

Evaluation and Adaptive Management of the Huron River Watershed Council Natural Areas Assessment and Protection Project



By

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Executive Summary

Problem Statement

Natural areas are critical to ecosystem resilience and ecosystem services, including water quality, but many are threatened by development, fragmentation, and habitat degradation. The Natural Areas Assessment and Protection Program (NAAP) was created in 2006 by the Huron River Watershed Council to map and assess the natural areas in the Huron River watershed of southeastern Michigan. The program shares both GIS and field-based data with decision-makers to inform the prioritization and management of areas with the highest ecological integrity. However, since the program's inception it has not undergone a thorough review. We systematically assessed and provided improvements for three main areas of the program: 1) Ecological integrity assessment, 2) Data management and integration, and 3) Engagement and impact.

Ecological Integrity Assessment

We compared NAAP's approach and its metrics for assessing ecological integrity with current conceptual perspectives on integrity and with other widely used assessment programs. We found that NAAP is in line with best practices, but also identified the following possible areas of improvement:

1. *Landscape*: Develop landscape context and buffer metrics similar to those in the reviewed state-based programs and integrate Bioreserve Map and field assessment levels to allow for better understanding and analysis of landscape-level trends.
2. *Soil*: Continue to assess soil at the rapid level and include relevant soil information collected from geospatial levels for additional context.
3. *Species*: Formally review and establish criteria for which individual plant species should contribute toward the integrity and disturbance scores, and which new "focal" species could be included in data collection for educational purposes but remain unscored.
4. *Additional non-ecological variables*: Include county-level GIS data on the zoning status of the sites being assessed, and possibly other social or demographic variables that could inform decision-making.
5. *Reporting*: Attach an ABCD or Stoplight System to integrity scores in order to increase the ease with which others can interpret relative score quality.
6. *Education*: Continue and expand the use of rapid field assessment training, data collection, and reports as opportunities for educating others about ecological integrity concepts.
7. *Future research*: Make a direct field comparison of NAAP and MiRAM ecological integrity assessments by determining scores of the same site.

Data Management & Integration

We evaluated NAAP's current data workflow and proposed a new workflow and recommendations to address challenges in three main areas: 1) data collection, 2) data management, and 3) data visualization. These challenges limited NAAP's desired integration of field assessment data with the Bioreserve Map. We researched and implemented the following solutions:

1. Assembled a spatial layer in ArcGIS to allow site-based field assessment data to be integrated with Bioreserve Map geospatial data.
2. Created a Survey123 form to facilitate collection & automatic entry of field assessment data into an ArcGIS file geodatabase.
3. Designed a dashboard and web map in ArcGIS Online to customize data viewing and sharing.

These solutions offer a new workflow for the program that reduces staff labor, streamlines the process of visualizing the data in GIS, and extends the impact of the program by augmenting data analysis and sharing possibilities. As key next steps we recommend:

1. Train staff and volunteers to use new data workflow (especially Survey123).
2. Follow consistent data quality checks and data creation practices.
3. Enhance reporting using Survey123 Feature Reports & findings from interviews and surveys.
4. Update the Bioreserve Map layer to reflect the current state of the watershed's natural areas.

Engagement and Impact

Given that the purpose of NAAP is to inform decision-making, we conducted surveys and interviews to evaluate the engagement, access, accuracy, and impact of NAAP and its products. Our recommendations for program improvement are based on user feedback from three key respondent groups: landowners, who own properties that have been assessed; stakeholders, who use NAAP data for land protection decisions; and volunteers, who help conduct NAAP field assessments.

Our most important recommendations for HRWC are:

1. Increase field assessment accuracy and volunteer confidence by providing a more robust training curriculum for volunteers and by having volunteers collect data with the Survey123 app, which includes built-in photos and support material to assist in data collection.
2. Include a glossary of ecosystem terminology and rank scores and sites from poor to excellent to improve user understanding of field assessment reports.
3. Provide landowners with instructions for next steps to take after having a field assessment done and provide contacts for organizations that can help with next steps in order to increase the long-term impact of NAAP.
4. Provide ongoing and independent access for landowners and stakeholders to NAAP data, possibly by adding a page on the HRWC website that provides user-specific access to field assessments as well as access to frequently updated Bioreserve Map PDF and shapefiles.

The Future of NAAP

Overall, our approach to evaluating NAAP brought to light how well this program conforms with best practice, has accumulated valuable data, and impacts landscape-scale conservation planning. It also allowed us to make recommendations and even implement changes to the operations of NAAP across the three program areas addressed. For example, as staff begin to use the new data management system to automatically generate user-tailored reports, they can incorporate our recommendations to better inform decision-makers about sites. Together these recommendations will increase the efficiency, accuracy, usability and long-term viability of this important natural area protection effort.

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Chapter 1: Natural Areas Assessment Program Background and Project Goals

Introduction

Natural areas are landscapes like forests, prairies, and wetlands; spaces where the ecological processes that maintain air, water, and soil quality can function undisturbed by human activity (Weber and Wolf, 2000). Due to their lesser disturbance, natural areas retain their historical function and provide critical ecosystem services, such as air and water filtration, nutrient cycling, biodiversity, food and lumber, and recreation, among many others (Costanza et al., 1998). Preserving large, contiguous expanses of natural areas is an effective way to protect naturally occurring, large-scale green infrastructure and all the ecosystem services it produces (Weber and Wolf 2000). For example, protecting wetlands as green infrastructure is a common management focus for increasing water quality because of the water purification ecosystem services wetlands provide (Grizzetti et al., 2016; Randhir et al., 2001).

Because human activity and land use conversion are contributing to the loss and degradation of natural areas, there is a need to protect natural areas and all the benefits that they provide (Snäll et al., 2016). Habitat fragmentation, habitat loss, and invasive species are consequences of human activity that threaten natural areas, and these threats are increasing due to climate change and continued development (Abell, Allan, and Lehner, 2007; Brockerhoff et al., 2017). However, due to limited economic resources and human demand, only some natural areas can be preserved. Certain natural areas must be designated for protection based on prioritization criteria in order to best inform land use planning (Margules, Pressey, and Williams, 2002).

The process for prioritizing natural areas for preservation requires the systematic collection of data on certain variables representing ecological integrity and the potential of the land to provide ecosystem services (Faber-Langendoen et al., 2019). Common variables include indicator species, functional groups, land cover type and vegetation, and soil conditions (Carignan and Villard, 2002; Langemeyer et al., 2016). The specific variables chosen for prioritization assessments often vary based on the unique site and scale of different landscapes. However, the main goal for selecting variables is to choose those that are the most indicative of the state of the ecosystem in question (Faber-Langendoen et al., 2019).

In addition to choosing variables of interest, prioritization requires processes to weigh these data in order to arrive at priority scores. Although there are many different methods, some common features of land prioritization assessments include ranking the relative importance of different areas based on variables of choice and having a concrete definition of the ecosystem service being protected (Lindenmayer et al., 2008; Lovejoy, 1997). This allows natural areas to be systematically ranked as higher or lower priority for protection based on organization-specific goals. Ecological integrity assessments use metrics such as land cover and vegetation type to create weighted scorecards that prioritize areas with healthy ecological functions (Comer and Faber-Langendoen, 2013). Other methods suggest prioritizing land areas based specifically on biodiversity data, collected by rapid field assessment (Margules, Pressey, and Williams, 2002). In a multi-criteria decision analysis approach, policy implementation can be guided by using weights to determine the importance of specific criteria on land prioritization. This approach emphasizes the importance of stakeholder equity in determining land-use and weighting criteria (Langemeyer et al., 2016).

Although there are many examples of land assessments available for reference, many implementation challenges remain. One major challenge is understanding how to select the best variables to use in decision-making. In order to increase the efficiency and accuracy of land assessments, a reliable method is needed to identify variables that are economically feasible, easy to collect data on, and strongly indicative of the topic of interest (Faber-Langendoen et al., 2019). Another significant challenge is determining the most effective and cost-efficient process for ranking natural areas based on these variables. Additional challenges include site-specific feasibility of land acquisition, public and stakeholder involvement, and allocation of resources (Margules, Pressey, and Williams, 2002). For example, conflicting stakeholder values can slow land prioritization processes. Contacting stakeholders early in the process can ensure participation in decision-making and increase awareness of trade-offs, thereby reaching a consensus on priority areas (Dendoncker et al., 2013).

The Huron River Watershed Council's Natural Areas and Assessment Program (NAAP) has been assessing ecological integrity in the watershed and sharing this information with stakeholders to inform land protection prioritization since 2006. This program faces many of the challenges of assessment and prioritization described above. As the program enters its 15th year, the Huron River Watershed Council (HRWC) needs a thorough evaluation of the program's data, operations, and impacts to improve its efficiency and efficacy towards achieving its goals.

Overview of the Huron River Watershed and the Activities of HRWC

The Huron River watershed in southeastern Michigan encompasses more than 900 square miles, with its many streams and tributaries draining into the Huron River. The Huron River flows for 125 miles, with the main stem starting in Big Lake near Pontiac before draining into Lake Erie. Seven counties fall within the river's drainage area: Oakland, Livingston, Monroe, Jackson, Ingham, Washtenaw, and Wayne (Figure 1.1). Collectively, these counties include approximately 650,000 residents and 63 municipal governments. The land use in this area is varied, split about evenly between agriculture, urban and developed areas, and forested and natural areas (Figure 1.2). Fragmentation of natural areas (largely due to increasing urban sprawl) in the region has increased in recent years and presents a large threat to the health of its ecosystems (Gounaridis et al., 2020).

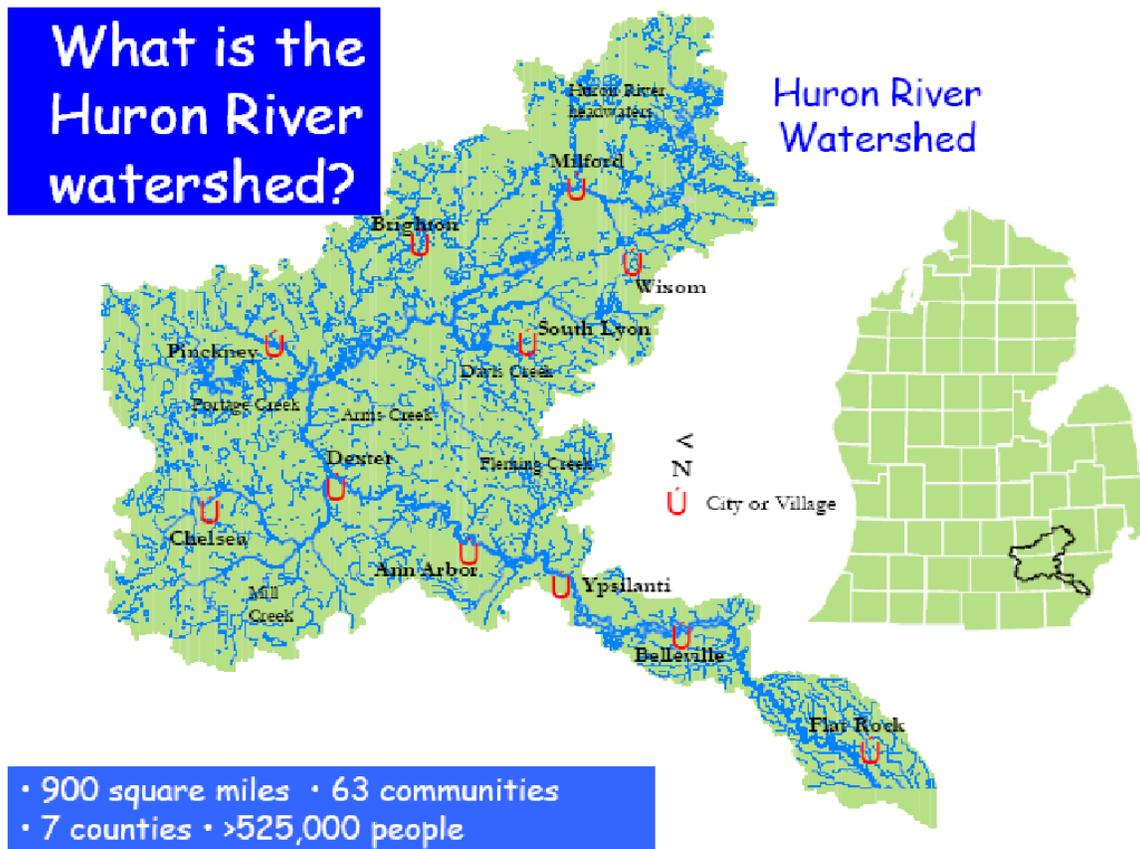


Figure 1.1: A map of the watershed and its major municipalities (Olsson, 2020).

The Huron River is considered to be one of the cleanest urban rivers in Michigan, although this was not always the case. Throughout the 1950s, suburban development and pollution highly degraded the river's quality. This crisis led to a water quality study managed by the Washtenaw County Planning Department, which, in 1957, recommended an agency be established to monitor the Huron River on a regular basis. In April 1958, after a year of discussion, consultation, and research, the Huron River Watershed Intergovernmental Committee (HRWIC) was formed to continually study the use and pollution of the Huron River. Four counties, eight cities and villages, and twenty townships joined.

The studies supported by HRWIC contributed to an improved understanding of the river's water quality and sources of contamination, but the Huron River Watershed still lacked a group in charge of coordinating the projects needed to clean up the river. In 1965, seventeen local governments petitioned the Water Resources Commission to form the Huron River Watershed Council (HRWC). The Huron River Watershed Council thus became the first watershed council in the state, and is now a nonprofit local to Ann Arbor. HRWC's work focuses on broad projects needed to maintain the health of the Huron River watershed. Defined by its mission "to protect and restore the river for healthy and vibrant communities," (Huron River Watershed Council, 2016) HRWC coordinates a wide range of programs to *study*, *restore*, and *protect* the watershed and to *connect* people and communities to the river. Within HRWC's team, scientists and volunteers focus on studying and analyzing the health of the watershed,

organizers work within the community to raise awareness and foster engagement, and policy experts work with authorities to create and push policy proposals crucial to the watershed's health.

HRWC's five program areas, outlined in their most recent [5-year Strategic Plan](#), are (Huron River Watershed Council, 2016):

1. *Engagement and Relationships* – Engage a diverse and inclusive group of partners and establish relationships to advance programs and policies.
2. *Science* – Collect and use scientific information to gauge the health of the watershed, direct programmatic priorities, and advance protection and restoration efforts.
3. *Advocacy and Implementation* – Set our watershed agenda and advance policies and projects at all levels of governments and with a range of partners.
4. *Communications* – Raise awareness of the river and watershed while advancing our program goals.
5. *Fundraising and Organization Foundation* – Develop strong relationships and systems to secure resources that accomplish HRWC's core mission.

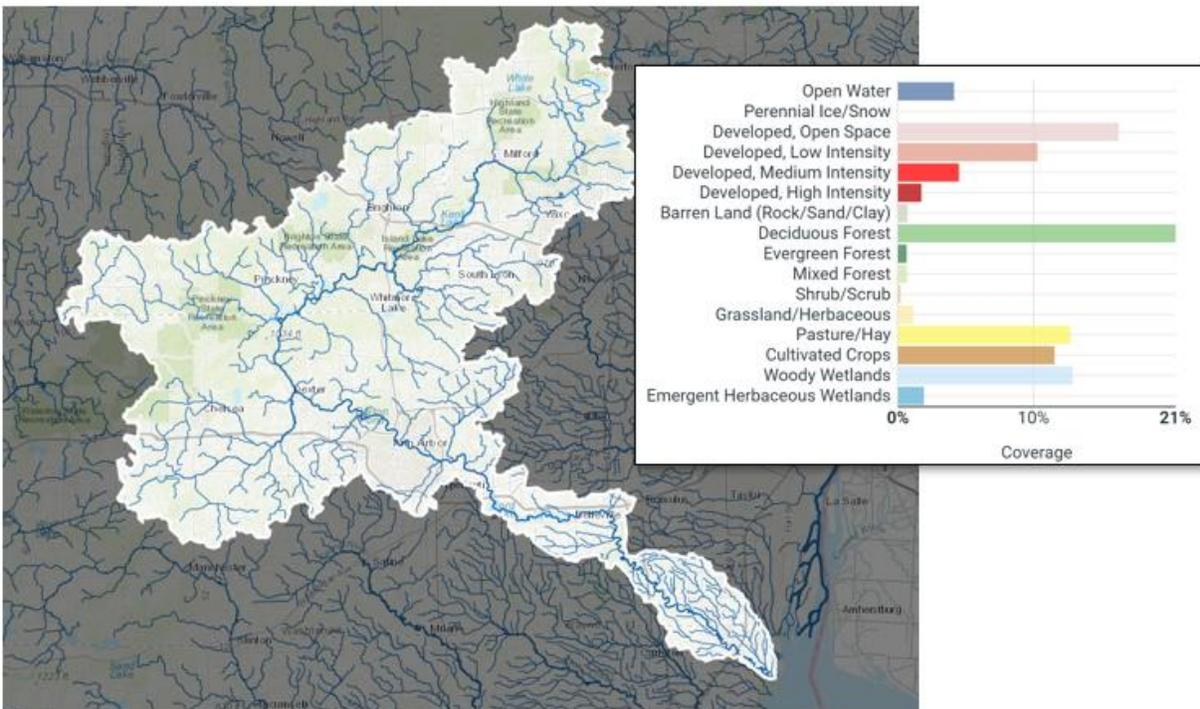


Figure 1.2: Boundaries and tributaries of the Huron River watershed (HUC 8) and land cover data from the [Model My Watershed](#) tool. Land cover graphic was created by the Model My Watershed tool using National Land Cover Dataset (NLCD) data from 2011.

The watershed's geology, as well as that of the rest of the upper Midwest, is largely defined by the glaciation that occurred during the Wisconsin stage of glacial activity of the Pleistocene epoch. The watershed is heavily influenced by the advance and later retreat of the Laurentide ice sheet. As it began its retreat around 15,000 years ago, it deposited sediment in the form of silt, clay, gravel, and sand in

ridges called end moraines. Glaciation's effects on the landscape allowed many diverse soil types to form, which today support many different ecosystems in the watershed (Figure 1.3). Prior to European settlement of the area, the watershed was primarily dominated by hardwood forests, varying from the predominant Oak-Hickory forest composition to other predominantly oak forest mixtures (MNFI, 2020), including oak barrens, prairies, wooded wetlands, and lake plain prairies.

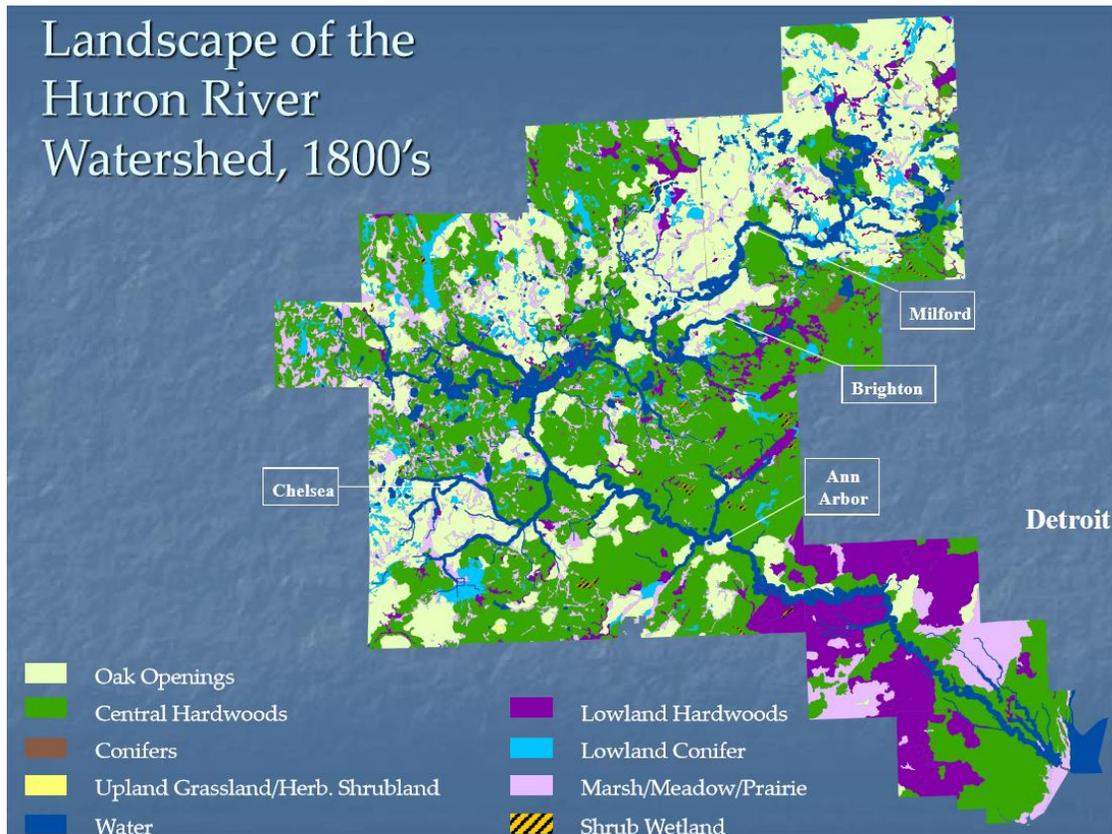


Figure 1.3: Watershed landscape prior to extensive settlement (Olsson, 2020).

In recent decades, the watershed has seen an advancement of suburban sprawl, and lands formerly characterized by other features have become defined by fragmentation and habitat loss due to development or other land use. Many local individuals and organizations have responded to the encroachment of development by organizing for the conservation of natural areas in the region. In Washtenaw County alone, 3,438 acres of land have been protected since 2001 by the Washtenaw County Natural Areas Preservation Program (NAPP), where the land was purchased by NAPP funds and is preserved by the Washtenaw County Parks and Recreation. But at the same time, many local government Master Plans and Zoning Ordinance build outs had little designated natural area to ensure long-term protection, and land protection organizations still needed to prioritize their efforts.

In response to these needs, HRWC developed the [Natural Areas Assessment Program \(NAAP\)](#). The aim of NAAP is to rank the value of the remaining natural areas in the watershed in terms of ecological integrity and restorability, and to provide access to this information so that governments, conservancies, and landowners can make informed decisions for protection and restoration of these lands.

There are two different but related components to NAAP: the Bioreserve Map and the rapid ecological field assessments. In 2006, HRWC developed the [Bioreserve Map](#), which identifies the natural areas across the whole watershed with the highest ecological value (Appendix A). The map was created by using aerial photographs taken over five counties (Oakland, Livingston, Wayne, Washtenaw, and Monroe), and drawing boundaries around what could be identified as woodland, wetland, or open field. This resulted in 1,700 sites, totaling 247,000 acres, which is approximately one-quarter the total area of the watershed (Olsson, 2020). To further refine the prioritization of these sites, HRWC collaborated with students in the School for Environment and Sustainability at the University of Michigan (known then as the School of Natural Resources and Environment) to develop a computerized model to rank each of those sites as high, medium, or low priority for protection. Ranks were based on available GIS data including size and connectivity of the area, presence of water features related to water quality and supply, diversity of geology and topography (as proxies for potential biodiversity), and overlap with historical high quality vegetation types.

In 2009, HRWC added a second layer of finer scale information to NAAP, the **rapid ecological field assessment** protocol and report (Appendix B). Based on the expert-designed Michigan Natural Features Inventory's rapid assessment method (Dorney et al., 2018), it was adjusted for use by volunteers who conduct the survey with expert oversight and minimal training. Volunteer teams conduct a two to four hour on-the-ground assessment on a site using over 30 variables including plant species present, evidence of disturbance and wildlife, and appearance of the soil and water. A weighted scoring system then uses these variables to produce an ecological integrity and disturbance score separately for each ecosystem type within a property. Field assessments are conducted on only a small portion of the ranked natural areas in the Bioreserve Map, but provide a detailed report for that area.

More than fourteen years into the program, the Bioreserve Map and field assessment reports are widely available and used by numerous stakeholders including local governments (Scio, Ann Arbor Township, Webster Township), conservancies (Legacy's strategic conservation plan, Livingston Land Conservancy's SCP), county programs (Washtenaw County Natural Areas Protection Program), and the City of Ann Arbor Greenbelt Program. The program's age and ubiquity creates an opportunity to evaluate and adaptively manage the program's work to date and address some of its identified limitations:

- Components of the Bioreserve Map could be updated with newer data sources and better integrated with assessment reports.
- The methods contained in the field assessments have not been critically reviewed nor compared to similar efforts since their formation.
- There has not been a systematic assessment of NAAP's long-term impact on natural area protection across the watershed.
- Though extensive, field data have not been analyzed or visualized to understand trends or patterns across the landscape, in large part because they are not automatically connected to the GIS data in the Bioreserve Map.

Project Goals

The purpose of this project was to evaluate and report on NAAP data, methods, and accomplishments relative to its goals, to provide solutions and suggestions, and to implement improvements to increase program effectiveness and efficiency. That is, we assisted in the adaptive management of HRWC. Adaptive management involves adjusting strategies in response to new information and feedback, so

that methods and approaches improve in effectiveness as new discoveries are incorporated into the decision-making process (Susskind, Camacho, and Schenk, 2012). Using an adaptive management approach helps ensure that the data and processes chosen to evaluate natural areas and sharing that information will be the most up-to-date, efficient, and informative for decision-making.

Specifically, we focused our evaluation and improvement of the program in three main areas:

1. Ecological integrity assessment
2. Data management and integration
3. Engagement and impact

In the first area of our project, we investigated how NAAP assessments of integrity compare with current conceptual perspectives on integrity and with other widely used assessment programs around the country. Secondly, we assessed and improved the structure and integration of the program's map and field assessment data. Finally, we evaluated the program's stakeholder engagement and impact on increasing conservation within the watershed. Our research questions and approaches are summarized in Figure 1.4.

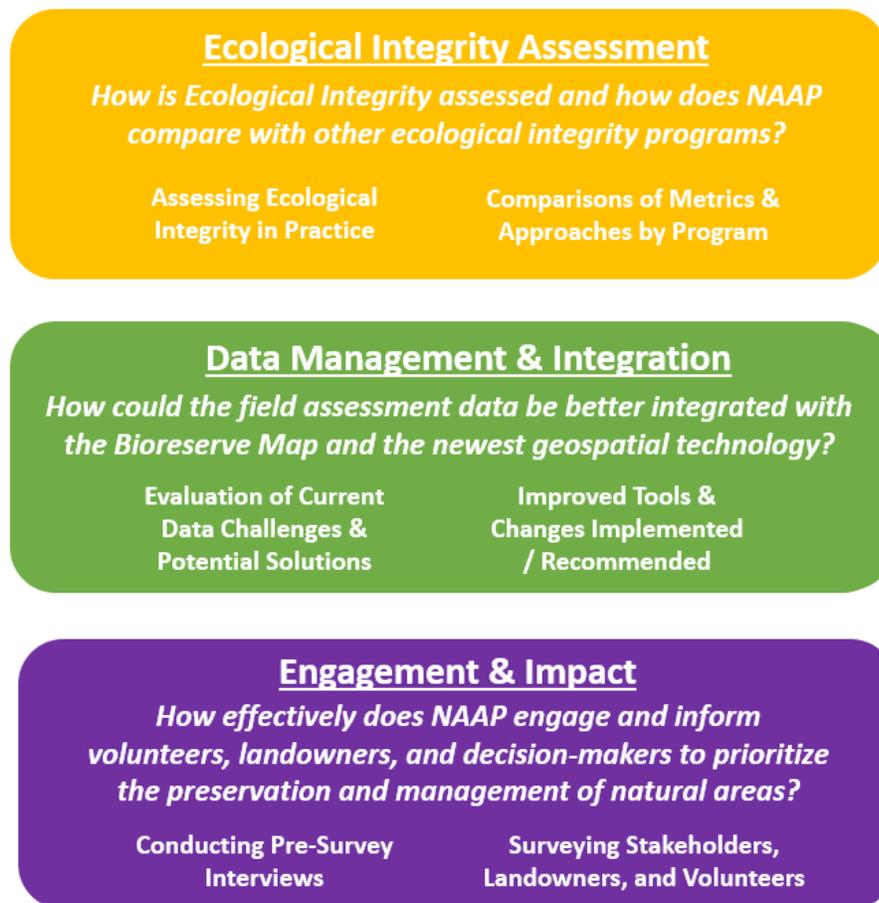


Figure 1.4: The three arms of our project and their overarching research questions.

Project Significance

The largest threat or barrier to improving the Natural Areas Assessment Program is the limited organizational capacity that HRWC can devote to program evaluation and analysis of alternatives, and our aim was to make it easier to conduct this assessment. This project strengthens and broadens the impact of NAAP by adding value to current program efforts (improved data visualizations, metrics of program success), streamlining processes, expanding the beneficiaries of the program, identifying key needs of stakeholders and data users, and tailoring the program to meet stakeholder and data users' needs. It also provides an opportunity for HRWC to reflect on NAAP and re-envision what the program could look like in the future. This fits into HRWC's larger research and advocacy missions by helping them make the best use of available science and raising awareness of HRWC's programs and the watershed itself. Ultimately, our work in these areas supports HRWC's core goals of protecting local water quality and creating vibrant communities.

Beyond our impact on HRWC, this project is relevant to decision-makers and stakeholders across the globe who face the challenge of how to prioritize land protection efficiently and accurately. For example, since the areas of natural lands differ in size, it is hard to optimally value environmental barriers to produce an accurate assessment for prioritization (Faber-Langendoen et al., 2019). The tools and data of NAAP and evaluation could inspire or become a model for other watersheds to use when assessing land areas.

We anticipate that this project will also have broader impacts on the community and natural environments. Our work may enhance the programming and decision-making processes of other organizations who use HRWC's NAAP data and may improve private landowners' perception and participation in the program. Programs like NAAP are essential to protect natural areas and all the ecosystem service benefits they provide. Our project ultimately helps maintain biodiversity and its benefits, which are essential to human health and well-being.

Approach and Chapter Overview

Three project arms (Figure 1.4) formed the basis for what became our research questions and the methods we used in answering them. They also form the basis of the three main chapters of this report which describe in detail how our research was conducted.

In Chapter 2, we review existing frameworks and methods to assess ecological integrity and make relevant comparisons with NAAP approaches to inform potential improvements. We focus on criteria of interest to HRWC, such as remotely assessed geospatial analysis, soil assessments, reporting, and other factors which account for the time and ease of completing an assessment.

In Chapter 3 we evaluate the program's current data workflows and propose a new workflow and recommendations to address challenges in three main areas: data collection, management, and visualization challenges. These challenges limited NAAP's desired integration of field assessment data with the Bioreserve Map. We begin by researching possible solutions to these data challenges—most importantly, data visualization—and describe potential solutions involving relational database management systems, ArcGIS geodatabases, and digital field assessment forms. We synthesize these findings into a new data workflow involving visualizing data in ArcGIS, a Survey123 form, and web maps

and dashboards in ArcGIS Online and offer recommendations for how this new data workflow can be used and improved upon.

Finally, in Chapter 4, we present the results of surveys and interviews conducted with individuals and organizations that engage with NAAP. The purpose of these surveys and interviews was to evaluate the level of engagement, access, accuracy, and usability of program products and services and generate recommendations for program improvements based on user feedback. We identified three respondent groups whose unique perspectives were critical to assessing the program: landowners, stakeholders, and volunteers. Pre-survey interviews were conducted with members of each group to inform the creation of the survey, which was then distributed to each group using Qualtrics Online Survey Software. Post-survey interviews were conducted with stakeholders to expand on survey responses. Finally, survey and interview results were compiled into a list of recommendations for improvements to NAAP.

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Chapter 2: Assessing Ecological Integrity in Practice: A Comparison of the Huron River Watershed Council Natural Areas Assessment Project with other Integrity Assessment Programs

Ecological Integrity: A Conceptual Goal of Conservation

A major goal of natural area and ecosystem management and protection is the conservation of biodiversity and the associated values and services it provides, from recreation to water quality (Lindenmayer et al., 2010; Chan et al., 2006). But the concept of protecting ecosystems by "maintaining" them is a broad and misleading phrase; ecosystems are dynamic over time, shaped by many forces large and small. They are not static, and even the most well "preserved" ecosystem changes in the long run. That said, the kind of natural ecosystem change a scientist can measure in the fossil record or observe by watching forest succession over many years is a process wholly distinct from the anthropomorphic alteration seen in the world today. With more than half the earth's land having been converted to support humans (Shukla et al. 2019), it is evident that humans have radically altered ecosystems across the globe. This wide scale change has led many to propose a new epoch known as the Anthropocene, in order to properly label the degree to which many landscapes now bear little resemblance to historical reference conditions prior to significant anthropogenic impact (Caro et al., 2012).

One concept frequently used to approximate historical conditions is "ecological integrity". The concept was first introduced by Aldo Leopold, who wrote, "...a thing is right when it tends to preserve the integrity, stability and beauty of the biotic community. It is wrong when it tends otherwise" (Leopold, 1949). Many scientists have defined the term with similar yet varying language (Table 2.1), but a common theme is that it "measures the composition, structure, and function of an ecosystem, as compared with its natural or historical range of variation" (Tierney et al., 2009; Wurtzebach et al., 2016).

Table 2.1: Definitions of ecological integrity as a measurable conservation goal (Adapted from Schueller et al., 2006).

<p>Ecological Integrity:</p> <ul style="list-style-type: none"> • “The capability of supporting and maintaining a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitat of the region” (Karr & Dudley 1981) • “Refers to a system’s wholeness, including the presence all appropriate elements and occurrence of all processes at appropriate rates” (Angermeier & Karr 1994) • “When subjected to disturbance, it sustains an organizing, self-correcting ability to recover toward an end-state that is normal and good for that system” (Regier 1993) • “The presence of structural, compositional, and functional characteristics within the natural range of variability for a particular ecosystem” (EPA Scientific Advisory Board 2002) • “Do the ecological systems, communities, and species that are the focus of conservation efforts occur with sufficient size, with appropriately functioning ecological processes, and with sufficiently natural composition, structure, and function to persist over the long term?” (Parrish et al. 2003)

Ecological integrity is a holistic concept not unlike ecosystem health and is similarly useful for goal-setting and prioritization. It can be used to "track important characteristics of focal biodiversity" (Parrish et al., 2003) or to "summarize the condition of ecosystems so that changes can be tracked over time" (Andreasen et al., 2001). Unlike ecosystem health however, ecological integrity is "concerned not only with ecological services for humans but also with the condition of the ecosystem for its own sake and for the sake of the species dependent on it (Andreasen et al., 2001, pg. 22). Integrity, therefore, acknowledges an inherent worth to an ecosystem beyond the services provided to humans.

Distinguishing aspects of ecological integrity is no small feat due to the complexity of ecosystems and their context. For example, macroinvertebrate die-off in a river may be caused by excessive nutrient runoff from nearby farms or an invasive species; just as a person's high blood pressure could be caused by some combination of overeating, smoking, and other factors. Assessments need to understand year to year stochasticity and include metrics of variables such as community structure, canopy size, as well as natural disturbance regimes such as fire, frost, flooding, and wind (Angermeier and Karr, 1994, Andreasen et al., 2001). Aside from operational challenges in reliably learning what regions were like in the past, assessments are complicated by agents of change such as global warming, invasive species, and further human modifications to the environment. Ecosystems are constantly being reshaped by these factors and while they may be moving towards some stable state, that stable state may not match the past (Hobbs et al., 2014). Thus, successfully evaluating ecological integrity requires an understanding of all of these dynamic relationships: both spatial and temporal, as well as the relationships, links, and interactions of the ecosystem that exist at various hierarchical levels (Figure 2.1).

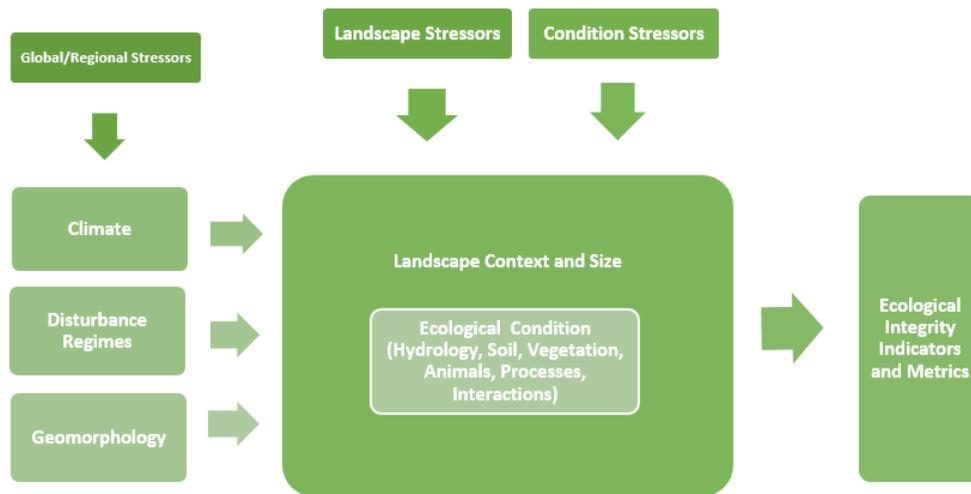


Figure 2.1: *Ecological Integrity Model, adapted from NatureServe EIA Manual (Faber-Langendoen, 2016).*

Assessing Ecological Integrity in Practice

To assess a holistic concept like ecological integrity in practice one can consider metrics of each of its components: composition, structure, and function. Integrity encompasses species composition, which would require meaningfully surveying for species presence and numbers across taxa and in many seasons. Assessing structure means examining the vegetation zones, vertical patterns, trophic levels, and more. Integrity also includes function, which means everything from pollination to disturbance and nutrient cycling. With assessments being conducted in particular time periods, results would also need to be understood with relation to stochastic variation.

Many efforts to measure integrity exist, with some efforts including multi-metric indices. These have different aims, yet all use indicators and degradation sensitivity in an attempt to gain broader insight into ecosystem characteristics. In the context of watershed analysis, the Wisconsin Index of Biotic Integrity is a multi-metric index which combines data from variables which include species richness, tolerant and intolerant species richness, trophic level composition, and more to determine the condition of a river or stream (Lyons et al., 1996). The Hilsenhoff Biotic Index incorporates species richness and tolerance values of macroinvertebrates in a similar manner (Hilsenhoff, 1982). Floristic quality indices (FQI) use vegetation coefficient of conservatism values and species richness to determine the ecological condition of a natural area (Rooney and Rogers, 2002). By sampling for species sensitivity to change, you can thus learn more about the ecosystem than simply species presence, distribution, and population size. You can learn about temperature fluxes in the water, food sources, soil erosion, community interactions, and more. While multi-metric indices make attempts to measure ecological integrity more manageable, they still require a high level of expertise and time.

With limited conservation and restoration funding, managers need to strike a balance between highly-detailed, highly-localized assessments and quicker, broader forms of assessment that can be performed even by non-experts. Meaningfully assessing a plot of land under an intensive integrity program can take

hundreds of hours and more than a year, including repeat site visits across different seasons. This need has resulted in the spread of rapid assessment programs, which are now widely used in many places around the United States and the world. Effective conservation does not rely solely on the natural sciences, but on the ability to work within operational constraints in a way that is informed by science. This is especially true for nonprofits, conservancies, and smaller governments, who are forced to be as accurate as possible with limited resources. It is absolutely necessary for these organizations to be able to assess a plot of land and inform their conservation decisions using the best possible knowledge.

The goal of rapid assessment programs is not to replace more thorough methods, but to inform management decisions with limited resources and to discover lines of questioning for more intensive analyses, among others (Faber-Langendoen et al., 2016). This can be done by examining proxy variables known to represent aspects of ecological integrity and the potential of the land to provide ecosystem services (Faber-Langendoen et al., 2019). Many methods use these to compare ecosystems against one another. Knowing relative worth and the presence of indicators can be used to prioritize land for conservation and to identify larger trends, among other ends.

The main goal for selecting variables is to choose those that are the most indicative of the state of the ecosystem in question and then objective, repeatable metrics to measure them (Faber-Langendoen et al., 2019). Common examples of these variables include indicator species, functional groups, land cover type and vegetation, landscape hydrology, and soil conditions (Carignan and Villard, 2002; Langemeyer et al., 2016). Specific variables chosen for prioritization assessments often vary based on the unique site and scale of different landscapes (Rocchio et al., 2016).

There are a growing number of rapid assessment programs that can inform the most effective approach and variables. These programs, while differing at times in variables, metrics, and operational methods, contain a number of common threads, many of which have been peer reviewed (Fennessy, 2007). One common thread is that many ecological integrity assessment methods are delineated into three separate levels (US EPA, 2020; Faber-Langendoen, 2016) which allow for differing lines of inquiry into integrity (Table 2.2).

Table 2.2: Three levels typically included in an ecological integrity assessment.

Level/Tier	Description and data sources
1: Remote Assessment	Relies heavily on geospatial variables, including aerial imagery, remotely sensed data and GIS layers, and can be done to draw broad conclusions while avoiding a site visit
2: Rapid Assessment	Involves a site visit but emphasizes using variables that can be understood quickly (in half a day or less with a small field crew) to gain larger insights
3: Intensive Assessment	Involves expanding on what is already known to draw conclusions more confidently than in the other two levels, i.e., using inferences on forest stand structure from Level 2 to conduct an intensive analysis on tree mortality

Each level can be used to validate and inform results from the others on the assessment area in question. Many integrity assessment programs involve or emphasize variables that fall into the category of a rapid assessment, for aforementioned reasons involving time and capacity constraints. Inferences can be gleaned at the second level not possible at the first, while avoiding the commitment of the third.

While linked in their primary goals and in their structure, the methods of different ecological integrity assessments nonetheless vary by time commitment, ecosystem focus, methods, and the emphasis placed on particular metrics, to name a few. While most are designed to be performed by trained ecologists, some are designed for volunteers or students and can be conducted with minimal training. Some use objective standards to determine attribute and final site scores, where others often rely on professional judgements. Many studies have been published on the efficacy of these programs, with some researchers examining whether their methods meet their stated goals (Fennessy, 2007) or comparing their efficacy in measuring integrity or biodiversity (Brown and Williams, 2016). Fennessy et al. (2007), for example, examined 40 rapid wetland integrity assessment methods at a glance, selecting 16 for more detailed review after removing those they determined to be more accurately categorized as remote or intensive methods. Of those, they found that only six met the following criteria for being truly rapid and scientifically verifiable:

1. The method must measure the current condition of the wetland.
2. The method must involve a site visit to assess the wetland's condition.
3. The method must be truly rapid (involve no more than two people performing a half day's worth of field work and another half day of office work).
4. The assumptions that underlie the method must be able to be verified, broadly defined as not overly relying on professional judgement to arrive at a final site score.

Research on existing assessment methods is useful for pointing out how few actually meet certain criteria, but they do not necessarily inform an individual program on how it can compare and learn from programs most similar to them in setting and scope. In the remainder of this chapter, our goal is to specifically compare several existing rapid assessment programs with the ecological integrity assessment approach of the Natural Areas Assessment and Protection Program (NAAP) of the Huron River Watershed Council (HRWC; Table 2.3 defines acronyms used throughout this chapter). Before the comparison we first describe NAAP in the context of the three levels of assessment common to many efforts (Table 2.2), and then outline the specific methods we used to compare NAAP with other programs. Our goal is to inform the adaptive management of NAAP's approach to assessing integrity of natural areas—both to determine which of its approaches are supported by the similarity with others and to highlight possible areas for improvement.

Table 2.3: *Definitions of acronyms used throughout the chapter.*

Table of Acronyms	
HRWC	Huron River Watershed Council
EIA	Ecological Integrity Assessment
NAAP	Natural Areas Assessment Program (of HRWC)
IBI	Index of Biotic Integrity
HBI	Hilsenhoff Biotic Index
FQI/A	Floristic Quality Index (Or Assessment)

Assessing Ecological Integrity in the Huron River Watershed

Our focal example of an ecological integrity assessment is NAAP, developed in order to assist in the conservation of natural areas in southeastern Michigan. The aim of NAAP is to provide objective, comparable information about natural areas in the form of integrative scores that can be compared against one another to rank the value of the watershed's remaining natural areas in terms of ecological integrity and restorability. This information is shared with governments, conservancies, and landowners to support informed decisions for protection and restoration of these lands. In line with these definitions, NAAP uses ecological integrity to guide their method, determining a score for integrity for each visited site. There are two different but related components to NAAP: the Bioreserve Map and the rapid ecological field assessments.

In 2006, HRWC developed the [Bioreserve Map](#), which identifies remaining natural areas across the whole watershed and ranks them by highest ecological value using existing spatial data (Appendix A). The map was created using aerial photographs taken over the watershed's five counties (Oakland, Livingston, Wayne, Washtenaw, and Monroe), and drawing boundaries around what could be identified as woodland, wetland, or open field. This delineation resulted in 1,700 sites totaling 247,000 acres, which is approximately one-quarter the total area of the watershed (Olsson, 2020). To further refine the prioritization of these sites, in 2006 HRWC collaborated with students in SEAS (at that time called the School of Natural Resources and Environment) to develop a computerized model to prioritize these sites for protection by a local government or conservancy. The metrics used in the ranking are size, core size, connectedness, buffer, rarity, remnant ecosystem, presence of a waterway or wetland, potential for groundwater recharge, unchanged vegetation, restorability, and known high quality plant communities, and biorarity.

In 2009, HRWC added a second layer of finer scale information to NAAP, the **rapid ecological field assessment** protocol and report (Appendix B). The goal of this on-site assessment is to acquire more detailed information than is available through the existing Bioreserve Map. The variables chosen for the assessment were informed by a Technical Advisory Committee and based on the integrity assessment method developed by the Michigan Natural Features Inventory (MNFI) (Dorney et al., 2018), but adjusted for use by volunteers rather than expert ecologists.

The Bioreserve Map fits the definition of a Level 1 method, and the rapid ecological field assessment is Level 2 (Table 2.2). Many of the Level 1 map metrics bear similarities to geospatial analysis metrics contained in other Level 2 rapid methods examined in detail below. Connectedness and buffer are widely used metrics in these methods, and the miscellaneous variables (known high value plant communities, biorarity) mimic the narrative ratings present in rapid assessment methods such as Ohio's and Michigan's. NAAP uses the Level 1 map and Level 2 field assessments together to inform prioritization of natural areas, with Level 3 only being done when needed in certain areas.

In practice, HRWC selects private and public properties for Level 2 field assessments based on Level 1 Bioreserve Map scores and interest from landowners and decision-makers. The teams which conduct field assessments consist of several volunteers who have attended a half-day training and who work in teams with a designated plant expert. Volunteer teams conduct a two to four hour on-the-ground assessment on a parcel of over 30 metrics including plant species present, evidence of disturbance and wildlife, and appearance of the soil and water. These metrics are then combined using a weighted scoring system which produces two scores: one for ecological integrity and another score for disturbance. Assessments are delineated by broad ecosystem types (forest, grassland, ecosystem, and waterway) and conducted within a parcel of land as defined by whichever entity controls it. To date field assessments have been conducted on only approximately 14% of Bioreserve Map areas.

A Comparison of Rapid Ecological Field Assessments

In order to inform the adaptive management of NAAP's approach to assessing integrity of natural areas we compare it with seven existing rapid assessment programs in use across the United States. We start by reviewing the NatureServe Wetland Ecological Integrity Assessment (EIA) because of the broad influence this program has had on others, and then we proceed to review other programs roughly in order of the year they started. These include:

1. NatureServe Wetland Ecological Integrity Assessment (EIA)
2. Ohio Wetland Rapid Assessment Method (ORAM)
3. California Rapid Assessment Method (CRAM)
4. Washington State Ecological Integrity Assessment
5. Michigan Natural Features Inventory (MNFI) Wetland Rapid Assessment Method (MiRAM)
6. New Hampshire Ecological Integrity Assessment for Wetlands
7. High Conservation Value (HCV) Forest Integrity Assessment

These seven programs were chosen for comparison because they were either recommended as being most relevant for analysis by those at HRWC or ecologists familiar with NAAP and its goals (Table 2.4). Several focus on measuring wetland ecosystems in large part because of the historical importance of assessing wetland integrity. Wetlands, as a broad classification, are of particular interest in conservation due to a myriad of provided ecosystem services. These services involve carbon sequestration, flood

mitigation, water filtration, habitat, and more. With global wetland loss estimates uncertain but substantial—one estimate found approximately 64-71% loss since 1900 (Davidson, 2014)—as they are converted to other land uses, wetlands are top priority for conservation. Much of this emphasis on wetland conservation has been historically spurred by the government, in particular the US Environmental Protection Agency (EPA), due to their role in implementing Section 404 protections of the Clean Water Act (US EPA, 2006) as well as developing more holistic approaches to wetland protection (Preston and Bedford, 1988). Many monitoring efforts sprang from the formation of its Wetlands Research Program and workshop in 1988. Among others, the workshop concerned addressing cumulative impacts on watersheds, measuring wetland function and condition, and how to develop measures of biological integrity (Preston and Bedford, 1988), eventually leading to progress in state programs (Wardrop et al., 2013, Pg 384). Later development of state and tribal assessment methods have been supported by EPA Wetland Program Development Grants (US EPA, 2006).

Methods

In order to thoroughly and consistently examine these assessments and in a manner that is most useful to HRWC, we ask the following questions:

1. What are the program's origins, and what influenced or created it?
2. Which ecosystem types is it meant to assess?
3. Which of the three defined levels of assessment (remote, rapid, and intensive) does the program include, and what can HRWC learn from their remote and rapid approaches?
4. How easy is it to conduct the rapid assessment? What level of training is needed for the program, and how long does it take?
5. What are the key variables/categories of the rapid assessment, and how do they compare to NAAP?
6. How does the method create and combine scores? To what extent do they use qualitative scoring or tangible scoring metrics?
7. How are results reported and/or shared?

In our comparison of the programs, we also focus on aspects that are of particular interest to HRWC and its efforts to improve NAAP. These include:

1. Remotely assessed geospatial metrics
2. Metrics to examine soil
3. Potential new metrics to consider

From this comparison, we highlight examples of how HRWC can alter their Bioreserve Map and/or rapid ecological field assessment in order to improve its ability to accurately capture ecological integrity. Answering some questions is challenging, because many of these programs predated and influenced one another in both directions, and they continue to change. Programs are revised continuously over time, and it is difficult to say that a program as it exists in 2021 is truly the same program as it was many years prior. As a case in point, Washington State published an updated v1.1 method for its ecological integrity assessment over the course of this master's project. These programs influence one another, and thus while it can be clearly read in the Ohio field manual that their scoring system was adapted from the Washington method, there is nothing stopping any earlier program from learning and adapting in kind.

Most research was conducted through the examination of field manuals and associated documentation provided by the assessment methods, though some practitioners and academic literature were also consulted. Method guides are published online, and in many cases peer reviewed and cross referenced, and thus can be easily compared. Note that our classification of Levels involved in the method in Table 2.4 is somewhat subjective, most states have trained scientists able to complete more intensive methods, but these are often not included in the field manuals which outline the Level 2 methods and do not apply to the same integrity score produced in line with the NatureServe method that is most comparable to NAAP. Exact methods also vary based upon ecosystem subtype as well, and these are not static approaches to ecosystem integrity.

Table 2.4: Comparison chart of the seven reviewed assessment methods.

Assessment Method	Levels	Main Metric Categories	Similarity to HRWC	Training Level(s) Used	Of Interest to HRWC	Source
NatureServe Ecological Integrity Assessment – Wetlands	1, 2, 3	Landscape, Buffer, Vegetation, Hydrology, Soil, Size	Limited soil metrics, native and invasive cover analysis	Implied ecological background but varies	Coarse woody debris, landscape context variables	https://www.natureserve.org/conservation-tools/ecological-integrity-assessment
California Rapid Assessment Method (CRAM) - Wetlands	1, 2, 3	Landscape, Buffer, Vegetation, Hydrology, Soil, Size	Limited soil metrics, native and invasive cover analysis	Trained scientist; course for certification	Water source metrics, Attribute and Index scoring methods, Landscape metrics	https://www.cramwetlands.org/
Washington Ecological Integrity Assessment – Wetland/Upland	1, 2, 3	Landscape, Buffer/Edge, Vegetation, (Hydrology), Soil, Size	Limited soil metrics, metric categories	Trained scientists	Landscape metrics, use of increaser and decreaser species	https://www.dnr.wa.gov/NHP-EIA/
Ohio Rapid Assessment Method for Wetlands (ORAM)	1, 2, 3	Size, Upland Buffers and Surrounding Land Use, Hydrology, Habitat, Special Wetland Communities, Vegetation	Limited soil metrics, narrative metrics to describe community types	Trained scientist; course for certification	Community interspersions measured through sight, use of narrative ratings	https://www.epa.ohio.gov/dsw/401/ecology/
Michigan Rapid Assessment Method for Wetlands (MiRAM)	1, 2, 3	Size, Hydrology, Soil & Habitat, Wetland Quality, Invasive Species, Microtopography & Interspersion, Cultural Value	Limited soil metrics	Trained Scientists	Cultural Value metrics	https://www.michigan.gov/egle/0,9429,7-135-3313_3687-240071--,00.html
New Hampshire Ecological Integrity Assessment for Wetlands	1, 2	Landscape Context, Buffer and Size, Vegetation, Hydrology, Soil	Soil metrics evaluated only by disturbance	Moderate level of ecological knowledge	Coefficient Table used in Landscape Context assessment and scoring	https://www.nh.gov/nhdfl/documents/l2-eia-manual_nhb_2018-7-11-public.pdf
HCV Network Forest Integrity Assessment Tool (FIAT)	2	Structure and Composition, Impacts and Threats	Scoring format is Presence/Absence, includes focal species	Designed to be completed by non-scientists	Focal species/habitats, counting and statistical analysis approach	https://hcvnetwork.org/library/forest-integrity-assessment-tool/

Reviewed Rapid Ecological Assessment Methods

NatureServe

The NatureServe Wetland Ecological Integrity Assessment, widely published in 2004 (Brown et al., 2004, Faber-Langendoen et al., 2006), is a biophysical assessment method by the NatureServe organization that assesses the “current status of the composition, structure, processes, and connectivity of a particular” ecosystem (Faber-Langendoen et al., 2016, Page 1). NatureServe's self-identified key goals are to define the status of the current ecosystem, identify drivers and stressors, key species, and ecological processes and transitions. As a program, it contains all three levels of assessment (Table 2.2) and was designed as a template to be easily adopted for use by partners in the NatureServe network across different ecosystem types, including several programs examined in detail below.

Key Variables

As NatureServe serves as a model for many of the methods to come, its grounding theories are important to understand. NatureServe focuses on the idea that a practical ecological assessment should embody six key criteria. It should be: grounded in natural history, relevant and helpful, multi-scaled, flexible, measurable, and comprehensive with regards to composition, structure, and function (Andreasen et al., 2001; Faber-Langendoen et al., 2006). In an early adaptation, NatureServe worked with an EPA advisory group to adapt existing integrity assessment methods to wetland delineation responsibilities the EPA performs (Faber-Langendoen, 2006). The method includes a landscape context category that measures buffer size, land fragmentation, and land use. For grounding the metrics in history, they utilized experts from around the United States to look at the land history of wetlands in different regions to formulate a group of ecological attributes that were helpful in indicating change in wetland ecological integrity (Faber-Langendoen et al., 2006).

NatureServe metrics consist of four main categories: Landscape Context, Biotic Condition, Abiotic Condition, and Size. NatureServe holds the expectation that partner methods will draw at least one metric from each category out of several presented (Faber-Langendoen et al., 2006). To ensure the assessment is malleable enough to be widely adapted, NatureServe metrics are split into two categories: core and supplementary. Core metrics are the minimal metrics that should be applied when assessing a wetland while the supplementary metrics are for a more in-depth assessment if more resources and time are available. By allowing flexibility in metrics there is also flexibility in the score calculation of ecological integrity (Faber-Langendoen et al., 2006).

NatureServe does not elaborate on needed time frames or experience level, and interpretations of their framework in practice vary. Given that NAAP was developed mainly through input provided by MiRAM professionals tied to the NatureServe program, it is useful to see just how closely NAAP's metrics adhere to NatureServe's updated guidelines (Table 2.5). From this comparison, we can see a large number of similarities in categories and metrics, though deeper dives into field manuals reveal differences in scoring and data collection.

Scoring System

While NatureServe does not contain an explicitly defined scoring method, its recommendations and guidelines have been incorporated into many other methods. Each assessment ends with a site letter grade correlated with a hierarchical numerical score, broadly known as an ABCD system. The ABCD system attaches a letter grade to category or site scores in order to make said scores more readily understandable. Data on the status of ecosystems and location of species around the United States are available on their website, which utilizes ArcGIS Online and accepts requests for data from interested parties.

California Rapid Assessment Method

The California Rapid Assessment Method for Wetlands (CRAM), designed in the early 2000s, is a large wetland rapid assessment program with a defined methodology and is a reference for many other states' wetland assessment programs. It contains metrics pertaining to all three assessment levels (Solek et al., 2011). Its major categories for metrics are Landscape Context, Hydrology, Physical Structure, and Biotic Structure (California Wetland Monitoring Workgroup, 2008). This is in line with definitions of ecological integrity as laid out by other researchers (Tierney et al., 2009, Brown and Williams, 2016). CRAM's methodology has been supported by research into its responsiveness to wetland quality and change (Stein et al., 2009). Some aspects vary based on which classified wetland type is being examined, including vernal pools.

Like the majority of the programs in this chapter, CRAM is designed to be carried out by trained scientists, which allows for additional assessment/methodological complexities that would not be possible in a program conducted by non-experts and volunteers. The methods' own authors estimate an assessment to take two to four trained people a half day of office prep and data analysis plus four hours of field work. Certification to conduct this kind of training can be completed after an approximately five-day course, depending on modules involved in the training (California Wetlands Monitoring Workgroup, 2013).

Key variables

Of the many variables CRAM uses in its wetland work that are of interest to HRWC, landscape context and buffer are two that can be quickly incorporated and assessed through GIS layers or aerial photography. Their methodology for doing so is similar to the methods used in both Michigan and Ohio.

Soil characteristics are somewhat represented under the Physical Structure attribute and its metrics Structural Path Richness and Topographic Complexity, but these do not completely overlap with NAAP's soil metrics and thus further study of this attribute could be of use to HRWC.

