DEVELOPING A LAND MANAGEMENT PLAN FOR KALAMAZOO NATURE CENTER'S EIGHT PROPERTIES

by

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ABSTRACT: Our project team partnered with the Kalamazoo Nature Center (KNC) in Kalamazoo, MI, to develop a comprehensive land management plan (LMP) for the organization's eight properties. We employed field-based methods, informal interviews, staff surveys, and feedback collected during staff meetings to gather data about KNC's properties and management paradigms. This information was compiled into a series of background chapters about KNC's management philosophy and common tools and strategies; individual site plans detailing the history, composition, and recommended management actions for each property; and appendices with invasive species management information and data collection details. In addition, we produced a how-to guide designed to help other organizations navigate the land management planning process. The comprehensive LMP, how-to guide, maps, and raw field data were delivered to KNC in April 2016.

Acknowledgements

The team would like to express our gratitude to our advisors, Professors Mark Robinson, Bob Grese, and Ines Ibáñez for providing insight into what data to collect, how to collect them, and how to present our findings. We would also like to thank Avik Basu, Erin Lane, and Diana Woodworth in SNRE for their guidance and support. The team also extends our appreciation to our client contacts, Sarah Reding and Ryan Koziatek, as well as Bill Rose, Tyler Bassett, and KNC staff for their guidance during this project. We are proud to provide them with this plan and thank them for their countless questions answered.

Thanks also to our families and colleagues for their support during our time at SNRE. Our sincerest gratitude for their love and friendship.

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INTRODUCTION

The University of Michigan's School of Natural Resources & Environment (SNRE) gives its students the opportunity to engage in real-world collaborative work with a vetted client. Karl Bosse, Kate Chapel, Jiawei Huang, Geneva Langeland, and Bo Li chose to be a part of this opus project because of our interests in land management, mapping, and nature centers as institutions. Our diverse undergraduate backgrounds and our chosen tracks here in SNRE created a rich environment in which to perform this work. We realized that each of us brings specific expertise that needed to be highlighted, as well as skills we were all hoping to learn for ourselves in the process of earning our masters degrees.

We chose to work with the Kalamazoo Nature Center (KNC) in Kalamazoo, Michigan. KNC has eight properties totaling over 1,400 acres of central hardwoods, wetlands, prairies, and areas for educational programming. There are currently 52 paid staff members and nearly 9,000 annual volunteer hours that help run this organization. KNC has the capacity to move a lot of earth and create a lot of tangible change. Our job for nearly two years was to create a document that could strategically guide those changes.

Tyler Bassett, a PhD candidate at Michigan State University, took the lead on developing an early land management plan (LMP) for KNC that was published in the early 2000s. The plan was supported by extensive research and fieldwork and became our starting point for updating, revising, and bolstering our own LMP. This previous LMP was only relevant to KNC's Main Site. The Main Site is the largest of the eight properties and contains the KNC's Interpretive Center, an extensive trail system, and most of the educational programming that KNC facilitates. KNC has seven smaller properties not adjacent to the Main Site that had little to no data collection associated with them and no consolidated documentation of KNC's goals for the sites.

This is the gap that our team filled during our time at Michigan. We decided to target our data collection within the seven peripheral sites while also repeating some survey plots on the Main Site to compare against survey results from the mid-2000s. The team also created stand-alone

site plans for each of the properties embedded within one integral document that contains the entirety of KNC's management philosophy, goals, and strategies. We have attempted to make this document easy to read, accessible to all kinds of users, and adaptable to new information. Unlike the last iteration of this LMP, this is a truly living document with recommendations for continued and regular updates rather than a tome that sits on a shelf used by just a few stewardship staff.

METHODS

The team utilized several different data collection and research methods to inform our finished product. We used quantitative and qualitative methods and used the breadth of knowledge and experience from KNC staff, our field work, and our advisors.

Gathering existing data

Initially, we started with simply collating the data and information already available to us. We needed to know what we didn't know and how to ask the right questions of the right people to gain needed answers. The team scoured KNC's shared research drive and spoke with Tyler Bassett so we could understand what had already been done on the property, what should be repeated, and where knowledge gaps remained. We also looked into what other nature centers of similar capacity had in terms of a land management plan or strategy. Each team member called various nature centers around the country and asked for their LMPs, in whatever form they happened to be in.

Field data collection

Quantitatively, we set up Modified-Whittaker Plots (MWP) and transects in several of the properties, which generated data used to calculate Floristic Quality Indices (FQI) and basal area and relative abundance of trees above 10 cm diameter at breast height (DBH). The quantitative data were useful in determining not only ecosystem health, but also the composition and structure of each of the sites we surveyed. Relative abundance of trees showed us that many of the surveyed forests were either skewed towards one particular tree species or were disproportionally low in tree species we expected to see. Detailed information can be found in each of the site plans and in our raw data given to KNC.

Informal walkabouts with KNC staff were also used to gather information during the field season. These were great ways to see entire properties beyond individual plots or transects. The team was able to create a more complete picture of the sites in this way by looking for erosion issues, getting a sense of invasive species severity, and sometimes simply stumbling onto unexpected insights. For example, walkabouts in the Heronwood Field Station property detected deer blinds and salt licks, evidence of previous and current hunting activity. In Harris Prairie, we encountered an individual foraging for mushrooms, which confirmed an assumption that the private properties were being used in ways inconsistent with KNC's leave-no-trace principles. All of these observations influenced our recommendations just as significantly as our hard data.

Interviews

Informal interviews with a diverse array of KNC staff were essential in shaping our LMP's content and structure. Each department has a different lens through which they look at the land under their care. The Stewardship staff is tasked with conserving, restoring, and monitoring more than a thousand acres of diverse habitats. The Education staff are tasked with conveying the message of this land's value and importance to the general public. Much of the institutional knowledge at KNC is wrapped up in the brains of these diverse staff members, so interviewing them was vital to learning about the current goals and intentions of KNC staff.

In each of these interviews, we asked the staff members to tell us stories about how they use the land. Most specifically, we asked what has changed (in land composition and attitudes) during the time they've worked for KNC. In this way we were able to see what was important to each staff member and understand their goals for the future. We incorporated these visions into the management recommendations for each site plan and into the philosophy and background sections of our LMP.

Surveys

The staff were also given a survey in Fall 2015 that they could answer anonymously. This survey was based on a staff survey originally distributed in 2004 by Tyler Bassett. We restructured some of the original questions and added questions regarding some of the other properties not included in the original survey. We also developed questions based on a pre-survey questionnaire asking staff and volunteers for additional items they viewed as management opportunities or concerns. These data were then incorporated into our recommendations, specifically in prioritizing management actions.

Staff Meetings

Staff meetings were another way we were able to have more face-time with the people who will actually use the LMP we've created. These meetings were geared mostly towards presenting our work, but also asking for direct feedback from staff and board members to better tailor our documents to their use.

We learned that one of the main barriers to using the previous LMP was simply its structure. It was a bulky, dense, scientific document that virtually no individual staff member had read all the way through. There were a few staff members that weren't quite sure if the LMP was even relevant to their work as educators, with the notion that it was only intended for stewardship staff use.

We were able to create staff buy-in through these meetings, showing staff the plethora of ways they could use this document to inform their day-to-day work. We also stressed the importance of creating a living document to ensure the LMP's sustainability for years to come.

RESULTS AND DISCUSSION

The deliverables to KNC can be found in their entirety in Appendix I and Appendix II of this report. The first appendix is the LMP that KNC will use and update for the next decade. The

second appendix is a how-to guide called *Navigating the Planning Process* that outlines easy-to-follow steps for other organizations seeking to develop LMPs.

Gathering existing data

We found that startlingly few other nature centers had formal LMPs. This confirmed KNC's suggestion that the broader nature center community would benefit from a how-to guide unpacking the land management planning process from start to finish. Our how-to guide is designed to be informal and accessible to any level of stakeholder, from a conservation-minded homeowner to the director of a large nature center. The guide is the culmination of our team's journey toward creating our own LMP, replete with tips, tricks, and questions to ask while taking the journey to a comprehensive strategic document.

While doing background research in KNCs current files, we discovered that the Main Site had some very high-quality compartments (FQI 35+), but also that there were many compartments with lower FQI scores, partially due to successional changes. For example, the Main Site's former gravel pits and agricultural fields have become burdened by pioneer invasive species as the habitats shift toward climax species compositions. Insights like this became the backbone of our management recommendations, designed to encourage ecosystems toward desired species compositions.

Field data collection

The results of our field work can be found in exhaustive detail in the site plans of Appendix I. To generalize across all of KNC's properties, we found some high-quality areas and some in need of restoration or maintenance. The MWPs were used to calculate basal area and relative dominance of trees, which shows the general distribution of species in that plot. They can also be used for understanding regeneration of tree species within a plot. The FQI scores for the sites give a baseline on the peripheral properties that will be essential for measuring success of management activities over time. We recommend that our plots and transects be surveyed again in the future, with FQI scores recalculated and compared against 2015 data.

The walkabouts resulted in qualitative observations and specific in-context recommendations included in each site plan.

Interviews

Information from the staff interviews helped tailor our management recommendations. We had only a brief window for conducting field research, so the institutional knowledge gained through these interviews allowed us to incorporate a tremendous amount of information that we couldn't have gathered in the field.

Surveys

The 2015 survey resulted in more staff awareness of our project in general, but also in more involvement by a larger range of staff than merely our contacts in the Stewardship Department. The survey helped staff understand that a new LMP was in the works and that it would represent

a significant new resource. This also gave KNC staff a chance to weigh funding and personnel constraints in ranking the perceived priority of various management concerns. We compared results from this survey against those from the 2004 survey to gain insights into shifting priorities of KNC. These results were essential in prioritizing the management recommendations in each of our sites plans. Thus the recommended management actions represent a fusion of our graduate-level knowledge and their on-the-ground expertise.

Staff meetings

This LMP may have had a radically different structure had the team not insisted on meeting with KNC staff. We learned that the old LMP was so cumbersome to use that few staff members took the time to read it. Together with the staff, we brainstormed different ways to avoid this pitfall, and these conversations resulted in the structure currently attached in Appendix I.

Each site plan can stand on its own for specific managers to use. In addition, all of the chapters and background sections are linked together and to the appendices where appropriate. This internal linking makes it much easier to flip back and forth between sections, giving the user a broader perspective of the document. For example, when a site plan talks about implementing a prescribed burning rotation, the reader can click on a link to take them to the background sections on prescribed burns as a management tool. Each site plan talks about managing invasive species and links to the invasive species appendix, where readers can find more detailed information on species identification and control.

CONCLUSION

We feel that our work over the last year and a half has gone a long way toward filling a tangible and immediate need at KNC, namely the need for a single, comprehensive land management plan. Our in-person, on-the-ground research revealed the best way to structure and compile a plan that will be useful and accessible to all KNC staff. We hope that our how-to guide will help other nature centers and land management organizations navigate the process toward developing their own LMPs. Our comprehensive LMP, how-to guide, maps, and raw data will all be delivered to KNC at the conclusion of the 2015-2016 school year for the organization’s ongoing use.

BIBLIOGRAPHY

All citations are located in footnotes within the land management plan.

APPENDIX I: LAND MANAGEMENT PLAN FOR THE KALAMAZOO NATURE CENTER

Kalamazoo Nature Center

Comprehensive Land Management Plan 2016

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Chapter 1: An Introduction

Welcome to the Kalamazoo Nature Center Land Management Plan (LMP)! This document codifies the history, current use, and proposed future management of eight properties owned or managed by the Kalamazoo Nature Center (KNC). These properties range from the 4.5-acre Urban Nature Park in downtown Kalamazoo, MI, to the Nature Center's 1,200-acre Main Site on Westnedge Avenue. This LMP captures a 10-year vision for KNC's ongoing efforts to restore and maintain the ecological integrity of these properties.

How to Use this Document

This document is designed for easy access by a variety of readers. Chapter 1 provides an orientation to the plan itself. Chapter 2 outlines KNC's history, landscape context, and philosophies regarding preservation and education. Chapter 3 digs into specific management actions like trail maintenance and water quality sampling. Chapters 4-11 are individual site plans providing detailed histories and management objectives for each of KNC's properties. These site plans are designed to function as stand-alone documents embedded in a broader contextual framework. For example, a reader might look to Chapter 3 for the rationale behind prescribed burns as management tools, then turn to Chapter 7 for a recommended burn schedule at Harris Prairie. The recommended management actions for each site plan are prioritized according to the following numerical scale:

1: Address within the next 3 years
2: Address within the next 5 years
3: Address within the next 10 years
4: Address in the next 10-year comprehensive LMP

Growing a Living Document

This plan was developed by five University of Michigan graduate students between January 2015 and April 2016. Coming from the School of Natural Resources and Environment, we brought expertise in areas ranging from conservation ecology to environmental policy to informatics and mapping. We worked closely with KNC's Stewardship Field Director Ryan Koziatek and Vice President of Conservation Stewardship Sarah Reding to assess the organization's needs and develop a meaningful and accessible plan.

The best way for the LMP to remain relevant is for it to grow and change as KNC does. Even after working with KNC staff for a year and a half, there are still staff members we never met, properties we never saw, and habitats we never explored. So we call this a "living document." We invite staff to continually add management actions, property details, updated scientific insights, and visions for the future to any and all chapters of the plan. We hope staff will use this as a repository for institutional knowledge, where insights and visions can be recorded for future generations of KNC staff to access and use.

KNC is already planning to convene a Land Management Council consisting of staff, volunteers, and members of the Board. We recommend that the Land Management Council review and update this LMP every six months to ensure that it remains relevant to the organization's goals. Before each review, the Council should solicit updates from all staff members and volunteers.

We believe this will help KNC prioritize its management actions efficiently and effectively. Finally, in 2026, the Council should commission a full update and launch a new 10-year plan.

Resources and Gratitude

We owe tremendous thanks to Michigan State University researcher Tyler Bassett, who developed KNC's previous LMP in the mid-2000s. The prior plan outlined KNC's management paradigm and provided compartment-level management information for KNC's Main Site. This document expands the previous plan to include up-to-date ecological research and KNC's additional properties.

Tyler Bassett also compiled the KNC BioInventory report which we drew from frequently and is cited often in this LMP.

We also drew heavily upon information from the Michigan Natural Features Inventory (MNFI) program stemming from Michigan State University. Unless otherwise noted, the plant community information in this plan was drawn from MNFI fact sheets and the book *A Field Guide to the Natural Communities of Michigan*.[1] MNFI also provided data about pre-settlement vegetation.

Additionally, we are indebted to Ryan and Sarah, KNC President Bill Rose, Heronwood Field Station Director Kim Lippke, and other members of the stewardship and education staff who provided insights and stories for this document.

Final thanks goes to our faculty advisor, Mark Robinson, and other staff and faculty at the University of Michigan who helped with advice, resources, and funding.

Karl Bosse: Environmental Informatics
Kate Chapel: Conservation Ecology
Jiawei Huang: Environmental Informatics
Geneva Langeland: Environmental Policy & Planning; Behavior, Education, and Communication
Bo Li: Conservation Ecology

[1] Cohen JG, Kost MA, Slaughter BS, Albert DA. A field guide to the natural communities of Michigan. Lansing (MI): Michigan State University Press; 2014 Dec 9. 362 p.

Chapter 2: KNC's History and Philosophy

A Brief History of KNC

Cooper's Glen has long been a draw in the Kalamazoo area. Evidence shows that Native Americans camped nearby prior to European settlement, and centuries later it was still used as a picnic site and place to enjoy nature. Dr. H. Lewis (Lew) Batts, Jr., a professor at Western Michigan University and noted environmentalist, was one of these visitors. When the land came available for sale, he organized a group to purchase the property and keep it out of the hands of encroaching gravel mining companies. His purchase eventually became the Kalamazoo Nature Center in October of 1960.[2]

KNC was founded with the vision of fostering an understanding and appreciation of our natural surroundings. This vision would be accomplished through educational programming, regular publications, scientific research, and recreational activities.

Getting the community involved with KNC was a key goal early on. The organization officially opened its doors to the public in May of 1962. The fledgling Nature Day Camp shifted from the Kellogg Bird Sanctuary to KNC's newly opened Interpretive Center. School groups were invited to tour the grounds, and new trails were put to use by the general public.

1962 also saw the start of a major membership effort at KNC. These memberships represent a way to draw support and participation from the public and local businesses. Within two years of offering memberships, KNC had 1,745 personal memberships representing 4,339 individuals.

Over the years, KNC has expanded its property holdings, either through purchasing properties or receiving land as gifts. The first additions were focused on acquiring land surrounding Cooper's Glen and the Trout Run stream to provide a buffer from development. Throughout the next three decades, additional land was purchased by or donated to KNC, eventually becoming today's 1,200-acre Main Site. Many pieces were privately purchased by Lew Batts on behalf of the organization.

The following list provides a timeline of property acquisitions in Cooper Township, Kalamazoo County, or elsewhere in Michigan:

- In 1962, KNC was gifted a 40-acre parcel in Van Buren County.
- In 1967, KNC purchased a 22-acre tract in Berrien County adjacent to what is now the Grand Mere State Park to prevent further sand mining. See Chapter 11 for more details on this property.
- In 1975, 2,600 acres of forest and wetlands in Michigan's Upper Peninsula were donated, followed by a 17-acre parcel gift in 1991 to fill a gap in the property.
- In 1979, 106 acres in Oshtemo Township were bequeathed to KNC consisting of woodlands, farmland, and remnant prairie. This is now the Harris Prairie property. See Chapter 7 for more details on this property.

[2] Kivikko R, Ferguson C, Evans M. Glimpsing the whole: the Kalamazoo Nature Center story. Beech Leaf Press; 1995 Jun. 188 p.

- In the 1970s, Batts purchased 40 acres around Bullhead Lake in Barry County to protect it from potential development, of which 12 acres was transferred to KNC ownership in 1997 along with a rustic cabin which is used by staff in warmer months. See Chapter 9 for more details on this property.
- In 2005, KNC purchased a brownfield site in downtown Kalamazoo which is currently undergoing construction to be turned into an Urban Nature Park to provide nature access to underserved populations. See Chapter 8 for more details on this property.
- In 2013, a 60-acre property was gifted to KNC, including a 5,000-square-foot home looking over ponds and forest. This property has been transformed into the Heronwood Field Station which serves as a programming hub for local students. See Chapter 5 for more details on this property.
- In 2015, the Stryker family donated 22 acres of land in Kalamazoo adjacent to KNC's Nature's Way Preschool facilities, as well as a matching grant to fund a new educational facility and ongoing maintenance. See Chapter 6 for more details on this property.

KNC's Management Philosophy

The 1995 publication, *Glimpsing the Whole: The Kalamazoo Nature Center Story*, describes the paradigm upon which KNC's founders built the organization:

> *"The underlying themes were a love of nature, a commitment to the preservation and sustainability of ecologically fragile natural communities, a concern for the quality of the environment in which humans live, and the need to pass on this outlook to future generations."*[3]

This has evolved into KNC's current mission, as stated on its website: "to inspire people to care for the environment by providing experiences that lead them to understand their connection to the natural world."[4]

A Blended Philosophy

Land management paradigms commonly fall on a spectrum between two distinct poles. The first pole, often associated with naturalist John Muir and the early environmental movements of the 1950s and 60s, represents the view that "nature knows best."[5] In this view, natural areas—or places that are being "returned to nature"—should be set aside from human interference. Plant and animal communities are allowed to self-regulate with little to no active management. In some cases, people can still access and enjoy these natural areas, but usually on designated trails and through approved activities.

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[3] Kivikko R, Ferguson C, Evans M. Glimpsing the whole: the Kalamazoo Nature Center story. Beech Leaf Press; 1995 Jun. 188 p.
[4] Welcome to the Kalamazoo Nature Center [Internet]. Kalamazoo (MI): Kalamazoo Nature Center. [cited 2016 Mar 26]. Available from http://naturecenter.org/Home/AboutKNC/tabid/128/Default.aspx
[5] Silveira SJ. The American environmental movement: surviving through diversity. Chestnut Hill (MA): Boston College Law Review; 2000 [cited 2016 Mar 26]. Available from https://www.bc.edu/content/dam/files/schools/law/lawreviews/journals/bcealr/28_2-3/07_TXT.htm

The second pole on the spectrum, which has risen in popularity in recent decades, represents the idea that humans are inextricably intertwined with the land and ecosystems they inhabit. This view acknowledges the depth of environmental destruction caused by human activity. At the same time, it emphasizes "hands-on" management, with human caretakers re-equipping the land with the species and ecosystem processes it needs to be resilient.

Over the decades, KNC staff have worked hard to strike an effective balance between these two poles. Lew Batts' choice to purchase at-risk properties was partially rooted in the first pole, the urge to save "natural" properties before human interference could taint them. His attitude toward using the properties—and the attitude he bequeathed to his organization—was more closely aligned with the second pole. This has formed the backbone of KNC's ongoing educational philosophy. Again, from *Glimpsing the Whole*:

> *"People are a part of nature and their well-being depends on the well-being of the environment. To feel at home in the outdoors and learn not to fear it, people, and especially children, need regular contact with the natural world. Only then will they learn to live in harmony with nature, rather than exploit it."*[6]

Managing for Ecosystems

KNC's on-the-ground management strategies have shifted across the decades in an ongoing effort to balance ecological resilience with meaningful educational access. In the past, KNC's managers often chose to let human-dominated areas, such as agricultural fields and gravel pits, fill in with whichever plants reached them first. This led to rapid, low-maintenance reforestation of many disturbed areas and allowed staff to focus on educational programming and interpretation.

This strategy has been challenged in recent decades by the rapid spread of invasive plant species and a greater knowledge of the region's ecological composition before the arrival of European settlers. KNC's managers began to realize that a more hands-on approach could revive long-lost habitats and promote a level of diversity that had both ecological and educational value. Management priorities shifted toward an ecosystem-level awareness of how water, nutrients, and creatures move through the landscape. Staff focused on shaping large, contiguous areas of various habitats. They assessed how each management decision might affect factors like water quality in Trout Run, migratory bird habitat, and invasive species colonization. They worked to restore the entire Trout Run watershed which Lew Batts had had the foresight to purchase. Through tools like the Michigan Natural Features Inventory, they recreated plant communities that would have existed before European settlement. They began planting prairies, running prescribed burns, and pulling bags and bags of garlic mustard.

Today, KNC aims to build or maintain resilient plant and animal communities, foster diverse populations of native species, and leave room for natural flows of water and nutrients through ecosystems. Staff make decisions that are consistent with the biotic needs of the broader ecosystem or region. At the same time, they leave room for people to access and enjoy the properties' resources. For some distant sites, such as the Bullhead Lake and Grand Mere Dunes

[6] Kivikko R, Ferguson C, Evans M. Glimpsing the whole: the Kalamazoo Nature Center story. Beech Leaf Press; 1995 Jun. 188 p.

properties, a minimalist, hands-off approach has been the best use of staff time and resources. For others, like the forthcoming Urban Nature Park, KNC has invested heavily in restoring long-lost wetland and forest habitats. For still others, including the Main Site and Nature's Way Preschool, KNC has prioritized building physical structures and robust youth programs.

Managing for large, contiguous, historic habitats can be highly labor- and time-intensive. While tallgrass and shortgrass prairies may be native to many of KNC's properties, for example, recreating a prairie from a woodlot or agricultural field requires years of sowing, mowing, burning, hand-pulling, and constant vigilance. Eventually, though, desired species begin to outweigh unwanted species, beneficial birds and insects move in, and the balance of the habitat grows stable enough to support itself with minimal human management.

This laborious, hands-on approach allows KNC's staff and visitors to actively participate in the protection and restoration of valuable ecosystems. It also lets KNC prioritize particular ecosystems, uses, or successional paths. For example, the DeLano Farm functions as an effective educational tool because KNC staff can manage it as a working farm, rather than stepping back and allowing the land to revert to woodland. The staff can choose to keep certain parts of the Main Site's gravel pit free from growth to make the site accessible to educational programs.

This level of control can lead to difficult management decisions. Staff must weigh the benefit of preserving diverse habitat pockets against the benefit of shaping a larger, contiguous swath of a single habitat. They must choose whether to invest significant time and resources to rebuild a prairie on a distant property parcel. They must balance aesthetics and guest safety with the wish to let leaves and branches decompose where they fall. Sometimes, they realize that a site's pre-settlement plant community simply couldn't thrive in that location anymore.

Adaptive Management

Thankfully, an adaptive management approach can make these tricky decisions easier to tackle.[7] Adaptive management acknowledges the uncertainties inherent in working with ecological systems. Rather than simply pursuing a management action from beginning to end, adaptive managers observe the results of every implemented step and allow those results to inform future steps. In other words, each management decision enters into a feedback loop. Adaptive management provides a valuable framework for approaching KNC's future management decisions.

Valuing Biodiversity

"Biodiversity" comes up so frequently in management discussions that its meaning has become diffuse and distorted. As discussed in KNC's previous LMP, "preserving biodiversity" can mean vastly different things to different people. In KNC's current management paradigm, preserving biodiversity could mean ensuring that a piece of land most accurately reflects a pre-European settlement plant community, if possible. This goal serves multiple purposes as it:

- Eradicates non-native plants, invasive or otherwise.

[7] Williams BK, Szaro RC, Shapiro CD. Adaptive management: the US Department of the Interior technical guide [Internet]. Washington, DC: US Department of the Interior; 2009 [cited 2016 Mar 26]. Available from https://www.usgs.gov/sdc/doc/DOI-%20Adaptive%20ManagementTechGuide.pdf

- Promotes native plants, which generally have adapted to thrive in southwestern Michigan's climate.
- Encourages the restoration of natural water and nutrient flows.
- Stimulates the return or growth of native insects, birds, mammals, amphibians, reptiles, and microorganisms, which promote overall ecosystem health.

Each of these factors is part of a robust, resilient, dynamic ecosystem.

That said, it may not be feasible to completely fill a piece of land with native plants. In many cases, it may be equally valuable to manage in such a way that favors non-native plants which don't spread aggressively, don't require substantial resource input, and which provide useful food or shelter to desired animals.

Of course, animals, microorganisms, and abiotic factors are all integral components of a robust, resilient, dynamic ecosystem. However, plant communities may be the easiest ecosystem facet to manage. KNC staff can't control the amount of rain falling on their properties, but they can strive to have plant communities that will trap and filter the rain before it runs off into nearby water bodies. They can't inoculate the soil with helpful microorganisms, but they can plant species whose roots feed those microorganisms. All kinds of beneficial animals and insects can thrive in a place if they have the right things to eat and hide in.

Framework for Land Managers

KNC's previous LMP included a paradigm laid out by Dale *et al*., reporting on behalf of the Ecological Society of America's Committee on Land Use, which suggests the following guidelines for land managers:[8]

- Examine impacts of local decisions in a regional context.
- Plan for long-term change and unexpected events.
- Preserve rare landscape elements and associated species.
- Avoid land uses that deplete natural resources.
- Retain large contiguous or connected areas that contain critical habitats.
- Minimize the introduction and spread of non-native species.
- Avoid or compensate for the effects of development on ecological processes.
- Implement land-use and management practices that are compatible with the natural potential of the area.

These guidelines are incorporated into the following management framework, both explicitly and implicitly.

KNC's Educational Philosophy

Education is one of the three areas of focus for KNC, in addition to land protection and research. KNC plays a unique educational role in the greater community of southwest Michigan. It

[8] Dale VH, *et al.* Ecological principles for managing land use [Internet]. Washington, DC: The Ecological Society of America; 2000 Jun 1 [cited 2016 Mar 26]. Available from http://www.esa.org/esa/science/reports/managing-land-use/

functions as an educational institution for the purpose of "*providing experiences that lead people to understand their connection to the natural world.*"[9] Visitors are introduced to the natural world through various educational programs. To create opportunities for environmental education and interpretation for active participants and casual visitors, many interactive, dynamic programs are provided for different age groups.

KNC's first program was a summer camp that focused on young children and families, who remain the main participants in KNC's educational programs. Today, staff and volunteers in the Education Department run diverse programs serving high school, undergraduate, and graduate students, as well as adults, to ensure that all people can have meaningful experiences in nature. KNC has established itself as a leader in the "No Child Left Inside" movement. The aim of this movement is to shape happier, healthier childhood through direct connections with the outdoors in children's daily lives.[10] Over 30,000 children participate each year in school programs provided by KNC, both outdoor on the Main Site and in the classrooms. The Nature's Way Preschool program has served the needs of two generations and is still going strong (see Chapter 6 for more information).

Besides being responsible for land protection, the Stewardship Department is also actively engaged in many outreach projects. For example, KNC operates one of the largest bird banding and monitoring programs in the Midwest, and leads the research and publication of the Michigan Breeding Bird Atlas. KNC has also partnered with the Imperiled Butterfly Conservation Initiative and the Michigan Butterfly Network. They are also currently working with private property owners, teaching them how to conserve and better protect their land. KNC works with partners throughout the state, such as libraries, minority neighborhoods, community associations, and park districts to conduct educational outreach programs.

On the Main Site, Cooper's Glen has been a hub for environmental education since before KNC's inception. Today, the majority of on-site education and interpretation programs occur at the Interpretive Center, the Arboretum, the Hummingbird/Butterfly Garden adjacent to the Arboretum, and the Barnyard. The Main Site's extensive trail system passes through a diverse array of habitats and ecosystems, allowing visitors to experience different habitat types, species, and successional stages. The River Walk Trail gives visitors an overview of the Kalamazoo River ecology and geologic history and provides opportunities to learn about the floodplain habitats. The Bluebird Trail shows visitors the importance of restoring and preserving prairie habitat. Areas in the gravel pit near the Interpretive Center are used to find and study fossils. Visitors to the DeLano Homestead will learn about small-scale farming and the history of the homestead. See Chapter 4 for more information about the Main Site. Off the Main Site, the Heronwood Field Station provides programming and project opportunities for local school districts, with fully equipped laboratories, a GIS station, and rooms for projects. A lab- and field-based course for high school students gives hands-on ecological experience (see Chapter 5).

[9] About the Kalamazoo Nature Center [Internet]. Kalamazoo (MI): Kalamazoo Nature Center. [cited 2016 Mar 28]. Available from http://naturecenter.org/Home/TheKNCMission.aspx

[10] No Child Left Inside [Internet].Kalamazoo (MI): Kalamazoo Nature Center. [cited 2016 Mar 30].Available from http://www.naturecenter.org/Programs/SchoolsandGroups/NoChildLeftInside.aspx

Plans for the Future

Many of KNC's plans for the future were well laid out in the previous iteration of this LMP. The general goals and operating mindset may be the same, but some updates have been made to reflect projects that have been completed. For example, the previous LMP focused heavily on increasing prairie habitat, but now that the Willard Rose Prairie is complete, that goal is less of a priority.

Far-sighted management of KNC's properties requires combining a diversity of goals, including research, education, restoration, and an overall harmony with nature. In general terms, this LMP encourages KNC to create large contiguous areas of similar habitat, a diverse array of these contiguous habitats, and robust corridors connecting these habitats to similar areas around the region.

Nested within these goals is the conservation of important plants and animals, including rare species and species of management concern. Alongside this larger ecological goal, this LMP also prioritizes KNC's ongoing task of fostering opportunities for environmental education and interpretation, both for the active participant and the casual visitor.

Staff Surveys

Staff surveys are a useful tool in assessing the priorities, goals, and concerns of the people that interact with this land. These surveys are designed to understand overarching priorities and to help allocate resources effectively. These data show the range of opinions across the organization and emphasize the need to communicate across departments when making decisions.

A survey was conducted in Winter 2004 seeking to understand what the staff viewed as opportunities, challenges, strengths and weaknesses in KNC's land management. A similar survey was conducted in Winter 2015 with the goals of understanding how feelings have changed over the last decade and identifying new opportunities and areas of concern.

The survey was broken into four categories: Opportunities, Concerns, Strengths, and Challenges. Table 2.1 provides the items with the highest and lowest average rankings within each category. Each question could be ranked from 1-5, with 1 indicating a low level of perceived importance and 5 indicating a high level of perceived importance. The full results of the 2015 survey are in Appendix IV.

Table 2.1: The highest and lowest average score for each section of the 2015 KNC staff survey.

Category	Question	Average Score
Opportunities	Build more funding in the general operating budget	4.52
	Expand the trail system in the Arboretum	2.39
Concerns	Insufficient staff to maintain existing properties, let alone newly added ones	4.26
	Not enough prairie habitat	2.54
Strengths	Having a variety of diverse habitats represented across the property	4.85
	Access to the Arboretum	2.93
Challenges	Insufficient staff to maintain both trails and invasive species control programs / insufficient long-term funding for existing programs and projects (tied)	4.39
	Effect of ecological succession in gravel pit on educational opportunities	3.04

Potential Restoration and Reconstruction Projects

Restoration refers to the practice of repairing a degraded system or community, while reconstruction creates a community "from scratch," as in converting a cornfield to a prairie. However, it is often more complicated than choosing the right plants to put in the ground. Ecological processes help structure spatial dynamics and other factors of plant communities, such as hydrology, determining the distribution of plant species.[11] Restoration of soil structure, hydrology, and other abiotic elements is essential to the effort. Additionally, site limitations must be considered. For example, tree replacement efforts in certain areas, especially where soil has been removed or adversely affected (e.g., the gravel pit) should be tempered with consideration of potential limiting factors like water and nutrient availability and mortality due to deer browse.[12] Fire is a conspicuous tool in the management of prairies and other ecosystems, but it is only one of many tools used to encourage diversity and stability. For example, when planning to convert an agricultural field into a prairie, it is a good idea to start a few years in advance by

[11] Gilbert, GS. Evolutionary ecology of plant diseases in natural ecosystems. Annual Review of Phytopathology. 2002; 40.1: 13-43.

[12] Hau, BCH, Corlett RT. Factors affecting the early survival and growth of native tree seedlings planted on a degraded hillside grassland in Hong Kong, China. Restoration Ecology. 2003; 11.4: 483-488.

changing agricultural practices (e.g., no-till, retaining stubble, planting a cover crop) in order to build up organic matter and soil health. This will result in living soils that will better support a prairie planting.

Questions one would want to ask a local soil conservation district or extension agriculture specialist include: What is the ideal rotation for this land? What soil manipulations will be compatible with these crops? These questions have been posed in the restoration literature and answers may be available in publications such as *Ecological Restoration, Restoration Ecology, Ecological Applications, Natural Areas Journal* and others.

Chapter 3: Today's Management Framework

Summary of Common Habitat Communities

Table 3.1 summarizes the distribution of common habitat communities across KNC's eight properties as of Spring 2016. The first grouping of habitat categories are based on a community classification developed by the Michigan Natural Features Inventory (MNFI). The second grouping includes more generalized habitat types. *Y* indicates the presence of a habitat on a given property. Individual management compartments are named, if relevant.

Table 3.1: Distribution of common habitat communities across KNC's eight properties.

	Habitat Description	Main Site	Harris Prairie	Heronwood Field Station	West Fork Campus	Urban Nature Park	Bullhead Lake	Grand Mere Dunes	Pitsfield Banding Station
MNFI Habitat Communities									
Oak Savanna (Oak Openings)	Forb-rich grassland with scattered oak trees and few shrubs					Y (upland unit)			
Dry-Mesic Southern Forest	Oak or oak-hickory forest	Y (P1-P5, U5)	Y (C1, C2, C3)				Y (Oak-hickory unit)		
Mesic Southern Forest	Beech-maple forest	Y (A1-A3, C1-C5, F3, F4, U1, U2, U3, U4, U6, U7)	Y (C4)	Y (C1)	Y (C1, C2)				Y
Southern Floodplain Forest	Deciduous or deciduous-conifer forest dominated by maple, ash; found near rivers	Y (F1, F2, Z)							
Mesic Prairie	Forb-rich grassland	Y (N1, N2, N3, O5, T1, O7, H2, H3, X)	Y (N1, N2, N3, N4)						Y
Southern Wet Meadow (Sedge Meadow)	Sedge-dominated wetland	Y (S2, S3)							

Emergent Marsh	Shallow-water wetland	Y (E1-E5)							
Inundated Shrub Swamp	Continually inundated shrub community with sparse herbaceous groundcover	Y (I1, I2, I3, I4)							
Southern Shrub-Carr	Shrub-dominant wetland characterized by willows, dogwoods	Y (S1)							
Non-MNFI Habitat Types									
Oldfield	Former agricultural field	Y (O1-O4, O6-O10)		Y (O1, O2)					
Pond	Seasonal or permanent	Y (POND1 - POND12)	Y	Y (W3, W4)					Y
Stream	--	Y			Y (W1, W2)				
Undifferentiated Wetland	Wetland with unknown species composition			Y (W1, W2)		Y (wetland unit)			
Active Agricultural field	--	Y (T2, H1, H4, H5)	Y (T1)						
Gravel pit	Inactive extraction site	Y (G)							Y
Dunes complex								Y	
Developed/ buildings		Y (M)		Y (D1)	Y (D1, D2)				

Nuisance Species

Invasive Species

The Invasive Species Handbook (Appendix II) provides detailed information on the ecology and control of specific invasive plant species. The Handbook also contains a prioritization scheme for approaching the control of invasive plants found on the property. In general, invasive species control efforts should focus first on high-quality, high-priority areas. Within those areas, while a site-specific decision should always be independently made, Priority 1 invaders should be the initial focus of control efforts. The threat of invasive species is a constantly shifting one, as new invaders arrive or existing species spread. The Handbook should be revisited and updated often to reflect new or spreading invasive species, innovative control methods, or hotspots to be targeted in future control efforts.

The Biological Inventory, which is not part of this LMP, contains information on invasive mammals, insects, and mollusks.

White-Tailed Deer

Native white-tailed deer (*Odocoileus virginianus*) become problematic when their populations grow to the point of ecological damage. Perhaps the most obvious way deer negatively affect an ecosystem is over-browsing. Deer browse on young growth so that seedlings, saplings, and much of a forest understory is depleted, jeopardizing tree recruitment and regeneration. [13] [14]

KNC produced a deer management plan in 2012. KNC has conducted deer culls on its Main Site and will continue to do so as an effective means of population control until a more efficient method is found. Culling the deer population is an effective way to strategically reduce the negative impacts of deer, but it also comes with some controversy. Educating the public on the importance of a cull may be necessary. Deer exclosures may also be a means to protect tree seedlings and saplings; however, this method only helps a slim selection of vulnerable plants and bears a high time-cost. Other management techniques, as described in the deer management plan, include:

- Trap and transfer
- Predator reintroduction
- Supplemental feeding
- Fencing and repellents
- Fertility control and sterilization

[13] Rawinski TJ. Impacts of white-tailed deer overabundance in forest ecosystems: an overview [Internet]. Newtown Square (PA): U.S. Forest Service; 2008 June [cited 2016 Apr 11]. Available from http://www.na.fs.fed.us/fhp/special_interests/white_tailed_deer.pdf

[14] Rooney TP, Waller DM. Direct and indirect effects of white-tailed deer in forest ecosystems [Internet]. Madison (WI): University of Wisconsin; 2003 May 6 [cited 2016 Apr 11]. Available from www.sciencedirect.com/science/article/pii/S0378112703001300)

Prescribed Fire

The Michigan Natural Features Inventory (MNFI) lists prescribed fire as a key management tool for many of the natural communities found at the Kalamazoo Nature Center including mesic prairies, southern wet meadows, and dry-mesic southern forests. Fire can help promote oak regeneration, reduce encroachment by invasive and other unwanted species, stimulate seed germination, and can lead to greater biodiversity. Conversely, there can be negative consequences if burn plans are made poorly or not carried out properly. Aside from the risk of fire spreading to unwanted locations if safety precautions are not followed, other potential consequences of poor planning can include endangering non-plant species residing in the habitats, damaging desired plant species, or even promoting invasive species spread. Each site where prescribed burns are recommended will have specific recommendations within the site plan.

KNC has been using prescribed fire as a management tool for several decades, going back to at least the early 1990s. Areas that have undergone fire management include the fens S1 and S3 and the restored prairies at KNC's Main Site, as well as parts of the Harris Prairie property. There has generally been a two- to four-year rotation between burns at a given site to provide refuge for species that inhabit the area. At each site where burns have been a part of the management strategy, the site plan will contain details of the burn history.

As with other management techniques, it is of paramount importance to understand what is being managed with fire. If the goal is to enhance native species diversity, the prescription will be different than if the goal is to control cool-season grasses. As Tyler Bassett noted in his prior plan: "while 'because it's a prairie' may seem a good enough reason on one level to burn (because prairies need fire to persist), the end results will be greatly improved if the goal is more specific." Bassett also noted that simulated beaver-floodings can be used in wetland habitats as a substitute for prescribed burns with similar results, such as reduced shrub cover.

There are several considerations that need to be made when planning a prescribed burn. One consideration is the timing of the burn. Different species (both native and invasive) have different life histories and their response to fire depends on when the burn occurs. There are two primary burn seasons: spring and fall, with spring being the longer season and split into two sections (mid-spring and late-spring).[15] Different management goals may require different burn timings. For instance, if trying to control woody plants, a late-spring burn may be most useful, but this can be detrimental to wildflowers. Bassett's 2004 LMP noted that summer burning can be effective for controlling spotted knapweed (*Centaurea maculosa*) in the Midwest. For more information on management recommendations for key invasive species at KNC, refer to Appendix II or individual site plans. Another consideration in planning is the time between burns. The MNFI notes that burning too often can reduce or eliminate the presence of fire-intolerant species that can be beneficial to the ecosystem, so waiting a few years between burns or alternating the burnings of adjacent areas can provide alternative habitats for these species.

[15] Sargent MS, Carter KS. Managing Michigan Wildlife: A landowner's guide [Internet]. East Lansing (MI): Michigan United Conservation Clubs; c1999. 297pp. Available from http://www.michigandnr.com/publications/pdfs/huntingwildlifehabitat/landowners_guide/

The Nature Conservancy provides a useful fire management manual online at http://www.tncfiremanual.org/index.htm.[16] The fire management process begins by asking if fire management is needed and how the fire fits into the site's conservation plan, as well as covering various planning requirements. The process of conducting a burn includes the following steps:

- Determine purpose of the burn.
- Develop site fire management plan.
- Develop or update prescribed burn plan.
- Get plan approval.
- Organize and train crew.
- Conduct burn.
- Evaluate burn.
- Monitor.
- Refine plans and burn again.

KNC's Great Lakes Ecological Management (GLEM) team works with landowners around the state of Michigan on all stages of land management, including prescribed burns. Ryan Koziatek, the field director of the GLEM team, helped organize the Burning Issues Symposium through the Lake States Fire Science Consortium which took place in February 2016. This symposium was planned with the idea of bringing together "land managers, researchers, resource specialists, and fire practitioners" to share expertise and discuss the future of fire as a management tool.

In the Western United States, climate change is leading to increased temperatures and drought, causing longer and more intense wildfire seasons. Similarly, in the Midwest, climate change is manifesting in the form of increasing temperatures and drier summers, accompanied with more extreme precipitation events in winter and spring.[17] This change will add more weight to the thoughtful planning of burns. Safety procedures will be increasingly important to prevent the spread of fires outside the planned boundaries. The 2014 National Climate Assessment report also suggests that climate change will bring greater competition from invasive and opportunistic species, further necessitating the wise implementation of prescribed burn plans.

Climate Change and Adaptation

Why Factor In Climate Change?

KNC is choosing to take a proactive approach toward climate adaptation. Rather than waiting to see how Michigan's climate changes in the next 50-100 years, KNC staff can glean insights from climate models and anticipate challenges before they arise. Understanding those challenges now will be the first step to taking action to prevent consequences down the road. Predictions in this section are drawn from established climate science and represent most likely scenarios for Michigan's future weather and climate conditions.

[16] Heumann, B. Fire Management Manual [Internet]. Arlington (VA): The Nature Conservancy; c2014 [cited 2016 March 20]. Available from http://www.tncfiremanual.org/

[17] National Climate Assessment (US). Global Climate Change Impacts in the United States [Internet]. Washington, DC: U.S. Global Change Research Program; 2014 Jun 13 [cited 2013 Sep 12]. Available from http://acd.od.nih.gov/Diversity%20in%20the%20Biomedical%20Research%20Workforce%20Report.pdf

Projected Climate Trends

Kalamazoo County is part of US Climate Division 8, as delineated by the National Oceanic and Atmospheric Administration.[18] Average annual temperatures in the Great Lakes region have already increased more than 1.5 degree Fahrenheit from 1900 to 2010.[19] Models predict that Michigan's climate will warm 10 times more quickly in the next 40 years than it did in the past 100 years. This could result in an average temperature increase of between 4.5 and 5.5 degrees Fahrenheit by 2100.[20] Warmer winters have already extended the frost-free season by 9 days since the 1950s and will continue to extend it further.[21]

Across the Midwest, rainfall during heavy precipitation events has already been increasing.[22] Since the 1950s, Great Lakes states have seen a 37-percent jump in heavy storm precipitation.[23] The region has seen an 11-percent rise in total annual precipitation since 1900.[24] In the future, warmer atmospheric conditions will generate stronger and more frequent extreme weather events. Precipitation levels are difficult to predict, but they will almost certainly become more chaotic and irregular. Michigan's winters will see more rain than snow, and summertime droughts will become the norm. Intense storms will deliver substantial amounts of precipitation, increasing flood risk.[25]

Models developed through the Great Lakes Integrated Sciences and Assessments program deliver specific annual forecasts for southern Michigan. In 2041-2070, this part of the state is predicted to see 20-40 more days over 90 degrees Fahrenheit, 25-30 fewer days below freezing, 40-50 more frost-free days, 2-4 more inches of average precipitation, and 0.5-1.5 more days of heavy precipitation.[26]

Ecosystem Effects

Plant species' habitats or life cycles may be interrupted by changes in temperature, precipitation, disturbance regime, ice and snow cover, and pollination or dispersal mechanisms. Animals may experience the same interruptions, as well as disruptions caused by shifts in the blooming or fruiting periods in key vegetative food sources. Historically, Michigan's average precipitation

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[18] History of the US climate divisional dataset [Internet]. Washington, DC: National Oceanic and Atmospheric Administration [cited 2016 Mar 28]. Available from http://www.ncdc.noaa.gov/monitoring-references/maps/us-climate-divisions.php

[19] Fact sheet: what climate change means for Michigan and the Midwest [Internet]. Washington, DC: The White House Office of the Press Secretary; 2014 May 6 [cited 2016 Mar 28]. Available from https://www.whitehouse.gov/sites/default/files/microsites/ostp/MICHIGAN_NCA_2014.pdf

[20] Hoving CL, Lee YM, Badra PJ, Klatt BJ. Changing climate, changing wildlife [Internet]. Lansing (MI): Michigan Department of Natural Resources; 2013 April [cited 2016 Mar 28]. Available from https://www.michigan.gov/documents/dnr/3564_Climate_Vulnerability_Division_Report_4.24.13_418644_7.pdf

[21] Climate change in the Great Lakes region. Ann Arbor (MI): Great Lakes Integrated Sciences and Assessment; 2014 Jun 18 [cited 2016 Mar 28]. Available from http://glisa.umich.edu/media/files/GLISA_climate_change_summary.pdf

[22] Fact sheet: what climate change means for Michigan and the Midwest [Internet]. Washington, DC: The White House Office of the Press Secretary; 2014 May 6 [cited 2016 Mar 28]. Available from https://www.whitehouse.gov/sites/default/files/microsites/ostp/MICHIGAN_NCA_2014.pdf

[23] Climate change in the Great Lakes region. Ann Arbor (MI): Great Lakes Integrated Sciences and Assessment; 2014 Jun 18 [cited 2016 Mar 28]. Available from http://glisa.umich.edu/media/files/GLISA_climate_change_summary.pdf

[24] Ibid.

[25] Fact sheet: what climate change means for Michigan and the Midwest [Internet]. Washington, DC: The White House Office of the Press Secretary; 2014 May 6 [cited 2016 Mar 28]. Available from https://www.whitehouse.gov/sites/default/files/microsites/ostp/MICHIGAN_NCA_2014.pdf

[26] Great lakes regional climate change maps [Internet]. Ann Arbor (MI): Great Lakes Integrated Sciences and Assessments. [cited 2016 Mar 28]. Available from http://glisa.umich.edu/resources/great-lakes-regional-climate-change-maps

has varied little from year to year, so increasing instability will make it difficult for water-sensitive plant and animal species to adapt.

Plants and animals facing climate change will most likely react in one or more of the following ways: move their range, change how they spread out across their range, adjust the timing of life cycle or behavioral stages (also called phenology), or experience changes in morphology and genetics.[27] Scientists have already recorded incidences of earlier frog breeding, fish spawning, springtime bird arrivals, plant blooming, and egg laying patterns.[28] These phenology shifts will only become more prominent as the frost-free season extends backward into the spring.

In southern Michigan, vulnerable plant and animal species can't move up in elevation to track with their shifting temperature niches. Instead, they must move up in latitude. Researchers estimate that species in mountainous regions must move about 170 meters upward in altitude to reach an area that is 1 degree Celsius cooler than its current spot; species in flat terrains must move about 145 kilometers to the north to achieve the same temperature difference.[29] Some models predict that animals in the Midwest will need to move 1 kilometer per year or faster to track with the shifting climate.[30]

Some native plant and animal species will thrive as new or broader niches open up. Others will also thrive, but will do so far from their historic ranges. Still others will be unable to move or adapt in time to avoid climate-driven stress and may decline toward extirpation or extinction. Plenty of non-native and invasive plant and animal species are already equipped with the adaptive tools to cope with new climate patterns. In some cases, this might be a good thing: as characteristically northern tree species shift out of southwest Michigan, characteristically southern species—already adapted to warmer, drier conditions—will gradually take their place. In other cases, aggressive species like garlic mustard (*Alliaria petiolata)* and oriental bittersweet (*Celastrus orbiculatus)* will find abundant new territory as native species weaken and die.

There will be no easy answers or solutions. Michigan's resources managers will need to allow their concept of "native vegetation" or "invasive species" to evolve as the landscape does. Some familiar species will simply no longer thrive in Michigan, no matter how thoroughly managers work to save them. Other species will find their habitats challenged by new pests, diseases, and aggressive invaders, some of which can be controlled by swift and conscientious action. Managers may do well to focus on shoring up landscapes and watersheds, nutrient flows and niches rather than individual species.

Terrestrial Habitats

Characteristic northern forest species like paper birch (*Betula papyrifera*), tamarack (*Larix laricina*), quaking aspen (*Populus tremuloides*), balsam fir (*Abies balsamea*), jack pine (*Pinus banksiana*), and white and black spruce (*Picea glauca, P. mariana*) will decline as they retreat northward; southern oaks (*Quercus spp*.) and pines (*Pinus spp.)* will shift northward into

[27] Hall K. Climate change in the Midwest: impacts on biodiversity and ecosystems [Internet]. The Nature Conservancy; 2012 [cited 2016 Mar 28]. Available from http://glisa.umich.edu/media/files/NCA/MTIT_Biodiversity.pdf
[28] Ibid.
[29] Ibid.
[30] Ibid.

southern Michigan.[31] [32] [33] Oak-hickory forests, found on some of KNC's properties, are predicted to fare well.[34] Threat of forest damage by insect pests and disease, drought, and wildfire will intensify.[35]

With warmer temperatures and milder winters, Michigan's growing season may increase by 4-9 weeks compared to the growing seasons in 1961-1990.[36] At the same time, agricultural fields will face wetter wet periods and drier dry periods, which may counteract any positive effects from the extended growing season. This trade-off could most directly affect KNC staff managing the DeLano farm. Properties surrounded by heavy agriculture may experience drops in the water table as nearby farmers rely more heavily on irrigation during dry summers. This can dry up surface water bodies and leave tree roots without access to water.

Aquatic Habitats

Many of KNC's properties include or are located near vernal pools, ponds, lakes, streams, or rivers. Thanks to summertime droughts, lighter snow accumulation, and decreased ice cover, water levels in inland lakes and wetlands are likely to decline.[37] All streams will experience reduced flows. Some streams, wetlands, shallow ponds, and vernal pools may dry up altogether or experience longer seasonal dry periods. In deeper ponds and lakes, rising surface temperatures may exaggerate the degree of temperature stratification at various depths, making it more difficult for oxygen and nutrients to move through the water column. This could create hypoxic dead zones along pond and lake beds. Stagnant waters may be more prone to algal blooms, which can range from decomposing nuisances to toxic hazards. Some cooler ponds and streams may warm to the point where cold-water fish and invertebrates lose their niches. Rivers and streams will be prone to flash flooding from heightened storms. They will also be vulnerable to increased sedimentation, runoff, erosion, and nutrient loading. Sedimentation can wipe out benthic habitat and nutrient overloads can stimulate over-productivity in algae and aquatic plants.

Wildlife

A 2013 vulnerability assessment run by the Michigan Department of Natural Resources estimated that 17 percent of terrestrial game species and 61 percent of terrestrial and aquatic

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[31] Fact sheet: what climate change means for Michigan and the Midwest [Internet]. Washington, DC: The White House Office of the Press Secretary; 2014 May 6 [cited 2016 Mar 28]. Available from https://www.whitehouse.gov/sites/default/files/microsites/ostp/MICHIGAN_NCA_2014.pdf

[32] Hoving CL, Lee YM, Badra PJ, Klatt BJ. Changing climate, changing wildlife [Internet]. Lansing (MI): Michigan Department of Natural Resources; 2013 April [cited 2016 Mar 28]. Available from https://www.michigan.gov/documents/dnr/3564_Climate_Vulnerability_Division_Report_4.24.13_418644_7.pdf

[33] Hodgins J. Warming climate has consequences for Michigan's forests [Internet]. Houghton (MI): United States Forest Service; 2014 Apr 11 [cited 2016 Mar 28]. Available from http://www.nrs.fs.fed.us/news/release/Mi-EVAS

[34] Hoving CL, Lee YM, Badra PJ, Klatt BJ. Changing climate, changing wildlife [Internet]. Lansing (MI): Michigan Department of Natural Resources; 2013 April [cited 2016 Mar 28]. Available from https://www.michigan.gov/documents/dnr/3564_Climate_Vulnerability_Division_Report_4.24.13_418644_7.pdf

[35] Hodgins J. Warming climate has consequences for Michigan's forests [Internet]. Houghton (MI): United States Forest Service; 2014 Apr 11 [cited 2016 Mar 28]. Available from http://www.nrs.fs.fed.us/news/release/Mi-EVAS

[36] Lusch DP. Climate change: water implications for Michigan's communities, landsystems, and agriculture [Internet]. Lansing (MI): Michigan State University [cited 2016 Mar 28]. Available from http://msue.anr.msu.edu/uploads/234/62936/Climate_Change_Water_Implications_for_Michigan.pdf

[37] Ibid.

"Species of Greatest Conservation Need" are vulnerable to climate change.[38] Examples of Michigan species predicted to be highly or extremely vulnerable to climate change include salamanders (*Caudata spp.)*, snails, eastern Massasauga rattlesnake (*Sistrurus catenatus*), Blanding's turtle (*Emydoidea blandingii*), freshwater mussels, Mitchell's satyr butterfly (*Neonympha mitchellii mitchellii*), Karner blue butterfly (*Lycaeides melissa samuelis*), and eastern box turtle (*Terrapene carolina carolina)*. Aquatic and cold-blooded species will be at particularly high risk, as will those that require cold or cool stream habitats.[39]

Some native animals seen in abundance around KNC's properties, such as white-tailed deer *(Odocoileus virginianus*) and wild turkey (*Meleagris gallopavo*), will not likely experience significant changes in population or distribution, although warmer winters could shift migration patterns and affect forest regeneration, particularly in the case of deer.[40]

Migratory birds passing through southern Michigan may be met with shifts and challenges at all points in their migratory pathways. In Michigan, the most likely threat will be a mismatch with the timing or availability of flowers, berries, and seeds that currently provide staple food sources for migrants. Habitat generalists are predicted to fare well, while habitat specialists may decline or face extinction.[41]

General Management Actions[42]

- Redesign parking lots, trails, and other drainage pathways to accommodate heavier precipitation; install rain gardens, bioswales, permeable pavement and other structures that encourage absorption of stormwater runoff.
- Install or protect riparian buffers along lakes, ponds, rivers, and streams.
- Preserve aquatic species by understanding and protecting wetlands, vernal pools, and free-flowing streams.
- Encourage intact river floodplains and wetlands to prevent flooding and erosion.
- Discourage or prohibit the movement of firewood or boats, which easily transport pests and invasive species.
- Install wind turbines in locations and positions that reduce impacts to migrating birds and bats.
- Create and preserve large areas of diverse habitat and ensure the habitats are connected by corridors of undeveloped land.
- Maintain, protect, and restore rare types of habitat.

[38] Hoving CL, Lee YM, Badra PJ, Klatt BJ. Changing climate, changing wildlife [Internet]. Lansing (MI): Michigan Department of Natural Resources; 2013 April [cited 2016 Mar 28]. Available from https://www.michigan.gov/documents/dnr/3564_Climate_Vulnerability_Division_Report_4.24.13_418644_7.pdf
[39] Hall K. Climate change in the Midwest: impacts on biodiversity and ecosystems [Internet]. The Nature Conservancy; 2012 [cited 2016 Mar 28]. Available from http://glisa.umich.edu/media/files/NCA/MTIT_Biodiversity.pdf
[40] Hoving CL, Lee YM, Badra PJ, Klatt BJ. Changing climate, changing wildlife [Internet]. Lansing (MI): Michigan Department of Natural Resources; 2013 April [cited 2016 Mar 28]. Available from https://www.michigan.gov/documents/dnr/3564_Climate_Vulnerability_Division_Report_4.24.13_418644_7.pdf
[41] Meyerson H. Climate change: the risks for Michigan birds [Internet]. The Outdoor Journal; 2014 Mar 7 [cited 2016 Mar 28]. Available from https://howardmeyerson.com/2014/03/07/climate-change-the-risks-for-michigan-birds/
[42] Hoving CL, Lee YM, Badra PJ, Klatt BJ. Changing climate, changing wildlife [Internet]. Lansing (MI): Michigan Department of Natural Resources; 2013 April [cited 2016 Mar 28]. Available from https://www.michigan.gov/documents/dnr/3564_Climate_Vulnerability_Division_Report_4.24.13_418644_7.pdf

- Foster microclimates with cooler or moister conditions, such as north-facing hillsides and streams with dense forest cover.[43]

Trail Maintenance and Development

Leave No Trace

Trails are more than pathways between two locations. They are also access points to unique ecosystems and places for relaxation and exploration. KNC's Main Site has a robust and well-maintained trail system. Other properties have small trail systems or informal footpaths. On its formal trails, KNC asks its trail users to observe "leave no trace" practices.[44] This means staying on marked paths, leaving natural objects where they are, carrying out all garbage, and respecting wildlife. Bicycles and dogs are not permitted. As staff develop trail systems on other properties, such as Harris Prairie or the Urban Nature Park, the same rules are expected to apply.

Designing Sustainable Trails

Whether they're heavily trafficked or rarely used, trails should be safe, accessible, and well-maintained. According to the National Parks Service, a sustainable trail is one that supports current and future use while discouraging inappropriate uses, causes minimal damage to soils and vegetation, keeps up with pruning and removal of encroaching plants, and doesn't adversely affect wildlife.[45] The Massachusetts Department of Conservation and Recreation further describes a sustainable trail as one that is located in areas already influenced by human activity, provides buffers to protect ecological and hydrologic systems, is designed to carefully manage stormwater runoff, limits tread erosion, and receives ongoing stewardship.[46]

Trail Placement

Trails should follow the contours of the natural terrain.[47] That said, water also moves along terrain contours, and water is a trail's greatest threat. Even small amounts of runoff, given enough time, can destructively erode the surface of the trail or the substrate supporting it. Some of the crushed stone trails on KNC's Main Site have become de facto drainage channels for rain falling on the Interpretive Center parking lot. Runoff has rutted the trails and deposited piles of crushed stone and soil on low-lying bridges. To avoid water problems, trails should be built on sites with good water flow and drainage. This will usually involve building on slopes and hills rather than on flat ground. Hillside trails should slope slightly away from the hill to allow water to drain off.[48] If a trail must be built near seasonally or perpetually damp environments, the trail

[43] Hall K. Climate change in the Midwest: impacts on biodiversity and ecosystems [Internet]. The Nature Conservancy; 2012 [cited 2016 Mar 28]. Available from http://glisa.umich.edu/media/files/NCA/MTIT_Biodiversity.pdf
[44] Trail map [Internet]. Kalamazoo (MI): Kalamazoo Nature Center [cited 2016 Mar 28]. Available from http://www.naturecenter.org/Portals/0/Trails/KNC%20Trail%20Map_2015.pdf
[45] Richards B. Pathways to trail building [Internet]. Tennessee Department of Environment and Conservation; 2007 Mar [cited 2016 Mar 28]. Available from http://atfiles.org/files/pdf/TNpathways.pdf
[46] Trail guidelines and best practices manual [Internet]. Boston (MA): Massachusetts Department of Conservation and Recreation; 2014 Oct [cited 2016 Mar 28]. Available from http://atfiles.org/files/pdf/MA-Trails-Guidelines-Best-Practices.pdf
[47] Jones M. ADA access on paved bikeway [Internet]. Folsom (CA): Alta Planning + Design; 2007 May 11 [cited 2016 Mar 28]. Available from http://www.parks.ca.gov/pages/1324/files/accessible_trails_fri2007.pdf
[48] Trail guidelines and best practices manual [Internet]. Boston (MA): Massachusetts Department of Conservation and Recreation; 2014 Oct [cited 2016 Mar 28]. Available from http://atfiles.org/files/pdf/MA-Trails-Guidelines-Best-Practices.pdf

should follow the edge of the wet habitat above the typical high-water line. If a trail must cross a wet environment, it should be elevated as a boardwalk or bridge.

Bridges can also help trail users cross ravines, creek beds, or sensitive habitats. Bridges can be constructed of lumber or recycled plastic "wood", should match the width of the trail, and should include railings between 42 and 48 inches high.[49]

In addition to several bridges, KNC also has a tunnel on the Main Site that allows trail users to pass underneath Westnedge Avenue to access Green Heron Ravine trail and a second tunnel beneath the railroad tracks on the east side of the property between the Beech Maple and River Walk trails. Tunnels can provide an effective way for trail users to cross a busy street without getting in harm's way. But tunnels come with their own set of challenges: permission from transportation officials, construction equipment, drainage, and lighting. KNC won't likely need to build any more street-crossing tunnels on the Main Site or any other properties. If further tunnels are needed, they can be built with corrugated metal or pre-cast concrete culverts, should rise at least 10 feet from the trail's surface, and should be at least the width of the trail.[50]

Facilitating Access and Use

Trailheads should be attractive and inviting, with all the information users need to be able to enjoy the trail as designed. For sites where trails are supposed to be used only lightly (such as those at Harris Prairie or Pitsfield Banding Station), simply leaving a trailhead inconspicuous or unmarked may not be enough to reduce curious traffic. It may be better to provide information and guide the behavior of users than to hope passersby ignore their curiosity and stay off the trails. Trail signs should be carefully designed for conveying information to all users. Attention should be paid to choosing weatherproof materials, legible fonts, and distinctive colors. More extensive trail systems, such as those in the Main Site, should be accompanied by portable maps. Wayfinding signs should be posted at each junction.

Trails catering to users of differing ages and abilities (such as those around the Interpretive Center or Nature's Way Preschool) should be wide, flat, densely packed, and with more space between the trail and surrounding vegetation.[51] Trails designed to mimic a "more natural" experience (like those at the Heronwood Field Station or proposed trails at Harris Prairie) should be narrower, closer to surrounding vegetation, and snug against the natural contours of the land. Benches and signs should be made of natural materials.

All available trail surface materials come with pros and cons. Most of KNC's trails are made of crushed stone or packed earth. These materials tend to be better for pedestrians than asphalt or concrete, because they're easier on users' knees and are less likely to develop cracks.[52] However, crushed stone or dirt trails are very susceptible to erosion, ruts, and tripping hazards from larger

[49] Bridges [Internet]. Rails-to-Trails Conservancy [cited 2016 Mar 28]. Available from http://www.railstotrails.org/build-trails/trail-building-toolbox/trail-building-and-design/bridges/

[50] Tunnels and underpasses [Internet]. Rails-to-Trails Conservancy [cited 2016 Mar 28]. Available from http://www.railstotrails.org/build-trails/trail-building-toolbox/trail-building-and-design/tunnels-and-underpasses/

[51] Ontario's best trails [Internet]. Trails for All Ontarians Collaborative; 2006 [cited 2016 Mar 28]. Available from http://atfiles.org/files/pdf/ontario-design-construction-maintenance-sustainable-trails.pdf

[52] Surfaces [Internet]. Rails-to-Trails Conservancy [cited 2016 Mar 28]. Available from http://www.railstotrails.org/build-trails/trail-building-toolbox/trail-building-and-design/surfaces/

rocks or raised roots. KNC should continue using crushed stone for heavily used trails wherever feasible. These materials blend well with the natural surroundings, allow for seamless trail edges, require little maintenance, and are cheaper. Wood chips are also a viable option but should only be used for short stretches of trail, as they must be rechipped or regraded every few years.[53] If the edges of the trails need to be protected, native material like logs, rocks, or taller vegetation should be used.

