Identifying and Ranking Natural Areas in the Huron River Watershed

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A practicum submitted in partial fulfillment of the
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April 27, 2002

Abstract

With rural development happening at rapid speed, there is a critical need to identify potential natural areas for preservation within the Huron River watershed. Geographic Information Systems (GIS) can provide a quick, cost effective methodology for the identification and assessment of natural areas and can guide conservation planning efforts. The authors of this study were invited by the Huron River Watershed Council (HRWC) to develop methodology for the ranking and prioritization of natural areas already identified by HRWC. A classification method based on seven major indicators of ecological diversity and hydrologic function was developed and implemented. Because of limitations discovered in the original site selection process, an alternative site selection methodology was developed. Using identical ranking criteria, the alternative sites selected were classified. The results of the two site selection processes are compared and improved methods for selecting and ranking natural areas are suggested.

Table of Contents

Abstract 2

Introduction

Orientation to the Watershed 4

The Implications of Unbridled Development 5

Humans, Nature and Preservation 6

Natural Areas Protection and GIS, a Literature Review 7

Conservation Planning in the Huron River Watershed 11

Project Goals 13

Methods

Identifying Natural Areas 14

Aerial Photography Site Selection Method 15

MIRIS Data Site Selection Method 16

Selection of Ranking Criteria 16

Discussion of Ranking Criteria 18

Ranking and Classification 24

Supplemental Data 26

Results

Natural Areas Identification 27

Natural Areas Ranking and Classification 28

Site Selection and Supplemental Data 31

Analysis

Site Selection 34

Data Limitations 37

Ranking and Classification 38

Examples 41

Bias in Classification 45

Discussion 46

Recommendations 48

Introduction

Orientation to the Watershed

The Huron River watershed is an hourglass shaped area of land covering most of Washtenaw County and parts of Jackson, Livingston, Monroe, Oakland and Wayne Counties in Southeastern Michigan. The upper reaches of the watershed are characterized by rolling topography and numerous lakes formed by remnant ice blocks as the last glaciers melted 14,000 years ago. As the Huron River flows southwest into Washtenaw county and curves to the southeast, the topography flattens, lakes become fewer, and the wooded hills give way to a relatively flat and open landscape. In the lowest reaches in Wayne and Macomb Counties, the river flows across the flat bottom of an ancient, glacial lake, ultimately emptying into Lake Erie.

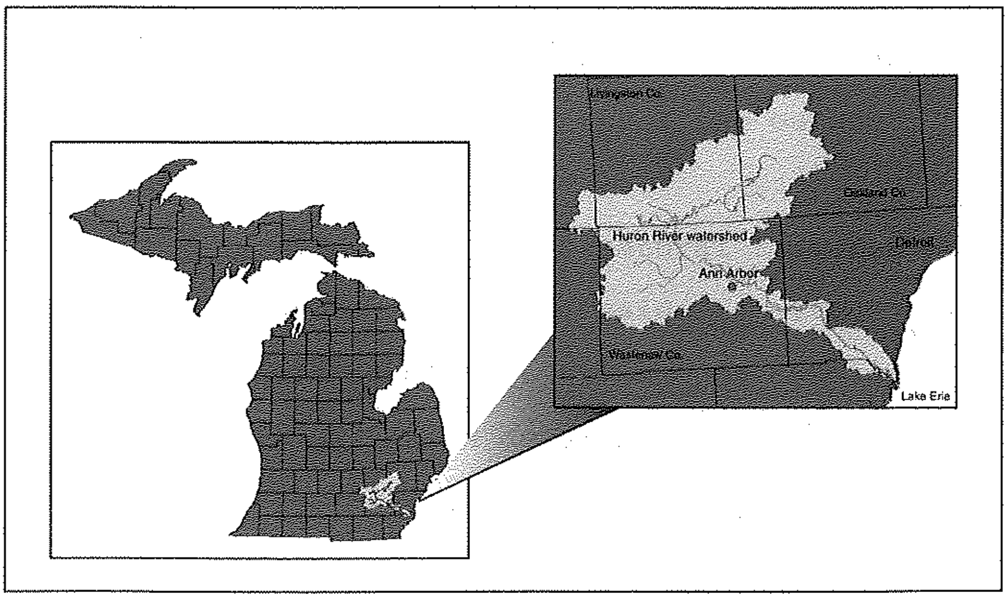


Figure 1. Location map of watershed

The Implications of Unbridled Development

The Huron River watershed is diverse in topography, vegetation and land use. This diversity is particularly striking when the watershed is compared to the flat, urbanized landscape of metropolitan Detroit immediately to the east. As regional population grows and rural developmental increases in areas farther from the Detroit urban core and other population centers such as Ann Arbor and Ypsilanti, the environment and water quality of the Huron River watershed is affected. Trees, water, and diverse topography are attractive to residential development, as illustrated by subdivision names like "Oak Valley" or "The Preserve." Although people move to the watershed for its interesting and unique natural features, their very arrival can compromise this natural quality. The upper reaches of the watershed are renown swimming, hiking and bicycling destinations. Residential encroachment on open land can spoil the outdoor experience.

Not only does the loss of natural features threaten the quality of life for human residents of the area, it threatens the health of regional ecological systems as well. Conventional human development as it occurs today in the Huron River watershed has harmful effects on interconnected terrestrial and aquatic systems of the region. Residential development has been shown to severely impact the hydrological processes of streams and rivers (Roesner, 2001, 201). Septic systems used for rural development can fail and lead to surface water or groundwater contamination. Negative changes in water quality, stream flows, and biotic communities have been shown to increase as the amount of urban use within a watershed grows (Wang, et al., 2001, 255). Unregulated development fragments native terrestrial habitats, which in turn threatens animal and plant species that rely on large areas of unbroken habitat for food and reproduction. The trees, woods and waters of the Huron River watershed are used as amenities for housing or other development, but natural areas must be preserved and restored to maintain water quality, protect habitat, and provide opportunity for human recreation and restoration.

Humans, Nature, and Preservation

The identification of natural areas remaining within the watershed is an important first step towards protecting ecologically valuable features from further development. Because few people actually agree on what "natural" means, the identification of "natural areas" within the watershed can be a challenge. To many people a natural area is anywhere outside of the human sphere of influence, but within the Huron River watershed, there are precious few areas that have never been cut, pastured or plowed. Although identifying pristine areas for preservation may be easy due to their limited number, identifying and preserving only untouched lands would not be a comprehensive land preservation strategy. Additionally, many of these near pristine areas are already under at least some sort of protection.

The length of time that an area is outside of human influence can lead to a certain degree of naturalness. Many attractive and diverse woodlands throughout the region were once cut or grazed, and one of the watershed's more diverse and interesting prairies was at one time a former gravel mine. Povlitus (2002) suggests that an area increases in naturalness "when people do the right things in terms of biodiversity, ecological health, and environmental sustainability." This unifying concept of humans as a potential force for ecological stewardship reinforces the need for natural areas identification and preservation. Although current development patterns rarely represent this new human-nature paradigm, humans have the opportunity to shake their historic role of environmental destroyer to one of caretaker, steward and guardian of natural areas. Without adequate preservation efforts today, we will not have the opportunity to move toward a society that sustains and protects natural areas as celebrated, integrated features of the community.

Natural Areas Protection and GIS, a Literature Review

The factors that compromise the natural environment and character of an area often go beyond political boundaries and need to be considered at a broader watershed scale. However, the coordinated conservation efforts needed to preserve and protect natural areas within a fragmented landscape are lacking. When preservation does occur, natural areas are all too often preserved because they are "not suitable for development" (i.e. due to steep slopes or poor soils) rather than being protected because of a concerted effort to preserve lands of high ecological value. Because of a lack of planning, these undeveloped areas fail to serve as a connected, landscape-scale ecosystem network (Ndubisi 160). Furthermore, when conservation based on the ecological value of an area does occur, it is frequently piecemeal and on a small, local scale, rather than a coordinated regional effort toward creating connected natural systems that stretch across political boundaries (Ndubisi 160).