Table 2.5: Comparison of the metrics used in a NatureServe wetland assessment and the Huron River Watershed Councils' Natural Area and Assessment Program field assessments and Bioreserve Map. The NatureServe metrics are tailored by Faber-Langendoen et al. (2006). Color-coding indicates the assessment tier of that metric (1= remote, 2= rapid field, and 3= intensive field assessment).

Category	Essential Ecological Attribute	NatureServe Indicator/Metric	NAAP Indicator/Metric	Bioreserve Map Metric				
Landscape Context	Landscape Composition	Adjacent Land Use	Visual landform checklist	Topographic variation				
		Buffer Width		Connectedness			Tier 1	
	Landscape Pattern	Percent of unfragmented land within 1 km		Glacial Variation			Tier 2	
		Distance to nearest road					Tier 3	
Biotic Condition	Community Structure	Stand live basal area	Vegetation Structure	Unchanged vegetation				Multiple Tiers
		Coarse woody debris (volume)	saplings/seedlings/trees of native woody species	Area of Michigan Natural Features Inventory community				
		Saplings/seedlings of native woody species	Invasive species	Biorarity				
		% of cover of native plant species	Native plant species	Remanant Ecosystems				
		Floristic Quality Assessment (Mean C) (where available)	Percent of native plant species cover					
			Invasive species distribution over land area					
Aibiotic Condition	Energy/Material Flow	Land use within the wetland	Human disturbance	Restorability				
		Sediment Loading Index						
	Hydrology	Water table depth (tier 2)	Hydrological conditions	Groundwater recharge				
		Water table depth (tier 3)		Waterways				
		Hydrological alterations						
		Surface water runoff index						
	Chemical Processes/Physical	Soil organic carbon						
		Soil bulk density						
		Nutrient/pollutant loading index						
	Size	Absolute Size	Absolute Size (Tier 1 & 2)		Size			
Relative Size		Relative Size (Tier 1 & 2)		Core Size				

CRAM incorporates subjective expert opinion into several of its metrics. For example, the buffer submetrics are split between those which can be easily quantified and those which are ranked by the practitioners' opinion. Percentage of the surrounding area that is a buffer and that buffer's width are easily quantifiable, but the buffer's condition assessment is not. This introduces a degree of subjectivity to the assessment outcomes.

Scoring system

CRAM's multi-layered and multi-metric scoring system is fully explained in the CRAM Methods and Manuals web page under a publication titled "A Practical Guide for the Development of a Wetland Assessment Method: The California Experience" as well as the CRAM Manual and Technical Bulletin (Sutula et al., 2006). In the "Practical Guide" publication, the authors advise on the shortcomings and advantages of using either a numeric or an ordinal (Good-Bad, A-F, etc.) scoring system. Data are entered and stored through an online portal, but access is not publicly available.

In Figure 2.2. we provide an example of a CRAM scoring table, where the final site score consists of several attribute scores (Buffer and Landscape Context, Physical Structure, Biotic Structure, Hydrology), each of which is composed of various levels of submetrics. Figure 2.3 further illustrates the tabulation processes for the Attribute score pertaining to the Buffer and Landscape Context Attribute. Buffer and Landscape Context is a larger Attribute score broken into six submetrics, which are split between two categories, Aquatic Area Abundance and Buffer. The submetrics are assessed and assigned a letter grade, and then this letter grade is also assigned a hierarchical point value, with more points for higher grades. The submetric scores are combined using the below formula and methods into metric scores and attribute scores which are eventually combined with all others into a usable Index score for the assessed area that can be used to gauge about how good a piece of land is compared to others.

AA Name:		Date:		
Attributes and Metrics		Scores		Comments
Attribute 1: Buffer and Landscape Context (pp. 8-18)				
<i>Aquatic Area Abundance Submetric 1:</i>	<i>Alpha</i>	<i>Numeric</i>		
<i>Stream Corridor Continuity</i>				
<i>Aquatic Area Abundance Submetric 2:</i>				
<i>Adjacent Aquatic Area</i>				
<i>Aquatic Area Abundance Submetric 3:</i>				
<i>Marine Connectivity</i>				
<i>Buffer submetric A:</i>				
<i>Percent of AA with Buffer</i>				
<i>Buffer submetric B:</i>				
<i>Average Buffer Width</i>				
<i>Buffer submetric C:</i>				
<i>Buffer Condition</i>				
Raw Attribute Score= $((1+2+3)/3) + [C \times (A \times B)^{1/2}]^{1/2}$			Final Attribute Score	$= (\text{Raw Score}/24)100$

Figure 2.2: An example of the metrics contained within CRAM's Landscape Buffer and Context Attribute (California Wetlands Monitoring Workgroup, 2013).

Table 3.11: Steps to calculate attribute scores and AA scores for most wetland types.

Step 1: Calculate Metric Score	For each Metric, convert the letter score into the corresponding numeric score: A=12, B=9, C=6 and D=3.
Step 2: Calculate raw Attribute Score	<p>For each Attribute, calculate the Raw Attribute Score as the sum of the numeric scores of the component Metrics, except in the following cases:</p> <ul style="list-style-type: none"> For Attribute 1 (Buffer and Landscape Context), the submetric scores relating to buffer are combined into an overall buffer score that is added to the score for the Aquatic Area Abundance, using the following formula: $\left(\text{Buffer Condition} \times \left(\% \text{ AA with Buffer} \times \text{Average Buffer Width} \right)^{\frac{1}{2}} \right)^{\frac{1}{2}} + \text{Aquatic Area Abundance}$ <ul style="list-style-type: none"> For Attribute 4 (Biotic Structure) Prior to calculating the Raw Attribute Score, average the three Plant Community sub-metrics. Then sum this result with the other two Biotic Structure metrics. Do not round the Raw Attribute scores to the nearest integer.
Step 3: Calculate final Attribute Score	For each Attribute, divide its Raw Attribute Score by its maximum possible score, which is 24 for Buffer and Landscape Context, 36 for Hydrology, 24 for Physical Structure, and 36 for Biotic Structure. Do not round the final Attribute scores to the nearest integer before calculating the AA Index Score. You may round the final Attribute score to the nearest integer for reporting purposes.
Step 4: Calculate the AA Index Score	Calculate the AA Index Score by averaging the Final Attribute Scores. Round this average to the nearest whole number (integer) to get the AA Index Score (0.5 or greater rounds up, less than 0.5 rounds down).

Figure 2.3: Step by step process for scores for metrics into broader category attribute scores (California Wetlands Monitoring Workgroup, 2013).

Scores are defined by the overall assessed area Index Score and its Attribute Scores. Index Scores are the final scores and are used to compare different assessment areas. These scores are comprised of Attribute Scores. These are separated into variables that measure some form of ecological integrity and the metrics used to measure the variables. Some metrics, such as biotic structure, are further broken down into submetrics (number of plant layers, percentage invasion, and # of co-dominant plant species). Similar to NAAP's Disturbance scorecard, a stressor checklist is brought out into the field that allows the researchers and managers to explore the possible relationships between the scores and stressors. The final report gives a score percentage out of one hundred for the attributes and compares them to the state averages (California Wetland Monitoring Workgroup, 2008).

Washington State Ecological Integrity Assessment Method

The Washington State EIA is a NatureServe network program used primarily to assess the ecological health of natural areas in the state. It existed as a monitoring and assessment program, integrity was first added as a secondary focus in 2007 and then officially incorporated as a primary area of interest in 2009. Interestingly, while being a part of a network of wetlands assessment methods around the country, is not purely wetlands focused. Washington adapted its wetland assessment metrics into an extremely similar upland ecological integrity method, with its own detailed field manual. Despite the different ecosystem types, the methods are largely the same. There are a few alterations for the upland

model, namely the lack of a scoring method for hydrology in upland sites and a few changes to naming conventions. In addition, the "Buffer" metrics for wetlands are renamed "Edge" for uplands to align with how scientific nomenclature uses buffers to describe wetland conditions and edges to describe forest landscapes.

Washington is much like many of the other methods examined here in that it is three-leveled and primarily completed by trained scientists. This analysis will focus on the Level 2 rapid portion most easily compared with NAAP. Washington's ecological integrity assessment approach is designed to be conducted by trained ecologists, so a level of familiarity with basic ecosystem science concepts is assumed, though the rapid portion can seemingly be conducted with a level of training comparable to that of other methods such as Ohio or NAAP.

Key variables

Several metrics are examined in the final ecological integrity score: Landscape Context, Buffer/Edge, Vegetation, Hydrology, Soil/Substrate, and Size. The Field Manual categorizes these metrics under several "Primary Rank Factors" which are described as "the components that capture the structure, composition, processes, and connectivity of an ecological system" (Figure 2.4). In addition, these metrics are often broken into submetrics, which are later combined after calculating quantitative scores in order to establish a "Major Ecological Factor" score.

Primary Rank Factor	Major Ecological Factor	Metric/Variant NAME	Where Measured	Apply to:
LANDSCAPE CONTEXT	LANDSCAPE	LAN1 Contiguous Natural Cover (0-500 m)	Office then field check	All Types (not for use with sub-AAs or points)
		<i>Submetrics:</i>		
		<i>Inner Landscape (0-100 m)</i>		
		<i>Outer Landscape (100-500 m)</i>		
		LAN2 Land Use Index (0-500 m)	Office then field check	All Types (not for use with sub-AAs or points)
		<i>Submetrics:</i>		
CONDITION	VEGETATION	VEG1 Native Plant Species Cover	Field	All Types; Use lowest submetric score
		<i>Submetrics:</i>		
		<i>Tree Stratum</i>		Flooded & Swamp Forest Formation
		<i>Shrub/Herb Stratum</i>		All Types
		VEG2 Invasive Nonnative Plant Species Cover	Field	All Types
		VEG3 Native Plant Species Composition	Field	All Types
		<i>Submetrics:</i>		
		<i>Native Diagnostic Species</i>		See USNNVC Subgroup descriptions for guidance
		<i>Native Species Sensitive to Anthropogenic Disturbance</i>		See USNNVC Subgroup descriptions for guidance
		<i>Native Species Indicative of Anthropogenic Disturbance</i>		See USNNVC Subgroup descriptions for guidance
		VEG4 Vegetation Structure	Field	All Types (variant differs by USNVC Formation)
		VEG4, variant 1		Flooded & Swamp Forest Formation
		VEG4, variant 3		Freshwater Marsh, Wet Meadow and Shrubland Formation
		VEG4, variant 4		Salt Marsh Formation
		VEG4, variant 5		Bog and Fen Formation
		VEG4, variant 6		Aquatic Vegetation Formation

Figure 2.4: A sample of the variables and metrics used to measure them under the Washington State Ecological Integrity Assessment Method (Rocchio et al., 2016).

A number of key metrics correlate with other programs, including NAAP. As in many other programs, the rapid assessment contains Landscape Context and Buffer/Edge metrics which are assessed remotely. The general point of the metrics and the grading methods behind them are broadly the same between many of these methods. Prior to arrival at the site, the assessor examines the site and its surrounding landscape using a land use classification index, such as the National Land Cover Database or NatureServe's own Ecological Systems map. Using the assessment area as a base, the author uses a Buffer function in a GIS program (or if necessary, draws the surrounding buffer by hand) between 0-500 meters, and determines the amount of natural area surrounding the property that is connected to the assessment area. The examination of field manuals revealed similar methods with some notable differences, such as whether the buffer is drawn in GIS and the range of surrounding land to examine for buffer.

Soil is also not a large part of the rapid assessment, and the Level 2 method limits examination of soil to disturbance which degrades the soil and is plainly visible to researchers. The field manual notes that metrics related to water quality (for wetlands) have been tested but found too difficult to be a Level 2 method. Aerial photographs are often consulted beforehand to identify potential disturbance and are ground truthed at the user's discretion. This allows for the quick assessment of problems with the soil but fails to capture information that would require a more intensive Level 3 assessment, such as soil moisture, organic carbon, cation exchange capacity, groundwater exchange, and other diversity which could be indicative of more biodiversity.

Washington does contain a few vegetation metrics which are comparable to those used by HRWC. One example is the "Stressor Checklists", simply a holistic diagnosis of a stressor to any aspect of integrity that can also be calculated and assigned an impact rating based upon predetermined criteria. Like many of the other state managed programs, Washington uses plots to examine composition of vegetation in their rapid level assessment. While conducting these plots, researchers make note of particular species, with two categories being those which increase or decrease with anthropogenic stressors, called "increaser" and "decreaser" species. Decreaser species are specifically identified as having a coefficient of conservation greater than or equal to 7, and increaser said to "often have" a coefficient of lower than or equal to 3. The field manual describes a subjective assessment on the part of the researcher, judging whether the presence of increasers or decreasers is outside their historic range, in the ABCD scale described below.

Scoring system

Scoring is conducted similarly to other state assessment programs. Letter grades of A, B, C, or D are given based upon rating criteria descriptions in the manual (for the Landscape Context Metrics, the criteria is the percentage of the surrounding landscape within distinct inner and outer zone areas from 0-500 m that is both natural and connected to the area). These letter grades are then assigned points (A = 4, B = 3, C = 2, D =1).

Table 11. Land Use Index Table

Worksheet : Land Use Categories	Weight	Inner Landscape (0-100 m)		Outer Landscape (100-500 m)	
		% Area (0 to 1.0)	Score	% Area (0 to 1.0)	Score
Paved roads / parking lots	0				
Domestic, commercial, or publicly developed buildings and facilities (non-vegetated)	0				
Gravel pit / quarry / open pit / strip mining	0				
Unpaved roads (e.g., driveway, tractor trail, 4-wheel drive, logging roads)	1				
Agriculture: tilled crop production	2				
Intensively developed vegetation (golf courses, lawns, etc.)	2				
Vegetation conversion (chaining, cabling, roto-chopping, clearcut)	3				
Agriculture: permanent crop (vineyard, orchard, nursery, hayed pasture, etc.)	4				
Intense recreation (ATV use / camping / popular fishing spot, etc.)	4				
Military training areas (armor, mechanized)	4				
Heavy grazing by livestock on pastures or native rangeland	4				
Heavy logging or tree removal (50-75% of trees > 30 cm DBH removed)	5				
Commercial tree plantations / holiday tree farms	5				
Recent old fields and other disturbed fallow lands dominated by ruderal and exotic species	5				
Dam sites and flood disturbed shorelines around water storage reservoirs and motorized boating	5				
Moderate grazing of native grassland	6				
Moderate recreation (high-use trail)	7				
Mature old fields and other fallow lands with natural composition	7				
Selective logging or tree removal (< 50% of trees > 30 cm DBH removed)	8				
Light grazing or haying of native rangeland	9				
Light recreation (low-use trail)	9				
Natural area / land managed for native vegetation	10				
Total Land Use Score					
A = ≥ 9.5 , B = 8.0-9.4, C = 4.0-7.9, D = < 4.0 Total Land Use Rating					
Combined Score (Inner score x 0.6)+(Outer Score X 0.4)					

Figure 2.5: Weighting method for Landscape Context. Weights are attached to the percentage of the surrounding landscape that pertains to that type and a score is created from it (Rocchio et al., 2016).

A similar process is followed for human land use and the landscape buffer in the surrounding area, the latter of which is defined as the percentage of surrounding area directly buffering the assessment area (Rocchio et al., 2016). Range ranks (AB, BC, etc.) are sometimes used if the reviewer is uncertain. These scores can be further modified to calculate quantitative scores based upon the characteristics of the metric and the field manual guide. Landscape Context is further modified by calculating a "sub-use land score" which is calculated by looking at all of the surrounding land uses, attaching pre-determined weights based upon land use type, and multiplying them together (Figure 2.5). In this way, one can

create a quantitative number for landscape context which can be compared against other assessed area landscape context scores. Similar policies are outlined for the other Primary Rank Factors.

What happens from here is up to the purview of the researcher. Some projects may simply seek to describe ecosystem characteristics under the major variables. But if one is interested in ranking and comparing areas *writ large*, the manual outlines methods by which these "Major Ecological Factor" scores can be combined into a final assessment area score.

Ohio Wetland Rapid Assessment Method

The Ohio Wetland Rapid Assessment Method (ORAM), originally developed in 2001, is a foundational wetlands monitoring plan used to assess federal and isolated wetland properties (Midwest Biodiversity Institute, 2020). Its primary metric categories are Size, Buffers and Land Use, Alteration and Disturbance, Hydrology, Special Wetland Communities, and Vegetation, Interspersion, and Microtopography. Parts of the ORAM scoring system were derived from an older version of the Washington State Wetlands Rating System and further developed with the aid of wetland experts, with its current operative version 5.0 being a departure from Washington's as it exists now. The method is mostly limited to Levels 1 and 2, with some geospatial variables and some rapid metrics non-scientists may find difficult. Its manual flatly states that it was designed to be used by a wide range of people with different experience and training, though it implies that a basic ability to delineate wetlands and other related natural science is helpful. There are affiliated training programs in carrying out these assessments, though they appear to have strict training requirements, with a training program and certificate upon completion (Midwest Biodiversity Institute, 2020). This may limit or hinder those who want to take part. While HRWC does have training requirements, they are not certificate based and give more room for those who know little about land assessments to volunteer and learn as they go, which may on the other hand lead to variability in the subjective scoring metrics.

Key variables

Soil is assessed based on whether any evidence of disturbance is present, and if so, to what degree and how recently it occurred. Soil disturbance, lacking a measurable metric in the manual, contains the potential for subjectivity as it relies on opinion. The geospatial categories bear a great deal of similarity to Washington and California, in that some aerial photograph or spatial image is established and then surrounding land use examined for buffer percentage and land use intensity. Although land use is "generally established" by the examiner rather than following a defined method such as in other programs.

Scoring system

The ORAM uses both a narrative rating and a quantitative rating system. The narrative rating is a quick assessment quiz designed to take advantage of what is known under Wetland Water Quality Standards and antidegradation rules. These questions are meant to be answered with literature review activities done in the office. In the end, the narrative assessment categorizes the wetlands from 1-3 with 1 being lowest quality; there is also an implied fourth category for wetlands that are degraded but restorable. This narrative rating was made to encourage the rater to consult known information on the wetland type.

The quantitative rating system is more in line with common practices such as those in second and third level NatureServe assessment methods. Its scoring range extends from 0 to 100. This was an explicit design choice, as it provides a large range of scores allowing for a visual spread on graphs, allows for easy comparison, and is inherently intuitive as a numerical base 10 scale. Ecosystem attributes and their metrics include wetland size, upland buffers and surrounding land use, hydrology, habitat, special wetland community types, vegetation, interspersions, and microtopography (Mack, 2001).

Michigan Rapid Assessment Method for Wetlands

The Michigan Rapid Assessment Method for Wetlands (MiRAM), developed in 2010 and housed under the state's Michigan Natural Features Inventory, is one of the many programs in the international NatureServe Network (Michigan Natural Features Inventory, 2020). MiRAM bears a number of similarities to NAAP, due partly to the close relationships between the state government and HRWC and the fact that Jacqueline Courteau, a lead contributor to the design of NAAP, worked at MNFI prior.

Based largely on the Ohio program, MiRAM also incorporates aspects of the Washington State Wetland Rating System and the Minnesota Routine Assessment Method (Michigan Department of Natural Resources and Environment, 2010). Much like the NatureServe EIA, the method consists of all three Levels. Its main metrics are Size and Distribution, Upland Buffers and Surrounding Land Use, Hydrology, Soil and Habitat Alteration, vegetation, microtopography and interspersions, and lastly two somewhat unique metrics in "Special Situations" and Scenic Recreational, and Cultural Value.

Key variables

Of the metrics most of interest to HRWC, MiRAM's quantitative geospatial and rapid portions contain a landscape context and buffer analysis that is similar to that of the Washington, California, and Ohio rapid assessments. MiRAM's geospatial metrics fall primarily those known broadly as the Land Use Index, which was explicitly identified in an interview with MNFI staff member Josh Cohen as being one of the most powerful metrics in the NatureServe arsenal (J. Cohen, personal communication, August 14, 2020). The specific metrics are named "Wetland Size and Distribution" and "Upland Buffers and Intensity of Surrounding Land Use", as well as each metrics' related submetrics (MIRAM, 2010). More points are scored for larger wetlands, under the assumption that this encompasses a higher function, more ecosystem services, and additional species than a smaller plot.

The method by which one sketches a buffer around a geospatial map of the assessment area is a bit simpler than other programs; MiRAM merely suggests hand drawing a buffer of 150 m and then estimating the average buffer around the entire area. Based upon a simple mean estimate, the user then breaks the buffer into one of four tangible categories of 150+ feet, 149-75, 74-25, and below 25. These are designated as options in their briefing document (MIRAM, 2010), though this method could be altered if one were looking to compare quickly between higher or lower quality wetlands than possible under these four groups. The other buffer submetric, intensity of surrounding land use, is broken down similarly wherein intensity is defined by dominant land use type, with dominance being established at 25% of land cover. This methodology stands apart from the other examined methods in its ease of use and could be incorporated into NAAP as an important variable in measuring ecological integrity.

Soil is examined to classify the wetland type, and certain disturbances to the soil regime are also considered, almost exactly as described in the Ohio method. When assessing, the user gives an expert

opinion on how disturbed the soil is based on a number of suggested criteria, including the estimated time since disturbance. The cut off for “significant” disturbance is more than 10% of the wetland area.

Scoring System

Despite its similarity to Ohio, MiRAM's scoring system contains a number of contrasts to other programs. MiRAM inherited their scoring method from their time as a part of the Nature Conservancy under the heritage system. As in Ohio, there is both a narrative and a quantitative rating system, but the narrative rating exists here as a simple precursor to the quantitative rating, with only four questions designed to establish whether the wetland is a rare type or is suitable for (or contains) rare, threatened, or endangered species. An answer of yes to any of the 4 narrative questions automatically qualifies the wetland as high quality, and detailed assessment is not necessary unless desired. This information about rarity is useful in many senses but prohibits the ability to compare between the narratively high wetlands, if that were a goal of an organization.

New Hampshire Ecological Integrity Assessment

The current version of the New Hampshire EIA for wetland systems debuted in 2015 in collaboration with the Natural Heritage Network, the Nature Conservancy, federal partners, and the EPA. Its overall form covers many of the same variables and metrics as other field assessments, and its main variables include Landscape Context, Buffer, Size, Soil, Hydrology, and Vegetation (native and invasive, plus the stand profile). As New Hampshire is in partnership with NatureServe, results from their assessments exist on NatureServe’s website. Time and experience needed to complete the assessment were not mentioned but it was implied that a working knowledge of wetland ecosystems is needed.

Key variables

The New Hampshire landscape and rapid geospatial analysis consists of a single Land Use Index, which consists of three metrics: landscape context, buffer, and size. Size is included only if an artificial change in wetland size is detected. Landscape and buffer metrics follow the same vein as many other major NatureServe methods, being directly adapted from CRAM. Prior to the site visit, the practitioner (a trained scientist) examines landscape context and the surrounding buffer using GIS or another spatial image and determines land usage in a certain boundary surrounding the assessment area.

The hierarchical nature of the coefficients and their related land use categories are of the utmost interest here. Categories are attached to a coefficient and incorporated into the final score (natural area scores highest at 10, pavement the lowest at 0) in a manner very similar to Washington's method. Stressor checklists, used as an aid, are created based on aerial images prior to the site visit as well. Stressors, such as tree removal, mowing, flooding, or invasive species, are characterized by scope, or proportion of wetland, and severity. These land use percentages, combined with their coefficients, are added into a final letter grade form, where each letter represents a predetermined range of scores (A is .95 - 1.00). Detailed instructions on how to perform this in ArcGIS are included on Page 29 of the state manual, though the authors note that analysis is also possible through an aerial photo (NH, 2018).

Similar to many of the programs here, the New Hampshire EIA evaluates soil condition only in the context of human-related impacts to the soil and surface substrates. Impacts include filling, grading, plowing, pugging, vehicle use, sedimentation, dredging, and other mechanical disturbances.

Scoring system

New Hampshire scores both the metrics and the entire wetland. All metrics are scored according to a quantified system and assigned a letter grade ranging from A to D, with some allowance for uncertainty (the user can write AB, BC, CD). The metrics that are calculated by a quantifiable score can be designated as +/- . Practitioners must provide an explanation of any variable scoring below an A. After field work is complete, the metric scores can be combined into a single integrity score for the entire wetland in order to compare the wetland against others assessed by the method (Nichols et al., 2015).

HCV Network Forest Integrity Assessment Tool

The High Conservation Value (HCV) Network has a Forest Integrity Assessment Tool (FIAT) developed in partnership with the World Wide Fund for Nature and serves as a useful contrast being one of the few programs examined in depth that are not explicitly affiliated with the NatureServe Program and the only other program explicitly designed to be carried out by non-scientists. Despite this difference, it affirms many of the strategies employed in the other programs.

FIAT is designed as a tool for conservation for locals, activists, and non-scientists, and its manual describes the intent as being for these groups to use and adapt this method to understand their own forests (Lindhe and Drakenberg, 2016). Thus, many of the complexities in scoring, sampling, or metrics present in other programs are not so here. The method exists explicitly as a Level 2 method and lacks any geospatial or intensive components. The authors posit that a day of training is enough for most people with an interest, with the possibility of another day or two being needed if someone is assessing large plots of land and needs experience with sampling methods.

Key variables

The method is organized into a questionnaire primarily consisting of questions pertaining to the Presence/Absence of Ecosystem Features. This format of variable selection and scoring bears many similarities to NAAP, which similarly looks for whether a particular ecosystem feature is present, rather than present and to what degree as in NatureServe metrics. This format (Figure 2.6) allows for easy collection of data but removes some of the quantitative certainty present in other Level 2 methods as well as more intensive Level 3 methods.

The broad categories in the HCV analysis break down between two categories: those which address biodiversity, and those which address the level of human disturbance; almost exactly the method NAAP uses. The field forms title these categories as 1) Structure and Composition, and 2) Impacts and Threats. Where the tool differs somewhat from NAAP is in its inclusion of a section of Focal Species and Focal Habitats.

It is important to realize that unlike many of the examined tools used as a part of state monitoring and assessment programs, this is not a tool specific to a region but is rather a guideline for others around the world to adapt. Moreover, it doubles as an engagement tool for non-scientists. This is not a set in stone method but rather a collection of suggestions adaptable for different ecosystems. Their website contains examples of the tool adapted to ecosystems in locations from Oceania to Scandinavia.

FIAT also contains a 'Focal' section of particular interest to HRWC. The Focal section includes focal species and focal habitats specific to one's own forest that have been chosen by the user to represent

what are important to their particular forest and/or region. This inclusion is included largely to facilitate outreach and education rather than create a more intensive analysis. However, it can be used as a predicate for intensive analysis and/or to generally track where certain focal examples are present. Examples of focal habitats include "forested wetlands, permanent dams, ponds, and lakes, salt licks and mineral mudflats important for wildlife, and more", and it's easy to imagine selecting charismatic megafauna, umbrella or keystone species, or intolerant species for one's own focal species section. This section is the closest any of the examined methods are toward incorporating individual species in ecological integrity scores in the way that NAAP captures certain native and invasive species.

STRUCTURE AND COMPOSITION 	
1. Naturally fallen tree > 40 cm	<input type="radio"/>
2. Naturally fallen tree > 60 cm	<input type="radio"/>
3. Several trees > 10 cm	<input type="radio"/>
4. Several trees > 20 cm	<input type="radio"/>
5. Tree > 40 cm	<input type="radio"/>
6. Several trees > 40 cm	<input type="radio"/>
7. Tree > 60 cm	<input type="radio"/>
8. Several trees > 60 cm	<input type="radio"/>
9. Tree > 80 cm	<input type="radio"/>
10. Several trees > 80 cm	<input type="radio"/>
11. Climber (liana, vine) > 10 cm	<input type="radio"/>
12. Tree with ferns or other plants not rooted in the soil (epiphytes)	<input type="radio"/>
13. Several trees with ferns or plants not rooted in the soil (epiphytes)	<input type="radio"/>
14. Tree with nestingshole	<input type="radio"/>
15. High tree crown with thick branches	<input type="radio"/>
16. Tree with marks from mammal, bird or lizard	<input type="radio"/>

Figure 2.6: An example scoring sheet using the HCV Approach (Linde and Drakenberg, 2016).

The assessment does not include geospatial variables in its questionnaire, and the discussion of this in the manual is limited to how one could use aerial photos to outline sampling methods. This mostly entails a transect process for large properties, which outlines a basic process for creating "subunits" of a property and then taking at least 10 samples from within that subunit. From here one can get a sense of the integrity of the subunit by calculating the mean score of different subunit sampling locations; with time one could likewise get a sense of the integrity of the entire property.

Similar to other examined methods, the Forest Integrity Assessment only includes soil variables related to human disturbance in its example scoresheet. In the example scoresheet these include noting signs of disturbance to the soil from apparent alterations for the purposes of agriculture, logging, grazing, and burning.

Scoring system

HCV's scoring system is much simpler than the methods examined above. Rather than have any sort of end score and coefficients to weight variable influence, the final score is calculated based upon the quantity of Presence/Yes answers. Questions as listed under the tool's field manual are broken down into 20 questions on Structure and Composition, 15 on Impacts and Threats, 11 Focal Habitats (broadly defined), and whatever number of focal species are indicated by the user. The more Yes answers, the higher the score.

Three theoretical methods of analyzing scores are described. These involve examining scores both spatially and temporally, with spatial analysis related to both the scores of certain properties and the prevalence of certain question answers as well. These analyses are:

1. Temporal — Calculating annual means of scores from all plots in a certain forest or subunit. As an example, one could track the aggregate score of a particular forest over time, to see if the number changes.
2. Spatial — Visualizing the spread across plots in a given year. This would reflect the variation of quality within a particular forest at a given moment in time and could be used to inform future monitoring locations.
3. Temporal — Calculating separate, annual means for each particular metric. That way, if more small and medium trees were dying over time, one could investigate the problem more seriously.

Discussion and Recommendations

From this review we find that HRWC's NAAP bears much similarity to other established ecological integrity assessment programs, including those designed, implemented, or updated since its initial conception. This is especially remarkable given that most of these programs and their Level 2 methods are designed for conservation practitioners, in contrast to the volunteers involved in the collection of data under NAAP. This similarity in NAAP's methods to those carried out by trained scientists indicates that the program is largely in line with current practices and further emphasizes the principle that the Level 2 method is truly rapid — because even those without specific knowledge are able to carry out the methods.

This review also pointed to possible areas of improvement for NAAP, including some alterations in methodology, additions to rapid assessment, and use of geospatial information to both shorten field time and to get more accurate pictures of the landscape. It also raises some questions to consider as well as changes that can be made as the program evolves. Below we elaborate on the rationale for each of the following recommendations for NAAP:

1. *Landscape*: Develop landscape context and buffer metrics similar to those in the reviewed state-based programs and integrate Bioreserve Map and field assessment levels to allow for better understanding and analysis of landscape-level trends.
2. *Soil*: Continue to assess soil at the rapid level and include relevant soil information collected from geospatial levels for additional context.

3. *Species*: Formally review and establish criteria for which individual plant species should contribute toward the integrity and disturbance scores, and which new "focal" species could be included in data collection for educational purposes but remain unscored.
4. *Additional non-ecological variables*: Include county-level GIS data on the zoning status of the sites being assessed, and possibly other social or demographic variables that could inform decision-making.
5. *Reporting*: Attach an ABCD or Stoplight System to integrity scores in order to increase the ease with which others can interpret relative score quality.
6. *Education*: Continue and expand the use of rapid field assessment training, data collection, and reports as opportunities for educating others about ecological integrity concepts.
7. *Future research*: Make a direct field comparison of NAAP and MiRAM ecological integrity assessments by determining scores of the same site.

1. Landscape Variables and the Integration of Bioreserve Map and Field Assessment Data

One of the largest differences between the assessment of integrity at the rapid level between NAAP and corresponding programs is the absence of Landscape Context and Buffer metrics contributing to the final site's integrity score (Figure 2.4). While some of this information is captured in the Bioreserve Map, this is currently organized as two different natural area rankings derived from two different data sources at two different spatial scales. The photo of the Watershed used to make the Bioreserve Map is based on an aerial photo of the watershed from the Southeastern Michigan Council of Governments now more than 20 years out of date (Figure 2.7). As the Bioreserve areas are merely remaining natural areas, they do not necessarily conform to the property boundaries that HRWC does when conducting a field assessment. This incongruence leads to difficulty if one needs to conduct statistical analyses between the Map and the field assessments, incorporate Level 1 data into decision making, properly value ecological integrity in line with common industry practice, and more.



Figure 2.7: Some land use changes between 2000-2018 in the watershed (Washtenaw County). Bioreserve areas (red, solid lines) were delineated in 2007 from aerial imagery circa 2000. Here they are overlaid on 2018 basemap aerial imagery from ESRI with changes in Bioreserve area boundaries highlighted (yellow, dashed lines). These examples show two losses of natural area: forest → agriculture conversion (Bioreserve area #320, upper left) and forest → residential conversion (Bioreserve area #349, upper right) — and one increase in natural area: agriculture → forest conversion (Bioreserve area #489, lower left).

Our research supports the conclusion that presenting the map and assessment separately creates an obstacle to effectively assessing and conserving natural areas. Survey results indicate that landowners are not as familiar with the Bioreserve Map or how to effectively use its data from the field assessment, with only 30% of landowners knowing how to locate and use this information after receiving their final assessment report. There is an interest in doing so among this group too; 40% of stakeholders who do not use the Bioreserve Map shapefiles are interested in doing so. Secondly, while in practice one can cite the area of the Bioreserve Map in the final assessment report from a property, this number is not integrated into the integrity score and thus does not completely conform to common practice used to assess ecological integrity elsewhere. While one can use the existing setup to make spatial inferences about a site by comparing its field assessment score to the Bioreserve area score of the area in which it resides, most parcels do not contain a remote score specific to that specific land area.

Discussion over whether to integrate the Bioreserve Map and the rapid field assessments is essentially a debate over how one wants to score and rank natural areas, both internally and to external stakeholders. In many ways, these two parts represent Levels 1 and 2 of ecological integrity assessments; but the differences in the scale at which they assess integrity creates a barrier to uniting the results of each of these levels into a reproducible score that stakeholders can use to rank, purchase or lien, and conserve these natural areas. One could update the Bioreserve Map using a current aerial image and delineated natural areas as was done in the past. This would resolve the errors with natural areas altered since 2001, but not the discontinuity between remote and field data scales.

In our opinion, the best possible solution can be gleaned from the NatureServe network and the methods that use its framework. Each of the state managed programs in this chapter contains methodology on rapid level landscape context and buffer analysis. Each of these metrics is capable of being performed quickly by someone even without intermediate experience in GIS programs. This is basically akin to drawing the Bioreserve Map sites down to the individual parcel or property layer. Integrating this metric would affect existing integrity scores, and one could easily, with the existing shapefiles outlining past assessed areas, go back and use aerial images to conduct the landscape analysis for existing sites to bring those scores in line with the updated methodology.

It is also important to consider how this would be conducted on an operational level. It could be done at the office and using GIS software by a trained staff member in a fairly short amount of time, less than an hour. But NAAP is also a tool for educating and interacting with the public; therefore, we recommend arriving prepared on site to work through this with volunteers. Some of the simplest methodology occurs in MiRAM's Landscape context field manual, which involves taking an aerial photo of the assessed area, outlining the buffer and landscape distance beforehand, and having volunteers work through the metrics themselves. This would fit in with both existing NatureServe methods and HRWC's existing structure and mission.

2. Assessing Soil at both Rapid Assessment and Geospatial Levels

Early on, soil was identified as being an area of improvement for HRWC. Its metrics describing soil condition are vague and subjective, and difficult for volunteers to confidently identify. Often, soil is not recorded during a site assessment at all. This led HRWC to question whether the soil metrics should be included. According to our analysis of rapid assessment programs, NAAP soil metrics are in line with common practice.

Other researchers have concluded similarly. According to Fennessy et al. (2007), soil is the metric most often left off rapid assessments; our research confirms such findings. Most soil metrics are indicators of anthropogenic disturbance or are used in soil type classification for simple samples taken from the ground. However, Fennessy et al. (2007) note that the soil metrics utilized by the Massachusetts Coastal Zone System involved some analysis of erosion and sedimentation. The measurement of no-disturbance metrics take time and expertise and are difficult to classify as rapid; moreover, they would not be easy to integrate into a program carried out by volunteers. Among the soil metrics we have found, the two approaches most capable of being described as rapid are: (1) Organic Soil Horizons and Soil Organic Matter Decomposition (Faber-Lagendoen et al., 2006); or assigning coefficients to human land-uses within a site based on their effect on function and integrity (Faber-Lagendoen et al., 2008). The latter is a practice that has been incorporated for landscape context metrics and involves weighting land use outside of an assessed area (Figure 2.5). Any of these approaches may be difficult to incorporate into a volunteer run assessment unless simplified metrics and techniques can be designed.

Similarly, soil metrics in NAAP are limited to a few broad categories: simple soil appearance, visible disturbances to soil, and the effect of previous land uses on soil. These are scored in several ways. The appearance category metrics mostly do not contribute to integrity or disturbance scores. They are recorded for classification purposes; the only metric scored is whether the top layer is uniform or not (the former adds points to disturbance, and the latter to integrity). Appearance metrics separately involve subjective assessment, with potential descriptions including Sandy, Heavy/slippery, Mixed, Glacial erratics, Light tan, Dark brown, and Mucky (smooth or fibrous). Aspects of this exist in other rapid assessments, where a practitioner may seek samples of soil in order to classify a type. The second category, human disturbance, describes several disturbances which contribute to the final disturbance score. The third, previous land uses of soil, takes into account historical and present-day land use.

Accordingly, there are many options for assessing soil remotely which can be performed as a part of a complementary Level 1 assessment. These would not be included in a rapid assessment score but could be of use to HRWC and stakeholders. Alternatively, HRWC could design additional geospatial metrics which could be incorporated into the rapid field assessment score. This is common, as seen in other methods' context and buffer metrics, but our research did not turn up geospatial metrics outside of these broad categories.

This raises the broader question of what HRWC wishes to know and what it wishes to provide to landholders. Does HRWC wish to collect soil data, does it have the workplace capacity to do so, and would it incorporate geospatial soil categories into an integrity score for ranking ecosystems, or would it simply note soil characteristics for reference? Sacrificing some measure of soil integrity is a tradeoff NAAP and other methods are willing to make. This isn't necessarily a detraction, as rapid assessments are already limited, but it does leave open the possibility of providing some aspect of soil integrity using other methods.

One possible option is to include soil types as part of an integrity score, using accessible soil type data through the Web Soil Survey operated by the USDA Natural Resources Conservation Service (NRCS). Federal, state, and local agencies along with private institutions partnered together to form the National Cooperative Soil Survey (NCSS). Through this partnership they work to identify, document, and publish soil information from around the country (USDA, 2020). The resulting publicly available (online) soil maps account for 95 percent of the nation's counties; 100 percent coverage is anticipated within a few years (USDA, 2019). The Web Soil Survey Site consists partly of an interactive online map that allows users to select any US county as an area of interest. Once selected, the area of interest will form an area

map with polygons containing soil type abbreviations. There is a key for the soil abbreviations along with how many acres and percent of that soil type which is in the area of interest. This portion of the assessment prior to the site visit could also be used to examine several of the topographical and historical "Characteristics of the Landscape" metrics geospatially and incorporated into volunteer education during the site visit. We recommend HRWC integrate these soil characteristics into decision making using a narrative rating framework akin to those used in Ohio and Michigan for rare or valuable ecosystem classification, and that HRWC also explore whether there is use for "Characterizations of the Landscape" metrics in the same way.

3. Assessing Species Composition

Our team investigated the possibility of expanding or altering the on-site identification and assessment of individual species. This involved several lines of questioning, including adding/removing certain plant species to the analysis and altering the criteria by which individual species are included in the field method. HRWC includes a sample of individual plants in its integrity score for several different reasons, with the assumption being that each plant included is indicative of integrity or disturbance in one way. That is, these plants were chosen because of their significance to the ecosystem, for a variety of reasons including their coefficient of conservatism, whether they are known habitat for rare species, whether they provide ecosystem services, or are otherwise known as keystone or indicator species. NAAP and its emphasis on flora has its roots in sound ecological logic, with the key assumption being that natural composition and structure of the plant community supports the same in wildlife communities (Cochran et al., 2011), though some research has resulted in evidence suggesting this is not so across all taxa (Barton et al., 2014). Other research has failed to find a connection between common integrity variables and wildlife richness, with one paper in a semi-arid rangeland finding only soil hardness, defined as "the pressure (kg/cm²) required for the end of a hand-held soil penetrometer (Humboldt, 200 mm Pocket Penetrometer) to penetrate the soil to a depth of 6.5 mm," to be a reliable predictor of animal species richness (Gollan et al., 2009).

Our research found that most other methods do not sample for individual species in their Level 2 assessments. There are several methods to assess vegetation composition, the most common being the percentage of native and invasive species through plot sampling. Other metrics include calculations of the number of increaser and decreaser species (described in more detail under Washington's section above), estimating the mean coefficient of conservatism of identified plant species, and examining the presence of diagnostic species. Diagnostic species are defined as "native plant species whose relative constancy or abundance differentiates one vegetation type from another, including character species (strongly restricted to a type), differential species (higher constancy or abundance in a type as compared to others), constant species (typically found in a type, whether or not restricted), and dominant species (high abundance or cover)" (Rocchio et al., 2016). NAAP already includes some of these in one form or another in their analysis. Percentage invasive and native is one such NAAP metric, and when included with native and invasive species themselves results in a sort "double counting", depending on how sampling for estimated native and invasive species presence is undertaken. The one method example that did allow for individual species, the HCV FIAT, includes them largely as an outreach and educational tool, and these are not included in the formal end of assessment site score, at least as intended by the method's original designers.

We examined changing or adding additional species to the assessment. Using search tool MichiganFlora.net, we examined plants with high coefficients of conservatism of plants already which Kris Olsson could recall noting during field assessments, as well as by other criteria. Because of this, we

also explored research conducted by MNFI scientists on which plants provided for rare or threatened and endangered species, for possible inclusion in the individual species assessment. After consulting with others, adding new plants to be included in integrity or disturbance was dropped as an option due to a fear that having too many individual plant species would result in a final score weighted too heavily towards individual plants, thus making the field assessment more akin to an FQI. However, there is potential for HRWC to follow the HCV's Forest Integrity method and include focal species for educational and tracking purposes, but not as part of a final integrity or disturbance score; this type of education accounting is something NAAP already uses for other variables.

HRWC has indicated an interest in adding more species to the method, but not in adding significantly to the individual species contributing to the quantitative scoring method. This brings the possibility of following HCV's example and including plant species as focal species of interest, for educational and or simple non-quantitative tracking purposes. Some metrics already used in their method fit this non-scoring definition as well; standing water is used as a community type indicator for wetlands. HRWC has indicated an interest in altering individual species which contribute to the integrity and disturbance score (one example discussed was replacing Joe Pye weed with Boneset). This discussion is complicated by the fact that there is no single criteria by which these species are included; how could HRWC establish which plants should contribute to an integrity score and which are merely there for education and tracking? Our recommendation is to formally review and establish the criteria for which individual plant species should contribute toward the integrity and disturbance scores, and then work through which new "focal" species could be included in data collection for educational purposes but remain unscored.

4. Zoning as a Non-Ecological Variable

Our team examined the possibilities of incorporating social or non-ecological variables into NAAP in order to broaden the analysis the organization conducts when it recommends natural areas to be conserved. We did not find examples to draw from in the literature or in practice, but believe there are manageable ways to incorporate this information.

Specifically, our team examined the potential for HRWC to use municipal zoning data to assess land development risk. While this is a variable which would not necessarily be included in the integrity or disturbance scores, it would still be of use to HRWC in decision-making. HRWC already possesses GIS shapefiles of zoning locations, though they have been identified by Kris Olsson as 20 years out of date.

To examine whether downloading and incorporating updated maps was even necessary, we used online accessible maps available through county governments to assess whether we could easily identify the zoning designation for four recently assessed properties in Lenawee and Livingston Counties. We found that one could easily identify zoning using the online resource for each of the four properties examined, and that development categorization and nearby designations varied between the sites. Therefore, we recommend using publicly available spatial zoning information in HRWC site reports and exploring other non-ecological variables useful under a multi criteria decision making framework.

5. Reporting Complicated Integrity Scores

At present, HRWC's final site assessment reports provide little context as to what their site scores mean, this may make it more difficult for at least some landowners and stakeholders to understand what is being communicated (for user feedback survey results see Chapter 4). While the content and scientific

backing of NAAP's assessment approach is strong, as indicated in this chapter, the meaning of assessment scores is not intuitive. Integrity and disturbance scores are also not meant to be absolute, but as relative scores to compare natural areas in the watershed against one another.

Many other programs communicate integrity scores in a way that may be more understandable and useful to stakeholders than current NAAP score reporting forms. The methods by which some methods report and combine their scores are elaborated on above (Figure 2.2, 2.3). Some score individual variables and then through simple or complicated methodology, combine them into a single site score. To simplify the complexity of the aspects of integrity and the final site integrity score itself, many assessments attach a tier system to objective metric scores. From our research we have found two such tiering methods which categorize scores into groups for easy reference: the ABCD scoring system and the "Stoplight" method (Mitchell, 2014; Tierney, 2013). Each attaches metrics to a hierarchical, tiered system. Under the ABCD method scores range across four letter grade categories and the Stoplight system merely uses a green, yellow, or red ranking to indicate whether a score is good, cautionary, or of some concern. We recommend HRWC select a method like these and use it to assist in interpretation of the scores reported to landowners and stakeholders.

6. Rapid Assessment as an Educational and Engagement Tool

As stated above, though many assessments imply the need for those with a working knowledge of landscape ecology, HRWC is able to achieve similar results in a program carried out by volunteers. Given that their assessments are done at the behest of private landowners, local conservancies, and local government entities, their work interfaces with the general public in a way that many state monitoring methods do not. Thus, their method exists not only to assess and rank, but to educate.

The simple and comprehensive nature of Level 2 rapid assessments suggests they can be one of the best educational tools that organizations can use to inform the general public about ecological integrity and the different aspects of ecosystems. This presents many possible positive consequences. One example is that it can be useful in training or educating those who may become future conservation practitioners or advocates. A training program of this type exists in Ohio. Another is already in practice with HRWC, which is the use of this assessment method to educate those not in the conservation field. This is possible in many ways: through learning variables to assess ecosystems, scientific metrics to judge them, and the final reports given to these stakeholders.

Metrics and the scoring system itself can be educational tools as well. The inclusion of glossaries and explanations for certain letter grades can help a stakeholder learn to associate metrics with integrity and disturbance of an ecosystem, and could encourage the landowner to further look into ways to help restore or maintain integrity. The narrative rating portion of the Ohio and Michigan methods, for example, engage the practitioner with questions about site history, the presence of rare and endangered species, and community types of the assessed wetland.

7. Direct Field Comparison of NAAP with MiRAM

Lastly, through conversations both among ourselves and with HRWC, we concluded that HRWC might gain direct insight into how their final integrity scores measure up against others in a concrete and quantifiable manner were they to conduct a field assessment belonging to another program. Should the comparison be carried out in the future, it is important to consider how these scores can be compared. That is, much like NAAP, other rapid methods collect and score for sites in a way that allows sites to be

directly compared to one another. However, these scores are generally not meant to be taken as an absolute measure of integrity, but rather as a means to compare one site to another and to inform prioritization and more intensive analyses. Therefore, while one could use a field manual to collect and score metrics from these programs, it would also be necessary to find out the distribution of scores on sites conducted by that program(s), so one would know how to interpret the score. We recommend HRWC take advantage of its pre-existing relationship with MNFI to undertake one of their assessments on several sites HRWC visits. This will give HRWC the opportunity to understand their MiRAM method and the scores it produces.

Conclusion: Can We Truly Assess Integrity?

Circling back to the beginning of the chapter, this section leads to the question of whether it is possible to truly assess integrity, especially for a rapid level assessment. Fennessy et al. (2007) found that most programs examined in detail do not meet certain criteria associated with both rapidity and scientific verifiability. Of the methods we examined, only three were also examined by Fennessy et al. (2007): New Hampshire, Washington, and Ohio. Of these three, only New Hampshire had been eliminated by Fennessy et al. as not being truly rapid, and for two reasons: length to complete, and not containing a complete site score. It is important to note that as these methods have since evolved, New Hampshire does now contain methodology in its field manual for overall site scores.

The methods we examined all contained a great deal in common with one another, suggesting both that any change to NAAP's method is likely to be small rather than whole scale, and that these methods have been developed from similar sources. HRWC utilized the expertise of many different technical advisors in order to form their individualized field assessment program, and after many years without change it nonetheless remains in line with the methods of its more frequently updated peers.

NAAP has targeted a balance between capturing the essential elements of the complex concept of integrity and engaging volunteers and stakeholders in the conservation process. This is a process which allows them to identify basic integrity characteristics and do so in a way that, however limited, advises and contributes to conservation in southeastern Michigan. We have seen, in many critical analyses of ecological integrity assessment methods (e.g., Brown and Williams, 2016; Gollan, 2009), that there are objections to assumptions made in these assessments, such as whether chosen measures truly link to more defined metrics of biodiversity. While these are vital questions to ask, it is also important to ask how much they matter. Does an integrity assessment need to reflect everything pertinent about that site, or just capture and share enough information to effectively guide prioritization and action? In the following chapters we focus on the information management and sharing process, each of which is equally important to what is measured. We resolve shortcomings of data management and integration, and we assess the effectiveness, from the perspective of volunteers, landowners, and stakeholders, of NAAP data on building understanding and guiding decision-making.

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Chapter 3: NAAP Data Management & Integration: How can the Data be Better Integrated and Workflows be Improved using the Latest Geospatial Technology?

The Natural Areas Assessment and Protection Program (NAAP) aims to protect the natural areas of the highest ecological integrity in the Huron River Watershed. To this end, the program assesses and measures ecological integrity in two ways: 1) a Geographic Information Systems (GIS)-based assessment using geospatial layers and 2) a rapid field assessment program involving a checklist and report of key plant and landscape characteristics. From the GIS-based assessment, HRWC has created a “Bioreserve Map”, which shows the location and ranking (from high to low estimations of ecological integrity) for all remaining natural areas in the watershed (Appendix A). From the rapid field assessments, HRWC has created a scoring system for both ecological integrity and human disturbances, which allows for natural areas to more easily be compared with one another and prioritized for protection (Appendix B). Results from both the Bioreserve Map and ecological field assessments are the primary components of reports delivered to landowners and land conservancies in the watershed (Appendix B); they inform how a property can best be managed and protected.

While the Bioreserve Map data (GIS-derived) and rapid field assessment data (field-derived) results can be viewed side by side, there are several limitations to using them together to create an integrated assessment of the watershed’s natural areas. Examining the relationships between GIS and field-based datasets is complicated by current data collection processes and storage formats, different spatial scales of the data, and other inefficiencies and challenges. This has hindered HRWC’s ability to analyze and share the program’s ecological assessment data and to increase the program’s positive impacts. In this chapter, we elaborate on these data collection and assessment challenges, outline potential solutions, and then recommend an updated set of tools and approaches to improve program effectiveness. Acronyms used throughout this chapter are captured in Table 3.1.

Table 3.1: Reference of abbreviations and acronyms used throughout Chapter 3.

Table of Acronyms in Chapter 3	
HRWC	Huron River Watershed Council
NAAP	Natural Areas Assessment Program (of HRWC)
GIS	Geographic Information Systems (type of software for managing, analyzing, and visualizing geographic data)
ESRI	Environmental Systems Research Institute (supplier of GIS software like ArcGIS)
RDBMS	Relational Database Management System (type of software for storing data, like Microsoft Access)
OLE DB	Object Linking and Embedding Database (extension for ArcGIS software that enables Microsoft Access databases to be linked to ArcGIS)
SQL	Structured Query Language (programming language used to manage data in a RDBMS)
CSV	Comma Separated Values (delimiting text file using commas to separate values, can be opened with spreadsheet programs like Microsoft Excel)
XLS Form	A form standard created to help simplify the authoring of data entry forms in Excel and used by the Survey123 Connect application to design Survey123 forms

Challenges in Data Collection, Management, and Visualization

To adaptively manage the program and create improved tools and procedures, we needed to first identify and better understand the program’s main data collection, management, analysis, and visualization problems. We started by talking with HRWC staff — specifically, Kris Olsson and Kate Laramie — and worked with these staff members closely throughout our involvement in this project. Kris Olsson joined HRWC in 1992 and currently serves as a Watershed Ecologist. Kris has been involved with NAAP since its inception and was an essential resource as we worked to develop improved tools and workflows for the program. Kate Laramie joined HRWC in 2020 and currently serves as a Watershed Ecology Associate. Kate has been involved in coordinating field data collection efforts and managing volunteers in several HRWC programs and will be overseeing large portions of NAAP in the coming field seasons. In addition to the challenges we identified through conversations with Kris and Kate, we identified some challenges on our own as we worked with these datasets, participated in mock field assessments, and consulted experts in data management & visualization (Shannon Brines, Peter Knoop, and others). We classified all of these problems and challenges into three categories: Data Collection & Entry, Data Management & Analysis, and Data Visualization challenges (Figure 3.1). Below, we first elaborate on each of the identified challenges before evaluating potential solutions and alternatives to NAAP’s existing data collection, analysis, and management workflows.

Current Data Challenges in NAAP

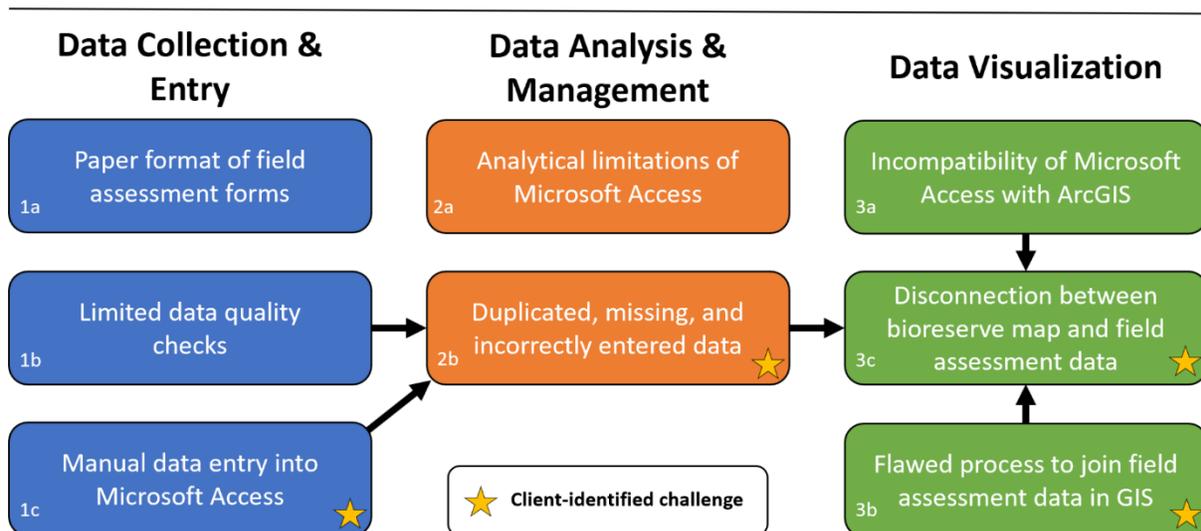


Figure 3.1: Data challenges in NAAP’s current workflows and connections between these challenges. Client-identified challenges are designated with stars and connections between challenges are identified with arrows. Client-identified challenges were indicated to us early on in the project through discussions with Kris Olsson and Kate Laramie and non client-identified challenges are other challenges realized through our involvement in the project.

1. Data Collection & Entry

a. Paper Format of Field Assessment Forms

Presently, field assessment data is recorded by volunteers on multi-sheet paper forms, but this format poses several challenges. One challenge for volunteer data collectors is managing a large number of paper sheets while in the field. This challenge is amplified in situations where a field assessment site contains many unique ecosystem types since separate forms must be filled out for each. Transportation of paper forms is another challenge. The process of printing and transferring forms between volunteers and the office generates ample opportunity for forms to become damaged or go missing.

b. Limited Data Quality Checks

There are few processes in place to deal with field assessment forms that are incompletely filled out, which can lead to missing or erroneous data. Some questions on the field assessment form may be left unmarked (e.g., if certain species are too difficult to identify) or sections may be skipped over entirely (e.g., soil-related questions may not be filled out if the weather is unfavorable or soil is not easily exposed). Without any indication of why these questions were left incomplete, it may be unclear whether they were left intentionally blank or were simply not assessed. Additionally, important identifiers like site name and ecosystem name are often left empty or incorrectly entered. Incomplete field assessment forms contribute to data management and analysis challenges and make it more difficult to draw accurate conclusions about the data. In the past, HRWC has hosted training sessions that are intended to standardize the data collection process and prepare volunteers for what they might observe in the field, but they have not held such training for several years.

c. Manual Data Entry into Microsoft Access

Field assessment data must be manually entered into a Microsoft Access database by an HRWC staff member; a process which is tedious and prone to human errors. This can lead to erroneous or missing data as well as inconsistency in the formatting of the data entered. Data formatting inconsistencies become especially problematic when attempting to analyze and visualize the data. In particular, data entry errors may result in blank or mistyped key site identifiers, like site names or parcel IDs, that are essential for statistical or spatial analyses. This contributes to problems 2b and 3c in Figure 3.1.

2. Data Management & Analysis

a. Analytical Limitations of Microsoft Access

Although Microsoft Access is a useful software for data storage, querying, and report generation, it is not the optimal database for conducting statistical analyses. Statistical analyses are made more difficult by the way data is stored in Microsoft Access (as a series of "0's" and "1's", spread out over multiple fields/columns and usually, separate worksheets). This way of storing data simplifies cross-worksheet queries and report generation, but it makes it difficult to interpret the raw data and to glean trends about the dataset as a whole. For example, to see all of the human disturbances for a given ecosystem, one would need to look across 13 separate columns (one for each

disturbance checkbox on the data entry form) or to compare disturbance levels between a forest and wetland on the same site, you would need to look across two separate worksheets. Microsoft Access does have basic statistical capabilities built in, but more complex statistical analyses are best performed in an external software program like R, which (in the case of the NAAP database) requires the preliminary steps of exporting the data, making field names consistent and understandable, and potentially merging multiple worksheets together.

b. *Duplicated, Missing, and Incorrectly Entered Data*

Manual data entry combined with the way data is entered and stored in Microsoft Access can lead to several problems that interfere with data analysis. Presently, field assessment data is entered into separate data entry forms for each ecosystem type and then stored in separate worksheets. Not only does this contribute to the tediousness of data entry, but it also leads to a duplication of some data in the database (particularly site information and survey questions common to all ecosystem types). This can potentially contribute to false conclusions when analyzing data from combined worksheets. Additionally, duplication of data takes up unnecessary data storage that could be better allocated elsewhere. Missing or incorrectly entered data, especially site identifiers, also make data analysis less effective. For example, some sites have slight name variations across the different worksheets and some records do not have any township or date information entered. This makes it more difficult to tie a set of records to a common site or to analyze trends across space and time.

