Natural Areas Stewardship at the University of Michigan Matthaei Botanical Gardens and Nichols Arboretum

by

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Abstract

The University of Michigan Matthaei Botanical Gardens and Nichols Arboretum (MBGNA) natural areas serve as exceptional laboratories for University faculty and students to conduct research and teaching. These lands have a deep and complex natural history closely linked with human activities such as Native American burning for thousands of years. More recently, they have provided beauty to the campus and space for recreation, inspiration and restorative time spent in nature. These natural areas harbor significant biological value and provide many ecological services, but face a number of eminent threats including invasion of exotic species, lack of fire, storm water caused erosion, and several others. Restoration of these areas is ongoing and gaining in sophistication, but requires a planning process which will involve stakeholders to develop stewardship plans for the properties.

In this thesis various conservation and educational organizations with similar missions to the MBGNA are examined and their goals discussed. A historical context is provided to help understand the evolution of these natural areas and the development of important threats. An inclusive decision making model is developed to help provide the framework for creating comprehensive, objective stewardship plans that recognize the complexities of the MBGNA mission, goals and stakeholder values. Within this model a ranking instrument is designed specifically to address the complex issues surrounding the MBGNA natural areas and to help with the prioritization of stewardship areas and activities. The formation of two natural areas advisory groups is also recommended to bring together important stakeholders and experts at key points during the process to offer guidance. This framework is then applied as an example to the Nichols Arboretum property. The Matthaei Botanical Gardens and Radrick Natural Area, Horner Woods/McLaughlin Tract and Mud Lake Bog properties of MBGNA are also described and discussed. It is recommended that this model be applied to create plans for each of the MBGNA properties. It is also strongly recommended that this model be applied to other important University of Michigan natural areas, leading to a more centralized, sophisticated, effective and reliable approach to natural areas stewardship.

Acknowledgements

Many people have helped me with my graduate work and I would like to sincerely thank them for their time and support with this effort. Robert Grese played the keystone role in guiding me through this complex process and helping me to see a vision of stewardship for the natural areas of the Matthaei Botanical Gardens and Nichols Arboretum. His patience and support over the years have made this work possible.

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I thank John Witter for his help in shaping the ideas of my thesis. I am deeply sorry that he is not well at this time and hope that he may recover his health in the nearest future. My thoughts are with him.

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I. Introduction

The University of Michigan, Matthaei Botanical Gardens and Nichols Arboretum (MBGNA) is responsible for the Stewardship of four separate properties totaling over 700 acres of land. This includes the Nichols Arboretum, the Matthaei Botanical Gardens & Radrick Natural Areas, The Horner Woods McLaughlin Tract, and Mud Lake Bog. Of the total acres of the four properties, the vast majority can be defined as "natural areas".

Figure 1. State, County and area map of MBGNA properties: Mud Lake Bog, Nichols Arboretum, Horner Woods/McLaughlin Tract and the Matthaei Botanical Gardens

Defining "Natural Areas"

Natural areas are "areas of land which have scientific, educational and esthetic value by reason of distinctive natural features," as defined by George B. Fell, the Natural Areas Association's founder (Natural Areas Association). The Forest service defines "research natural areas" as,

> "A physical or biological unit in which current natural conditions are maintained insofar as possible. These conditions are ordinarily achieved by allowing natural

physical and biological processes to prevail without human intervention. However, under unusual circumstances, deliberate manipulation may be utilized to maintain the unique feature that the Research Natural Area was established to protect" (U.S. Forest Service. National Headquarters. 2005.)

Figure 2. Dow Field, Nichols Arboretum, fall 2008. Photo by Jeff Plakke

For MBGNA a natural area may further be defined as a natural landscape containing native plants and natural processes, but also imbedded within it a horticultural collection or a number of exotic plant specimens, as is found in abundance within the Nichols Arboretum. It may also include highly altered landscapes including abandoned gravel mines, old fields recovering after agricultural use, fading tree plantations, and storm water drainages engineered with native plants and natural materials. The natural areas of the landscape contain several unique features, complex and varied geologic and land use history. They contain a number of rare and unique natural communities, ecosystems and several threatened and endangered species. These landscapes are affected and shaped by the regional and local climate, hydrology, natural processes such as fire and flooding, and the rise and fall of populations and movement of many species. They provide a significant opportunity to conserve local and regional biodiversity, to conduct scientific research, to educate students, and to inspire and connect people to the natural world.

Threats to Natural Areas

MBGNA natural areas also face several critical threats and will benefit over all from a framework for conservation planning that considers the needs of the many stakeholders of these lands as well as their conservation value. While some areas are high in floristic quality and conservation value, many acres of these natural areas have been degraded over time by such human activities as logging, livestock grazing, plowing, mining of sand and gravel, and fragmentation of the landscape. Many of the terrestrial and some wetland natural communities are considered fire-dependent ecosystems and suffer from a lack of regular burning, a once common practice of Native Americans that sustained these ecosystems for millennia. They have also been impacted by the invasion of numerous non-native species which can wipe out other species and create fundamental changes to ecosystem processes leading to cascading losses in biodiversity. Portions have been impacted by repeated mowing and others by various recreational activities (jogging, hiking and sledding/skiing). Some areas suffer severe erosion from high levels of storm water runoff.

Figure 3. Garlic Mustard Invasion, floodplain forest, NewComb Tract, spring 2007.
Photo by Jeff Plakke

Teaching and Research

The two main properties, the Matthaei Botanical Gardens and the Nichols Arboretum, have had a number of research projects done in their natural areas including ecosystem study and mapping, floristic inventory and quality assessment, management planning for fens, and the improvement and maintenance of the Arboretum trail system. In addition, several studies evaluated and proposed environmental education strategies and general master plans for the properties.

Figure 4. *Viburnum acerifolium*, Radrick Forest, fall 2007. Photo by Jeff Plakke

The other properties have also been used for classes and some research, but with less specific information contributing to management. The studies and observations of these properties have helped to guide stewardship and ecological restoration activities which have been taking place now for several years.

While the natural areas of these properties have hosted several research projects and offer regular course support for the School of Natural Resources and Environment (SNRE) and the Department of Ecology and Evolutionary Biology (EEB), there is ample room for their utilization by university faculty and students to be expanded and improved.

The Need for a Process and a Plan for Stewardship

MBGNA would benefit from a planning process and a comprehensive plan for the stewardship of all its natural areas. This planning process must take into account several specific variables related to the University of Michigan's mission, the history and potential of the properties, and the desires of stakeholders, such as faculty, students, staff, local residents and other conservation organizations in the area. Because this process and its goals are quite complex, a methodology for ranking and prioritizing areas and strategies is also necessary.

> "The Mission of the University of Michigan is to serve the people of Michigan and the world through preeminence in creating, communicating, preserving and applying knowledge, art, and academic values, and in developing leaders and citizens who will challenge the present and enrich the future" (University of Michigan Office of the President 2008).

Figure 5. University of Michigan Mission Statement

This is an ideal time to address the need because MBGNA as a whole is also entering into a strategic planning phase with the intent to engage stakeholders and appropriate advisors for the various parts of its mission. There is an opportunity to propose a new advisory structure for natural areas stewardship that will engage experts from the University and local organizations and agencies through a "Natural Areas Advisory Group" formed of these and other appropriate stakeholders to provide advice at key points during this new decision-making process.

This decision-making process must be holistic to take into account a number of different factors. It should recognize the ecological value of rare natural communities and those high in biodiversity, natural areas providing habitat for rare and endangered species, and those which protect water quality. It must consider the needs of the MBGNA to be an inviting and useable resource to the faculty and students of the

University of Michigan for teaching and research. A new process must weigh the resources of the MBGNA such as their staff, equipment and tools, and those human resources potentially available to them such as student and other volunteer groups and the faculty and staff experts within the University community and within the community of environmental experts in the area. Finally, a model for decision making is needed which might serve as a basis for evaluating and making decisions about all the natural areas of the University as a whole, to help consolidate resources and expertise and to demonstrate and share the value of natural areas stewardship.

The New Decision-Making Model and its Context

Figure 6. Spring Burn, Dow Field 2006.
Photo by Jeff Plakke

In this thesis, the properties and natural areas stewardship by MBGNA are examined and discussed. Several natural areas methods for planning, natural areas plans, and tools for prioritizing natural areas and protected areas are reviewed. Also discussed is the potential designation as "research natural areas" of the natural areas of MBGNA. A number of vision and mission statements of similar organizations are reviewed and considered to find common themes and concepts helpful to the development of these statements for the MBGNA.

A historical context is provided by discussing the geological and ecological history of the region including the critical role that humans have played in shaping the

landscape and biota for millennia. The importance of the continuing human role in the future care of these areas is emphasized. There is a discussion of the many ecological changes since the time of European settlement, including the suppression of fire and the introduction of exotic invasive species, and how these changes have led to the decline of several natural communities and species within the MBGNA natural areas.

A framework and model for decision making is then developed for MBGNA natural areas stewardship. Also introduced is a ranking method and instrument specific to MBGNA to help prioritize the many different natural areas of this organization for restoration, protection, teaching and research and continued enjoyment by the community. This is followed by a discussion of the opportunities and strategies MBGNA has available and may consider expanding or adding. A sample mission statement and vision statement are conceived and may provide the impetus for further refinement of these statements which may help to concisely define and communicate the MBGNA natural areas program.

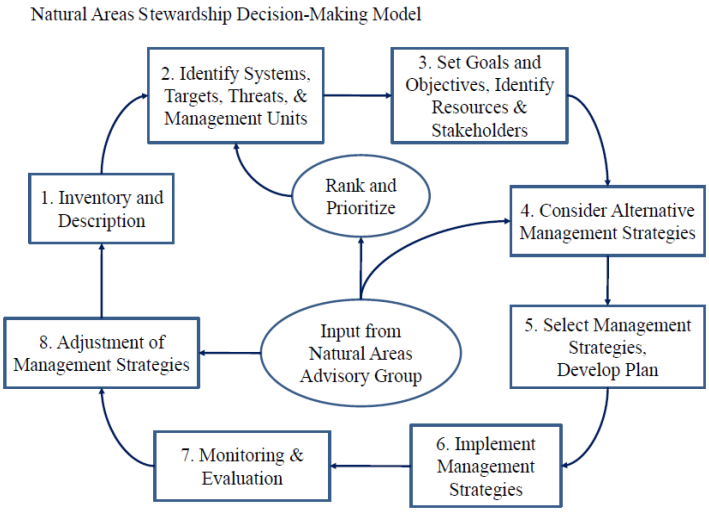

Figure 7. Model showing important steps in decision-making and planning process

A stewardship plan outline is then offered as a template for the development of natural areas stewardship plans for each of the properties and specific target areas. To

illustrate a draft stewardship plan for the natural areas of the Nichols Arboretum is provided. This section includes a brief property description and location, a description of the soils, the ecological history, its present ecological condition, threats to biodiversity and future trajectory, the connectivity of these areas with the greater landscape ecology, the use of the site by both the University and its neighbors and the impacts this has on the natural systems. Also mentioned is the present and potential risks as well as opportunities offered; the impact and management of exotic invasive species, erosion control, and the management of native natural processes including the reintroduction of fire into the fire dependent ecosystems as well as improved university and community involvement. Lastly, a number of research questions are suggested specific to this property. This plan is followed by a more brief description and discussion of the other three properties of MBGNA, the Matthaei Botanical Gardens and Radrick Natural Area, Horner Woods McLaughlin Tract, and Mud Lake Bog. Some of the more significant differences between them as well as some of the distinct challenges and opportunities associated with each property are discussed.

Natural Areas Stewardship expanded at the University of Michigan

The final section discusses the potential benefit in creating an internally coordinated group for the natural areas stewardship of the many acres of University of Michigan property. Currently these lands are overseen by various departments, sometimes with insufficient resources to be fully aware of their lands and to devote to the task of land stewardship. The need for such coordination to help plan for and protect its environmental and land resources was mentioned in two University of Michigan

campus plans produced in 1999 and 2001 (Andropogon Associates and M.R. Nalbandian & Associates 2001, Andropogon Associates and Turner Environmental 1999). These plans highlight the need for a more coordinated and holistic approach to evaluating and protecting these valuable natural areas as well as promoting these resources to achieve the most productive use by the University for teaching, research and creating a sense of place.

Other University of Michigan Natural Areas

The University of Michigan SNRE is also responsible for several properties in Washtenaw County, MI which total over one thousand acres. Three of these properties currently have student caretakers living on them, which provides for basic security and some maintenance of the facilities and trails, but the school lacks a property manager with land management experience or faculty with sufficient resources and authority to direct the active stewardship of these lands. Very little information about these properties is available on the school's website.

EEB manages the E.S. George reserve in Livingston County, a 1500 acre tract of land with diverse natural features, with several scientific experiments taking place, and that supports the EEB "Field Methods in Forest Ecology" class. While the property website provides considerable information and the research done on the property is documented with some ongoing long-term studies, stewardship of the property is inconsistent and attempted with minimal resources. A single caretaker living on-site is responsible and lacks the resources necessary to initiate a thorough and effective stewardship program (Plakke 2007 Personal Observation).

The U of M Grounds Department has begun to steward the various woodlots, riparian areas and other natural areas around North Campus which total more than several hundred acres. While this department has significant resources for the management of landscapes on and around campus, they may lack the scientific expertise and experience with ecological restoration work or ability to coordinate faculty and student research in natural areas. These areas may also benefit from a more coordinated internal approach for dealing with their stewardship.

Centralize U of M Natural Areas Stewardship

A centralized group could consolidate expertise and resources and be responsible for the evaluation, monitoring, promotion and coordination with academic units, university planners, and outside stakeholders as well. It would play a pivotal role in assessing landscape value from the perspective of environmental research, education, conservation and preservation. This approach could also regularly monitor critical information for environmentally conscious University planning and development. This group could work in conjunction with the MBGNA organization and utilize the planning and monitoring expertise already functioning here.

Figure 8. *Eurithronium Americanum*, Nichols Arboretum, Spring 2008. Photo by Jeff Plakke

These University of Michigan lands are extremely valuable; however an appropriate level of internal organization and awareness is lacking to realize that value within the University community and beyond. This awareness and understanding of these lands is critical not only to their full utilization by faculty and staff in teaching and research, but in the long-term conservation and protection of their biotic communities. They require monitoring and care that is engaged, consistent and ongoing by a team of educated people with the knowledge, skills and resources to steward these lands appropriately.

I hope that this thesis will shed light on the natural areas of MBGNA and the University of Michigan as a whole and highlight their great value and potential. I hope this work will continue to provide momentum and consolidate the resources needed to fully engage and steward the significant natural areas the university owns.

II. Theory and Methods

Planning, Plans and Prioritization

The following is an analysis of several planning processes, natural areas plans and evaluations, and methods of prioritization for protected areas and natural areas. The documents reviewed include: The Nature Conservancy's; "Conservation by Design", "Measures of Success" and "The Five-S Framework for Site Conservation". Also the World Wildlife Federation "Guide for Ecoregion Conservation in Priority Areas", Washtenaw County Department of Planning and Environment's "A Comprehensive Plan for Washtenaw County: A Sense of Place, A Sustainable Future" and the Michigan Natural Features Inventory's, "Potential Natural Areas Plan for Oakland County". The Goal is to develop a framework based on successful organizations and studies in conservation planning that begins broadly and focuses in on southeast Michigan. The framework will be examined and later tailored to fit the unique opportunities and needs of the University of Michigan's MBGNA natural areas.

The Nature Conservancy; Conservation by Design

The Nature Conservancy has developed a general conservation approach they call "Conservation by Design" (The Nature Conservancy 2004). The process starts with setting goals and priorities, then developing

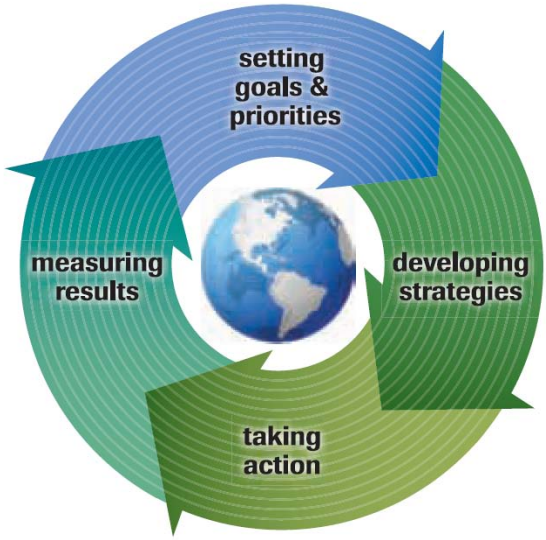

Figure 9. Conservation by Design Framework (The Nature Conservancy 2004)

strategies, taking action, and measuring results. 'Setting goals and priorities' requires the best available scientific information to set both long-term and near-term goals for conservation which may include natural communities, natural processes or individual species. It requires an understanding of threats, as well as strategic opportunities for a high conservation return on the investment of time and resources. 'Developing Strategies' requires a partnership with stakeholders that consider the needs of people and ecosystems on multiple scales. 'Taking Action' requires the bulk of the organization's resources and requires developing many strong relationships with partners and exercising tactics. 'Measuring results' answers two questions; "How is biodiversity doing?" and "Are our actions having the intended impact?" The answers to these questions help to determine adjustments in goals, priorities and strategies (The Nature Conservancy 2004). This process while being very broad and applicable to protected areas around the world could also help provide a chronological model for decision making within the MBGNA Natural Areas Program.

The Nature Conservancy: Measures of Success

An approach developed by the Nature Conservancy for measuring effectiveness of conservation efforts called "Measures of Success" was also examined (Parrish et. al. 2003). This approach suggests that measuring threat status and ecological integrity are the two most important measures to communicate effectiveness of conservation efforts. The framework for decision-making emphasizes identifying a limited number of conservation targets, those key attributes critical to these targets, identifying an acceptable range of variation for each attribute based on appropriate indicators, and a

rating system which is based on the measure of the attribute within the acceptable range of variation.

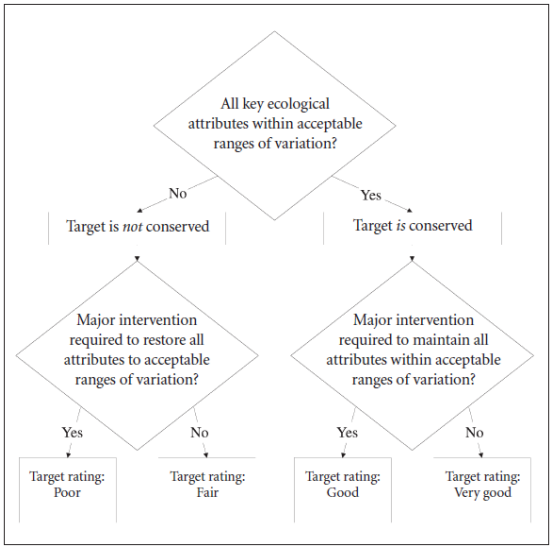

Figure 10. "Measures of Success" breakdown of rating system for key ecological attributes (Parrish et. al. 2003)

An example of using this method at the MBGNA might be identifying an oak opening natural community, such as the Kirk's Woods at the Matthaei Botanical Gardens, then identifying critical attribute or processes to its conservation, in this case perhaps regular fires. Then define an acceptable range for the use of prescribed burning in that area. The range may be a desired frequency, such as at least one burn every 3 years, up to once a year for the first 5 years, or it may be an area; at least 60% of the area and not more than 80% should burn during a single fire, or some combination of frequency and area, which would be the most thorough. If the area is not burned within the set range, the area would be considered "not conserved", if it is within the range the "target is conserved".

This system allows measures and a rating system which is effective, yet remains within the resource limits of many organizations and limited specialization of most land managers (Parrish et. al. 2003). This may be important for the natural areas of MBGNA because with current resources, thorough site inventories of all species may take several years to complete and require engaged collaboration and coordination with experts from around the university community. While this is an excellent goal for the organization, Stewardship activities should be able to move forward more quickly in the natural areas

still with a sensible and measurable goal for conservation. This framework also encourages comprehensive strategies for conservation which might help managers to avoid a common method of ad hoc threat abatement without restoring critical ecological processes (Parrish et. al. 2003).

The Nature Conservancy; The Five-S Framework for Site Conservation

The Nature Conservancy's "Five-S Framework for Site Conservation" offers a simple outline of steps to conservation planning: systems, stresses, sources, strategies, and success. Systems are the conservation targets occurring at a site, and the natural processes that maintain them. Stresses are the types of degradation and impairment that affect the systems at a site. Sources are the agents generating the stresses, such as invasive species, pollution, etc. Strategies are the types of conservation activities initiated to deal with sources of stress (threat abatement) and persistent stresses (restoration). Success is defined by measures of biodiversity and threat abatement at a site (The Nature Conservancy 2003).

There are three concepts that are central to understanding the Five-S approach to site conservation: scales of biodiversity and geography, functionality of conservation sites, and functional landscapes (The Nature Conservancy 2003). Scales of biodiversity and geography is the measure of both the size of the site and the scale of species, communities and systems which may become the conservation targets. Site functionality is a measure of how well the site maintains viable conservation targets, and functional landscapes are typically large areas that are intended to maintain a number of

different systems and communities. Site conservation plans should be developed by interdisciplinary teams. These teams should:

- Assess and rank conservation targets (systems), stresses, and sources of stress.
- Develop strategies to abate threats and enhance the viability of conservation targets.
- Assess measures of conservation success—biodiversity health and threat abatement.
- Periodically review and up-date the plan

(The Nature Conservancy 2003)

The implicit goal of this model is to maintain viable occurrences of conservation targets; therefore, threat abatement is a central priority. It is important to both remove sources of stress and mitigate the stresses that may remain once the source is removed through ecological restoration. This planning method could be extremely valuable for conservation efforts for the MBGNA natural areas and aspects of it should be incorporated into its new model, however this TNC model does not take into account important mission goals of the University of Michigan such as research and education as well as maintaining lands for public use.

Important planning steps under the Five-S model include defining the conservation targets and ranking them in terms of their viability. This may be done by measuring their size, condition and landscape condition. Then identify major stresses to the systems and rank the stresses. Then identify the sources of the stress and rank the sources. Identify critical threats and persistent threats and assign a threat status to the site. Consider all strategies, develop a list of them to use and rank them. The Nature Conservancy goes on to stress that a lead person or organization is critical to the success

of the process. Creating a simple approach will help ensure success because the more complex the strategy, the more likely unanticipated events will affect the outcome (The Nature Conservancy 2003). This may prove helpful advice for an academic organization to actively put conservation efforts 'on the ground'.

The process of ranking targets, stresses, threats, and strategies, suggested in this model would help MBGNA with prioritization and planning. As more properties and management zones are considered and the process becomes more thorough and long-term in scope, it will become much more complex and quickly exceed available resources. A ranking system based on the mission and goals of MBGNA would help establish priorities and focus limited resources where they will be most effective at conserving and utilizing these areas, and help identify the best strategies to achieve the defined goals.

For example, several areas at Matthaei Botanical Gardens could be ranked according to attributes specific to MBGNA goals to determine which areas should receive attention first. Then a number of stresses and threats could be ranked, such as exotic invasive species invasion, lack of fire, lack of native species diversity, visitor concern caused by a lack of information, erosion along trails, etc. These would vary depending on the severity of degradation, visibility and use of the site and previous stewardship activities. Then strategies could be considered and ranked for addressing and mitigating these threats, stresses or other site specific needs. These might include the use of prescribed burning, annual mowing or brush cutting, the removal and chemical treatment of invasive species, the addition of interpretive signs or information

to the website about stewardship activities, and the repair and maintenance of foot trails, etc.

The 5-S approach measures of success are reflected by biodiversity health, measured by the element occurrence (EO) method developed by TNC, and repeated every three to five years. Threat status should be measured, mapped by its rank and re-assessed every 2 to three years. Conservation capacity is dependent on three key factors: project leadership and support, strategic approach, and adequate funding. Monitoring should focus on the size, condition, and landscape context of the focal conservation targets, on the severity and scope of stresses to the focal targets, and on the status of critical threats (The Nature Conservancy 2003). This method of monitoring may need modifications to measure what is important to the MBGNA mission for the stewardship of its natural areas. While the TNC's mission is to protect a growing number of acres around the world, MBGNA is focused on increasing its capacity to meet University goals on a defined set of properties and number of acres.

World Wildlife Federation Guide for Ecoregion Conservation in Priority Areas

In the World Wildlife Federation's Guide for Ecoregion Conservation they focus on several key elements to achieve an effective conservation effort. These include; identifying key stakeholders and their roles, indentifying important biological targets, monitoring biodiversity and threats and evaluating performance, and maintaining resilience to ecological change within conservation areas (Loucks et. al. 2004). They emphasize several key elements of conservation biology that must be considered such as

maintaining large sized tracts of conservation land, improving or protecting connectivity in the landscape, preserving critical biological processes and focal species.
Like the TNC planning methodology, the approach is very effective and provides many useful insights for MBGNA, particularly an emphasis on identifying key stakeholders and their roles. For example, key stakeholders might include the University faculty interested in environmental research, the University Planners Office, and local conservation groups such as NAP and Washtenaw County Parks and Recreation.

A Comprehensive Plan for Washtenaw County: A Sense of Place, A Sustainable Future

Washtenaw County, MI created a comprehensive plan for the county which was released in 2004. This plan considered numerous areas of interest including development, population growth, mass transit etc. with the intent to focus on a sense of place and a sustainable future (Washtenaw County 2004). The plan mentions the importance of "open space" in the future of the county. The plan states that… "preserving large tracts of natural ecosystems and linkages between these ecosystems is an important part of developing an open space plan." It goes on stating… "corridors and natural connections between ecosystems provides for a natural flow that stands in stark contrast to small, isolated pockets of open space leftover from developments that disrupt natural water systems or trap wildlife. Preserving existing natural linkages will also promote wildlife and plant health and diversity." One of the plan's recommendations is for each population center to include green space planning for buffers which contain natural areas that preserve species and provide a sense of place (Washtenaw County 2004). While this plan is very broad, it repeats some of the previous themes of

conservation planning important to consider. It also highlights the value of several of the MBGNA natural areas as important green spaces surrounding the populated urban center of Ann Arbor, something which is more closely aligned with the organizational mission and goals than the methods discussed used by international conservation organizations such as The Nature Conservancy and the World Wildlife Federation.

Michigan Natural Features Inventory: Potential Natural Areas Plan for Oakland County

Michigan Natural Features Inventory (MNFI) prepared a Potential Natural Areas Plan for Oakland County and a version was released in 2004. The criteria for ranking and selecting natural areas includes total size and size of core area, buffer area, the presence or absence of a stream (riparian) corridor, connectivity measured by adjacent natural areas or those in close proximity, and restorability. Much of this information is gathered and analyzed through the use of GIS and spatial data available for the state. Also considered was the vegetation quality of each natural area. "As a surrogate to field surveys, a vegetation change map comparing the 2000 Integrated Forest Monitoring Assessment and Prescription (IFMAP) landcover datalayer to the circa 1800 vegetation datalayer was created" (Oakland County Planning & Economic Development Services 2004). The degree of parcel fragmentation and the number of conservation element occurrences (rare communities and/or species) on the site were also examined. These variables were then given point scores for each area in the county to be considered for conservation. Once scored, the areas are ranked level one, two and three priority for conservation (Oakland County Planning & Economic Development Services 2004). The results are mapped using GIS to highlight the potential areas within the county for

consideration. In the final section of the plan, comments and recommendations are given which include involving important stakeholders in the area to help with the long-term conservation strategy (Oakland County Planning & Economic Development Services 2004).

With GIS resources available to the MBGNA and the possibility of including student projects to gather and process information, an analysis of this type could be a useful exercise that provides valuable information. Also involving stakeholders to help with conservation efforts in the long-term might suggest a strategy of bringing MBGNA neighbors to the table early in the process to keep them informed and hopefully enlist their support in reaching the organization goals for conservation and education.

Identifying and Ranking Conservation Targets

The identification, assessment, mapping and ranking of conservation areas is important for establishing conservation targets and monitoring them over time. Two documents were reviewed which should provide very useful information and methods; the "Natural Communities of Michigan: Classification and Description" by the Michigan Natural Features Inventory (MNFI) and "Floristic Quality and Assessment" by the Michigan Department of Natural Resources (MDNR).

MNFI Natural Community Classification and Description

"Natural Communities of Michigan: Classification and Description" is a tool developed by the Michigan Natural Features Inventory that is intended to help practitioners identify

and describe the diverse natural communities found in the State of Michigan (Kost et. al. 2007).

> A natural community is defined as an assemblage of interacting plants, animals, and other organisms that repeatedly occurs under similar environmental conditions across the landscape and is predominantly structured by natural processes… (Kost et. al. 2007).

This document contains detailed descriptions of 76 recognized natural communities including an overview and landscape context, soils, natural processes, vegetation, noteworthy and rare plants and animals, management considerations, variation and similar natural communities. It shows their range within the stated, their state and global rankings and contains a dichotomous key to these communities. Presently the MBGNA properties, without more careful study, appear to have over 20 natural communities present (Appendix A.), at least 4 of which are critically imperiled communities in the state, and one is Globally imperiled, the Oak Openings (Kost et. al. 2007). Using this document to identify, map and rank the natural communities may provide a useful framework for further breakdown of these areas by their quality and need for conservation.

MDNR Floristic Quality Assessment

"Floristic Quality Assessment (FQA)" is a tool widely used to assist land managers and stewards in assessing the floristic significance of a given area, and therefore the natural significance. It is used by the MNFI, MDNR, and the Ann Arbor Natural Area Preservation just to name a few, to identify important areas and prioritize them for restoration and continued monitoring. The FQA is intended to be applied to

complement and corroborate with other methods of evaluating the natural quality of a site rather than acting as a stand-alone method (Herman et. al. 2001). It uses a thorough list of vascular plants known to occur within the State and has assigned them a coefficient of conservatism. This value (1-10) represents how likely a plant is to occur in a landscape unaltered from pre-settlement conditions. Some plants which tend to occur only in these high quality sites are given a ranking of "10," other plants which are more common in disturbed landscapes are given a lower value. The coefficients of conservatism are then used to calculate the Floristic Quality Index, which can be applied to an entire site and allow for comparison and raking between sites of varying sizes and quality (Herman et. al. 2001).

These two tools for identifying and ranking conservation targets might be used together to provide extremely useful information for the stewardship of MBGNA properties in terms of conservation. First establishing relative boundaries for communities and ranking their importance, their probability for providing habitat for listed species, etc. then determining the quality of the communities using an FQA is one possibility to identify, map and rank targets and monitor them over time. Also, the methodology is relatively common and standardized allowing for comparisons with other sites from around Michigan.

Summary of Planning and Ranking Methods

These processes for conservation planning and examples of prioritizing provide useful background models for the development of a natural areas stewardship plan for MBGNA. Utilizing the repeated themes of conservation biology, such as patch size, the presence of rare communities or species, floristic quality, the presence of riparian

habitat, etc. will be important in thinking through a long-term process for determining priorities and developing plans for the natural areas in the years and decades to come.

MBGNA also has the central mission of the University of Michigan to consider. Research, education and the development of leaders in their fields will need to be weighed along with the variables related specifically to conservation when setting stewardship priorities for these properties. Education and research will play an important role in determining stakeholders and involving them in the assessment and application of the restoration activities throughout these natural areas over time. MBGNA is also faced with the challenge of being a relatively small organization with limited resources to devote to the task of land stewardship. In the management and stewardship of its lands it must address the needs of several user groups including the University's students and faculty, the general public, its neighbors, nature enthusiasts and others with special interests. MBGNA is connecting to these many stakeholders through natural areas stewardship yet there is room to expand. Through activities such as ecological monitoring of plants, animals, birds and insects it can connect nature enthusiasts with the research community at the University. By continuing to engage the public through activities like controlling invasive species and conducting prescribed

Figure 11. U of M Student Volunteers helping with Ecological Restoration at the Nichols Arboretum. Winter 2005. Photo by Jeff Plakke

burns, MBGNA can bring several more interest groups together to become engaged in the stewardship of these properties. The planning process for MBGNA will need to consider all of these opportunities and challenges as stewardship plans are made.