Conservation biologists increasingly advocate a larger scale approach to natural areas conservation (Noss in Lanthrop, 27). A comprehensive *regional* planning method that targets valuable ecological resources is needed. Methods that identify natural areas by targeting remaining parcels of high ecological value must be developed, rather than simply "preserving" land that is not suitable for human use. Natural areas preservation must consider the individual qualities of the units to be preserved *and* the connection of these units to larger regional or even national ecological networks. A logical first step is the development and refinement of methodology that targets valuable ecological resources at a local scale.

In the Huron River watershed, field study as a means to assess preservation needs is impractical, not only due to the size of the watershed, but also because much of the land area in the watershed is privately owned. The development of a quick and cost effective methodology for the identification and assessment of natural areas can guide conservation efforts. Additionally, determining the location of high quality natural areas across the watershed can lead planners to a better understanding of places where development may be more appropriate. Finally, identification of smaller natural areas could help planners develop a larger, interconnected network of reserves throughout the entire watershed.

According to Lee, et al (2001) much effective conservation planning utilizes GIS in a multi-layer landscape approach that analyzes numerous, complex spatial data features. GIS is a powerful tool for the manipulation and analysis of spatial data from disparate sources (Veitch, et al. 92) and digital spatial data and user-friendly GIS technology is increasingly available. Examples of the use of GIS in conservation planning abound in the literature. Although each differs in scale and focus, each application is a unique, multi-factor analysis of natural features and human impacts combined to provide information toward more effective management decisions.

At a large scale, Loomis and Echohawk (1998) used GIS to identify ecological provinces in the United States that were under-represented as parts of the US National Wilderness Preservation System. In the United Kingdom, GIS has been used to help mitigate the impacts of roads. Treweek and Vietch (1996) analyzed the hypothetical routes of two roads to determine regional and local impacts of road construction on land consumption and habitat fragmentation.

At smaller scales, Lanthrop and Bognar (1998) effectively used GIS to prioritize land in the Sterling Forest along the New York/New Jersey border for conservation protection. This study took into account traditional limitations to development such as soil constraints, but also analyzed geographically variable factors such as non-point source pollution potentials, habitat fragmentation potential, and visibility impacts from the Appalachian and local trails. The Missouri Department of Conservation has effectively used GIS to make management decisions by combining traditional fisheries sampling techniques (species richness), the habitat characteristics of river reaches, percent of public land, and number of human impacts, such as mining or agriculture on a watershed (Hawks et. al. 2000). Like the Sterling Forest case study, this study prioritized areas for conservation by using remotely sensed data to minimize extensive field checking, speeding land preservation acquisition while focusing the scarce resources of a state organization. In each of these examples, the use of GIS offers considerable advantages over manual analysis because of its speed and flexibility (Lee 2001) and it is effectively being used in ecosystem management approaches to natural areas preservation (Weber and Wolf, 2000).

Conservation Planning in the Huron River Watershed

The Huron River Watershed Council (HRWC) recognized the need for information about remaining natural areas in the region, and began a project to find the location and ecological quality of natural areas throughout the watershed. The 1999 proposal, "Conservation Planning in the Huron River Watershed" noted development as a major threat to the Huron River, and stressed the need for a rapid, qualitative assessment of the areas that remained. The proposal suggested the development of a methodology to inventory natural areas and features because detailed information from field studies about critical habitats and natural areas was lacking. The project's broad goals aimed to empower communities to make more informed decisions about land use planning by identifying and ranking areas with high conservation value throughout the watershed.

HRWC began the project by identifying existing natural areas through a combination of land use data, visual analysis of aerial photographs, and GIS. Because land use data is frequently outdated and is not always field checked between releases, the HRWC used visual inspection of aerial photographs to literally see whether or not "open" land in the land use data had been covered with housing, bisected by roads, or otherwise compromised prior to including it as a natural area. The authors of this study were invited to take these natural areas that the HRWC already identified and develop methodology to rank and prioritize them based on ecological diversity and hydrologic function.

Because this "aerial photograph" method used by the HRWC for identifying natural areas was both time-consuming and difficult to replicate, we proposed a second process for a more rapid identification of natural areas. We hypothesized that existing, publicly available land use data that was unmodified by manual checking would yield similar results to the HRWC aerial photograph process. This MIRIS method (named for the state land use data sets from which the information is derived) uses identical criteria and ranking methodology as that used on the HRWC aerial photo natural areas - without the intermediary step of aerial photography review. We developed a method to rank the natural areas selected by both the MIRIS and aerial photo methods and compared the results of the rankings to assist the HRWC in perfecting methodology for future land preservation.

Studies prioritizing natural areas can help agencies select areas where they will concentrate conservation efforts. At a broad level, our work will help the Huron River Watershed Council advocate preservation of the most appropriate areas for land acquisition or conservation easements. At the very least, this study will help the HRWC change attitudes about the Huron River by alerting citizens to some of the last and most diverse areas in the watershed.

Goals

1. Assist in the creation of a comprehensive regional conservation plan for the Huron River Watershed by ranking and prioritizing natural areas within the watershed.

Our first goal was to rank natural areas identified by the Huron River Watershed Council for ecological diversity and hydrologic function. The ranked natural areas will be used in the creation of a comprehensive regional conservation plan for the watershed, thereby protecting habitat, water quality, and quality of life for the residents of the watershed.

2. **Develop an automated, replicable, time efficient process for identification and prioritization of natural areas, in the watershed and beyond.**

Problems of replication and time efficiency exist in the HRWC aerial photography selection method. In order to amend some of these limitations, a method that was quicker, simpler and eliminated arbitrary decisions was explored. This method allows townships or non-profit planning organizations with limited technology and expertise to replicate this process on a wider scale, increasing the likelihood of effective and comprehensive conservation plans.

Methods

Identifying Natural Areas

Using Geographic Information Systems (GIS), two different methods were used to identify natural areas to be ranked. Both methods use MIRIS (Michigan Resource Information Service) land use data as a preliminary means for identifying existing natural areas. MIRIS data illustrates land use and land cover for the entire state of Michigan and is compiled from aerial photography and USGS topographic information. Intended uses of MIRIS data are general regional, county, and township planning. This analysis used MIRIS data from 1995, the most recent available. MIRIS data was queried to identify parcels containing open land (woodland, wetland, pasture). After querying this open land information, the two methods for identifying natural areas diverge.

"Aerial Photo" Site Selection used by HRWC

MIRIS data indicating open land was overlayed with aerial photography from 2000. Each unit of open land was then visually inspected to determine its quality as a natural area. The border of each area was manually digitized in a GIS shape file. Areas containing houses, agricultural fields, or development visible from the aerial photo were not included in the natural area. Mostly, but not always, natural areas that crossed roads were divided along that road into separate areas. Areas identified on MIRIS data as farmland that had returned to quasi-natural vegetation on the DOQ were sometimes included in the natural area. Any area identified as woodland or other habitat type that had been converted to agriculture, commercial or residential use was not included in the natural area. To eliminate sliver polygons (triangular shaped slivers of land where data do not exactly line up with one another or where data is nonexistent), all digitally selected natural areas less than five acres were removed from the data. GIS technicians of the Huron River Watershed Council inspected and manually digitized each of the natural areas.

MIRIS Data Site Selection

An alternate set of natural areas was developed by selecting open land (woodland, wetland, pasture) from the MIRIS data. No visual inspection of the data was used, and none of the areas were removed as a result of development, encroachment or change in land use or cover. Various land cover categories (e.g. woodland or wetland) were combined to form larger heterogeneous natural areas units. To eliminate sliver polygons all areas less than one acre were removed from the data. To closer match HRWC methodology, the natural areas were intersected by roads and divided into smaller parcels.

Selection of Ranking Criteria

Natural areas in the GIS were ranked according to ecological diversity and hydrologic function. Though natural areas were identified through two different methods, the ranking method outlined below was used for natural areas selected through both the aerial photograph and MIRIS data methods.

The HRWC initially developed a long list of criteria to rank natural areas (Table 1). Some of these criteria were beyond the scope of GIS technology while others failed to have continuous data - information did not cover the entire watershed and thus could not be used as a means to compare watershed-wide natural areas. Finally, other criteria were social factors that did not capture an intrinsic attribute of a natural area, but instead the social situation around it. This study focuses on seven factors that adequately represent either ecological diversity or hydrologic function on a site by site level.

