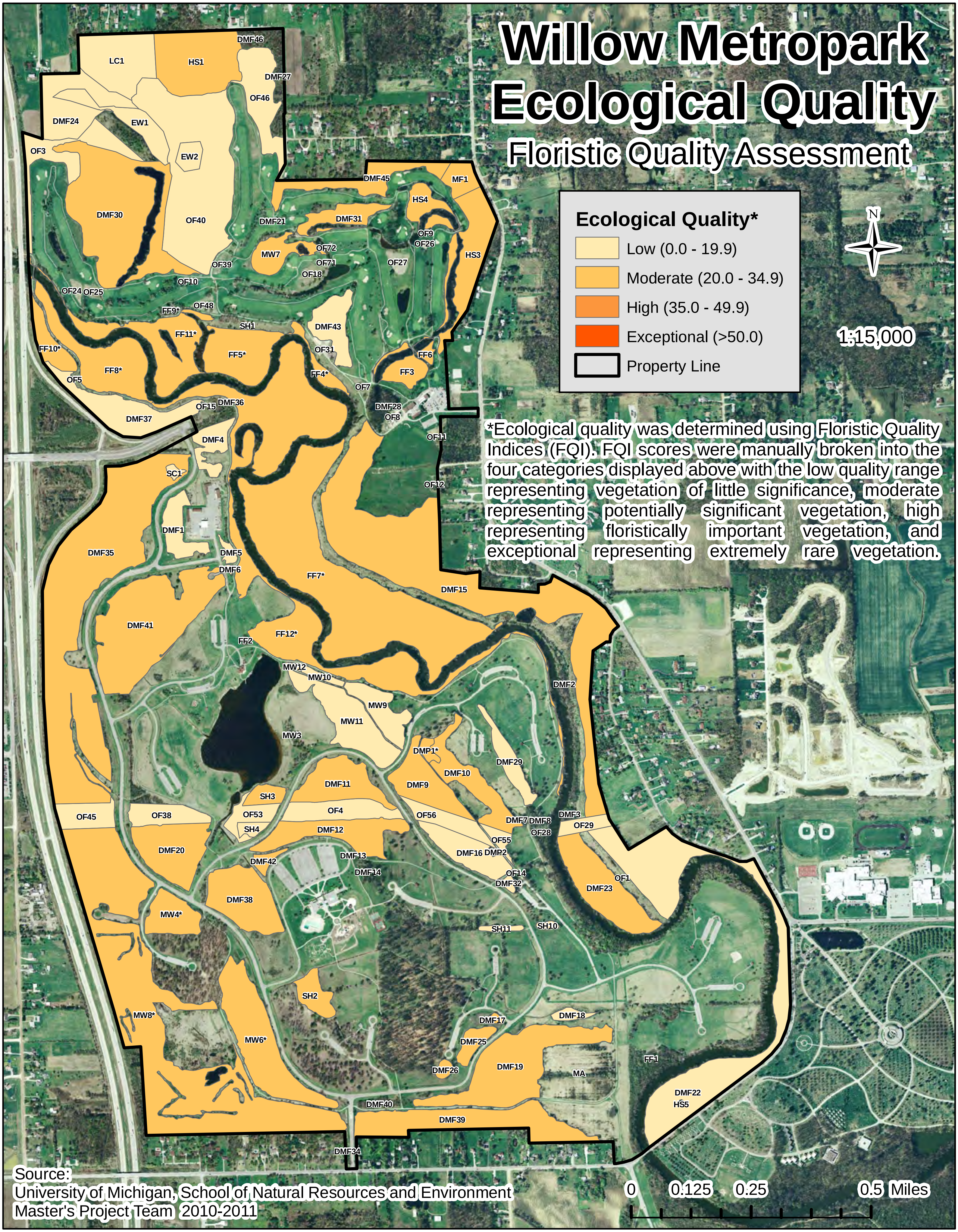
DMF26
DMF19
DMF39


Lower Huron Metropark
Ecological Quality
Floristic Quality Assessment
Ecological Quality*
Low (0.0 - 19.9)
Moderate (20.0 - 34.9)
High (35.0 - 49.9)
Exceptional (>50.0)
Property Line
N
1:30,000
*Ecological quality was determined using Floristic Quality Indices (FQI). FQI scores were manually broken into the four categories displayed above with the low quality range representing vegetation of little significance, moderate representing potentially significant vegetation, high quality representing floristically important vegetation, and exceptional representing extremely rare vegetation.
0
0.3
0.6
1.2 Miles
Source:
University of Michigan
School of Natural Resources and Environment
Master's Project Team
2010-2011


Willow Metropark
Ecological Quality
Floristic Quality Assessment
Ecological Quality*
Low (0.0 - 19.9)
Moderate (20.0 - 34.9)
High (35.0 - 49.9)
Exceptional (>50.0)
Property Line
N
1:15,000
*Ecological quality was determined using Floristic Quality Indices (FQI). FQI scores were manually broken into the four categories displayed above with the low quality range representing vegetation of little significance, moderate representing potentially significant vegetation, high representing floristically important vegetation, and exceptional representing extremely rare vegetation.
Source:
University of Michigan, School of Natural Resources and Environment
Master's Project Team 2010-2011
0 0.125 0.25 0.5 Miles
LC1
HS1
DMF46
DMF27
OF46
DMF24
EW1
EW2
OF3
DMF30
OF40
DMF45
MF1
HS4
DMF21
DMF31
OF9
OF26
HS3
MW7
OF72
OF71
OF27
OF39
OF18
OF10
OF24
OF25
OF48
FF9*
SH1
DMF43
FF11*
FF10*
FF5*
OF31
FF6
FF8*
FF4*
FF3
OF5
OF7
OF15
DMF36
DMF28
OF8
DMF37
DMF4
OF11
SC1
OF12
DMF1
DMF35
DMF5
DMF6
FF7*
DMF15
DMF41
FF12*
FF2
MW12
MW10
DMF2
MW9
MW11
MW3
DMP1*
DMF29
DMF10
DMF11
DMF9
SH3
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OF56
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OF29
OF28
SH4
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OF55
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OF14
DMF32
OF1
DMF23
DMF38
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SH11
SH10
SH2
DMF18
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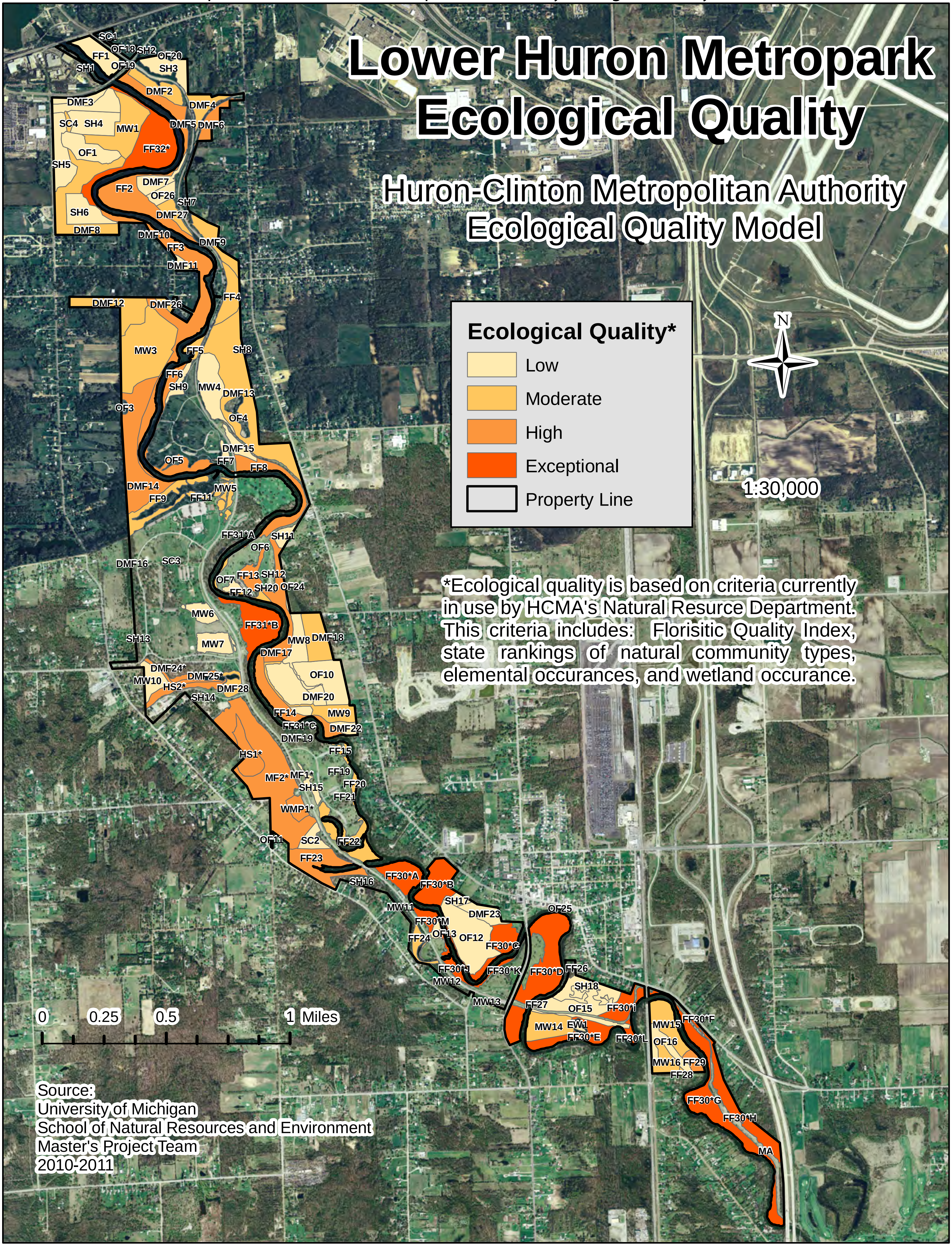
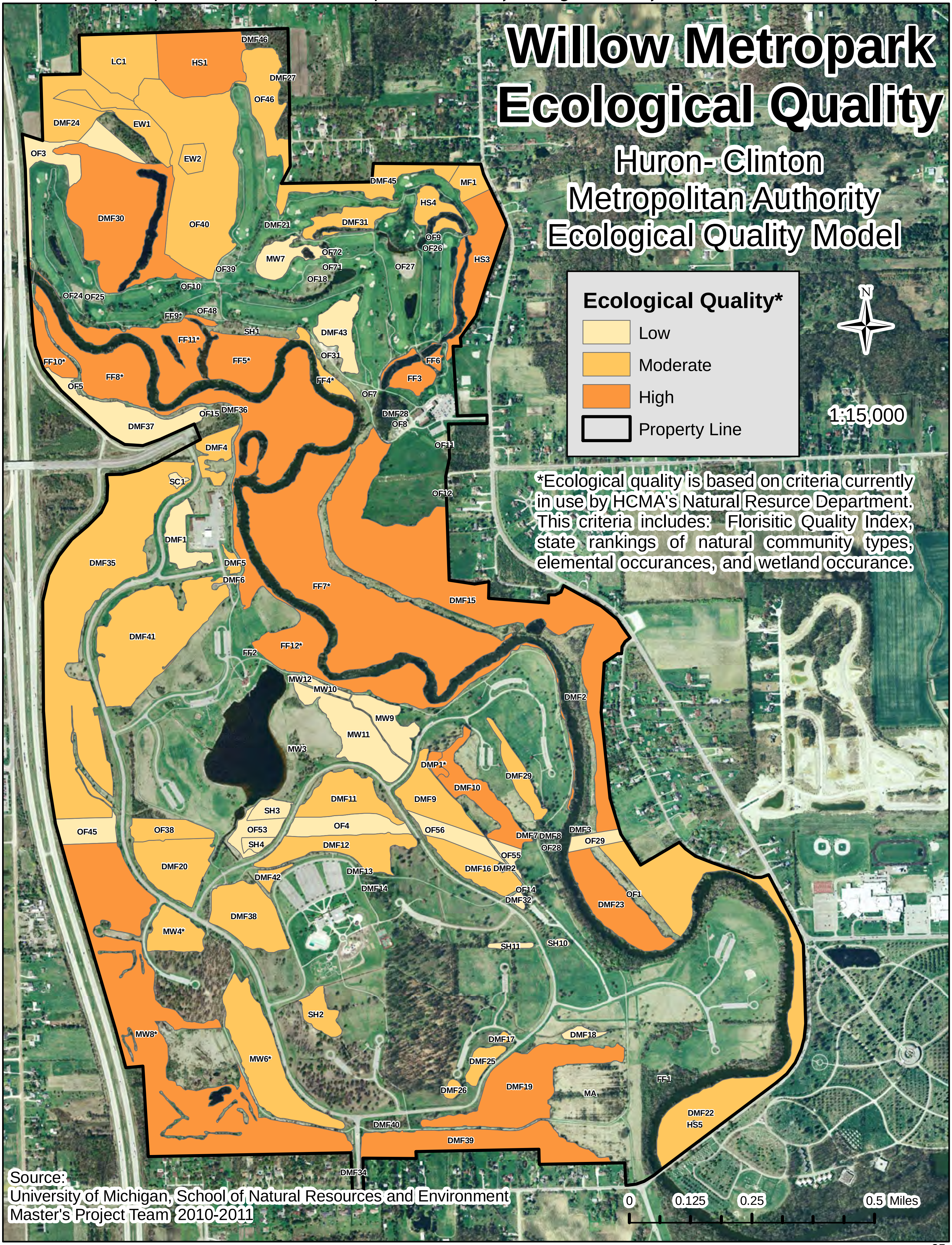
DMF40
DMF39
DMF34


Lower Huron Metropark
Ecological Quality
Huron-Clinton Metropolitan Authority
Ecological Quality Model
Ecological Quality*
Low
Moderate
High
Exceptional
Property Line
N
1:30,000
*Ecological quality is based on criteria currently in use by HCMA's Natural Resurce Department. This criteria includes: Florisitic Quality Index, state rankings of natural community types, elemental occurances, and wetland occurance.
0
0.25
0.5
1 Miles
Source:
University of Michigan
School of Natural Resources and Environment
Master's Project Team
2010-2011