Stewardship Plans

An examination of several stewardship plans from similar natural areas and organizations provides another perspective of the planning process. A master plan for the University of Wisconsin – Madison Lakeshore Nature Preserve, a Stewardship Plan written by the Michigan Natural Features Inventory for the Island Lake Recreation Area in the Michigan State Parks system, and a Stewardship Plan from the Ann Arbor Natural Areas Preservation for the Bird Hills Nature Area serve as examples.

The University of Wisconsin-Madison,

Lakeshore Nature Preserve Master Plan Summary

The Lakeshore Nature Preserve Master Plan Summary offers a concise look at this extensive plan and its approach and findings (University of Wisconsin Madison, Lakeshore Nature Preserve 2006). The writers of this plan considered the recreational use of this University Natural Area in addition to the conservation of biological diversity, which may be similar in some ways to that of the MBGNA priorities for its natural areas and therefore useful to examine. The report begins with a description of the property and the goal of integrated management which involves a holistic assessment of the landscape and its users, something important for a planning process at the MBGNA as well. It then gives a brief description of some important threats to the

preserve including erosion, invasive species and poor management of human use to name a few. It provides a mission statement, and a list of guiding principles. These include following the underlying principles of conservation biology and ecology, sustainability and educational interpretation designed to connect people with nature (University of Wisconsin Madison, Lakeshore Nature Preserve 2006).

The summary includes recommendations for future vegetation, recommendations to abate erosion, to preserve cultural resources, proposed changes to trails and roads to circulate people through the preserve, and proposals to restore historic views through the removal of exotic invasive species. This is an important consideration at Nichols Arboretum especially with long views being an important emphasis of the historic design of the landscape plantings (Callery et. al. 1988). Input and commentary from interested stakeholders and from the public at large was sought throughout the planning process and members of the Friends of the Lakeshore Nature Preserve were heavily involved (University of Wisconsin Madison, Lakeshore Nature Preserve 2006). Identifying and involving stakeholders in this way will be important for MBGNA as well. Each property has its own unique natural features and group or groups of people who are connected to them. In the case of the Arboretum, there are is a highly diverse set of stakeholders with different interests that, in some cases may be conflicting. Each MBGNA property also has a distinct group of neighbors surrounding it which may provide opportunities in some cases or resistance in others depending on the activities or developments that are proposed. Getting the stakeholders to the discussion table during the early stages may slow down decision-making initially, but may provide a more thorough plan and better chance of success in the long-term.

Stewardship Management Plan: Island Lake State Recreation Area

A conservation stewardship plan written by Glenn Palmgren, Stewardship Ecologist for the Michigan Natural Features Inventory, for the Island Lake State Recreation Area in Michigan gives excellent insight into the information that is important to create an effective plan for a State Recreation Area.

The first section of the plan consists of a thorough site description. This contains basic information about location, size and administrative details of the Recreation Area. It describes the natural ecosystems including the regional ecosystem context, water resources, climate, geology and topography, soils, pre-settlement conditions and critical ecosystem processes. All of these items will be important to mention in the MBGNA natural areas stewardship planning as well. The Island Lake Plan also describes the natural communities of oak barrens, dry mesic southern forest and prairie fens as a few of the important natural communities that can still be found on this site, several of the same systems found on the MBGNA natural areas. It states that the most important critical ecosystem process for maintaining these communities is fire because several of the historic natural communities are fire dependent (Palmgren 2002).

The Island Lake Plan describes the land use and cover history, mentioning the Native Americans that once lived in the area. It discusses the current land use, which is primarily for recreation. It describes land cover and natural communities, including vegetation surveys and indications of a number of high quality remnants of the historic natural communities including Oak Barrens. It mentions the presence of many invasive exotic species, as well as native mammals, insects, and special concern species including

the eastern box turtle (*Terrapene carolina Carolina)* and the eastern massasauga (*Sistrurus catenatus catenatus*). This inventory of species of special concern will be important to note and plan for inventorying methods at MBGNA which also has occurrences of a number of state-listed species.

The Island Lake Plan also describes the surrounding land use, which in this case is primarily residential, commercial and industrial, adding to the value of conserving this property's natural resources. It mentions a number of cultural resources including Native American artifacts and early settlement structures that should be monitored and treated with care if park improvements are made. While this aspect may not be discussed in as great a detail in a natural areas stewardship plan at MBGNA, cultural history is definitely of importance for MBGNA. There is information about Native American artifacts found on the properties in the past as well, and several structures from the early settlement time period, each with their own unique history, and often linkages to the land use that affected the ecology dramatically during settlement. This topic may also provide interesting and productive student projects adding to the organizations information on these lands over time.

The Island Lake Plan then lists the conservation targets of natural communities, with flora and fauna to be protected within the context of these communities. MBGNA may benefit from this method of identifying natural communities as primary conservation targets because the individual species can best be protected through preserving their habitats (Palmgren 2002). This also greatly simplifies both the identification of targets and the measures of successful restoration. The primary conservation targets in the park are the oak barrens, prairie fens, relict conifer swamps,

southern floodplain forests, and the Huron River natural communities. Many of these communities exist within the MBGNA natural areas as well.

A threat assessment identified lack of fire due to fire suppression as a primary threat to conservation. It also lists altered vegetation composition and structure due to a number of impacts including historic grazing and introduction of non-native invasive species. Habitat destruction in the past from conversion to agriculture, mining of sand and gravel and damage from ORV's and other activities still remains a threat at Island Lake. MBGNA lands are perhaps less likely to be impacted in this way, yet primary habitat destruction through development remains a threat to some other University lands. If the University continues its development and expansion without complete information of the ecological value of its natural areas or a holistic planning process, its biodiversity and natural communities remain at risk (Andropogon Associates & Turner Environmental 1999).

Habitat fragmentation and hydrologic disruptions are also considered important threats within the Island Lake Recreation Area. The creation of roads, clearing of areas for agriculture, and other developments have created many divisions in the landscape. These are historically important within the MBGNA natural areas as well and will need to be addressed on all four of the properties. In some cases changing mowing or burning patterns may help to reduce distinct edges that have formed between areas which may have similar community potential. With several wetland communities of importance and stormwater issues being of concern, understanding and monitoring hydrologic conditions will be important to MBGNA.

Palmgren's plan for Island Lake Recreation Area mentions the favorable outlook for restoration of the rare oak barrens natural community after observed dramatic improvements from prescribed burns conducted in the area. He goes on to describe the vision for the area in the long-term with the entire area being restored, historic fire regimes, native plant communities, and the entire associated ecology. He also sees educational opportunities being realized in the Recreation Area and a future of engaged volunteers and regular ecological monitoring being completed with their help and it turning into a recreational activity (Palmgren 2002). The exercise of imagining or envisioning what the future should be can help create the strategic steps to get to that goal and achieve the vision. This process of visioning the future may prove useful for the MBGNA natural areas program as well.

The Island Lake Plan goes on to describe in detail the management and

Timeline for Tasks: January – December 2003

Task	Units	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Burning & related preparation													
Install burn lines	12	Unit 12											
Maintain burn lines	1,6,7,11,13	Units 1,6							Units 7,11,13				
Prescribed burn	1,6,12												
Submit FTPs for 2003	7,11,13												
Invasive species control													
Herbicide phragmites	16												
Herbicide/pull garlic mustard	1,6												
Cut & herb invasive brush,trees	1,6,11,12,13												
Seeding & Collection													
Collect seed	1,3,6,13,16												
Monitoring													
Breeding bird surveys	all (as needed)												
Invasive plants (ocular surveys)	1,6,11,12,13												
Survey Huron Rvr for invasives	all (as needed)												
Insects (blcklight/sweepnet)	1,5,11,13							Sweepnet		Blacklight			
Photo-monitoring	1,5,6,11-13				Install points & repeat photos								

Figure 12. Annual task list from Appendix J (Palmgren 2002)

monitoring objectives for each natural community, and general park wide objectives including volunteer recruitment, the development of educational materials, and the acquisition of appropriate funds to support the program into the foreseeable future. It

describes long-term and ongoing tasks for each management unit broken down in chronological format. This serves as an excellent planning model for tasks and projects through the changing seasons.

Finally it describes a thorough monitoring plan. The first section of this plan states that the intent of monitoring is to document overall trends in biological response to management to determine whether management objectives are being met and not to produce in-depth research on plant or animal populations (Palmgren 2002). Taking this approach may also help MBGNA to avoid getting mired in detailed studies and overabundance of data that does not necessarily help with stewardship planning or activities. However, MBGNA can consider what research questions related to these properties they can encourage the University community to attempt to answer to help MBGNA accumulate more detailed information about the properties over time. The MBGNA is an organization supporting research at the University of Michigan, but for the purposes of determining conservation targets and measuring stewardship success, simple yet effective measures may be most effective.

Ann Arbor, Natural Areas Preservation: Bird Hills Nature Area Stewardship Plan

The City of Ann Arbor Natural Area Preservation (NAP) serves as an excellent example in natural areas stewardship in Southeast Michigan in and around the City of Ann Arbor and is an important partner to the MBGNA. They are widely supported by the community in their effort to protect and restore local natural areas. They have an engaged volunteer coordination effort, a wide ranging monitoring program, they aggressively control invasive species and they have an active prescribed burning

program. For each of their parks or designated “Natural Area” they create a management plan.

The Stewardship Plan for the Bird Hills Nature Area follows a standard format for NAP stewardship plans. It begins with a site overview including many of the same items as in the previous plans; geography, geology and physiography, and a description of the biotic communities present in the park as well as important wildlife which presently focuses on the avian community. The plan describes the land use history which mentions logging and tree planting, fire suppression and the purchase of the land for a city park. It then describes current land use including for hiking and general use by nature enthusiasts.

The Bird Hills Plan then lists the conservation targets and goals for the site including the restoration of the oak-hickory/dry-mesic forest, beech-maple/mesic forest, the forested ravines which contain special concern species *Carex jamesii* and *Jeffersonia diphylla*. This format seems to follow the method described earlier of identifying natural communities as primary conservation targets.

This plan then outlines the stresses and conservation strategies for each of the conservation targets listed. Stresses include a list of the invasive plants affecting each site, fire suppression, and in this case erosion of soil from hiking trails. Then a number of strategies are listed to deal with each of the stresses; for example managing invasive species through hand pulling, use of herbicides, girdling and burning. The simple strategy to deal with the fire suppression is the reintroduction of fire through prescribed burning. Erosion on trails is abated through maintenance of water-bars, etc. This streamlined approach of identification of conservation targets, stresses and threats, and

the listing of strategies to deal with each of them seems an effective way to communicate the stewardship plan. What follows this is an "Annual Site Management Plan" which simply lays out the management units, objectives, strategies, schedule and priority.

Property Designation

Figure 13. Research Property sign. University of Michigan NewComb Tract. Spring 2007. Photo by Jeff Plakke

Designating the MBGNA natural areas as "Research Natural Areas" would help to establish official guidelines and policies related these lands. The Forest Service manual section 4063 was consulted describing the designation of a "Research Natural Area" and what this might include and exclude in terms of activities in the MBGNA natural areas.

> Research Natural Areas are part of a national network of ecological areas designated in perpetuity for research and education and/or to maintain biological diversity on National Forest System lands. Research Natural Areas are principally for nonmanipulative research, observation, and study. They also may assist in implementing provisions of special acts, such as the Endangered Species Act of 1973 and the monitoring provisions of the National Forest Management Act of 1976 (U.S. Forest Service 2005).

While the policy states that the goals are primarily conservation related with minimal intervention, the policy does allow for measures to be taken in accordance with a management plan. Activities such as invasive species control, prescribed burning, grazing, or other measures could be taken to preserve critical habitat or target species (U.S. Forest Service 2005).

The Research Natural Area designation states that the prime management consideration is the maintenance of natural ecological processes and the protection against human activities that threaten them. In the case of the MBGNA natural areas, the reintroduction of fire is appropriate in many natural areas to continue the critical natural ecological process and protect these areas from fire suppression. Logging and wood gathering is discouraged unless necessary for restoration of the site. This may be important to continue in certain areas of the MBGNA natural areas for example, where senescing pine plantations are dying and will be converted to native vegetation over time. As they die from insects and disease they are leaving large volumes of dead material which may cause a fire hazard or interfere with restoration activities in the area.

Research activities are expressly encouraged with some restrictions. Manipulations that may threaten conservation targets within the area should not be permitted.

> Encourage the use of Research Natural Areas by responsible scientists and educators. Do not authorize educational use of the Research Natural Area if it is probable that such use will cause unacceptable impact on the values for which the Research Natural Area was established (U.S. Forest Service 2005).

This policy then goes on to describe the necessary documentation to establish a Research Natural Area, including an outline of the site information and the development of a management plan. The management plan describes all the activities planned for the site including the removal of exotic invasive species, prescribed burning, etc. It also requires and outline for an ecological assessment and monitoring program.

Providing this documentation as part of a designation process could provide a helpful template which would clearly communicate concepts and help apply this method to many of the University of Michigan properties.

Developing Vision and Mission Statements

Having a vision of the future and a mission with specific goals will help to concisely define and communicate the MBGNA natural areas program. A vision statement communicates a picture of the organization having met its goals and achieving success in the future. In descriptive terms it helps to frame daily activities within a "big picture" for the staff. For those outside the organization it can communicate more broadly what the organization is about. The mission statement describes the goal of the organization, or what it strives to achieve.

Figure 14. Nichols Arboretum, winter 2007. Photo by Jeff Plakke

The vision and mission statements of the University of Michigan and the MBGNA provide the framework for the development of a MBGNA natural areas vision and mission. Several vision and mission statements, guiding principles and goals for similar organizations were also reviewed. These serve as a reference and guide to forming the MBGNA vision and mission.

The University of Michigan Mission

The mission of the University of Michigan is to serve the people of Michigan and the world through preeminence in creating, communicating, preserving and applying knowledge, art, and academic values, and in developing leaders and citizens who will challenge the present and enrich the future (University of Michigan Office of the President 2008).

The University of Michigan,

Matthaei Botanical Gardens and Nichols Arboretum Mission

The mission of Matthaei Botanical Gardens and Nichols Arboretum is to promote environmental enjoyment, stewardship and sustainability through education, research, and interaction with the natural world.

Our purpose:

- provide a hands-on community and University laboratory for conserving, restoring, and celebrating the environment

Our business:

- promote environmental education, research and public outreach
- develop citizens and leaders dedicated to appreciating, understanding and restoring our environment

Our values:

- engage scientists and artists in research, teaching, and outreach activities
- advance sustainable practices and the conservation of biodiversity, particularly that of the Great Lakes Region.
- apply ecological principles in our horticulture and land stewardship
- inspire and enrich people's lives through contact with plants and nature
- recognize the restorative value of nature and beautiful gardens.

Example Mission and Vision statements from similar organizations

The guiding statements consulted for ideas and concepts were those from the Arnold Arboretum of Harvard University, City of Ann Arbor Natural Area Preservation,

Holden Arboretum, Lakeshore Nature Preserve of the University of Wisconsin-Madison, Island Lake State of Michigan Recreation Area, Morris Arboretum of the University of Pennsylvania, Morton Arboretum, North Carolina Botanical Garden, Shaw Nature Preserve of the Missouri Botanical Gardens, and University of Wisconsin-Madison Arboretum.

Several common themes were repeated throughout these mission and vision statements. Each of these concepts is important to the future of MBGNA's natural areas as well and can be incorporated into the vision and mission statements to be created.

- *Conservation*, preservation, environmental stewardship and restoration, sustainability, and demonstrating high quality horticulture.
- *Connect people to nature*, creating a sense of place, promoting environmental enjoyment, providing for recreation, helping to foster a healthy relationship with nature and developing an environmental ethic. Also important in these statements was the idea of supporting and providing
- *Promote education and research* in the fields of the natural sciences and horticulture.
- *Protect cultural, historic and aesthetic landscape features* was a theme also mentioned in several mission statements and guiding principles.

Field Methods and Experience

Site Surveys, Analysis and Observations

Figure 1. State, County and area map of MBGNA properties: Mud Lake Bog, Nichols Arboretum, Horner Woods/McLaughlin Tract and the Matthaei Botanical Gardens.

Each property was visited during every season starting in the spring of 2003, the Arboretum received the most stewardship attention and site visits. General observations were made regarding native and invasive plant populations, wildlife sign, natural communities, community succession, hydrologic features, glacial features, evidence of land use history, trespass and vandalism, and general use. The property boundaries were all field checked as well as significant natural features visible from aerial photos and satellite images such as the Huron River, Mud Lake, Fleming Creek, Radrick and Kirk's Fens, unnamed intermittent streams, vernal ponds, open fields and any visible structures.

Figure 15. Mud Lake Bog, fall 2006. Photo by Jeff Plakke

ArcGIS data analysis

Spatial data including property boundaries, roads, trails, ecosystems, soils types, vegetation and other information was examined for each of the properties using ArcGIS. Several maps were created for the properties. Additional maps were created for the Nichols Arboretum to display landscape and natural areas features for its stewardship plan. GIS as a tool was reviewed and considered for multiple aspects of landscape planning, natural areas monitoring and research. The ArcGIS software tool combined

with the GPS offers extensive opportunities for planning and tracking spatial elements and other information about stewardship activities, as well as more detailed research with appropriate coordination and organization of the data. With the proper framework in place, this tool will allow for the accumulation, organization and standardization of retrievable data on the properties as students and researchers gather information over the course of several distinct studies.

Ecological Restoration Experience

Beginning in April of 2003 the author joined ongoing natural areas stewardship efforts at the Nichols Arboretum property. Field experience includes: planning and conducting prescribed fires, annual brush hogging, invasive species identification and control practicing a variety of methods and techniques, native species ID, monitoring, seed collection and propagation, ecological restoration workday planning and leadership. Many invasive species were identified throughout the natural areas and various methods were used for their control and removal. The chainsaw, brush blade and brush hog mower along with hand pulling and the use of herbicides were all methods used to help re-establish native plants and discourage the encroachment of exotic species and invasive native species.

A variety of desirable native plant species were identified and seeds were collected, processed and stored for later propagation. Thousands of plugs of native plants were grown from this seed in the greenhouses at the Matthaei Botanical Gardens starting in 2005. They were planted in a number of natural areas on the properties in

various stages of restoration and based on observations have varied in their success to become established.

Drafting Field Guides for Training and Education

A growing list of invasive species is still being assembled of exotic plants displaying invasive characteristics in the Arboretum. A short document was created of the most significant 23 invasive species in the Arboretum. This contains specific information about each species including the history of introduction at the Arboretum when appropriate, location and character of spread as well as successful management techniques.

A document is also under construction containing information on native plants. It contains photos taken of plants with mature seeds, some information about their specific location in the Arboretum, general site preference, and time of seed collection as well as storage and propagation methods. More refined versions of these documents and others like them could become effective field guides created by the MBGNA to assist in teaching interns and students, community members and other natural areas stewards about invasive and native plants, ecological restoration techniques, and other concepts and facts related to the field.

Planning and Leading Volunteer Workdays in Ecological Restoration

Ecological Restoration workdays with various volunteers from the university and the local neighborhood have been a regular monthly event at the Nichols Arboretum and the Matthaei Botanical Gardens for many years. With the help of enthusiastic students

and dedicated neighbors and community members, the MBGNA have successfully cleared many acres of invasive plant species, collected volumes of native plant seeds, planted thousands of native plant plugs and performed other tasks over the past several years. With increasing coordination and supervision, the Washtenaw County Sheriff's Department work program has also contributed many hours of labor toward the improvement of our natural areas. The "Restoration Workdays" require a thoughtful approach to the capacity of each group of individuals as well as the needs of the natural areas and how best to combine them. In the planning process for these workdays the potential of volunteers has been carefully considered as an important resource for completing the organization's stewardship tasks as well as an area where the fostering of connections between nature and people is strong.

The MBGNA has also initiated a "Natural Areas Steward" program to recruit dedicated individuals who are willing to take a more active role in the stewardship of a particular area, want to learn a special skill set, or are interested in natural areas stewardship in a more general sense across the organization's properties and enjoy being involved by leading Restoration Workdays with other volunteers.

III. Historical Context

Geologic History of Earth

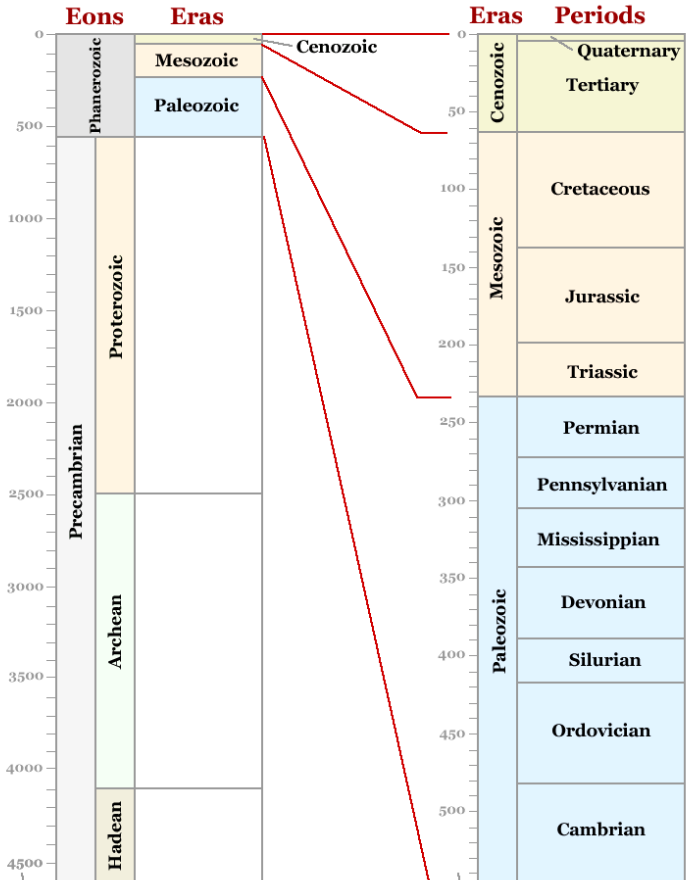

Figure 16. The Geologic Timescale. (Geology.com)

To understand the landscapes and natural communities of today and to set appropriate conservation goals for the future, we must put them into context of the vast and complex history of the earth. The Geologic Timescale shows the age of the earth at approximately 4.5 billion years. About 87% of geologic time falls within the Precambrian Eon, before the presence of life. During the Phanerozoic Eon to follow, life began to evolve. This eon encompasses around 570 million years and is broken into three primary eras; the Paleozoic, Mesozoic and Cenozoic. The end of the Mesozoic Era is marked by the extinction of the dinosaurs and the beginning of the "Age of Mammals" or the Cenozoic Era which begins around 66.4 million years ago (Tarbuck and Lutgens. 1993). This era is further divided into the Tertiary and Quaternary Periods. The Quaternary Period is dissected into two epochs (not shown): the Pliocene, starting around 1.8 million years ago, and the Holocene starting around 10,000 years ago. These two epochs encompass

the entire evolution of *Homo sapiens*. Human history on the geologic timescale is infinitesimal, but our impact on the earth since our beginnings is vast and undeniably tied to the rest of the natural world.

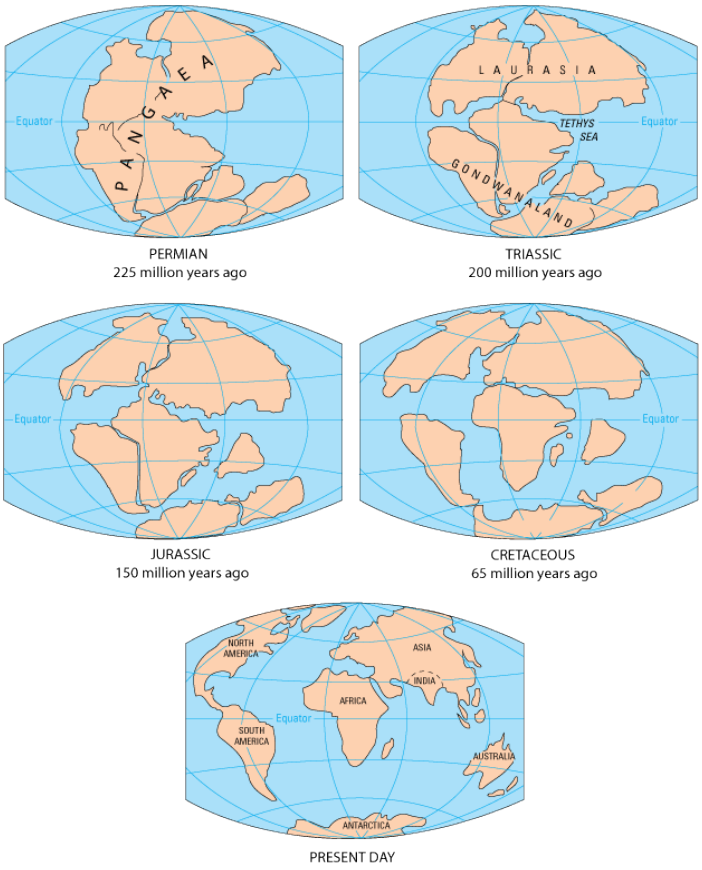

Figure 17. Plate Tectonics. (Kios and Tilling 2007)

History of the Continent

North America has a complex and dynamic history of its own. Over millions of years the continents of the earth as we know them were formed and drifted apart through a process known as plate tectonics (Tarbuck and Lutgens. 1993). Around 66.4 million years ago, at the end of the Mesozoic Era and about the time of the birth of North America as a continent, there was an enormous impact of a massive meteor in what is now the Yucatan Peninsula of Mexico. This event punctuated the end of the "Age of Dinosaurs". The impact and its effects left North America barren for several centuries (Flannery 2001). Life on the continent gradually began to recover and creatures evolved. Around 15,000 years before present, mega fauna such as *Mammuthus primigenius* the wooly mammoth, *Mammut americanum* the

mastodon, *Smilodon spp.* saber-toothed cats, *Megalonyx jeffersonii* the giant sloth, *Castoroides ohioensis* giant beaver, *Arctodus simus* short faced bear, *Canis dirus* dire wolf and other huge mammals had spread to inhabit most of the landscapes of North America (Flannery 2001). These giant animals of the past existed until the arrival of the Clovis Hunters; humans crossing the Bering land bridge, around 14,000 years ago (McCann 1999, Flannery 2001). Within one thousand years after the arrival of humans in North America, most of the Mega fauna had become extinct (McCann 1999, Mann 2006). There is still debate about a connection to humans or climactic changes causing these extinctions, but several scientists feel the evidence points to human hunting (Mann 2006, McCann 1999).

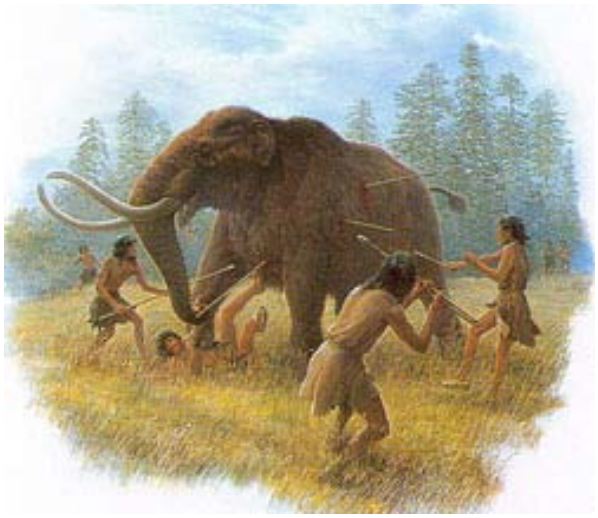

Figure 18. Clovis Hunters Attacking a Wooly Mammoth (Archeology of Illinois)

Human use of Fire Shapes the Land

Human use of fire has also shaped most North American biomes since prehistory and the signature of this impact remains today (Flannery 2001, Pyne 1982, Dickman and Leefers 2003). Fire being the single most important tool that the Native American's had to manage the landscape for thousands of years, natural communities evolved not only to tolerate frequent fires, but to depend on them. The effects of humans ritually setting the

landscape ablaze still echoes in the present through the presence of these many lingering fire dependent natural communities (McCann 1999, Spieles 1999).

The Native Americans burned the landscape for several documented reasons including; hunting, managing their crops, and improving grazing habitat for animals they hunted such as deer, elk, and buffalo. They used fire to manage insect pests, for warfare and signaling, to fell trees, and to clear riparian areas of brush and encourage new plant growth, as well as for other reasons (Williams 2003). Certainly they saw that this was a powerful tool to manage the landscape to their advantage creating many desired effects and integral to their lives in so many ways.

Figure 19. Spring Burn at Nichols Arboretum, Dow Field 2006. Photo by Jeff Plakke

11,000 – 9,000 years ago, toward the end of the Pleistocene Epoch, the glaciers of the Wisconsin stage had receded. Although the glaciers only extended just beyond Michigan and Wisconsin, they had a dramatic impact on the vegetation farther south. Boreal vegetation was the dominant species in the central states region until the oak forest took over (Fralish 2004, Barnes et. al. 1998). By 10,000 years before present, oak hickory forests occupied most of the eastern United States (Abrams 1992). During the Hypsithermal period, 10,000 – 5,000 years before present, the climate became warmer and drier, making conditions for fires more favorable. Early American peoples

increased the occurrence of fire, and fire dependent ecosystems spread across most of the landscape (Fralish 2004). After 5000 years before present, the precipitation levels increased and Native Americans began to settle and develop agriculture, continuing to burn the landscape. Prairies and savannas were widespread and oak hickory forests expanded on upland sites and mesic hardwood species began to replace the oak in ravines and stream terraces (Fralish 2004).

The tall-grass prairie ecosystem of North America, once the largest grassland in the world, was dependent upon regular fires which were often set by Native Americans (Flannery 2001, McCann 1999, Pyne 1989). The oak openings of the Midwest, now almost entirely extirpated from Michigan, were maintained by frequent fires (Cohen 2004). The oak hickory forests of the northeast too were maintained by frequent, cool surface fires (Lee 2007). Even wetlands such as emergent marshes and prairie fens were subject to fire when bordering the fire dependent uplands, facilitating the expression of the seed bank (Kost et. al. 2007). Nearly all the terrestrial ecosystems that we investigate in Southeast Michigan have some history of fire.

> The modification of the American continent by fire at the hands of [Native Americans] was the result of repeated, controlled, surface burns on a cycle of one to three years, broken by occasional holocausts from escape fires and periodic conflagrations during times of drought. […] So extensive were the cumulative effects of these modifications that it may be said that the general consequence of the Indian occupation of the New World was to replace forested land with grassland or savannah, or, where the forest persisted, to open it up and free it from underbrush. Most of the impenetrable woods encountered by explorers were in bogs or swamps from which fire was excluded; naturally drained landscape was nearly everywhere burned […] (Pyne 1982: 79-80).

Europeans Make Contact

Since Columbus and his expedition made contact with Native Americans in 1492 and other Europeans began to explore and eventually settle the landscape, dramatic ecological changes have taken place throughout North America. The most dramatic change started when Native Americans contracted and began to spread diseases such as smallpox, influenza, hepatitis and others throughout their population and across the continent. Because Native Americans had no immunity to the diseases carried by the Europeans, the diseases spread far ahead of the advancing Euro American settlers (McCann 1999, Mann 2006). While the numbers are still sharply contested, Several experts now believe that as much as 90% of the Native American population, which may have been near 100 million people in the Americas, may have been lost to introduced diseases in the first two centuries after contact, well before European settlement (McCann 1999, Mann 2006). While the exact figures are not agreed upon, there is agreement that Native Americans died in significant numbers and their population was dramatically reduced.