Trail users shouldn't have to duck to avoid low-hanging branches; vegetation overhanging the trail should be trimmed to at least 8 feet above the ground. The same goes for vegetation on the sides. Plants growing, leaning, or falling into the path from the sides should be moved or trimmed back. Sometimes, trails will carry users past plants which shouldn't be touched. Staff should clear all trails and edges of plants with thorny stems (raspberry, blackberry), rash-inducing leaves (poison ivy, poison sumac, stinging nettle), or clingy seeds. If the trail goes through a dense patch of any of these plants, the surrounding vegetation should be trimmed back far enough to allow two people to walk next to each other without brushing the plants. If foot traffic isn't heavy enough to prevent plants from growing up through the trail surface, the trail should be regularly mowed or weed-whacked.

Balancing Access with Preservation

Land managers must decide when it's appropriate to build a trail so people can visit and enjoy a particular location, and when it's appropriate to leave the area inaccessible to visitors. For example, constructing a trail through one of KNC's Main Site sedge meadows would give visitors a close-up look at a unique ecosystem with plants not found anywhere else on the property.

However, building the trail would irreversibly damage the ecosystem, especially because the area's moisture would require heavier infrastructure (boardwalk or elevated walkway) than trails through wooded areas. Facilitating access also increases the likelihood that visitors will leave the trail and probe farther into the sedge meadow, causing damage and disturbing wildlife.

Examples of habitats where trails may not be appropriate include: wetlands and other seasonally or perpetually inundated landscapes, steep hillsides, prairies, areas where ground-nesting birds have been identified, areas where endangered plant or animal species have been identified, and working farms.[54]

Sometimes the best thing is to build an overlook that brings visitors right to the edge of the ecosystem and provide signs describing what species and natural processes exist within it.

[53] British Columbia State Park trail design and construction standards manual [Internet]. Trails to Build; 2014 [cited 2016 Mar 28]. Available from http://www.trailstobuild.com/Articles/BC%20Trail%20Standards/contents.htm

[54] Developing trails in sensitive areas [Internet]. Rails-to-Trails Conservancy [cited 2016 Mar 28]. Available from http://www.railstotrails.org/build-trails/trail-building-toolbox/trail-building-and-design/developing-trails-in-sensitive-areas/

Water Quality

River and Stream Water Quality Monitoring

The Kalamazoo River and its tributaries form a network draining approximately 2,020 square miles of southwest Michigan.[55] The Nature Conservancy has identified the Spring Brook-Kalamazoo Nature Center region as one of the more important areas in the Kalamazoo River Watershed because of the endangered Mitchell's Satyr butterfly (*Neonympha mitchellii*).[56]

However, the watershed faces its share of challenges, largely stemming from industrial legacy pollutants. Historical contamination from polychlorinated biphenyls (PCBs) generated by paper mills led the EPA to classify 80 miles of the Kalamazoo River as a Superfund cleanup site.[57] The Enbridge oil spill of 2010 dumped 843,000 gallons of crude oil, which spread along 38 miles of the Kalamazoo River and required extensive remediation.[58]

KNC hopes to establish consistent water-quality monitoring and hydrological data collection in all of its on-site streams. Long-term monitoring data can demonstrate the status and trends of a stream's water and habitat quality, which can assist in targeting management actions toward specific problem areas.

The Michigan Clean Water Program (MiCorps) is a network of volunteer water monitoring programs in Michigan.[59] Standard MiCorps monitoring methods include stream habitat assessments and macroinvertebrate sampling, which will be described below.[60] The macroinvertebrate community is monitored and identified to the ordinal level twice annually in April and October. Habitat is also monitored at least every five years before leaf-out in the spring or after leaf-off in the fall.

The Kalamazoo River Guardians (KRG) is a volunteer water-monitoring program established by KNC, Kalamazoo College, Western Michigan University, Michigan State University, and the Kalamazoo River Watershed Council.[61] This program has been sampling on the Kalamazoo River and its tributaries since 2011, following MiCorps aquatic macroinvertebrate sampling methods. The data collected by KRG is summarized to compute the MiCorps Stream Quality Index score and total diversity measured across macroinvertebrate taxa.

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[55] Wesley JK. Kalamazoo River assessment [Internet]. Lansing (MI): Michigan Department of Natural Resources; 2005 Sep [cited 2016 Apr 11]. Available from http://www.michigandnr.com/PUBLICATIONS/PDFS/ifr/ifrlibra/Special/Reports/sr35/SR35.pdf

[56] Kalamazoo Watershed [Internet]. Watershed Central Wiki. [cited 2016 Mar 30]. Available from https://wiki.epa.gov/watershed2/index.php/Kalamazoo_Watershed

[57] Kalamazoo River superfund project [Internet]. Washington, D.C.: U.S. Environmental Protection Agency; 2016 Apr 5 [cited 2016 Apr 11]. Available from https://www3.epa.gov/region5/cleanup/kalproject/

[58] Mitchell A. Timeline of major events in Kalamazoo River oil spill [Internet]. Kalamazoo (MI): MLive; 2015 Jul 20 [cited 2016 Apr 11]. Available from http://www.mlive.com/news/kalamazoo/index.ssf/2015/07/kalamazoo_river_oil_spill_time.html

[59] About Michigan Clean Water Corps [Internet]. Michigan Clean Water Corps. [cited 2016 Mar 30]. Available from https://micorps.net/

[60] Latimore J. MiCorps Volunteer Stream Monitoring Procedures [Internet]. Ann Arbor (MI): Huron River Watershed Council; 2006 Aug [cited 2016 Mar 30]. Available from https://micorps.net/wp-content/uploads/VSMP-Macro-MonitoringProcedures.pdf

[61] River guardians [Internet]. Kalamazoo (MI): Kalamazoo River Watershed Council [cited 2016 Apr 4]. Available from http://kalamazooriver.org/events/river-gaurdians/

Stream Habitat Assessment

The MiCorps stream habitat assessment evaluates stream conditions and watershed characteristics, which can provide clues to the causes of stream degradation. Water quality parameters are evaluated against the state's surface water quality standards, as delineated by the Michigan Department of Environmental Quality (MDEQ).[62]

- **Water temperature**: directly affects many physical, chemical, and biological characteristics in aquatic ecosystems. Water temperature should be measured by a thermometer 3 feet below the surface. State standards set monthly caps on acceptable water temperatures for coldwater and warmwater fish habitats; the caps can be found on page 57 of the MDEQ Water Resources Protection Act, Part 4: "Water Quality Standards."[63]
- **Dissolved oxygen (DO)**: a measure of the amount of oxygen freely available in water, as a concentration in terms of milligrams per liter (mg/L) or ppm, or as a percent saturation. DO shouldn't fall below 5-7 mg/L, depending on the type of aquatic habitat.[64]
- **pH** a measure of the acidity or alkalinity of a water sample, on a scale of 0 to 14. pH for all surface waters should stay between 6.5 and 9 units.[65]
- **Turbidity:** a measure of water cloudiness, or the amount of material suspended in the water column. Greater quantities of material can raise water temperature or block sunlight. MDEQ standards state that surface waters shouldn't include an "unnatural" or "injurious" level of turbidity.[66]

Macroinvertebrate Sampling

Because of their varying tolerances to physical and chemical conditions, macroinvertebrates can serve as indicators of stream conditions. Data on macroinvertebrate populations are used to calculate the MiCorps Stream Quality Index and provide a straightforward summary of the ecological conditions of the stream that can be tracked over time.

MiCorps macroinvertebrate monitoring methods involve recording sampling location and stream conditions including average water depth, siltation, and embeddedness. Macroinvertebrates are collected from all available habitats within the stream. Then, all collected macroinvertebrates are identified to their order or sub-order using taxonomic keys. Macroinvertebrate data are summarized for reporting into four metrics: all taxa, insects, EPT (Ephemeroptera + Plecoptera + Trichoptera), and sensitive taxa. Units of measure are families counted in each metric. The total Stream Quality Index scores are calculated to rank the site as excellent, good, fair, or poor.

[62] Part 4. Water quality standards [Internet]. Lansing (MI): Department of Environmental Quality. [cited 2016 Mar 30]. Available from http://w3.lara.state.mi.us/orr/Files/AdminCode/302_10280_AdminCode.pdf
[63] Ibid.
[64] Ibid.
[65] Ibid.
[66] Common pollutants, sources and water quality standards [Internet]. Benton Harbor (MI): Southwest Michigan Planning Commission [cited 2016 Apr 11]. Available from http://www.swmpc.org/downloads/PPRW_Apdx9.pdf

Pond Water Quality Monitoring
Healthy ponds are important for maintaining water quality, hydrological processes, and viable animal populations. Water quality sampling methods can mimic those previously described for rivers and streams.

Septic Tank Evaluations
All KNC-owned houses on the Main Site have septic tanks. As Tyler Bassett has suggested, septic tanks should be tested for leakage and groundwater contamination every 3-5 years, or if evidence of contamination near any of the KNC-owned homes warrants a test.

Research

Field-based research is one of KNC's crucial components. Staff in KNC's Research Department partner with outside scientists, students, and volunteers to conduct a variety of ongoing and stand-alone research studies.

Research Grants and Expenditures
KNC receives research grants from a number of private and public organizations. According to internal records, research expenditures during the 2014 fiscal year accounted for 18.5 percent of KNC's total income and 23.2 percent of total expenses, second only to education program expenditures.[67]

University Collaborations
KNC often partners with universities and research institutions. Kalamazoo is home to Western Michigan University, Kalamazoo Valley Community College, and Kalamazoo College. KNC also cooperates with the University of Michigan, Michigan State University, Fort Hays State University, Central Michigan University, Wayne State University, Eastern Michigan University, Michigan Technological University, and Hope College.[68] Researchers from some of these schools have served KNC as board members.

This LMP was generated as a culminating project for five master's students at the University of Michigan School of Natural Resources and Environment (UM SNRE). Similar projects can and should be conducted in the future. As of Spring 2016, the primary contact for coordinating student projects UM SNRE is Erin Lane (eeallen@umich.edu).

Citizen Science
Citizen science at KNC includes a set of volunteer programs involving the public in scientific research. These volunteers work with research biologists and local university faculty to collect meaningful and useful data about habitats and species found on KNC's properties. As training is provided for most programs, volunteers need not have a professional science background, just a

[67] Combined Financial Statements (Year Ended August 31, 2014 with Comparative Totals for 2013). Kalamazoo (MI): Kalamazoo Nature Center. 2014.
[68] Developing a Comprehensive Land Management Plan for the Kalamazoo Nature Center's Eight Properties [Internet]. Ann Arbor (MI): School of Natural Resources and Environment, University of Michigan. [cited 11 Apr. 2016]. Available from http://www.snre.umich.edu/current_students/masters_projects/developing_a_comprehensive_land_management_plan_for_the_kalamazoo

will to learn and the ability to meet the time commitments. This is an effective way to let the public contribute to research, learn about the environment, and connect with nature. Many of these programs are also suitable for kids.

Currently, KNC offers many different scientific projects that the public can become involved with. Some of the opportunities offered as of 2016 include:

- **Avian surveys:** KNC works with the Michigan Audubon Society and other organizations to conduct bird surveys and counts throughout the year. These include the winter feeder survey (November-May), seasonal surveys, bluebird nest box monitoring, and Christmas bird counts.[69]
- **Butterfly monitoring**: participants are trained to identify common butterfly species, then conduct their own surveys at sites of their choosing. Data are submitted to the Michigan Butterfly Network (MiBN).[70]
- **River sampling:** KNC staff and volunteers spend a day sampling the Kalamazoo River watershed for aquatic macroinvertebrates as a part of the Michigan Clean Water Corps stream monitoring program twice a year.[71]
- **Monarch tagging:** Since 2006, KNC has coordinated volunteer activities to tag Monarch butterflies (*Danaus plexippus*).

In the future, survey and monitoring activities could be extended to include amphibians and mammals, perhaps by conducting a BioBlitz. According to National Geographic, a BioBlitz is:

> *"an event that focuses on finding and identifying as many species as possible in a specific area over a short period of time. At a BioBlitz, scientists, families, students, teachers, and other community members work together to get an overall count of the plants, animals, fungi, and other organisms that live in a place."*[72]

Property-specific research opportunities are highlighted in individual site plans.

[69] Citizen science [Internet]. Kalamazoo (MI): Kalamazoo Nature Center. [cited 2016 Apr 1]. Available from http://www.naturecenter.org/ConservationStewardship/CitizenScience.aspx
[70] Ibid.
[71] Ibid.
[72] BioBlitz 2016 [Internet]. National Geographic Society. [cited 2016 Apr 1]. Available from http://education.nationalgeographic.org/projects/bioblitz/

Chapter 4: Main Site

Main Site Management Plan

7000 N Westnedge Ave, Kalamazoo, MI 49009
(43.36349N, 85.59011W)

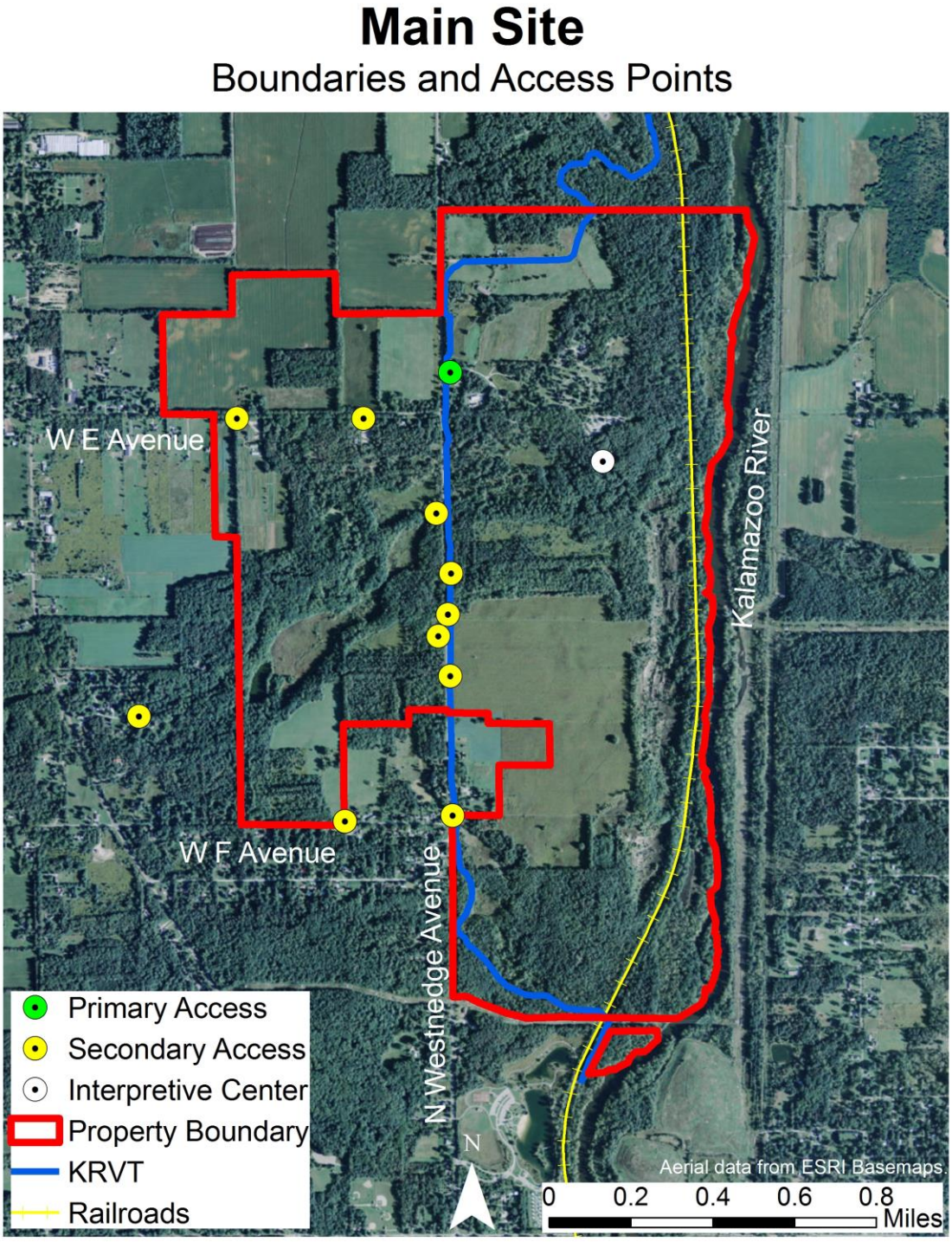

Figure 4.1: Main Site boundaries, access points, and built features.

Introduction

As KNC's largest and oldest property, the Main Site's 1,140 acres showcase diverse habitats and provide educational opportunities for a range of users. This location also houses KNC's Interpretive Center, summer camp facilities, staff offices, and an extensive trail system. A previous land management plan was developed for the Main Site in the mid-2000s. This 2016 update incorporates species inventory data and the results of priority-ranking surveys sent to KNC staff and volunteers in 2015.

History

The 85-acre portion of the property referred to as Cooper's Glen was purchased in 1960 by a group of community leaders to protect it from the expansion of nearby graveling operations. Dr. H. Lewis Batts, Jr. was the driving force behind the purchase of Cooper's Glen and the incorporation of the Kalamazoo Nature Center on the site.[73] After years of land acquisition by Dr. Batts, the current landholdings at the Main Site have now reached 1,140 acres.

Property acquisition history:

- 1960: 85-acre Cooper's Glen parcel, purchased from Koetje.
- 1961: Steele property north of the eastward extension of E Avenue, purchased from Steele.
- 1961: Pelikan property at 6960 N. Westnedge; now a staff residence.
- 1961: Moravetz property south of Cooper's Glen, purchased from Steele; the house and several acres surrounding it were added in 1969.
- 1962: Lancaster house at 6980 N. Westnedge; now a staff residence.
- 1963: Santee property at 6970 N. Westnedge.
- 1966: 40-acre Dykehouse property including Source Pond north of F Avenue.
- 1966 and 1968: DeLano Homestead and surrounding properties, purchased from Westras.
- 1968: 40-acre Johnson property at the northwest corner of E Avenue and Westnedge.
- 1968: Thole property along E Avenue.
- 1968: Koetje property, an irregularly shaped parcel on the west side of Westnedge.
- 1969: Russell property north of the Koetje property.
- 1971: Austin property east of the DeLano Homestead.
- 1972: 40-acre Earl property at 6601 N. Westnedge.
- 1977: parcel at the southwest corner of E Avenue and Westnedge.
- 1982: Centennial Farm south of the Earl property, purchased from the Laytons.
- 1990 and 1992: several large parcels at the south end of KNC, purchased from the Balkemas.

[73] Panich L. Make a statement: Kalamazoo Nature Center [Internet]. Kalamazoo (MI): Kalamazoo Nature Center; 2015 Jan 19 [cited 2016 Mar 30]. Available at http://blog.eccu1.org/kalamazoo-nature-center/

Property Composition

Landscape Context

KNC's Main Site is located in a rural area four miles north of Kalamazoo, MI. The property is surrounded by agricultural fields, residential parcels, a mining operation to the north, and Markin Glen County Park to the south. North Westnedge Avenue bisects the property from north to south. E Avenue and F Avenue both enter KNC's property from the west and dead-end at Westnedge. East of Westnedge, the Main Site is bounded to the south by a utility right-of-way and to the east by the Kalamazoo River. A railroad runs north to south through floodplain forest habitat in the east portion of the Main Site.

Property Composition

Geology and Glacial History

The Main Site is located within the Mississippian shale formation, which dates to the Paleozoic Era.[74] [75] The region was completely covered by glaciers until about 12,000 years ago.[76] The retreating glaciers deposited a hilly ridge of sediment and rocky debris, which is now called the Kalamazoo moraine and runs across southern Michigan from Hastings to Lenawee County.[77] The Main Site sits on the eastern edge of the Kalamazoo moraine's Lake Michigan lobe.[78] A layer of glacial material about 50-100 meters deep still sits atop the Main Site.[79] An esker, or raised ridge of sand and gravel, runs northeast-southwest across the middle of the property.[80] Other glacial features, such as kettle lakes and kames, are common in nearby areas.

Soil Types

According to USDA soil survey data, soils in upland areas at the Main Site are in the Oshtemo and Kalamazoo series, as well as some urban soil types. Lowland areas support soils of the Glendora series along the Kalamazoo River and the Houghton-Sebewa series elsewhere.

Watersheds and Aquatic Features

The Main Site occupies the central portion of the Kalamazoo River Valley. The valley is 2 kilometers wide, 50 meters deep and lies parallel to the Kalamazoo moraine.[81] The 250-km Kalamazoo River drains a watershed of more than 5,000 square kilometers before emptying into Lake Michigan near Saugatuck, MI.[82]

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[74] Albert DA. Regional landscape ecosystems of Michigan, Minnesota and Wisconsin: a working map and classification. St. Paul (MN): U.S. Forest Service North Central Forest Experiment Station; 1995.
[75] Kozlowski AL, Kehew AE, Bird BC. Outburst flood origin of the central Kalamazoo River valley, Michigan, USA. Quaternary Science Reviews. 2005; 24(22): 2354-2374.
[76] Dorr JA, Eschman DF. Geology of Michigan. Ann Arbor (MI): University of Michigan Press; 1970. 476 pp.
[77] Schaetzl R. Moraines [Internet]. Lansing (MI): Michigan State University [cited 2016 Apr 11]. Available from http://geo.msu.edu/extra/geogmich/moraines.html
[78] Kozlowski AL, Kehew AE, Bird BC. Outburst flood origin of the central Kalamazoo River valley, Michigan, USA. Quaternary Science Reviews. 2005; 24(22): 2354-2374.
[79] Passero RN, Chase KM, Chase LJ, Straw WT. Kalamazoo: geology and the environment. Kalamazoo (MI): Western Michigan University; 1978. 144 p.
[80] Bassett T. Kalamazoo Nature Center Land Management Plan 2012. Lansing (MI): Michigan State University; c2012. Available upon request from Kalamazoo Nature Center.
[81] Kozlowski AL, Kehew AE, Bird BC. Outburst flood origin of the central Kalamazoo River valley, Michigan, USA. Quaternary Science Reviews. 2005; 24(22): 2354-2374.
[82] Ibid.

Five watersheds overlap with the Main Site's boundaries: Trout Run, North Stream, South Stream, Northwest Drainage, and Kalamazoo River (see Figure 4.2). The entire Trout Run watershed is contained within the Main Site, a legacy of KNC founder Lew Batt's strategic property acquisitions. Of the Main Site's total acreage, Trout Run drains 625 acres, North Stream drains 200 acres, and South Stream drains 324 acres. Northwest Drainage covers 51 acres and drains to the north. The 94-acre floodplain forest between the railroad and the Kalamazoo River drains directly into the river.

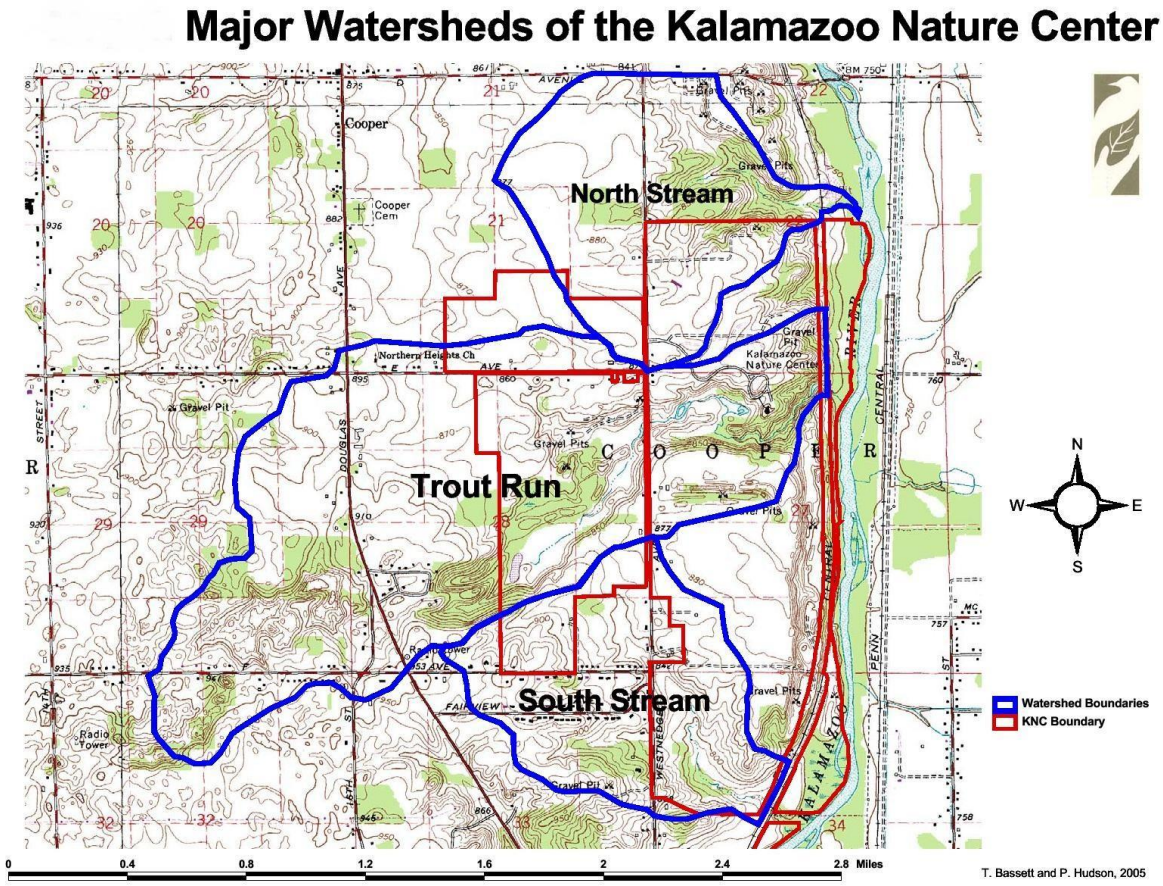

Figure 4.2: Major watersheds on the Main Site.

Trout Run itself meanders through an ice block valley formed during glaciation.[83] These wetland soils are mainly alkaline with patches of acid soils (peat moss) and beds of silt detritus. The streambed is deep muck for the first two-thirds of the stream's length, supporting the growth of sedge meadow, after which the streambed is mainly composed of either sand or gravel.[84]

[83] Vandermeulen, J. Hydrogeologic investigation of the source wetland. Kalamazoo (MI): Western Michigan University and Kalamazoo Nature Center; 1982
[84] Ibid.

The Main Site also includes a host of permanent ponds, vernal pools, wetlands, groundwater seeps, springs, and rivulets.

Pre-Settlement Vegetation
Before European settlement, Kalamazoo County enjoyed a diverse set of habitats shaped by glacial advances and retreats. These communities consisted of beech-maple forests, oak openings, bur-oak plains, prairies, wetlands, wet prairies, marshes, and swamp forests.[85]

Habitat Communities
The following list describes the Main Site's primary habitat communities. These descriptions are highly generalized and cannot accurately convey the level of diversity found within and among the habitats. Communities often exist on a continuum along elevation or water gradients, mixing and blending in ways that are difficult to delineate. Habitats also shift over time as hydrological conditions change or successional stages give way.

Individual compartments containing these habitat communities will be listed later in this site plan. The compartments were named in the early 2000s using Michigan Natural Features Inventory (MNFI) land cover mapping codes. Compartment names consist of an initial corresponding with the relevant habitat type (as listed below) and a number. Since the names were assigned, some habitats have changed and no longer correspond with the compartment's name. However, to preserve continuity, the name will be retained and the compartment description updated to reflect current composition.

Unless otherwise noted, all community information comes from MNFI. When relevant, the text is linked to community profiles developed by MNFI to provide detailed information about soil types and plant and animal species associated with each community. Many habitats are ranked according to their rarity in Michigan, as determined by the Nature Conservancy. A rank of S1 means that the habitat is extremely rare and vulnerable to extirpation; a rank of S5 means that the habitat is extremely common and secure. See Appendix I for a full explanation of the rankings.

- **G: Gravel pit;** former extractive site. Highly disturbed and vulnerable to poor soil conditions, invasive species, patches of exposed gravel and grit.
- **M: Manicured land**; developed and subject to intense human use.
- **T: Tilled agricultural field**; currently or formerly used for row crops.
- **H: Hayfield**; currently or formerly used to grow hay.
- **N: Native grassland/mesic prairie**; forb-rich grassland community found on glacial outwash. Provides important habitat for insect and songbird species. State rank: S1.
- **O: Oldfield**; former agricultural field allowed to succeed to grassland, woods, or shrub thicket.
- **U: Upland shrub thicket**
- **C: Central hardwood forest or mesic southern forest**; American beech- and sugar maple-dominated forest found on flat to rolling topography. State rank: S3.

[85] Kivikko R, Ferguson C, Evans M. Glimpsing the whole: the Kalamazoo Nature Center story. Beech Leaf Press; 1995 Jun. 188 p.

- **F: Floodplain forest**; bottomland deciduous or deciduous-conifer forest community occupying low-lying areas adjacent to streams and rivers. Subject to flooding and cycles of erosion and deposition. Frequent site of vernal pools, important amphibian habitat. State rank: S3.
- **A: Aspen/birch forest**
- **P: Pine forest**
- **I: Inundated shrub swamp or shrub-scrub wetland**; shrub-dominated community characterized by poor drainage, nearly continuous inundation or saturation, and dominance by buttonbush. State rank: S3.
- **E: Emergent marsh**; shallow-water wetland characterized by grasses, sedges, and grass-like plants as well as floating-leaved herbs. State rank: S4.
- **S: Sedge/wet meadow;** open, groundwater-influenced, sedge-dominated wetland. State rank: S3. May occur with southern shrub-carr, a successional shrub community dominated by willows, dogwoods, winterberry, and bog birch. State rank: S4.

Built Features

The Main Site includes many built components associated with KNC's educational programs, including the 33,000-square-foot Interpretive Center, enclosed structures housing non-releasable birds of prey, storage sheds, parking lots and driveways, and the DeLano Homestead.[86] KNC also keeps several residential homes as staff and volunteer quarters.

Trail System

The Main Site has 13 trails that cover more than 10 miles in total (see Figure 4.3). This trail system not only offers visitors a great opportunity to explore a diversity of habitats, from forest to prairies, ponds and fens, but they also link KNC staff to more efficient implementation of conservation practices and educational programs.

[86] Kalamazoo Nature Center [Internet]. Kalamazoo (MI): Volunteer Kalamazoo [cited 2016 Apr 14]. Available from http://go.volunteerkalamazoo.org/agency/detail/?agency_id=27314

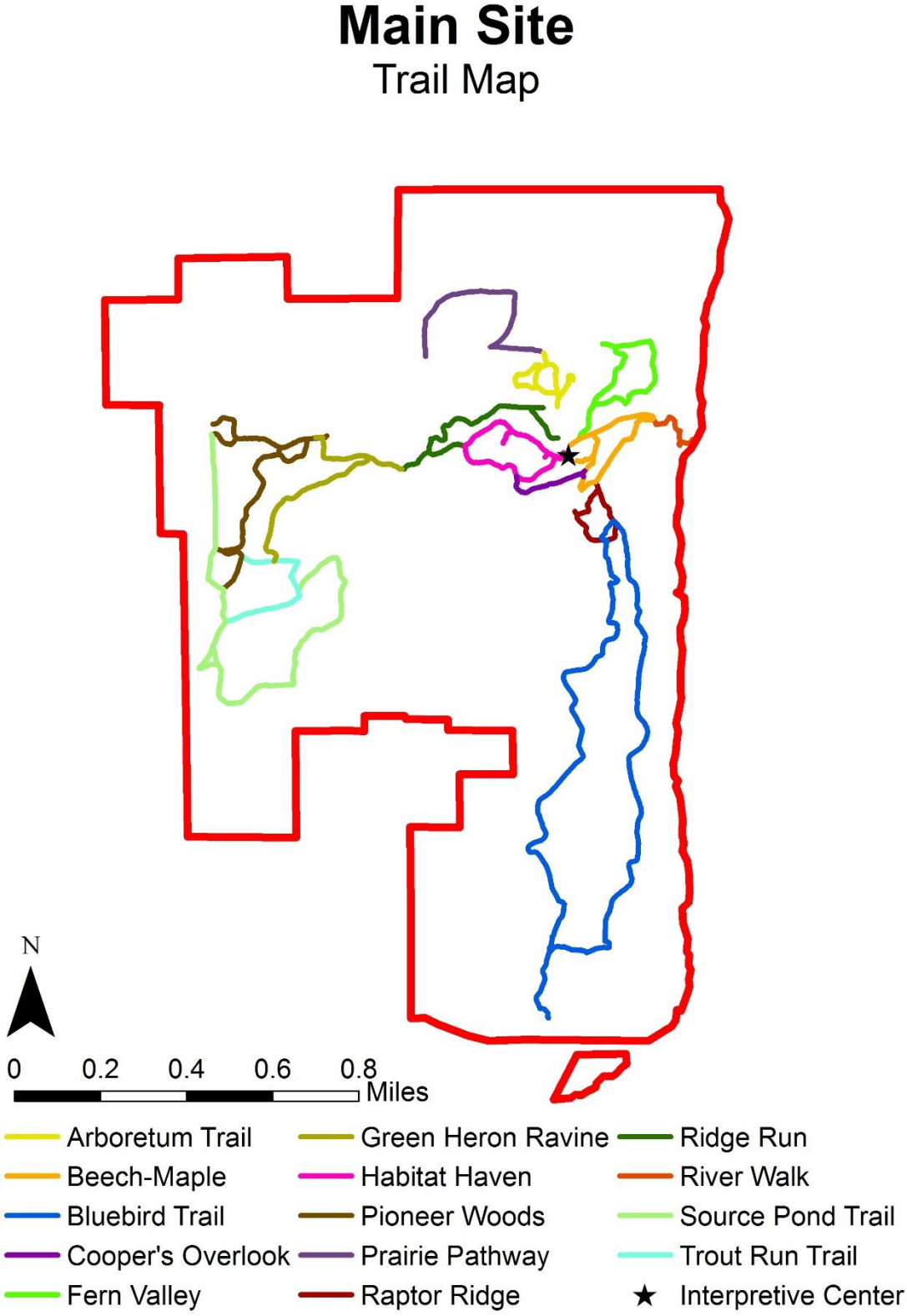

Figure 4.3: Trail system on the Main Site.

Table 4.1 gives an idea of how the Main Site's thirteen trails connect, as well as their context within the compartments and management units. Use this table to know exactly which Management Units and Compartments can be found along each trail.

Table 4.1: Trail system on the Main Site.

TRAIL NAME	TRAIL DESCRIPTION	MANAGEMENT UNIT(S)	COMPARTMENT(S)
Trout Run Trail	0.4 miles; secluded trail along Trout Run Stream, connecting all trails in DeLano Woods	C	I2, I4, C4
River Walk	0.2 miles; boardwalk to Kalamazoo River	B	F1
Ridge Run	0.6 miles; connects to Habitat Haven Trail to provide an overlook of the fen	A, B	S2, O3, U1
Raptor Ridge [units/compartments combined with Bluebird Trail]	0.4 miles; connects Beech-Maple and Bluebird Trails, providing overlook of Kalamazoo Valley	B, E, F	C2, C3, H2, O4, O5, O6, O7, P3, T1, E4, E5, U2, F2, F4, G, Z
Bluebird Trail [units/compartments combined with Raptor Ridge]	2.7 miles; loops through 140-acre restored prairie	B, E, F	C2, C3, H2, O4, O5, O6, O7, P3, T1, E4, E5, U2, F2, F4, G, Z
Prairie Pathway	0.5 miles; crosses open restored prairie	A	P1, P2, A1, H1, O1, N1, N2
Pioneer Woods	1.0 mile; trail through young forest, evergreen forests, farm fields	A, C	O10, P5

Source Pond Trail	0.7 miles; trail along Trout Run Stream through old growth forest, links DeLano entrance to Source Pond	A, C, D	H4, H5, U5, U6, U7, I3, E1, E2, E3, C4, C5, O8, O9, A2, A3, X
Habitat Haven	0.6 miles; exits Interpretive Center, circles fen	B	S1, S2, O3, I1
Green Heron Ravine	0.7 miles; covers fields, young forest, several shallow ponds	C	U4, S3
Fern Valley	0.7 miles; covers sugar maple grove; eastern trail portion leads to secluded pond	B	C1
Cooper's Overlook	0.2 miles; ridge overlooking Trout Run	B	F3
Beech Maple	0.7 mile; exits Interpretive Center, crosses old-growth beech-maple forest	B	F3, M

Data Collection

As part of a 2005 BioInventory, Modified-Whittaker plots and transects were constructed in several Main Site compartments. To investigate changes in biodiversity, seven of these plots and transects were replicated in May, July, and September, 2015. Five Modified-Whittaker plots were constructed in C1, C2, C3, C4, and F1, respectively. Transects were conducted in two sedge meadows, S1 and S3. A detailed description of how Modified-Whittaker plots were set up can be found in Appendix III.

The resulting plant species lists were used to calculate Floristic Quality Index (FQI) scores for the flora of these seven compartments (see Appendix III for FQI calculations). The FQI scores should represent the importance of protecting each compartment. An FQI above 35 indicates a high-quality native natural community and is considered floristically important in Michigan. The inventory data collected by setting up Modified-Whittaker Plots were also used to calculate basal area and relative abundance of trees over 10 centimeters in diameter at breast height (DBH).

Data Results

The 2005 BioInventory found eight compartments with an FQI above 35 (S3, E1, E2, F3, S1, C2, C3, C4). Table 4.2 displays the changes in calculated FQI scores for seven compartments between 2005 and 2015.

Table 4.2: FQI scores by compartment for 2005 and 2015.

Compartment	FQI (2005)	FQI (2015)
C1	54.7	27.4
C2	43	24.1
C3	47.3	22.8
C4	49.1	28
F1	62.1	34.6
S1	41.7	34.8
S3	35.5	25.6

Table 4.2 demonstrates an obvious decrease in the FQI scores for each Main Site compartment that was resampled in 2015. However, this does not necessarily indicate a decrease in the floristic importance of these seven compartments. The 2005 BioInventory almost certainly captured a full catalog of all present plant species, as the assessment was conducted by a highly experienced field technician. The repeated 2015 inventory was conducted by a team of graduate students with limited in-field experience. Consequently, the 2015 inventory could have inadvertently omitted a substantial number of species whose coefficients of conservation would have driven the FQI scores higher.

Basal area and relative abundance metrics were calculated in 2015 for C1, C2, C3, C4,and F1, which are shown from Table 4.3 to Table 4.7 (See Appendix III for detailed information on how to calculate these metrics).

Table 4.3: Basal area and relative abundance of tree species above 10 cm DBH for C1

Species	**Basal Area (m^2/ha)**	**Relative Dominance (%)**
Acer saccharum (Sugar Maple)	816.4	54.49
Quercus rubra (Northern Red Oak)	510.3	34.06
Zanthoxylum americanum (Prickly-ash)	104.6	6.98
Gleditsia triacanthos (Honey Locust)	45	3.00
Prunus serotina (Black Cherry)	11	0.73
Ostrya virginiana (Ironwood)	11	0.73
Total	1498.3	

Table 4.4: Basal area and relative abundance of tree species above 10 cm DBH for C2

Species	**Basal Area (m^2/ha)**	**Relative Abundance (%)**
Acer saccharum (Sugar Maple)	4158	45.88
Prunus serotina (Black Cherry)	3760.4	41.49
Ostrya virginiana (Ironwood)	745.4	8.22
Fagus grandifolia (American beech)	399.6	4.41
Total	9063.4	

Table 4.5: Basal area and relative abundance of tree species above 10 cm DBH for C3

Species	**Basal Area (m^2/ha)**	**Relative Abundance (%)**
Acer saccharum (Sugar Maple)	917.6	57.46
Prunus serotina (Black Cherry)	378.2	23.68
Carya cordiformis (Bitternut Hickory)	161.4	10.11
Ostrya virginiana (Ironwood)	126.5	7.92
Quercus alba (White Oak)	13.2	0.83
Total	1596.9	

Table 4.6: Basal area and relative abundance of tree species above 10 cm DBH for C4

Species	**Basal Area (m^2/ha)**	**Relative Abundance (%)**
Acer saccharum (Sugar Maple)	14354.8	66.97
Quercus rubra (Northern Red Oak)	2365.1	11.03
Liriodendron tulipifera (Tulip Tree)	2158	10.07
Prunus serotina (Black Cherry)	1453.5	6.78
Ostrya virginiana (Ironwood)	1102.4	5.14
Total	21433.8	

Table 4.7: Basal area and relative abundance of tree species above 10 cm DBH for F1

Species	**Basal Area (m2/ha)**	**Relative Abundance (%)**
Carpinus caroliniana (Musclewood)	210	88.27
Ostrya virginiana (Ironwood)	16.9	7.10
Carya cordiformis (Bitternut Hickory)	11	4.62
Total	237.9	

General Recommendations

- Leave decaying leaves, branches, and other organic material in place whenever possible to build soil nutrient profile.
- Regularly walk all trails on the property and remove intrusive dead wood, encroaching plants, or hanging branches.
- Monitor trails for signs of erosion and develop strategies to restore trails damaged by foot traffic or water runoff. See Chapter 3: Trail Maintenance and Development for more details, and Appendix V for details on an erosion risk study for the Main Site.
- Choose plants and seeds that are genotypically native to Michigan.
- Use aerial surveys and on-the-ground detection methods to track deer populations. Install deer-proof fences or cages around sensitive plant species. Continue deer culls as a strategy for promoting smaller, healthier deer populations.
- Regularly conduct water-quality monitoring and hydrological data collection in streams and ponds. See Chapter 3: Water Quality.
- Conduct fish species surveys in Trout Run and the Kalamazoo River.
- Regularly evaluate the merits of keeping current agricultural fields in active production. If fields aren't profitable, consider converting them into forest or prairie habitats.
- Coordinate development of a watershed management plan for Trout Run. Survey area residents to gauge knowledge of water quality and watershed management. Conduct educational programs within Trout Run and Kalamazoo River watersheds on watershed management issues.
- Create a map of streams and ponds that includes all names staff members use for each water feature. Often, these features can have multiple nicknames, which can lead to uncertainty and mislabeling. For example, staff members occasionally refer to Stoddard Creek, Batts Creek, and Little Trout Run, but the precise locations of these water bodies is unknown.

Invasive Species

Invasive species contribute to habitat stress and biodiversity loss. Based on the 2015 survey of KNC staff and volunteers, invasive plant species are widely viewed as a major concern (Appendix IV). Garlic mustard (*Alliaria petiolata*), multiflora rose (*Rosa multiflora)*, and honeysuckles (*Lonicera spp.*) are some of the most problematic invasive species on the Main Site. Appendix II lists other invasive species found on or likely to threaten KNC's properties.

To prevent invasive species from outcompeting natives, immediate actions are highly recommended and should be considered a top priority for most management units on the Main Site, particularly those containing rare or sensitive natural communities. Ponds should be monitored for invasion by aquatic plant species. Some invasive species control methods include hand-pulling, digging, cutting, applying herbicide, or prescribed burning. Choose methods appropriate for targeted species within each habitat community. Detailed descriptions of invasive species and specific removal methods can be found in Appendix II.

Erosion

Erosion is also a major concern for the Main Site. Erosion, usually due to foot traffic or undesired water movement, decreases soil quality, damages trails, and creates fertile ground for invasive plant species. Some of the Main Site's trails show visible erosion damage, particularly the heavily traveled trails around the Interpretive Center. Appendix V details a GIS-based erosion risk assessment for the Main Site. According to the assessment, the areas at highest risk are the forested area directly southeast of the Interpretive Center, the agricultural fields north of DeLano, and the slopes between the Willard Rose Prairie and the Kalamazoo River.

KNC has developed a stormwater management plan for the parking lots around the Interpretive Center. In coming years, the parking lots may be redesigned to channel stormwater into rain gardens rather than leaving it free to run along trails. Before and after this redesign, areas at risk for erosion damage should be monitored frequently. Special attention should be paid to steep trails and those leading directly away from the Interpretive Center. Other areas with ongoing erosion issues, such as the Trout Run/Westnedge Avenue crossing and the South Property also require immediate attention. The parts of the property under agricultural rotations face an increased risk of erosion due to soil degradation, and it is recommended that techniques such as conservation tillage and winter cover crops be used to mitigate this risk.

Prescribed Burns

KNC's stewardship crews periodically run prescribed burns at the Main Site to encourage native plant growth and discourage the growth of woody vegetation in open habitats. See Chapter 3: Prescribed Fire for a detailed explanation of prescribed burning as a management tool.

Table 4.8 offers a proposed schedule for prescribed burning cycles on the Main Site. Each burn unit is divided in half, and each half is burned in a three- or four- year rotation.

Table 4.8: Proposed prescribed burn cycle.

Burn Unit	Last Burned	Cycle 1	Cycle 2	Cycle 3	Cycle 4
N1-East	2014	2017	2020	2023	2026
N1-West	2015	2018	2021	2024	2027
N2	2015	2018	2021	2024	2027
N3	2014	2017	2020	2023	2026
S1-East	2013	2016	2019	2022	2025
S1-West	2014	2017	2020	2023	2026
S3-East	2013	2016	2019	2022	2025
S3-West	2012	2016	2020	2024	2028

Management Units

Recommended management actions for each management unit are prioritized according to the following numerical scale:

1: Address within the next 3 years
2: Address within the next 5 years
3: Address within the next 10 years
4: Address in the next 10-year comprehensive LMP

Management Unit A—Coppertree/North Prairie (272 acres)

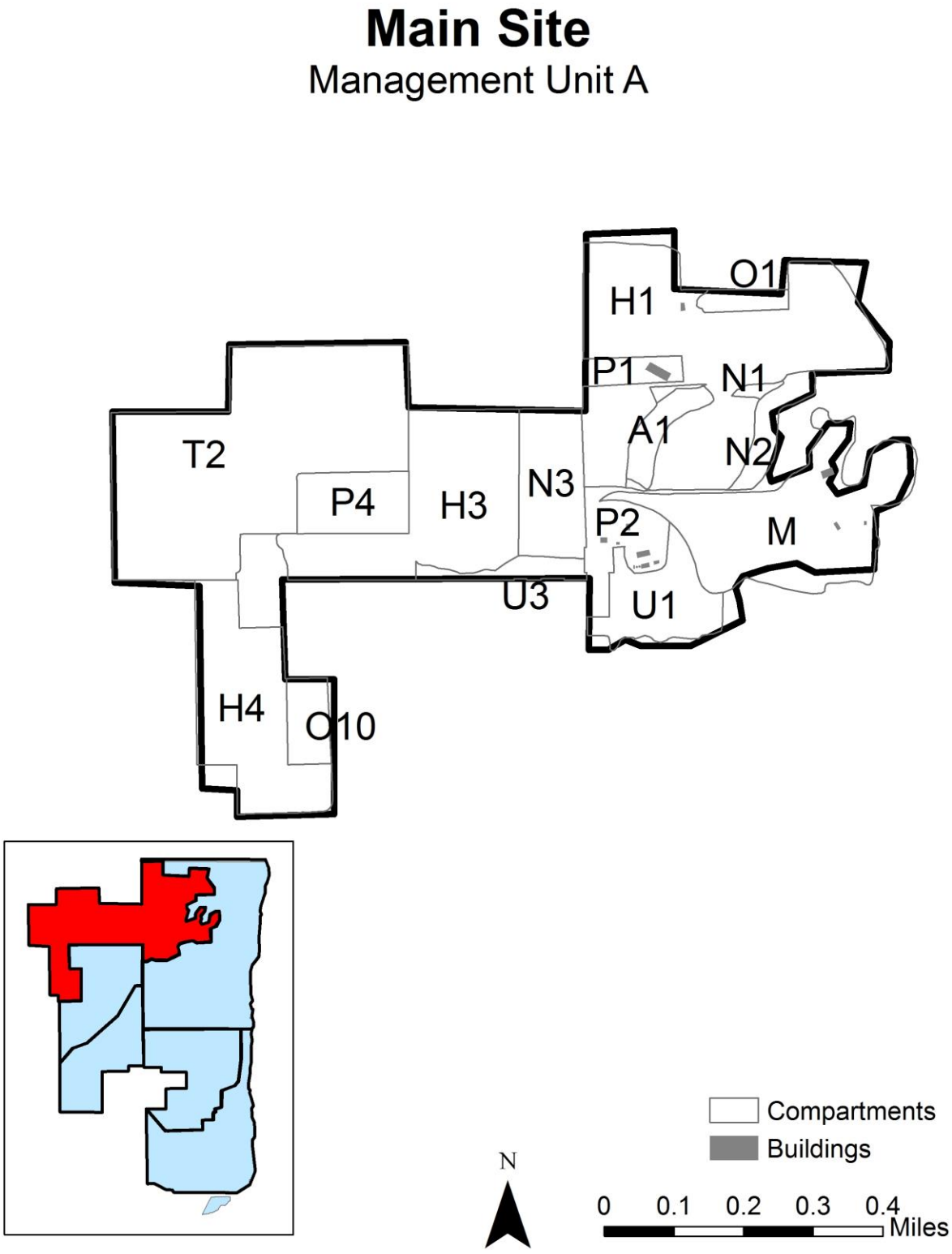

Figure 4.4: Habitat compartments and features found within Management Unit A.

Description

This unit includes the DeLano Homestead, an active Community-Supported Agriculture program and educational site. Most of this unit was previously employed as cropland, as well as some managed timber, including poplars planted for fuelwood. A small amount of gravel extraction also occurred here in the 1950s. Now, much of this unit consists of fallow and active agricultural land, haying, and conifer stands. Some of the agricultural fields have been reconstructed into the Emma Pitcher Prairie. The unit contains areas surrounding the Interpretive Center, including the Arboretum and Barnyard, all highly modified landscapes used primarily for education and interpretation. E Avenue runs through the southern part of the unit and Westnedge bisects it north to south.

- *Compartments* (see Figure 4.4): A1, H1, H3, H4, M, N1, N2, N3, O1, O10, P1, P2, P4, T2, U1, U3
    - **A1: Hybrid poplar monoculture** originally planted as fuelwood for the Interpretive Center
    - **H1: Active hayfield**
    - **H3: Hayfield** north of E Avenue
    - **H4: Hayfield** along E Avenue on Main Site's western border; original DeLano Homestead
    - **M: Manicured area** including Arboretum, parking lots
    - **N1: Restored prairie** first planted in mid-1970s
    - **N2: Prairie,** mostly established by vegetative volunteers
    - **N3: Restored prairie**; previously farmed for vegetables
    - **O1: Oldfield**
    - **O10: Oldfield**, now successional shrub/open woodland; part of DeLano Homestead
    - **P1: Pine forest**; north end of poplar stand
    - **P2: Pine forest**; south end of poplar stand
    - **P4: Pine forest**; walnut stand
    - **T2: Active corn/soy rotation** leased to farmer
    - **U1: Open upland hillside**; important buffer for east fen (S1)
    - **U3: Band of shrubs** along E Avenue
- *Trails*
    - **Prairie Pathway**: P1, P2, A1, H1, O1, N1, N2
    - **Ridge Run**: U1
    - **Pioneer Woods**: O10
    - **Source Pond Trail**: H4
    - **North of DeLano Homestead:** T2, P4, H3, N3, U3

Recommendations

- 1: Control invasive species to maintain native biodiversity. Refer to Appendix II for detailed descriptions and control methods.
- 1: Delay hay-cutting in active hayfields until at least August 1 to protect the nesting of grassland birds like the bobolink and sedge wren.
- 2: Reduce amount of mowing in Arboretum (M). In the 2015 survey, KNC staff and volunteers ranked "too much mowed area" as a relatively high concern (see Appendix

IV). Considerable time and fuel resources are devoted to maintaining the Arboretum lawns. Some mowing is necessary to provide a positive and enriching visitor experience.

- 2: Encourage eastern Massasauga rattlesnake (*Sistrurus catenatus)* habitat by thinning woody plants growing on the hillside (U1) north of the fen (S1). Rattlesnakes require adjacent open upland, such as U1, for nesting.
- 3: Expand prairie to increase grassland habitat and remove windbreaks/tree rows where appropriate.
- 3: Survey populations of grassland bird species.
- 3: Survey populations of butterflies and other insect species in agricultural fields and in prairies.
- 4: Resurface heavily used trails, particularly Ridge Run. Consider installing asphalt to make the trails accessible to a wider variety of users. Before installing asphalt, though, verify that runoff from the Interpretive Center parking lot has been completely re-routed from the trails, as erosion underneath an asphalt trail can completely destroy the surface.

Measures of Success

- Results of soil testing in agricultural fields
- Results of butterfly and insect monitoring
- Results of grassland bird surveys
- Growing population of eastern Massasauga rattlesnake
- Visual surveys of trail erosion
- FQI scores rising above 35

Management Unit B—Cooper's Glen (328 acres)

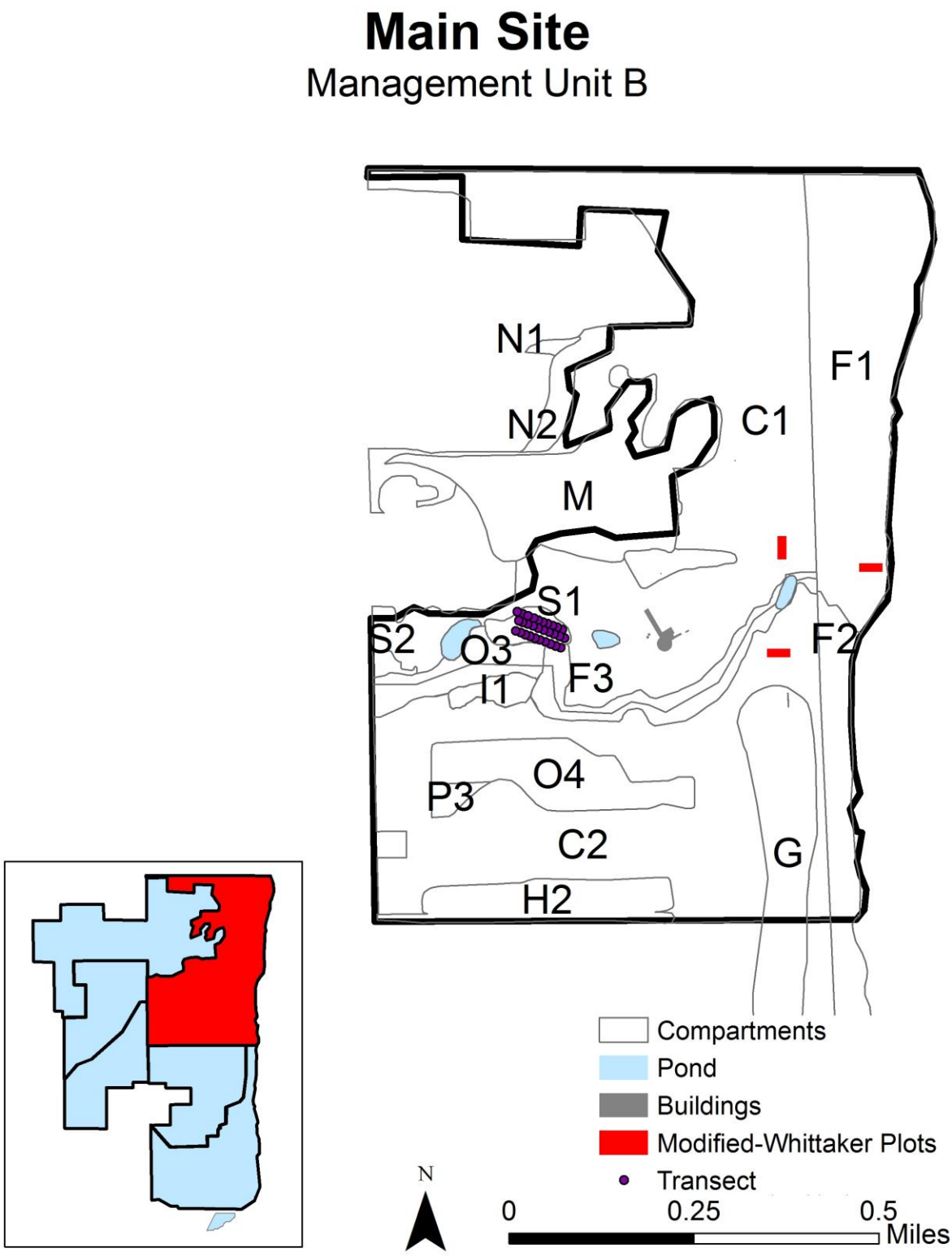

Figure 4.5: Habitat compartments, survey sites, and features within Management Unit B.

Description

This riverside unit includes Cooper's Glen, the Main Site's oldest, original forest tract and a hub for interpretive and recreational activities even before KNC existed as an organization. Gravel extraction, timber cutting, and crop production all have historically occurred here. This unit has an extensive trail system, and the majority of KNC's bird-banding activities occur here. Westnedge Avenue runs along the western edge of the unit. A railroad track runs north to south between C1 and F1 and between C2 and F2; a tunnel underpass allows visitors on the Beech-Maple and River Walk trails to safely cross beneath the tracks. The northernmost portion of the unit is known as Coppertree Farms.

- *Compartments* (see Figure 4.5): C1, C2, F1, F2, F3, G, H2, I1, M, N1, N2, O3, O4, P3, S1, S2
    - **C1: Cooper's Glen, high-quality central hardwood** (beech-maple) forest with younger forest to the north. One of the two highest-quality forest compartments on the Main Site. Site of regular bird-banding. Contains the Interpretive Center. Field surveys in 2015 (see Figure 4.5) revealed spicebush (*Lindera benzoin*), honey locust (*Gleditsia triacanthos*), and prickly ash (*Zanthoxylum americanum*). A box turtle (*Terrapene* sp.) was also found, a positive indicator of biodiversity. An unusual number of dead pignut hickories (*Carya glabra*) were also noted. A cluster of garlic mustard was found at the top of an otherwise abundantly diverse hill above the survey site.
    - **C2: Young central hardwood** (sugar maple) forest with sparse understory. Runs along esker, margins of gravel pit (G). Field surveys were conducted in 2015 (see Figure 4.5).
    - **F1: High-quality forested wetland** along Kalamazoo River; grades from floodplain forest to backswamp to sedge meadow to beech-maple forest. Includes some truly enormous swamp white oaks (*Quercus bicolor*). Contains confluence of Trout Run and Kalamazoo River. Separated from C1 by raised railroad tracks and tunnel underpass. Field surveys in 2015 (see Figure 4.5) detected marsh marigold (*Caltha palustris*), spicebush (*Lindera benzoin*), Michigan lily (*Lilium michiganense)*, green dragon (*Arisaema dracontium*), and abundant skunk cabbage (*Symplocarpus foetidus*). Plot was highly saturated, though it's uncertain if standing water is a permanent feature or a fluke of a very wet season. Poison ivy (*Toxicodendron radicans*) and beaked sedge (*Carex rostrata*) were spotted outside of the survey plot. Backswamp area yielded a variety of native species, such as musclewood (*Carpinus caroliniana*), chinkapin oak (*Quercus muehlenbergii*), and chokecherry (*Prunus virginiana*).
    - **F2: Forested wetland** along Kalamazoo River; similar community gradient as F1; steeper and more narrow floodplain with terraces further south
    - **F3: Floodplain forest**; fast-moving stream in steep valley; follows Trout Run from lowlands to railroad tracks.
    - **G: Former open gravel pit** with some relics of extractive equipment; very little soil; dominated by spotted knapweed and other weedy species.
    - **H2: Restored prairie**; part of the larger Willard Rose Prairie to the south (see Unit E).
    - **I1: Inundated scrub-shrub wetland**; formerly open meadow

    - **M: Manicured area** including Arboretum, parking lots
    - **N1: Restored prairie** first planted in mid-1970s
    - **N2: Prairie**, mostly established by vegetative volunteers
    - **O3: Oldfield esker** with thin canopy cover or shrubby lower cover; acts as buffer for floristically dissimilar S1 and S3
    - **O4: Oldfield**
    - **P3: Pine forest** on edge of oldfield
    - **S1: Sedge wet meadow** known as East Fen; high-priority compartment circled by Habitat Haven Trail with bench on north side and bridge on south side. Contains portion of Trout Run. Field surveys in 2015 (see Figure 4.5) revealed several patches of Michigan lily (*Lilium michiganense*). Contains small populations of honeysuckle (*Lonicera spp.)*, autumn olive (*Elaeagnus umbellata*), Oriental bittersweet (*Celastrus orbiculatus*) and buckthorn (*Rhamnus spp.)* worth prioritizing for control.
    - **S2: Sedge meadow**; tamarack (*Larix laricina)* stand on edge. Contains portion of Trout Run.
- *Trails*
    - **Beech Maple**: F3, M
    - **Habitat Haven**: S1, S2, O3, I1
    - **Fern Valley**: C1
    - **Ridge Run**: S2, O3
    - **River Walk**: F1
    - **Cooper's Overlook**: F3
    - **Bluebird Trail / Raptor Ridge**: C2, H2, O4, P3, G

Recommendations

- 1: Conduct prescribed burns in fens (S1, S2), combined with other forms of woody plant management. Maintaining open fen conditions will benefit the state-threatened plant cut-leaved water parsnip (*Berula erecta*) and many other sensitive plant species. A sample burn plan can be found in the *Prescribed Burns* section.
- 1: Control/eradicate small populations of honeysuckle, autumn olive, and buckthorn in S1.
- 1: Add interpretive signs to the bench and bridge around S1 to explain the sedge meadow's ecological value.
- 1: Consult with staff in the Education Department to delineate an area of the gravel pit (G) that should be kept free of woody vegetation. Education staff currently use the northern end of the gravel pit near the Interpretive Center for fossil-hunting and other programming.
- 1: Control erosion on Beech-Maple trail.
- 1: Control garlic mustard and other invasive species, particularly in Cooper's Glen (C1) and North Floodplain (F1).
- 2: Maintain vegetated buffers around S1 and S2 to preserve appropriate water flows.
- 3: Repeat Modified-Whittaker plots and transects to compare species composition over time.
- 3: Thin vegetation in O3 to provide nesting habitat for eastern Massasauga rattlesnake.

- 3: Control erosion along Westnedge Avenue to reduce disturbance and improve stream quality. Monitor erosion patterns throughout spring, summer, and fall.
- 3: Allow succession in oldfields (O3, O4) to restore contiguity of closed-canopy forests. Remove detrimental species such as hybrid poplar and multiflora rose. Consider planting desirable tree species to speed the transition.
- 4: Reconstruct river terrace in upland portions of F2. Given the presence of bur oak (*Quercus macrocarpa*), this area could be reconstructed to become a bur oak plains reference site. This habitat falls somewhere on the continuum between mesic prairie and mesic southern forest.
- 4: Reconstruct natural communities in former gravel pits. Dry sand prairie, oak barren, and oak opening are all potential target communities for this highly degraded area.

Measures of Success

- Findings of repeated Modified-Whittaker plots, transects, other baseline vegetation studies
- Results from continued bird-banding
- Results from garlic mustard monitoring
- Reduced erosion damage to Beech-Maple trail
- FQI scores rising above 35

Management Unit C—Pioneer Woods (134 acres)

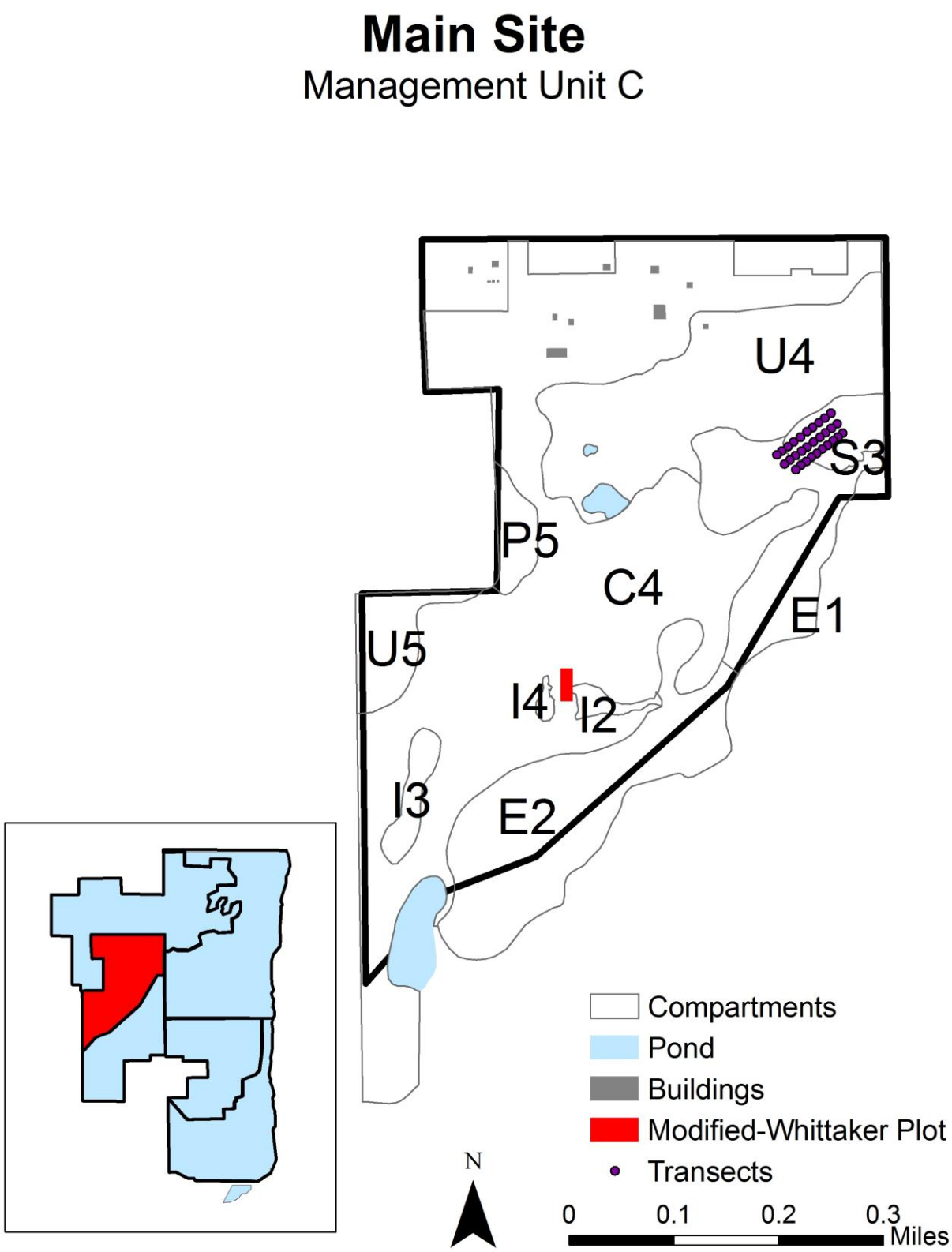

Figure 4.6: Habitat compartments, survey sites, and features within Management Unit C.