3. Data Visualization

a. *Incompatibility of Microsoft Access with GIS*

The file format of Microsoft Access databases (.accdb) is not very compatible with ESRI's ArcGIS software (including ArcMap and ArcGIS Pro), which makes it difficult to spatially visualize the field assessment data. Although it is technically still possible to connect an Access Database to ArcMap using an ArcMap software extension (the OLE DB extension), there are two problems with doing so. First, data must still be joined to a spatial layer, which is cumbersome to do with this dataset (see problem 3b in Figure 3.1). Second, and more importantly, the particular extension that enables cross-platform compatibility is not currently supported in ESRI's newer platform, ArcGIS Pro, threatening the future viability of any workflow that relies upon it.

b. *Flawed Process to Join Field Assessment Data to Spatial Layer*

Although HRWC does have a process in place to join the field assessment data to a spatial layer in ArcGIS (so that the data can be represented spatially), this process is both *inefficient* and *ineffective*. HRWC's current process to join the field assessment data involves first creating a layer of legally defined land ownership parcels in GIS and then using an attribute join in ArcGIS to match field assessment data to parcels based on Parcel ID codes (which are manually entered into Microsoft Access beforehand). This process is *inefficient* because the field assessment data must be joined to three separate layers (county parcel boundaries for the 3 counties in the watershed) before being merged into a single output layer. Furthermore, this process must be repeated every time a new layer of field assessed parcels is created. It is *ineffective* because the Parcel ID codes entered into Microsoft Access are often incorrect, inconsistent (e.g., some

include hyphens and others do not), or missing, leaving many field assessment records unjoined to a parcel layer. An increasing number of data entry errors over time have continued to make this problem worse.

c. *Disconnection Between the Bioreserve Map and Field Assessment Data*

Perhaps the biggest challenge the program faces is the lack of integration between the Bioreserve Map and field assessment data, which makes it difficult to compare and combine the two datasets for analyses. The Bioreserve Map is derived from GIS layers and is stored in a file geodatabase and only includes GIS-based rankings/estimates of ecological integrity, not results from the rapid field assessments. The field assessment data, on the other hand, is tabular (stored in a table format — in this case, Microsoft Access worksheets) and there are barriers to representing this data spatially alongside bioreserve GIS layers (see problems 3a and 3b). Although the Bioreserve Map data and field assessment data can be included side-by-side in individual site reports generated for landowners, it is difficult to visualize and glean landscape-level trends from the data. In order to do so, several data analysis and visualization challenges — namely, problems 2a, 2b, 3a, and 3b — must also be addressed to enable a more seamless integration of the two datasets.

Collectively, these data collection, management, analysis, and visualization challenges hinder the ability of the program to: 1) operate effectively, 2) conduct statistical and spatial analyses, and 3) glean landscape-level patterns and trends from the data. Addressing these issues by implementing new data management systems and workflows will improve operational efficiency and effectiveness and increase the positive impacts of the program. In the following section, we will describe some potential solutions to these problems and our process of determining which solutions to implement.

Evaluating Potential Workflow Solutions

Alternative Relational Database Management Systems: One Approach to Better Integrate Bioreserve Map and Field Data

In order to effectively and holistically address the aforementioned challenges, we started by addressing the data visualization challenges and worked backwards to address the other challenges. Otherwise, we risked repeating the same mistakes of the original workflow by producing a solution that still lacked integration between the field assessment data and the Bioreserve Map in GIS. Starting with data visualization was also important because these challenges connect back to challenges in data collection and data management/analysis (Figure 3.1). One data visualization change could have a rippling effect throughout the entire workflow, thus affecting our approach to solving the other challenges. For example, if we introduced new software programs into the workflow to bypass challenges with Microsoft Access, analytical challenges associated with the new system might be different and the door might be opened to using other data collection tools.

Our initial approach to better integrating the Bioreserve Map and field assessment data was to explore alternative Relational Database Management Systems (RDBMS) to Microsoft Access. Storing the field assessment data in an ArcGIS-compatible RDBMS would enable more seamless connection between the field assessment data and GIS layer, and allow for easier visualization and spatial analysis of the field assessment data. For some additional background on RDBMS and how they work, refer to Appendix C.

While Microsoft Access has certain advantages when compared with other RDBMS options (compatibility with other Microsoft products, simple user interface, widespread usage, and low costs), it is not optimal for usage with ArcGIS — a widely used GIS software platform developed by ESRI and used by HRWC. Linking the contents of a Microsoft Access database to a spatial layer in ArcGIS is possible, but it is a cumbersome process. Although ArcGIS programs (ArcMap, ArcGIS Pro) *can* import Excel and CSV files, they *cannot* read or write to the Microsoft Access “accdb” file format unless the Object Linking and Embedding Database (OLE DB) extension is installed. Unfortunately, ESRI does not currently enable the OLE DB extension for their newest and most widely used platforms, ArcGIS Pro & ArcGIS Online. Their older platform, ArcMap, seems destined to gather dust as it is no longer receiving any new software updates. Moreover, ArcGIS Online — which offers attractive new capabilities via networking, real-time GIS connectivity across multiple organizations, and shareable maps — is rapidly growing, but is not as fluidly and easily connected to ArcMap as it is ArcGIS Pro.

This presents a problem for existing users of both ArcMap and Microsoft Access who must decide whether to continue with their existing workflows for linking data to spatial layers or pursue alternative platforms and processes. Some alternatives could involve using: different GIS platforms (such as QGIS); new data management workflows (e.g., exporting the Access database to a CSV file prior to joining it with a GIS layer); or alternative RDBMS that are more compatible with ArcGIS. HRWC already uses ArcMap and ArcGIS Pro extensively in their programs (making a shift to a new GIS platform unlikely) and documentation on alternative workflows is sparse. Therefore, we decided to look deeper into RDBMS options in hopes of migrating the data to a new platform more compatible with ArcGIS.

There are several ArcGIS-compatible RDBMS options to choose from, with tradeoffs in storage size, speed, scalability, and other factors. From our research, the best options for HRWC are SQLite and PostgreSQL. We summarize our findings on these RDBMS options in Table 3.2.

Table 3.2: Comparison of several *Relational Database Management Systems*, adapted and expanded from an article published on [Digital Ocean](#) (updated March, 2021).

Name	ArcGIS Compatible	Advantages	Disadvantages	When to use	When not to use
SQLite 	Yes Both ArcMap and ArcGIS Pro	<ul style="list-style-type: none"> > Small footprint > Easy to use (no configuration required) > Portable (entire database stored in single file) 	<ul style="list-style-type: none"> > Limited concurrency (only one process can edit database at a time) > No user management > Limited security options 	<ul style="list-style-type: none"> > Embedded applications (apps that require portability, but not future expansion) > Disk access replacement (reading and writing directly to disk) > RDBMS testing, simple setups 	<ul style="list-style-type: none"> > Very large database sizes > High write volumes (lots of edits and by multiple users) > Network access is required (DB saved locally)
MySQL 	Yes, with OLE DB extension ArcMap only	<ul style="list-style-type: none"> > High popularity, easy to use > Security > Speed > Replication (reliability and database backup) 	<ul style="list-style-type: none"> > Known limitations (not designed for full SQL compliance) > Licensing, proprietary issues > Stagnant software development > Not ideal for geographic data 	<ul style="list-style-type: none"> > Need high security > Websites and web applications > Expected future growth 	<ul style="list-style-type: none"> > SQL compliance is required (more limited function) > Concurrency and high write volumes (not great with many users)
PostgreSQL 	Yes, with PostGIS extension Both ArcMap and ArcGIS Pro	<ul style="list-style-type: none"> > Open source > SQL compliance (supports most SQL functionality) > Strong user community > Strong third party support 	<ul style="list-style-type: none"> > Memory Performance (can be slower to run) > Lower Popularity 	<ul style="list-style-type: none"> > Data integrity > Integration (with other programming languages, platforms) > Complex operations (requiring multiple users) > Require GIS compatibility 	<ul style="list-style-type: none"> > Speed is required > Simple setup required > Replication
Microsoft SQL Server 	Yes, with Microsoft ODBC installed Both ArcMap and ArcGIS Pro	<ul style="list-style-type: none"> > Scalability > Security > Database backup & recovery 	<ul style="list-style-type: none"> > Expensive licensing > Windows only > Difficult to setup and manage 	<ul style="list-style-type: none"> > Already working within the Windows/Microsoft platform > Large databases with high security needs 	<ul style="list-style-type: none"> > Simple setup required > Need an easy to use RDBMS
Microsoft Access 	Yes, with OLE DB extension ArcMap Only	<ul style="list-style-type: none"> > Simplicity (easy to create and manage) 	<ul style="list-style-type: none"> > Small Database Size (limited to 2 GB per database) 	<ul style="list-style-type: none"> > Simple setup and management (need system to be usable by non-technical staff) > Only require RDBMS capabilities beyond Excel (but nothing elaborate) 	<ul style="list-style-type: none"> > Large database sizes > Require enterprise-level RDBMS > Require ArcGIS Pro compatibility

Database Storage within the ESRI Ecosystem: The Most Feasible Option for Integration of all NAAP Data Sources

While we succeeded in identifying some RDBMS alternatives to Microsoft Access that could solve the data integration problem (and which may still be viable options for use in the future or in other HRWC projects), we decided to pursue a more immediately feasible alternative instead. Migrating the data to one of the RDBMS alternatives in Table 3.2 would require more time, extensive programming experience, and RDBMS knowledge than is currently available in the project team or, likely, HRWC staff. Moreover, the future usability of the new system depends on continued support by HRWC staff, which would be put at risk if it were difficult to understand or adapt to. Instead, we decided to look into data storage and data collection alternatives within the ESRI ecosystem and ArcGIS platform itself. Because HRWC already uses ESRI products, the adoption of an ESRI-based solution would incur minimal operational friction. It would also allow for a more immediately feasible transition.

ESRI's geodatabases, which have most of the same structure and functionality as other RDBMS, offer compatibility with ArcGIS software and the capability to manage both geographic and tabular data. While such benefits are not unique to geodatabases (see RDBMS options in Table 3.2), using a geodatabase is superior to using any other RDBMS — at least, from the perspective of visualizing the data spatially in ArcGIS. Storing NAAP data within an ArcGIS geodatabase eliminates any potential for software incompatibility between the database and ArcGIS, addresses data visualization challenges 3a and 3c (Figure 3.1), and has the potential to simplify project workflows.

In ESRI's suite of applications, data is stored in one of three types of geodatabases. Much like Microsoft Access databases, geodatabases are built on relational database concepts: "the core of the geodatabase is a standard relational database schema (a series of standard database tables, column types, indexes, and other database objects), which define the integrity and behavior of the geographic information. Simple tables and well-defined attribute types are used to store the schema, rule, base, and spatial attribute data for each geographic dataset" ([ArcGIS Help — The architecture of a geodatabase](#)). There are three basic types of geodatabases used within ArcGIS to manage both spatial and tabular data — personal geodatabases, file geodatabases, and enterprise geodatabases — key differences are summarized in Table 3.3 below.

Table 3.3: Comparison of the major differences between ESRI Database Types (personal geodatabases, file geodatabases, and enterprise geodatabases), adapted from [ArcGIS Help](#).

ESRI Database Type	Storage Size	Speed	Platform	Number of Users	Licensing Requirements
Personal Geodatabase	2 GB	Slowest	Windows only	1 at a time (locks for editing)	ArcGIS License
File Geodatabase	1 TB	Fast	Cross-platform (Windows, Unix, Solaris, Linux)	Unlimited (supports concurrent editing)	ArcGIS License
Enterprise Geodatabase	Unlimited	Fastest	Cross-platform (Windows, Unix, Solaris, Linux)	Unlimited (supports concurrent editing)	Enterprise License (more expensive)

Although personal and enterprise geodatabases come with many benefits, file geodatabases are the best choice for managing NAAP's data. File geodatabases offer numerous advantages over personal geodatabases that make them better suited for the data storage and analysis needs of NAAP. One of the biggest advantages of file geodatabases is their larger storage capacity (a limit of 1 terabyte compared to the Microsoft Access database limit of 2 gigabytes per database). The current rapid field assessment database is not very large (roughly 12 MB), so a file geodatabase or personal geodatabase would be sufficient for storing this volume of data. However, continued field data collection and HRWC's interest in the possibility of saving photos within the database give a slight edge to using the file geodatabase structure. More importantly, the file geodatabase can hold multiple datasets in one database, whereas a personal database cannot. This would allow, for example, the Bioreserve Map GIS layers, Survey123 feature layers, and supplementary GIS layers to be packaged into a single file geodatabase, making it easier to share data. Additionally, using a file geodatabase opens up opportunities to utilize these databases in multi-user scenarios, as opposed to personal geodatabases which place locks on the number of concurrent users/editors. Enterprise geodatabases are another option with even larger storage capacity and faster processing speeds than file geodatabases, but they require expensive enterprise-level licenses from ESRI and are typically used by organizations with much larger ArcGIS needs. At this point in time, file geodatabases are more than sufficient for the needs of NAAP.

While shifting to the ArcGIS file geodatabase format would offer many benefits, there are also limitations to the format. One limitation of file geodatabases (along with personal and enterprise geodatabases) is that they are encrypted. This means that ESRI credentials and software are required to access geodatabases. If an organization lacks ESRI software or credentials, then they must download software extensions or establish other workflows to access the data. Therefore, shifting data storage to a geodatabase can make it more difficult to integrate data with software outside of the ESRI ecosystem of applications. Additionally, licensing and data storage costs for an organization can add up quickly, especially if heavily leveraging capabilities through ArcGIS Online. Credits are not as much of a concern for smaller organizations, but should be factored in when examining organizational growth and dependency on ESRI apps. For some alternatives to ESRI geodatabases and applications, such as QGIS and ODK, refer to our discussion of data collection and management options in this chapter's recommendations. With all benefits and drawbacks considered, we maintain that the ArcGIS file

geodatabase would be the best option for geodatabase longevity and usability, especially as HRWC increasingly uses ESRI products across their projects and programs.

Solving Data Collection Challenges: Choosing between Collector and Survey123

After deciding to shift storage to the file geodatabase format to address data visualization challenges, we worked backwards to identify and develop solutions to the program's data collection and data management challenges (Figure 3.1). Since any new data collection and management solutions needed to be compatible with the file geodatabase structure we chose, we began our search by investigating data collection applications within the ESRI ecosystem. ESRI offers two main data collection apps that make it easier to collect, manage, and analyze field-collected data — Collector and Survey123. These applications allow the user to create streamlined data entry forms which can be filled out either in a web browser or via a smartphone/tablet in the field (data can also be collected offline and synced later). Data collected through these applications is saved directly into a file geodatabase, via ArcGIS Online hosted feature layers, which effectively bypasses the step of manually entering field-collected data into a database. This seamless integration between data collection apps and ArcGIS Online reduces labor and the potential for data entry errors during data collection & entry steps. It also facilitates data analysis and data visualization through ArcGIS Online and ArcGIS Pro — making it easier to run spatial queries and spatial analyses and to share the data through dashboards or web mapping applications. Because of all of the advantages to working in the ArcGIS suite of applications, we decided that developing one of these two data collection tools was the best path forward for addressing this program's challenges.

While Collector and Survey123 are very similar, they have key differences that make them useful in different contexts — most importantly a difference in focus between *map-centric* (Collector) and *form-centric* (Survey123) data collection. This means that the focus in Collector is *where* features are collected (making it useful in contexts where a lot of survey points are collected over a short period), whereas the focus in Survey123 is on the *attributes* of the features (making it useful in contexts where detailed information is collected for a few survey points). A comparison chart from ESRI's community website highlights some of the other key similarities and differences between these applications (Table 3.4). After researching and testing the functionality, user interface, and overall performance of both of these apps, we determined that Survey123 provides a better fit for the style of data collection in NAAP. The form-centric focus of Survey123 allowed us to replicate (as closely as possible) the paper form data entry experience while in the field. It also offered more options for customizing question appearance, allowing us to tailor the survey more closely to anticipated surveyor needs.

Table 3.4: Comparison of Survey123 and Collector as data collection tools within ArcGIS, taken from an [ESRI Community page](#). The biggest difference between the two is the form-centric (Survey123) vs map-centric (Collector) data collection style.

Comparison Metric	Survey123 for ArcGIS	Collector for ArcGIS
Data collection style	Form Centric	Map Centric
Supports capturing new data	Yes (points, lines, polygons)	Yes (points, lines, polygons)
Supports editing existing data	Yes	Yes
Supports deleting existing data	No	Yes
Smart forms	Yes (xForms)	No
Supports reverse geocoding	Yes	No
Works offline	Yes	Yes
Can work with versioned geodatabase layers	No	Yes
Can work with related records	Yes	Yes
Supports external GNSS receivers	Yes	Yes
Supports integration with Spike	Yes	No
Supports integration via webhooks	Yes	No
Supports anonymous access	Yes	No
Platforms	iOS, Android, Windows, (7,8,10), Mac, Linux, Web	iOS, Android And Windows 10 with Classic
Technical Support	Esri & Community	Esri & Community
Developer opportunities	Yes	No

It is important to note that Survey123 and Collector are part of a rapidly evolving portion of geospatial field technology and these apps may continue to change. One indication of how quickly these apps are evolving is ESRI's recent release of a new data collection app called Field Maps (still in its first of three phases of development as of April 2021). This app is meant to integrate functionality across many of its now separate field applications (including Collector, Explorer, Navigator, Tracker, and Workforce). Field Maps itself is a separate application from Survey123, but it does include smartform capabilities and is intended to support app linking (to facilitate multi-app workflows). This means that, for the foreseeable

future, Survey123, Collector, or Field Maps will be available and supported as standalone applications or can be used in tandem. That opens up the possibility for using both Survey123 and Field Maps for field assessment data collection — for example, a workflow could involve volunteers using Field Maps to navigate to the field assessment site and then opening a link to the Survey123 form on their device. Field Maps could potentially be a useful tool for this program, so we recommend keeping a close eye on its development as ESRI releases more documentation and wraps up beta testing. Having decided on a file geodatabase for storing data and Survey123 form for collecting data, we then implemented these solutions (and others) to enhance NAAP's workflow. These details are laid out in the following section.

Improved Tools & Workflow Changes Implemented

As we developed improved tools and implemented changes for NAAP, we sought to address as many of the data challenges as possible, starting with the data visualization challenges and working backwards to address data management and data collection challenges (Figure 3.1). Based on our review of relational database management systems and ESRI's data collection applications, we concluded that a **file geodatabase** would be the optimal format (from a data visualization and analysis perspective) for storing the program's data and that a **Survey123 form** would be the optimal way to enter information into that geodatabase. Alongside the Survey123 form we also developed several other solutions and tools, including creating a **GIS layer to join the field assessment data to**, and creating **ArcGIS Online web maps** and an **ArcGIS Online dashboard** to dynamically display field assessment results.

Each of these interrelated solutions address a different set of challenges (Figure 3.2) and together provide an improved workflow for the program. These solutions do not solve NAAP's limited data quality checks, but we discuss in the recommendations how this might be addressed. Using this new workflow will allow the program to operate more efficiently and effectively, increasing its positive impacts. Below we elaborate on how and why each of these solutions were implemented so as to provide clear documentation for future users of these tools and datasets.

Current Data Challenges in NAAP

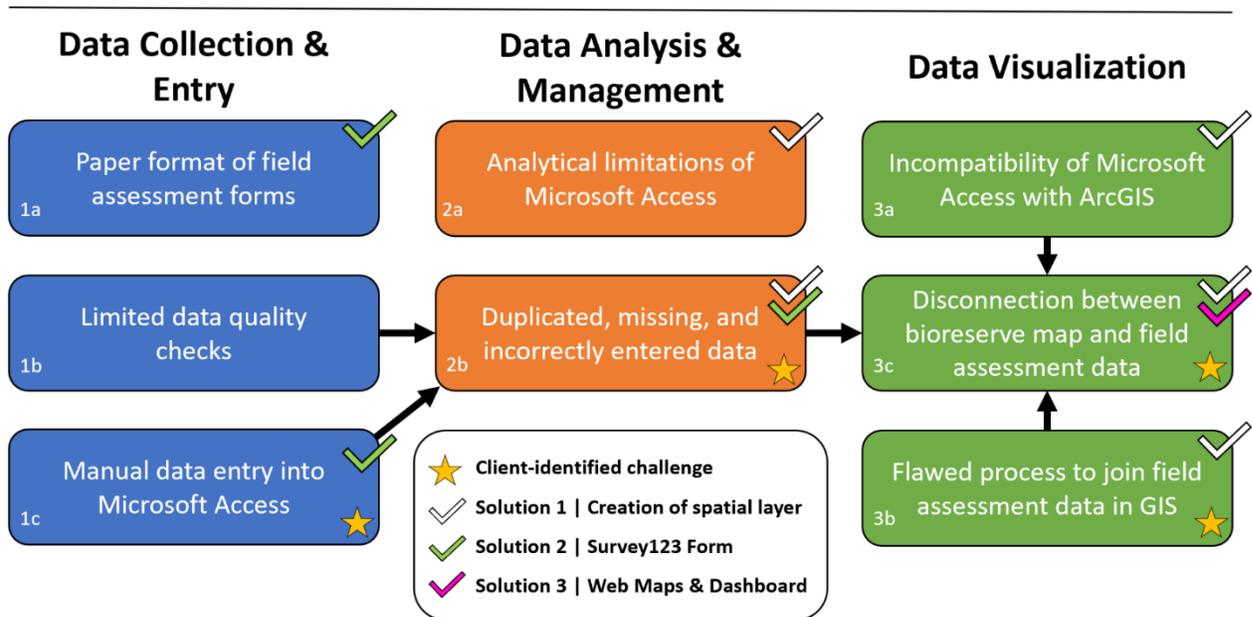


Figure 3.2: Data challenges in current NAAP workflows updated to show the data challenges addressed or partially addressed by Solution 1 (Creation of a spatial layer), Solution 2 (Survey123 Form), and Solution 3 (ArcGIS Online web maps & dashboard) that we developed (white, green, and pink checkmarks, respectively).

Solution 1: Creation of Spatial Layer & Joining of Field Assessment Data to Integrate the Bioreserve Map and Field Assessment Data

NAAP lacked a good way to link the field assessment data from Microsoft Access to a spatial layer in ArcGIS, which hindered both the visualization of the field assessment data and a more integrated, landscape-level assessment of the Huron River watershed's natural areas. We addressed these challenges (Figure 3.2) by creating a new layer in an ArcGIS file geodatabase and joining the field assessment data to this layer. In order to accomplish this successfully, we first cleaned and reformatted the Microsoft Access data and GIS layer. These steps are laid out in detail below. To understand how this solution was implemented and can be used, we need to clarify some terminology about the spatial units of NAAP data and explain how they are related.

Bioreserve Areas, Sites, and Ecosystems — What is the Difference?

NAAP collects and shares data at several different spatial units — each of different sizes and extents. This includes Bioreserve areas, sites, parcels, and ecosystems. This can be a source of confusion when discussing the program's data and methods, but more importantly, these different spatial units limit the degree to which the Bioreserve Map and field assessment data can be compared, related, or cross-analyzed. We describe and illustrate these spatial units below (Figure 3.3).

- **Bioreserve Area**

A natural area within the Huron River Watershed that is at least 2 acres in size and encompasses several **sites** and **ecosystems** and many **parcels**. These polygons were manually digitized in GIS by HRWC in 2006 (when the Bioreserve Program began) from aerial imagery provided by the Southeastern Michigan Council of Governments. Using this layer, HRWC derived geospatial estimates of ecological integrity by scoring and ranking the sites on 15 criterion (Appendix A). HRWC has also used this layer, in part, to inform priority areas for conducting rapid field assessments.
- **Site**

Site polygons are nested within each **Bioreserve area**. Sites, or “field assessment sites”, are areas under private ownership (usually a single landowner) which encompasses several **ecosystem** areas and **parcels**. Rather than field assessing the entirety of a Bioreserve area (which would be prohibitively time and resource intensive), HRWC selects one or more ecologically representative **sites** per Bioreserve area to be field assessed. These sites are typically the largest landowners within a Bioreserve area, but may sometimes just be the landowners most agreeable to an assessment of their property. In a typical field assessment, HRWC staff and volunteers travel to a single site to conduct a field assessment and survey and score each individual ecosystem within that site for ecological integrity/ disturbance. HRWC manually digitizes site polygons in ArcGIS by referencing property ownership data, aerial imagery, and the Bioreserve Map. Presently, this layer is used by HRWC for producing site maps for field assessment volunteers and GIS maps of assessed areas for internal use.
- **Ecosystem**

Ecosystem polygons are nested within each **site**. These polygons represent the dominant ecosystem type of that particular area — forest, grassland, or wetland — which corresponds to one of HRWC’s three broad ecosystem classifications on their rapid field assessment data entry forms. A single **site** polygon often contains several ecosystem polygons within it, which may be of different ecosystem types. Since natural ecosystem boundaries do not necessarily align with human-assigned **parcel** boundaries, the polygons of ecosystems and parcels do not align. A single ecosystem polygon may contain/overlap several parcels, or, depending on size, a single parcel may contain/overlap several ecosystem polygons. Ecosystem polygons within sites are usually contiguous, but could be separated by a matrix of agricultural/urban land.
- **Parcel**

Parcels are legal land ownership polygons with a single landowner per parcel. Whereas the Bioreserve area, site, and ecosystem layers are created by HRWC, the parcels layer is first derived from external sources before HRWC modifies it for their purposes. To create this layer, HRWC downloads GIS parcel data from each county in the watershed, clips it to the boundaries of the Bioreserve area polygons, and then combines it into a single layer. The parcels layer is primarily used for reporting purposes to inform land protection agencies, local governments, and landowners of high-priority conservation areas on a parcel-by-parcel basis, as determined from HRWC’s GIS and field-based estimates of ecological integrity and disturbance. HRWC also uses the parcels layer when delineating field assessment **sites** in GIS.

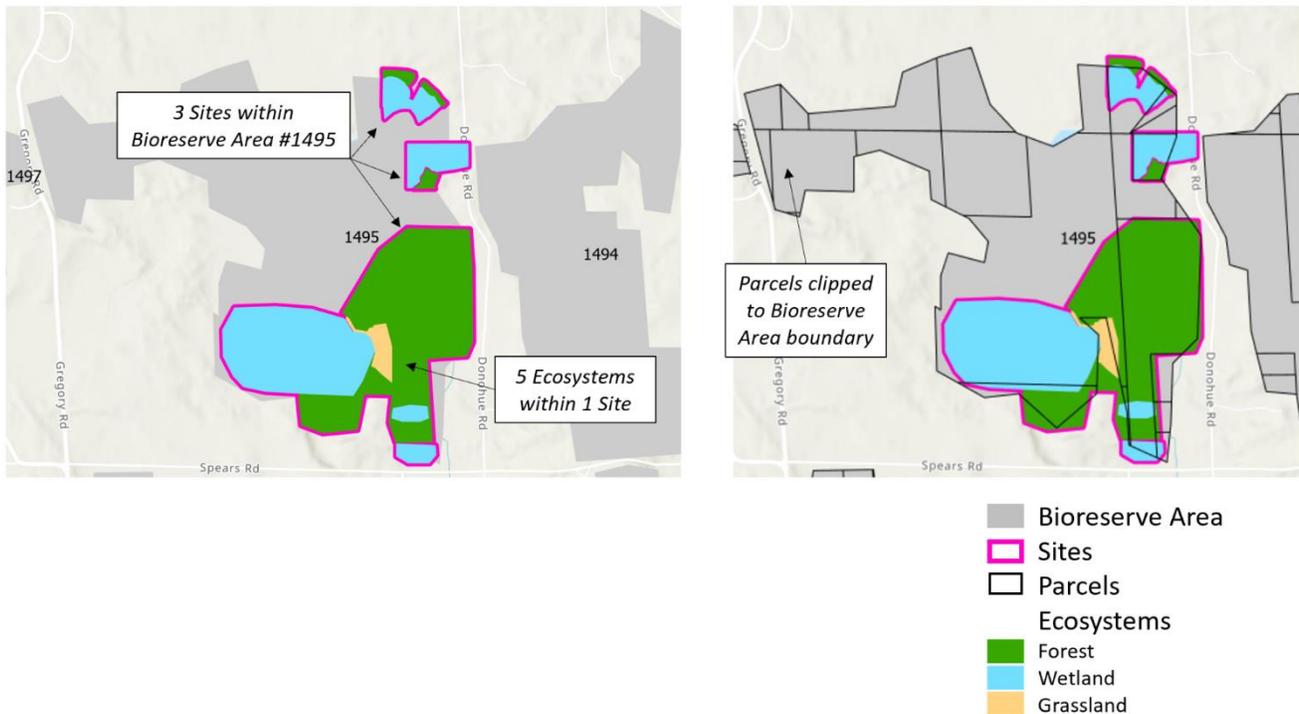


Figure 3.3: Relationship between spatial units in NAAP. Bioreserve areas, sites, and ecosystems are nested within one another (Bioreserve areas are the largest and ecosystems are the smallest) and the boundaries of these layers align closely with one another. Parcels, however, are derived from a different GIS source (and then clipped to the boundaries of the Bioreserve area polygons), so parcel boundaries may not align with the boundaries of the sites or ecosystems.

Each of the four spatial units above has different identifiers in NAAP's datasets. These identifiers support organization, management, and analysis of the field assessment data and also provide a pathway to link this data with GIS layers. Bioreserve areas are each assigned a unique number between 1 and 1718. Sites are uniquely identified using a three-part naming scheme that includes information about the township, Bioreserve area, and property owner. For example, "Dexter625Bach" refers to land in Dexter township within Bioreserve area #625 and owned under the name "Bach". Within each site, individual ecosystems are identified using an ecosystem type followed by a letter (e.g., "Forest A", "Forest B", "Wetland A", "Grassland C", etc.). Therefore, a unique ecosystem can be identified by adding on to the end of the unique site name (e.g., "Dexter625BachForestA"). Parcels each have a unique alphanumeric code, but the format of this code differs by county because the GIS data was downloaded separately from each county in the watershed.

Why do these Different Spatial Units Matter for Integrating the Field Assessment Data and Bioreserve Map?

There is a discrepancy between the scale at which data in this program has been summarized through GIS (Bioreserve area), collected through rapid field assessments (site/ecosystems), and reported to landowners and stakeholders (site/ecosystem) and land conservancies (parcel). Therefore, this program

faces a major challenge with how to compare and translate data from one scale to another—specifically, how to compare GIS-derived estimates of ecological integrity (summarized at the bioreserve level) with field observations recorded and summarized at the ecosystem level. Not only do these estimations of ecological integrity draw from different sources (GIS layers vs. field observations), the areas they represent are also of different sizes.

This problem is not a new one for ecologists—many efforts have been made to understand and address the scale problem, which is one of the most pressing challenges for ecological research (Miller, 2004). Landscapes and ecological systems are incredibly complex, especially in very heterogeneous and patchy landscapes like SE Michigan. While ecological modeling can be effective at a highly localized or regional level, it is often more difficult to model ecological processes at an intermediate, landscape level because many ecological patterns and processes are scale-dependent (Newman, 2019). Furthermore, spatial models are typically built on highly quantifiable biophysical measurements rather than more qualitative metrics like what can be derived from rapid ecological integrity assessments. These difficulties do not mean that it is impossible to extrapolate site-level measurements of ecological data to a bioreserve or landscape level or to integrate datasets from different scales. However, doing so requires extensive knowledge of local biogeography and statistical expertise and there may be a high degree of uncertainty to the findings (Miller, 2004). One possible solution to this problem of scale is to collect geospatial assessment metrics at the same scale as the rapid field assessments—a solution that we elaborate on in Chapter 2 and in the Chapter 3 recommendations. These new geospatial metrics could then be more directly compared to the rapid field assessment data. This could be useful for the future of NAAP, but making this change was outside the scope of our project objectives to integrate the *current* Bioreserve Map and field assessment data. We recommend additional research—possibly from a future SEAS Masters Project team into the extrapolation of ecological field assessment data across landscapes (especially heterogeneous landscapes like SE Michigan) and converting data between different spatial scales.

To address the lack of integration between the current Bioreserve Map and field assessment data, and to facilitate comparison and analysis (especially GIS analysis) between both datasets, the Microsoft Access data needed to be joined to a spatial layer in GIS. Our process to integrate the Bioreserve Map and field assessment data involved joining historical field assessment data to GIS polygons (choosing one of the spatial scales listed above) so that the field assessment data (previously saved as *aspatial*, tabular information in Access) had a spatial reference. We also wanted the spatial scale that we chose to be the same between the historical and newly collected data (through Survey123) such that they could easily be added to a single dataset and compared with one another. However, gaps in the historical data, usability concerns with Survey123, and goals for reporting and presenting information complicated the process of selecting a spatial unit to use.

Which Spatial Unit Makes the Most Sense for Displaying Field Assessment Data in GIS?

In our first approach, we attempted to use parcels as the spatial unit of reference. We chose to use parcels because they are the same unit at which HRWC often reports field assessment results and because HRWC expressed interest in doing so. However, we encountered several significant problems with this approach. First, parcel ID information in the Microsoft Access dataset was often missing or erroneous, which limited the success of the attribute join between the GIS and field datasets. Although the correct parcel information was stored elsewhere in the Microsoft Access database or could be retrieved online/from GIS, it would have required many hours of labor to copy over the correct parcel ID information and verify it. Secondly, this approach would have worsened data challenge 2b by

introducing more data duplication to the dataset. Records in the Access database with multiple parcel ID values (e.g., cases where the surveyed ecosystem overlapped multiple parcels) needed to first be separated into a single row per parcel ID because attribute joins only match records with exactly matching values. Third, scale was a source of concern: even though parcels may have been the ideal scale for reports to land conservancies, they were not the ideal scale for collecting information in the field. As discussed above, actual surveyed ecosystems (forest/grassland/wetland) did not necessarily align with parcel boundaries and, since Survey123 forms are coded to display a single survey form per polygon, covering an entire ecosystem area composed of many small parcels would have required submitting many separate forms. Fourth, using the parcels layer brought up privacy and security concerns if the field assessment data were to be shared publicly. Lastly, we had concerns with the source of the GIS data: since the parcels GIS data set is built from a compilation of several different sources each representing features at only a single point in time, the parcel ID systems vary by county and parts of the dataset may not be up to date with the latest changes to ownership or parcel boundaries. This would make use of the parcels GIS data increasingly difficult over time.

Because of these problems, we opted to use ecosystems as the spatial unit of reference. Compared with parcels, the ecosystems layer has a more manageable ID system, more closely resembles the actual field-assessed area, and simplifies the data entry process through Survey123. The main disadvantage of this approach was that, unlike the parcels layer, ecosystem polygons in GIS either did not exist for many sites or were scattered across many separate HRWC databases and ArcGIS projects. Therefore, prior to attempting a join in GIS, we needed to first create a single GIS layer of all surveyed ecosystems. We tried two approaches: 1) re-creating rough approximations of the sites from the parcels layer (which already existed) and 2) stitching together individual GIS polygons from HRWC into a single layer. In the first approach, we quickly realized several flaws including misalignment of parcel boundaries and actual surveyed areas, missing parcel ID data, and, in some cases, difficulty distinguishing boundaries between ecosystem types in the output. The second approach (stitching together individual GIS polygons) turned out to be successful, but still required a lot of data cleanup (of both field assessment data and GIS data) before the field assessment data could be successfully joined to this GIS layer. We clarify this cleanup process below.

How was the *Ecosystems GIS Layer* Created and Cleaned in Preparation for the Attribute Join?

In preparation for joining the field assessment data, we needed to make sure that the GIS layer met two requirements: 1) it must be a single GIS layer of all ecosystem polygons and 2) it must contain a unique attribute “key” (an alphanumeric string common between the source and target attribute tables) to enable a join with the field assessment data. We received a file geodatabase of ecosystem polygons from HRWC (which they had previously used to delineate field assessment areas and for other internal uses), but each site in the geodatabase had its own separate layer of ecosystems and many of these layers had different sets of attributes. Combining all of these individual ecosystem layers would give us a single GIS layer (solving half of the challenge), but we also needed to consider what to use for the attribute key. The easiest key to use, in this case, was a combination of the site name and ecosystem name since this information appeared to be fairly complete (without missing cells) in both the GIS and Microsoft Access datasets. For example, combining the site name “Dexter625Bach” with the ecosystem name “Forest A” would uniquely identify the ecosystem “Dexter625BachForestA”. To merge the individual ecosystem polygon layers together while maintaining the site and ecosystem name attributes, we used the Merge geoprocessing tool in ArcGIS Pro. Prior to merging the layers, three steps were taken:

- 1) Adding all site layers to the same geodatabase (already done for us by HRWC).
- 2) Naming each layer using its site name (e.g., “Dexter625Bach”). This would become the site name attribute in the merged output (as long as the box to “add source information to the output” was selected in the Merge tool).
- 3) Deleting all attributes except for ecosystem name and renaming the field containing ecosystem names to “EcoName”. Because the Merge tool adds all unique attributes from the input layers to the output, this simplified the attribute table in the output layer and ensured that all of the ecosystem names would be saved to a single field).

After running the Merge tool, we were left with a single layer representing all ecosystems in the watershed and containing attributes for both site name and ecosystem name. Joining the site name and ecosystem name attributes provided us with the key necessary to link between the field assessment and GIS data. We created this key by adding a new field and using the Field Calculator in ArcGIS (calculating the value of the new field as “SiteName” + “EcoName”). Finally, we needed to make sure that the site name and ecosystem name matched between the GIS layer and the field assessment data and fix any errors. This process is described in detail in the following section. Other attributes of interest, such as township, Bioreserve area, or acreage, were added later either from the field assessment data (after the attribute join) or by adding and calculating a new field in GIS (with the Field Calculator) using the polygon’s geometry and other overlapping layers. With this GIS layer created, we could proceed to preparing and cleaning up the field assessment data.

How was the *Field Assessment Dataset* Cleaned up in Preparation for the Attribute Join?

The field assessment dataset required considerably more data cleanup before it was ready to be joined to the ecosystems GIS layer created above. The biggest challenge here was that a sizable fraction of the site and ecosystem names were either missing from the field assessment data in Microsoft Access (were never manually entered into Access) or had slight typing errors or variations in spelling. Since these fields were critical components of the attribute key that would be used to join the two datasets, correcting these errors was our first priority in cleanup of the field assessment data. Some common errors included records where an ecosystem type was listed, but without a letter to uniquely identify it (e.g., “Wetland” instead of “Wetland A”), site or ecosystem names with typos or inconsistent capitalizations, and different formatting or numbers of spaces between words (e.g., “ Wetland A” or “Wetland A”). Correcting these errors was more than just a cosmetic fix—it improved the success rate of the attribute join to help better integrate the field assessment data with GIS.

Because of our familiarity with Microsoft Excel and the functionality it has to manage and manipulate data, we performed all data cleanup in Excel. First, we exported the wetland, forest, and grassland worksheets from Microsoft Access (containing the raw field assessment data for each assessed ecosystem) to CSV files and then saved them together as individual worksheets in a single Excel workbook. This ensured that, should we wish to go back to the raw data after making edits, we could simply re-export the data from Access. We also exported the ecosystems GIS layer as a CSV file and saved it to the same Excel workbook to aid in cleaning up site name mismatches (see process below).

Next, we filled in missing/empty site names in the dataset by recreating the 3-part site names (e.g., “Dexter625Bach”) in Excel. To do this, we used Excel’s concatenate function (**CONCAT**). Similar to how we used the Field Calculator in ArcGISPro to combine site and ecosystem names, we used the concatenate function to combine text from the township, Bioreserve area ID, and ownership fields.

=CONCAT("township"+"bioreservearea"+"owner")

After all records had site names, we verified whether the site names matched between the field assessment data (now in Excel) and the ecosystems GIS layer and fixed any mismatches. We took three steps here:

- 1) Created two lists of all unique site names: one from the ecosystems GIS layer and another from the field assessment data (forest, wetland, and grassland worksheets combined, with duplicate names removed). We put these lists side by side in a new worksheet.
- 2) Used Excel's **COUNTIF** function (in two new columns) to determine if a specific text string (the site name) was present in another column (the field assessment or GIS site name lists, respectively). This allowed us to identify where site name mismatches were located, but a third step (below) was required to determine the source of the problem and where edits might be needed.

=IF(COUNTIF(\$A:\$A, B3)=0, "No Match", "")

where column A = list of site names from GIS
 column B = list of site names from Microsoft Access

- 3) Scanned through each row in the worksheet that indicated there was no matching site name between the field and GIS data and determining whether:
 - a) A site name in the field assessments data had no matching GIS polygon, indicating that the polygon still needed to be created in GIS (**B not in A**).
 - b) A GIS polygon had never been surveyed and thus had no field assessment corresponding to it, indicating a possible site for a future field assessment (**A not in B**).
 - c) There was a typing error or text inconsistency in either the field assessment or GIS site name lists that needed to be fixed, in which case we edited all cells in both the spreadsheet and GIS layer containing the typo.

Given data entry errors and slight variations in site names between the two sources, there were a considerable number of changes that needed to be made. While making any edits in this worksheet with the site name lists, we made the same changes in each individual ecosystem worksheet (containing all of the field assessment data) as well as the ecosystems GIS layer in ArcGIS Pro. After this process, we had prepared half of the text key that would be used for the attribute join. The other half (the ecosystem name) still needed to be edited.

The ecosystem name attribute was more completely filled out in both the ecosystems GIS layer and field assessments worksheets, so this required less editing than the site name. Ecosystem names were blank/empty for some records in the GIS layer, but present for nearly all records in the field assessment worksheets. In both the GIS and field assessment data, however, there were slight typos or variations in spelling. The biggest challenge here was that many records stated the ecosystem type (wetland/grassland/forest), but did not distinguish between ecosystems of the same type (e.g., "Wetland A", "Wetland B", etc.). HRWC staff helped us edit these ecosystem names and we then proceeded with a few final data cleanup steps, including formatting the field assessment data to match the style of data storage from Survey123 forms.

How was the Format of the Data Adjusted to Match Survey123?

After the above data cleanup steps, one significant challenge remained: the format of the field assessment data (originally from Microsoft Access) did not match the format of the future field assessment data to be collected through Survey123. This presented a problem for viewing and analyzing the historical data and newly collected data together. If the goal of the above data cleanup steps was to integrate the field assessment data with GIS, then the goal of reformatting the data was to integrate the historical data with future data collection (through Survey123).

The biggest difference in data format between Microsoft Access and Survey123 is the way that they handle multiple choice questions, which comprise most of the questions on the field assessment data entry forms. In Microsoft Access, multiple choice questions are saved as a series of '0's and '1's, so a species box checked as present in the data entry form shows up as a '1' in the worksheet's attribute table (Figure 3.4). Each checkbox on the data entry form has its own column in the attribute table, so a single question on the data entry form (for example, listing all tree species present) is represented with many columns in the attribute table (one per checkbox). In contrast, Survey123 multiple choice questions are saved as a string of comma-separated text values and all responses for a particular question are saved to a single column/field (Figure 3.4). For example, checking the box that maple and oak trees are present would result in the text "maple, oak" in the output attribute table. This presents a problem for displaying historical and future data collections together, so one format must be modified to match the other.

Rather than attempt to modify the output format of Survey123, which was not very malleable to modification, we decided to reformat the historical field assessment data (originally from Microsoft Access) to match Survey123's format (Figure 3.5). To do that, we needed to replace '0's and '1's in the field assessment data with text and combine columns corresponding to the same question. We did this using a combination of 'Find and Replace', concatenate (**CONCAT**), and trim (**TRIM**) functions in new columns in our cleaned-up Excel workbook. 'Find and Replace' was used to replace '0's and '1's with text values, the concatenate function was used to combine text from multiple columns (belonging to the same multiple-choice question), and trim was used to remove excess spaces between values created by the concatenate function. All of the original data from the Microsoft Access worksheets was preserved through this process but reformatted to match the output format of Survey123.

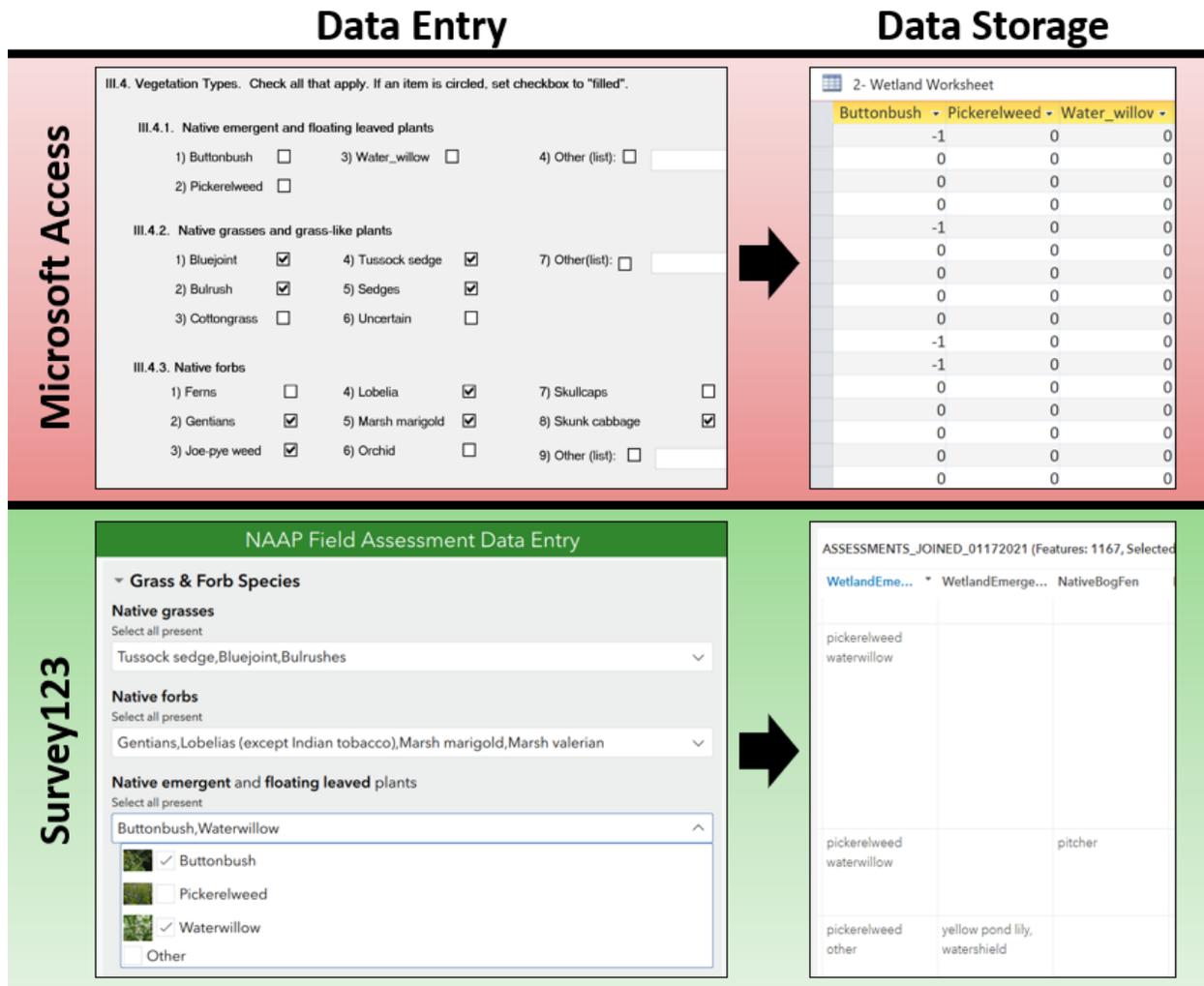


Figure 3.4: Data entry and data storage in Microsoft Access (top) vs. in Survey123 and ArcGIS (bottom). Microsoft Access saves multiple choice questions as a series of '0's and '1's with a separate column for each checkbox, whereas Survey123 saves multiple choice questions as comma separated text with a single column per question.

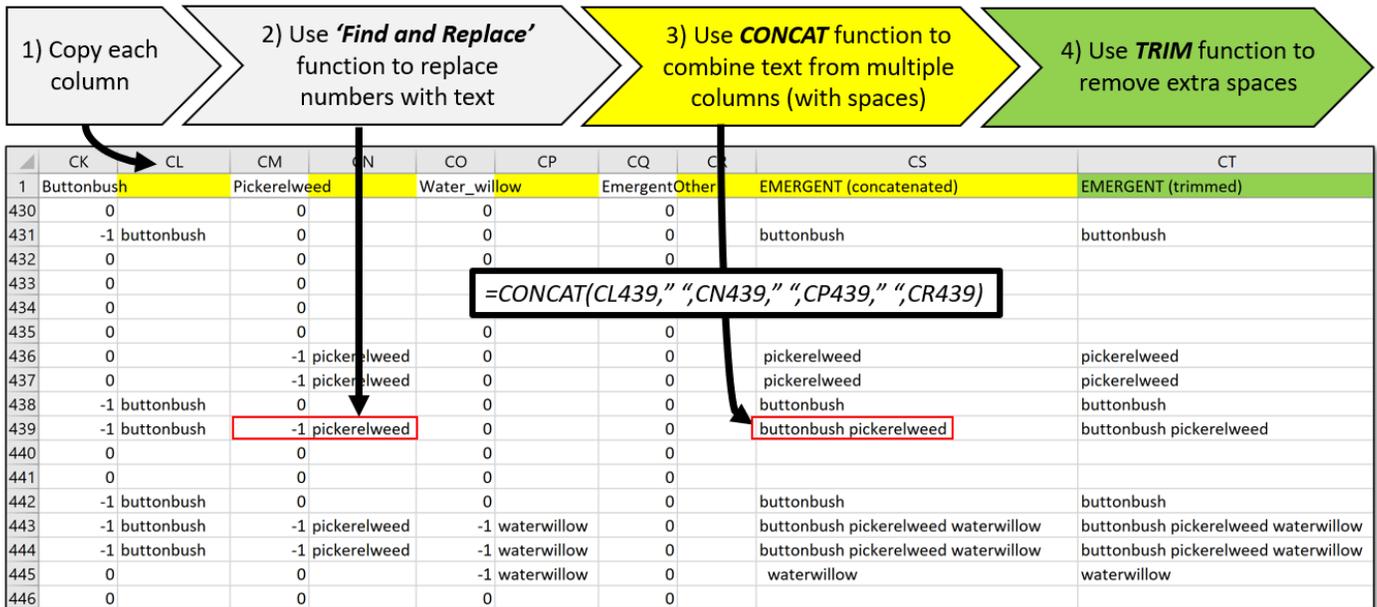


Figure 3.5: Data cleanup process in Microsoft Excel to convert data from the Microsoft Access forest, grassland, and wetland worksheets into the same data storage format as Survey123. Yellow columns are intermediate steps (columns that were concatenated together) and the green column is the final, fully edited column matching the data storage format of Survey123.

How Were the Field Assessment Data Joined to GIS and What Were the Results?

After the above steps, we joined the field assessment data to the newly created GIS layer using a many-to-many attribute join in ArcGIS Pro. We used a many-to-many join because there were some duplicate names in both the field assessment records (possibly indicating a repeat assessment conducted on the same site, $n=7$) and the GIS polygons (indicating polygons that should have been saved as multipart polygons, $n=78$). The many-to-many join would ensure that all assessed GIS polygons would have data and all repeat assessments were included. The result was overwhelmingly successful: 869 of 1022 unique field assessment records (**85%**) were successfully matched to 869 of 1,089 unique GIS polygons (**80%**). This left **153** field assessment records without a polygon layer and **220** GIS polygons without any field assessment data (having never been field-assessed). Opportunities for additional cleanup of this data set are listed in the recommendations.

Solution 2: Survey123 Form & ArcGIS Online Hosted Feature Layer to Collect Data

After joining the *historical* field assessment data to a GIS layer (Solution 1), we needed a way to integrate this layer with *future* field assessment collection so that all of the data could be viewed and analyzed together. In other words, we needed a living GIS layer containing all of the NAAP field assessment data. We concluded from our review of data collection tools above that Survey123 would be the optimal way to collect data in this new system and would most effectively address the data collection and management challenges we identified. This Survey123 form and its associated ArcGIS Online “hosted feature layer” (a GIS layer housed in an ArcGIS Online server) function as replacements for the paper field assessment forms and the Microsoft Access database, respectively, and enable more automatic data entry and syncing between the database and GIS layer.

Before creating our Survey123 form, we first had to decide whether to design and publish it using the [Survey123 website](#) or using the downloadable application [Survey123 Connect](#). The website-based form editor is streamlined and designed for simplicity. On the other hand, Survey123 Connect offers greater customizability of questions and a better interface for managing repeat sections, external data tables, and calculation type questions—all of which were needed for our form. After designing, creating, and piloting surveys from both formats, we decided that Survey123 Connect provided a more suitable solution for our survey design goals.

Forms are created in Survey123 Connect by filling in an XLSForm spreadsheet, which is essentially a specialized Excel document for designing powerful survey forms. The key components of the XLS Form are the survey worksheet, which has three required columns (survey question type, name, and label), and the choices worksheet, which stores possible responses to multiple choice questions. New surveys can be started from a blank template or previous XLSForms (in which a new ArcGIS Online hosted feature layer is created upon publishing), or a pre-existing ArcGIS Online hosted feature layer (in which future survey data will be entered into that layer). However, if using an ArcGIS Online layer as the template, there may be errors if publishing surveys that contain ‘repeat’ question type questions (for these cases, the GIS layer must also have a related table with a name and fields that exactly match the questions in the repeat). Because of those complications, we opted to start our first form using a blank template and use existing XLSForms as the template when creating new form iterations.

In our Survey123 form we included all questions from the forest, wetland, and grassland field assessment forms and logically divided the form into three separate pages for ease of data entry. The first page of the form contains site and survey information, including survey date, site/ecosystem/Bioreserve area identifiers, and location (represented by a polygon). The second page contains a species list question, wherein the surveyor can search for and select any species observed in that ecosystem from a lengthy list, generated by HRWC for NAAP, of SE Michigan flora. Lastly, the third page of the form contains all other survey questions from the forest, wetland, and grassland worksheets, including landscape characteristics and species observed; responses to these questions are used to determine ecological integrity and disturbance scores. We ordered the pages in this way to mimic how field assessments have typically been conducted in the field: surveyors first name the species observed during a walkthrough of the site and then fill in the remaining assessment questions while still on-site or later off-site. Putting all of these pages (and questions for multiple ecosystem types) into a single form serves to keep all of the data together in the ArcGIS Online hosted feature layer which makes it easier to analyze and share the data.

We also incorporated a few ease-of-use improvements into the survey to improve the efficiency and usability of data entry with the form. For example, adding conditional questions or choice options to hide items not relevant to the ecosystem type being surveyed, condensing and collapsing groups of questions, and leaving hints and descriptions for many questions. Additionally, we added photos for most of the key species on page 3 of the form, which are not intended to replace a detailed field guide but may help facilitate plant identification in the field (Figure 3.6).

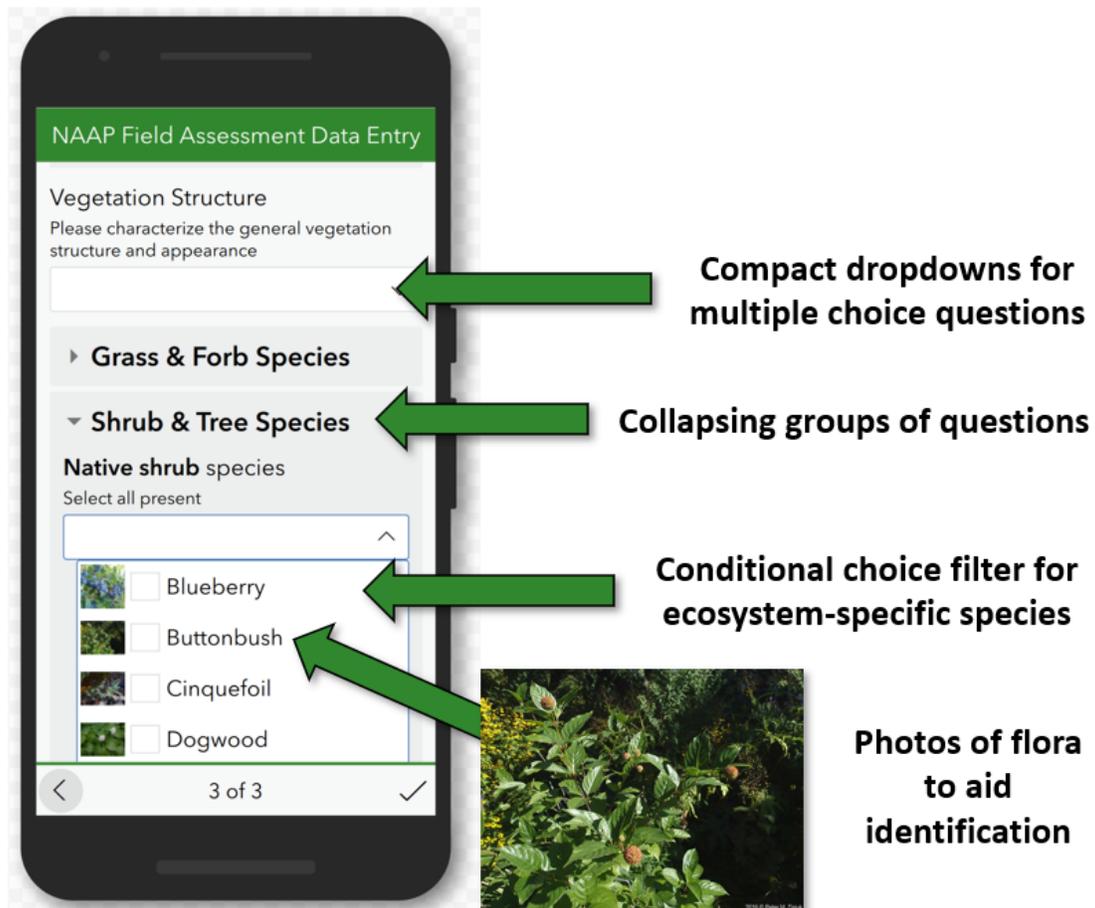


Figure 3.6: View of page 3 of new field assessment Survey123 form showing some of the modifications made to improve the efficiency and usability of the form.