Figure 20. Christopher Columbus woodcut (University of Michigan News Service)

Three hundred years later, the early 1800's, is marked as the time of European settlement in the Midwest. For three centuries the ecosystems of North America responded and changed after the rapid decline of the once pervasive and shaping force on the landscape, the Native Americans. With relatively small recovering populations,

the near absence of their former impact on the land through hunting, agriculture and fire, must have left a dramatic vacuum in North American biomes. The ecological significance of this time period is still under debate and speculation but should not be underestimated. For example, the target of pre-settlement vegetation, circa 1800, is often used to determine ecological restoration goals. Understanding that the Native American's use of fire and other impacts on the biota were substantial for several thousand years prior and that the resulting rebound of ecosystems under the substantial reduction of this activity for two centuries would likely be significant; a re-thinking of restoration goals in terms of long-term target plant communities may be in order.

Geological and Ecological History of Michigan

Michigan is covered with ground-up sediment from the underlying bedrock by multiple advances and retreats of enormous glaciers. The ice age was at its peak around 20,000 years ago. The glaciers lingered until less than 10 thousand years ago. These enormous moving masses descended from the north and covered the Michigan landscape with ice and snow over a mile thick. The colossal weight and slow movement combined to

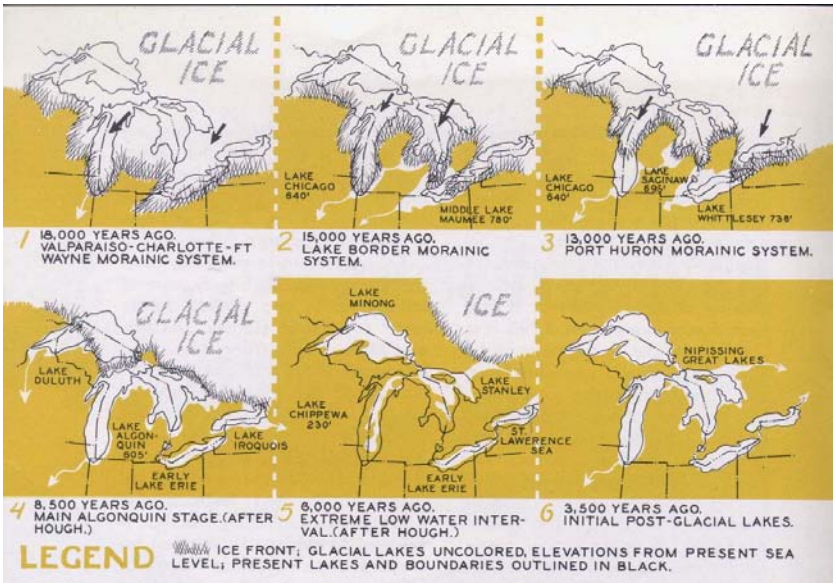

Figure 21. Glacial Advance and Retreat (Kelly and Campbell 1960)

create an incredible erosive force which plowed and ground up the deep sediments that form the foundation of Michigan's ecosystems. Figure 21. shows several influential glacial advances and retreats, but more recent geologic studies suggest there may have been several more glacial events that were less extensive, but also helped to shape the complex and deep sediments of Michigan.

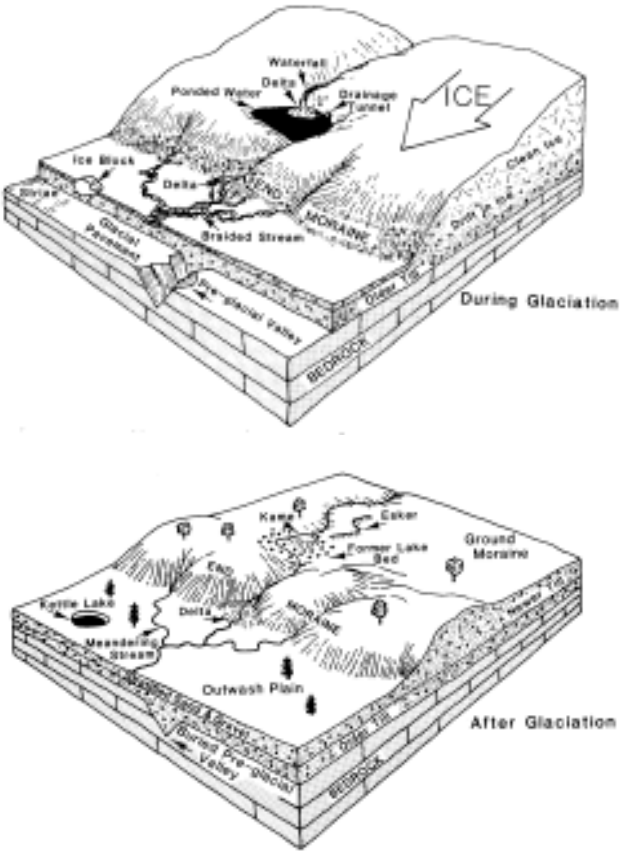

Figure 22. Glacial Landforms (Farrand 1998)

In what is now Southeast Michigan where the MBGNA properties are located, dominant glacial landforms include ground moraines, end moraines, and outwash, and lake plain (Barnes et. al. 1998, Dorr and Eschman 1970). Much of the soil sediments are medium to fine textured glacial till with an abundant limestone component leading to a neutral to alkaline soil condition being common. The abundance of limestone rich deposits in the heterogeneous glacial soils can create alkaline groundwater seeps. This unique condition of slow moving alkaline ground water coming to the surface often forms rare natural communities known as fens. These communities are somewhat common in the Southeast Michigan area, but are globally rare because they only occur in the glacial Midwest (Spieles 1999). The

combination of the mineral rich glacial soils and the frequent fires set by Native Americans formed many of the unique natural communities found in Southeastern Michigan.

Fire in Michigan

The importance of fire as a regular occurrence in the landscape in Michigan over the centuries through Native American burning is important to recognize as one of the key forces affecting natural communities. This is true for the majority of the terrestrial natural communities found in Lower Michigan (Kost et. al 2007). It was the single most important process that maintained the open conditions of prairies and savannas once common in the Ann Arbor area (O'Connor 2006). It was also essential to the maintenance of the oak hickory forests which were the most common forest community in Washtenaw County (Lee 2007, Albert 1995).

> The annual fires burnt up the underwood, decayed trees, vegetation, and debris in the oak openings, leaving them clear of obstructions. You could see through the trees in any direction, save where the irregularity of the surface intervened, for miles around you, and you could walk, ride on horse-back, or drive a wagon wherever you pleased in these woods, as freely as you could in a neat and beautiful park (Van Buren 1884 as quoted in O'Connor 2006).

Park-like oak lands of the southern tiers of Michigan were tempting to early Settlers. Easier to clear than the thick forests, these oak openings could quickly be plowed for early agriculture (Dempsey 2001).

Exploitation of Michigan's Natural Resources

Also creating major changes was hunting, trapping and the extensive fur trade. Extirpation of many of the Michigan's top predators such as wolves, bears and cougar as well as animals such as the beaver had a dramatic impact on the landscape (Dickman and Leefers 2003, Dempsey 2003). It is suggested that extensive acres of land around Detroit were impacted by beaver damming streams and rivers, creating large areas of shallow wetlands which have long since declined without the beaver maintaining these areas (Dempsey 2001).

Figure 23. Logging in Michigan (Dickman and Leefers 2003)

As European settlement continued, the plundering of the forests began. Around 1850 the lumber boom was moving vast quantities of lumber out of the woods throughout Michigan (Dickman and Leefers 2003). When the pines had fallen and the slash piles were abundant, dry weather brought on catastrophic wildfires which scorched large areas of the state during the 1870's that are still recovering today (Dickman and Leefers 2003, Barnes et. al. 1996). Second growth forests of particularly oaks and hickories, which could sprout back from their stumps, were later logged again (Dickman and Leefers 2003). The repeated logging and the catastrophic fires of the 1800's has dramatically altered Michigan forests for centuries to come (Dickman & Leefers 2003, Barnes et. al. 1998).

Wind erosion in a cutover area in Clare County.

Figure 24. Devastation cause by early logging (Dickman and Leefers 2003)

Biodiversity in Times of Rapid Change

Humankind has drastically changed the face of the earth with industrialization, over-exploitation and development in the past few centuries. "Many ecosystems are dominated directly by humanity, and no ecosystem on Earth's surface is free of pervasive human influence" (Vitousek et. al. 1997). As has been discussed, the landscape of North America and that of Michigan prime examples. Logging, agriculture, fire suppression, suburban and urban development, and the introduction of invasive species have all degraded and fragmented the vast majority of acres across the state and southeast Michigan perhaps the most, in just over two centuries. This makes undeveloped lands and intact refugia for biodiversity all the more important to protect and care for as we move into this century (Dickman and Leefers 2003). A growing list of threatened and endangered species, declining natural communities and an increasing awareness of the critical nature of our environmental problems may provide the momentum for making important changes and raising awareness of the valuable Natural Areas of MBGNA and the University of Michigan as a whole.

Threats to Biodiversity

Habitat destruction is currently the number one threat to biodiversity worldwide (Wilcove et. al. 1988). Primary

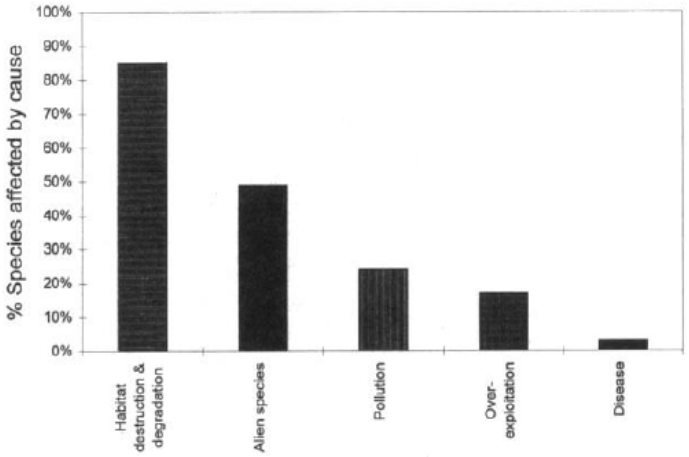

Figure 25. Major Threats to biodiversity (Wilcove et. al. 1998)

habitat destruction is perhaps less an eminent threat to the properties of the MBGNA because they are owned by the University of Michigan and unlikely to be extensively altered without planning and review. However, historically many University of Michigan lands have been and continue to be developed and therefore habitat destruction should not be dismissed entirely as a threat.

The spread of exotic invasive species is the second leading threat to biodiversity (Wilcove et. al. 1988). These "out of place" species can wreak ecological havoc on invaded landscapes. They can kill other species outright, as with the chestnut blight, Dutch elm disease, and the emerald ash borer. They may compete with other species directly for light or other critical resources. They can also alter important ecological processes such as nutrient availability and decomposition, hydrology, the suppression or destruction of keystone species, etc. Invasive species are present on all properties and there is reason to believe they are causing considerable damage and degradation throughout the natural areas of MBGNA. Common buckthorn (*Rhamnus spp.*), honeysuckle (*Lonicera spp.*), oriental bittersweet (*Celastrus orbiculatus*), garlic mustard (*Alliaria petiolata*), and dames rocket (*Hesperis matronalis*) are just a few of the most common. Because they are quite numerous and well established and habitat destruction through development is less eminent, invasive species may be considered the primary threat to MBGNA natural areas.

Exotic Invasive Species

Exotic species introductions began with imports for agriculture, in the ballast water of ships, and with the early introduction of ornamental plants and seeds (Czarapata

2005). Nowhere is the introduction for ornamental purposes more apparent than at Botanical Gardens and Arboretum. The Nichols Arboretum, for example, began planting honeysuckle by 1910 (Nichols Arboretum Card Files). Statewide many species such as autumn olive (*Eleagnus umbellata)* and multiflora rose (*Rosa multiflora*), which were later found to be invasive, were sold by Soil Conservation Districts, subsidized by the state, and planted for the purposes of conserving wildlife habitat as late as the 1990's (Personal experience as a Conservation District Forester).

Figure 26. *Lonicera maakii*, Amur Honeysuckle, Matthaei Botanical Gardens. Fall 2008. Photo by Jeff Plakke

Introduced Invasive species tend to have life history characteristics that allow them to tolerate a wide range of environmental conditions, possess high reproductive capability, and exert strong and often direct pressure on native species. Also, based on literature reviewed, they tend to accelerate nutrient cycling (Rice et. al. 2004, Ehrenfeld et. al. 2001, Ashton et. al. 2005, Henegan et. al. 2002). This is illustrated in Table #. Because of their tendency to effect nutrient cycling in this way, it also appears they have greater impacts on ecosystems that have low nutrient availability as speeding up nutrient cycling can change species composition.

Black locust (*Robinia pseudoacacia*) is a common nitrogen fixing invasive plant found throughout the Arboretum and also occurring at the Botanical Gardens,

Horner Woods and Mud Lake Bog. It was widely planted throughout the state of Michigan for ornamental, erosion control and commercial purposes (Barnes and Wagner 2004). A study done on this species invading pine-oak stands in New York found that soils of invaded sites had 1.3 to 3.2 times the nitrogen of non-invaded soils (Rice et. al. 2004). Net nitrification rates increased 25 to 120 times and there were nearly 90 kg of nitrogen per hectare per year in leaf litter returned compared to just 19 kg in the pine-oak stands, significantly altering nutrient cycling in this nutrient-poor, pine-oak ecosystem (Rice et. al. 2004). The more labile substrates of the black locust litter stimulate decomposition resulting in a greatly reduced litter depth of less than half that of pine-oak forests. This has further implications to plant succession by reducing fuel for surface fires which are an important natural process required to maintain pine-oak ecosystems (Barnes et. al. 1998).

Other plant species such as *Rhamnus cathartica, Berberis thunbergii, Lonicera spp., Rosa multiflora* and *Acer platanoides,* while not nitrogen fixers, also significantly increase the amount of nitrogen available in the leaf litter and soil (Ehrenfeld 2001, Ashton et. al. 2005, Henegan et. al. 2002). In their study of common buckthorn, Henegan, Clay, and Brundage concluded that the relatively high nitrogen content of the litter of *Rhamnus cathartica* may be stimulating soil microbial populations, leading to an accelerated decomposition of all the organic matter in the forest litter. In fact, another study found this to be true. Not only did the litter of exotic species tend to decompose more quickly and release nitrogen significantly faster than native species, they found litter of all species types decomposing faster in invaded sites, suggesting large scale alterations in decomposition and nutrient cycling (Ashton et. al. 2005). This could be

creating a significant shift in the soil microbial communities which would be consistent with studies done in upland forest ecosystems where each distinct ecosystem was found to contain a distinct microbial community adapted to the specific litter substrate of that ecosystem (Myers et. al. 2001).

Earthworms

Another important invader of terrestrial ecosystems in the Midwest is the exotic earthworm. Often introduced by recreational fisherman throughout this century, there are now over 45 introduced species of earthworm in North American ecosystems (Burtelow et. al. 1998). The earthworm breaks down the litter layer in the forest sometimes greatly increasing fluxes of both carbon and nitrogen (Burtelow et. al. 1998, Hendrix and Bohlen 2002). Their impact on nutrient turnover could also be more severe in systems where nutrients are scarce than where they are abundant and cycling more quickly. They can have a similar effect on the soil to other invasive species by stimulating the microbial communities of the invaded sites and mixing litter into the upper soil layers, breaking down litter more quickly and speeding up nutrient cycling (Burtelow et. al. 1998, Hendrix and Bohlen 2002). This also results in the removal of fuel for surface fires, which are an important ecosystem process in the more nutrient limited oak systems (Barnes et. al. 1998).

Low Nutrient Communities Primed for Invasion

In ecosystems where native plant species have adapted to low nutrient conditions (Hobbie 1992), they are physiologically less capable of responding when nutrient levels

are quickly raised by the invading exotics (Vitousek 1982, Chapin III et. al. 1986). The native species in these systems have less plasticity than many exotic invasive plant species and ecosystem succession will likely be sped up or take on an entirely different trajectory (Chapin III et. al. 1986, Ehrenfeld et. al. 2001). If we also consider the substantial increase in atmospheric nitrogen deposition due to human fossil fuel burning along with the tendency of an ecosystem to increase in invasibility as nutrients are added (Lonsdale 1999, Schlesinger 1997), the previously low nutrient oak hickory and savanna ecosystems may be primed for increasing pressure from invasion by exotic species. This will further disrupt their characteristic nutrient cycles, potentially resulting in accelerating losses in their native species diversity (Schlesinger 1997, Hobbie 1992, Davis et. al. 2000).

Other Impacts from Invasive Shrubs

Another finding in a dendro-ecological study done in Southwest Ohio was that forest trees have significantly reduced growth rates after invasion of the understory by *Lonicera maakii* (Hartman and McCarthy 2007). This suggests that the dominance of the understory of a forest by this shrub species can also affect growth rates of the current generation of overstory trees in addition to shading out their regeneration.

In studies done in the Morton Arboretum, it was found that robins nesting in *Lonicera* and *Rhamnus* species were significantly more likely to suffer nest predation than when nesting in native trees and shrubs (Schmidt and Whelan 1999). This suggests that the removal of exotic invasive shrubs and the restoration of native plant

communities may also benefit the reproduction of surrounding avian communities (Schmidt and Whelan 1999).

Because of these and additional cascading impacts of exotic invasive species on native species and fundamental processes in ecosystems, they should be carefully monitored, studied and effectively controlled through a variety of proven strategies and methods to best protect MBGNA natural areas. They are likely the most important and eminent threat to biodiversity found on these lands.

History of Perceptions about Humans and the Natural World

This study will not delve deeply into a discussion of evolving philosophies about nature or natural resource use or discuss the many policies and changes throughout our nation's history related to natural resources and conservation. However, these basic beliefs about nature, wilderness and the human element are still important to acknowledge and begin to understand because they surface repeatedly in the present as measures are taken to restore the ecological health of the land. People's strength in these beliefs can at times create considerable hurdles if not derail stewardship efforts all together.

While even the preceding brief investigation into ecological history reveals how interwoven humans are in the landscape, beliefs and perceptions about nature and wilderness and about what is natural and artificial have varied widely over the course of human history. There has been a deep division drawn between the civilized world of humans and wilderness in the history of western civilization which still persists.

Gifford Pinchot, creator of the U.S. Forest Service, was a strong proponent of utilitarianism, which connected the value of nature and natural resources exclusively to the wants and needs of humans suggesting resources be used for… "the greatest happiness for the greatest number" (Knight and Bates 1995). This philosophy essentially summarized the management regime of the National Forests at the turn of the 20th Century and highlights the anthropocentric view of early resource managers in the United States (Knight and Bates 1995).

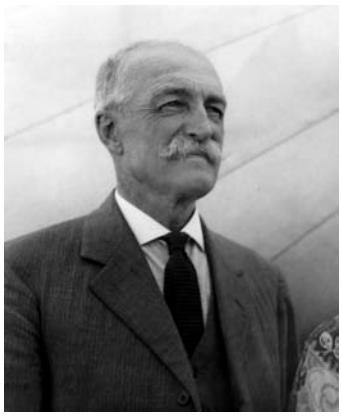

Figure 27. Gifford Pinchot (U.S. Forest Service).

A parallel anthropocentric belief was taking hold around the same time in American history; that nature is pure and pristine and should be protected and preserved by removing humans and their presence. This view was strongly promoted by early American naturalist, John Muir and suggest wilderness as an ideal state of nature defined by its absence of human influence. Any activities or artifacts of human origin are considered unnatural and a corruption of wilderness (Knight and Bates 1995).

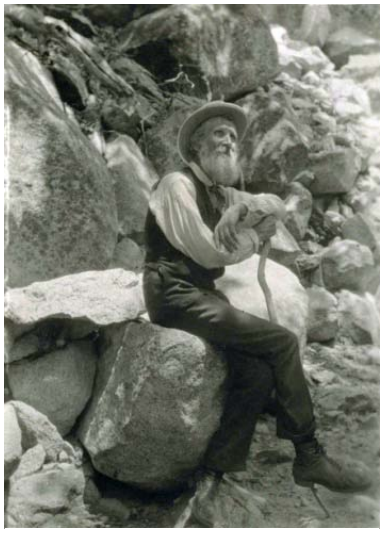

Figure 28. John Muir, Naturalist and early American Preservationist (LibraryThingbeta)

Each of these concepts is based on a division between humans and nature with one or the other taking preference. The later sentiment is also apparent in The Wilderness Act signed in 1964. The Act states:

A wilderness […] is hereby recognized as an area where the earth and its community of life are untrammeled by

> man, where man himself is a visitor who does not remain. An area of wilderness is further defined to mean […] an area of undeveloped Federal land retaining its primeval character and influence, without permanent improvements or human habitation, which is protected and managed so as to preserve its natural conditions and which (1) generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable;…

Eric Katz suggests in his article titled "The Big Lie: Human Restoration of Nature", that human restored nature is "...on the most fundamental level, an unrecognized manifestation of the insidious dream of the human domination of nature… The processes of the natural world that are free of human interference are the most natural." This idea might suggest humans are not inherently connected to the natural world, and their impacts are negative and made purely by choice. However, the relationship that humans have had with the rest of the world since their arrival is not out of choice, but out of necessity.

Native American cultures and spirituality have often been looked to by environmentalist thinkers for inspiration and guidance and a way toward a more environmentally conscious future (Nadasdy 2005). However, critics of this suggest an ideal of ecological nobility is unattainable and denies the realities of indigenous peoples' lives (Nadasdy 2005).

The fact is that humans are connected to the natural world and their impact on the ecosystems around them is an unavoidable reality and has been throughout history. This fact does not excuse over-exploitation and destruction of the natural world so acute in the present time, but humans have and will always need resources, and it has often been advantageous to encourage and steward those resources if possible. Humans, wherever they live on earth, have always played a keystone role in shaping the ecosystems in which they live since their evolution as a species. Humans have no choice but exist in

relationship to the natural world but can choose if that relationship is healthy or dysfunctional.

Understanding the complex history of MBGNA natural areas within the context of the evolving landscape of North America and Michigan will help to put natural areas stewardship goals and threats in perspective. As changes and pressures from regional development and fragmentation of the landscape, invasive species, lack of fire, rising and falling wildlife populations, and atmospheric deposition and global climate change all continue to impact natural areas, goals and strategies may need to change as well. Building a system with adaptability and understanding of the past will be important in dealing with a landscape and natural areas that are changing, sometimes rapidly, in ways we may not yet understand or be able to predict in the future.

IV. Natural Areas Stewardship Planning at MBGNA

Refining the Definition of "Natural Area"

Figure 29. *Gentianopsis crinita,* Matthaei Botanical Gardens, Fall 2008.
Photo by Jeff Plakke

Working through the planning and historical documents and considering the needs of the MBGNA, a definition of "natural area" appropriate for this organization was created. It is defined for the purposes of MBGNA with several themes in mind including; conservation, teaching and research, and public outreach. A "natural area" can be defined by these values:

- *Conservation*: A natural area provides habitat for a variety of species, ranging from those that are common to those state or federally listed threatened and endangered. It protects water quality. It creates connectivity in the landscape to other natural areas which provides expanded habitat for species movements and genetic diversity.
- *Teaching and Research*: The area is appropriate for teaching and research in the environmental sciences, providing an ideal outdoor laboratory for learning about land forms and geology, hydrology, ecosystems, species, stewardship activities and the impacts of the built environment on ecological processes and storm water management practices.

- *Public Outreach*: The area is valued for its natural beauty and restorative qualities, providing people with space for outdoor recreation and for exercising or rebuilding our relationship with nature.

Property Designation: Recommendations

Currently MBGNA natural areas do not have a formal designation as such. These portions of MBGNA's lands could benefit from being defined by a designation such as "Research Natural Area" (RNA) as used by the United States Forest Service (U.S. Forest Service 2005). This designation would provide a framework for the defining policies for natural areas within the MBGNA land holdings. While this particular designation by the Forest Service has the objective of land preservation, many activities can still be allowed as defined through a management or stewardship plan with the goal of ecosystem and biodiversity preservation. This allows the natural areas manager, with guidance from the advisory groups, to develop plans for these areas and define the types of activities that will be allowed within research natural areas. This might include the removal and control of exotic invasive species, the use of prescribed fire, or the propagation and reintroduction of rare species. It can also help to define the types of activities that are restricted such as, general recreation access by visitors, or the installation of structures that could impact the vegetation or soils.

To implement a "research natural areas" designation for portions of MBGNA properties, the appropriate areas would be mapped and marked with discreet signage explaining this designation. This would have two clear advantages: 1) it would

indicate to neighbors and others exploring or hunting when they have crossed into a MBGNA natural area, and 2) it would signal to visitors that the on-going stewardship activities they might encounter are going on as part of a larger management plan for the natural areas.

This thesis provides only a brief introduction to the topic of officially designating the natural areas, however, the organization of MBGNA is encouraged to consider a designation or designations for all of its natural areas to help define their status and objectives, to further protect them and encourage the acquisition of adequate resources for their continued stewardship.

Natural Area Advisory Groups

MBGNA is currently in the process developing two groups to help with natural areas planning and advice. These groups will include various stakeholders in MBGNA natural areas planning and will be useful for seeking advice as well as to form collaborative partnerships. The first group would be composed primarily of people from within the University responsible for properties containing significant natural areas. The purpose would be to coordinate activities and catalog the resources available for teaching and research. Members of this group would include some MBGNA staff, University of Michigan planners, and property managers or others from U of M Grounds, Radrick Farms Golf Club, the Department of Ecology and Evolutionary Biology (EEB), the School of Natural Resources and Environment (SNRE) , the Biological Station (UMBS), and possibly others. Also members of the U of M faculty and staff from the EEB, SNRE, the Museum of Zoology and

Herbarium may also be approached to contribute. A second group would include local stakeholder organizations such as the City of Ann Arbor NAP, Washtenaw County Parks and Recreation, the Stewardship Network, the Michigan Department of Natural Resources (MDNR) and potentially others. This group would help to foster collaborative management and a potential learning from these other organizations. The goal is to get as many stakeholders and experts at the table at the initial stages of planning to provide advice through the process, suggest additional resources and alternative strategies, and help make adjustments. Initially the groups may meet more frequently, but once goals have been met for planning, the group could be dissolved or meet only as needed.

A Decision-Making and Planning Model

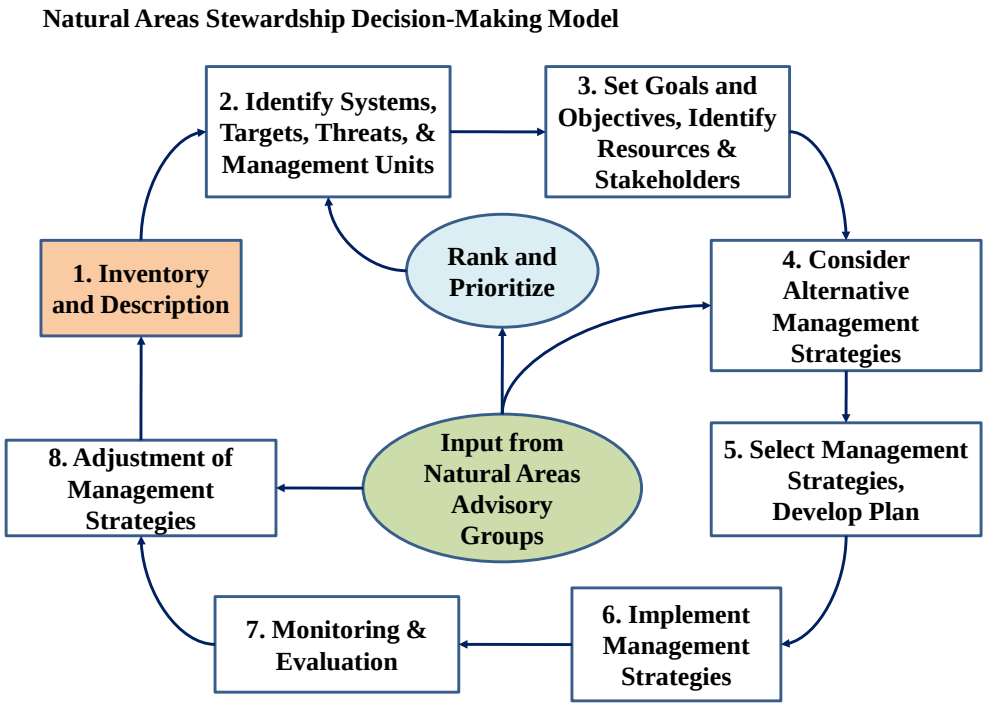

Figure 30. Decision-Making Model showing inputs during Planning Process

A decision making model was created for the MGBNA natural areas considering the preceding definition, the review of plans, planning processes and prioritization methods and missions of other conservation oriented and educational organizations, and the missions and visions discussed in Chapter II (Figure 30). This model also takes into account the historical context of the MBGNA natural areas, geology, impacts on the land from humans, and the development of threats such as invasive species and the suppression of fire described in Chapter III. Finally this model was intended to incorporate the mission, stakeholders, opportunities, challenges and special needs specifically of the MBGNA and potentially the University of Michigan natural areas more broadly.

The model provides a framework for making decisions in creating stewardship plans for each MBGNA property or designated area. Once the model has been followed through once, proceeding cycles will continue to gather information and make revisions to the plan as appropriate, as well as changes in strategies and implementation. Much information will be accumulated throughout this process, and creating a strategy for organizing and storing this information to make it easily retrievable will be crucial. Maintaining data accuracy and validity is also a high priority. The first cycle may take a year or more to be completed for a given area and each subsequent cycle could span several years. However, reasonable deadlines for the steps and repeated cycles through the model should be planned to insure that the process is paced and the stewardship plans for natural areas are kept reasonably current and active.

1. Inventory and Description

The inventory and description includes gathering basic information about each site through site visits to determine and assess property boundaries, basic floristic quality, note obvious threats or other issues, roughly estimate degree of degradation if applicable, and take photographs or measurements to illustrate. Also during this stage analysis of aerial photos and satellite imagery should begin. Background information appropriate for the site should be obtained and gathered together. This includes general information on the geology, soils, hydrology, etc. as well as specific historical information about land use and current land use. Personal accounts from neighbors or users of the property may also be helpful. Any data, research experiments, previous management recommendations, studies or other accounts of the property readily available should be included and summarized to help with decision-making. Some of this information is important to get started, but more information will be gathered and accumulated as the plan for the area repeats the cycle again, so moving forward with incomplete but adequate information is appropriate.

2. Identify Systems, Targets, Threats, Management Units: Rank & Prioritize

This step should result in the identification of natural communities such as described by MNFI (Kost et. al. 2007). If possible, the list of inventoried plant species should be used to create an FQI ranking to assist with determining conservation targets (Herman et. al. 2001). Conservation targets might include the ecological community itself such as an oak hickory forest or prairie fen and/or

individual species such as the Eastern Massasauga or Duke's Skipper butterfly, for example. Threats should be identified and ranked as well, such as invasive shrub encroachment, lack of fire, storm water caused erosion etc. Then a logical management unit can be delineated or adjusted based on experience and needs associated with the area. With input from the natural areas advisory group and using the prioritization and raking instrument created, management units or properties can also be ranked and prioritized.