Description

Like Unit B, this unit has an extensive trail system and is heavily used for educational programs. Westnedge Avenue forms the eastern boundary of this unit; a tunnel underpass provides safe passage for visitors on the Ridge Run and Green Heron Ravine trails. Until 2004, the City of Kalamazoo held claim to a portion of this unit, which they used historically as a sand mine. Timbering, grazing, and agriculture have all taken place here. This is the original site of Tillers International, a nonprofit launched in 1981 to teach farming and homesteading skills.[87]

- *Compartments* (see Figure 4.6): C4, E1, E2, I2, I3, I4, P5, S3, U4, U5
    - **C4: Central hardwood forest** known as Pioneer Woods or DeLano Woods, south of DeLano Homestead. High-quality compartment contains esker, depressional wetlands, extensive trails, stands of beech, diverse fungi. Includes the north half of Source Pond (adjacent to E2). Bounded to north by E Avenue. Field surveys in 2015 (see Figure 4.6) revealed extremely high maple recruitment.
    - **E1: Groundwater-fed emergent marsh/wet meadow** occupying long glacial kettle; divided from west fen (S3) by stream and from Source Marsh (E2) by trail. Contains portion of Trout Run.
    - **E2: Groundwater-fed emergent marsh/wet meadow** known as Source Marsh. Contains portion of Trout Run.
    - **I2: Inundated scrub-shrub depressional wetland** dominated by red maple, silver maple, and ash; seasonally inundated.
    - **I3: Inundated scrub-shrub wetland** with vernal pool in middle
    - **14: Inundated scrub-shrub depressional wetland**
    - **P5: Pine stand**; grades east to forest and west to oldfield
    - **S3: High-quality sedge meadow or fen** laced with streams and rivulets. Contains portion of Trout Run. Adjacent to Westnedge Avenue and thus is particularly vulnerable to invasive species. Field surveys in 2015 (see Figure 4.6) revealed the presence of joe-pye weed (*Eupatorium maculatum*), shrubby cinquefoil (*Dasiphora fruticosa*), and other important wetland plants. Large ant hills, a characteristic of sedge meadows. Burn scars on standing dead wood indicated previous prescribed burns. Small patches of purple loosestrife (*Lythrum salicaria*), multiflora rose (*Rosa multiflora*), and some buckthorn.
    - **U4: Upland shrub thicket** with open woods and non-native grassland; former sand mine
    - **U5: Upland shrub thicket**
- *Trails*
    - **Green Heron Ravine**: U4, S3
    - **Pioneer Woods:** P5
    - **Source Pond Trail**: U5, I3, E1, E2, C4
    - **Trout Run Trail**: I2, I4, C4

Recommendations

- 1: Maintain Green Heron Ravine trail (U4, S3). Trim back species crowding into the trail and surrounding benches. Especially focus on controlling poison sumac (*Toxicodendron*

[87] History [Internet]. Cooks Mill (MI): Tillers International [cited 2016 Apr 12]. Available from http://tillersinternational.org/about/history/

vernix), which is abundantly present along trail and around benches. Clear grape vines overgrowing the sign leading west into the tunnel underpass.

- 1: Control erosion along Trout Run to improve water quality.
- 1: Conduct prescribed burns in the Source Marsh (E1, E2), in conjunction with cutting of woody plant species. A sample burn plan can be found in the *Prescribed Burns* section.
- 1: Control purple loosestrife, multiflora rose, and buckthorn in S3. See Appendix II for removal methods.
- 2: Block access to informal offshoot trails branching off Trout Run and Source Pond trails. Offshoots are unmarked on maps and lead to confusion.
- 2: Monitor water quality in Source Marsh (E1, E2) and Source Pond.
- 2: Continue monitoring the pond next to the DeLano House (U4). This pond dries out during summer and fills in with wetland vegetation. The pond tested high for nitrates years ago, sourced from farm and barn runoff into the pond. See Chapter 3: Water Quality for sampling methods and parameters.
- 2: Control erosion along Westnedge Avenue near Trout Run to reduce disturbance and improve stream quality. Monitor for signs of erosion throughout the spring, summer, and fall.
- 2: Reassess the extent of mowing on the DeLano Homestead.
- 2: Run study to assess effects of Westnedge Avenue culvert on fen hydrology.
- 3: Repeat plot and transect surveys in S3 and C4 (see Figure 4.6).
- 3: Survey fish populations in Trout Run

Measures of Success

- Results of rare species monitoring
- Results of regular water quality monitoring
- Results of repeated surveys in S3 and C4
- Results of fen hydrology study
- Results of Trout Run fish population surveys
- FQI scores rising above 35

Management Unit D—Dykehouse Woodlands (123 acres)

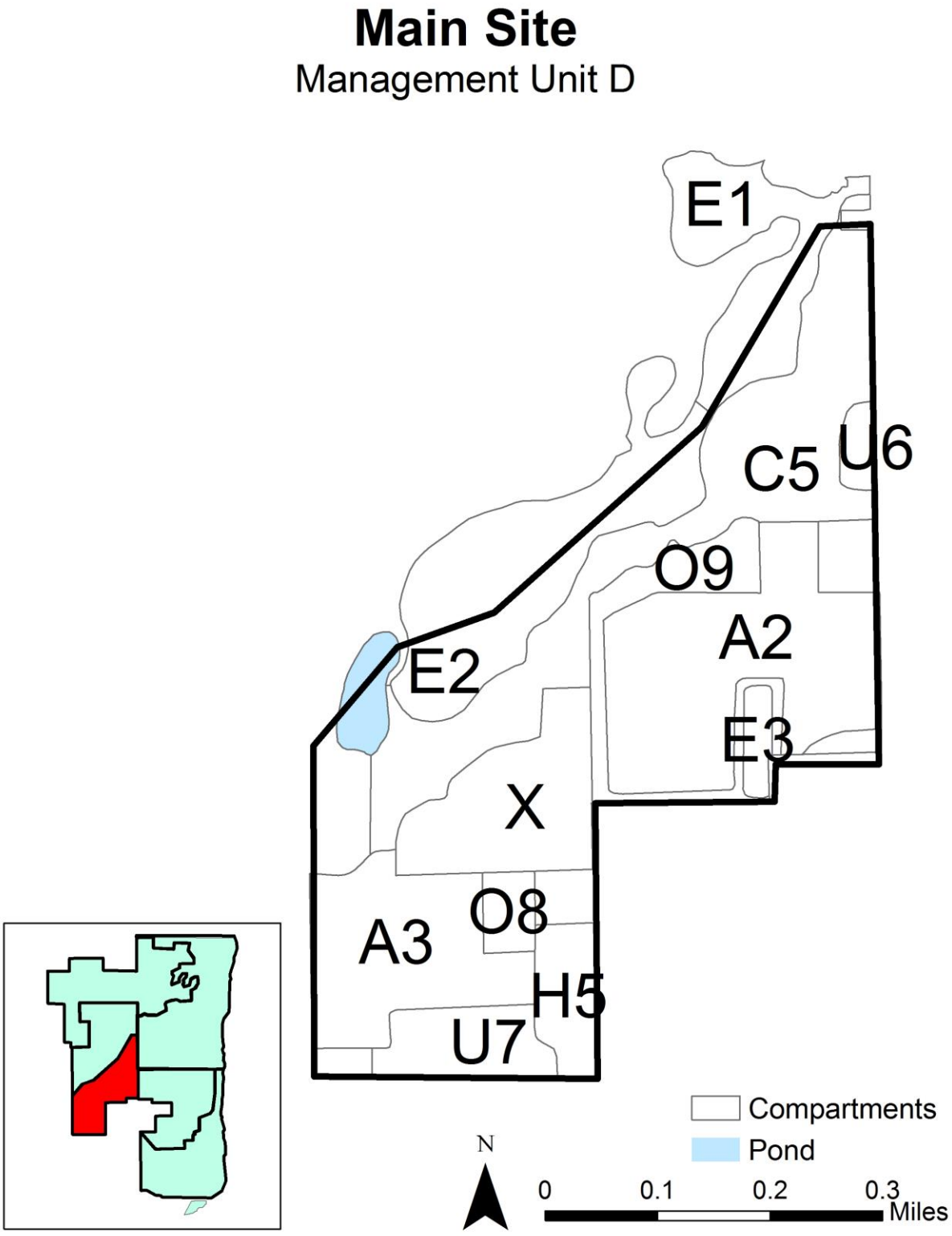

Figure 4.7: Habitat compartments and aquatic features within Management Unit D.

Description

This unit borders the closed-canopy forest of Markin Glen County Park to the south. Westnedge Avenue forms the unit's eastern boundary. Early-successional forest and oldfield habitat has potential for restoration or other active management. A large amount of the land is fallow agricultural land, including two large stands of hybrid poplar and some oldfield. A thin strip of young forest occupies the slope above the Source Marsh (E1, E2). Horse pasture and hayfields also are present. Historically, cropland and managed timber lots dominated this unit. Grazing most likely also occurred.

- *Compartments* (see Figure 4.7): A2, A3, C5, E1, E2, E3, H5, O8, O9, U6, U7, X
    - **A2: Hybrid poplar monoculture,** originally planted as fuelwood for Interpretive Center; succeeding to maple forest
    - **A3: Hybrid poplar monoculture,** originally planted as fuelwood for Interpretive Center; sparsely treed with oldfield and orchard vegetation
    - **C5: Young central hardwood forest** forming ravine-striped corridor along slope above Source Marsh (E1, E2); anecdotal evidence of trash, disturbed areas, garlic mustard. Contains southern half of Source Pond (adjacent to E2).
    - **E1: Groundwater-fed emergent marsh/wet meadow** occupying long glacial kettle; divided from west fen (S3) by stream and from Source Marsh (E1, E2) by trail. Contains portion of Trout Run.
    - **E2: Groundwater-fed emergent marsh/wet meadow** known as Source Marsh. Contains portion of Trout Run.
    - **E3: Wet meadow/shrub-carr wetland** at head of South Stream watershed (F4); bird-banding site
    - **H5: Hayfield** along F Avenue
    - **O8: Oldfield**
    - **O9: Oldfield**, fence row wrapping around poplar stand in A2
    - **U6: Grassy upland shrub opening**; former site of Solar Homestead house, which burned in 1993
    - **U7: Central hardwood forest** (maple) along F Avenue
    - **X: Horse pasture**
- *Trails*
    - **Source Pond Trail**: H5, U6, U7, E1, E2, E3, C5, O8, O9, A2, A3, X

Recommendations

- 1: If H1 is still being mowed for hay, delay hay-cutting until at least August 1 to protect the nesting of grassland birds like the bobolink and sedge wren.
- 1: Conduct prescribed burn in Source Marsh (E1, E3), in conjunction with cutting of invasive woody species. Particularly target glossy buckthorn. A combination of cutting and herbicide is often recommended (see Appendix II). Burning is also essential as a follow-up to buckthorn removal.
- 1: Control garlic mustard populations; refer to Appendix II for a detailed description of removal and management.
- 2: Use prescribed burns or selective thinning where lily-leaved twayblade (*Liparis liliifolia*) occurs. This rare plant, found in this unit, requires some disturbance and declines under closed-canopy conditions.

- 2: Monitor water quality in Source Marsh (E1, E2) and Source Pond. See Chapter 3: Water Quality for sampling methods and parameters.
- 3: Use natural caging to protect lady's slipper and twayblade orchids found in this unit. Caging can protect sensitive plants from deer browsing or human foot traffic.
- 4: Plant oldfields to augment closed-canopy forest. Some management may be necessary to guide succession, such as planting desirable tree species and removing invasive species.

Measures of Success

- Results of water quality surveys
- Results of bird-banding efforts
- Results of informal plant surveys and rare species monitoring
- FQI scores rising above 35

Management Unit E—South Prairie (179 acres)

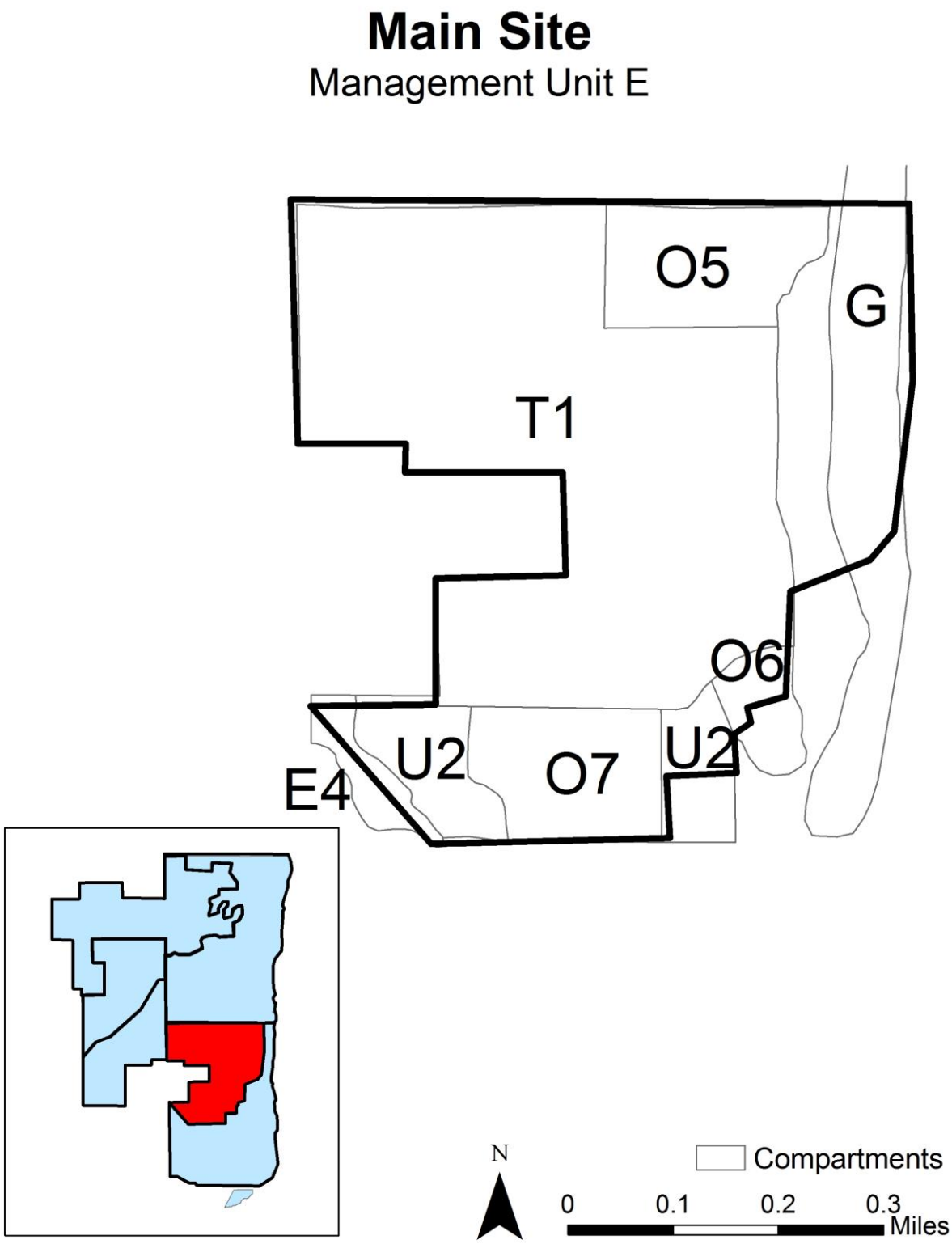

Figure 4.8: Habitat compartments within Management Unit E.

Description

More than half of the area of this unit is now a 140-acre restored tallgrass prairie. This habitat is named the "Willard Rose Prairie" after KNC's current president, Bill Rose. The prairie also includes compartment H2 in Management Unit B. Mowed paths allow visitors to explore the prairie without straying into the vegetation. Bluebird nesting boxes are monitored throughout the prairie. Successional systems make up the remainder, including oldfields and the gravel pit. Westnedge Avenue forms part of the unit's western boundary.

- *Compartments* (see Figure 4.8): E4, G, O5, O6, O7, T1, U2
    - **E4: Emergent marsh/wet meadow** or marsh; largely a reed canary grass (*Phalaris arundinacea)* monoculture with glossy buckthorn around edges. Sometimes called "south marsh." Adjacent to South Stream.
    - **G: Former open gravel pit** with some relics of extractive equipment; very little soil; dominated by spotted knapweed and other weedy species. The east half of the Bluebird Trail loop runs down the gravel pit's center. Informal observations in 2015 noted a substantial overgrowth of spotted knapweed (*Centaurea maculata)* and sweet clover (*Melilotus spp.*) surrounding the trail all the way through this compartment.
    - **O5: Restored prairie**; beautiful view over G, Willard Rose Prairie, and Kalamazoo River
    - **O6: Oldfield**; honeybees historically kept here
    - **O7: Restored prairie**; former orchard
    - **T1: Restored prairie**
    - **U2: Upland shrub thicket** split into two sections by O7; west compartment is shrubby slope to E4; east section is restored prairie and catalpa stand.
- *Trails*
    - **Bluebird Trail / Raptor Ridge**: O5, O6, O7, T1, E4, U2, G

Recommendations

- 1: Install 1-2 benches along mowed trail through Willard Rose Prairie.
- 1: Install educational signs describing the importance, history, and species composition of the Willard Rose Prairie.
- 1: Conduct prescribed burns and other invasive species control measures to maintain native biodiversity in Willard Rose Prairie. See Appendix II for detailed descriptions of invasive species and control methods.
- 1: Target spotted knapweed and sweet clover infestations on east loop of Bluebird Trail and near where the west loop of the trail re-enters the woods.
- 1: Target garlic mustard patches along west loop of Raptor Ridge Trail.
- 1: Conduct soil tests in restored prairie areas.
- 1: Restore E4 to improve species diversity and downstream water quality. Remove reed canary grass and replace with more diverse native wetland plantings. Consider pursuing a Wetlands Reserve Program cost-sharing agreement with the USDA-NRCS.
- 2: Interview visitors to gauge perceptions of and reactions to restored prairie areas.
- 2: Monitor use of nest boxes.
- 3: Expand a Willard Rose Prairie trailhead off Westnedge. Slightly expand the parking area, install signs, and mow a path that connects to Bluebird Trail.

- 3: Monitor for erosion along Westnedge Avenue throughout spring, summer, and fall; take protective measures as needed.
- 3: Maintain or plant vegetation on upper banks of gravel pit (G) to restore habitat and soil stability.
- 4: With permission from the Education Department, restore southern section of gravel pit (G) to mesic prairie or oak savanna habitat to encourage habitat diversity. Given the poor soil health condition, prairie or savanna reconstruction in these areas may be greatly improved by first building up soil health.

Measures of Success

- pH, soil nitrogen, mycorrhizae, and other soil factors to assess prairie reconstruction efforts
- Results of visitor interviews
- Results of nest box monitoring
- Results of reed canary grass monitoring in conjunction with plant and animal surveys in the South Marsh (E4)
- FQI scores rising above 35

Management Unit F—South Property (205 acres)

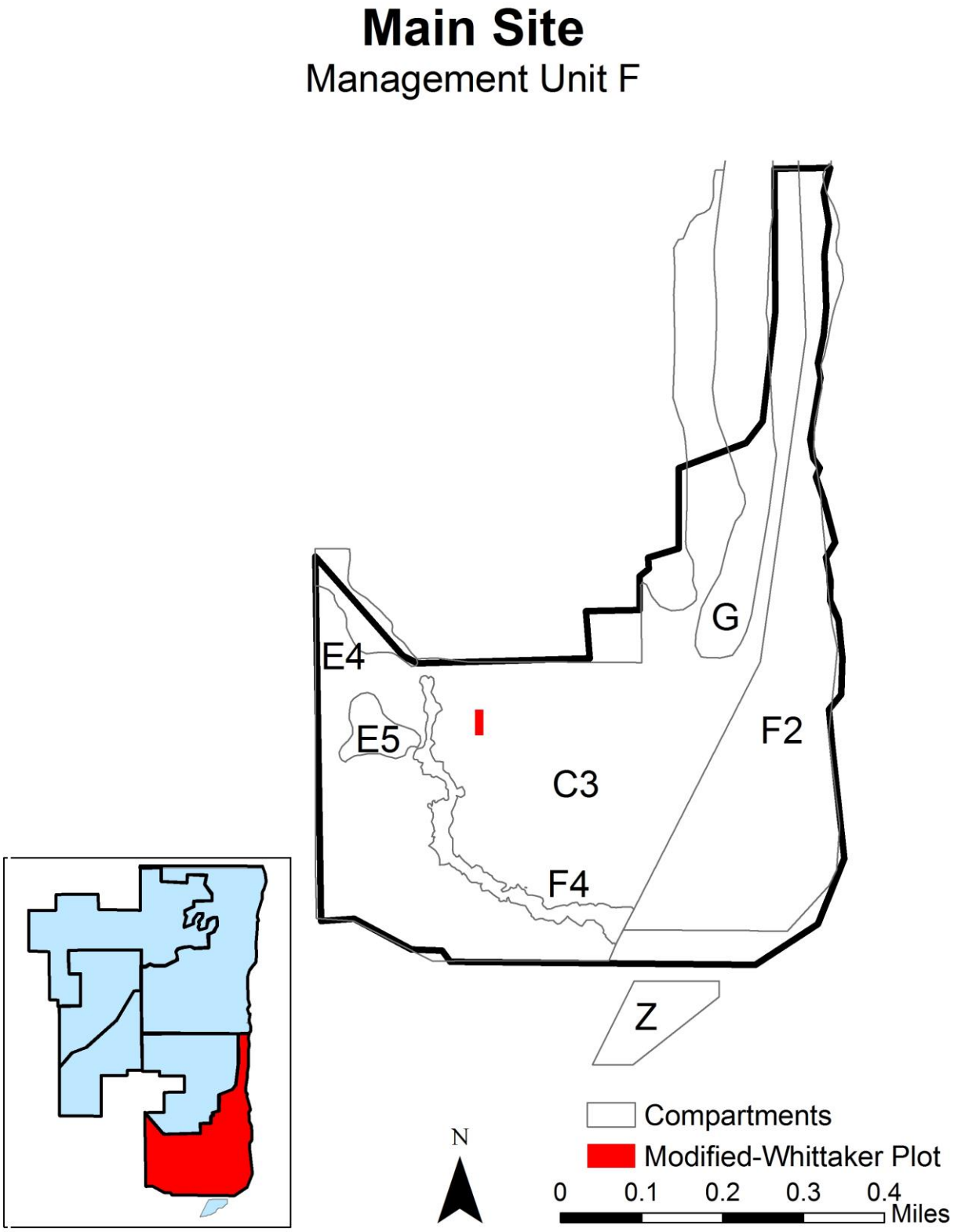

Figure 4.9: Habitat compartments and survey location within Management Unit F.

Description

Largely inaccessible to KNC visitors, this riverside unit is mostly in succession to closed-canopy forest and is important for preserving water quality for the South Stream watershed and the Kalamazoo River. The unit includes the southern Kalamazoo River floodplain. Forested floodplains and uplands help buffer streams and rivers, as well as anchoring steep slopes and protecting groundwater seepages.

This area has a history of disturbance by off-road vehicle (ORV) use and other unwanted high-impact recreational uses. A railroad runs north-south through this unit between C3 and F2. Westnedge Avenue forms the unit's western boundary. The unit contains areas that were historically graveled, cropped, and grazed.

- *Compartments* (see Figure 4.9): C3, E4, E5, F2, F4, G, Z
    - **C3: Young central hardwood forest** with some hawthorn thicket; supports considerable groundwater seepage, perched springs, some larger wetland openings (E5). Patches of ginger and ferns. Includes chinkapin oak-dominated knoll resembling oak savanna habitat. Field surveys in 2015 (see Figure 4.9) revealed substantial dead and downed wood.
    - **E4: Emergent marsh/wet meadow**; largely a reed canary grass monoculture with glossy buckthorn around edges. Sometimes called "South Marsh." Adjacent to South Stream.
    - **E5: Emergent wetland** opening on slope, surrounded by central hardwood forest. Adjacent to South Stream.
    - **F2: High-quality forested wetland** along the Kalamazoo River; grades from floodplain forest to backswamp to sedge meadow to beech-maple forest; steeper and more narrow floodplain with terraces further south. South Stream crosses southern tip.
    - **F4: Floodplain forest** in bottomlands between E4 and railroad; follows South Stream from its sources in E4 and E5.
    - **G: Former open gravel pit** with some relics of extractive equipment; very little soil; dominated by spotted knapweed and other weedy species
    - **Z: Floodplain** segment separated from F2 by utility right-of-way; confluence of South Stream and Kalamazoo River.
- *Trails*
    - **Bluebird Trail / Raptor Ridge**: C3, E4, E5, F2, F4, G, Z

Recommendations

- 1: Control spread of invasive species. Frequent disturbance can make floodplain forests more susceptible to invasive species. Actively monitor F2 for early colonization. See Appendix II for species detailed descriptions and control methods.
- 1: Restore E4 to improve species diversity and downstream water quality. Remove reed canary grass and replace with more diverse native wetland plantings. Consider pursuing a Wetlands Reserve Program cost-sharing agreement with the USDA-NRCS.
- 1: Monitor water quality in E4 and South Stream in F4.
- 2: Repeat Modified-Whittaker plot in C3 to measure succession. See Appendix III for instructions.

- 2: Limit foot traffic in C3 to protect springs and seeps. Refrain from establishing a trailhead nearby.
- 3: Post property boundary signs along F2 and C3 to discourage trespassing and inappropriate use (such as ORV use, wildflower collecting, poaching, or vandalism). Encourage neighbors to report signs of inappropriate access.
- 3: Improve chinkapin oak savanna habitat on knoll in C3 to widen the viewscape and further habitat diversity.
- 4: Establish erosion control measures along Westnedge Avenue. Erosion should be monitored throughout the spring, summer, and fall.
- 4: Reconstruct natural communities in former gravel pits. Dry sand prairie, oak barren, and oak opening are all potential target communities for this highly degraded area.

Measures of Success

- Results of water quality monitoring
- Results of Modified-Whittaker plot in C3
- Results of reed canary grass removal efforts, in conjunction with plant and animal surveys in E4
- FQI scores rising above 35

Climate Change: Adaptation and Mitigation

See Chapter 3: Climate Change and Adaptation for details about Michigan's shifting climate and its species impacts. It is important to strengthen general ecosystem health to withstand the coming effects of climate change. Habitats sensitive to changes in water level will be particularly vulnerable. Avoid unnecessary disturbances to wetland areas, plant vegetative buffers, and reduce erosion near water bodies. Climate-driven disturbances will give a leg up to invasive species, so controlling infestations should be a top priority.[88] Restoring diverse native flora and fauna may also ward off invasive species by making the system more resilient to disturbance. Warmer climate conditions might lead to an increase of deer populations, which could add browsing stress to forest ecosystems.[89] Therefore, deer management is essential to protect plant regeneration.

[88] Szyniszewska A. Invasive Species & Climate Change [Internet]. Washington, DC: Climate Institute; [Cited 2016 Mar 30]. Available from http://www.climate.org/topics/ecosystems/invasivespecies.html

[89] Swanston C, Janowiak M. Forest adaptation resources: Climate change tools and approaches for land managers [Internet]. Newtown square (PA): USDA Forest Service; 2012 May [Cited 2016 Mar 30]. Available from http://www.nrs.fs.fed.us/pubs/gtr/gtr_nrs87.pdf

Chapter 5: Heronwood Field Station

Heronwood Field Station Management Plan

6378 Hart Drive, Kalamazoo, MI 49009
(42.35402N, 85.67936W)

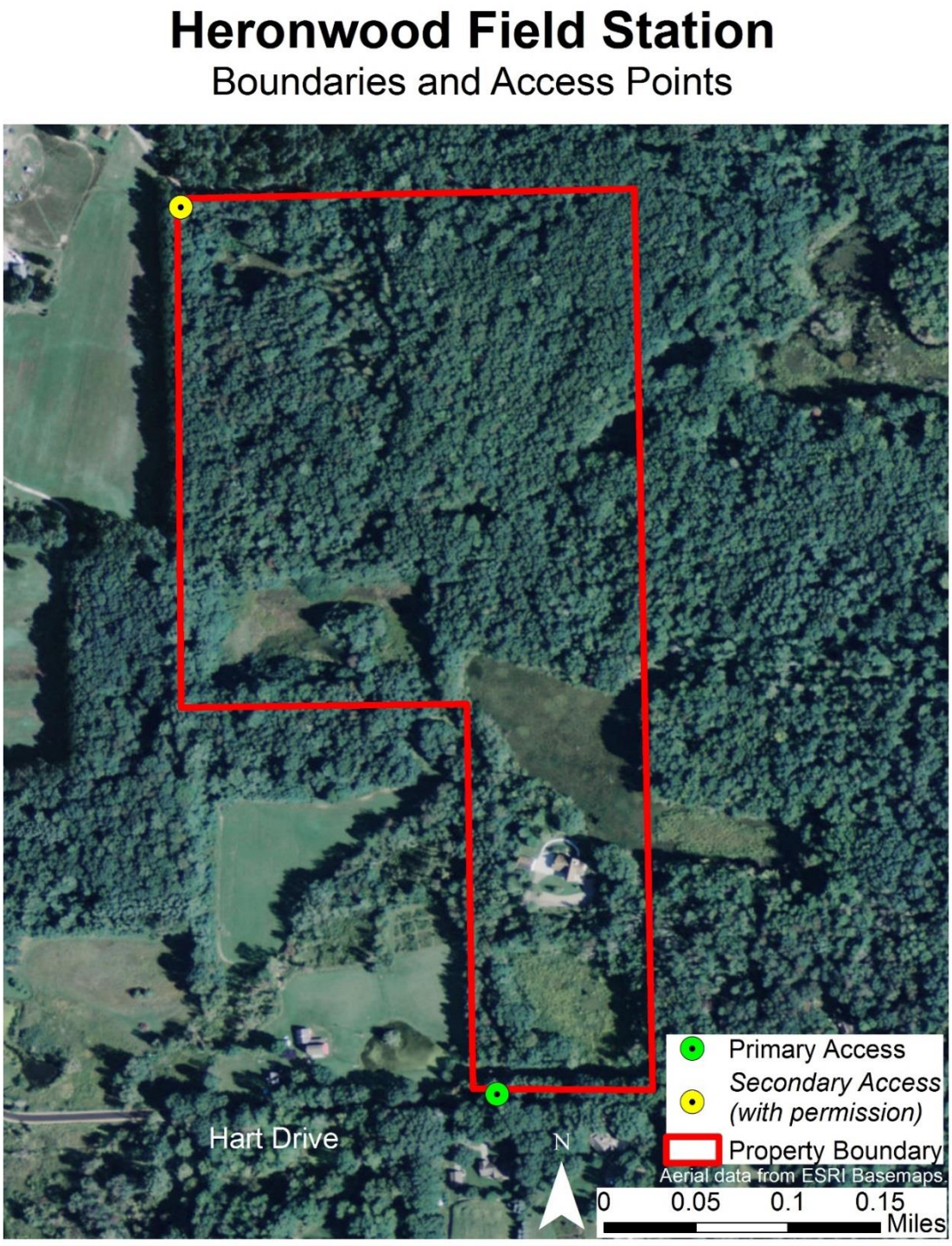

Figure 5.1: Heronwood Field Station boundaries and access points.

Introduction

The Heronwood Field Station (HFS) property sits on 60 acres of rolling hills, oak forest, grasslands and wetlands. This site plan uses the acronym HFS to refer to the entire property. The main structure on the site is a 5,000-square-foot facility (once a private home) that was generously donated to the Kalamazoo Nature Center in 2013. With fully equipped laboratories, a GIS station, a greenhouse, and plenty of project room, the converted facility is an ideal space for research and education.[90] High school students, college students, and graduate students use HFS to work on a variety of field- and lab-based projects.

History

Prior to European settlement in the 1800s, this area was dominated by black oak barrens. Before KNC acquired this property, it was a private residence with little to no development or activity in the wooded areas.

The HFS high school program started in 2013. So far, it has been exceptionally successful and is unique in Michigan. Two 90-minute high school classes meet at HFS every school day. These students come from several nearby school districts, with approximately 50 participants in 2016. Students interact with a variety of conservation professionals and tools and learn to conduct research projects. Plans for upcoming work include butterfly and moth research and rearing.

This site is currently under a Conservation Easement (CE) which protects the ecological integrity of the property and provides oversight regarding property management. The CE limits construction efforts and recommends strategies for managing flora and fauna. To see the CE documentation, contact Sarah Reding.

Property Composition

Landscape Context

The Heronwood Field Station is located in a sparsely residential area northwest of Kalamazoo, MI, and due west of KNC's Main Site (see Figure 5.2). Sand Creek and the Kalamazoo River Valley Trail both run just west of HFS.

[90] Heronwood Field Station [Internet]. Kalamazoo (MI): Kalamazoo Nature Center [cited 2016 Apr 13]. Available from http://www.naturecenter.org/ConservationStewardship/HeronwoodFieldStation.aspx

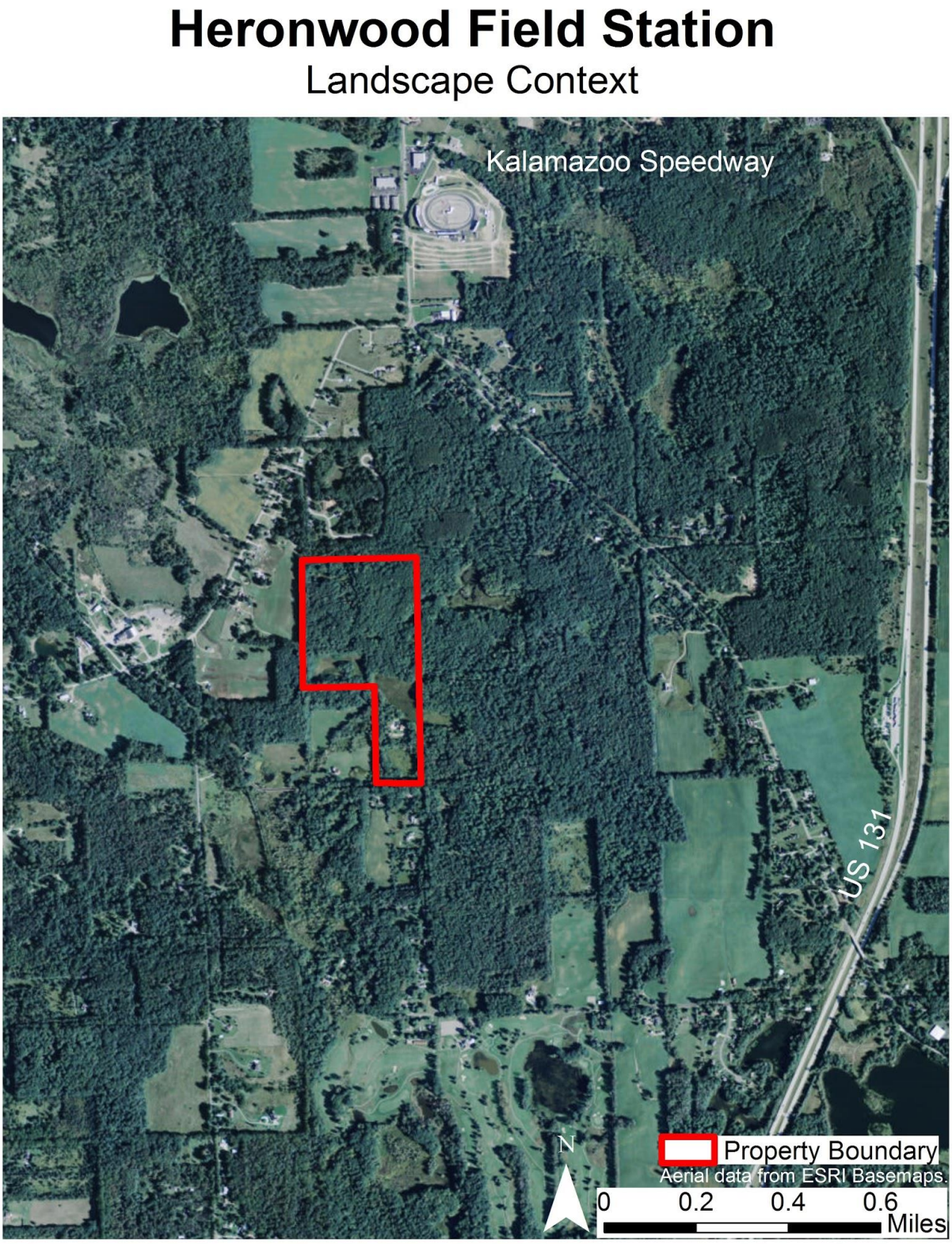

Figure 5.2: Landscape context surrounding Heronwood Field Station property.

Property Composition

The site contains central hardwood forest (C1), a larger pond (W1), small sections of wetland scattered throughout (W2, W3, W4), and some oldfields (O1 & O2), all of which can be seen in Figure 5.4. In addition to the main educational facility (a converted private residence), the property also includes a greenhouse, parking area, paved driveway, and trail system.

The HFS property is mostly surrounded by woods (see Figure 5.2) which helps to insulate the property from invasive species. Unlike most of KNC's properties, the forest surrounding HFS is dominated by oaks (*Quercus spp.*). As the majority of KNC's nearby Main Site is dominated by beech-maple climax forest, HFS represents an equally important and refreshingly distinct forest type.

Data Collection

In order to understand the property's features and stressors more clearly, data were collected in Summer 2015 in the form of floristic inventories (via a Modified-Whittaker plot), informal walkabouts, and interviews with KNC staff. See Appendix III for a detailed description of Modified-Whittaker plots, a method tailored to capture measurements at different layers within a forest. Inventory data collected through the Modified-Whittaker plot in C1 (see Figure 5.3) were used to calculate a Floristic Quality Index (FQI) score and the basal area and relative abundance of trees with a diameter at breast height (DBH) above 10 cm (Table 5.1).

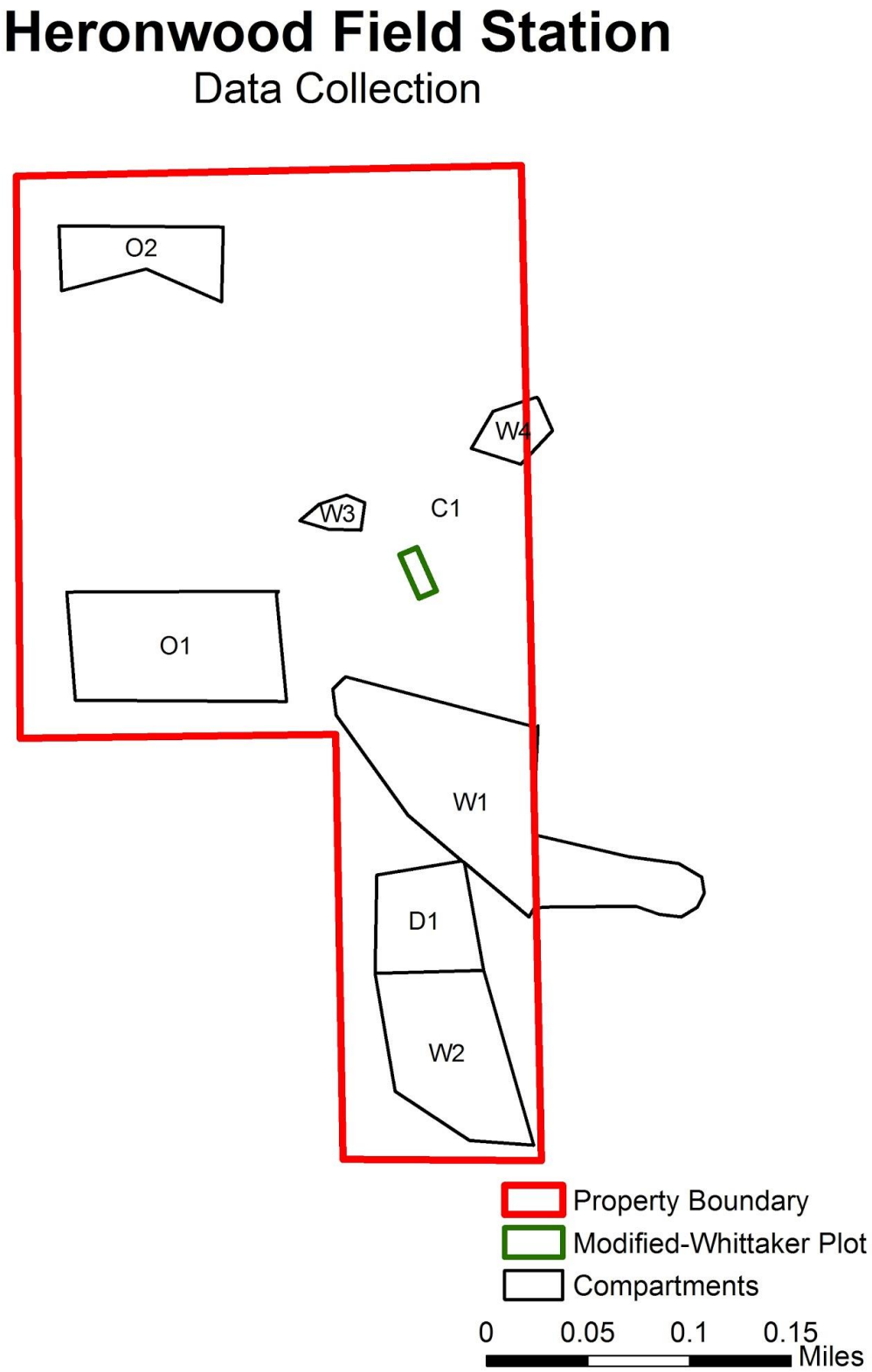

Figure 5.3: Location of Modified-Whittaker plot constructed for Summer 2015 data collection.

Informal walkabouts elsewhere on the property helped provide a sense of the property's overall health. These walkabouts yielded partial lists of invasive and indicator plant species, highlighted stressors, and pointed to potential places for restoration. KNC staff, particularly Kim Lippke, provided information about current classes at HFS, the land's history, public engagement, and plans for the future.

Data Results

Metrics from the Modified-Whittaker plot data are a useful supplement to otherwise qualitative observations. The FQI score for the forest in C1 was calculated at 20.24 (including all species) or 21.8 (only including native species). Generally, a score of 35 is considered to be a conservation priority, and a score of 50 or above is considered exceptional. Through active management of invasive species, encouraging tree regeneration, and restoration of prairie and wetlands on the site, this score could increase significantly.

Table 5.1 shows the basal area and relative abundance calculated using trees above 10 cm DBH. The dominance of oak in this oak-hickory system is in line with the goals for the site, but the abundance of sugar maple, rather than hickory, is something that should be addressed.

Table 5.1: Basal area and relative abundance of tree species above 10 cm DBH

Species	**Basal Area (m^2/ha)**	**Relative Abundance (%)**
Quercus rubra (Northern Red Oak)	5392.4	85.26
Acer saccharum (Sugar Maple)	701.5	11.09
Prunus serotina (Black Cherry)	191.4	3.03
Carya cordiformis (Bitternut Hickory)	13.2	0.21
Sassafras albidum (Sassafras)	13.2	0.21
Cornus florida (Flowering Dogwood)	13.2	0.21
Total	6324.9	

General Recommendations

- Double-check that all actions taken at HFS are consistent with the legal interpretation of the Conservation Easement placed on this property.
- Turn data collection and management actions into educational opportunities for HFS students. At the same time, ensure that all conservation and restoration actions fit with the site's primary use as a learning facility. Also make sure that all management tools and strategies are safe for young users.
- Update and revise this site plan with major management actions or collected data. Consider using staff, students, and volunteers to run rapid ecological assessments, BioBlitzes, and ongoing monitoring programs to better understand how the property functions and changes.

Management Units

Many of KNC's properties are divided into management units, each containing habitat compartments, to aid in targeting management actions and resources. This plan includes the oldfields, forest, and small ponds (which may be vernal) as one unit; the larger ponds/wetlands as a second unit; and the buildings as a third unit. Each unit is broken into smaller habitat compartments (see Figure 5.4).

Each unit includes a series of prioritized management recommendations tailored to the unit's unique features and challenges. Recommended management actions are prioritized according to the following numerical scale:

1: Address within the next 3 years
2: Address within the next 5 years
3: Address within the next 10 years
4: Address in the next 10-year comprehensive LMP

Some of the management recommendations receive extra weight, because they were flagged in a 2015 survey distributed to KNC staff and volunteers. The survey asked participants to rate the perceived importance of various management concerns, with 1 indicating low perceived importance and 5 indicating high perceived importance. See Appendix IV for survey results and details.

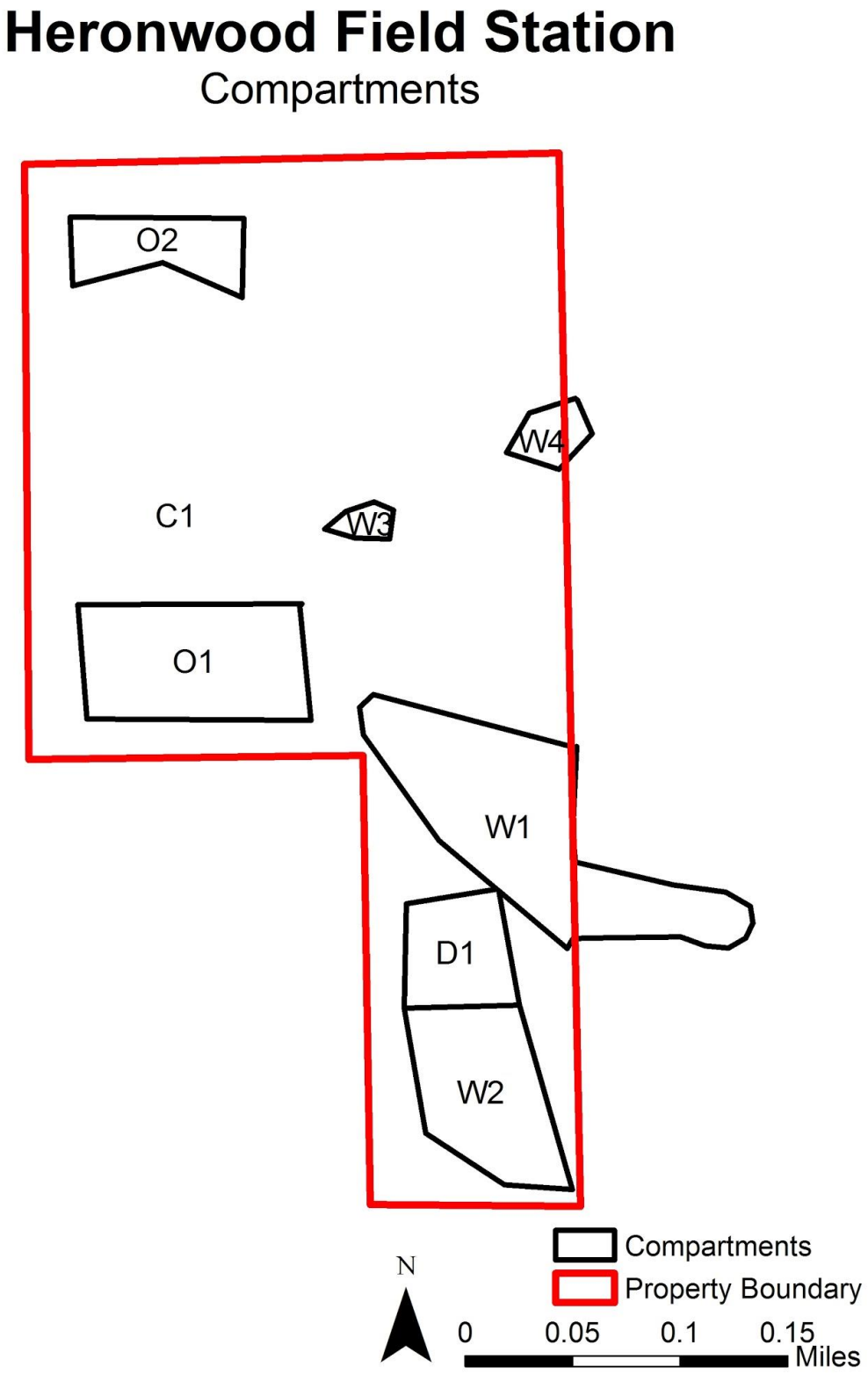

Figure 5.4: Heronwood Field Station habitat compartment boundaries.

Management Unit A

Description

- **C1: Central hardwoods, oak-hickory forest complex**. Where the topography drops down to W3 and W4, dry-mesic southern forest gives way to mesic southern forest. While the uplands are dominated by oaks and hickories, the lowlands have more maples (*Acer spp.*), ironwood (*Ostrya virginiana*), and cherries (*Prunus spp*.). Also contains abundant sassafras (*Sassafras albidum*) recruitment. The forest displays less-than-ideal oak recruitment, possibly due to deer overpopulation. Field observations in 2015 indicated that northern red oak (*Quercus rubra*) exhibited lower regeneration than white oak (*Q. alba*). This is a fire-dependent ecosystem, and a fire regime should be considered to assist in oak regeneration. Regeneration is important; since this forest type thrives in a drier landscape, it may be more resilient to climate change as droughts become more frequent and intense. At present, prescribed burns are not being conducted in this compartment, and regeneration is mostly encouraged by small-scale wind throw events (gaps opened by blown-down trees).
- **O1: Oldfield/open area**. This compartment has been mowed and could be managed to become a mesic prairie ecosystem. A mowed trail follows the rolling topography and provides a lovely view from the top of a hill. Rare mesic prairie habitat is maintained through fire, and a fire regime would need to be implemented in order to keep this compartment healthy.
- **O2: Oldfield/open area**. Due to dense underbrush, this compartment is currently inaccessible from the rest of the trail system.
- **W3: Small pond.**
- **W4: Small pond**.

This unit has plenty of opportunities for getting students involved with expanding and maintaining forest trails, potential prairie units, and potential prairie trails.

The unit shares its western elbow border with a farm where, in Summer 2015, a neighbor had placed a salt lick just on the edge of the woods (see Figure 5.5). This suggests that neighbors are luring deer out of HFS for hunting purposes.

Figure 5.5: Salt lick at edge of Heronwood Field Station property (photo credit: Kate Chapel, 2015)

Recommendations

Invasive Species Control

KNC staff gave invasive species control a priority ranking of 4.46 out of 5.

- 1: Monitor for invasive species along trails and forest edges, as these disturbed areas are easier for invasive plants to colonize.
- 1: Aim to completely eradicate invasive species populations in the interior of C1, as these populations are already low.
- 1: Involve HFS students in invasive species eradication measures. However, only allow staff members to handle chainsaws, pesticides, and other potentially hazardous equipment.
- 1: Prioritize management in the following order (based on current population size, projected population size, and ease of management). Find more details on removal methods in Appendix II.
    - Spotted knapweed (*Centaurea maculosa*) (mostly in O1)
    - Garlic mustard (*Alliaria petiolata*) (throughout in pockets)
    - Honeysuckle (*Lonicera tartarica & L. maackii*) (mostly in C1)
    - Multiflora rose (*Rosa multiflora*) (mostly in C1)
    - Autumn olive (*Elaeagnus umbellata*) (mostly in C1)
- 2: Repeat Modified-Whittaker plot survey in C1 (see Figure 5.3).

Deer Blinds

- 1: Remove deer blinds, particularly before they decay into safety hazards.

Prairie Restoration

KNC staff gave the ecological and environmental value of restored prairie habitat a ranking of 4.6 out of 5.

- 1: Control spotted knapweed (*Centaurea maculosa*) in O1. See Appendix II.
- 2: Use prescribed burns to shift oldfield habitats into mesic prairie ecosystems. Develop a burn rotation schedule that targets one-third of the prairie site every year.
- 2: In addition to burning, plant these prairie species:
    - Big bluestem (*Andropogon gerardii*)
    - Little bluestem (*Schizachyrium scoparium*)
    - American hazelnut (*Corylus americana*)
    - Prairie coreopsis (*Coreopsis palmata*)
    - Culver's root (*Veronicastrum virginicum*)
    - Rattlesnake-master (*Eryngium yuccifolium*)
    - Golden alexander (*Zizia aurea*).
- 2: Continue mowing trails in O1 to provide access to new reference sites.
- 2: Add a viewing bench and educational sign along the hilltop trail in O1.

Ponds

W3 and W4 are relatively unexplored and undocumented.

- 2: Collect baseline data on depth, temperature, dissolved oxygen, conductivity, etc. See Chapter 3: Water Quality for methods.
- 2: Determine if ponds are vernal or permanent by visiting in multiple successive seasons.

Signs

- 2: Add signs along eastern property border to alert people that they are entering private property and to discourage people from hunting. Signs should include the KNC logo, which is acceptable within the provisions of the Conservation Easement.
- 3: Add a sign or communicate with neighbor to the west who is baiting deer; ask neighbor to remove salt lick.

Oak Regeneration

- 3: Explore options for restricting deer movement within the oak-hickory forest to limit herbivory and encourage oak regeneration. Options include:
    - Putting cages around oak seedlings (efficient and cost-effective, but temporary; could get students involved)
    - Setting up a deer fence (effective and permanent, more expensive; could get students involved)
    - Culling the deer (potentially controversial; no student involvement)
    - Prescribed burns
    - Combination of the above
- 3: Consider developing a burn rotation schedule for C1 to encourage oak regeneration.

Trail Building and Maintenance

KNC staff voiced concerns about erosion, giving it a priority ranking of 3.68 out of 5 on the staff survey. Lack of erosion controls was ranked 4.04. See Appendix V for details on an erosion study conducted on KNC's Main Site. See Chapter 3: Trail Maintenance and Development for details about building and maintaining sustainable trails.

- 3: Watch for compaction, ruts, and other signs of erosion in trails running along the tops of slopes, especially where C1 meets the western adjacent property.
- 3: Extend a trail into the northernmost portion of the property, extending from the western to eastern borders. This section is thickly vegetated and installing a trail will require concerted effort.

Measures of Success

- Removal of deer blinds
- Results of pond data collection
- Reduced number of hunters seen on the property
- Diminished observations of invasive plant species
- Results of repeated Modified-Whittaker plot sampling in C1 (should see decrease in percent cover of known invasive species, increase in stems at sapling level)
- Results of vegetative studies in proposed restored prairies
- Addition of new trails
- Reduction in signs of erosion on new and existing trails

Management Unit B

Description

- **W1: Wetland, larger pond behind the main building (house).** Large scenic pond in full view of house's primary gathering room. Substantial presence of buttonbush (*Cephalanthus occidentalis*). Water lilies (*Nymphaea spp.*) are taking over the pond, making it difficult to canoe with the kids, taking away habitat for birds and turtles, and potentially removing food sources for fish in the pond by preventing underwater plants from growing. With a thick blanket of vegetation, no sunlight is penetrating into the water, which may reduce energy production below the surface. Migratory waterfowl may find this lack of open water unappealing for landing and resting.
- **W2: Wetland, smaller in front of the main building (house)**. There is some degraded wetland located between Hart Road and the main building (house) that KNC would like to restore to higher quality. Blanding's turtles (*Emydoidea blandingii*), a species of concern in the state of Michigan, have been found in this compartment. They are very loyal to their wetlands, and therefore it is important to maintain high-quality natural habitats. The turtle uses wetlands for feeding and hibernating and upland fields as nest sites.[91]

[91] Blanding's turtle (*Emys blandingii*) [Internet]. Lansing (MI): Michigan Department of Natural Resources [cited 2016 Apr 13]. Available from https://www.michigan.gov/dnr/0,4570,7-153-10370_12145_12201-60647--,00.html

Recommendations

Water Lilies

- 1: Remove water lilies on W1 by hand, using waders and canoes to access the pond's interior. This strategy will likely need to be repeated several times. Otherwise, consider applying aquatic grade herbicide. This may be more effective but would exclude HFS students from being heavily involved. Care would need to be taken to not negatively affect other flora or fauna.

Wetland Restoration

- 1: Begin regular bird-watching logs to understand waterfowl use of W1 and W2. These data can be compared over time as the wetland is restored.
- 2: Perform baseline water quality analyses in W1 and W2 and repeat as restoration activities are undertaken.
- 3: Maintain wetland and upland habitats for Blanding's turtles.
- 3: Enlist HFS students to help with planting and restoration activities in W2.

Measures of Success

- Reduced area of W1 covered by water lilies
- Increase in number and diversity of migratory waterfowl
- Rising proportion of native wetland species over invasive species
- Improved water quality and hydrology measurements.

Management Unit C

Description

- **D1: Developed area**. Includes the converted house, greenhouse, and paved area. A small "front yard" separates the house from the largest pond (WI). After a cement path was installed, the grass was allowed to grow unruly and is now visible from the primary gathering room of the converted house. Though most of HFS should be maintained as natural habitat communities, this particular patch is so highly visible that it should be kept more manicured. The buildings in this compartment are maintained well and should continue in their current use. The compartment hosts a substantial population of Canada geese (*Branta canadensis*). The geese are a nuisance and leave inconvenient droppings.

Recommendations

"Front Yard" Beautification

- 1: Decorate the front yard with native plantings, chosen to be attractive and relatively tidy to maintain the view from the house.
- 1: Remove invasive species using control methods suitable for wetlands and aquatic habitats.

- 1: Consider multiple control methods for Canada geese, as recommended by the Michigan DNR:[92]
    - Off-putting visual stimuli (bird balloons, mylar tape, plastic flags)
    - Scare devices activated when geese arrive (shell crackers, bird alarm calls)
    - Doggie "predator" borrowed from KNC staff or volunteer and allowed to patrol the yard on a regular basis
    - Repellent made from grape extract, applied to lawn
    - Swaths of tall grasses planted or left unmowed along pond and wetland edges
    - Longer lawn turf

Rain Garden Installation

KNC gave the organization's lack of a property-wide stormwater management plan a priority ranking of 3.75 out of 5.

- 2: Install a preventative and educational rain garden at the downslope of the driveway. The rain garden will join the wetlands in acting as a buffer and sink for excess water coming off the driveway. This will be particularly important as climate change ushers in more extreme storms and unpredictable precipitation.

Measures of Success

- Reduced presence of geese
- Increased access to the pond
- Increased aesthetics and preserved lines of sight
- Level of runoff from paved areas reaching the rain garden

Climate Change: Adaptation and Mitigation

See Chapter 3: Climate Change and Adaptation for details about Michigan's shifting climate and its species impacts. The recommendations here ultimately add up to a more resilient ecosystem that can bounce back from large storms, extended droughts, and other predicted effects of global climate change. Robust tree recruitment will enable the forest to remain healthy should wind storms or pests come through. Much of this site plan also acts to maintain or create habitat and food sources for native flora and fauna and mitigate the influence of invasive species that take advantage of climate-driven disturbance. Climate change may create more opportunities for invasive species to take over, since these non-native plants tend to be more drought-resistant and tolerant of extreme conditions.

[92] Goose-human conflicts and control techniques [Internet]. Lansing (MI): Michigan Department of Natural Resources [cited 2016 Apr 13]. Available from https://www.michigan.gov/dnr/0,4570,7-153-10370_12145_25065-59467--,00.html

Chapter 6: West Fork Campus

West Fork Campus Management Plan

West Fork: 2315 Angling Road, Kalamazoo, MI 49008
Nature's Way Preschool: 4326 Oakland Drive, Kalamazoo, MI 49008

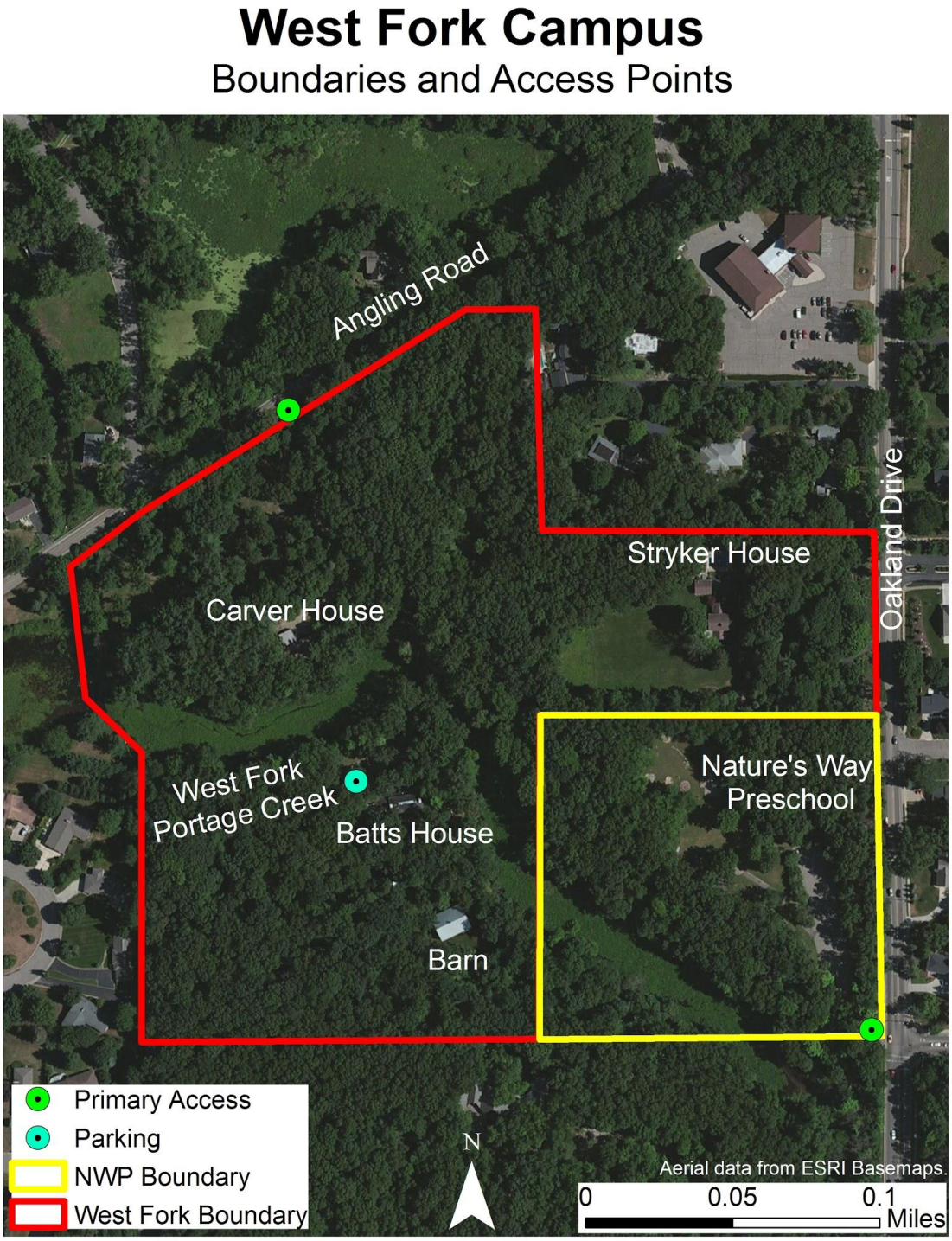

Figure 6.1: Boundaries, access points, and built features on West Fork Campus.

Introduction

The West Fork Campus is an educational complex located in suburban Kalamazoo, MI. In 2015, the Kalamazoo Nature Center received a 22-acre land donation from Kalamazoo native and philanthropist Jon Stryker. The donated land, located along the West Fork of Portage Creek, borders the grounds of KNC's existing Nature's Way Preschool. Together, the new West Fork property and existing Nature's Way property make up the 33-acre West Fork Campus (see Figure 6.1). West Fork and Nature's Way will be managed as distinct properties, as reflected in the management recommendations in this site plan.