Table 1. HRWC Suggested Ranking Criteria

- Level of fragmentation
- Areas containing wetlands and uplands
- Presence of waterway or lake
- Potential for restoration in surrounding area
- Potential for groundwater recharge
- Extent
- Topographical variation
- Glacial variation
- Records of endangered or threatened species
- Area a remnant tamarack swamp, lowland hardwood, oak savanna and barrens, or wet prairie
- Natural community element occurrence according to the Nature Conservancy
- Whether examples of endangered ecosystems are already under protection
- Closeness to other areas an potential for greenways
- Areas where vegetation is least changed from resettlement types
- Area that have habitats used by declining or extirpated species
- Areas within a first or second order stream
- Area within wellhead protection area
- Whether area is at risk of development
- Feasibility of protection for the area

The seven indicators of ecological diversity and hydrologic function that were used to rank natural areas are described in detail below. Generally, natural areas scored points for ecological diversity based on topographic relief variation, size, geologic variation, the presence of wetlands, and rare pre-European settlement vegetation communities. The ranking was based on measured hydrologic function through the presence of rivers, streams or lakes and an above mean level of groundwater infiltration.

Description of Ranking Criteria

1. Topographic Relief Variation

The number of slopes and aspects in a natural area is an indicator of ecosystem diversity. Northeast slopes tend to be cooler and moister, while southwest aspects tend to be warmer and drier. Additionally steeper slopes shed water faster leaving less moisture available for plants (Spurr, 1980). 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. Natural breaks are statistical groupings of data that naturally occur. The natural breaks classification method helps to maximize the between-class differences of the data while minimizing the within-class differences and ensures that like data is being compared as much as possible. The natural breaks method is used in this analysis when data is continuous and must be broken into categories. For topographical diversity, five natural breaks categories were selected and those sites with the most TIN's (topographic diversity) received 100 points, those grouped as the second most diverse received 80 points, etc. Sites with the least topographic diversity received a zero.

2. Glacial Variation

12,000 to 14,000 years ago, the glaciers that rested atop the Huron River valley began to break apart and melt. In some areas of the watershed, glacial melt water flowed across the land, leaving soil that is characterized by banded layers of sand and fine gravel. Other areas have a heavy soil made up of fine clay particles that were crushed and ground beneath the extreme weight of the moving ice sheet. Finally, many of the lakes in the northern reaches of the watershed were once large blocks of ice resting within the earth. Known as kettle lakes, these features are often located near kames, hills made up of sand, rocks and gravel that settled through holes in the melting ice. Because of soil and site differences caused by the glaciers, variation in glacial landform is another important component of ecosystem variation in southeastern Michigan. Ecosystem classification methods often use landform as a means of characterizing a site. (Hills, 1948, Comer, 1996)

The digital information illustrating glacial variation was initially mapped by Farrand (et. al. 1982) and was digitized by the Michigan Department of Natural Resources in 1998 as Quaternary Geology of Michigan. 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. Because all sites are located on at least one landform, areas containing only one landform received no points.

3. Presettlement Vegetation

Prior to European settlement, the Huron River watershed had a diverse mix of vegetation and ecosystems. Many of these ecosystems were dependent on fires started by Native Americans as a means of clearing the landscape for hunting, food production, and open stands of trees. The watershed was initially settled in the early 1800's and since that time the landscape has changed drastically. Forests, oak openings, and prairies were destroyed to make way for agricultural lands. A diversity of wetland ecosystems dependent on various groundwater and fire regimes was also present in pre-European settlement times. As steam shovels, dynamite, and drain tiles came into use in the early 1900's, swamps and wetlands were blasted and drained to make way for more agricultural land. Because the entire landscape has changed so drastically in the past 200 years, it is particularly important to identify and preserve areas where these pre-European settlement vegetation communities continue to exist or could be restored.

Information on presettlement vegetation came from the Michigan Land Use circa 1800 data set, (Comer et al, 1998) which was derived from original survey information recorded in the General Land Office surveys of 1816 to 1856. Five presettlement ecosystem types were identified by the HRWC as rare and in need of preservation; black oak barren, mixed hardwood swamp, mixed conifer swamp, wet prairie, and mixed oak savannah. Natural areas were analyzed to see if they had formerly contained any of this presettlement vegetation type in the hopes that restoration to that rare ecosystem could occur. The number 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.

4. Size

Size is a key factor in planning for natural areas. Forman et al (1995) discuss the importance of "patch size," essentially the size of a natural area as being important for that area to maintain its ecological function. Although ecological function in relation to patch size must be defined by a target function (e.g. songbird nesting or wolf habitat) larger size patches generally exhibit a higher likelihood of retaining their ecological integrity. Ironically, although larger parcels are the most important to preserve, they are also the easiest and cheapest to develop. A larger scale development reduces per unit costs for road, sewer, and water infrastructure. The importance of large, ecologically healthy preserves combined with the threat to larger undeveloped parcels leads to a higher rank for larger areas.

Natural areas were sorted according to their size and divided into five categories using natural breaks. The largest areas received 100 points, smallest parcels received zero.

5. Wetlands

Wetlands were an extremely common feature in presettlement Michigan, and many of Michigan's original wetlands have been lost. Wetlands serve numerous functions. They store and clean surface water, serve as places for water to infiltrate into the ground, and are areas where groundwater discharges to the surface. Additionally, wetlands provide habitat to a large number of species and add to the overall diversity of a natural area.

MIRIS data for wetlands was intersected with natural areas. Natural areas containing any wetlands present received 100 points while natural areas without wetlands received 0.

6. Rivers and Streams

Rivers and streams add to landscape diversity and serve important ecological and habitat functions. They act as areas for groundwater discharge, carry storm water, and provide human recreational opportunities. Rivers and streams are ecological assets that are particularly threatened by development because of the amenity waterways provide to residential development. Additionally, development can alter the hydrology of waterways, causing lower base flows and prolonged peak flows.

MIRIS data for rivers and streams was intersected with natural areas. Natural areas containing rivers or streams received 100 points, natural areas without waterways received zero.

7. Darcy Map

The quantity and quality of groundwater is obviously important for human use. The cycle of infiltration and discharge of groundwater to other parts of the watershed is important to the ecological health of wetland and fluvial habitats. This cycle of infiltration and discharge can be illuminated by applying Darcy's Law, a generalized relationship for flow in porous media, on a watershed scale. A map illustrating how Darcy's law applies to groundwater flow has been created for the entire lower peninsula of Michigan (Baker and Wiley 2001).

The Darcy map is a graphical model of potential groundwater flow delivery to surface water systems. It indicates areas where soil types are more likely to allow infiltration leading to groundwater discharge. Discharge is quantified in standard deviations above or below the normal rate of discharge for an area, in this case, the Huron River watershed.

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.

Ranking and Classification

The ranking and classification schemes for each criterion are outlined in Table 2. All of the indicators were weighted evenly; each indicator could receive a potential of 100 points and a natural area could potentially score a total of 700 points.

The scores from each of the indicators were classified in one of three ways. First, data that was continuous (having a wide, differing range of values, e.g. parcel size, topographic variation) was divided into five

Table 2. Ranking of Natural Areas by Criteria

Category and units	highest ranking				lowest ranking	Breaks	Method
Topographic	100	75	50	25	0	5	Natural Breaks
TINs	Maximum				Minimum		
Glacial variation	100	66	33		0	4	Numeric
Number of different landforms	4	3	2		1		
Presettlement vegetation	100	75	50	25	0	5	Numeric
Number of rare presettlement vegetation types	4	3	2	1	0		
Size	100	75	50	25	0	5	Natural Breaks
Acres	Highest				Lowest		
Wetlands	100				0	2	Presence Absence
	Present				Absent		
Rivers	100				0	2	Presence Absence
	Present				Absent		
Darcy	100	75	50	25	0	5	Natural Breaks
Infiltration	Highest				Lowest		

categories using a natural breaks classification. Data that had an individual score such as amount of glacial variation was classified numerically, and criteria with presence or absence of a particular feature were ranked with scores of 100 (present) or zero (absent). The scores for the seven criteria were added together to create a final rank for each natural area in the watershed. This final rank indicated the potential for ecological diversity or hydrologic function and was sorted into three major groups by natural breaks. Natural areas were classified into high, middle, and low rankings.