Natural Areas Prioritization and Ranking

A proposed ranking system was created to help determine a quantitative value for the different properties and many different management zones and subzones within each property. The goal is determine a number value for each area or zone and then to group areas based on decided cut-off values as a level one, two or three priority, similar to the Nature Conservancy's method for Island Lake Park (Palmgren 2002).

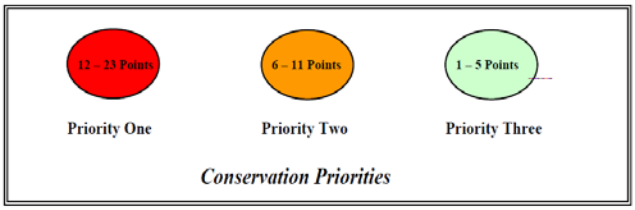

Figure 31. Illustration of Conservation priority groups (Palmgren 2002)

A number of important variables were considered related to the unique opportunities and needs presented in the MBGNA's vision and mission (Table 1.). These variables were lumped into one of three broader categories by which each area can be considered and ranked on a scale of 1 - 10: Conservation and Preservation; Education, Visitor & Neighbor impact; and Feasibility & Cost of Implementation.

Conservation & Preservation	**Education, Visitor Impact, & Neighbors**	**Feasibilit & Ease of Implementation**
High Biodiveristy and Floristic Quality	Passive Interpretation	Site Preparation
Rare Ecosystems	Part of Educational Tour	Investment of Time to Implement
Threatened and Endangered Species	Impacting Collection / Project Area	Investment of Equipment to Implement
Least Disturbed	Class Project and Field Day Potential	Accessibility
Creates Connectivity to other natural areas	Research Potential	Distance from Headquarters
Large Area / Desirable Shape	Visitor Scrutiny of Area	Ability to utilize Interns and Work-studies
Protects Water Quality	Neighbor Connections	Ability to utilize Volunteers

Table 1. Categories of Criteria for Ranking

Other variables would likely fall into each of these categories and there is inevitably overlap between them and some will counter each other as they are measured depending on the area being considered. However, with the goal to rank the areas into three categories, whether one area is slightly higher or lower than another may not compromise the effectiveness of the instrument. If it can rank the areas intuitively correct, the planning process can proceed.

Once an area has been ranked on a scale of 1 – 10, 10 being highest for each category, the numbers are multiplied by a fixed value determined for each category. This allows the instrument to be calibrated for differences in values across the broader categories. For example, when resources are scarce, 'Feasibility and Ease of Implementation' may be given a lower value than the other categories to emphasize the need to work within tightly restricted resource limits.

Property: Arboretum			
Zone: Prairie/Savanna			
subcategory: Dow Field			
Variable	Fixed Value	Site Value	Product
Conservation & Preservation	10	8	80
Education, Visitor Impact, & Neighbors	9	9	81
Feasibility & Ease Implementation	8	8	64
		Sum & Score	**225**

Table 2. Examples of Custom Ranking Method for MBGNA natural areas: Arboretum, Prairie/Savanna, Dow Field Area Rank

Property: Arboretum			
Zone: Geddes Entrance			
Subcategory: Main Valley Overlook			
Variable	Fixed Value	Site Value	Product
Conservation & Preservation	10	6	60
Education, Visitor Impact, & Neighbors	9	8	72
Feasibility & Ease of Implementation	8	7	56
		Sum & Score	**188**

Table 3. Examples of Custom Ranking Method for MBGNA natural areas: Arboretum, Geddes Entrance, Main Valley Overlook

For this example involving two areas at the Nichols Arboretum, the fixed value for Conservation is 10. For Education, Visitor impact and Neighbors the fixed value is set at 9, and feasibility and cost of implementation has a fixed value of 8. These values were chosen based on best judgment and experience with natural areas stewardship at MBGNA and to serve as a starting point for further adjustments to this model. While a process such as this inherently involves some subjectivity, this is an attempt to objectify rankings as a way of setting priorities.

In the example given, the Dow Field has a higher score than the Main Valley Overlook. This is not to suggest that the overlook is not important, just that the Dow Field scored higher across the multiple variables that were selected and therefore it is perhaps a higher priority to establish a plan for this area and it may initially receive more attention. As the property zones are ranked, they can be divided into several categories which

3. Set Goals and Objectives, Identify Resources & Stakeholders

This step involves determining objectives and identifying measureable and achievable goals for the area being considered if possible. This could include the reintroduction of fire on a specific number of acres during the first two burn seasons. It could also identify an area for invasive shrub removal and a goal for removal by the following year and follow-up treatments for the next 2 years.

Identifying resources would include those that are available and also those that are still needed for all stewardship activities including tools and equipment, accessibility of the site, ability to utilize volunteer workdays or community service hours to help with work or the potential to assign a natural areas Steward to a particular area.

Stakeholders might include those who would benefit from being incorporated into a research framework on a particular conservation target, such as faculty and students with an interest in reptiles studying the eastern massasauga (*Sistrurus catenatus catenatus*) a rare snake species. Stakeholders might also include avid bird watchers at the Arboretum who could provide MBGNA with useful bird population

data but who may also desire a less aggressive invasive shrub removal initiative or more active native shrub planting effort to help keep birds at eye level for spotting.

4. Consider Management Strategies

This step would consider all possible strategies for reaching the objectives and goals laid out in the previous step. This would include a defined strategy to reintroduce fire with a burn plan for the area, invasive species techniques for control, collecting seed and propagating plugs of native plants for restoration, and other options such as annual mowing, etc. It also includes developing a recruitment and training strategy for volunteers to help with stewardship. The natural areas advisory group should be involved in this step as well to evaluate, consider the strategies, goals and other conclusions made, and offer suggestions and advice.

5. Select Management Strategies and Develop a Plan

Management strategies would then be selected based on relative agreement from the advisory group with the discretion of the MBGNA Director and Natural Areas Manager to make adjustments. A plan for the area would then be written or the existing plan would be revised and updated to reflect any changes in findings or future direction. The following is an outline of a natural areas stewardship plan to be created for each property or area. The stewardship plan puts into a written document the important information and results of following the Decision Making Model and becomes the evolving document which reflects the goals and outcomes of MBGNA stewardship activities. The outline was organized in such a way that a plan could be

written along with the steps through the natural areas Decision-Making Model as they are taken.

Outline for MBGNA Natural area Stewardship Plan

Area Description and Analysis

- Location, size & shape, ownership, accessibility, boundaries, general description of landscape and neighbor information
- Geology, soils & hydrology
- Ecological, cultural and land use history
- Current ecological condition, natural communities and their trajectory, notable species, threats and stresses
- University use for education and research – class use and previous research data, etc.
- Community use – passive recreation, physical training, events, illegal hunting, etc.
- ID important resources, alliances, university connections or the lack of them; course support and research opportunities.
- Suggested research topics and questions
- Include GIS and other maps within appropriate sections: management zones, natural communities, target areas, rare species, invasive species, prescribed burns, etc.

Natural area Stewardship Implementation

- Stewardship targets and ranking: natural communities, processes, species, etc. and describe acceptable variations. Other targets ranked: boundary delineation, cultural resource protection, important view shed restoration, trail maintenance, access improvements, infrastructure concerns, etc.
- Threats to these targets and their ranking: invasive species, lack of fire, erosion, neighbor encroachment, dogs off leash, high deer population, etc.
- Strategies and their ranking:
  - ✓ General monitoring program
  - ✓ Survey & monitoring plan for listed species
  - ✓ Plan for controlling invasive species
  - ✓ Prescribed burn and semiannual mowing plans
  - ✓ erosion control and storm water planning

- ✓ Trail monitoring and maintenance plan
- Create timeline for stewardship activities

6. Implementation

This step is where the evaluation of resources, planning and prioritizing will pay off. By identifying and aligning available resources with appropriate strategies in the proper place at the right time, natural areas stewardship ideals can become a reality. However, effective implementation may be the most challenging of the steps to anticipate, predict and execute. Working with individual staff and staff teams, volunteer work groups, people filling community service hours all bring different levels of experience and judgment to the field and can propel efforts far ahead of set goals, or be derailed by project complexities, equipment failures or miscommunications and fall short.

Since most of the labor is completed by temporary employees, student and community member volunteers or service workers, MBGNA must make sure that this step is as educational, engaging, inspiring, and as motivating as possible. Directions need to be clear and thoughtful process in place for training people. With many students cycling through the staff several times a year, basic training on a variety of field equipment, tools and safe procedures is necessary to repeat frequently. Finally, teaching employees how to lead, troubleshoot and learn the tools of the trade can dramatically increase the organizations capacity for stewardship activities. Staff and volunteers with knowledge and skills acting as effective leaders should be actively supported and encouraged.

7. Ecological Monitoring and Evaluation

While this subject is a single step in the decision-making model, it is one of the most critical in creating an objective and accurate picture of the natural areas and measure of success or failure of conservation efforts. It also provides an excellent opportunity to connect with the research community at the University of Michigan and ultimately to share information about the properties and stewardship methods with outside organizations. To be successful it involves a well thought out program to achieve desired outcomes.

"Monitoring programs to support the measurement of bio-diversity and threat status are globally recognized as crucial elements of any protected area management program" (Parrish et. al. 2003). Currently there is a need to develop a conceptual framework for an ecological monitoring approach for MBGNA natural areas. "Without reliable information on changes in the quality of… (natural areas), and on the causes of those changes, decision-making cannot deal efficiently with these issues" (Vos et. al. 2000). To begin an ecological monitoring initiative, natural communities and ecosystems must first be delineated and a purpose for the monitoring must be defined. This happens in step 2 of the decision-making model. Also, a "just knowing what's going on" approach to monitoring can lead to a desire to simply collect more data without a clear objective (Vos. et. al. 2000). This can lead to costs that outweigh benefits for data collection, handling, maintenance and organization (Vos et. al. 2000). Defining a clear function and objectives for monitoring is an important first step before initiating.

Currently, only a limited number of local botanists, faculty and students from the School of Natural Resources and Environment and the Department of Ecology and Evolutionary Biology utilize the Nichols Arboretum and Matthaei Botanical Gardens for their research and teaching or are familiar with the botanical gardens or arboretum properties. The farther reaches of Mud Lake Bog and Horner Woods are relatively unknown to the University community. U of M researchers or students looking for study sites for their ecological work may not have sufficient information to know if these natural areas would be appropriate. A coordinated, organized long-term approach to obtain information and share that information will also raise awareness and raise the perceived value of these natural areas for MBGNA.

Primary functions of an Ecological Monitoring Program for MBGNA:

- Detection and routine surveillance of natural communities, rare communities threatened and endangered species, and other conservation targets.
- Early warning system for exotic invasive species and other potential threats.
- Evaluation of effectiveness of stewardship activities over time through comparing FQAs or other measures.
- Platform for student Master's and Doctoral research projects.
- Engage volunteers and special interest groups among our stakeholders (i.e. butterfly surveys).

Potential Goals of an Ecological Monitoring Program for MBGNA:

- To provide a framework and involve faculty and students in on-going monitoring efforts providing cumulative information about the natural areas.
- To increase efficiency of conservation and stewardship activities.

- To highlight opportunities and knowledge gaps for research questions.
- To gather information with which to educate the U of M community and the public about MBGNA properties.

8. Adjustment of Management Strategies

As the results of ecological monitoring are analyzed and management strategies can be evaluated, those strategies may require adjustments, or new strategies may need to be considered. This step is important in determining "what is working" and "what is failing" to bring us closer to stewardship goals. It is important that results of management strategies be presented in an objective and measureable way as to make this clear and comparable with other strategies. Anecdotal evidence and personal opinions should be avoided in determining changes to the strategies in most cases. However, there is still much to be learned in the field of natural areas stewardship, restoration ecology and ecology. The evaluation of applied methods continues to rely heavily on the experience and judgment of practitioners in the field (Packard and Mutel 2005). Therefore, a balanced approach which may allow for experimentation and testing of different strategies should be used.

Strategies and Opportunities for MBGNA

Reintroduction of Fire through Prescribed Burning

"The most effective tool a manager can use to maintain prairies and savannas is fire" (O'Connor 2006). Many of MBGNA natural areas contain natural communities which evolved with the critical process of fire for millennia.

Figure 32. Prescribed fire in Dow Field, fall 2008. Photo by Jeff Plakke

Many of these areas now suffer from a lack of fire through suppression for many years. Prescribed burns have been used to reintroduce this process and restore these natural communities. Some natural areas, however, will require other measures than fire to best manage them. An ecosystem-based approach to determining important natural processes effecting natural communities and the needs of their species is needed for holistic natural areas stewardship.

Prescribed burns can help suppress the woody plants and encourage grasses, sedges and forbs in a variety of natural communities. Many orchids respond exceptionally well to fire. A nature sanctuary in Southeast Michigan reported a tenfold increase in a population of the state threatened white lady's slippers (*Cypripedium candidum*) after prescribed burning (O'Connor 2006). A single fire in a degraded oak opening community can increase light penetration enough to invigorate grasses, sedges and wildflowers. A doubling and doubling again of light

penetration may occur with each successive burn for several years (Packard and Mutel 2005).

It is thought that fires occurred at a frequency of anywhere from annually to every 20 years depending on a number of variables (O'Connor 2006). Prescribed burns should be executed on a frequency at or above that of historical fire frequencies to aid in restoration. Annual fires may be appropriate for many areas to help restore light penetration, soil characteristics, to stimulate the native seed-bank and to control invasive plant infestations (O'Connor 2006, Packard and Mutel 2005, Czarapata 2005). As natural communities become more biologically diverse and stable, fire frequency may be decreased to every few years on an irregular cycle. Burns should also provide patches of refuge for native insects (Packard and Mutel 2005).

Figure 33. Oak Savanna, Nichols Arboretum, fall 2008. Photo by Jeff Plakke

Fires have the most adverse effect on plants that are actively growing, therefore prescribed burns should be executed at appropriate times to both discourage undesirable species and encourage biodiversity (O'Connor 2006). Historically fires have burned the landscape in the spring, summer and fall. Spring burns may discourage cool season grasses, spring blooming wildflowers and encourage warm season grasses (O'Connor 2006). Summer fires by contrast, inhibit the growth of warm season grasses; more severely set back woody plants, and can

have the effect of stimulating spring flora (O'Connor 2006). Fall fires are often more difficult to conduct because of shortening days, cooling temperatures and damp vegetation, but should be conducted as part of a diverse prescribed burning program (Packard and Mutel 2005).

Prescribed fire requires high levels of coordination involving multiple staff and volunteers on short notice to take advantage of appropriate weather conditions during an often short window of time during the year. It requires some specialized equipment and competent, trained and experienced leadership to execute as well. Detailed burn permits and prescriptions must be approved by local fire officials and all precautions must be taken to avoid smoke problems or starting an uncontrolled wildfire.

MBGNA should determine which areas are appropriate for fire management, prioritize them for prescribed burning. They should also continue to increase the diversity of timing and frequency for burns to help increase biodiversity and resiliency in its natural areas. MBGNA should also continue to increase its capacity to execute prescribed burns in fire dependent communities and increase the acres it successfully burns into the foreseeable future. In addition to adding tools and equipment to its inventory for this task, with limited resources and a desire to meet its stewardship goals, MBGNA may also consider hiring local contractors to assist in putting fire back into critical areas as soon as possible.

Manually cutting and clearing; mowing, brush-hogging, and hand cutting

Used with the appropriate timing and frequency and in combination with other techniques, removal of the aboveground portion of plants with mowers, brush hogs, and hand-held brush cutters can be an effective tool to increase biodiversity and control invasive exotic plants (Collins et. al. 1998, Packard and Mutel 2005). It may mimic in some ways, the once important effect of browsing and grazing by historically abundant animals such as the American buffalo (*Bison bison*) (Dempsey 2001). Prairie restoration projects often benefit from a single mid-season mowing to reduce competition as native plants are establishing their root systems (Packard and Mutel 2005). Savannas choked with native and invasive shrubs can be brush hogged or cleared with brush cutters, stumps can be treated with herbicide or subsequent burns can be used to control re-sprouting (O'Connor 2006). Caution should be used in wetland areas as heavy equipment and even humans walking with brush cutters may cause damage in spring and fall when soils are saturated (O'Connor 2006). In some cases brush hogging may provide effective maintenance in keeping open areas from filling in with brush or a simple stopgap measure to remove woody growth until such time as a fire can be planned and executed for the same area. This is apparent in several areas at the Matthaei Botanical Gardens and Nichols Arboretum where annual mowing has successfully maintained open areas dominated by some grasses and forbs where exotic and native shrubs would almost certainly otherwise have become dominant.

Execution of mowing once or twice a year in some areas may be preferred where conducting prescribed fires is more limited and difficult. Mowing once or

twice a year may provide useful results while requiring only one staff person familiar with the equipment operating in a wide range of weather and without permitting requirements. MBGNA should continue to use this method and study and experiment with combinations of this and other methods to help meet its stewardship goals.

Invasive Species Management

Invasive species are the second leading threat to biodiversity worldwide (Wilcove et. al. 1998). Invasive plants now cost our society $35 billion annually (Czarapata 2005). Their impact on MBGNA natural areas is variable, but pervasive with extreme degradation in some areas and less impact in others. In any case, their presence and spread should be considered a significant long-term threat. The management of invasive species throughout the MBGNA natural areas should remain a primary focus of the stewardship planning process to improve and protect the biodiversity of its natural areas.

Exotic insects and diseases have had a dramatic effect through the widespread death of American elms (*Ulmus americana*) by the Dutch Elm Disease early last century and more recently the white ash (*Fraxinus americana*) by the emerald ash borer. The impacts of these species is still being felt and may provide interesting opportunities for research as ecosystems respond to the loss and possibly the recovery of these species.

The invasive species that are most abundant and causing the most disruption in MBGNA natural areas are the plants, some of which were purposely planted in

garden areas. There are a variety of methods and techniques being used now in combination and over time to control them. A mapping initiative has begun showing several new invasive plants as they move along corridors through natural areas and begin their invasion. A continuing effort should be made to map the invasive species, their concentration (high, med, low) and their spread over time. Strategies should be implemented to remove them and control their return based on a prioritization of their invasiveness when applicable. The City of Ann Arbor NAP has a list of over 125 exotic invasive species broken down into four classes of invasiveness. This document is available online (City of Ann Arbor *NAP's Invasive Plant Fact Sheet*).

There are numerous methods and techniques used with specific timing to control invasive plant species. A comprehensive management program will include many of them working together for best control. Some of the primary methods already being used are: prescribed burning, hand pulling, mechanical cutting, herbicide treatments, and biological control. There are several excellent resources available to find volumes of information on the control of specific species including the book *Invasive Plants of the Upper Midwest, An Illustrated Guide to their Identification and Control* by author Elizabeth J. Czarapata, and The Nature Conservancy's Global Invasive Species Team website of invasive plant documents and photographs which has an extensive list of invasive plants that can be searched for specific information on any species (The Nature Conservancy Invasive Species Initiative). Control techniques and their combinations should continue to be tested to find best overall methods. MBGNA should encourage further experimentation by

considering certain zones within its natural areas as appropriate laboratories for studying invasive species, their impacts and methods to control them. Information and data regarding this effort should be organized and made available to U of M faculty, staff and outside organizations to aid in the effort to control these species.

Native plant seed collection and propagation

In many cases, restoration of degraded natural areas will require the introduction of native plant seeds and possibly of native plant plugs to bring back native plant populations and increase species diversity (Packard and Mutel 2005). A native plant seed collection and plant production effort was started at MBGNA several years ago to aid in restoration efforts and to grow native plant material for horticultural collections as well. This effort should continue to become more coordinated and strategic in the years to come. It should be supported by effective monitoring and data gathering that can produce quantitative results that are tracked over time giving objective measures of success or failure of species, techniques, methods, timing of plantings and other variables that may affect seed germination and plant survival. This information will be valuable for MBGNA in the future stewardship of its natural areas and may provide helpful information to

Figure 34. Native Plants, germination trays, Botanical Garden Greenhouse, spring 2005. Photo by Jeff Plakke

other land stewards. It also provides another excellent opportunity to engage the research community within the University of Michigan to help answer specific questions and gather the extensive amount of information about specific details and variables related to plant propagation.

Another aspect of this program that could be expanded is the propagation of rare and endangered plants. This will require a thoughtful approach to collection and introduction into new areas, and could provide important information and action to help save species and increase biological diversity. It remains critical, however, to protect and maintain wild populations of rare plants in their native communities, therefore propagation and expansion of rare plant populations should not be considered a substitution for proper stewardship of natural communities in which they already exist and critical natural process upon which they depend (Falk et. al. 1996, Packard and Mutel 2005).

Engaging Volunteers

There has been and continues to be an active monthly volunteer restoration workday happening at the Nichols Arboretum and more recently at the Matthaei Botanical Gardens as well. These workdays bring members of the community and university into the natural areas to help with activities such as invasive species control, native seed collection, and the planting of plugs. MBGNA more recently hired a full time volunteer coordinator to run the volunteer program and connect volunteers with programs and projects throughout the organization. The Volunteer Coordinator working together with the natural areas Manager can continue to recruit

and grow the volunteer base for natural areas stewardship. Natural areas stewards, volunteers with a deeper commitment and interest in stewardship work or a specific natural area, have also been added to the ranks of volunteers. Their addition has further increased capacity at MBGNA to manage workdays with other volunteers and to build knowledge and skills with these individuals and a desire to protect and care for these areas.

Careful consideration of volunteers as a resource for natural areas restoration, monitoring, and as important stakeholders in the MBGNA natural areas stewardship program is critical to its success. Much of the work needed to be done is dependent on their many hands. Their involvement also provides the space for public education, for people to develop a strong sense of place and it may help to foster among them an environmental ethic, arguably a growing necessity in creating sustainability within the society at large.

Education and Research in Natural Areas Stewardship

As has been mentioned throughout this work, opportunities for education and research in natural areas stewardship abound. At every turn, there is more to be learned about natural communities and their species, threats to these, and the many methods and techniques of stewardship activities to care for and protect natural areas. Careful consideration should be made not only for finding the best information for making management decisions about MBGNA natural areas stewardship, but how these areas can best serve the University and other organizations as appropriate outdoor classrooms and laboratories. Each property,

natural area, or specific zone has questions it provokes and lessons to teach. Intertwining planning and active stewardship of the natural areas with education and research is essential and should become a consistent theme in decision making at MBGNA.

Creating Beauty through Stewardship

Lastly, an important and historically significant component of landscape design at MBGNA is to recognize and plan for the aesthetic quality of the landscapes (Simonds 2000). Pleasing views, variations in patters and textures, and creating a sense of mystery were all important components in the design of the Nichols Arboretum by O.C. Simonds. The landscapes around the Matthaei Botanical Gardens were also carefully and thoughtfully designed to be aesthetically pleasing. Because many of the formal areas, collections and specimens of the MBGNA are imbedded within a matrix of varying natural areas, the stewardship of these areas should incorporate a consideration of aesthetics and place high importance on preserving a beautiful landscape.

With early descriptions of the southern parts of Michigan before European settlement being filled with exclamations of the landscapes' beauty, natural areas stewardship should be easily compatible with this goal. As areas are restored to ecological integrity, we may expect beautiful and pleasing landscape to evolve. Consider this quotation by an early visitor in Michigan:

> "To the traveler, the country presents an appearance eminently picturesque and delightful… The towering forest and grove, the luxuriant prairie, the crystal lake and limpid rivulet, are so frequently and happily blended together, especially in the southern section of the peninsula, as to confer

> additional charms to the high finishing of the landscape, whose beauty is probably unrivaled by any section of the country (John T. Blois 1838 quoted in Dempsey 2001).

MBGNA Natural Areas Vision and Mission

To begin a long-term approach for the natural areas of MBGNA, a statement which describes the vision of the future desired state and a statement of the mission has been created. These suggested statements of the vision and mission may serve as a starting point for further development as an inclusive process for decision-making is developed. These statements, when used effectively, can provide consistency and direction for stewardship activities as changing daily tasks, seasonal events, evolving threats and new conservation targets and other obligations can distract from the overall mission of the program. While these statements can serve as an initial starting point, they should also be periodically revisited and appropriately revised so as to evolve to accommodate changes through time.

MBGNA Natural Areas Mission Statement:

To restore, protect, promote, and monitor the ecological integrity of natural areas of the University of Michigan for purposes of research, education, and public outreach goals.

MBGNA Natural Areas Stewardship Vision Statement:

MBGNA natural areas will contain healthy, biologically diverse natural communities that provide prime examples of the highest quality conservation and stewardship. They will become exemplary laboratories for University faculty

and students to produce environmental and ecological research yielding valuable findings for the scientific community. MBGNA natural areas will become a place of abundant natural beauty and source of respite, renewal and inspiration for all who visit them.

Strategic Goals for MBGNA

- An inclusive planning process and decision-making model will be developed to produce comprehensive stewardship plans for MBGNA natural areas.
- The natural communities and critical natural processes are identified, mapped and monitored over time as well as threatened and endangered and other important native species, invasive species and stewardship activities.
- Stewardship activities will be regularly practiced by a highly involved and invested team of professional staff and a community of students, neighbors and volunteers.
- The natural areas will improve in ecological quality and integrity and serve to protect a number of ecosystems, threatened and endangered species and many native species still common to our region. They provide connectivity to other important natural areas in the area and help to clean the water and air that flow through them.
- The natural areas will provide enhanced field research and educational opportunities to the students of the University of Michigan and produce valuable scientific information.

- The natural areas will continue to inspire students and visitors to create beautiful artwork and help to nourish the souls of the people who visit them by connecting them with nature.
- MBGNA's practice of conservation and stewardship will provide ecological education and heightened awareness and serve as an example of excellence in our region and around the country and the world.
- MBGNA's leadership and research will serve to educate students, land owners and land managers, who in turn will help to protect a growing number of acres of natural areas, Ecosystems, and Species beyond these borders.

V. The Natural Areas Stewardship Plan

The following section outlines and provides an abbreviated example stewardship plan for the Nichols Arboretum. This example illustrates an application of the process described in the previous chapter. As a demonstration, it is intended to help show where changes are still needed in the planning process, what additional information should be included with a stewardship plan and what information might better be catalogued separately.

Outline for MBGNA Natural Area Stewardship Plan

Area Description and Analysis

- Location, size & shape, ownership, accessibility, boundaries, general description of landscape and neighbor information
- Geology, soils & hydrology
- Ecological, cultural and land use history
- Current ecological condition, natural communities and their trajectory, notable species, threats and stresses
- University use for education and research – class use and previous research data, etc.
- Community use – passive recreation, physical training, events, illegal hunting, etc.
- ID important resources, alliances, university connections or the lack of them; course support and research opportunities.
- Suggested research topics and questions
- Include GIS and other maps within appropriate sections: management zones, natural communities, target areas, rare species, invasive species, prescribed burns, etc.

Natural Area Stewardship Implementation

- Stewardship targets and ranking: natural communities, processes, species, etc. and describe acceptable variations. Other targets ranked: boundary delineation, cultural resource protection, important view shed restoration, trail maintenance, access improvements, infrastructure concerns, etc.

- Threats to these targets and their ranking: invasive species, lack of fire, erosion, neighbor encroachment, dogs off leash, high deer population, etc.
- Strategies and their ranking:
    - ✓ General monitoring program
    - ✓ Survey & monitoring plan for listed species
    - ✓ Plan for controlling invasive species
    - ✓ Prescribed burn and semiannual mowing plans
    - ✓ erosion control and storm water planning
    - ✓ Trail monitoring and maintenance plan
- Create timeline for stewardship activities

Following the Nichols Arboretum example, each of the other properties will be discussed more briefly to examine some of the differences and similarities between these properties. They can then be examined as a whole to determine possibilities and priorities for the entire natural areas complex of MBGNA. With an evolving system for decision making in place and a process for gathering information about these properties, MBGNA can make progress on all of its natural areas over time.

MBGNA Natural Areas Stewardship Plan for Nichols Arboretum

Location and General Description

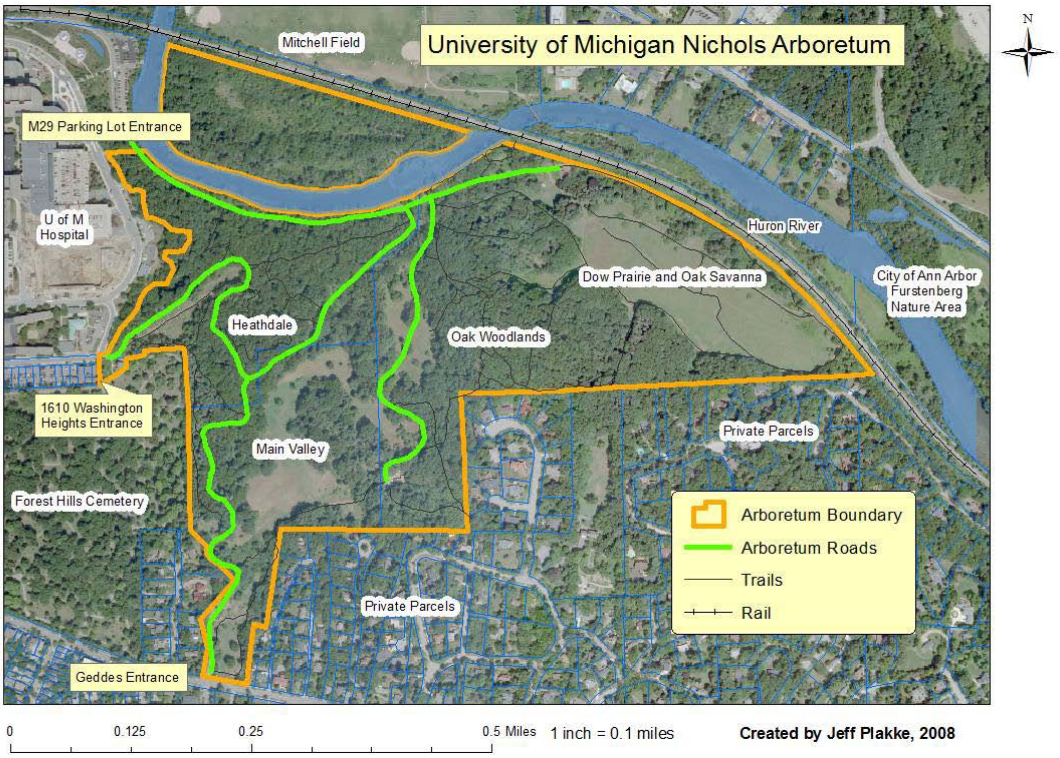

Figure 35. Nichols Arboretum and Area Map

Nichols Arboretum, established initially as the University of Michigan Botanical Garden in 1907, is located at 1610 Washington Heights, Ann Arbor, MI 48104. It is in Ann Arbor Township, within the northwest quarter of section 27 and the northeast quarter of section 28. The property is owned by the University of Michigan with a portion owned by the City of Ann Arbor. The University of Michigan is responsible for its management. It is nestled within the city limits of Ann Arbor, on the east side of the University of Michigan's central campus along the Huron River. The Arboretum is 123 acres in size and roughly triangular in shape with a long northern boundary that partially follows the Huron River and then follows the Norfolk and Southern Railway east. An

additional 40 acres of University land across the river from Nichols Arboretum is also managed by MBGNA. It has three main entrances; the primary entrance on Washington Heights where the visitor center called the "Reader Center" is located, the main service entrance along the Huron River off the University of Michigan Parking Lot M29, and the southern entrance off Geddes Ave. These three entrances, as well as other unofficial points of entry allow an estimated 100,000 visitors into the Arboretum each year.