West Fork

The West Fork land currently holds several residential homes. In addition to the land donation, Stryker has committed to a 2-to-1 matching grant of up to $700,000. This grant will go toward building a proposed educational facility in West Fork and renovating and maintaining existing buildings.[93] Conditions of the donation also require conservation easements to be placed on the land.[94] The first phase of the project is expected to cost approximately $1.4 million (see Figure 6.2).

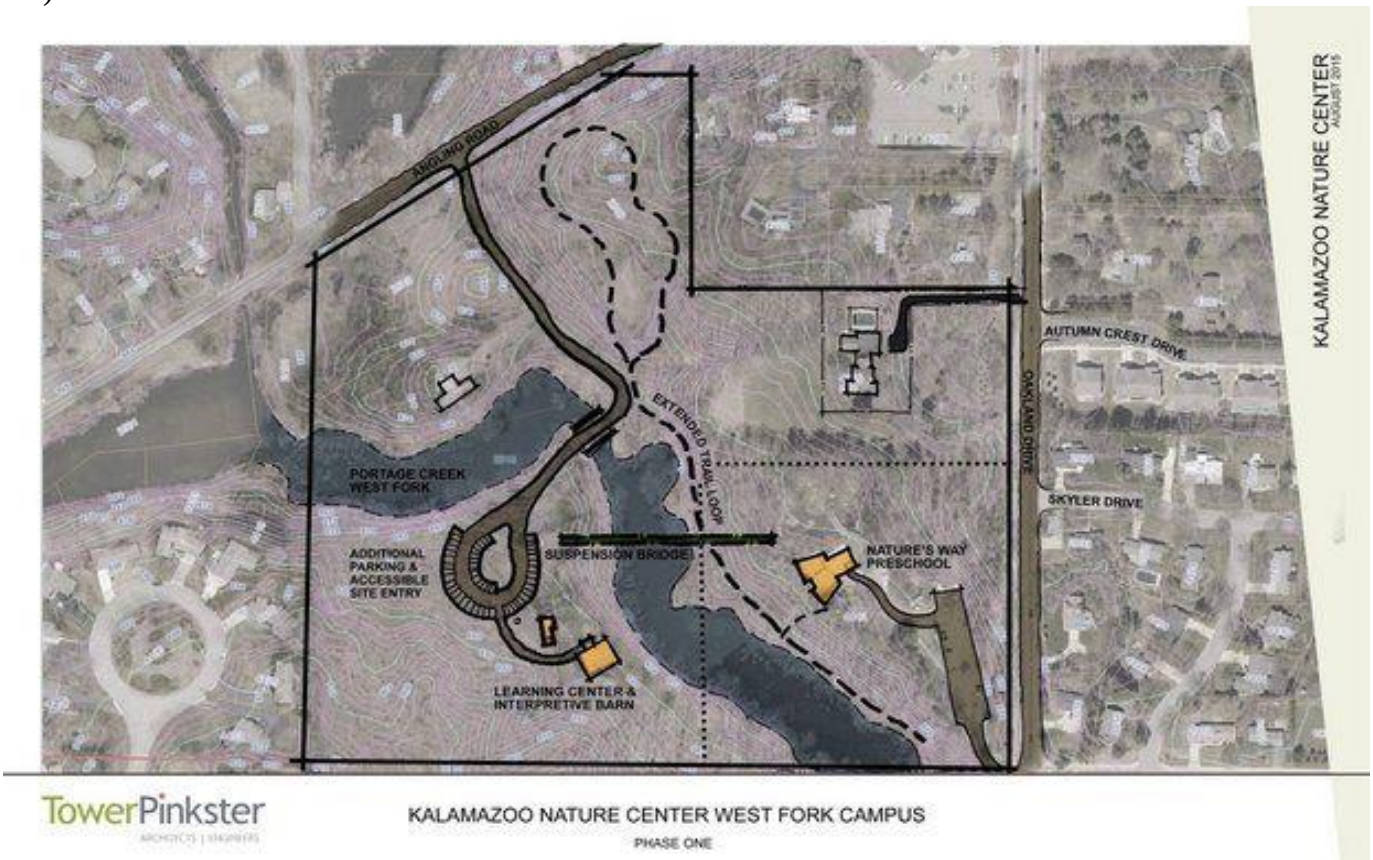

Figure 6.2: Diagram of proposed Phase 1 construction on West Fork Campus.

[93] Kalamazoo Nature Center getting 22-acre land donation [Internet]. Washington, DC: the Washington Times; 2015 Aug 17 [cited 2016 Mar 14]. Available from http://m.washingtontimes.com/news/2015/aug/17/kalamazoo-nature-center-getting-22-acre-land-donat/

[94] Parker R. Jon Stryker donates land, up to $700,000 to Kalamazoo Nature Center [Internet]. Kalamazoo (MI): MLive; 2015 Aug 17 [cited 2016 Apr 3]. Available from http://www.mlive.com/news/kalamazoo/index.ssf/2015/08/stryker_donates_22_acres_along.html

Nature's Way Preschool

According to the Natural Start Alliance, "Preschool educators have long known that animals, plants, water, and other aspects of the natural world delight children and draw them in as learners."[95] Nature-based preschools share the same child development goals held by traditional preschools with an additional commitment to accomplishing those goals through experiences in and with nature. Weaving nature into preschool curriculum fosters a child's physical, mental, and emotional development. Nature-based education also helps pique curiosity and awareness about environmental issues.

Nature's Way is an award-winning nature preschool with a mission "to bring the outdoors in."[96] It is owned and managed by KNC and is licensed by the State of Michigan. It is one of only 25 nature-based preschools in the nation, and also the fourth longest-running nature-based preschool in the country.[97]

Nature's Way runs two programs for 3-4-year-olds, one for 4-year-olds (as of the 2014-2015 school year), and 6 different classes. Courses use thematic nature experiences centered on topics like animals, seasons, weather, plants, art, language, and math.

History

West Fork

The newly-donated West Fork land within the West Fork Campus was previously owned by KNC founder and nationally known environmentalist Dr. H. Lewis Batts, Jr. and his wife Jean. Jon Stryker purchased the land from the Batts estate and maintained a home there. Stryker donated the land to KNC with the knowledge that it would be used for research and to educate generations to come, be accessible by a wider public, and be better restored and preserved.[98]

Nature's Way Preschool

Prior to its purchase by Dr. Batts, this land was used as a YWCA camp. Dr. Batts' purchase included a one-room YWCA cabin built in the 1960s. Nature's Way Preschool was founded in 1982, operating out of the cabin until 2012 when an updated facility was built to accommodate increasing numbers of staff and students. The new building brought the preschool facility to 6,000 square feet. The building was designed by the parent of a former Nature's Way student. The building's windows employ a unique UV coating designed to prevent birds from accidentally flying into the glass.[99]

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[95] What Is a nature preschool? [Internet]. Natural Start Alliance [cited 2016 Mar 14]. Available from http://naturalstart.org/nature-preschool/what-is-a-nature-preschool

[96] Natural Start Alliance map [Internet]. Natural Start Alliance [cited 2016 Apr 6]. Available from http://naturalstart.org/map

[97] Gignac E. New location for Kalamazoo Nature Center's Nature's Way Preschool opens August 15 [Internet]. Kalamazoo (MI): MLive; 2013 Jun 16 [cited 2016 Mar 20]. Available from http://www.mlive.com/news/kalamazoo/index.ssf/2013/06/kalamazoo_nature_centers_new_n.html

[98] Kalamazoo Nature Center announces major land donation from Kalamazoo native Jon Stryker [Internet]. Kalamazoo (MI): Kalamazoo Nature Center; 17 Aug. 2015 [cited 2016 Mar 20]. Available from http://www.naturecenter.org/Donate/StrykerMatch.aspx#sthash.Yi8jbp2f.dpuf

[99] Cantero C. Nature's Way Preschool celebrates opening of new, innovative building [Internet]. Kalamazoo (MI): MLive; 2013 Sep 18 [cited 2016 Mar 20]. Available from http://www.mlive.com/news/kalamazoo/index.ssf/2013/09/natures_way_preschool_opens_wi.html

Property Composition

Landscape Context

The West Fork Campus is surrounded by residential communities to the north, east, and west. Woods extend south from the property. Two major highways also surround the property, with I-94 approximately ½-mile south and US-131 approximately 1 mile east of the property boundary. The West Fork of Portage Creek, which gives the property its name, meanders through the middle of the property. Along an upstream segment of Portage Creek to the northwest of the property is the Parkview Hills housing community (see Figure 6.3). Parkview Hills was designed by Dr. Batts and Burton Upjohn to reflect eco-friendly values.[100] There is also a church to the northeast side of the property. Because the property is partially surrounded by neighborhoods, habitat degradation may be prominent where property boundaries abruptly meet the suburban developments.

Property Composition

The West Fork of Portage Creek flows through the West Fork Campus, forming one edge of the boundary between the West Fork and Nature's Way Preschool properties. The Campus also contains central hardwood forests and a few developed areas including the preschool facility, several houses, and a barn.

[100] Bennett K. Parkview Hills Neighborhood celebrates 40 years [Internet]. Kalamazoo (MI): MLive; 2010 Sep 29 [cited 2016 Apr 1]. Available from http://www.mlive.com/living/kalamazoo/index.ssf/2010/09/post_13.html

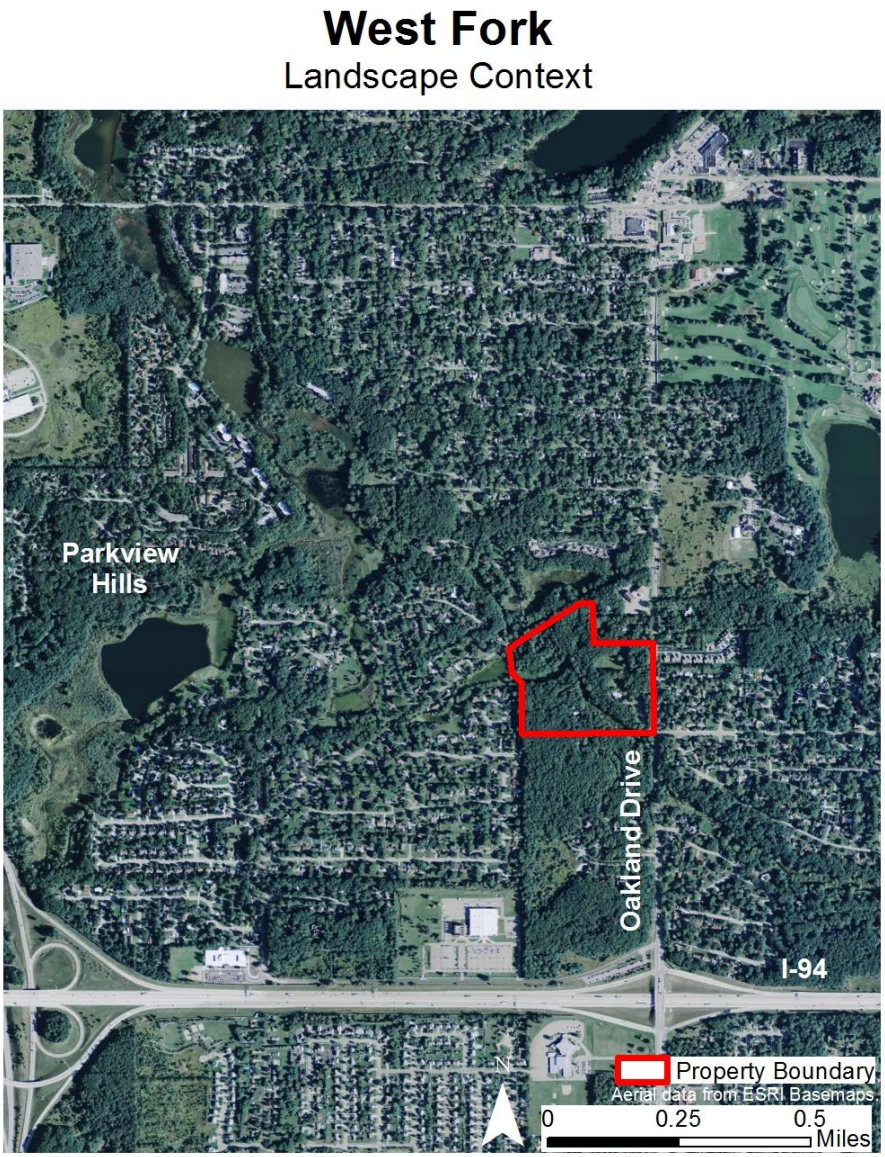

Figure 6.3: Landscape context of West Fork Campus.

Data Collection

Informal walkthroughs in July 2015 resulted in a partial species list for the West Fork Campus, including notable invasive plant species.

Data Results

The informal survey of the West Fork Campus revealed the presence of a number of invasive and native species. The following list consists of species that were identified and recorded within the newly-acquired West Fork portion of the Campus:

Creekbank plants:

- Catalpa (*Catalpa speciosa*)
- Willows (*Salix* spp.)
- Buttonbush (*Cephalanthus occidentalis*)
- Arrow arum (*Peltandra virginica*)
- Purple loosestrife (*Lythrum salicaria*)—invasive
- Reed canary grass (*Phalaris arundinacea*)—invasive

Woodland plants

- Virginia creeper (*Parthenocissus quinquefolia*)
- Raspberry (*Rubus idaeus*)
- Sassafras (*Sassafras albidum*)
- Indian pipe *(Monotropa uniflora)*
- Poison ivy *(Toxicodendron radicans)*
- Bur oak *(Quercus macrocarpa)*
- White pine *(Pinus strobus)*
- California redwood (*Sequoia sempervirens*)—non-native transplant
- Oriental bittersweet (*Celastrus orbiculatus*)—invasive
- Japanese barberry (*Berberis thunbergii*)—invasive
- Garlic mustard (*Alliaria petiolata*)—invasive
- Honeysuckle (*Lonicera maackii*)—invasive
- Dame's rocket *(Hesperis matronalis)*—invasive

Woodland fauna

- Wild turkey (*Meleagris gallopavo*)
- White-tailed deer *(Odocoileus virginianus)*
- Eastern box turtle (*Terrapene carolina carolina*)

General Recommendations

The main goal of management is to restore the favorable conservation status of habitats and species of community interest. Due to the educational programs conducted on the property, enhanced educational program quality is also a goal. Recommended management actions are prioritized according to the following numerical scale:

1: Address within the next 3 years
2: Address within the next 5 years
3: Address within the next 10 years
4: Address in the next 10-year comprehensive LMP

- 1: Track information about research projects and management actions. Discuss projects with current research director. Store information about research findings and management results in a central location.

- 1: Conduct complete biological inventory. Consider running a BioBlitz or another rapid ecological assessment. Set up more formal transects or Modified-Whittaker plots where appropriate.
- 2: Build relationships and connections with residents in adjacent neighborhoods, some of which directly abut the property line. Encourage them to better understand the natural resources in their backyard.
- 3: Host a public meeting with the neighbors to explain management practices that may be unfamiliar.

Management Units

As noted previously, the West Fork Campus is divided into two separately managed properties which will be treated here as distinct management units: Nature's Way Preschool and West Fork. See Figure 6.1 for unit boundaries. Each unit is further broken down into three habitat compartments: Developed Areas, Woods and Creek.

Management Unit A: Nature's Way Preschool

Description

- **D1: Developed areas.** The primary feature is the new two-classroom preschool facility (see Figure 6.4). This compartment also includes two playgrounds and a paved parking lot up a short hill from the preschool. The parking lot has generated a lot of downhill runoff, washing sediment into the creek. Rock and riprap have been added to prevent further erosion, but this is only a temporary fix. A rain garden near the parking lot was permanently flooded in Summer 2015. Currently there are several trails that the children hike every day. One trail leads to a creekside dock. Other trails lead to the woods.

Figure 6.4: Interior of Nature's Way Preschool classroom (photo credit: KNC)[101]

[101] Summer program at Nature's Way Preschool [Internet]. Kalamazoo (MI): Kalamazoo Nature Center [cited 2016 Apr 11]. Available from http://www.naturecenter.org/Preschool.aspx

- **C1: Central hardwood forest.** The preschool unit has 9 acres of natural area, including forests and the creek. Recommendations for managing the creek and forest habitats will be discussed in the West Fork management unit. The natural areas serve as a daily extension of the classroom and facilitate creative outdoor play. Signs of browsing by white-tailed deer *(Odocoileus virginianus)* were found near the play area. The play areas around the building are mostly patchy grass and exposed soil with a handful of play structures.
- **W1: Wetland/creek.** Portage Creek's West Fork enters from the west and passes south of Nature's Way Preschool. A small dock allows the students to walk up to the water's edge. Buttonbush grows near the dock. All recommendations for the creek will be discussed in the West Fork management unit.

<u>*Recommendations*</u>

Trail Cleaning

- 1: Remove broken glass and crockery from the edges of trails.
- 1: Remove dead branches overhanging trails.

Beautification of Natural Play Areas

- 1: Install clean soil or mulch around play areas.
- 2: Fence off the play area to reduce deer browse.

Reduce Runoff

- 2: Re-design rain garden, or install additional plantings in the garden.
- 3: Enlarge rain garden's footprint.

Reduce Facility Energy Use

- 1: Develop a system to track building energy use.
- 1: Seal windows and doors to avoid heat loss.
- 1: Turn off the heating system and lights when not in use.
- 1: Use ceiling fans instead of air conditioning.
- 2: Install a window shading system that reduces summer heat and maximizes winter sunshine.
- 2: Only replace appliances when they no longer work; bring old ones to appropriate disposal or recycling facility.
- 3: Install a solar-powered hot water.

Balance Future Development with Ecological Needs

- 2: Develop strategies for making better use of natural areas immediately surrounding the facility; scale back on use farther away from the building.
- 3: When building or expanding any component of the site, capitalize on areas that have already been disturbed.
- 3: Consider adding a natural exhibition room near the existing preschool facility.

Trail Extension

- 2: Extend trails into the wooded portions of the new West Fork unit. The first phase of the West Fork development project includes the construction of a new bridge over Portage Creek that would connect Nature's Way to the West Fork unit (see Figure 6.2).

Measures of success

- Results of play area planting and beautification efforts
- Annual energy consumption of the building
- Decreased sediment erosion into the creek
- Construction of new trails and bridge
- Decreased deer browse near play areas

Management Unit B: West Fork

Description

- **D2: Developed areas.**
    - *Batts House:* Dr. Batts' private home is on Angling Road in the northern part of West Fork. The house is in poor shape and will likely be taken down and replaced with a parking area (see Figure 6.2).
    - *Carver House*: This Frank Lloyd Wright-inspired house was already on the land when Batts bought the property. Currently, KNC plans to keep the house intact, as it serves as an example of interesting historical architecture.
    - *Stryker House:* After Stryker purchased the land, he removed some outbuildings, and constructed his own home. The fate of this house is unknown at the time of this writing.
    - *Stryker Barn*: Stryker purchased this historic barn from another site and had it reconstructed at West Fork as an event space (see Figure 6.5). The well-maintained barn has hardwood floors and high windows. In Summer 2015, extensive vinca (*Vinca minor*) was noted around the barn, but it was mostly contained by the lawn. Adjacent to the barn is a large transplanted California redwood (*Sequoia sempervirens*).
    - *Proposed Additions*: Phase 1 of the West Fork Project calls for a bridge to be constructed over Portage Creek and natural wetlands, linking Nature's Way Preschool with the West Fork barn and programming area (see Figure 6.2). Phase 1 also involves adding parking lots and retrofitting the barn into a primary education programming facility. [102]

[102] Niles D. Kalamazoo Nature Center grateful for Jon Stryker donation [Internet]. Kalamazoo (MI): MLive; 2015 Aug 17 [cited 2016 Apr 3]. Available from http://www.mlive.com/news/kalamazoo/index.ssf/2015/08/kalamazoo_nature_center_gratef.html


Figure 6.5: Interior and exterior views of the Stryker barn (photo credit: Daytona Niles)[103]

- **C2: Central hardwood forest.**
  - *Floral community:* Limited tree regeneration could be due to deer browse, canopy cover, or overabundance of woody debris. Efforts to open the upper canopy should be weighed against the increased risk of colonization by invasive species, including oriental bittersweet (*Celastrus orbiculatus*). A partial list of species noted during an informal July 2015 survey:
    - Oriental bittersweet (*Celastrus orbiculatus*)—invasive
    - Japanese barberry (*Berberis thunbergii*)—invasive, but a low-level threat
    - Garlic mustard (*Alliaria petiolata*)—invasive
    - Honeysuckle (*Lonicera maackii*)—invasive
    - Dame's rocket (*Hesperis matronalis*)—invasive
    - Virginia creeper (*Parthenocissus quinquefolia*)
    - Raspberry (*Rubus idaeus*)
    - Sassafras (*Sassafras albidum*)
    - Indian pipe (*Monotropa uniflora*)
    - Poison ivy (*Toxicodendron radicans*)
    - Bur oak (*Quercus macrocarpa*)
    - White pine (*Pinus strobus*)
    - Chicken-of-the-woods fungus (*Laetiporus* sp.)
  - *Faunal community:* Wild turkeys (*Meleagris gallopavo*) were seen during the 2015 survey. West Fork hosts a flock of about 30 individuals (see Figure 6.6). Turkeys are native to Michigan and live in open fields and woods and nest on the ground. Their preferred diet includes insects, grasses, nuts, and berries.[104] An eastern box turtle (*Terrapene carolina carolina*) was also spotted during the survey (Figure 6.7). This is Michigan's only truly terrestrial turtle. They are uncommon to rare in this part of Michigan. Michigan law protects them as a species of special concern. Their population has declined mainly due to habitat loss, collection, and road mortality. Their habitat includes open woodlands and adjacent meadows, thickets, and gardens, often near shallow ponds, swamps, or

[103] Niles D. Kalamazoo Nature Center grateful for Jon Stryker donation [Internet]. Kalamazoo (MI): MLive; 2015 Aug 17 [cited 2016 Apr 3]. Available from http://www.mlive.com/news/kalamazoo/index.ssf/2015/08/kalamazoo_nature_center_gratef.html
[104] Wild Turkey (*Meleagris Gallopavo*) [Internet]. Lansing (MI): Michigan Department of Natural Resources [cited 2016 Apr 3]. Available from https://www.michigan.gov/dnr/0,4570,7-153-10370_12145_12202-52511--,00.html

streams. Many box turtles stay within a small home range (under five acres) for most of their lives.[105]

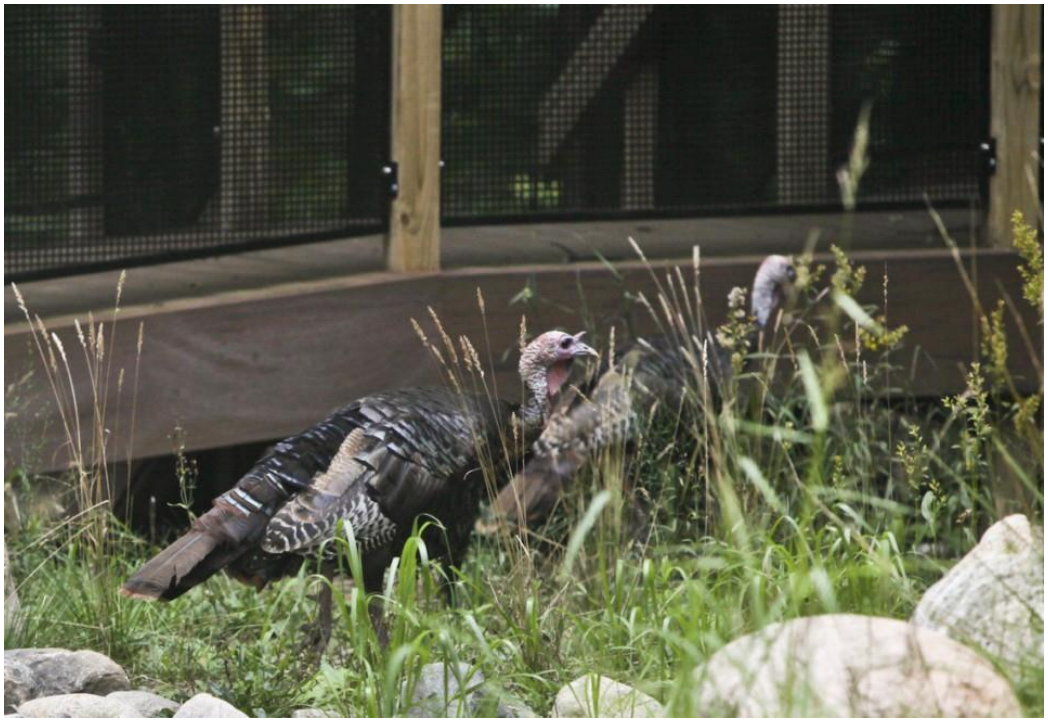

Figure 6.6: Members of the West Fork turkey flock (photo credit: Daytona Niles)[106]

Figure 6.7: Eastern box turtle found in West Fork in July 2015 (photo credit: Kate Chapel)

[105] DNR Wildlife & Habitat Wildlife Species Amphibians & Reptiles [Internet]. Lansing (MI): Michigan Department of Natural Resources [cited 2016 Mar 6]. Available from http://www.michigan.gov/dnr/0,4570,7-153-10370_12145_12201-60648--,00.html
[106]Niles D. Kalamazoo Nature Center grateful for Jon Stryker donation [Internet]. Kalamazoo (MI): MLive; 2015 Aug 17 [cited 2016 Apr 3]. Available from http://www.mlive.com/news/kalamazoo/index.ssf/2015/08/kalamazoo_nature_center_gratef.html

- **W2: Wetland/creek.**
    - *Floral communities:* Purple loosestrife (*Lythrum salicaria*) and reed canary grass (*Phalaris arundinacea*) are invasive species that were found along the creek during the 2015 field season. Other species found in 2015 include:
        - Catalpa (*Catalpa speciosa)*
        - Willows (*Salix* spp.)
        - Buttonbush (*Cephalanthus occidentalis*)
        - Arrow arum (*Peltandra virginica*)
    - *Water quality:* the West Fork of Portage Creek flowing through this site is one of the four subwatersheds that flow to the Portage-Arcadia Creek Watershed. This site is part of the floodplain for Portage Creek near the headwaters, which could explain the slow-moving, highly-vegetated qualities of this site. USGS stream gauge reports indicate that West Fork has stable flow levels.[107] A series of water quality surveys conducted from 2002 to 2009 in West Fork Portage Creek (at east side of Burdick Street at Candlewyck Apartments) sampled *E. coli* bacterial loads.[108] 26 percent of the 71 samples contained bacterial levels not suitable for partial-body contact (wading, fishing) and 24 percent had levels unsuitable for total-body contact (swimming). Detailed results, including pH, conductivity, water temperature, DO, total dissolved solids, turbidity and bacteria can be found here at the Kalamazoo County Health and Community Services website.

Recommendations

Safety and Accessibility

- 1: Remove chicken-of-the-woods for drying and display to prevent curious children from sampling this potential mildly toxic fungus **OR**
- 1: Incorporate awareness of chicken-of-the-woods and hazardous plants like poison ivy into educational programming.
- 2: Monitor for potential threats to children from aggressive wild turkeys.
- 2: Clear snags and dead branches that interfere with trails, but leave other dead wood in place.

Forest Regeneration

- 2: Plant saplings to fill gaps left by fallen trees.
- 3: Use no-cull methods to mitigate deer browse in wooded areas.

Invasive Species Management

- 1: Remove invasive species flagged in 2015 species survey, particularly garlic mustard and Oriental bittersweet. See Appendix II.
- 2: Monitor for regrowth and/or new infestations, especially in canopy gaps left by blown-down trees.

[107] Wesley JK. Draft Kalamazoo River Assessment [Internet]. Lansing (MI): Michigan Department of Natural Resources; 2005 [cited 2016 April 13]. Available from http://www.michigan.gov/documents/KalamazooRA_text_tables_117809_7.pdf
[108] West Fork Portage Creek water quality data [Internet]. Kalamazoo (MI): Kalamazoo County [cited 2016 Apr 11]. Available from https://www.kalcounty.com/eh/swreport.php?sws=12&sw=West Fork Portage Creek

Water Quality Monitoring and Management

- 1: Gather baseline water quality data for this portion of Portage Creek's West Fork. See Chapter 3: Water Quality for methods and parameters.
- 1: Survey macroinvertebrates, amphibians and fish.
- 1: Sample *E. coli* levels across at least one full field season for three years in a row.
- 1: Inventory riparian plant species lining the creek.

Prevent Runoff

- 1: Develop stormwater management plan for new facilities.
- 1: Install native plantings along the driveway to the proposed learning center to mitigate runoff from increased paved areas.
- 2: Install a rain garden along the parking lot to capture runoff.
- 2: Install permeable pavement on proposed driveway and parking lot.

Measures of Success

- Decreased presence of invasive species in woods and along creek
- Results of periodic water quality assessments and bacterial sampling
- Decrease in woody debris blocking trails
- Results of repeated plant species inventories, seeing an increase in FQI over time
- Results of animal, insect, and fish species inventories

Climate Change: Adaptation and Mitigation

See Chapter 3: Climate Change and Adaptation for details about Michigan's shifting climate and its species impacts.

Wild Turkeys

According to the Audubon Society, wild turkeys will lose 87 percent of their current winter range by 2080.[109] Potential expansion during the summer may give the bird a boost in its trek northward. In fact, wild turkeys have already been shifting northward in recent years.

Water Levels

Currently the water level in the West Fork of Portage Creek fluctuates a lot. It is predicted that climate change will bring even more droughts and more flash floods, with precipitation being more concentrated and intense. On the other hand, because of warmer weather, stream flow will peak earlier in the spring; low stream flow will begin earlier in the summer and last longer into the fall.

[109] Climate threatened wild turkey [Internet]. Audubon Society [cited 2016 Mar 30]. Available from http://climate.audubon.org/birds/wiltur/wild-turkey

Fish

Fish often have highly specialized temperature ranges. Increased water temperatures affect energetics, development rates, and phenology. Generally, climate change will favor warmwater fish over coldwater fish. Therefore, methods should be adopted to actively protect coldwater species from competition with warmwater species. In addition, increased flood frequency and magnitude removes woody debris, erodes channels, increases egg or fry mortality, or washes fish into unfavorable habitats.[110] According to the *Union of Concerned Scientists*, "water level changes stress aquatic plants and animals that have adapted to specific low-flow conditions. The survival rates of fish such as salmon and trout are known to diminish when water levels in rivers and streams are dangerously low." [111]

Energy Consumption

Climate change has fewer impact on human-dominated features. However, climate change has important effects on energy consumption. Studies show that if the climate warms by 1.8 degree Fahrenheit, the demand for energy used for cooling will increase by about 5-20 percent. Warming is likely to increase summer peak electricity demand in most regions of the US.[112] Therefore, it is even more important to conserve energy under this situation.

[110] Rutherford E. Future Great Lakes fish communities: influence of climate change, land use, and invasive species [Internet]. Ann Arbor (MI): Great Lakes Environmental Research Laboratory; 2015 Mar 26 [cited 2016 Apr 13].
[111] Lakes and rivers [Internet]. Union of Concerned Scientists [cited 2016 Mar 31]. Available from http://www.climatehotmap.org/global-warming-effects/lakes-and-rivers.html
[112] Karl TR, Melillo JM, Peterson TC. Global climate change impacts in the United States. New York (NY): Cambridge University Press; 2009.

Chapter 7: Harris Prairie

Harris Prairie Management Plan

4313 10th Street North, Kalamazoo, MI 49009
(42.32671N, 85.66798W)

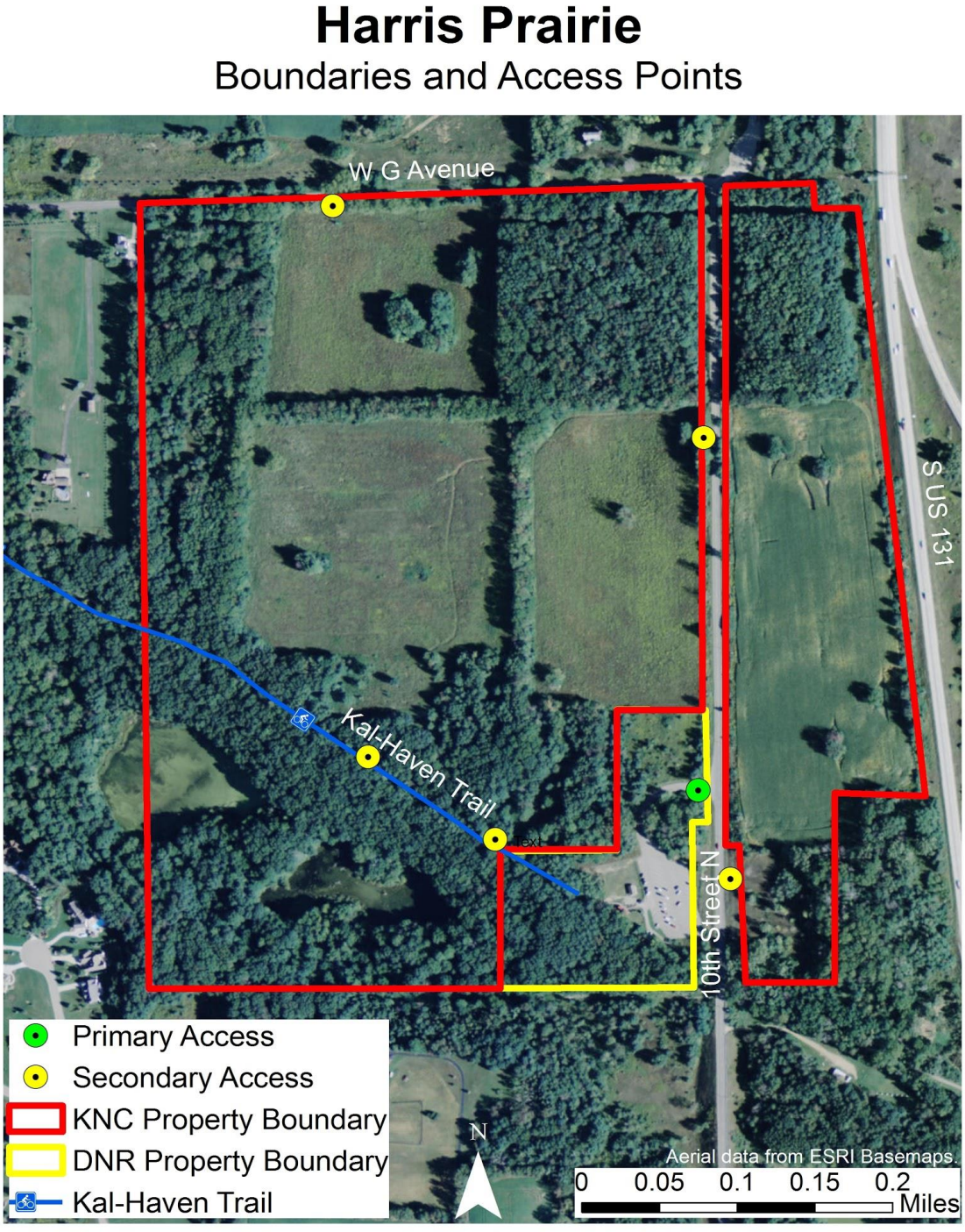

Figure 7.1: Boundaries of the Kalamazoo Nature Center's Harris Prairie property.

Introduction

The Harris Prairie property consists of 110 acres in Oshtemo Township, made up of woodland, prairie, ponds, and active farmland. The Kal-Haven Trail, connecting Kalamazoo to South Haven, runs through the property with a trailhead and parking lot adjacent to the natural areas.

KNC's management on the site to this date can be split into two primary components: restoration of prairies from former agricultural fields and maintenance of the remnant prairie. To this point, KNC has not done any programming on the property nor opened it to the public.

History / Property Composition

Landscape Context

The broader landscape surrounding the Harris Prairie property is quite diverse and can be seen in Figure 7.2 below. Running alongside the property to the east is a highway: US 131 and its business loop, a high-traffic route that many commuters use on their way in and out of Kalamazoo. Just to the north of the property is a gravel extraction operation. A residential subdivision lies immediately to the southwest of the property, with additional neighborhoods further south. In addition to the more developed landscape, the Harris Prairie property is also surrounded by a mix of forested area and agricultural fields. A pair of waterbodies (the Twin Lakes) lie on the other side of the highway from the property.

The forested areas in Harris Prairie appear to connect to a longer contiguous area that could provide a useful wildlife corridor through the developed landscape. Additionally, the increased biodiversity in the restored prairies could serve as a haven for pollinators.

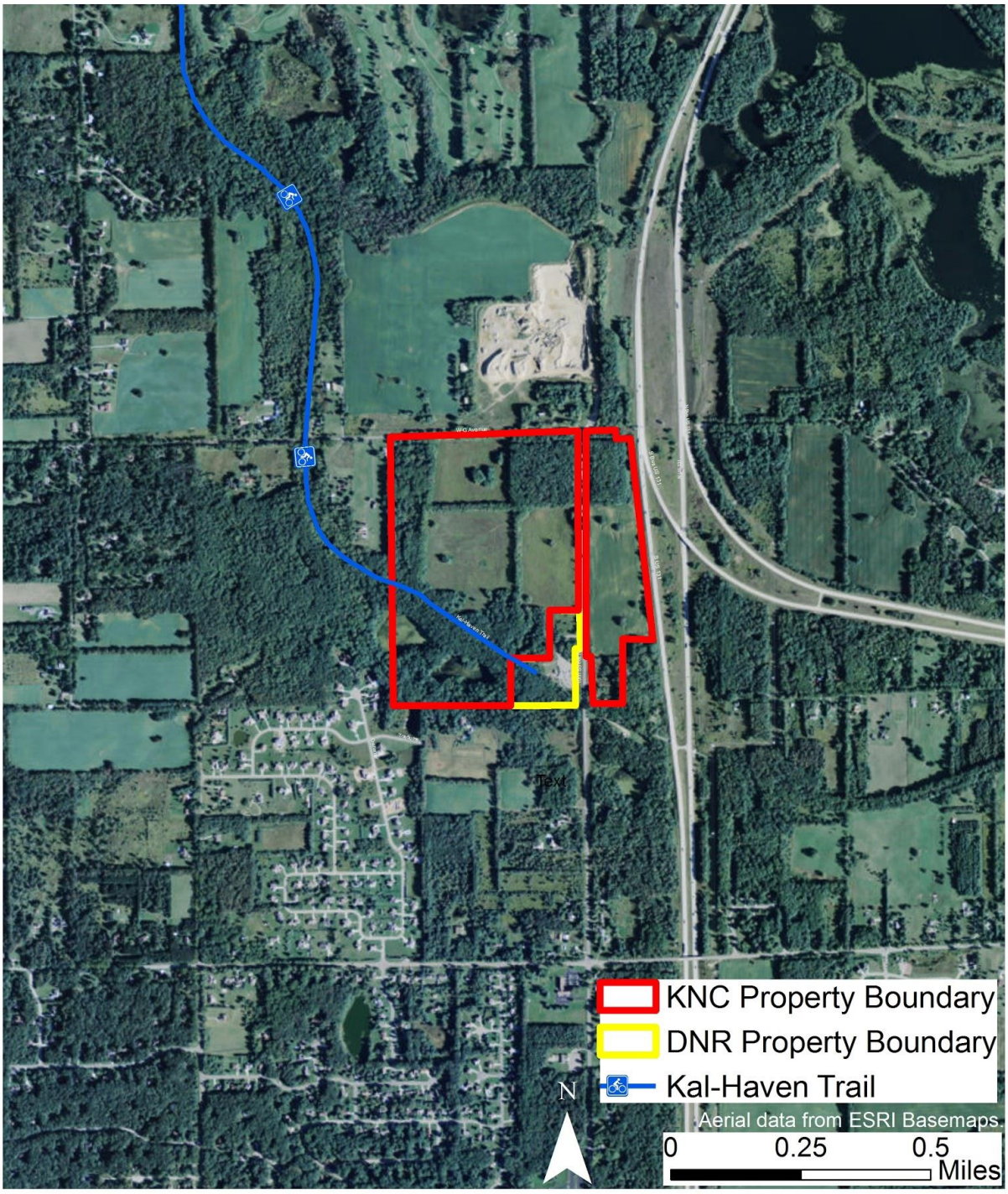

Figure 7.2: Harris Prairie landscape context.

Property Composition

In 1979, 106 acres of property in Oshtemo Township were bequeathed to the Kalamazoo Nature Center. This property included woodland, farmland, and 6 acres of remnant prairie. Of that original bequeathment, some pieces have remained mostly untouched, some is still actively farmed, and a large portion of the property has gone through a prairie restoration process. See Figure 7.1 for a map showing the boundaries of the Harris Prairie property and access points for entry to the property.

Remnant prairie is a natural community that has survived through periods of settlement without having been plowed, though was likely previously part of a larger mesic prairie landscape. Preserving these natural areas is very important as prairie communities can help to control soil erosion, sequester carbon, and provide habitat for a diverse range of plants, birds, pollinators, and other species. This native grassland community was once common in southwestern Michigan but is now considered by the Michigan Natural Features Inventory (MNFI) to be "critically imperiled in the state," earning its highest ranking for protection (S1). At the global level, mesic prairie is considered vulnerable (G3).

The remnant prairie on this property still has some of the original prairie vegetation, but has in large part become overgrown with trees and shrubs due to the lack of natural suppressive processes like fire over the years. This has led the remnant to become fragmented and limits its ability to provide valuable ecosystem services. With the goals of preserving the prairie and oak savanna species present in the remnant and expanding the amount of open habitat available, KNC has been managing the prairie with fire since the 1970s. In 2013, KNC staff selectively cleared in the remnant area using brush cutters and chainsaws and there have also been efforts to reduce canopy cover in order to recombine patches of remnant prairie that had grown isolated.

The original bequest also included several pieces of agricultural land which had been in a rotation between corn and soybeans throughout the 1900s. With funding from the U.S. Department of Agriculture's Conservation Reserve Program (CRP), KNC began the process of converting these agricultural fields into restored mesic prairie in the early 1990s. One 16-acre plot has been undergoing restoration since 1993, which included clearing the field and replanting with a CRP-approved prairie mix that was heavily weighted towards grasses. This prairie has also been managed with a prescribed burn regime. Two other restoration plots, approximately 10 and 12 acres in size, were planted in 2010. These plantings used a CRP seed mix more evenly distributed between grasses and forbs, reflecting an evolving understanding of what constitutes a healthy prairie. The original bequeathment also included a 29-acre parcel on the east side of 10th Street, separated from the remnant and restored prairies. Included in this parcel is an 18-acre plot of agricultural land still under active cropping rotations.

The property also includes several acres of forested area. The primary forest type is dry-mesic southern forest which is considered vulnerable in Michigan (S3) and "apparently secure" on the global scale (G4). There is one large plot of this type on the northeastern corner of the property (12 acres on the west side and 6 acres on the east side of 10th Street), but the community can also be seen bordering the prairies and around the outside of the property. These forested areas primarily consist of oak and hickory trees. The southwestern portion of the property consists largely of mesic southern forest which also ranks as vulnerable in Michigan (S3) but is on the

line between imperiled and vulnerable at the global level (G2/G3). This portion of the property is mostly unexplored, but appears to consist primarily of beech and maple species and also contains two small ponds. An initial exploration into this area revealed good diversity of natives and few invasive species. None of the forested areas appear to be undergoing active management.

In 1989, the Kal-Haven Trail (formerly the Kal-Haven Trail Sesquicentennial State Park) opened, which provided a hiking and biking trail from Kalamazoo to South Haven, MI and Lake Michigan. The trail runs through the Harris Prairie property, south of the remnant and restored prairies and north of the mesic southern forest. Kalamazoo Nature Center donated 9 acres of their Harris Prairie property to the Michigan Department of Natural Resources (DNR), which now serves as the eastern trailhead including a parking lot and small visitor center.

Data Collection

In order to better understand the biological value currently provided by the Harris Prairie property, data were collected in Summer 2015 through Modified-Whittaker plots, prairie transects, informal walkabouts, and conversations with KNC staff. The transects were conducted in the prairie restoration plot that was planted in 1993 (compartment N2, see Figure 7.5 for a map showing all compartments). Two Modified-Whittaker plots (MWP) were used, one in the remnant prairie (compartment N4) and one in the oak-hickory forest (compartment C2) at the northeast corner of the property. To see the precise locations of the plots and transects, refer to the data collection map in Figure 7.3. From the MWP data, metrics were calculated including Floristic Quality Index (FQI) and relative abundance measures. FQI was calculated from the transect data. See Appendix III for more details on how the MWPs and transects were set up and performed as well as information about how the metrics were calculated based on field data. Informal walkabouts, covering small portions of compartments N3 and N4, consisted of walking through plots taking mental notes of the vegetation seen and issues that might need to be addressed. Conversations with KNC President Bill Rose, Sarah Reding and Ryan Koziatek rounded out the information collected about the property.

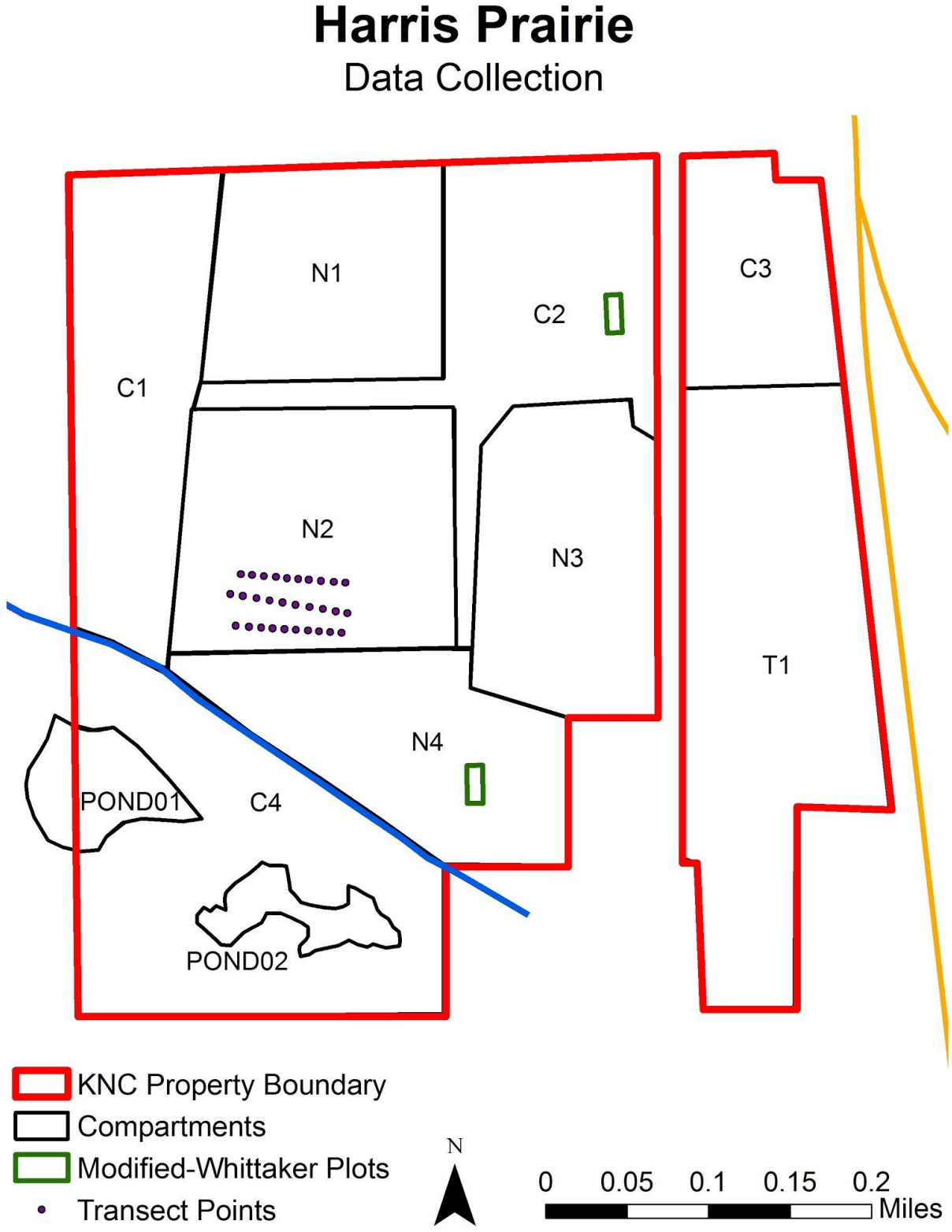

Figure 7.3: Map showing the location of transects and Modified-Whittaker Plots at the Harris Prairie property. Modified-Whittaker Plots were performed in May 2015. Transects were performed in July and September of 2015.

Data Results

As mentioned above, MWPs were conducted in the remnant prairie (N4) and in one of the oak-hickory forest plots (C2). From these MWPs, basal area and relative abundance metrics were calculated. These can be seen in Tables 7.1 and 7.2 below:

Table 7.1: Basal area and relative abundance of tree species above 10 cm DBH in N4

Species	**Basal Area (m^2/ha)**	**Relative Abundance (%)**
Red Oak (*Quercus rubra*)	6,707.5	62.10
White Oak (*Quercus alba*)	2,563.8	23.74
Bitternut Hickory (*Carya cordiformis*)	759	7.03
Sugar Maple (*Acer saccharum*)	384.1	3.56
Black Cherry (*Prunus serotina*)	232.5	2.15
Elm (*Ulmus sp.*)	153.9	1.42
Total	**10,800.8**	

Table 7.2: Basal area and relative abundance of tree species above 10 cm DBH in C2

Species	**Basal Area (m^2/ha)**	**Relative Abundance (%)**
Black Cherry	3,982.2	51.24
Sugar Maple	3,031	39
Red Oak	759.2	9.77
Total	**7,772.4**	

FQI was calculated for each of the compartments where MWPs were performed as well as for N2 where data was collected in the form of transects. FQI scores can be seen in Table 7.3.

Table 7.3: FQI Scores for Harris Prairie compartments

Compartment	**Data Collection Method**	**FQI (natives only)**	**FQI (including invasives)**
C2	MWP	19.7	17.2
N2	Transect	20.2	18.2
N4	MWP	25.4	23.1

Details on the calculation and interpretation of these metrics can be found in Appendix III.

General Recommendations

As a reminder, each recommendation is given a priority between 1 and 4, with each priority level defined below:

1: Address within the next 3 years
2: Address within the next 5 years
3: Address within the next 10 years
4: Address in the next 10-year comprehensive LMP

- 1: Track new projects and results in a centralized location. Before beginning a project on this property, speak to the Biological Research Director (Ashley Wick, as of 2016) about the research location and goal. Record the actions taken and send any results to the research director for centralized recording.
- 1: Conduct additional surveys of the undocumented areas as outlined in the recommendations below. This will flesh out preliminary data collected during the summer 2015 fieldwork.
- 1: Prescribed burns are a primary management recommendation in many parts of the Harris Prairie property.
    - According to the MNFI chapter on mesic prairies, "managing mesic prairie requires frequent prescribed burning to protect and enhance plant species diversity, prevent encroachment of trees and tall shrubs, and control non-native invasive species." A naturalistic fire regime will help to control the spread of grasses, limit the further spread of species like raspberry, and allow for a better diversity of species to spread throughout.
    - The MNFI chapter on dry-mesic southern forest indicates that "fire is the single most significant factor in preserving oak ecosystems." The reintroduction of a fire regime to this unit will help to promote oak regeneration, deter the growth of maple and other shade-tolerant trees, and reduce the presence of invasive species.
    - As mentioned in Chapter 3: Prescribed Fire, burn rotations need to be established between the various prairie plots and the woodlands to be burned. This will allow for the protection of fire-sensitive insect and bird species residing in the community. Burn units should be burned approximately once every three years. Potential groupings of compartments that can be burned in rotating years can be found in Table 7.4.

Table 7.4: Suggested burn units.

Burn Unit A	**Burn Unit B**	**Burn Unit C**
N1	N2	N3
N4	C3	C1
		C2

- 2: Raspberry (*Rubus* spp.), while not an invasive species, has become a nuisance species throughout the Harris Prairie property, taking over large areas and crowding out more valuable natives. Due to it being native, it is not necessary to eradicate raspberry's presence, but controlling its further spread is recommended. All members of the *Rubus* family are sensitive to fire, so the re-introduction of burns will help to curb their dominance. However, in areas where the dominance persists through fire, additional measures may be necessary. Individual raspberry plants can be controlled by cutting the stem and applying a 20 percent glyphosate solution to the cut area. Foliar spray techniques are not recommended in order to protect other desirable species in the area.[113]
- 3: Conversations with KNC President Bill Rose suggest that educational trails leading off of the Kal-Haven Trail are desired as time and funding allow.
    - The trail to the restored prairie should follow the path seen in Figure 7.4 below as it is short and avoids most of the remnant area and the small valley in N4.
    - For the segment of the trail connecting the Kal-Haven Trail to the restored prairie, clear the shrubs along the path and create a boardwalk through the woods with steps connecting it to the Kal-Haven Trail so as to prevent trampling of native species.
    - Mow a wide path through the prairie for the trail in order to create a firebreak between different prairie plots or burn units.
    - Place educational signs along the proposed trail, including details about the history of the property, the value of prairie restoration, fire management in prairies, and information about the species that are present.
    - During prescribed burns, take special care to avoid the signs or remove them prior to burning.
    - See Chapter 3: Trail Maintenance and Development for more details on how to design sustainable trails.

Management Units

The Harris Prairie property has been divided into distinct management units. These units will have separate management objectives which are laid out below. Each management unit is made up of one or more compartments. See Figure 7.5 for a map showing all the compartments.

[113] Control of Invasive Plants in Oak Savannas [Internet]. Madison (WI): Savanna Oak Foundation, Inc. [cited 2016 March 20]. Available from http://oaksavannas.org/invasives.html

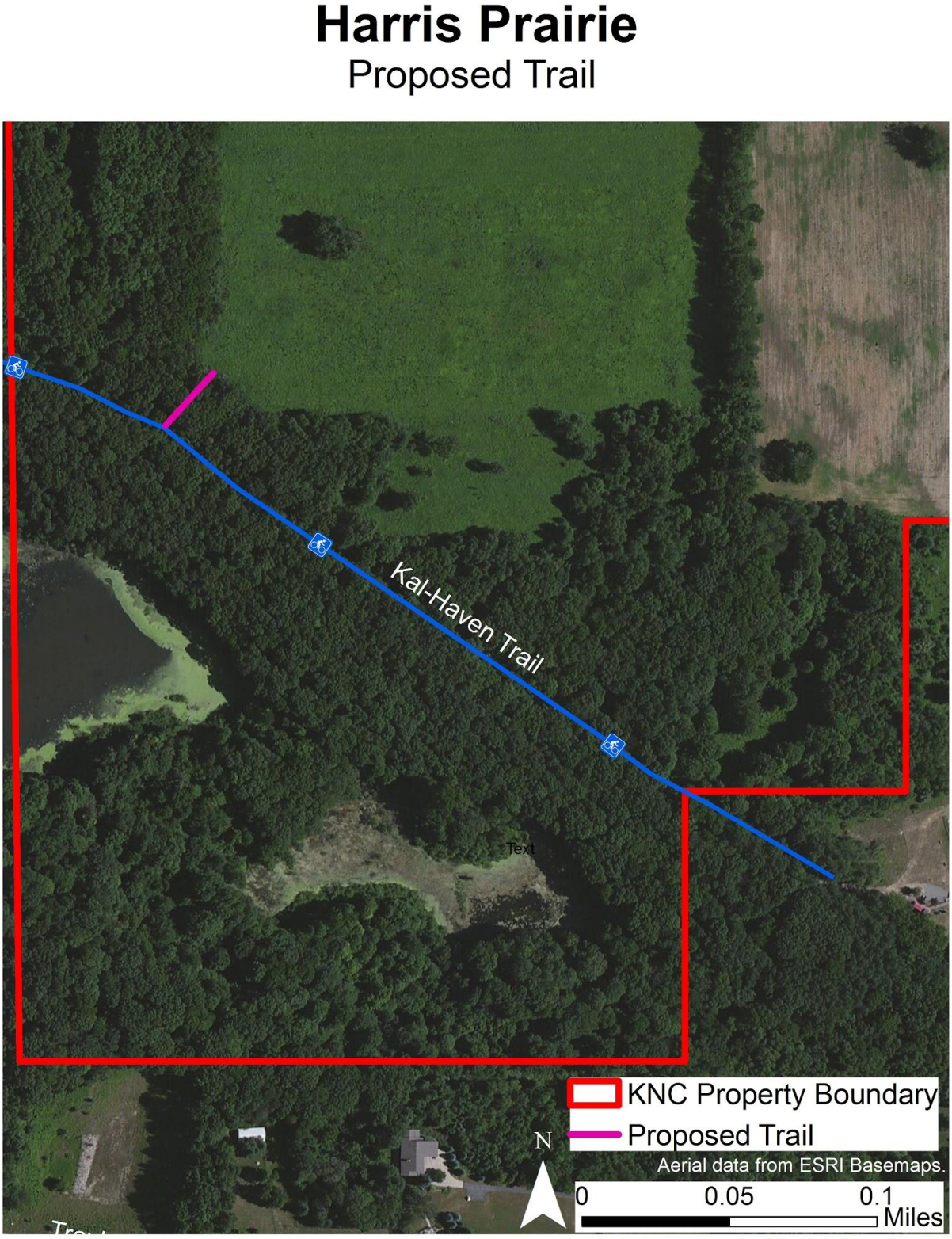

Figure 7.4: Map showing a proposed path from the Kal-Haven Trail to the prairies for a future educational trail.

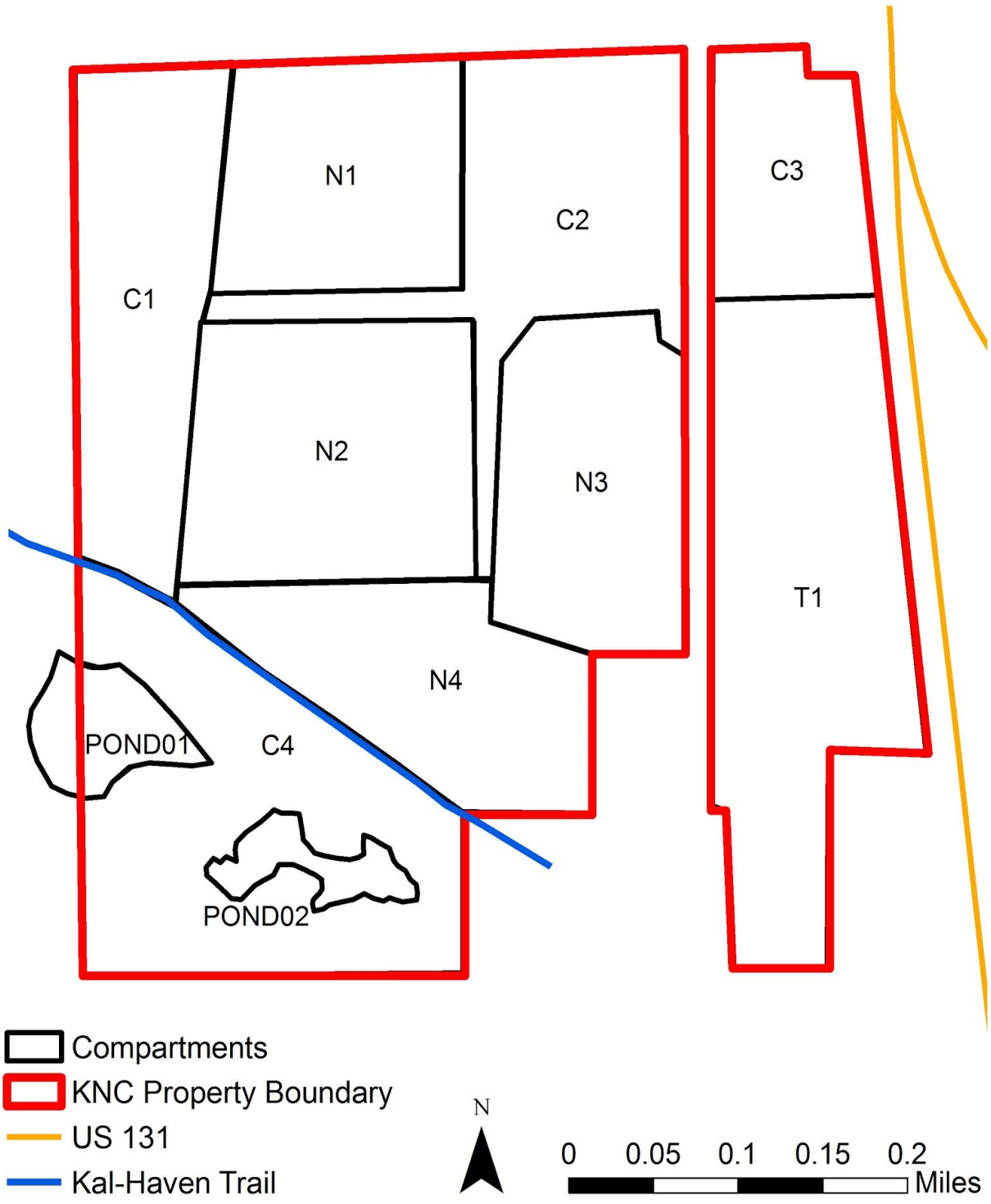

Figure 7.5: Harris Prairie habitat compartments.

Restored Prairie Unit

Description

Compartments: N1, N2, N3

This unit contains three separate restored prairie plots, two of which were planted in 2010 (N1, N3) with the other planted in 1993 (N2). These plots had been in a soy-corn crop rotation prior to the property's transfer to KNC. Different seed mixes were used between the early and late plantings, with N2 being more grass-dominant while N1 and N3 are more evenly mixed with grasses and forbs. Little management has been done in this unit, aside from prescribed burns in N2 in 2010 and 2013. Unit likely provides habitat for a variety of mammals, birds, and insects. The FQI in N2 was calculated to be 20.2 when excluding non-native plants (it was 18.2 when including the non-natives). This was one of the lower scores found throughout the surveyed properties. With a score of 35 being considered a conservation priority and 50 being exceptional, there is a lot of room to improve.

Recommendations

- 1: Invasive species are a concern in this management unit. Yellow and white sweet clover (*Melilotus officinalis* and *M. alba*), St. John's wort (*Hypericum perforatum*), and raspberry (*Rubus spp.*) were found in the 2015 transects in N2. Except for St. John's wort (whose management steps can be found below), more details on these species and recommendations for their management can be found in Appendix II.
    - Fire is not an effective long term tool for management of St. John's wort, so manual and chemical steps are needed. Hand-pulling can be useful for smaller patches. Wearing gloves is necessary to prevent the plant's phototoxins from contacting skin, and the plant needs to be completely pulled including all lateral roots. Chemical control methods include the application of herbicides such as 2,4-D on new seedlings directly after germination but before blossoms open.[114]
- 1: Conduct prescribed burns in the restored prairies following the schedule laid out in the general recommendations above.
- 1: The transects through N2 also revealed oak seedlings. Protecting these seedlings from fire until they have grown large enough to withstand the disturbance could help to promote more of an oak openings system which would add another layer of diversity to the Harris Prairie property and add a potential reference community for education purposes.
- 2: The 2015 transects were limited to N2, and the bio-inventory only included plant species. Butterfly surveys have been conducted in the past, with results from 2013 available to explore here. Performing further inventories, potentially through a BioBlitz, is recommended to gain a fuller understanding of the species diversity in the system. Inventory surveys should try to focus on rare species as identified by the MNFI page on mesic prairies, including eastern Massasauga rattlesnakes.
- 2: Collect pH, soil nitrogen, mycorrhizae and other soil factor levels in each of the restored prairies. These may need to be tested at the nearest university extension program.

[114] Northeastern Area State and Private Forestry (US). Common St. John's Wort [Internet]. Newtown Square (PA): USDA Forest Service (US); c2015 [cited 2016 March 20]. Available from http://na.fs.fed.us/fhp/invasive_plants/weeds/common-st-johns-wort.pdf

- 3: As mentioned previously, N2 was initially planted with a grass-heavy seed mix while N1 and N3 were planted with a mix that was more evenly split between grasses and forbs to better reflect a healthy mesic prairie. Maintaining these different prairie types could be interesting from a research perspective to see what sort of insect and animal species utilize each and what happens to the soil ecology. However, if a heavier forb mix is desired throughout the unit, dispersing a forb-heavy seed mix after burns in N2 could help generate a more balanced species diversity.

Measures of Success

- Findings of repeated baseline vegetation studies (looking for an increase in native floral species and a decrease in non-natives, which should result in increased FQI)
- Results of insect and butterfly surveys
- Results of rare species monitoring
- Improvements in pH (ideally between 6 and 7), soil nitrogen (not too high, as this will promote invasives), mycorrhizae and other soil factor levels as the management actions above are conducted

Remnant Prairie Unit

Description

Compartments: N4

Contains the property's remnant prairie, which is largely surrounded by oak-hickory forest and overgrown shrubs. The southern edge of this unit abuts the Kal-Haven trail after a relatively steep fall in terrain (approximately a 20-foot drop). There is also a small valley running through this unit, with the bottom being approximately 50 feet lower than the rest of the unit. Little management is being done currently—some canopy reduction and shrub clearing occurred in winter/spring 2013 to prevent further woody plant dominance and a prescribed burn took place on a subset of the unit in 2010. This unit should continue to be managed so that it can return to a healthy, ecologically diverse mesic prairie and oak openings. The primary goal is to enlarge the existing remnant so that it connects to the restored prairie compartments.