Lastly, we set up the form with offline functionality and inbox and outbox features to improve the performance of the form under different contexts. Offline functionality means that a surveyor can fill out a form without an internet connection, so long as they download it to their device via the internet ahead of time. The inbox feature means that ecosystem areas can be created prior to the assessment and stored as selectable survey options for volunteers (selectable from a list or map), rather than digitized by volunteers in the field. Basic information about the ecosystem (such as site name, ecosystem name, and Bioreserve area) can be entered for inbox polygons, thus reducing the possibility for data entry errors, and streamlining the data entry process for volunteers. Currently, inbox polygons are defined by the 'SurveyYear' field (this can be configured in the XLSForm options), so any record with

a survey year of 2021 will show up as a selectable survey option within the app (the inbox must be “refreshed” in the app in order for new inbox polygons to appear). The outbox feature allows forms to be temporarily saved on a surveyor’s device as drafts and submitted later. This is particularly useful in cases where volunteers are traversing multiple ecosystems on a site, as volunteers can simply save the current survey form and open the form for the ecosystem they are moving into. They can then collectively submit all of their forms once the assessment is complete. These functions improve the viability of the Survey123 form under a broader range of contexts, enhancing its usability.

In addition to templates and samples with which to create surveys, Survey123 Connect offers “tutorials” and “community” tabs that provide additional resources and support. We heavily referenced the tutorials tab, along with help from the [Survey123 documentation](#) and [XLSForm Essentials](#) web pages when designing the form. These resources were particularly helpful for creating calculation type questions used in ecological integrity and disturbance scoring (Figure 3.7). We recommend referring to the Survey123 tutorials and extensive online Survey123 documentation when making changes or alterations to the form and exploring the community tab for discovering and sharing ideas with other organizations using Survey123. This chapter’s references contain a complete list of ESRI Support websites that we referenced throughout this project.

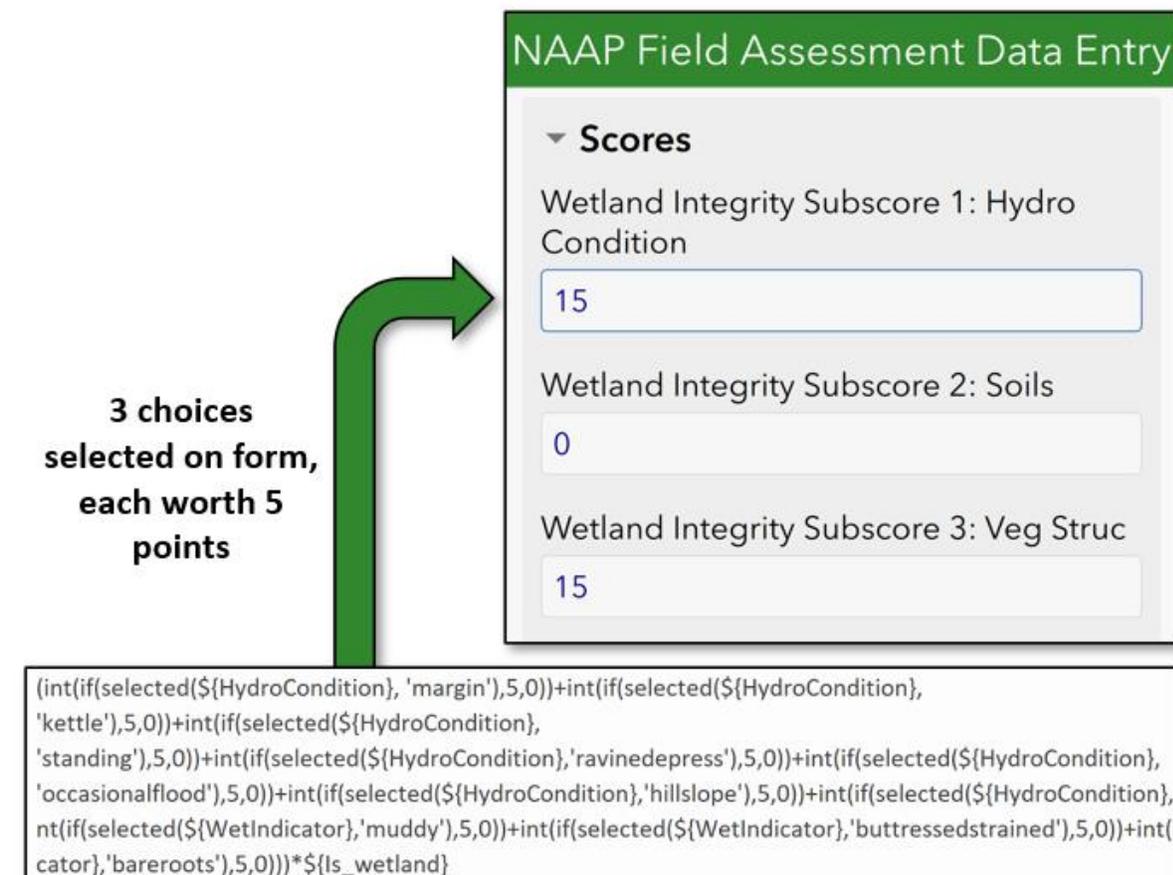


Figure 3.7: Example of a wetland integrity score that is automatically calculated based on responses to previous survey questions. Shown here is the formula in the XLSForm for calculating this value (bottom) and the display that a surveyor would see in the app (top).

Solution 3: ArcGIS Online Web Maps & Dashboards to Visualize & Share Data

Because we used a hosted feature layer in ArcGIS Online to store the field assessment data, we took advantage of some of the tools and applications ArcGIS Online offers to present and share data: specifically, web maps and dashboards. These tools make it easier to customize the display of data, incorporate multiple data layers together in maps, and share data with stakeholders and data users, thus addressing the disconnection between the field assessment and Bioreserve Map data (Figure 3.2).

Web maps offer ways to customize a particular view or version of the hosted feature layer (without having to alter the original feature layer itself) and also present data from multiple layers (integrating the Bioreserve Map and field assessment data into a single map). The web map we created from the NAAP hosted feature layer focuses on the field assessments' ecological integrity and human disturbance scores. We customized this map by editing the properties of the layer within the web map, namely the pop-up information, labeling, and symbology. Our goal with this map was to show only general site information along with the site's corresponding scores. So, if a user selects the "GreenOak1523 HCMAH Meadows Forest C" polygon, they will receive the ecosystem name (Forest C), site name (GreenOak1523HCMAHMeadows), Bioreserve area number (1523), acreage, and the forest's ecological integrity and disturbance scores. Polygons are labeled by site name and the map also includes a search tool to allow users to quickly navigate to any property or Bioreserve area in the watershed. Most importantly, this map is dynamically linked to the hosted feature layer, so any newly submitted data through Survey123 is automatically reflected in this map—eliminating the need for joining/transferring field assessment data between databases/GIS layers.

These web maps can then be imported into ArcGIS Online dashboards. Dashboards provide an intuitive and interactive way to view data and they combine maps with various informatics (charts, indicators, etc.) to convey patterns and trends. We created a dashboard that displays the field assessment scores and Bioreserve areas (from the web map we created) alongside dynamic charts and gauges (configurable from the map panel while editing the dashboard) that change depending on user-defined filters and the viewable map extent (Figure 3.8). These components make it easier to view ecological integrity data at a glance for the entire watershed and sharing this dashboard could be one way to help make the field assessment results more accessible for data users.

The maps and dashboards that we have created here provide a starting point and a template for designing future tools. Both web maps and dashboards can be customized for the needs of different data users (land conservancies, HRWC staff, landowners, etc.) and a single hosted feature layer can be used in any number of web maps and dashboards. Additionally, formatting styles saved to the web maps and dashboards won't alter the display of the hosted feature layer they reference. This means that HRWC can create and manipulate any number of maps/dashboards to best suit their purposes and meet the needs of different data users. We recommend continually modifying, using, and sharing these maps and dashboards as a way to take full advantage of hosting data in ArcGIS Online and to enhance the accessibility of the data for data users.

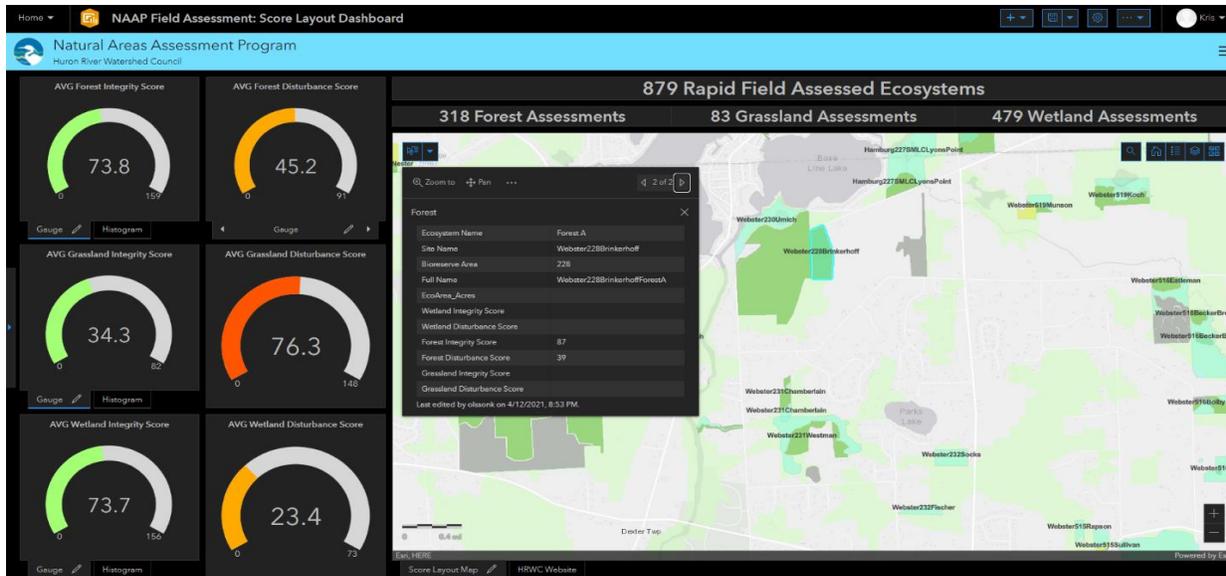


Figure 3.8: Screenshot of the ArcGIS Online dashboard we created with an interactive map panel (right) and dynamic gauges to display ecological integrity and disturbance scores from the rapid field assessments (right).

Recommendations & Next Steps

The research we conducted and the improved tools we implemented have allowed us to develop a new data workflow that both addresses most of the program's data challenges and augments the program's capabilities and reach (Figure 3.9). The greatest advantages of this new workflow are automatic data entry and database-GIS layer synchronization, easier visualization of field assessment data, and a more integrated approach to sharing NAAP data from multiple sources (specifically, the Bioreserve Map and rapid field assessments). Using this new workflow will allow the program to operate more efficiently and effectively, increasing its positive impacts.

To most effectively leverage and expand upon this new system, we recommend the following highest priority next steps for HRWC:

1. Train staff and volunteers to use new data workflow (particularly Survey123).
2. Follow consistent data quality checks and data creation practices.
3. Enhance reporting using Survey123 Feature Reports & findings from surveys.
4. Update the Bioreserve Map layer to reflect the current state of the watershed's natural areas.

Below, we elaborate on 6 more general recommendations for how to improve NAAP's data workflows:

1. Take steps to improve data quality by improving attribute join success, filling gaps in the data, and increasing data quality checks and training.
2. Consider data collection and management alternatives (if program needs shift).
3. Use ArcGIS and R for data analysis.
4. Investigate extrapolation and downscaling of ecological integrity data between different scales.
5. Update the Bioreserve Map to reflect the current state of the watershed's natural areas.
6. Generate field assessment reports using Survey123 Feature Reports & ArcGIS Pro.

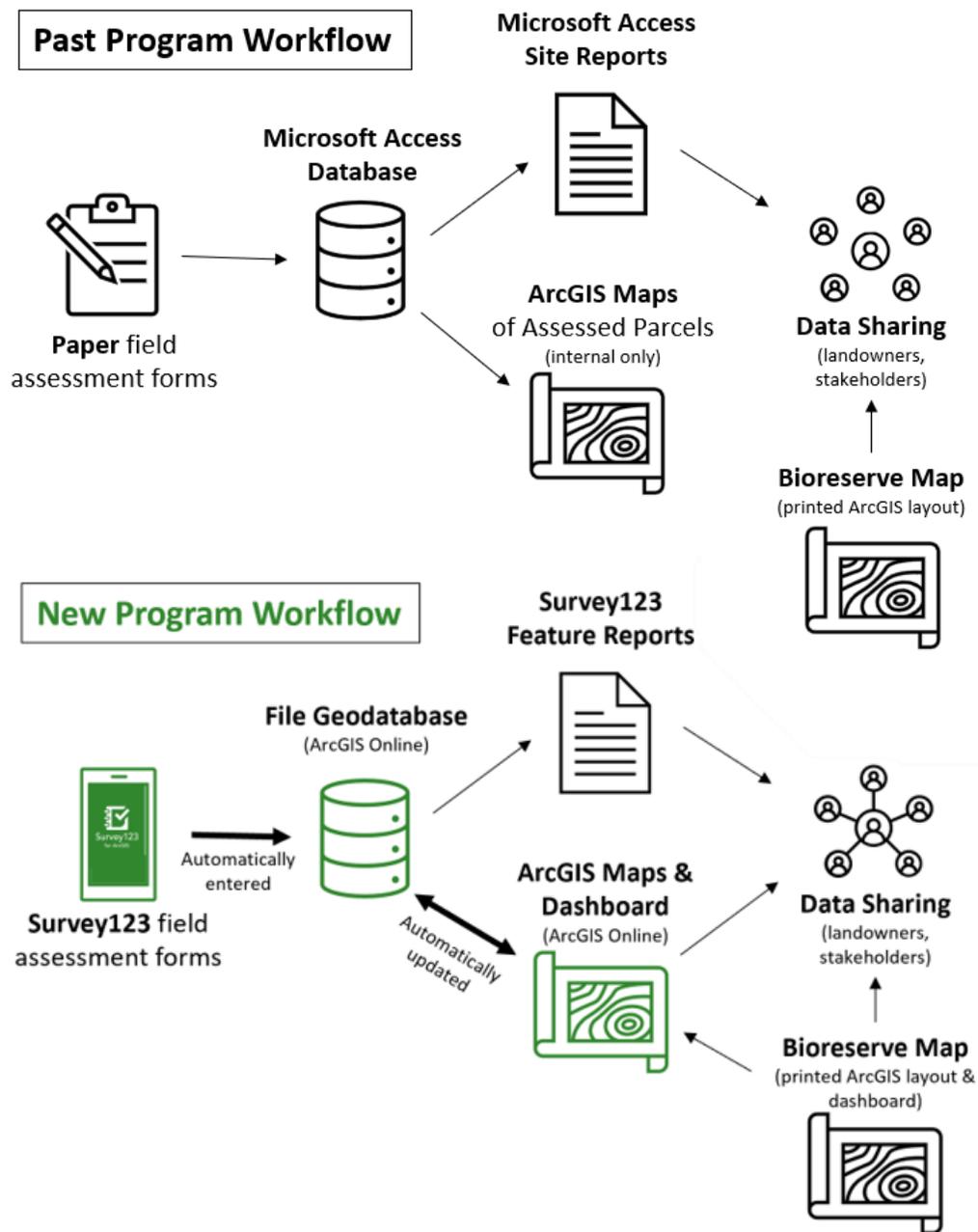


Figure 3.9: Schematic illustrating past data collection, storage, and sharing processes (top) and a new, alternative set of processes which we have developed and recommended for future data collection, storage, and sharing (bottom).

1. Take Steps to Improve Data Quality

Although our team has already conducted a significant amount of data cleanup, there are still more opportunities for improving the quality of the field assessment data in GIS. Listed below are some additional improvements that could be made and our thoughts on how they could be implemented. Of these improvements, the highest priority (*designated with an asterisk below) are digitizing ecosystem polygons, reinstating volunteer training sessions, and following consistent data creation practices. The remaining improvements, while important, can be viewed as lower priority items.

Improving Attribute Join Success

a. Digitizing Ecosystem Polygons*

Some records failed to join, not because the site or ecosystem names did not match, but because a GIS polygon did not exist meaning the area needed to be digitized. We found **153** such records (15% of the dataset). These polygons can be digitized manually using aerial imagery and parcel boundaries or by referencing other pre-existing maps and documents. After digitizing these polygons, the cleaned-up field assessment data can be re-appended to the ArcGIS Online hosted feature layer. This step is key to ensuring success of the attribute join and bringing all of the field assessment data into GIS.

b. Addressing Repeat Assessments on the Same Site

Because of the way Survey123 forms are structured (a single form corresponds to a single polygon), a site/polygon that is assessed again in the future will overwrite previous data. One approach to avoid overwriting data would be to add new site polygons with their own unique name (e.g., SiteName + "2ndVisit") prior to conducting a repeat assessment. Following a consistent protocol here is important for ensuring quality of the data for management and analysis, although these cases are likely few and far between.

Filling Gaps in the Data

a. Adding Survey Date & Time to the Dataset

Temporal data would be useful as a reference and for statistical or time-series analyses, but it is mostly missing from the ecosystems GIS layer we created. Survey date information is more complete in the site worksheet but has yet to be copied over to the GIS layer. To add this data, we recommend joining/relating the site information worksheet (after cleanup) to the ecosystems GIS layer. Some survey date/time records may still need to be filled in manually.

b. Verifying Township/Bioreserve Area Information in Site Names

Although the three-part site names are mostly complete in both the GIS and Access data, there are some discrepancies in the township and Bioreserve area components (e.g., cases where there are multiple different Bioreserve area codes per site or where the site falls in a different township than the township used in its name). For the purpose of accuracy and clarity, we recommend reviewing the site names to verify that the Bioreserve areas and townships are indeed correct (even though these inconsistencies do not impact the function of the site name identifiers). This data could be manually edited or calculated in GIS by overlaying multiple layers together (Appendix D).

c. *Adding Questions to the Survey123 Form (As Needed)*

Although the Survey123 form we created contains all of the important field assessment questions, it does not fully cover all questions on the original data entry forms—specifically, it leaves out the site information worksheet and soil questions. We omitted these from the form for simplicity and because there are other, better options for entering this data. For example, site information can be manually entered into the related site overview table (so that it does not need to be filled in for each individual ecosystem on the site) and soils can be geospatially assessed using existing GIS data (this approach is taken by some ecological integrity programs—see Chapter 2). However, if these questions (or others) are desired in the form, they can be added by editing and re-publishing the XLS Form. Note that although new questions can be added to the XLS Form without issue, repeat names, repeat questions, and question types cannot be edited or else all data in the hosted feature layer will be erased ([ArcGIS Survey123 - Publish a survey](#)).

Increasing Data Quality Checks & Training

a. *Reinstating Volunteer Training Sessions**

Reinstating semi-regular volunteer training sessions will help ensure that data is entered completely and correctly. This will be especially key given new data collection using Survey123, since even the most experienced volunteers may need instruction on how to use this digital data collection tool.

b. *Following Consistent Data Creation Practices**

It will be important for new ecosystem sites to follow established conventions for digitization and naming. All key pieces of information (site name, ecosystem name, Bioreserve area, township, and survey year) need to be entered into GIS in a consistent manner. Taking these steps will help limit gaps or errors in the data, which in turn will make continued data management easier and data analysis more meaningful.

c. *Reviewing the Data for Errors*

It is important to catch errors and gaps in the data as they happen to avoid the need for significant data cleanup in the future. We therefore recommend that HRWC designate a staff member to periodically review the data for missing or erroneous data, particularly during the transition to the new data workflow.

d. *Creating Regular Backups of the Field Assessment Data*

To avoid potential data loss/corruption problems that come with hosting the field assessment data in an online layer, we recommend periodically creating backups of the data to a local file. The data in ArcGIS Online can be exported as a file geodatabase and saved in a folder or ArcGIS Pro project locally. Then, if the feature service data is lost or it becomes corrupted, the backup can be re-appended to the online layer.

2. Consider Data Collection and Management Alternatives (if program needs shift)

If the future goals and projects of HRWC/NAAP require additional or non-ESRI methods for data collection and management (for cost-related reasons or otherwise), we recommend alternatives to Survey123/file geodatabases: namely, some of the RDBMS listed in Table 3.4, ESRI FieldMaps, and

workflows with ODK + QGIS. We identified several RDBMS options that are more compatible with ArcGIS than Microsoft Access (SQLite, PostgreSQL, and Microsoft SQL Server); any of which could replace the file geodatabase for storing data. The most promising data collection alternatives to Survey123 forms are FieldMaps and ODK. FieldMaps is a newly developed ESRI application that can integrate with (and could eventually replace) the Survey123 application, so we recommend keeping a close eye on its development. QGIS, which is a growing, free, open-source GIS application, provides much of the same functionality of ESRI's ArcGIS platform without licensing or credit restrictions. Although QGIS lacks anything similar to ArcGIS Online (at least as of April 2021), its rapidly growing user base means that it is increasingly being integrated into other software; this makes it a potentially attractive option for HRWC and other non-profits. ODK is a data collection application that can feed data directly into a QGIS database (as opposed to an ArcGIS file geodatabase), offering a potential non ArcGIS-based workflow for collecting data directly into a GIS database. None of these alternatives are immediately necessary if the new Survey123/ArcGIS workflow we developed works well for NAAP, but it is important to be aware of these options if circumstances change.

3. Use ArcGIS Pro and R for Data Analysis

The new workflow we have implemented increases the effectiveness of, and opens the door to, many kinds of data analyses. Analyses could include querying features of interest from the data (Figure D.1), generating summary statistics (Figure D.2 and Figure D.3), overlaying the data with other layers or tables (Figure D.4), or running statistical analyses through ArcGIS or programs like R. While we lacked the time to perform many of these analyses, we have listed some examples of the type of data analysis questions that can be answered in this new system in Appendix D.

4. Investigate the Extrapolation and Downscaling of Ecological Integrity Data

Since data in this program have been collected at several different spatial scales (field assessments at a site level and GIS assessment at a Bioreserve area level), fully integrating the field and GIS datasets for analysis will require methods to translate or scale data from one unit to another. Although our new workflow provides an integrated way of viewing these datasets together, it does not offer a solution to this problem of scale. Extrapolating ecological data from a site to a Bioreserve or landscape would be challenging—especially with a more qualitative metric like ecological integrity—and doing so would require a significant amount of research on appropriate methods and SE Michigan biogeography. Likewise, downscaling data from a Bioreserve or site level to a parcel level is also potentially problematic. As one potential solution to this problem of scale, we recommend investigating the collection of geospatial assessment metrics at the same scale as the rapid field assessments (see recommendation 5 for more). This is an area where future SEAS Masters Project teams could greatly expand upon our work.

5. Update the Bioreserve Map to reflect the current state of the watershed's natural areas

Updating the Bioreserve Map layer was one of our initial project goals, but we lacked the time necessary to achieve this. We have several thoughts and recommendations about a few possible approaches to updating the Bioreserve Map if a future HRWC staff member or SEAS Masters Project seeks to do so. First, the Bioreserve Map rankings could simply be re-calculated by following the same Bioreserve Map method performed in 2007 (Appendix A), but replacing each metric (landscape connectivity, unchanged vegetation, restorability, etc.) with more recent GIS layers. Additional geospatial metrics such as landscape context, edge/buffer zones, zoning, and soil could also be added, as informed by our review

of ecological integrity assessment programs in Chapter 2. This method would account for some changes in natural areas since the first Bioreserve Map was created, but many of the scoring metrics in the original Bioreserve Map likely have not changed and the boundaries of those original Bioreserve areas may no longer be the same. A second option would be to conduct a Level 1 assessment (geospatial) using the newly created ecosystem GIS polygons instead of the Bioreserve area polygons. By measuring ecological integrity with two methods at the same spatial scale, it would be easier to compare integrity scores between the field and GIS datasets. This approach makes the most sense for cross analysis between the datasets, but if a new Bioreserve area layer is required, a third possible approach using supervised land cover classification and remotely sensed data might be the most useful and reproducible. With this third method, new natural area boundaries could be delineated based on high-resolution satellite imagery by using preexisting Bioreserve areas as training data (helping the classification tool determine which groupings of pixels correspond to natural areas compared to other land cover types).

As a result of the vast number of studies on land cover classification methods, machine learning methods, and an improved availability and affordability of high-resolution aerial imagery (such as imagery from NAIP, also known as the National Agriculture Imagery Program), the accuracy of land cover classification has greatly improved (Khatami & Stehmen, 2016; Mahdianpari, 2020). Some land cover GIS products are already available for southeastern Michigan—for example, the Southeast Michigan Council of Governments already has land use GIS products based on their own 30m resolution aerial imagery (SEMCOG, 2020) and the USGS publishes a GAP/LANDFIRE National Ecosystems dataset aimed at mapping ecosystems down to a 1-acre level (USGS, 2020). In the GAP/LANDFIRE dataset, ecosystems are classified to the same levels as NatureServe (USGS, 2020). However, since these products may be too coarse in resolution to accurately map the watershed's smaller Bioreserve areas, independently produced supervised land cover classification may still be a good option to consider.

6. Generate Field Assessment Reports using Survey123 Feature Reports & ArcGIS Pro

NAAP's new ArcGIS-based workflow provides more effective ways than Microsoft Access to generate automated but still customizable reports. We provide an evaluation of several reporting generation options below and in Table 3.5, and recommend that HRWC uses this assessment of options to choose and implement new reporting methods as soon as possible.

Table 3.5: Comparison of report generation options through Survey123 and ArcGIS Pro.

Option 1: Survey123 Feature Reports	
Advantages	Drawbacks
<ul style="list-style-type: none"> 1) Semi-automated and easy to generate reports 2) Highly customizable report structure & appearance 3) Good documentation and support for report design 	<ul style="list-style-type: none"> 1) Costs ArcGIS Online credits (0.5 credit per record in report) 2) Limited ability to aggregate data from multiple records 3) Lacks map layout customizability 4) Potential for errors/failure if assessment questions or layer change (not durable)
Option 2: ArcGIS Pro Reports	
Advantages	Drawbacks
<ul style="list-style-type: none"> 1) Highly customizable map layouts 2) Ability to aggregate data from multiple records 3) Good documentation and support for report design 	<ul style="list-style-type: none"> 1) Initial setup requires more work 2) Less automated — requires more manual data entry & editing 3) Less customizable report structure and appearance 4) Potential for errors/failure if assessment questions or layer change (not durable)
Option 3: Manual report creation (using a template or hybrid of options 1 & 2)	
Advantages	Drawbacks
<ul style="list-style-type: none"> 1) Highly customizable map layouts & report structure 2) Best option for aggregating data from multiple records 3) Most durable option if assessment questions / feature layer change 	<ul style="list-style-type: none"> 1) Not automated — report generation would be very time intensive
Option 4: Programming/scripting in ArcGIS Pro (using ArcPy)	
Advantages	Drawbacks
<ul style="list-style-type: none"> 1) Highly automated — limited manual data entry required 4) Ability to aggregate data from multiple records 	<ul style="list-style-type: none"> 1) Initial setup requires a lot of work 2) Limited documentation for developing the necessary code 3) Manual editing may still be necessary 4) Potential for errors if assessment questions or layer change (not durable)

Although the Survey123 Feature Reports and ArcGIS Pro Reports have very similar aims, they employ different approaches and consequently offer different, yet complimentary, advantages. The Survey123 Feature Reports have a limited ability to aggregate data from multiple records (which is important if multiple ecosystems were surveyed on the site) and do not allow for much map layout customization. However, their use of simple expressions and Microsoft Word format allows for a highly customizable report appearance. On the other hand, ArcGIS Pro Reports have a less customizable report structure and appearance (given limited layout and formatting options in ArcGIS Pro), but do a better job of aggregating data from multiple reports and printing attractive map layouts.

Because the advantages Survey123 Feature Reports and ArcGIS Pro Reports are so complimentary, we recommend generating reports manually using a hybrid approach: Option 3 (Table 3.5). Using this approach, one could first use ArcGIS Pro reports to create a map layout/title page to present aggregate data for all ecosystems on a site and then append these pages to a customized Survey123 Feature Report template. The main disadvantage of this hybrid approach is that it would require more work than Option 1 or Option 2 alone: certain areas would need to be manually edited and working through two applications to develop reports is inherently more complex. Nevertheless, this approach would provide a partially automated form of report generation and out of all of the options above, might be most capable of mimicking the structure and appearance of Microsoft Access reports. Documentation for [ArcGIS Pro Reports](#) and [Survey123 Feature Reports](#) can be found on ESRI help pages.

As HRWC decides on a method for report generation, we recommend that they also take into account the key findings of the following chapter (Chapter 4) in which we use survey and interview data to capture feedback from the producers and end-users of NAAP data. These results can inform how report generation, as well as other aspects of this new data workflow, can be adjusted to best meet the needs of different data users and improve the impact that NAAP has on land management and protection.

List of Helpful ESRI Support Websites

- ArcGIS Help: The architecture of a geodatabase. Retrieved April 18, 2021, from <http://desktop.arcgis.com/en/arcmap/10.3/manage-data/geodatabases/the-architecture-of-a-geodatabase.htm>
- ArcGIS Pro: Overlay Layers (Geoanalytics). Retrieved April 26, 2021 from <https://pro.arcgis.com/en/pro-app/latest/tool-reference/big-data-analytics/overlay-layers.htm>
- ArcGIS Pro: Reports in ArcGIS Pro. Retrieved April 18, 2021, from <https://pro.arcgis.com/en/pro-app/latest/help/reports/reports-in-arcgis-pro.htm>
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- ArcGIS Survey123: Report templates. Retrieved April 18, 2021, from <http://doc.arcgis.com/en/survey123/browser/analyze-results/featurereporttemplates.htm>
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- ArcGIS Survey123: XLSForm essentials. Retrieved April 18, 2021, from <https://doc.arcgis.com/en/survey123/desktop/create-surveys/xlsformessentials.htm>
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Chapter 4: How Effectively Does the Natural Areas and Assessment Program (NAAP) Engage and Inform Volunteers, Landowners, and Decision-Makers to Prioritize the Preservation and Management of Natural Areas?

Introduction

The Huron River Watershed Council's Natural Areas Assessment Program (NAAP) has a core mission of impacting local and landscape-scale land protection that relies heavily on private landowners, local communities, conservancies, and government agencies using the information and tools it produces. These tools include the Bioreserve Map, which identifies the location and ecological quality of natural areas in the watershed in PDF and GIS shapefile formats (Appendix A), and volunteer produced field assessments, which evaluate the ecological integrity and level of human disturbance of each natural area (Appendix B).

In order for the program to achieve its desired impacts on restoration and conservation, the data it produces must be shared effectively with a variety of audiences. As part of our approach to informing the adaptive management of NAAP, it was essential for us to learn the perspectives of the broad set of individuals and organizations who engage with HRWC. We examined several aspects of NAAP's communication and engagement process, including accessibility of services and data, the content of NAAP-produced information, and the impact of that information on land management and protection. Specifically, we used interviews and surveys to address the following research questions:

1. *How easy is it to engage with NAAP services and operations?*
2. *How easy is it to obtain NAAP data (maps and field assessments) or updates?*
3. *To what extent is the information provided by NAAP accurate, adequate and clear?*
4. *How is this information actually used by landowners and decision-makers? What impact does it have on management and protection?*

We identified three respondent groups whose perspectives were critical to assessing the program: landowners, stakeholders, and volunteers. In this report, "landowners" refer to individuals who own one or more properties within the Huron River Watershed that have been assessed by NAAP. "Stakeholders" refer to individuals or organizations that use NAAP data to aid in land protection efforts, and "volunteers" refer to individuals who participate in conducting NAAP field assessments. To address the research questions above, we asked each group of respondents multiple-choice and short-answer questions through online surveys, and expanded on their responses with follow-up interviews. This feedback was used to produce the final result of the survey portion of this Master's Project: a summary of which NAAP components are already working well, which components could be improved, and recommendations for how to make those improvements.

This is the first time in the 14-year history of the program that such a comprehensive analysis of user feedback has been conducted. The data outlined in this chapter will help HRWC improve user experience, communication, and the overall impact and effectiveness of NAAP. Though our main audience is HRWC, our approach is relevant to any land conservation organizations that are working to engage and inform diverse audiences.

Methods

To better understand what kind of survey questions would best address our four research questions, we first conducted remote pre-survey interviews with members of the respondent groups; this process is described in more detail below. Based on the information collected from these interviews, we created three respondent-group specific surveys designed to reflect the specific needs of each respondent group while answering our research questions. Because only eight individuals were sampled as part of the stakeholder group, we decided it would be valuable to collect additional information from them via post-survey interviews. Figure 4.1, below, depicts our research methods. Full pre-and post-interview guides, survey questions, and survey responses, can be found in Appendix E and F. Full transcripts from interviews were not included for privacy reasons.

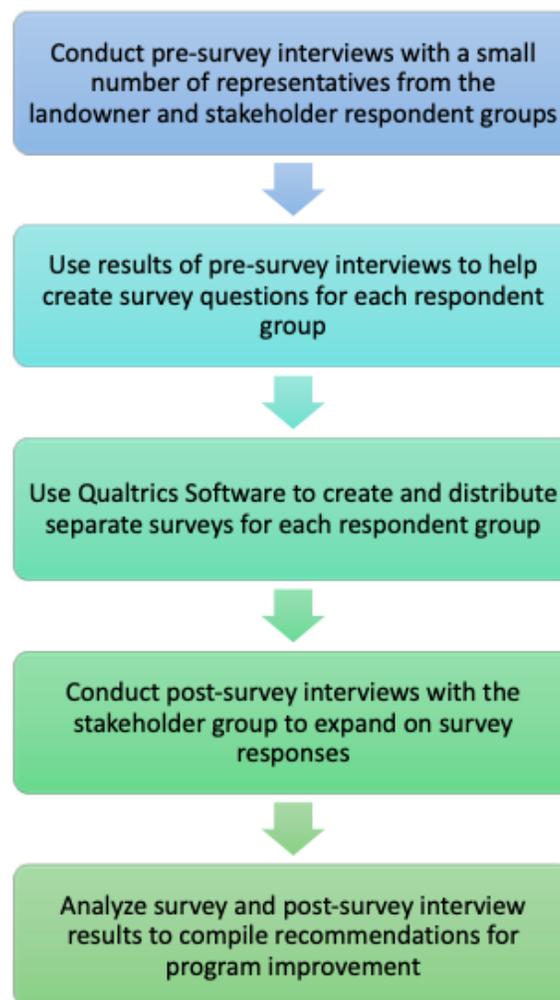


Figure 4.1: An overview of the survey and interview methods.

Pre-Survey Interviews

In order to generate survey content and become familiar with the constituents of the respondent groups, we conducted three pre-survey interviews: one with a landowner and two with stakeholders. These interviews were necessary to generate tailored and relevant survey questions because we lacked some basic information about the level of understanding, involvement, and use of NAAP products and terms by stakeholders and landowners. We did not interview any volunteers because their involvement with NAAP (completing training on field assessment criteria, then conducting field assessments) is more straightforward. In order to facilitate efficiency and reproducibility between interviews, we created a pre-survey interview guide composed of questions about the respondent's use of NAAP data and services, as well as their recommendations for useful survey questions for their respective respondent group (Figure 4.2). Interview transcripts were analyzed to generate survey questions. Full interview guides can be found in Appendix E.

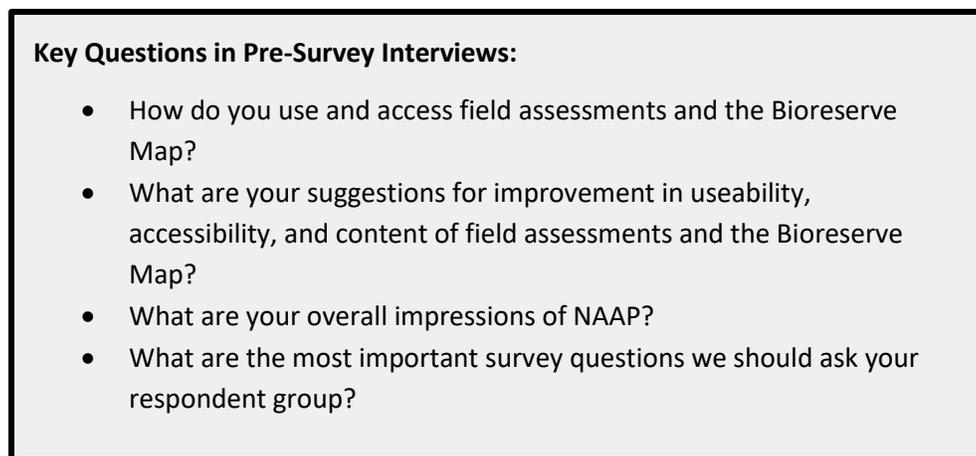


Figure 4.2: Key questions from pre-survey interviews.

Surveys of Landowners, Volunteers, and Stakeholders

The purpose of the survey was to get a large volume of quantifiable feedback across the three respondent groups and use this to advise HRWC on how to improve their programs. Based on the content of our pre-survey interviews, we compiled a set of survey questions that best address our research questions. Three separate surveys were created (one for each respondent group). All survey questions can be viewed in Appendix E. Gift cards were used to incentivize survey respondents. Respondents from the landowner and volunteer groups were entered into a raffle to win a \$75 gift card, while respondents from the smaller stakeholder group were entered into a raffle to win a \$50 gift card.

We used Qualtrics Online Survey Software to create and distribute the surveys because Qualtrics is well known and widely used and has a user-friendly design for both survey creators and respondents. A unique survey was created for each survey group, but we kept questions that were relevant to all three survey groups identical across forms in order to facilitate meaningful comparisons of responses between the three groups. Each survey was prefaced with a brief explanation of the objectives of HRWC, the purpose of the survey, and a reminder about the gift card incentive. Question types included single-response multiple choice, multiple-response multiple choice, and short answer. Display logic was used

to selectively display subsequent questions depending on previous answers in order to optimize response accuracy and user experience. At the end of each survey, landowner and volunteer respondents were prompted to submit contact information if they were interested in answering follow-up questions, while stakeholder respondents were prompted to schedule a meeting time for their post-survey interview.

To distribute the survey, we obtained contact information for each of the three respondent groups from HRWC in Microsoft Excel format. These were converted to CSV format to align with Qualtrics requirements; once uploaded, contacts were used to generate individual and personal links. Individual links do not display the respondents' names in the survey data but are not fully anonymized in the Qualtrics software, allowing completion status information to be stored. Personal links display the names of the respondents in the survey data. We used individual links for distribution of both the landowner and volunteer surveys so that reminders could be sent periodically to individuals who had yet to start their surveys in the hopes of increasing response rate. Personal links were used for the distribution of stakeholder surveys since we needed to know the stakeholders' identities in order to schedule their interviews. All surveys were linked within the body of an explanatory email that had similar information to the survey preface (see Appendix E for the full email text). The landowner and volunteer surveys were initially sent out via email on October 30th, 2020, with reminder emails sent on November 10th, November 18th, December 1st, and December 16th of 2020. Due to the smaller size of the stakeholder group, all eight stakeholder surveys were sent out later: on November 10th, 2020. All stakeholders responded by December 11th and all agreed to participate in follow-up interviews. Response collection was closed on January 4th, 2021.

Post-Survey Interviews with Stakeholders

Follow-up interviews with stakeholders were conducted to create case studies that would provide anecdotal examples of program successes and add detail to our recommendations. The stakeholder group was small enough to allow for post-survey interviews, and it was critical to collect their perspectives on NAAP because, of the three groups, they are the most directly involved with larger-scale land protection efforts. The post-survey interview guide can be found in Appendix E.

Results & Discussion

While survey response rates were relatively low across all groups except for the stakeholders, we believe that the responses accurately capture the sentiments of the three respondent groups. Table 4.1, below, shows the response rate for each group. It should also be noted that not every person who started the survey completed it. This means some questions were answered by a different number of people. A full list of results with the number of people who answered each question can be found in Appendix F.

Table 4.1: Survey response rate across groups.

	Total Sent	Responses	Response rate
Landowners	158	29	18%
Stakeholders	8	8	100%
Volunteers	92	24	26%

The following sections summarize the results of all three Qualtrics surveys and the post-survey interviews with stakeholders.

Accessibility of Services & Opportunities: How Easy is to Engage with NAAP Services and Operations?

Landowners, stakeholders, and volunteers first came into contact with NAAP in different ways (Table 4.2). Most landowners first heard of the program through a letter. Others heard about the program were through personal contacts, research into land conservancy opportunities, and township board presentations. The majority of stakeholders first heard about NAAP through a long-standing partnership between their organization and HRWC. One stakeholder who answered “other” heard about the program through a job hunt. The majority of volunteers either heard about NAAP through previous involvement with HRWC programs or answered “other.” While most volunteers who answered “other” did not remember, some found the program through personal contacts, newspapers, or an HRWC representative's visit to a University of Michigan class.

Table 4.2: How different groups first heard of HRWC's NAAP with highest percentages highlighted.

Method	Landowner n = 29	Stakeholder n = 8	Volunteer n = 24
Previous involvement with HRWC programs	13%	0%	28%
An HRWC event	13%	0%	24%
Another HRWC volunteer	n/a	n/a	12%
Another organization	6%	12.50%	8%
A letter from HRWC	35%	0%	0%
A long-standing partnership between my organization and HRWC	n/a	75%	n/a
Another Landowner	10%	n/a	n/a
Other	23%	12.5%	28%

Most volunteers indicated that the process of becoming a volunteer was relatively easy. The majority (84%) of volunteers heard back from HRWC in a timely manner after completing the volunteer sign-up

form. Not all volunteers (72%) indicated that they understood what their volunteer experience would be like beforehand, which means that HRWC could improve upfront communication of volunteer duties to new recruits. Most (44%) volunteers have only completed between 1-3 assessments, 39% have completed between 4-10 assessments, and 17% have completed over 10 assessments. Even though the minority of surveyed volunteers have completed a large number of assessments to date, volunteer interest is strong: 82% of volunteers plan on volunteering again, 76% have recommended the experience in the past, and 76% plan on recommending volunteering with HRWC to someone in the future. Though we did not ask about what factors limit the number of assessments volunteers have conducted, strong volunteer interest suggests that HRWC could possibly expand on volunteer opportunities and recruitment.

Stakeholders and landowners had slightly different experiences with scheduling and recommending field assessments. While not all stakeholders (74%) have scheduled a field assessment, of those, 100% agree that it is easy to schedule. Additionally, 100% of stakeholders have recommended an HRWC field assessment report to another person, and 100% of stakeholders plan on recommending the program to others in the future. Landowners, on the other hand, vary in satisfaction with the process. While 86% of the landowners surveyed agreed that scheduling a field assessment with HRWC was easy, some landowners experienced difficulty with the communication process prior to the actual field visit. Of the landowners who had difficulty setting up the field assessment (14%), most found it difficult to find the correct website and get in contact with someone. This could be resolved by advertising the contact information in a more prominent way on the website. 60% of landowners have recommended an HRWC field assessment to another landowner and 53% plan on doing so in the future.

One way to increase landowner satisfaction with the field assessment process would be for HRWC to create a more personalized experience, where landowners are guided through, starting with the formation of goals and ending with recommendations for next steps based on assessment results. Similarly, it would improve landowner experience to cut out unnecessary communication. As stated by one respondent, "there were four thousand reply all emails, that swirled around between HRWC, and the volunteers about scheduling. It would be a lot better if it were cleaner. If one person...who was the point person for the contact with the landowner made certain that they serve as a concierge tray...don't draw the landowner into the web, make it easy for them." Lastly, one stakeholder mentioned that creating a partnership with other organizations could help coordinate communication. Some people might trust HRWC over government organizations, so HRWC could help be a liaison between landowners and government organizations. Also, because word of mouth is the way most of this conservation information is transferred, being able to track land preservation recommendations and decisions between organizations would help the land preservation community as a whole.

One stakeholder drew attention to how landowner and volunteer behavior can affect field assessment experiences. NAAP volunteers do not receive extensive coaching on how to interact with landowners. Negative interactions may dissuade both landowners and volunteers from continuing their affiliation with NAAP. To promote volunteer safety, volunteers should be trained how to respond to potentially negative situations, such as a hostile landowner. Across the board, the program would benefit from providing volunteers with interpersonal training.

HRWC could consider other possible communication and engagement recommendations from respondents to increase overall access and awareness of NAAP assessment services. Stakeholders suggested recruiting volunteers and spreading NAAP awareness by reaching out to University of

Michigan students or setting up a table at the Ann Arbor Farmers Market. They also suggested that HRWC should consider expanding efforts like NAAP to other watersheds.

Access to Bioreserve and Field Assessment Data for Landowners and Stakeholders: How Easy is it to Obtain the Information and Updates?

The majority of landowners and stakeholders concurred with the statement that they received their field assessment reports in a timely manner after their field assessments were completed. In cases where a stakeholder had sought a specific report for a plot of land independent of any request for a field assessment, most received the report in a timely manner (Table 4.3). Even though most people received copies of their reports, many respondents whose assessments took place in the past were no longer in possession of the report nor knew how to obtain a new copy.

Table 4.3: *Accessibility and timeliness of receiving a field assessment report.*

Question	Landowner Responses	Stakeholder Responses
After the assessment was completed, I received a field assessment report from HRWC	93% agree n = 27	100% agree n = 6
I received my field assessment report in a timely manner.	86% agree n = 22	100% agree n = 6
When I need to view a field assessment report, I am able to gain access to it in a timely manner.	n/a	87% agree n = 8

Access to the Bioreserve Map was another story; while 62% of landowners were interested in accessing the map, only 36% knew how to access the map after reading their report. Others were confused as to what the map actually is. Most had used the Bioreserve Map PDF, but few had used the shapefiles as discussed above. While landowners were less likely to use the Bioreserve Map than stakeholders, the high amount of interest indicates that providing access to the map will increase its usage and facilitate a better understanding of the value of their land within the larger context and mission of NAAP. Most stakeholders indicated that they would prefer to access the Bioreserve Map by downloading it directly from HRWC's website (Table 4.4). As stated by one stakeholder, "...if [the Bioreserve Map shapefiles and PDF] were freely available to download... that would be nice so that when Kris goes away, I can just get them." Another stakeholder, who answered "other," suggested creating an online map that they can access to zoom to parcels or areas and download data.

Table 4.4: Preferred map access method for stakeholders.

Access Method	Stakeholder Responses n = 8
Downloading directly from the HRWC website	42%
Receiving an email from HRWC containing links to the Bioreserve Map	33%
Receiving instructions for access in a field assessment report	17%
Other	8%

Although stakeholders and landowners had difficulty accessing the Bioreserve Map, they did indicate that the Bioreserve Map PDF was easier to navigate and understand than the shapefiles (Table 4.5). Overall, stakeholders had an easier time understanding the Bioreserve Map PDF than landowners, and this gap in understanding might be due to landowner inexperience with GIS based land assessments. However, both landowners and stakeholders found the shapefiles difficult to understand. The accessibility of the map also differed by delivery method and respondent group. Most landowners had not seen or used the Bioreserve Map, either as a PDF (74%) or as shapefiles (84%). While all of the 8 stakeholders who took the survey were actively using the Bioreserve Map, most (62.5%) use the PDF version exclusively. Only 1 of the 8 stakeholders was using the shapefiles exclusively, and 2 were using both. The fact that stakeholders use the Bioreserve Map more than landowners likely reflects not only their higher need for work-related landscape-level planning, but also their ability to access Bioreserve Map files more easily. Most stakeholders reported that they could quickly and easily access the shapefiles (66%) and PDF (71.5%).

Table 4.5: Understanding and navigating the Bioreserve Map PDF and shapefiles.

Question	Landowner Responses	Stakeholder Responses
The Bioreserve Map <u>PDF</u> is easy to navigate and understand	80% agree n = 5	100% agree n = 4
The Bioreserve Map <u>shapefiles</u> are easy to navigate and understand	33% agree n = 3	33% agree n = 3

To remedy problems with access to Bioreserve Map and field assessment data, we strongly recommend that HRWC create a page on their website where stakeholders can search for field assessment reports and download the Bioreserve Map PDF and shapefiles. We also recommend including clearer descriptions of the terminology and scoring methods used in the reports, what the Bioreserve Map communicates, and what purpose both serve for HRWC. Providing access to updated Bioreserve Map data is just as important. One stakeholder stated, “I also wasn't sure they were actively updating that map and that's something I should be getting, you know, once a year or once every five years or something.” HRWC should clearly indicate “last updated” dates for all of its data and when HRWC

updates its shapefiles and/or PDF, it could upload the new data to the website in a timely manner and alert stakeholders of the update via email. Finally, many of those who have had their land assessed or do not work in natural resources have not had experience using geospatial tools and would not know what to do with the shapefiles. HRWC could incorporate an instructional guide for how to upload and use shapefiles in ArcGIS or a similar open source software (i.e., QGIS) in a new section of their webpage. Such changes could help stakeholders and landowners' access and utilize the Bioreserve Map.

To What Extent are the Field Assessment Reports and Scores Clear, Accurate, and Adequate?

Several stakeholders and landowners had difficulty understanding the scores in the field assessment report, especially the disturbance scores (Table 4.6). Their responses indicated that translating the numerical scores into a more narrative structure would support greater understanding. A narrative structure may be more useful for land that is being considered for restoration or preservation. For example, one stakeholder stated that "...using [the report] means being able to read and understand all the numbers and how your particular piece of property compares to what they consider a high quality environment. And that isn't always easy to understand for the average person... I think a narrative... would be [more] helpful than just the numbers." Another said "It can be a little complex, complicated. There's all these comparisons of numbers that rate various levels of quality of different landforms and different habitats. ...it could probably be translated into a more accessible narrative for the homeowners that are the property owners." This sentiment was prevalent among landowners and stakeholders; they indicated that it would be helpful if the overall ecological quality of the land as well as field assessment scores were summarized on a scale from 'poor' to 'excellent' (see Table 4.6).

Table 4.6: *Understanding and interpreting field assessment scores.*

Question	Landowner Responses n = 22	Stakeholder Responses n = 8
I understand how to interpret the Ecological Integrity Scores provided in field assessment reports	81% agree	75% agree
I understand how to interpret the Disturbance Scores provided in field assessment reports	59% agree	87.5% agree

Volunteers are vital to HRWC, and there are some aspects of volunteer training that need to be adjusted in order to increase volunteer understanding of ecological integrity and how to measure it accurately (Table 4.7). First, 14% of surveyed volunteers have not completed the volunteer training. Of those that had completed the training, all had done so more than two years ago. Ensuring that every volunteer receives formal training as well as periodic training refreshers should aid in volunteer understanding. Overall, survey results also indicated that volunteers want more in-depth training, with many wanting deeper explanations of the variables used in field assessments. Only 39% agreed they could correctly identify species on the worksheet with many calling for the need of an "expert" in the field to help them identify plants. Even though HRWC has a Plant Guide to aid in identifying species, 72% reported they did not use it. Similarly of concern in terms of possible effects on assessment accuracy, 44% said they guessed when filling out the field assessments. This may mean the volunteers forgot about the Plant

Guide, it was not talked about enough in training, or that they actually did not need it for plant identification, but instead needed more information on other aspects of the assessment.

Training refreshers may help volunteers both use the Plant Guide and better understand any definitions of unclear variables. It may be helpful to include a checklist and definition sheet with the physical field assessment sheets or within the Survey 123 app (as discussed in Chapter 3) in order to ensure that volunteers have all of the resources they need to produce accurate field assessment results. Although 53% of volunteers stated that they did not want to use a mobile app to conduct field assessments, 29% agree that a mobile app would increase accuracy. The newly developed Survey 123 form (Chapter 3) has not been used yet by any volunteers, and app hesitancy may be a reflection of volunteer demographics; older or previous volunteers could prefer the more familiar paper forms. It is likely that future volunteers will be more comfortable with technology. Moreover, the Survey 123 app could be used to engage with and recruit younger volunteers, like college and high school science students.

Table 4.7: *Understanding of key concepts for volunteers.*

Question	Volunteer Responses n = 18
I understand what the purpose of field assessments are.	94.5% agree
While volunteering, I felt like I understood all of the ecosystem terminology on my field assessment worksheet.	78% agree
While volunteering, I felt that I could correctly identify the species on my field assessment worksheet.	39% agree
While volunteering, I used the Bioreserve Project Rapid field assessment Plant Guide to help me fill out the field assessment worksheet.	28% agree
While volunteering, I felt like I guessed for many of my answers on my field assessment worksheet.	44% agree

Almost all (94%) of surveyed volunteers agreed that there were no major ecological variables or indicators of ecological integrity missing from field assessment worksheets. When the few who disagreed were asked what was missing, one answered, "I probably would have selected some different indicator species for some habitats based on the areas that I surveyed." This supports the value of using indicator species in field assessments of ecological integrity discussed in Chapter 2. While 91% of landowners said that no variables were missing from the field assessment reports, talking to landowners individually about their goals showed that there were some additional variables of interest unique to certain sites. For example, one landowner stated, "the neighboring farm has several drainage ditches that have negatively impacted soil-water content on my property. This impact was not addressed in the survey." This impact on soil quality could potentially affect the watershed and could be important to HRWC. Another landowner stated, "the wetland on my property is a part of a small triplet of wetlands that depend on each other to provide the valuable resource that it had evolved into over the last 10,000 years." The presence of this resource may impact the score given to the site and missing it on the assessment may create a report which is lacking hydrologic context.

While most respondents agreed that there were no ecological variables missing, survey results highlight other additions would most increase the value of the field assessment report (Table 4.8): a deeper explanation of the scores, rankings of “poor to excellent” for integrity or overall land quality scores, and a way to access reports independently, as already discussed above. While 100% of landowners and 87% of stakeholders agreed that they understood the ecosystem terminology in the report, more definitions of terms would be useful, as indicated by one stakeholder: "and so for me, it's less of a challenge than it is for someone who doesn't have the background that I do. So perhaps a glossary of terms might be helpful." Similarly, adding an overall ranking of the ecological quality of the land from poor to excellent would be helpful to landowners who may not have the ecological knowledge necessary for understanding the more technical aspects of all the scores.

There were several other specific suggestions of what would be helpful to add to the field assessment reports. Respondents raised the need for a clear one page executive summary up front, a floristic quality index for species, an ecosystem services financial valuation of parcels, an analysis of township-level land conversion threats, or even specific guidance on dealing with property developers who threaten wetlands. One stakeholder expressed interest in integrating HRWC's green infrastructure program into NAAP. Seeing the current zoning of each site, along with the master plan and how many building permits have been pulled could greatly impact the decision-making process. They stated “I don't care if its masterplan [says] high density residential if there's only been 10 building permits pulled in the last five years. I doubt that high density residential is ever going to get constructed... However, if it's low density residential... and 500 building permits have been pulled in the last five years. Yeah, it seems like there's actually a marketable threat to property, which then is a threat to ecological integrity.” Integrating this information into site reports or even site scores in the future could help land conservancies prioritize land protection.

Table 4.8: Elements to add to field assessment reports to increase user understanding of the results with highest percentages highlighted.

Question	Landowner Responses n = 18	Stakeholder Responses n = 7
An overall ranking of the quality of my land on a scale like this: Poor--Fair--Good--Very Good--Excellent	20%	14%
A list of organizations to contact to further improve my land once the field assessment is completed	17%	5%
A ranking of the Ecological Integrity Score and Disturbance Score on a scale like this: Poor--Fair--Good--Very Good--Excellent	15%	19%
A way to access field assessment reports independently (for example, by downloading them directly from the HRWC website) when I need to use them	15%	19%
A glossary of the science terminology used in the report	13%	5%
Details for next steps to take to further improve my land after the assessment is completed	11%	5%
A detailed explanation of what the Ecological Integrity Score and Disturbance Scores are and how they are determined	7%	19%
Other	2%	14%

To What Extent are the Bioreserve Map & Associated Scores Clear, Accurate, and Adequate?

Landowners struggled more than stakeholders to understand the definition of the Bioreserve Map or the Bioreserve Map Score (Table 4.9). Overall, both landowners and stakeholders need more clarity on the scoring system used to produce the map and the metrics used to create the score.

Table 4.9: Understanding and interpreting the Bioreserve Map and Bioreserve Map scores.

Question	Landowner Responses	Stakeholder Responses
The definition of the Bioreserve Map was clearly explained to me in my field assessment report.	53% agree n = 17	87.5% agree n = 8
I understand how to interpret the Bioreserve Map Score provided in field assessment reports.	33% agree n = 18	62.5% agree n = 8

Addressing how the Bioreserve Map is presented may improve understanding. For example, one stakeholder stated “display has always been something that I've been trying to improve on because it's a very messy data set... it just has weird edges and it's best when it's laid over like an aerial [image] ... And I think that for lay people, it just kind of fuzzies up their brain and I've had to simplify it over and over again to get them to pay attention to ‘this is the important part of this data. This is what this is saying.’” Another stakeholder suggested that HRWC create a “story map or some sort of platform, where you can just click on the polygon and the information [shown on the] PDF...the scores just pop up.” If resources allow, we believe that creating an interactive map that links Bioreserve polygons to their scores would greatly improve user understanding of the Bioreserve Map.

Finally, 72% of stakeholders agreed that the Bioreserve Map accurately conveys the ecological integrity of a site. When asked if the Bioreserve Map is accurate with regards to site location and ecological quality one stakeholder answered “people just need to understand that this is all using GIS data and data doesn't know everything. So I always try to give that disclaimer, and that's why the GIS plus the field assessment part is so necessary.” We believe this is an important point which should be noted when the map is distributed. Combining the map data and field data is integral to fully understanding each site.

How are the Map and Reports Actually Used by Landowners and Decision-Makers? What Impact Do They Have on Management and/or Protection?