With glacial formed forested hills of oaks and hickories, several open valleys of mowed grass, quiet glens, an expansive prairie, bits of oak savanna, and a long section of the Huron River, the Arboretum is an impressive retreat near the busy city. Designed by O.C. Simonds in the early 20th century, it is a beautiful property which has become a rich natural refuge, a valuable educational resource, and historically significant landscape beloved by the community. It contains several collections and numerous specimen plants dating back to the early 1900's. The Arboretum is also renowned as one of the best "birding" spots in the county and a group of birders meet there weekly during spring and fall migration periods to spot and observe birds and keep an ongoing count of the area.

Figure 36. Nichols Arboretum Main Valley, Feb 2008. Photo by Jeff Plakke

It borders the Forest Hill Cemetery to the west and lies across the street from the University Hospital to the northwest. To the north across the Norfolk and Southern rail

line is the University's Mitchell Athletic Field and the Gallup Park Bicycle Trail. To the northeast across the Huron River is the City of Ann Arbor's Furtstenberg Nature Area. Bordering the south and east boundaries are a number of private residences with smaller parcels. A list of neighbor addresses is available for prescribed burn notifications.

Geology

The Arboretum lies along the Defiance Moraine and contains moraine, ice-contact terrain and outwash plain as major glacial features (Tepley 2001). There are several additional landform level features including variations on the end moraine, Ice

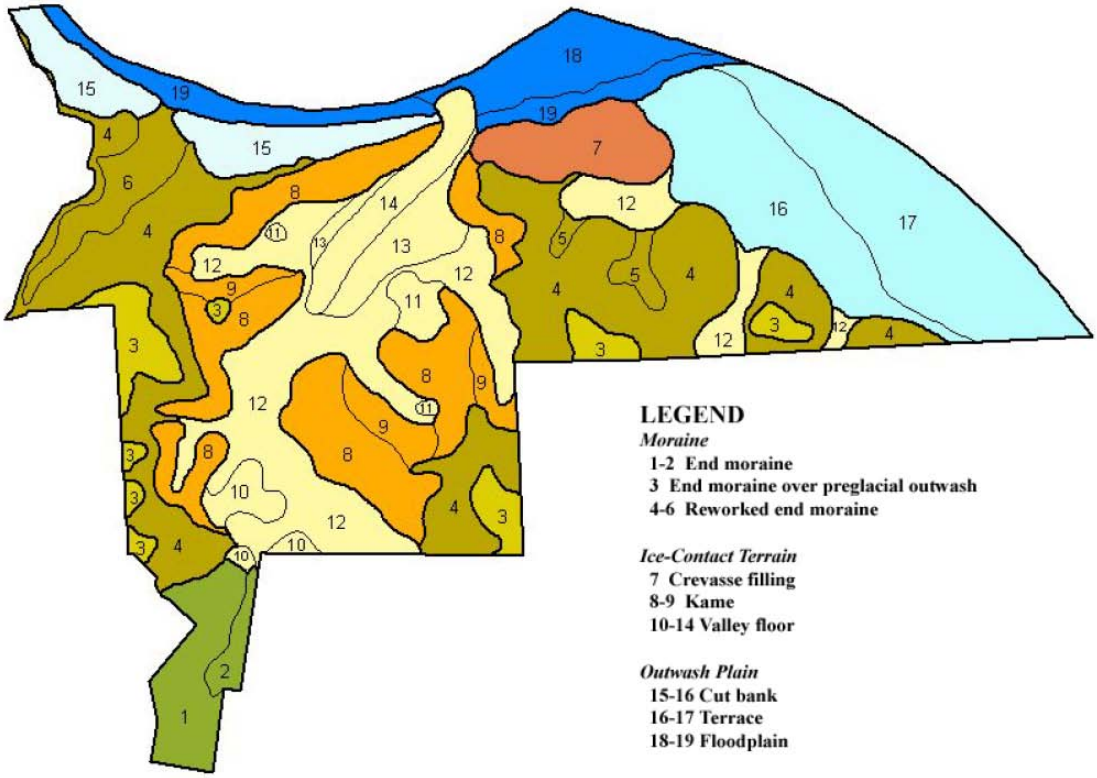

Figure 37. Physiography of Nichols Arboretum (Tepley 2001)

contact terrain features including crevasse filling, kame and valley floor, and outwash plain cut bank, terrace and floodplain features (Tepley 2001). These features are discussed and analyzed in detail in Alan Tepley's Thesis "Landscape Ecosystems of the Nichols Arboretum, University of Michigan" completed in 2001.

Soils

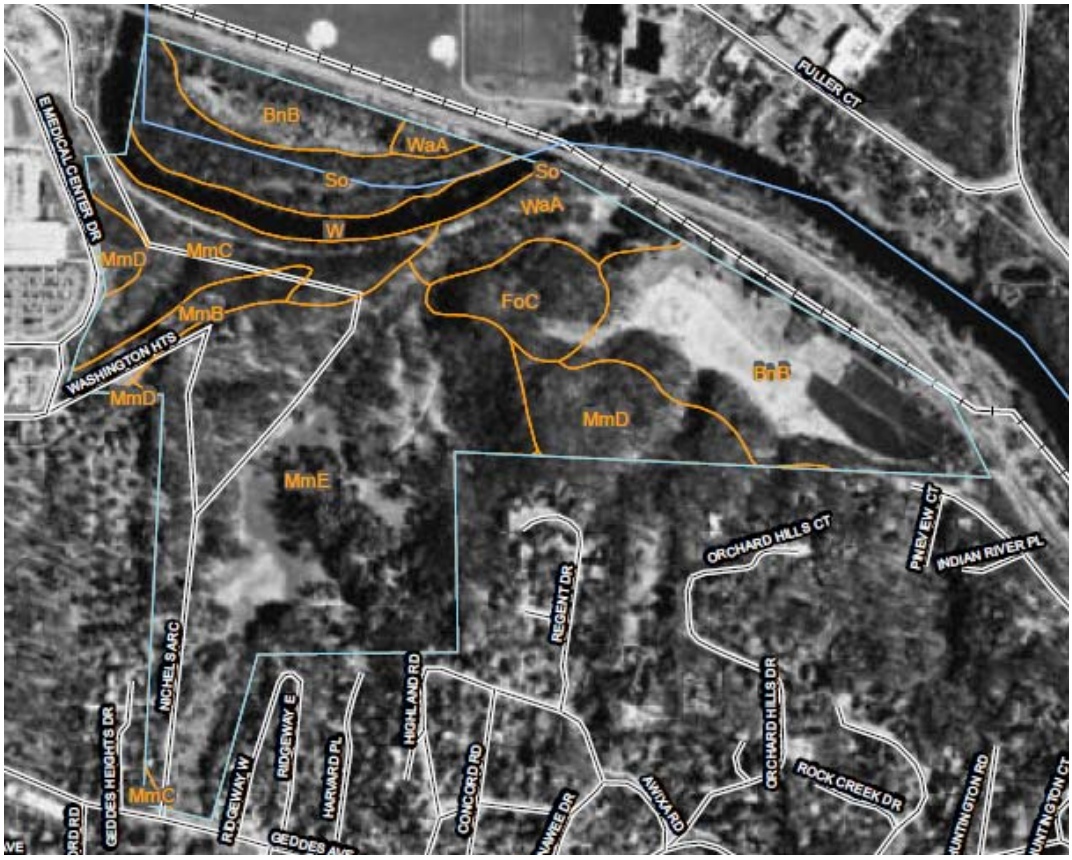

Figure 38. Soil Survey map of Arboretum (See Appendix C. for detail)
(USDA Natural Resources Conservation Service)

These complex and diverse landforms create a complex heterogeneous mix of parent materials that form the foundation of the soils and the ecosystems that have

developed in the Arboretum. See Appendix C. for the NRCS Soil Survey Map of the area.

Over 50% of the soil type found in the Arboretum is Miami series of varying slopes. This soil series consists of very deep, moderately well drained soils of dense till. The Miami soils formed in silty material and in the underlying loamy till. They are on till plains. Slope ranges from 0 to 60 percent" (Soil Survey Staff 2008). Also significant is the Boyer soil series which covers over 20% of the Arboretum. This soil series consists of very deep, well drained soils formed in sandy and loamy glacial drift underlain by sand or gravelly sand outwash at depths of 20 to 40 inches. The soils are on outwash plains, valley train, kames, beach ridges, river terraces, lake terraces, deltas and moraines. Permeability is moderately rapid in the loamy horizons and very rapid in the sandy horizons (Soil Survey Staff 2008).

Hydrology

An approximately one half mile long section of the Huron River runs through the northern end of The Arboretum. This adds significant riparian habitat, aquatic diversity as well as several challenges to the stewardship of this area. This section of the Huron River is relatively shallow and fast moving which, in terms of river habitat, is rarer than deeper, slow moving sections of the Huron both above and below the section that passes through the Arboretum.

Three small intermittent streams also flow about a quarter of a mile each and empty into the Huron River. One stream which flows through School Girls Glen has created considerable erosion since the development of storm water systems of the

University which empty into this ravine. Tamara Orlow's Master's study of the glen revealed the dramatic extent of the erosion and makes suggestions for continued improvements (Orlow 2003). At the upper reaches of this stream was created in 2003, the Gateway Garden at the Reader Center. This garden was a combination of step-pools and native plantings creating effective storm water filtration as well as a beautiful rain garden of native plants for perhaps the Nichols Arboretum's busiest entrance.

The second stream runs through the center of the Arboretum north and through a forested wetland community where a boardwalk was recently built. This area is rich in plant diversity including typical wetland plants such as Skunk Cabbage (*Symplocarpus foetidus*) Wetland Joe Pye (*Eupatorium maculatum*) and many others. It has recently become a favorite spot for bird watchers during spring and fall migrations. It is also invaded by a number of exotic species, but restoration has made great progress in this area in recent years.

The final stream is at the far east end of Dow Field and appears to be running almost all year. This area has been highly invaded by a number of exotic and undesirable native species, but has begun with the removal of many large exotic shrubs and trees, and regular pulling of garlic mustard (*Alliaria petiolata*) populations in the spring.

Topography

Complex and steep topography adds further diversity to the soils and natural communities that have developed in the Arboretum over time (Figure 39). Steep slopes facing north or south can have a dramatic effect on the microclimate and water run-off in

a particular area and the resulting development of soils and plant communities. The complexity and severity of topography also adds the challenge of storm water management in the Arboretum. A long and winding network of roads and trails are highly vulnerable to damage and degradation from storm water caused erosion.

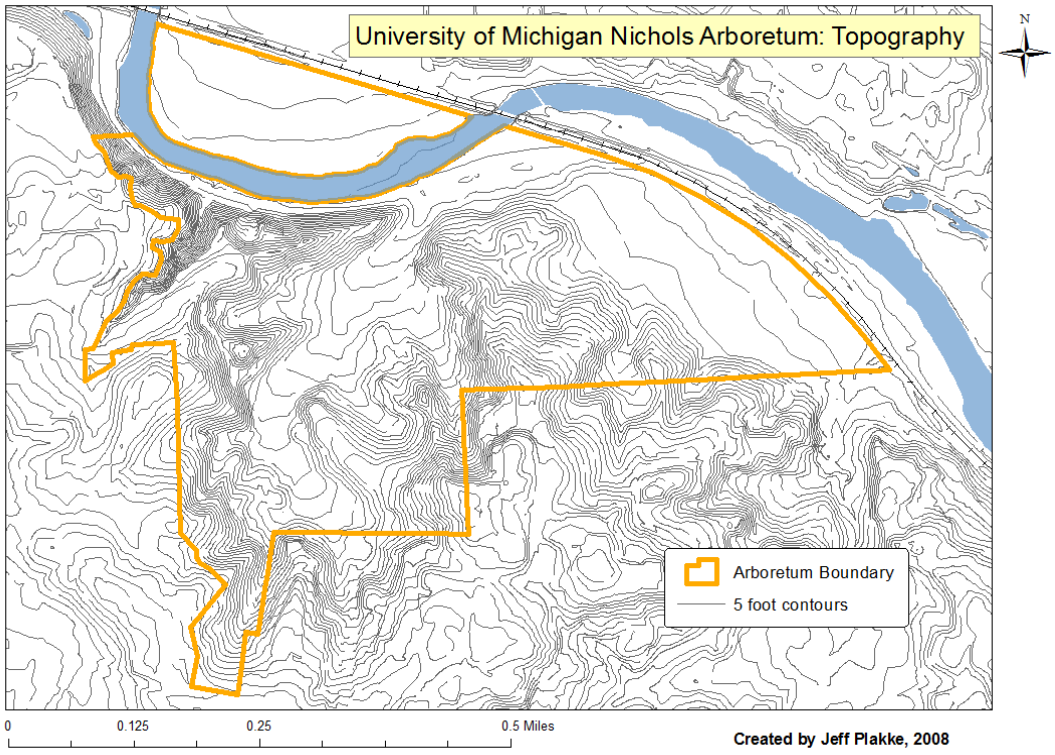

Figure 39. Topography of the Arboretum shows the complex and in some locations, very steep slopes creating a diverse matrix of natural communities and soils.

The long steep hills have also enticed university students to brave the snowy slopes on sleds or cafeteria trays for decades. While sledding is not illegal, damaging plant material in the Arboretum is, and sledding can create considerable damage to collections planted on steep slopes.

Ecological and Cultural History

General Land Office Survey Notes were examined at the State of Michigan Archives in Lansing, MI. These surveyor's notes from the 1819 survey of the area describe the vegetation and landscape and help reveal the pre-settlement ecology of the landscape. "Hilly oak land" and "Level thin land with black oak and white oak" are some of the comments found describing the land around and within the Arboretum at that time. It describes willow trees, ash, and basswood near the river, but primarily a mixture of oak and hickory is recorded in the uplands (U.S. General Land Office 1819). A Pre-settlement vegetation map of Washtenaw County is also available online through the MNFI website (MSU Extension).

Before these lands were given to the University of Michigan, the property was logged, farmed in some areas, and grazed in others. A long section of the original railroad once ran through the Arboretum as well and may have been the source of frequent wildfires which likely helped to maintain the populations of native prairie and savanna species still found and being restored along the northern edge of the Arboretum.

After the development of the Arboretum began, perhaps one of the most significant impacts to the land would begin with the introduction of a host of exotic plant species. In a University Arboretum this is to be expected, but what was not anticipated was the impact some of these exotic species would have on the surrounding ecosystems within which these new specimens and collections would be imbedded. Honeysuckle (*Lonicera spp.)*and buckthorn (chiefly *Rhamnus cathartica* but also *R. frangula*) have proven to be two of the most damaging of exotic invasive species in the Midwest. The Nichols Arboretum was actively planting these species as early as the 1910's. Several

collections of honeysuckle once existed in the Arboretum as well as numerous plantings of common and glossy buckthorn.

Many of the natural areas of the Nichols Arboretum have been under restoration over the past 20+ years and have been steadily improving in quality. Removal of many invasive species has been ongoing and prescribed fire was first introduced to its Dow Prairie in 1987. Prescribed burning has been an annual occurrence in some part of the prairie and increasingly in woodland areas ever since.

Along the Huron River near the northwest point of the property a short distance inside the vehicle gate at the University M-29 parking lot, half way up the steep slope and under cover of large trees, there is the foundation of what is described as the "pump house" on some old maps. Spring water still seeps from this old foundation and a layer of tufa has formed on the surface of the ground extending down some 20 feet to the ditch along the roadway. This area is now difficult to notice and largely shaded and obscured by tree-of-heaven (*Ailanthus altissima)*, Norway maple (*Acer platanoides)*, and some native trees. With some careful clearing this area may offer a wonderful opportunity to both restore the native vegetation that grows on this calcium rich substrate and illustrate this rare ecosystem to visitors as they enter the Arboretum and walk along this road. There are other such occurrences of tufa along the Huron where the characteristic vegetation still exists. With permission from property owners, perhaps seeds could be collected or individual plants transplanted to the area in the Arboretum after this hillside has been cleared.

Current Ecological Conditions

Generally speaking the natural oak and hickory forest communities of the Nichols Arboretum are becoming dominated in the understory by native meisc species such as *Acer rubrum*, *Acer saccharum* and *Acer negundo* moving in from the lowlands into the upland communities. This is due primarily to the lack of fire for over a century.

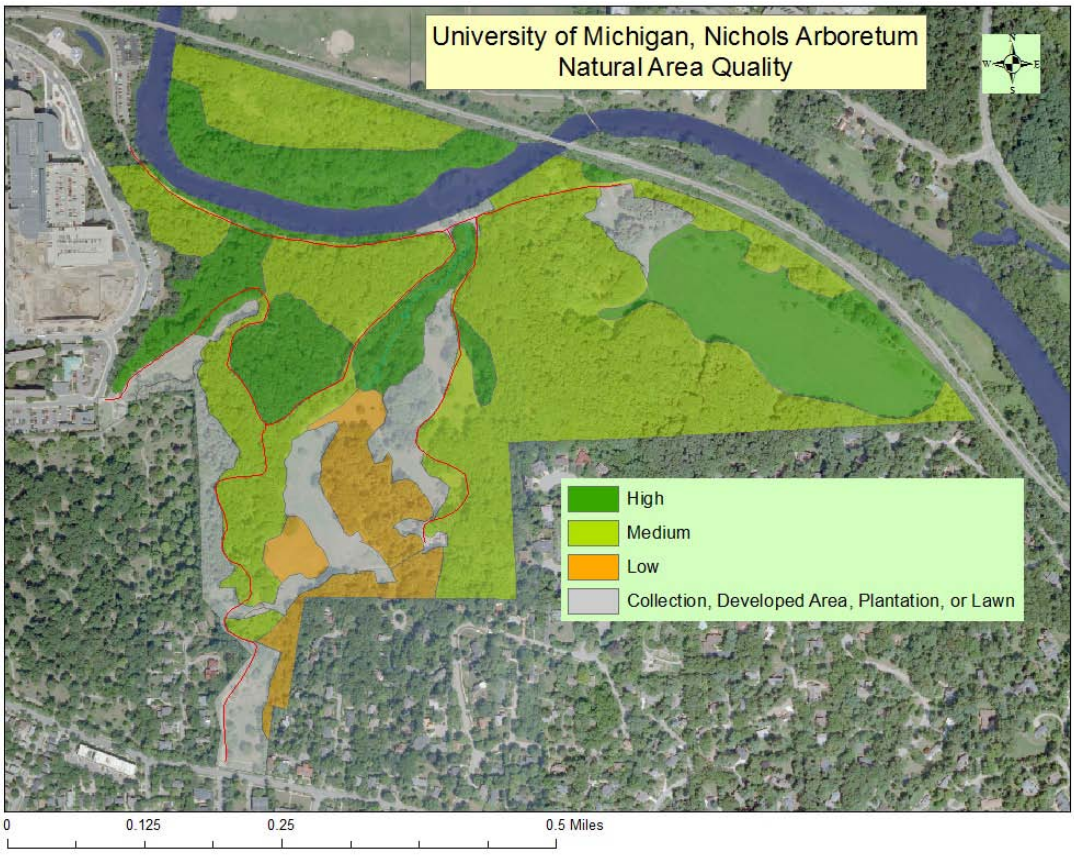

Figure 40. GIS Map of natural areas generalized by quality – an interpretation of natural community uniqueness, native plant diversity and abundance, degradation from exotic plants or other stresses, visitor disturbance to area, successful use of fire, etc.

Adding to this the widely planted and spreading exotic species such as honeysuckle (*Lonicera spp.*), buckthorn (*Rhamnus spp.*) and black locust (*Robinia pseudoacacia*), forest floor conditions including soil moisture and nutrient availability have likely changed dramatically since the early surveys were done. Wetland areas have

filled in with invasive exotic shrubs, but several areas have been successfully cleared and are being followed up with treatments of re-sprouting vegetation. Spring flora in these areas seems to be making a comeback.

The Huron River floodplain, Dow Field and surrounding oak savanna and oak woodlands make up the largest contiguous natural area of the arboretum. This large section falls within several of the management zones indicated on the map in Appendix G. Currently these areas are under restoration and being managed for invasive species such as garlic mustard, dame's rocket, honeysuckle, buckthorn, oriental bittersweet, Norway maple and several others. It is also being managed through the reintroduction of fire on a rotational basis in the Dow Prairie and opportunistically throughout the oak woodlands as invasive shrubs are removed and oak litter can accumulate.

Natural Communities

More careful examination is necessary using the MNFI's classification and description of natural communities of Michigan along with more extensive field surveys to determine precisely which natural communities existed previously and remain present in the Arboretum. What follows is an initial approximation based on site visits and a brief analysis of previous research.

Oak openings and *Oak Barrens* are likely present in degraded form occurring along a gradient merging from the oak hickory forest (*Southern Dry Forest*) likely depending on a combination of soil characteristics, topography and historical frequency of fire. Dow Field likely contains a *prairie* community, either *dry-mesic*, *mesic* or *mesic sand* or a combination. The oak openings and barrens have filled in with native and

exotic woody species, some have been partially restored, but all were significantly degraded before restoration began. *Floodplain Forest* also likely occurs in pockets along the Huron River as well as possibly *Southern Wet Meadow* and *Southern Shrub-Carr* occurring across the river in the river floodplain, although routine flooding of these systems has stopped with the construction of dams on the Huron River. Areas of so*uthern Mesic Forest* were also present in areas such as School Girl's Glen.

Notable Rare Species

A complete inventory of rare species of the Arboretum is needed and planning should begin to survey for and inventory these species over time. Susan Fruchey's "*Flora of the Nichols Arboretum, Ann Arbor, MI"* has been important in providing a baseline of the plant community and identifying plant species of note. Some listed plant species and species of concern that are known to occur are Leiberg's panic grass (*Dichanthelium leibergii*), James sedge (*Carex jamesii*), and yellow pimpernel (*Taenidia integrima*) to name a few.

Bird species that have been spotted in the Arboretum include bald eagle (*Haliaeetus leucocephalus*), osprey (*Pandion haliaetus*), as well as a nesting pair of coopers hawks (*Accipiter cooperii*). There are likely others in this category and information from the birding community would help to complete this list. The MBGNA already has lists from surveys done in the early 1900's which could be interesting for comparison.

Insects, mammals, reptiles and amphibians should also be surveyed for likely rare species. MNFI data is available which gives possible listed species and appropriate

survey times for each species. The process of surveying for rare species is an extensive project and requires special skills and resources to achieve valid results. This process should be prioritized along with other stewardship activities and should not necessarily be required as a precursor to protecting and conserving these areas.

Stresses and Threats

Invasive plant species are likely the most pervasive threat in the Nichols Arboretum. They cause loss of native plants through direct competition for light resources as well as changing nutrient cycling characteristics of the soils. They have been naturalized in the Arboretum for many decades and amount to a formidable restoration project to bring their populations under control.

While several of the most common and problematic exotic invasive plant species can be found in the Arboretum, there are also a number of exotic species that have not been widely planted elsewhere, but appear to exhibit invasive tendencies. Species such as the Kalopanax tree (*Kalopanax septemlobus*), the golden rain tree (*Koelreuteria paniculata*), tree lilac (*Syringa reticulata*), jet bead (*Rhodotypos scandens*), and American yellowwood (*Cladrastis kentukea)* (which is considered rare in its home range), are becoming invasive in the Arboretum and some have been found in neighboring natural areas. The herb greater celandine (*Chelidonium majus*) is also less widely discussed as an invasive species but has spread significantly in the Arboretum and may be considered a problem.

The frequency and abundance of dogs on and off leash in the Arboretum would suggest they are also an important stress on natural communities. Dogs create

significant impact to wildlife populations. Several studies have found significant reduction in bird diversity, predator activity, and small and large mammal abundance in natural areas were dogs are present (Banks and Bryant 2007, Lenth and Knight 2008).

Storm water caused erosion is another important threat causing significant damage to slopes and soils along steep paths. Strong rains bring large volumes of water through the Arboretum into several key areas of concern: The Gateway Garden, the Cemetery Drain, the Harvard Drain, and to a lesser extent, the stream through the wetland area. Combined with sometimes massive erosion along the banks of the Huron River, erosion requires constant maintenance to abate.

Visitor impacts are also a source of stress on natural areas. Many visitors trample vegetation, sled down slopes in the winter, gather berries and branches off of trails, and cause other disruptions to ecosystems. While some of this activity should be allowed or even encouraged to reach our public outreach goals, it is important to regulate these activities in sensitive areas, such as wetlands, where damage to soils and vegetation from people can be significant and lasting.

Current Management Zones

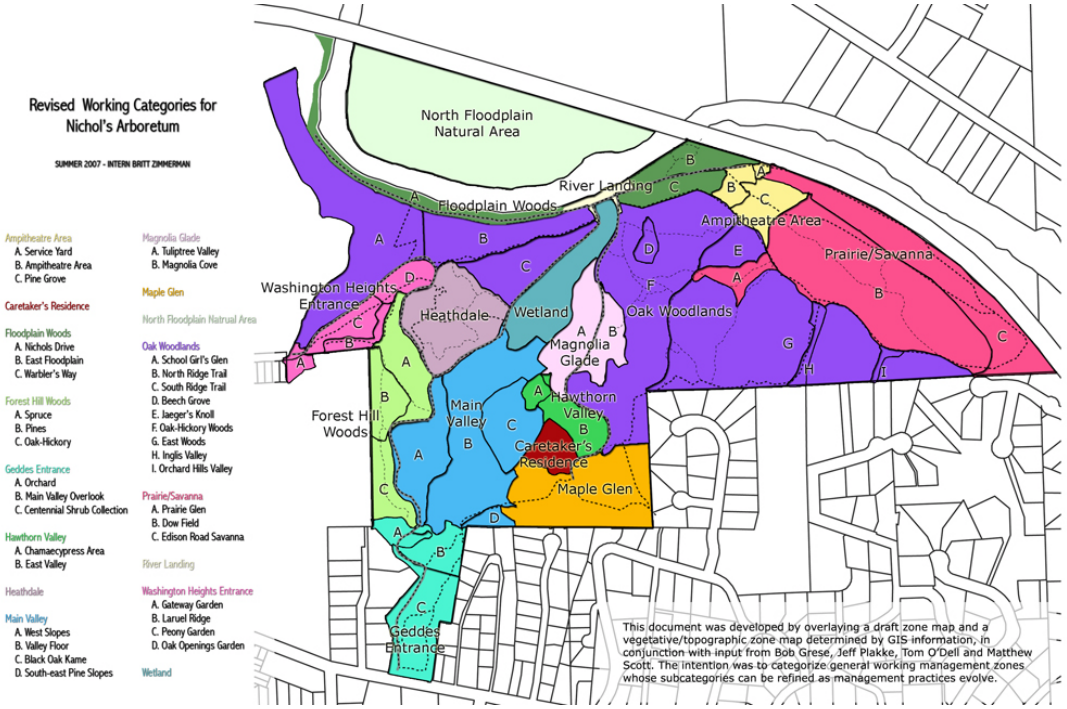

Figure 41. Management Zones of the Nichols Arboretum (See also Appendix G)

The preceding figure illustrates the establishment of management zones for planning purposes at the Nichols Arboretum. These were established by staff discussion and analysis in conjunction with using Alan Tepley's thesis "*Landscape Ecosystems of the Nichols Arboretum, University of Michigan"*, and thinking about goals for collections and use areas at the Arboretum.

These zones allow categorization of the landscape into units with similar management requirements or themes. They may or may not coincide with natural community boundaries or the quality of natural areas; however, they are useful in identifying other aspects of the landscape and significant features which may require consideration when planning for natural areas stewardship activities.

University Use: Education and Research

University classes use the arboretum for collecting woody plant samples, for field trips, art projects and installations, and wildlife projects such as bird observation. There are several classes that regularly use the Arboretum, but most currently plan their use ad hoc.

A number of research projects, practicum and theses have been completed in the Arboretum over many years. These projects have helped with learning about management objectives and alternatives. This incomplete list of projects includes:

- Callery, T., M. Canteberry, D. Havens, C.B. Hill, S. I. Houseal, S.-O. Kim, and M. Youngquist's "Nichols Arboretum A Master Plan" (1988)
- Boyle, T., K. Nebel, M. Psaraouthakis, G. Quaderer, S. Simon, and M. Wyatt's "Nichols Arboretum: Improving Visitor Experience." (1996)
- Shalini Priyadarshini's "A Home for the Arboretum." (1999)
- Lara Treemore Spears's "Effects of prescribed burning on the arthropod community of Dow Field Prairie." (2000)
- Alan Tepley's "Landscape Ecosystems of the Nichols Arboretum, University of Michigan" (2001)
- Tamara Orlow's "Restoring School Girls Glen: Case Study and Recommendations, Nichols Arboretum, Ann Arbor, Michigan" (2004)
- Susan Fruchey's "Flora of the Nichols Arboretum" (2003)
- Christopher Smith's "Creating and Managing Sustainable Trails In Nichols Arboretum" (2006)

Community Use

The Nichols Arboretum is a beloved, even sacred landscape to many of the residents of Ann Arbor. University of Michigan Alumni often have fond memories of "the Arb" as a place they once walked with their sweethearts, or where they went sledding in the winter time. Many of the neighbors regularly use the roads and trails and enjoy the plants and birds and mesmerizing views along the Riverfront. With recent improvements and added seating along the river, a beautiful spring day can draw hundreds of people from the city and campus to take leisurely walks along the river, play games in the main valley, or use the winding trails up the hills for physical training.

The monthly ecological restoration workdays draw a number of local community members and student to help with the restoration of the Arb's natural areas. These workdays are critical to the work being done in the Arboretum. Volunteers are a major resource in achieving conservation goals in the Arboretum and at MBGNA.

Analysis of Resources and Alliances

Equipment and Tools

The Nichols Arboretum has on site a garage with sufficient hand tools, power tools, herbicide and application equipment, utility vehicles, and a fueling station to support a wide variety of stewardship activities at the Arboretum. There is also a utility trailer with prescribed fire equipment which can be easily brought to the site of a burn. An inventory of this equipment and needs for future stewardship activities may help to ensure that MBGNA can proceed at the Arboretum without setbacks or inefficiencies.

Resident Student Caretakers

There are currently five resident caretakers living at the "caretaker cottage" and "Reader Center apartment". These students each working 10 hours per week provide a variety of services for the Arboretum including security and weekend and evening support. They also help with natural areas stewardship activities. Each caretaker is taught how to use and maintain equipment and tools. They each take an exam with the Michigan Department of Agriculture to become certified as a Commercial Pesticide Applicator and they also help significantly by supporting and leading monthly restoration workdays.

Figure 42. Caretakers chipping invasive shrubs at restoration workday, winter 2007. Photo by Jeff Plakke

Internships and work-study student jobs

Several summer internships are available through MBGNA to work on natural areas stewardship. These positions offer students a full time job for the summer and a chance to learn and practice natural areas stewardship at the MBGNA properties. This also provides the organization with significant resources over the course of the summer to meet stewardship goals. Students working several hours a week for Work-study during the school year also contribute significantly to natural areas work. Their effort combined with the Washtenaw County Sheriff's Work Program, bringing five to ten

people to the site for a day's labor once a week, provides significant labor resources throughout the year. Some of these students can come with exceptional skills and experience while others are relatively new to the field. In either case, they all have an eagerness to learn and desire to be engaged in this work.

Volunteers

Natural Areas Stewards, volunteers with a special interest and higher level of commitment have more recently begun helping with workdays. These positions could be expanded more to further increase MBGNA capacity for stewardship activities.

Student volunteers, working in groups each month along with local community members also provide significant labor and help stewardship activities significantly. A number of student organizations now repeatedly join regular restoration workday. Many of the students find the work interesting and fun.

Ann Arbor Natural Areas Preservation program *(NAP)*

NAP is a local ally in natural areas stewardship and developing a working partnership with them could provide both organizations with significant benefits. MBGNA might partner with NAP to discuss strategies and plans, share native plant seeds for restoration and work to provide better continuity throughout the natural areas connected in the same local landscape. City property, for example, is just across the railroad tracks from the Nichols Arboretum and Furstenberg Nature Area is down the Huron River only a half a mile on the opposite shore from the Nichols Arboretum and

shares many of the same natural communities, native species, likely the same local genotypes, and relies on the same natural processes.