Supplemental Data

One additional data set, the Michigan Natural Features Inventory (MNFI), was not used in the ranking process but is presented in the results. This data set is not contiguous (it shows point or incident occurrences rather than data across the entire watershed) but helps the reader to see how the visual and digital methods for ranking natural areas compare with casual field observations. The MNFI identifies populations of rare or threatened plant and animal species and plant communities throughout the state. MNFI data is organized by incident occurrences. Because this data is only as complete as the surveying that has been done in a particular area, it cannot be used as a classification method for the natural areas of the entire watershed. However, it can be used to highlight areas of biological diversity or interest. MNFI data is presented with natural areas derived by both aerial photograph and MIRIS data site selection methods.

Results

Natural Areas Identification

Results from the application of ranking criteria were generated for both Aerial Photo and MIRIS land selection methods. Tables 3 and 4 illustrate the differences in land areas selected by the two methods, in particular, the number of sites selected and the range of parcel sizes.

Table 3. Aerial Photo Selection Results by Criteria

Total number natural areas = 677

Category	Units	High	Low	Mean
Size	Acres	3167.37	4.91	201.47
Topographic variation	TINs	311	1	18
Glacial variation	Landform types	4	1	2
Presettlement vegetation	Number of occurances	4	0	1
Darcy	Standard deviations	44.81	0	3.52

	Present	Absent
Wetlands	473	204
Rivers and Streams	566	111

Table 4. MIRIS Data Selection Results by Criteria

total number natural areas = 3226

Category	Units	High	Low	Mean
Size	Acres	2237.54	1.003	66.03
Topographic variation	TINs	290	1	7
Glacial variation	Landform types	4	1	1
Presettlement vegetation	Number of occurances	4	1	1
Darcy	Standard deviations	112.3	-0.6	2.88

	Present	Absent
Wetlands	1057	2169
Rivers and Streams	1393	1833

Natural Areas Ranking and Classification

Table 5 shows results from the ranking process of each of the natural areas selection methods. This table shows how many parcels were selected as high, medium and low ranks from the two different site selection methods and highlights the total acreage, mean acres and range of acres for each method.

Table 5. Area and number of units by rank for natural area selection methods

	Aerial Photo Site Selection				MIRIS Data Site Selection			
	units	total acres	mean	Range	units	total acres	mean	range
Lowest Rank	217	15395.5	70.9	367.7	1456	17947.3	12.3	256.3
Middle Rank	345	50528.9	146.5	600.9	1133	38352.4	33.9	467.1
Highest Rank	115	70471.1	612.8	3120	637	156711.4	246	2236
Totals	677	136395.5	--	--	3226	213011.1	--	--

Figure 2 illustrates the location and ranking of parcels identified by the aerial photo site selection method. Figure 3 illustrates the location and ranking of parcels identified through MIRIS data selection. Ranking occurred only in the counties where aerial photo site selection was complete.

Figure 2
Final Rankings of Natural Areas: Aerial Photography Method

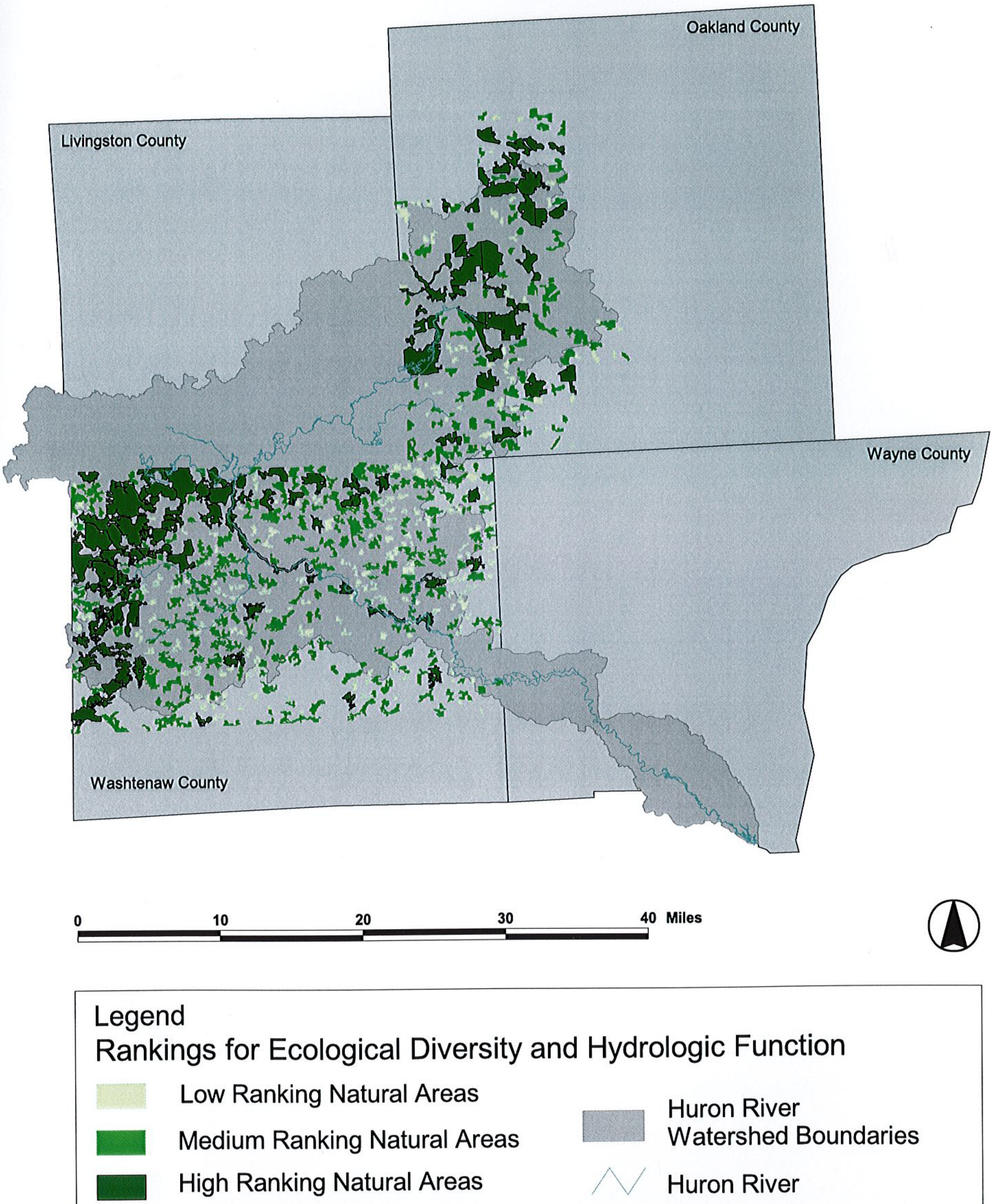
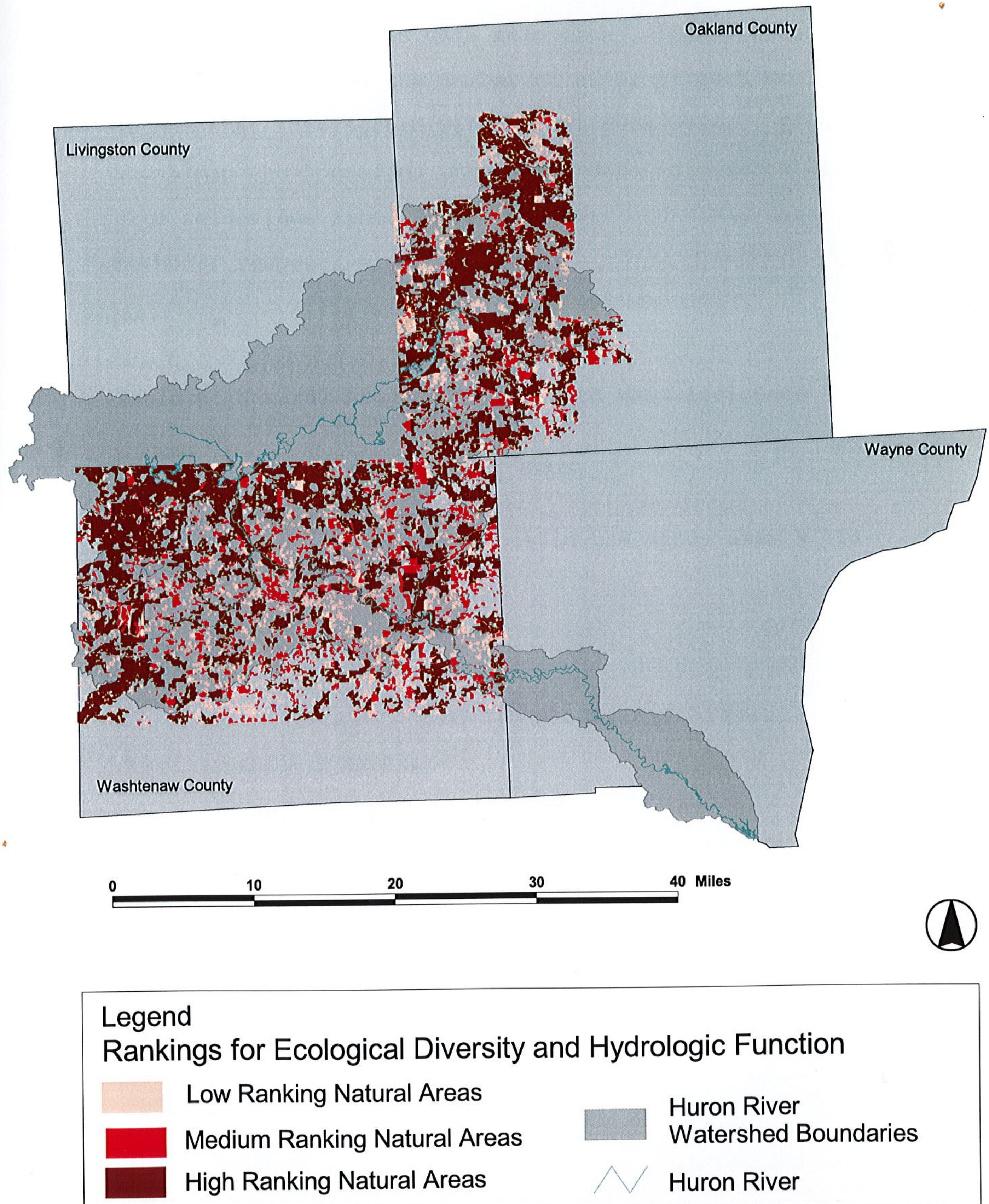