Use of the field assessment report varied based on each landowner’s goal, as many landowners had unique reasons for scheduling a field assessment (Table 4.10). The most common reason that landowners scheduled field assessments was simply out of curiosity about their land. One landowner mentioned that their goal was to evaluate land for the development of a public park. Another mentioned that they thought “the results were more for HRWC, rather than us...that they were getting a broader view of all the lands in the Huron watershed.” The majority of landowners answered that their goals for their land were accomplished by having a field assessment done. However, one respondent gave a very specific goal—to use the report to “force MDEQ to conduct a real evaluation that included the impact to the entire area before providing a building permit.” This respondent is still waiting “for an effective response from HRWC to challenge MDEQ’s dismissive attitude that the wetlands are not worth protecting.”

Table 4.10: Landowner goals and outcomes for field assessments with highest percentages highlighted.

Goal	My goal(s) for having HRWC do a field assessment on my property was: (Please select all that apply) n = 29	Having the field assessment done helped me accomplish the following for my property: (Please select all that apply) n = 25
I was just curious about the state of my land and I wanted to find out more	37%	60%
I didn't have a specific goal in mind; HRWC asked me if I wanted to have a field assessment done	24%	N/A
I wanted to improve the ecological quality of my land	15%	24%
I wanted to get a conservation easement for my property	12%	4%
I wanted to protect my property by means other than a conservation easement	3%	4%
Other	9%	8%

In order to help landowners realize their goals, we recommend that HRWC increase communication with landowners about post-assessment action. During interviews, many stakeholders indicated that it would be beneficial for HRWC to follow up with landowners after field assessment completion because some landowners will "...not know what to do or what is in their capacity to do." Surveys of landowners confirm this: most (60%) of landowners were not sure what to do after they got their reports back and 55% of landowners said they desired follow-up contact from HRWC about next steps. HRWC could address this by simply including a page at the end of each report that outlines possible next steps along with contact information for relevant organizations. For example, one stakeholder suggested "not only recommendations [of next steps], but also how to go about pursuing those courses of action. So, if someone were interested in improving their properties, the names of companies like Plantwise... that do restorations or the names of the local conservancies that will help them protect the properties."

Stakeholders repeatedly stated that field assessments reports are extremely useful and are an integral part of their land protection processes. Some stakeholders use them as "an attachment to an application for a grant from the Michigan Natural Resources Trust Fund," while others "have also taken some of the questions from that field assessment... and included them in our own little field assessment sheet that we do," and still others "take the report to various land conservancies" for the purpose of

purchasing and protecting land. One stakeholder revealed how integral NAAP information has become in their decision-making process: “If we look at properties or there’s something that we want to take a look at, and it's in the watershed, we immediately think of an assessment. ... It's just part of our protocol now to contact them immediately... And I can think of many properties that have helped us—that the report, it's helped us say, Okay, this has scored really high we're going to go for this. Or on the other hand, it didn't look so good, it was highly invaded, and we decided, you know, we don't want to spend ...either our money or time going after something that's so severely impacted.”

The value of the assessments was not only recognized as part of a decision-making process, but also as building site knowledge. For example, a stakeholder stated that “the most valuable asset that the Bioreserve assessments field reports offer are an insight for someone like myself, who's not an ecologist, to see a qualified report on what are the ecosystem values or the conservation values of a property in pretty decent detail.”

Landowners and stakeholders generally agreed upon which parts of field assessment reports were the most useful, despite using the report for different purposes (Table 4.11). Both groups highlighted the importance of the site overview and species list. One landowner who answered “other” said that wetland information was the most helpful, and one stakeholder who answered “other” simply stated that they find the entire report valuable.

Table 4.11: *Parts of field assessment reports landowners and stakeholders found most useful.*

Question	Landowner Responses n = 17	Stakeholder Responses n = 7
Section 2: Map and scores	18%	23%
Section 3: Scores for natural area	18%	14%
Section 4: Site landscape context	5%	9%
Section 6: Site overview	20%	23%
Section 7: Species list	25%	23%
Info about invasive species mgmt.	12%	4.50%
Other	2%	4.5%

One point of interest was that some stakeholders were not as concerned with personally understanding ecological scores, since they mainly use field assessment reports to influence decision-makers with greater ecological knowledge. These individuals expressed that the depth of the ecological concepts can be overwhelming to individuals who lack formal ecological training. For example, one stakeholder stated, “so as far as really in-depth details from a scientific standpoint, I'm not gonna be able to get into it, you know, that deep.” However, this deep scientific data is invaluable when presented to a committee. For example, when asked one stakeholder stated “There's one [person on the board who] loves this and she's like, ‘if it's prioritized and high quality based on [the report and map], we should get it. If it's not, forget it.’” Some “go through it with the help of the scientists and try to further understand the property.” Overall, these results indicate that not all stakeholders need or even want to understand

all the higher-level ecological concepts if they plan on simply giving the report to a decision-maker who values the depth of scientific knowledge.

Several stakeholders expressed that the combination of the field assessment report and Bioreserve Map was critical for decision-making. For example, they understand that "... with any GIS driven landscape level analysis, there's always going to be qualifiers that you miss, that you need to have a [field assessment] report on to capture." Without the full picture of the site shown in the combination of the map and report, important details might be missed. Simply looking at the Bioreserve Map score could limit policymakers' understanding of a site. For example, "...a D-minus property might be adjacent to a protected B-plus property, in which case we want to build contiguous protected lands. So the D qualifier really undermines the landscape level value of protecting a large block of land, even if it is the highest quality ecosystem may create a contiguous block.... the map certainly lends itself to not necessarily intuiting that information." Confirming the need to integrate the Bioreserve Map and field assessment data (also identified in Chapters 2 and 3), one stakeholder mentioned "...I think what we are all wondering is indeed how close, how accurate, is the GIS data based on the field assessment data ...I do think that relationships should absolutely be explored."

For some stakeholders, the field assessment reports were "not formally part of our evaluation process at all," and they rely solely on the Bioreserve Map. Stakeholders use the Bioreserve Map for a variety of purposes as seen in Table 4.12. For example, one said that the board of their organization uses the Bioreserve Map as a key component of their own scoring system. Others use the map more as "just another set of numbers to put a qualifier on a piece of land or a patchwork of ecosystems, landscape." This sentiment is similar for many stakeholders who use the map. For example, one stakeholder said "so when a landowner calls me and says 'I want to conserve my property,' the first thing I do is put it into our ArcMap system, which has data including the bioreserve rankings and other information like the county and wetlands maps and other more specific details about property." And "the Bioreserve program isn't our sole criteria for conserving a piece of property, but we definitely look at its score and it plays a part into what we recommend to the committee."

Table 4.12: *How stakeholders use the Bioreserve Map.*

Map use	Stakeholder Responses n = 7
To prioritize land for protection	27%
To visualize where sites of interest are in relation to each other	23%
To persuade committee members to acquire a certain site	23%
To understand how site scores compare to each other	23%
As a base that I modify to better suit my specific needs	4%

Stakeholders found the Bioreserve Map so valuable that one stakeholder even told us that they decided to "use the exact same GIS model that HRWC was using" and that they were "very excited about it being

updated because [they have] seen that some of the polygons aren't applicable anymore because it was done in 2007, and a lot of them have been developed.”

Overall, from the stakeholders' perspective, field assessment reports and the Bioreserve Map have helped realize the program's goal of positively impacting the Huron River Watershed. For example, 87.5% of stakeholders agree that HRWC has increased the amount of natural protected area. One stakeholder described HRWC as an “important liaison” for natural areas protection, and 87.5% of stakeholders agree that the reports helped them determine which areas to protect.

It was suggested that HRWC could increase the usage of the field assessment reports by providing nominal funding for private land protection projects and tying such funding to assessment results. One stakeholder explicitly suggested such a program as a means to “push the needle in the right direction in terms of water quality in the watershed and make those funds contingent upon a Bioreserve field assessment.” The stakeholder also mentioned that while some landowners are interested in getting an assessment done, they are reluctant to allow people onto their property. Providing funding would not only incentivize conservancies, it would also incentivize reluctant landowners to participate in the program. Funding the project could also bring publicity to HRWC, which might help engage new organizations.

Key Recommendations and Other Considerations Moving Forward

The results of our survey and interviews show that HRWC has successfully provided stakeholders and landowners with valuable field assessment reports and GIS data, but could benefit from implementing certain changes to increase engagement, access, accuracy, and impact. Our most important recommendations for HRWC are:

1. Increase field assessment accuracy and volunteer confidence by providing a more robust training curriculum for volunteers and by having volunteers collect data with the Survey123 app, which includes built-in photos and support material to assist in data collection.
2. Include a glossary of ecosystem terminology and rank scores and sites from poor to excellent to improve user understanding of field assessment reports.
3. Provide landowners with instructions for next steps to take after having a field assessment done and provide contacts for organizations that can help with next steps in order to increase the long-term impact of NAAP.
4. Provide ongoing and independent access for landowners and stakeholders to NAAP data, possibly by adding a page on the HRWC website that provides user-specific access to field assessments as well as access to frequently updated Bioreserve Map PDF and shapefiles.

The accuracy of field assessment reports plays a determinant role in their usability, reliability and impact. A high percentage of volunteers said they guessed on the field assessment worksheet and indicated that they could not accurately identify the species. By increasing the amount and scope of volunteer training, and employing the use of the Survey123 app, it is likely that volunteers can conduct field assessments with greater efficiency, effectiveness, and confidence.

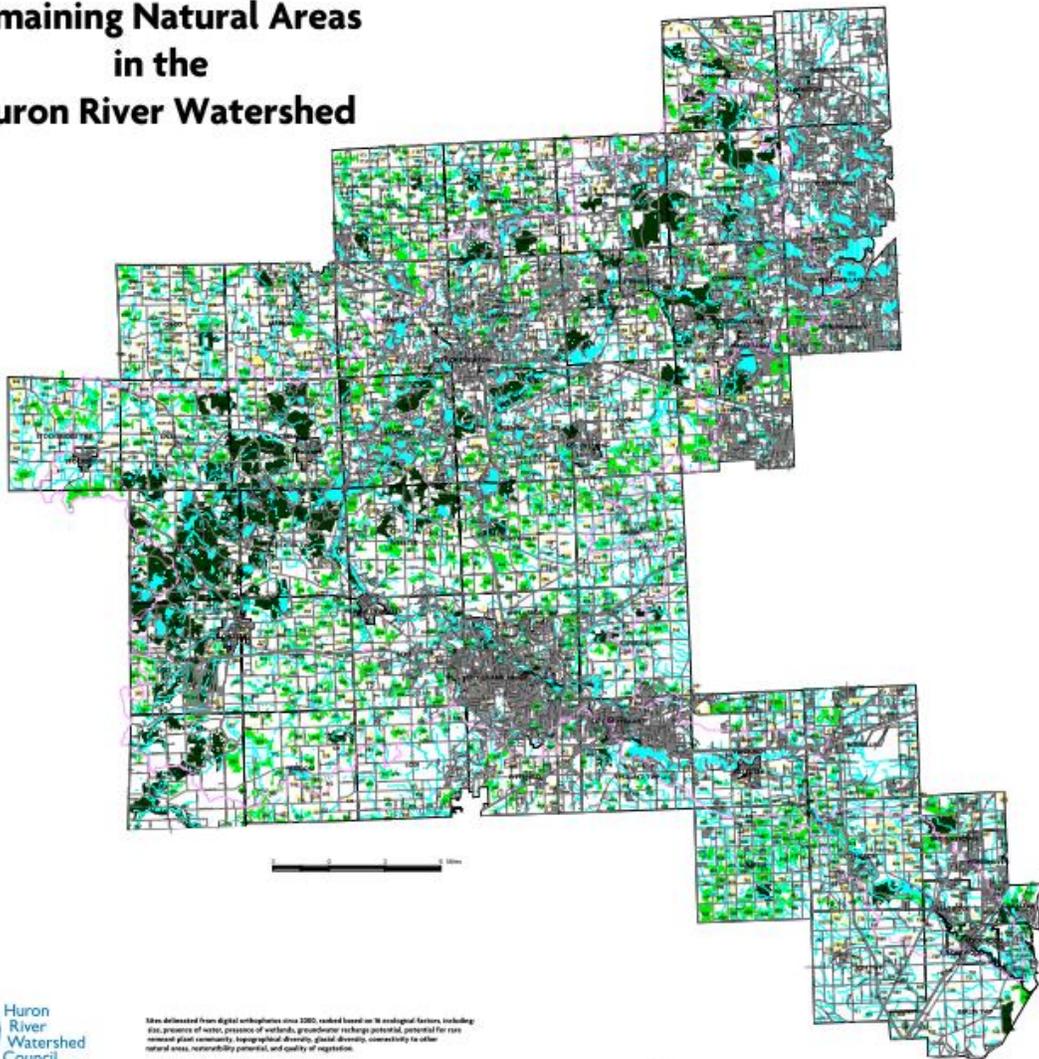
The addition of a terminology glossary and more expansive descriptions and rankings of the ecological and Bioreserve Map scores, will make the reports easier for people without formal ecological training to understand. This will increase the usability of HRWC products. Providing landowners and stakeholders

with independent access to field assessment reports and the Bioreserve Map will improve the access and impact of HRWC products. Also, providing information for next steps after field assessment completion will help landowners develop and follow through with conservation goals for their land. Overall, we believe that these recommendations will make NAAP products and services more reliable, usable, and impactful.

Appendix A: Bioreserve Map Materials

PDF

The Bioreserve Project: Remaining Natural Areas in the Huron River Watershed



Protecting the river since 1965

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

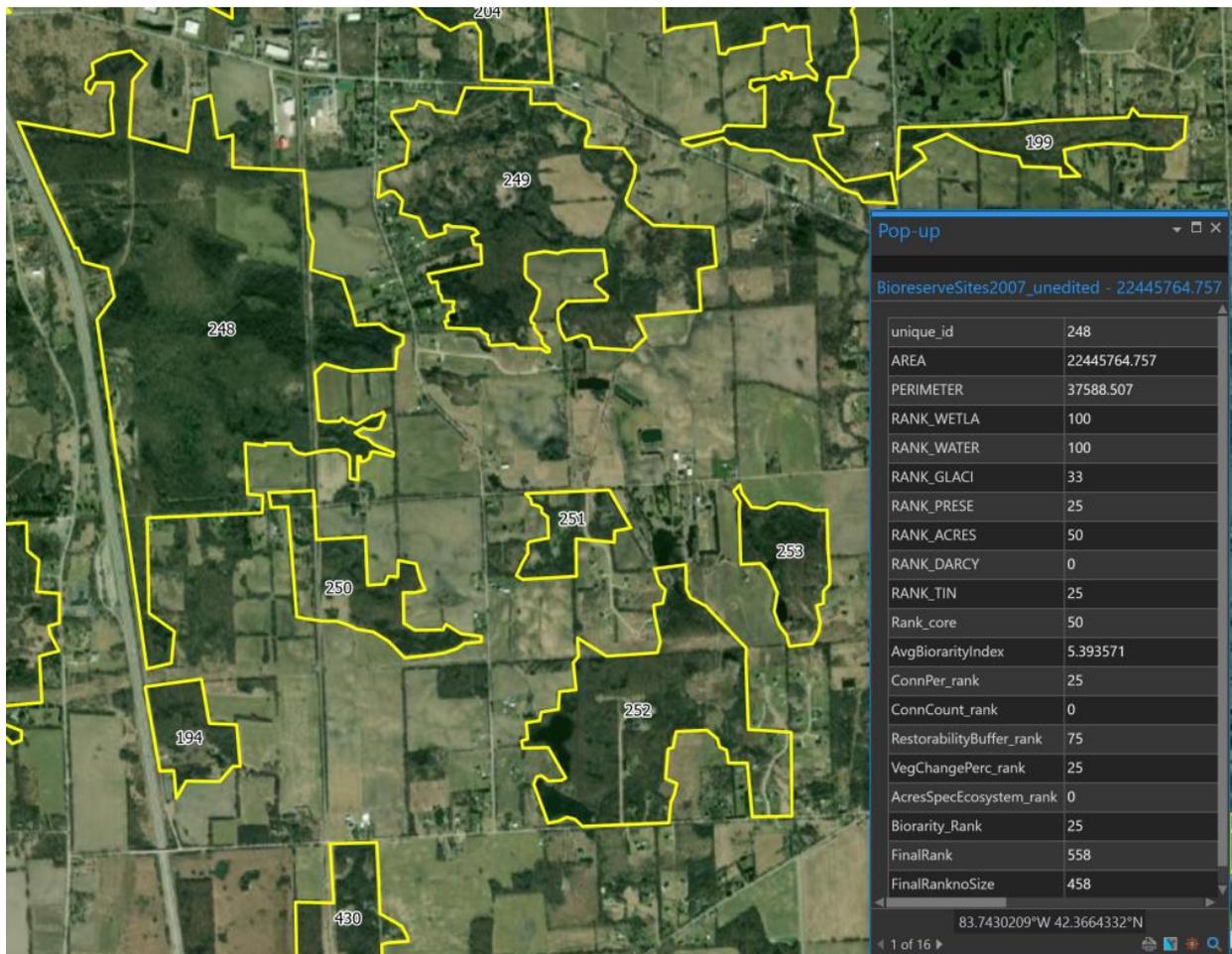
Data delineated from digital orthophotographs circa 2000, coded based on 18 ecological factors, including: elevation, presence of water, presence of wetlands, groundwater recharge potential, potential for rare natural plant community, topographical diversity, glacial diversity, connectivity to other natural areas, riparianity potential, and quality of vegetation.

June 2007

For more information, contact Kirk Clemons, Huron River Watershed Council
734 769 9555
www.hrwac.org

Priority	Highways	Rivers and Streams
Lower	County Roads	Lakes
Medium	Municipal boundaries	Watershed Boundary
Highest		

Example of Bioreserve Map Shapefiles





Huron
River
Watershed
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(734) 769-5123
www.hrwc.org

Bioreserve Method

Following is a breakdown of the scoring for each criterion:

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

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

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

Ranking breakdown by category

<i>Category and units</i>	<i>Highest ranking</i>	<i>Lowest ranking</i>	<i>Breaks</i>	<i>Method</i>
Size Acres	100 75 50 25 0		5	Natural Breaks
	Highest acreage Lowest acreage			
Core Size Acres	100 75 50 25 0		5	Natural Breaks
	Highest acreage Lowest acreage			
Waterways	100 0		2	Presence Absence
	Rivers present Rivers absent			
Wetlands	100 0		2	Presence Absence
	Wetlands present Wetlands absent			
Groundwater recharge Average of standard deviations per unit	100 75 50 25 0		5	Natural Breaks
	Highest infiltration Lowest infiltration			
Remnant ecosystems Number of rare presettlement vegetation types	100 75 50 25 0		5	Numeric
	4 3 2 1 0			

Glacial variation Number of different landforms	100 66 33 0	4	Numeric
	4 3 2 1		
Topographic variation TINs	100 75 50 25 0	5	Natural Breaks
	Max. Number of TINs Min. number of TINs		
Connectedness Number of bioreserve sites w/in 100 ft. buffer	100 66 33 0	4 4	Numeric
	8 – 11 4 – 7 2 – 3 1		
Connectedness	100 75 50 25 0	5	Natural
Percent of ¼ mile buffer that is a Bioreserve Site	Highest percentage Lowest percentage		Breaks

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

Biorarity Average Biorarity score for Site	100 75 50 25 0	5	Natural Breaks
	Highest score Lowest score		

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

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

Appendix B: Field Assessment Materials

Volunteer Field Assessment Form

Date:

Site Name[Twp_ID#_Owner]:

Surveyors:

Time spent at site:

INSTRUCTIONS

1. The attached aerial photo is marked to indicate a proposed route and provisional boundaries of different natural area types: Wetlands, Grasslands/Shrublands, Forests, and Creeks.
2. As you walk through the site, fill out a worksheet for each different natural area (wetland vs. grassland vs. forest vs. creek) that you encounter (this may be different from what is indicated on the aerial). Make sure to bring several copies of each worksheet, since you may find more than one wetland, forest or grassland as you walk the site. LABEL EACH WORKSHEET. If there is more than one natural area, note by a letter on the map and the worksheets (fill in the blank on both sides of the worksheet: "WETLANDS ").
3. Check here how many of each worksheet you filled out.
 - 1) Wetlands Worksheet: Area has standing water occasionally or periodically during year. #
 - 2) Grasslands/Shrublands Worksheet: Grasses, forbs, shrubs occupy >50% of the area. #
 - 3) Forests Worksheet: Trees occupy >50% of the area. #
 - 4) Creeks Worksheet: #
4. Sketch the actual boundaries of each natural area you assess on the aerial. In the office, we will be recording the size of each natural area.
5. Sketch the route you took through the property.
6. After completing all the worksheets, fill out the LANDFORM AND WILDLIFE (Part II) and the SITE SUMMARY WORKSHEET (Part VII).

II. LANDFORM AND WILDLIFE. Keep these questions in mind as you walk through the site, and answer them considering how they apply to the ENTIRE site. Use additional sheets of paper as necessary.

II.1. Characterize the landscape and landforms in the site (check all that apply).

- 1) Flat
- 2) Gently rolling
- 3) Hilly, occasionally steep

- 4) Glacial lake plain
- 5) Glacial outwash plain
- 6) Glacial till or moraine

- 7) Kettle, kame, or esker
- 8) Large boulders (glacial erratics)
- 9) Other (describe):

For characteristics checked off above, CIRCLE those that occupy the largest area of the site.

II.2. WILDLIFE HABITAT. Small natural areas may provide important wildlife habitat in an increasingly urbanized environment. Check off any of the following wildlife signs or sightings for the entire site.

- 1) Antler rubs
- 2) Bird nests
- 3) Carcasses or bones
- 4) Deer
- 5) Deer tracks, deer browse
- 6) Droppings or scat

- 7) Fish other aquatic vertebrates
- 8) Frogs, toads
- 9) Ground-nesting birds (grouse, turkeys, etc.)
- 10) Migratory waterfowl
- 11) Raptors, raptor nests

- 12) Small mammals (squirrels, mice, rabbits, raccoons, etc.)
- 13) Small mammal burrows, tracks
- 14) Songbirds
- 15) Salamanders
- 16) Turtles
- 17) Other (describe):

Additional notes on wildlife (including stories or other anecdotal evidence from land-owner). If you know particular species, especially of frogs, toads, or salamander, please enter that here:

III. WETLANDS WORKSHEET

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

- 1) At margin of river, stream, lake, or pond
- 2) Kettle lake or pond
- 3) Standing water
- 4) In ravine or depression

- 5) Appears occasionally flooded
- (vernal pond, floodplain forests)
- 6) At base of hill or slope
- 7) Groundwater seepage area
- 8) Source of water not apparent, if no standing water...

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

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

- 1) Sandy
- 2) Heavy, slippery, loam-clay
- 3) Mixed w/ pebble or gravel
- 4) Glacial erratics (large rocks)

- 5) Light tan or brown
- 6) Dark brown
- 7) Mucky (circle: smooth; fibrous)
- 8) Peaty

- 9) Top 6–12" layered or banded
- 10) Top 6–12" appear uniform
- 11) Other (describe):

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

- 1) Vegetation clumped in distinct areas or patches or
- 2) Vegetation has no distinct zones

Check all that apply :

- 3) Open-water area (no plants)
- 4) Emergent marsh area (plants rooted under water; some leaves above surface)

- 5) Wet meadow or marsh area (dominated by grass-like plants)
- 6) Forb area (broad-leafed plants)

- 7) Fen area (grasslike & broad- leafed plants; peat/sphagnum moss)
- 8) Bog area (sphagnum moss, low broad-leafed evergreen shrubs)
- 9) Dense tall shrub area
- 10) Forest (swamp, floodplain) area
- 11) Other (describe):

III.4. Vegetation types. Check off all species that you recognize in the following vegetation groups. Within each group of species, CIRCLE any that predominate.

III.4.1. Native emergent and floating-leaved plants

- 1) Buttonbush
- 2) Pickerelweed
- 3) Water-willow

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

- 1) Bluejoint grass
- 2) Bulrushes

- 3) Cottongrass
- 4) Tussock sedge

- 5) Sedges, uncertain or other
- 6) Uncertain

III.4.3. Native forbs

- 1) Ferns (cinnamon or royal)
- 2) Gentians
- 3) Joe-pye weed

- 4) Lobelias (except Indian tobacco)
- 5) Marsh marigold
- 6) Orchids

- 7) Skullcaps
- 8) Skunk cabbage

III.4.4. Native shrubs

- 1) Blueberries
- 2) Buttonbush
- 3) Cinquefoil, shrubby

- 4) Dogwoods, shrubby (gray, red-osier, silky)
- 5) Leatherleaf
- 6) Michigan holly

- 7) Ninebark
- 8) Poison sumac
- 9) Willows (shrubby)

Continue on reverse side

III.4.5. Native trees

- 1) Ashes
- 2) Birch (yellow)
- 3) Cedar, northern white

- 4) Larch (tamarack)
- 5) Maples (Circle: red; silver; other)
- 6) Oaks (Species:)

- 7) Spruce, black
- 8) Sycamore

III.4.6. Native plants of bogs and fens

- 1) Cottongrass
- 2) Leatherleaf
- 3) Pitcher plants
- 4) Sphagnum moss
- 5) Sundews

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

- 1) Black alder
- 2) Buckthorns (Circle: glossy; common)
- 3) Cat-tails (dense, extensive)
- 4) Phragmites (common reed)
- 5) Purple loosestrife

- 6) Reed canary-grass

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

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

	None (0%)	A little (1–10%)	Common (10–25%)	Abundant (25–50%)	Dominant (>50%)
III.5.1. Native emergent plants	•	•	•	•	•
III.5.2. Native grasses	•	•	•	•	•
III.5.3. Native forbs	•	•	•	•	•
III.5.4. Native shrubs	•	•	•	•	•
III.5.5. Native trees	•	•	•	•	•
III.5.6. Native bog/fen plants	•	•	•	•	•
III.5.7. Invasive species	•	•	•	•	•

III.6. Invasive species distribution within wetland area. 1 vs. 2, then check rest that apply.

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

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

- 1) Bulldozed clearings
 2) Ditches, channels, or tiling (circle one)
 3) Drainpipes
 4) Berms, dams to divert H2O
 5) Erosion (gullies, washouts)
 6) Erosion control fencing
 7) Gravel or rubble fill or piles
 8) Dirt roads (graveled or unimproved two tracks)
 9) ATV or off-road vehicle trails

- 10) Fences
- 11) Agricultural use (describe):
- 12) Rock piles
- 13) Evidence of plowing

- 14) Wheel ruts, compacted areas
- 15) Trampled or rutted areas
- 16) Footpaths
- 17) Other (describe):

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

- 1) Extensive (>50% of area)
- 2) Partial (25–50% of area)

- 3) Moderate (10–25% of area)
- 4) Mild (<10% of area)

- 5) Uncertain
- 6) None apparent

III.9. Additional notes:

Field Assessment Report Example



Protecting the river since 1965

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

HRWC Bioreserve Site Assessment

Site: Parcels xx-xxx-xxx-xxx, about 95 acres of the 331-acre Bioreserve Site #517: [Webster517xxxx].

I. Site Location, Route, and Natural Areas Assessed:



HRWC Bioreserve Site Assessment #Webster517Davis

II. Bioreserve Map and Field Assessment Score:

The site receives scores based on the GIS model behind the Bioreserve Map and based on the field assessment.

The first column in the table on page 3 lists how the Bioreserve Map ranks the site for 15 ecological criteria. Rankings for each criteria range from 0 to 100.

The total score is **616**, which places it in the **highest-range** [lower range: 25-366; mid-range: 366-591; highest range: 591 – 1224] of all the Bioreserve Sites in the watershed ranging from 25 – 1244. See "Bioreserve Map Method" for more details on how the sites were scored on the Bioreserve Map.

The next two columns give scores for each type of natural area visited by the field assessment team. For each answer a team could enter on the worksheet, the site receives a certain number of points. For instance, for each plant a team checks off on the plant list, the site receives 5 points. If invasive species are listed as dominant, the site receives fewer points than if native species are checked as dominant. Each ecosystem within the natural area receives two scores, one for ecological integrity and one for level of disturbance.

Potential maximum points each type of natural area could receive:

Ecosystem Type	Ecological Integrity (higher score indicates higher quality site)	Level of Disturbance (higher score indicates higher level of disturbance on site)
Wetlands		
Bog or fen	255	100
Other wetlands	171	110
Forests	144	154
Grasslands	126	239
Waterways	51	n/a

HRWC Bioreserve Site Assessment #Webster517Davis

III. Scores for the Natural Area:

SITE NO. 517					
	Entire site's GIS scores	This parcel's field scores			
Ranking Criteria	Site #517 Ranking	Ecological integrity	Level of disturbance		
Rank for Size	25				
Rank for Core Size	25				
Rank for Water	100				
Rank for Wetlands	100				
Rank for Groundwater	0				
Rank for Remnant Ecosystems	25				
Rank for Glacial Diversity	33				
Rank for Topography	25				
Rank for Connectedness Count	33				
Rank for Connectedness%	50				
Rank for Potentially Unchanged %	50				
Rank for Potentially Unchanged Area	25				
Rank for Restorability	75				
Rank for MNFI Communities	0				
Rank for Biorarity	50				
Final Rank	616				
This parcel's natural area sites:					
	Forest A:			90.5	42
	Wetland A:	39.8	0		
	Wetland B:	71	14		
	Wetland C:	56	0		

HRWC Bioreserve Site Assessment #Webster517Davis

IV. Site Landscape Context:

Landscape of the 1800s: Nearly the entire site is located in a former Inland Wet Prairie community type with the exception of the southern portion containing Wetland C and the southern extent of the Forest. This southern portion was covered in a White Oak/Hickory hardwood forest. The Inland Wet Prairie ecosystem type has undergone drastic reductions as the area has been settled and is considered an endangered ecosystem.

Glacial geology: fine textured glacial till to the south, and outwash sand/gravel and postglacial alluvium to the north

V. Field Assessment:

The volunteer team visited the site on 8/3/2009 and spent about 3 hours assessing the site.

For the purposes of the assessment, the team delineated 4 different ecosystems on aerial photos of the site: 3 different wetlands (A, B, C); and 1 forest.

VI. Site Overview:

The glacial landscape in this area is flat and gently rolling with a mosaic of diverse community types. Overall, the team found very little disturbance of the site; only some fencing was noted. Invasive species were found in only isolated pockets of a single community, Forest A. The team reported many signs of wildlife, including carcasses, and deer and deer tracks, and droppings. Wildlife observed included Frogs and toads, ground-nesting birds, migratory waterfowl, raptors, small mammals, songbirds and salamanders.

A. Wetland A:

Ecological Integrity Score: 39.8 out of 171 possible

Disturbance Score: 0 out of 100 possible

Two small vernal ponds measuring less than ½ acre are located in the northern portion of the site within the forest. Standing water was observed by the team but the source of water was not apparent. The area appears to occasionally flood as evidenced by bare muddy ground. Where soil was exposed from a tree tip-up or animal digging, the team observed smooth mucky soils. The vegetation structure is characterized as distinct areas of open-water and forest. Native trees are dominant, including red maple, swamp white oak and cottonwood. Native grasses such as sedges and native forbs such as lady fern are common. No invasive species or signs of human disturbance were observed.

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Wetland B:

Ecological Integrity Score: 71 out of 171 possible

Disturbance Score: 14 out of 100 possible

This wetland is fed by groundwater and occupies a large portion of the site, measuring approximately 31 acres. Standing water was observed by the team. The vegetation structure can be characterized as distinct areas of emergent marsh, wet meadow, forbs and dense tall shrub. Inland Wet Prairie occupied this part of the site prior to settlement and appears to remain relatively intact here. Soils here also are smooth muck. Native grasses, such as tussock sedge, bulrushes, and other sedges, and forbs, such as cinnamon ferns, Joe-pye weed, and skullcaps, are dominant. Native emergent plants, such as buttonbush, are common. Native shrubs, such as shrubby cinquefoil, gray dogwood, red-osier dogwood, and poison sumac, also are common. A few elm trees were observed as well. Invasive species glossy buckthorn and reed canary-grass occur in isolated pockets in small numbers, but left unchecked they will increase rapidly. No signs of human disturbance were observed.

Wetland C:

Ecological Integrity Score: 56 out of 171 possible

Disturbance Score: 0 out of 100 possible

This buttonbush swamp is ringed with silver maple within Forest A at the southern end of the site, and measures approximately 2.5 acres. The source of water was not apparent but the team did observe standing water in the wetland as well as bare muddy ground. The soil here was smooth muck as in the other wetlands. Vegetation is clumped in distinct patches of open-water, emergent marsh, dense tall shrub and forest. Native emergent plants, such as buttonbush, and native trees, such as silver maple, swamp white oak and ash, are dominant. Native grasses and sedges and native forbs are common. Neither invasive species nor human disturbance was observed.

Forested Swamp Overview:

A swamp is any wetland dominated by woody plants. Swamps are characterized by saturated soils during the growing season, and standing water during certain times of the year. The highly organic soils of swamps form a thick, black, nutrient-rich environment for the growth of water-tolerant trees. Some swamps are dominated by shrubs, such as Buttonbush or Smooth Alder. Many plants, birds, fish, and invertebrates require the habitats provided by swamps. Many rare species depend on these ecosystems as well.

Functions & Values of Forested Swamps:

Swamps serve vital roles in flood protection and nutrient removal. Floodplain forests are especially high in productivity and species diversity because of the rich deposits of alluvial soil from floods. Many upland creatures depend on the abundance of food found in the lowland swamps, and valuable timber can be sustainably harvested to provide building materials for people.

HRWC Bioreserve Site Assessment #Webster517Davis

Status of Forested Swamps:

Due to the nutrient-rich soils present in swamps, many of these fertile woodlands have been drained and cleared for agriculture and other development. Over 70% of the Nation's floodplain forested swamps have been lost. Historically, swamps have been portrayed as frightening no-man's-lands. This perception led to the vast devastation of immense tracts of swampland over the past 200 years.

Source: U. S. Environmental Protection Agency

Functional Values of Wetlands

Smaller wetlands isolated from lakes and streams can serve as many ecological functions as larger wetlands.

Water quality protection

Acting as living filters, wetlands filter pollutants from rain water and snow melt that flows off of developed areas and farm fields. Wetland plants remove phosphorus and nitrogen from the water. Wetlands also adsorb bacteria, toxic metals, pesticides, and grease.

Protection from shoreline/streambank erosion

Wetland plant roots stabilize soil and help prevent soil erosion. Vegetation dampens wave action along lakes and moderates the current of rivers.

Wildlife and plant habitat

Over half of Michigan's wildlife depends upon wetlands for food, shelter, or nesting habitat, including endangered and threatened species like the bald eagle, osprey, loon and sandhill crane. Wetlands support some of the most diverse plant communities of all ecosystems. Nearly all fish species and amphibians require wetlands for food and shelter, and they are the preferred habitat of muskrat, otter, beaver, mink and raccoon.

Aesthetics and recreation

Wetlands provide recreation such as hiking, birdwatching, nature photography, canoeing, hunting, fishing, and trapping, and generate revenues to the local community through these activities. Wetlands greatly enhance the value of neighboring properties.

Flood and stormwater control

Wetlands hold rainwater and snow melt during wet times, decreasing flooding. They release the water gradually in dry times, thus helping streams maintain steady flows.

Groundwater recharge

Just as wetlands can hold water in wet times, they become sources of water during dry periods. They can serve as recharge areas to local aquifers, keeping our groundwater supply constant.

Source: Huron River Watershed Council, Ann Arbor, MI, 2002

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B. Forest A:

Ecological Integrity Score: 90.5 out of 144 possible

Disturbance Score: 42 out of 154 possible

The forest occupies approximately 30 acres of the site and runs the length of the site from north to south. Its general structure includes a mix of tree sizes, standing dead trees, fallen trees and branches, and tree tip-up mounds. Evidence of wetland conditions is indicated by bare, muddy areas. Where soils were exposed by animal burrows and fallen trees, the team observed light tan or brown soils.

Tree species observed include: ash, basswood, black cherry, red maple, silver maple, sugar maple, swamp white oak, white oak, red oak, and black oak of all sizes. On the ground, the team observed native grasses and sedges, trillium, wild ginger, poison ivy and witch-hazel. The team also found invasive species such as autumn olive, common and glossy buckthorn, garlic mustard, and Oriental bittersweet, growing along the forest edge and trails, within the forest interior and in isolated pockets. The team found signs of mild human disturbance to the site in the form of ATV/off-road vehicle trails and fences.

Forest Overview:

A healthy forest is a complex, interdependent community of plants, animals and soil. Each layer of the forest provides diverse habitats and helps to protect clean water. The canopy is the forest's top layer. It shades and protects animals and plants below, while also intercepting and slowing rainfall. Beneath the canopy is the understory, a second layer made up of smaller trees and shrubs. As older trees die and leave gaps in the canopy, younger trees grow to replace them. The next layer, the forest floor, is populated by vines, grasses, mosses, worms, insects, fungi, bacteria and other small plants and animals. They continually decompose leaves, wood and other organic material that falls to the forest floor so that it may be reused by larger plants. This layer is also a storehouse of nutrients. The litter on the forest floor protects the soil, the bottom layer of the forest. Healthy forests often contain more living biomass in the soil below ground than on the surface.

Values & Functions:

Forests protect clean water:

Similar to wetlands, forests act as giant sponges that absorb and slowly release pollutants like nutrients and sediment from stormwater runoff. Forests store, clean and slowly release about two-thirds of the water that maintains stream flow and replenishes groundwater. Riparian forests that buffer streams significantly reduce the amount of excess nitrogen and phosphorus that enters a water body, sometimes by as much as 30 to 90 percent. Forests protect and filter drinking water for people. Mature trees provide deep root systems that hold soil in place, helping to stabilize stream banks and reduce erosion.

Forests provide habitat for wildlife:

Healthy forests provide food, shelter, nesting sites and safe migration paths for critters in the water and on the land. Riparian forests shade the water beneath their canopies, maintaining

HRWC Bioreserve Site Assessment #Webster517Davis

cooler water temperatures in summer, an important factor for spawning fish. Decaying l and wood on the forest floor are also essential links in the food web.

Forests clean the air:

Forests absorb and trap nitrogen, particulates and other pollutants released into the atmosphere by cars, industries, agriculture and construction. Forests retain more than 8 percent of the nitrogen deposited on them from the air. Trees also produce the oxygen i breathe.

Source: Chesapeake Bay Program

VII. Species List:

Wetland A:

Grasses/Sedges

Bulrush
Sedges spp.
Grass spp.1
Grass spp. 2

Forbs

Hedge nettle
Lady fern
Joe-pye weed
Mad dog skullcap
Sensitive fern

Trees

Red maple
Cottonwood
Swamp white oak

Wetland B:

Grasses/Sedges

Tussock sedge
Sedges uncertain
Bulrush

Forbs

Joe-pye weed
Cinquefoil, shrubby
Skullcaps
Cinnamon fern
Tall goldenrod
Common milkweed
Sensitive fern
Mint spp.
Nettle spp.
Roneset
Marsh bellflower
Narrow-leaved mountain mint
Water smart weed
Goldenrod

Nettle spp.2
Aster spp. 2
Thistle spp.
Swamp milkweed
Valerian spp.
Jewelweed
Curly dock
Deadly nightshade
Whorled loosestrife
Marsh skullcap

Trees

Elm
Black willow

Shrubs/Vines

Buttonbush
Grey dogwood
Red-osier dogwood
Poison sumac

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Shrubby willow
Grape
Currant

Wetland C:Grasses/Sedges

Sedges (3 spp.)
Grass spp.

Forbs

Lady fern spp.
Nettle spp.
Sensitive fern
Wild ginger
Northern bugleweed
Self heal
Bedstraw
Iris
Violet

Forest:Grasses/Sedges

Forest sedges spp.2
Bottlebrush grass
Smooth brome grass
Woodland sedge (Pennsylvania)
Timothy grass

Groundcover

Wild ginger
Witch hazel
Hog peanut
Non-common milkweed
Clear weed
Trillium
May-apple
Heartleaf aster
Indian pipe
Bedstraw spp.
Violet
Jack-in-the-pulpit
Yarrow
Avens
Jumpseed
Ragweed
Small flower agrimone
Common milkweed

Invasives

Buckthorn, glossy
Reed canary-grass
Cat-tail

Trees

Silver maple
American Elm
Swamp white oak
Ash

Shrubs/Vines

Swamp buttonbush

Invasives

Reed canary- grass

Burdock
Wild rose
Aster
Nightshade
Meadow rue
Queen Anne's lace
Daisy fleabane
Purple clover
Self heal
Solomon's seal
Tall goldenrod

Trees

Basswood
Ash
Sugar maple
Silver maple
Black oak
White oak
Black cherry
Red maple
Swamp white oak
White oak
Ironwood
Service berry
Sassafras

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Shagbark hickory
Wild cherry, black
American elm
Red oak
Cedar
Cottonwood
Non-shagbark hickory
Sweet cherry
Slippery elm

Shrubs/Vines

Poison ivy
Rubus
Moonseed

Black raspberry
Virginia creeper
Grey dogwood
Ribes (currant)
Prickly ash

Invasives

Glossy buckthorn
Garlic mustard
Oriental bittersweet
Autumn olive
Common buckthorn
Multi-flora rose

A note about invasive species and their management:

Most properties in southeast Michigan have at least some invasive plant species growing on them. Invasive plants are plants which grow quickly and aggressively, spreading and displacing other plants. Invasives are usually introduced by people either accidentally or intentionally, into a region far from their native habitat. Whether your property is found to be minimally or pervasively covered with invasive species now is the time to understand which species grow there and what management options you have to control and, if possible, eradicate them. The following practical steps for managing invasive plants are from the Pennsylvania Department of Conservation and Natural Resources.

What Can I Do about Invasive Plants?

The best insurance against future problems is to avoid the use of known invasive plants and educate others about the problems of invasives. This web site lists many of the plants that are invasive in Pennsylvania. Plants on this list should be avoided because they can escape cultivation and aggressively move into surrounding ecosystems. One way to avoid invasives is to choose plants that are native to your area. Natives often are adapted to a specific environmental niche, and have natural controls that keep them in balance.

Minimize landscape disturbance. Invasive plants thrive on bare soil and disturbed ground where the native plant community has been displaced. The key to controlling invasives is to protect healthy native plant communities.

Use fertilizers wisely. Proper site preparation begins with a soil test before applying fertilizer. High nitrogen levels sometimes give an advantage to invasive species that are better adapted to using plentiful nutrients for explosive growth. For soil fertility, try using organic, slow-decomposing compost and mulches

Have a land management plan for maintenance over time. It makes sense when designing a property to plan for future maintenance. Lawns are maintained by weekly mowing, while gardens are often hand-weeded. Meadows in Pennsylvania may need to be mowed every year. Woodlands are probably the lowest-maintenance landscape, but they too will need to be monitored and invasive plants removed.

Scout your property annually for invasives or other problems. The best way to control invasives is prevention, and prevention can only happen through vigilance. Listed on this web site are resources to help property owners.

Remove invasives before they are a problem. Effective scouting or monitoring means that problems are found while they are still small and easily controllable. For instance, do not let invasive plants go to seed. Mechanical removal through digging or cutting is preferred. Large

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populations of invasives may need to be stopped chemically with spot applications of herbicide by trained individuals or by homeowners carefully following label instructions.

Replace invasive plants with native or noninvasive species. Invasives are good at exploiting bare soil and empty niches. When you remove an invasive plant, unless there is another plant substituted, the invasive will tend to come right back. What grows in the future depends largely on what is there now; so it is important to fill that niche with a desirable plant that will provide seed for the future.

Remove invasives first when their densities are low. This gives the most immediate success because invasive plant control works best where there is a functioning native plant community still in place which can move right into the empty niche.

- Avoid using known invasive plants
- Minimize landscape disturbance
- Protect healthy native plant communities
- Use fertilizers wisely
- Have a land management plan for maintenance over time
- Scout regularly
- Remove invasive plants when they are present in low numbers or when they are confined to a small area before they become a problem
- Dispose of removed invasive plants wisely
- Replace invasive plants with native or noninvasive species
- Clean equipment that has been used in an area having invasive plants

Disclaimer: The Rapid Ecological Assessment (Assessment) provides on-the-ground field assessment of a natural area. The Assessment provides detailed information about the ecological quality of a site for the purposes of the HRWC Bioreserve Project and is conducted by a team of trained volunteers. The Assessment is not a professional ecological inventory and should not be interpreted as a scientifically complete ecological inventory or plant list.

Appendix C: How Relational Database Management Systems Work

A relational database management system (RDBMS) is a type of software that manages relational databases, which are characterized by storing data in multiple, separate tables that can be joined together using a shared attribute. Take the following example, in which field observations of species are recorded. This example is very similar to the way that NAAP field assessment data is stored in Microsoft Access, but is simplified for explanation purposes. Observations might be entered into the “Species” table while site information might be stored in the “Site” table (Figure C.1). Looking at each of these tables individually only yields some information, so it is often useful to combine information across multiple tables—this is exactly what relational databases do.

Site Table

Site ID	Site Name	Landowner
1	Miller Marsh	Johnson
2	Miller Marsh	Williams
3	Brauer Wetland	Adams

Species Table

Site ID	Date	Species Count
1	8/1/2020	12
1	7/3/2020	4
2	4/18/2020	7
2	6/4/2020	18
3	5/12/2020	6
3	6/12/2020	14
3	7/17/2020	11

Joined Tables

Site ID	Date	Species Count	Site Name	Landowner
1	8/1/2020	12	Miller Marsh	Johnson
1	7/3/2020	4	Miller Marsh	Johnson
2	4/18/2020	7	Miller Marsh	Williams
2	6/4/2020	18	Miller Marsh	Williams
3	5/12/2020	6	Brauer Wetland	Adams
3	6/12/2020	14	Brauer Wetland	Adams
3	7/17/2020	11	Brauer Wetland	Adams

Figure C.1: Example of relational database storage showing how data can be stored in separate tables (Species Table, top left, and Site Table, bottom left) vs stored in a single, combined table (Joined Tables, right). Relational Database Management Systems store the relationship between individual tables so that data can be retrieved when needed.

By using the “Site ID” field in this example, information from the “Site” table (join table) can be joined to the corresponding rows in the Species table (target table). RDBMS store relationships between tables in this way so that the data can be retrieved when needed, but the tables are still stored separately from one another. This form of storing data is optimal for data entry and editing (since information about the site name and landowner only needs to be added/edited in one place) and is also more efficient for storage (the combined 30 cells of the Species and Site tables in this example are still less than the 35 cells of the joined table). This ability, combined with programming language or loops of code that can be re-run, make RDBMS incredibly powerful tools and contributes to their widespread popularity for storing data and managing data.

Appendix D: Using the New NAAP System for Data Analysis

In addition to its strengths as a data collection and data visualization platform, ArcGIS Pro also excels when it comes to data analysis. ArcGIS Pro's broad palette of geoprocessing tools can be applied to answer a wide range of questions, adding value and new insights to the field assessment dataset. For example, tools in ArcGIS Pro can be applied to show how features are distributed or aggregated across an area, how one location's values compare with nearby or distant locations, or how a geospatial layer (such as the rapid field assessment feature layer) compares with the attributes or geometry from overlapping layers. The knowledge of how to leverage and apply these tools unlocks the full potential of ArcGIS Pro and the new data workflow that we developed.

In this appendix, we provide examples to highlight some of the analytical capabilities of ArcGIS Pro and also demonstrate possible approaches to answering questions that we lacked the time/data/process to directly address in our project. We have grouped these data analysis examples into 4 categories on the basis of the type of question they seek to answer:

1. Analyzing the distribution of features using Attribute Queries
2. Calculating summary statistics using Summarize Within tool
3. Comparing & combining data with overlapping GIS layers
4. Using the geodatabase with R to answer analytical questions

The first three categories relate to questions that can be answered in ArcGIS Pro: questions on the distribution, summary statistics, and spatial overlap of features. The final category concerns statistical questions best answered in R/GeoDa. This can serve as a guide for HRWC staff, interns, or another SEAS Masters Project, so that more involved data analysis can pick up where we left off.

Analyzing the Distribution of Features Using Attribute Queries

The **Select by Location** and **Select by Attribute** queries in ArcGIS Pro make it easy to manage, manipulate, and subset a dataset. These queries are often the first step to more complex data analysis questions and are particularly useful for questions about the number or distribution of certain features. For example, these tools could be used in this dataset to find the distribution of a particular plant species or vernal pools among surveyed sites. These queries can also be used in tandem with one another to create even more specific subsets of the data. For example, surveyed sites that have vernal pools and are located within a specific township. Newly selected data can be saved as a new layer or used as the input for other geoprocessing tools. Below is a step-by-step process for using the Select by Attribute / Location queries alone or together.

1. Open the Attribute Tables for the Layers You Want to Select Features From

If you want to also select features from a related table (e.g., the species list table), make sure the table and layer are first related to one another and "Automatically select related data" is turned on in the selection properties for each.

2. **Click *Select by Attribute* and Add a New Query Expression**

You can make a new selection, or subset/add/remove items from the current selection. If you are selecting a text field, you can search for a text string that exactly matches or a smaller string contained within that field.

3. **Click *Select by Location* from the Map Tab, choose your Input and Selection Layers, and Add a New Query Expression**

The input layer will be selected based on its spatial relationship to the selection layer. There are a wide range of spatial relationships to choose from, including intersect, contains, has center in, or is within a set distance. Again, you can choose to make this a new selection or add to the currently selected features. Using this tool, you could select all polygons within a particular Bioreserve area, creek shed, or township.

4. **Calculate a Field / Export the data to a New Layer /**

From here, you can manage and manipulate the data in a variety of ways. For example, you can calculate/populate attributes for the selected fields (without modifying values in the unselected records) or export the selected polygons to a new layer.

Huron River Watershed Vernal Pools (April 2021)

Locations of vernal pools identified from several sources

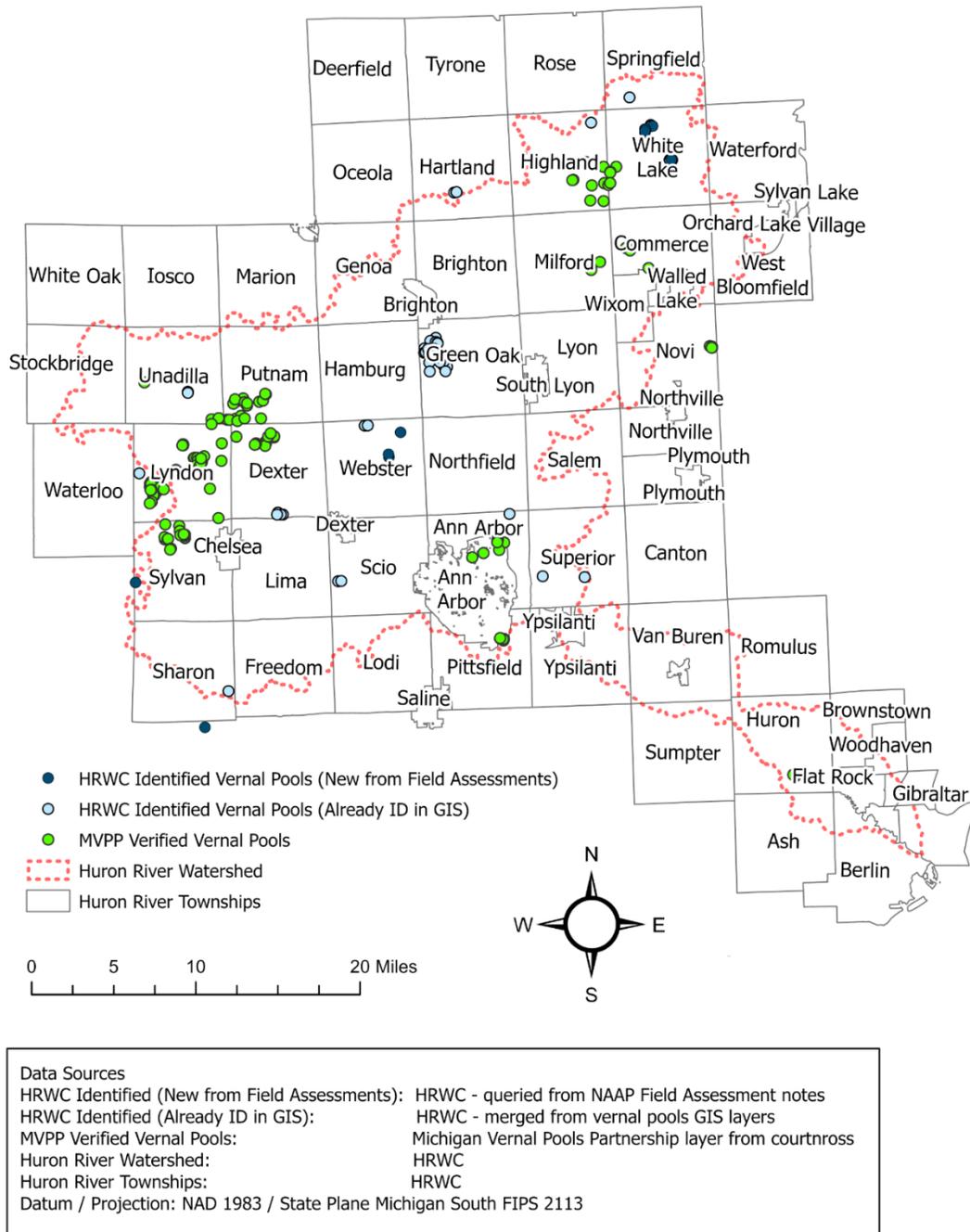


Figure D.1: Map of identified and potential vernal pools in the Huron River Watershed including pools verified by the Michigan Vernal Pools Partnership (green), pools marked in HRWC’s existing GIS dataset (light blue), and pools queried from HRWC’s rapid field assessment data (dark blue).

Calculating summary statistics using Summarize Within tool

The Summarize Within and Summary Statistics tools in ArcGIS Pro offer powerful ways to generate summary statistics and explore geographical relationships within a dataset. For example, counting the number of field assessments conducted in a particular township/creek shed or finding the mean ecological integrity score for several field assessments conducted on each bioserve site. In ArcGIS Pro (or ArcMap), the simplest way to answer these kinds of questions are by using the **Summarize Within** or **Summary Statistics** geoprocessing tools. Below is a step-by-step process for the Summarize Within tool that can be tweaked to fit similar questions.

*[Step 1 **Optional** — only necessary if you want a count of features instead of area]*

- 1. Run the **Feature to Point** Tool to Convert the Polygon Layer of Assessed Ecosystems into a Point Layer**

This tool produces a new output layer and the type (point/polygon) matters for the following step with the Summarize Within tool. If summarizing polygons, a sum of the area will be added to the output. If summarizing points, a sum of the number of points will be added to the output. In both cases, mean/min/max/standard deviation/range statistics can be added to the output.

- 2. Run the **Summarize Within** Tool Using the Field Assessment Layer as the Summary Layer and Some Larger Polygon Layer (e.g., Townships or Creek sheds) as the Summarize Within Layer**

Select summary fields (mean/min/max/standard deviation) and “group by” fields (calculate statistics separately for each unique attribute) as desired. If summarizing polygons, the “sum” statistic will add the sum of the polygon area to the output. If summarizing points, the “sum” statistic will add the total number of points to the output.

*[Steps 3-4 **Optional** — only necessary if you want to join the statistics back to another polygon layer]*

- 3. Join the Newly Created Layer from Step 2 to the Original Polygon Layer Using the Unique “FullName” Attribute as the Join key and Export it Afterwards to a New Layer**

The FullName key is a combination of the site name and the ecosystem name and should uniquely identify each ecosystem polygon in the dataset. Exporting to a new layer will make the join permanent.

- 4. Remove All Duplicate Fields from the Output and Delete All Intermediate Layers**

Duplicate fields and intermediate layers may cause confusion later, so it is best to remove them. Duplicate fields are created from the join process (because both tables contain some of the same attributes) and intermediate layers (anything that is not the final output) are created from running the tools in Step 1 and Step 2. Be sure to differentiate the final layer from the original layer using naming mechanisms or geodatabases designated for temporary/final outputs.

Statistics can be viewed for any numerical field in the attribute table by right-clicking the field and selecting *'Statistics'*. These statistics can also be filtered by selection, enabling quick comparisons between different subsets of the data. For example, comparing the forest integrity score of Dexter township with the entire dataset (Figure D.3). The Summary Statistics geoprocessing tool works very similarly, but can summarize several fields simultaneously and generate statistics grouped by values in another field (for example, finding the mean forest integrity score by Bioreserve area or township). These tools can be used to answer most kinds of statistical questions involving numerical variables, but there are more statistical capabilities built into ArcGIS Pro — for more information, refer to this [overview of the Statistics toolset](https://pro.arcgis.com/en/pro-app/latest/tool-reference/analysis/an-overview-of-the-statistics-toolset.htm) (URL: <https://pro.arcgis.com/en/pro-app/latest/tool-reference/analysis/an-overview-of-the-statistics-toolset.htm>).