Willow Metropark
Ecological Quality
Huron- Clinton
Metropolitan Authority
Ecological Quality Model
Ecological Quality*
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Moderate
High
Property Line
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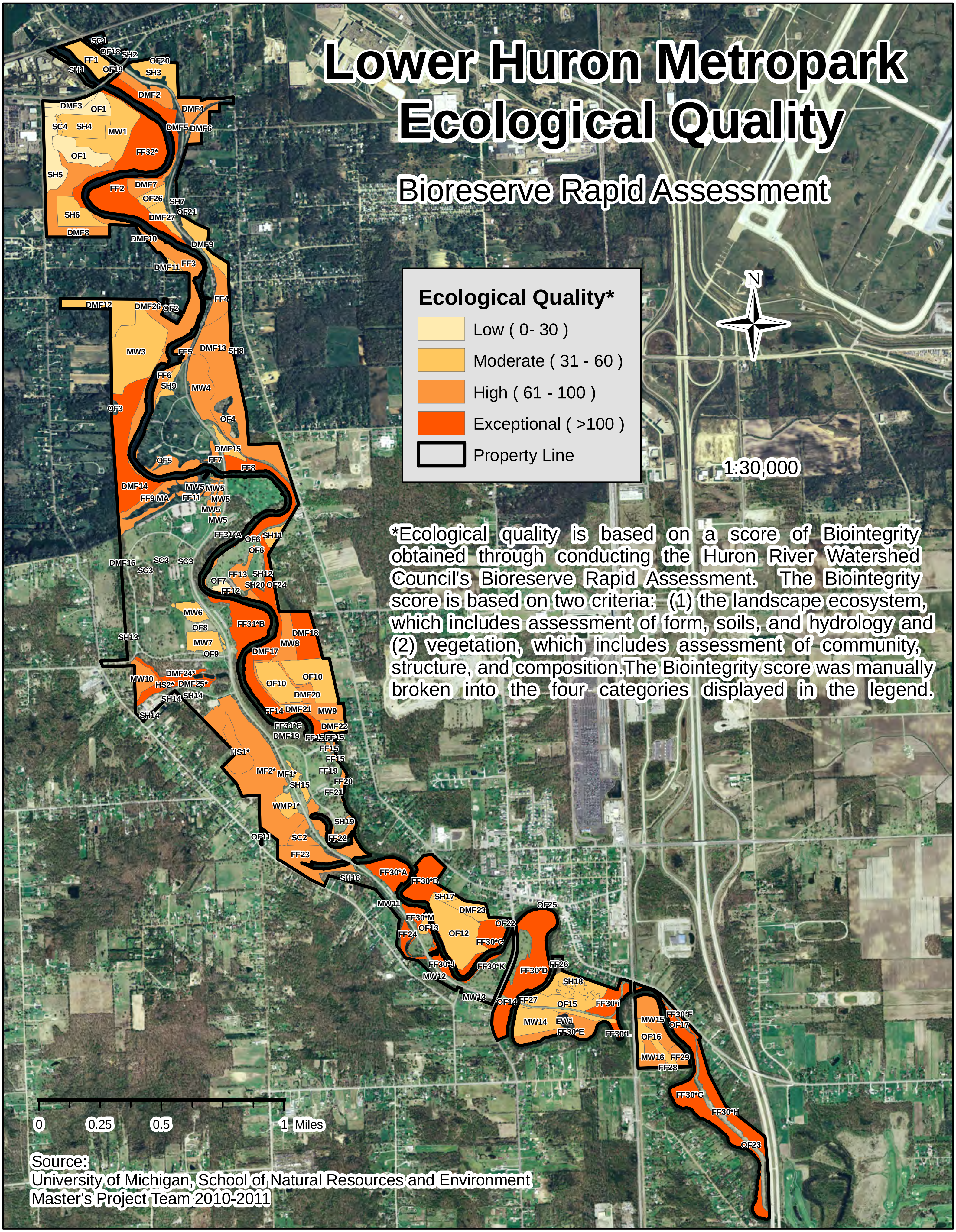
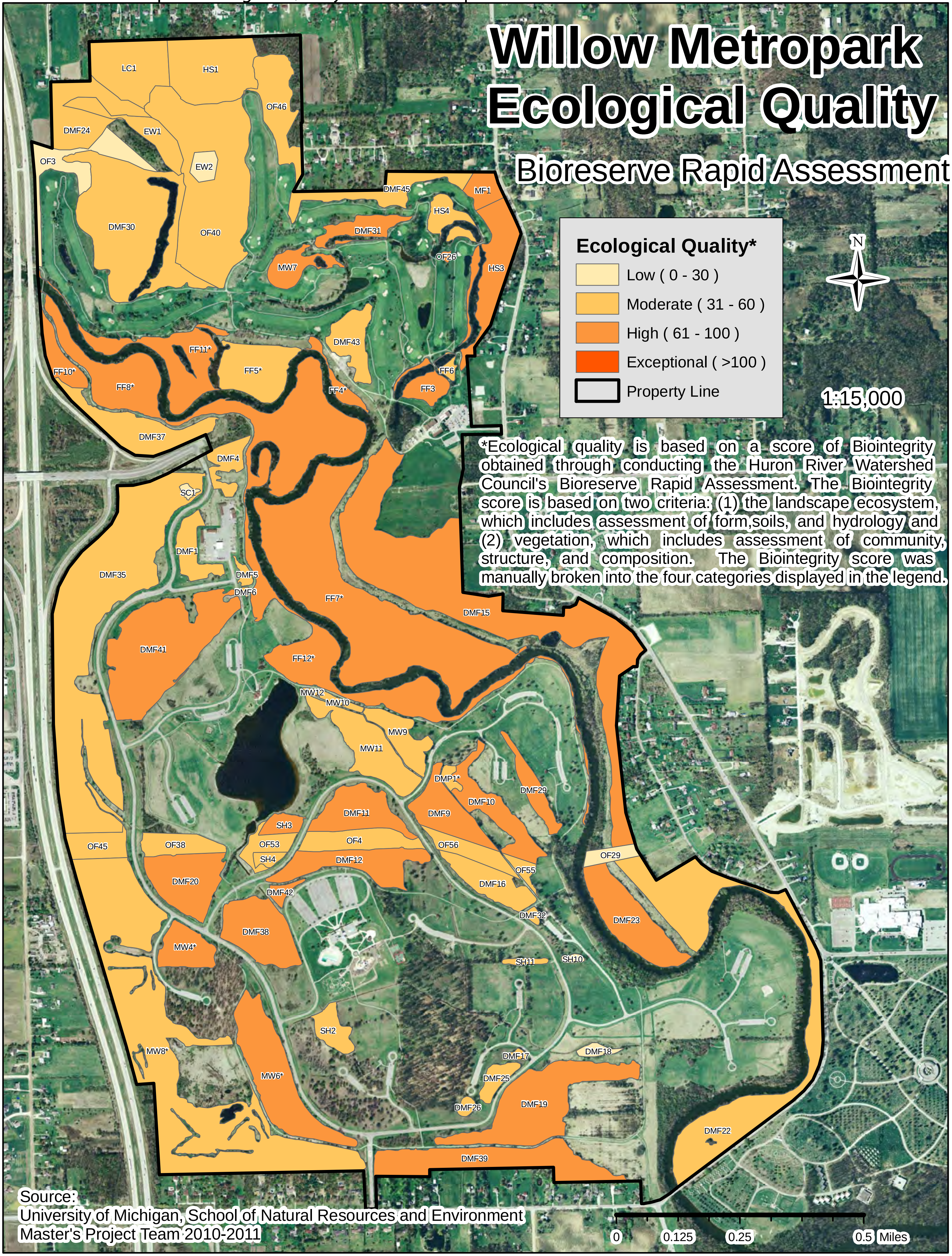
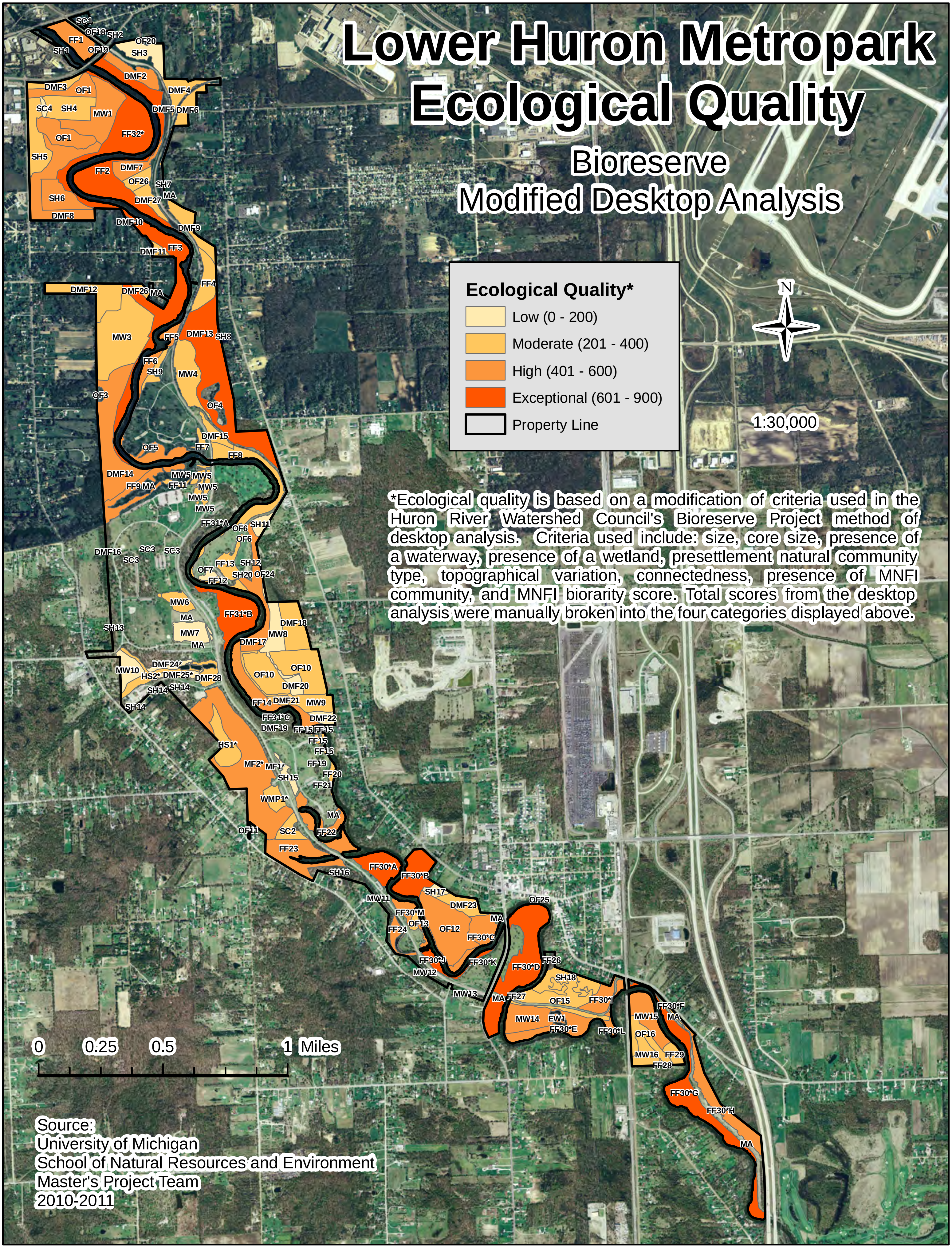
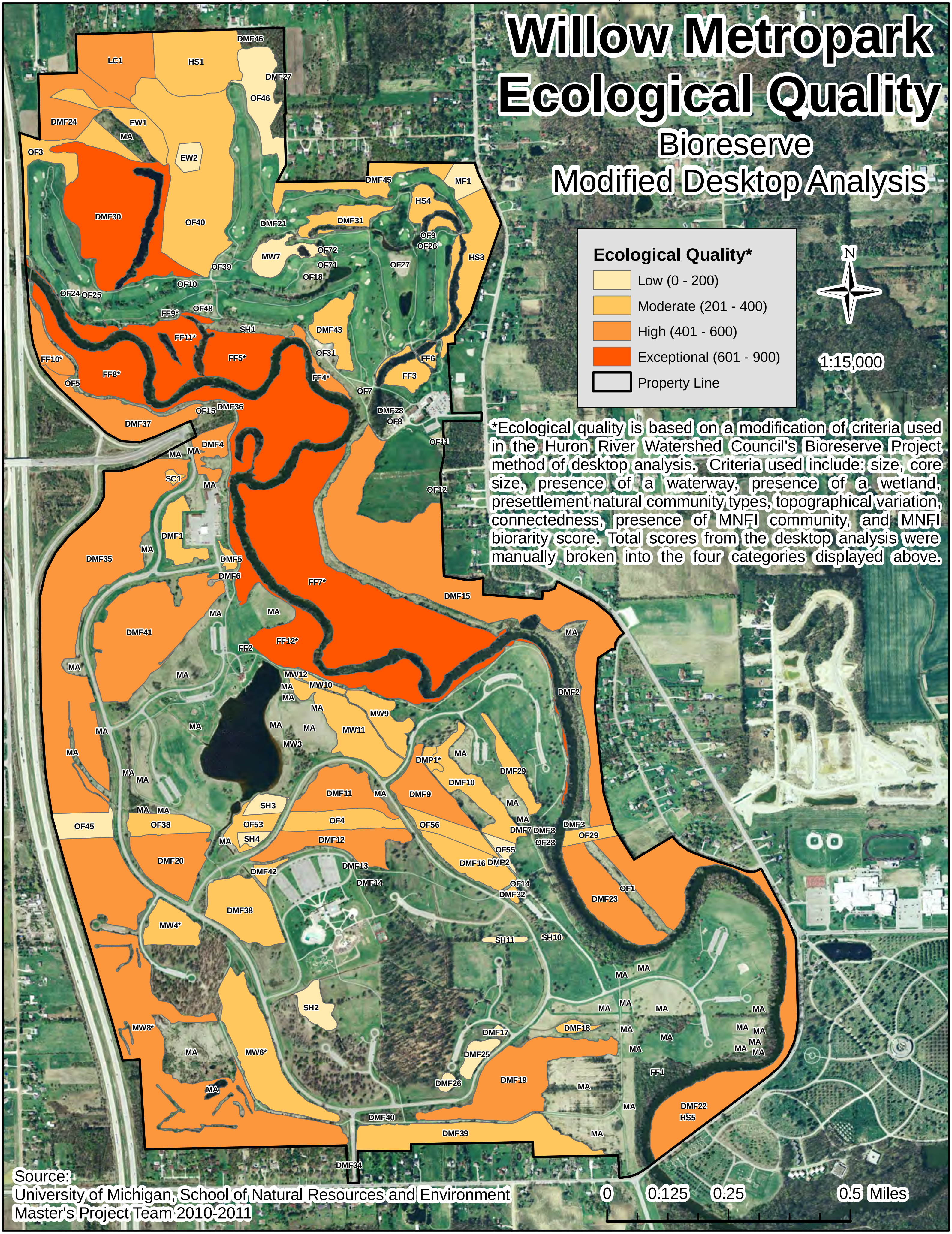
1:15,000
*Ecological quality is based on criteria currently in use by HCMA's Natural Resurce Department. This criteria includes: Florisitic Quality Index, state rankings of natural community types, elemental occurances, and wetland occurance.
Source:
University of Michigan, School of Natural Resources and Environment
Master's Project Team 2010-2011
0
0.125
0.25
0.5 Miles
DMF46
LC1
HS1
DMF27
OF46
DMF24
EW1
EW2
OF3
DMF30
OF40
DMF45
MF1
HS4
DMF21
DMF31
OF9
OF26
HS3
MW7
OF72
OF71
OF18
OF27
OF39
OF10
OF24
OF25
FF9*
OF48
SH1
DMF43
FF11*
FF5*
OF31
FF6
FF10*
FF8*
FF4*
FF3
OF5
OF7
DMF28
OF8
OF15
DMF36
DMF37
DMF4
OF11
SC1
OF12
DMF1
DMF35
DMF5
DMF6
FF7*
DMF15
DMF41
FF2
FF12*
MW12
MW10
DMF2
MW9
MW11
MW3
DMP1*
DMF29
DMF10
SH3
DMF11
DMF9
OF45
OF38
OF53
OF4
OF56
DMF3
SH4
DMF12
DMF7
DMF8
OF28
OF29
OF55
DMF20
DMF42
DMF13
DMF16
DMP2
DMF14
OF14
DMF32
OF1
DMF23
DMF38
MW4*
SH11
SH10
SH2
DMF18
MW8*
DMF17
MW6*
DMF25
DMF26
DMF19
MA
FF1
DMF22
HS5
DMF40
DMF39
DMF34


Lower Huron Metropark
Ecological Quality
Bioreserve Rapid Assessment
Ecological Quality*
Low (0- 30)
Moderate (31 - 60)
High (61 - 100)
Exceptional (>100)
Property Line
N
1:30,000
*Ecological quality is based on a score of Biointegrity obtained through conducting the Huron River Watershed Council's Bioreserve Rapid Assessment. The Biointegrity score is based on two criteria: (1) the landscape ecosystem, which includes assessment of form, soils, and hydrology and (2) vegetation, which includes assessment of community, structure, and composition.The Biointegrity score was manually broken into the four categories displayed in the legend.
0
0.25
0.5
1 Miles
Source:
University of Michigan, School of Natural Resources and Environment
Master's Project Team 2010-2011


Willow Metropark
Ecological Quality
Bioreserve Rapid Assessment
Ecological Quality*
Low (0 - 30)
Moderate (31 - 60)
High (61 - 100)
Exceptional (>100)
Property Line
N
1:15,000
*Ecological quality is based on a score of Biointegrity obtained through conducting the Huron River Watershed Council's Bioreserve Rapid Assessment. The Biointegrity score is based on two criteria: (1) the landscape ecosystem, which includes assessment of form,soils, and hydrology and (2) vegetation, which includes assessment of community, structure, and composition. The Biointegrity score was manually broken into the four categories displayed in the legend.
LC1
HS1
OF46
DMF24
EW1
OF3
EW2
DMF45
MF1
HS4
DMF30
OF40
DMF31
OF26
MW7
HS3
DMF43
FF11*
FF10*
FF5*
FF6
FF8*
FF4*
FF3
DMF37
DMF4
SC1
DMF1
DMF35
DMF5
DMF6
FF7*
DMF15
DMF41
FF12*
MW12
MW10
MW9
MW11
DMP1*
DMF29
DMF10
DMF11
DMF9
SH3
OF45
OF38
OF53
OF4
OF56
OF29
SH4
DMF12
OF55
DMF20
DMF16
DMF42
DMF32
DMF23
DMF38
MW4*
SH11
SH10
SH2
DMF18
MW8*
DMF17
MW6*
DMF25
DMF26
DMF19
DMF22
DMF39
Source:
University of Michigan, School of Natural Resources and Environment
Master's Project Team 2010-2011
0
0.125
0.25
0.5 Miles



Lower Huron Metropark
Ecological Quality
Bioreserve
Modified Desktop Analysis
Ecological Quality*
Low (0 - 200)
Moderate (201 - 400)
High (401 - 600)
Exceptional (601 - 900)
Property Line
N
1:30,000
*Ecological quality is based on a modification of criteria used in the Huron River Watershed Council's Bioreserve Project method of desktop analysis. Criteria used include: size, core size, presence of a waterway, presence of a wetland, presettlement natural community type, topographical variation, connectedness, presence of MNFI community, and MNFI biorarity score. Total scores from the desktop analysis were manually broken into the four categories displayed above.
0 0.25 0.5 1 Miles
Source:
University of Michigan
School of Natural Resources and Environment
Master's Project Team
2010-2011


Willow Metropark
Ecological Quality
Bioreserve
Modified Desktop Analysis
Ecological Quality*
Low (0 - 200)
Moderate (201 - 400)
High (401 - 600)
Exceptional (601 - 900)
Property Line
N
1:15,000
*Ecological quality is based on a modification of criteria used in the Huron River Watershed Council's Bioreserve Project method of desktop analysis. Criteria used include: size, core size, presence of a waterway, presence of a wetland, presettlement natural community types, topographical variation, connectedness, presence of MNFI community, and MNFI biorarity score. Total scores from the desktop analysis were manually broken into the four categories displayed above.
Source:
University of Michigan, School of Natural Resources and Environment
Master's Project Team 2010-2011
0 0.125 0.25 0.5 Miles
DMF46
LC1
HS1
DMF27
OF46
DMF24
EW1
MA
EW2
OF3
DMF30
OF40
DMF45
MF1
HS4
DMF21
DMF31
OF9
OF26
HS3
MW7
OF72
OF71
OF39
OF18
OF27
OF10
OF24
OF25
OF48
FF9*
SH1
DMF43
FF11*
FF5*
OF31
FF6
FF10*
FF8*
FF4*
FF3
OF5
OF7
DMF28
OF8
OF15
DMF36
DMF37
OF11
DMF4
SC1
OF12
DMF1
DMF35
DMF5
DMF6
FF7*
DMF15
DMF41
FF12*
FF2
MW12
MW10
DMF2
MW9
MW11
MW3
DMP1*
DMF29
DMF10
DMF11
DMF9
SH3
OF45
OF38
OF53
OF4
OF56
DMF7
DMF8
DMF3
OF28
OF29
SH4
DMF12
OF55
DMF20
DMF42
DMF13
DMF16
DMP2
DMF14
OF14
DMF32
OF1
DMF23
DMF38
MW4*
SH11
SH10
SH2
DMF18
DMF17
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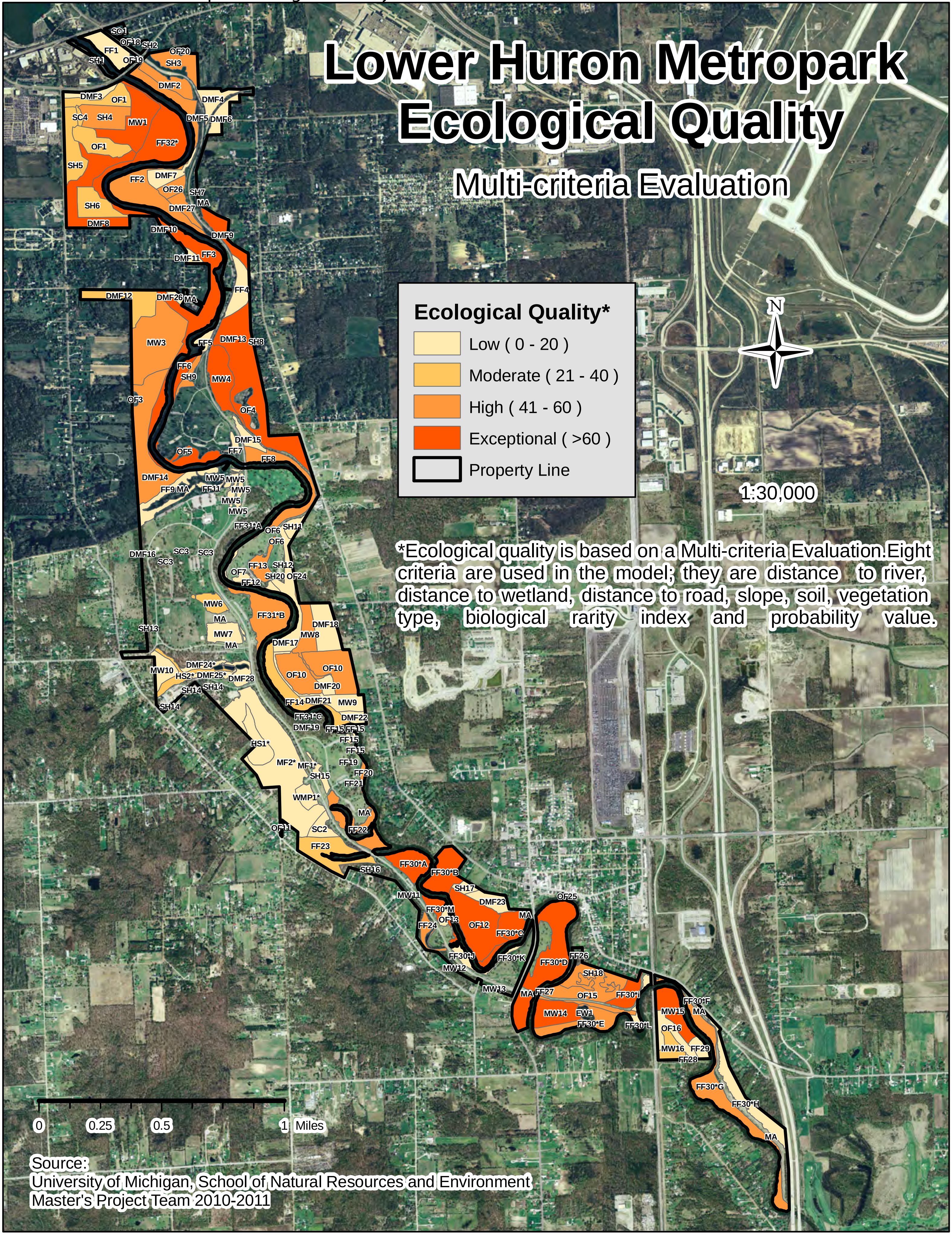
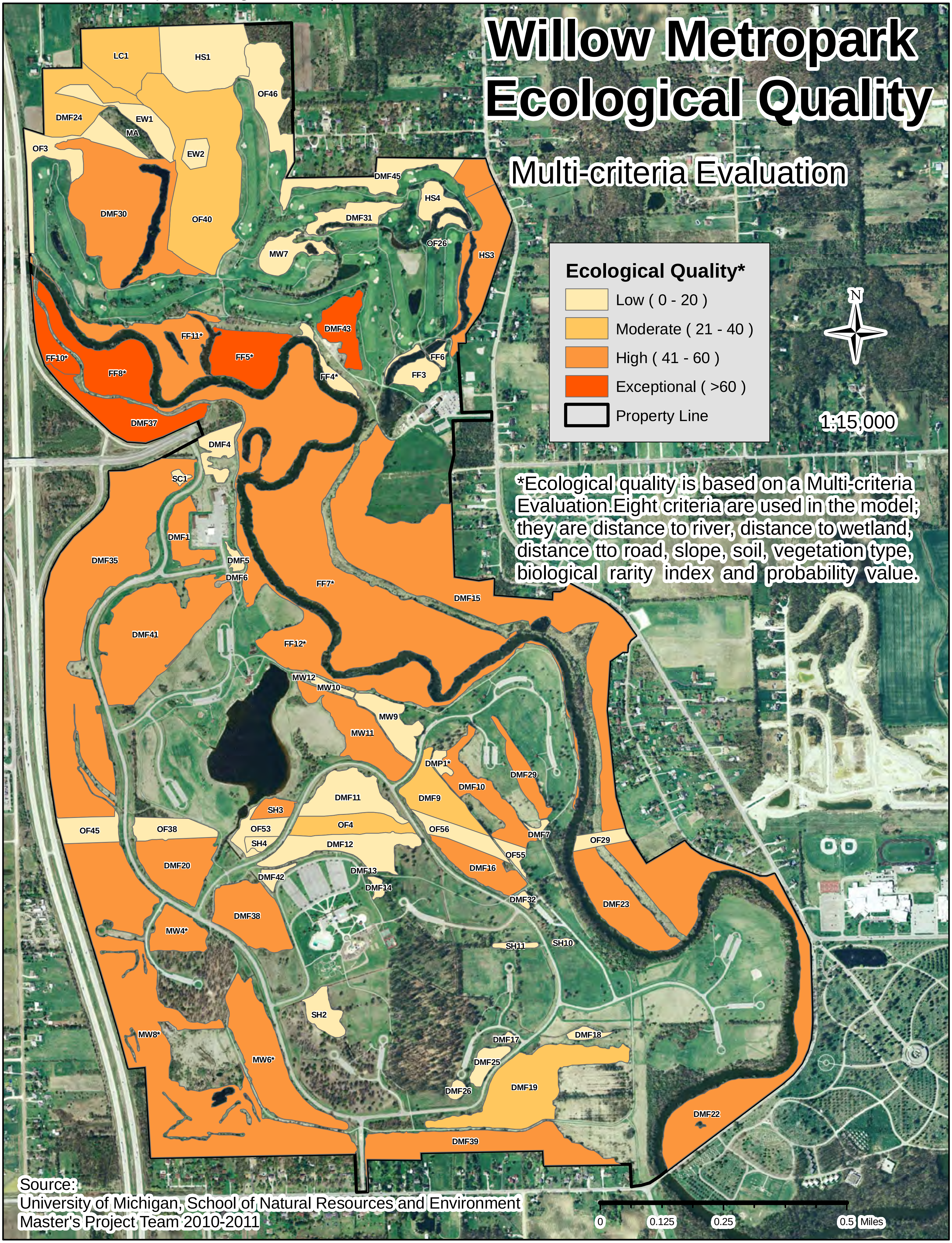
MW6*
DMF25
FF1
DMF26
DMF19
DMF22
HS5
DMF40
DMF39
DMF34



Lower Huron Metropark
Ecological Quality
Multi-criteria Evaluation
Ecological Quality*
Low (0 - 20)
Moderate (21 - 40)
High (41 - 60)
Exceptional (>60)
Property Line
N
1:30,000
*Ecological quality is based on a Multi-criteria Evaluation.Eight criteria are used in the model; they are distance to river, distance to wetland, distance to road, slope, soil, vegetation type, biological rarity index and probability value.
0 0.25 0.5 1 Miles
Source:
University of Michigan, School of Natural Resources and Environment
Master's Project Team 2010-2011



Willow Metropark Ecological Quality
Multi-criteria Evaluation
Ecological Quality*
Low (0 - 20)
Moderate (21 - 40)
High (41 - 60)
Exceptional (>60)
Property Line
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1:15,000
*Ecological quality is based on a Multi-criteria Evaluation.Eight criteria are used in the model; they are distance to river, distance to wetland, distance tto road, slope, soil, vegetation type, biological rarity index and probability value.
LC1
HS1
OF46
DMF24
EW1
MA
OF3
EW2
DMF45
HS4
DMF30
OF40
DMF31
OF26
MW7
HS3
DMF43
FF11*
FF10*
FF8*
FF5*
FF6
FF4*
FF3
DMF37
DMF4
SC1
DMF1
DMF35
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DMF6
FF7*
DMF15
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FF12*
MW12
MW10
MW9
MW11
DMP1*
DMF29
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DMF11
DMF9
SH3
OF45
OF38
OF53
OF4
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DMF7
OF29
SH4
DMF12
OF55
DMF20
DMF42
DMF13
DMF16
DMF14
DMF32
DMF23
DMF38
MW4*
SH11
SH10
SH2
MW8*
DMF18
DMF17
MW6*
DMF25
DMF19
DMF26
DMF22
DMF39
Source:
University of Michigan, School of Natural Resources and Environment
Master's Project Team 2010-2011
0
0.125
0.25
0.5 Miles

Appendix E: Herpetofauna Results and Discussion

E.1 Methods for Herpetofauna Data Analysis

Herpetofauna survey areas were created using ArcMap version 9.3.1. The data was created using the NWI wetland polygon layers for both Lower Huron and Willow Metroparks. This data includes information regarding the spatial location of surveyed wetlands by the NWI team, as well as additional attribute information. Because the team did not survey all existing NWI areas, existing polygons were assigned a score of either 0 or 1 indicating areas were data was collected. In the case that the team surveyed an area which was determined to be a possible wetland habitat area, but did not directly match an existing NWI area, a new polygon was created. This process was carried out through the digitization of aerial photos or MNFI polygons that were representative of the survey area.