Figure 3
Final Rankings of Natural Areas: MIRIS Data Method



Site Selection and Supplemental Data

Table 6 shows results from the overlay of MNFI incidence occurrence data with the classified results of aerial photo and MIRIS data selection. "Occurrences captured" indicates the number of sites of each analysis method that intersected with a MNFI data point. Figures 4 and 5 map the locations where MNFI data intersects with site selections from the aerial photo and MIRIS data methods, respectively.

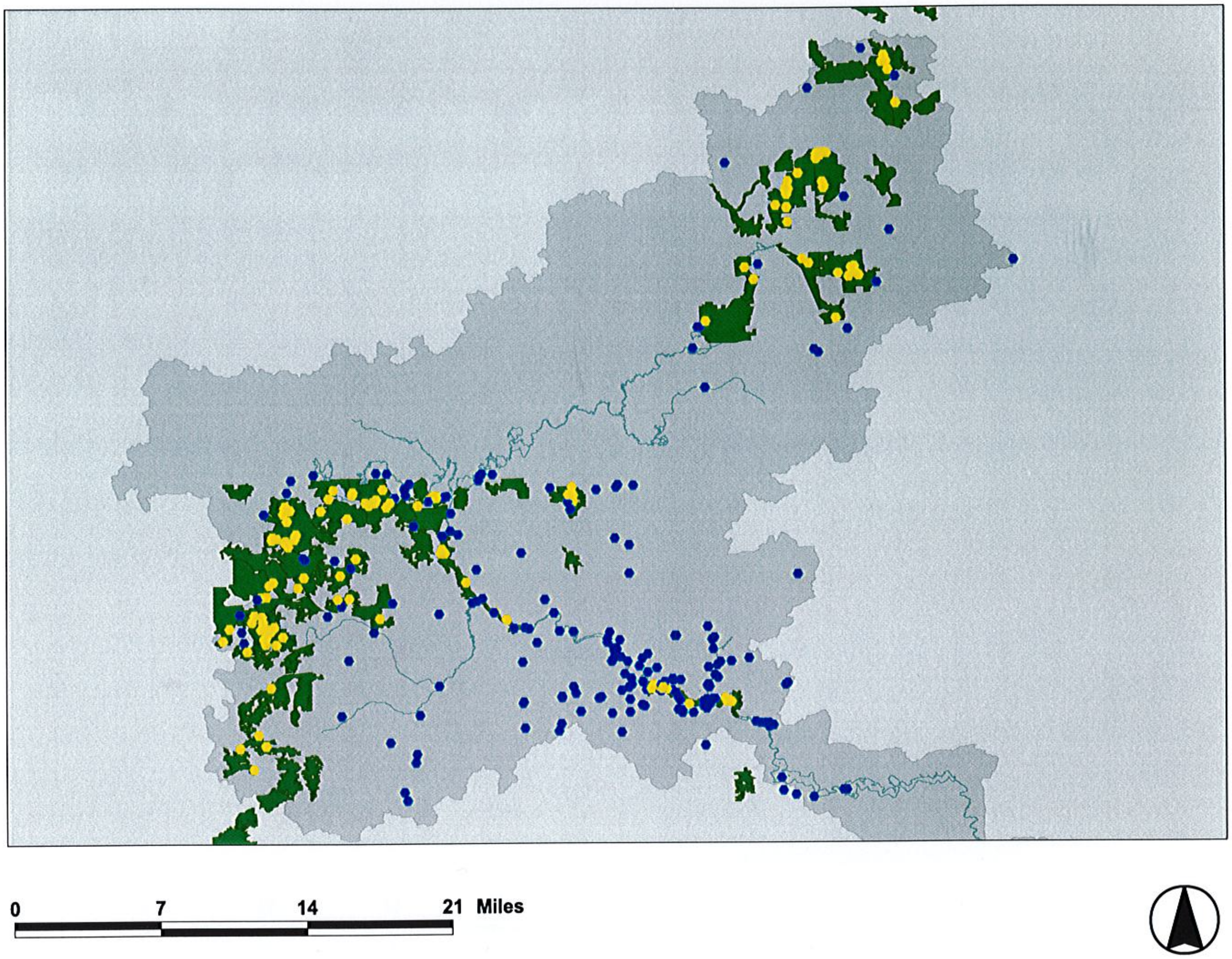
Table 6. Natural Areas compared with MNFI incidence Occurrence Data