University Faculty and Staff

University faculty and staff from the SNRE and EEB could become more engaged resources to help with ecological monitoring, studies and surveys of Arboretum natural areas. Their interest in research related to the environmental sciences, combined with questions the MBGNA would benefit from answering could provide a mutually beneficial combination.

Suggested Research Questions

The Nichols Arboretum offers a number of interesting and unique questions which may lead to productive research in the environmental sciences. Several sections are included discussing knowledge gaps and presenting opportunities for scientifically significant findings that are also practically useful for natural areas stewardship at MBGNA.

Invasive species

Because the Arboretum was established over 100 years ago, it has been a repository for exotic species for decades. There are numerous species which have demonstrated their ability to spread throughout the natural areas. Many of these species are well known but other species exhibiting invasiveness were not so widely planted elsewhere. These plants currently have not been extensively studied and some have only

recently made it on to invasive species lists. The Nichols Arboretum may offer the first useful field test on several of these exotic species.

The removal of many exotic invasive plant species (trees, shrubs, vines and herbs) is happening throughout the Arboretum in several different ecosystems and using a variety of techniques at different times of the year. Many opportunities for research exist in the Arboretum in the field of restoration ecology looking at these different species and the various techniques used to control them. Because this field is still relatively new and ecosystems are so complex, much can still be learned about exotic invasive plants, their spread in ecosystems under varying conditions, their impacts on ecosystems, and the ability of ecosystems to recover when these species are removed.

Visitor Impacts on Natural Areas

With an estimated 100,000 visitors per year, the Nichols Arboretum offers numerous experimental opportunities to evaluate the impacts of visitors on natural areas. Trail systems become degraded, dogs are threatening to wildlife, and the constant presence of humans certainly excludes numerous species of wildlife. However, some plant communities in the forests and aquatic communities within the river may not be so affected by Arboretum visitors. Quantifying these impacts could prove very useful to natural areas managers who are faced with stewarding areas with both high biological diversity and high demand for visitor use. Understanding the impacts could help determine how resilient different ecosystems are to various types of visitor use or what more severe restrictions may be necessary to protect them over time.

Prescribed Burning

Fire has been re-introduced into many of the natural areas of the Arboretum for several years. Limited resources at MBGNA have allowed only basic data of areas burned and the year and season they were burned to be captured. Two master's students have studied the effects of fire in some capacity at the Arboretum and many studies have been done elsewhere. There is the potential for many detailed follow-up studies to be conducted at the Arboretum. Everything from the impacts on soils, insects, plants, and animals could show significance in the different ecosystems where fire is now used. Also the impact of burning different ecosystems in the spring, summer and fall pose interesting questions. The character of fire (heat, resident time, flame height) is also something that could be described in the different ecosystems which would certainly affect the vegetation community.

Soft Engineering Techniques for Erosion Control

Nichols Arboretum faces significant challenges due to its steep topography and erodible soils as well as having a long section of the Huron River with one particularly steep bend running through its northern end. These challenges also offer important opportunities to study erosion in several forms as well as the improved soft engineering techniques now used to control erosion.

A section of the Huron River's shoreline at the River Landing area was extensively repaired in 2005-06. The process involved re-grading of the slope, addition of city compost, planting hundreds of native plugs grown at the Botanical Gardens and

live stakes harvested from local wetlands. All this is protected by an installed rock toe of limestone.

Another section of the shoreline was repaired the spring of 2007 using similar vegetative measures but adding extensive rock veins into the current of the river at this steep bend to redirect the flow toward the center of the Huron River. It is at this stretch of the river that a large section of the south bank began to "slump" after a heavy rain in September of 2006.

A master's project by Tamara Orlow was conducted in the School Girls' Glen of the Arboretum where she studied the impact of erosion and installed several structures and plantings to help mitigate storm water damage. A beautiful formal garden also acting as a storm water filter was installed, called the Gateway Garden, at the upper end of this ravine containing a wide variety of native plants. These were planted in constructed step pools which help to slow the storm water and collect silt and sediment preventing it from entering the Huron River. Presently many homeowners and municipalities are now strongly encouraged or required by law to handle all of their storm water onsite, therefore further study of this garden, its effectiveness and maintenance requirements could provide useful information as storm water management becomes increasingly important.

These projects could offer continued research for years to come as the forces of the river continue to pose a significant challenge to permanence of any installations along its bank.

The Ecology of the Urban Huron River

The Nichols Arboretum seems an ideal location for river research. With a long, free running section of the Huron River less than a mile from central campus on University of Michigan managed property, access is proximity are extremely good. Monitoring of fish and invertebrate species that use this section of the river may be valuable to track. With its close proximity to the city, other unique opportunities may be available here. Measurements of negative impacts as well as progress toward a cleaner river could be taken here over time showing the effects of the city storm, often acutely obvious along this section.

Natural Areas Stewardship Implementation

For the following section two areas of the Nichols Arboretum were selected and run through the ranking instrument which was developed to determine their relative priority. Then a simple management plan was created for each area assuming for this example that the ranking is appropriate. In a complete plan for the Arboretum, all of the management zones and subzones will be ranked and evaluated with input from the Natural Areas Advisory Groups, and placed into categories of priority before management plans for each area are created.

Property: Arboretum			
Zone: Prairie/Savanna			
subcategory: Dow Field			
Variable	Fixed Value	Site Value	Product
Conservation	10	8	80
Education, Visitor Impact, & Neighbors	9	9	81
Cost & Implementation	8	8	64
		Sum & Score	**225**

Table 4. Ranking of Property: Arboretum, Zone: Prairie/Savanna, subcategory: Dow Field

Property: Arboretum			
Zone: Main Valley			
Subcategory: Black Oak Kame			
Variable	Fixed Value	Site Value	Product
Conservation & Preservation	10	5	50
Education, Visitor Impact, & Neighbors	9	6	54
Feasability & Cost of Implementation	8	6	48
		Sum & Score	**152**

Table 5. Ranking of Property: Arboretum, Zone: Main Valley, subcategory: Black Oak Kame

Priority 1

Zone: Prairie/Savanna

Subcategory: Dow Field, approximately 40 acres.

Target & Goals: Prairie community: to conserve this rare and unique community type, to increase biological diversity of species common to this natural community.

Threats & Stresses:

1. Over-dominance of big bluestem (*Andropogon gerardii*) suppressing other native plant species, lack of species diversity.
2. Low abundance of conservative native plant species in close enough proximity to supply seed and add diversity without intervention.
3. Invasive species including spotted knapweed, white sweet clover, Canada goldenrod, burdock, and oriental bittersweet displacing native plants.
4. High level of visitor use and high numbers of dogs on and off leash disrupting wildlife and decreasing site biodiversity

Strategies:

1. Use techniques to suppress big bluestem and encourage other species including varied seasonality and frequency of burns, annual mowing, or other techniques. Involve University faculty and students to aid in research and monitoring the application of new methods.
2. Spread seed and possibly plant plugs of desirable native plant species of local genotype into summer burned or mowed areas. Collaborate with NAP and other local land owners to obtain seed from needed species.
3. Remove invasive species using appropriate techniques and methods. Utilize labor resources of staff and volunteers when applicable.
4. Inform and educate visitors on the impacts of dogs on wildlife through interpretive materials and direct contact. Enforce leash laws with assistance from the University Of Michigan Department Of Public Safety.

Priority 2

Zone: Main Valley

Subcategory: Black Oak Kame, approximately 5 acres

Target & Goals: Oak barrens community: to restore and preserve this rare and unique community. To highlight large, open grown oaks on the kame. To improve the health and aesthetic quality of the collections and specimens that exist in this zone during restoration.

Stresses and Threats:

1. Tree, shrub, vine and herb encroachment and invasion: Invasive exotics include; Norway maple (*Acer platanoides*), tree of heaven (*Ailanthus altissima*), common buckthorn (*Rhamnus cathartica*), honeysuckle species (*Lonicera spp.*), white mulberry (*Morus alba*), oriental bittersweet (*Celastrus orbiculatus*), pachysandra (*Pachysandra terminalis)* and curly doc (*Rumex crispis*). Native invaders include Black Cherry (*Prunus serotina*).
2. Massive accumulation of dead and downed pine logs from pine plantation die-off and senescence of specimen plantings.
3. Lack of native plant species diversity.
4. Lack of fire.
5. Steep path experiencing erosion

Strategies:

1. Remove encroaching trees and shrubs using appropriate methods including cutting, cutting and treating stumps with herbicide, or basal herbicide treatments before cutting tree of heaven and foliar herbicide treatments during the dormant

season for pachysandra. Will require extensive use of wood chipper and chainsaws and the use of herbicides. Utilize County Sheriff's work crew and staff workdays for labor moving brush and logs.

2. Cut and remove dead pine logs and senescing specimen plants in collections around the kame borders. Use tree clearing equipment. Coordinate with U of M Grounds to allow wood material to be brought to North Campus facility.
3. Introduce appropriate species of native plants through seeding and planting plugs. Collect see from elsewhere on property. Coordinate with local agencies and landowners to acquire seed if necessary.
4. Begin prescribed burning once excess dead woody material has been removed and collections can be protected.
5. Install water bars on path to divert storm water and mitigate erosion. Make job a caretaker project to cut limbs for use and install. Caretakers can then monitor the water bars afterward to assess and make adjustments if necessary.

Planning and Implementation of Stewardship on the other Properties of MBGNA

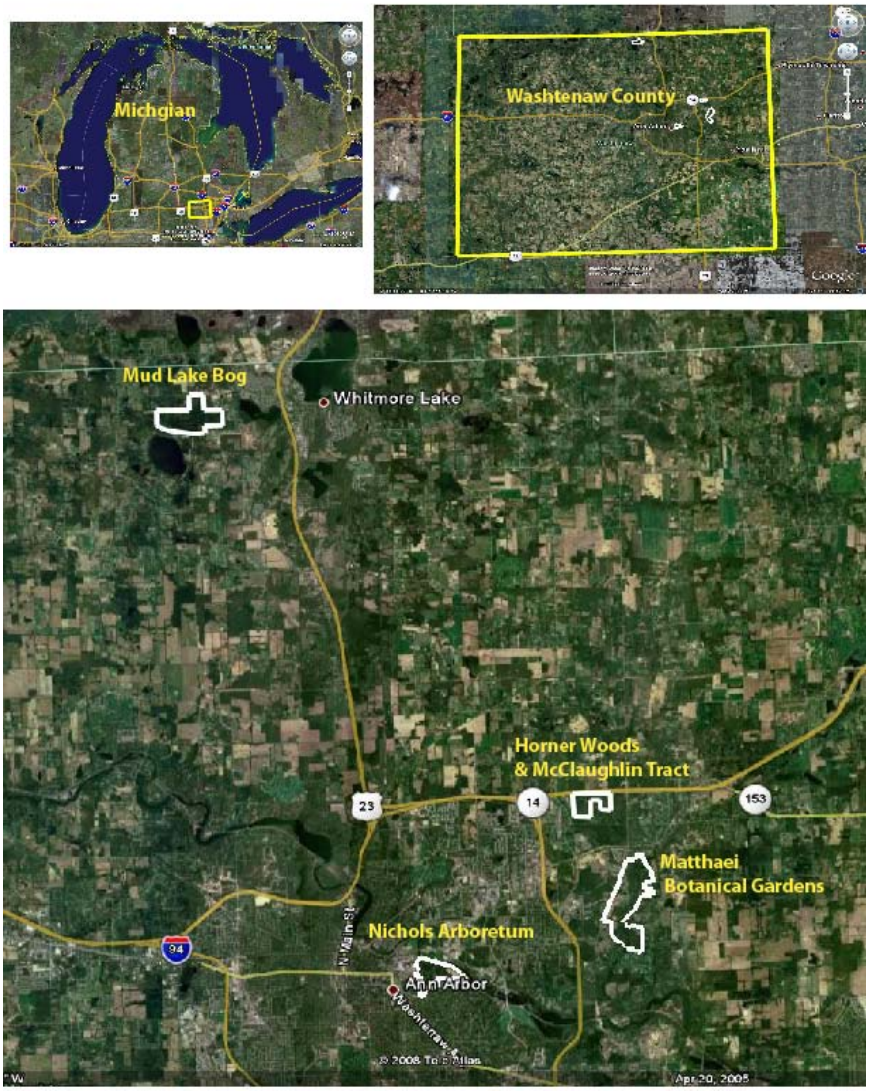

Figure 1. State, County and area map of MBGNA properties: Mud Lake Bog, Nichols Arboretum, Horner Woods/McLaughlin Tract and the Matthaei Botanical Gardens.

MBGNA has four properties all located in Washtenaw County. Nichols Arboretum has been discussed at length and an example plan was created to show some of the unique opportunities and challenges associated with this property. The other properties also have their own story and will require a unique approach to management,

however ultimately the same general framework for decision making can be applied to each property and zone regardless off scale. The following section highlights some of the unique features, opportunities and challenges along with some background on these properties.

Matthaei Botanical Gardens and Radrick Natural Area

Figure 43. Matthaei Botanical Gardens Visitor Entrance and Conservatory. Photo by Jeff Plakke

General Description

Matthaei Botanical Gardens lies on the border between Ann Arbor Township and Superior Township in Washtenaw County. The property spans the eastern portions of sections 13 and 24 in Ann Arbor Twp, as well as the west edge of section 18 and 19 in Superior Twp. It is nearly 350 acres in size and shares boundaries and management agreements with Radrick Farms Golf Club and the U of M Recreation Department.

This property contains the Conservatory as well as several greenhouses used for research and propagation. It is also the primary building space used by the organization

for administrative and educational purposes. In contrast to the Arboretum the Botanical Gardens property lies outside of the city limits, it enjoys ample parking, necessary facilities and space for large events. Several acres of land around the building are devoted to a number of stunning display gardens.

The surrounding natural area is no less valuable and impressive. The Matthaei Botanical Gardens property protects a long winding section of Fleming Creek and its floodplain. This is one of the cleanest and most biologically healthy tributaries of the Huron River downriver of Ann Arbor and the floodplain forest is richly diverse. It contains areas of sedge dominated wetlands, flat sandy areas with high water tables and huge spreading bur oaks, and a variety of other interesting features. This area with trails running along the creek on both sides and several service drives surrounding it may be a prime area for research, restoration, and protection. A study was done mapping the ecosystems of the floodplain by Allan Tepley in 2001. This could be used to help make decisions about management and research as more active stewardship of this area is initiated.

Soils

Soils of the Matthaei Botanical Gardens are much different from those of the Nichols Arboretum. The sandy loam and loamy sand soils of Boyer and Fox series characterize much of the property along with the Sloan series of wet silt loam along the river floodplain. See Appendix D for soil survey map of the Matthaei Botanical Gardens.

Natural Systems

The Matthaei Botanical Gardens property also contains at least two occurrences of very unique ecosystems which are found only in the glaciated Midwest called fens. Radrick and Kirk's Fens are wetlands characterized by the formation of sphagnum peat on top of groundwater saturated soils. The groundwater that flows through these systems is very rich in calcium and therefore, very alkaline, or high in pH. This extreme chemistry severely restricts nutrient uptake by many plants and therefore results in unique plant community of calciphiles as well as some acidophiles. These interesting and unique ecosystems are highly vulnerable to being invaded by glossy buckthorn *(Rhamnus frangula)* and they are currently experiencing an increasing threat from this species. A general management plan for the fens was written by Brad Rhufel in 2005 and contains specific information about their qualities and management considerations. Connie Crancer continues research presently on Kirk's Fen and is planning to look at the effects of reintroducing fire into this natural community. These important and rare natural communities offer significant opportunities and challenges managing the Matthaei Botanical Gardens Property.

Figure 44. Radrick Forest, fall 2007.
Photo by Jeff Plakke

At the south end of the property is the oak hickory woodland known as Radrick Forest. It is considered an important research area

for ongoing vegetation sampling plots continuously sampled by Barnes and Hammitt since the since the 1960's. This very old forest has many large oaks and hickories at its core, but it is slowing giving way to the more shade tolerant black maple (*Acer nigra*). This forest is also, however, being invaded by exotic shrubs and garlic mustard (*Alliaria petiolata*) which threaten the understory community.

Kirk's Woods is found near the northern end of the property and near Kirk's Fen. This woodland is a fine example of an old oak savanna. There are several large oaks there that appear to be of pre-settlement age, judging from from ring counts on a large limb that has fallen recently. This woodland is also currently under restoration through the removal of invasive exotic species, mesophitic native species and the reintroduction of periodic surface fires.

The Botanical Gardens Property is also home to at least two species of note; the eastern massasauga rattlesnake (*Sistrurus catenatus catenatus*) and the duke's skipper butterfly (*Euphyes dukesi*). Both of these species depend on natural communities that require periodic fires, although the individuals themselves may be very sensitive to a burn event. Therefore, managing for these species must be done with extreme caution but with the realization that they depend on natural communities that must be preserved through the historically important natural processes.

Botanical Gardens Management Zones

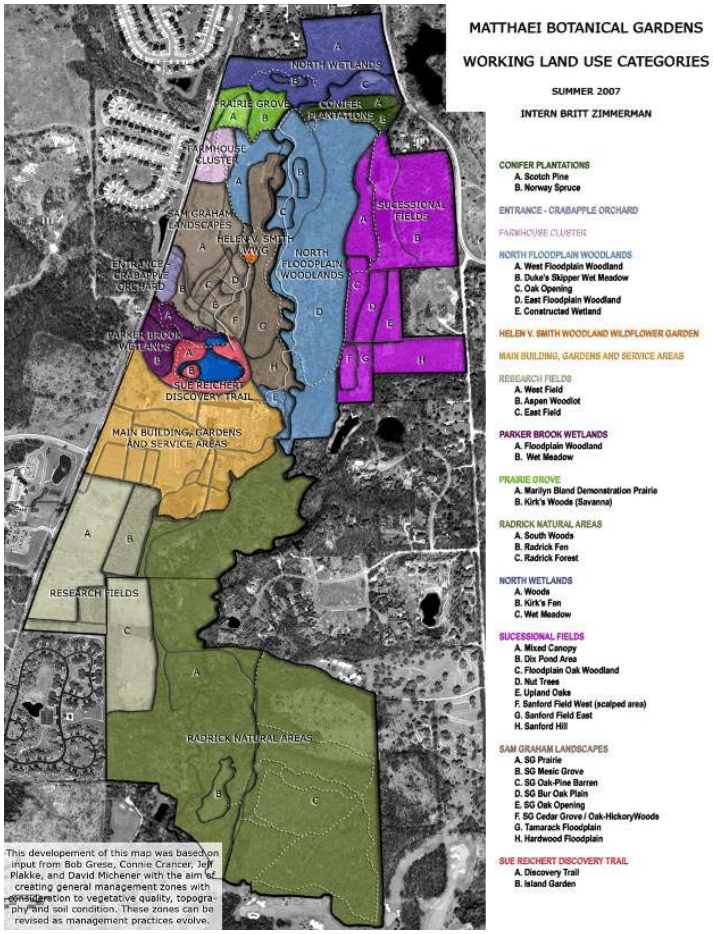

Figure 45. Matthaei Botanical Gardens Zone Map (See Appendix H)

As with the Nichols Arboretum, management zones were established for the Matthaei Botanical Gardens that highlight specific areas of the property. These were established by staff discussion and analysis in conjunction with using Alan Tepley's thesis *"Landscape Ecosystems of the Nichols Arboretum, Univeristy of Michigan"*, and thinking about goals for collections and use areas at the Arboretum. This zone map can be used for prioritizing and planning natural areas stewardship at the botanical gardens property. See Appendix H for larger version.

Research

The Botanical Gardens property has long been a site for research of many kinds including environmental research and monitoring. A long list of studies, surveys and

research projects on the property spans back several decades and would be should be included in a detailed account of the property. The property continues to provide MBGNA with a highly diverse and interesting natural laboratory. With indoor classrooms and labs to compliment the lands, this facility is perhaps the most useable for research purposes. It contains several unique natural features, rare species and may have specific areas where manipulative research would be possible where as the other properties are not likely to accommodate such activities.

Research Questions

Wildlife Populations

The Matthaei Botanical Gardens has a large deer population evident from numerous paths, browsing damage on many plants, and the need to build a large deer exclosure around the formal gardens outside the conservatory. White-tailed deer populations are problematic over much of eastern North America and many land management agencies are being forced to take measures to reduce deer herd sizes in the interest of conservation of certain plant species. Currently, a more precise count of the deer population is lacking at the botanical gardens and a detailed study and comparison of deer browsing habits could lead to interesting results. Also looking at methods for controlling the deer herd could prove useful in the near future if MBGNA must take action to reduce the deer heard on its properties. There are currently several small deer exclosures which could be replicated in other habitats and more carefully measured and monitored over time to assess the impact deer are having on the natural areas.

Rare species

The Botanical Gardens property could serve as an excellent laboratory for surveying and studying several species of note. The eastern massasauga is threatened by habitat destruction and may benefit from prescribed fires at the Botanical Gardens, however fire may also pose a serious threat to individuals if timing of the burn is inappropriate. Quantifying the effects of well timed burns on the population of massasauga and the dukes skipper could provide reassurance that reintroduction of fire into these habitats is appropriate for their conservation.

The Horner Woods/McLaughlin Tract

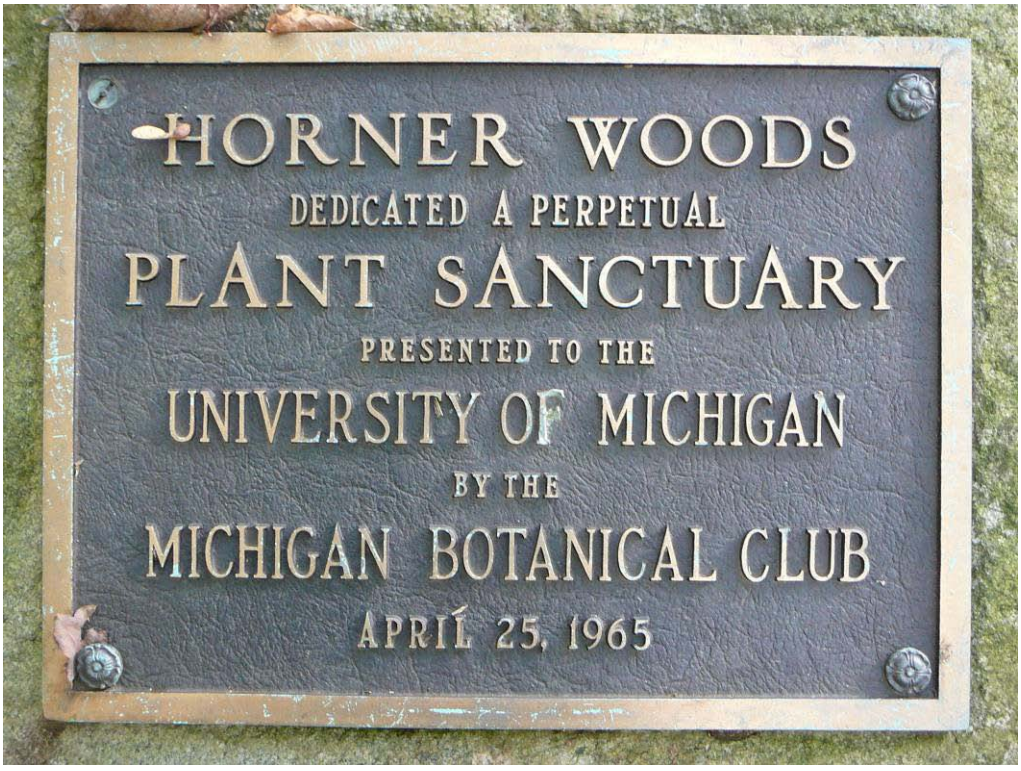

Figure 46. Horner Woods Plaque at the Property, fall 2006. Photo by Jeff Plakke

General Description

About six miles east of Ann Arbor and just a few miles north of the Matthaei Botanical Gardens, near the small village of Dixboro, lays the Horner/McLaughlin tract of MBGNA. Located in Ann Arbor Township, in the southern half of Section 12 this wildflower sanctuary is around 90 acres. The property was donated to the University of Michigan by the Michigan Botanical Club in 1964 as a plant sanctuary for scientific, educational and aesthetic purposes. It contains oak-hickory woodlands, old field and rolling terrain, several small woodland ponds and streams, and a sizeable buttonbush swamp. This protected tract of land boarders the Domino Farms property to the west, the M-14 highway to the north and several private lands to the south.

Washtenaw County Parks Department has recently obtained a 10 acre parcel to bordering the Horner/McLaughlin property on the east called the Goodrich Preserve. This property now links the Horner/McLaughlin tract to Dixboro road. The county has installed a small parking area as well as a small kiosk for signage. Their first trail loop on the Goodrich preserve is currently being marked and plans are underway to link this trail to a much larger loop through the Horner Woods and McLaughlin tract. This will add great value to the community and the property by increasing its accessibility to the public, however there are many factors that should be considered to help protect the property and its ecosystems from unintended damage by additional visitors.

The heart of the property is the original land donation by the Michigan Botanical Club: a very old oak hickory woodland with a number of very large old trees

in the canopy. There is also a sizeable old-field area which has mowed paths maintained by one of the neighbors.

Soils

Figure 47. Horner Woods Soil Survey Map (See Appendix E)

The soils of this property are primarily Miami loam and Conover loam. See Appendix E. for larger soil map. These soils may have supported a more mesic forest community in some areas on the property in the past. However, the presence of many very large bur oaks (*Quercus macrocarpa*) and white oaks (*Quercus alba*) as well as species such a Pennsylvania sedge (*Carex pennsylvanica*) in the understory in some

areas indicates that fire was also likely an important natural process affecting the natural communities of this area.

Current Ecological Condition

Much of the Horner Woods McLaughlin Tract is composed of an old oak-hickory forest that, in the absence of periodic fire, is gradually giving way to sugar maple. There are several ancient sugar maple trees present which are the source for the now thousands of young maples coming along in the understory. Without fire and given enough time, this oak-hickory forest will succeed into a degraded oak woods becoming dominated by sugar maple. The slow decomposition of the oak leaves and the slow nutrient cycling has already begun to change in some areas. The addition of maple leaves to the forest litter and top soil with their high nitrogen and low carbon content compared with oak leaves, will feed the microbes in the soil and speed up the turnover of nitrogen. This, in turn, will further give the advantage to the maples species that can more readily utilize the addition of nutrients. As the maples succeed, so will the shade in the forest become denser. With the darkening shade and the accumulation of organic matter in the soil in the absence of

Figure 48. Large bur oaks with encroaching sugar maple, Horner Woods, fall 2007.
Photo by Jeff Plakke

fire, the moisture holding capacity of the soil is also increasing. This, another critical element influencing the survival of different plant species, will again favor the survival and growth of maples and other mesic species until their dense shade and the lack of fire will suppress and eventually eliminate most oak and hickory regeneration. Stewardship of these lands could consider allowing the succession to continue in some areas and to use fire in other to create more diversity of natural communities which may support great plant diversity as well.

This property also has several very special wetland habitats. The tall canopy of the oaks and hickories nicely shades a kettle hole of nearly 50 meters across. Buttonbush (*Cephalanthus occidentalis*) crowds the interior of this wetland, but there is ample open water around the exterior for salamander breeding. With the abundance of coarse woody debris from dying oak and hickory trees, it is likely that several species of salamander may be present in this water body. Because it does not contain fish, the salamanders can safely breed in this woodland pond surrounded by their preferred habitat.

The McLaughlin tract is a large old field area that is relatively open, with an abundance of European grasses, spotted knapweed and many very large and robust exotic invasive autumn olive shrubs (*Eleagnus umbellata*). There are also several wildflowers of note around the periphery of this section of the property including old field thistle (*Cirsium discolor*).

University Use: Education and Research

Currently there is no research being conducted on the property. The Forest Ecology course, once taught by Dr. Burton Barnes, would often use the site to examine the interesting glacial landforms, dig into the soil and outline the soil profile, and discuss the succession of the oaks and maples. It has also been used extensively by various courses teaching spring flora. There is a plant list for Horner Woods compiled by Bev Walters in 2003 (Appendix I.)

Research Questions

Vernal ponds, forest streams and forest wetlands

This property contains a number of what appear to be high quality forest wetland communities. A survey of the aquatic life and amphibians breeding in these ponds would be interesting and useful information to gather. Having a baseline study inventory of these areas would allow future research in these areas to build on this foundation.

Forest Succession

The encroachment of the sugar maples in the understory of the large oaks of the forest is the classic picture of succession. In the absence of fire, the mesic species are advancing and may slowly assume dominance in the forest. It could be interesting to study how this change is taking place across the landscape there and see if there are any significant differences in the success of the sugar maple in landscape and if this appears to correlate to any characteristics of the soils, moisture or other variables.

Impacts of white-tailed deer

In a conversation with Bob Grese, Director of the Matthaei Botanical Gardens and Nichols Arboretum, he mentioned the steady decline of the large flowered trillium in the woodlands over more than a decade due to over-browsing by a high white-tailed deer population. Efforts could be made to determine the size of the deer population as well as the specific effects their browsing is having on this wildflower sanctuary. The use of deer exclosures could be helpful and very educational for visitors. They could be placed in several natural communities to see if the deer are having a more pronounced effect on certain wildflower species or whole ecosystems. This may provide valuable information to determine if controlled hunting might be a reasonable method of controlling the deer population, thereby preserving the diversity and abundance of woodland wildflowers.

Mud Lake Bog

Figure 49. Mud Lake Bog. Photo by Jeff Plakke

General Description

The Mud Lake Bog property is nearly 260 acres and certainly the most remote and rugged of MBGNA properties. It is located in the southern half of section 1 and the northern portion of section 12 of Webster Township in northern Washtenaw County. This property is primarily a very large wetland area with some swamp hardwood forest, open marshes and a bog at its center. It rests on an underlying landscape that gently undulates with shallow kettles and small kames.

This property directly adjoins Independence Lake County Park to the south, a Washtenaw County Park. It is also surrounded by several land owners with relatively large holdings of 10 to 40 acres. The highlight of this property is as the name suggests; a black spruce and tamarack bog. Venturing deep into the property from the north, it can be found with its classic bog mat of sphagnum and with many interesting and unique plants growing around the open water of the small lake.

Surrounding the bog is a large wetland area composed primarily of cattails (*Typha* spp.), sedges (*Carex* spp.), and numerous wetland shrubs including abundant poison sumac (*Toxicodendron vernix*). There are also areas of swamp hardwoods with the remnants of numerous Ash trees which have now gone the way of the many American Elms that once populated much of this property. In several areas there are also small 'islands' of oak hickory forests with a healthy herb layer of Pennsylvania sedge (*Carex pensylvanica*). These small patches seem to indicate the presence of fire as a historically important process maintaining these communities.

Ecology and History

The property once held an impressive swamp hardwood forest with American elms (*Ulmus americana*) dominating the canopy (Dr. Burton Barns personal communication 2008). When the Dutch elm disease struck and the elms died off, the pumping action through transpiration of these many large trees stopped and the water table began to rise. As the water raised many of the other associated tree species began to die off as well, allowing the water table to rise further until much of the area became inundated year round in shallow surface water. The results were the loss of much of the surrounding swamp forest and the development of a large, mostly open marsh filled primarily with narrow leaved cattail (*Typha angustifolia*), an exotic species.

The bog itself and its associated vegetation remained, although the larger individual trees of tamarack (*Larix laricina*) and black spruce (*Picea mariana*) have died off as well. With the recent outbreak of the emerald ash borer, the remaining white and black ash trees which survived the rising water table are now also dead or dying.