The FQI in N4 (based on the MWP data collection) was calculated to be 25.4 when excluding non-native plants (it was 23.1 when including the non-natives). With a score of 35 being considered a conservation priority and 50 being exceptional, this was one of the higher scoring plots surveyed for this study. Note though that many of the species identified were not prairie species, so the high score does not necessarily suggest a well-functioning prairie. The MWP data showed a relative abundance of: 62.1 percent for red oak, 23.7 percent for white oak, 7 percent for bitternut hickory, 3.5 percent for sugar maple, 2.2 percent for black cherry, and 1.4 percent for elm. This composition is good for an oak-hickory forest, but not for a mesic prairie.

Recommendations

- 1: Continuing to clear the canopy and removing woody plants will be a key step in restoring the remnant prairie to an ecologically sound system. After clearing the smaller shrubs, applying herbicide to the stumps to prevent regrowth is advised.

- 1: Invasive species are a concern in this management unit. Honeysuckle (*Lonicera spp.*), multiflora rose (*Rosa multiflora*), and raspberry were found in the MWP in N4. More details on these species and recommendations for their management can be found in Appendix II.
- 1: Conduct prescribed burns in the remnant prairie following the schedule laid out in the general recommendations above.
- 2: Since the remnant was isolated for many years, reintroducing important native prairie species through seeds or transplanting could be a useful technique to help the system recover more quickly. The CRP seed mix used in the restored prairies could be used here.
- 2: The 2015 inventory was limited to the area falling within the Modified-Whittaker plots and only included plant species. Performing further inventories is recommended to gain a fuller understanding of the species diversity in the system. Inventory surveys should try to focus on rare plant species as identified by the MNFI chapter on mesic prairies (such as purple coneflower) that may have persisted in the remnant, as well as animal and insect species that may be present. BioBlitz methods should be avoided to prevent unnecessary trampling through the area.
- 2: Collect pH, soil nitrogen, mycorrhizae and other soil factor levels in each of the restored prairies. These may need to be tested at the nearest university extension program.

Measures of Success

- Findings of repeated baseline vegetation studies (looking for increased FQI and greater representation of prairie species)
- Results of rare species monitoring
- Improvements in pH (ideally between 6 and 7), soil nitrogen (not too high, as this will promote invasives), mycorrhizae and other soil factor levels as the management actions above are conducted

Oak-Hickory Forest Unit

Description

Compartments: C1, C2, C3

This unit is split into two main sections: the area that makes up the western edge of the property north of the Kal-Haven Trail (C1) and the section at the north-eastern corner of the property (C2 and C3, separated by 10th Street). This unit falls under the dry-mesic southern forest community type and is largely oak-hickory forest. The woodland also extends as a buffer between the restored prairies. KNC's management in this unit has been minimal, though walkabouts through the unit have shown signs of use by the public (ATV tracks, fires, litter, etc.).

The FQI in C2 (based on the MWP data collection) was calculated to be 19.7 when excluding non-native plants (it was 17.2 when including the non-natives). This was one of the lower scoring plots that was surveyed. The MWP data showed a relative abundance of 39 percent for sugar maple, 51 percent for black cherry, and just under 10 percent for red oaks. The management actions below should help restore a greater abundance of appropriate species.

Recommendations

- 1: Invasive species are a concern in this management unit. Garlic mustard (*Alliaria petiolata*), honeysuckle, multiflora rose, and raspberry were found in the MWP in C2. More details on these species and recommendations for their management can be found in Appendix II.
- 1: Conduct prescribed burns in the unit following the schedule laid out in the general recommendations above.
- 2: For the transitional areas along the prairie edge, accompanying the prescribed burns with manual thinning of trees can open up holes in the canopy helping to create more of an oak openings system. Applications of herbicide to the stumps of unwanted tree species including maples can help keep them from returning.
- 2: The 2015 inventory was limited to the MWP in C2 and only included plant species. Performing further inventories, potentially through a bio-blitz, is recommended to gain a fuller understanding of the species diversity in the system. Inventory surveys should focus on rare plant, animal, and insect species as identified by the MNFI chapter on dry-mesic southern forests.
- 3: Black cherry will not be controlled by fire, so selective removal of black cherry trees will be needed to reduce their domination in the overstory.
- 3: There were considerable signs of unwanted anthropogenic use in C2, including ATV trails, small fire remnants, mushroom picking, and garbage along the trails. These uses can act as a vector for invasive species and may damage sensitive plants and animals. Installation of signs around the exterior indicating that it is KNC property or with rules of use could discourage this unwanted behavior.

Measures of Success

- Findings of repeated baseline vegetation studies (looking for an increase in relative abundance of oak and hickory trees, with corresponding declines in maple and cherry trees; as well as fewer non-native species)
- Results of rare species monitoring
- Results of signs on decreasing unwanted anthropogenic uses

Beech-Maple Forest/Ponds Unit

Description

Compartments: C4, POND01, POND02

This unit is south of the Kal-Haven Trail and is made up of mesic southern forest. There is a large slope descending from the trail, with the floor of the unit around 60-80 feet lower in elevation than the trail. There are two ponds in this unit, possibly vernal pools, with part of POND01 falling outside the KNC property boundary. An incomplete inventory of species found in C4 can be seen in Table 7.5. KNC's management in this unit has been minimal. It is unknown how much foot traffic comes in from the adjacent housing developments.

Table 7.5: Initial species inventory of C4

Common Name	**Scientific Name**
Hepatica	*Hepatica acutiloba*
Wild leek	*Allium tricoccum*
Solomon ’s seal	*Polygonatum biflorum*
Viburnum	*Viburnum acerifolium*
Beech	*Fagus grandifolia*
Sugar Maple	*Acer saccharum*
Black Cherry	*Prunus serotine*
Bloodroot	*Sanguinaria canadensis*
Red oak	*Quercus rubra*
Musclewood	*Carpinus caroliniana*
Jewelweed	*Impatiens capensis*
May apple	*Podophyllum peltatum*
Indian pipe	*Monotropa uniflora*
Violet	*Viola spp.*
Wild lettuce	*Lactuca spp.*
Doll’s eye	*Actaea pachypoda*
Cohosh	*Caulophyllum thalictroides*

Recommendations

- 1: The MNFI chapter on mesic southern forest indicates that allowing “natural processes to operate unhindered” is the best way to enhance biodiversity in this community type. This unit should be left free from programming, with minimal management activity focused on the few items below.
- 1: The Summer 2015 data collection did not include a full inventory of this unit. In order to more fully understand the flora of this unit, a MWP survey is recommended. Inventories of the fauna, particularly around the ponds, will also be useful for understanding the conservation value of this area. A BioBlitz inventory method is not recommended as the increased foot traffic may do more harm than good.
- 1: Invasive species did not appear to be a major problem based on a limited survey of C4. Since invasive species appear to be relatively sparse, a dedicated effort over a few years should be sufficient to eradicate the present species. However, if an inventory reveals a larger invasive presence, a more concerted long-term effort may be needed following the methods outlined in Appendix II.
- 2: If the inventory finds that deer browse is a concern, population control methods may be needed, as well as deer exclosures to protect concentrations of sensitive species.
- 2: Water quality monitoring should be implemented to track the health of the ponds, and can help guide management decisions. As mentioned in the previous land management plan, data should be collected on phosphorus, nitrates, and other excess nutrients; *E. coli* and other microbial pests; volume, velocity, seasonality of flows, temperature and other variables. See Chapter 3: Water Quality for more details.

- 3: POND02 seemed relatively healthy while POND01 appeared to be largely covered with duckweed. This plant can deprive ponds of oxygen, limiting the ability of algae, fish and other species to survive. Controlling duckweed can be done in two steps. First, the existing duckweed should be removed, which can be done with a pool net and is easiest done on a windy day when it will gather on one end of the pond. Second, the high nutrient levels in the pond need to be controlled. Building a riparian buffer with native shrubs like flowering dogwood (*Cornus florida*) and spicebush (*Lindera benzoin*) could help to trap nutrient runoff, trap additional sediments, and provide habitat for wildlife.[115]
- 3: This unit is directly adjacent to a residential area. This could put it at greater risk of anthropogenic influence, including introduction of invasive species, removal of plants, and trampling of important species. Installing signs indicating that the area is KNC property could help deter trespassing. Additionally, educating the nearby residents could help prevent unwanted behaviors and could identify volunteers who might help with monitoring or inventories.

Measures of Success

- Findings of baseline vegetation studies (paying close attention to the presence of invasive species and rare or sensitive species as highlighted in the MNFI page on mesic southern forests)
- Results of rare species monitoring
- Results of deer browse monitoring
- Visual appearance of POND01 and POND02 in terms of duckweed
- Results of water quality monitoring
- Engagement with nearby residents

Active Agriculture Unit

Description

Compartments: T1

This unit is on the east side of 10th Street and is made up of an active agricultural plot in a soy-corn rotation. The southernmost portion of this unit consists of a cleared field with a few trees that does not appear to be used for anything.

Recommendations

- 2: Conduct initial butterfly and bird surveys to see what species are visiting this unit.
- 3: For now, given the limited availability of time and funding for management of the existing prairies, this plot should continue to be leased out for agricultural purposes in order to raise funds for KNC. If more funding becomes available through budget restructuring or incoming grants, this plot could begin to be restored into mesic prairie like its neighbors across 10th Street.

[115] DeCecco JA, Brittingham MC. Riparian Buffers for Wildlife [Internet]. University Park (PA): Pennsylvania State University; c2011 [cited 2016 April 4]. Available from http://extension.psu.edu/natural-resources/wildlife/habitat-management/pa-wildlife-16-riparian-buffers-for-wildlife

- 3: Coordinating with the current farmer to try to implement a few best practices to mitigate erosion and runoff in the agricultural fields is advised. In Tyler Bassett's previous land management plan he gave the following advice for preparing an agricultural field for prairie restoration: "it is a good idea to start a few years in advance by changing agricultural practices (e.g., no-till, retaining stubble, planting a cover crop) in order to build up organic matter and soil health… This will result in living soils that will better support a prairie planting when that time comes."[116]
- 3: Collect baseline pH, soil nitrogen, mycorrhizae and other soil factor levels.

Measures of Success

- pH, soil nitrogen, mycorrhizae and other soil factors in the agricultural field as the soil-building and restoration processes continue
- Results of species surveys

Climate Change: Adaptation and Mitigation

See Chapter 3: Climate Change and Adaptation for details about Michigan's shifting climate and its species impacts. According to the 2014 National Climate Assessment, the future of the Midwestern United States likely contains rising temperatures, wetter winters and springs with drier summers leading to more extreme rain events and longer droughts, and increased invasive species presence.[117] The report also notes that while all ecosystems in the region will be affected by the changes, they won't all be impacted in the same way, suggesting that forests dominated by beech and maple are likely to decline while oak forests are projected to expand their range. This difference between community types was mentioned in other publications as well.

The dry-mesic southern forest community type largely consists of oak and hickory trees, though as seen above, the 2015 inventory revealed a large relative abundance of sugar maple and black cherry trees as well. According to a report by the Huron River Watershed Council (HRWC), these forest types are expected to have "low vulnerability to climate change."[118] It is thought that the increased temperatures and longer growing seasons could lead to greater productivity of oak and hickory species and potential expansion of their current range. A report released in 2011 by the Michigan Natural Features Inventory (MNFI) suggested that dry-mesic southern forest habitats are expected to react negatively to reduced water levels and the combination of wetter winters and drier summers (they also indicated that they could not predict how increased invasives would affect this habitat type due to a lack of expert data). [119] Overall, dry-mesic southern forest is expected to perform slightly better under the conditions associated with climate

[116] Bassett T. Kalamazoo Nature Center Land Management Plan 2012. Lansing (MI): Michigan State University; c2012. Available upon request from Kalamazoo Nature Center.
[117] National Climate Assessment (US). Global Climate Change Impacts in the United States [Internet]. Washington, DC: U.S. Global Change Research Program; 2014 Jun 13 [cited 2013 Sep 12]. Available from http://acd.od.nih.gov/Diversity%20in%20the%20Biomedical%20Research%20Workforce%20Report.pdf
[118] Climate Resilient Communities. Review of climate impacts to tree species of the Huron River watershed. Ann Arbor (MI): Huron River Watershed Council; c2013 [cited 2016 March 20]. Available from http://www.hrwc.org/wp-content/uploads/2013/03/Natural%20Infastructure.pdf
[119] Kost MA, Lee YM. Climate Change Vulnerability Assessment of Natural Features in Michigan's Coastal Zone – Phase I: Potential Changes to Natural Communities [Internet]. Lansing (MI): Michigan Natural Features Inventory; 2011 Nov 15 [cited 2016 March 20]. Available from http://mnfi.anr.msu.edu/reports/2011-17_Climate%20Change%20Vulnerability%20Assessment%20Phase%20I_Natural%20Community%20Report.pdf

change, though there was low confidence in this projection. The decline of water supply is not something that KNC can manage around, but the management of invasive species laid out above will help with one of the largest potential stressors. The natural increase in disturbance will likely be good for restoring a higher abundance of oak species and may reduce the management steps that KNC has to take.

Mesic prairie is the primary community type at the Harris Prairie property, so making sure that it can survive through climate change is a priority. There appear to be different opinions on how mesic prairie will react to the changes ahead. The MNFI report mentioned above suggested that mesic prairie was slightly more likely than dry-mesic southern forest to be positively impacted by climate change, with a significant boost from the potential of increased disturbances and also likely positive reactions to increased temperatures, drier climate, and longer growing season. The Wisconsin Department of Natural Resources, in a currently-under-review revision to a 2005 Wildlife Action Plan, indicates that "increased CO_2, warmer temperatures, earlier springs, and reduced snowpack" as a result of climate change could provide better conditions for invasive species and could also help the nearby forests expand into the prairie community.[120] Prescribed burns and selective cutting can help with the spread of trees, but managing for invasive species will involve regular monitoring, careful planning, and quick responses as laid out in Appendix II. Additionally there is concern that changing conditions, particularly with extreme heat and drought, could impact the ability to conduct prescribed burns. Careful planning and the enforcement of strong safety measures should allow these to remain feasible into the future.

The community of greatest concern in this property is the mesic southern forest. In the Harris Prairie property, this community largely consists of maple and beech trees along with two potentially vernal pools. According to the aforementioned HRWC report, American beech trees are likely to disappear from much of their current range as a result of the increased temperatures. The same report suggests that sugar maple trees are likely to be extirpated from Michigan entirely except for the northernmost latitudes, though red maple trees are expected to fare better and could be planted as an alternative. The MNFI report showed that mesic southern forest is highly susceptible to many of the expected changes, particularly the increased frequency of disturbance, the drier climate, and the increase in invasive species. The vernal pools in the unit may be at even more risk. These pools are largely dependent on precipitation, collecting water in the winter and spring and losing volume in the dry season. Climate change could lead to more fluctuations in water levels or long term disappearances under prolonged droughts. Additionally, the increased temperatures would likely raise the water temperature, potentially changing the chemistry and altering the life that can be supported. It appears that the changes in temperature are likely going to remove mesic southern forest from the southern Michigan landscape before long, but until then, judicious management of invasive species could be the best strategy to preserve the community.

[120] Draft Wisconsin Wildlife Action Plan [Internet]. Madison (WI): Wisconsin Department of Natural Resources (US); 2015 Sep 30 [cited 2016 March 20]. Available from http://dnr.wi.gov/topic/wildlifehabitat/documents/4_4_3GrasslandGrp_FWSFinal.pdf

Chapter 8: Urban Nature Park

Urban Nature Park Management Plan

427 E. Michigan Avenue, Kalamazoo, MI 49001 (approx.)
(42.29325N, 85.57811W)

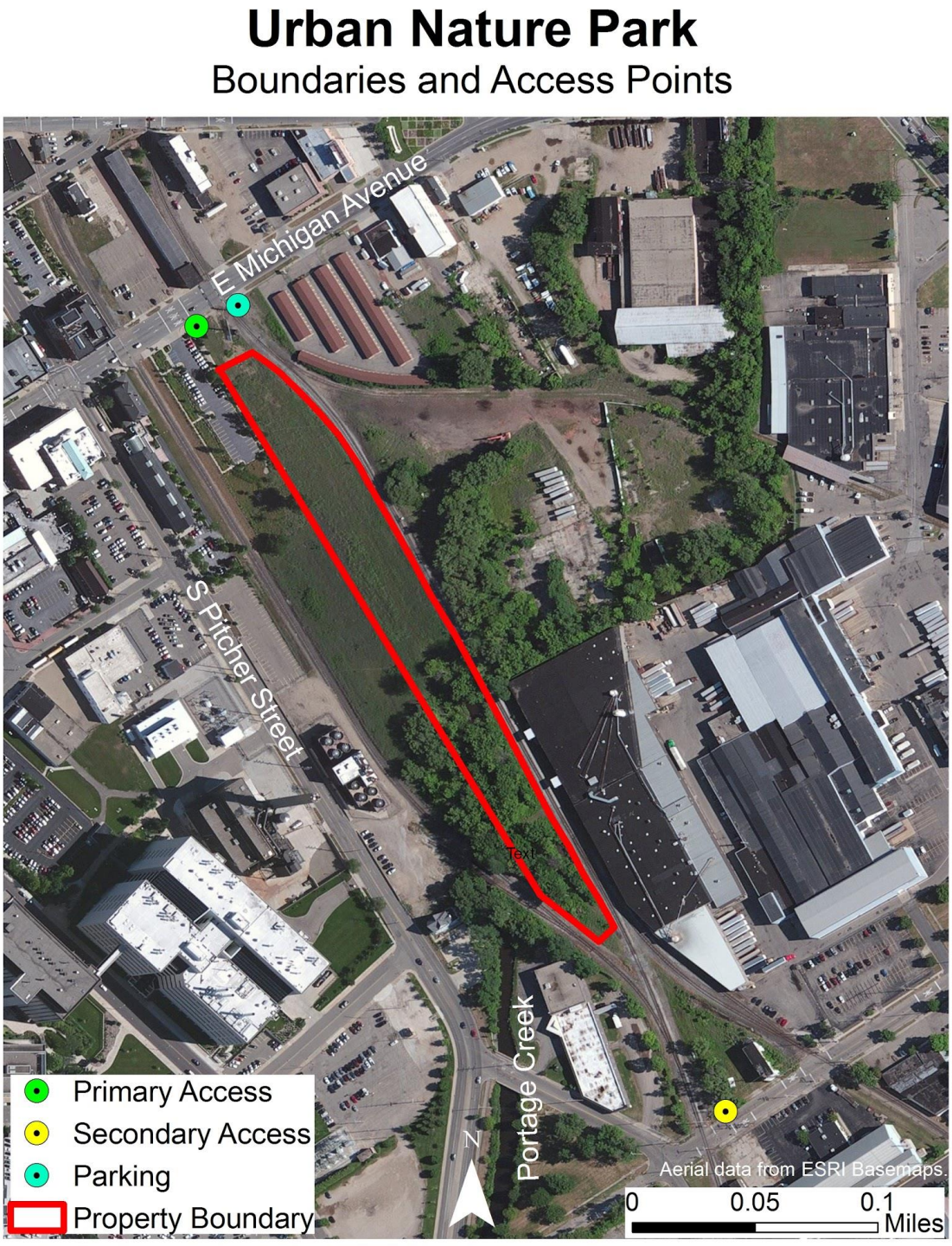

Figure 8.1: Urban Nature Park boundaries, access points, and built features.

Introduction

The Urban Nature Park (UNP) is a 4.5-acre parcel of former railroad property in the heart of downtown Kalamazoo, MI (see Figure 8.1). Long and narrow, the property angles along Pitcher Street, south of East Michigan Avenue. Portage Creek cuts across the property's southern tip. KNC has worked to restore the former brownfield industrial site to a pre-settlement state and will soon open it as a new public green space for urban residents and guests.

KNC has thoroughly planned for the design and construction of this park. Management plans will develop and evolve after the park opens. Until then, this site plan will function as a repository for the park's history and design; staff should update this plan as management strategies evolve.

History

Urban Nature Park is located in the Kalamazoo River floodplain. Prior to European settlement, this site was dominated by southern floodplain forest. Just west of the floodplain were substantial swaths of oak savanna habitat.[121]

Prior to KNC's acquisition, the parcel was owned by Canadian Rail, formerly Grand Trunk Railroad. The company was interested in selling the property, as it was far removed from their major operations and was surrounded by land owned by the Norfolk Southern Railroad. In 2005, KNC president Bill Rose recognized that the land was well-positioned to become a valuable asset for the downtown area. He wanted to leverage KNC's assets and experiences in a new way to develop an entirely urban park.

Visions for the Park's Future

According to Bill Rose, KNC hopes that the park will:

- Provide inner-city green space to underserved populations and break down access barriers that often prevent people from engaging with natural areas "in their own backyards."
- Demonstrate the process for returning a brownfield site to a pre-settlement, "natural" state.
- Encourage Kalamazoo's city officials to reimagine development in the urban core. Despite the property's removal from the city's tax rolls, the city can see the park as an investment in the community which could ultimately drive redevelopment, draw more valuable businesses and property owners, bring higher tax revenues, and create a more attractive and liveable city.
- Connect to a larger system of trails and greenways existing and planned for the city of Kalamazoo.

[121] Hodler TW, *et al.* Presettlement vegetation of Kalamazoo County [Internet]. Kalamazoo (MI): Western Michigan University; 1981 [cited 2016 Mar 23]. Available from http://cf.wmich.edu/planning/history/AsylumLakeandBakerFarm/1981GeographyMap/11x17Map_KalCountyVegetation1825.pdf.

- Increase Portage Creek's floodplain holding capacity, via increased wetland area and a more naturalized stream channel. This could reduce damage to downtown infrastructure inflicted by heavy rainfall, particularly when such rainfall events become more common as a result of climate change.
- Foster biodiversity through its upland and wetland units.

The City of Kalamazoo's leaders have already recognized UNP's potential value. The city included UNP in its 2008 downtown comprehensive plan.[122] City planners indicated that they are looking for a site that's central, enclosed on all sides, capable of active edge use and flexible function, safe and free from hiding places, and low-maintenance. While UNP will be open on all sides, KNC believes that the park has the potential to fill each of the other criteria. In 2010, UNP was awarded the Michigan Plaque from Keep Michigan Beautiful, the local affiliate of the non-profit organization Keep America Beautiful.[123]

After negotiations and a 6-month feasibility study, KNC purchased the land from Canadian Rail in 2005 with major funding from the Arcus Foundation.[124] As of this writing, KNC is in talks with Norfolk Southern to purchase or lease additional land to the east of the existing park property. As of 2015, KNC has been granted access to the property and is conducting environmental studies.

Brownfield Redevelopment

Before the land could become a park, the site required significant remediation. KNC had to contend with 150 years of industrial contamination in the form of coal piles, industrial debris, garbage, and soils contaminated with polychlorinated biphenyls (PCBs) historically produced by upstream paper mills (see Figures 8.2 and 8.3).

[122] The promise of downtown [Internet]. Kalamazoo (MI): Downtown Kalamazoo, Inc; 2009 Apr [cited 2016 Mar 24]. Available from http://www.downtownkalamazoo.org/DKI/media/dki/Documents/Complete_Plan_1.pdf

[123] Kalamazoo Nature Center's Urban Nature Park gets statewide award [Internet]. Kalamazoo (MI): Kalamazoo Gazette; 2010 Oct 13 [cited 2016 Mar 24]. Available from http://www.mlive.com/living/kalamazoo/index.ssf/2010/10/kalamazoo_nature_centers_urban.html

[124] Koziatek R. Kalamazoo Nature Center's Urban Nature Park under construction [Internet]. Kalamazoo (MI): Freshwater Future; 2014 [cited 2016 Mar 23]. Available from http://freshwaterfuture.org/services/publications/freshwater-voices-newsletter-archive/2014-issue-1/kalamazoo-nature-centers-urban-nature-park-under-construction/

Figure 8.2: Industrial debris on the site before clean-up efforts (photo credit: KNC)

Figure 8.3: Debris in woodland before clean-up efforts (photo credit: KNC)

Due to the presence of the PCBs, the site qualified as an EPA brownfield redevelopment site. KNC developed a phased plan for documenting and remediating existing contaminants. KNC was required to prove that its plan, which included covering the damaged soils with 8-10 inches of clean topsoil and plants, would leave no contact points between contaminated soil and the public. Only then could KNC begin restoring the site's ecological integrity and public accessibility, which would include clearing debris, installing native plants, adding features for human accessibility, and monitoring the site's safety and ecological health.

By 2007, cement, telephone poles, metal scraps, invasive plant species, and other debris had been removed from the site (see Figure 8.4). KNC planted a cover crop to prevent recolonization by invasive plant species (see Figure 8.5).

Figure 8.4: Workers removing concrete, asphalt, and bricks (photo credit: KNC)

Figure 8.5: Cover crop planted on the cleared property (photo credit: KNC)

Also in 2007, the EPA crafted plans to remove PCB-contaminated Portage Creek sediments as part of the Region 5 Allied Paper, Inc / Portage Creek / Kalamazoo River Superfund site project.[125] The EPA started its cleanup in the southern end of the park in March 2013, diverting water from the creek to remove, regrade, and replenish the affected soil (see Figure 8.6). EPA cleanup efforts finished in November 2013 after 23,700 cubic yards of contaminated soil were removed to a landfill.[126] Meanwhile, KNC had been forced to abandon the cover crop planted before the EPA moved in, and invasive plant species retook the site.

[125] Environmental Protection Agency. Kalamazoo River superfund project [Internet]. Kalamazoo (MI): EPA; 2015 Sep [cited 2016 Mar 23]. Available from https://www3.epa.gov/region5/cleanup/kalproject/

[126] Environmental Protection Agency. PCB cleanup of Portage Creek is complete [Internet]. Kalamazoo (MI): EPA; 2013 Nov [cited 2016 Mar 3]. Available from https://www3.epa.gov/region5/cleanup/kalproject/pdfs/kalproject-fs-201311.pdf


Figure 8.6: Portage Creek during the EPA's Superfund Clean-up (photo credit: KNC)

In Fall 2015, the upland unit was graded, including the footprint of the future trail. The upland planting will be completed in 2016, depending on the delivery and installation of asphalt for the trail and parking areas.

Property Composition

Landscape Context
Originally settled in the 1830s, the city of Kalamazoo bears few traces of its original ecology. The UNP site is no exception; nearly two centuries of intensive railroad and industrial development thoroughly altered its soil profile, topography, and species inventory. UNP is located near the center of downtown and is surrounded by development on all four sides, including railroad tracks, restaurants, a community center, and industrial buildings (see Figure 8.7). The Kalamazoo River flows east of the site.

Figure 8.7: Urban Nature Park's context within downtown Kalamazoo.

Property Composition

This section reflects the fact that the park is still in major transition from a contaminated brownfield site to a set of ecologically diverse habitats. When completed, the park will consist of two management units: an oak savanna upland unit and a lower wetland unit. These habitat types have been chosen to represent the site's pre-European settlement state, based on historical records, site soil types, and similar regional ecosystems. Precise boundaries of those units should be mapped and added to this plan after reconstruction is complete. The proposed species composition of both units will be discussed in greater detail below.

The park also contains a reconstructed railroad bridge originally built in the late 1800s to early 1900s. This bridge now marks the edge of the wetland unit. The bridge will connect to a meandering asphalt path that leads through the center of the upland unit. KNC may also construct a parking lot if an agreement cannot be reached for sharing parking spaces with existing businesses.

KNC is negotiating with Norfolk Southern to lease the underused triangular parcel of land on the eastern side of UNP. The railroad has already granted KNC an environmental right-of-entry to conduct environmental assessments.

General Recommendations

KNC already has a well-developed vision for shaping and running the park. Many of the following recommendations reiterate steps the organization is already planning to take regarding park maintenance, outreach, safety, and ongoing vision. As a result, most of these recommendations receive a priority listing of 1, indicating that they should be accomplished during the coming 3 years. The rest of the prioritization scheme is as follows:

1: Address within the next 3 years
2: Address within the next 5 years
3: Address within the next 10 years
4: Address in the next 10-year comprehensive LMP

Updating the Land Management Plan

- 1: When reconstruction is complete, use aerial imagery or handheld GPS units to delineate the boundaries of the upland and wetland units and create a more formal map of the property.
- 2: Update this management plan with any deviations from or additions to the proposed reconstruction and development plan for the site.

Safety and Accessibility

- 1: Construct a parking lot, or contract to share a lot with a nearby building.
- 1: Post a schedule of public hours. Visitors and neighbors should be encouraged to report abuse of these hours to KNC staff or Kalamazoo Public Safety.
- 1: Build split-rail fences on the east and west boundaries of the park to prevent patrons from straying within 50 feet of the railroad tracks flanking the east and west sides of the park.

- 1: Monitor for signs of vandalism and graffiti. Any incidents should be reported immediately to the urban outreach coordinator, who can launch clean-up efforts.
- 1: Coordinate with Kalamazoo Public Safety's fleet of bicycle cops to add UNP to their usual route, thus providing a regular, benign police presence.
- 1: Install at least one covered trash can and recycling bin at the park entrance.
- 1: Hire a snow removal service to plow and de-ice the trail and bridge as needed, **OR**
- 1: Post a sign at the park entrance clearly stating that winter maintenance will not be conducted on the trail and bridge.
- 1: Install 2-3 recycled plastic benches at the trailhead, along the trail, or near the bridge.
- 1: If nearby water lines are accessible with minimal surface disruption, install a drinking fountain near the park entrance.

Interpretation

- 1: Recognize, embrace, and juxtapose the park's industrial surroundings against its recreated natural setting. The planned oak savanna will introduce few trees to block visitors' views of nearby breweries, parking lots, railroads, and factories. Visitors will experience near-constant ambient noise from a large industrial facility to the west. Rather than attempting to block out or apologize for these industrial surroundings, make them part of the UNP experience.
- 1: Design interpretive signs for the trail. Potential topics: native upland and wetland plants, invasive plants, railroad history, brownfield redevelopment, current use of surrounding industrial buildings.
- 2: Commission durable, weatherproof artwork to position along the trail.

Programming and Public Involvement

Programming will fall under the purview of KNC's urban outreach coordinator.

- 1: Host tours, high-profile events, and attractive programming in the weeks and months after the park's opening. This will introduce a variety of new patrons to the park and its amenities. Examples include: field trips from nearby schools, picnics catered by local restaurants, tours for employees of neighboring businesses.
- 1: Develop regular formal or informal programming and events to continue bringing visitors back after their initial contact with the park. Examples include: therapy walks for hospital or clinic patients, wildflower and wetland plant tours, classes on Kalamazoo's industrial history, photography and art workshops, and "Brews in the Park" with Bell's Brewery or Old Dog Tavern.
- 2: Leverage the park's visibility and accessibility to form new partnerships with individuals, businesses, and communities in urban Kalamazoo. These partnerships could also help KNC tap into new volunteer pools. Examples include: Kalamazoo Community Foundation, staff and patrons from nearby breweries and restaurants, staff and patients at the Western Michigan University hospital, faculty and students from the forthcoming Kalamazoo Valley Community College culinary and health campus.
- 2: Target outreach efforts in the underserved Edison community. This is Kalamazoo's most populous neighborhood, a dense and diverse community prone to high rates of crime, gun violence, and gang activity.
- 3: Offer incentives, such as free or reduced-cost membership, for new long-term volunteers who get involved in park maintenance.

Expanding the Vision

- 1: Continue negotiations with Norfolk Southern to lease the eastern parcel.
- 2: If acquired, plant the eastern parcel as an extension of the upland oak savanna habitat.
- 3: Support UNP's inclusion in the expanding Portage Creek and Kalamazoo River Valley Trail systems.
- 4: Keep track of Kalamazoo Valley Community College's planned expansion near UNP and seek ways to connect KVCC faculty and students to programming and volunteer opportunities at the park.

Measures of Success

- Verbal or written feedback from park visitors
- Tally of new members and volunteers for whom UNP was their first experience with KNC
- Feedback from Kalamazoo Public Safety officers

Management Units

Upland Unit

Description

As previously mentioned, the upland unit in the northern portion of the property was graded in Fall 2015 and may be planted in 2016. In this unit, KNC will reconstruct an open oak savanna with short, mesic prairie grasses and wildflowers. Oak savanna is characterized by scattered oak species (between 1 and 15 trees per acre) and a grassy or herbaceous understory. Oak savanna habitat has a state rank of S1, indicating that it is critically imperiled in Michigan and at imminent risk of disappearing. UNP's oak savanna could become an important reference site for a vanishing habitat community.

Pin oak (*Quercus palustris*) will form the backbone of the oak savanna. The pin oak is native to southern Michigan, grows quickly, tolerates pollution, and can thrive in wet, flood-prone soils. Around the oaks, KNC will plant a low- or no-mow grass and a host of wildflowers. Staff considered a native buffalo grass but concluded that a non-aggressive, non-native fescue would be a better option. The wildflower community will include nitrogen-fixing, native, and rare species. Examples include black-eyed susan (*Rudbeckia hirta)*, purple coneflower *(Echinacea purpurea*), gentian (*Gentianaceae* sp.) spiderwort (*Tradescantia* sp.), common milkweed (*Asclepias syriaca*), wild white indigo (*Baptisia alba macrophylla*), cardinal flower (*Lobelia cardinalis*), and rattlesnake master (*Eryngium yuccifolium*).

Oak savanna habitat is maintained through frequent, low-intensity fires. This prevents overgrowth by trees and woody shrubs, clears herbaceous understory growth, and stimulates nutrient cycling. KNC could choose to pursue prescribed burns as a management strategy for UNP's recreated oak savanna. However, such burns may prove unfeasible, given the site's proximity to railroad tracks, industrial buildings, and densely populated urban areas. In this case, KNC will need to develop an alternative management strategy for mimicking the positive effects of fire.

Recommendations

- 1: Remove invasive or undesirable plant species and monitor the removal sites for reoccurrences. Potential trouble plants include:
    - Queen Anne's lace (*Daucus carota*): pull by hand or mow before seeds are produced in late summer.
    - Mullein (*Verbascum* spp.): remove first-year leaf rosettes with shovel or mow taller plants.[127]
    - Poison ivy (*Toxicodendron radicans*): sprinkle borax powder on leaves to kill plant within three weeks; or cut stem at ground level, taking care to avoid leaves.[128]
    - Any unplanted shrubs or unplanted trees: dig out rootball and replant off site; or cut stump and apply herbicide.
    - Buckthorn (*Rhamnus* sp.), spotted knapweed (*Centaurea maculosa*), garlic mustard (*Alliaria petiolata*): see Appendix II.
- 1: Establish a mowing rotation to discourage invasive species and replicate positive effects of fire.[129] Mow when weedy plants are under 6-8 inches tall and well before weeds go to seed. Avoid raking, as this removes nutrients from the system and stimulates weed growth. Between mowings, hand-pull invasive herbaceous plant species and pull or cut undesired woody species.
- Year 1: mow 3-4 times. Mower blades should be set around 4-5 inches, or higher than the height of the prairie seedlings.
    - Year 2: mow 1-2 times. Mower blades should be set to 8 inches or higher to preserve prairie seedlings.
    - Year 3+: mow a third of the site each year.
- 1: Keep mature prairie plantings between knee and breast height (approximately 2-4 feet). This height will discourage people from leaving the asphalt path, while also keeping sight lines open for an added sense of security (i.e. providing a sense that the vegetation isn't tall enough to conceal a person).
- 2: Continue planting prairie seedlings or sowing seed to add species diversity.
- 2: Monitor for the emergence of unwanted species introduced by the new layer of topsoil.
- 3: Conduct surveys to measure bird, insect, and small mammal populations.

Measures of Success

- Findings of informal walkabouts demonstrating a healthy balance of grasses and forbs, limited woody growth, and few invasive or undesired plant species
- Increasing FQI score over repeated formal vegetation studies
- Results of songbird and insect surveys

[127] Rosenberg M. Controlling common mullein in pastures [Internet]. Brookings (SD): South Dakota State University; 2014 May 22 [cited 2016 Apr 11]. Available from http://igrow.org/agronomy/corn/controlling-common-mullein-in-pastures/
[128] Meister KK. Poison ivy [Internet]. East Lansing (MI): 2006 Nov [cited 2016 Apr 11]. Available from http://msue.anr.msu.edu/uploads/files/e2946.pdf
[129] Prairie maintenance [Internet]. St Paul (MN): National Park Service; c2016 [cited 2016 Mar 24]. Available from http://www.nps.gov/miss/learn/nature/prairestmain.htm

Wetland Unit

Description

The southern unit will be planted as a wetland, though its precise habitat community identity is not yet known. It may take the form of wet prairie, a habitat with a state rank of S1, indicating that it is critically imperiled and at immediate risk of extirpation from the state. In Michigan, it can be found in the southwest part of the state. Wet prairie thrives under dual disturbance regimes: fire and fluctuating water levels. This habitat usually occurs adjacent to other fire-dependent systems, including oak savanna. Seasonal saturation and fire discourage most trees and shrubs. Some woody species which thrive in this habitat include dogwoods (*Cornus* spp.) and willows (*Salix* spp.).

The park's lower wetland unit was previously the site of a corporate wetland mitigation project. In Fall 2015, the ¼-acre wetland unit was re-graded with organic wetland topsoil. The unit will be planted with sedges, grasses, and high-quality wetland species like Michigan lily (*Lilium michiganense*), spicebush (*Lindera benzoin*), marsh marigold (*Caltha palustris)*, silky or red-osier dogwood (*Cornus* spp.), buttonbush (*Cephalanthus occidentalis*), and various sedges (*Carex* spp.). KNC opted to leave a handful of pre-existing silver maples (*Acer saccharinum*) on the southeast bank of Portage Creek to encourage bank stability. KNC doesn't plan to plant additional trees in the wetland unit.

Recommendations

- 1: Remove invasive and undesired plant species and monitor the removal site for recurrences. Nutrient enrichment and the suppression of fires and floods will make the wetland unit vulnerable to species like reed canary grass (*Phalaris arundinaceae),* glossy buckthorn (*Frangula alnus*), multiflora rose (*Rosa multiflora*), autumn olive (*Elaeagnus umbellata*), phragmites (*Phragmites australis australis*), purple loosestrife (*Lythrum salicaria*), and narrow-leaved cat-tail (*Typha angustifolia*). See Appendix II for control methods.
- 1: Post interpretive signs at the unit boundary to discourage entry and inform guests about wetland plant species, floodplain hydrodynamics, etc.
- 2: Refrain from installing a path through the wetland, as this would unnecessarily disturb delicate plants and soggy soils. Staff and volunteers should stay out of the unit as much as possible, except to remove trash or invasive species.
- 3: Conduct surveys to measure bird, insect, and amphibian populations.

Measures of Success

- Rising FQI score over repeated vegetation studies
- Results of bird, insect, and amphibian surveys

Climate Change: Adaptation and Mitigation

See Chapter 3: Climate Change and Adaptation for details about Michigan's shifting climate and its species impacts. Ideally, an established low-grass prairie in the upland unit will be robust against the increasing temperatures and chaotic precipitation of a changing climate. The USDA suggests that southern Michigan will become slightly more ideal habitat for pin oak, though the trees will face a rising threat from disease and insect pests.[130]

The wetland unit will be more vulnerable to the effects of climate change. During dry spells, the wetland plants may not receive enough moisture to thrive. Bouts of heavy precipitation may drive massive fluctuations in Kalamazoo River and Portage Creek water levels. Thankfully, these periodic disturbances can positively shape wetland habitats, provided that invasive plant species aren't allowed to take hold after the flood waters recede.

[130] Pin oak (*Quercus palustris*) [Internet]. United States Department of Agriculture Forest Service; unknown [cited 2016 Mar 24]. Available from http://www.fs.fed.us/nrs/atlas/tree/830

Chapter 9: Bullhead Lake

Bullhead Lake Management Plan

9850 Wildwood Road, Delton, MI 49046
(42.59495N, 85.47575W)

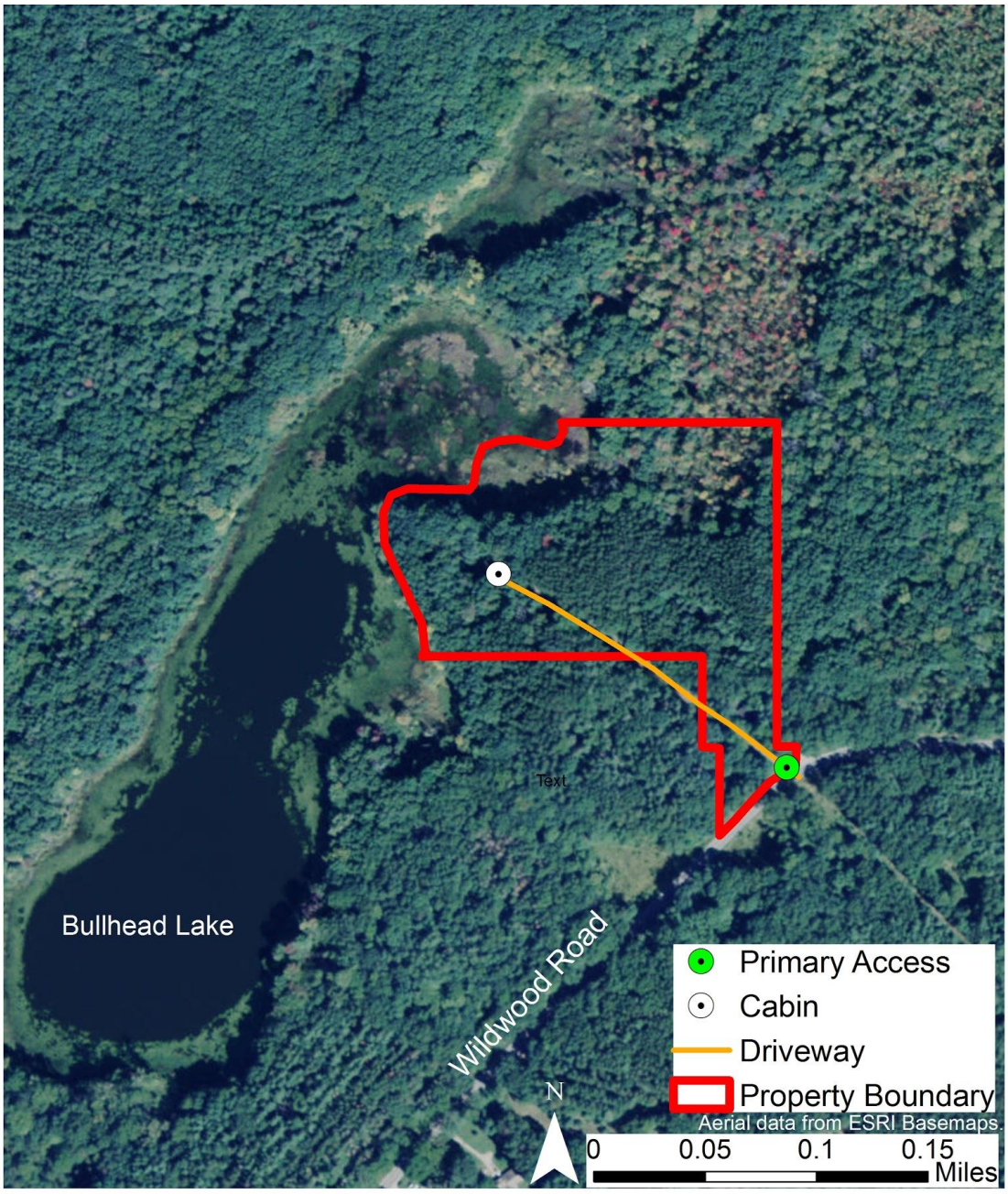

Figure 9.1: Bullhead Lake property boundaries, primary access point, and built features.

Introduction

The Kalamazoo Nature Center's Bullhead Lake property (see Figure 9.1) is located at 9850 Wildwood Road, Delton, MI 49046. The parcel consists of 12 acres of lakefront and forested land located on the eastern side of Bullhead Lake in Barry County, MI. The property undergoes minimal management and is used by KNC staff as a retreat destination during warm-weather months.

History

Barry County boasts diverse ecological communities built on the rolling topography left behind by glacial activity.[131] Abundant wetlands made the county a less attractive site for early development and agriculture, leaving the region with large tracts of minimally disturbed land. Sandy soils encouraged oak-dominated ecosystems across the county. Data from the Michigan Natural Features Inventory indicate that, before European settlement in the 1800s, the eastern side of Bullhead Lake was vegetated primarily by mixed oak forest and the western side by oak-hickory forest.

The region around Bullhead Lake and nearby Gun Lake was historically used as hunting grounds by the Algonquin tribe before European homesteaders began arriving in the 1830s.[132] A century of farming exhausted the land, much of which was subsequently bought by the federal government and reforested through the WWII-era Civilian Conservation Corps program. In 1943, the federal government turned the land over to the State of Michigan and it entered the state park system. Today, the 5,200-acre Yankee Springs is a popular recreation destination, offering opportunities to hike, camp, fish, bike, and ski. State land farther to the east of Bullhead Lake became the Barry State Game Area.

Wishing to protect disappearing oak-dominated ecosystems from future development, KNC founder Lew Batts purchased several private parcels of land in Barry County, including one which would later become the Pierce Cedar Creek Institute near Hastings, MI. In the 1970s, Batts bought the 40-acre Bullhead Lake as a private retreat and to protect it from potential development. As Yankee Springs rose up around the property, Batts sold the majority of his parcel to the State to become part of the State Recreation Area and State Game Area. He transferred the remaining 12 acres of land and a rustic cabin to KNC in 1997. The cabin had been used as a KNC summer camp program destination until the 1990s, when the teen programs began traveling farther afield. Now, it serves as a retreat for KNC staff. Staff conduct an annual work day to maintain the cabin and grounds.

Note that Barry County is home to a second water body called Bullhead Lake about 12 miles to the south near Hickory Corners; this lake bears no connection to KNC's Bullhead Lake property.

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[131] Potter WW. History of Barry County, Michigan, with biological sketches of prominent men by Ford Hicks and Edward Butler [Internet]. Grand Rapids (MI): Reed-Tandler Company; 1912. Available from http://quod.lib.umich.edu/m/micounty/BAD0847.0001.001%3Frgn%3Dmain%3Bview%3Dfulltext%3Bq1%3DBarry%2BCounty%2B%2BMich

[132] Yankee Springs Recreation Area [Internet]. Middleville (MI): Michigan Department of Natural Resources; undated [cited 2016 Mar 24]. Available from http://www.michigandnr.com/parksandtrails/details.aspx?id=511&type=SPRK

Property Composition

Landscape Context
Except for KNC's property, all other parcels around Bullhead Lake are owned by the Michigan Department of Natural Resources (see Figure 9.2). Being flanked by so much undeveloped or minimally developed land puts the Bullhead Lake property at lower risk of colonization by invasive species. However, the proximity of patrons at Yankee Springs, Gun Lake, and the Barry State Game Area does increase the likelihood of non-KNC visitors straying onto the property.

Property Composition
The parcel is accessed off of Wildwood Road. Posted signs alert Yankee Springs patrons when they encounter the property line. The area around the lake is dominated by oak-hickory forest and a swath of red pine plantation. The property also includes a Consumers Energy right-of-way and a portion of wetland on the northern edge of the property.

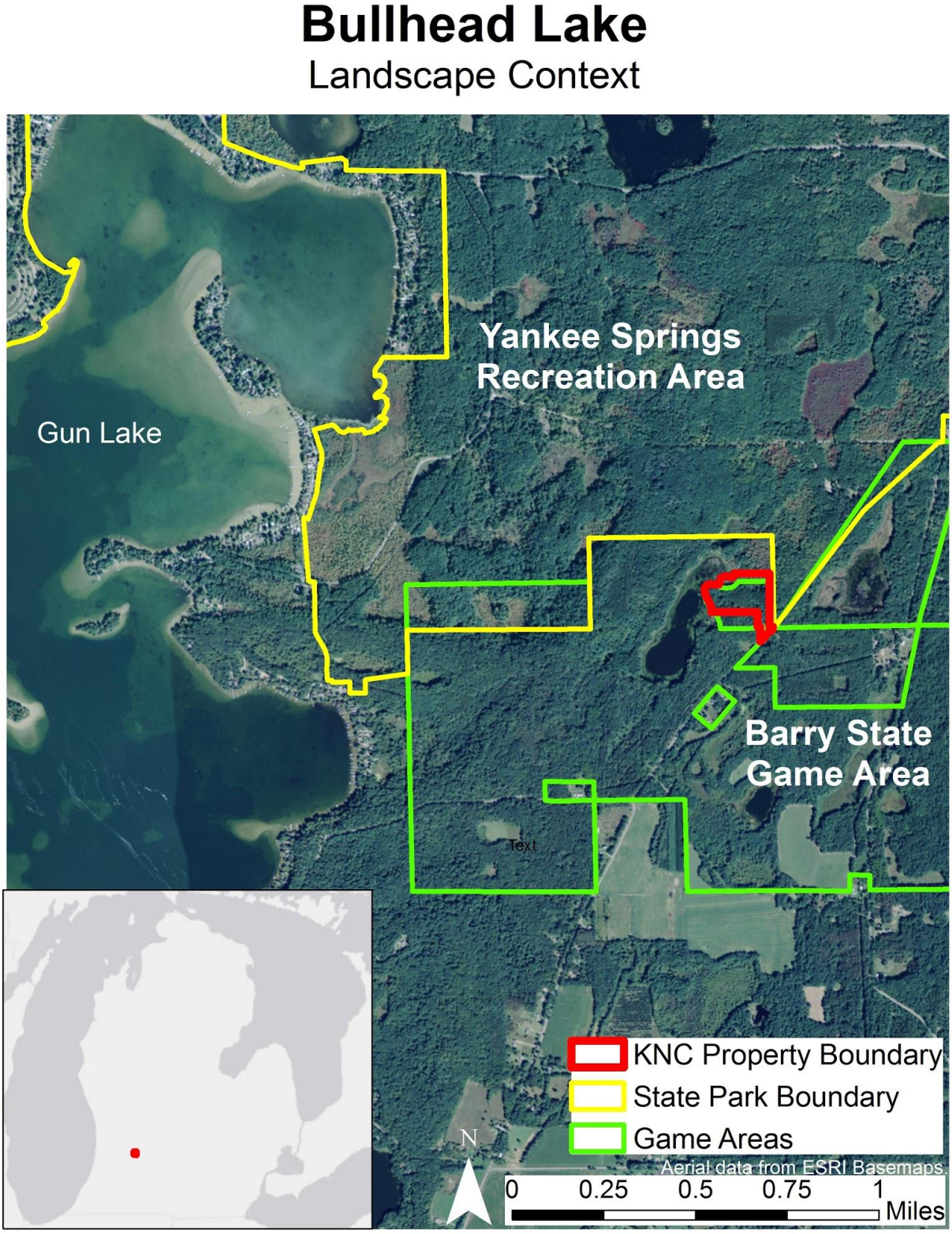

Figure 9.2: Bullhead Lake property is located within the Barry State Game Area and Yankee Springs Recreation Area in southwest Michigan.

General Recommendations

The current paradigm for the property is "minimal use, minimal management". Staff have no plans to reintroduce programming or engage in long-term or large-scale landscape changes. Unless this changes, the staff's main objective should simply be to manage for a resilient ecosystem in the pine plantation and riparian zones around the lake. This should require regular low-level monitoring and removal of invasive plant, insect, and fish species. Staff should continue the combination of an annual work day and a leave-no-trace ethic to maintain the cabin's long-term use.

Recommended management actions are prioritized according to the following numerical scale:

1: Address within the next 3 years
2: Address within the next 5 years
3: Address within the next 10 years
4: Address in the next 10-year comprehensive LMP

Updating Management Plan

- 1: As of this writing, little is known about the species composition of this property. At a minimum, update this site plan with rough observational records of the property's floral and faunal communities in the red pine, oak-hickory, and riparian habitats.
- 1: Encourage staff visiting the cabin to walk around the property and note any seasonal species or habitats (e.g. vernal pools, native wildflowers, songbirds) that might merit further study or protection.
- 1: Use GPS points and GIS mapping to update the map of habitat boundaries.
- 1: Use GPS points to map the Consumer's Energy right-of-way.
- 2: Conduct a formal survey of plant, animal, and insect species in the three habitat zones.
- 3: Collect data on the lake's estimated depth, fish and bird species, algal cover, and riparian health.
- 3: If management or programming intensify, use aerial images and on-the-ground walkabouts to delineate more formal management units on the property. These could parallel the habitat zones used in this plan.

Communicating with Neighbors

- 1: Initiate an annual telephone meeting with the Yankee Springs and Barry State Game Area park managers to address any potential areas of collaboration or conflict.

System for Monitoring, Reporting, and Removing Invasive Species

- 1: Coordinate with a Facilities Management staff member to set up an invasive species reporting system. Anyone who signs up to use the cabin should receive this staff member's contact information. Currently, staff receive a form before using the cabin, which they submit afterward to report any necessary maintenance or repairs; the form should be modified so staff members can also report sightings of invasive plant, insect, or fish species. The Facilities Management contact should keep a running list of all reported invasive species at the property and use this list to inform future management efforts.
- 1: Provide informational materials about common invasive species at the cabin.

- 1: Include invasive species monitoring and removal on the task list distributed for the annual work day. Staff should walk the property near the cabin, lakeshore, and roads (likely spaces for invasive plants to take root). They should note the presence of any fallen trees or canopy gaps near disturbed or open spaces, as those would be most vulnerable to colonization by invasive plant species. Staff should remove and properly dispose of any invasive plants already growing in those locations, as well as planting colored flags near the removal site to aid future monitoring efforts.
- 1: Leave downed wood and snags intact; minimize the creation of beaten footpaths when possible.

Measures of Success

- Feedback from annual phone conversation with Yankee Springs and Barry staff
- Number of species flagged in invasive species monitoring system
- Collected data on lake's estimated depth, fish and bird species, algal cover, riparian health

Management Units

The Bullhead Lake property undergoes such minimal management that this plan does not differentiate the site into formal, discrete management units or compartments. Instead, the plan uses more generalized habitat types to categorize notes about property composition and management recommendations. See Figure 9.3 for the approximate boundaries of each habitat.

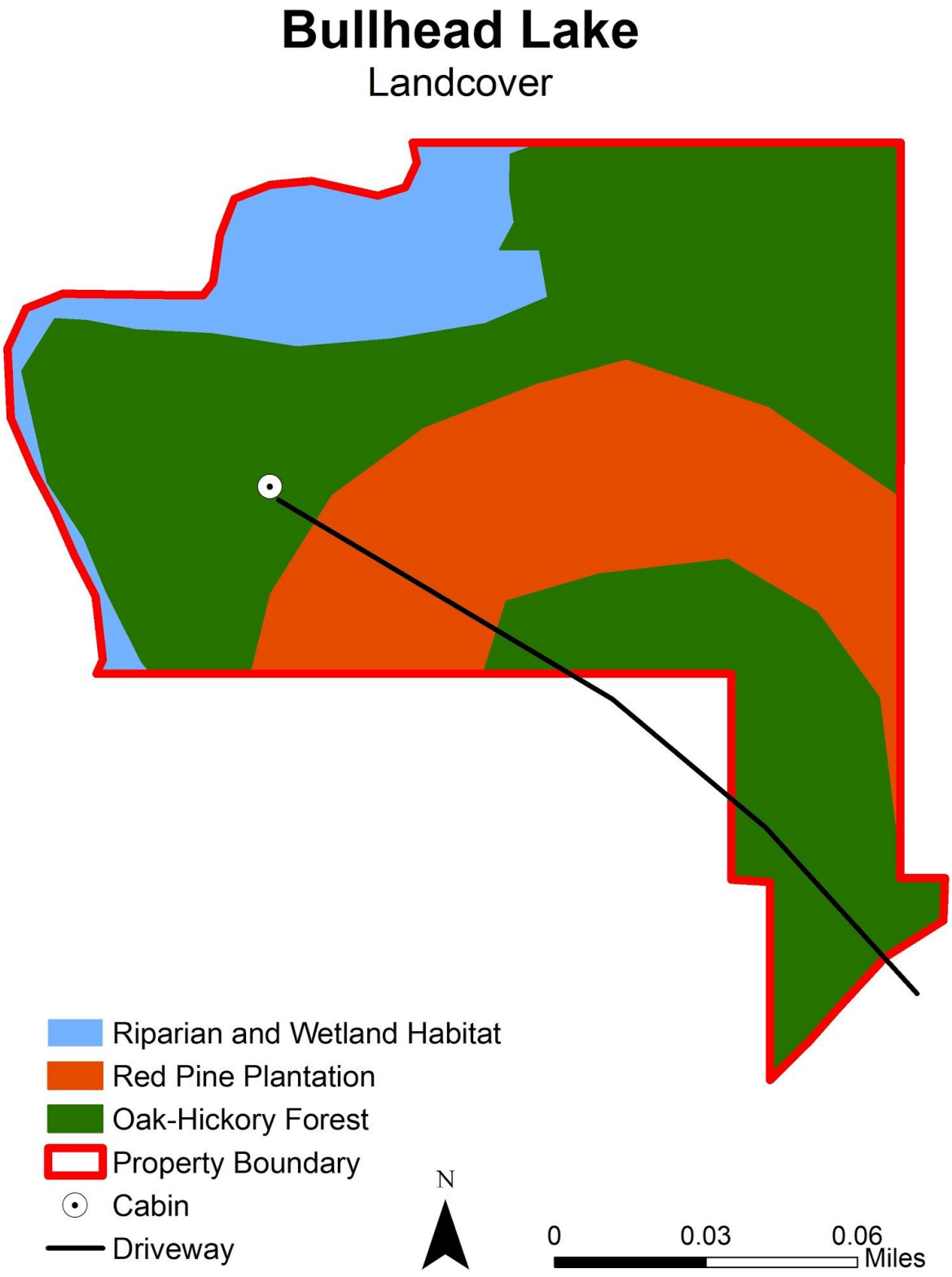

Figure 9.3: Approximate boundaries for Bullhead Lake's major habitat compartments.

Oak-Hickory Forest

Description

This habitat unit includes the retreat cabin and most of the driveway off Wildwood Road. Bullhead Lake's oak-hickory forest is an example of dry-mesic southern forest habitat, which is prevalent in southern Michigan's glacier-shaped landscapes.

Though little is known about the precise species composition in the Bullhead Lake forest at the time of this writing, dry mesic-southern forests are commonly dominated by white oak (*Quercus alba*) and hickories such as pignut (*Carya glabra*), shagbark (*C. ovata*), and bitternut (*C. cordiformis)*. Other trees like red maple (*Acer rubrum)*, black cherry (*Prunus serotina*), basswood (*Tilia americana*), and sassafras (*Sassafras albidum*) are often found in the canopy as well.

Oak-hickory forest relies on fire to promote a semi-open canopy and stimulate oak regrowth. Without frequent fires, the forest canopy may close and transition toward oaks or shade-tolerant species, like maples. Under the current management paradigm, KNC staff should not dedicate resources to conducting prescribed burns on this property.

Recommendations

- 1: Monitor for invasive plant species. Remove and report any instances of species like garlic mustard (*Alliaria petiolata),* spotted knapweed (*Centaurea maculosa*), autumn olive (*Elaeagnus umbellata*), honeysuckle (*Lonicera* spp.), and buckthorn (*Rhamnus* spp.). See Appendix II for control methods.
- 2: Encourage the growth of native species associated with oak-hickory forests. Associated trees include black cherry, basswood, sassafras, dogwood (*Cornus* spp.), and chokecherry (*Prunus virginiana*). Shrubs include maple-leaf viburnum (*Viburnum acerifolium*), prickly-ash (*Zanthoxylum americanum*), gooseberry (*Ribes* spp.), blackberry (*Rubus fruticosus*), raspberry (*Rubus idaeus*), and wintergreen (*Gaultheria procumbens*). Groundlayer species include doll's-eyes (*Actaea pachypoda*), jack-in-the-pulpit (*Arisaema triphyllum*), big-leaved aster (*Eurybia macrophylla*), tick-trefoil (*Desmodium*), bedstraw (*Galium*), wild strawberry (*Fragaria vesca*), round-lobed hepatica (*Hepatica nobilis*), jumpseed (*Polyganum virginianum)*, mayapple (*Podophyllum*), poison ivy (*Toxicodendron radicans*), trillium (*Trillium* spp.), and violets (*Viola* spp.).
- 3: Watch for increasing erosion and blowdowns due to stronger storms. These disturbances provide fresh ground for colonization by invasive plant species and should be monitored closely.

Measures of Success

- Results of informal walkabouts
- Number of species flagged in invasive species monitoring list
- Surveys of understory oak regeneration

Red Pine Plantation

Description

This habitat unit contains part of the driveway between the cabin and Wildwood Road. About a third of the KNC parcel consists of red pine (*Pinus resinosa*) plantation. According to the Michigan Natural Features Inventory, red pines didn't grow in this area before European settlement. The pine plantation may date from WWII-era Civilian Conservation Corps planting projects conducted in the area. The Corps planted pines (mostly red pine, jack pine, and/or white pine) across the country to anchor eroding soil, restore depleted nutrients, and generate biomass for future timber harvests.

Red pine occurs naturally in northern to mid-Michigan, Wisconsin, and Minnesota. Its current range covers about 1.9 million acres in these three states, down from a historical range of 22 million acres.[133] Today, most of Michigan's red pines are in single-species, even-age plantations. Red pine thrives in well-drained, sandy soil and is shade intolerant. Red pine naturally succeeds early species like aspen and jack pine, and is often followed by later species like white pine and hardwoods. Red pine was historically disturbed by periodic fire, high-intensity windstorms, and a variety of insects and pathogens. The high-density stands favored by timber planters discourage branching and foster height growth.

Given KNC's current and anticipated management priorities, timber harvests on this property are unlikely. Stuff must decide whether to maintain the red pine plantation or allow successional species to take over. Single-species stands reduce floral and faunal diversity, even when left unharvested and untended, as the Bullhead Lake stand has been. However, red pine habitat has diminished so dramatically that this habitat could hold ecological value for that reason.

Red pine stands depend on regular disturbances from fire to clear the underbrush for new seedlings. Given KNC's current and anticipated management priorities, prescribed burns on this property are unlikely to become management tools for the staff. Without fire, red pine stands will gradually progress to the next successional stage. In southern Michigan, the succeeding stage could include white pine (*Pinus strobus*), balsam fir (*Abies balsamea)*, paper birch (*Betula papyrifera*), and red maple (*Acer rubrum*). However, given that this stand is totally surrounded by oak-hickory forest, it's far more likely that this community will move in as the red pines die away.

Recommendations

- 1: Monitor for the same suite of invasive species as mentioned for the oak-hickory habitat.
- 2: Assess the amount of red pine regeneration in the understory. If new red pines are successfully regenerating, don't encourage succession toward a different forest composition. If red pines aren't regenerating, fill significant canopy gaps or large blowdowns by planting saplings. These species can either represent the next successional stage (such as white pine, balsam fir, paper birch, and red maple) or can transition the forest toward oak and hickory species.

[133] Ek AR, *et al.* Red pine management guide: a handbook to red pine management in the North Central Region [Internet]. Minneapolis (MN): University of Minnesota and United States Forest Service. [cited 2016 Mar 24]. Available from http://www.ncrs.fs.fed.us/fmg/nfmg/rp/docs/rp_all.pdf

- 3: Watch for full-foliage color changes (green to yellow to rusty) or ground-level damage to trunks of mature trees (see Figure 9.4). Either symptom can signal the presence of pine root collar weevil (*Hylobius radicis* Buchanan), which girdles pines at or just below ground level. This can weaken or kill mature trees and make them susceptible to blow-down in high winds. Adult weevils are sensitive to temperature and light, so scraping away litter and surface soil to expose the weakened trunk area can deter further damage.

Figure 9.4: The left image shows an adult pine root collar weevil. The right image displays characteristic signs of weevil damage in a mixed red and Scots pine stand.[134]

- 3: Watch for dead branches near the tops of trees (see Figure 9.5). Drought-weakened or stressed trees may become susceptible to pine bark beetles (*Scolytidae* or *Ips* spp.). Pine beetle damage moves downward from the crown, so dead branches near the tops of trees will be the first signal. Affected trees can either be left to die or cut down. If the trees are cut, affected branches must be burned, removed, or otherwise destroyed within 3 weeks.[135] [136] The best way to prevent bark beetle outbreaks is to avoid cutting or otherwise injuring trees (i.e. creating beetle breeding material) during the beetles' active season of March 1 through August 1 or during periods of prolonged drought.