	Aerial	MIRIS
Occurrences captured	223	246
Occurrences missed	121	98

Total MNFI incident occurrences in the study area = 344

Figure 4

MNFI Occurances within High Ranking Natural Areas: Aerial Photograpy Method



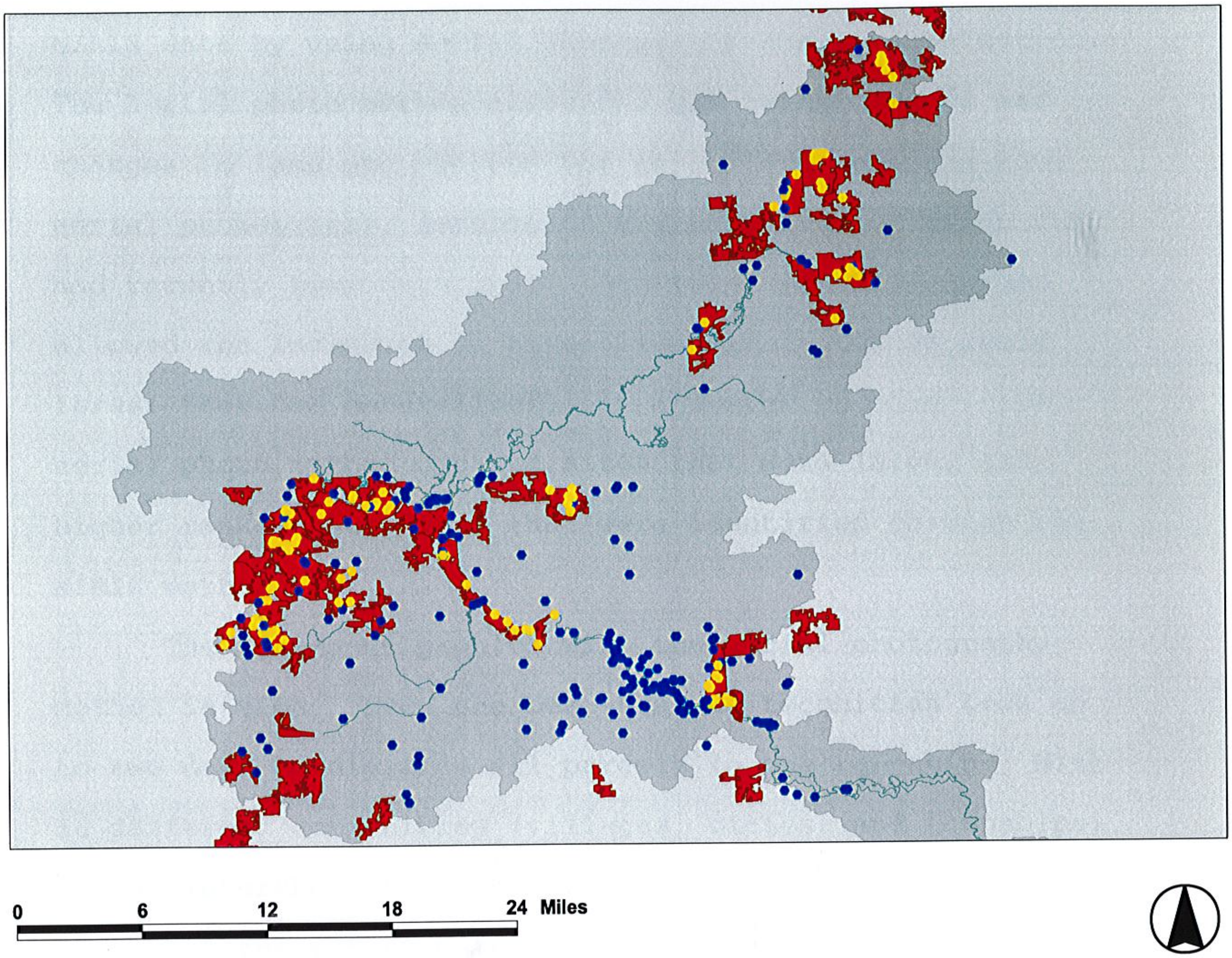
146 out of 344 MNFI occurances were within High Ranking Natural Areas using the Aerial Photography Method.

Legend

- Huron River Watershed Boundaries
- Huron River
- High Ranking Natural Areas (Aerial Photography)
- MNFI occurances within High Ranking Natural Areas
- MNFI occurances outside of High Ranking Natural Areas

Figure 5

MNFI Occurances within High Ranking Natural Areas: MIRIS Data Method



126 out of 344 MNFI occurances were within High Ranking Natural Areas using the MIRIS Data Method.

Legend

- Huron River Watershed Boundaries
- Huron River
- High Ranking Natural Areas (MIRIS Data)
- MNFI occurances within High Ranking Natural Areas
- MNFI occurances outside of High Ranking Natural Areas

Analysis

Site Selection

1. Aerial Photo Site Selection

The HRWC solved a number of problems inherent in MIRIS data by using aerial photographs for site selection. The aerial photo method allowed a GIS technician to see changes in land use between the 1995 MIRIS data and 2000 aerial photography, leading to the exclusion of areas that had recently been developed. Additionally, this method allowed the inclusion of sites like old fields or young forest that had naturalized. In a number of cases, the aerial photo method created sites that were larger and higher ranked than sites that were identified through the MIRIS method.

The paramount problem with the aerial photography method is time. Even the best-trained technician took up to two days to digitize all parcels in one township. With 56 different communities (villages, cities, and townships) in the watershed, the digitizing process is immense. The fact that the entire watershed was not analyzed in this project (and the non-conforming shape of the study area to the watershed) was due to the fact that natural areas in Livingston, Wayne and Monroe counties had not yet been manually digitized.

Consistency of the human digitizers plays an important part in the overall quality of the data. Although natural areas were not intended to include roads, the digitizers sometimes allowed a natural area to cross them. A number of parcels with high acreage were large because they were not divided along roadways. Lakes were included in the selection of the natural area, but only if they had no development along their shores. The largest parcel outlined in the aerial photo method was over 30% larger than the largest MIRIS parcel, and illustrates the problematic nature of human manipulation of copious amounts of data. If manual processes for the identification of natural areas are to be used, a standard method that clips reserves at roads and consistently treats water bodies must be developed.

Because of the considerable amount of time needed to manually identify parcels, any parcel under five acres was not digitized for the aerial photo method. However, if a small area looked "natural" from aerial photography and was adjacent to larger areas, occasionally these small areas were included as part of a larger natural area. This further compounded the difficulty of maintaining consistency in the visual selection process.

Discarding small parcels from the selection process can also compromise the overall picture of regional preservation. Small parcels can be an important part of a larger network of natural areas throughout a watershed, acting as stepping stones, corridors for wildlife movement and habitat connection. Although the removal of small parcels helped streamline an already time consuming process, removing this information also limits the applicability of the selection process for planning extensive networks of linked preserves.

Overall, the visual selection process can provide a first level of accuracy checking of the data. By identifying if a parcel has been developed, it slightly improves the accuracy of ranking "natural areas" as all of the parcels ranked will be at least somewhat natural. Ground truthing, the act of going to a site and performing a biological inventory, is still a necessity to determine the overall quality of each natural area. The question remains whether or not the limited improvement in accuracy generated through visual inspection justifies the additional time it takes to perform aerial photo analysis.

2. MIRIS Data Site Selection

One of the most important benefits of the MIRIS data site selection process is a significant savings in time. Whereas the aerial photo site selection process took hundreds of person hours and is still incomplete, the selection of natural areas from MIRIS data took one day. With the exception of being clipped to match the HRWC data, the selection process is complete for the entire watershed. Where the aerial photo method was challenged with consistency issues, the MIRIS data method was consistent and replicable. Lakes were not included in the total land area of the site and natural areas were consistently separated along roads. The MIRIS data site selection process also involved thousands of smaller parcels throughout the watershed. This more detailed level of analysis allows the conservation planner to see smaller sites that may be of ecological importance. These sites can be included a stepping stones or corridors to larger habitat areas.

Data Limitations

While a quantity of spatial data is becoming increasingly available, the quality of all data used must be carefully examined. MIRIS data used for both selection processes is out of date. The last publication of the data in 1995 was updated from aerial photography - not from actual ground truthing. Because MIRIS data does not always accurately represent what is on the ground, its use can challenge any GIS analysis. Because of its reliance on existing land use data and lack of aerial reconnaissance, the MIRIS data method will rely more heavily on ground truthing than its visual counterpart.

MIRIS data is plagued by sliver polygons, areas that contain no data or data that overlaps and is therefore inconsistent. Sliver polygons were problematic to both selection methods, and led to 1 acre as the minimum size for MIRIS data and 4.9 acres for the Aerial photo method.

Presettlement vegetation is also problematic to use because of the scale of data originally collected. Data for the presettlement map was taken from original survey records from the early 1800's. Although occasionally surveyors sketched maps that indicated topography and vegetation types, in most cases this information was recorded only at the intersection of one mile grid sections. The "Section trees", as the largest trees nearest this corner are known, were noted for size and distance apart. Although this information gives us an interesting look into past land cover types, with only one data point per square mile the information is extremely coarse. To rank natural areas, many of which are far smaller than a square mile according to such coarse information may lead to inaccurate assumptions about the ecological value of a natural area.