NAAP Rapid Field Assessments (April 2021)

Summarized Acreage by Creekshed & Township

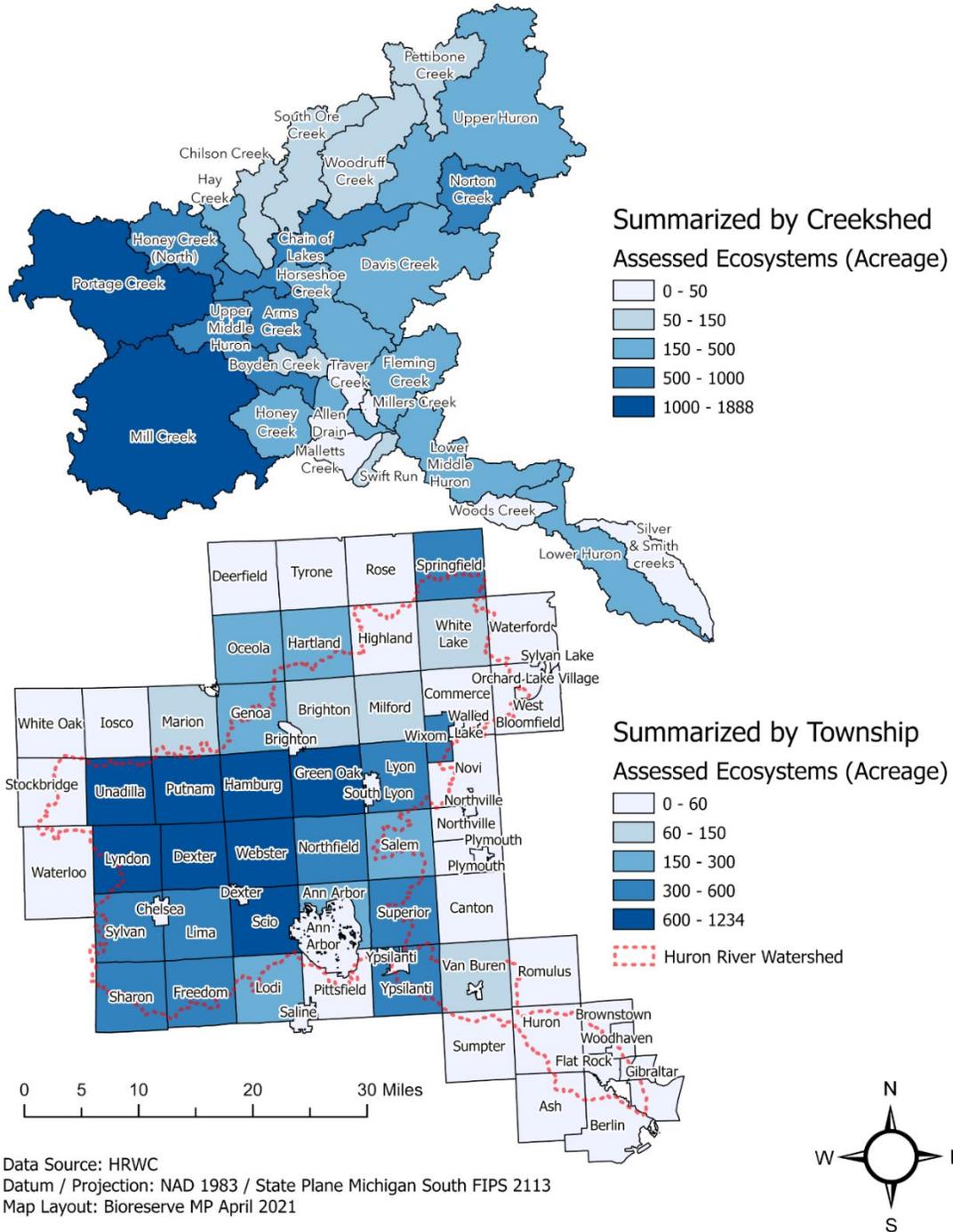


Figure D.2: Map of NAAP field assessed ecosystems, summarized by total acreage at the creek shed (above) and township (below) levels with the Summarize Within geoprocessing tool.

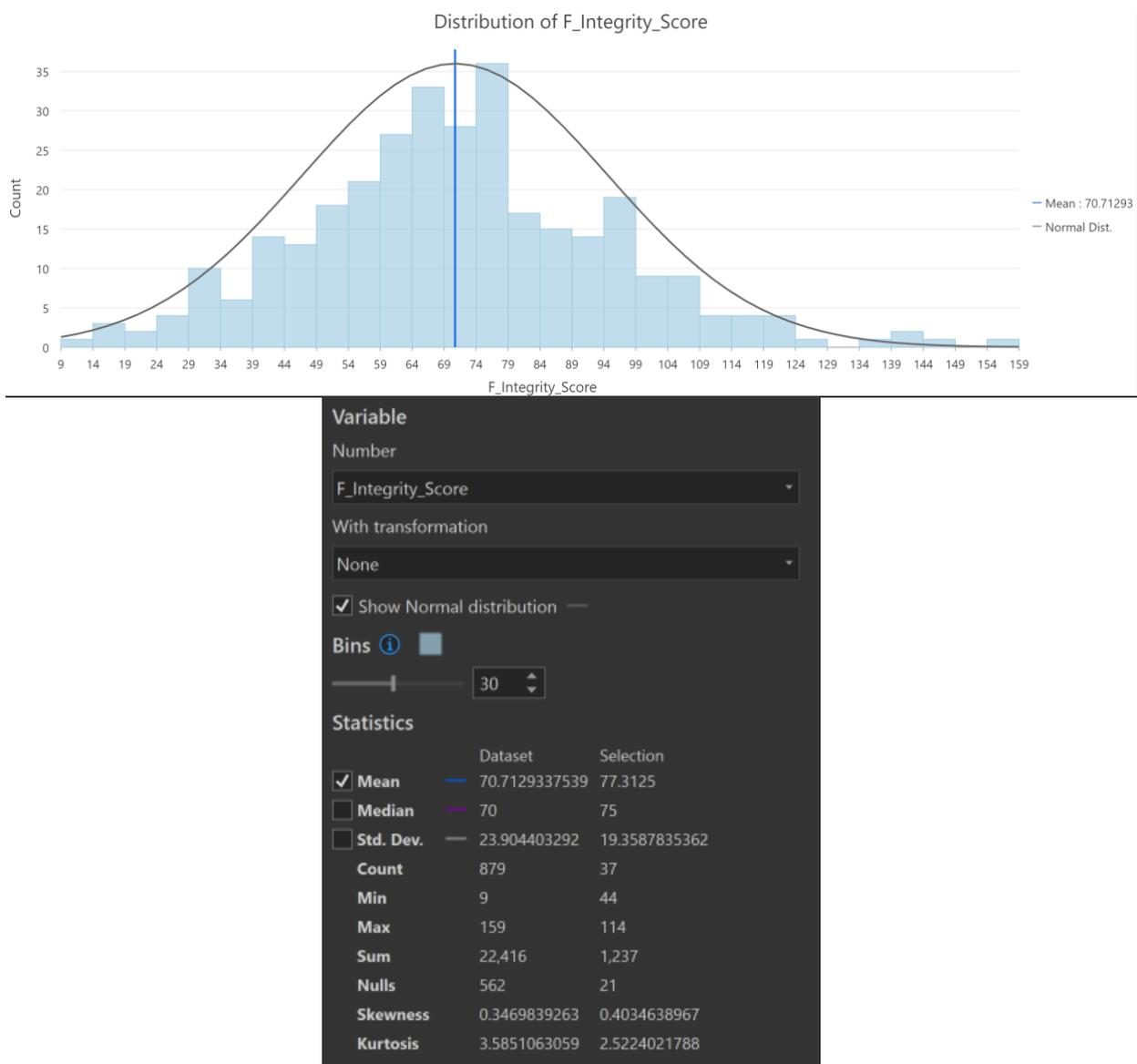


Figure D.3: Viewing statistics for the forest integrity score in the attribute table in both chart and panel form. Selection is for all sites within Dexter township.

Comparing & Combining Data with Overlapping GIS Layers

Another powerful advantage to storing data in a file geodatabase is that it can be compared or combined with data from other spatial layers. For example, the USA Soils Map Units feature layer (derived from the SSURGO dataset) could be imported into an NAAP map along with other layers that are being analyzed. This soils layer could then be manipulated and even combined with some of the other layers to form a single layer containing certain NAAP *and* soil data. The process of comparing and combining these layers can be completed through various tools, including the **Overlay Layers** and **Merge Layers** functions. Below is a step-by-step process performed in ArcGIS Online for using the **Overlay Layers** tool that can be manipulated to fit various merging tasks.

- 1. Import the USA Soils Map Units Feature Layer from the *Living Atlas Layer* Under the Add Data Option**

The Living Atlas option allows users to import publicly available layers into their web maps and perform analysis. In this case, we are interested in soil data that overlaps with our NAAP field assessment layer polygons.

- 2. Run the *Overlay Layers* tool in the Analysis Tab to Combine Multiple Layers into One Single Layer**

This tool produces a new output layer based on the chosen input layers. This tool is explained as “looking through a stack of maps and combining all the information from these maps into one map” ([ArcGIS Pro](#)). The options to overlay include intersect, union, and erase. If this workflow is to be completed in ArcGIS Pro, the user will find these tool names to perform the “overlay layers” function. This tool is particularly useful when spatial relationships are important to the analysis, otherwise the “merge layers” tool can be an alternative.

- 3. Select the NAAP Field Assessments Layer as the Input Layer, the USA Soil Map Units Layer as the Overlay Layer, and *Intersect* as the Overlay Method**

The intersect method will produce a new layer that only contains information from the input and overlay layers where they intersect geospatially. Information from both layers will be included in the output layer and dataset. The intersect method allows for users to specify if the output layer is to be in areas, points, or lines. In this case, we will keep the default of “areas” as both the layers to be combined are polygon features.

- 4. Give a New Name to the Resulting Layer and Decide Target Area**

The overlay layers tool can be used to overlay entire layers or just within a specified extent. We decided to focus on one specific area of the NAAP field assessment layer to save on credit usage. An alternative to consider is to use these combining tools in ArcGIS Pro, although some additional steps will be needed. We advise referring to the documentation on the ArcGIS website to better understand these overlay/combining tools.

- 5. Edit the Output Layer’s Pop-up Information, Symbology, and Other Visual Help**

As with any new layer added to a map, there will be a default placed on the visibility and general user interface. We recommend cutting down on any unnecessary data (the USA Soil Map Units layer is a rather large data set) that may be included in this new output layer. This can include deleting fields, deleting features, or simply managing the pop up and symbology of the layer. Customize to fit the map however necessary.

NAAP Field Assessment Soil Map (April 2021)

Overlay of NRCS Soils and Field Assessments

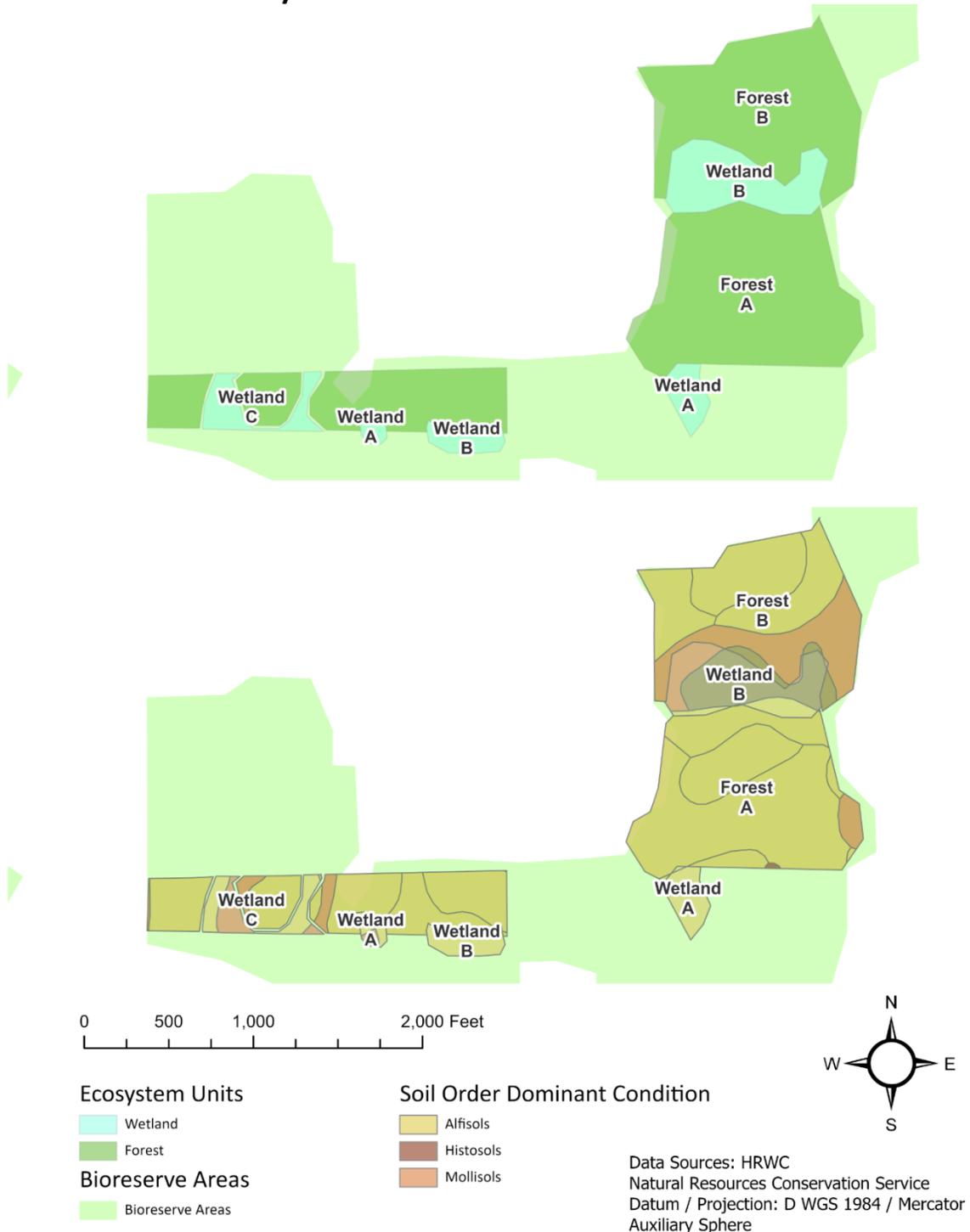


Figure D.4: Map of intersected overlay between NAAP ecosystems polygons and NRCS soil polygons (bottom) in relation to the ecosystems and Bioreserve area boundaries (above).

Using the Geodatabase with R to Answer Analytical Questions

For more detailed statistical analyses or multivariate analyses, we recommend exporting the layer's attribute table to a CSV file and then importing it into R. In R, as is the case with using any data table in R, it may be necessary to modify or remove some fields from the CSV file prior to any statistical analyses for best results. The R software environment offers many powerful statistical capabilities and can quickly process large datasets, making it ideal for gleaning trends about the dataset as a whole. Specifically, multivariate analysis methods such as principal components analysis and cluster analysis could be useful for analyzing statistical trends across the entire dataset. Here are some research questions that could be answered with R:

Comparison between scoring metrics

1. To what extent can the GIS (Bioreserve Map) score be used to predict the field assessment score? (based on preliminary attempts to answer this, it appears that the ability to predict one score with the other is very limited)
2. How do field assessment, bioreserve, and FQI, and Nature Serve scores differ for the same site?

Comparison between non-scoring variables in dataset

3. How much does the score depend on the season or year assessed?
4. How do the scores obtained from trained volunteers differ from expert assessment of the same sites? Does score correlate with certain volunteers being part of the assessment?
5. Are there any highly correlated variables that could be eliminated to reduce redundancy and make training volunteers and collecting data more efficient?

Comparison with other GIS data

6. Are high scoring areas correlated with other patterns on the landscape such as land use history, historical ecosystem types, creek shed, jurisdiction, or water quality?
7. Is the ecological integrity score a good predictor of water quality (based on water chemistry or macroinvertebrate data)?
8. Which measures are most related to water quality, based on spatial correlation with HRWC stream quality scores?

Appendix E: Interview and Survey Materials

Pre-Survey Interview Guide

Outline

Section 1: Intro

- 1 Personal intros
- 2 Overview of the master's project
- 3 Purpose of the interview
- 4 Who is part of the interview, how long it will take, etc.
- 5 If they have questions
- 6 Their background/position

Section 2: Overview of the program

- 1 Just to make sure we are on the same page....
- 2 Bioreserve Map, field assessment
- 3 Interview outline

Section 3: Bioreserve Map

- 1 What do you know about it?
- 2 Do you use it? How? Toward what goals?
- 3 How did you access it? How accessible is it for you?
- 4 What facilitates your use of the Bioreserve Map? Is it easy to use?
- 5 Are there any barriers to using it? If so, what are they?
- 6 Are there any changes you would like to see in the Map's data or the way you access it?

Section 4: Field Assessments

- 1 What do you know about field assessments?
- 2 Do you use it? How? Toward what goals?
- 3 How did you access field assessment data? How accessible is it for you?
- 4 What facilitates your use of field assessment data? Is it easy to use?
- 5 Are there any barriers to using it? If so, what are they?
- 6 Are there any changes you would like to see in the field assessment data or the way you access it?

Section 5: Overall impressions

- 1 Does NAAP effectively assess NA
- 2 Does NAAP effectively protect NA
- 3 Ideas for survey? Did we miss anything? Other sources to talk to?

Thank you!

Post-Survey Stakeholder Interview Guide

Part 1: Field Assessments

Field assessments are carried out by teams of HRWC volunteers that visit properties to look for indicators of ecological integrity and record their findings. Afterwards, these findings are compiled into a field assessment report that is sent to the owner of the property. Field assessment reports include a

Bioreserve Map score for the entire property as well as Ecological Integrity and Disturbance Scores for each individual natural area assessed on the property.

Do you have any suggestions for how the process of setting up the field assessments and communicating with HRWC could be improved?

If you feel that something important was missing from field assessment reports, please specify what you think was missing including explanations or examples:

Do you have any additional suggestions for how to make the field assessment reports easier to interpret and understand, more useful, or more accurate?

Part 2: The Bioreserve Map

The Bioreserve Map ranks natural areas in the watershed based on their priority for protection. This ranking is derived from Bioreserve Map scores, which are based on features such as aerial photos, geology, and historical vegetation. Bioreserve Map scores are different from field assessment scores, but are important because they provide additional insight into the ecological value of natural areas. One version of the Bioreserve Map is a GIS map with multiple layers that show the location and Bioreserve Map score of all natural areas within the watershed. It consists of shapefiles that can only be viewed and manipulated with GIS software. There is also another version of the Bioreserve Map, which is a static PDF that does not need to be viewed with GIS software. The PDF version also outlines the location and priority status of all natural areas within the watershed. Bioreserve Map scores listed and explained in section II of field assessment reports.

Do you have any suggestions for improving access to Bioreserve Map data?

Would you like to share an example of how you have used the Bioreserve Map in the past?

Overall:

Please share any examples you may have about HRWC's impact on increasing the amount of protected natural areas.

Do you have any additional comments or suggestions about the HRWC Natural Areas Assessment Program as a whole - the resources provided or the assessment processes?

Survey questions

Landowner Survey

Q1: The Huron River Watershed Council's Natural Areas and Assessment Program (NAAP) aims to map and assess the remaining natural areas in the Huron River watershed of southeastern Michigan, and to prioritize the preservation and management of areas with the highest ecological integrity. We are graduate students from the University of Michigan School for Environment and Sustainability working on a master's project for HRWC to improve the effectiveness, outreach, and impact of NAAP.

You are receiving this survey because you have had a Rapid Ecological Field Assessment completed on one or more of your properties. The first part of this survey will focus on field assessments and the second part will focus on the Bioreserve Map. It may be helpful to refer to your copy of your field assessment report, if you have it.

Your response will directly impact land protection efforts in the area and help improve biodiversity and water quality in the Huron River watershed. Also, when you submit your response to this survey, you will be entered into a raffle to win a \$75 gift card to a local business!

You can turn "Mobile view" off by toggling the Mobile view button in the upper right corner of your browser.

Q2: Field Assessments:

Field assessments are carried out by teams of HRWC volunteers that visit properties to look for indicators of ecological integrity and record their findings. These findings are compiled into a field assessment report that is sent to the owner of the property. Field assessment reports include a Bioreserve Map score for the entire property as well as Ecological Integrity and Disturbance Scores for each individual natural area assessed on the property.

Q3: Setting up a Field Assessment:

Q4: I heard about HRWC's field assessments through:
(Please select all that apply)

- Another landowner
- A letter from HRWC
- An HRWC event
- Previous involvement with HRWC programs (as a field volunteer, educator, etc.)
- Another organization
- Other: (text entry)

Q5: It was easy to set up a field assessment with HRWC.
Strongly disagree-Disagree-Neutral-Agree-Strongly agree (SD-D-N-A-SA)

Q6: (shown if Q5=SD or D)

It was difficult for me to set up a field assessment with HRWC because:
(Please select all that apply)

- It was difficult to find their website
- It was difficult to locate their contact information
- It was difficult to get in touch with someone
- I had to do a lot of searching to find out about HRWC
- They did not respond in a timely manner
- Other: (text entry)

Q7: After the assessment was completed, I received a field assessment report from HRWC.

- Yes
- No

Q8: (shown if Q7=Yes)

I received my field assessment report in a timely manner.

SD-D-N-A-SA

Q9: Optional: Do you have any suggestions for how the process of setting up the field assessments and communicating with HRWC could be improved?

-Text entry

Q10: Field Assessment Content:

Q11: Overall, I understand the ecosystem terminology used in my field assessment report.

SD-D-N-A-SA

Q12: I understood how to interpret the Ecological Integrity Scores provided in my field assessment report.

SD-D-N-A-SA

Q13: I understood how to interpret the Disturbance Scores provided in my field assessment report.

SD-D-N-A-SA

Q14: To the best of my knowledge, the field assessment scores in my report accurately capture the ecological quality of my land and the species present on it.

SD-D-N-A-SA

Q15: I feel that one or more important variables for measuring ecological integrity and disturbance are missing from the field assessment report.

-Yes

-No

Q16: (shown if Q15=Yes)

Please specify what you think was missing including explanations or examples:

-Text entry

Q17: To me, the most valuable sections of the field assessment report were:

(Please select the 3 that were the most valuable)

-Section II: Bioreserve Map and field assessment Scores

-Section III: Scores for the Natural Area

-Section IV: Site Landscape Context

-Section VI: Site Overview

-Section VII: Species List

-The information about invasive species management

-Other: (text entry)

Q18: It would be helpful to me if HRWC field assessment reports also included:

(Please select 3 that you would find the most helpful)

-A glossary of the science terminology used in the report

- A list of organizations to contact to further improve the land once the field assessment is completed
- Details for case-specific next steps to take after the assessment is completed
- A more detailed explanation of what the Ecological Integrity Score and Disturbance Scores are and how they are determined
- A ranking of the Ecological Integrity Score and Disturbance Score on a scale like this: Poor--Fair--Good--Very Good--Excellent.
- An overall ranking of the quality of the natural area on a scale like this: Poor--Fair--Good--Very Good--Excellent
- A way to access field assessment reports independently (for example, by downloading them directly from the HRWC website) when I need to use them
- Other: (text entry)

Q19: Optional: Do you have any additional suggestions for how to make the field assessment reports easier to interpret and understand, more useful, or more accurate?

- Text entry

Q20: Follow-up:

Q21: My goal(s) for having HRWC do a field assessment on my property was:

(Please select all that apply)

- I wanted to get a conservation easement or otherwise explore permanent protection of my property.
- I wanted to improve the ecological quality of my land.
- I was curious about the state of my land and I wanted to find out more.
- HRWC contacted me about having a field assessment done.
- Another organization contacted me about having a field assessment done through HRWC.
- Other: (text entry)

Q22: Having the field assessment done helped me accomplish the following for my property:

(Please select all that apply)

- Get a conservation easement for my property
- Protect my property by means other than a conservation easement
- Improve the ecological quality of my land
- Learn more about the state of my land
- Other: (text entry)

Q23: I feel that my field assessment report gave me a good sense of what to do next with my property after the assessment was completed.

SD-D-N-A-SA

Q24: I would like to receive follow-up contact from HRWC about next steps I can take with my property.

SD-D-N-A-SA

Q25: I have recommended an HRWC field assessment to another landowner.

- Yes
- No

Q26: I plan to recommend an HRWC field assessment to another landowner.

SD-D-N-A-SA

Q27: The Bioreserve Map

The Bioreserve Map ranks natural areas in the entire watershed based on their priority for protection. This ranking is derived from Bioreserve Map scores, which are based on features such as aerial photos, geology, and historical vegetation. *Bioreserve Map scores are different from field assessment scores*, but are important because they provide additional insight into the ecological value of natural areas. One version of the Bioreserve Map is a GIS map with multiple layers that show the location and Bioreserve Map score of all natural areas within the watershed. It consists of shapefiles that can only be viewed and manipulated with GIS software. There is also another version of the Bioreserve Map, which is a static PDF that does not need to be viewed with GIS software. The PDF version also outlines the location and priority status of all natural areas within the watershed. Bioreserve Map scores are listed and explained in section II of field assessment reports.

The rest of this survey will focus on the Bioreserve Map.

Q28: The definition of the Bioreserve Map was clearly explained to me in my field assessment report.

SD-D-N-A-SA

Q29: After reading my field assessment report, I understood how to access either the Bioreserve Map shapefiles or the Bioreserve Map PDF.

SD-D-N-A-SA

Q30: I have seen or used the Bioreserve Map shapefiles.

-Yes

-No

Q31: (shown if Q30=Yes)

The Bioreserve Map shapefiles are easy to navigate and understand.

SD-D-N-A-SA

Q32: I have seen or used the Bioreserve Map PDF.

-Yes

-No

Q33: (shown if Q32=Yes)

The Bioreserve Map PDF is easy to navigate and understand.

SD-D-N-A-SA

Q34: (shown if Q30=Yes and Q32=No)

I would like to access the Bioreserve Map PDF.

SD-D-N-A-SA

Q35: (shown if Q30=No and Q32=Yes)

I would like to access the Bioreserve Map shapefiles.

SD-D-N-A-SA

Q36: (shown if Q30=No and Q32=No)
I am interested in accessing the Bioreserve Map.

Q37: I understood how to interpret the Bioreserve Map Score provided in my field assessment report.
SD-D-N-A-SA

Q38: Optional: Do you have any additional comments or suggestions about the HRWC Natural Areas Assessment Program as a whole - the resources provided or the assessment processes?
-Text entry

Q39: May we contact you with additional follow-up questions?
-Yes
-No

Q40: Please enter the email address you would like us to use to follow up with you: (text entry)

Stakeholder Survey

Q1: The Huron River Watershed Council's Natural Areas and Assessment Program (NAAP) aims to map and assess the remaining natural areas in the Huron River watershed of southeast Michigan, and to prioritize the preservation and management of areas with the highest ecological integrity. We are graduate students from the University of Michigan School for Environment and Sustainability working on a master's project for HRWC to improve the effectiveness, outreach, and impact of NAAP.

You are receiving this survey because you have had a Rapid Ecological Field Assessment completed on one or more of your properties. The first part of this survey will focus on field assessments and the second part will focus on the Bioreserve Map. It may be helpful to refer to your copy of your field assessment report, if you have it.

Your response will directly impact land protection efforts in the area and help improve biodiversity and water quality in the Huron River watershed. Also, when you submit your response to this survey, you will be entered into a raffle to win a \$75 gift card to a local business!

You can turn "Mobile view" off by toggling the Mobile view button in the upper right corner of your browser.

Q2: Field Assessments

Field assessments are carried out by teams of HRWC volunteers that visit properties to look for indicators of ecological integrity and record their findings. Afterwards, these findings are compiled into a field assessment report that is sent to the owner of the property. Field assessment reports include a Bioreserve Map score for the entire property as well as Ecological Integrity and Disturbance Scores for each individual natural area assessed on the property.

Access to Field Assessments:

Q3: I heard about HRWC through:

(Please select all that apply)

- A long standing partnership between my organization and HRWC
- A letter from HRWC
- An HRWC event
- Previous involvement with HRWC programs (as a field volunteer, educator, etc.)
- Another organization
- Other: (text entry)

Q4: When I need to view a field assessment report, I am able to gain access to it in a timely manner.

SD-D-N-A-SA

Q5: I have scheduled field assessments through HRWC.

- Yes
- No

Q6: (shown if Q5=Yes)

It is easy to set up field assessments with HRWC.

SD-D-N-A-SA

Q7: (shown if Q6=SD or D)

It was difficult for me to set up a field assessment with HRWC because:

(Please select all that apply)

- It was difficult to find their website
- It was difficult to locate their contact information
- It was difficult to get in touch with someone
- I had to do a lot of searching to find out about HRWC
- They did not respond in a timely manner
- Other: (text entry)

Q8: (shown if Q5=Yes)

When I schedule a field assessment with HRWC, I always receive a field assessment report.

- Yes
- No

Q9: (shown if Q5=Yes)

When I schedule a field assessment with HRWC, I always receive a field assessment report in a timely manner.

SD-D-N-A-SA

Q10: Overall, I understand the science terminology used in field assessment reports.

SD-D-N-A-SA

Q11: I understand how to interpret the Ecological Integrity Scores provided in field assessment reports.

SD-D-N-A-SA

Q12: I understand how to interpret the Disturbance Scores provided in field assessment reports.

SD-D-N-A-SA

Q13: To the best of my knowledge, field assessment scores accurately capture the ecological quality of the land and the species present on it.

SD-D-N-A-SA

Q14: I felt that one or more important variables for measuring ecological integrity and disturbance were missing from the field assessment report.

-Yes

-No

Q15: (shown if Q14=Yes)

Please specify what you think was missing including explanations or examples: (text entry)

Q16: The most valuable sections of field assessment reports are:

(Please select 3 sections that are the most valuable)

-Section II: Bioreserve Map and Field Assessment Scores

-Section III: Scores for the Natural Area

-Section IV: Site Landscape Context

-Section VI: Site Overview

-Section VII: Species List

-The information about invasive species management

-Other: (text entry)

Q17: It would be helpful to me if HRWC field assessment reports also included:

(please choose the 3 that you would find the most helpful)

-A glossary of the science terminology used in the report

-A list of organizations to contact to further improve land once the field assessment is completed

-Details for property-specific next steps to take after the assessment is completed

-A more detailed explanation of what the Ecological Integrity Score and Disturbance Scores are and how they are determined

-A ranking of the Ecological Integrity Score and Disturbance Score on a scale like this: Poor--Fair-

-Good--Very Good--Excellent.

-An overall ranking of the quality of the natural area on a scale like this: Poor--Fair--Good--Very Good--Excellent

-A way to access field assessment reports independently (for example, by downloading them directly from the HRWC website) when I need to use them

-Other: (text entry)

Q18: Field assessment reports help me determine which natural areas are the most important to protect.

SD-D-N-A-SA

Q19: To the best of my knowledge, HRWC has helped increase the amount of protected natural areas.
SD-D-N-A-SA

Q20: I have recommended an HRWC field assessment to a landowner or another organization.
-Yes
-No

Q21: I plan to recommend an HRWC field assessment to a landowner or another organization.
SD-D-N-A-SA

Q22: The Bioreserve Map

The Bioreserve Map ranks natural areas in the watershed based on their priority for protection. This ranking is derived from Bioreserve Map scores, which are based on features such as aerial photos, geology, and historical vegetation. Bioreserve Map scores are different from field assessment scores, but are important because they provide additional insight into the ecological value of natural areas. One version of the Bioreserve Map is a GIS map with multiple layers that show the location and Bioreserve Map score of all natural areas within the watershed. It consists of shapefiles that can only be viewed and manipulated with GIS software. There is also another version of the Bioreserve Map, which is a static PDF that does not need to be viewed with GIS software. The PDF version also outlines the location and priority status of all natural areas within the watershed. Bioreserve Map scores listed and explained in section II of field assessment reports.

The rest of this survey will focus on the Bioreserve Map.

Q23: The definition of the Bioreserve Map was clearly explained to me in my field assessment report.
SD-D-N-A-SA

Q24: I primarily use:
-the Bioreserve Map shapefiles
-the Bioreserve Map PDF
-Both
-Neither, I have not accessed the Bioreserve Map before

Q25: (shown if Q24≠Neither, I have not accessed the Bioreserve Map before)

I use the Bioreserve Map:

(Please select all that apply)

- To prioritize land for protection
- To visualize where sites of interest are in relation to each other
- To persuade committee members to acquire a certain site
- To understand how site scores compare to each other
- As a base that I modify to better suit my specific needs
- Other: (text entry)

Q26: (shown if Q24=the Bioreserve Map shapefiles or Both)

I am able to access the Bioreserve Map shapefiles quickly and independently when I need to use it:

SD-D-N-A-SA

Q27: (shown if Q24=the Bioreserve Map shapefiles or Both)
The Bioreserve Map shapefiles are easy to navigate and understand.
SD-D-N-A-SA

Q28: (shown if Q24=the Bioreserve Map PDF or Both)
I am able to access the Bioreserve Map PDF quickly and independently when I need to use it:

Q29: (shown if Q24=the Bioreserve Map PDF or Both)
The Bioreserve Map PDF is easy to navigate and understand.
SD-D-N-A-SA

Q30: (Q24=the Bioreserve Map shapefiles or Neither, I have not accessed the Bioreserve Map before)
I am interested in accessing the Bioreserve Map PDF.
SD-D-N-A-SA

Q31: (Q24=the Bioreserve Map PDF or Neither, I have not accessed the Bioreserve Map before)
I am interested in accessing the Bioreserve Map shapefiles.
SD-D-N-A-SA

Q32: I would prefer to access the Bioreserve Map PDF and/or shapefiles (please choose 2 options that you would prefer the most):

- By downloading them directly from the HRWC website
- Through an interactive web map
- By receiving instructions for accessing them in a field assessment report
- By receiving an email from HRWC containing links to the Bioreserve Map
- Other: (text entry)

Q33: I understand how to interpret the Bioreserve Map Score provided in field assessment reports.
SD-D-N-A-SA

Q34: To the best of my knowledge, the Bioreserve Map scores accurately convey the ecological integrity of the site being assessed.
SD-D-U-A-SA

Q35: The best times for me to have a brief 20–30-minute follow-up conversation about my responses in this survey are:
(Please select all that apply)

- list of dates & times

Volunteer Survey

Q1: The Huron River Watershed Council's Natural Areas and Assessment Program (NAAP) aims to map and assess the remaining natural areas in the Huron River watershed of southeast Michigan, and to prioritize the preservation and management of areas with the highest ecological integrity. We are

graduate students from the University of Michigan School for Environment and Sustainability working on a master's project for HRWC to improve the effectiveness, outreach, and impact of NAAP.

You are receiving this survey because you have had a Rapid Ecological Field Assessment completed on one or more of your properties. The first part of this survey will focus on field assessments and the second part will focus on the Bioreserve Map. It may be helpful to refer to your copy of your field assessment report, if you have it.

Your response will directly impact land protection efforts in the area and help improve biodiversity and water quality in the Huron River watershed. Also, when you submit your response to this survey, you will be entered into a raffle to win a \$75 gift card to a local business!

You can turn "Mobile view" off by toggling the Mobile view button in the upper right corner of your browser.

Q2: I heard about HRWC through:

(Please select all that apply)

- Another HRWC volunteer
- A letter from HRWC
- An HRWC event
- Previous involvement with HRWC programs
- Another organization
- Other: (text entry)

Q3: After submitting my volunteer sign-up form, I heard back from HRWC in a timely manner.

SD-D-N-A-SA

Q4: I completed a NAAP volunteer training.

- Yes
- No

Q5: (shown if Q4=yes)

When did you complete the training?

- Less than 1 year ago
- 1-2 years ago
- More than 5 years ago

Q6: I understand what the purpose of the field assessments are.

SD-D-N-A-SA

Q7: Before volunteering, I felt like I had a good understanding of what my volunteer experience would be like (i.e., how long it would take, what I was supposed to do).

SD-D-N-A-SA

Q8: While volunteering, I felt like I understood all of the ecosystem terminology on my field assessment worksheet.

SD-D-N-A-SA

Q9: While volunteering, I felt that I could correctly identify the species on my field assessment worksheet.

SD-D-N-A-SA

Q10: I have completed ____ field assessments

-1-3

-4-10

-More than 10

Q11: While volunteering, I used the Bioreserve Project Rapid Field Assessment Plant Guide (the spiral-bound booklet with pictures of the most common plant species for each ecosystem type) to help me fill out the field assessment worksheet.

SD-D-N-A-SA

Q12: While volunteering, I felt like I guessed for many of my answers on my field assessment worksheet.

SD-D-N-A-SA

Q13: I believe that the field assessment worksheet covered all of the important aspects of ecological integrity.

SD-D-N-A-SA

Q14: I feel that something important was missing from the field assessment worksheet.

-Yes

-No

Q15: (shown if Q14=Yes)

Please specify what you think was missing including explanations or examples:

Q16: During field assessments, I would prefer to enter information on a mobile app rather than on sheets of paper.

SD-D-N-A-SA

Q17: I think that the accuracy and efficiency of field assessments would be improved by entering information on a mobile app rather than on a sheet of paper.

SD-D-N-A-SA

Q18: I plan to complete volunteer field assessments with HRWC again.

SD-D-N-A-SA

Q19: I have recommended volunteering with HRWC to a friend.

-Yes

-No

Q20: I will recommend volunteering with HRWC to a friend.

SD-D-N-A-SA

Q21: Optional: Do you have any suggestions for how volunteer training could be improved?

-Text entry

Q22: Optional: Do you have any suggestions for how to increase the accuracy of the field assessments?

-Text entry

Q23: Optional: Do you have any suggestions for how to improve volunteer experience?

-Text entry

Q24: Optional: Do you have any additional comments or suggestions?

-Text entry

Q25: May we contact you with follow up questions?

-Yes

-No

Survey distribution email example (body of email sent to landowners)

With the holidays around the corner, we were wondering if you could dedicate a few minutes to water quality in the Huron River watershed by answering a brief survey.

The Huron River Watershed Council's Natural Areas and Assessment Program (NAAP) aims to map and assess the remaining natural areas in the Huron River watershed of southeast Michigan, and to prioritize the preservation and management of areas with the highest ecological integrity. We are graduate students from the University of Michigan School for Environment and Sustainability working on a master's project for HRWC to improve the effectiveness, outreach, and impact of NAAP.

You are receiving this survey because you have had a field assessment done on one or more of your properties. Your response will directly impact land protection efforts in the area and help improve biodiversity and water quality in the Huron River watershed. Also, when you submit your response to this survey, you will be entered into a raffle to win a \$75 gift card to a local business!

The survey will take approximately 5-10 minutes to complete.

If you are having any issues opening the survey, disabling AdBlock may help!

Follow this link to the Survey:

[\\${!://SurveyLink?d=Take the Survey}](#)

Or copy and paste the URL below into your internet browser:

[\\${!://SurveyURL}](#)

Follow the link to opt out of future emails:

[\\${!://OptOutLink?d=Click here to unsubscribe}](#)

Appendix F: Full Survey Results

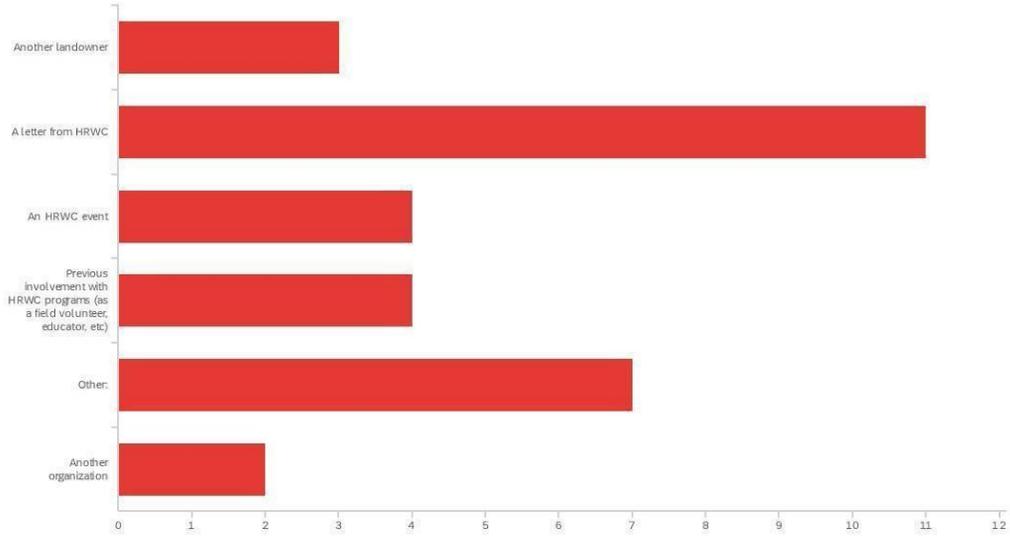
Landowners

Default Report

HRWC Masters Project Survey for Landowners

January 21, 2021 11:45 AM MST

Q4 - I heard about HRWC's field assessments through: (Please select all that apply)



#	Field	Choice Count
1	Another landowner	9.68% 3
2	A letter from HRWC	35.48% 11
3	An HRWC event	12.90% 4
4	Previous involvement with HRWC programs (as a field volunteer, educator, etc)	12.90% 4
5	Other:	22.58% 7
6	Another organization	6.45% 2

31

Showing rows 1 - 7 of 7

Q4_5_TEXT - Other:

Other:

Don't remember

Other:

Sale of conservation easement

HRWC field assessment completed on county property at my request

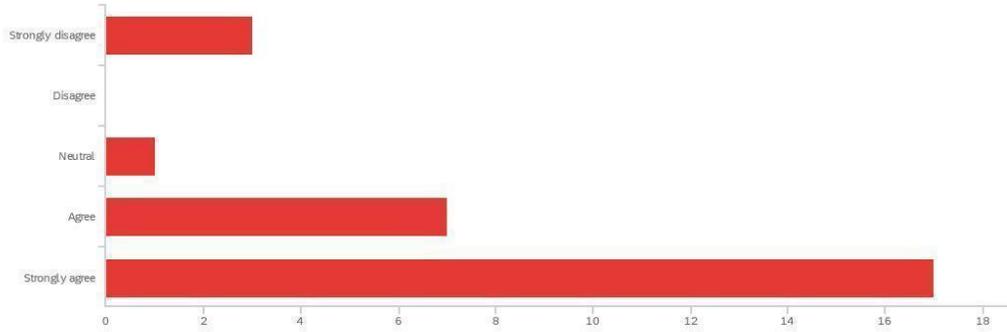
Terri Wilkerson

Mlive

research into land conservancy

Township board presentation

Q5 - It was easy to set up a field assessment with HRWC.



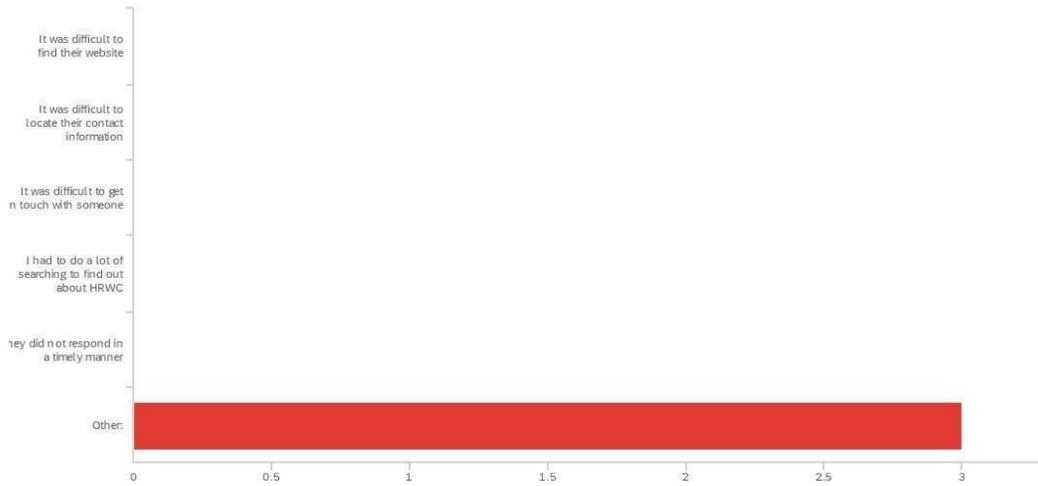
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	It was easy to set up a field assessment with HRWC.	1.00	7.00	5.75	1.90	3.62	28

#	Field	Choice Count
1	Strongly disagree	10.71% 3
3	Disagree	0.00% 0
4	Neutral	3.57% 1
5	Agree	25.00% 7
7	Strongly agree	60.71% 17
		28

Showing rows 1 - 6 of 6

Q6 - It was difficult for me to set up a field assessment with HRWC because: (Please

select all that apply)



#	Field	Choice Count
1	It was difficult to find their website	0.00% 0
2	It was difficult to locate their contact information	0.00% 0
3	It was difficult to get in touch with someone	0.00% 0
4	I had to do a lot of searching to find out about HRWC	0.00% 0
5	They did not respond in a timely manner	0.00% 0
6	Other:	100.00% 3

Showing rows 1 - 7 of 7

Q6_6_TEXT - Other:

Other:

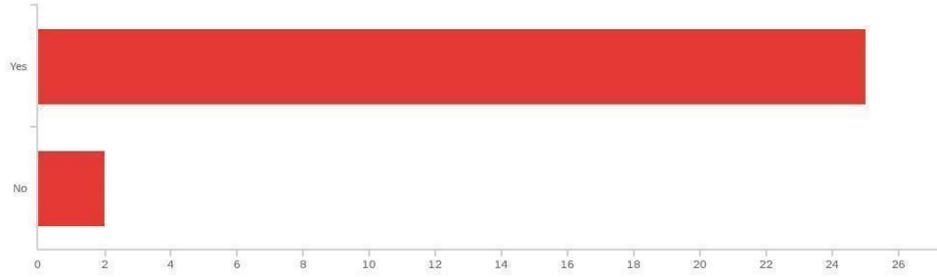
None of our properties are in Huron River Watershed. All is River Raisin.

It wasn't a problem for me to work the arrangements for the team to show up

Other:

No issue

Q7 - After the assessment was completed, I received a field assessment report from HRWC.



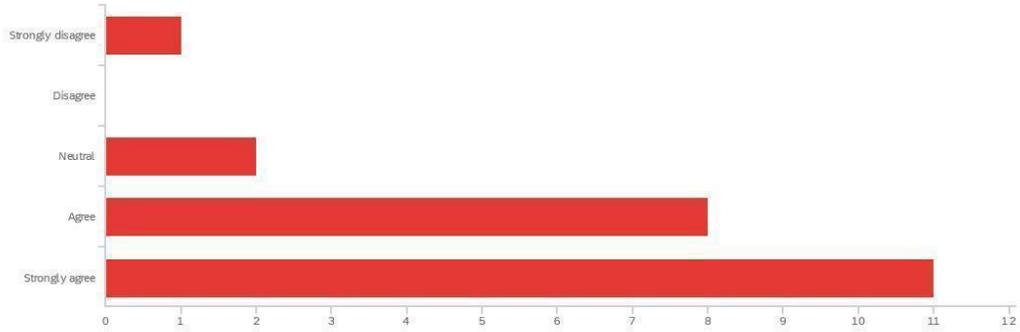
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	After the assessment was completed, I received a field assessment report from HRWC.	1.00	2.00	1.07	0.26	0.07	27

#	Field	Choice Count
1	Yes	92.59% 25
2	No	7.41% 2

27

Showing rows 1 - 3 of 3

Q8 - I received my field assessment report in a timely manner.



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	I received my field assessment report in a timely manner.	1.00	5.00	4.27	0.96	0.93	22

#	Field	Choice Count
1	Strongly disagree	4.55% 1
2	Disagree	0.00% 0
3	Neutral	9.09% 2
4	Agree	36.36% 8
5	Strongly agree	50.00% 11
		22

Showing rows 1 - 6 of 6

Q9 - Optional: Do you have any suggestions for how the process of setting up the field assessments and/or communicating with HRWC could be improved?

Optional: Do you have any suggestions for how the process of setting up the...

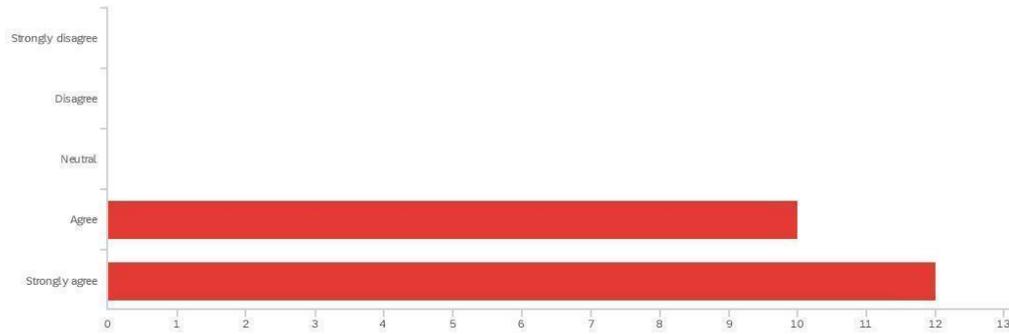
Nope. You made it easy.

Yes I would like to discuss it further

mine was quite a long time ago. Not sure my answers are relevant to current practices

Q11 - Overall, I understand the ecosystem terminology used in my field assessment

report.

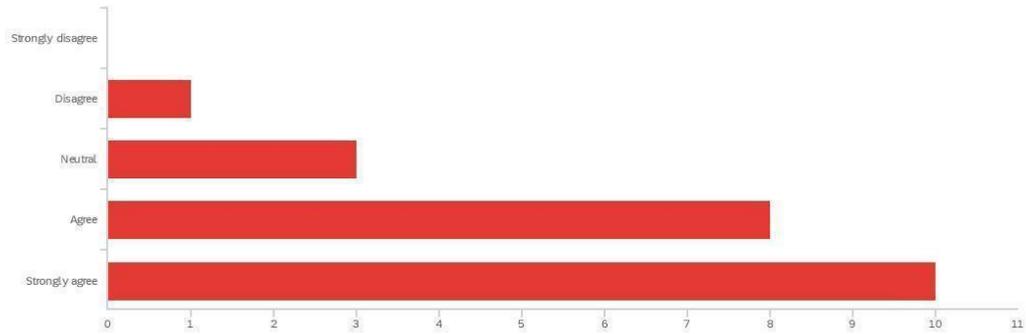


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Overall, I understand the ecosystem terminology used in my field assessment report.	4.00	5.00	4.55	0.50	0.25	22

#	Field	Choice Count
1	Strongly disagree	0.00% 0
2	Disagree	0.00% 0
3	Neutral	0.00% 0
4	Agree	45.45% 10
5	Strongly agree	54.55% 12
		22

Showing rows 1 - 6 of 6

Q12 - I understood how to interpret the Ecological Integrity Scores provided in my field assessment report.

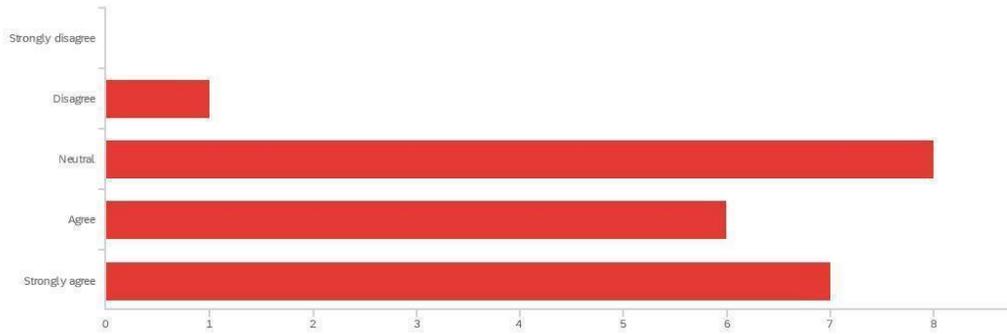


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	I understood how to interpret the Ecological Integrity Scores provided in my field assessment report.	2.00	5.00	4.23	0.85	0.72	22

#	Field	Choice Count
1	Strongly disagree	0.00% 0
2	Disagree	4.55% 1
3	Neutral	13.64% 3
4	Agree	36.36% 8
5	Strongly agree	45.45% 10
		22

Showing rows 1 - 6 of 6

Q13 - I understood how to interpret the Disturbance Scores provided in my field assessment report.

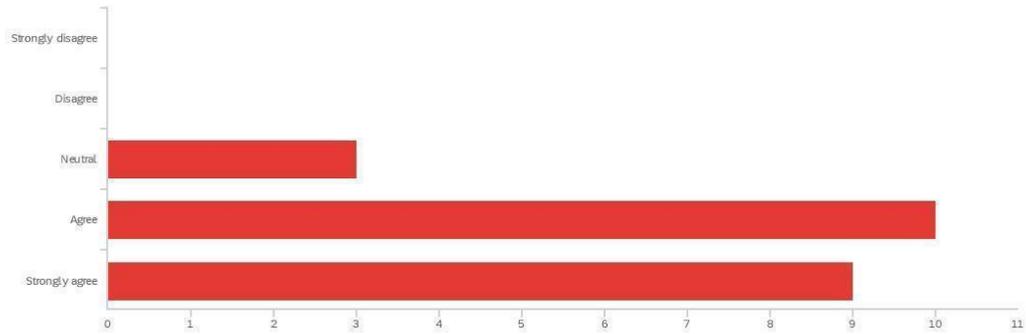


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	I understood how to interpret the Disturbance Scores provided in my field assessment report.	2.00	5.00	3.86	0.92	0.85	22

#	Field	Choice Count
1	Strongly disagree	0.00% 0
2	Disagree	4.55% 1
3	Neutral	36.36% 8
4	Agree	27.27% 6
5	Strongly agree	31.82% 7
		22

Showing rows 1 - 6 of 6

Q14 - To the best of my knowledge, the field assessment scores in my report accurately capture the ecological quality of my land and the species present on it.

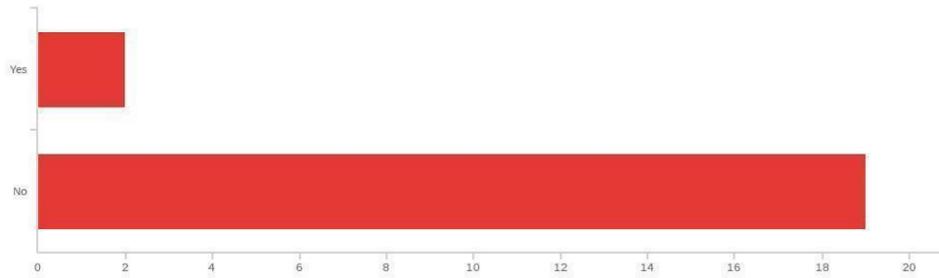


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	To the best of my knowledge, the field assessment scores in my report accurately capture the ecological quality of my land and the species present on it.	3.00	5.00	4.27	0.69	0.47	22

#	Field	Choice Count
1	Strongly disagree	0.00% 0
2	Disagree	0.00% 0
3	Neutral	13.64% 3
4	Agree	45.45% 10
5	Strongly agree	40.91% 9
		22

Showing rows 1 - 6 of 6

Q15 - I feel that one or more important variables for measuring ecological integrity and disturbance was missing from the field assessment report.



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	I feel that one or more important variables for measuring ecological integrity and disturbance was missing from the field assessment report.	1.00	2.00	1.90	0.29	0.09	21

#	Field	Choice Count
1	Yes	9.52% 2
2	No	90.48% 19

21

Showing rows 1 - 3 of 3

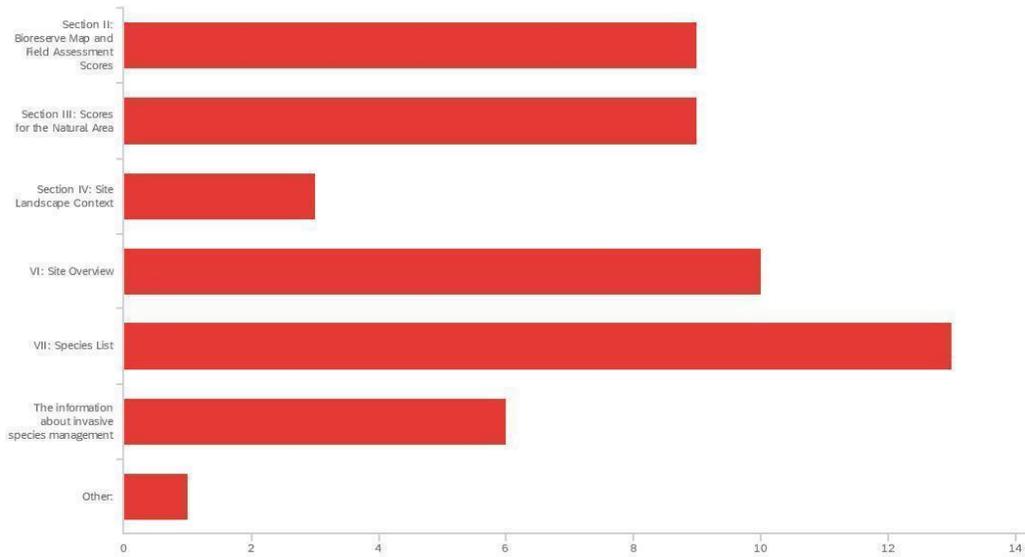
Q16 - Please specify what was missing including explanations or examples:

Please specify what was missing including explanations or examples:

The neighboring farm has several drainage ditches that have negatively impacted soil-water content on my property. This impact was not addressed in the survey.