[134] Van Driesche RG, *et al.* Pine root collar weevil [Internet]. University of Massachusetts, United States Forest Service, and University of Georgia. [cited 2016 Mar 24]. Available from http://forestpests.org/book/381.html
[135] How to identify and manage pine bark beetles [Internet]. Minnesota Department of Natural Resources, Division of Forestry [cited 2016 Mar 29]. Available from http://files.dnr.state.mn.us/assistance/backyard/treecare/forest_health/barkbeetles/barkbeetlebroch.pdf
[136] Pine bark beetle [Internet]. Minnesota Department of Natural Resources [cited 2016 Mar 29]. Available from http://dnr.state.mn.us/treecare/forest_health/barkbeetles/index.html

Figure 9.5: The left image shows an adult pine shoot beetle (Tomicus piniperda).137 The right image shows typical pine shoot beetle damage to a pine tree.[138]

Measures of Success

- Findings of informal walkabouts
- Survey of red pine regeneration
- Number of species flagged in invasive species monitoring list

Riparian Habitat - Wetland and Lakeshore

Description

While staff anecdotes and aerial images confirm the presence of a wetland in the northeast portion of the property, nothing is known about the condition or species composition of this habitat. The same is true of the remainder of the riparian zone that forms the western boundary of the parcel. Staff confirm that the lake supports a healthy fish community and is good for recreational boating and fishing.

Recommendations

- 1: Watch for and remove invasive plants like purple loosestrife (*Lythrum salicaria*), reed canary grass (*Phalaris arundinacea*), and phragmites (*Phragmites australis*). See Appendix II for control methods.
- 1: Install new or revised signs along the property line which request that people refrain from bringing boats across the boundary. While staff enjoy boating and fishing on the lake, apparently so do visitors from the game area. Park patrons have been known to drag boats from the park into Bullhead Lake, presenting a very clear vector for the transfer of invasive species like purple loosestrife or zebra mussels (*Driessena polymorpha*). Boundary signs should also include language explaining the rationale for preventing cross-lake boat traffic (i.e. that boats carry troublesome plant and animal species from one lake to another).

[137] Common pine shoot beetle [Internet]. United States Department of Agriculture National Invasive Species Information Center. [cited 2016 Mar 24]. Available from http://www.invasivespeciesinfo.gov/animals/psb_child.shtml

[138] Thomas MC, Dixon WN, Fasulo TR. Pine shoot beetle [Internet]. Gainesville (FL): University of Florida; 2010 Sept. [cited 2016 Mar 24]. Available from http://entnemdept.ufl.edu/creatures/trees/beetles/pine_shoot_beetle.htm

- 2: Avoid fishing, boating, or swimming if an algae bloom is visible in the water (see Figure 9.6). Blooms can range from stinky nuisances to toxic hazards, depending on the algae species and the amount of material washing up on shore. Blooms can appear foamy, scummy, matted, or like spilled paint.

Figure 9.6: Examples of algae blooms in small lakes.[139] [140] [141]

- 3: Report signs of unusual fish populations. The presence of non-staff fishers may lead to bait fish being released into Bullhead Lake. At low levels, this behavior shouldn't cause problems. However, if staff members fishing on the lake catch or notice signs of unusual fish populations, they should report those observations to the invasive species monitor as they would any other species.

Measures of Success

- Findings of repeated vegetative studies
- High FQI score for wetland plants
- Inventories of riparian birds, insects, amphibians
- Number of species flagged in invasive species monitoring list

[139] Craven S. Water science photo gallery: algal bloom in a small lake in Great Britain [Internet]. United States Geological Survey; 2015 Jul 24 [cited 2016 Mar 24]. Available from http://water.usgs.gov/edu/gallery/algal-lakes-britain.html
[140] Gill C. Project to reduce risk of harmful algal blooms in ponds and lakes [Internet]. University Park (PA): Pennsylvania State University; 2015 Jun 25 [cited 2016 Mar 24]. Available from http://news.psu.edu/story/361695/2015/06/25/research/project-reduce-risk-harmful-algal-blooms-ponds-and-lakes
[141] Harmful algal blooms in Ohio's inland lakes, rivers and streams [Internet]. Batavia (OH): Clermont Health District. [cited 2016 Mar 24]. Available from http://www.clermonthealthdistrict.org/hab.aspx

Climate Change: Adaptation and Mitigation

See Chapter 3: Climate Change and Adaptation for details about Michigan's shifting climate and its species impacts. Given KNC's current minimal management of this property, climate-driven changes may not open up much potential for additional management. On the whole, staff should be prepared to monitor more thoroughly for disturbances and colonization by invasive species in all habitat units. Stronger storms will increase the likelihood of erosion and blowdowns in forested areas. Warming patterns will drive later fall frosts and earlier spring thaws, which will widen the season for insect pests and diseases that might damage trees and herbaceous plants.

In general, oak-hickory forest in the Great Lakes basin is projected to thrive under climate change.[142] Regeneration in red pines is projected to increase with above-average precipitation, but decrease under above-average temperatures.[143] The future effect of these combined factors on regeneration in Bullhead Lake's red pine plantation is unknown.

Dropping water tables, declining winter ice cover, increased heat-driven evaporation, and less reliable precipitation will combine to drive down Bullhead Lake's average water level. This may constrict habitat for some fish species. The exposed shorelines will be vulnerable to colonization by invasive plants.[144]

Warmer lake temperatures will promote stratification of water levels, making it harder for oxygen and nutrients to move through the water column. This will increase the likelihood of summertime oxygen depletion in deeper regions, which could cause fish die-offs. Increased erosion and runoff into the lake, combined with warmer water temperatures, could drive more frequent algal blooms. As the algal cells die and sink to the lakebed, decomposition depletes oxygen levels, exacerbating other anoxic factors. Warmer temperatures could also weaken or kill fish, amphibian, and insect species that prefer cooler water.

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[142] Rustad L, *et al.* Changing climate, changing forests: the impacts of climate change on forests of the northeastern United States and Eastern Canada [Internet]. Newtown Square (PA): United States Forest Service; 2014 Aug [cited 2016 Mar 24]. Available from http://www.fs.fed.us/nrs/pubs/gtr/gtr_nrs99.pdf

[143] Hauser SA. *Pinus resinosa* [Internet]. Fort Collins (CO): Rocky Mountain Research Station, United States Forest Service; 2008 [cited 2016 Mar 24]. Available from http://www.fs.fed.us/database/feis/plants/tree/pinres/all.html

[144] Lusch DP. Climate change: water implications for Michigan communities, landsystems, and agriculture [Internet]. Lansing (MI): Michigan State University. [cited 2016 Mar 24]. Available from http://msue.anr.msu.edu/uploads/234/62936/Climate_Change_Water_Implications_for_Michigan.pdf

Chapter 10: Pitsfield Banding Station

Pitsfield Banding Station Management Plan

5616 S Avenue East, Vicksburg, MI 49097
(42.17193N, 85.51813W)

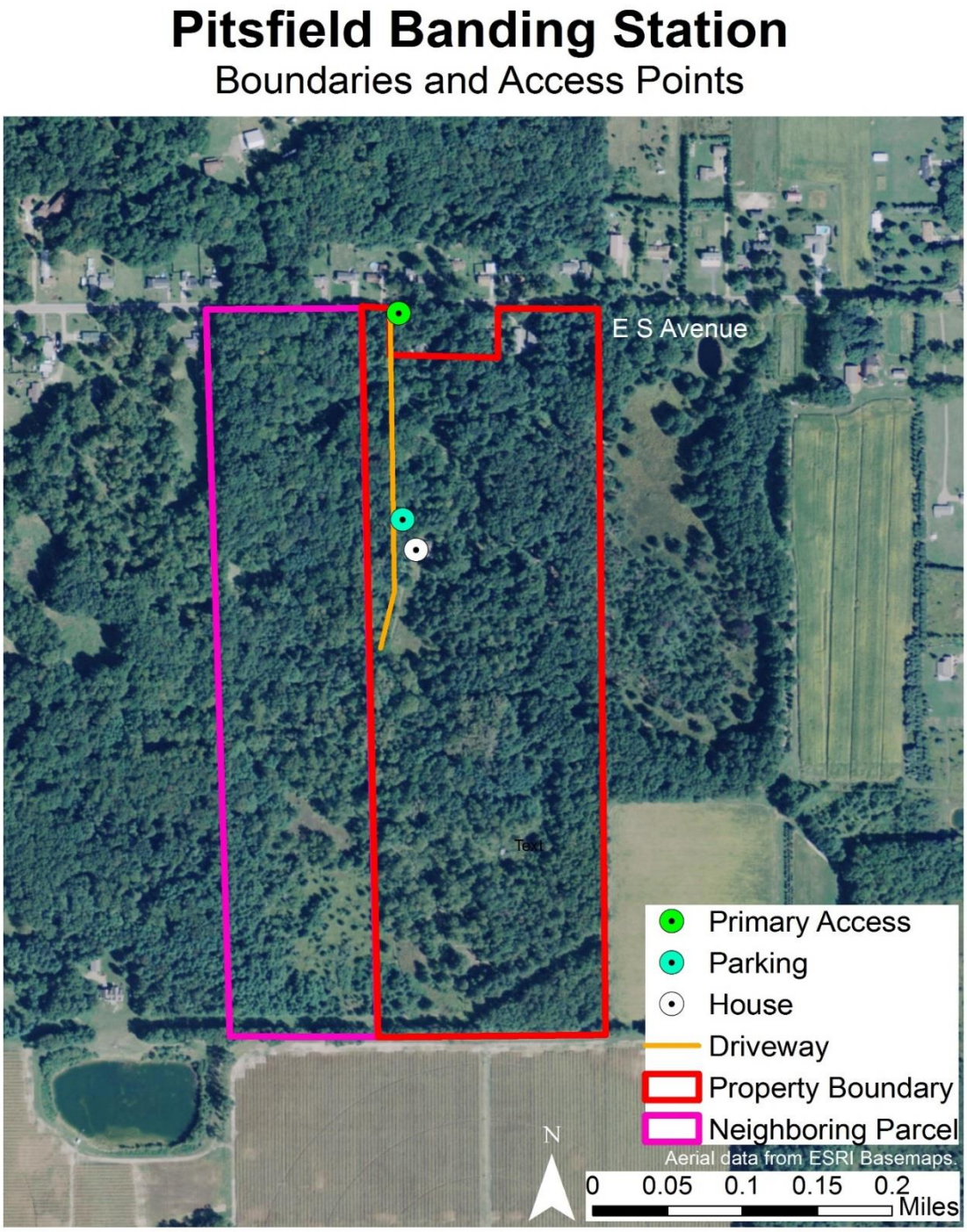

Figure 10.1: Pitsfield Banding Station boundaries, primary access points, and built features. Note the habitat-rich neighboring parcel to the west, held by the brother of Pitsfield's owner.

Introduction

The Pitsfield Banding Station (see Figure 10.1) is a privately owned 43-acre parcel of woodland and restored prairie in a rural residential area near Vicksburg, MI (5616 S Avenue East, Vicksburg, MI 49097). The property is currently used as an annual bird banding site by the Kalamazoo Valley Bird Observatory (KVBO), an affiliate of KNC.

History

Pre-settlement vegetation at this site consisted of shrub swamp/emergent marsh in the northern half and mixed oak savanna in the southern half.

The property is currently owned by Richard and Brenda Keith, having been in Richard's family for many years. As director of the Kalamazoo Valley Bird Observatory, Richard has partnered with KNC to run an annual bird banding program on the Pitsfield property.

Bird Banding Program

The site is currently used by the Kalamazoo Valley Bird Observatory, an affiliate of KNC, as one of its primary bird banding sites. Michigan's nonresident songbird species travel through Kalamazoo during their annual fall migration period of August 25 to October 31. Banding occurs during that time interval, with volunteers capturing and tagging birds between sunrise and six hours after sunset. According to the KVBO Fall 2013 report, the group bands upwards of 12,000 birds per year at Pitsfield and other local sites. Spring migrations occur in March and April, though KVBO doesn't currently conduct spring banding.

Banding at Pitsfield began in 1990 when Rich and Brenda Keith took over the program. Since 1990, 119 species have been banded at Pitsfield, part of the 126 total species recorded across the KVBO program. Between 2010 and 2013, Pitsfield averaged 4,156 birds per year. In 2013, KVBO managed 33 nets at Pitsfield and banded 3,989 birds there.

Stopover Ecology

The term "stopover ecology" can be used to describe habitat parameters preferred by migratory songbirds as they pause to rest and refuel during their seasonal migrations.[145] During their northbound migration in April and May, birds commonly rely on springtime insect population booms as a major food source. Some species that encourage beneficial insects—and may additionally provide edible blossoms—include oaks (*Quercus* spp.), willows (*Salix* spp.), hackberry (*Celtis occidentalis*), serviceberry (*Amelanchier arborea, A. laevis*), wild columbine (*Aquilegia canadensis*), coneflowers (*Echinacea* spp.), and native varieties of asters, milkweeds, and goldenrods.[146]

[145] Migratory stopover ecology [Internet]. Dearborn (MI): Rouge River Bird Observatory. [cited 2016 Mar 25]. Available from http://www.rrbo.org/conservation-science/research/migration-stopover-ecology/

[146] Southeast Michigan: a critical stopover site for migrant birds [Internet]. Dearborn (MI): Rouge River Bird Observatory. [cited 2016 Mar 25]. Available from http://www.rrbo.org/pdf/landscapingbirds.pdf

In the fall, as birds move south, they rely more on plant species that produce small fruits. Some species that produce suitable berries include gray dogwood (*Cornus racemosa*), red-osier dogwood (*C. stolonifera*), Virginia creeper (*Parthenocissus quinquefolia*), spicebush (*Lindera benzoin*), wild grapes (*Vitis* sp.), mapleleaf viburnum (*Viburnum acerifolium),* and poison ivy (*Toxicodendron radicans*).[147] Additionally, oaks, hickories (*Carya* spp.), and conifers produce nuts valuable to migrating birds. Seeds from native wildflowers, such as the species mentioned previously, can be valuable fall food sources.

Some central tenets of landscaping for migratory birds include:[148]

- Using native plants, though some non-natives, such as buckthorn and honeysuckle, produce edible fruit.
- Providing layers of vegetative structure (including leaf litter and low herbaceous plants, understory shrubs and vines, and trees of varying ages) for foraging and safety.
- Reducing or eliminating the use of chemical pesticides.
- Replacing lawn with diverse plantings.
- Leaving dead wood in place to provide additional hiding and foraging places.

Property Composition

Landscape Context

The Pitsfield Banding Station is about 5 miles southwest of the town of Portage, MI, and 5 miles north of Vicksburg, MI. The surrounding region consists of residential neighborhoods, agricultural fields, and a golf course (see Figure 10.2). Small kettle lakes and several preserves and parks provide access to natural areas. More locally, the property is flanked by agricultural fields to the south and east. A 35-acre wooded parcel runs along the western border. Several sizeable wooded parcels are situated to the north, separated from Pitsfield by smaller residential parcels along S Avenue.

[147] Southeast Michigan: a critical stopover site for migrant birds [Internet]. Dearborn (MI): Rouge River Bird Observatory. [cited 2016 Mar 25]. Available from http://www.rrbo.org/pdf/landscapingbirds.pdf
[148] Ibid.

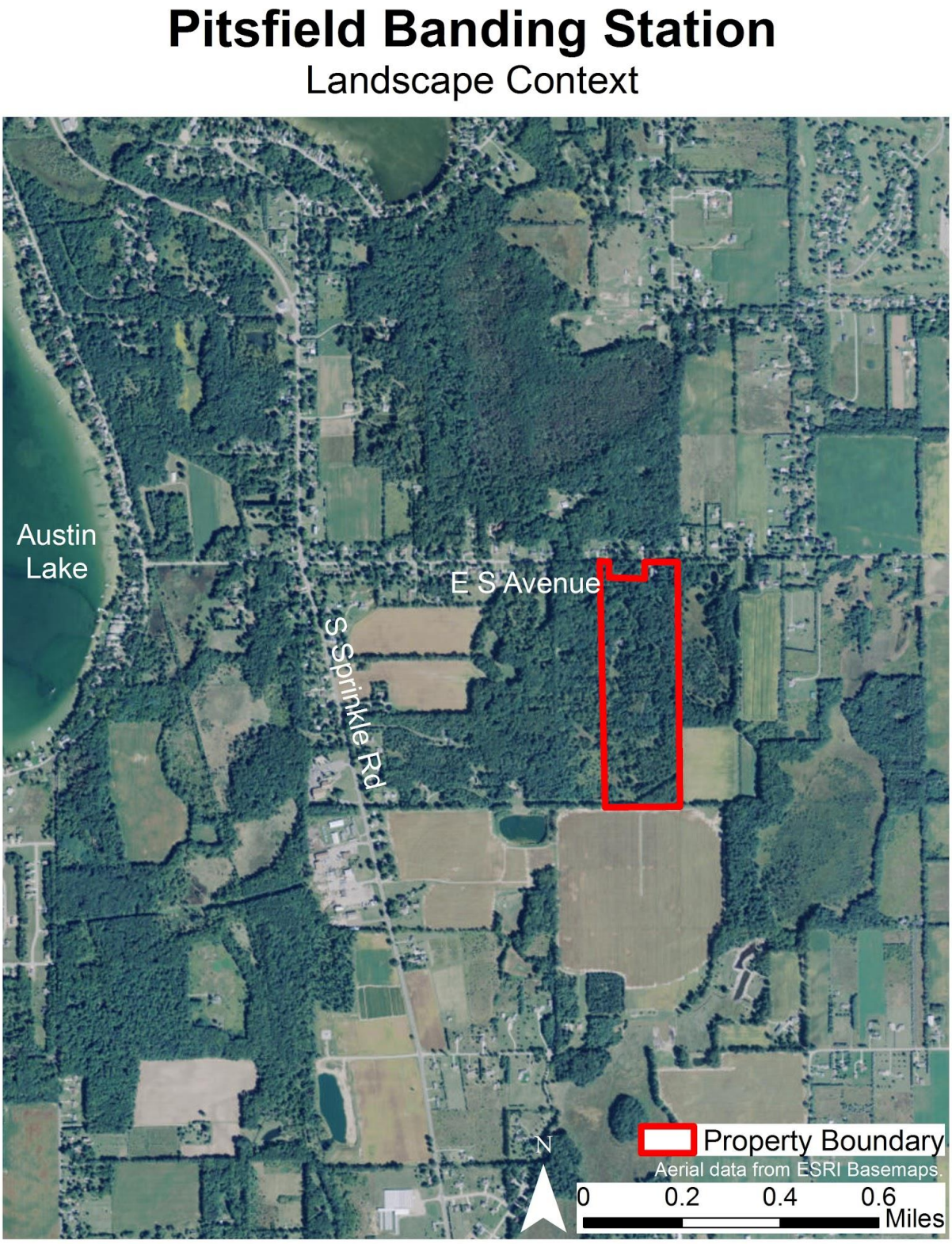

Figure 10.2: Pitsfield Banding Station is surrounded by agricultural fields, residential parcels, and several small lakes and ponds.

Property Composition

According to KVBO records, the site consists of about 10 acres of mature woods, 12 acres of marsh and peat bog, and 5 acres of restored mesic prairie. The remainder of the property consists of woodland around old gravel pits, along with several small ponds. The southern portion is laced with mossy trails which allow volunteers to access the bird banding nets. See Figure 10.3 for approximate distributions of these habitats. A 35-acre parcel to the west is owned by Dennis Keith, Richard's brother and overlaps (perhaps intentionally) with portions of Pitsfield's restored prairie and trail system.

As of this writing, no attempt has been made to update maps of these habitat regions. Previous habitat maps created for the banding program may no longer accurately reflect the distribution of habitats across the property.

The site also includes a driveway along the western boundary, two single-family residences (the primary residence being the house near the end of the driveway), and several sheds.

Data Collection

Species inventory data were collected on two occasions from distinct habitats within the property. In May 2015, in the midst of a cool, damp spring, a Modified-Whittaker plot was constructed in the wooded area east of the house, according to the model described in Appendix III. In July 2015, a single 70-meter transect was plotted in the restored prairie remnant, an attenuated version of the model described in Appendix III. However, GPS data revealed that the transect was conducted outside the property boundaries. See Figure 10.4 for plot and transect locations relative to the property boundaries. Inventory data from these surveys were combined with informal walkabouts to reach conclusions about habitat quality and potential management strategies.

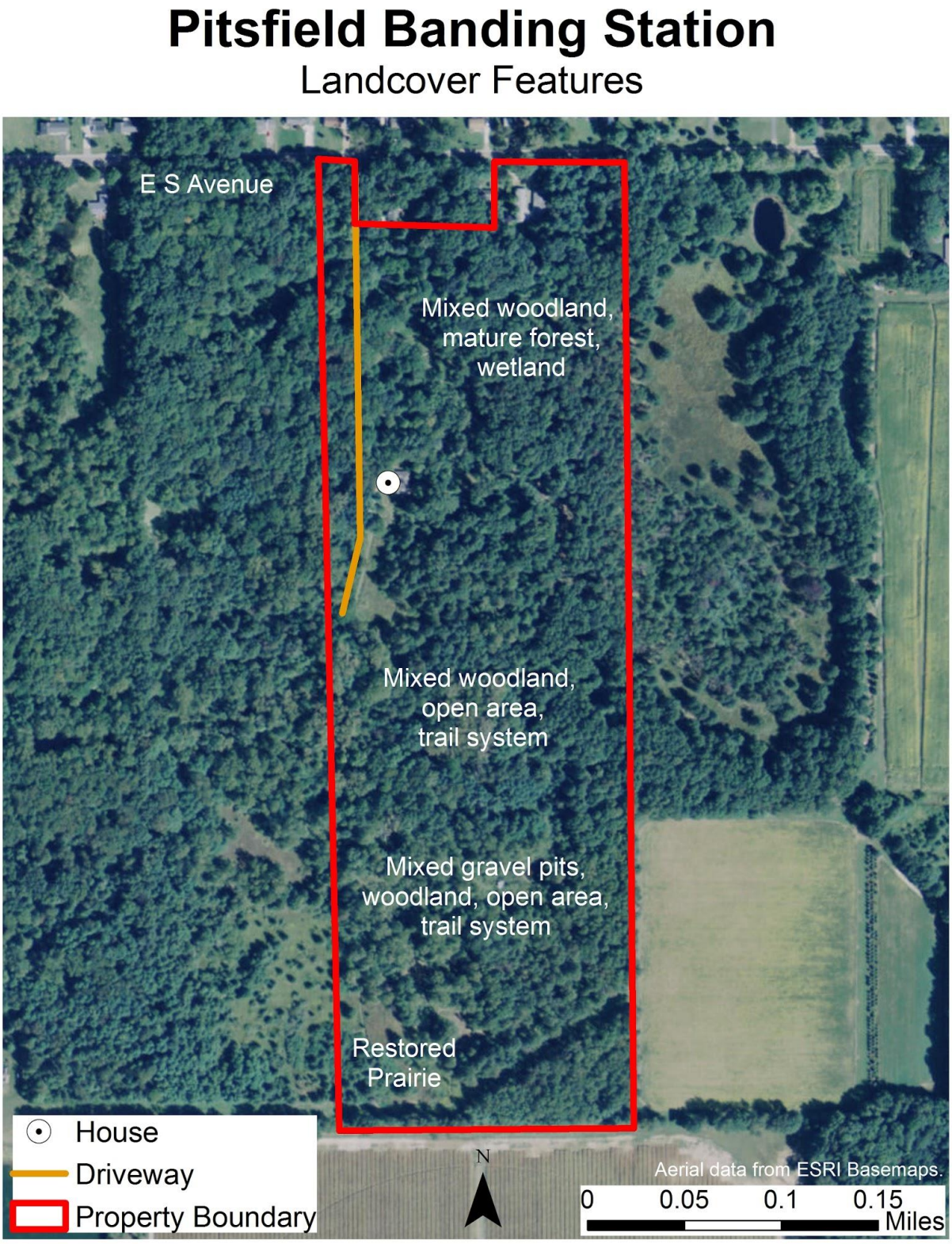

Figure 10.3: Generalized habitat regions at Pitsfield Banding Station, according to anecdotal evidence.

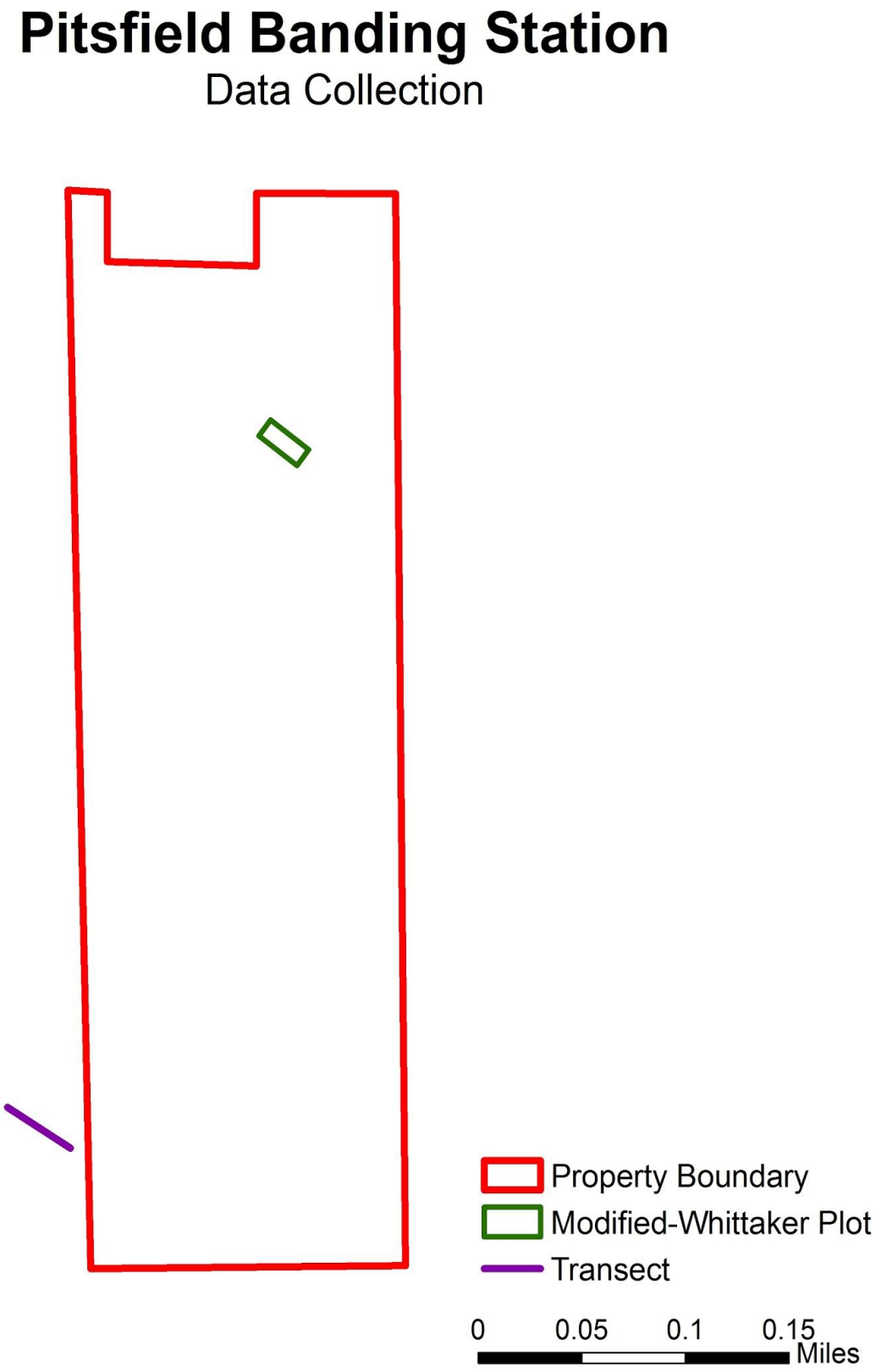

Figure 10.4: Locations of woodland Modified-Whittaker plot and prairie transect.

Data Results

Woodland Modified-Whittaker Plot

The woodland plot was constructed on May 14, 2015 (see Figure 10.4). Further walkabouts of the property revealed that the plot was not located in a representative region of the site and thus demonstrated little about the property's overall species composition. However, data and observations from the May 2015 survey will be included here.

The plot was surrounded by several large blowdowns, perhaps due to the trees' inability to stay rooted in the area's saturated soil. The holes vacated by the root systems of these trees had filled with water and produced small pools which were still waterlogged during the follow-up visit in July 2015.

The plot's substrate consisted largely of leaf litter, moss, and downed wood. Much of the leaf litter was saturated, due to the spring's late snowmelt and high level of precipitation. The plot revealed a high prevalence of wild blueberry (*Cyanococcus* sp.), mature red oak (*Quercus rubra*), and immature buckthorn (*Rhamnus* sp.). Present in smaller quantities were sugar maple (*Acer saccharum*), strawberry (*Fragaria ananassa*), poison ivy (*Toxicodendron radicans*), viburnum (*Viburnum* sp.), raspberry (*Rubus idaeus*), wood fern (*Dryopteris*), cherry seedlings (*Prunus serrulata)*, and several species of sedge (*Carex* spp.) and grass.

During the July 2015 return visit, the plot had been overtaken by grasses, sedges, and ferns. The buckthorn had matured into 6-foot shrubs and seemed to have overwhelmed the blueberry bushes.

The resulting Floristic Quality Index (FQI) score for the Modified Whittaker plot was 13.27, including non-native plants, and 13.91 with only native plants (see Appendix III for FQI calculations). These ratings indicate that the property exhibits low vegetative quality with no particular conservation value. However, given that the plot was not representative of the property's species composition, this rating should be taken with a grain of salt.

Prairie Transect

The transect was constructed on July 16, 2015 in the pocket of restored prairie in the southern portion of the site. GPS points collected during the transect set-up later revealed that the transect had unwittingly been constructed on the neighboring parcel just west of the property boundary (see Figure 10.4). Consequently, while the resulting data may represent the species composition of the prairie as a whole, they don't accurately capture species growing on the Pitsfield property.

The transect intersected predominantly with goldenrod (*Solidago* spp.), asters (*Asteraceae* spp.), yarrow (*Achillea millefolium*), and timothy-grass (*Phleum pratense*). Other species present in smaller quantities included raspberry (*Rubus idaeus*), grape vine (*Vitis vinifera*), black locust (*Robinia pseudoacacia*), dandelion (*Taraxacum officinale*.), black cherry seedlings (*Prunus serotina*), common cinquefoil (*Potentilla simplex*), poison ivy (*Toxicodendron radicans*), Virginia creeper (*Parthenocissus quinquefolia*), dogbane (*Apocynum cannabinum*), Christmas fern (*Polystichum acrostichoides*), sumac (*Rhus* spp.), spotted knapweed (*Centaurea maculosa*), Queen Anne's lace (*Daucus carota*), and chokecherry (*Prunus virginiana*).

Also present, but not located directly along the transect, were black-eyed Susan (*Rudbeckia hirta*), bergamot (*Monarda fistulosa*), grey-headed coneflower (*Ratibida pinnata*), immature sassafras (*Sassafras albidum*), hickory (*Carya* spp.), autumn olive (*Elaeagnus umbellata*), lupine (*Lupinus* spp.), strawberry (*Fragaria ananassa*), mature black oak (*Quercus velutina*), hairy vetch (*Vicia villosa*), and bladder campion (*Silene vulgaris*).

In sum, forbs far outweighed grasses, with varieties of goldenrods and asters making up the dominant species. Several specimens of nuisance plants such as Virginia creeper and poison ivy were noted. Oriental bittersweet (*Celastrus orbiculatus*) was present in several locations along the transect, which was unsurprising, given its near-total grip on the surrounding woodlands. Plants along the edges of the prairie, particularly near the borders of paths, tended to be more diverse than plants on the interior. It has not been determined whether the path borders had been seeded with a different mix than the interior, if this was a result of self-seeding in easily accessible and sunny soils, or if the effect was coincidental. It's also unknown whether or not the restored prairie has ever been burned.

The FQI score for the Pitsfield prairie transect was 15.14, including non-native plants, and 19.35 with only native plants. These indicate that the prairie exhibits low vegetative quality with no particular conservation value. However, given the scarcity of prairie habitat in southern Michigan and its potential to provide food and shelter to migratory songbirds, this portion of the site deserves more attention than this rating would suggest.

Neighboring Parcel Walkabout

A cursory walkabout was also conducted along the edge of the neighboring parcel west of Pitsfield. Owned by Dennis Keith, the neighboring parcel appeared to have a diverse habitat reminiscent of the historic shrub swamp. Several low-lying areas were thickly vegetated and full of water during the July 2015 visit. The mature woods bordering the Pitsfield driveway had an unexpectedly minimal amount of ground cover and tree re-growth, which gave the impression of some kind of ecological instability which might diminish the biodiversity value of the site. However, few conclusions can be drawn about the property's composition, as only a brief tour was conducted along the property's boundary with Pitsfield.

General Recommendations

At the time of this writing, it's unclear whether or not KNC will ever acquire this property or how long the bird banding efforts will continue. These management recommendations are designed to encourage healthy, diverse woodland and prairie ecosystems, in addition to maintaining conditions conducive to migrating songbirds—which are worthy goals, regardless of the property's ownership or use. The recommendations are prioritized according to the following numerical scale:

1: Address within the next 3 years
2: Address within the next 5 years
3: Address within the next 10 years
4: Address in the next 10-year comprehensive LMP

Property Ownership

- 4: Negotiate to buy the property, unless an avian-oriented conservation organization expresses interest in it. In that case, KNC may wish to defer to the interested organization and turn its own attention to properties of more inherent ecological and educational value.
- 4: If KNC purchases Pitsfield, consider leaving the property open only to banding program staff and volunteers. Staff should think carefully before attempting to launch programming at the site; this would require allocating staff time and funds to maintaining Pitsfield as a public space. Pitsfield Banding Station is a 30-minute drive from the Main Site and Interpretive Center, and staff are already concerned about having enough employees and funds to wisely use KNC's existing properties.
- 4: Explore options for purchasing the neighboring parcel. This would require an extensive species inventory to determine the property's ecological value. If KNC acquires Pitsfield and not the neighboring parcel, any property transfers must account for the fact that some of Pitsfield's trails and restored prairie habitat overlap with the neighboring parcel.

Updating the Management Plan

- 1: Verify anecdotal evidence suggesting the presence of extensive Michigan Holly, a valuable native shrub, in a wet portion of the property. Ensure that no invasive species overtake the shrubs' habitat.
- 1: Conduct an informal survey of the mature woods and woodland portions of the property. Update the site plan with this information.
- 2: Update a formal map of the trail system and make it available electronically or in print.

Banding Program and Bird Habitat

- 1: Continue the bird banding program on the site as long as funding and volunteer willpower remain.
- 1: Communicate with Dennis Keith about the presence of trails and valuable prairie habitat on his property. If possible, secure written permission to cross the property line on trails or in the prairie. If permission isn't forthcoming, post signs along the western property line to discourage accidental trespassing.
- 1: Leave the network of mossy footpaths intact, as the moss muffles footsteps and allows banding personnel to move without interrupting bird activity.
- 1: Leave dead wood in place, unless it encroaches on trails or is otherwise unsafe. If safety is a concern, the wood should be moved only as far as needed.
- 2: When choosing trees, shrubs, or forbs to plant on the property, always opt for native species that encourage beneficial insects or produce berries, nuts, or seeds for migrating birds to eat. Examples of trees and shrubs include oaks, willows, hackberry, dogwoods, spicebush, mapleleaf viburnum and serviceberry. Examples of wildflowers include coneflowers, asters, milkweeds, and goldenrods.
- 2: Craft layers of vegetative structure to provide hiding and foraging places. This includes planting low shrubs near solitary trees, as well as planting future trees and shrubs in clusters.
- 2: Reduce or eliminate the use of chemical pesticides when alternative forms of control can be used. If chemical-free options aren't feasible, the chemicals should be applied outside of the March-April and August-October migration periods.

- 3: Provide bird baths or shallow tubs for birds to stay hydrated.
- 4: If future volunteers observe a mismatch between the birds' arrival and the availability of berries or seeds, they should install feeders in all habitats around the property to supplement the birds' diets.

Measures of Success

- Results from ongoing bird-banding operations
- Informal surveys of bird-friendly fruit production

Management Units

Delineating management units within the Banding Station would be difficult without more formal walkabouts and GPS data. Instead, this site plan relies on general habitat descriptions to describe suggested management actions. See Figure 10.3 for approximate locations of these habitat types.

House and Yard

- 2: Remove human debris in the woodland east and south of the driveway, such as the makeshift campsite south of the house, two unusable automobiles, a rusted metal drum, and a deer blind. Several of these items are located within sight of the main house and detract from the aesthetic value of the natural areas.
- 4: Consider removing the single-family house on the property. If KNC acquires the site, the house could be converted into a permanent banding program office. However, KNC would then be responsible for paying for maintenance, repairs, taxes, and services on a little-used, distant building. Leaving the building empty and unmonitored could invite vandalism and unsafe conditions. Instead, KNC should consider taking it down after removing all reusable or recyclable materials. The house's footprint should be replanted with a variety of native shrubs and forbs.

Woodland and Trail System

- 1: Keep the network of mossy footpaths intact, as the moss requires little to no maintenance, discourages erosion and weed growth, and eliminates the need for introduced materials like wood chips or gravel. The moss also muffles footsteps and allows banding personnel to move without interrupting bird activity.
- 1: Make all possible attempts to control the spread of oriental bittersweet through the woodland areas, particularly before it threatens the prairie. The plant spreads prolifically through seeds and root suckers. Given the scale of this infestation, yanking down individual vines will likely do more damage than good. Two recommended methods of removal include:[149]
    - Basal bark application: use a trimmer or hand saw to cut away foliage a few feet above the ground, then apply herbicide (such as triclopyr or glyphosphate) to exposed stems.

[149] Swearingen JM. Oriental bittersweet [Internet]. Washington, DC: National Park Service; 2009 Jul 7 [cited 2016 Mar 26]. Available from https://www.nps.gov/plants/alien/fact/ceor1.htm

    - Cut stem application: cut vine stem 2 inches above the ground and immediately apply herbicide to exposed surface.
    - Either treatment should be applied in the fall or winter to minimize damage to desired plants.
- 1: Hand-pull common woodland invasives, like garlic mustard, multiflora rose, and Japanese barberry, on sight.
- 2: Control buckthorn populations in the woodland south of the house. In May 2015, the plants were small enough to be controlled through pulling or cutting. By the time management occurs in the area, the shrubs may require cutting and cut-stump pesticide application for several years before the infestation can be controlled.[150]
- 2: Run 1-2 additional Modified-Whittaker plots in more diverse wooded portions of the site, like the northeast corner.

Prairie

- 2: Repeat the initial prairie transect, if permission can be obtained from Dennis Keith or the current property owner. If not, set up a new transect located fully on Pitsfield property.
- 3: Consider conducting a prescribed burn on one-third of the 5-acre prairie each year for three years. This rotation should be started as soon as possible to ensure the long-term viability of the prairie habitat.

Measures of Success

- Rising FQI scores in repeated prairie vegetation surveys and woodland Modified-Whittaker plots
- Reductions in bittersweet and buckthorn populations
- Results of ongoing bird-banding operations

Climate Change: Adaptation and Mitigation

See Chapter 3: Climate Change and Adaptation for details about Michigan's shifting climate and its species impacts. It's difficult to predict how bird migratory patterns and pathways will shift as the climate changes. As the growing season stretches earlier into the spring, migrating birds may encounter a widening gap between their arrival and the availability of vital fruit and insect food sources. The ranges of important plant and tree species may also shift away from migratory pathways. Thus out of synch with their natural food sources, highly specialized migrants will be forced to adapt their timing and routes, or face extinction.[151] Generalist species are expected to fare well and even thrive in the new paradigm.

[150] Common buckthorn. Lansing (MI): Michigan Department of Natural Resources; 2012 Feb [cited 2016 Mar 26]. Available from http://mnfi.anr.msu.edu/invasive-species/CommonBuckthornBCP.pdf

[151] Hovin CL, *et al.* Changing climate, changing wildlife [Internet]. Lansing (MI): Michigan Department of Natural Resources; 2013 April [cited 2016 Mar 25]. Available from https://www.michigan.gov/documents/dnr/3564_Climate_Vulnerability_Division_Report_4.24.13_418644_7.pdf

Chapter 11: Grand Mere Dunes

Grand Mere Dunes Management Plan

Waverland Path, Stevensville, MI 49127
(41.98756N, 85.553092W)

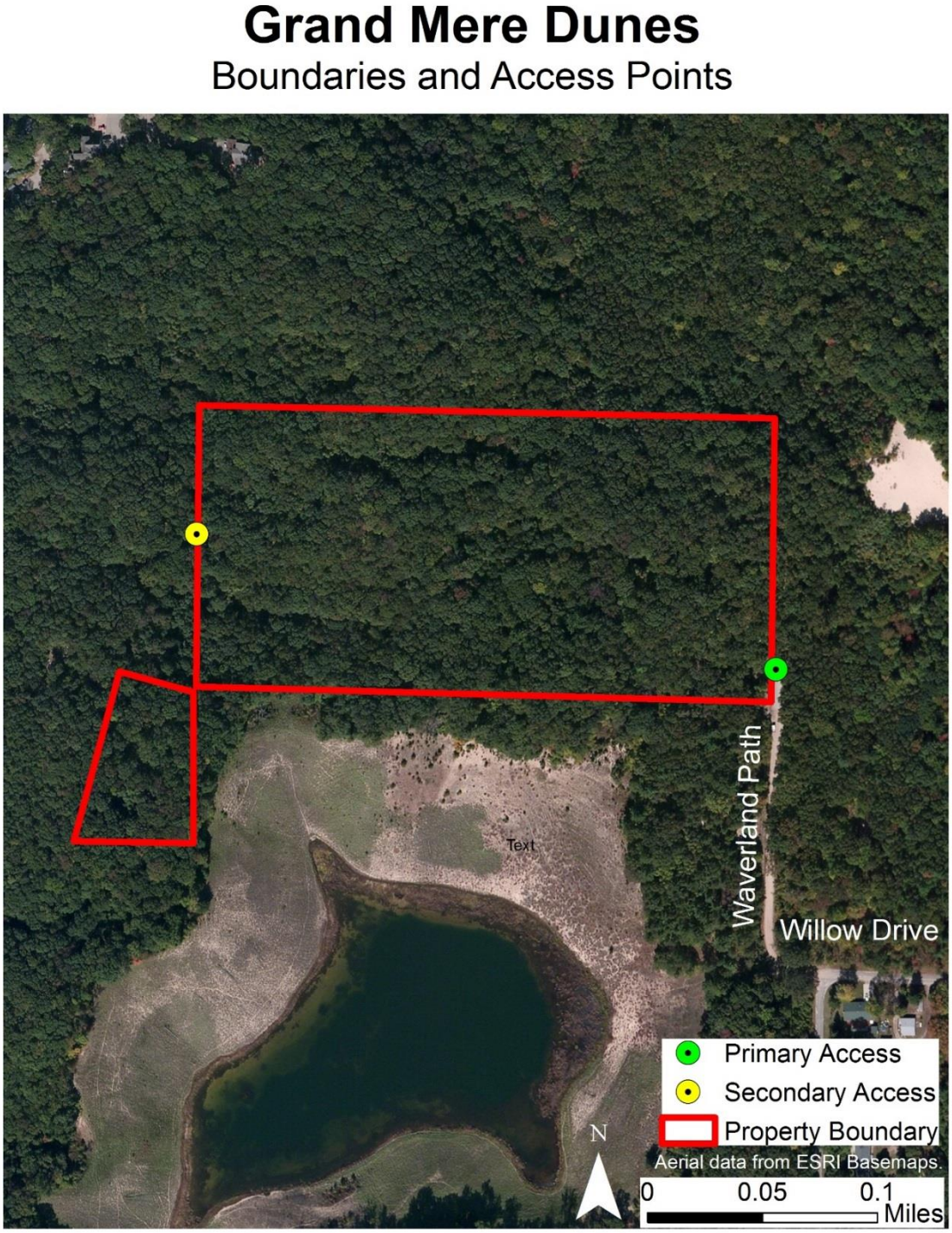

Figure 11.1: Grand Mere Dunes property boundary

Introduction

The Grand Mere Dunes property (see Figure 11.1) is located on the boundary of Grand Mere State Park in Stevensville, Michigan. Being within the Grand Mere State Park puts this property at a distinct ecological advantage (see Figure 11.2). This helps to insulate the property from invasive species and protect it from encroaching urbanization.

History

This region was subject to sand mining in the 1960s. As the mining operations moved further north, KNC founder Lew Batts and other local conservation organizations started pushing to protect the ecologically important habitat by making it a state park. In the late 1960s, Batts bought a 28-acre parcel strategically located to block the mining operation's line of advance. The Nature Conservancy bought another nearby parcel and eventually transferred it to the State. The community momentum formed during this time led to the creation of the Sarett Nature Center near Benton Harbor, MI in 1963.

Property Composition

Landscape Context
Grand Mere Dunes State Park is located directly along the Lake Michigan shoreline. Residential parcels and extractive industries flank it to the north, south, and east.

Property Composition
This property is quite unique in that it is part of a drastically reduced ecosystem (open dunes) that is now uncommon in the state of Michigan. MNFI lists Grand Mere State Park as a specific place for the public to visit to showcase this rare ecosystem type. Open dunes are given a state ranking of S3, indicating that they are vulnerable in Michigan (see Appendix I for more details on the ranking system). Some aerial images of this property show vegetation on the site, so the soil may be stabilizing into a closed canopy forest.

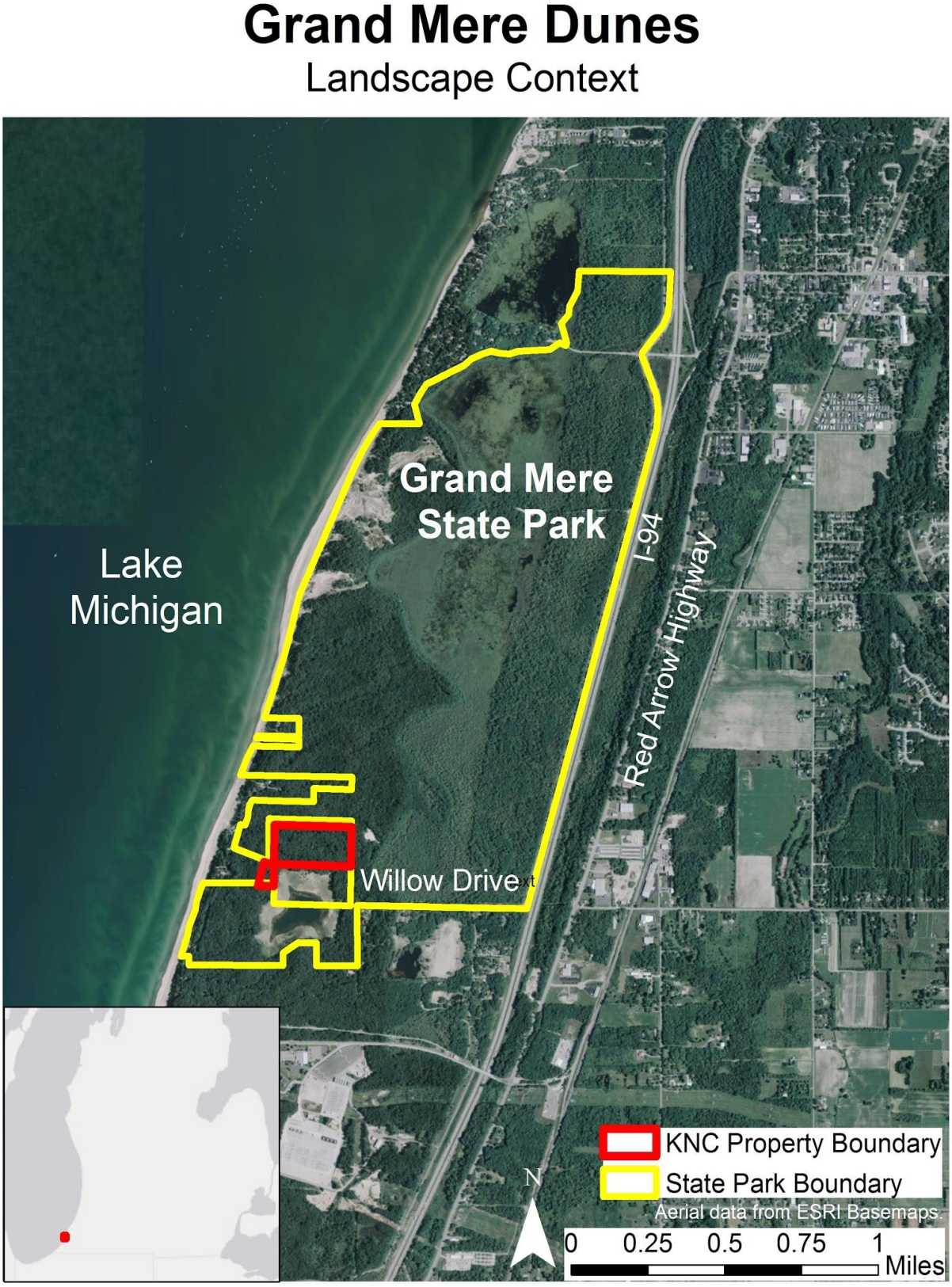

Figure 11.2: Landscape context of Grand Mere Dunes property within state park

Data Collection / Data Results

This property is not currently being utilized by either the staff or the public. For this reason, there is no robust data on this site. No fieldwork was conducted on the property to assist in the development of this plan.

General Recommendations

Recommended management actions are prioritized according to the following numerical scale:

1: Address within the next 3 years
2: Address within the next 5 years
3: Address within the next 10 years
4: Address in the next 10-year comprehensive LMP

Ownership and Use

- 1: Continue striving to sell or donate this parcel to the State of Michigan so it can join the greater Grand Mere State Park. Previous efforts to negotiate with the state have failed.
- 2: Provide special tours through the property to showcase this rare and vulnerable open dunes ecosystem.

Boundary markers

Signs are limited on this property for a number of reasons, but primarily because KNC does not use or visit this property often. Because of the lack of signs, the public is generally not aware of the point when they leave the state park and enter private property.

- 1: Install boundary signs with the KNC logo, website, and a positively-worded message, such as "You are now entering property owned by the Kalamazoo Nature Center." This presents KNC's welcoming public face, while still alerting people to the fact that they're on private property.

Regular Monitoring Visits

- 1: Devise a schedule of regular staff walkabouts on the property, aiming for 1-2 visits per calendar year. These visits should be concentrated during the growing season to observe invasive or rare plant species.
- 1: Monitor trails for signs of erosion.

Data Collection

At this time, there is little to no biological data associated with this site.

- 3: Collect baseline data in either a set of transects or a Modified-Whittaker Plot depending on the level of stratification in the vegetation (see Appendix III for more details). Compare this inventory to the *open dunes* community description in the Michigan Natural Features Inventory to prioritize any species for restoration/planting activities. This will also help determine whether or not this site has transitioned to closed-canopy forest.

- 4: Collaborate with university-level researchers, citizen scientists, and staff and volunteers from the Sarett Nature Center to conduct BioBlitzes and other intensive species inventories every 5-10 years.

Measures of Success
Measuring successful implementation on this property will simply involve whether the above recommendations were acted on or not. The highest priority on this site is to develop baseline data of present species. Depending on how KNC decides to maintain this property, some of these recommendations may no longer be relevant in the near future. The next revision of this site plan may shift the recommendations and the measures may change.

Climate Change: Adaptation and Mitigation

See Chapter 3: Climate Change and Adaptation for details about Michigan's shifting climate and its species impacts. It is currently unclear how exactly climate change will affect open sand dunes. These ecosystems are strongly affected by the winds coming off the lake. As the direction and intensity of the winds change, so will the shape and integrity of the sand dunes adjacent to the lake. Changing patterns of precipitation, temperature, and disturbance (human or otherwise) have the potential to drastically change the type and abundance of vegetation that can exist in these ecosystems as well. The only way to accurately display these changes is to have baseline studies of these ecosystems in addition to continued monitoring to understand if and how the site changes.

Appendix I: Michigan Natural Features Inventory Quick References

Global Ranks

- **G1: Critically imperiled**: at very high risk of extinction due to extreme rarity (often 5 or fewer occurrences), very steep declines, or other factors.
- **G2: Imperiled**: at high risk of extinction due to very restricted range, very few occurrences (often 20 or fewer), steep declines, or other factors.
- **G3**: **Vulnerable**: at moderate risk of extinction due to a restricted range, relatively few occurrences (often 80 or fewer), recent and widespread declines, or other factors.
- **G4: Apparently secure**: uncommon but not rare; some cause for long-term concern due to declines or other factors.
- **G5: Secure**: common; widespread.
- **GU: Currently unrankable** due to lack of information or due to substantially conflicting information about status or trends.
- **GX: Eliminated**: eliminated throughout its range, with no restoration potential due to extinction of dominant or characteristic species.
- **G?: Incomplete data**.

State Ranks

- **S1: Critically imperiled** in the state because of extreme rarity (often 5 or fewer occurrences) or because of some factor(s) such as very steep declines making it especially vulnerable to extirpation from the state.
- **S1: Imperiled i**n the state because of rarity due to very restricted range, very few occurrences (often 20 or fewer), steep declines, or other factors making it very vulnerable to extirpation from the state.
- **S3: Vulnerable** in the state due to a restricted range, relatively few occurrences (often 80 or fewer), recent and widespread declines, or other factors making it vulnerable to extirpation.
- **S4: Uncommon** but not rare; some cause for long-term concern due to declines or other factors.
- **S5: Common** and widespread in the state.
- **SX: Extirpated** from the state. Not located despite intensive searches of historical sites and other appropriate habitat, and virtually no likelihood that it will be rediscovered.
- **S?: Incomplete data.**

MNFI Resources

- MNFI website: https://mnfi.anr.msu.edu/
- Invasive species factsheets: https://mnfi.anr.msu.edu/invasive-species/factsheets.cfm
- Natural community profiles: https://mnfi.anr.msu.edu/mnfi/communities/index.cfm

Appendix II: Invasive Species Handbook

Introduction

This Appendix has been updated from its original form in the previous LMP for clarity, readability, and current prioritization of invasive species. Much of the language is the same as the last edition of this document, but it has been edited for length and directness.

Attempting to deal with invasive species is a dynamic process, requiring a balanced understanding of a number of multifaceted issues. Most importantly, one must know what makes a plant, animal or other species invasive[152]. Then, there is comprehension of the ecological significance of plant and animal invasions, and why *and if* they are a problem. If limited resources are to be expended on an invasive species, it is essential to determine if that species is actually problematic where and when it occurs. Also required are knowledge of the flora prior to European settlement (i.e., before widespread plant invasions occurred) and an understanding of plant community dynamics which drive change in ecosystems. Finally, a prioritization of invasive species must occur, taking into account all relevant parameters, including economic considerations and biological costs and benefits. There are a variety of management techniques, and each species is only controllable by some of these, if at all. Advances are constantly being made and published; this knowledge should be actively sought out. Invasive animal species (deer, wild turkey, Chinese snail) are discussed elsewhere.

Although it is difficult to predict whether or not a particular plant species has invasive potential[153], invasive alien plants do share some common characteristics. These may include any combination of these traits:

- rapid growth and maturity
- prolific seed production
- highly successful seed dispersal
- germination and colonization
- rampant vegetative spread
- ability to out-compete native species and cause extirpations or extinctions
- ability to alter the fire regime, nutrient cycling, hydrology and energy budgets in native ecosystems
- high cost to remove or control[154]

The list above was curated by Tyler Bassett, drawing mainly from Virginia's Department of Conservation and Recreation website.

[152] Mack et al. Biotic Invasion: Causes, Epidemiology, Global Consequences & Control. Ecological Society of America. 2000; 5:1-22.
[153] Ibid.
[154] Ibid.

Invasive species work in at least three ways:

1) Overgrowing and taking over an entire community (e.g., *Melaleuca* in the everglades, or its northern counterpart, glossy buckthorn),

2) Removing a dominant plant species (often a fungal or insect pest, such as those that affect chestnut, American elm, ash species and many more), and

3) Affecting native species or groups of them, as through allelopathy or by simply consuming them.[155]

Invasive species issues also apply to the native species that become invasive by a significant change in a natural process (e.g., hydrology, fire regime), including native species that expand their populations to form a monoculture at the expense of other species (e.g., cattails [*Typha* spp.]). Some native species also may become established in relatively stable natural communities in such numbers or distribution that their presence disrupts the local ecological balance (e.g., dogwoods [*Cornus* spp.] or sumac [*Rhus* spp.] in a fen) by altering water levels or reducing populations of key species in that environment. Once again, this is commonly in response to a drastic change in community stability.

Climate change will impact the natural communities in ways not always easily predicted. Each plant community is at one point in its succession, and each site has a different land use history.[156] The nature of the climatological changes influences future succession, which is especially uncertain in the face of global climate change[157]. At times the management of invasives can forestall the community successional processes that would eventually take place in the absence of human intervention. However, neglecting the effects of invasive species can have even more damaging consequences for a community. Additional conflicts may occur when invasive species provide strong benefit to members of the community while at the same time negatively impacting other elements of that community. As mentioned above, these are complex decisions, generally involving no clear answers.

Management

In most cases the likelihood of eradication of a troublesome species is low when compared with the more realistic outcome of simply achieving control of that species, unless the population is discovered early enough. Control was accomplished at KNC with the wetland invasive purple loosestrife (*Lythrum salicaria*).

The effects of soil erosion, soil and water contamination, thermal pollution and other stormwater-related issues, and a host of other anthropogenic effects are what create the environment for invasion in the first place. Disturbed ground is usually a zone of colonization of

[155] Simberloff D. Eradication of island invasives: practical actions and results achieved. Trends Ecol. Evol. 2001; 16: 273-274.
[156] Kettle WD et al. Land-use history in ecosystem restoration: a 40-year study in the prairie-forest ecotone. Restoration Ecology. 2000; 8(3):307-317.
[157] Lavendel B. Ecological Restoration in the Face of Global Climate Change: Obstacles and Initiatives. *Ecological Restoration* 2003; 21(3):199-203.

invasive species. Forming creative solutions to these problems will be among the most important means of prevention available.

Ecosystem management

No matter what species is considered for control and/or eradication, two points need to be taken into account. First, the appropriate treatment depends on the particular situation. Surrounding vegetation, quality or degradation of the surrounding ecosystem and proximity to water and human habitation all weigh into a management decision. For example, whether a particular native species is being affected by a pathogen or habitat loss due to an invasive plant, our response would lie somewhere on a continuum from focusing on simply saving that species, to saving the natural processes that support that species.[158] Second, it is more useful to manage an invasive species using a *system* approach rather than simply a *species* approach, or to heal the ecosystem instead of simply battling a few invaders.[159] [160]

> "Aggressive plants are typically not a problem in a healthy, well-managed system. Many exotic plants can be controlled…by restoring natural processes such as fire and the natural hydrologic regime. *Attempts to control problem species without restoring such natural processes may offer merely short-term relief* "[161] (Italics added.)

> "Invasives may be a symptom of another ecological problem (e.g., overgrazing of grasslands, eutrophication of waterways due to deforestation), such that management of particular invasives may not provide a lasting solution, and/or may simply lead to their replacement by other invasive species" (GISP 2005).

Simberloff (2001) illustrates this point by describing success in using prescribed fire to effectively manage invasive plants in longleaf pine forests in the southeastern United States.[162] This technique is used in a variety of habitats in southwest Michigan, as well.

Choosing a target community becomes an issue when taking the ecosystem approach in the management of an invasive species and its surroundings. There are a number of approaches to take, depending on the nature of the site.[163] One approach is to consult the presettlement vegetation map for your region, and attempt to reproduce the same community that existed on the site in presettlement times. Frequently, site conditions will no longer support the same community, or the site has been degraded to such a point where its restoration is not feasible. In this case, the natural community most closely represented by the site may be more desirable, or perhaps two or more communities, as the site dictates. This is perhaps the best way of remaining consistent with the succession of the communities on site.

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[158] Simberloff D. Eradication of island invasives: practical actions and results achieved. Trends Ecol. Evol. 2001; 16: 273-274.
[159] Mack et al. Biotic Invasion: Causes, Epidemiology, Global Consequences & Control. Ecological Society of America. 2000; 5:1-22.
[160] Solecki MK. Controlling invasive plants. In Packard S, Mutel CF, editors. The tallgrass restoration handbook. Washington (DC): Island Press; 1997. p. 63-88.
[161] Ibid.
[162] Simberloff D. Eradication of island invasives: practical actions and results achieved. Trends Ecol. Evol. 2001; 16: 273-274.
[163] Packard S, Mutel CF, editors. The tallgrass restoration handbook. Washington (DC): Island Press; 1997. p. 63-88.

The Michigan Natural Features Inventory provides useful outlines of the natural communities in Michigan to assist with this decision. Any valuable or rare plant or animal species or natural processes present may point to a particular target community. Sometimes it is necessary to provide as large of a habitat as possible for a rare species, even if that means clearing more regionally common presettlement habitat. Or, if one community type, say prairie, is well represented nearby, consider encouraging another type, such as forest or savanna. The feasibility of reinstituting natural disturbances or processes can come into play, as well. For example, a prairie restoration may not make sense on a large-scale unless prescribed burns are practical. If there is little ecological integrity at a sight, consider reconstructing the rarest or highest priority community that is practical on the site. Many resources are available to assist in these decisions. The Tallgrass Restoration Handbook is extremely useful, especially chapters 4 and 5.[164]

Prioritization of Species

Below is a proposed order of prioritization for control of invasive plant species at The Kalamazoo Nature Center. This prioritization is based on the last edition of the LMP and updated to reflect current populations of invasive species. These priority rankings are generalized for all properties owned and managed by KNC. Individual sites may find that certain species would be prioritized higher than what is generalized here. Always refer to the specific site plan for the property you are working on for the most up-to-date and highest priorities for that particular site.

Priority 1. Species currently established that pose an immediate threat or have already altered their host ecosystem considerably. These species may continue to spread; there is suitable habitat vulnerable to their invasion. There are also sufficient resources available to manage these species.
Recommended action. Control/eradication accompanied with figuring of costs for each long-term management option.

Priority 2. Species currently established, but perhaps not at a critical phase. Resources are fewer because of allocation to species of higher priority. These species may invade as management of other invasives disturbs habitat and opens up niche-space.
Recommended action. Monitor closely and figure general expense of management. Manage if impacts in highest quality areas are likely in next 10 years.

Priority 3. Species known to be invasive in the area, but not observed at the Kalamazoo Nature Center.
Recommended action. A "watch list" is provided, by habitat.

Priority 4. Species known to be invasive and that may be harmful, but have not established themselves significantly. This may be due to lack of invasible habitat, or other reasons. Also included here are those species which pose no current threat, but may hinder future restoration efforts.
Recommended action. Monitor populations.

[164] Packard S, Mutel CF, editors. The tallgrass restoration handbook. Washington (DC): Island Press; 1997. p. 63-88.

Priority 5. Some species may be under control, or innocuous.
Recommended action. None.

Priorities are set by the frequency or spread of a species, or by the quality of the communities they inhabit, and should be reexamined every three to five years. Some species may be given a number of different priorities based upon the specific communities in which they occur. However, in attempting to deal with one species, if an ecosystem approach is taken and the result is an entire community returning to greater stability, other potentially harmful species may be controlled successfully before becoming a problem. Finally, it may be reasonable to manage actively a species of lower priority while dealing with a high priority species. For example, in a wetland being overrun with shrubs, it may require little extra effort to control dogwood species (where necessary) if glossy buckthorn is the primary target species.

Control methods

There are a few methods of control/eradication that are commonly used to deal with invasive species, sometimes used in concert with each other. These are burning, manual (cutting, pulling, girdling), mowing, biological control, restored hydrology and application of herbicides.[165] All these methods have associated cautions. For example, *biological controls* are screened meticulously for host-specificity. It must be certain that the selected insect(s) will attack only the invasive plants under scrutiny, and not decimate the landscape like the Japanese beetle, which was introduced in the western United States to control St. John's-wort (*Hypericum perforatum*). The USDA requires an extensive screening process before approving release of any biological control agents (B. Blossey, Tyler Bassett comm.). Many *manual* methods can significantly disturb an ecosystem that is under restoration, encouraging further invasions. Prescribed burns can have the same effects, if done improperly. A primarily goal in land management should be reducing unnecessary disturbance. Following these treatments, appropriate native plants often are put in place of those removed, or simply interseeded among other plants; preference should be given to seeds of a local genotype. For some of the invasive species considered below, specific native plants are recommended as replacements that occupy a similar niche (e.g., food source, soil stabilization, and cover for wildlife). Frequently, a recommendation is only possible based upon the plant community where the invasive plant is found.

In any case where *herbicides* are mentioned as a control method, they are recommended for use when all other viable options have been exhausted or deemed ineffective or impractical. Opinions vary on their use. Advocates point to chemophobia from a time of rampant overapplication of poisons such as DDT and their unintended effects[166], while opponents warn of the influence of corporate objectives on environmental management decisions. KNC should be an example of environmental practices[167]. If used, especially if used inappropriately, any herbicide has the chance of detrimentally affecting wanted vegetation and water systems at KNC and throughout the watershed. This is especially true when managing large stands of some

[165] Solecki MK. Controlling invasive plants. In Packard S, Mutel CF, editors. The tallgrass restoration handbook. Washington (DC): Island Press; 1997. p. 63-88.
[166] Simberloff D. Eradication of island invasives: practical actions and results achieved. Trends Ecol. Evol. 2001; 16: 273-274.
[167] Theodoropoulos DI. Invasion biology: critique of a pseudoscience. Blythe (CA): Avvar Books; 2003.

species, such as reed canary grass.[168] However, the effects of the human community include proliferation of certain invasive species due to horticultural introduction, landscape and hydrological alteration, modified nutrient cycles and other changes.