Ranking and Classification

Ranking is an important first step toward prioritizing natural areas for preservation or acquisition. The ranking process for both methods of natural areas selection was relatively straightforward and, as evidenced by the corresponding MNFI incident occurrence data, quite effective. Many of the natural areas overlapped with occurrences of rare plants or animals in the MNFI data set. Natural areas that ranked high but do not have MNFI occurrences may be likely places to begin field study.

To compare ranking outcomes, an identical classification scheme was used for both sets of natural areas. However, the large number of natural areas generated by the MIRIS data was problematic when using this classification scheme and illustrated that a common ranking and classification scheme is not appropriate for all data generated. Although the MIRIS data selected smaller parcels, the classification scheme failed to give these smaller parcels adequate consideration. Of the 3226 units generated through MIRIS data site selection, 637 showed to have the highest ranking. (Through the aerial photo method, only 677 *total* natural areas units were identified.) Those 637 MIRIS sites had a total area of 156,711 acres, whereas the total acreage of all aerial photo selected parcels was only 136,395 acres. For more meaningful data to be generated through the MIRIS data method, a more meaningful classification scheme tailored to the desired outcomes of a project is necessary. The final rank of each natural area potentially allows for a more appropriate and meaningful manipulation of the data (i.e. the top ten sites less than 50 acres).

The large number of small sites generated through the MIRIS data method also significantly altered the overall Darcy averages. The vast majority of sites in the Huron River watershed are below the mean standard deviation for groundwater recharge. Although many of the smallest sites generated Darcy scores of zero or less, some small sites had extremely high Darcy scores, (Table 4) which lowered the Darcy score (and final rank) of many of the largest MIRIS data selected parcels.

Because the MIRIS data site selection method generates such a large number of small parcels, it is important to compare parcels that lie within reasonable ranges of one another. Many of the smallest natural areas generated by the MIRIS method ended up in the lowest ranked category. A more appropriate analysis could rank the smallest areas among themselves, rather than comparing them to larger parcels that usurp the largest share of points. The classification system used in this analysis compared the aerial photo and MIRIS data site selection methods. Because MIRIS selection generates so many small sites, a classification process that divides the area into more than three natural breaks and classifies areas of like size would prove most meaningful and would best serve watershed planners.

The number of sites generated through MIRIS data changed the overall applicability of the classification system. Three classifications for over 3000 areas in the watershed fail to give a reasonable idea of how sites should be ranked. Sites could be classified using more divisions (e.g. 10). Another method could break sites into categories based on a given class size, better informing the researcher of the best sites in a given size category.

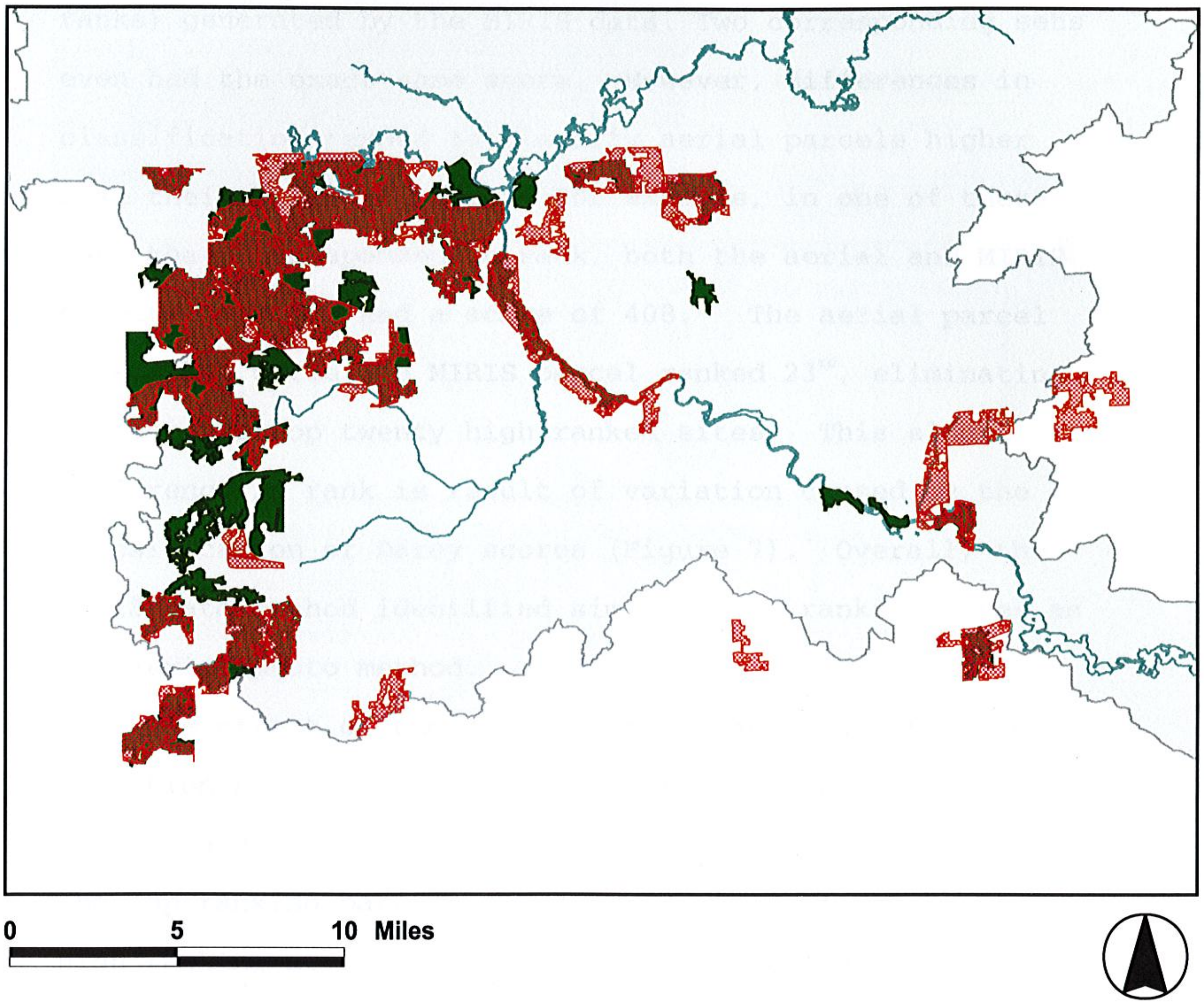
Examples

To better illustrate some of the issues uncovered in the selection, ranking and classification of natural areas, the parcels with top 20 ranks from the aerial photo and MIRIS data selection methods were compared. Because many of the parcels received the same numeric rankings (i.e. five sites received the top score of 700), the top twenty numeric ranks of parcels (as opposed to the top twenty parcels) were chosen for comparison. In the aerial photo method, 70 parcels received the top twenty rankings while the MIRIS data method generated 68 parcels within the top twenty rankings.

Although this comparison showed overall similarities in the top ranking parcels between the two methods, it also illustrated differences caused by classification and parcel delineation. Of the 70 aerial photo parcels, 58 overlapped with top ranking parcels from the MIRIS data (Figure 6). By analyzing the remaining twelve parcels that did not have MIRIS data analogues, the effects of the two selection methods on ranking are brought to light. Differing boundaries for the same general area of land and the effect of including smaller size parcels in the digital selection method have significant effects on the overall classification system.

Figure 6

Comparison of Top Ranking Natural Areas from Both Methods



The two methods produced a number of similar highly ranking sites. Signifigant overlapping occured in the top ranking areas. However, sites from one method did not always correspond with the other. A discussion of these differences can be found in Figure 6 and the results section of the report.