The wetland on my property is a part of a small triplet of wetlands that depend on each other to provide the valuable resource that it had evolved into of the last 10,000 years

Q17 - To me, the most valuable sections of the field assessment report were: (Please select 3 sections that were the most valuable)



#	Field	Choice Count
1	Section II: Bioreserve Map and Field Assessment Scores	17.65% 9
2	Section III: Scores for the Natural Area	17.65% 9
3	Section IV: Site Landscape Context	5.88% 3
4	VI: Site Overview	19.61% 10
5	VII: Species List	25.49% 13
6	The information about invasive species management	11.76% 6
7	Other:	1.96% 1
		51

Showing rows 1 - 8 of 8

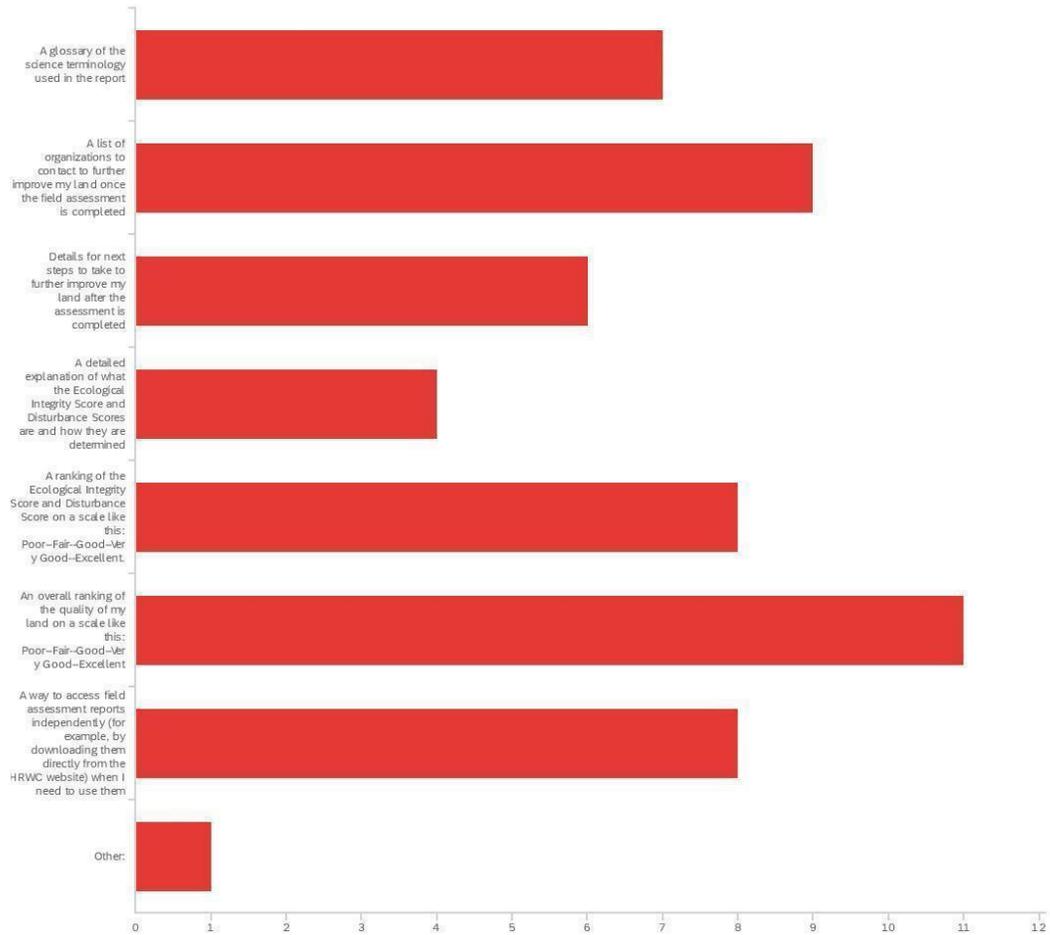
Q17_7_TEXT - Other:

Other:

Other:

The nature of the wetland in this location as the only aquifer recharge site in Livingston county that has an MDEQ protected area

Q18 - It would be helpful to me if HRWC field assessment reports also included: (Please select 3 that you would find the most helpful)



#	Field	Choice Count
1	A glossary of the science terminology used in the report	12.96% 7
2	A list of organizations to contact to further improve my land once the field assessment is completed	16.67% 9
3	Details for next steps to take to further improve my land after the assessment is completed	11.11% 6
4	A detailed explanation of what the Ecological Integrity Score and Disturbance Scores are and how they are determined	7.41% 4

#	Field	Choice Count
5	A ranking of the Ecological Integrity Score and Disturbance Score on a scale like this: Poor–Fair–Good–Very Good–Excellent.	14.81% 8
6	An overall ranking of the quality of my land on a scale like this: Poor–Fair–Good–Very Good–Excellent	20.37% 11
7	A way to access field assessment reports independently (for example, by downloading them directly from the HRWC website) when I need to use them	14.81% 8
8	Other:	1.85% 1

54

Showing rows 1 - 9 of 9

Q18_8_TEXT - Other:

Other:

Provide guidance on dealing with an adjacent property developer that has manipulated stormwater impact data that only allowed for the dry months used in their development plans. Create more of a presence at the township level in the Planning of new projects and put as much work into protecting the watershed wetlands as the actual Huron river is getting for overlay districts, appropriate setbacks

Q19 - Optional: Do you have any additional suggestions for how to make the field assessment reports easier to interpret and understand, more useful, or more accurate?

Optional: Do you have any additional suggestions for how to make the field...

I had the assessment performed at least 4 years ago. I do not remember any of this.

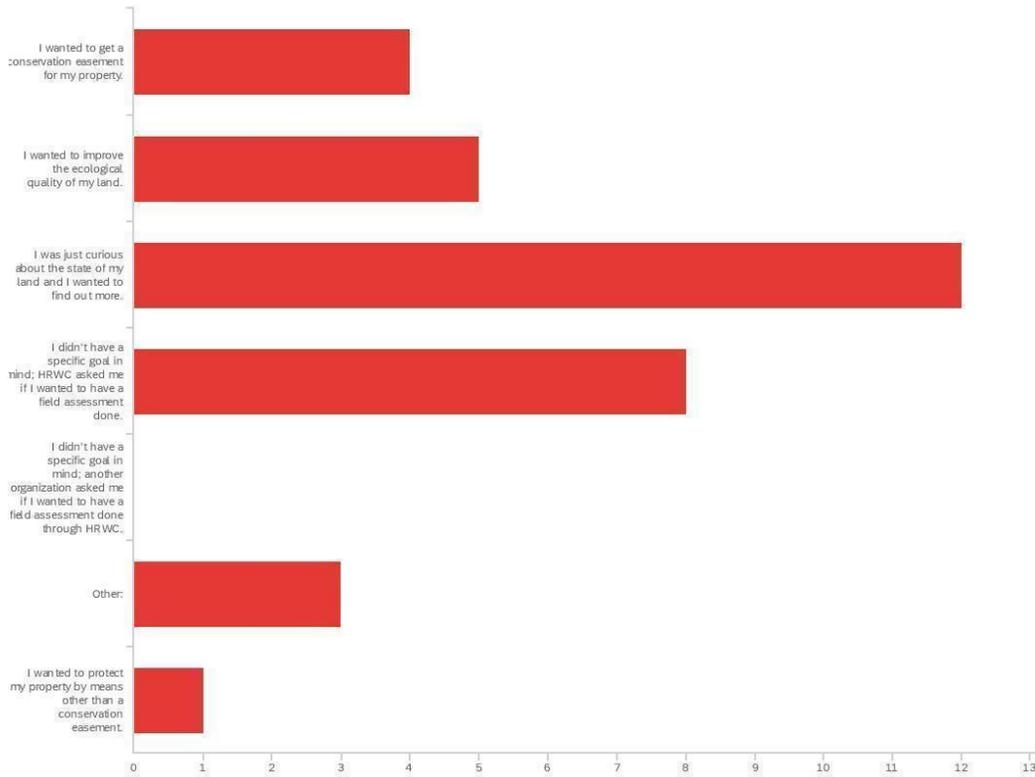
Yes but this isn't enough space to explain it all

Assessments should be done 5 year intervals and at least 10 years. I have issues right now with road closure and bridge being unsafe. Lots of unwanted trespassers are going around signs to get to bridge leaving lots of trash. Big problem for water/landscape management!

No. It was a fascinating walking tour

Q21 - My goal(s) for having HRWC do a field assessment on my property was: (Please

select all that apply)



#	Field	Choice Count
1	I wanted to get a conservation easement for my property.	12.12% 4
2	I wanted to improve the ecological quality of my land.	15.15% 5
3	I was just curious about the state of my land and I wanted to find out more.	36.36% 12
4	I didn't have a specific goal in mind; HRWC asked me if I wanted to have a field assessment done.	24.24% 8
5	I didn't have a specific goal in mind; another organization asked me if I wanted to have a field assessment done through HRWC.	0.00% 0
6	Other:	9.09% 3
7	I wanted to protect my property by means other than a conservation easement.	3.03% 1
		33

Showing rows 1 - 8 of 8

Q21_6_TEXT - Other:

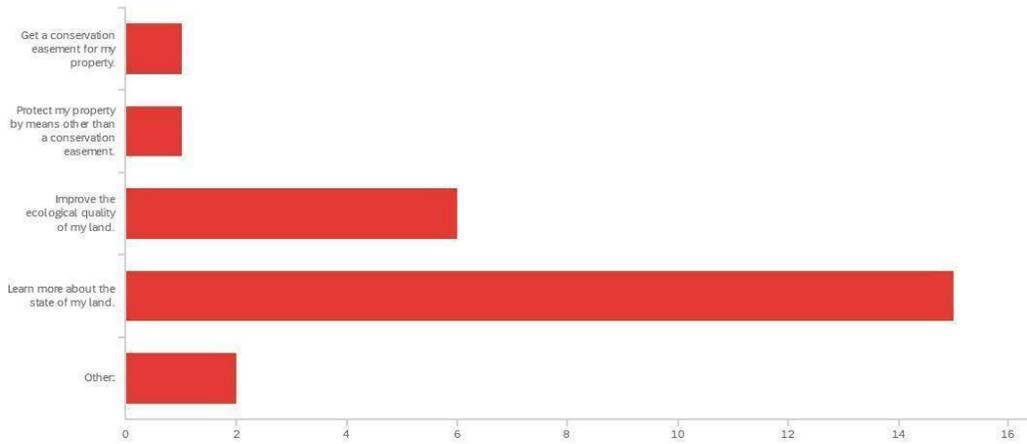
Other:

For the future development of a public park

I was thinking the results were more for HRWC, rather than us...that they were getting a broader view of all the lands in the Huron watershed.

I needed more help in standing up to MDEQ and the developer to confront their misdirection and force MDEQ to conduct a real evaluation that included the impact to the entire area before providing a building permit

Q22 - Having the field assessment done helped me accomplish the following for my property:(Please select all that apply)



#	Field	Choice Count
1	Get a conservation easement for my property.	4.00% 1
2	Protect my property by means other than a conservation easement.	4.00% 1
3	Improve the ecological quality of my land.	24.00% 6
4	Learn more about the state of my land.	60.00% 15
8	Other:	8.00% 2
		25

Showing rows 1 - 6 of 6

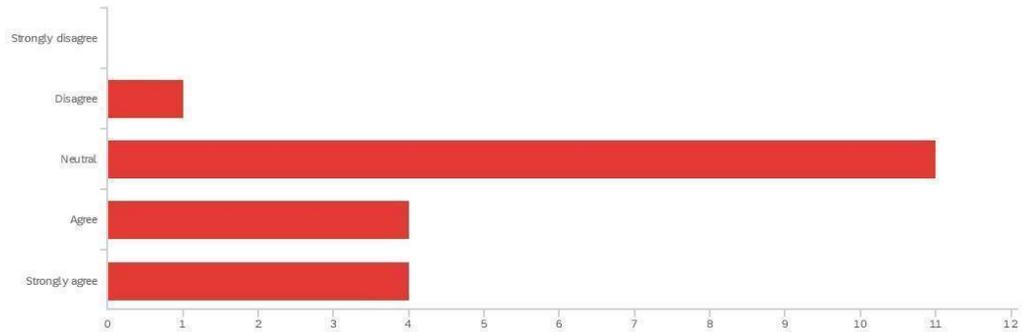
Q22_8_TEXT - Other:

Other:

Still waiting fir an effective response from HRWC to challenge MDEQ's dismissive attitude that the wetlands are not worth protecting

provides me with a document to begin discussion about possible future conservancy

Q23 - I feel that my field assessment report gave me a good sense of what to do next with my property after the assessment was completed.

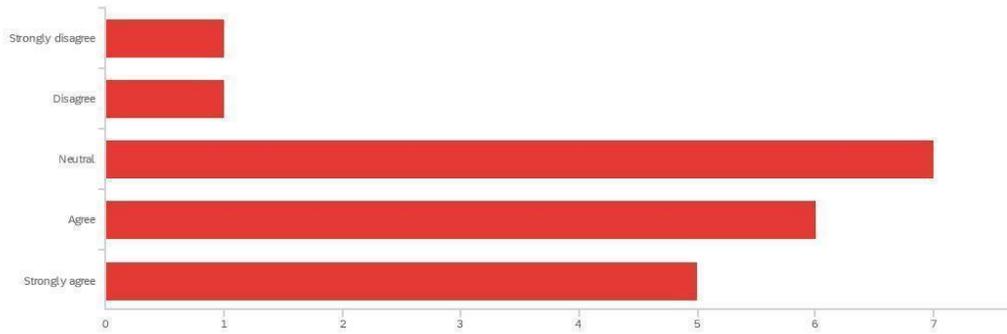


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	I feel that my field assessment report gave me a good sense of what to do next with my property after the assessment was completed.	2.00	5.00	3.55	0.86	0.75	20

#	Field	Choice Count
1	Strongly disagree	0.00% 0
2	Disagree	5.00% 1
3	Neutral	55.00% 11
4	Agree	20.00% 4
5	Strongly agree	20.00% 4
		20

Showing rows 1 - 6 of 6

Q24 - I would like to receive follow-up contact from HRWC about next steps I can take with my property.

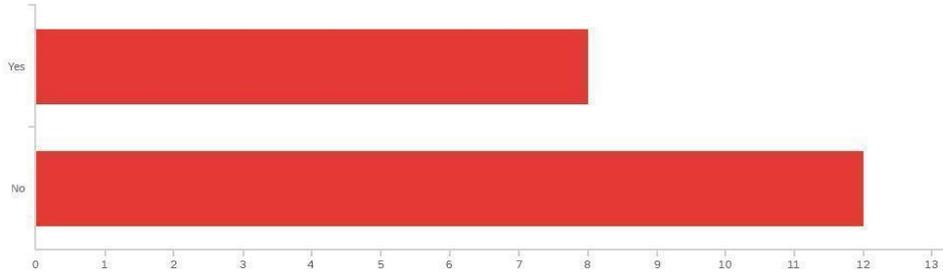


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	I would like to receive follow-up contact from HRWC about next steps I can take with my property.	1.00	5.00	3.65	1.06	1.13	20

#	Field	Choice Count
1	Strongly disagree	5.00% 1
2	Disagree	5.00% 1
3	Neutral	35.00% 7
4	Agree	30.00% 6
5	Strongly agree	25.00% 5
		20

Showing rows 1 - 6 of 6

Q25 - I have recommended an HRWC field assessment to another landowner.



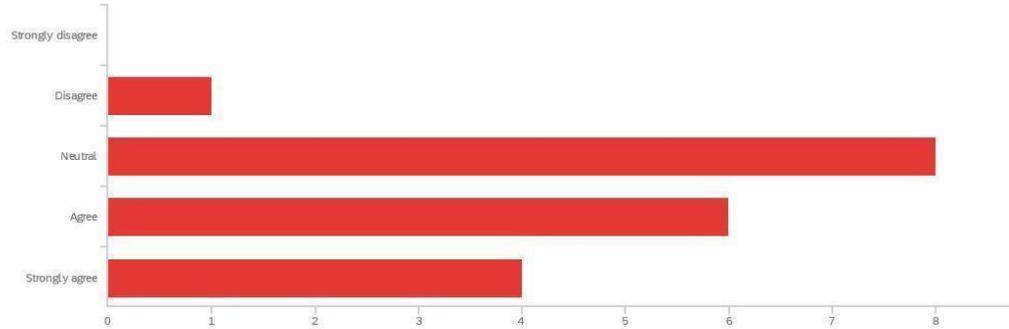
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	I have recommended an HRWC field assessment to another landowner.	1.00	2.00	1.60	0.49	0.24	20

#	Field	Choice Count
1	Yes	40.00% 8
2	No	60.00% 12

20

Showing rows 1 - 3 of 3

Q26 - I plan to recommend an HRWC field assessment to another landowner.



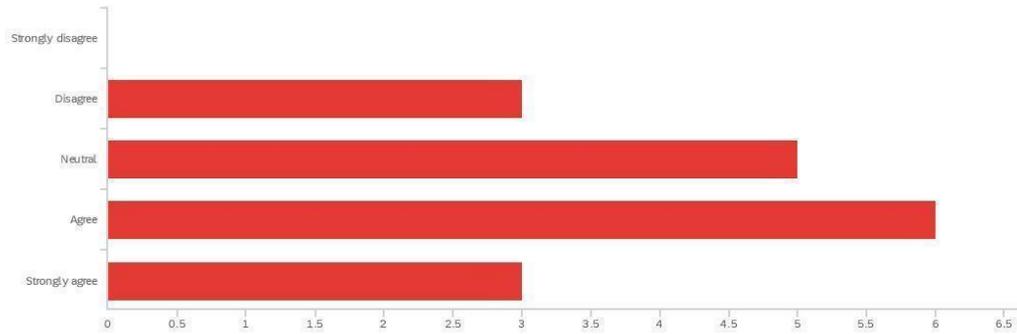
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	I plan to recommend an HRWC field assessment to another landowner.	2.00	5.00	3.68	0.86	0.74	19

#	Field	Choice Count
1	Strongly disagree	0.00% 0
2	Disagree	5.26% 1
3	Neutral	42.11% 8
4	Agree	31.58% 6
5	Strongly agree	21.05% 4
		19

Showing rows 1 - 6 of 6

Q28 - The definition of the Bioreserve Map was clearly explained to me in my field

assessment report.

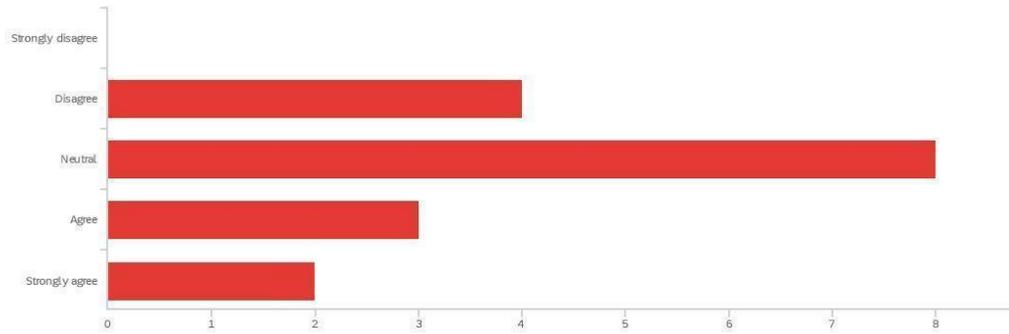


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	The definition of the Bioreserve Map was clearly explained to me in my field assessment report.	2.00	5.00	3.53	0.98	0.96	17

#	Field	Choice Count
1	Strongly disagree	0.00% 0
2	Disagree	17.65% 3
3	Neutral	29.41% 5
4	Agree	35.29% 6
5	Strongly agree	17.65% 3
		17

Showing rows 1 - 6 of 6

Q29 - After reading my field assessment report, I understood how to access either version of the Bioreserve Map.

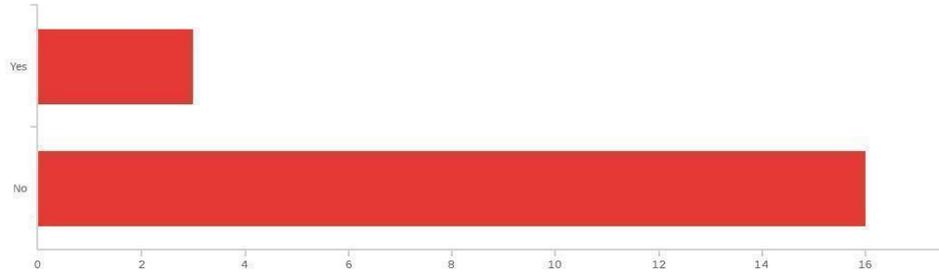


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	After reading my field assessment report, I understood how to access either version of the Bioreserve Map.	2.00	5.00	3.18	0.92	0.85	17

#	Field	Choice Count
1	Strongly disagree	0.00% 0
2	Disagree	23.53% 4
3	Neutral	47.06% 8
4	Agree	17.65% 3
5	Strongly agree	11.76% 2
		17

Showing rows 1 - 6 of 6

Q30 - I have seen or used the Bioreserve Map shapefiles before.

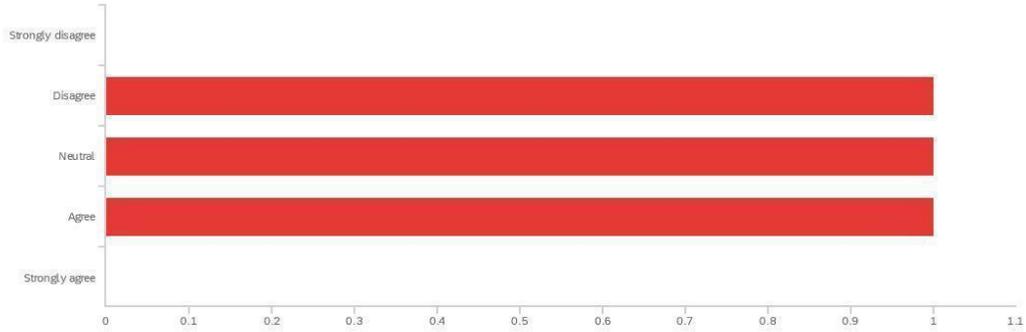


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1.	I have seen or used the Bioreserve Map shapefiles before.	1.00	2.00	1.84	0.36	0.13	19

#	Field	Choice Count
1	Yes	15.79% 3
2	No	84.21% 16
		19

Showing rows 1 - 3 of 3

Q31 - The Bioreserve Map shapefiles are easy to navigate and understand.

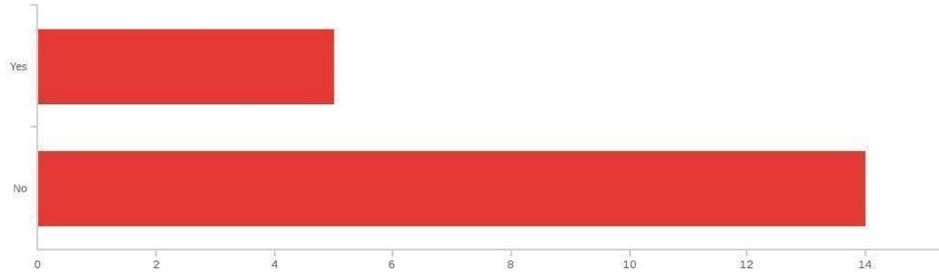


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	The Bioreserve Map shapefiles are easy to navigate and understand.	2.00	4.00	3.00	0.82	0.67	3

#	Field	Choice Count
1	Strongly disagree	0.00% 0
2	Disagree	33.33% 1
3	Neutral	33.33% 1
4	Agree	33.33% 1
5	Strongly agree	0.00% 0
		3

Showing rows 1 - 6 of 6

Q32 - I have seen or used the Bioreserve Map PDF before.



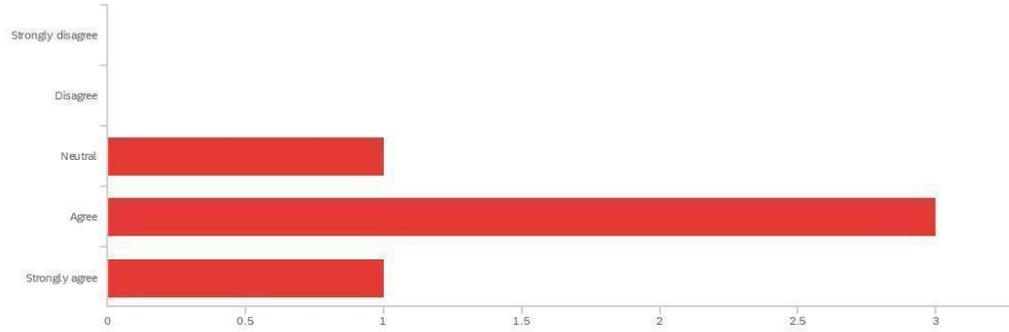
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	I have seen or used the Bioreserve Map PDF before.	1.00	2.00	1.74	0.44	0.19	19

#	Field	Choice Count
1	Yes	26.32% 5
2	No	73.68% 14

19

Showing rows 1 - 3 of 3

Q33 - The Bioreserve Map PDF is easy to navigate and understand.

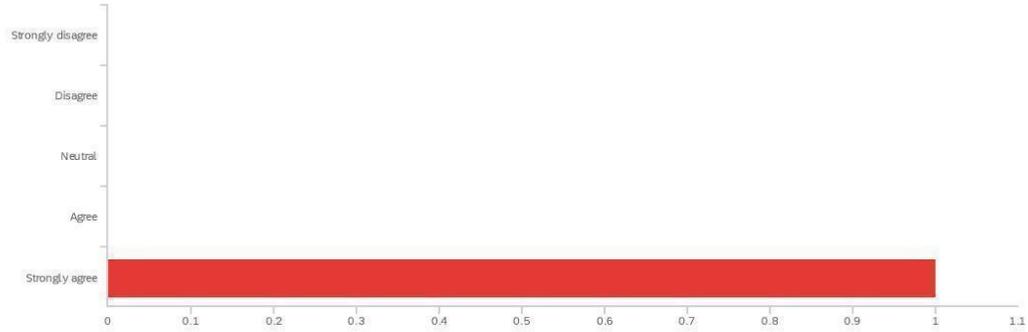


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	The Bioreserve Map PDF is easy to navigate and understand.	3.00	5.00	4.00	0.63	0.40	5

#	Field	Choice Count
1	Strongly disagree	0.00% 0
2	Disagree	0.00% 0
3	Neutral	20.00% 1
4	Agree	60.00% 3
5	Strongly agree	20.00% 1
		5

Showing rows 1 - 6 of 6

Q34 - I would like to access the Bioreserve Map PDF.

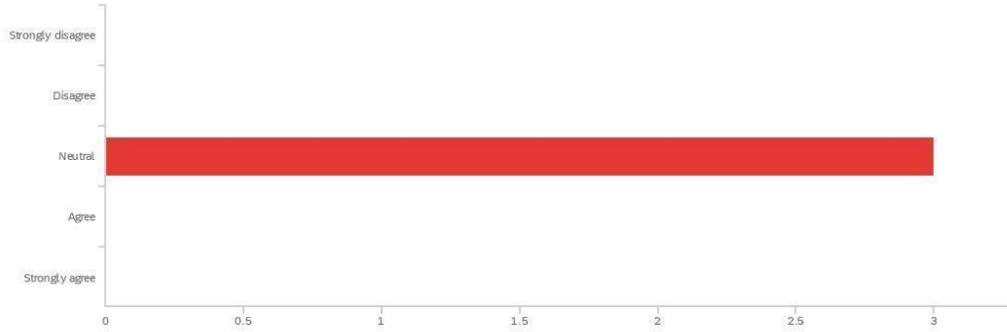


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	I would like to access the Bioreserve Map PDF.	5.00	5.00	5.00	0.00	0.00	1

#	Field	Choice Count
1	Strongly disagree	0.00% 0
2	Disagree	0.00% 0
3	Neutral	0.00% 0
4	Agree	0.00% 0
5	Strongly agree	100.00% 1
		1

Showing rows 1 - 6 of 6

Q35 - I would like to access the Bioreserve Map shapefiles.

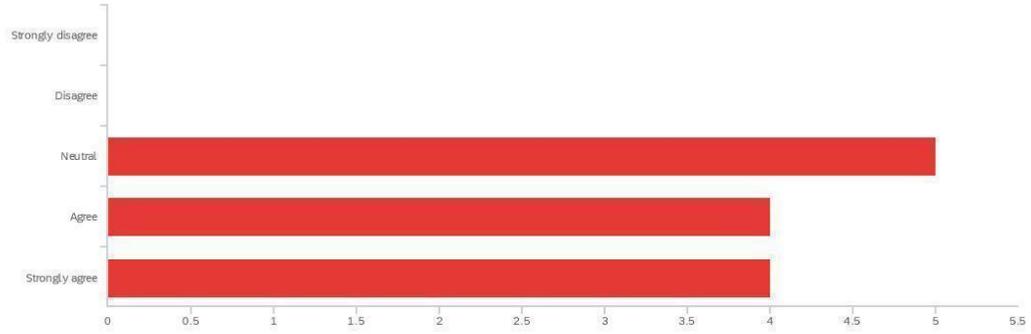


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	I would like to access the Bioreserve Map shapefiles.	3.00	3.00	3.00	0.00	0.00	3

#	Field	Choice Count
1	Strongly disagree	0.00% 0
2	Disagree	0.00% 0
3	Neutral	100.00% 3
4	Agree	0.00% 0
5	Strongly agree	0.00% 0
		3

Showing rows 1 - 6 of 6

Q36 - I am interested in accessing the Bioreserve Map.



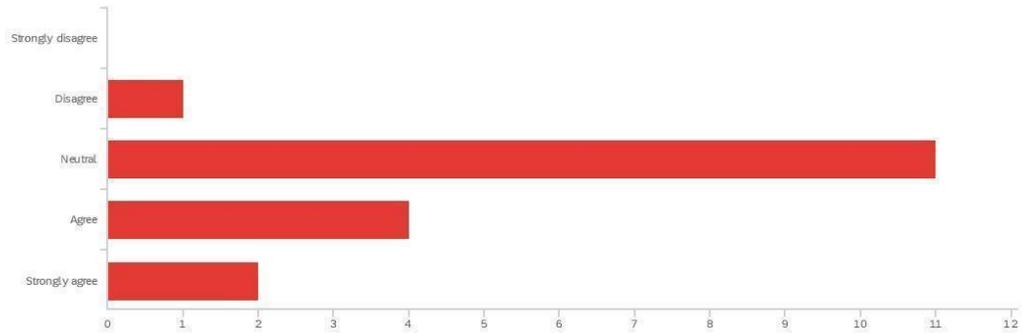
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	I am interested in accessing the Bioreserve Map.	3.00	5.00	3.92	0.83	0.69	13

#	Field	Choice Count
1	Strongly disagree	0.00% 0
2	Disagree	0.00% 0
3	Neutral	38.46% 5
4	Agree	30.77% 4
5	Strongly agree	30.77% 4
		13

Showing rows 1 - 6 of 6

Q37 - I understood how to interpret the Bioreserve Map Score provided in my field

assessment report.



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	I understood how to interpret the Bioreserve Map Score provided in my field assessment report.	2.00	5.00	3.39	0.76	0.57	18

#	Field	Choice Count
1	Strongly disagree	0.00% 0
2	Disagree	5.56% 1
3	Neutral	61.11% 11
4	Agree	22.22% 4
5	Strongly agree	11.11% 2
		18

Showing rows 1 - 6 of 6

Q38 - Optional: Do you have any additional comments or suggestions about the HRWC Natural Areas Assessment Program as a whole - the resources provided or the assessment processes?

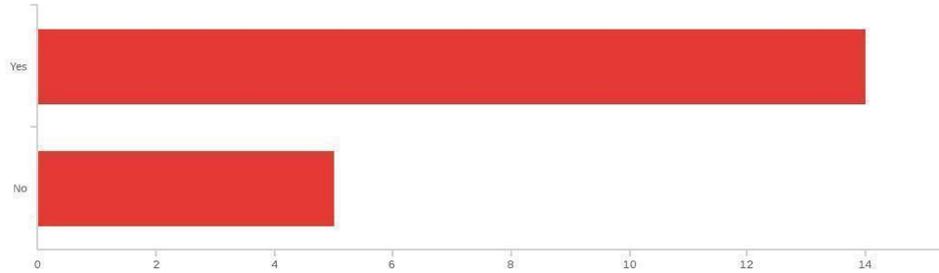
Optional: Do you have any additional comments or suggestions about the HRWC...

Yes but there is not enough room in this format

Livingston County and Washtenaw County struggle with Bowditch Road contour problems for care and maintenance. Portage stream bridge in particular needs addressing for full closure to protect bioserve!

I am really grateful to have this tool available.

Q39 - May we contact you with additional follow-up questions?



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	May we contact you with additional follow-up questions?	1.00	2.00	1.26	0.44	0.19	19

#	Field	Choice Count
1	Yes	73.68% 14
2	No	26.32% 5

19

Showing rows 1 - 3 of 3

Q40 - Please enter the best email to reach you at for follow up questions:

Please enter the best email to reach you at for follow up questions:

Smithpg6641@gmail.com

KKline-Hudson@livgov.com

gkole@charter.net

scottrosencrans@comcast.net

tmfriedlander@hughes.net

djg392dimples@gmail.com

dhbrooks@umich.edu

Jmalek35@gmail.com

carol401@comcast.net

chris.ferszt@gmail.com

suzwright2@aol.com

doverbey@overbey.info

chabotpl@gmail.com

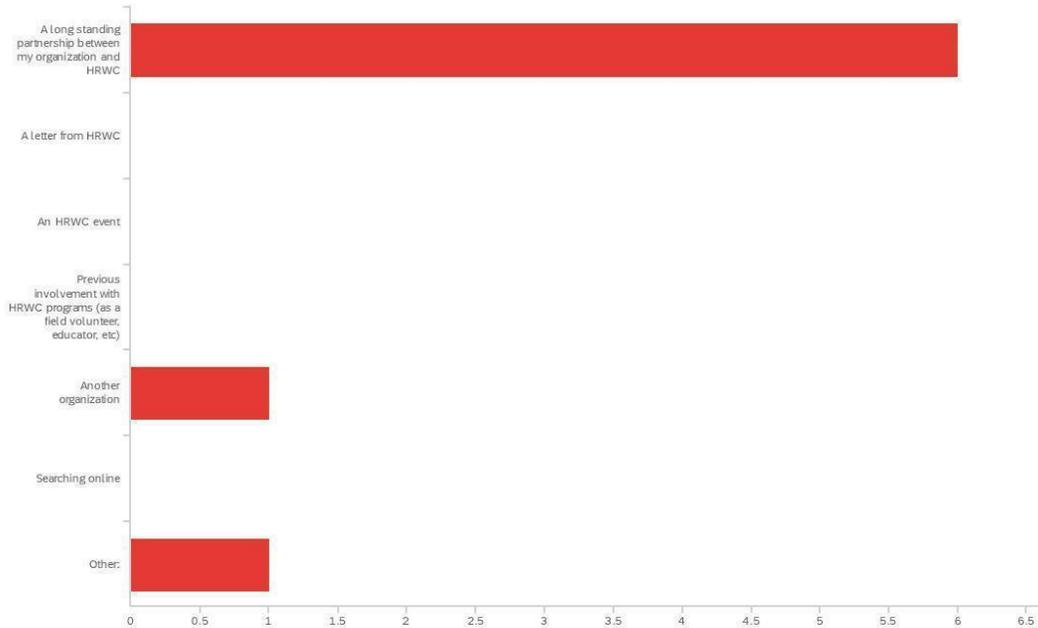
Craig@bjwgroup.com

End of Report

Stakeholders Default Report

HRWC Masters Project Survey for Stakeholders
December 30, 2020 5:07 PM MST

Q3 - I heard about HRWC through: (Please select all that apply)



#	Field	Choice Count
1	A long standing partnership between my organization and HRWC	75.00% 6
2	A letter from HRWC	0.00% 0
3	An HRWC event	0.00% 0
4	Previous involvement with HRWC programs (as a field volunteer, educator, etc)	0.00% 0
5	Another organization	12.50% 1
6	Searching online	0.00% 0
7	Other:	12.50% 1
		8

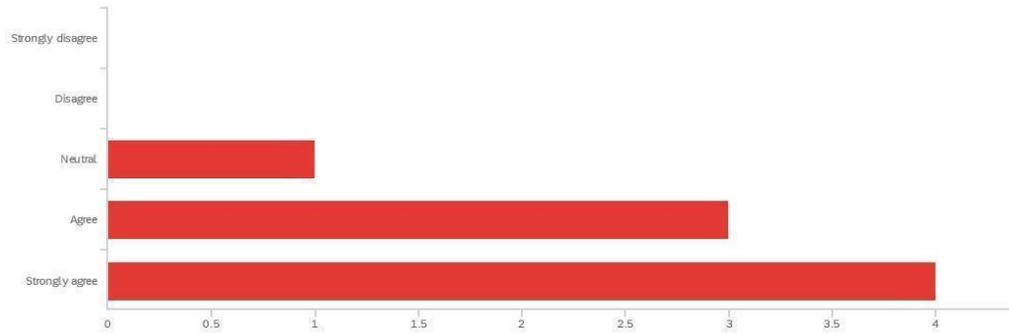
Showing rows 1 - 8 of 8

Q3_7_TEXT - Other:

Other:

hunting for jobs in the environmental field out of undergrad

Q4 - When I need to view a field assessment report, I am able to gain access to it in a timely manner.

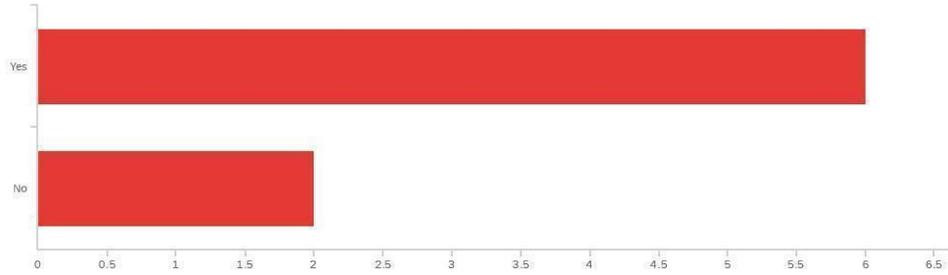


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	When I need to view a field assessment report, I am able to gain access to it in a timely manner.	3.00	5.00	4.38	0.70	0.48	8

#	Field	Choice Count
1	Strongly disagree	0.00% 0
2	Disagree	0.00% 0
3	Neutral	12.50% 1
4	Agree	37.50% 3
5	Strongly agree	50.00% 4
		8

Showing rows 1 - 6 of 6

Q5 - I have scheduled field assessments through HRWC.



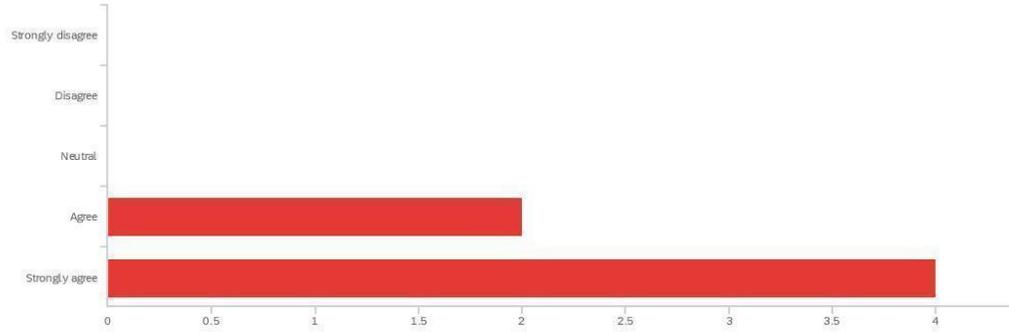
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	I have scheduled field assessments through HRWC.	1.00	2.00	1.25	0.43	0.19	8

#	Field	Choice Count
1	Yes	75.00% 6
2	No	25.00% 2

8

Showing rows 1 - 3 of 3

Q6 - It's easy to set up a field assessment with HRWC.

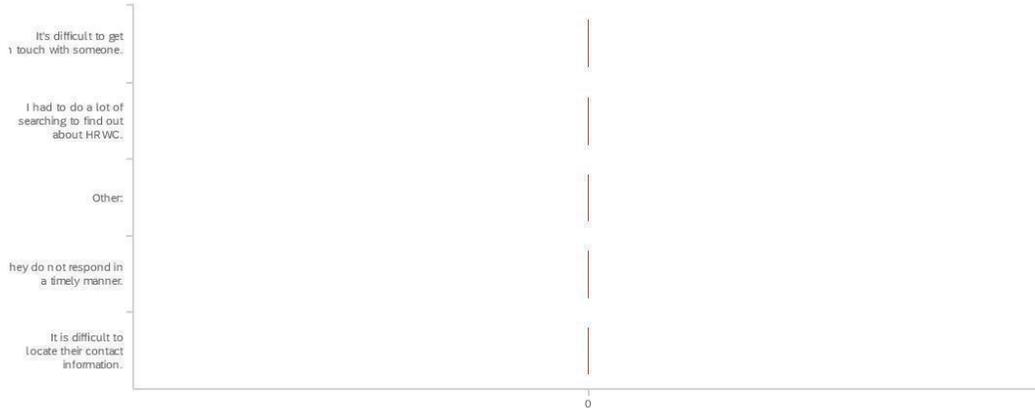


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	It's easy to set up a field assessment with HRWC.	4.00	5.00	4.67	0.47	0.22	6

#	Field	Choice Count
1	Strongly disagree	0.00% 0
2	Disagree	0.00% 0
3	Neutral	0.00% 0
4	Agree	33.33% 2
5	Strongly agree	66.67% 4
		6

Showing rows 1 - 6 of 6

Q7 - It is difficult to set up field assessments with HRWC because: (Please select all that apply)



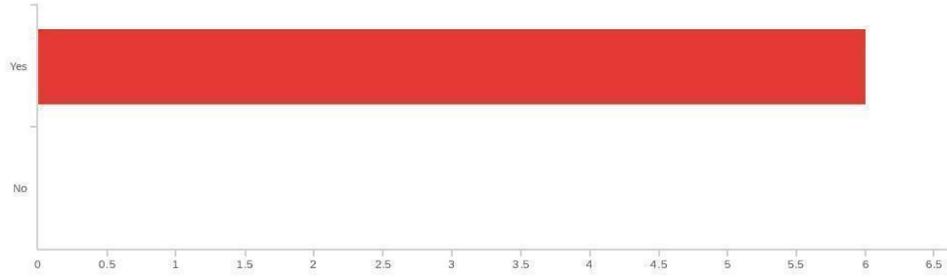
#	Field	Choice Count
1	It's difficult to get in touch with someone.	0.00% 0
3	I had to do a lot of searching to find out about HRWC.	0.00% 0
4	Other:	0.00% 0
5	They do not respond in a timely manner.	0.00% 0
6	It is difficult to locate their contact information.	0.00% 0
		0

Showing rows 1 - 6 of 6

Q7_4_TEXT - Other:

Other:

Q8 - When I schedule a field assessment with HRWC, I always receive a field assessment report.

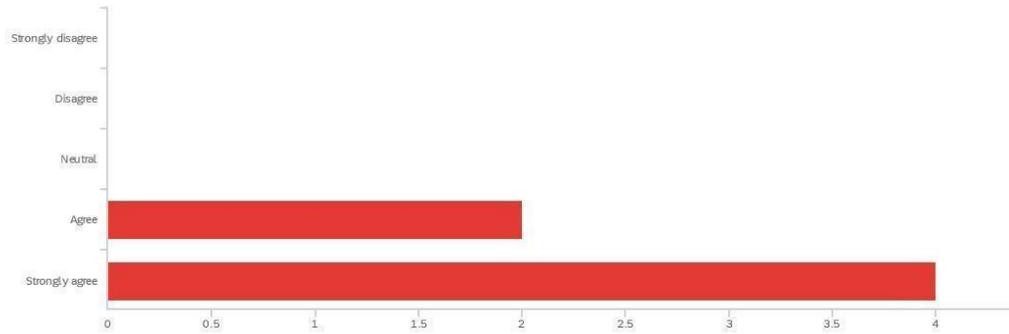


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	When I schedule a field assessment with HRWC, I always receive a field assessment report.	1.00	1.00	1.00	0.00	0.00	6

#	Field	Choice Count
1	Yes	100.00% 6
2	No	0.00% 0
		6

Showing rows 1 - 3 of 3

Q9 - When I schedule a field assessment with HRWC, I always receive a field assessment report in a timely manner.

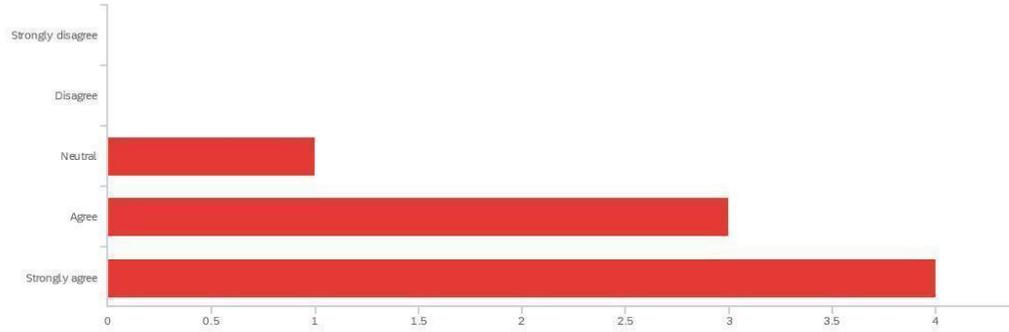


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	When I schedule a field assessment with HRWC, I always receive a field assessment report in a timely manner.	4.00	5.00	4.67	0.47	0.22	6

#	Field	Choice Count
1	Strongly disagree	0.00% 0
2	Disagree	0.00% 0
3	Neutral	0.00% 0
4	Agree	33.33% 2
5	Strongly agree	66.67% 4
		6

Showing rows 1 - 6 of 6

Q10 - Overall, I understand the ecosystem terminology used in field assessment reports.

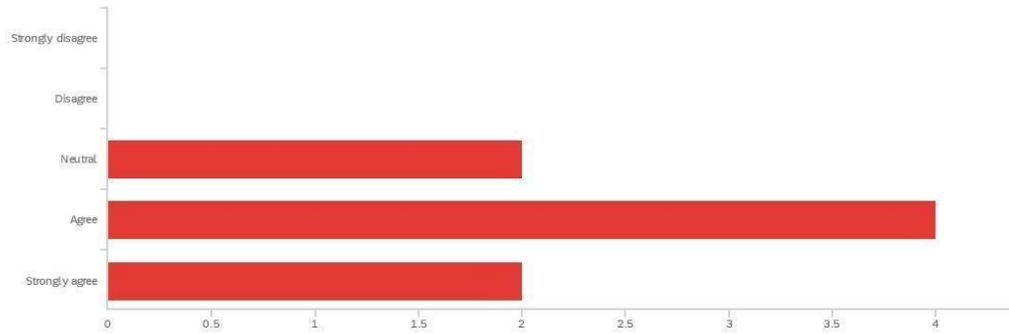


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Overall, I understand the ecosystem terminology used in field assessment reports.	3.00	5.00	4.38	0.70	0.48	8

#	Field	Choice Count
1	Strongly disagree	0.00% 0
2	Disagree	0.00% 0
3	Neutral	12.50% 1
4	Agree	37.50% 3
5	Strongly agree	50.00% 4
		8

Showing rows 1 - 6 of 6

Q11 - I understand how to interpret the Ecological Integrity Scores provided in field assessment reports.

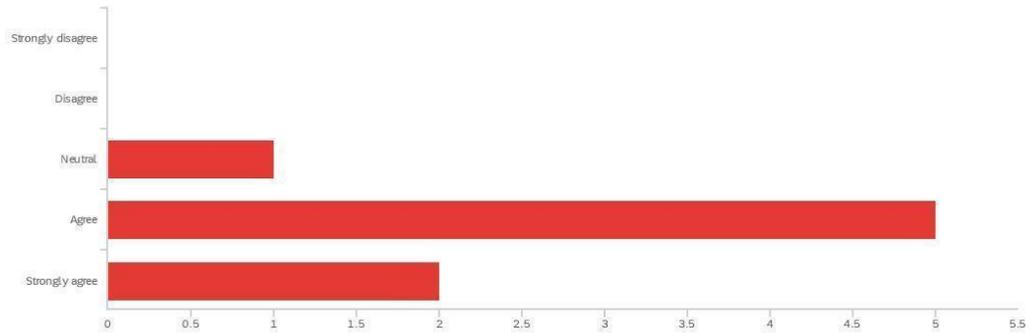


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	I understand how to interpret the Ecological Integrity Scores provided in field assessment reports.	3.00	5.00	4.00	0.71	0.50	8

#	Field	Choice Count
1	Strongly disagree	0.00% 0
2	Disagree	0.00% 0
3	Neutral	25.00% 2
4	Agree	50.00% 4
5	Strongly agree	25.00% 2
		8

Showing rows 1 - 6 of 6

Q12 - I understand how to interpret the Disturbance Scores provided in field assessment reports.

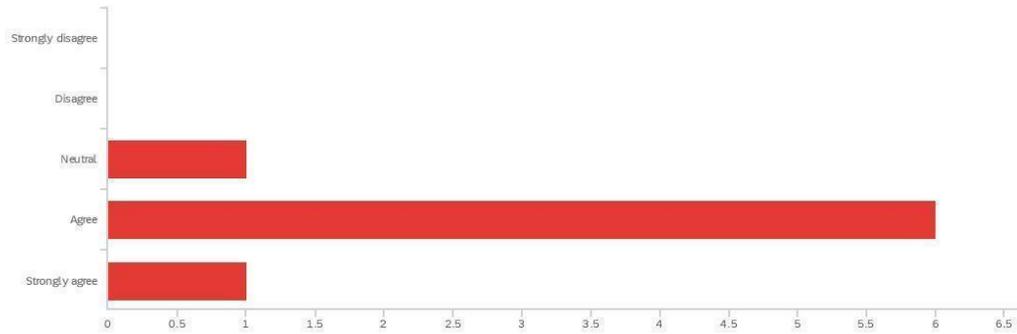


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	I understand how to interpret the Disturbance Scores provided in field assessment reports.	3.00	5.00	4.13	0.60	0.36	8

#	Field	Choice Count
1	Strongly disagree	0.00% 0
2	Disagree	0.00% 0
3	Neutral	12.50% 1
4	Agree	62.50% 5
5	Strongly agree	25.00% 2
		8

Showing rows 1 - 6 of 6

Q13 - To the best of my knowledge, field assessment scores accurately capture the ecological quality of the natural area and the species present on it.

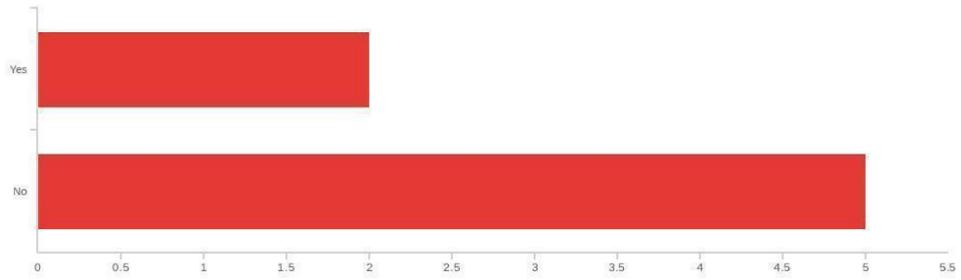


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	To the best of my knowledge, field assessment scores accurately capture the ecological quality of the natural area and the species present on it.	3.00	5.00	4.00	0.50	0.25	8

#	Field	Choice Count
1	Strongly disagree	0.00% 0
2	Disagree	0.00% 0
3	Neutral	12.50% 1
4	Agree	75.00% 6
5	Strongly agree	12.50% 1
		8

Showing rows 1 - 6 of 6

Q14 - I feel that one or more important variables for measuring ecological integrity and disturbance are missing from field assessment reports.



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	I feel that one or more important variables for measuring ecological integrity and disturbance are missing from field assessment reports.	1.00	2.00	1.71	0.45	0.20	7

#	Field	Choice Count
1	Yes	28.57% 2
2	No	71.43% 5

7

Showing rows 1 - 3 of 3

Q15 - Please specify what was missing including explanations or examples:

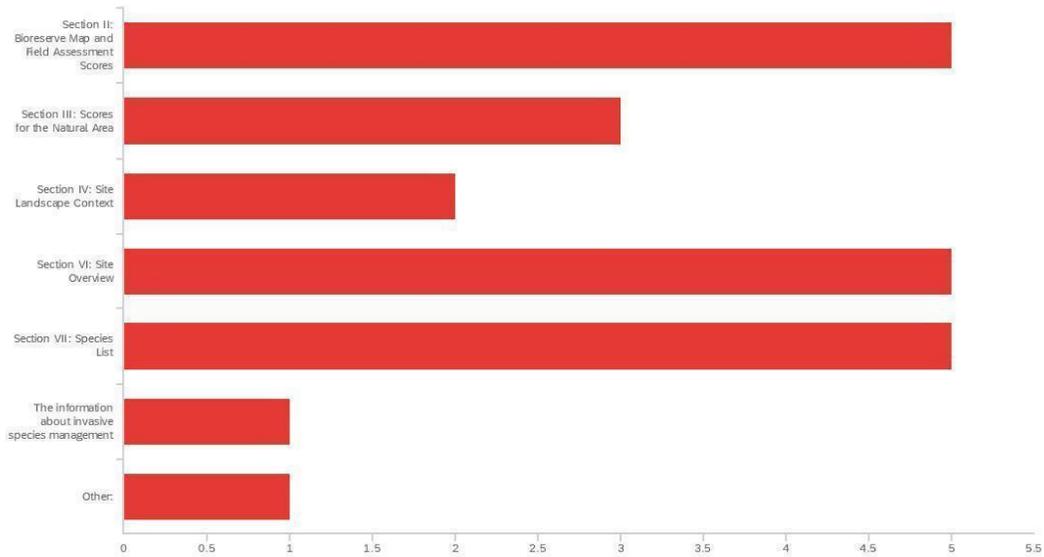
Please specify what was missing including explanations or examples:

I would like to see stronger requirements for fauna reporting

description of surrounding properties

Q16 - The most valuable sections of field assessments reports are: (Please select 3

sections that are the most valuable)



#	Field	Choice Count
1	Section II: Bioreserve Map and Field Assessment Scores	22.73% 5
2	Section III: Scores for the Natural Area	13.64% 3
3	Section IV: Site Landscape Context	9.09% 2
4	Section VI: Site Overview	22.73% 5
5	Section VII: Species List	22.73% 5
6	The information about invasive species management	4.55% 1
7	Other:	4.55% 1
		22

Showing rows 1 - 8 of 8

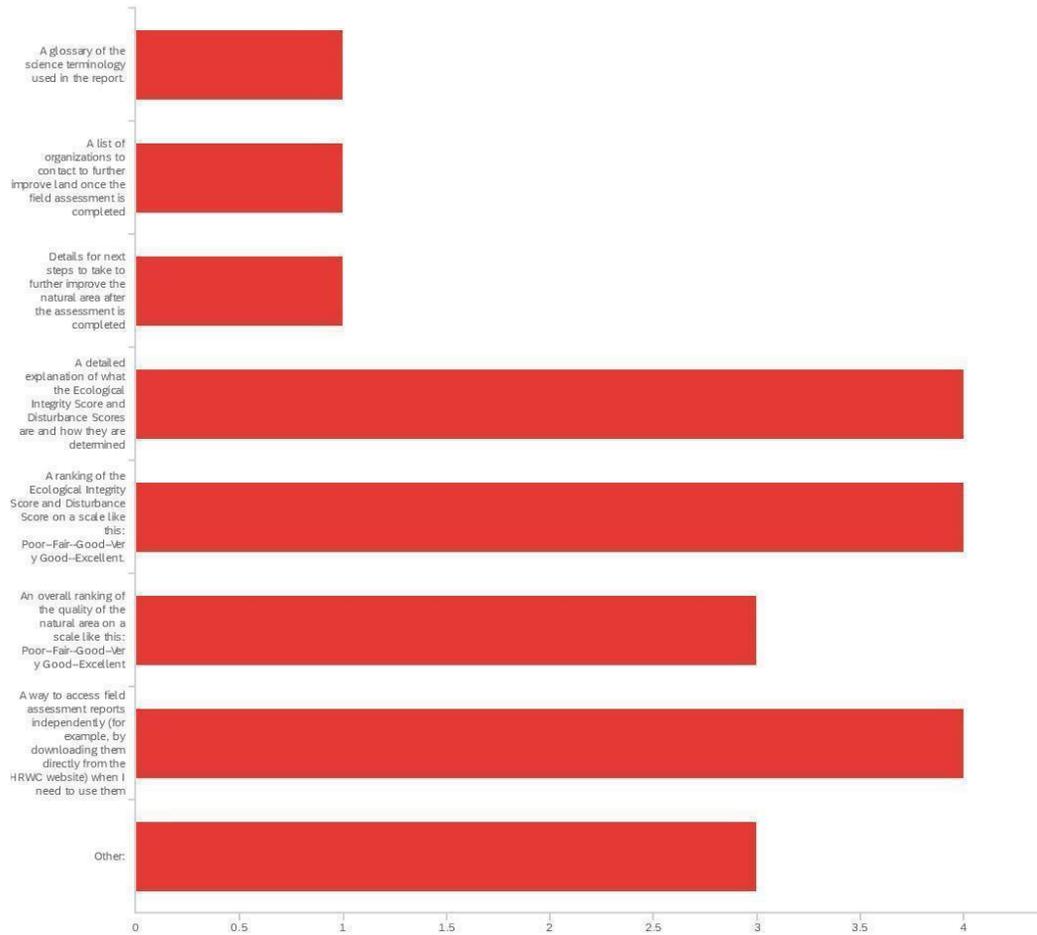
Q16_7_TEXT - Other:

Other:

Other:

I find it all to be valuable

Q17 - It would be helpful to me if HRWC field assessment reports also included: (Please select 3 that you would find the most helpful)



#	Field	Choice Count
1	A glossary of the science terminology used in the report.	4.76% 1
2	A list of organizations to contact to further improve land once the field assessment is completed	4.76% 1
3	Details for next steps to take to further improve the natural area after the assessment is completed	4.76% 1
4	A detailed explanation of what the Ecological Integrity Score and Disturbance Scores are and how they are determined	19.05% 4

#	Field	Choice Count
5	A ranking of the Ecological Integrity Score and Disturbance Score on a scale like this: Poor–Fair–Good–Very Good–Excellent.	19.05% 4
6	An overall ranking of the quality of the natural area on a scale like this: Poor–Fair–Good–Very Good–Excellent	14.29% 3
7	A way to access field assessment reports independently (for example, by downloading them directly from the HRWC website) when I need to use them	19.05% 4
8	Other:	14.29% 3
		21

Showing rows 1 - 9 of 9

Q17_8_TEXT - Other:

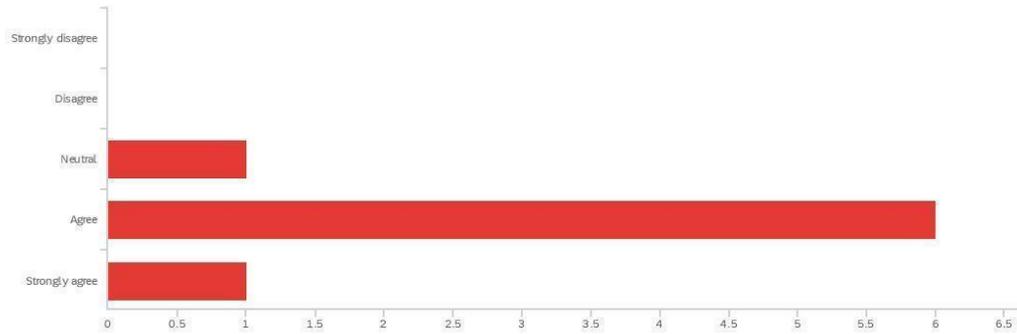
Other:

FQI for species identified

Kind of like tanking EIS and DS on a Poor to Excellent scale—I'd like to see rankings compared to other property rankings. What does excellent actually look like? What ranking is likely worth preserving and which is not?