After the creation of the herpetofauna survey areas, the data collected from the field surveys was tabulated to correspond with the spatially represented survey area. Each survey area was coded with a value that corresponded to the age class of each herpetofauna species observed within the wetland area [Table E.1.1]. Maps were created to depict areas in the park where herpetofauna data was collected [Maps E.1.1 and E.1.2].

Table E.1.1 Coded Values indicating observed presence and age class for herpetofauna species.

Code	Observations
-1	No Data
0	Species Unobserved
1	Observed Adult
2	Observed Larvae
3	Observed Adult and Larvae
4	Observed Egg Mass

E.2 Herpetofauna Survey Results

Lower Huron Metropark

Our team surveyed nine of the twenty-five potential herpetofauna habitat areas in Lower Huron (Map E.1.1). Herpetofauna were present in all areas surveyed except for Mixed Woodland 6 (FID 5 in the Lower Huron attribute table) where zero species were observed. In total, eleven species of herpetofauna were observed in Lower Huron (Table E.2.1). All of the observed species are considered to be common species, with the exception of the Northern Leopard Frog, *Rana pipiens*, a state listed species of concern. No salamander species were observed within any of the survey areas.

The most biodiverse survey areas were Floodplain Forests 30 B and 2 (FID 6 and 3), in which nine and six herpetofauna species were observed respectively. The third most biodiverse area was the constructed wetland in Old Field 8 (FID 8), in which we identified five herpetofauna species.

The following surveyed areas were recorded as amphibian breeding grounds based on the observed presence of larvae and/or egg masses: Hardwood Swamp 1/ Mesic Forest 2 (FID 1), Old Field 8 (FID 8), and Floodplain Forests 32, 2, and 30B (FID 2, 3, 6). Floodplain Forest 2 was the richest area in terms of amphibian age class diversity with two species being represented by larvae and adults, one species being represented by larvae only, and three species being represented by adults only.

Table E.2.1 – Lower Huron Metropark Observed Herpetofauna Species List

Scientific Name	**Common Name**
Bufo americanus	Eastern American Toad
Chelydra serpentina serpentina	Common Snapping Turtle
Chrysemys picta	Painted Turtle
Graptemys geographica	Common Map Turtle
Hyla versicolor	Eastern Gray Treefrog
Pseudacris crucifer	Northern Spring Peeper
Pseudacris triseriata	Western Chorus Frog
Rana clamitans	Green Frog
Rana pipiens	Northern Leopard Frog
Rana sylvatica	Wood Frog
Thamnophis sauritus septentrionalis	Northern Ribbon Snake

Willow Metropark

Our team surveyed seven of the thirty-one potential herpetofauna habitat areas in Willow habitat (Map E.1.2). All of these areas were observed as habitat for herpetofauna, except for Dry Mesic Forest 12 (FID 3), where zero species were observed. In total, eight herpetofauna species were observed in Willow (Table E.2.2). All of the observed species are considered common species, with the exception of the Northern Leopard Frog, *Rana pipiens*, a state listed species of concern. No salamander species were observed within any of the survey areas.

The most biodiverse survey areas in Willow were Old Field 56, a wet meadow, and Dry Mesic Forest 30 (FID 4 and 6), in which four and three herpetofauna species were observed respectively. It should be noted that while these were the most biodiverse areas in Willow, they each contain less than half the number of species found in Lower Huron's most biodiverse areas.

The following surveyed areas were recorded as amphibian breeding grounds based on the observed presence of larvae: Old Fields 4, 56, and 37 (FID 2, 4, 9) and Dry Mesic Forest 30 (FID 6). Old Field 4 (FID 2), a wet meadow located under a power line right-of-way, was the richest area in terms of amphibian age class diversity with two species being represented by larvae and adults, and two species being represented by adults only.

Table E.2.2 – Willow Metropark Observed Herpetofauna Species List

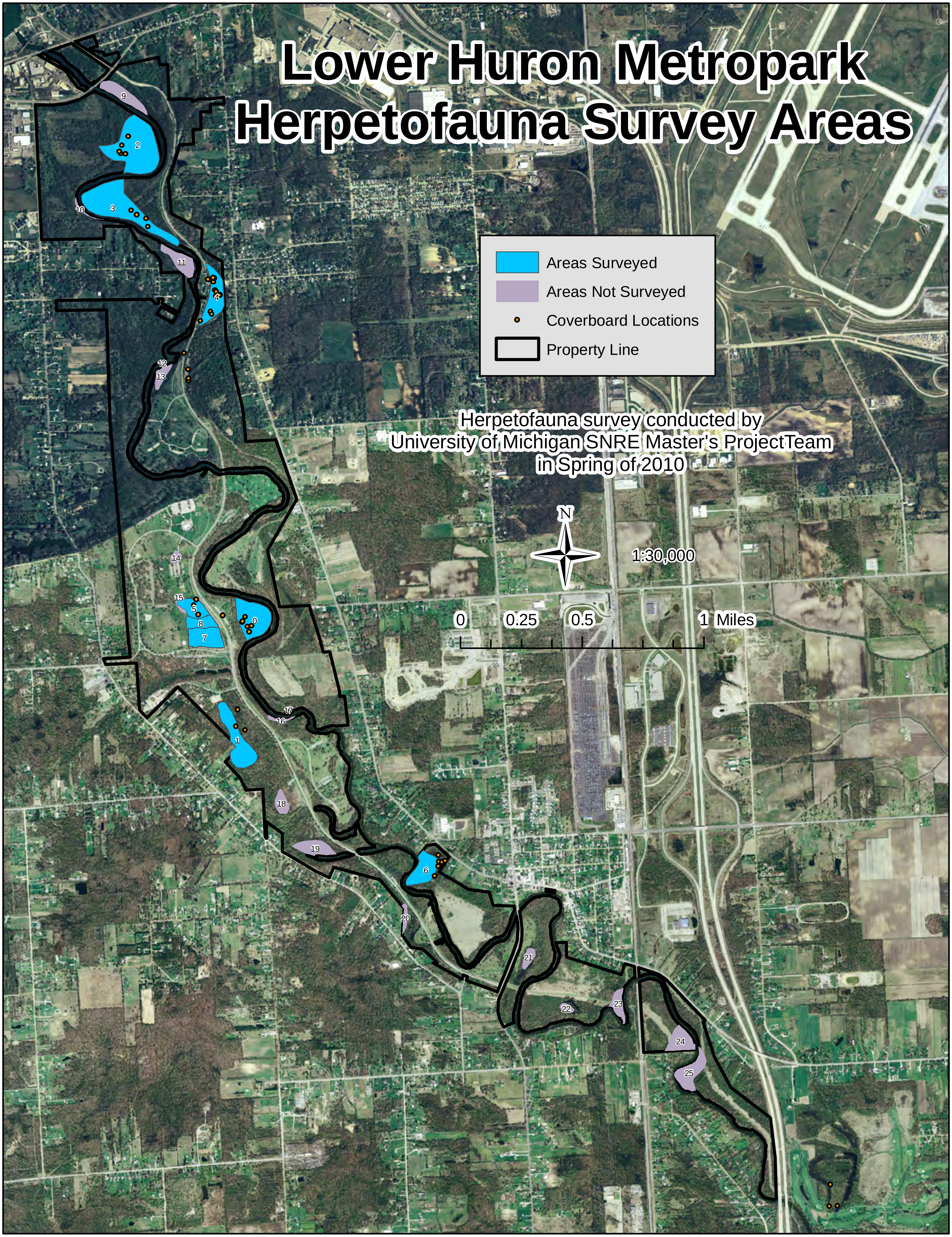
Scientific Name	**Common Name**
Bufo americanus	Eastern American Toad
Chelydra serpentina serpentina	Common Snapping Turtle
Hyla versicolor	Eastern Gray Treefrog
Pseudacris crucifer	Northern Spring Peeper
Pseudacris triseriata	Western Chorus Frog
Rana clamitans	Green Frog
Rana pipiens	Northern Leopard Frog
Rana sylvatica	Wood Frog

E.3 Discussion

Due to the limited breadth and scope of this herpetofauna data, it cannot be appropriately incorporated into the other ecological assessments, nor can it provide any insight of statistical significance. However, it may be useful to note that the species observed throughout both parks were predominantly frogs and turtles, suggesting that the wetlands within Lower Huron and Willow are suitable habitats for these particular species, and in some instances, suitable breeding grounds for wood frogs (*R. sylvatica*), western chorus frogs (*R. triseriata*), and the eastern American toad (*B. americanus*). The most biologically diverse areas, in both species and age classes, were within wet meadows beneath transmission lines that were shallow, ephemeral, and disconnected from the Huron River's surface water.

Most other wetlands occurred within floodplains along the Huron River, and as such, the direct hydrologic connection to surface water allowed for the presence of fish during high floodwaters. Fish often act as predators to amphibian eggs and tadpoles, effectively reducing amphibian populations in localized areas (Vrendenberg 2004, Semlitsch 1987). Salamanders, including the smallmouth salamander (*A. texanum*) require shallow, emphemeral, fish-free pools in order to breed (Semlitsch 1987, Ambystoma texanum, Smallmouth Salamander…[updated 2007]) For these reasons, we speculate that wetland habitats found within Lower Huron and Willow are not ideal amphibian breeding grounds, and are ill-fitted areas for salamander populations. However, as previously mentioned, our data cannot confirm this statement.

Despite the limited success of a single-season herpetofauna survey, we encourage the NRD to pursue the possibility of using wildlife data as criteria for ecological assessments. We also recommend that the NRD consider this existing data in future plans, and time their management activities appropriately. Finally, we recommend that the NRD continue to collect wildlife data, particularly herpetofauna data, as they work to develop comprehensive data sets for natural areas within the Metroparks for conservation and land management planning.


Lower Huron Metropark
Herpetofauna Survey Areas
Areas Surveyed
Areas Not Surveyed
Coverboard Locations
Property Line
Herpetofauna survey conducted by
University of Michigan SNRE Master's ProjectTeam
in Spring of 2010
N
1:30,000
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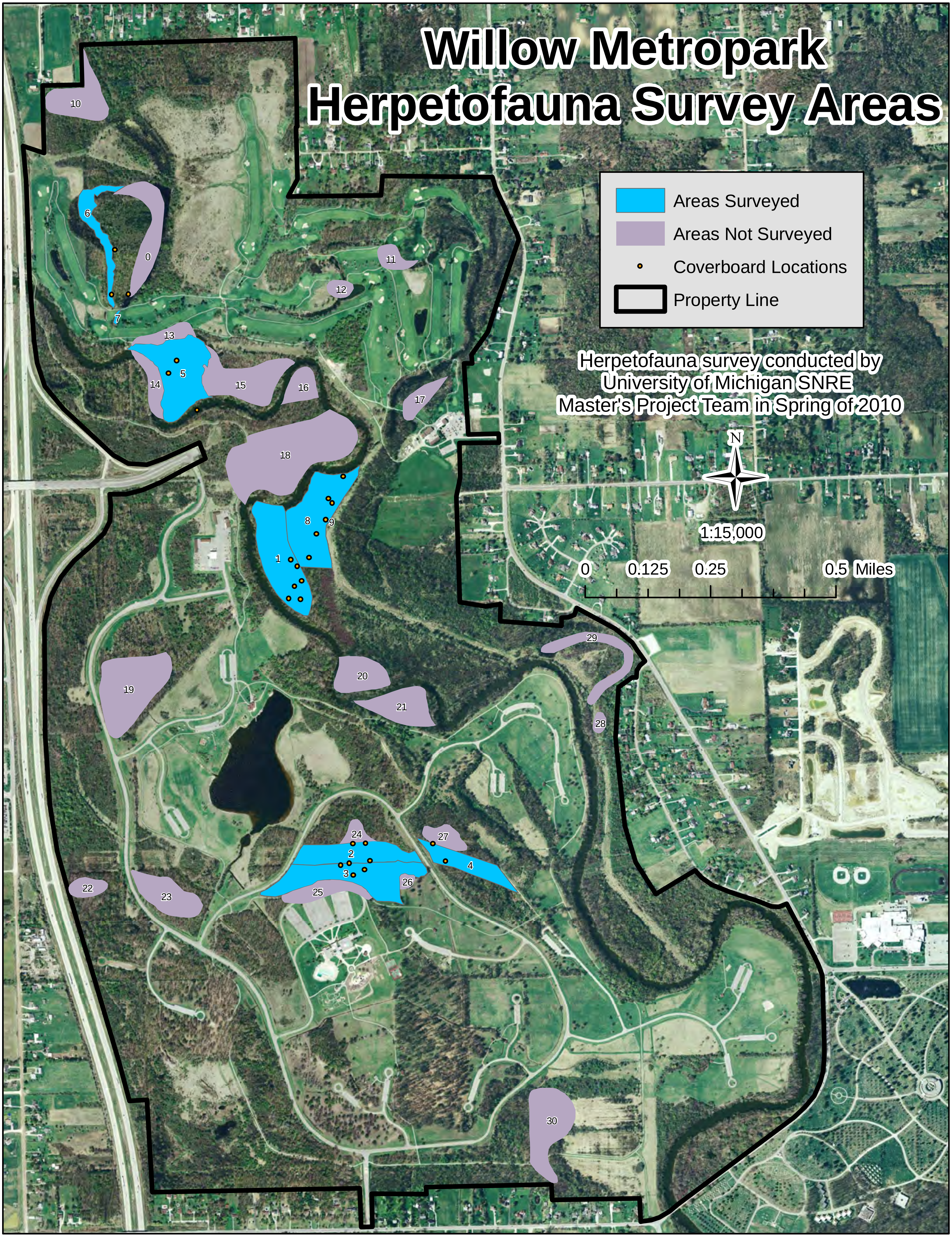
Willow Metropark
Herpetofauna Survey Areas
Areas Surveyed
Areas Not Surveyed
Coverboard Locations
Property Line
Herpetofauna survey conducted by
University of Michigan SNRE
Master's Project Team in Spring of 2010
N
1:15,000
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0.125
0.25
0.5 Miles
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Appendix F: Natural Community Descriptions

Compiled from Kost et al. (2010).

Black Ash Swamp (Northern Hardwood Swamp)

State rank: S3

Overview and Landscape Context

A northern hardwood swamp is a seasonally inundated, deciduous swamp forest that is dominated by black ash (*Fraxinus nigra).* These ecosystems are typically found in depressions on glacial lake plains, glacial tills, and outwash plains. They occur on poorly drained soils in areas that flood seasonally or have high water tables. Vernal pools are common in these ecosystems. The microclimate of northern hardwood swamps is typically cooler than that of surrounding areas because these ecosystems are found in depressions

Soils

In northern hardwood swamps, a shallow layer of muck overlays poorly drained mineral soil. The soil type is typically a sandy clay loam. Usually these areas are perched over a clay layer, further contributing to drainage problems.

Natural Processes

The most common disturbance in a northern hardwood swamp is seasonal flooding, leading to a plant community composed of species adapted to wet conditions, and is highly dependent on the timing, extent, and duration of flooded conditions. Drought is less common of a problem in northern hardwood swamps because of the high water-retaining capabilities of the soils. Wind throws can also play a large role in community makeup by altering microtopography, adding pits and mounds.

Vegetation

The dominant canopy is mostly composed of black ash, though other species may be present. The subdominant layer is the shrub and sapling layer. The ground flora is a unique characteristic of northern hardwood swamps, as it is seasonally and spatially patchy due to flooding

Animals

Black ash provides an important food source for many wildlife species. The seeds and leaves can provide food for a number of fauna. Beavers can alter the hydrology of areas, causing extensive flooding and eventual mortality of many species.

Oak Barrens (Black Oak)

State Rank: S1

Overview and Landscape Context

Oak barrens are fire-dependent savannas, dominated by oaks with 5-60% canopy cover. They occur on droughty glacial outwash with sandy soils, and are restricted to the driest of landscape types.

Soils

Typical soils for an oak barrens are infertile, coarsely-textured, well-drained sand or loamy sand with little organic matter. They are usually medium to slightly acidic with low water retention capabilities.

Natural Processes

Repeated low-intensity fires, drought, frost, and wind throw maintain oak savanna ecosystems. When these conditions are combined with infrequent, high-intensity fires, mature oaks are killed and barrens conditions are created. Oak barrens are also characterized by scattered ant mounds which play a crucial role in the development of soils. A dense herbaceous litter layer preserves open canopy conditions and limit s seedling establishment.

Vegetation

The canopy layer is dominated by black oak, with other types of oak being subdominant. A shrub layer may or may not be present. The graminoid ground layer is representative of prairie and forest communities.

Animals
Oak barrens support a rich diversity of invertebrates such as butterflies, skippers, grasshoppers, and locusts. Mound-building ants play a large role in ecosystem function and soil development.

Bog
State Rank: S4

Overview and Landscape Context
A bog is a nutrient-poor peatland characterized by acidic, saturated peat and the prevalence of sphagnum mosses and ericaceous shrubs. They occur in kettle depressions on glacial moraines, outwash, and lake plain landscapes. Bogs can occupy entire basins or can occur as floating or grounded vegetation mats along the margins of lakes.

Soils
The soils of bogs are composed of saturated fibric peat that contains partially decomposed organic matter. The soils are very acidic, cool, and characterized by low levels of nutrients and dissolved oxygen. The water tables in bogs are near the surface of the soil due to the water-retaining ability of sphagnum peat.

Ecosystem Processes
Water-logged conditions inhibit the decomposition of organic matter, allowing for the accumulation of peat. Under these cool, anaerobic and acidic conditions, organic matter accumulates much faster than it decays. The establishment of sphagnum on a peat mat leads to the maintenance and enhancement of saturated, acidic conditions, thus promoting further peat accumulation. Peat mats develop and expand in two different ways: lake-filling and paludification. Lake-filling occurs in calm lakes where peat can accumulate and form a floating or grounded mat. Paludification is the accumulation of peat over soil in terrestrial ecosystems. In both cases, the ecosystem is eventually isolated from the influence of groundwater.
Disturbances common to bogs include fire, flooding, wind throw, and insects. Fire maintains the ecosystems by killing encroaching trees. Fire frequency and severity is dependent on water levels and adjacency to areas that also burn. Drought allows the peat mat to dry out and can lead to fire. Flooding maintains bog conditions and can kill the roots of trees when water levels rise high enough. Insect outbreaks limit plant survival in bogs and can significantly influence plant community makeup.