Soils

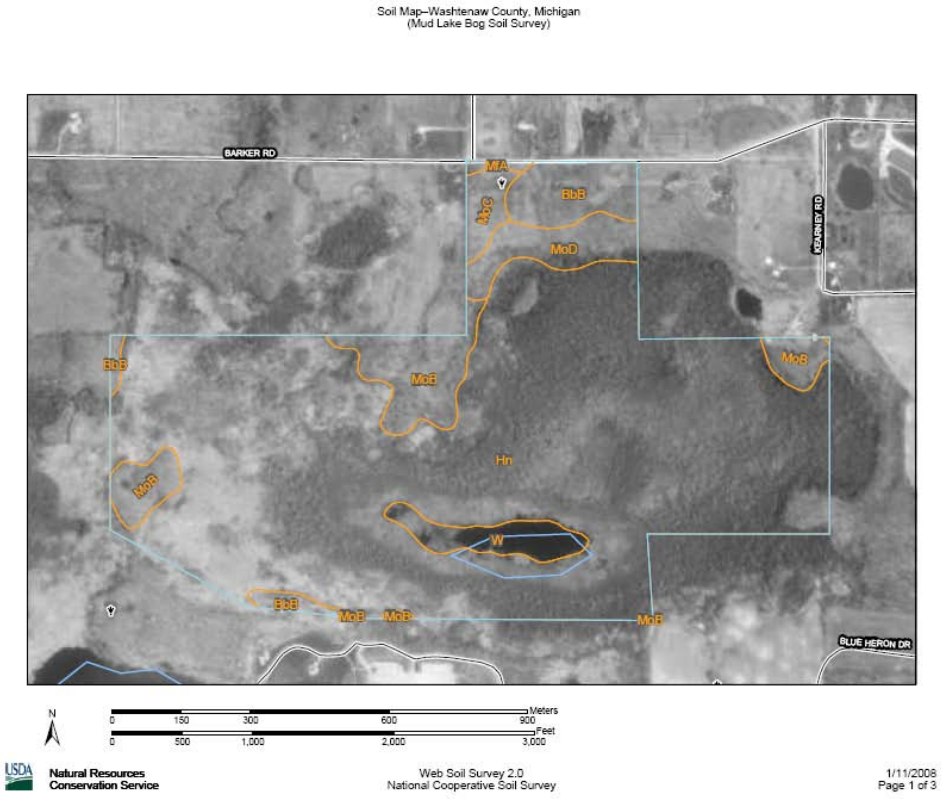

Figure 50. Soil Survey Map for Mud Lake Bog (USDA Natural Resources and Conservation Service)

Most of the property is covered in saturated Houghton muck soils. There are also small areas of Boyer and Miami loam and sandy loam that support the pockets for oak and hickory forests and old field area near the Northern border of the property. See Appendix F. for a soil survey map of Mud Lake Bog (USDA Natural Resource Conservation Service).

Property Use

The bog itself is used by the woody plants class for one of their many outdoor labs identifying trees, shrubs and vines. Each section ventures through the swampy forest for nearly half a mile before walking across the bog mat to inspect the unique plants found there. Students often fall through and damage sections of the mat and damage sections along the trail as well. Seldom do others from the University of Michigan use the site for any purposes.

Figure 51. Path through wetland area leading to bog mat, Mud Lake Bog, fall 2007. Photo by Jeff Plakke

The surrounding wetlands and woodlands have evidence of neighbors hunting in several locations. Creating a relationship with neighbors who already use this property may be a productive way to help protect it. Allowing several neighbors to bow hunt white tailed deer on the property would help to establish contact and get feedback from the few regular users of this remote and rugged property. Their impact on the deer herd would likely be minimal, yet a connection to these neighbors could lead to valuable information if not only an elevated level of awareness of this property.

The property shares a long border with Independence Lake County Park and provides an excellent opportunity for a partnership. With this being the most remote of the MBGNA's properties, establishing a relationship with another land agency on its boarder that has similar aspects to its mission to protect natural areas and has facilities and staff nearby may help provide some level of protection and surveillance for

property. The MBGNA Mud Lake Bog property provides a large wetland and natural area buffer to the North of the count park and may also offer exceptional views and abundant habitat for a diversity of wildlife viewing opportunities.

Potential Research Questions

Aquatic ecology of the bog

A study of the aquatic ecology of the bog seems a logical first step to gathering important data about this system. Faculty and students of the university in the field of aquatic ecology may find the bog an interesting and challenging environment to study that is less typical of wetland habitats found in the area. Surveys of the aquatic communities could also provide valuable data for MBGNA and for future research at Mud Lake Bog.

Global Climate change

Bogs are often studied as indicators of climate change using fluctuations of carbon, changing water levels and plants sensitive to these subtle changes as indicators. Monitoring of these measures at Mud Lake Bog could produce interesting results in a time of increasing and accelerating climate change. A study by Pennington in 1906 was done describing the landscape, history and plant community of the Mud Lake (Pennington 1906). This could provide interesting comparative data if methods were repeated.

Ecological History

Bogs also offer an excellent repository for historical information. Acidic, stagnant water with low levels of oxygen reduce the rates of decomposition considerably. Taking cores from the sediments in the bog to study pollen records, deposition of ash from fires, etc. and other artifacts is possible because these are preserved for centuries in the sediments of bogs.

VI. Conclusions and Recommendations

Figure 52. *Trillium Grandiflorum*, Nichols Arboretum, spring 2008. Photo by Jeff Plakke

The University of Michigan MBGNA natural areas have a deep and complex history of evolving natural communities and natural processes supporting a great diversity of species, closely linked with human activities, such as Native American burning, for thousands of years. While these natural areas still include many healthy natural communities and support a wide variety of species, many face significant threats. These threats include habitat destruction (particularly on surrounding lands), invasion of exotic species, degradation through lack of fire, nitrogen pollution, disturbance from humans and dogs-off-leash, storm water caused erosion and several others. Through thoughtful and engaged natural areas stewardship, these areas can be restored, protected and conserved.

The University of Michigan MBGNA has an extremely valuable resource in its natural areas. In addition to their conservation value, these areas serve as exceptional laboratories for University faculty and students to conduct research and to study the environment. A point made in a Master Plan for the Matthaei Botanical Gardens in 1999 by JJR Inc. was that the focus of most botanical gardens at that time had turned toward an ecological emphasis. They mentioned that the Matthaei Botanical Gardens wanted, "to become a leader in nature preservation and provide examples of ecological preservation." A strong step forward to expand on this goal is adopting a planning process and decision making model. A holistic stewardship program can also provide the framework of information needed to facilitate research and teaching in these areas.

Figure 53. Hawthorn Valley, Nichols Arboretum, winter 2008. Photo by Jeff Plakke

The MBGNA natural areas also provide space for recreation, inspiration and restorative time spent in nature. People can enjoy the natural beauty of these areas and reconnect to nature through these lands. MBGNA can encourage appropriate public use, protecting the natural areas from visitor impacts, while teaching the public about nature through passive education and direct experience. And they can steward its natural areas and engage and teach together through ecological restoration workdays with citizen and student volunteers.

In this thesis various conservation and educational organizations were examined and discussed with similar missions to the MBGNA. A historical context was provided to help understand the current landscape that supports the various natural communities and species of these natural areas. An inclusive decision making model was then developed to help provide the framework for creating comprehensive, objective stewardship plans that recognize the various complexities of the University of Michigan MBGNA properties goals, mission and vision and stakeholder values. Within this model was designed a ranking instrument specifically to address the multiple and complex issues surrounding the MBGNA natural areas and to help prioritized the different properties and many different management zones within them. Also as a critical part of decision making, the formation of one or more natural areas advisory groups is suggested to bring together University faculty and land managers, local conservation experts, neighbors and other stakeholders to help provide feedback and advice at key points during the process.

This framework was then applied as an example, without the benefit of the advisory groups at this time, to the Nichols Arboretum property to help further develop and refine this methodology. Matthaei Botanical Gardens, Horner Woods/McLaughlin Tract and Mud Lake Bog properties of MBGNA were also described and discussed in the context of the planning process to highlight some of the similarities and differences, and opportunities and challenges that will be encountered when developing stewardship plans for these areas.

The MBGNA natural areas program should utilize this model for decision making and planning to create stewardship plans for each of the properties that can evolve and grow through time as information is gathered and stewardship activities are practiced. The process should remain inclusive, utilizing the natural areas advisory groups to help make decisions and make recommendations at key stages.

As this model is applied, evolves and becomes successful, it will lead to more effective long-term conservation of MBGNA natural areas, to more faculty and student research and teaching, and to increased public involvement and a better 'sense of place'. The model could then be applied to other important University of Michigan natural areas, leading to a more centralized, sophisticated and reliable approach to natural areas stewardship at the University of Michigan in collaboration with or perhaps even lead by the MBGNA.

Presently the University owns numerous properties in southeast Michigan containing many valuable natural areas adding up to thousands of acres. Currently these properties are managed by several different schools and departments within the University. Through this division of the properties to independent departments with limited resources, expertise and coordination, all of these properties are suffering from a lack of attention and care. With effective natural areas stewardship covering all of these areas through an inclusive process by an engaged group of experts, they could be more appropriately described and protected, utilized for research and teaching, or chosen for development with full awareness of the ecosystems being sacrificed. Ongoing monitoring of rare and endangered species, exotic invasive

species, the development of stewardship plans, and the clearinghouse for environmental information could be centralized with the MBGNA.

Figure 54. Nathan Haan, Student Caretaker, Nichols Arboretum Dow Field, prescribed fire, fall 2008. Photo by Jeff Plakke

It is strongly recommended that the University of Michigan evaluate their resources for land protection and management, follow this path and centralize natural areas stewardship for the University of Michigan within the MBGNA. Departments currently managing these properties should remain the primary stakeholders in their management and use. However decision-making about stewardship should become inclusive and resources pooled to effectively handle the large area and diversity of land holdings the University owns. This direction will help the University of Michigan to promote itself as a responsible steward of the environment, and to further establish itself as a leader in research and teaching.

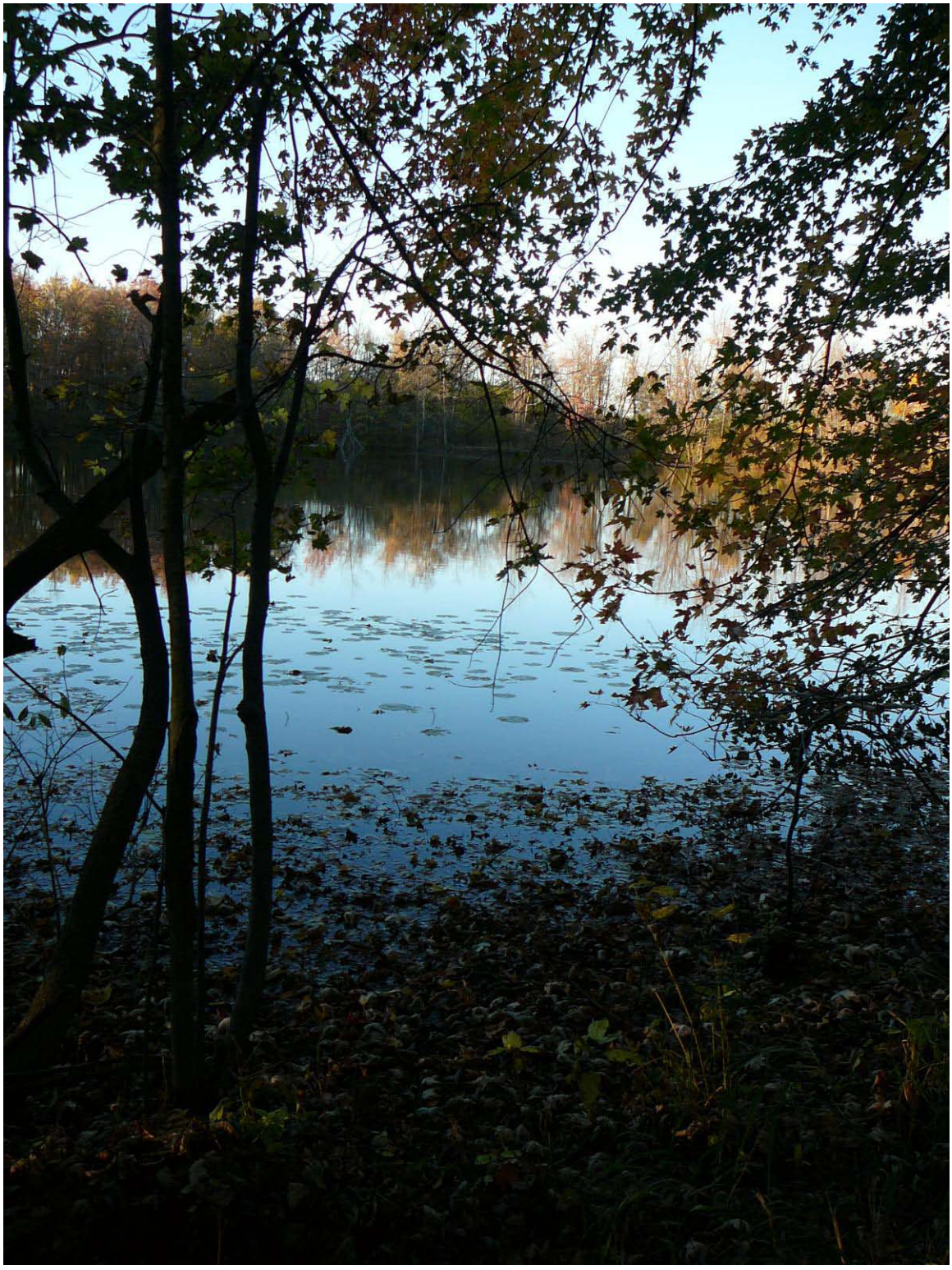

Figure 55. Pond at NewComb Tract, fall 2007. Photo by Jeff Plakke

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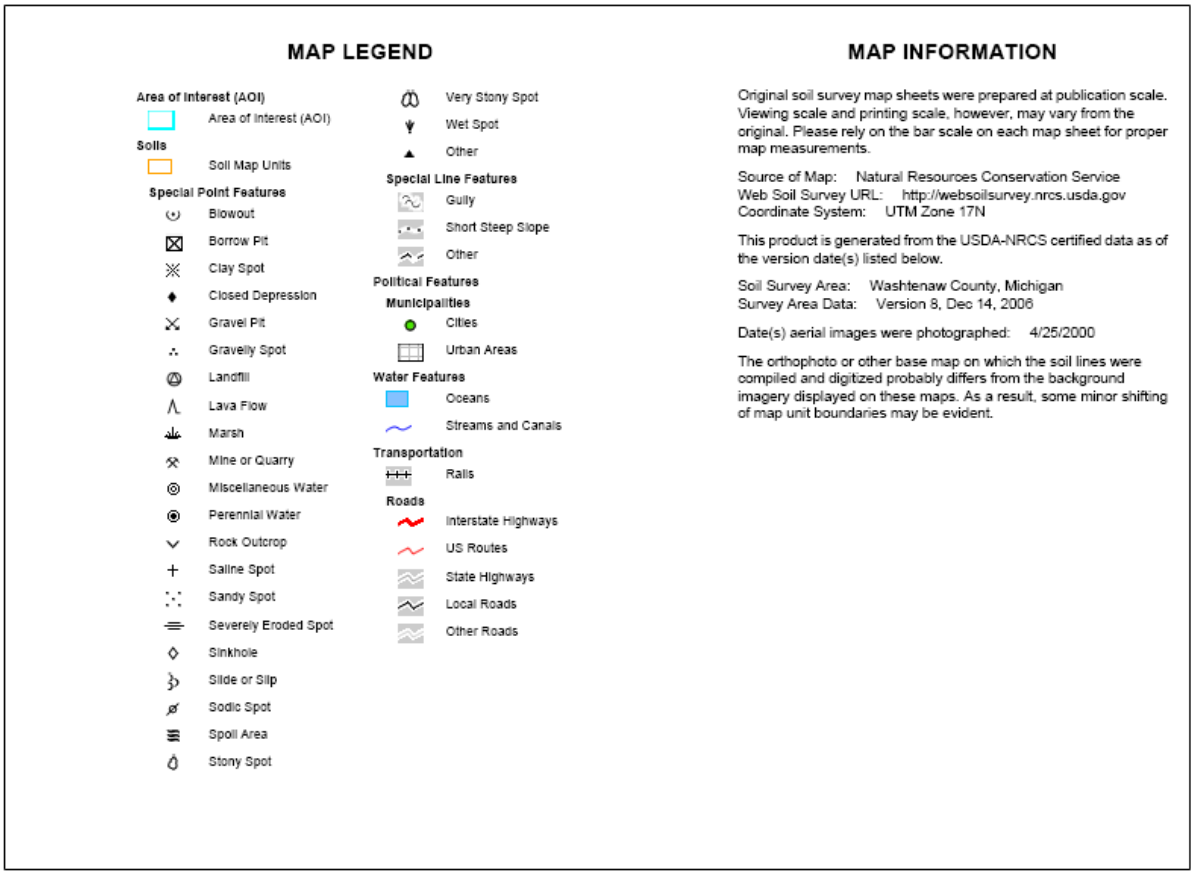
Appendix A. MNFI Natural Communities Global and State Rankings. Communities which may occur on MBGNA lands are highlighted.

Natural Community Global and State Ranks

Community Name	State Rank	Global Rank
Alvar	S1	G2?
Bog	S4	G3G5
Boreal Forest	S3	GU
Bur Oak Plains	SX	G1
Cave	S1	G4?
Coastal Fen	S2	G1G2
Coastal Plain Marsh	S2	G2
Dry Northern Forest	S3	G3?
Dry Sand Prairie	S2	G3
Dry Southern Forest	S3	G4
Dry-mesic Northern Forest	S3	G4
Dry-mesic Prairie	S1	G3
Dry-mesic Southern Forest	S3	G4
Emergent Marsh	S4	GU
Floodplain Forest	S3	G3?
Granite Bedrock Glade	S2	G3G5
Granite Bedrock Lakeshore	S2	G4G5
Granite Cliff	S2	G4G5
Granite Lakeshore Cliff	S1	GU
Great Lakes Barrens	S2	G3
Great Lakes Marsh	S3	G2
Hardwood-Conifer Swamp	S3	G4
Hillside Prairie	S1	G3
Inland Salt Marsh	S1	G1
Interdunal Wetland	S2	G2?
Intermittent Wetland	S3	G2
Inundated Shrub Swamp	S3	G4
Lakeplain Oak Openings	S1	G2?
Lakeplain Wet Prairie	S1	G2
Lakeplain Wet-mesic Prairie	S1	G1?
Limestone Bedrock Glade	S2	G2G4
Limestone Bedrock Lakeshore	S2	G3
Limestone Cliff	S2	G4G5
Limestone Cobble Shore	S3	G2G3
Limestone Lakeshore Cliff	S2	G4G5
Mesic Northern Forest	S3	G4
Mesic Prairie	S1	G2
Mesic Sand Prairie	S1	G2
Mesic Southern Forest	S3	G2G3
Muskeg	S3	G4G5
Northern Bald	S1	GU
Northern Fen	S3	G3
Northern Hardwood Swamp	S3?	G4
Northern Shrub Thicket	S5	G4
Northern Wet Meadow	S4	G4G5
Oak Barrens	S1	G2?
Oak Openings	S1	G1
Oak-Pine Barrens	S2	G3
Open Dunes	S3	G3
Patterned Fen	S2	GU
Pine Barrens	S2	G3
Poor Conifer Swamp	S4	G4
Poor Fen	S3	G3
Prairie Fen	S3	G3
Rich Conifer Swamp	S3	G4
Rich Tamarack Swamp	S3	G4
Sand and Gravel Beach	S3	G3?
Sandstone Bedrock Lakeshore	S2	G4G5
Sandstone Cliff	S2	G4G5
Sandstone Cobble Shore	S2	G2G3
Sandstone Lakeshore Cliff	S2	G3
Sinkhole	S2	G3G5
Southern Hardwood Swamp	S3	G3
Southern Shrub-Carr	S5	GU
Southern Wet Meadow	S3	G4?
Submergent Marsh	S4	GU
Volcanic Bedrock Glade	S2	GU
Volcanic Bedrock Lakeshore	S3	G4G5
Volcanic Cliff	S2	G4G5
Volcanic Cobble Shore	S3	G4G5
Volcanic Lakeshore Cliff	S1	GU
Wet Prairie	S2	G3
Wet-mesic Flatwoods	S2	G2G3
Wet-mesic Prairie	S2	G2
Wet-mesic Sand Prairie	S2	G2G3
Wooded Dune and Swale Complex	S3	G3

Appendix B. Soil Survey Map Legend



MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Units

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other

Special Line Features
- Gully
- Short Steep Slope
- Other

Political Features

Municipalities
- Cities
- Urban Areas

Water Features
- Oceans
- Streams and Canals

Transportation
- Rails

Roads
- Interstate Highways
- US Routes
- State Highways
- Local Roads
- Other Roads

MAP INFORMATION

Original soil survey map sheets were prepared at publication scale. Viewing scale and printing scale, however, may vary from the original. Please rely on the bar scale on each map sheet for proper map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: UTM Zone 17N

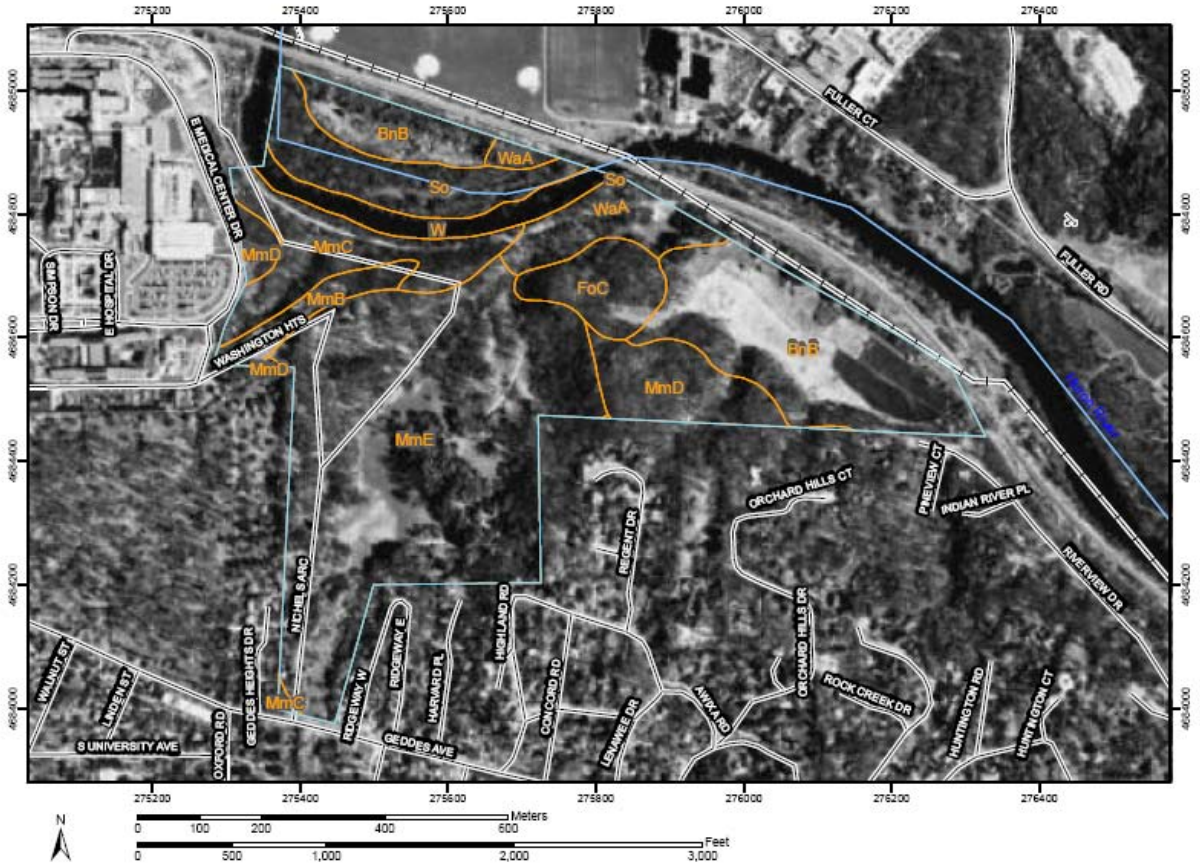
This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Washtenaw County, Michigan
Survey Area Data: Version 8, Dec 14, 2006

Date(s) aerial images were photographed: 4/25/2000

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

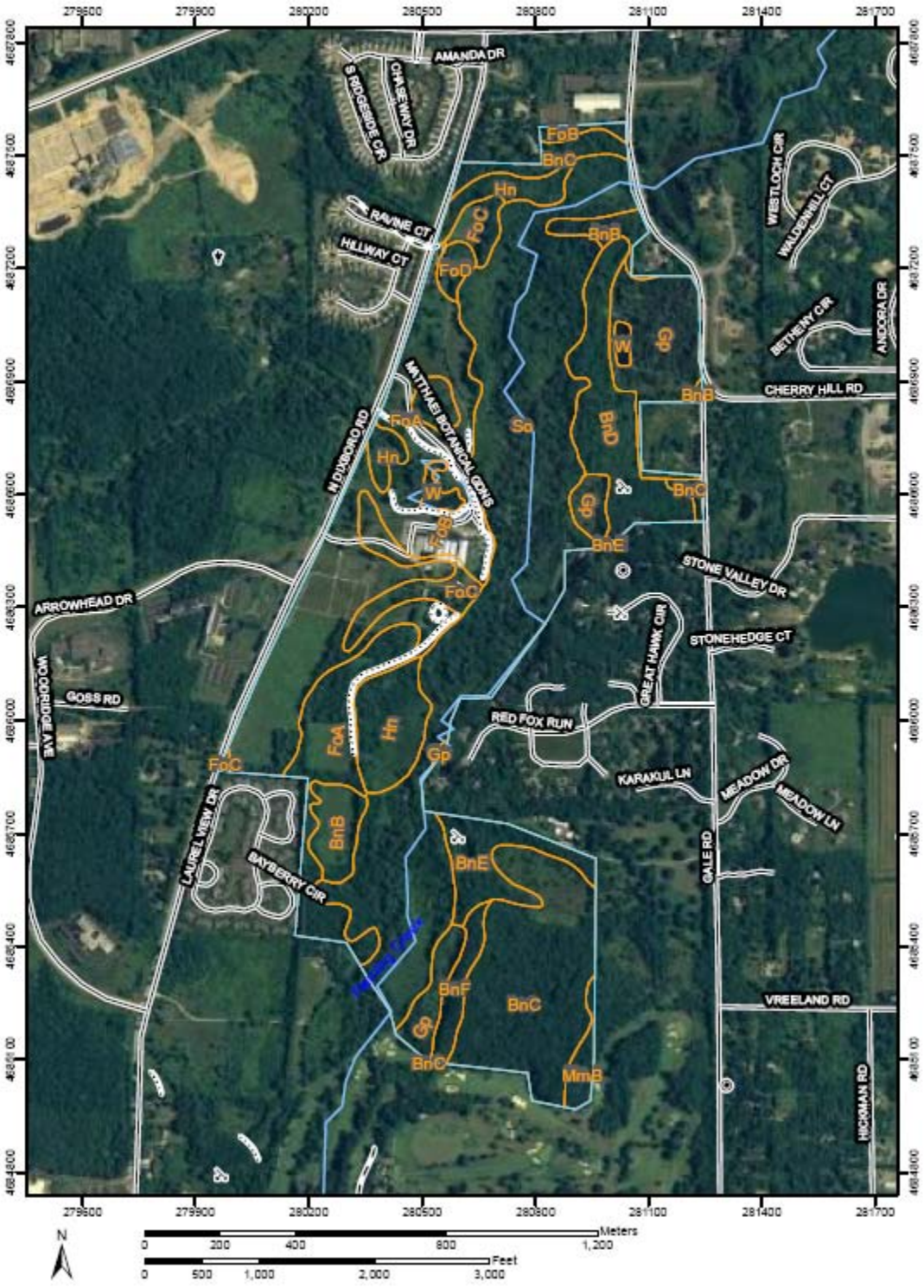
Appendix C. Arboretum Soil Survey



Map Unit Legend

Washtenaw County, Michigan (MI161)			
Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
BnB	Boyer loamy sand, 0 to 6 percent slopes	28.7	20.7%
FoC	Fox sandy loam, 6 to 12 percent slopes	6.1	4.4%
MmB	Miami loam, 2 to 6 percent slopes	3.4	2.5%
MmC	Miami loam, 6 to 12 percent slopes	11.1	8.0%
MmD	Miami loam, 12 to 18 percent slopes	9.3	6.7%
MmE	Miami loam, 18 to 25 percent slopes	57.6	41.5%
So	Sloan silt loam, wet	10.0	7.2%
W	Water	5.2	3.7%
WaA	Wasepi sandy loam, 0 to 4 percent slopes	7.4	5.3%
Totals for Area of Interest (AOI)		138.7	100.0%

Appendix D. Matthaei Botanical Gardens Soil Survey

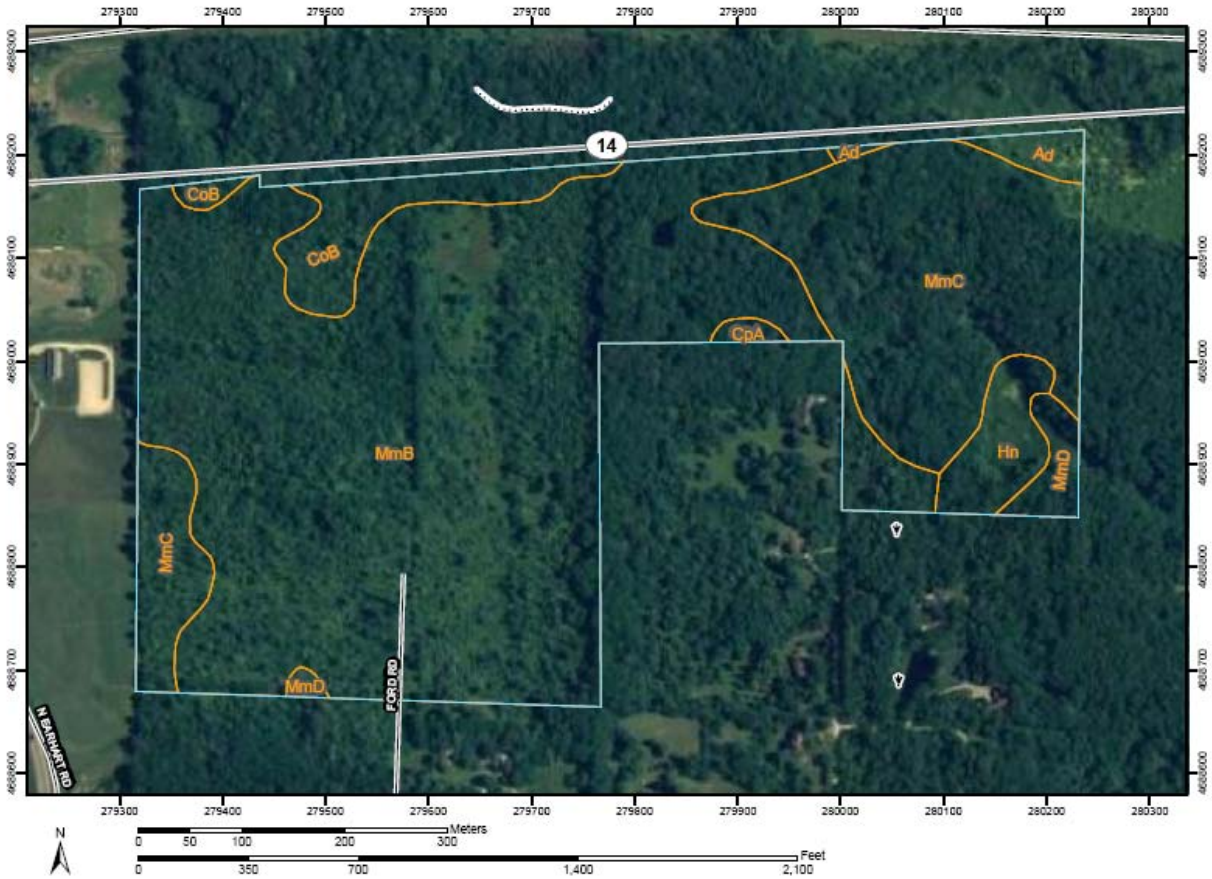


Appendix D. Continued

Map Unit Legend

Washtenaw County, Michigan (MI161)			
Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
BnB	Boyer loamy sand, 0 to 6 percent slopes	11.6	2.9%
BnC	Boyer loamy sand, 6 to 12 percent slopes	50.6	12.7%
BnD	Boyer loamy sand, 12 to 18 percent slopes	23.4	5.9%
BnE	Boyer loamy sand, 18 to 25 percent slopes	12.2	3.0%
BnF	Boyer loamy sand, 25 to 40 percent slopes	5.4	1.4%
FoA	Fox sandy loam, 0 to 2 percent slopes	25.6	6.4%
FoB	Fox sandy loam, 2 to 6 percent slopes	72.9	18.2%
FoC	Fox sandy loam, 6 to 12 percent slopes	13.8	3.4%
FoD	Fox sandy loam, 12 to 18 percent slopes	2.6	0.6%
Gp	Gravel pit	28.4	7.1%
Hn	Houghton muck	21.7	5.4%
MmB	Miami loam, 2 to 6 percent slopes	3.4	0.9%
So	Sloan silt loam, wet	125.0	31.3%
W	Water	3.1	0.8%
Totals for Area of Interest (AOI)		399.5	100.0%