An analysis of the township-level land conversion threats (e.g. Northfield Township's greatest land conversion pressure is conversion to 2-acre residential lots, and Pittsfield Township's greatest pressure may be conversion to PUD or Commercial/Mixed Use complexes. Beyond natural features of the property, what are the (relatively) tangible threats to the ecological integrity of the parcel if it is not permanently protected? Also, an estimated ecosystem services financial valuation of the parcel – that was if the conservation easement is valued at \$250K but the ecosystem services are worth \$50K/year then local units of government can see their ROI.

Q18 - Field assessment reports help me determine which natural areas are the most important to protect.

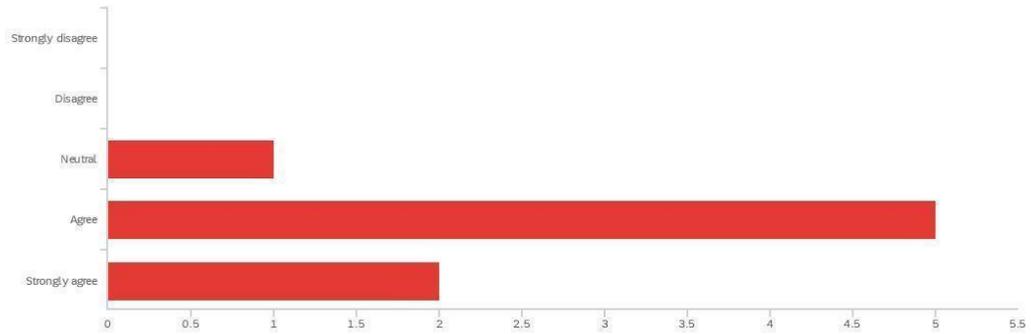


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Field assessment reports help me determine which natural areas are the most important to protect.	3.00	5.00	4.00	0.50	0.25	8

#	Field	Choice Count
1	Strongly disagree	0.00% 0
2	Disagree	0.00% 0
3	Neutral	12.50% 1
4	Agree	75.00% 6
5	Strongly agree	12.50% 1
		8

Showing rows 1 - 6 of 6

Q19 - To the best of my knowledge, HRWC has helped increase the amount of protected natural areas.

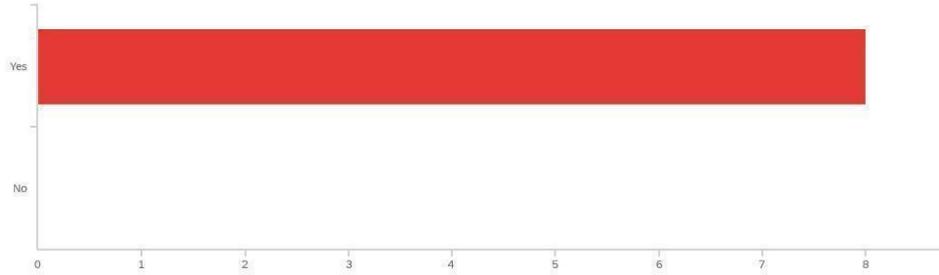


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	To the best of my knowledge, HRWC has helped increase the amount of protected natural areas.	3.00	5.00	4.13	0.60	0.36	8

#	Field	Choice Count
1	Strongly disagree	0.00% 0
2	Disagree	0.00% 0
3	Neutral	12.50% 1
4	Agree	62.50% 5
5	Strongly agree	25.00% 2
		8

Showing rows 1 - 6 of 6

Q20 - I have recommended an HRWC field assessment to a landowner or another organization.



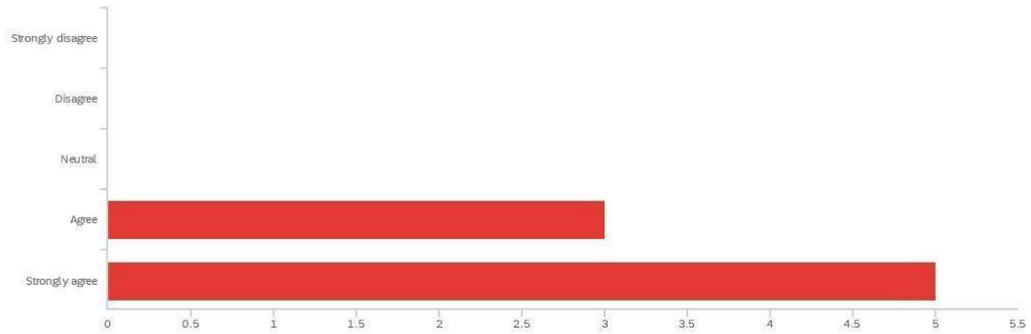
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	I have recommended an HRWC field assessment to a landowner or another organization.	1.00	1.00	1.00	0.00	0.00	8

#	Field	Choice Count
1	Yes	100.00% 8
2	No	0.00% 0

8

Showing rows 1 - 3 of 3

Q21 - I plan to recommend an HRWC field assessment to a landowner or another organization.



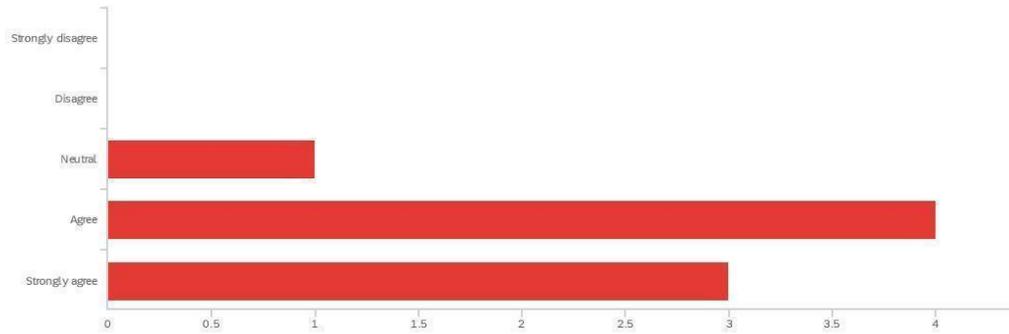
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	I plan to recommend an HRWC field assessment to a landowner or another organization.	4.00	5.00	4.63	0.48	0.23	8

#	Field	Choice Count
1	Strongly disagree	0.00% 0
2	Disagree	0.00% 0
3	Neutral	0.00% 0
4	Agree	37.50% 3
5	Strongly agree	62.50% 5
		8

Showing rows 1 - 6 of 6

Q23 - The definition of the Bioreserve Map was clearly explained to me in my field

assessment report.

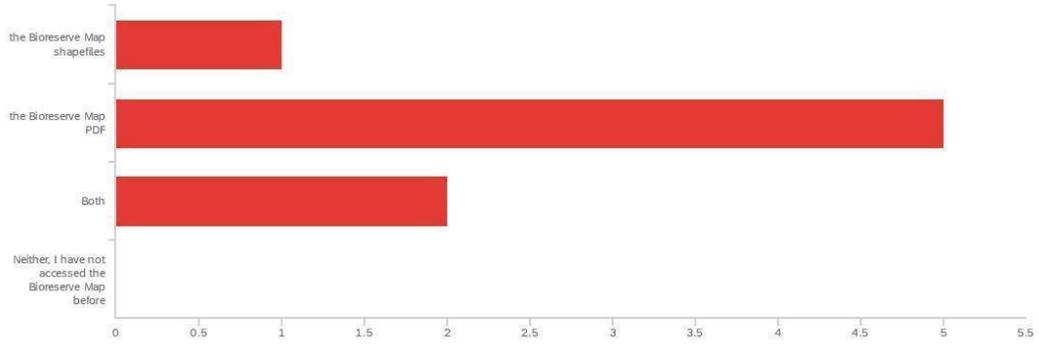


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	The definition of the Bioreserve Map was clearly explained to me in my field assessment report.	4.00	7.00	6.13	0.93	0.86	8

#	Field	Choice Count
1	Strongly disagree	0.00% 0
2	Disagree	0.00% 0
4	Neutral	12.50% 1
6	Agree	50.00% 4
7	Strongly agree	37.50% 3
		8

Showing rows 1 - 6 of 6

Q24 - I primarily use:

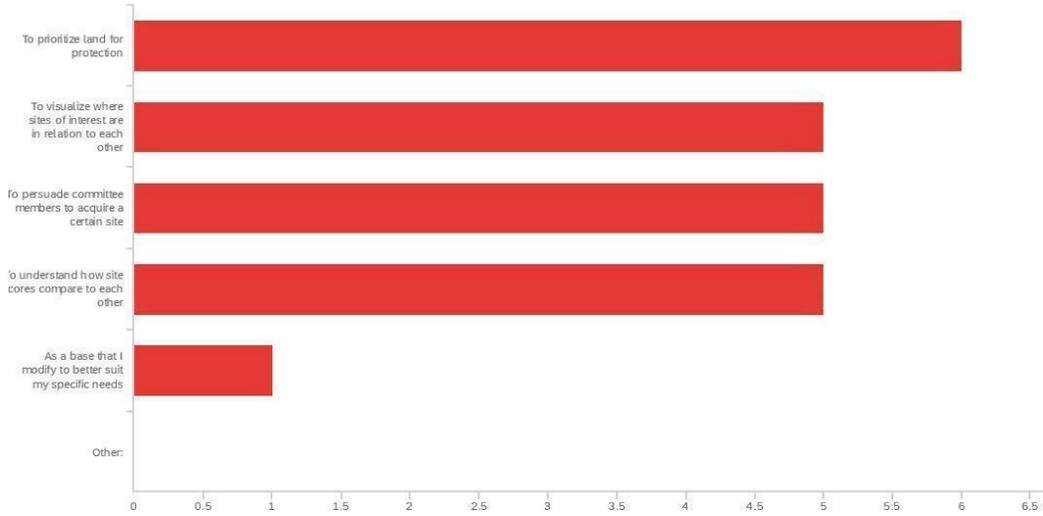


#	Field	Choice Count
1	the Bioreserve Map shapefiles	12.50% 1
2	the Bioreserve Map PDF	62.50% 5
5	Both	25.00% 2
6	Neither, I have not accessed the Bioreserve Map before	0.00% 0

8

Showing rows 1 - 5 of 5

Q25 - I use the Bioreserve Map: (Please select all that apply)



#	Field	Choice Count
1	To prioritize land for protection	27.27% 6
2	To visualize where sites of interest are in relation to each other	22.73% 5
3	To persuade committee members to acquire a certain site	22.73% 5
4	To understand how site scores compare to each other	22.73% 5
5	As a base that I modify to better suit my specific needs	4.55% 1
6	Other:	0.00% 0

22

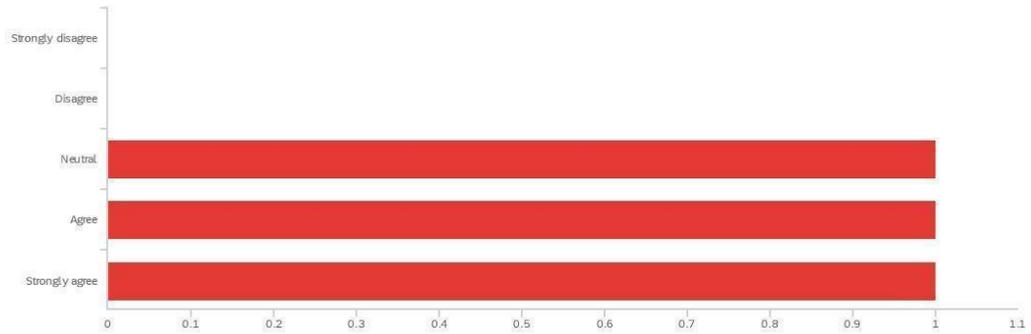
Showing rows 1 - 7 of 7

Q25_6_TEXT - Other:

Other:

Q26 - I am able to access the Bioreserve Map shapefiles quickly and independently

when I need to use them.

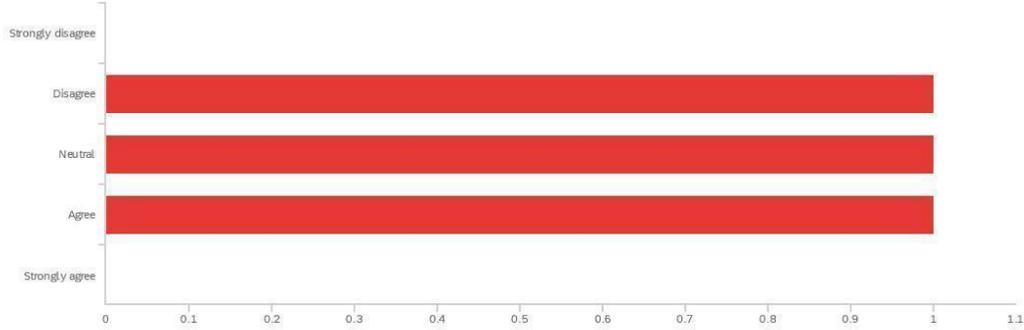


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	I am able to access the Bioreserve Map shapefiles quickly and independently when I need to use them.	3.00	5.00	4.00	0.82	0.67	3

#	Field	Choice Count
1	Strongly disagree	0.00% 0
2	Disagree	0.00% 0
3	Neutral	33.33% 1
4	Agree	33.33% 1
5	Strongly agree	33.33% 1
		3

Showing rows 1 - 6 of 6

Q27 - The Bioreserve Map shapefiles are easy to navigate and understand.

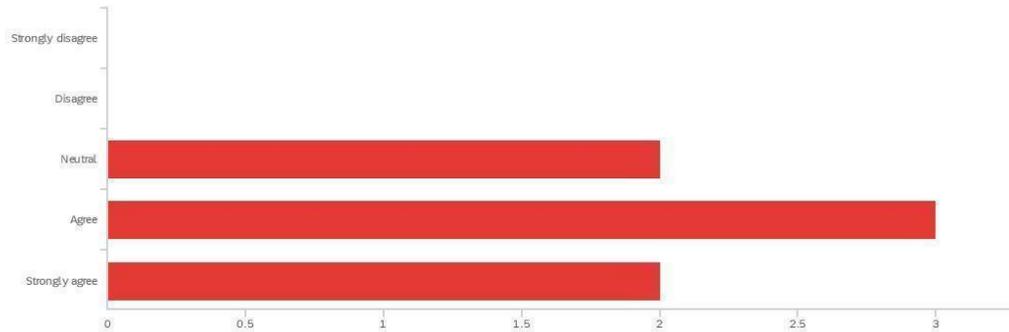


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	The Bioreserve Map shapefiles are easy to navigate and understand.	2.00	6.00	4.00	1.63	2.67	3

#	Field	Choice Count
1	Strongly disagree	0.00% 0
2	Disagree	33.33% 1
4	Neutral	33.33% 1
6	Agree	33.33% 1
7	Strongly agree	0.00% 0
		3

Showing rows 1 - 6 of 6

Q28 - I am able to access the Bioreserve Map PDF quickly and independently when I need to use it.

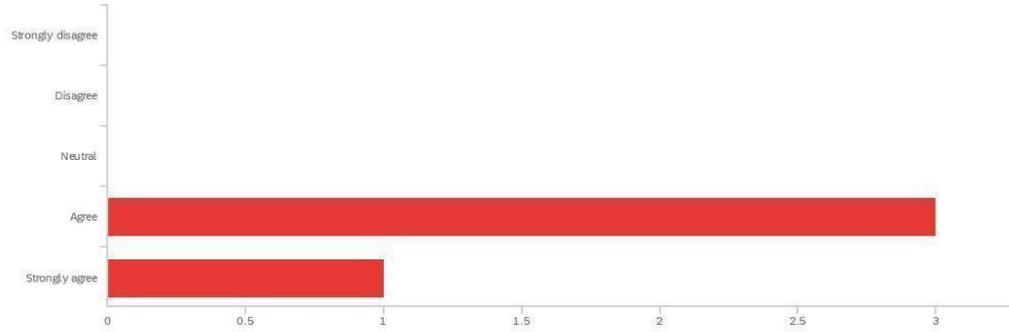


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	I am able to access the Bioreserve Map PDF quickly and independently when I need to use it.	3.00	5.00	4.00	0.76	0.57	7

#	Field	Choice Count
1	Strongly disagree	0.00% 0
2	Disagree	0.00% 0
3	Neutral	28.57% 2
4	Agree	42.86% 3
5	Strongly agree	28.57% 2
		7

Showing rows 1 - 6 of 6

Q29 - The Bioreserve Map PDF is easy to navigate and understand.

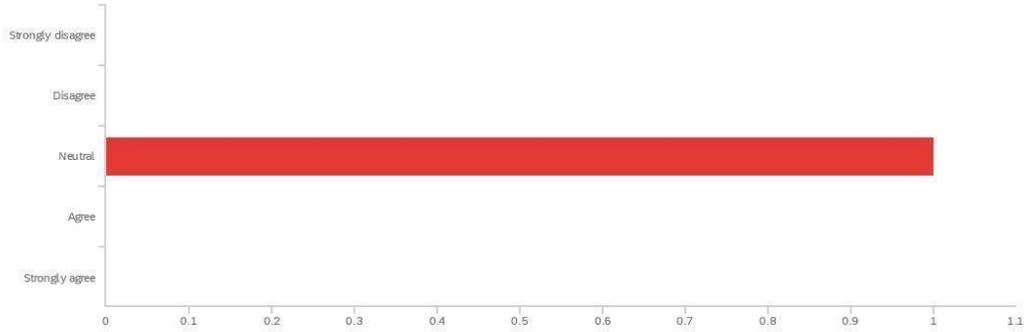


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	The Bioreserve Map PDF is easy to navigate and understand.	6.00	7.00	6.25	0.43	0.19	4

#	Field	Choice Count
1	Strongly disagree	0.00% 0
2	Disagree	0.00% 0
4	Neutral	0.00% 0
6	Agree	75.00% 3
7	Strongly agree	25.00% 1
		4

Showing rows 1 - 6 of 6

Q30 - I am interested in using the Bioreserve Map PDF.

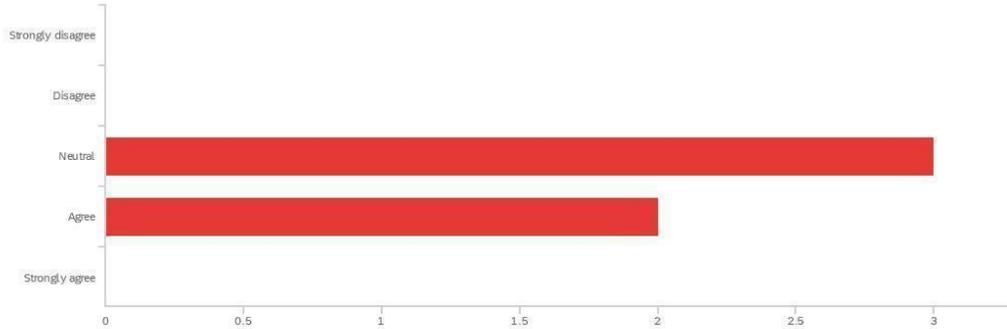


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	I am interested in using the Bioreserve Map PDF.	3.00	3.00	3.00	0.00	0.00	1

#	Field	Choice Count
1	Strongly disagree	0.00% 0
2	Disagree	0.00% 0
3	Neutral	100.00% 1
4	Agree	0.00% 0
5	Strongly agree	0.00% 0
		1

Showing rows 1 - 6 of 6

Q31 - I am interested in using the Bioreserve Map shapefiles.

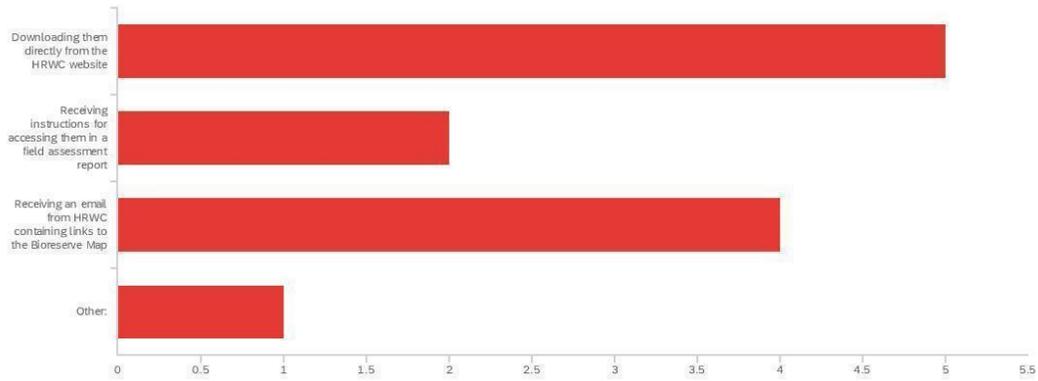


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	I am interested in using the Bioreserve Map shapefiles.	3.00	4.00	3.40	0.49	0.24	5

#	Field	Choice Count
1	Strongly disagree	0.00% 0
2	Disagree	0.00% 0
3	Neutral	60.00% 3
4	Agree	40.00% 2
5	Strongly agree	0.00% 0
		5

Showing rows 1 - 6 of 6

Q32 - I would prefer to access the Bioreserve Map PDF and/or shapefiles by:(Please choose 2 options that you would prefer the most)



#	Field	Choice Count
1	Downloading them directly from the HRWC website	41.67% 5
2	Receiving instructions for accessing them in a field assessment report	16.67% 2
3	Receiving an email from HRWC containing links to the Bioreserve Map	33.33% 4
4	Other:	8.33% 1

12

Showing rows 1 - 5 of 5

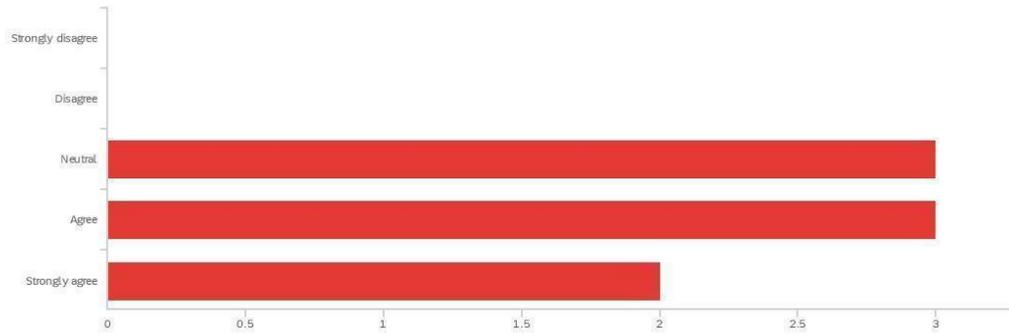
Q32_4_TEXT - Other:

Other:

an online map that I can use, zoom to parcels or areas, download the data etc.

Q33 - I understand how to interpret the Bioreserve Map Score provided in field

assessment reports.

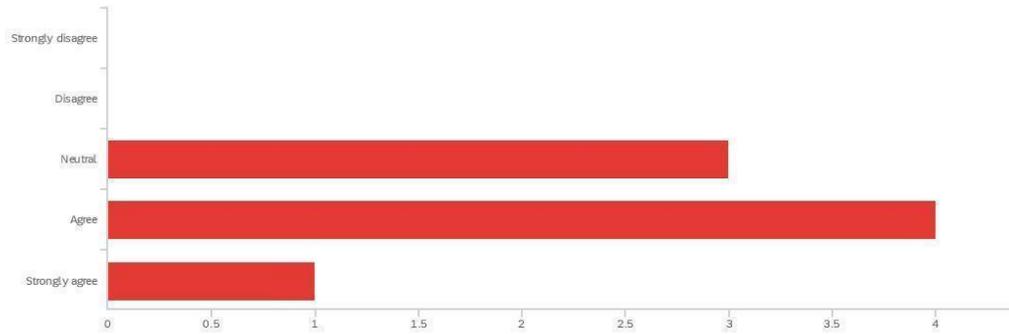


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	I understand how to interpret the Bioreserve Map Score provided in field assessment reports.	3.00	5.00	3.88	0.78	0.61	8

#	Field	Choice Count
1	Strongly disagree	0.00% 0
2	Disagree	0.00% 0
3	Neutral	37.50% 3
4	Agree	37.50% 3
5	Strongly agree	25.00% 2
		8

Showing rows 1 - 6 of 6

Q34 - To the best of my knowledge, the Bioreserve Map scores accurately convey the ecological integrity of the site being assessed.



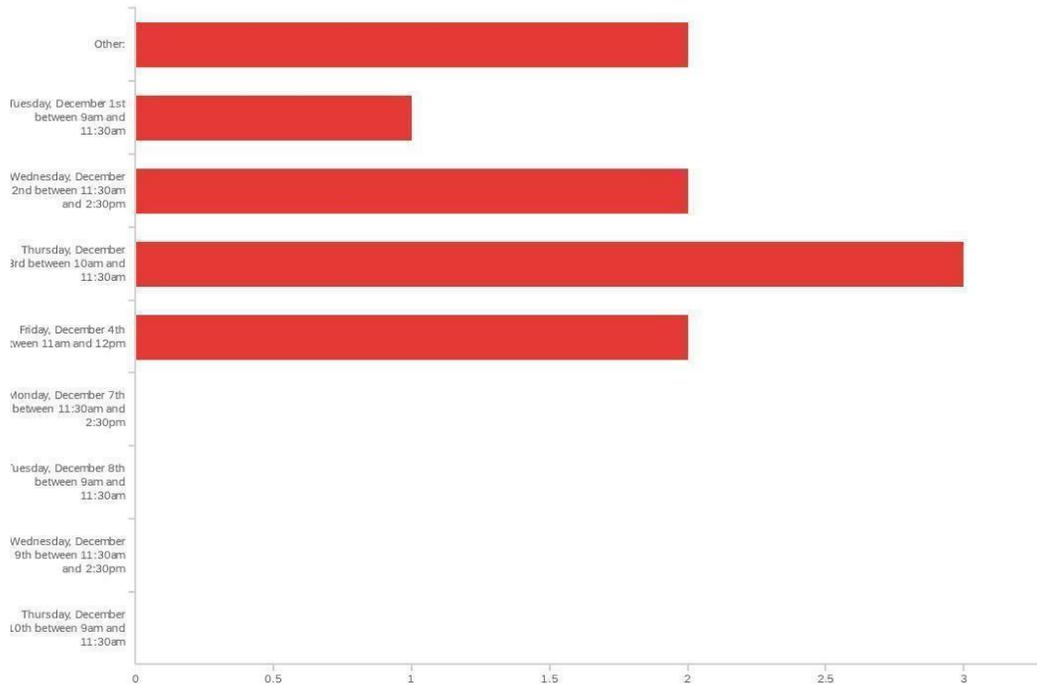
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	To the best of my knowledge, the Bioreserve Map scores accurately convey the ecological integrity of the site being assessed.	3.00	5.00	3.75	0.66	0.44	8

#	Field	Choice Count
1	Strongly disagree	0.00% 0
2	Disagree	0.00% 0
3	Neutral	37.50% 3
4	Agree	50.00% 4
5	Strongly agree	12.50% 1
		8

Showing rows 1 - 6 of 6

Q35 - The best times for me to have a brief 20-30 minute follow-up conversation about

my responses in this survey are: (Please select all that apply)



#	Field	Choice Count
9	Other:	20.00% 2
18	Tuesday, December 1st between 9am and 11:30am	10.00% 1
19	Wednesday, December 2nd between 11:30am and 2:30pm	20.00% 2
20	Thursday, December 3rd between 10am and 11:30am	30.00% 3
21	Friday, December 4th between 11am and 12pm	20.00% 2
22	Monday, December 7th between 11:30am and 2:30pm	0.00% 0
23	Tuesday, December 8th between 9am and 11:30am	0.00% 0
24	Wednesday, December 9th between 11:30am and 2:30pm	0.00% 0
25	Thursday, December 10th between 9am and 11:30am	0.00% 0

#	Field	Choice Count
		10

Showing rows 1 - 10 of 10

Q35_9_TEXT - Other:

Other:

Any day between December 14th and Dec 31st

we have an appointment tomorrow from 9:30-10 am

End of Report

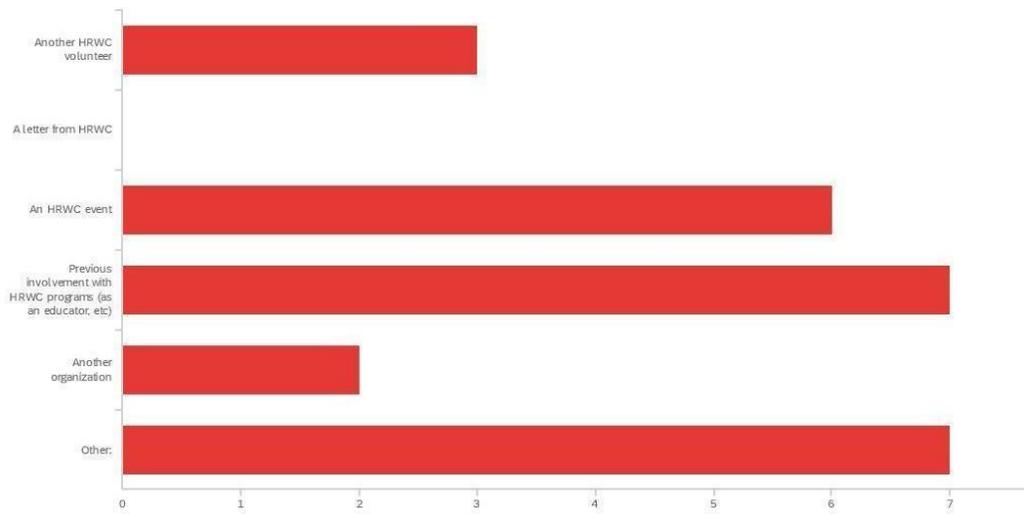
Volunteers

Default Report

HRWC Masters Project Survey for Volunteers

December 30, 2020 5:06 PM MST

Q2 - I heard about HRWC through: (Please select all that apply)



#	Field	Choice Count
1	Another HRWC volunteer	12.00% 3
2	A letter from HRWC	0.00% 0
3	An HRWC event	24.00% 6
4	Previous involvement with HRWC programs (as an educator, etc)	28.00% 7
5	Another organization	8.00% 2
6	Other:	28.00% 7

25

Showing rows 1 - 7 of 7

Q2_6_TEXT - Other:

Other:

Don't remember

Other:

can't recall, have been a volunteer for many years

through Laura Rubin, 20 years ago (as a friend)

Don't remember

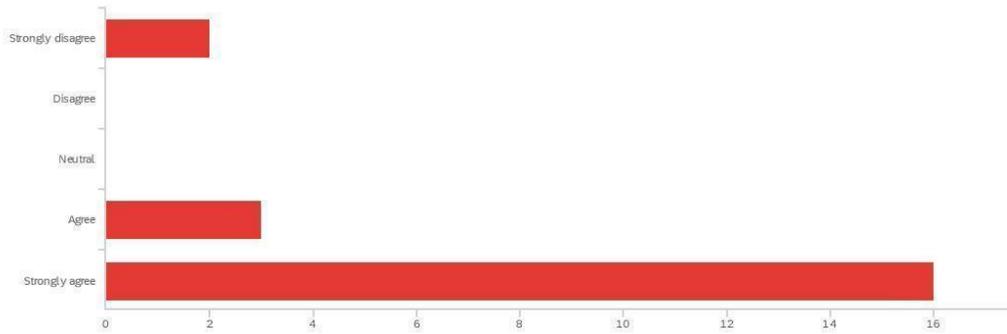
newspapers

I don't remember. It was years ago.

visited during a UM class

Q3 - After submitting my volunteer sign-up form, I heard back from HRWC in a timely

manner.

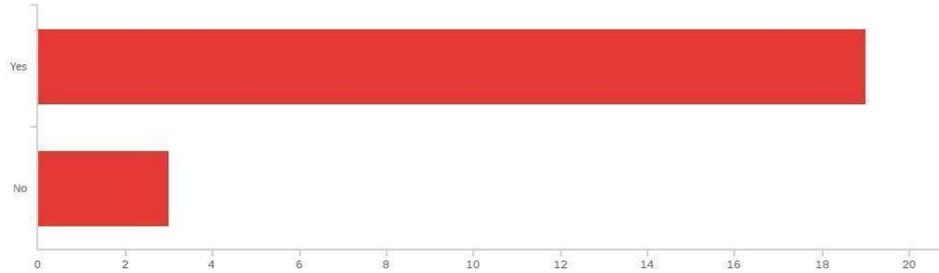


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	After submitting my volunteer sign-up form, I heard back from HRWC in a timely manner.	1.00	5.00	4.48	1.18	1.39	21

#	Field	Choice Count
1	Strongly disagree	9.52% 2
2	Disagree	0.00% 0
3	Neutral	0.00% 0
4	Agree	14.29% 3
5	Strongly agree	76.19% 16
		21

Showing rows 1 - 6 of 6

Q4 - I completed NAAP volunteer training.



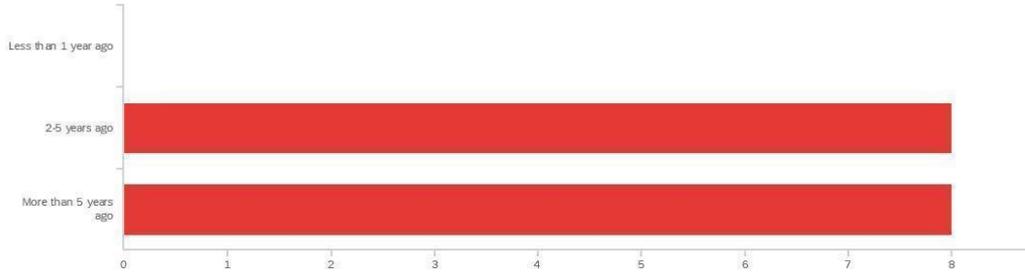
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	I completed NAAP volunteer training.	1.00	2.00	1.14	0.34	0.12	22

#	Field	Choice Count
1	Yes	86.36% 19
2	No	13.64% 3

22

Showing rows 1 - 3 of 3

Q5 - I completed NAAP volunteer training:

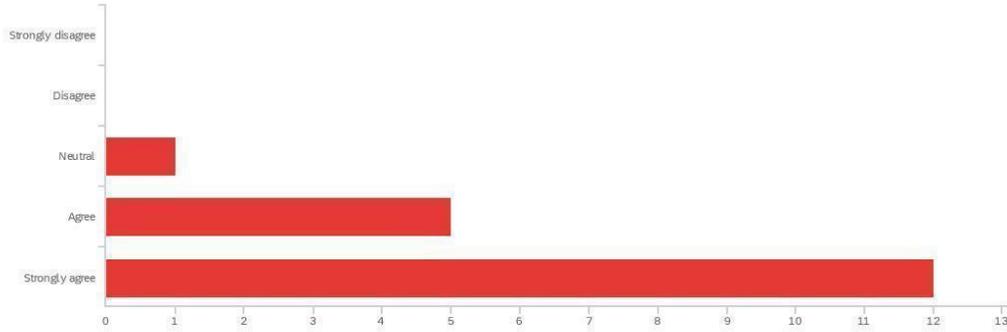


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	I completed NAAP volunteer training:	2.00	3.00	2.50	0.50	0.25	16

#	Field	Choice Count
1	Less than 1 year ago	0.00% 0
2	2-5 years ago	50.00% 8
3	More than 5 years ago	50.00% 8
		16

Showing rows 1 - 4 of 4

Q6 - I understand what the purpose of field assessments are.

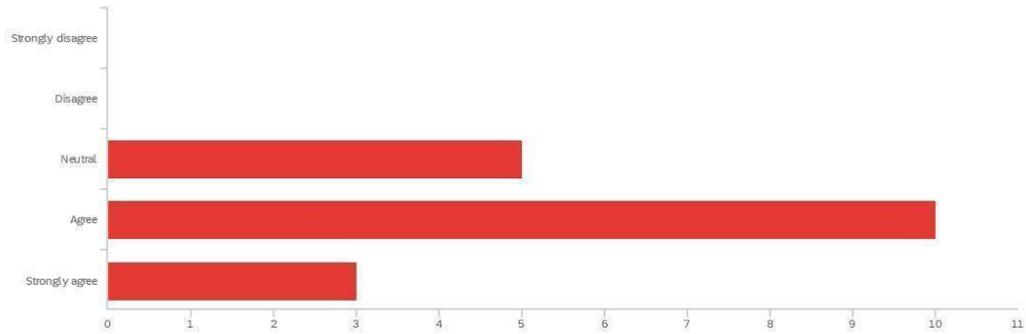


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	I understand what the purpose of field assessments are.	3.00	5.00	4.61	0.59	0.35	18

#	Field	Choice Count
1	Strongly disagree	0.00% 0
2	Disagree	0.00% 0
3	Neutral	5.56% 1
4	Agree	27.78% 5
5	Strongly agree	66.67% 12
		18

Showing rows 1 - 6 of 6

Q7 - Before volunteering, I felt like I had a good understanding of what my volunteer experience would be like (i.e. how long it would take, what I was supposed to do.)

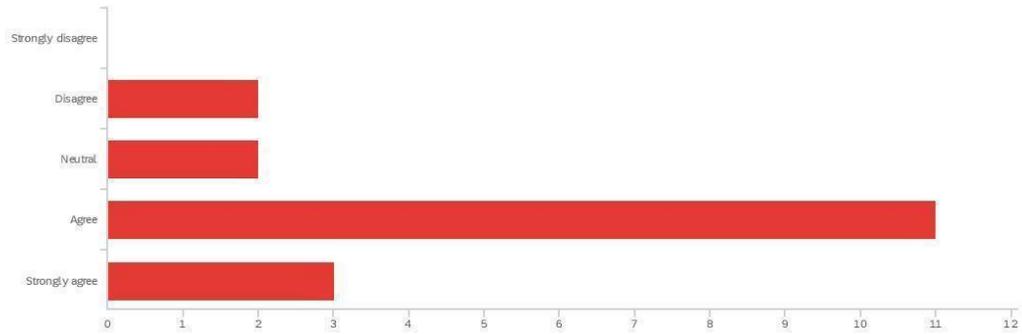


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Before volunteering, I felt like I had a good understanding of what my volunteer experience would be like (i.e. how long it would take, what I was supposed to do.)	3.00	5.00	3.89	0.66	0.43	18

#	Field	Choice Count
1	Strongly disagree	0.00% 0
2	Disagree	0.00% 0
3	Neutral	27.78% 5
4	Agree	55.56% 10
5	Strongly agree	16.67% 3
		18

Showing rows 1 - 6 of 6

Q8 - While volunteering, I felt like I understood all of the ecosystem terminology on my field assessment worksheet.



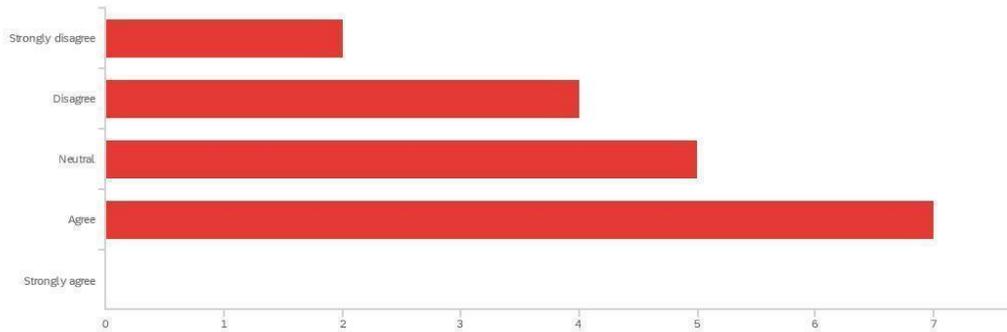
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	While volunteering, I felt like I understood all of the ecosystem terminology on my field assessment worksheet.	2.00	5.00	3.83	0.83	0.69	18

#	Field	Choice Count
1	Strongly disagree	0.00% 0
2	Disagree	11.11% 2
3	Neutral	11.11% 2
4	Agree	61.11% 11
5	Strongly agree	16.67% 3
		18

Showing rows 1 - 6 of 6

Q9 - While volunteering, I felt that I could correctly identify the species on my field

assessment worksheet.

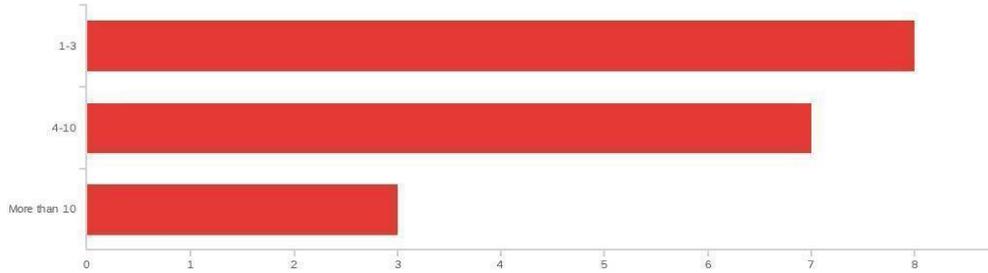


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	While volunteering, I felt that I could correctly identify the species on my field assessment worksheet.	1.00	4.00	2.94	1.03	1.05	18

#	Field	Choice Count
1	Strongly disagree	11.11% 2
2	Disagree	22.22% 4
3	Neutral	27.78% 5
4	Agree	38.89% 7
5	Strongly agree	0.00% 0
		18

Showing rows 1 - 6 of 6

Q10 - I have completed ____ field assessments.

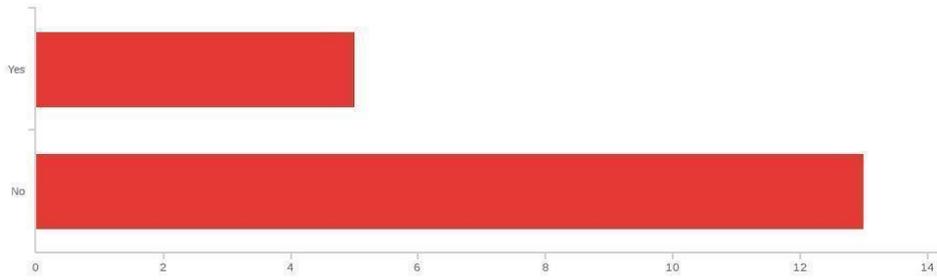


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	I have completed ____ field assessments.	1.00	3.00	1.72	0.73	0.53	18

#	Field	Choice Count
1	1-3	44.44% 8
2	4-10	38.89% 7
3	More than 10	16.67% 3
		18

Showing rows 1 - 4 of 4

Q11 - While volunteering, I used the Bioreserve Project Rapid Field Assessment Plant Guide (the spiral-bound booklet with pictures of the most common plant species for each ecosystem type) to help me fill out the field assessment worksheet.



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	While volunteering, I used the Bioreserve Project Rapid Field Assessment Plant Guide (the spiral-bound booklet with pictures of the most common plant species for each ecosystem type) to help me fill out the field assessment worksheet.	1.00	6.00	4.61	2.24	5.02	18

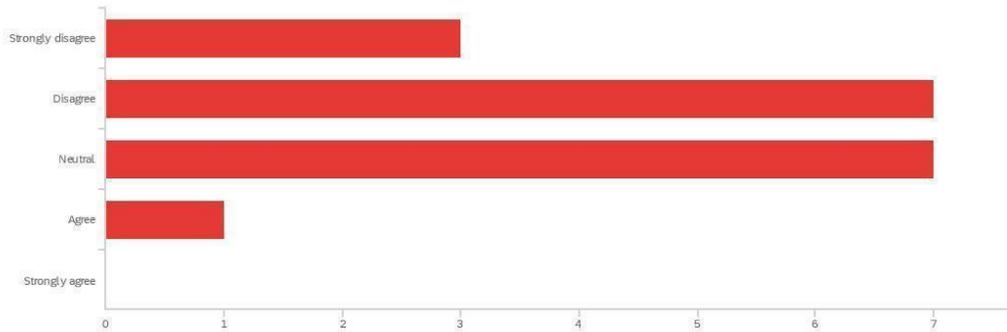
#	Field	Choice Count
1	Yes	27.78% 5
6	No	72.22% 13

18

Showing rows 1 - 3 of 3

Q12 - While volunteering, I felt like I guessed for many of my answers on my field

assessment worksheet.

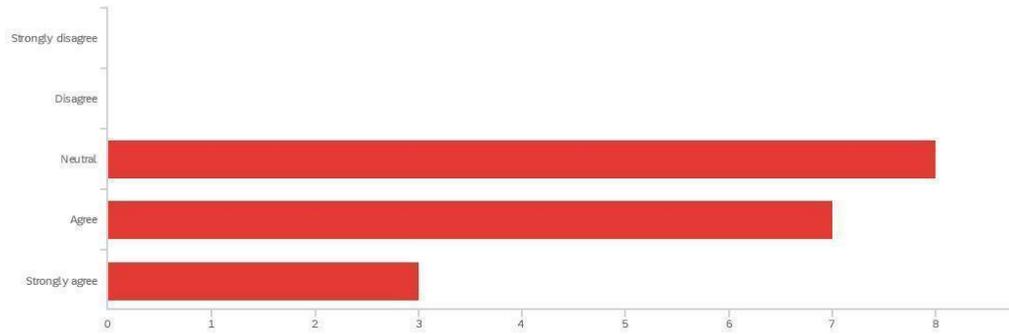


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	While volunteering, I felt like I guessed for many of my answers on my field assessment worksheet.	1.00	4.00	2.33	0.82	0.67	18

#	Field	Choice Count
1	Strongly disagree	16.67% 3
2	Disagree	38.89% 7
3	Neutral	38.89% 7
4	Agree	5.56% 1
5	Strongly agree	0.00% 0
		18

Showing rows 1 - 6 of 6

Q13 - I believe that the field assessment worksheet covered all of the important aspects of ecological integrity.

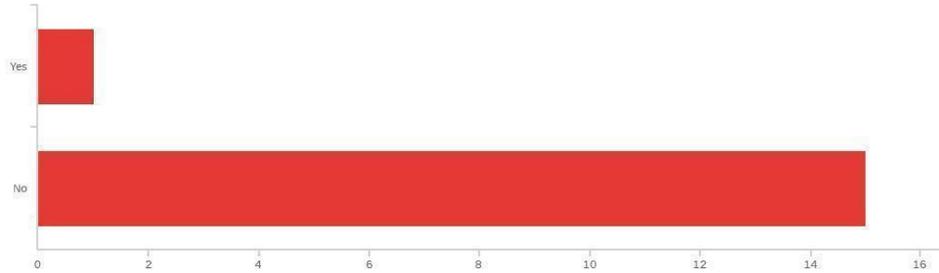


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	I believe that the field assessment worksheet covered all of the important aspects of ecological integrity.	3.00	5.00	3.72	0.73	0.53	18

#	Field	Choice Count
1	Strongly disagree	0.00% 0
2	Disagree	0.00% 0
3	Neutral	44.44% 8
4	Agree	38.89% 7
5	Strongly agree	16.67% 3
		18

Showing rows 1 - 6 of 6

Q14 - I feel that something important was missing from the field assessment worksheet.



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	I feel that something important was missing from the field assessment worksheet.	1.00	2.00	1.94	0.24	0.06	16

#	Field	Choice Count
1	Yes	6.25% 1
2	No	93.75% 15

16

Showing rows 1 - 3 of 3

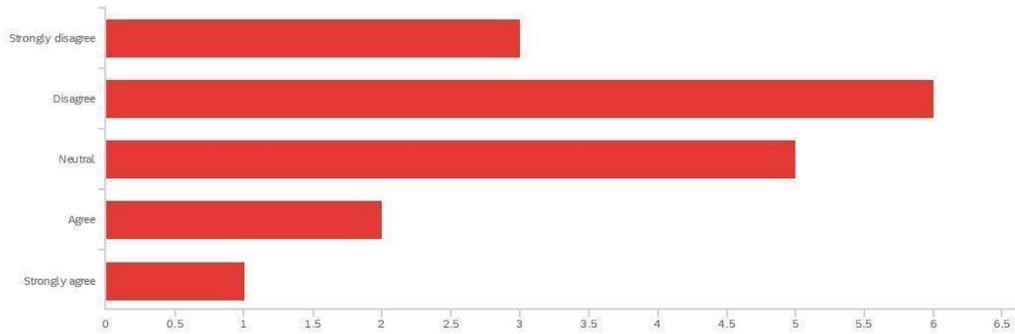
Q15 - Please specify what was missing:

Please specify what was missing:

I probably would have selected some different indicator species for some habitats based on the areas that I surveyed

Q16 - During field assessments, I would prefer to enter information on a mobile app

rather than on sheets of paper.

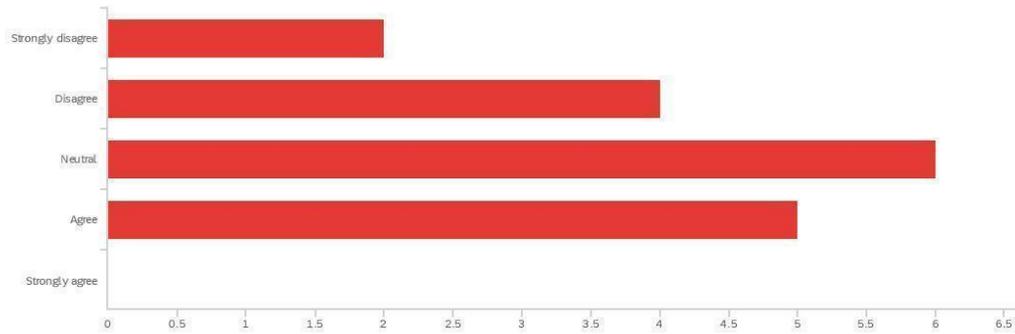


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	During field assessments, I would prefer to enter information on a mobile app rather than on sheets of paper.	1.00	5.00	2.53	1.09	1.19	17

#	Field	Choice Count
1	Strongly disagree	17.65% 3
2	Disagree	35.29% 6
3	Neutral	29.41% 5
4	Agree	11.76% 2
5	Strongly agree	5.88% 1
		17

Showing rows 1 - 6 of 6

Q17 - I think that the accuracy and efficiency of field assessments would be improved by entering information on a mobile app rather than on sheets of paper.

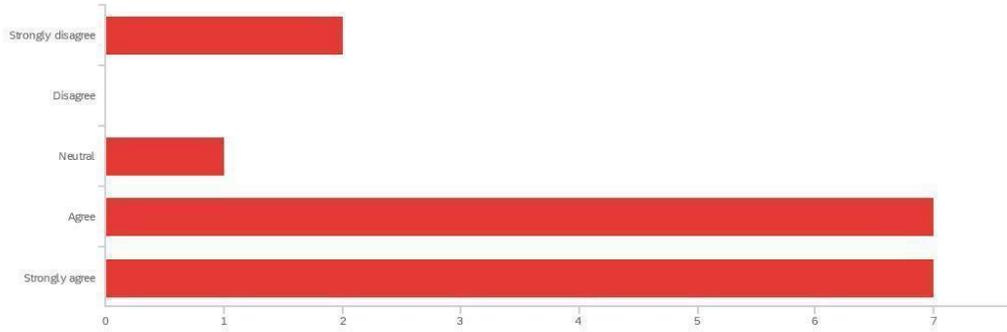


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	I think that the accuracy and efficiency of field assessments would be improved by entering information on a mobile app rather than on sheets of paper.	1.00	4.00	2.82	0.98	0.97	17

#	Field	Choice Count
1	Strongly disagree	11.76% 2
2	Disagree	23.53% 4
3	Neutral	35.29% 6
4	Agree	29.41% 5
5	Strongly agree	0.00% 0
		17

Showing rows 1 - 6 of 6

Q18 - I plan to volunteer with HRWC again.

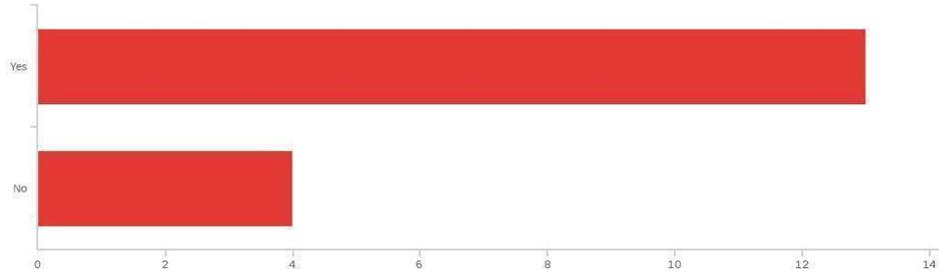


#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	I plan to volunteer with HRWC again.	1.00	5.00	4.00	1.24	1.53	17

#	Field	Choice Count
1	Strongly disagree	11.76% 2
2	Disagree	0.00% 0
3	Neutral	5.88% 1
4	Agree	41.18% 7
5	Strongly agree	41.18% 7
		17

Showing rows 1 - 6 of 6

Q19 - I have recommended volunteering with HRWC to a friend.



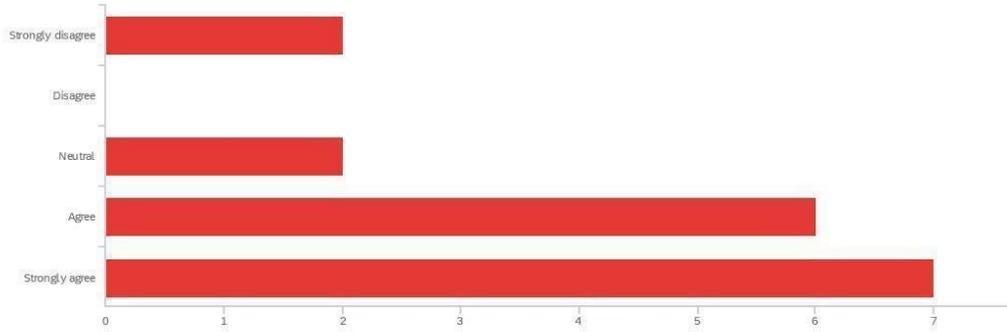
#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1.	I have recommended volunteering with HRWC to a friend.	1.00	2.00	1.24	0.42	0.18	17

#	Field	Choice Count
1	Yes	76.47% 13
2	No	23.53% 4

17

Showing rows 1 - 3 of 3

Q20 - I will recommend volunteering with HRWC to a friend.



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	I will recommend volunteering with HRWC to a friend.	1.00	5.00	3.94	1.26	1.58	17

#	Field	Choice Count
1	Strongly disagree	11.76% 2
2	Disagree	0.00% 0
3	Neutral	11.76% 2
4	Agree	35.29% 6
5	Strongly agree	41.18% 7
		17

Showing rows 1 - 6 of 6

Q21 - Optional: Do you have any suggestions for how volunteer training could be improved?

Optional: Do you have any suggestions for how volunteer training could be i...

waders need to be more clearly marked for size

On the ground and in the field with an experienced "expert" for the first couple of times out would be good.

My training was basically working along with another volunteer. Circumstances were such that I learned what I needed to know. However, I did not fo the formal training so I cannot evaluate it.

I didn't have enough knowledge to begin with.

Nope

Q22 - Optional: Do you have any suggestions for how to increase the accuracy of field assessments?

Optional: Do you have any suggestions for how to increase the accuracy of f...

More pull downs

Plant ID could be assisted in the field with an app like iNaturalist. Some apps may not give correct IDs, tho. Standardizing on one recommended app might help.

delete people like me.

Compare volunteers on standardized Species identifications or assessments both the evaluate their accuracy and also to train them.

Refresher training for people who went through training years ago.

Honestly, having the guide for most common species is SOLIDLY the most helpful. Also, having at least one "expert" with experience in field ID can do a LOT to help. Maybe having a way to associate pictures with assumed id so people can double check back at the office?

Q23 - Optional: Do you have any suggestions for how to improve volunteer experience?

Optional: Do you have any suggestions for how to improve volunteer experien...

Share site final reports and any feedback from or actions taken on recommendations from site owners.

I shouldn't have been there.

Nope

Q24 - Optional: Do you have any additional comments or suggestions?

Optional: Do you have any additional comments or suggestions?

The field book re: species was not relevant to my service as a river flow/particulate monitor.

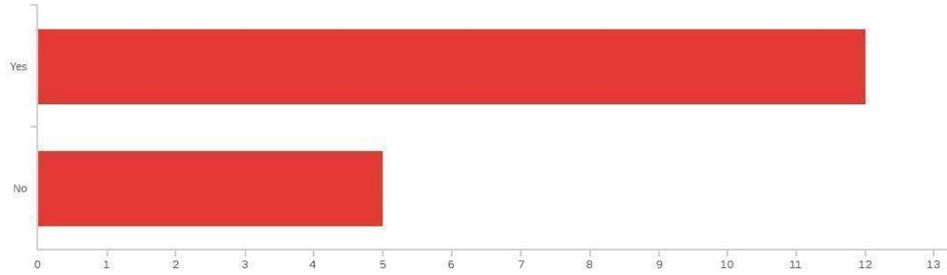
It's been quite a few years since I started as a bioserve volunteer and have truly enjoyed getting to some lovely private properties that otherwise would not have public access. Unfortunately, I will need to decline future field adventures for now due to limited mobility.

no

If this survey is just about the Bioserve Assessments, my survey results should probably be removed because I only did data entry for those. But if this can include the stream surveys, then my responses should be included since that's 90% of what I did.

When I've volunteered with HRWC, I've always felt like my contributions were valued.

Q25 - May we contact you with follow up questions?



#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	May we contact you with follow up questions?	1.00	2.00	1.29	0.46	0.21	17

#	Field	Choice Count
1	Yes	70.59% 12
2	No	29.41% 5

17

Showing rows 1 - 3 of 3

Q26 - Please enter the best email to reach you at for follow up questions:

Please enter the best email to reach you at for follow up questions:

kfpeabody@gmail.com

Sucila@umich.edu

worldsmith@me.com

t_spears2000@yahoo.com

conruth@umich.edu

dengel@chikamingopenlands.org

mary@megatechnologies.com

leejburton@charter.net

jbeach89@hotmail.com

pamela.rose.baker@gmail.com

Larry.a.scheer@gmail.com

chknight@umich.edu

End of Report