Vegetation
Bogs are characterized by a mat of sphagnum moss, a species-poor herbaceous layer, and low, ericaceous, evergreen shrubs, and scattered and stunted conifer trees.

Animals
An animal population in most bogs is low because of the low productivity and general inedibility of bog vegetation. High acid levels in the water and soil inhibit animal colonization of bogs. Beavers can influence flooding patterns of bogs.

Dry-Mesic Forest (Northern)
State Rank: S3

Overview and Landscape Context
A northern dry-mesic forest is a pine or pine-hardwood forest that typically occurs on sandy glacial land types.

Soils
Acidic sandy loams and sands are typical soils of northern dry-mesic forests. A surface layer of more humus (mostly undecomposed plant matter) accumulates due to the accumulation of pine needles
Natural Processes
Infrequent, intense fires and frequent moderate fires are typical disturbances in northern dry-mesic forests. Wind throw and insect outbreaks are also common disturbances.

Vegetation
White pine is usually the dominant canopy species in northern dry-mesic forests. There is typically a shrub and herbaceous subcanopy and ground layer. Parasitic and saprophytic plants are also common in northern dry-mesic forests.

Animals
Northern dry-mesic forests provide nesting habitat for migrating birds, especially those that nest in forest interiors.

Dry-Mesic Prairie
State Rank: S1

Overview and Landscape Context
A dry-mesic prairie is a native grassland community dominated by grasses. This community occurs on level to gently sloping sites of glacial outwash, coarse-textured end moraines, and glacial till plain. These ecosystems are associated with historic oak openings. Today this community is almost entirely restricted to railroad right-of-ways, which typically border agricultural fields.

Soils
The soils of dry-mesic prairies are typically strongly acidic to circumneutral sandy loams or occasionally loamy sand. The soils usually have a moderate water-retaining capacity.

Natural Processes
Fire maintains the o0pen conditions characteristic of dry-mesic prairies. Fires also suppress the encroachment of woody plant species.

Vegetation
Grasses and sedges dominate dry-mesic forests while the subdominant layer is composed of herbaceous species.

Animals
Ants play an important role in mixing and aerating soils. Moles, mice, skunks and badgers also play a large role in soil mixing and aeration. Large herbivores also alter ecosystem processes in dry-mesic prairies.

Emergent Marsh/Emergent Wetland
State Rank: S4

Overview and Landscape Context
An emergent marsh is a shallow-water wetland that occurs along the shores of lakes and streams. It is characterized by emergent herbs and grass0like plants as well as floating herbs. Emergent marshes line the margins of many streams and inland lakes, as well as protected portions of the Great Lakes shoreline, in which case it is classified as a Great Lakes marsh.

Soils
Emergent marshes develop on all textures of glacial sediment. Typically accumulations of circumneutral to alkaline fine organic sediments overlay mineral soils. In cases where acidic soil conditions exist, these wetlands develop into peatlands rather than remain as a marsh.

Natural Processes
Emergent marshes are subject to frequent, seasonal flooding. Seedling recruitment occurs in periods of low water levels. Flooding creates anoxic conditions and promotes the accumulation of peat. Beavers can alter hydrologic processes and muskrat feeding can create openings that can be colonized by submergent and floating herbs.

Vegetation
Emergent marshes are dominated by a wide variety of emergent and floating herbaceous plant species. Marsh vegetation is usually divided into distinct zones. Along the drier margins grasses and sedges dominate. Closer to the open water, species diversity is restricted due to waves or current, anaerobic conditions, and deeper water. Most species in the outer marsh are perennial rhizomatous plants adapted to aquatic conditions.

Animals
Emergent marshes support a broad diversity of aquatic invertebrates. Muskrats and beavers often drastically alter hydrologic regimes. Seasonal flooding provides habitat and spawning grounds for fish and other organisms.

Floodplain Forest
State Rank: S3

Overview and Landscape Context
A floodplain forest is a bottomland, deciduous or deciduous-conifer forest. These communities occupy low-lying areas adjacent to streams and rivers and are influenced greatly by periodic over-the-bank flooding and cycles of erosion and deposition. Species composition can be altered by the frequency and duration of flooding.

Soils
The soils found in floodplain forests are highly variable and characteristic of fluvial landforms. Progressively finer soil particles are deposited with increasing distance from the stream. Periodic flooding inhibits the accumulation of organic soils. Farther from the stream, lower frequency of flooding, lower velocity and prolonged saturation can lead to the accumulation of sapric peat. These soils are generally circumneutral to mildly alkaline, and are characterized by high nutrient availability.

Natural Processes
Disturbances in floodplain forests include over-the-bank flooding, bank cutting and sedimentation. These processes can contribute to the frequency of tree falls and wind throws. Debris alters ecosystem processes, such as nutrient cycling, and community makeup. Riparian vegetation slows the flow of water and decreases the transportation of sediments. Floodplain forests are the areas where terrestrial and aquatic ecosystems directly interact with each other. Floodplain forests vary because of many processes and changes in nutrient cycling.

Vegetation
Natural disturbances common to stream channels cause vegetation in floodplain forests to be composed of small patches of different species compositions and successional stages. Trees compose the dense canopy layer, while the ground layer is composed of herbaceous plants.
Animals
Large, continuous tracts of mature floodplain forests provide habitat for cavity nesters, species of detritus-based food webs, canopy-dwelling species, and interior forest obligates, including numerous neotropical migrants.

Hardwood Swamp (Southern)
State rank: S3

Overview and Landscape Context
A southern hardwood swamp is a forested wetland with no conifers that occurs over mineral or organic soils that occupy poorly drained shallow depressions and stream drainages.

Soils
Soils in hardwood swamps are usually loam or silt loam, but can be sandy or clay loam. Usually these soils are of neutral or slightly alkaline pH with a thin layer of muck. These ecosystems usually are perched above a layer of clay which contributes to drainage problems.

Natural Processes
Seasonal flooding contributes to harsh conditions in hardwoods swamps. Anaerobic conditions lead to increased wind throw. Increased wind throws cause pits and mounds and contribute to changes in microclimate. Large pieces of woody debris line the ground of hardwood swamps.

Vegetation
Dominance patterns in hardwood swamps vary, based on characteristics of substrate, hydrologic patterns, and regional vegetation distributions. Typically, the ground layer of hardwood swamps is scarce due to flooding patterns.

Animals
Beavers can alter hydrology in hardwood swamps, and can convert these ecosystems into different wetland types.

Lowland Conifer (Rich Conifer Swamp)
State Rank: S3

Overview and Landscape Context
A lowland conifer ecosystem is a groundwater-influenced, minerotrophic, forested wetland dominated by northern by northern white-cedar (*Thuja occidentalis*) that occurs on organic soils. This community has also been referred

to as cedar swamps. These communities occur on outwash landforms and in depressions on moraines. Cold air drains from surrounding uplands causing condensation to collect on plants, providing a constant source of nocturnal moisture. The drainage of cold air can also cause nighttime temperatures to drop below freezing throughout the growing season. The insulating properties of sphagnum moss allow ice to remain within the upper layers of soil through mid-summer, and to remain unfrozen into winter months. Thus, rich conifer swamps have shorter, cooler, and more humid growing seasons than surrounding areas.

Soils
The soils in rich conifer swamps are composed of saturated, coarse woody peat and may vary significantly in depth of organic matter. They range from neutral to moderately alkaline but very may be strongly acidic near the surface where sphagnum mosses dominate the ground layer.

Natural Processes
Seasonal and beaver flooding, groundwater influence, wind throw and fire are the most common disturbances in rich conifer swamps. Constant saturation and inundation causes the rooting zone in lowland conifer areas, which increases the chances of wind throw.

Vegetation
The canopy of a rich conifer swamp is dominated by northern white cedar, which is a short tree that often forms a dense, low canopy preventing the establishment of other tree species. Further impeding the establishment of seedlings are the root hummocks of northern white-cedar, which are often elevated to avoid water in the soil. Tall and low shrubs are common, especially within recent windfalls. Mat-forming mosses can also cover large portions of these ecosystems.

Animals
These systems provide critical winter habitat for deer and snowshoe hare. Beavers can cause flooding resulting in plant mortality.

Mesic Forest (Southern) (also Beech-Maple Forest)
State rank: S3

Overview and Landscape Context
A southern mesic forest is dominated by beech and sugar-maple. Historically, this forest type occurred as a matrix system, dominating vast areas of the Great Lakes region. Multi-generational forests were common with old-growth sections that lasted for many centuries. . This community type is found on flat or rolling topography such as end moraines and glacial lake plains.

Soils
Soils in mesic forests are highly variable, though loam is the predominant texture. Soils are usually well-drained with high water retaining capabilities. High decomposition rates maintain high nutrient levels as well as soil organism populations. Soil pH is also highly variable in mesic forests.

Natural Processes
Disturbances in mesic forests typically take the form of wind disturbance and gap-phase dynamics, indicating that these ecosystems are constantly going through different stages of succession. Frequent small-scale disturbance generates a mosaic of different-aged forest patches. Infrequent large scale disturbances maintain multi-generational communities.

Vegetation
Canopy species usually dominate in mesic forests, though there commonly is a prolific subcanopy. Ground layer flora is defined by spring ephemerals, high diversity, and a highly homogenous community makeup.

Animals
Large patches of old-growth mesic forest provide habitat for cavity nesters, canopy dwellers, interior forest obligates, and members of detritus-based food webs. Vernal pools in these ecosystems provide critical habitat for herpetofauna.

Mixed Conifer Swamp (Hardwood-Conifer Swamp)
State Rank: S3

Overview and Landscape Context
A mixed conifer swamp is a wetland forest dominated by both hardwoods and conifers. It occurs on a variety of landforms with poorly drained soils. These areas are often associated with groundwater discharge. These ecosystem types are typically associated with headwater streams or shallow kettle depressions. In areas where peat accumulates, these areas turn into bogs or muskegs. Mixed conifer swamps are typically narrow (less than 500m).

Soils
Soils in mixed conifer swamps are highly variable, even within a single stand of trees. The most common soil type is a thin organic layer atop poorly drained mineral soils. Organic matter is composed of highly decomposed muck that occasionally contains pieces of coarse wood. Mineral soils are often acidic, but that is also variable due to groundwater influence and vegetation type.

Natural Processes
Mixed conifer swamps are highly influenced by seasonal flooding and groundwater. Due to the high water table, wind throw also is a common disturbance in these areas. Common plant species in these ecosystems preferentially establish themselves on hummocks or decaying logs. Hydrologic patterns influence plant species composition.

Vegetation
The canopies of these areas depend on soil characteristics and site disturbance history. The subcanopy can be open or closed, but is typically composed of small trees and tall shrubs. Ground layers in these areas are often sparse due to low light conditions, but are dominated by moss- and litter-covered hummocks and saturated or inundated hollows on muck soils. These hollows are typically less colonized by plants than the hummocks or large woody debris. In the canopy and along streams, vines are often conspicuous.

Animals
Beavers can significantly alter plant community structure through flooding, hydrologic change and herbivory. Insect outbreaks and plant parasites can also alter plant community composition and structure.

Mixed Hardwood Swamp (Mesic Northern Forest)
State Rank: S3

Overview and Landscape Context
A mesic northern forest is a forest of moist to dry-mesic sites dominated by northern hardwoods. It is typically found on coarse-textured ground and end moraines. They are also common on silty and clayey lake plains, thin glacial till over bedrock, and medium-textured moraines. This community type usually occurs on kettle-kame topography on moderately well-drained to well-drained soils.

Soils
Soils in mesic northern forests are highly variable, but most typical are loamy sand and sandy lam. Also highly variable is soil pH, ranging from medium to extremely acidic.

Natural Processes
Frequent, small-scale wind disturbance and gap-phase dynamics are the most common disturbances in mesic northern forests. Long intervals between large-scale disturbance events cause multi-generational communities in these forests. Low-intensity fires sometimes affect community makeup in these forests as well.

Vegetation
Sugar maple and other hardwoods typically dominate the canopy in mesic northern forests, and conifers often subdominate. The proportion of conifers and hardwoods other than sugar maple increases with influence of water. A shrub layer and herbaceous layer are also present, and typically dominated by upland plants.

Animals
Mesic northern forests provide habitat for cavity nesters, canopy-dwellers, interior forest obligates and detritus-based food webs.

Mixed Woodland
State Rank: Unranked

Overview and Landscape Context
A mixed woodland is not an ecosystem type defined by MNFI; it is defined by HCMA. A mixed woodland is an old field in which shrubs and trees have invaded (Gajewski, personal comm, February 2011).

Mixed Oak Forest (Dry Southern Forest)
State Rank: S3

Overview and Landscape Context
A mixed oak forest is a dry, fire-dependent forest type that usually occurs on glacial outwash, and less frequently on sandy dunes, glacial lake plains and moraines. This ecosystem usually occurs with other fire-dependent systems, both upland and wetland.

Soils
Soils in mixed oak forests are usually infertile, well-drained, sand, loamy sand or sandy loam. These soils usually have a medium to strongly acidic pH and low water-retention.

Natural Processes
Common disturbances in mixed oak forests are fire, wind throw, and insect and pathogen outbreaks. Low-productivity soils with little water-retaining capabilities influence plant community structure. Fires sustain oak regeneration and reduce populations of pathogens and soil acorn predators. Prolonged fire suppression in mixed oak forests results in a closed canopy.

Vegetation
The canopies in mixed oak forests are dominated by black and white oak. The subcanopy layer is dominated by shrubs.

Mixed Oak Savanna (Oak Opening)
State Rank: S1

Overview and Landscape Context
Mixed Oak Savannas are fire-dependent areas dominated by oaks, with 10-60% canopy. These communities usually occur on dry-mesic loams on the level to rolling topography of outwash plains and end moraines. These communities are known primarily from historical literature and data derived from severely disturbed sites, as these communities have been nearly extirpated from Michigan.

Soils
Oak openings typically have well-drained, moderately fertile sandy loam or loam soils. They are slightly acidic to neutral pH with moderate water retention capabilities.

Natural Processes
Repeated low-intensity fires, drought, and wind throw maintain open conditions in oak savanna systems. Nearly annual fires were most likely the primary disturbance factor in mixed oak savannas. Abundant grass and herbaceous litter maintain fire regimes. Mound-building ants play a crucial role in soil development in mixed oak savannas.

Vegetation
Oak openings were described by Michigan settlers as park-like savannas of widely spaced mature oaks, with a wide range of shrub cover above the forb and graminoid ground layer. The flora of a mixed oak savanna is representative of prairie and forest ecosystems. Many species are savanna specialists that thrived in mottled light conditions. The canopy is dominated by white oaks with codominants including bur oak and chinquapin oak. A shrub layer may or may not be present. The herbaceous layer is dominated by graminoid species associated with prairie and forest communities.

Animals
These communities supported a rich diversity of invertebrates including butterflies, skippers, grasshoppers, and locusts. Mound-building ants significantly influence soil development in these areas.

Muskeg
State Rank: S3

Overview and Landscape Context
A muskeg is a nutrient poor peatland characterized by acidic, saturated peat, and scattered or clumped, stunted conifer trees mixed amongst sphagnum mosses and ericaceous shrubs. Muskegs occur on broad, flat areas or mild depressions of glacial outwash and glacial lake plains. They also occur on pitted outwash and moraines.

Soils
Soils in muskegs are composed of a layer of peat overlaying sand. Peat depth is typically greatest near the center of a peatland and decreases toward the edges of the peat mat or in areas where groundwater influences acidity and nutrient levels. The rooting zone in muskegs is shallow, only where there is sufficient dissolved oxygen to permit aerobic respiration.

Natural Processes
Saturated conditions inhibit decomposition of organic matter leading to the accumulation of peat. Peat mats develop and expand in two different ways: lake-filling and paludification. Lake-filling occurs in calm lakes where peat can accumulate and form a floating or grounded mat. Paludification is the accumulation of peat over soil in terrestrial ecosystems. In both cases, the ecosystem is eventually isolated the area from the influence of groundwater. Given stable hydrology and a lack of fire, muskegs can persist for hundreds of years. Trees in muskegs are particularly threatened by wind throw, because peat provides a poor substrate for anchoring themselves. Parasites and insect pests contribute to the mortality of plants in muskegs.

Vegetation
Plant communities in muskegs are characterized by a poor herbaceous layer dominated by sedges and a hummocky carpet of sphagnum moss, low ericaceous, evergreen shrubs, and widely scattered or clumped, stunted conifers. The community is homogenous and of limited diversity, exhibiting uniform structure and composition across their range.

Animals
Animal populations in muskegs are low because of the low productivity of peatland plants, general inedibility of vegetation, and high acidity of peat.

Oak Barrens
State Rank: S1

Overview and Landscape Context
An oak barren is a fire-dependent savanna dominated by oaks. The canopy layer is sparse and the ecosystem may or may not have a shrub layer. The ground layer is composed of species associated with both prairie and forest communities. Oak barrens occur on well-drained glacial outwash or sometimes on sandy moraines or ice-contact features on the driest landscape positions

Soils
Soils of oak barrens are infertile, coarsely-textured, well-drained sand or loamy sand. These soils are medium pH to slightly acidic with low water-retaining capabilities. They contain little organic matter or fine-textured soil particles that are characteristic of more productive soils.

Natural Processes
Low-intensity fires, drought, frost, and wind throw work together to maintain oak savanna ecosystem. Fires prevent canopy closures and dominance of woody vegetation. These ecosystems often have scattered ant mounds. These ants play a crucial role in the maintenance of these systems, aerating and mixing soil horizons. Herbivores limit the establishment and growth of woody plants. A dense layer of herbaceous litter maintains fire regimes an open canopies.

Vegetation
The sparse canopy layer of oak barrens usually varies from 5-60% cover and is dominated by black or white oak (*Quercus velutina, Q. alba)*. There is usually a sparse shrub layer. The ground layer is dominated by graminoids and forbs. Invasive species are often common in these ecosystems.

Animals
Oak barrens and the prairie habitats that surround them have historically supported a rich diversity of invertebrates. Mound-building ants are often prevalent and can influence nutrient cycles and other ecosystem processes.

Oak-Hickory Forest (Dry-Mesic Southern Forest)
State Rank: S3

Overview and Landscape Context
An Oak-Hickory forest is a fire-dependent forest that occurs on various types of glacial landforms.

Soils
Usually, soils in oak-hickory forests occur on sandy loams or loams. Slightly acidic to neutral pH is typical.

Natural Processes
The most important disturbances that occur in these forests are fire, wind throw, insect outbreaks and pathogens. Frequent, low-intensity fires encourage oak regenerations and decrease populations of pathogens and soil organisms that attack acorns. Small-scale disturbances encourage gap-phase dynamics and leads to different stages of succession in these areas.

Vegetation
The canopy of oak-hickory forests is usually dominated by white and black oak. Codominant canopy species include red oak, pignut hickory, shagbark hickory, and bitternut hickory. There is usually a shrub and herb layer present in the understory.

Old Field
State Rank: Unranked

Overview and Landscape Context
An old field is not an ecosystem type defined by MNFI; it is defined by HCMA. It is an open area that used to be used for agriculture (Gajewski, Personal comm, Feb 2011)

Shrub-Carr
State Rank: S5

Overview and Landscape Context
A southern shrub-carr is a moderate to long-persistent successional shrub community. This community type is intermediate among open, herbaceous wetlands and forested wetlands. These communities usually occur as bands along streams, rivers, and lakes, on glacial lake plains and outwash plains, within outwash channels and depressions on ice-contact topography and moraines. Sites usually have little to no slope. This community often occurs as a part of a larger wetland complex, as a transitional zone.

Soils
Shrub-carrs are usually found on seasonally inundated, saturated organic soils. Soils are typically neutral to mildly alkaline and have excessive water-retention capabilities.

Natural Processes
Shrub-carrs typically originate when shrubs invade wetlands following fire suppression or alterations to hydrologic processes. Frequent disturbance allows the persistence of a shrub-carr rather than allowing the transition to a forested community. Though these ecosystems are adapted to seasonal flooding, prolonged high water levels can kill shrubs and convert the area to different types of wetlands depending on the ecosystem type.

Vegetation
Shrub-carrs typically have three distinct vegetation layers: a dominant shrub layer; an intermediate layer of short shrubs, sedges and tall herbaceous layer; and a third layer of small herbaceous species. Vegetation is highly variable.

Animals
The prevalence of fruit provides foraging habitat for migrating and over-wintering songbirds. Large ant mounds observed in shrub-carrs indicate that the area most likely was an open herbaceous wetland prior to shrub colonization.

Shrubland
State Rank: Unranked

Overview and Landscape Context
A shrubland is an ecosystem that is not defined by MNFI; it is defined by HCMA. It is an old field that has been invaded by shrubs (Gajewski, personal comm, February 2011)

Shrub Swamp (Inundated)
State Rank: S3

Overview and Landscape Context
An inundated shrub swamp is characterized by poor-drainage that nearly continuously inundated or saturated, and is typically dominated by buttonbush (*Cephalanthus occidentalis*). These communities typically occupy kettle depressions on outwash and sandy lake plains.

Soils
Inundated shrub swamps typically have shallow muck over clay. Acidity ranges from strongly acidic to moderately alkaline. Organic portions of the soil are more acidic than mineral portions. Soils usually remain inundated throughout the year, but may become dry during periods of persistent drought.

Natural Processes
An inundated shrub swamp is successionally intermediate between emergent swamp and a swamp forest. This community usually becomes established as shrubs become tolerant of long periods of inundation.