NOTE: all photographs and links come from the University of Michigan Herbarium website at Michiganflora.net.

[168] Lyons KE. Element stewardship abstract for *Phalaris arundinacea* L. Reed canarygrass. [Internet]. Arlington (VA): The Nature Conservancy; 1998 [cited 2016 April 1]. Available from http://www.invasive.org/weedcd/pdfs/tncweeds/phalaru.pdf

PRIORITY 1:

Garlic Mustard *(Alliaria petiolata)*

Life history

Garlic mustard is a disturbance-adapted biennial herb found across the United States. It spreads primarily by prolific seed production. Its competitiveness can be explained in part by its physiology. It has been found that garlic mustard roots exude phytotoxins (i.e., harmful to other plants), the leaves have higher chlorophyll content in shade leading to more vigorous shoot production, its photosynthetic peak is in early April (i.e., when many native ground layer species are not active), and there is a significant correlation between garlic mustard density and

decreases in the arbuscular mycorrhizal (AM) fungi potential of the soil, which many native herbs may depend upon.[169] [170] [171] [172]

Garlic mustard can reduce both perennial and ephemeral cover by 30-50 percent while increasing the cover of disturbance-adapted annual species by 6-10 percent. These effects would be particularly damaging in the beech-maple forests that dominate KNC's uplands, where a considerable amount of the plant diversity is represented by spring ephemeral species. Garlic mustard has been implicated in the death of native butterfly larvae when eggs are laid on this plant in lieu of a native host.[173] Also, garlic mustard (and, presumably, other invasives) poses particularly high risks because communities with high species richness are not necessarily resistant to its invasion.[174]

Due to its biennial nature, the mat of vegetation its population forms can grow and shrink in deceptive magnitude, but severity of control methods should not depend upon this fluctuation.

Management methods

Plants should be stuffed in black plastic bags after hand-pulling and left to rot in the sun, then buried or placed in a central location; this location should be monitored closely for the next five years and watched thereafter for germinating seeds. It only takes one plant to start a population.

Fire as a control for garlic mustard can encourage its spread unless the fire is slow and hot enough to burn through accumulated leaf litter. Leaf litter will protect the secondary buds of the plants; then again, the seeds will remain viable, and may respond positively to this disturbance.

Applying herbicide (1-2 percent solution of glyphosate) in the dormant season (generally late October to late March in southern Michigan) may be the most effective control, as it reduces disturbance to surrounding plants and habitat. It requires less time spent trampling over the ground, and is done when most plants are not active; garlic mustard is still green and quite visible year-round. Use of a non-toxic dye is useful to mark locations of plants already hit with herbicide. (You must apply herbicide directly to a plant to kill it; if you miss one, the population may continue to expand!) Herbicide application should be done during a period when rain is not anticipated for several hours.

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[169] Vaughn SF, Berhow MA. Allelochemicals isolated from tissues of the invasive weed garlic mustard (Alliaria petiolata). *Journal of chemical ecology*. 1999; 25(11), 2495-2504.

[170] Meekins JF, McCarthy BC. Responses of the biennial forest herb Alliaria petiolata to variation in population density, nutrient addition and light availability. *Journal of Ecology*. 2000; 88(3), 447-463.

[171] Myers CV, Anderson, RC. Seasonal variation in photosynthetic rates influences success of an invasive plant, garlic mustard (Alliaria petiolata). *The American midland naturalist*. 2003; 150(2), 231-245.

[172] Roberts KJ, Anderson RC. Effect of garlic mustard [Alliaria petiolata (Beib. Cavara & Grande)] extracts on plants and arbuscular mycorrhizal (AM) fungi. *The American Midland Naturalist*. 2001; 146(1), 146-152.

[173] Porter A. Implications of introduced garlic mustard (*Alliaria petiolata)* in the habitat of *Pieris virginiensis* (Pieridae). *J. Lepid. Soc.* 1994; 48:171-172.

[174] Nuzzo VA. Element Stewardship Abstract for Alliaria petiolata (Alliaria officinalis) Garlic mustard [Internet]. Arlington (VA): The Nature Conservancy; 2000 [cited 2016 April 1]. Available from http://www.invasive.org/weedcd/pdfs/tncweeds/allipet.pdf

Persistence is the key with this pest; prevention of seed production should be continued until the seed bank is depleted (5 years or more). The species advances as satellite populations up to one kilometer away.

Focus first on identifying and eliminating satellite populations, then moving towards the center of larger infestations from the outside. Monitoring along trails, roads, and the railroad will prevent this plant from spreading from these common points of entry.

Caveats/Considerations

When pulling the plant, any portion of root can resprout from secondary buds. This is of less concern while the plant is flowering and its resources are in the aerial portions of the plant (stem, etc.), but a flower can mature to seed even if separated from the plant.

Any pulling can lead to much disturbance, so pulling should be followed up by tamping the soil to decrease the potential for reestablishment. Similarly, disturbance resulting from removal of Amur honeysuckle (*Lonicera maackii*) has resulted in an increase in garlic mustard abundance.[175] Due to this disturbance, removal of large populations of garlic mustard and other woody invasives may require replanting with native species to ensure recovery of the community. This will depend upon the community under management, but should include both groundlayer species and shrubs (if appropriate for the site) to insure community structure.

What to replace with

Reseed/replant with common native understory species.

Locations

Garlic mustard at KNC was mapped extensively with a GPS unit in the early 2000s, both as point locations and, where appropriate, area of coverage was also mapped. Many large infestations were mapped, as well as isolated "satellite" populations. Although not every occurrence was mapped, Figure A2.1 illustrates where concentrations of the plant occur and how populations spread from roadways, railroads, and other corridors in the Main Site. This map does not represent the full extent of garlic mustard on the property.

Since garlic mustard is unlikely to be completely eradicated from KNC's grounds, the approach should be to keep this plant out of higher quality communities, such as Cooper's Glen (C1), the north floodplain (F1), and Pioneer Woods (C4). It has been documented in a total of 30 (out of 59) compartments on the Main Site, and occurs on other properties as well. In particular, the recent tree removal along the utility right-of-way parallel to Westnedge Avenue has disturbed soil and opened up the canopy along this edge. As garlic mustard is already established in many linear sections of this right-of-way this area should be patrolled for garlic mustard every spring.

[175] Swab RM. Effectiveness of Lonicera Maackii Removal from a Bottomland Hardwood Forest in Central Ohio (dissertation). The Ohio State University; 2005.

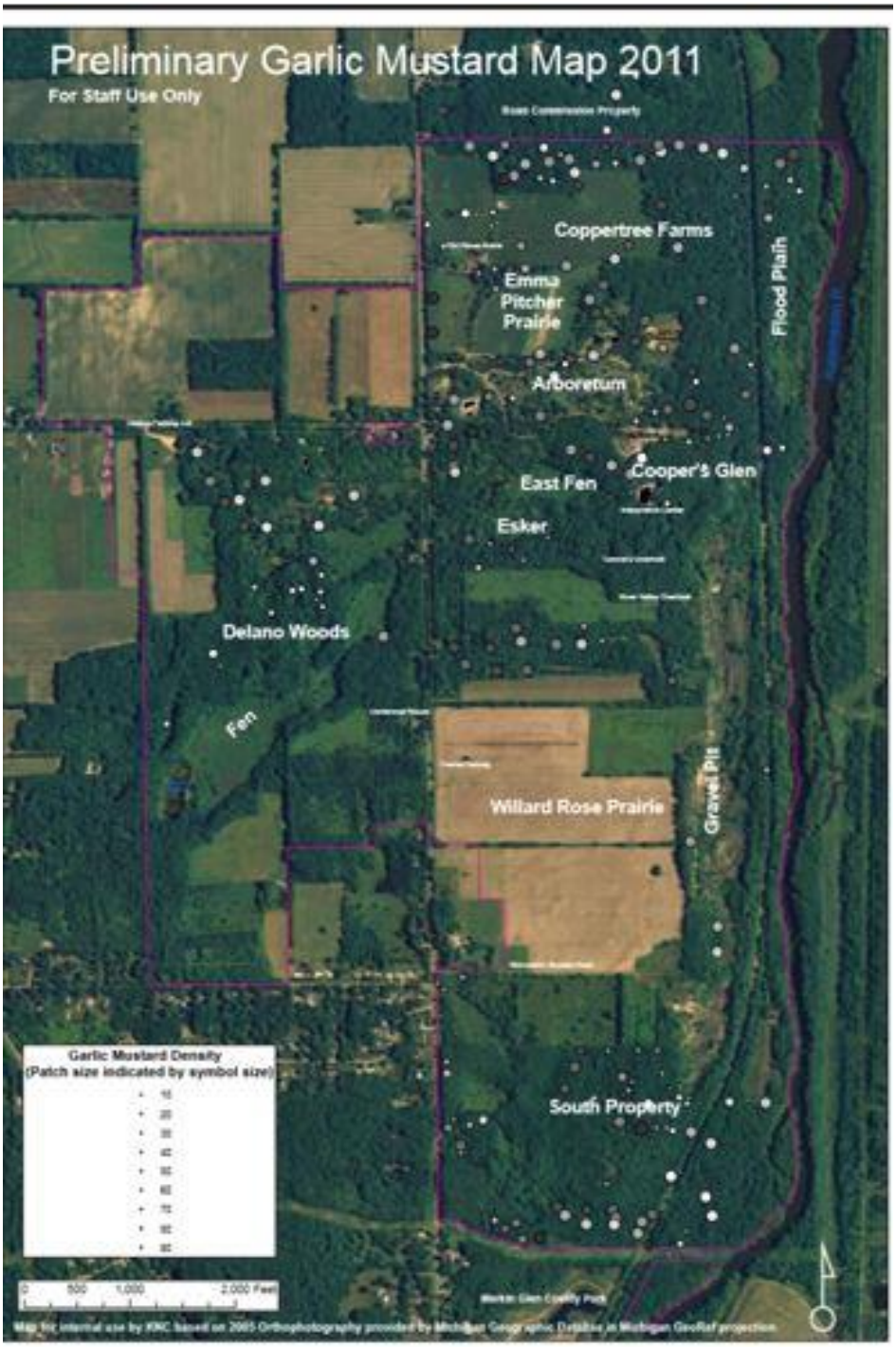

Figure A2.1: Preliminary Garlic Mustard map, 2011

Multiflora rose *(Rosa multiflora)*

Life history

The U.S. Soil Conservation Service recommended and planted multiflora rose to control erosion, for natural windbreaks and food and cover for wildlife as recently as the 1960s. The plant spreads mostly by seed, which falls near the plant and is dispersed by birds.[176]

As with glossy and common buckthorn (see below), birds rely on multiflora rose as a food source in the fall and winter when a native food source is not available. Additionally, many songbird species nest in large multiflora rose bushes.

Management methods

It can be mowed or pulled 3-6 times a year for 2-4 years; filling mower tires with foam avoids deflation from the many thorns of this shrub. Natural reseeding frustrates a land manager if the plant simply is cut or pulled; difficulties are apparent with mowing or bulldozing dense populations in hilly and forested environments. It can be cut and herbicided in the dormant season to avoid harming active surrounding vegetation.

[176] Hoffman R, Kearns K, editors. Wisconsin manual of control recommendations for ecologically invasive plants. [Internet]. Madison (WI): Wisconsin Dept. Natural Resources, Bureau of Endangered Resources; 1997 [cited 2016 Apr 15]. Available from http://www.invasive.org/species/list.cfm?id=139

What to replace with

It should be replaced with native roses and small shrubs. Roses native in Michigan include prairie rose (*Rosa setigera*) in woods and thickets, swamp rose in wetlands and lake margins, pasture rose (*R. carolina*) in dry woods and otherwise sandy or dry places, prairie rose (*R. arkansana*) in fields, river banks and lake shores and wild rose (*R. blanda*) in sandy and dry places, river banks and thickets.[177]

Locations

It is now a widespread problem mostly in oldfields and prairies and is a problem in young forests which have succeeded from oldfields and other disturbed openlands.

Multiflora rose occurs in almost every habitat on the Main Site, open and shaded, wet and dry (a total of 34 compartments). As well as removing this invasive from higher-quality habitats, multiflora rose should be removed from open environments (i.e., oldfields) that are succeeding to forest as it will remain dominant in a forested environment as well, possibly reducing plant diversity.

The Bush Honeysuckles (*Lonicera* spp.)

Lonicera tatarica


Lonicera maackii

Life history

These shrubby pests are escapees from cultivation to disturbed native forests, urban forests and forest edges of the northeastern United States. They are Tatarian, Morrow's, Belle's, and Amur honeysuckle (*Lonicera tatarica, L. morrowii, L. x bella* and *L. maackii,* respectively).

[177] Voss EG. Michigan Flora Part 2 Dicots. Ann Arbor (MI): Cranbrook Institute Science Bulletin 59 and The University of Michigan Herbarium; 1985.

Documented effects include reduction of tree seedling density and species richness, of herb cover and richness, of tree regeneration and of herb seedling establishment.[178] [179]

A native honeysuckle, red honeysuckle (*Lonicera dioica*), was observed along the esker in Pioneer Woods (C4). This woody vine has similar leaves that are perfoliate and more glaucous than the non-native honeysuckles.[180] It is only likely to be confused with other honeysuckles when young; when older its viney habit and larger red flowers will differentiate this species.

Management methods

Control is possible by cutting during the growing season when the plant's resources are allocated to aggressive growth (winter cutting encourages resprouts). However, most sources advocate some use of herbicides, usually after cutting woody stems close to the ground.[181]

Caveats/Considerations

Pulling or digging stumps is practical when shrubs are young, but causes significant soil disturbance which may encourage invasion by garlic mustard and other plants.[182]

What to replace with

Any eradication of honeysuckle must coincide with replacement by native shrubs to fill the vacated niches. They do provide fall and winter food for birds and mice (despite bitter taste and low fat content) after high-quality native food sources are depleted. Some examples of native shrub species are spicebush (*Lindera benzoin*), American high-bush cranberry (*Viburnum opulus* var. *americanum*), arrowwood (*Viburnum dentatum*), gooseberry (*Ribes* spp.), blueberry (*Vaccinium* spp., in part), native rose (*Rosa* spp., discussed above) and serviceberry (*Amelanchier* spp.). These taxa all occur at KNC, so it would be possible to propagate additional populations from seeds collected on site.

[178] Swab RM. Effectiveness of Lonicera Maackii Removal from a Bottomland Hardwood Forest in Central Ohio (dissertation). The Ohio State University; 2005.
[179] Batcher MS, Stiles SA. Element stewardship abstract for Lonicera maackii (Rupr.) Maxim (Amur honeysuckle), Lonicera morrowii A.Gray (Morrow's honeysuckle), Lonicera tatarica L. (Tatarian honeysuckle), Lonicera× bella Zabel (Bell's honeysuckle) [Internet]. Arlington (VA): The Nature Conservancy; 2000 [cited 2016 April 1]. Available from http://www.invasive.org/weedcd/pdfs/tncweeds/loni_sp.pdf
[180] Voss EG. Michigan Flora Part 3 Dicots cont'd. Ann Arbor (MI): Cranbrook Institute Science Bulletin 61 and the University of Michigan Herbarium; 1996.
[181] Batcher MS, Stiles SA. Element stewardship abstract for Lonicera maackii (Rupr.) Maxim (Amur honeysuckle), Lonicera morrowii A.Gray (Morrow's honeysuckle), Lonicera tatarica L. (Tatarian honeysuckle), Lonicera× bella Zabel (Bell's honeysuckle) [Internet]. Arlington (VA): The Nature Conservancy; 2000 [cited 2016 April 1]. Available from http://www.invasive.org/weedcd/pdfs/tncweeds/loni_sp.pdf
[182] Swab RM. Effectiveness of Lonicera Maackii Removal from a Bottomland Hardwood Forest in Central Ohio (dissertation). The Ohio State University; 2005.

Locations

Morrow's and mostly Tartarian honeysuckle are common on the Main Site; Belle's honeysuckle, a frequent hybrid between the two former species, is likely more common than indicated by the two compartments for which it was documented. These species are well-established in all the forested portions of the Main Site except the north floodplain (F1). Control should be focused on the highest priority areas, i.e., Cooper's Glen (C1), Pioneer Woods (C4) and others. In some of the successional uplands (U2, U7, among others) honeysuckle could be removed to assist in the succession to a more native species-rich forest.

Reed Canary Grass (*Phalaris arundinacea*)

Life history

Reed canary grass is often considered circumpolar (found around the world), and its native status is certainly questionable in North America.[183] This is a cool-season, sod-forming grass that spreads also by seed, conferring definite advantages in northern climates. Rhizome growth is most active in early spring and late fall.[184] It occurs both in wetland environments and the surrounding open slopes. It has been shown that reed canary grass is not able to thrive in low-

[183] Lyons KE. Element stewardship abstract for *Phalaris arundinacea* L. Reed canarygrass. [Internet]. Arlington (VA): The Nature Conservancy; 1998 [cited 2016 April 1]. Available from http://www.invasive.org/gist/moredocs/phaaru01.pdf

[184] Pizzo J, Schroeder N. Using a plant's lifecycle against itself: A timeline for controlling reed canarygrass and common reed (Illinois). Ecological Restoration. 2001; 19:184-185.

light conditions, such as in a closed-canopy forest.[185] Its sod-forming character (it excludes all other plants) leads to the danger of erosion of exposed soil and re-invasion if a large population is removed without replacing with a rich mix of native species. It is believed that sediment-rich runoff facilitates invasion of wetlands by reed canary grass (and other invaders) by altering community characteristics and increasing nutrient availability.[186]

Management methods

A number of control options have been explored, and none have been absolutely successful.[187] Burning in late spring or fall for 5 or 6 years, or simply mechanical or manual removal are preferable. Burning may be difficult during late spring or late fall due to potentially wet conditions. Mechanical/manual techniques include hand chopping, digging and pulling and, when it exists as a monoculture, disking or plowing may be effective. A variety of herbicides have been effective on large monotypic stands, although they have been more effective on upland populations. If such a stand is small enough, covering with black plastic for a season or more sometimes has been effective.

Most effective control will probably result from a mix of many methods, including mowing in the spring (to prevent seed set) and fall (to provide lots new growth) followed by herbiciding with up to 30 percent glyphosate, and interseeding with a diverse mix of native species, including some aggressive ones (e.g., cordgrass [*Spartina pectinata*]).[188] Once natives are established, a burn regime can be initiated, preferably sometime between November and March when reed canary grass is active and most natives are not.[189]

Caveats/Considerations

Maurer et al. give the following suggestions for reed canary grass management:[190]

- Maintain or encourage rapid development of vegetation with a dense canopy.
- Plant native species that can compete with reed canary grass, such as widespread non-invasive graminoids and forbs.
- Integrate microtopography into restoration sites to facilitate the development of species-rich vegetation.
- Quickly remove new invader populations to prevent their spread.
- Monitor and control sedimentation and nutrient loading.

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[185] Maurer DA et al. The Replacement of Wetland Vegetation by Reed Canarygrass (Phalaris arundinacea). Ecological Restoration. 2002; 21(2):116-119.
[186] Ibid.
[187] Hoffman R, Kearns K, editors. Wisconsin manual of control recommendations for ecologically invasive plants. [Internet]. Madison (WI): Wisconsin Dept. Natural Resources, Bureau of Endangered Resources; 1997 [cited 2016 Apr 15]. Available from http://www.invasive.org/species/list.cfm?id=139
[188] Pizzo J, Schroeder N. Using a plant's lifecycle against itself: A timeline for controlling reed canarygrass and common reed (Illinois). Ecological Restoration. 2001; 19:184-185.
[189] Ibid.
[190] Maurer DA et al. The Replacement of Wetland Vegetation by Reed Canarygrass (Phalaris arundinacea). Ecological Restoration. 2002; 21(2):116-119.

What to replace with

Reseeding with natives certainly should be done in concert with any method.

Locations

The most persistent stand of this species at KNC is found in the wetland (E4) where South Stream originates. Aside from two zones of strong groundwater seepage, the vegetation is almost purely reed canary grass. Adjacent uplands and some downstream areas also support smaller populations of this species. A few persistent stands also occur in light gaps along the Kalamazoo River (F1). These populations will probably be significantly reduced if these light gaps close.

Common buckthorn (*Rhamnus cathartica*)

Life history

Common buckthorn, a Eurasian species, is a more robust plant than glossy buckthorn (see below) and occurs in more shady environments. The fruits of this plant, and to a lesser extent the leaves, have been shown to exhibit allelopathic effects on other plants, aiding its invisibility.[191] The seeds are also distributed easily as the fruits have a diuretic effect and are quickly eliminated by birds that eat them. It is questionable how nutritious the fruits are to birds, especially considering how quickly they are eliminated.

The native alder-leaved buckthorn (*R. alnifolia*) is distinguished from common buckthorn by its more acute and alternate leaves.[192] Alder-leaved buckthorn is smaller, at about 3 feet in height, on average.[193] Also, the only coexistent habitat is low, deciduous woods, where the native species rarely occurs.

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[191] Seltzner S, Eddy TL. Allelopathy in Rhamnus Cathartica, European Buckthorn [Internet]. Ann Arbor (MI): The Michigan Botanist; 2003 [cited 2016 April 1]. Available from http://hdl.handle.net/2027/spo.0497763.0042.201

[192] Voss EG. Michigan Flora Part 2 Dicots. Ann Arbor (MI): Cranbrook Institute Science Bulletin 59 and The University of Michigan Herbarium; 1985.

[193] Hoffman R, Kearns K, editors. Wisconsin manual of control recommendations for ecologically invasive plants. [Internet]. Madison (WI): Wisconsin Dept. Natural Resources, Bureau of Endangered Resources; 1997 [cited 2016 Apr 15]. Available from http://www.invasive.org/species/list.cfm?id=139

The Michigan state champion common buckthorn is found at the Kalamazoo River (F1) along one of KNC's bird banding net lanes.[194] Champions are chosen based on a combination of girth, height, and crown spread.

Management methods

Repeated cutting (necessary to deter resprouts) and pulling of common buckthorn cause excessive soil disturbance, so are not desirable. Burning may be effective, as well as combining chosen control methods with underplanting native woody species (see the Bush Honeysuckles). The most effective control, as with other shrubs that resprout, is cut-stump applications of glyphosate or triclopyr.

Caveats/Considerations

Converse lists the following reasons for the invasiveness of glossy (*R. frangula*) and common buckthorn:[195]

- They became widespread in North America when various disturbances (drainage, lack of fire, woodland grazing, cutting, etc.) created ideal habitat for seedling recruitment and maintenance of sexually mature adults.
- Naturalized habitats are similar to indigenous habitats.
- Seed production, dispersal and germination are effective.
- Adult plants form dense colonies, have large shading leaves and are persistent.
- Plants vigorously resprout after top removal

What to replace with

Replant with native shrubs/understory species.

Locations

Invasion is greatest in selectively cut or grazed woods, along woodland edges and in openings created by windfalls or dead trees. Open oak woods and lowland woods are more frequently invaded.[196]

Common buckthorn poses a potential threat to all forested compartments on the property, and occurs in many oldfield and upland shrub areas as well. As with other invasives, efforts should be focused on higher priority areas.

[194] Ehrle EB. The Champion Trees and Shrubs of Michigan. The Michigan Botanist. 2003; 42(1):3-46.

[195] Converse CK. Element Stewardship Abstract for Rhamnus cathartica and Rhamnus frangula [Internet]. Arlington (VA): The Nature Conservancy; 1984 [cited 2016 April 1]. Available from http://www.invasive.org/gist/esadocs/documnts/franaln.pdf

[196] Ibid.

Purple Loosestrife (*Lythrum salicaria*)

Life history

This plant can form a monoculture quickly; coordinated attempts to control it should be aggressively maintained. One plant can grow two meters in height over a season, producing 30-50 stems. Annual seed production can be up to 300,000 per stalk and over 2 million seeds for a

single plant.[197] The seeds are dispersed by flowing water and will germinate on any wet, exposed soil. The attractive magenta flowers of this plant inspired its translocation from its native Europe in the 1800s for use as a garden perennial. By the middle of the 19th century it was naturalized along the Eastern seaboard. Through water and roadways, it now has infested all continental United States and Canadian provinces except Florida and is illegal to possess or sell in 24 states.[198] Section 286.216a of Act 189 of 1931, The Insect Pest and Plant Disease Act, was put into effect on March 28, 1996, and states that all but sterile cultivars of non-native *Lythrum* species are illegal in the state of Michigan (see www.michiganlegislature.org for more information).

Dense stands of purple loosestrife can alter the function of wetlands, suppress native plant and animal populations, and choke up the flow of streams.[199] Recent research has observed negative effects of purple loosestrife on frog and toad populations as compared to native flora.

Management methods

Purple loosestrife is controllable by pulling; spot application of water-sensitive glyphosate or Triclopyr (herbicides) has met with some success. Common garden tools may be of use in digging up the plants with minimal soil disturbance. Examples of these include a tool such as a weed wrench and a mini-tiller (three prongs on one side of head).

While herbicide use is a final consideration in some instances, it is problematic near water. Manual control is a frustrating process, as a seed source upstream may furnish a yearly supply of seeds to a growing population. Research has been done on the use of native and non-native herbivorous beetles as natural predators.[200] [201] Cornell University has produced two videos on the biocontrol of purple loosestrife (see end of this chapter). The ideal prevention for purple loosestrife is early detection and quick eradication.

Caveats/Considerations

Management goals may range from containment to complete eradication. Since there are no large infestations (thanks in large part to previous efforts), eradication should be the goal at KNC.

Pulling needs to be done with care to avoid leaving sproutable stem parts in the soil. Removing inflorescences is not recommended; the remaining stems may resprout even more flowers than were originally present.

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[197] Hoffman R, Kearns K, editors. Wisconsin manual of control recommendations for ecologically invasive plants. [Internet]. Madison (WI): Wisconsin Dept. Natural Resources, Bureau of Endangered Resources; 1997 [cited 2016 Apr 15]. Available from http://www.invasive.org/species/list.cfm?id=139

[198] Ibid

[199] Ibid

[200] Salatas JH. Removal of inflorescences not recommended for controlling purple loosestrife. *Ecological Restoration*. 2000; 18(3):205.

[201] Malecki RA, Blossey B, Hight SD, Schroeder D, Kok LT, Coulson JR. Biological control of purple loosestrife. Bioscience. 1993; 43:480-486.

What to replace with

Allow natives to fill space, monitor closely.

Locations

A small population was observed in 2015 in compartment S3 (Management Unit C) and should be eradicated before it spreads.

PRIORITY 2:

Glossy buckthorn (*Rhamnus frangula*)

Life history

Glossy buckthorn alters the composition of wetlands, in particular by lowering water levels and shading out shade-intolerant species. Glossy buckthorn tends to leaf out earlier in the spring than other plants. Whereas its establishment is encouraged by hydrologic alterations, its dense root system can further lower water tables, exacerbating the plant's effects.

There is a similar native shrub, alder-leaved buckthorn (*Rhamnus alnifolia*), also occurring in many wet habitats, including alkaline fens and lowland deciduous woods.[202] It can be differentiated from glossy buckthorn most clearly by its toothed leaves (as opposed to smooth-edged), as well as rarely exceeding a height of one meter. *R. alnifolia* occurs interspersed with tussock sedge throughout the Source Marsh (E1 and E2).

[202] Voss EG. Michigan Flora Part 2 Dicots. Ann Arbor (MI): Cranbrook Institute Science Bulletin 59 and The University of Michigan Herbarium; 1985.

Management methods

For glossy buckthorn, a combination of cutting and spot application of a glyphosate herbicide is most often recommended.[203] Herbicide use is intended to discourage the vigorous resprouting characteristic of this species, which may even persist despite the application of herbicides. Label precautions must be followed, particularly restrictions about use near water. Most experiments combining cutting and herbiciding have occurred in the fall and spring, but there has been some success with winter cutting.[204]

Wetland environments plagued by buckthorn can be improved by restoring original water levels or hydrologic cycles. Water levels should not be raised above historic water levels.[205] [206] This would be an involved process at KNC, including, but not limited to changes in how stormwater is managed and plugging culverts or creating temporary dams. However, other invasives such as reed canary grass and most wetlands shrubs may be managed this way concurrently.

Caveats/Considerations

Resprouting can be combatted by repeated cutting within a season to drain the plant's carbohydrate supply, although this necessitates more disturbance and is not effective in the absence of herbicide application.[207] Simply pulling out stumps creates even more disturbance and is extremely work intensive.

Burning alone has had mixed results, and will encourage growth if not repeated over 5 or 6 successive years.[208] Burning is more effective on seedlings and resprouts, and may be more effective in the spring after buckthorn leafs out and before much of the native flora is active. However, this is often an extremely wet period, which could inhibit the effectiveness of burning. For fire-dependent ecosystems (prairie, wet meadow, oak forest), burning is essential as a follow-up to buckthorn removal, in order to deter re-establishment.

What to replace with

Another necessary follow-up, especially where dense stands of buckthorn have been removed to expose bare soil, is reseeding with native species appropriate to the site. When removed from woodlands or other sites where woody vegetation is appropriate, replacement with native shrubs is important as birds use buckthorn as a food source in the fall and winter (see Bush Honeysuckle for suitable replacements).

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[203] Converse CK. Element Stewardship Abstract for Rhamnus cathartica and Rhamnus frangula [Internet]. Arlington (VA): The Nature Conservancy; 1984 [cited 2016 April 1]. Available from http://www.invasive.org/gist/esadocs/documnts/franaln.pdf

[204] Reinartz JA. Controlling glossy buckthorn (*Rhamnus frangula* L.) with winter herbicide treatments of cut stumps. Natural Areas Journal. 1997; 17:38-41.

[205] Tu M, Hurd C, Randall JM. Weed Control Methods Handbook: Tools and Techniques for Invasive Species Control in Natural Areas [Internet]. Davis (CA): The Nature Conservancy's Wildland Invasive Species Team; 2001 [cited 2016 April 1]. Available from http://www.invasive.org/gist/handbook.html

[206] Heidorn R. Vegetation management guideline: exotic buckthorns [Internet]. Champaign (IL): Illinois Nature Preserves Commission; 1990 [cited 2016 April 1]. Available from http://wwx.inhs.illinois.edu/research/vmg/buckthorn/

[207] Converse CK. Element Stewardship Abstract for Rhamnus cathartica and Rhamnus frangula [Internet]. Arlington (VA): The Nature Conservancy; 1984 [cited 2016 April 1]. Available from http://www.invasive.org/gist/esadocs/documnts/franaln.pdf

[208] Solecki MK. Controlling invasive plants. In Packard S, Mutel CF, editors. The tallgrass restoration handbook. Washington (DC): Island Press; 1997. p. 63-88.

Locations

Glossy buckthorn is not a serious problem at KNC, but it can invade and dominate wetlands, and occurs throughout the property. For example, it is frequent along the woodland edge of the south property marsh (E4); potential restoration efforts there should include planning for glossy buckthorn management.

Oriental bittersweet *(Celastrus orbiculata)*




Life history

Oriental (Asiatic) bittersweet (*Celastrus orbiculata*, synonym: *C. orbiculatus*) is differentiated from the native American or climbing bittersweet (*C. scandens*) by a few floral or fruit characteristics. The Oriental species has small clusters of 3-7 fruits in cymes in the axils of the leaves, while the American species bears many fruit in terminal panicles. The fruit of both

species is a red aril, a soft, berry-like fruit type. Oriental bittersweet generally has a yellow outer fruit covering, and the American orange, although this character is less reliable. These two species are otherwise indistinguishable, and there is evidence of hybridization between them, generating concern for the status of the American species.[209]

Oriental bittersweet forms dense thickets in a number of environments, including young forests and alluvial woods, and along forest edges. In these and other environments, the woody vine covers the ground and chokes trees that it climbs.

Management methods

If populations are small enough, they are controllable by hand pulling and/or digging. However, cutting followed by spot application of glyphosate herbicide with a sponge applicator (as with glossy buckthorn) may be necessary for large infestations. Smaller resprouts should be pulled out immediately. No biological controls are known for this species.

Caveats/Considerations

Burning may actually stimulate growth.

What to replace with

Replant with native shrubs.

Locations

It is not common on the property but forms dense thickets where it does occur, as along Green Heron trail in U4, and can spread easily.

[209] Dryer GD. Element stewardship abstract for *Celastrus orbiculata*: Asiatic bittersweet [Internet]. Arlington (VA): The Nature Conservancy; 1994 [cited 2016 April 1]. Available from http://www.invasive.org/weedcd/pdfs/tncweeds/celaorb.pdf

Common Privet *(Ligustrum vulgare)*

Life history

Privet is another shrub that easily escapes from cultivation to form dense monospecific thickets. It is a common and popular border plant, often pruned to a neat "box-like" shape along sidewalks and driveways. Once established, it is difficult to eradicate due to large numbers of viable seeds distributed by birds and apparent absence of natural pests and predators.[210]

Management methods

Suggested approaches to control common privet are mechanical (cutting or pulling) if the population is small, or foliar herbicide application if the thicket is extremely dense and desirable species are not found nearby. Batcher[211] recommends a 1-2 percent solution of glyphosate with a 0.5 percent non-ionic surfactant to wet the leaves, 2 percent solution of triclopyr with surfactant or a similar concentration of metsulfuron. To avoid the risk of affecting non-target vegetation, privet can be cut close to the ground and a 25 percent solution of glyphosate applied with a sponge applicator to inhibit resprouting. Nothing in the literature describes multiple cutting regimes.

[210] Batcher MS. Element Stewardship Abstract for Ligustrum spp. [Internet]. Davis (CA): The Nature Conservancy's Wildland Invasive Species Team; 2000 [cited 2016 April 1]. Available from http://www.invasive.org/weedcd/pdfs/tncweeds/ligu_sp.pdf
[211] Ibid.

Caveats/Considerations

Foliar spraying is practiced on the assumption that few if any other plants will grow in the shade of such a thicket.

What to replace with

Privet can be replaced by many of the same native shrubs listed above under bush honeysuckles.

Locations

No known populations at 2015.

Spotted Knapweed *(Centaurea maculosa)*

Management methods

Spotted knapweed is controlled most effectively by early detection. Intense burns can help reduce populations; the more intense the fire is, the better the results. Biological control and herbicides have met with varied success.[212]

Testing different burn treatments over a four year time period at nearby Fort Custer Training Center,[213] found that only annual summer burning was effective in reducing overall population growth rates by reducing reproduction of adult plants. This approach may have negative effects on non-target plant species (i.e., desired native prairie forbs).

[212] Hoffman R, Kearns K, editors. Wisconsin manual of control recommendations for ecologically invasive plants. [Internet]. Madison (WI): Wisconsin Dept. Natural Resources, Bureau of Endangered Resources; 1997 [cited 2016 Apr 15]. Available from http://www.invasive.org/species/list.cfm?id=139

[213] Emery SM, Gross KL. Effects of timing of prescribed fire on the demography of an invasive plant, *Centaurea maculosa* (spotted knapweed). *Journal of Applied Ecology*. 2005; 42:60-69.

Caveats/Considerations

While a major rangeland weed in western states, it also readily invades disturbed, relatively dry upland sites throughout North America. Most research has focused on reestablishing productive rangelands.[214]

What to replace with

Replant with native forbs and other common species to the site.

Locations

At KNC, this species is not a high priority because invasible habitat is limited and those sites tend to be highly disturbed. However, it can be found in most open sites on the Main Site, especially highly disturbed soils resulting from tillage or gravel extraction (i.e., compartments G and U4), sometimes in a dominant role. Spotted knapweed is a major problem species in prairie and savanna restorations. It is currently a major issue in the Heronwood Field Station's Management Unit A, compartment O1.

[214] Mauer T, Russo MJ, Evans M. 1987 Element Stewardship Abstract for Centaurea maculosa (Spotted Knapweed) [Internet]. Arlington (VA): The Nature Conservancy; 1987 [cited 2016 April 1]. Available from http://www.invasive.org/weedcd/pdfs/tncweeds/centmac.pdf

Autumn-olive *(Elaeagnus umbellata)*

Life history

Information was mostly taken from Sather and Eckardt (1987).[215] Autumn-olive was introduced to North America for cultivation from China, Korea and Japan in 1830, favored because it grows in all but the most extreme soil conditions, even improving the soil by fixing nitrogen. However, the rampant nitrogen-fixing activity can offset the nutrient balance of a host ecosystem as well as conferring competitive advantages to this plant. It also fruits prolifically, resprouts readily after being cut and withstands some shade, although it thrives in full sun; it is also found in both wet and dry habitats. Autumn-olive is another problem species that typically only becomes invasive in open environments but can persist, with reduced fitness, in considerable shade.

Management methods

Control of autumn-olive is difficult without the use of herbicides to inhibit resprouting. Burning, cutting or combinations of these rarely are effective in large infestations without herbicides.

[215] Sather N, Eckardt N. Element Stewardship Abstract for Elaeagnus umbellata (Autumn olive) [Internet]. Arlington (VA): The Nature Conservancy; 1987 [cited 2016 April 1]. Available from http://www.invasive.org/weedcd/pdfs/tncweeds/elaeumb.pdf

Caveats/Considerations

Like other invasive shrubs, autumn-olive provides food and nest cover for many birds.

What to replace with

It should be replaced with native, open-grown shrubs like dogwood, prairie, pasture, or wild rose or a native species of plum (*Prunus* spp.), crab apple (*Malus* spp.), or hawthorn (*Crataegus* spp.), unless an abundant food source is available nearby for grassland birds.

Locations

This shrub was planted widely in the 1960's and 1970's for wildlife and soil conservation; the Kalamazoo Nature Center followed this trend. Major threats that this plant poses are to the native prairie plantings (N1-3).

Sweet-clover *(Melilotus spp.)*

Melilotus alba

Melilotus officinalis

Life history

Sweet-clover was introduced into North America as a forage crop for livestock, and as a soil builder due to its tolerance of alkaline and clayey soils, and for its nitrogen-fixing capabilities.

Management methods

Most effective controls include burning for larger areas, and hand pulling/digging for small areas where that is feasible. The burning technique involves burning initially in the dormant season to stimulate germination of seedlings, then burning in the second subsequent growing season, to eliminate most of those seedlings.

Caveats/Considerations

Some have suggested that this is an aesthetic pest more than an ecological burden.[216]

What to replace with

Replant with native species common to the site.

Locations

This is a pest in open, upland sites (i.e., prairies). These species occur at KNC mostly in severely disturbed habitats (e.g., the gravel pit [G]).

[216] Eckardt N. Element stewardship abstract for Melilotus alba – sweetclover or white sweetclover, Melilotus officinalis – yellow sweetclover [Internet]. Arlington (VA): The Nature Conservancy; 1987 [cited 2016 April 1]. Available from http://www.invasive.org/weedcd/pdfs/tncweeds/melioff.pdf

Common Reed *(Phragmites australis)*

Life history

Although this species was not observed at KNC, and may never be, much research had been done to separate native and non-native strains. It is a case that is very illuminating on the nature of invasive species and plant genetics in general.

In the northern United States, common reed is a frequent sight in ditches alongside highways, and is especially invasive along the eastern seaboard, where it can dominate hundreds of wetland acres. Common reed has also been the subject of a great deal of debate regarding whether or not it is native in the US,[217] as it is found on every continent except Antarctica.[218]

Recently published genetic research with specimens from Europe and America has shown that there are indeed native populations on both continents, as well as more than one invasive strain in North America.[219] Non-native *Phragmites* grows more densely, tall and aggressively here than in its native range. It is a tall grass with showy silvery-maroon plumes, growing in dense stands. The native types tend to be smaller, less dense and paler in color than the non-native (therefore, invasive) populations.

[217] Marks M, Lapin B, Randall J. Element Stewardship Abstract for Phragmites australis [Internet]. Arlington (VA): The Nature Conservancy; 1993 [cited 2016 April 1]. Available from http://www.invasive.org/weedcd/pdfs/tncweeds/phraaus.pdf
[218] Tucker GC. The genera of Arundinoideae (Gramineae) in the southeastern United States. Journal of the Arnold Arboretum. 1990; 71:145-177.
[219] Saltonstall, K. Cryptic invasion by a non-native genotype of Phragmites australis into North America. Proceedings of the National Academy of Sciences. 2002; 99(4):2445-2449.

PRIORITY 3:

The following is a limited listing of some species not observed with much frequency but may occur at KNC now or in the future. Many other species could be included here; these are the most pernicious.

Wetlands/Aquatics:

European swamp thistle *(Cirsium palustre)*

Life history

This is a thistle with winged stems like bull thistle (*C. vulgare*), but smaller heads.[220]

Locations

It has so far spread throughout the Upper Peninsula and northern Lower Peninsula of Michigan, but may eventually spread along the interstate system to southwestern corner of the state.

[220] Voss EG. Michigan Flora Part 3 Dicots cont'd. Ann Arbor (MI): Cranbrook Institute Science Bulletin 61 and the University of Michigan Herbarium; 1996.

Eurasian water-milfoil *(Myriophyllum spicatum)*

Locations

First found in the state in 1970, this aggressive aquatic plant has spread throughout the state in lakes and larger streams.[221] If noted in KNC's aquatic systems, such as one the larger ponds, it should be removed immediately and with great care.

[221] Voss EG. Michigan Flora Part 2 Dicots. Ann Arbor (MI): Cranbrook Institute Science Bulletin 59 and The University of Michigan Herbarium; 1985.

Openlands:

Leafy spurge *(Euphorbia esula)*

As with spotted knapweed, this short herb is a serious pest in western rangelands, where it may cover the landscape with a yellow-green hue. This is a more familiar scene in northern Michigan, but it has been documented in Kalamazoo County and may be seen at KNC.[222]

[222] Voss EG. Michigan Flora Part 2 Dicots. Ann Arbor (MI): Cranbrook Institute Science Bulletin 59 and The University of Michigan Herbarium; 1985.

Sericea *(Lespedeza cuneata)*

Differing from its native cousins with cream-colored flowers (which flower terminally) by having inflorescences in the leaf axils, this bush-clover has been documented in Kalamazoo county.[223] It is a serious problem in the prairies to the south and west of Michigan, but can be a pesky weed here, as well.

[223] Voss EG. Michigan Flora Part 2 Dicots. Ann Arbor (MI): Cranbrook Institute Science Bulletin 59 and The University of Michigan Herbarium; 1985.

Woodlands:

Japanese barberry *(Berberis thunbergii)*


Life history

This shade-loving, compact, spiny shrub is sold as an ornamental. Native to Japan, it is becoming a more common component of disturbed native forests.[224]

Management methods

In small populations, pulling is feasible, as long as thick gloves are worn for protection from the many spines along the plant's branches.[225] If soil disturbance is a problem, cut stumps can be treated with a 2-3 percent solution of glyphosate. Fire may also deter its growth.[226]

Locations

It is present in most forested compartments at KNC (except for C1 and F1), but never at infestation levels. It should be monitored to ensure it remains at low levels. It was also observed on many other KNC properties, but again at low levels and should be monitored.

[224] Hoffman R, Kearns K, editors. Wisconsin manual of control recommendations for ecologically invasive plants. [Internet]. Madison (WI): Wisconsin Dept. Natural Resources, Bureau of Endangered Resources; 1997 [cited 2016 Apr 15]. Available from http://www.invasive.org/species/list.cfm?id=139

[225] Rhoads AF, Block TA. Japanese barberry *Berberis thunbergii* DC. barberry family (Berberidaceae). [Internet]. Philadelphia (PA): Morris Arboretum of the University of Pennsylvania; 2002 [cited 2016 Apr 15]. Available from http://paflora.org/original/pdf/INV-Fact%20Sheets/Berberis%20thunbergii.pdf

[226] Hoffman R, Kearns K, editors. Wisconsin manual of control recommendations for ecologically invasive plants. [Internet]. Madison (WI): Wisconsin Dept. Natural Resources, Bureau of Endangered Resources; 1997 [cited 2016 Apr 15]. Available from http://www.invasive.org/species/list.cfm?id=139

Wintercreeper *(Euonymus fortunei)*

This evergreen trailing vine is well-known from the urban landscape. It can monopolize a large portion of the forest floor (like myrtle and English ivy) and even climb trees and choke them out (like English ivy and Oriental bittersweet).

Swallow-wort *(Vincetoxicum* spp.*)*

This is a problematic vine in the forests of New England (Tyler Basset, pers. obs.), and has potential for becoming a serious weed in Michigan.[227] A member of the milkweed family, it has similar flowers to common milkweed (*Asclepias syriaca*), and large, glossy, opposite leaves.

[227] Voss EG. Michigan Flora Part 3 Dicots cont'd. Ann Arbor (MI): Cranbrook Institute Science Bulletin 61 and the University of Michigan Herbarium; 1996.

PRIORITY 4:

Shrubs and Trees:

Norway maple *(Acer platanoides)*

Life history

Norway maple is a popular street tree for its durability and ease of propagation, but these characteristics also facilitate its spread into urban forests. Once there, it can become dominant enough to displace native tree and groundlayer species. Norway maple is found in the south DeLano woods (C5). This long-lived tree species may out compete its native counterpart, the sugar maple (*Acer saccharum*), thus interfering with natural succession.

Care must be taken in identification since the native sugar maple (*Acer saccharum*) has a similar appearance and is a widespread and important native tree. They can be differentiated in the winter by sugar maple's smaller, more acute buds (~5cm long; Norway maple has wider buds, ~ 6 cm long). In the fall, Norway maple has a more widely diverging fruit (the familiar samara, or "helicopter" fruit characteristic of maples and ashes).[228]

Management methods

It can be controlled by girdling or by pulling smaller plants. One of many tools designed specifically for uprooting young trees could be used for this purpose (e.g., the Weedwrench [Dunmore 2000] or Root Talon).

[228] Barnes BV, Wagner WH. Michigan Trees: A Guide to the Trees of Michigan and the Great Lakes Region. Ann Arbor (MI): University of Michigan Press; 1981. 383 p.

What to replace with

Replacement of Norway maple is dependent upon the target community. Sugar maple, American beech (*Fagus grandifolia*), basswood (*Tilia americana*) and other dominants would encourage a southern mesic forest community. Oaks (*Quercus* spp.) and hickories (*Carya* spp.) would encourage dry and dry-mesic forest, or a savanna community.

Winged wahoo *(Euonymus alata)*

This popular ornamental bush (usually sold as "burning bush") is naturalized in woodlands throughout the eastern U.S. Its impacts are uncertain, but success is a result of wide dissemination as a landscaping plant, and prolific seed production. It has been reported as growing in dense thickets, but this may only be under certain conditions, such as recent soil disturbance. If management is required, seedlings can be pulled with little or no soil disturbance, and shrubs can be cut and stumps treated with glyphosate.[229] Replacement with native shrubs is encouraged (see Bush Honeysuckles).

[229] Martin T. Euonymus alatus [Internet]. Arlington (VA): The Nature Conservancy; 2000 [cited 2016 April 1]. Available from http://wiki.bugwood.org/Euonymus_alatus

Cool-season grasses:

Kentucky and Canada bluegrass *(Poa pratensis* and *P. compressa)*

Poa pratensis

Poa pratensis

Poa compressa

Life history

These are both rhizomatous, perennial, cool-season grasses naturalized in North America (i.e., not from Kentucky or Canada). This means they grow aggressively in the spring and some in the fall, but go dormant in the summertime. They grow well in alkaline and wetter (not submerged) conditions, but not so well in highly acidic soils, especially Kentucky bluegrass.[230] Canada bluegrass can be found in dry, sterile, acidic soils, and thus distinguished from its more common congener.[231] Their growth is concentrated in the rhizomes that bind populations of clones together. Most other non-native grasses (brome, timothy, orchard grass, quack grass, etc.) are cool-season species and can be treated similarly to the bluegrasses.[232] The ubiquity of Kentucky bluegrass as a turf grass makes it more common, especially on more mesic and fertile soils.

Except when on dry, acidic soils, some believe it to be more of a problem species than Canada bluegrass.[233]

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[230] Sather N. Element Stewardship Abstract for Poa pratensis, Poa compressa (Kentucky Bluegrass, Canada Bluegrass) [Internet]. Arlington (VA): The Nature Conservancy; 1996 [cited 2016 April 1]. Available from http://www.invasive.org/gist/esadocs/documnts/poa_pra.pdf

[231] Hoffman R, Kearns K, editors. Wisconsin manual of control recommendations for ecologically invasive plants. [Internet]. Madison (WI): Wisconsin Dept. Natural Resources, Bureau of Endangered Resources; 1997 [cited 2016 Apr 15]. Available from http://www.invasive.org/species/list.cfm?id=139

[232] Ibid.

[233] Sather N. Element Stewardship Abstract for Poa pratensis, Poa compressa (Kentucky Bluegrass, Canada Bluegrass) [Internet]. Arlington (VA): The Nature Conservancy; 1996 [cited 2016 April 1]. Available from http://www.invasive.org/gist/esadocs/documnts/poa_pra.pdf

Management methods

Where appropriate (and it usually is), management for native warm-season grasses such as big bluestem (*Andropogon gerardii*) will help exclude these non-native invasives. A spring-time burn (when the warm-season natives are dormant and the cool-season grasses are growing) in concert with management for native warm-season grasses can be enormously effective.[234] Fires are especially important when a good mix of prairie grasses and forbs is present. Use of herbicides is impractical under these conditions, but may be beneficial if bluegrass is growing in a monoculture.

Caveats/Considerations

Cutting of the sod (disking, etc.), is mostly ineffective or counterproductive unless done annually for several years, and mowing or grazing may stimulate new growth unless only done in the spring when the plant's nutrient reserves are mostly in the above-ground stems.[235] Even then, success is unpredictable. The dense rhizomes of these grasses ensure their dominance.

What to replace with

If native species are not present, they should be added when bluegrass is under control; if added prematurely, their success will be hindered by the dense rhizomes of the invasive grass.[236]

[234] Sather N. Element Stewardship Abstract for Poa pratensis, Poa compressa (Kentucky Bluegrass, Canada Bluegrass) [Internet]. Arlington (VA): The Nature Conservancy; 1996 [cited 2016 April 1]. Available from http://www.invasive.org/gist/esadocs/documnts/poa_pra.pdf

[235] Ibid.

[236] Packard S, Ross LM. Restoring remnants. In Packard S, Mutel CF, editors. The tallgrass restoration handbook. Washington (DC): Island Press; 1997. p. 63-88.

Tall fescue *(Festuca arundinacea)*

Life history

Tall fescue is another rhizomatous, cool-season, perennial grass. It can be superficially distinguished from other grasses in seed by the generally purple color of its inflorescence. It is planted frequently for both turf and forage, and tolerates both drought and high water tables. It is useful for reclaiming erosion-sensitive areas (airports, playgrounds, parking lots, cuts and fills, eroding gullies and highway corridors), but it spreads easily into grasslands and quickly becomes dominant.

Management methods

It forms a very tough sod and is extremely difficult to eradicate. Experimenters have found success with early spring, pre-emergence herbicide applications preceded by burning and followed by interseeding with native warm season grasses such as big bluestem (*Andropogon gerardii*), Indian grass (*Sorghastrum nutans*), and little bluestem (*Schizachyrium scoparium*).[237] While burning during active growth in early spring may contain this grass, it is unlikely to reduce cover without the aid of herbicides and some interseeding or interplanting of native grassland species, including legumes, which have been shown to exhibit competitive effects on tall fescue.[238] The use of more persistent herbicides such as imazapic and clethodim has proven quite effective in establishing native grassland in dense cover of tall fescue without harming native grasses and forbs, although the less-persistent glyphosate may be sufficient.[239]

[237] Washburn BE, Barnes TG, Sole JD. No-till establishment of native warm-season grasses in tall fescue fields first-year results indicate value of new herbicide. *Ecological Restoration*. 1999; 17.3: 144-149.
[238] Batcher MS. Element stewardship abstract for Festuca Arundinacea [Internet]. Arlington (VA): The Nature Conservancy; 2000 [cited 2016 April 1]. Available from http://www.invasive.org/weedcd/pdfs/tncweeds/festaru.pdf.
[239] Ruffner ME, Barnes TG. The efficacy of herbicides for eradicating tall fescue. Proc. N. Am. Prairie Conf. 2004; 22:67-74.

Smooth brome *(Bromus inermis)*

Life history

Smooth brome is a common perennial forage grass, often found to be the dominant grass in oldfields and along highway rights-of-way. Because it forms a dense sod, it may outcompete native species and lower diversity. However, smooth brome does provide habitat for some important animal species, especially in the tallgrass prairie region. Rare grassland birds such as the Henslow's sparrow utilize brome fields (hayfields and pasture) because they provide a similar structure to that of the once extensive acreage of mesic tallgrass prairie.

Management methods

Spreading extensively by runners and tillers, it is controllable with mowing, burning, and herbicides, or a combination of these techniques. Mowing or cutting while in the boot stage (inflorescence still in sheath), when carbohydrate levels are low in the roots can control this species.[240] Prescribed fire has had mixed results. In areas where native warm-season tallgrass

[240] Sather N. Element stewardship abstract for Bromus inermis [Internet]. Arlington (VA): The Nature Conservancy; 1987 [cited 2016 April 1]. Available from http://www.invasive.org/weedcd/pdfs/tncweeds/bromine.pdf

prairie species provide significant cover (N1, N2), a prescribed burn during tiller elongation but before heading (about early to mid-May) can be effective.[241] Where native species are not present in significant numbers, a combination of well-timed mowing and herbiciding in combination with interseeding of natives is recommended.[242] [243]

Caveats/Considerations

Tilling or discing is not recommended and is probably counterproductive, unless followed by well-timed herbicide application.

Locations

This community now only persists in small remnants of .6 to 13 acres in Michigan[244] and the Henslow's sparrow rarely utilizes grasslands less than 250 acres in size.[245]

Groundcovers:

Crown Vetch *(Coronilla varia)*

Life history

Synonym: *Securigera varia*. Originally planted for erosion control (especially roadsides) and for nitrogen-fixing benefits of its root nodules (it is a member of the pea family), crown vetch has proven more of a pest. Its benefits turn out to be less effective, as the roots are weak and the

[241] Willson GD, Stubbendieck J. A provisional model for smooth brome management in degraded tallgrass prairie. Ecological Research. 2000; 18(1): 34-38.
[242] Ibid
[243] Sather N. Element stewardship abstract for Bromus inermis [Internet]. Arlington (VA): The Nature Conservancy; 1987 [cited 2016 April 1]. Available from http://www.invasive.org/weedcd/pdfs/tncweeds/bromine.pdf
[244] Kost MA. Natural community abstract for dry sand prairie [Internet]. Lansing (MI): Michigan Natural Features Inventory; 2004 [cited 2016 April 1]. Available from https://mnfi.anr.msu.edu/abstracts/ecology/Dry_sand_prairie.pdf
[245] Currier C. Special animal abstract for Ammodramus henslowii (Henslow's Sparrow) [Internet]. Lansing (MI): Michigan Natural Features Inventory; 2001 [cited 2016 April 1]. Available from http://www.dnr.state.mi.us/publications/pdfs/HuntingWildlifeHabitat/Abstracts/zoology/ammodramus_henslowii.pdf

dense foliage prevents the establishment of deep, fibrous-rooted species that would actually control erosion. Mostly a problem in open, sunny locations, this plant tolerates some shade.[246]

Management methods

Mowing repeatedly throughout the growing season will at least deter its spread, including that of its seed. Mowing once in June and again in late August may be effective, both times when the plant is leafing out.[247] Herbicides (glyphosate, triclopyr, 2,4-D amine) have been found effective for large infestations in which native species diversity is low.

Locations

There have been no uncontrollably large infestations observed at KNC. Existing populations (along the west side of Westnedge Ave. across from the old entry road) are small and should be contained before they spread.

Periwinkle or Myrtle *(Vinca minor)*

Life history

This plants form dense carpets in the shade, which is why they are planted often in urban landscapes where sun exposure is rare. Where planted, this and other evergreen vines (wintercreeper, English ivy [*Hedera helix*]) grow at the expense of nearly all other groundlayer species and eventually engorge the trunks of trees (periwinkle does not), killing them.

[246] Hoffman R, Kearns K, editors. Wisconsin manual of control recommendations for ecologically invasive plants. [Internet]. Madison (WI): Wisconsin Dept. Natural Resources, Bureau of Endangered Resources; 1997 [cited 2016 Apr 15]. Available from http://www.invasive.org/species/list.cfm?id=139

[247] Ibid

Management methods

Herbicide applications have a host of complications, due to the waxy cuticle covering their evergreen leaves. Suggested eradication techniques involve raising the stems with a rake and then pulling them out manually.[248]

Caveats/Considerations

Care must be taken as any and all sections of roots can resprout.

What to replace with

Areas denuded should be replanted with native groundcover and herbaceous species.

Locations

A small population of English ivy was documented (and quickly removed) in the southern floodplain (F2), perhaps washed downstream from the city of Kalamazoo, Parchment, or Comstock.

[248] Bean C, Russo MJ. Element stewardship abstract: Vinca major [Internet]. Arlington (VA): The Nature Conservancy; 1988 [cited 2016 April 1]. Available from http://www.invasive.org/gist/esadocs/documnts/vincmaj.pdf

Clonal trees:

Tree-of-heaven *(Ailanthus altissima)*

Tree-of-heaven is a fast-growing clonal tree, and a prolific seed producer.[249] It is able to grow in the most adverse conditions, even thriving in sidewalk cracks and where buildings meet the concrete, and is well-established from coast to coast. At KNC, it thrives in the gravel pit (G) and along disturbed ravines in the south DeLano woods (C5). It sprouts readily when cut.

[249] Hoshovsky MC. Element stewardship abstract: Ailanthus altissima (tree of heaven) [Internet]. Arlington (VA): The Nature Conservancy; 1988 [cited 2016 April 1]. Available from http:/www.invasive.org/weedcd/pdfs/tncweeds/ailaalt.pdf

Poplar/Aspen *(Populus* spp.*)*

Populus grandidentata

Populus tremuloides

The native species of poplar or aspen (*Populus grandidenta*, *P. tremuloides*) are considered problematic invaders in native grassland, in which they grow aggressively from root suckers and shade out desirable species.[250] At KNC, stands of hybrid poplar of uncertain origin were planted in the 1970's to be used as fuelwood. While they are not problematic at KNC where they occur, they do occupy considerable acreage that could be converted to more diverse native communities. It is then that their persistence would be problematic, especially if the desired target community is prairie or savanna, much in the same way as other *Populus* spp.

Due to their clonal nature, simply cutting the trees down only encourages aggressive regrowth and root suckering. If done in late June or July after leaf expansion ceases, regrowth may not be as severe.[251] Prescribed fire may be applied incrementally along the edge of a clone, in conjuction with cutting of the smaller stems that occur there. Girdling is the preferred control method.[252] In the spring, apply a cut two inches long to all stems in a clone greater than one inch in diameter.

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[250] Hoffman R, Kearns K, editors. Wisconsin manual of control recommendations for ecologically invasive plants. [Internet]. Madison (WI): Wisconsin Dept. Natural Resources, Bureau of Endangered Resources; 1997 [cited 2016 Apr 15]. Available from http://www.invasive.org/species/list.cfm?id=139

[251] Converse CK. Element Stewardship Abstract for Populus spp (North American invasive poplars/aspens) [Internet]. Arlington (VA): The Nature Conservancy; 1987 [cited 2016 April 1]. Available from http://www.invasive.org/gist/esadocs/documnts/poputre.pdf

[252] Hoffman R, Kearns K, editors. Wisconsin manual of control recommendations for ecologically invasive plants. [Internet]. Madison (WI): Wisconsin Dept. Natural Resources, Bureau of Endangered Resources; 1997 [cited 2016 Apr 15]. Available from http://www.invasive.org/species/list.cfm?id=139

Black Locust *(Robinia pseudoacacia)*

Black locust is native to the eastern United States, and is considered native as near to Michigan as southern Indiana. As is the case for many invasive plants (and often the reason for their prevalence), this aggressively clonal tree is well-suited to disturbed and contaminated soils. It has been used quite successfully to reclaim mine sites.

Due to a combination of shade intolerance and aggressive colonial spread, black locust only poses a threat to grasslands and other open habitats. Converse provides a summary of reasons for its threat:[253]

1. Its natural range has been expanded by planting for erosion control windbreaks, afforestation, and mine reclamation beginning in the early 1900s.
2. It tolerates dry sites probably because of an extensive fibrous root system.
3. It grows and propagates most vigorously in full sun and where herbaceous vegetation is sparse.
4. It most frequently reproduces by rapid vegetative growth and colonial spread. Vegetative growth is more rapid than seedling growth.
5. Vigor of suckers and sprouts usually increases following top removal by fire, cutting, dozing, etc.

Control is difficult by girdling, cutting, burning, and cut stump herbicide application. Preventing its spread is the most reasonable management option, if management is desired.

[253] Converse CK. Element stewardship abstract for Robinia pseudoacacia [Internet]. Arlington (VA): The Nature Conservancy; 1984 [cited 2016 April 1]. Available from http://www.invasive.org/weedcd/pdfs/tncweeds/robipse.pdf

Aggressive herbaceous species:

Cattails *(Typha* spp.*)*

Typha latifolia

Typha angustifolia

Broad-leaved, or common cattail (*Typha latifolia*) is a native, opportunistic species historically occurring (i.e., in a balanced ecosystem) mostly as smaller scattered populations within sedge meadows and emergent marshes. Changes in surface level hydrology, wildfire suppression and wetland enrichment have encouraged its proliferation to become monocultures at the expense of many native wetland species. Such is also the case for narrow-leaved cattail (*T. angustifolia*), an adventive in the upper Midwest,[254] which invades deeper waters and more disturbed habitats than the common species.[255] Their effects include closing open waters, eliminating habitat and species diversity and reducing opportunities for other populations to establish and/or survive.

The object with these species is simply to control their spread, not to eradicate them. Covering with polyethylene tarps for less than 60 days killed new shoots in one study.[256] Water levels above emerging shoots in the spring will retard growth significantly.[257] This can be achieved artificially. Disking, cutting and shearing in late spring when carbohydrate supplies are in the above-ground portions can be effective if combined with the previous method.[258] Finally, a prescribed burn in the winter, the only time with enough fuel and dry conditions, may be effective.[259]

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[254] Hoffman R, Kearns K, editors. Wisconsin manual of control recommendations for ecologically invasive plants. [Internet]. Madison (WI): Wisconsin Dept. Natural Resources, Bureau of Endangered Resources; 1997 [cited 2016 Apr 15]. Available from http://www.invasive.org/species/list.cfm?id=139

[255] Herman KD et al. Floristic quality assessment with wetland categories and examples of computer applications for the State of Michigan-revised, 2nd edition. Lansing (MI): Michigan Department of Natural Resources, Wildlife, Natural Heritage Program; 2001.

[256] Motivans K, Apfelbaum S. Element stewardship abstract for Typha spp., North American cattails [Internet]. Arlington (VA): The Nature Conservancy; 1987 [cited 2016 April 1]. Available from http://www.invasive.org/gist/esadocs/documnts/typh_sp.pdf

[257] Hoffman R, Kearns K, editors. Wisconsin manual of control recommendations for ecologically invasive plants. [Internet]. Madison (WI): Wisconsin Dept. Natural Resources, Bureau of Endangered Resources; 1997 [cited 2016 Apr 15]. Available from http://www.invasive.org/species/list.cfm?id=139

[258] Ibid

[259] Ibid

Canada thistle *(Cirsium arvense)*


Despite its name, this strongly clonal member of the aster family is not native to North America. This shade-intolerant species can be problematic in native grasslands and restorations, and is also considered a pest by farmers and ranchers (L. Dyer, Tyler Bassett pers. comm.). It hosts more insect pollinators than any other thistle (*Cirsium* spp. and *Carduus* spp., including native species),[260] but it has strong negative effects on native plant communities that, with a diversity of species, may support an even greater diversity and number of pollinators.

This invader spreads primarily by means of underground roots that quickly give rise to additional fertile shoots. Application of glyphosate is most effective in the fall a few weeks before first frost, when native plants are less likely to be active, although growing season application when root reserves are lowest (June) and plants are in flower and/or bud stage may be effective. Use a concentration of about 2.5 percent, as higher concentrations may kill leaves too quickly for the plant to absorb the chemical.[261] Dormant season fires may keep the plant in check, and may help native species to compete. Encouraging competitive natives may be the most valuable tool. The intensity of mowing required to control Canada thistle (monthly up to four years) may not be feasible in natural areas, although selective cutting with a scythe or similar tool may be practical.[262] All treatments are more effective when the plant is under stress; it is both drought and cold-sensitive.

[260] Nuzzo V. Element Stewardship Abstract for Cirsium arvense [Internet]. Arlington (VA): The Nature Conservancy; 1997 [cited 2016 April 1]. Available from http://www.invasive.org/weedcd/pdfs/tncweeds/cirsarv.pdf
[261] Ibid.
[262] Hoffman R, Kearns K, editors. Wisconsin manual of control recommendations for ecologically invasive plants. [Internet]. Madison (WI): Wisconsin Dept. Natural Resources, Bureau of Endangered Resources; 1997 [cited 2016 Apr 15]. Available from http://www.invasive.org/species/list.cfm?id=139

Japanese knotweed *(Polygonum cuspidatum)*

This eastern Asian native grows in dense stands mostly in disturbed ground, such as roadsides and along the edges of cultivated fields, is rhizomatous, and requires full sun.[263] It also appears to be sensitive to late or early frost (Tyler Bassett, pers. obs.). Its occurrence at KNC is limited to small, yet continuous patches. Control could be effectively carried out by repeated mowing,[264] perhaps combined with interseeding of native species appropriate to its location.