Legend

- Top Ranking Natural Areas from MIRIS Data Method
- Top Ranking Natural Areas from Aerial Photography Method
- Huron River Watershed Boundaries
- Huron River

Although twelve of the top ranking aerial photo parcels did not have corresponding top ranking MIRIS data parcels, almost all showed corresponding *high*-ranking parcels (even though they were not among the top twenty ranks) generated by the MIRIS data. Two corresponding sets even had the exact same score. However, differences in classification tended to classify aerial parcels higher than their MIRIS analogue. For example, in one of these sets that corresponded in rank, both the aerial and MIRIS selected parcels had a score of 408. The aerial parcel ranked 20th while the MIRIS parcel ranked 23rd, eliminating it from the top twenty high ranked sites. This slight difference in rank is result of variation caused by the classification of Darcy scores (Figure 7). Overall, the MIRIS data method identified similar high ranking sites as the aerial photo method.

The effect of human error in the aerial photo site selection process on the final ranking of individual natural areas is also highlighted through a comparison of the top ranking parcels. First, four out of the twelve high ranking aerial selected parcels that did not show correspondingly high MIRIS selected parcels had been selected without appropriate clipping by roads. Secondly, the manual processes used in the aerial method resulted in frequent inconsistencies between what the GIS technician included as part of a natural area and what MIRIS identified as open space. Three of the twelve non-

Figure 7

[hatched green]	High ranking Visual Selection parcel (of top twenty ranks)
[pink]	Lowest ranking Digital Selection parcels
[red]	Medium Ranking Digital Selection Parcels
[dark red]	High Ranking Digital Selection Parcel.
——	County Roads

This graphic taken from the GIS data and accompanying table illustrates several of the issues encountered when comparing the Digital and Visual Selection methods:

- Unlike the Digital Selection parcels, the Visual Selection parcel crosses roads, leading to an unrealistically large natural area.
- The Visual Selection parcel crosses areas that are not identified in the open space data used to define the Digital Selection parcels.

On the table below, mean Darcy value for the high ranking MIRIS parcel is very similar to the mean value of the Aerial Photo parcel(in red). However, the ranking that the criteria received is different. The Darcy ranking for the MIRIS parcel is 25, while the Darcy ranking for the Aerial Photo parcel received 50 (in blue). This difference in classification is due to the large amount of acreage in the MIRIS data set (mostly in small parcels) that have low mean values.

Criteria	Acres		Wetlands		Water		Mean Darcy		# of TINs		Glacial Variation		Presettle-ment		Final Rankings
	score	rank	score	rank	score	rank	score	rank	score	rank	score	rank	score	rank	
MIRIS Data Parcel (Low Rank)	1.5	**0**	0	**0**	0	**0**	4.43	**25**	1	**0**	1	**0**	1	**25**	**50**
MIRIS Data Parcel (Low Rank)	3.7	**0**	0	**0**	0	**0**	18.11	**50**	2	**0**	1	**0**	1	**25**	**75**
MIRIS Data Parcel (Medium Rank)	12.6	**0**	0	**0**	0	**0**	11.97	**50**	7	**0**	3	**66**	2	**50**	**166**
MIRIS Data Parcel (High Rank)	179.5	**25**	1	**100**	1	**100**	7.06	**25**	12	**25**	3	**66**	3	**75**	**416**
Visual Selection Parcel (Highest Rank)	210.3	**25**	1	**100**	1	**100**	7.31	**50**	16	**25**	3	**66**	3	**75**	**441**

analogous parcels included areas of land unselected as open space in the MIRIS data, but identified as such by the GIS technician. The inconsistencies inherent in the manual processes of aerial photo site selection resulted in artificially large sections of land. Because of their size, they scored higher in several criteria (including presence of wetlands and water, a higher number of TINs, and increased glacial variation and presettlement vegetation) than the smaller MIRIS parcels with which they corresponded.

Bias in Classification

The classification method used in this analysis led to the prioritization of a certain type of natural area. By ranking sites for topographic and ecological diversity (particularly water features like wetlands or streams) the study leaned away from certain ecological types like dry prairies or oak barrens that are associated neither with water or topography. Because the classification process also favors size (in a number of compounding ways) it is unlikely to give a high ranking to even the highest quality small prairie remnant.

Discussion

The study of the two selection processes gives us interesting insight into how natural areas can be identified and ranked on a watershed scale. Using this ranking methodology, both natural area selection methods identified similar sites with high ecological diversity and hydrologic function. How can the lessons learned from this study be used to create a tool that can better identify and prioritize land use on an appropriate regional scale?

The necessity of having clear and specific goals when utilizing a GIS analysis is perhaps one of the most important lessons that can be learned from the application of the HRWC method. HRWC had a broad array of questions that they were hoping to solve with the results generated from this project. Some, like finding restorable patches of presettlement vegetation, are currently impossible to assess through GIS. At the suggestion of the HRWC, the intersection of natural areas with presettlement vegetation types was included - even though there is no clear link between the former presence of those ecosystems and their potential restoration. Though it is impossible to use GIS in this way now, it is important to remember these questions because as GIS data improves, (particularly MIRIS land cover data) questions such as these will become feasible to answer.

For the time being, effective GIS use requires a clear understanding of the limits of the technology and the limits of the data. Additionally, appropriate goal setting could have saved the HRWC considerable time in delineating natural areas by hand. By realizing that many of the initial criteria for ranking natural areas would be impossible with the data available, time could have been more efficiently spent converting data and finding appropriate ranking methods and checking sites against aerial photography after a coarser level of selection.

Because one of the goals of the HRWC study was to create a linked system of reserves throughout the watershed, including smaller parcels in the analysis is of utmost importance. Smaller parcels provide potential links between larger natural areas and serve as stepping stones for migratory species. With encroachment of suburban residential development of rural lands, small natural parcels also provide a focal point for conservation and human activity in an area. Including and highlighting these small natural features in the study gives people a reason to feel like even the smallest parcels are worth preserving and restoring because they are part of a larger ecological framework. Although larger networks serve incredible ecological importance, it is smaller parcels that can link people to the place they live.

Recommendations

Conservation planning in the Huron River watershed is an important component to the preservation of ecological valuable systems. Appropriate regional planning can also create networks of open space that connects habitats, preserves the hydrologic cycle and provides places for human restoration. To better realize the vision of connected ecological networks in the Huron River Watershed, we recommend the following methodology and approach:

1. Use the MIRIS data site selection method to identify a maximum number of potential preservation sites. Although some sites may seem small, even insignificant, these sites can provide groundwater recharge, a link between habitats for a threatened species, or a starting point for conservation efforts by the immediate community. This fine scale can also help planners create a clearer picture of a preservation network.

2. Break up the MIRIS data into more meaningful units. Townships are an appropriate level for the number of sites generated by MIRIS data, but ambitious counties could also find natural areas preservation data at this level of detail helpful. Local citizens would also be interested in previously unknown natural areas "discovered" in their community through the MIRIS data method. If a client has a particularly large amount of natural areas in their area, parcels could be sorted by

size to be able to better understand the best areas in a given size range. Regardless of the method, classifying the small MIRIS into a finer grain allows for the meaningful analysis that will make natural areas networks possible.

3. Aerial photos are a necessary addition to the analysis. At the community scale they allow people to get a clearer understanding of landscape patterns that are threatening natural systems. Aerial photos draw people together - to find their school, house, or favorite park. Rather than include the aerial photos as part of an initial winnowing of sites, photos can confirm information that is generated by the GIS system and excite communities about preserving natural areas networks.

4. Finally, the authors encourage the Huron River Watershed Council to share this approach with as many community members and citizens as possible. Present the idea of natural areas networks to them. Talk to them about their nearest natural area, ask them where they go to be outside and help them find those places on the map. Local citizens have an incredible breadth of information about the places they live, and exciting them to the ideas of natural areas networks is critical.

In conclusion, although inherent biases exist in the methodology, the method presented here is a rapid way to identify natural areas that have high diversity and may be most important to preserve. The method minimizes arbitrary decision making, maximizes time and relies on easily available data.

Natural areas, rivers and animals traverse township borders. Because GIS can manage the complex data associated with planning at a regional scale, this model can help townships and small non-profits plan locally while keeping the regional framework in mind. Although this methodology alone should not be used as a final decision making tool, it can be a rapid method for understanding a broader conservation picture. When used in combination with aerial photos, community workshops, field checking, and other planning tools, this method has the potential to assist planners in the complex step of identifying important areas for conservation - before they are lost forever.

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