Vegetation
This community typically exhibits a scattered shrub-dominated overstory and sparse herbaceous cover. The most dominant species in the shrub layer is buttonbush, which represents 50% of the cover of the shrub canopy. Frequent flooding and prolonged inundation causes the sparse herbaceous layer. The only rare plant found in inundated shrub swamps is *Wolffia papulifera* (water-meal, state threatened).

Animals
This community provides critical breeding habitat to amphibians and aquatic invertebrates. Snakes also use this area for foraging habitat.

Wet Prairie
State Rank: S2

Overview and Landscape Context
A wet prairie is a native lowland grassland occurring on level, saturated or seasonally inundated floodplains, lake margins, and isolated depressions. It is typically found on outwash plains and channels near moraines.

Soils
Soils of wet prairies are usually sandy or silty loam but can also be silty clay or clay. Wet prairie soils usually have a neutral pH, high organic content, and good water-retaining capacity. Muck is not present or forms only a thin layer over mineral soils.

Natural Processes
Fluctuating water levels and fires help to maintain biological diversity and open conditions. Seasonal saturation and/or inundation restrict the establishment of trees and shrubs. Fire facilitates the germination of seeds, opens microsites for seedling establishment and growth of small species, and releases nutrients

Vegetation
Grasses and sedges dominate the plant communities of wet prairies, with a subdominant herbaceous layer. Invasive species, specifically *Phalaris arundinaceae* (reed canary grass) are common in some cases. Diversity is variable.

Animals
Beavers alter hydrologic patterns and can significantly influence water levels and flooding patterns in wet prairies.

Wet-Mesic Prairie
State Rank: S2

Overview and Landscape Context
A wet-mesic prairie is a native lowland grassland that occurs on moist, occasionally inundated stream and river floodplains, lake margins, and isolated depressions. These prairies are typically found on outwash plains and channels near moraines.

Soils
Wet prairie soils are usually loam or silty loams and are less often sandy loam, silty clay, or clay. Characterized by neutral pH, and high organic content, these soils have good water-retaining capacities. Muck layers are usually absent or form a thin layer over mineral soil.

Natural Processes
Variable water levels and fire help to maintain diversity and open conditions. Seasonal flooding restricts shrub and tree encroachment. Fires encourage the recruitment of seedlings and release nutrients into the soil layer.

Vegetation
Grasses and sedges dominate wet prairies, often with a subdominant herbaceous layer. Diversity is variable.

Animals
Beavers reduce shrub and tree cover by causing flooding, raising local water tables, and through herbivory.

Appendix G: Master Species List

Scientific Name	Common Name	Physiogamy	Native	Wetland	C of C	Elemental Occurance
Acer ginnala	Amur Maple	ATREE	0	UPL	0	
Acer negundo	Boxelder	NTREE	1	FACWET-	0	
Acer nigrum	Black Maple	NTREE	1	FACUP	4	
Acer platanoides	Norway Maple	ATREE	0	UPL	0	
Acer rubrum	Red Maple	NTREE	1	FAC	1	
Acer saccharinum	Silver Maple	NTREE	1	FACW	2	
Acer saccharum	Sugar Maple	NTREE	1	FACUP	5	
Achillea millefolium	Yarrow	NFORB	1	FACUP	1	
Actea pachypoda	Doll's Eyes	NFORB	1	UPL	7	
Adiantum pedatum	Maidenhair Fern	NFERN	1	FAC-	6	
Aesculus hippocastanum	Horsechestnut	ATREE	0	UPL	0	
Agalinis paupercula	Small-Flowered Gerardia	NFORB	1	OBL	8	
Agalinis purpurea	Purple Gerardia	NFORB	1	FACW	7	
Agalinis tenuifolia (Gerardia tenuifolia)	Slender Gerardia	NFORB	1	FACW	5	
Agastache foeniculum	Blue Giant Hyssop	AFORB	0	UPL	0	
Agastache scrophulariifolia	Purple Giant Hyssop	NFORB	1	UPL	5	
Agrimonia spp.	Agrimony	NFORB		----		
Agropyron repens	Quackgrass	AGRASS	0	FACUP	0	
Ailanthus altissima	Tree-Of-Heaven	ATREE	0	UPL	0	
Alisma plantago-aquatica	Water-Plantain	NFORB	1	OBL	1	
Alisma triviale	Northern Water Plantain	NFORB	1		2	
Alliaria petiolata	Garlic Mustard	AFORB	0	FAC	0	
Allium schoenoprasum	Chives	AFORB	0	FAC+	0	
Alnus rugosa	Speckled Alder	NSHRUB	1	OBL	5	
Amaranthus retroflexus	Rough Pigweed	AFORB	0	FACU+	0	
Ambrosia artemisiifolia	Common Ragweed	NFORB	1	FACU	0	
Ambrosia trifida	Great Ragweed	NFORB	1	FAC+	0	
Amelanchier arborea	Downy Serviceberry	NTREE	1	FACU	4	
Amphicarpaea bracteata	Hog-Peanut	NFORB	1	FAC	5	
Andropogon gerardii	Big Bluestem	NGRASS	1	FAC-	5	
Anemone cylindrica	Long-Headed Thimbleweed	NFORB	1	UPL	6	

Scientific Name	Common Name	Physiogamy	Native	Wetland	C of C	Elemental Occurance
Anemone quinquefolia	Wood Anemone	NFORB	1	FAC	5	
Anemone spp.	Anemone	NFORb		---		
Anemone virginiana	Thimbleweed	NFORB	1	UPL	3	
Antennaria neglecta	Field Pussytoes	NFORB	1	UPL	3	
Apios americana	Groundnut	NFORB	1	FAC-	3	
Aplectnum hyemale (Sedum telephium)	Puttyroot	NFORB	1	FAC-	10	
Apocynum androsaemifolium	Spreading Dogbane	NFORB	1	UPL	3	
Apocynum cannabinum	Indianhemp	NFORB	1	FAC	3	
Apocynum medium	Intermediate Dogbane	AFORB	0	---	0	
Apocynum spp.	Dogbane	NFORB		UPL		
Aquilegia canadensis	Wild Columbine	NFORB	1	FAC-	5	
Aralia nudicaulis	Wild Sarsaparilla	NFORB	1	FACU	5	
Arctium minus	Common Burdock	AFORB	0	UPL	0	
Arisaema triphyllum	Jack-In-The-Pulpit	NFORB	1	FACW-	5	
Aristolochia serpentaria	Virginia Snakeroot	NFORB	1	UPL	10	1
Asarum canadense	Wild Ginger	NFORB	1	UPL	5	
Asclepias incarnata	Swamp Milkweed	NFORB	1	OBL	6	
Asclepias purpurascens	Purple Milkweed	NFORB	1	FACU	10	
Asclepias syriaca	Common Milkweed	NFORB	1	UPL	1	
Asclepias tuberosa	Butterfly-Weed	NFORB	1	UPL	5	
Asclepias variegata	White Milkweed	AFORB	0	FACU	0	
Asimina triloba	Pawpaw	NTREE	1	FAC	9	
Asparagus officinales	Asparagus	AFORB	0	FAC	0	
Asplenium platyneuron	Ebony Spleenwort	NFERN	1	FACU	2	
Aster cordifolius	Heart-Leaved Aster	NFORB	1	UPL	4	
Aster divaricatus	White Wood Aster	AFORB	0		0	
Aster dumosus	Bushy Aster	NFORB	1	FAC+	7	
Aster ericoides (Symphotrichum ericoides)	Heath Aster	NFORB	1	FACU-	4	
Aster firmus	Smooth Swamp Aster	NFORB	1	OBL	4	
Aster laevis	Smooth Aster	NFORB	1	UPL	5	
Aster lanceolatus	Panicled Aster	NFORB	1	FACW	2	
Aster lateriflorus	Calico Aster	NFORB	1	FACW-	2	
Aster lowrieanus	Lowrie's Aster	AFORB	0	----	0	

Scientific Name	Common Name	Physiogamy	Native	Wetland	C of C	Elemental Occurance
Aster macrophyllus	Big-Leaved Aster	NFORB	1	UPL	4	
Aster novae-angliae	New England Aster	NFORB	1	FACW	3	
Aster pilosus	Hairy Aster	NFORB	1	FACU+	1	
Aster puniceus	Purple-Stemmed Aster	NFORB	1	OBL	5	
Aster sagittifolius	Arrow-Leaved Aster	NFORB	1	UPL	2	
Aster spp.	Aster	FORB		----		
Aster tradescanti (Symphotrichum ontarionus)	Tradescant's Aster	NFORB	1	FAC	4	
Aster umbellatus	Tall Flat-Top White Aster	NFORB	1	FACW	5	
Aster undulatus	Wavy-Leaved Aster	AFORB	0	----	0	
Aster vimineus	Small White Aster	NFORB	1	FACW-	1	
Athyrium filix-femina	Lady Fern	NFERN	1	FAC	4	
Avena fatua	Wild Oats	AGRASS	0	UPL	0	
Avena sativa	Common Oat	AGRASS	0	UPL	0	
Barbarea verna	Early Wintercress	AFORB	0	UPL	0	
Barbarea vulgaris	Winter Cress	AFORB	0	FAC	0	
Berberis thunbergii	Japanese Barberry	ASHRUB	0	FACU-	0	
Berteroa incana	Hoary Alyssum	AFORB	0	UPL	0	
Betula alleghaniensis	Yellow Birch	NTREE	1	FAC	7	
Betula pendula	European White Birch	ATREE	0	FACW+	0	
Bidens comosa	Leafy-Bracted Beggar-Ticks	NFORB	1	FACW	5	
Bidens connata	Purplestem Beggar-Ticks	NFORB	1	OBL	5	
Bidens coronatus	Tall Swamp Marigold	NFORB	1	OBL	7	
Bidens discoidea	Few-Bracted Beggarticks	NFORB	1	FACW	7	
Bidens frondosa	Devil's Beggartick	NFORB	1	FACW	1	
Bidens spp.	Beggarticks; Bur-Marigold; Sticktights	FORB		----		
Bidens tripartita	European Beggarticks	NFORB	1	FACW	7	
Blephilia ciliata	Downy Wood-Mint	NFORB	1	UPL	7	
Boehmeria cylindrica	False Nettle	NFORB	1	OBL	5	
Botrychium virginianum	Rattlesnake Fern	NFERN	1	FACU	5	
Brachyelytrum erectum	Long-Awned Wood Grass	NGRASS	1	UPL	7	
Calamagrostis canadensis	Bluejoint Grass	NGRASS	1	OBL	3	
Caltha palustris	Marsh-Marigold	NFORB	1	OBL	6	
Calystegia spithamaea	Hedge Bindweed	NFORB	1	UPL	8	

Scientific Name	Common Name	Physiogamy	Native	Wetland	C of C	Elemental Occurance
Campsis radicans	Trumpet Creeper	AVINE	0	FAC	0	
Cannabis sativa	Marijuana	AFORB	0	FAC	0	
Carduus nutans	Nodding Thistle	AFORB	0	UPL	0	
Carex grayi	Gray's Sedge	NSEDGE	1	FACW+	6	
Carex lupulina	Hop Sedge	NSEDGE	1	OBL	4	
Carex lurida	Shallow Sedge	NSEDGE	1	OBL	3	
Carex spp.	Sedge	SEDGE		----		
Carpinus caroliniana	American Hornbeam; Musclewood	NTREE	1	FAC	6	
Carya cordiformis	Bitternut Hickory	NTREE	1	FAC	5	
Carya glabra	Pignut Hickory	NTREE	1	FACU	5	
Carya laciniosa	Shellbark Hickory	NTREE	1	FACU	5	1
Carya ovata	Shagbark Hickory	NTREE	1	FACU	5	
Castanea dentata	American Chestnut	NTREE	1	UPL	9	
Catalpa speciosa	Northern Catalpa	ATREE	0	FACU	0	
Celastrus orbiculata	Oriental Bittersweet	AVINE	0	UPL	0	
Celastrus scandens	American Bittersweet	NVINE	1	FACU	3	
Celtis occidentalis	Northern Hackberry	NTREE	1	FAC-	5	
Centaurea maculosa	Spotted Knapweed	AFORB	0	UPL	0	
Centaurea scabiosa	Great Knapweed	AFORB	0	----	0	
Cephalanthus occidentalis	Common Buttonbush	NSHRUB	1	OBL	7	
Cercis canadensis	Redbud	NTREE	1	FACU	8	
Chaiturus marrubiastrum	Horehound Motherwort	AFORB	0	UPL	0	
Chamaedaphne calyculata	Leatherleaf	NSHRUB	1	OBL	8	
Chamerion angustifolium	Fireweed	NFORB	1	FAC	2	
Chelone glabra	Turtlehead	NFORB	1	OBL	7	
Chenopodium album	Pigweed	AFORB	0	FAC-	0	
Chimaphila umbellata	Pipsissewa	NFORB	1	UPL	8	
Cichorium intybus	Chicory	AFORB	0	UPL	0	
Cicuta bulbifera	Bulb-bearing Water-Hemlock	NFORB	1	OBL	5	
Cicuta maculata	Water-Hemlock	NFORB	1	OBL	4	
Cimicifuga racemosa	Black Cohosh	AFORB	0	FACU	0	
Circaea alpina	Smaller Enchanter'S Nightshade	NFORB	1	FACW	4	
Circaea lutetiana	Enchanter's Nightshade	NFORB	1	FACU	2	

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Cirsium arvense	Canada Thistle	AFORB	0	FACU	0	
Cirsium discolor	Field Thistle	NFORB	1	UPL	4	
Cirsium horridulum	Yellow Thistle	AFORB	0	FAC	0	
Cirsium muticum	Swamp Thistle	NFORB	1	OBL	6	
Cirsium palustre	Marsh Thistle	AFORB	0	FACW+	0	
Cirsium pumilum	Pasture Thistle	AFORB	0	FAC	0	
Cirsium spp.	Thistle	FORB		---		
Cirsium vulgare	Bull Thistle	AFORB	0	FACU-	0	
Clematis virginiana	Virgin's Bower	NFORB	1	FAC	4	
Collinsonia canadensis	Horse-Balm	NFORB	1	FAC	8	
Comandra umbellata	Bastard Toadflax	NFORB	1	FACU	5	
Conopholis americana	Squawroot	NFORB	1	UPL	10	
Convallaria majalis	Lily-Of-The-Valley	AFORB	0	UPL	0	
Convolvulus arvensis	Field Bindweed	AFORB	0	UPL	0	
Conyza canadensis	Horseweed	NFORB	1	FAC-	0	
Coreopsis tripteris	Tall Coreopsis	NFORB	1	FAC	7	
Cornus alternifolia	Alternate-Leaved Dogwood	NTREE	1	UPL	5	
Cornus amomum	Silky Dogwood	NFORB	1	FACW+	2	
Cornus drummondii	Rough-Leaved Dogwood	NSHRUB	1	FAC	6	
Cornus florida	Flowering Dogwood	NTREE	1	FACU-	8	
Cornus foemina	Gray Dogwood	NSHRUB	1	FACW-	1	
Cornus stolonifera	Redosier Dogwood	NSHRUB	1	FACW	2	
Coronilla varia	Crown-Vetch	AFORB	0	UPL	0	
Corylus americana	American Hazelnut	NSHRUB	1	FACU-	5	
Crataegus punctata	Dotted Hawthorn	NTREE	1	UPL	1	
Crataegus spp.	Hawthorn	TREE		----		
Cryptotaenia canadensis	Canadian Honewort	NFORB	1	FAC	2	
Cuscuta gronovii	Dodder	NFORB	1	FACW	3	
Cyperus esculentus	Yellow Nutsedge	NSEDGE	1	FACW	1	
Dactylis glomerata	Orchardgrass	NGRASS	1	FACU	6	
Daucus carota	Queen Anne'S Lace	AFORB	0	UPL	0	
Delphinium tricorne	Dwarf Larkspur	AFORB	0		0	
Deparia acrostichoides (Athyrium	Silvery Glade Fern	NFERN	1	FAC	6	

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thelypteroides)						
Desmodium canadensis	Showy Tick-Trefoil	NFORB	1	FAC-	3	
Desmodium ciliare	Small-Leaved Tick Trefoil	NFORB	1	UPL	10	
Desmodium cuspidatum	Largebract Ticktrefoil	NFORB	1	UPL	5	
Desmodium glutinosum	Pointed-Leaf Tick-Trefoil	NFORB	1	UPL	5	
Desmodium nudiflorum	Naked Flowered Tick-Trefoil	NFORB	1	UPL	7	
Desmodium paniculatum	Panicled Tick-Trefoil	NFORB	1	FACU	4	
Desmodium spp.	Ticktrefoil	NFORB		----		
Dianthus armeria	Deptford Pink	AFORB	0	UPL	0	
Diarrhena americana	Beak Grass	NGRASS	1	FACW	9	1
Diervilla sessilifolia	Southern Bush Honeysuckle	NSHRUB	1	UPL	4	
Dioscorea villosa	Wild Yam	NVINE	1	FAC-	4	
Dipsacus sylvestris, Dipsacus laciniatus	Teasel	AFORB	0	UPL	0	
Dirca palustris	Leatherwood	NSHRUB	1	FAC	8	
Doellingeria umbellata	Flat-Topped White Aster	NFORB	1	FACW	5	
Dryopteris carthusiana	Spinulose Woodfern	NFERN	1	FACW-	5	
Echinochloa crus-galli	Barnyard Grass	AGRASS	0	FACW	0	
Echinocystis lobata	Wild Cucumber	NVINE	1	FACW-	2	
Elaeagnus umbellata	Autumn-Olive	ASHRUB	0	FACU	0	
Elymus spp.	Wild Rye	GRASS		----		
Epilobium coloratum	Cinnamon Willow-Herb	NFORB	1	OBL	3	
Epilobium glandulosum	Northern Willow-Herb	NFORB	1	FACU	5	
Epilobium leptophyllum	Narrow-Leaved Willow-Herb	NFORB	1	OBL	6	
Equisetum arvense	Field Horsetail	NFERN	1	FAC	0	
Equisetum hyemale	Common Scouring Rush	NFERN	1	FACW-	2	
Equisetum laevigatum	Smooth Scouring-Rush	NFERN	1	FACW	2	
Equisetum pratense	Meadow Horsetail	NFERN	1	FACW	10	
Equisetum spp.	Horsetail	FERN		FACW		
Equisetum sylvaticum	Woodland Horsetail	NFERN	1	FACW	5	
Equisetum variegatum spp. variegatum	Variegated Scouring Rush	NFERN	1	FACW	8	
Eragrostis spectabilis	Purple Lovegrass	NGRASS	1	UPL	3	
Erechtites hieracifolia	Pilewort	NFORB	1	FACU	2	
Erigeron annuus	Daisy Fleabane	AFORB	0	UPL	0	

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Erigeron philadephicus	Common Fleabane	NFORB	1	FACW	2	
Erigeron spp.	Fleabane	FORB		----		
Euonymus alata	Burningbush	ASHRUB	0	UPL	0	
Euonymus atropurpurea	Eastern Wahoo	NSHRUB	1	FAC-	8	
Euonymus europaea	Spindle Tree	ASHRUB	0	UPL	0	
Euonymus obovata	Creeping Strawberry-Bush	NSHRUB	1	UPL	5	
Euonymus spp.	Spindletree	----	----	----		
Eupatorium dubium	Joe-Pye-Weed	NFORB	1	OBL	4	
Eupatorium fistulosum	Hollow joe-pye-weed	NFORB	1	OBL	10	
Eupatorium maculatum	Spotted Joe-Pye Weed	NFORB	1	OBL	4	
Eupatorium perfoliatum	Boneset	NFORB	1	FACW+	4	
Eupatorium purpureum	Sweet Joe-Pye Weed	NFORB	1	FAC	5	
Eupatorium rugosum	White Snakeroot	NFORB	1	FACU	4	
Eupatorium sessilifolium	Upland Boneset	NFORB	1	UPL	10	1
Euphorbia maculata	Nodding Spurge	NFORB	1	FACU-	0	
Euphorbia spp.	Spurge	FORB		-----		
Eurybia macrophylla	Bigleaf Aster	NFORB	1	UPL	4	
Euthamia graminifolia	Common Flat-Topped Goldenrod	NFORB	1	FACW-	3	
Fagus grandifolia	American Beech	NTREE	1	FACU	6	
Fallopia japonica	Japanese Knotweed	AFORB	0	FACU	0	
Fragaria spp.	Strawberry	NFORB		----		
Fragaria virginiana	Wild Strawberry	NFORB	1	FAC-	2	
Fraxinus americana	White Ash	NTREE	1	FACU	5	
Fraxinus nigra	Black Ash	NTREE	1	FACW+	6	
Fraxinus pennsylvanica	Green Ash	NTREE	1	FACW	2	
Fraxinus quadrangulata	Blue Ash	NTREE	1	UPL	8	
Galium aparine	Cleavers	NFORB	1	FACU	0	
Galium asprellum	Rough Bedstraw	NFORB	1	OBL	5	
Galium boreale	Northern bedstraw	NFORB	1	FAC	3	
Galium circaezans	Wild White Licorice	NFORB	1	FACU-	4	
Galium concinnum	Shining Bedstraw	NFORB	1	FACW+	6	
Galium spp.	Bedstraw	FORB		----		
Galium trifidum	Northern Three-Leaved Bedstraw	NFORB	1	FACW+	6	