[263] Seiger L. Element Stewardship Abstract for Polygonum cuspidatum [Internet]. Arlington (VA): The Nature Conservancy; 1991 [cited 2016 April 1]. Available from http://www.invasive.org/weedcd/pdfs/tncweeds/polycus.pdf
[264] Ibid.

Dame's rocket *(Hesperis matronalis)*

Dame's rocket is an attractive member of the mustard family, a biennial plant often found in popular wildflower mixes. Additional keys to success for this familiar plant are its heavy seed-set and shade tolerance. Pulling is an effective method of control especially when the soil is moist, but should be done while the population is contained.[265] Use of a dandelion digger may lessen one problem, as soil disturbance is a result of its large roots. It is rarely a problem in undisturbed natural areas.

This is starting to become an issue on the Main Site (Management Unit B) and should be monitored closely.

[265] Hoffman R, Kearns K, editors. Wisconsin manual of control recommendations for ecologically invasive plants. [Internet]. Madison (WI): Wisconsin Dept. Natural Resources, Bureau of Endangered Resources; 1997 [cited 2016 Apr 15]. Available from http://www.invasive.org/species/list.cfm?id=139

Wild parsnip *(Pastinaca sativa)*

This tall member of the parsley family (Apiaceae) is well-known for the severe blister its sap can produce; ecologically it appears to be restricted to recently disturbed areas.[266] Although not reported in recent years at KNC, it has been seen along the railroad corridor in the past. It can be pulled or otherwise removed manually, taking care *to not expose bare skin to its sap*, which can form a blister when exposed to the sun. It is only a threat when occurring adjacent to open areas. In the case of native prairie, the best approach is probably to encourage healthy growth of prairie species.[267]

[266] Eckardt N. Element stewardship abstract for Daucus carota [Internet]. Arlington (VA): The Nature Conservancy; 1987 [cited 2016 April 1]. Available from http://www.invasive.org/weedcd/pdfs/tncweeds/dauccar.pdf
[267] Ibid.

Common teasel *(Dipsacus fullonum)*

This prolific seed-producer has spread extensively along highways and other corridors in the past 30 years. It is similar to wild parsnip in many respects although it can form dense stands and even monocultures. It is controllable by cutting, digging, and burning.[268]

[268] Hoffman R, Kearns K, editors. Wisconsin manual of control recommendations for ecologically invasive plants. [Internet]. Madison (WI): Wisconsin Dept. Natural Resources, Bureau of Endangered Resources; 1997 [cited 2016 Apr 15]. Available from http://www.invasive.org/species/list.cfm?id=139

PRIORITY 5:

Cattails, dogwoods, and staghorn sumac (*Rhus typhina*) are all native plants also occurring in innocuous stands. Wild parsnip, teasel, smooth brome, and many other non-natives occur in this manner. This is to say, there are situations where their presence does not pose a threat to the surrounding environment, and may be providing benefit. Any management would be intended only to curtail an advancing edge of growth, for example, by cutting back a stand of sumac on the edge of a prairie before a prescribed burn.[269] As described above, many invasive plants provide important ecological functions. Frequently, even if possible, the intent should not be to completely eradicate these plants, especially if eradication would involve excessive ecological disturbance.

Summary and Conclusion

Most exotic plant species are not invasive, and some are only annual weeds that colonize recently disturbed ground only to be replaced quickly by more hardy and aggressive species.[270] Native plants can also be invasive. Plant species that do demonstrate invasive characteristics are invasive because they have advantages over naturally occurring species and are a symptom of a system out of balance. It is therefore consistent with the Kalamazoo Nature Center's mission of stewardship of the natural world to ameliorate these disturbances.

Applying the methods of invasive species control outlined, including the decision-making process behind prioritization and choosing specific methods, should fall under the discipline of ecological restoration. Removal of invasive species needs to be complemented with the return of native plant and animal populations and natural ecological processes. Local environmental and academic institutions (e.g., Southwest Michigan Land Conservancy, Wild Ones, Kalamazoo College, Western Michigan University) may assist in achieving these goals. Furthermore, control methods used and success rates should be specifically documented, for the benefit of the academic community and other land managers. An Environmental Impact Statement or similar documentation of when invasive species control is implemented would be helpful. The science of ecological restoration is still relatively young, and empirical data of this nature are valuable and under-represented.

Another precaution concerns retaining biodiversity and ecological integrity. In the process of restoring these communities, care should be taken to maintain proper habitat for fishes, amphibians, reptiles, birds, mammals and insects, as well as considering soil structure and hydrological function. It is possible, with the best of intentions, to degrade these conservative ecosystems. One example of these precautionary measures is the quick replacement of buckthorn and non-native honeysuckle with native shrubs, as mentioned above.

[269] Hoffman R, Kearns K, editors. Wisconsin manual of control recommendations for ecologically invasive plants. [Internet]. Madison (WI): Wisconsin Dept. Natural Resources, Bureau of Endangered Resources; 1997 [cited 2016 Apr 15]. Available from http://www.invasive.org/species/list.cfm?id=139

[270] Packard S, Ross LM. Restoring remnants. In Packard S, Mutel CF, editors. The tallgrass restoration handbook. Washington (DC): Island Press; 1997. p. 63-88.

INVASIVE SPECIES RESOURCES

Cornell University
Two videos for biocontrol of purple loosestrife
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John Bagley - Regional Stewardship Organizer (*Western Lower Peninsula*)
866/223-2231
http://www.michigannature.org/
michigannature@michigannature.org

The Nature Conservancy, Michigan Chapter
517/316-0300
www.nature.org
michigan@tnc.org

The Pierce Cedar Creek Institute
269/721-4190
www.cedarcreekinstitute.org

Society for Ecological Restoration
202/299-9518
www.ser.org
info@ser.org

SouthWest Michigan Land Conservancy
269/324-1600
www.swmlc.org
ConserveLand@swmlc.org

Wild Ones Natural Landscapers: Kalamazoo Chapter
http://www.kalamazoowildones.org/
info@kalamazoowildones.org

Appendix III: Data Collection and Calculations

This appendix covers the field collection methods used in Summer 2015 as well as the procedures for calculating the metrics based on fieldwork data, including the Floristic Quality Index (FQI), basal area, and relative abundance.

Modified-Whittaker Plots

The Modified-Whittaker plot design is a vegetation sampling design that can be used for assessing plant communities at multiple scales. To determine the locations for plots, points were selected in forests of interest across 4 different properties (5 on the Main Site, 2 in Harris Prairie, 1 at the Heronwood Field Station, and 1 at Pitsfield Banding Station). The plots were set up based on methods used by Tyler Bassett's 2003-2004 biological inventory (more details can be found in Stohlgren et. al (1995)[271]). In short, a 20 m x 50 m plot was set up at each random point; the 50 m axis was set up along the environmental gradient (i.e. forward) and the 20 m axis oriented to the left when facing along the 50 m axis. Within the full 1000 m^2 plot there were 13 subplots: 1 at 100 m^2 in the center of the plot, 2 at 10 m^2 placed in opposite corners of the plot, and 10 at 1 m^2 (a diagram showing the arrangement of these subplots can be seen below). The data collected differed at the different scales as well. All species present were recorded in all subplots. Percent cover was recorded as following: vegetation under 50 cm tall for the 1 m^2 subplots, vegetation greater than 50 cm tall but under 2.5 cm DBH for the 10 m^2 subplots, woody plants 2.5-9.9 cm DBH for the 100 m^2 subplot, and all woody plants with DBH greater than 10 cm for the 1000 m^2 plot.

Advantages of this plot design include its ability to calculate species area curves, native species richness, non-native species richness, and total plant species richness at the 1 m^2 , 10 m^2 , 100 m^2 , and 1000 m^2 scales. Disadvantages include the time it takes to complete each plot and field difficulties in certain habitats.

[271] Stohlgren TJ, Falkner MB, Schell LD. A Modified-Whittaker nested vegetation sampling method. Vegetatio. 1995; 117:113-121.

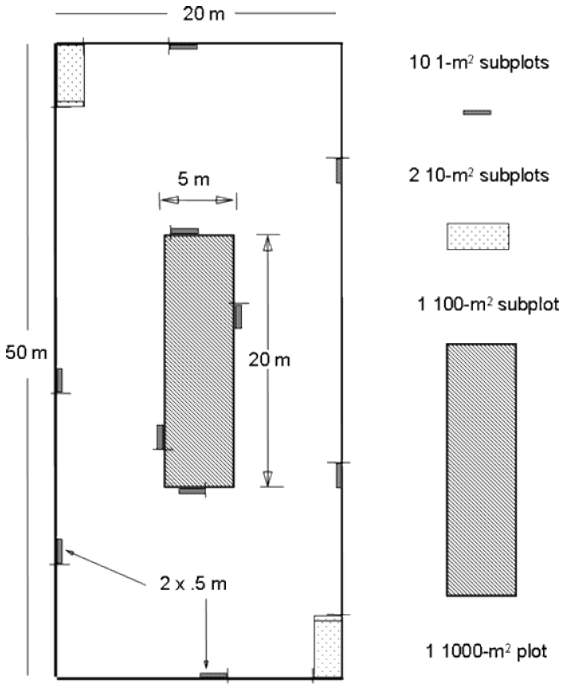


Figure A3.1: Modified-Whittaker Plot set up

Transects

In areas without the natural stratification of a forest, transects were used instead of Modified-Whittaker Plots. Transects are ideal in prairies, emergent marshes, sedge meadows, and other ecotypes without extensive tree cover. For this report, two sets of transects were set up at the Main Site, one at Harris Prairie, and one at Pitsfield Banding Station.

For each data site, where possible, three parallel 100 meter transects were set up 25 meters apart using 100 meter transect tape. Full plant species inventories were performed along the entire length of the transects, including individuals directly and partially under the transect tape. More detailed percent coverage data was taken for each species present in a 1 m^2 PVC frame every 10 meters along each transect.

Floristic Quality Index

The Floristic Quality Assessment (FQA) was developed by the Natural Heritage Program of the MDNR.[272] Given a list of plant species, the FQA allows the user to calculate the mean coefficient of conservatism (C) and the floristic quality index (FQI) for the flora of the site. The coefficient of conservatism, a number between 0 and 10, "is applied to a plant based upon its fidelity to a presettlement landscape, not its rarity or legal status", where a 10 indicates a plant found only in undisturbed habitats (e.g., old growth), and a 0 indicates a plant that could be found even in the most disturbed sites (e.g., recently tilled ground).

[272] Herman KD, Masters LA, Penskar MR, Reznicek AA, Wilhelm GS, Brodovich WW, Gardiner KP. Floristic quality assessment with wetland categories and examples of computer applications for the State of Michigan-revised, 2nd edition. Lansing (MI): Michigan Department of Natural Resources (US); 2001.

The fieldwork performed in summer 2015 resulted in species inventories for many compartments across the Kalamazoo Nature Center's properties. Using the Michigan Flora website, coefficients of conservatism were identified for all the species found at each site. Some plant specimens could not be identified to the species level (including some grasses and sedges) and were excluded from the calculations.

In order to calculate the FQI, the inventory for a specific site needs to be cleaned so that a given species only appears once in the calculations (for the transect data, the inventory for each of the three transects was recorded separately, so a given species could appear up to three times on a site inventory). Then, the sum of the coefficient of conservatism values for all species found on that site (C) is divided by the square root of the number of species found on the site (N):

$$FQI = C / \sqrt{N}$$

Note: Since invasive species are treated as if they have a coefficient of 0, the FQI will always decrease if invasive species are included in the calculation (the value of N will increase if they are included while the C value stays the same).

An area with an FQI above 35 is considered floristically important, and most likely ecologically important in the state. An area with a FQI higher than 50 is highly valued and its preservation is of utmost priority. With a complete list of plants for an area, the FQA provides a means of assessing that area based on the fidelity of those plants to presettlement conditions. Therefore, the FQA is only relevant for compartments or plant communities where a conscientious effort was made to compile a complete list of plant species.

Basal Area and Relative Dominance

The basal area table (Table A3.1) below was used to estimate the basal area (m^2) of each individual tree 10+ cm DBH in all Modified-Whittaker Plots sampled during summer 2015 field work. This can then be used to find the relative abundance for each tree species. With the relative abundance metrics, it can be determined if the forest in question has an appropriate mix of tree species for the forest type.

In order to find the basal area for a specific tree, that tree's DBH is multiplied by the corresponding basal area coefficient in Table A3.1, then divided by 0.1 hectares (the size of the 1000 m^2 plot) to arrive at the correct units. To find the basal area for a given species, one just needs to sum the basal areas for each individual tree of that species. All species' basal areas within a plot can then be summed to arrive at a total basal area for the plot. Relative dominance for each species within a plot was then calculated as a simple percentage of the whole, by dividing the basal area for that species by the total basal area within the plot.

Table A3.1: Basal area coefficients corresponding with diameter at breast height

Diameter (cm)	Basal Area (m^2)	Diameter (cm)	Basal Area (m^2)
10	0.008	40	0.126
11	0.010	41	0.132
12	0.011	42	0.139
13	0.013	43	0.145
14	0.015	44	0.152
15	0.018	45	0.159
16	0.020	46	0.166
17	0.023	47	0.173
18	0.025	48	0.181
19	0.028	49	0.189
20	0.031	50	0.196
21	0.035	51	0.204
22	0.038	52	0.212
23	0.042	53	0.221
24	0.045	54	0.229
25	0.049	55	0.238
26	0.053	56	0.246
27	0.057	57	0.255
28	0.062	58	0.264
29	0.066	59	0.273
30	0.071	60	0.283
31	0.075	61	0.292
32	0.080	62	0.302
33	0.086	63	0.312
34	0.091	64	0.322

35	0.096	65	0.332
36	0.102	66	0.342
37	0.108	67	0.353
38	0.113	68	0.363
39	0.119	69	0.374
40	0.126	70	0.385

Appendix IV: Survey Results

This survey was administered to KNC staff in the winter of 2015 as a follow up to a similar survey administered in the winter of 2004. The goal of the survey was to identify which items the staff viewed as opportunities, challenges, strengths, and weaknesses.

The specific items in the survey are a combination of items held over from the 2004 survey (some items were removed as they have since become irrelevant), items that were added based on conversations with Ryan Koziatek, and items that came from a preliminary survey that was sent out in September 2015 to staff. These questions were then formatted into a survey in Google Forms which was sent out to an email list including all KNC staff and volunteers in November 2015.

The values below are the mean score for each item based on 28 total responses to the survey. For details on the scale of the numbers, refer to the description under each category heading.

Opportunities

KNC has many exciting opportunities to improve land management and programming. Read each statement and ask yourself, "How important is this issue to me?" Rate each statement on a scale of 1-5, where 1 = not important and 5 = very important.

• Increase programming at the DeLano property	3.464
• Clean the DeLano ponds for use	2.607
• Make Batts Creek more accessible to visitors	2.815
• Increase habitat management along the Kalamazoo River floodplain	3.607
• Manage strategically for diverse habitats	4.429
• Diversify long-term ecological research	3.929
• Expand the trail system in the Arboretum	2.393
• Improve river access for canoes	3.143
• Create a maintenance schedule for the trail system	4.036
• Improve visitor access to raptor mews	3.357
• Enhance KNC's grounds to provide an ever-changing, new experience	3.821
• Foster stronger neighborhood relationships	3.679
• Use the horse barn on Copper Tree Farm	2.607
• Improve readability of trail markers and trail map	4.214
• Re-purpose agricultural land currently used for corn, soybeans, and hay	3.536
• Increase programming about the Kalamazoo River	4.179
• Increase trout management along Batts Creek	3.286
• Improve habitat for Massassauga rattlesnake and other rare species	4.107
• Manage land for sugar maple trees near Sugar Shack	3.821
• Engage in long-term invasive species control	4.464
• Build more funding into the general operating budget	4.519

• Produce an accessible land management plan	4.111
• Collect rare and special forb species to be propagated and grown on KNC property	3.500
• Develop property and programming at Urban Nature Park	4.250
• Develop property and programming at the new West Fork Campus	3.786

Challenges

KNC faces different kinds of resource challenges. Read each statement and ask yourself, "How important is this issue to me?" Rate each statement on a scale of 1-5, where 1 = not important and 5 = very important.

• Effect of ecological succession in gravel pit on educational opportunities	3.036
• Uncontrolled spread of invasive plant and animal species	4.321
• Uncontrolled spread of native species, like turkey and deer	3.893
• Loss of surrounding habitat due to regional development	4.179
• Foraging, poaching, and other violations of KNC's no-take ethics	3.536
• Degradation of the Batts Creek watershed	3.607
• Lack of a property-wide stormwater management plan	3.750
• Modern cultural impacts on KNC mission and programming	3.714
• Anticipated and unknown changes due to climate change	3.929
• Insufficient long-term funding for existing programs and projects	4.393
• Lack of erosion control on trails and roads	4.036
• Insufficient staff to maintain both trails and invasive species control programs	4.393

Strengths

KNC stands as a leader in the field of environmental education. Read the following statements about KNC's strengths and ask yourself, "How much do I value these existing aspects of KNC?" Rate each statement on a scale of 1-5, where 1 = not very much and 5 = a lot.

• The ecological and educational value of our restored prairie habitat	4.593
• Having a variety of diverse habitats represented across the property	4.852
• Owning the complete Trout Run watershed	4.250
• Offering butterfly and hummingbird gardens as a good introduction to nature	3.929
• Ephemeral ponds in Pioneer Woods	3.643
• Offering yoga and art programs in the woods	3.143
• The ecological and educational value of our beech-maple climax forest	4.464
• Preserving the river floodplain	4.333

• Access to the Arboretum	2.929
• Having a large, contiguous protected area	4.679
• Having resources and human power for stewardship and education	4.643
• The ability to think about KNC's future and direction	4.630
• Having two miles of Kalamazoo River frontage	4.286
• Facilitating meaningful public access to high quality natural areas while minimizing the extent of our impacts	4.607

Concerns

Inevitably, KNC's land management and programming strategy has its drawbacks. Read the following statements about current concerns regarding KNC's land management and programming strategy. Ask yourself, "How much do I worry about these aspects of KNC?" Rate each statement on a scale of 1-5, where 1 = not very much and 5 = a lot.

• Not enough prairie habitat	2.536
• Old trash piles of farm debris	2.714
• Too many obviously disturbed areas	2.964
• Poor handicap access to the Habitat Haven trail	3.571
• Too much mowed area	3.821
• Limited long-term funding for land management	4.143
• Lack of trails in high-quality areas	2.964
• Trail markings and maps that aren't designed for easy use by the color-blind	2.750
• Insufficient management of invasive plants	3.536
• Lack of erosion control	3.679
• Too much impermeable surface	2.929
• Insufficient maintenance of old-growth and native habitat areas	3.250
• Educational programs tending to attract more attention and funding than stewardship	3.000
• Insufficient staff to maintain existing properties, let alone newly added ones	4.259
• Ineffective use of certain natural areas made inaccessible by invasive undergrowth	3.407
• Assuring continued, sustainable funding for land management work	4.179
• Inability to keep up with the demands of natural area management	3.889
• Failure to prioritize ecosystem integrity over more immediate (but not necessarily more important) tasks	3.679

Appendix V: Erosion Risk at the Main Site

To study the risk of erosion at the main property of the Kalamazoo Nature Center, the Revised Universal Soil Loss Equation (RUSLE) was used.[273] This equation estimates the soil loss due to erosion based on 6 factors, following this equation:

A = R x K x L x S x C x P

In this equation, **A** is the estimated annual soil loss due to erosion, measured in tons per acre per year. **R** represents the rainfall-runoff erosivity factor and is a measure of precipitation. **K** represents the soil erodibility factor, where higher values are susceptible to erosion (high silt soils have high K, high sand or clay soils have lower K values). **L** represents the slope length factor and **S** represents the slope steepness factor. Soil erodibility increases as the steepness increases and the slope length gets longer. **C** represents the cover-management factor and is a measure of how landcover and land management practices affect erosion. Natural areas will have a lower C value, while more disturbed areas (such as farmland) will have higher levels of C. **P** represents the support practice factor and reflects the impact of erosion mitigation practices.

For this project, the equation was reduced to the following:

A = K x LS x C

The R factor was taken out of the equation because it is assumed that precipitation is consistent across the extent of the main property. The P factor was also removed, as it is tied more to the agricultural roots of the equation, with factors based on practices such as contouring and stripcropping. These practices are not relevant across much of the property, but could impact the findings in the parts of the property used for agriculture. Also, the L and S factors were combined as they are calculated together using a digital elevation model. With this modified equation, the resulting A value is no longer an actual estimate of soil loss, but instead represents a range of erosion risk. Higher values of A mean that there is a higher risk of soil loss due to erosion.

K factors across the property were derived from data from the Natural Resource Conservation Service (NRCS) Web Soil Survey. This data comes from a soil survey of the Kalamazoo area completed in the 1970s. One problem encountered with this data is that it gives the gravel pit values of 0 for K. Since much of the area that was considered gravel pit then has become reclaimed, it was necessary to assign a K factor to these areas, otherwise, they would wind up with an erosion risk of zero. Based on an article by Wischmeier et al.,[274] the K factor should be reduced about 10% for soils with "stratified subsoils that include layers of small stones or gravel without a seriously impeding layer above them." So for the areas assigned as gravel pit in the 1970s, a best guess was made as to the soil type before it was used for gravel extraction, then

[273] Ouyang D. RUSLE On-Line Soil Erosion Assessment Tool [Internet]. East Lansing (MI): Michigan State University; 2002 [cited 2016 March 28]. Available from http://www.iwr.msu.edu/rusle/

[274] Wischmeier WH, Johnson CB, Cross BV. A soil erodibility nomograph for farmland and construction sites. Journal of Soil and Water Conservation. 1971; 26:189-193.

that soil type's K value was multiplied by 0.9. The soil types found on the main property and their associated K values can be seen in the table below:

Soil Symbol	Soil Description	K Factor
Gn	Glendora sandy loam	0.17
Hs	Houghton and Sebewa soils, ponded	0
KaA	Kalamazoo loam, 0 to 2 percent slopes	0.32
KaB	Kalamazoo loam, 2 to 6 percent slopes	0.32
KaC	Kalamazoo loam, 6 to 12 percent slopes	0.32
OsB	Oshtemo sandy loam, 0 to 6 percent slopes	0.17
OsC	Oshtemo sandy loam, 6 to 12 percent slopes	0.17
OsD	Oshtemo sandy loam, 12 to 18 percent slopes	0.24
OsE	Oshtemo sandy loam, 18 to 35 percent slopes	0.24
Pb	Pits, gravel	0.216/0.288
W	Water	0

C factors were derived from the results of the 2011 National Land Cover Database (NLCD), released through the USGS. This dataset is based on automated land cover classifications of satellite data. There were a few spots on the property that were misclassified, so some modifications to the original data file were made to better represent reality. The C factors are region-specific, so an SNRE practicum project using RUSLE in Minnesota was used to find appropriate factors.[275] The cultivated crops land cover type is broken into two factors since land in a corn/soy rotation is more damaging to the land. The land cover and associated C factors used can be seen in the table below:

[275] Doucet-Bëer, E. MODELING ALTERNATIVE AGRICULTURAL SCENARIOS USING RUSLE AND GIS TO DETERMINE EROSION RISK IN THE CHIPPEWA RIVER WATERSHED, MINNESOTA [Internet]. Ann Arbor (MI): University of Michigan; 2011. 87 p. Available from https://deepblue.lib.umich.edu/bitstream/handle/2027.42/88166/edoucetbeer_ms_practicum_final.pdf?sequence=1

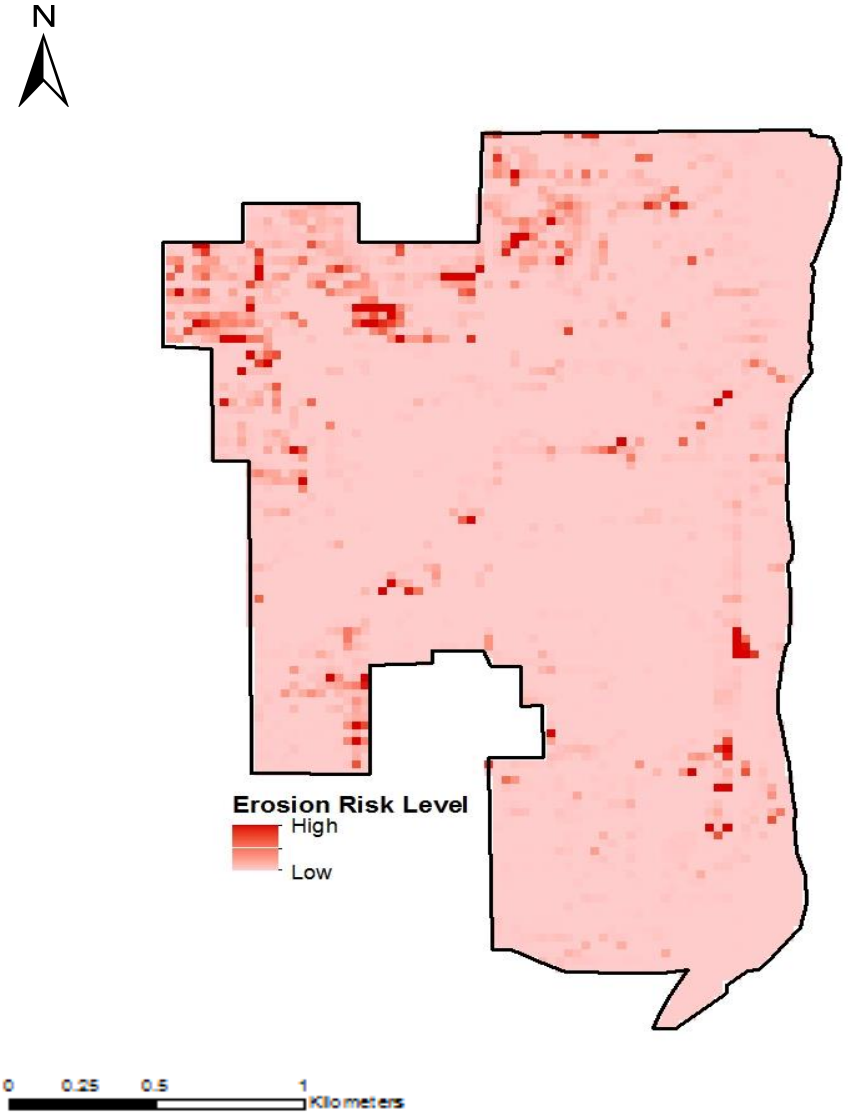
Land Cover	C Factor
Open Water	0
Developed, Open Space	0.003
Developed, Low Intensity	0
Developed, Medium Intensity	0
Developed, High Intensity	0
Barren Land	0.3
Deciduous Forest	0.002
Evergreen Forest	0.002
Mixed Forest	0.002
Shrub/Scrub	0.24
Grassland/Herbaceous	0.005
Pasture/Hay	0.05
Cultivated Crops (DeLano Farms)	0.173
Cultivated Crops (Corn/Soy Rotation)	0.24
Woody Wetlands	0.001
Emergent Herbaceous Wetlands	0.001
Open Water	0
Developed, Open Space	0.003

The LS factors were derived from a 1/3 arcsecond (~10 meters) resolution digital elevation model (DEM) retrieved from The National Map. The Unit Stream Power Erosion and Deposition (USPED) model[276] was used to calculate LS factors. Shown below are the ArcMap steps needed to come up with the LS factor raster file.

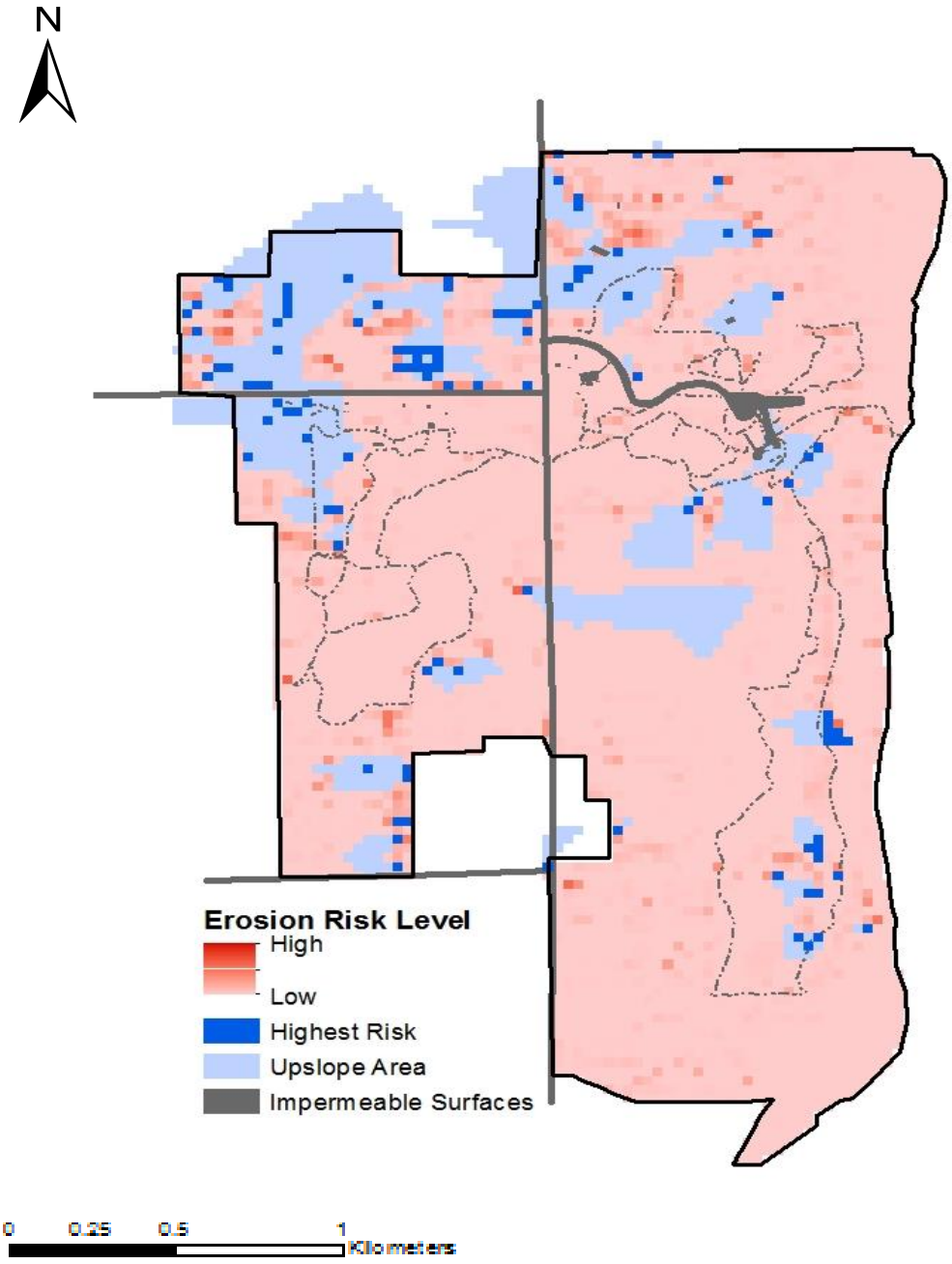
1) Downloaded DEM for entire Kalamazoo River watershed (this is useful in order to calculate accurate flow accumulation values).
2) Using the 'Fill' tool in ArcMap, filled sinks in the DEM in order to create a depressionless DEM.
3) Calculated flow direction using the 'Flow Direction' tool in ArcMap with the depressionless DEM as input.
4) Calculated flow accumulation using the 'Flow Accumulation' tool with the flow direction raster as input.
5) Calculate slope of watershed in degrees using the 'Slope' tool with the depressionless DEM as input.
6) Calculate LS factor using the following equation in the 'Raster Calculator' tool: *Power("flowacc" * 10/22.1, 0.6)*Power(Sin("sloperasterdeg" * 0.01745)/0.09, 1.3)*1.6*

[276] Pelton J, Frazier E, Pickilingis E. Calculating Slope Length Factor (LS) in the Revised Universal Soil Loss Equation (RUSLE). Boise (ID): Boise State University; 2014 [cited 2016 March 28]. Available from http://gis4geomorphology.com/wp-content/uploads/2014/05/LS-Factor-in-RUSLE-with-ArcGIS-10.x_Pelton_Frazier_Pikcilingis_2014.docx

After generating the K, C, and LS factors, each map layer was converted to a raster. Then, the 'Raster Calculator' tool in ArcMap was used to multiply the values of each layer together. This resulted in the following map, showing the erosion risk throughout the KNC main property, where darker red values mean a higher risk of erosion.



It is understood that impervious surfaces also contribute to erosion, as they provide a surface for water to travel over, leading to increased surface water flow in concentrated areas. The RUSLE model does not incorporate impervious surfaces, so a different way of viewing this risk was needed. The decided-on method was to find the areas of highest risk for erosion, and find whether any impervious surfaces were upslope (and would thus increase the surface water flow to these already at-risk areas). GIS shapefiles for the roads, buildings, and trails on the property represent the impervious surfaces. The highest risk areas on the property as the raster cells with values two standard deviations above the mean. The 'Watershed' tool in ArcMap was used to find the areas upslope of these cells. By overlaying the impervious surfaces over the high risk and upslope areas layers, it was possible to view areas where impervious surfaces might provide additional risk of erosion, as seen in the map below.


N
Erosion Risk Level
High
Low
Highest Risk
Upslope Area
Impermeable Surfaces
0
0.25
0.5
1
Kilometers

APPENDIX II: NAVIGATING THE PLANNING PROCESS

Navigating the Land Management Planning Process

Kalamazoo Nature Center,
Kalamazoo, MI
2016

About the authors:

This guide was born out of a project conducted by five graduate students at the University of Michigan School of Natural Resources and Environment (UM SNRE) in Ann Arbor, MI. In 2015, we were tasked with developing a comprehensive land management plan for the Kalamazoo Nature Center in Kalamazoo, MI. The Nature Center also asked us to generate a how-to guide that could help other organizations successfully navigate the land management planning process. This guide represents a year-and-a-half of insights gained, lessons learned, and resources used. We hope it helps ease your way!

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Navigating the Land Management Planning Process

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AN INTRODUCTION

About land management planning:

Land management planning, taken at face value, is precisely what it sounds like: the act of compiling a plan for managing a piece of land. Dig deeper, though, and you'll discover that the planning process offers an opportunity to get acquainted with your land in new ways. **A good land management plan (LMP) can direct you and your organization toward enacting a meaningful vision for your land's future**.

About this guide:

This guide aims to provide advice for everyone from a rural property owner to a stewardship officer at a large land conservancy. Every organization (if you're part of an organization at all) has different visions and needs. Every patch of land has unique features and stressors. So, naturally, every planning process and resulting LMP will look a little different.

Rather than giving you a template to fill out, **this guide walks through common steps in the planning process and invites you to think creatively about whichever avenues of inquiry are relevant to your particular situation.**

A typical planning sequence:

- Understand how your **organizational context** will shape your land management plan and its development.
- Brainstorm how you want your land to look and function in the future—your **outcome**.
- Choose which specific products or **outputs** you want the planning process to generate. These include items like maps, planting lists, or databases.
- Assemble a project **team**.
- Lay out a planning **roadmap**. As you navigate your roadmap, you'll **gather information** by digging up existing data and talking to experts. You may also **get to know your land** by conducting fieldwork.
- Assemble a list of recommended **management actions** that will guide your land toward its outcome. These recommendations will form the backbone of your written LMP.

- **Package your information** into a written plan accompanied by other outputs.
- Start **managing your land**! But the planning process needn't end there. You'll be **managing your document** too. You can build in feedback loops to assess how your management is progressing and adapt your management actions and goals as you go. You can also use your plan as a repository for fresh data, updated outputs, new perspectives, and emerging science.

Essentially, you start at the end of the process—your desired outcome—and work backwards. Your outcome will inform the outputs you'll need, which will dictate the types of information you'll gather, which will guide the way you assemble your team. At the same time, the results of your information-gathering or team-building could prompt you to re-evaluate your outputs or even your outcome. That's okay. You get to decide what makes the most sense for your project.

In fact, that's the main goal of this guide: helping you decide what makes the most sense for your project and your land. This guide will ask many questions and introduce many avenues of inquiry. Pursue the answers you find most relevant to your situation. **Stay flexible, curious, and forward-thinking, and you'll wind up with a LMP tailored to your land and reflective of your unique strengths and needs.**

LAUNCHING THE LAND MANAGEMENT PLANNING PROCESS

Understand your organizational context:

Know your organization's strengths and weaknesses

Every organization has a unique personality. **Understanding your organization's personality will be key to ensuring a smooth planning process, a realistic outcome, and meaningful management actions.**

- Assess your organization's usual way of doing things. What are some "standard operating procedures" for running projects, communicating with outside organizations, requesting funds, etc.? What organizational operating procedures might help or hinder this project?
- What, if anything, is your organization's typical approach to starting a land management project? What have you found successful about this approach? What has been frustrating or unhelpful?
- What are your organization's go-to land management procedures or tools? What existing procedures might be useful for managing this land? Which procedures might need to be modified or replaced?
- Who needs to get involved with this project? What skills or expertise would they bring to the table?
- What resources are already at your disposal, in terms of people, equipment, funds, or data?
- Who will be held accountable for successfully implementing the LMP?

Engage stakeholders

Land management planning often involves more than just you and your organization. In many cases, **people outside of your organization will rightfully want a voice in the planning process**. They could be neighbors, investors, board members, city planners, or taxpayers. Before you seek outside input, consider these questions:

- How much input and influence should each stakeholder rightfully have in the planning process?
- What tools can you use to engage their opinion?
- How can you keep them updated through the planning process?
- How might you publicize your LMP or the results of your future management actions?

Once you've decided what you want to say and what you want in return, assess various avenues for public engagement:

- Surveys and interviews
- Workshops
- Conference calls and webinars
- Town hall meetings
- Press releases
- Newsletter articles or newspaper editorials

Identify readers

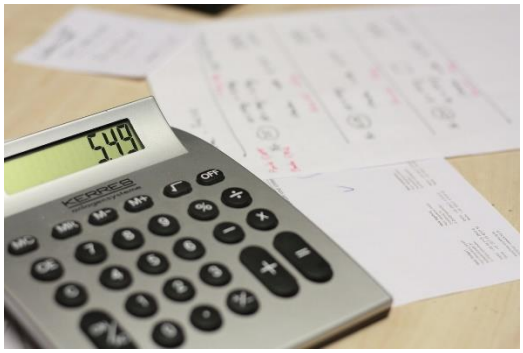
Your LMP will have one guaranteed group of readers: whoever manages your land. This might be you, others inside your organization, or outside parties. But your LMP's readership may extend farther than that. Maybe some of the stakeholders mentioned above will want to read it. Perhaps your organization will distribute it to new employees as part of their orientation training. Maybe you'll present parts of it to your county, township, or city government.

Remember that every primary and secondary reader comes from a different professional background. Not every reader received formal ecological training, recognizes botanical Latin, and understands the ins and outs of prescribed fire. Be prepared to work around jargon and unpack ecological concepts. Understanding these readers now will help you craft an accessible, usable plan down the road.

Assess budgets

Budgetary constraints will affect both the planning process and the way your plan is implemented in the future. Get a clear sense of your budget before you begin:

- How will you pay for expenses associated with planning (survey materials, staff hours, mapping software, printing costs)?
- How will you pay for expenses associated with implementing the LMP (purchasing, restoring, and/or managing your property)?
- Where might you need to hire outside contractors (graphic designers, GIS specialists)?
- Can you apply for any grant funding, either for planning or ongoing implementation?
- Could activities on your land generate revenue?



Scope out time horizons

Understand how much time you have to develop your LMP. Anticipate the arrival of certain milestones, like the beginning of the next growing season, the start of a new fiscal year, or the projected opening of a new park. Also realize that, after your plan is developed and management has begun, you may need to measure and report the success of your management actions to stakeholders, funders, supervisors, or the public. Ask questions like:

- Does your organization already own or manage your land? If not, what's the timeline for acquiring it?
- When will the next management season (usually spring) start?
- How long can you wait to see results? Do you have stakeholders who will need to see changes within a season or two? Or can you launch a ten-year rebuilding process?

Envision outcomes:

Solidify a desired outcome

If possible, brainstorm with other people who have a vested interest in the land management planning process and outcome. Recall why this land first caught your eye. Why are you still interested in it?

The Aldo Leopold Foundation suggests framing discussions around the following vision statement:

> ***"What do you want your land to look like in 10, 20, or 50 years? Where do you see your land fitting into the mosaic of your area? What role can you play in guiding your land in that direction?"***[1]

Fundamentally, you need to answer two questions:

- What **natural communities** would you like to see on this land?
- What **human activities** do you hope to encourage on this land?

The answers to these questions will become your guiding vision, or **outcome**.

Be specific and realistic

Solidifying an outcome for your land may lead to some difficult questions. It's easy to use words like "preserve" and "restore" without knowing precisely what they look like in practice. Some organizations look to pre-settlement vegetation as a baseline: using available data about habitat cover on their land before European settlers colonized the area, they work to recreate those plant and animal communities. Other organizations want to maintain whatever community types already exist on their land by limiting the spread of invasive plant species and avoiding signs of human development. Still others want to use their land for agriculture, education, or development in a way that leaves room for healthy plant and animal communities.

Your organization may already have a preferred paradigm for what to do with land once you've acquired it. Maybe not. Either way, **be prepared to flesh out, in fairly precise terms, what kinds of human, plant, and animal communities you hope will flourish on your land.**

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[1] Management plan [Internet]. Baraboo (WI): The Aldo Leopold Foundation [cited 2016 Mar 29]. Available from http://www.aldoleopold.org/WoodlandSchool/assets/papers/blank%20management%20plan.pdf

At the same time, be realistic about outcomes you may or may not be able to achieve within budgetary and time constraints. An urban brownfield site will require intense remediation before becoming a functional prairie. Beech-maple forests don't grow overnight. Understand what kinds of plants existed on your land before settlers arrived. This information is often available from your state government's natural resources office or from local universities. Also understand how the geological or hydrological features of your land might affect which types of plants and animals can thrive there.

Choose tangible outputs:

Choose primary and secondary outputs

Your primary output will be a written narrative framed around a series of recommended management actions. Figure out, in general terms, what other kinds of tangible outputs your organization wants to see at the end of the planning process. Outputs could include:

- Statement of mission, purpose, or vision
- Step-by-step maintenance guide
- Detailed survey of plants, animals, hydrology, and soils
- Record of human activity
- Prescribed burn schedule
- Glossy poster to be displayed at meetings
- Printed, bound document
- Interactive online map
- Line-item budget
- Newsletter article or blog post

A single LMP could incorporate any or all of these components. Your chosen outcome will intuitively lead you to create particular outputs. If you're trying to create a shortgrass prairie (outcome), you'll probably want a soil survey, species planting list, and prescribed burn schedule (outputs). If your primary outputs are a map and a budget, you may not need to run a full species inventory.

Different outcomes will also prompt differing levels of specificity in your outputs. For example, a large property with a small section of wetland will have different management needs than a small piece of property being transformed into a brand-new wetland. The existing wetland may just need routine surveillance for invasive species, whereas the new wetland will need detailed hydrologic maps, soil analyses, and planting plans.

Control scope

Be flexible and adapt to new ideas as they come along. You may realize as you go through the planning process that your desired outputs or outcomes are shifting. For the most part, that's fine; just let your planning roadmap shift to match. At the same time, be wary of "scope creep." In other words, don't let the process run away from you. You should always be working toward a meaningful outcome and realistic, concrete outputs.

If you find yourself biting off more than you can chew, outsource. You can often find other people or organizations better equipped to do some of your output-generating legwork. Look for contacts at local colleges and universities, land banks, conservancies, birding organizations, master landscaper or gardening clubs, landscape design firms, or watershed and riverkeeper groups.

Assemble a team:

Balance the workload

With too few people, the planning workload feels burdensome and individual team members may get burned out. With too many people, responsibility grows diffuse and the project can stray off track. **It may be best to have a core team that keeps the land management planning project on their permanent radar and who can reach out to peripheral members as needed.** Make sure the core team knows that this will be a long-term commitment. They should be willing to see it through to the end—or find themselves a competent replacement.

Not everyone must be equally involved at every stage of the project. Permanently busy people might be more effective as consultants than as core team members. People whose job duties fluctuate through the year may be more available during some seasons than others. Some will be most valuable during fieldwork. Some can be conducting interviews, handing out questionnaires, or doing online research in the background. Some may not come into play until you're ready to write or design the final product.

Seek diversity

Create a team of an appropriate size and skill composition for your project needs. Depending on your outputs, you may need mappers, database managers, botanists, ecologists, land stewards, historians, landscape architects, writers, or graphic designers.

Cast a wide net. Understand what your organization's members can and cannot do themselves, then look for outside parties to fill the gaps. As previously mentioned, look for contacts at local colleges and universities, land banks, conservancies, birding organizations, master landscaper or gardening clubs, landscape design firms, or watershed and riverkeeper groups.

Remember that many people come with hidden expertise. Maybe your organization's financial officer is also an avid birder and could help run avian surveys. Perhaps your stewardship intern has writing or graphic design skills. Explore creative ways to add expertise to your team.

Get to know each other

If possible, have your team meet face-to-face, at least once. Otherwise, schedule a conference call or video chat. Get to know each other. Outline what each person brings to the table and what they hope to gain from the process. Tease out which tasks people may or may not be comfortable participating in.

Leave room for creativity

Make time and space for your team to offer their ideas about outputs and outcomes at the beginning of the process. If they weren't part of the initial brainstorming, give their ideas weight and consideration.

Also, remember that this process isn't entirely about outputs and outcomes. Each team member should view this project as an opportunity for professional development or personal growth. Members should be able to gain new skills, connections, or responsibilities along the way.

Assign ongoing tasks

Even with a small team, it's important to assign roles for conducting regular, ongoing tasks. Responsibilities could be assigned permanently to individual members or could rotate through the team. Useful roles include:

- **Communicator**: acts as point-of-contact for stakeholders or outside organizations
- **Record-keeper**: creates and distributes agendas, takes meeting notes
- **Meeting coordinator**: sets up meeting room, orders food, keeps discussions on track
- **Financial coordinator**: stores receipts, tracks spending, updates budget

Meet regularly

Set aside a time to meet regularly. This can happen as often as your team needs it to: weekly, bi-weekly, monthly, etc. During meetings, leave time to check in with each other. Once in a while, step back from the nitty-gritty details and evaluate your progress to make sure the project is staying on track.

Meeting frequency can fluctuate as levels of project activity change; if your team has nothing to talk about, hold an informal brainstorming session, or don't meet at all. But be sure to keep momentum going by maintaining an appropriate number of meetings on the calendar.

Don't be afraid to pull some meetings out of the office. Wander around your land. Get dinner as a group. Go to breakfast. Just make sure these are productive meetings, not merely social gatherings.

Designate an information hub

Cultivate a single hub where all files and data can be accessed by all team members. If possible, **choose a server- or cloud-based hub that will consistently contain updated versions of all files**. This will help avoid the confusion of emailing overlapping drafts of documents back and forth. Some hubs include:

- Folder on a shared server
- Google Drive
- Dropbox
- Box
- Microsoft OneDrive

Google Drive is uniquely useful for team projects. This online storage service is free to anyone with a Gmail account (also free). In addition to file storage, Drive employs its own word-processing software programs, known as Google Docs, Sheets, and Slides (analogous to Microsoft Word, Excel, and PowerPoint) and a survey-design program called Forms. Google Docs, Sheets, and Slides easily convert into their equivalent Microsoft files, and vice versa. The true value of Google Drive lies in the fact that multiple users can edit a single document at the same time, with changes saved in real-time.

Consider a team charter

This isn't completely necessary, **but a written, signed procedural agreement can set up a system for effective communication and transparent decision-making.** Group dynamics are inherently difficult, especially when everyone's busy and the project is long. Even tiny, niggling complaints can wear away at team cohesion. Develop a system for conflict resolution. Perhaps everyone can agree that interpersonal conflicts will be settled through direct conversations between the aggrieved parties. The team might choose to designate a mediator outside the project who can step in as necessary. Also, decide how to decide. Will you put decisions to a vote? Will you aim to build a consensus? Must all core team members be present when a decision is made?

Finally, sign the charter. Hold team members accountable to their word. But leave room for amending the charter by group consensus.

Draw out a roadmap:

Now that your team has been assembled, it's time to draw a roadmap that will set up the next few stages in the process.

Set deadlines

Begin attaching potential deadlines to each output. **Deadlines should be both ambitious and achievable**. Looking at a calendar, walk backward from your proposed deadlines and figure out how to distribute the workload between now and then. Consider breaking up larger outputs into smaller, more manageable intermediate deadlines (finish summer plant surveys by this date, send documents to a graphic designer by this date, print maps by this date).

Assess existing tools and resources

Figure out which documents and datasets you already have access to, either in printed or electronic form. Get contact information for anyone who has connections with your land or whose expertise could inform your information-gathering strategies. If you'll be conducting fieldwork, make a list of equipment and tools you already have, can borrow, or need to purchase.

Gather outside information:

Interview people with experience or expertise

Talk to people who used to hunt on your land, who know something about frogs or prescribed burns, or who could give you the name of a great graphic designer. Take them out for coffee, set up a phone call, or perhaps exchange emails. Let them tell stories and share photographs.

Anytime you have an extended conversation with someone about your land or its management, treat the conversation like an interview. Take notes during the discussion or immediately afterward. If possible, get their permission to record the conversation on a laptop, smartphone, or voice recorder.

Read and research

Quite often, information about your land's history, current use, and plant and animal communities already exists. The trick is to find it. Universities, extension offices, state agencies, land conservancies, and nonprofits are great resources for finding fact sheets, pre-settlement vegetation data, ecological research literature, or management strategies. Check county offices, public libraries, state agencies, and universities for archival information about your site's historical ownership and use. Much of this information is available online, but you may need to sift through printed maps or books to find it all.

You may wish to conduct your own surveys of soil types, hydrology or geology. If not, federal, state, and county governments provide a wealth of this information. The USDA hosts a database of soil survey data, sorted by state and county. Look to the USGS for data at a variety of landscape scales regarding watersheds, streams, and geologic formations. Data may be available for download as tables, maps, or GIS files.

Consider ways to capture interesting tidbits that may not fit into your final plan. If managed productively, informational detours could turn into newsletter articles, blog posts, video clips, posters, additional maps, or public lectures.

Keep track of your information and data sources so you can give them credit through footnotes or reference pages in your written LMP. This will also help future readers people retrace your steps and dig into the sources themselves.

Get to know your land:

Go out and stand on the edge of your land. What do you see? What stands between your land's current state and its desired outcome? The bulk of land management planning involves digging deep into the composition of your land and evaluating its features, habitat communities, potential uses, and sources of stress. Once you understand your land, you can begin recommending specific actions for managing it.

Prepare wisely for fieldwork

This section outlines a host of fieldwork-based strategies for uncovering the characteristics of your land. Fieldwork is often time-consuming, labor-intensive, and tiring. While it's worth gaining intimate knowledge of your land, always keep your outputs in mind. Figure out what types of data—and what levels of data specificity—will help you generate your outputs. For example, if garlic mustard has become a major nuisance on your property, you might produce a map of garlic mustard hotspots and a three-year pulling schedule. In that case, your fieldwork could focus on collecting GPS points in garlic mustard patches and estimating population density.

No matter how much fieldwork you conduct, there's always more you could do. Rather than trying to collect every scrap of data now, consider turning additional fieldwork into a recommended management action in your final plan.

Also, remember that fieldwork is intrusive. Not all plants, animals, or soil types bounce back easily after being disturbed by human activity. There's an inevitable trade-off between the value of data and the value of leaving plant and animal communities alone. **Trust your instincts and be sensitive to the needs of the communities on your land.** In particularly delicate areas, aim for minimally invasive survey methods or look for similar, more robust habitats that you could survey instead.

Distinguish among surveys, inventories, maps, and monitoring

The U.S. Fish and Wildlife Service draws distinctions among various strategies for exploring the composition of a piece of land.[2] An **inventory** is a census meant to catalog all target species or features found in that location. A **survey** looks at a representative species or section of the site.

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[2] Managing invasive plants: concepts, principles, and practices--inventory/survey [Internet]. Washington, D.C.: U.S. Fish and Wildlife Service; 2009 Feb 18 [cited 2016 Apr 9]. Available from http://www.fws.gov/invasives/staffTrainingModule/assessing/inventory.html

Maps graphically display the results of an inventory or survey. **Monitoring** involves returning repeatedly to a given location and tracking compositional changes over time.

For example, a prairie inventory would catalog every plant species growing within the prairie boundaries. A survey could catalog every plant growing along a straight-line transect bisecting the prairie. A map would display the locations of rare or threatened plants found during the inventory or survey. A monitoring system would mark off individual plots within the prairie, which would be inventoried repeatedly over months or years.

For the most part, this guide uses "survey" to describe most cataloging efforts. Unless your property is small, you won't likely be able conduct an exhaustive inventory of every plant, animal, or insect species. So a survey, where you deeply investigate a particular plot, transect, or species, will probably more feasible.

Assess human features

In all likelihood, your land was occupied by humans at some point. What evidence of human activity is still present on the site? Is there anything you might want to keep, such as a parking lot, driveway, fence, building, trail, or garden? What's present that you might need to remove, such as garbage piles (buried or on the surface), buildings, asphalt, concrete, or gravel? These details can all be codified into management actions in your final LMP.

As you consider removing elements of human activity, remember that the act of removal will be a disturbance in and of itself. **Make sure that any removal actions you recommend will enhance the property in the long run.** Also, aim to keep as much debris out of landfills as possible. Specify management actions that help your organization reuse, recycle, or donate materials.

Gauge aquatic health

Consider testing the health of any ponds, wetlands, rivers, streams, or lakes on your land. Compare your results against state water quality standards and use them as baselines for repeated testing. Your sampling efforts could include:

- **Physical parameters:** temperature, dissolved oxygen, pH, stream flow, lake depth.
- **Bacterial loads:** usually *E. coli*, whose population levels can indicate whether or not a water body is safe for human use.
- **Benthic macroinvertebrates:** insects or other sediment-dwelling creatures that act as indicators of habitat quality.

Get acquainted with natural features

Your land hosts a complex network of living creatures: plants, animals, insects, fungi, and microbes. How much effort you put into cataloging and identifying each of these features will be up to you. **If you can't inventory every living thing in every habitat, pick the portions that are the most interesting, most diverse, most threatened, or least understood.**

Remember: it's valuable to understand these features before developing management actions for your plan. But don't be afraid to take some of the fieldwork out of the planning stage and put it into your management actions as recommendations for future research.

For your own fieldwork, decide on the level of detail you want your surveys to detect. If you're mostly concerned about identifying the tree species on a small piece of property, an informal walkabout may suffice. If you want to catalog every species, from trees to birds to insects, you'll need a robust surveillance strategy and a stable of experts at your disposal.

No matter which level of detail you choose, **consider inviting experts to help**. Reach out to local colleges or university extensions for potential contacts. If you want to understand your property's fungi, ask for a mycologist. Assemble a team of avid birders to patrol your property once a week throughout the year and send you their findings. A visit from an entomologist or herpetologist could provide valuable insights into existing and potential insect, reptile, or amphibian habitats.

Some potential survey methods include:

- **Transect**: a species survey run along a straight line; ideal for relatively flat habitats.
- **Plot**: a species survey conducted within a box; ideal for relatively homogenous habitats.
- **Modified-Whittaker Plot**: a species survey conducted within a nested series of boxes; ideal for habitats with varied vegetation height. For detailed instructions, follow the link in this footnote.[3]
- **BioBlitz**: an intensive species inventory conducted during a specific, brief period of time (usually 24 hours) by volunteers from the community; ideal for creating educational opportunities for students and families.

[3] Modified-Whittaker [Internet]. National Institute of Invasive Species Science; 2016 Apr 1 [cited 2016 Apr 10]. Available from http://www.niiss.org/WebContent/cwis438/download_files/ModWhit.pdf

- **Informal walkabout**: a casual tally of species and other features encountered during a walk through the land; ideal for detecting patterns, anomalies, or sources of stress.
- **Satellite imagery or aerial photographs**: a bird's-eye view of the land which can reveal habitat types based on variations in vegetative cover.
- **Motion-capture camera traps**: a stream of photographs snapped by motion-activated cameras placed in areas where animals are known or suspected to live; ideal for larger mammals in places with little to no human traffic.
- **Bird calling:** a method for detecting the presence of particular bird species by mimicking or playing back their calls.
- **Banding/capture-recapture:** a system of gently capturing targeted animal species, marking them with an identification tag (ear tag, leg band, radio collar, etc.), and releasing them, with the potential for recapture; ideal for larger organizations with resources and time to run a capture-recapture program across multiple years or in different locations.

Many survey methods can be adapted to detect either plant or animal species. For example, transects can be used to tally oak trees, grasshoppers, or squirrels. However, a single transect shouldn't be used to survey all three at the same time. Divide and conquer. Some methods, like Modified-Whittaker plots, are designed specifically for plants. Others, like camera traps and bird calling, are clearly designed for animals. Once you know what kinds of natural features you want to catalog, research the best survey designs for those particular features.

Aim to run at least one survey in each habitat type found on your land. Try breaking the property into habitat compartments, quadrants, or logical transect lines. Again, do some triage: focus survey efforts on the most interesting or least understood regions or species.

If possible, **repeat your surveys at different points through the field season** to capture species at various parts of their growth cycles. Plants that were tricky to identify from early leaves might become instantly recognizable when they bloom later in the season. Animals may be elusive during one season and ubiquitous during another. Try to survey at least once in the spring (April or May, depending on your growing region), once in mid-summer (July), and once in late summer or early fall (August or September). Schedule wildlife surveys during the animals' most active periods (mating or migration season, day vs. night, etc.).

Run species calculations

Species surveys can yield much more beyond inventory lists. Find ways to dig deeper with your data. Some animal surveys can generate information about age, weight, sex, and overall health. Many plant and animal surveys can lead to calculating species abundance or density. Predict which

calculations you might run, then collect data that would best inform those calculations. Keep thorough records and be complete.

Some examples of potential calculations include:

- **Density**: the number of individuals per unit area; for example, 5 white-tailed deer in 1 square mile.
- **Frequency**: out of the total number of points sampled, how many sampling points contained the species in question; for example, finding squirrels at 10 of 15 sampling points.
- **Basal area**: the area taken up by woody plants, usually trees.
- **Floristic Quality Index**: a standardized measurement of a plant species' sensitivity; a plot full of highly sensitive plants indicates a high-quality, relatively undisturbed habitat.

Recommend management actions:

So, you've captured a snapshot of your land as it is right now. Now you have the opportunity to start laying the groundwork for transforming your land toward its envisioned outcome. Your **recommended management actions will provide detailed instructions for future land managers** (which may or may not include you). These recommendations will likely be geared around dictating human use of the site, encouraging sources of strength, mitigating sources of stress, or offering avenues for future investigations and updates.

Be detailed and specific

Specific, detailed recommendations are much easier to put into practice than vague generalizations. A recommendation telling land managers to "remove invasive plant species" is far less helpful than one urging them to organize a volunteer-driven garlic mustard pull focused on specific areas before a specific annual date. Consider adding priority rankings to ease future decision-making.

Describe optimal human use

Whether it's in the backwoods or downtown, people will eventually find their way onto your land—if they're not on it already. With your chosen outcome as a guide, think about how you want people to interact with your land. Consider developing recommendations about the following:

- Primary user groups you envision using your land (preschool students, dog walkers, birdwatchers, researchers)
- Secondary user groups you hope will use your land (rock climbers, mushroom hunters, triathletes)
- Activities you hope to prevent (smoking, driving motorized vehicles, nighttime access, hunting)
- Strategies for attracting desired groups or uses and dissuading undesired activities
- Restricting access to your land (gates, fences, admission fees, hours of use, boundary signs)
- Best or worst places for trails (in terms of geology, hydrology, or habitat communities)
- Best places for signs, benches, parking lots, or buildings

Reduce sources of stress

Many of your recommendations will be derived from sources of stress on your land. Recommend specific actions that combat challenges like:

- Erosion and drainage issues
- Habitat degradation on or surrounding your land that discourages native plant, animal, and insect species from becoming established
- Invasive or nonnative plant and animal species
- Poor water quality in ponds and streams
- Trespassing or damage from human activity

Encourage sources of strength

No matter what your outcome looks like, you'll want to equip your land to be strong and resilient in the face of natural or human-driven threats. Strength and resilience come from a multitude of intersecting factors, including diverse plant and animal communities, uninterrupted nutrient flows, robust soil, and adequate amounts of water and sunlight. As you develop your recommended management actions, encourage decisions that will equip your land to: [4]

- Resist or recover from long-term changes (increasing development in surrounding areas, climate change) and unexpected events (flood, fire, new disease or pest)
- Retain rare landscape elements and associated species
- Include or link up with large areas of similar habitat
- Resist the spread of invasive or nonnative plant and animal species

Keep the LMP "alive"

Consider your LMP to be a "living document." In other words, it should shift and change as your land does—or as your visions and priorities do. Build in recommendations for regularly updating and re-evaluating the LMP. Set up recommended management actions like a checklist to be crossed off or added to as management progresses. This might require an annual or semiannual review by a specific group of people. Or it might involve one person being charged with adding continual updates and revisions.

As previously mentioned, there will probably be plenty of fieldwork you simply didn't have the time or resources to accomplish before developing your plan. Consider recommending specific surveys,

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[4] Dale VH, *et al.* Ecological principles for managing land use [Internet]. Washington, DC: The Ecological Society of America; 2000 Jun 1 [cited 2016 Mar 26]. Available from http://www.esa.org/esa/science/reports/managing-land-use/

inventories, or avenues for research. The results can be rolled back into the LMP itself, a feature of its status as a "living document."

Outline measures of success

For each recommended management action, think about ways to measure its success, whatever "success" might mean. This could be as simple as checking a box to indicate that the action was taken, that the trail was built or the maple trees were planted.

But consider deeper and more specific ways to measure success. Since the trail's construction, how many people use it per week? How often should land managers walk the trail to make sure it is free from potholes and dropped branches? Will the maple trees still be thriving five years after their installation?

Look for numerical ways to measure success, such as rising floristic quality indices, decreases in stream bacterial counts, or results from yearly butterfly surveys. Plan for repeated surveys or inventories to gauge how a habitat's composition is improving. These can provide concrete evidence that your management actions are working, which can in turn draw interest—and potentially funds—from stakeholders inside or outside your organization.

On the other hand, **measures of success help demonstrate if management actions *aren't* working**. At that point, the land's managers will need to re-evaluate their actions and potentially choose a different course—which can then be codified in the living LMP.

Package information into primary and secondary outputs:

At this point, most of the legwork is done. You understand the context and current state of your land. You've set concrete, specific recommendations for bringing your land toward its desired outcome. Now, start transforming those insights into your chosen outputs. **Your primary output will be your written plan**, which could include sections about history of use, landscape context, management tools, inventory results, and recommended management actions.

In addition to the written plan, as mentioned before, the rest of your outputs can include anything from maps to prescribed burn schedules to soil survey results to budgets. As you assemble your outputs, **make sure every component would be clearly understandable to someone brand-new to your land**. Remember your primary and secondary readers and use your best judgment in choosing how to present information in ways that a variety of readers will be able to grasp. Use a few extra words or sentences to unpack ecological concepts and management tools; avoid jargon.

Use mapping software

ArcGIS and other mapping software provide powerful tools for visualizing data. These programs hold your data in manipulable forms, allowing you to update maps or migrate pieces of data into other formats. However, the software is expensive and can have a steep learning curve. If your team doesn't include someone with GIS or mapping skills, consider contracting with an external specialist or talking with faculty at a local college or university. You can also opt for free, open source software like QGIS.

Plan for data storage and delivery

Be courteous to others who will use your files down the road. Use the folder and file names to clearly state both content and date of creation or finalization. Be careful to choose a data storage method that future land managers can easily update. Whenever possible, keep electronic records of your data and how and when you collected it (details known as "metadata"). Consider putting survey and inventory data into spreadsheets and including a separate metadata document.

Specify print vs. electronic distribution

Keep in mind that some of your outputs will be designed for printing and others will remain electronic. Make sure that printable maps and images have sufficiently high resolution to print without looking grainy. Embedded links are fabulous ways to direct readers to specific websites or files, but only if the file is designed to be distributed electronically.

Start managing your land!

With fieldwork and research in the rearview mirror and your written plan and outputs in hand, it's time to start managing! Launch into your own recommendations, or hand the LMP off to the land's managers. But remember: the planning process shouldn't end when your plan is complete.

Keep managing the LMP

Your measures of success will act as feedback loops that assess how management is progressing. Adapt your management actions and goals accordingly. Use your plan as a repository for fresh data, updated outputs, new perspectives, and emerging science. Check off completed management actions and add new ones to the list. Schedule a major overhaul in 10-15 years. If you achieve your outcome, fantastic! Set a fresh vision and forge ahead.