Appendix E. Horner Woods/McLaughlin Tract Soil Survey

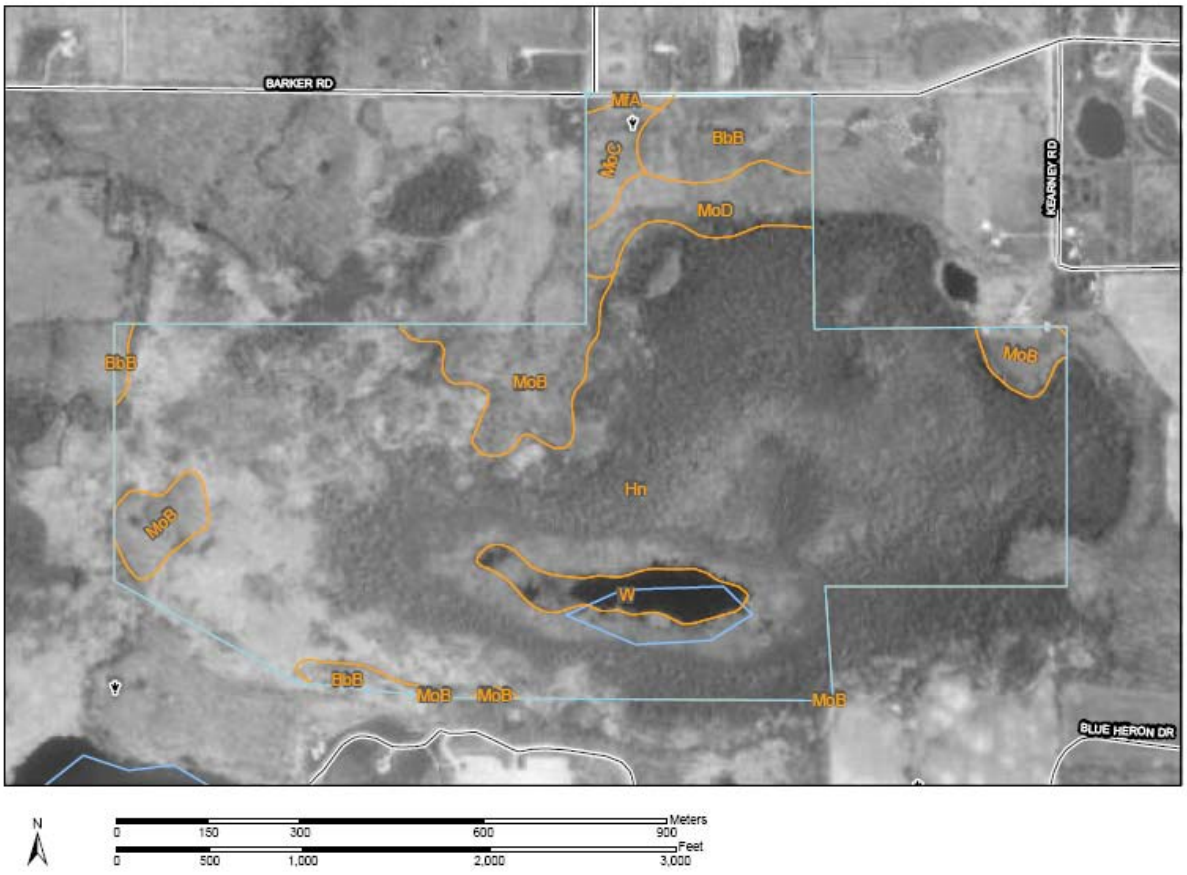


Soil Map–Washtenaw County, Michigan — Horner McLaughlin Tract

Map Unit Legend

Washtenaw County, Michigan (MI161)			
Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
Ad	Adrian muck	1.0	1.2%
CoB	Conover loam, 0 to 4 percent slopes	4.0	4.6%
CpA	Conover-Brookston loams, 0 to 2 percent slopes	0.3	0.4%
Hn	Houghton muck	2.6	2.9%
MmB	Miami loam, 2 to 6 percent slopes	57.9	66.1%
MmC	Miami loam, 6 to 12 percent slopes	20.2	23.1%
MmD	Miami loam, 12 to 18 percent slopes	1.4	1.6%
Totals for Area of Interest (AOI)		87.5	100.0%

Appendix F. Mud Lake Bog Soil Survey

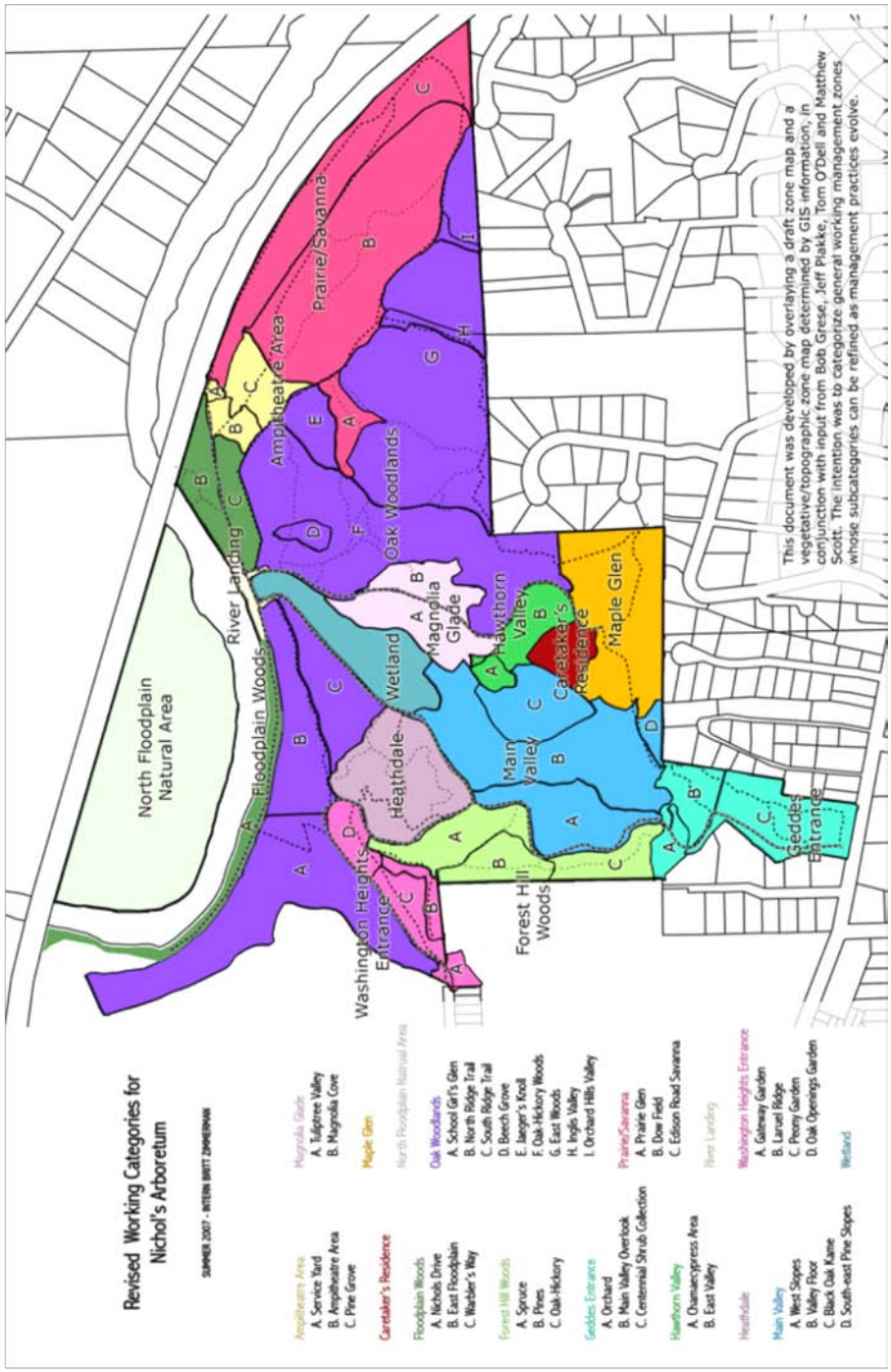


Soil Map–Washtenaw County, Michigan — Mud Lake Bog Soil Survey

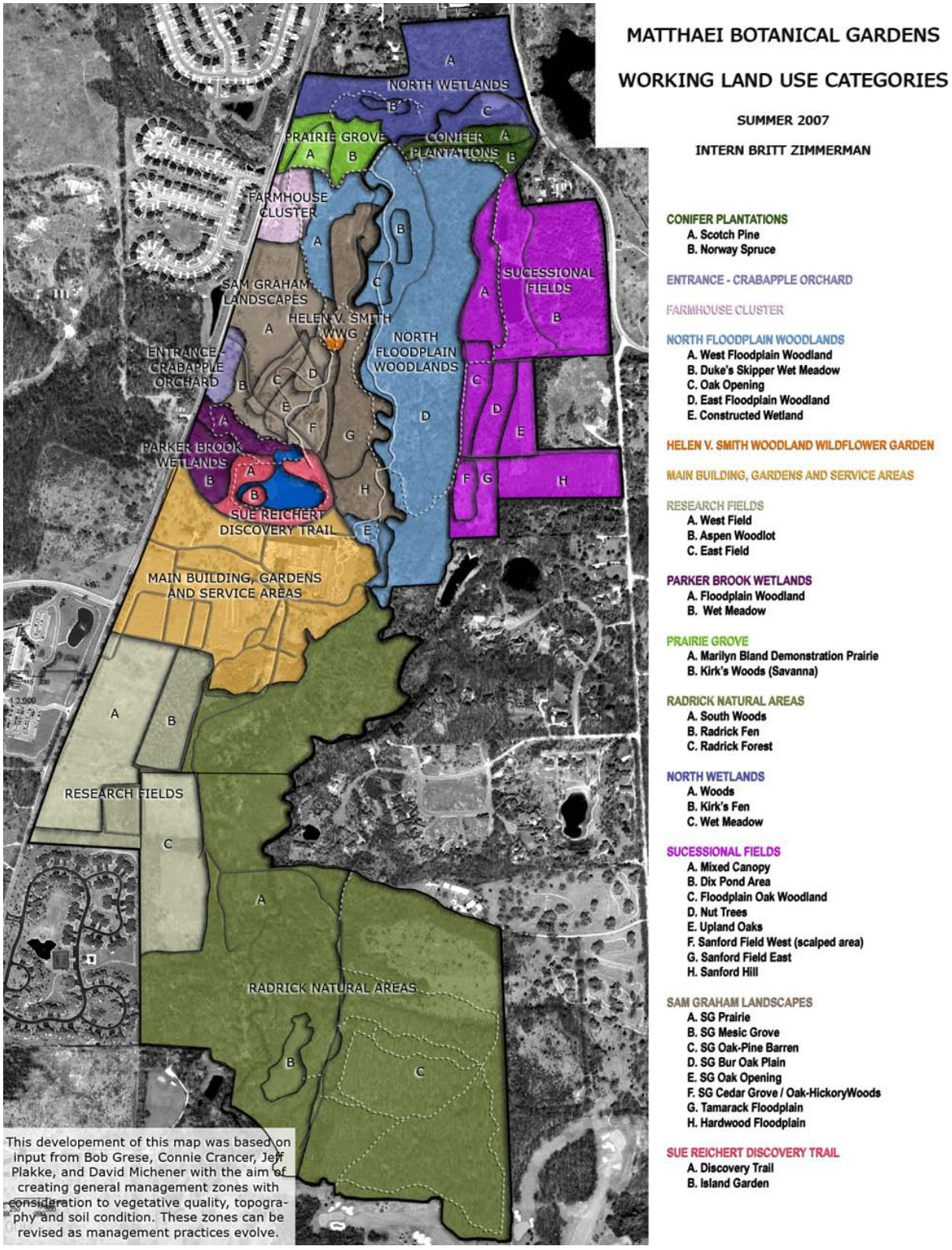
Map Unit Legend

Washtenaw County, Michigan (MI161)			
Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
BbB	Blount loam, 2 to 6 percent slopes	10.9	4.5%
Hn	Houghton muck	195.1	80.2%
MfA	Metamora sandy loam, 0 to 4 percent slopes	0.7	0.3%
MoB	Morley loam, 2 to 6 percent slopes	18.2	7.5%
MoC	Morley loam, 6 to 12 percent slopes	3.6	1.5%
MoD	Morley loam, 12 to 18 percent slopes	8.3	3.4%
W	Water	6.5	2.7%
Totals for Area of Interest (AOI)		243.4	100.0%

Appendix G. Arboretum Zone Map



Appendix H. Matthaei Botanical Gardens Zone Map



Appendix I. Horner Woods 2003 Plant List Inventory

Horner Mclaughlin Woods — Horner Woods

City of Ann Arbor
Natural Area Preservation
Compiled by Bev Walters, 2003

SCIENTIFIC NAME	COMMON NAME	FAMILY	W	LISTED	RATING
Acer rubrum	RED MAPLE	Aceraceae	0		1
Acer saccharinum	SILVER MAPLE	Aceraceae	-3		2
Acer saccharum	SUGAR MAPLE	Aceraceae	3		5
Actaea pachypoda	DOLL'S-EYES	Ranunculaceae	5		7
Adiantum pedatum	MAIDENHAIR FERN	Polypodiaceae	1		6
Agrimonia gryposepala	TALL AGRIMONY	Rosaceae	2		2
Agrimonia parviflora	SWAMP AGRIMONY	Rosaceae	-1		4
AJUGA REPTANS	CARPET BUGLE	Lamiaceae	5		*
Alisma plantago-aquatica	WATER-PLANTAIN	Alismataceae	-5		1
ALLIARIA PETIOLATA	GARLIC MUSTARD	Brassicaceae	0		*
Allium tricoccum	WILD LEEK	Liliaceae	2		5
Amelanchier laevis	SMOOTH SHADBUSH	Rosaceae	5		4
Amphicarpaea bracteata	HOG-PEANUT	Fabaceae	0		5
Anemone quinquefolia	WOOD ANEMONE	Ranunculaceae	0		5
Anemonella thalictroides	RUE ANEMONE	Ranunculaceae	5		8
Apocynum androsaemifolium	SPREADING DOGBANE	Apocynaceae	5		3
Arisaema triphyllum	JACK-IN-THE-PULPIT	Araceae	-2		5
Asarum canadense	WILD-GINGER	Aristolochiaceae	5		5
Aster lateriflorus	SIDE-FLOWERING ASTER	Asteraceae	-2		2
Aster macrophyllus	BIG-LEAVED ASTER	Asteraceae	5		4
Athyrium filix-femina	LADY FERN	Polypodiaceae	0		4
BERBERIS THUNBERGII	JAPANESE BARBERRY	Berberidaceae	4		*
Bidens sp.	TICKSEED species	Asteraceae			*
Boehmeria cylindrica	FALSE NETTLE	Urticaceae	-5		5
Brachyelytrum erectum	LONG-AWNED WOOD GRASS	Poaceae	5		7
Bromus pubescens	CANADA BROME	Poaceae	3		5
Campanula americana	TALL BELLFLOWER	Campanulaceae	0		8
Cardamine douglassii	PINK SPRING CRESS	Brassicaceae	-3		6
Cardamine pensylvanica	PENNSYLVANIA BITTER CRESS	Brassicaceae	-4		1
Carex bebbii	SEDGE	Cyperaceae	-5		4
Carex blanda	SEDGE	Cyperaceae	0		1
Carex bromoides	SEDGE	Cyperaceae	-4		6
Carex cephalophora	SEDGE	Cyperaceae	3		3
Carex comosa	SEDGE	Cyperaceae	-5		5
Carex crinita	SEDGE	Cyperaceae	-4		4
Carex digitalis	SEDGE	Cyperaceae	5		5
Carex gracillima	SEDGE	Cyperaceae	3		4
Carex grayi	SEDGE	Cyperaceae	-4		6
Carex grisea	SEDGE	Cyperaceae	-3		3
Carex hirtifolia	SEDGE	Cyperaceae	5		5
Carex intumescens	SEDGE	Cyperaceae	-4		3
Carex jamesii	JAMES' SEDGE	Cyperaceae	5		8
Carex lacustris	SEDGE	Cyperaceae	-5		6
Carex lupulina	SEDGE	Cyperaceae	-5		4
Carex pensylvanica	SEDGE	Cyperaceae	5		4
Carex radiata	STRAIGHT-STYLED WOOD SEDGE	Cyperaceae	1		2
Carex rosea (C. convoluta)	CURLY-STYLED WOOD SEDGE	Cyperaceae	5		2
Carex sparganioides	SEDGE	Cyperaceae	0		5
Carex stipata	SEDGE	Cyperaceae	-5		1
Carex stricta	SEDGE	Cyperaceae	-5		4
Carex tenera	SEDGE	Cyperaceae	-1		4
Carex tribuloides	SEDGE	Cyperaceae	-4		3
Carex woodii	SEDGE	Cyperaceae	0		8
Carpinus caroliniana	BLUE-BEECH	Betulaceae	0		6

Appendix I. Continued

SCIENTIFIC NAME	COMMON NAME	FAMILY	W	LISTED	RATING
Carya cordiformis	BITTERNUT HICKORY	Juglandaceae	0		5
Carya glabra (C. ovalis)	PIGNUT HICKORY	Juglandaceae	3		5
Carya ovata	SHAGBARK HICKORY	Juglandaceae	3		5
Cephalanthus occidentalis	BUTTONBUSH	Rubiaceae	-5		7
CERASTIUM FONTANUM	MOUSE-EAR CHICKWEED	Caryophyllaceae	3		*
Chelone glabra	TURTLEHEAD	Scrophulariaceae	-5		7
Cinna arundinacea	WOOD REEDGRASS	Poaceae	-3		7
Circaea lutetiana	ENCHANTER'S-NIGHTSHADE	Onagraceae	3		2
Claytonia virginica	SPRING-BEAUTY	Portulacaceae	3		4
Collinsonia canadensis	RICHWEED	Lamiaceae	0		8
CONVALLARIA MAJALIS	LILY-OF-THE-VALLEY	Liliaceae	5		*
Cornus florida	FLOWERING DOGWOOD	Cornaceae	4		8
Cornus foemina (C. racemosa)	GRAY DOGWOOD	Cornaceae	-2		1
Crataegus sp.	HAWTHORN species	Rosaceae			*
Desmodium glutinosum	CLUSTERED-LEAVED TICK-TREFOIL	Fabaceae	5		5
Dioscorea villosa	WILD YAM	Dioscoreaceae	1		4
Dryopteris carthusiana (D. spinulosa)	SPINULOSE WOODFERN	Aspleniaceae	-2		5
Dryopteris cristata	CRESTED SHIELD FERN	Aspleniaceae	-5		6
ELAEAGNUS UMBELLATA	AUTUMN-OLIVE	Elaeagnaceae	3		*
Elymus villosus	SILKY WILD-RYE	Poaceae	3		5
Elymus virginicus	VIRGINIA WILD-RYE	Poaceae	-2		4
Epilobium coloratum	CINNAMON WILLOW-HERB	Onagraceae	-5		3
Erigeron philadelphicus	MARSH FLEABANE	Asteraceae	-3		2
Erythronium americanum	YELLOW TROUT LILY	Liliaceae	5		5
EUONYMUS ALATA	WINGED WAHOO	Celastraceae	5		*
EUONYMUS EUROPAEA	SPINDLE TREE	Celastraceae	5		*
EUONYMUS FORTUNEI	WINTERCREEPER	Celastraceae	5		*
Euonymus obovata	RUNNING STRAWBERRY BUSH	Celastraceae	5		5
Fragaria virginiana	WILD STRAWBERRY	Rosaceae	1		2
Fraxinus americana	WHITE ASH	Oleaceae	3		5
Fraxinus nigra	BLACK ASH	Oleaceae	-4		6
Fraxinus pennsylvanica	RED ASH	Oleaceae	-3		2
Galium aparine	ANNUAL BEDSTRAW	Rubiaceae	3		0
Galium asprellum	ROUGH BEDSTRAW	Rubiaceae	-5		5
Galium concinnum	SHINING BEDSTRAW	Rubiaceae	3		5
Galium triflorum	FRAGRANT BEDSTRAW	Rubiaceae	2		4
Geranium maculatum	WILD GERANIUM	Geraniaceae	3		4
Geum canadense	WHITE AVENS	Rosaceae	0		1
Glyceria striata	FOWL MANNA GRASS	Poaceae	-5		4
Hackelia virginiana	BEGGAR'S LICE	Boraginaceae	1		1
Hamamelis virginiana	WITCH-HAZEL	Hamamelidaceae	3		5
HEMEROCALLIS FULVA	ORANGE DAY-LILY	Liliaceae	5		*
Hieracium sp.	HAWKWEED species	Asteraceae			*
Hydrophyllum appendiculatum	GREAT WATERLEAF	Hydrophyllaceae	5		7
Hystrix patula	BOTTLEBRUSH GRASS	Poaceae	5		5
Ilex verticillata	MICHIGAN HOLLY	Aquifoliaceae	-4		5
Impatiens capensis	SPOTTED TOUCH-ME-NOT	Balsaminaceae	-3		2
Iris virginica	SOUTHERN BLUE FLAG	Iridaceae	-5		5
Jeffersonia diphylla	TWINLEAF	Berberidaceae	5	SC	9
Juglans nigra	BLACK WALNUT	Juglandaceae	3		5
Juncus dudleyi	DUDLEY'S RUSH	Juncaceae	0		1
Juniperus communis	COMMON or GROUND JUNIPER	Cupressaceae	3		4
Laportea canadensis	WOOD NETTLE	Urticaceae	-3		4
Leersia oryzoides	CUT GRASS	Poaceae	-5		3
Leersia virginica	WHITE GRASS	Poaceae	-3		5
Lemna minor	SMALL DUCKWEED	Lemnaceae	-5		5
Lemna trisulca	STAR DUCKWEED	Lemnaceae	-5		6
LIGUSTRUM VULGARE	COMMON PRIVET	Oleaceae	1		*
Lilium michiganense	MICHIGAN LILY	Liliaceae	-1		5
Lonicera dioica	RED HONEYSUCKLE	Caprifoliaceae	3		5
LONICERA MAACKII	AMUR HONEYSUCKLE	Caprifoliaceae	5		*
LONICERA XBELLA	HYBRID HONEYSUCKLE	Caprifoliaceae	3		*

Appendix I. Continued

SCIENTIFIC NAME	COMMON NAME	FAMILY	W	LISTED	RATING
Lycopus americanus	COMMON WATER HOREHOUND	Lamiaceae	-5		2
Menispermum canadense	MOONSEED	Menispermaceae	0		5
NARCISSUS sp.	NARCISSUS species	Liliaceae			*
Onoclea sensibilis	SENSITIVE FERN	Polypodiaceae	-3		2
Ostrya virginiana	IRONWOOD; HOP HORNBEAM	Betulaceae	4		5
Oxalis fontana (O. europaea)	YELLOW WOOD-SORREL	Oxalidaceae	3		0
Panicum implicatum	PANIC GRASS	Poaceae	0		3
Penthorum sedoides	DITCH STONECROP	Penthoraceaee	-5		3
Phlox divaricata	WOODLAND PHLOX	Polemoniaceae	3		5
Pilea pumila	CLEARWEED	Urticaceae	-3		5
POA COMPRESSA	CANADA BLUEGRASS	Poaceae	2		*
Podophyllum peltatum	MAY APPLE	Berberidaceae	3		3
Polygonatum pubescens	DOWNY SOLOMON SEAL	Liliaceae	5		5
Polygonum amphibium	WATER SMARTWEED	Polygonaceae	-5		6
POLYGONUM PERSICARIA	LADY'S THUMB	Polygonaceae	-3		*
Polygonum virginianum (Tovara v.)	JUMPSEED	Polygonaceae	0		4
Polystichum acrostichoides	CHRISTMAS FERN	Polypodiaceae	5		6
Populus grandidentata	BIG-TOOTHED ASPEN	Salicaceae	3		4
Populus tremuloides	QUAKING ASPEN	Salicaceae	0		1
Potentilla simplex	OLD-FIELD CINQUEFOIL	Rosaceae	4		2
Prenanthes sp.	WHITE LETTUCE species	Asteraceae			*
Prunella vulgaris	LAWN PRUNELLA	Lamiaceae	0		0
PRUNUS AVIUM	SWEET CHERRY	Rosaceae	5		*
Prunus serotina	WILD BLACK CHERRY	Rosaceae	3		2
Prunus virginiana	CHOKE CHERRY	Rosaceae	1		2
Pyrola elliptica	LARGE-LEAVED SHINLEAF	Pyrolaceae	5		6
Quercus alba	WHITE OAK	Fagaceae	3		5
Quercus bicolor	SWAMP WHITE OAK	Fagaceae	-4		8
Quercus macrocarpa	BUR OAK	Fagaceae	1		5
Quercus muehlenbergii	CHINQUAPIN OAK	Fagaceae	5		5
Quercus rubra	RED OAK	Fagaceae	3		5
Quercus velutina	BLACK OAK	Fagaceae	5		6
Ranunculus abortivus	SMALL-FLOWERED BUTTERCUP	Ranunculaceae	-2		0
Ranunculus hispidus	SWAMP BUTTERCUP	Ranunculaceae	0		5
Ranunculus recurvatus	HOOKED CROWFOOT	Ranunculaceae	-3		5
Ranunculus sceleratus	CURSED CROWFOOT	Ranunculaceae	-5		1
RHAMNUS CATHARTICA	COMMON BUCKTHORN	Rhamnaceae	3		*
RHAMNUS FRANGULA	GLOSSY BUCKTHORN	Rhamnaceae	-1		*
Ribes americanum	WILD BLACK CURRANT	Grossulariaceae	-3		6
Ribes cynosbati	PRICKLY or WILD GOOSEBERRY	Grossulariaceae	5		4
Rosa carolina	PASTURE ROSE	Rosaceae	4		4
ROSA MULTIFLORA	MULTIFLORA ROSE	Rosaceae	3		*
Rosa palustris	SWAMP ROSE	Rosaceae	-5		5
Rubus hispidus	SWAMP DEWBERRY	Rosaceae	-3		4
Rubus occidentalis	BLACK RASPBERRY	Rosaceae	5		1
Sanguinaria canadensis	BLOODROOT	Papaveraceae	4		5
Scirpus cyperinus	WOOL-GRASS	Cyperaceae	-5		5
Scutellaria galericulata	COMMON SKULLCAP	Lamiaceae	-5		5
Scutellaria lateriflora	MAD-DOG SKULLCAP	Lamiaceae	-5		5
Senecio aureus	GOLDEN RAGWORT	Asteraceae	-3		5
Sisyrinchium albidum	COMMON BLUE-EYED-GRASS	Iridaceae	3		7
Sium suave	WATER-PARSNIP	Apiaceae	-5		5
Smilacina racemosa	FALSE SPIKENARD	Liliaceae	3		5
Smilacina stellata	STARRY FALSE SOLOMON-SEAL	Liliaceae	1		5
Smilax ecirrata	UPRIGHT CARRION-FLOWER	Liliaceae	5		6
Smilax tamnoides (S. hispida)	BRISTLY GREEN-BRIER	Liliaceae	0		5
SOLANUM DULCAMARA	BITTERSWEET NIGHTSHADE	Solanaceae	0		*
Solidago caesia	BLUE-STEMMED GOLDENROD	Asteraceae	3		7
Solidago flexicaulis	BROAD-LEAVED GOLDENROD	Asteraceae	3		6
Sparganium eurycarpum	COMMON BUR-REED	Sparganiaceae	-5		5
Spiraea alba	MEADOWSWEET	Rosaceae	-4		4
TARAXACUM OFFICINALE	COMMON DANDELION	Asteraceae	3		*

Appendix I. Continued

SCIENTIFIC NAME	COMMON NAME	FAMILY	W	LISTED	RATING
Thalictrum dioicum	EARLY MEADOW-RUE	Ranunculaceae	2		6
Thelypteris palustris	MARSH FERN	Polypodiaceae	-4		2
Tilia americana	BASSWOOD	Tiliaceae	3		5
Toxicodendron radicans	POISON-IVY	Anacardiaceae	-1		2
Triosteum aurantiacum	HORSE-GENTIAN	Caprifoliaceae	5		5
Tsuga canadensis	HEMLOCK	Pinaceae	3		5
Typha latifolia	BROAD-LEAVED CAT-TAIL	Typhaceae	-5		1
Ulmus americana	AMERICAN ELM	Ulmaceae	-2		1
Ulmus rubra	SLIPPERY ELM	Ulmaceae	0		2
Vaccinium pallidum	BLUEBERRY	Ericaceae	5		7
Verbena urticifolia	WHITE VERVAIN	Verbenaceae	-1		4
Viburnum acerifolium	MAPLE-LEAVED ARROW-WOOD	Caprifoliaceae	5		6
Viburnum lentago	NANNYBERRY	Caprifoliaceae	-1		4
VIBURNUM OPULUS	EUROPEAN HIGHBUSH CRANBERRY	Caprifoliaceae	0		*
Viburnum rafinesquianum	DOWNY ARROW-WOOD	Caprifoliaceae	5		5
Viola conspersa	DOG VIOLET	Violaceae	-2		3
Viola sororia	COMMON BLUE VIOLET	Violaceae	1		1
Vitis riparia	RIVERBANK GRAPE	Vitaceae	-2		3
Zanthoxylum americanum	PRICKLY-ASH	Rutaceae	5		3
Zizia aurea	GOLDEN ALEXANDERS	Apiaceae	-1		6

Total Species:	198
Total Native Species:	171
Total Coefficient:	730
Average Coefficient:	4.3
Floristic Quality Index:	55.8