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Galium triflorum	Fragrant Bedstraw	NFORB	1	FACU+	4	
Gaultheria procumbens	Wintergreen	NSHRUB	1	FACU	5	
Gentiana andrewsii	Bottle Gentian	NFORB	1	FACW	5	
Gentianopsis crinita	Fringed Gentian	NFORB	1	FACW+	8	
Geranium maculatum	Wild Geranium	NFORB	1	FACU	4	
Gerardia spp.	Gerardia	FORB				
Gerardia tenuifolia	Slender Gerardia	NFORB	1	FACW	6	
Geum aleppicum	Yellow Avens	NFORB	1	FAC+	3	
Geum canadense	White Avens	NFORB	1	FAC	1	
Geum laciniatum	Rough Avens	NFORB	1	FACW	2	
Geum rivale	Purple Avens	NFORB	1	OBL	7	
Geum spp.	Avens	FORB		---		
Gleditsia triacanthos	Honeylocust	NTREE	1	FAC	8	
Gnaphalium obtusifolium	Sweet Everlasting	NFORB	1	UPL	2	
Gymnocladus dioicus	Kentucky Coffee-Tree	NTREE	1	UPL	9	
Hackelia virginiana	Beggar's-Lice	NFORB	1	FAC-	1	
Hamamelis virginiana	Witch-Hazel	NSHRUB	1	FACU	5	
Hedera helix	English Ivy	NVINE	1	---	0	
Helenium autumnale	Sneezeweed	NFORB	1	FACW+	5	
Helianthus annuus	Common Sunflower	AFORB	0	FAC-	0	
Helianthus decapetalus	Thinleaf Sunflower	NFORB	1	UPL	5	
Helianthus divaricatus	Woodland Sunflower	NFORB	1	UPL	5	
Helianthus giganteus	Tall Sunflower	NFORB	1	FACW	5	
Helianthus laetiflorus var. rigidus	Showy Sunflower	NFORB	1	---	8	
Helianthus spp.	Sunflower	FORB		---		
Helianthus strumosus	Pale-Leaved Wood Sunflower	NFORB	1	UPL	4	
Helianthus tuberosus	Jerusalem Artichoke	NFORB	1	UPL	6	
Heliopsis helianthoides	Oxeye	NFORB	1	UPL	5	
Hepatica americana	Roundlobe Hepatica	NFORB	1	UPL	6	
Hesperis matronalis	Dame's Rocket	AFORB	0	UPL	0	
Hydrastis canadensis	Goldenseal	NFORB	1	UPL	10	1
Hydrophyllum virginianum	Virginia waterleaf	NFORB	1	FACW-	4	
Hylotelephium telephium ssp. telephium	Witch's Moneybags	AFORB	0	----	0	

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Hypericum ellipticum	Pale St. Johnswort	NFORB	1	OBL	9	
Hypericum kalmianum	Kalm's St. Johnswort	NFORB	1	FACW	5	
Hypericum mutilum	Dwarf St. Johnswort	NFORB	1	FAC	5	
Hypericum perforatum	Common St. Johnswort	AFORB	0	UPL	0	
Hypericum punctatum	Spotted St. Johnswort	NFORB	1	FAC+	4	
Hypericum pyramidatum	Great St. Johnswort	NFORB	1	FAC+	2	
Hypericum spathulatum	Shrubby St. Johnswort	NSHRUB	1	FACU	5	
Hyssopus spp.	Hyssop	AFORB		UPL		
Hystrix patula	Bottlebrush Grass	NGRASS	1	----	2	
Impatiens capensis	Jewelweed	NFORB	1	FACW	2	
Ipomoea lacunosa	Small White Morning-Glory	AVINE	0	---	0	
Ipomoea purpurea	Morning Glory	AFORB	0	FACU-	0	
Iris spp.	Iris	FORB		----		
Juglans nigra	Black Walnut	NTREE	1	FACU	5	
Juncus spp.	Rush	FORB		-----		
Juniperus virginiana	Eastern Redcedar	NTREE	1	FACU	3	
Lactuca biennis	Tall Blue Lettuce	NFORB	1	FAC	2	
Lactuca canadensis	Wild Lettuce	NFORB	1	FACU+	2	
Lactuca serriola	Prickly Lettuce	AFORB	0	FAC	0	
Lamium album	White Dead-Nettle	AFORB	0	UPL	0	
Lamium amplexicaule	Henbit	AFORB	0	UPL	0	
Laportea canadensis	Wood Nettle	NFORB	1	FACW	4	
Lapsana communis	Nipplewort	AFORB	0	UPL	0	
Lemna spp.	Duckweed	NFORB		OBL		
Leonurus cardiaca	Motherwort	AFORB	0	UPL	0	
Lepidium virginicum	Poor-Man'S Pepper	NFORB	1	FACU-	0	
Lespedeza capitata	Round-Headed Bush-Clover	NFORB	1	FACU	5	
Lespedeza violacea	Bush Clover	NFORB	1	UPL	5	
Leucanthemum vulgare	Oxeye Daisy	AFORB	0	---	0	
Liatris squarrosa	Scaly Blazing-Star	NFORB	1	UPL	10	
Ligustrum spp.	Privet	ASHRUB		----		
Ligustrum vulgare	Common Privet	ASHRUB	1	FAC-	0	
Linaria vulgaris	Butter-And-Eggs	AFORB	0	UPL	0	

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Lindera benzoin	Spicebush	NSHRUB	1	FACW-	7	
Linum medium	Small Yellow Flax	NFORB	1	FACU	7	
Liriodendron tulipifera	Tuliptree	NTREE	1	FACU+	9	
Lobelia siphilitica	Great Blue Lobelia	NFORB	1	FACW+	4	
Lobelia spp.	Lobelia	FORB				
Lonicera dioica	Red Honeysuckle	NVINE	1	FACU	5	
Lonicera hirsuta	Hairy Honeysuckle	NSHRUB	1	FAC	6	
Lonicera japonica	Japanese Honeysuckle	AVINE	0	FACU	0	
Lonicera maackii	Maack's Honeysuckle	ASHRUB	0	UPL	0	
Lonicera morrowii	Morrow's Honeysuckle	ASHRUB	0	UPL	0	
Lonicera spp.	Honeysuckle	ASHRUB		UPL		
Lonicera tatarica	Tartarian Honeysuckle	ASHRUB	0	UPL	0	
Lycopus americanus	Common Water-Horehound	NFFORB	1	OBL	2	
Lycopus rubellus	Stalked Water-Horehound	NFORB	1	OBL	8	
Lycopus uniflorus	Northern Bugleweed	NFORB	1	OBL	2	
Lycopus virginicus	Bugleweed; Virignia Bugleweed	NFORB	1	OBL	8	1
Lysimachia ciliata	Fringed Loosestrife	NFORB	1	FACW	4	
Lysimachia nummularia	Moneywort	AFORB	0	FACW+	0	
Lysimachia quadrifolia	Whorled Loosestrife	NFORB	1	OBL	8	
Lythrum alatum	Wing-Angled Loosestrife	NFORB	1	OBL	9	
Lythrum salicaria	Purple Loosestrife	AFORB	0	OBL	0	
Lythrum virgatum	European Wand Loosestrife	AFORB	0		0	
Maianthemum canadense	Canada Mayflower	NFORB	1	FAC	4	
Malus pumila	Common Apple	ATREE	0	UPL	0	
Malus spp.	Apple; Crabapple	TREE		---		
Malus coronaria	Sweet Crab Apple	NTREE	1	UPL	4	
Malva neglecta	Common Mallow	AFORB	0	UPL	0	
Matricaria discoidea	Pineappleweed	AFORB	0	FACU	0	
Matteuccia struthiopteris	Ostrich Fern	NFERN	1	FACW	3	
Melilotus	Sweet Clover	AFORB	0	----	0	
Melilotus alba	White Sweet Clover	AFORB	0	FACU	0	
Melilotus officinalis	Yellow Sweet Clover	AFORB	0	UPL	0	
Menispermum canadense	Canada Moonseed	NVINE	1	FAC	5	

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Mentha arvensis	Wild Mint	NFORB	1	FACW	3	
Mentha piperita	Peppermint	AFORB	0	OBL	0	
Mentha spp.	Mint	FORB				
Mimulus alatus	Sharp-winged monkey-flower	NFORB	1	OBL	9	
Monarda fistulosa	Wild Bergamot	NFORB	1	FACU	2	
Monotropa uniflora	Indian Pipe	NFORB	1	FACU	5	
Morus alba	White Mulberry	ATREE	0	FAC	0	
Morus rubra	Red Mulberry	NTREE	1	FAC-	9	1
Morus spp.	Mulberry	TREE		----		
Nasturtium officinale	Watercress	AFORB	0	OBL	0	
Nymphaea spp.	Waterlily	NFORB		OBL		
Nyssa sylvatica	Blackgum; Black Tupelo	NTREE	1	FACW+	9	
Oenothera biennis	Common Evening Primrose	NFORB	1	FACU	2	
Oenothera spp.	Evening Primrose	FORB		----		
Onoclea sensibilis	Sensitive Fern	NFERN	1	FACW	2	
Optunia humifusa	Prickly-Pear	NSHRUB	1	UPL	7	
Osmorhiza berteroi	Sweet Cicely	NFORB	1	UPL	5	
Osmunda cinnamonea	Cinnamon Fern	NFERN	1	FACW	5	
Osmunda claytoniana	Interrupted Fern	NFERN	1	FAC+	6	
Osmunda regalis	Royal Fern	NFERN	1	OBL	5	
Ostrya virginiana	Hop-Hornbeam	NTREE	1	FACU-	5	
Oxalis montana	Common Wood Sorrel	NFORB	1	FACU	7	
Oxalis stricta	Yellow Wood-Sorrel	NFORB	1	FACU	0	
Oxypolis rigidior	Cowbane	NFORB	1	OBL	6	
Panax trifolius	Dwarf Ginseng	NFORB	1	UPL	10	
Panicum capillare	Witchgrass	NGRASS	1	FAC	1	
Parthenocissus quinquefolia	Virginia Creeper	NVINE	1	FAC-	5	
Pennisetum setaceum	Purple Fountain Grass	AGRASS	0		0	
Pennistum spp.	Fountain Grass	GRASS				
Phalaris arundinacea	Reed Canarygrass	NGRASS	1	FACW+	0	
Phleum spp.	Timothy	GRASS		----		
Phragmites australis	Common Reed	NGRASS	1	FACW+	1	
Phryma leptostachya	American Lopseed	NFORB	1	UPL	4	

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Phyla lanceolata	Fogfruit	NFORB	1	OBL	6	
Physalis alkekengi	Chinese-Lantern Plant	NFORB	1	UPL	4	
Physocarpus opulifolius	Ninebark	NSHRUB	1	FACW-	4	
Physostegia virginiana	False Dragonhead	NFORB	1	FACW	8	
Phytolacca americana	Pokeweed	NFORB	1	FAC-	2	
Picea abies	Norway Spruce	ATREE	0	UPL	0	
Picea glauca	White Spruce	NTREE	1	FACU	3	
Picea spp.	Spruce	TREE		----		
Pilea pumila	Clearweed	NFORB	1	FACW	5	
Pinus nigra	Black Pine	ATREE	0	OBL	0	
Pinus resinosa	Red Pine	NTREE	1	FACU	6	
Pinus strobus	Eastern White Pine	NTREE	1	FACU	3	
Pinus sylvestris	Scots Pine	ATREE	0	UPL	0	
Plantago lanceolata	English Plantain	AFORB	0	FAC	0	
Plantago major	Broadleaf Plantain	AFORB	1	FAC+	0	
Plantago rugelii	American Plantain	NFORB	1	FAC	0	
Plantago spp.	Plantain	FORB		---		
Platanus occidentalis	Sycamore	NTREE	1	FACW	7	
Poa pratensis or Poa compressa	Bluegrass (Kentucky Or Canada)	AGRASS	0	FAC	0	
Podophyllum peltatum	Mayapple	NFORB	1	FACU	3	
Polygala sanguinea	Field Milkwort	NFORB	1	FACU	4	
Polygonatum biflorum	Solomon's Seal	NFORB	1	FACU	4	
Polygonatum pubescens	Hairy Solomen's Seal	NFORB	1	UPL	5	
Polygonum amphibium	Water Smartweed	NFORB	1	OBL	6	
Polygonum aviculare	Prostrate Knotweed	AFORB	0	FAC-	0	
Polygonum coccineum	Swamp Smartweed	NFORB	1	OBL	6	
Polygonum hydropiperoides	Mild Water-Pepper	NFORB	1	OBL	5	
Polygonum lapathifolium	Pale Smartweed	NFORB	1	FACW+	0	
Polygonum pensylvanicum	Pennsylvania Smartweed	NFORB	1	FACW+	0	
Polygonum persicaria	Lady's Thumb	AFORB	0	FACW	0	
Polygonum sagittatum	Arrow-Leaved Tear-Thumb	NFORB	1	OBL	5	
Polygonum scandens	Climbing False Buckwheat	NVINE	1	FAC	2	
Polygonum spp.	Knotweed; Smartweed	FORB		---		

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Polygonum virginianum	Jumpseed	NFORB	1	FAC	4	
Polypodium virginianum	Common Polypody	NFERN	1	UPL	8	
Polystichum acrostichoides	Christmas Fern	NFERN	1	UPL	6	
Populus alba	European White Poplar	ATREE	0	UPL	0	
Populus deltoides	Eastern Cottonwood	NTREE	1	FAC+	1	
Populus grandidentata	Bigtooth Aspen	NTREE	1	FACU	4	
Populus spp.	Cottonwood	TREE	---	----		
Populus tremuloides	Quaking Aspen	NTREE	1	FAC	1	
Potentilla anserina	Silverweed	NFORB	1	FACW+	5	
Potentilla norvegiaca	Rough Cinquefoil	NFORB	1	FAC	0	
Potentilla simplex	Common Cinquefoil	NFORB	1	FACU-	2	
Prenanthes alba	White Lettuce	NFORB	1	FACU	5	
Prenanthes serpentaria	Lion's Foot	AFORB	0	---	0	
Prunella vulgaris	Heal-All; Selfheal	AFORB	0	FAC	0	
Prunus avium	Sweet Cherry	ATREE	0	UPL	0	
Prunus serotina	Black Cherry	NTREE		FACU	2	
Prunus virginiana	Choke Cherry	NSHRUB	1	FAC-	2	
Pteridium aquilinum	Brackenfern	NFERN	1	FACU	0	
Pycnanthemum muticum	Short-Toothed Mountain-Mint	NFORB	1	OBL	10	
Pycnanthemum spp.	Mountain Mint	NFORB		----		
Pycnanthemum tenuifolium	Narrow-Leaved Mountain-Mint	NFORB	1	FAC	6	
Pycnanthemum virginianum	Common Mountain Mint	NFORB	1	FACW+	5	
Quercus alba	White Oak	NTREE	1	FACU	5	
Quercus bicolor	Swamp White Oak	NTREE	1	FACW+	8	
Quercus coccinea	Scarlet Oak	NTREE	1	UPL	7	
Quercus imbricaria	Shingle Oak	NTREE	1	FAC-	5	
Quercus macrocarpa	Bur Oak	NTREE	1	FAC-	5	
Quercus muehlenbergii	Chinkapin Oak	NTREE	1	FAC-	5	
Quercus palustris	Pin Oak	NTREE	1	FACW	8	
Quercus prinus	Chestnut Oak	ATREE	0	FACU-	0	
Quercus rubra	Northern Red Oak	NTREE	1	FACU	5	
Quercus spp.	Oak					
Quercus velutina	Black Oak	NTREE	1	UPL	6	

Scientific Name	Common Name	Physiogamy	Native	Wetland	C of C	Elemental Occurance
Quercus ellipsoidalis	Northern Pin Oak	NTREE	1	UPL	4	
Ranunculus abortivus	Small-Flowered Buttercup	NFORB	1	FACW-	0	
Ranunculus hispidus	Swamp Buttercup	NFORB	1	FAC	5	
Ranunculus pensylvanicus	Bristly Buttercup	NFORB	1	OBL	6	
Ranunculus recurvatus	Hooked Buttercup	NFORB	1	FACW	5	
Ranunculus spp.	Buttercup	FORB		---		
Ratibida pinnata	Prairie Coneflower	NFORB	1	UPL	4	
Rhamnus cathartica	Common Buckthorn	ATREE	0	FACU	0	
Rhamnus frangula	Glossy Buckthorn	ASHRUB	0	FAC+	0	
Rheum spp.	Rhubarb	FORB				
Rhus aromatica	Fragrant Sumac	NSHRUB	1	UPL	7	
Rhus glabra	Smooth Sumac	NTREE	1	UPL	2	
Rhus spp.	Sumac	N ----		---		
Rhus typhina	Staghorn Sumac	NTREE	1	UPL	2	
Ribes americanum	American Black Currant	NSHRUB	1	FACW	6	
Ribes cynosbati	Prickly Gooseberry	NSHRUB	1	UPL	4	
Ribes lacustre	Bristly Black Currant	NSHRUB	1	FACW	6	
Robinia pseudoacacia	Black Locust	ATREE	0	FACU-	0	
Rosa carolina	Carolina Rose	NSHRUB	1	FACU-	4	
Rosa multiflora	Multiflora Rose	ASHRUB	0	FACU	0	
Rosa palustris	Swamp Rose	NSHRUB	1	OBL	5	
Rosa spp.	Rose	SHRUB				
Rubus allegheniensis	Highbush Blackberry	NSHRUB	1	FACU+	1	
Rubus canadensis	Smooth Blackberry	NSHRUB	1	UPL	2	
Rubus flagellaris	Northern Dewberry	NSHRUB	1	FACU-	1	
Rubus hispidus	Swamp Dewberry	NSHRUB	1	FACW	4	
Rubus occidentalis	Black Raspberry	NSHRUB	1	UPL	1	
Rubus pubescens	Dwarf Red Raspberry	NFORB	1	FACW+	4	
Rubus spp.	Blackberry	NSHRUB		---		
Rubus strigosus	Wild Red Raspberry	NSHRUB	1	FACW-	2	
Rudbeckia hirta	Black-Eyed Susan	NFORB	1	FACU	1	
Rudbeckia laciniata	Green-Headed Coneflower	NFORB	1	FACW+	6	
Rudbeckia subtomentosa	Sweet Coneflower	AFORB	0	FACU	0	

Scientific Name	Common Name	Physiogamy	Native	Wetland	C of C	Elemental Occurance
Rumex crispus	Curled Dock	AFORB	0	FAC+	0	
Rumex obtusifolius	Broad Dock	AFORB	0	FACW	0	
Rumex patientia	Patience Dock	AFORB	0	UPL	0	
Rumex spp.	Dock	FORB				
Sagittaria latifolia	Common Arrowhead	NFORB	1	OBL	1	
Salix alba	White Willow	ATREE	0	FACW	0	
Salix alba var. vitellina	Weeping Willow	ATREE	0	FACW	0	
Salix amygdaloides	Peachleaf Willow	NTREE	1	FACW	3	
Salix bebbiana	Bebb's Willow	NSHRUB	1	FACW+	1	
Salix exigua	Sandbar Willow	NSHRUB	1	OBL	1	
Salix lucida	Shining Willow	NSHRUB	1	FACW+	3	
Salix nigra	Black Willow	NTREE	1	OBL	5	
Salix sericea	Silky Willow	NSHRUB	1	OBL	6	
Salix spp.	Willow	---		---		
Sambucus canadensis	Common Elder	NSHRUB	1	FACW-	3	
Sanguinaria canadensis	Bloodroot	NFORB	1	FACU-	5	
Sanicula gregaria	Black Snakeroot	NFORB	1	FACU	4	
Saponaria officinalis	Bouncing Bet	AFORB	0	FACU	0	
Sassafras albidum	Sassafras	NTREE	1	FACU	5	
Schizachyrium scoparium	Little Bluestem	NGRASS	1	FACU-	3	
Schoenoplectus spp.	Bulrush	NSEDGE		OBL		
Scrophularia lanceolata	Hare Figwort	NFORB	1	FACU+	5	
Scrophularia marilandica	Carpenter'S Square; Maryland Figwort	NFORB	1	FACU-	5	
Scrophularia spp.	Figwort	NFORB		FACU		
Scutellaria laterifolia	Mad-Dog Skullcap	NFORB	1	OBL	5	
Scutellaria nervosa	Veined Skullcap	NFORB	1	UPL	10	1
Sedum spp.	Stonecrop	AFORB		UPL		
Sedum telephium	Orpine	AFORB	0	UPL	0	
Senecio aureus	Golden Ragwort	NFORB	1	FACW	5	
Senecio vulgaris	Common Groundsel	AFORB	0	UPL	0	
Setaria pumila	Yellow Foxtail	AGRASS	0	UPL	0	
Setaria viridis	Green Foxtail	AGRASS	0	UPL	0	

Scientific Name	Common Name	Physiogamy	Native	Wetland	C of C	Elemental Occurance
Silene latifolia	Bladder Campion	AFORB	0	UPL	0	
Silphium integrifolium	Rosinweed	NFORB	1	UPL	10	1
Silphium perfoliatum	Cup Plant	NFORB	1	FACW-	10	1
Silphium terebinthinaceum	Prairie Dock	NFORB	1	FACU	6	
Silphium trifoliatum	Whorled Rosinweed	AFORB	0	---	0	
Sium suave	Water-Parsnip	NFORB	1	OBL	5	
Smilacina racemosa	False Solomon'S Seal	NFORB	1	FACU	5	
Smilacina stellata	Starry False Solomon'S Seal	NFORB	1	FAC-	5	
Smilacina trifolia	Three-Leaved False Solomon's Seal	NFORB	1	OBL	10	
Smilax ecirrhata	Upright Carrion-Flower	NFORB	1	UPL	6	
Smilax lasioneura	Carrion-Flower	NFORB	1	FAC	8	
Smilax rotundifolia	Round-leaved greenbriar	NVINE	1	FAC	5	
Smilax spp.	Greenbriar	N---		---		
Smilax tamnoides	Bristly Greenbrier	NVINE	1	FAC	5	
Solanum dulcamara	Bittersweet Nightshade	AVINE	0	FAC	0	
Solanum lycopersicum	Cherry Tomato	AFORB	0	---	0	
Solidago altissima	Tall Goldenrod	NFORB	1	FACU	1	
Solidago caesia	Blue-Stemmed Goldenrod	NFORB	1	FACU	7	
Solidago canadensis	Canada Goldenrod	NFORB	1	FACU	1	
Solidago flexicaulis	Zigzag Goldenrod	NFORB	1	FACU	6	
Solidago gigantea	Late Goldenrod; Giant Goldenrod	NFORB	1	FACW	3	
Solidago graminifolia	Lance-Leaved Goldenrod	NFORB	1	FACW-	1	
Solidago juncea	Early Goldenrod	NFORB	1	UPL	3	
Solidago macrophylla	Largeleaf Goldenrod	AFORB	0	---	0	
Solidago nemoralis	Gray Goldenrod	NFORB	1	UPL	2	
Solidago odora	Sweet Goldenrod	AFORB	0	---	0	
Solidago patula	Roundleaf Goldenrod; Rough-leaved Goldenrod	NFORB	1	OBL	6	
Solidago puberula	Downy Goldenrod	AFORB	0	---	0	
Solidago riddellii	Riddell's Goldenrod	NFORB	1	OBL	6	
Solidago rugosa	Rough-Stemmed Goldenrod	NFORB	1	FAC+	3	
Solidago shortii	Short's Goldenrod	AFORB	0	---	0	
Solidago spp.	Goldenrod	FORB		----		

Scientific Name	Common Name	Physiogamy	Native	Wetland	C of C	Elemental Occurance
Solidago squarrosa	Stout Goldenrod	AFORB	0		0	
Solidago tenuifolia	Slender Fragrant Goldenrod	AFORB	0	---	0	
Solidago ulmifolia	Elm-leaved Goldenrod	NFORB	1	UPL	5	
Sonchus arvensis	Field Sow-Thistle	AFORB	0	FAC-	0	
Sonchus asper	Spiny-Leaved Sow Thistle	AFORB	0	FAC	0	
Sonchus oleraceus	Common Sowthistle	AFORB	0	FACU	0	
Sparganium americanum	Bur-Reed	NFORB	1	OBL	6	
Spartina pectinata	Cord Grass	NGRASS	1	FACW+	5	
Spergularia rubra	Sand Spurrey	AFORB	0	FACU	0	
Sphagnum spp.	Sphagnum Moss	NMOSS		OBL		
Spiraea spp.	Meadowsweet	----		----		
Spiranthes cernua	Nodding Ladies'-Tresses	NFORB	1	FACW-	4	
Stachys albens	White Hedgenettle	AFORB	0	---	0	
Stachys tenuifolia var. hispida	Rough Hedge-Nettle	NFORB	1	OBL	5	
Staphylea trifolia	American Bladdernut	NSHRUB	1	FAC	9	
Stellaria graminea	Lesser Stitchwort	AFORB	0	UPL	0	
Strophostyles hevulva	Wild Bean	NFORB	1	FAC+	8	1
Symphoricarpus occidentalis	Western Snowberry	NSHRUB	1	UPL	4	
Symphyotrichum patens	Late Purple Aster	AFORB	0	---	0	
Symplocarpus foetidus	Skunk Cabbage	NFORB	1	OBL	6	
Syringa vulgaris	Common Lilac	ASHRUB	0	UPL	0	
Taraxacum officinale	Dandelion	AFORB	0	FACU	0	
Taxus canadensis	Canada Yew	NSHRUB	1	FACU	5	
Teucrium canadense	Germander	NFORB	1	FAC-	4	
Thalictrum dasycarpum	Purple Meadow-Rue	NFORB	1	FACW-	3	
Thalictrum dioicum	Early Meadow-Rue	NFORB	1	FACU+	6	
Thalictrum polygamum	Tall Meadow-Rue	AFORB	0	FAC	0	
Thalictrum spp.	Meadow-Rue	NFORB		---		
Thelypteris noveboracensis	New York Fern	NFERN	1	FAC+	5	
Thelypteris palustris	Eastern Marsh Fern	NFERN	1	FACW+	2	
Thelypteris spp.	Fern	NFERN		----		
Thelypteris palustris	Marsh Fern	NFERN	1	FACW+	2	
Thuja occidentalis	Northern White-Cedar	NTREE	1	FACW	4	

Scientific Name	Common Name	Physiogamy	Native	Wetland	C of C	Elemental Occurance
Tilia americana	American Basswood	NTREE	1	FACU	5	
Tovara virginiana	Virginia Knotweed	NFORB	1	FAC	4	
Toxicodendron radicans	Poison Ivy	NVINE	1	FAC+	2	
Toxicodendron vernix	Poison Sumac	NSHRUB	1	OBL	6	
Tragopogon pratensis	Yellow Goat's Beard	AFORB	0	UPL	0	
Tridens flavus	Purpletop	NGRASS	1	UPL	3	
Trifolium hybridum	Alsike Clover	AFORB	0	FAC-	0	
Trifolium pratense	Red Clover	AFORB	0	FACU+	0	
Trifolium repens	White Clover	AFORB	0	FACU+	0	
Trifolium spp.	Clover	AFORB		-----		
Trillium spp.	Trillium	NFORB		----		
Triosteum aurantiacum	Horse Gentian	NFORB	1	UPL	5	
Triosteum perfoliatum	Feverwort	NFORB	1	UPL	5	
Typha angustifolia	Narrow-Leaved Cattail	AFORB	0	OBL	0	
Typha latifolia	Common Cattail	NFORB	1	OBL	1	
Typha spp.	Cattails	FORB		OBL		
Ulmus americana	American Elm	NTREE	1	FACW-	1	
Ulmus pumila	Siberian elm	ATREE	0	UPL	0	
Ulmus rubra	Slippery Elm	NTREE	1	FAC	2	
Urtica dioica	Stinging Nettle	NFORB	1	FAC+	1	
Urtica gracilis	Slender Nettle	NFORB	1	FAC+	4	
Vaccinium spp.	Blueberry	NSHRUB		----		
Vaccinium angustifolium	Lowbush Blueberry	NSHRUB	1	FACU	4	
Verbascum blattaria	Moth Mullien	AFORB	0	FACU-	0	
Verbascum thapsus	Common Mullein	AFORB	0	UPL	0	
Verbascum thapsus	Mullien	AFORB	0	UPL	0	
Verbena hastata	Blue Vervain	NFORB	1	FACW+	4	
Verbena officinalis	European Vervain	AFORB	0	FACU	0	
Verbena spp.	Vervain	FORB		---		
Verbena stricta	Hoary Vervain	NFORB	1	UPL	4	
Verbena urticifolia	White Vervain	NFORB	1	FAC+	4	
Verbesina alternifolia	Wingstem	NFORB	1	FACW	4	
Vernonia fasciculata	Western Ironweed	AFORB	0	---	0	

Scientific Name	Common Name	Physiogamy	Native	Wetland	C of C	Elemental Occurance
Vernonia gigantea	Giant Ironweed; Tall Ironweed	NFORB	1	FAC	3	
Vernonia missurica	Missouri Ironweed	NFORB	1	FAC+	4	
Vernonia spp.	Ironweed	FORB		FAC		
Veronica longifolia	Speedwell	AFORB	0	UPL	0	
Veronica peregrina	Purslane Speedwell	NFORB	1	FACW+	0	
Veronicastrum virginicum	Culver's Root	NFORB	1	FAC	8	
Viburnum acerifolium	Maple-Leaved Viburnum	NSHRUB	1	UPL	6	
Viburnum dentatum	Southern Arrowwood	NSHRUB	1	FACW-	6	
Viburnum lentago	Nannyberry	NSHRUB	1	FAC+	4	
Viburnum opulus	European Highbush-Cranberry	ASHRUB	1	FAC	0	
Viburnum spp.	Viburnum	SHRUB		----		
Viburnum trilobum	Highbush-Cranberry	NSHRUB	1	FACW	5	
Vinca spp.	Periwinkle	ASHRUB		UPL		
Viola spp.	Violet	FORB		---		
Vitis aestivalis	Summer Grape	NVINE	1	FACU	6	
Vitis riparia	River-Bank Grape	NVINE	1	FACW-	3	
Zanthoxylum americanum	Prickly-Ash	NSHRUB	1	UPL	3	

Date: **Park:** **UNIT:**

Time spent at site: **Surveyors:**

II. WETLANDS __ WORKSHEET

III.1. Hydrological conditions. Wetlands are areas that have standing water periodically, for at least some part of the year, where plants with particular adaptations to wet conditions typically grow, and organic (muck or peat) soils may develop. Characterize the area where this wetland occurs. *Check all that apply.*

- ☐ 1) At margin of river, stream, lake, or pond
- ☐ 2) Kettle lake or pond
- ☐ 3) Standing water
- ☐ 4) In ravine or depression
- ☐ 5) Appears occasionally flooded (vernal pond, floodplain forests)
- ☐ 6) At base of hill or slope
- ☐ 7) Groundwater seepage area
- ☐ 8) Source of water not apparent

<u>If no standing water…</u>

- ☐ 9) Bare muddy ground
- ☐ 10) Tree trunks buttressed/stained
- ☐ 11) Tree roots bare or spreading
- ☐ 12) Other (describe):

III.2. Appearance of soil. If there is bare soil in the area from a tree tip-up, animal digging, or human activities, characterize the soil. *Check all that apply.*

- ☐ 1) Sandy
- ☐ 2) Heavy, slippery, loam-clay
- ☐ 3) Mixed w/ pebble or gravel
- ☐ 4) Glacial erratics (large rocks)
- ☐ 5) Light tan or brown
- ☐ 6) Dark brown
- ☐ 7) Mucky (circle: smooth; fibrous)
- ☐ 8) Peaty
- ☐ 9) Top 6–12" layered or banded
- ☐ 10) Top 6–12" appear uniform
- ☐ 11) Other (describe):

III.3. Vegetation structure. Observe the features and patterns of the vegetation.

- ☐ 1) Vegetation clumped in distinct areas or patches

  or
- ☐ 2) Vegetation has no distinct zones

Check all to right that apply :

- ☐ 3) Open-water area (no plants)
- ☐ 4) Emergent marsh area (plants rooted under water; some leaves above surface)
- ☐ 5) Wet meadow or marsh area (dominated by grass-like plants)
- ☐ 6) Forb area (broad-leafed plants)
- ☐ 7) Fen area (grasslike & broad-leafed plants; peat/sphagnum moss)
- ☐ 8) Bog area (sphagnum moss, low broad-leafed evergreen shrubs)
- ☐ 9) Dense tall shrub area
- ☐ 10) Forest (swamp, floodplain) area
- ☐ 11) Other (describe):

III.4. Vegetation types. Check off all species that you recognize in the following vegetation groups.

→ *Within each group of species, CIRCLE any that predominate.*

III.4.1. Native emergent and floating-leaved plants

- ☐ 1) Buttonbush
- ☐ 2) Pickerelweed
- ☐ 3) Water-willow
- ☐ 4) Other (list):

III.4.2. Native grasses and grass-like plants (sedges, rushes)

- ☐ 1) Bluejoint grass
- ☐ 2) Bulrushes
- ☐ 3) Cottongrass
- ☐ 4) Tussock sedge
- ☐ 5) Sedges, uncertain or other
- ☐ 6) Uncertain
- ☐ 7) Other (list):

III.4.3. Native forbs

- ☐ 1) Ferns (cinnamon or royal)
- ☐ 2) Gentians
- ☐ 3) Joe-pye weed
- ☐ 4) Lobelias (***except*** Indian tobacco)
- ☐ 5) Marsh marigold
- ☐ 6) Orchids
- ☐ 7) Skullcaps
- ☐ 8) Skunk cabbage
- ☐ 9) Other (list):

III.4.4. Native shrubs

- ☐ 1) Blueberries
- ☐ 2) Buttonbush
- ☐ 3) Cinquefoil, shrubby
- ☐ 4) Dogwoods, shrubby (gray, red-osier, silky)
- ☐ 5) Leatherleaf
- ☐ 6) Michigan holly
- ☐ 7) Ninebark
- ☐ 8) Poison sumac
- ☐ 9) Willows (shrubby)
- ☐ 10) Other (list):

III.4.5. Native trees

- ☐ 1) Ashes
- ☐ 2) Birch (yellow)
- ☐ 3) Cedar, northern white
- ☐ 4) Larch (tamarack)
- ☐ 5) Maples (Circle: red; silver; other)
- ☐ 6) Oaks (Species: ______________)
- ☐ 7) Spruce, black
- ☐ 8) Sycamore
- ☐ 9) Other (list):

III.4.6. Native plants of bogs and fens

- ☐ 1) Cottongrass
- ☐ 2) Leatherleaf
- ☐ 3) Pitcher plants
- ☐ 4) Sphagnum moss
- ☐ 5) Sundews
- ☐ 6) Other (list):

III.4.7.Invasive species (grass-like plants, forbs, shrubs, trees)

- ☐ 1) Black alder
- ☐ 2) Buckthorns (Circle: glossy; common)
- ☐ 3) Cat-tails (dense, extensive)
- ☐ 4) Phragmites (common reed)
- ☐ 5) Purple loosestrife
- ☐ 6) Reed canary-grass
- ☐ 7) Other (list):

III.4.8. Estimate the total number of species of all types (even if you can't identify them): _________

III.5. Vegetation cover. Estimate the area covered by each type of plants. (Vegetation types may overlap, so total cover can be greater than 100%).

	None (0%)	A little (1–10%)	Common (11–25%)	Abundant (26–50%)	Dominant (>50%)
III.5.1. Native emergent plants	☐	☐	☐	☐	☐
III.5.2. Native grasses, grass-like plants	☐	☐	☐	☐	☐
III.5.3. Native forbs	☐	☐	☐	☐	☐
III.5.4. Native shrubs	☐	☐	☐	☐	☐
III.5.5. Native trees	☐	☐	☐	☐	☐
III.5.6. Native bog/fen plants	☐	☐	☐	☐	☐
III.5.7 Invasive species (all types)	☐	☐	☐	☐	☐

III.6. Invasive species distribution within wetland area. *Check all that apply*.

- ☐ 1) Primarily along trails and wetland edges (exterior)
- ☐ 2) Within wetland interior
- ☐ 3) Occur in isolated pockets
- ☐ 4) Occur in large monotypic stands
- ☐ 5) Pervasive throughout wetland (interior and exterior)
- ☐ 6) Other (describe)

III.7. Human disturbances to wetland area. If possible, walk around the perimeter of the wetland to look for possible draining or ditching. *Check all that apply, and **CIRCLE** all that appear on-going or severe.*

- ☐ 1) Bulldozed clearings
- ☐ 2) Ditches, channels, or tiling (circle one)
- ☐ 3) Drainpipes
- ☐ 4) Berms, dams to divert H_20
- ☐ 5) Erosion (gullies, washouts)
- ☐ 6) Erosion control fencing
- ☐ 7) Gravel or rubble fill or piles
- ☐ 8) Dirt roads (graveled or unimproved two tracks)
- ☐ 9) ATV or off-road vehicle trails
- ☐ 10) Fences
- ☐ 11) Agricultural use (describe):
- ☐ 12) Rock piles
- ☐ 13) Evidence of plowing
- ☐ 14) Wheel ruts, compacted areas
- ☐ 15) Trampled or rutted areas
- ☐ 16) Footpaths
- ☐ 17) Other (describe):

III.8. Characterize the extent of the disturbance(s) to this wetland area:

- ☐ 1) Extensive (>50% of area)
- ☐ 2) Partial (25–50% of area)
- ☐ 3) Moderate (10–25% of area)
- ☐ 4) Mild (<10% of area)
- ☐ 5) Uncertain
- ☐ 6) None apparent

III.9. Additional notes (continue on notes sheet if necessary):

Date: **Park:** **UNIT:**

Time spent at site: **Surveyors:**

IV. GRASSLANDS/SHRUBLANDS__ WORKSHEET

IV.1. Appearance of soil. If there is bare soil in the area from a tree tip-up, animal digging, or human activities, characterize the soil. *Check all that apply.*

- ☐ 1) Sandy
- ☐ 2) Heavy, slippery, loam/clay
- ☐ 3) Pebbly or gravelly
- ☐ 4) Glacial erratics (boulders)
- ☐ 5) Light tan or brown
- ☐ 6) Dark brown
- ☐ 7) Mucky (Circle: smooth; fibrous)
- ☐ 8) Peaty
- ☐ 9) Top 6–12” layered or banded
- ☐ 10) Top 6–12” appear uniform
- ☐ 11) Other (describe):

NOTE: If soil is mucky or peaty, or if there is standing water >24 hours after a rain or >1 week after snowmelt, PLEASE FILL OUT A WETLANDS WORKSHEET (III) FOR THIS AREA.

IV.2. Vegetation structure: Tree and shrub canopy. *Choose a or b for each.*

- ☐ 1a) No mature (med-lg) trees
- ☐ 1b) Mature trees have low, spreading canopies
- ☐ 2a) Mature trees far apart; branches do not touch
- ☐ 2b) Mature trees close; branches touch or overlap
- ☐ 3a) Trees cast dappled shade
- ☐ 3b) Trees cast dense shade
- ☐ 4a) Saplings, small trees scattered, occasional
- ☐ 4b) Saplings, small trees in dense thickets
- ☐ 5a) Sight lines open across area
- ☐ 5b) Sight lines blocked by saplings, shrubs

IV.3. Vegetation structure: Tree size distribution. ***Estimate the area*** *covered by each of following size classes of trees.* **NOTE: DBH = estimated diameter at breast height; visual estimates based on comparison to this 8.5” by 11”sheet of paper are adequate.**

	None (0%)	A little (1–10%)	Common (11–25%)	Abundant (26–50%)
IV.3.1. Very large (>18 dbh)	☐	☐	☐	☐
IV.3.2. Large (>10” dbh)	☐	☐	☐	☐
IV.3.3. Medium (6–10” dbh)	☐	☐	☐	☐
IV.3.4. Small (2–6” dbh)	☐	☐	☐	☐
IV.3.5. Saplings (<2” dbh, 3–15’ tall) and seedlings (<2” dbh, <3’ tall)	☐	☐	☐	☐

IV.4. Vegetation types. Check off all species that you recognize in the following species groups.

→ ***Within each group of species, circle the one(s) that predominate.***

IV.4.1. Native grasses

- ☐ 1) Big bluestem
- ☐ 2) Little bluestem
- ☐ 3) Bluejoint grass
- ☐ 4) Bulrushes
- ☐ 5) Tussock sedge
- ☐ 6) Uncertain (but grows in clumps)
- ☐ 7) Other (name):

NOTE: If 3, 4, or 5 checked, also fill out worksheet III for WETLANDS.

IV.4.2. Non-native grasses (green early & late in season)

- ☐ 1) Bluegrass (Ky, Canada)
- ☐ 2) Cat-tails in dense stands
- ☐ 3) Orchardgrass (grows in clumps)
- ☐ 4) Uncertain
- ☐ 5) Other (name):

IV.4.3. Native forbs

- ☐ 1) Blazing stars
- ☐ 2) Butterflyweed
- ☐ 3) Goldenrods, short (<chest ht.)
- ☐ 4) Lespedezas, ticktrefoils
- ☐ 5) Milkweeds (***except*** common and whorled)
- ☐ 6) Mountain mints
- ☐ 7) Other (name):

IV.4.4. Invasive forbs (native and non-native old-field weeds)

- ☐ 1) Goldenrods, tall (≥ waist ht.)
- ☐ 2) Mullein
- ☐ 3) Queen Anne’s lace
- ☐ 4) Spotted knapweed
- ☐ 5) Swallow-wort, black or white
- ☐ 6) Sweet clover (white, yellow)
- ☐ 7) Teasels (common, cut-leaved)
- ☐ 8) Thistles (bull, Canadian, etc.)
- ☐ 9) Other (name):

IV. 4.5. Native shrubs (typically grow in clumps of woody stems)

- ☐ 1) Dogwoods, shrubby (Circle: gray, red-osier, silky)
- ☐ 2) Hazelnut
- ☐ 3) Ninebark
- ☐ 4) Poison sumac
- ☐ 5) Rose (Carolina or prairie)
- ☐ 6) Willows, shrubby
- ☐ 7) Other (name):

IV.4.6. Native trees. ***Check off ALL size classes in which you observe each species.***

Tree Species	Very Large	Large	Medium	Small	Sapling/Seedling
1) Ashes	☐	☐	☐	☐	☐
2) Black cherry	☐	☐	☐	☐	☐
3) Black locust	☐	☐	☐	☐	☐
4) Box-elder	☐	☐	☐	☐	☐
5) Maples (circle: red; silver; sugar)	☐	☐	☐	☐	☐
6) Oaks	☐	☐	☐	☐	☐
Species: ____________________)					
7) Other (name):	☐	☐	☐	☐	☐

IV.4.7. Non-native shrubs and trees

- ☐ 1) Autumn olive
- ☐ 2) Bittersweet, oriental
- ☐ 3) Black alder
- ☐ 4) Buckthorns (circle: common; glossy)
- ☐ 5) Honeysuckles, bush
- ☐ 6) Multiflora rose
- ☐ 7) Privets
- ☐ 8) Other (name):

IV.4.8. Estimate the total number of species of all types (even if you can't identify them): ________

IV.5. Vegetation cover. Estimate the area covered by each type of plants. (Types may overlap, so total may be >100%).

		None (0%)	A little (1–10%)	Common (10–25%)	Abundant (25–50%)	Dominant (>50%)
V.5.1.	**Native grasses**	☐	☐	☐	☐	☐
V.5.2.	**Non-native grasses**	☐	☐	☐	☐	☐
V.5.3.	**Native forbs**	☐	☐	☐	☐	☐
V.5.4.	**Invasive forbs (old-field weeds)**	☐	☐	☐	☐	☐
V.5.5.	**Native shrubs**	☐	☐	☐	☐	☐
V.5.6.	**Native trees**	☐	☐	☐	☐	☐
V.5.7.	**Non-native shrubs and trees**	☐	☐	☐	☐	☐

IV.6. Invasive species distribution within grassland/shrubland area. *Check all that apply***.**

- ☐ 1) Along trails, edges
- ☐ 2) Within interior of area
- ☐ 3) In isolated pockets
- ☐ 4) In large monotypic stands
- ☐ 5) Pervasive throughout area
- ☐ 6) Other (describe):

IV.7. Evidence of plowing (arranged by increasing likelihood of plowing). *Check all that apply.*

- ☐ 1) Soil feels spongy
- ☐ 2) Dense grass clumps
- ☐ 3) Thick sod
- ☐ 4) Appears unplowed
- ☐ 5) Rocks, if present, scattered on surface
- ☐ 6) Soil feels hard underfoot
- ☐ 7) Rocks in piles
- ☐ 8) Ridges and furrows visible
- ☐ 9) Soil buildup along fencerows
- ☐ 10) Appears plowed
- ☐ 11) Uncertain if plowed

IV.8. Human disturbances in grassland/shrubland area. ***Circle*** *all that appear on-going or severe.*

- ☐ 1) Bulldozed clearings
- ☐ 2) Agricultural field (plowed)
- ☐ 3) Paved or gravel roads
- ☐ 4) Railroads
- ☐ 5) Ditches
- ☐ 6) ATV/off-road vehicle trails
- ☐ 7) Dirt roads (unimproved, 2-tracks)
- ☐ 8) Agricultural field (grazed)
- ☐ 9) Abandoned agricultural field
- ☐ 10) Abandoned tree farm, orchard
- ☐ 11) Fences
- ☐ 12) Abandoned homestead
- ☐ 13) Rock piles
- ☐ 14) Dumping, trash piles
- ☐ 15) Footpaths
- ☐ 16) Other (describe):

IV.9. Characterize the extent and effects of human disturbance(s) in grassland/shrubland area.

- ☐ 1) Extensive (>50% of area)
- ☐ 2) Partial (25–50% of area)
- ☐ 3) Moderate (10–25% of area)
- ☐ 4) Mild (<10% of area)
- ☐ 5) None apparent
- ☐ 6) Other (describe):

Date:	**Park:**	**UNIT:**
Time spent at site:	**Surveyors:**	

V. FORESTS__ WORKSHEET

V.1. General forest structure and appearance. NOTE: DBH = estimated diameter at breast height; for reference, this sheet of paper is 8.5" by 11." *(Check all that apply.)*

- ☐ 1) Old orchard
- ☐ 2) Old tree farm or nursery
- ☐ 3) Pine plantation
- ☐ 4) Trees mostly the same size
- ☐ 5) Trees are a mix of sizes
- ☐ 6) Open-grown ("wolf") trees
- ☐ 7) Standing dead trees
- ☐ 8) Large rotting logs
- ☐ 9) Fallen trees and branches
- ☐ 10) Tree tip-up mounds
- ☐ 11) Pits left from fallen trees
- ☐ 12) Extensive tree mortality (e.g., emerald ash borer, oak wilt, larch budworm). Species affected: ______________________

<u>Wetland indicators</u>

- ☐ 13) Water lines on tree bases
- ☐ 14) Bare, muddy areas
- ☐ 15) Buttressed trunks, spreading roots
- ☐ 16) Other (describe):

V.2. Appearance of soil. If there is bare soil in the area from a tree tip-up, animal digging, or human activities, characterize the soil. *Check all that apply.*

- ☐ 1) Sandy
- ☐ 2) Heavy, slippery, loam/clay
- ☐ 3) Pebbly or gravelly
- ☐ 4) Glacial erratics (large rocks)
- ☐ 5) Light tan or brown
- ☐ 6) Dark brown
- ☐ 7) Mucky (circle: smooth; fibrous)
- ☐ 8) Peaty
- ☐ 9) Top 6–12" layered or banded
- ☐ 10) Top 6–12" appear uniform
- ☐ 11) Other (describe):

NOTE: If soil is mucky or peaty, or if there is standing water >24 hours after a rain or >1 week after snowmelt, PLEASE ALSO FILL OUT A WETLANDS WORKSHEET (III) FOR THIS AREA.

V.3. Vegetation structure: Tree sizes. *Estimate and circle the overall area covered by each size class of trees.*
NOTE: DBH = estimated diameter at breast height; visual estimates based on comparison to this 8.5" by 11"sheet of paper are adequate.

	None (0%)	**A little (1–10%)**	**Common (11–25%)**	**Abundant (26–50%)**	**Dominant (>50%)**
V.3.1. Very large (>18 dbh)	☐	☐	☐	☐	☐
V.3.2. Large (>10" dbh)	☐	☐	☐	☐	☐
V.3.3. Medium (6–10" dbh)	☐	☐	☐	☐	☐
V.3.4. Small (2–6" dbh)	☐	☐	☐	☐	☐
V.3.5. Saplings and Seedlings (<2" dbh, under 15' tall)	☐	☐	☐	☐	☐

V.4.1. Vegetation types: Tree species. *Check off ALL size classes in which each species appears.*

Species	**Large to Very Large**	**Medium**	**Small**	**Sapling/Seedling**
1) Ashes	☐	☐	☐	☐
2) Basswood	☐	☐	☐	☐
3) Beech	☐	☐	☐	☐
4) Birch (yellow)	☐	☐	☐	☐
5) Black cherry	☐	☐	☐	☐
6) Box-elder	☐	☐	☐	☐
7) Cedar, Northern white	☐	☐	☐	☐
8) Hemlock	☐	☐	☐	☐
9) Larch (tamarack)	☐	☐	☐	☐
10) Maples (Circle: red; silver; sugar; other)	☐	☐	☐	☐
11) Oaks	☐	☐	☐	☐
List oak species observed: ______________________				
12) Sycamore	☐	☐	☐	☐
13) Invasives (e.g., Norway maple, Scotch pine, white mulberry)	☐	☐	☐	☐
List species observed: ______________________				
14) Other (list):	☐	☐	☐	☐

V.4.2. Native shrubs and woody vines

- ☐ 1) Blueberries, huckleberries
- ☐ 2) Hazelnut
- ☐ 3) Michigan holly
- ☐ 4) Poison sumac
- ☐ 5) Spicebush
- ☐ 6) Witch-hazel
- ☐ 7) Other (name):

V.4.3. Native herbaceous ground cover and spring flora

- ☐ 1) Doll's eyes
- ☐ 2) Grasses, sedges
- ☐ 3) Hepatica, sharplobe
- ☐ 4) Marsh-marigold
- ☐ 5) Skunk-cabbage
- ☐ 6) Trilliums
- ☐ 7) Trout lilies
- ☐ 8) Wild ginger
- ☐ 9) Other (name):

V.4.4. Invasive species (small trees, shrubs, woody vines, and ground cover)

- ☐ 1) Autumn olive
- ☐ 2) Bittercress
- ☐ 3) Buckthorns (Circle: common; glossy
- ☐ 4) Burningbush
- ☐ 5) Dame's rocket
- ☐ 6) Garlic mustard
- ☐ 7) Honeysuckles (bush)
- ☐ 8) Japanese barberry
- ☐ 9) Oriental bittersweet
- ☐ 10) Privets
- ☐ 11) Other (name):

<u>Homestead indicators</u>

- ☐ 12) Day lilies
- ☐ 13) English ivy
- ☐ 14) Lilacs
- ☐ 15) Lily-of-the-valley
- ☐ 16) Vincas (periwinkles)

V.4.5. Estimate the total number of species of all types (even if you can't identify them): _____

V.5. Vegetation cover. Estimate the area covered by each type of plants. (Vegetation types may overlap, so total cover can be greater than 100%).

		None (0%)	A little (1–10%)	Common (11–25%)	Abundant (26–50%)	Dominant (>50%)
V.5.1.	**Native trees**	☐	☐	☐	☐	☐
V.5.2.	**Native shrubs**	☐	☐	☐	☐	☐
V.5.3.	**Native ground cover**	☐	☐	☐	☐	☐
V.5.4.	**Invasive species (all types)**	☐	☐	☐	☐	☐

V.6. Invasive species distribution within forested area. *Check all that apply*.

- ☐ 1) Along trails, edges
- ☐ 2) Within forest interior
- ☐ 3) In isolated pockets
- ☐ 4) In large stands
- ☐ 5) Pervasive throughout area
- ☐ 6) Other (describe):

V.7. Human disturbances in this forested area. *Check all that apply;* ***circle*** *all that appear on-going or severe.*

- ☐ 1) Residential/farm buildings
- ☐ 2) Bulldozed clearings
- ☐ 3) Dirt roads (graveled or unimproved two tracks)
- ☐ 4) ATV/off-road vehicle trails
- ☐ 5) Drains, ditches
- ☐ 6) Rutted, furrowed, or hard, compacted soil
- ☐ 7) Abandoned homestead
- ☐ 8) Abandoned agricultural field
- ☐ 9) Rock piles
- ☐ 10) Fences
- ☐ 11) Soil buildup along fencerows
- ☐ 12) Evidence of plowing
- ☐ 13) Cut tree stumps (describe size & number):
- ☐ 14) Footpaths
- ☐ 15) Other (describe):

V.8. Characterize the extent of human disturbance(s) in this forested area:

- ☐ 1) Extensive (>50% of forest)
- ☐ 2) Partial (25–50% of forest)
- ☐ 3) Moderate (10–25%)
- ☐ 4) Mild (<10%)
- ☐ 5) None apparent
- ☐ 6) Other (describe):

V.9. Additional notes (continue on summary sheet if needed):

Date: **Park:**

Time spent at site: **Surveyors:**

VII. SITE SUMMARY WORKSHEET *Keep these questions in mind as you walk through the site, and answer them considering how they apply to the ENTIRE site. Use additional sheets of paper as necessary.*

Summarize your evaluation of the condition of the site. What are the outstanding characteristics? Would you consider this site, or any parts of it, as a high-quality natural area? Is it worth additional inventory and protection efforts? Why or why not? Include notes on any rare/threatened plant or animal species seen, note the diversity of habitat found within the unit, and note any human disturbance, and the extent of the disturbance.

II.1. **Invasive species overall. After traversing the site, characterize the overall pattern(s) of species invasions.** *Check all that apply*.

- ☐ 1) Primarily at roadsides and trail edges (exterior)
- ☐ 2) Pervasive throughout site (interior as well as exterior)
- ☐ 3) Isolated pockets within a single community
- ☐ 4) Large monotypic stands in one community
- ☐ 5) Large monotypic stands in two or more communities
- ☐ 6) Other (describe)

Appendix H.2: Bioreserve Rapid Assessment Model Scoring System (adapted from Kalfsbeek and Riggs 2009).

Forest Integrity:

V.1. General forest structure and appearance		Trees mostly same size	2
		Trees mixed size	5
		Standing dead trees	5
		Large rotting logs	5
		Fallen trees	3
		Tree tip-up mounds	3
		Pits left	3
		Water lines	10
V.2 Appearance of soil		Mucky	5
		Peaty	5
		Top layered	5
V.3 Vegetation structure	Very Large	None	0
		A little	2
		Common	4
		Abundant	6
		Dominant	8
	Large	None	0
		A little	1
		Common	2
		Abundant	3
		Dominant	4
	Medium	None	0
		A little	1
		Common	2
		Abundant	2
		Dominant	1
	Small	None	0
		A little	1
		Common	2
		Abundant	1

		Dominant	0
	Saplings	None	0
		A little	1
		Common	2
		Abundant	1
		Dominant	0
V.4.1 Vegetation types: Tree species		Basswood	5
		Beech	5
		Birch (yellow)	5
		Cedar	15
		Hemlock	15
		Larch	15
		Maple	5
		Oak	5 for one check and 10 for more than one check
		Sycamore	5
V.4.2 Native shrubes and woody vines		Blueberry	5
		Hazelnut	5
		Michigan holly	5
		Spicebush	5
		Witch-hazel	5
V.4.3 Native herbaceous ground cover and spring flora		Wild ginger	5
		Trout lilies	5
		Trilliums	5
		Skunk cabbage	10
		Marsh marigold	10
		Hepatica	5
		Doll's eyes	5
V.4.5 Total number of species			Total number of species/10
V5. Vegetation Cover	Native trees	Dominant	4
		Abundant	3
		Common	2
		A little	1

		None	0
	Native shrubs	Dominant	0
		Abundant	1
		Common	2
		A little	1
		None	0
	Native ground cover	Dominant	2
		Abundant	2
		Common	2
		A little	1
		None	0
	Invasive species (all)	Dominant	0
		Abundant	1
		Common	2
		A little	4
		None	8

Forest Disturbance:

V.1. General forest structure and appearance		Old orchard	4
		Old tree farm	4
		Pine plantation	4
		Trees mostly same size	4
		Open grown	4
		Tree mortality	4
V.2 Appearance of soil		Top uniform	4
V.4.1 Vegetation types: Tree species		Box-elder	4
		Invasives	5
V.4.4 Invasive species		Autumn Olive	3
		Bittercress	5
		Buckthorn	5
		Burningbush	5
		Dames's rocket	5
		Garlic Mustard	5
		Honeysuckle	5
		Japanese barberry	5
		Oriental bittersweet	5
		Privet	5
		Day lily	5
		English ivy	5
		Lilac	5
		Lily of the valley	5
		Vincas	5
		Others	5
V5. Vegetation Cover	Invasive species (all)	Dominant	8
		Abundant	6
		Common	4
		A little	2
		None	0
V.6 Invasive species distribution within forest		Along trail	2
		Within Forest	4

	Isolated pockets	2
	In large stands	4
	Pervasive	8
V.7. Human Disturbance	Residential	4
	Bulldozed	4
	Dirt road	4
	ATV trails	4
	Drains	4
	Rutted	4
	Abandoned homstead	4
	Abandoned ag field	4
	Rock piles	4
	Fences	4
	Soil buildup	4
	Evidence plowing	4
	Cut tree stumps	2
	Footpaths	0
V.8 The extent of human disturbance	Extensive	8
	Partial	6
	Moderate	4
	Mild	2
	None	0

Wetland Integrity:

III.1.Hydrological conditions		At Margin	5
		Kettle lake	5
		In ravine	5
		Appears flooded	5
		At base of hill	5
III.2.Appearance of Soil		Heavy, slippery	5
		Mucky (smooth/fibrous)	5
		Peaty	5
III.3.Vegetation structure		Vegetation clumped	5
		Wet meadow	5
		Forb area	5
		Fen area	5
		Bog area	5
		Dense shrub	5
		Forested area	5
III.4. Vegetation type	III.4.1.Native emergent and floating leaved plants	Button bush	5
		Pickerelweed	5
		Water willow	5
	III.4.2.Native grasses and grass-like plants	Blue joint	5
		Bulrush	5
		Cottongrass	5
		Tussock sedge	5
		Sedges	3
	III.4.3.Native forbs	Fern	5
		Gentians	5
		Joe-pye weed	5
		Lobelia	5
		Marsh marigold	5
		Orchid	5
		Skullcaps	5
		Skunk cabbage	5
	III.4.4.Blueberry	Blueberry	5

		Cinquefoil	5
		Leatherleaf	5
		Holly	5
		Ninebark	5
	III.4.5.Native trees	Birch	5
		Cedar	10
		Larch	10
		Maple	5
		Oak	5
		Spruce	5
		Sycamore	5
	III.4.6.Native plants of bogs and fens	Pitcher	5
		Sphagum	5
		Sundew	5
	III.4.8.Total number of species		total number of species/10
	III.5.Vegetation cover	Invasive species/dominant	0
		Abundant	0
		Common	1
		A little	3
		None	5

Wetland disturbance:

III.4.Vegetation type	III.4.7.Invasive species	Alder	5
		Buckthorn	5
		Cattail	5
		Phragmites	5
		Loosestrife	5
		Reed canary	5
		Others	5
III.5.Vegetation cover	Invasive species	Dominant	8
		Abundant	6
		Common	4
		A little	2
		None	0
V.6 Invasive species distribution within wetland		Along trail	2
		Within Forest	4
		Isolated pockets	2
		In large stands	4
		Pervasive	8
V.7. Human Disturbance to wetland area		Bulldozed claering	4
		Ditches, channels	4
		Drainpiples	4
		Berms, dams	4
		Erosion	2
		Erosion control fencing	4
		Gravel or rubble	4
		Dirt road	4
		ATV trails	4
		Fences	4
		Agriculture uses	0
		Rock pile	0

	Wheel ruts	4
	Trampled areas	4
	Evidence of plowing	8
	Footpaths	2
V.8 The extent of human disturbance	Extensive	8
	Partial	6
	Moderate	4
	Mild	2
	None	0

Grassland Integrity:

IV.1.Appearance of soil	Top layered			5
IV.4. Vegetation type	IV.4.1.Native grasses	Bluestem		5
		Little bluestem		5
	IV.4.3.Native forbs	Blazing stars		5
		Butterflyweed		5
		Goldenrods		5
		Lespedezas		5
		Milkweed		5
		Mountain mints		5
	IV.4.5.Native shrubs	Hazelnut		5
		Ninebark		5
		Rose		5
	IV.4.6.Native trees	Oaks	one check for 5 and more than one check for 10	
	IV.4.8. Total number of species		Total number of species/10	
IV.5.Vegetation cover	NATIVE GRASSES	Dominant		5
		Abundant		5
		Common		3
		A little		3
		None		3
	Non-native grasses	Dominant		0
		Abundant		0
		Common		1
		A little		3
		None		3
	Native forbs	Dominant		0
		Abundant		4
		Common		4
		A little		4
		None		4
	Invasive forbs	Dominant		0
		Abundant		0
		Common		1

	A little	3
	None	3
Native shrubs	Dominant	2
	Abundant	2
	Common	3
	A little	3
	None	3
None native shrubs	Dominant	0
	Abundant	0
	Common	1
	A little	3
	None	3

Grassland Disturbance:

IV.1.Appearance of soil		Top uniform	4
IV.2.Vegetation structure		Mature trees close	3
		Trees cast dense	3
		Saplings dense	5
		Sight lines blocked	5
IV.3.Vegetation structure: tree size distribution	Small	None/A little	0
		Abundant	5
	Saplings	None/A little	0
		Abundant	5
IV.4.2.None-native grasses	Bluegrass		5
	Cattail		5
	Orchardgrass		5
	Uncertain		5
	Other		5
IV.4.4 Invasive forbs	Goldenrods		5
	Mullein		5
	Queen anne's lace		5
	Spotted knapweed		5
	Swallow-wort		5
	Sweet clover		5
	Teasel		5
IV.4.6. Native trees	Ashes		3
	Black locust		5
	Box-elder		5
IV.4.7.None native shrubs and trees	Autumn olive		5
	Bittersweet		5
	Black alder		5
	Buckthorn		5
	Honeysuckle		5
	Multiflora rose		5
	Other		5
IV.5.Vegetation cover	Non-native grasses	Dominant	8

		Abundant	6
		Common	4
		A little	2
		None	0
	Invasive forbs	Dominant	8
		Abundant	6
		Common	4
		A little	2
		None	0
	None native shrubs	Dominant	8
		Abundant	6
		Common	4
		A little	2
		None	0
IV.6 Invasive species		Along trail	2
		Within Forest	4
		Isolated pockets	2
		In large stands	4
		Pervasive	8
IV.7.Evidence of plowing		Soil feels hard	3
		Rocks in piles	3
		Ridges and furrows	5
		Soil buildup	5
		Appears plowed	5
IV.7. Human Disturbance		Ag fields plowed	4
		Bulldozed clearing	4
		Dirt road	4
		ATV trails	4
		Railroad	4
		Ditches	4
		Abandoned tree farm	4
		Abandoned ag field	4
		Abandoned homestead	4

	Ag field grazed	4
	Dumping	4
	Rock piles	4
	Fences	4
	Soil buildup	4
	Evidence plowing	4
	Footpaths	2
	Other	2
IV.8 The extent of human disturbance	Extensive	8
	Partial	6
	Moderate	4
	Mild	2
	None	0