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Use of Remote Sensing and GIS to Better Manage the Huron-Erie Corridor

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State of the Strait

Use of Remote Sensing and GIS to Better Manage the Huron-Erie Corridor

2012

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Preface

Understanding the Patterns and Successes of Our Huron-Erie Corridor

The Huron-Erie Corridor, centered by Detroit, Michigan and Windsor, Ontario, is an exceptional example of a place with a concentration of various natural and human boundaries, contrasts, and complex dynamics. The inherent diversity and abundance of habitats in the Corridor in relation to the North American continent and the Great Lakes Basin gives it a centrality that has long attracted both wildlife and people. Of primary importance is the U.S.-Canada border which bisects the Corridor, often cited as the location of the largest flow of transnational trade on Earth. Here, a combination of geographical and historical factors intersected with access to abundant natural resources to allow the creation of one of the most heavily industrialized waterways ever to exist. Unfortunately, nature was degraded by intense urbanization and industrialization to the point that by 1970 the St. Clair, Clinton, Rouge, Ecorse, and Detroit rivers, and the River Raisin, were grossly polluted, and Lake Erie was overwhelmed by excessive phosphorus loadings, wastewater treatment plant effluent that was only receiving primary or minimal treatment, and persistent toxic substances. Since then, great efforts have been made by many to preserve and restore environmental integrity, bringing ecosystems back to a level of health perhaps unimaginable 40 years ago.

Superimposed upon all this is the Detroit River International Wildlife Refuge – established in 2001 as the only international wildlife refuge in North America. This unprecedented international wildlife refuge represents a major opportunity to continue to restore and protect ecosystems in a socially, economically, and environmentally sustainable manner.

While environmental conditions within the Huron-Erie Corridor and Detroit River International Wildlife Refuge have improved substantially, certain challenges remain to be dealt with. Ecological threats from over a hundred invasive species continue to mount, and urbanization, agriculture, industry, and global climate change present their own management concerns. Scarce economic resources make it increasingly difficult for governments and stakeholders to provide support for environmental concerns. This means that money and efforts directed towards environmental cleanup and ecosystem restoration must be managed and deployed efficiently and effectively, as well as monitored to determine the success of natural resource management practices.

To this end, geospatial data and information, largely collected via remote sensing, compiled with topographic map features within a geographic information system (GIS), provide an indispensible toolkit in support of environmental management decision support and monitoring. Use of traditional ecological field sampling with remotely-sensed imagery, digitally integrated and analyzed within a geographic information system, continues to emerge as an essential component of comprehensive environmental and natural resource protection and management. Such spatial decision support systems can help account for a complex set of interacting social, economic, political, cultural, and natural factors.

Remote sensing, GIS, and field data collection represent the best, perhaps only, means to capture and understand the diverse geographical and ecological patterns and processes that exist within the Huron-Erie Corridor, focused on the goal of successful environmental protection and adaptive management.

Bill Welsh
Eastern Michigan University
Ypsilanti, Michigan

Acknowledgements

The biennial State of the Strait Conference is a collaborative effort of numerous Canadian and U.S. agencies, institutions, and organizations. Any binational effort covering such a broad scope, by nature, requires considerable collaboration and numerous contributions. The 2011 State of the Strait Conference and this report would not be possible without the generous support of our many partners. We gratefully acknowledge the following supporters:

- Canadian Consulate
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- Detroit River Canadian Cleanup
- Eastern Michigan University
- Environment Canada
- Essex Region Conservation Authority
- Friends of the Detroit River
- International Joint Commission, Great Lakes Regional Office
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The management and direction of this project was provided by the State of the Strait Steering Committee, made up of the following members:

- Raj Bejankiwar, International Joint Commission
- Mary Bohling, Michigan Sea Grant

- Luca Cargnelli, Environment Canada, Conference Co-Chair
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We would also like to extend our gratitude to those who shared their data and research through presentations, posters, and displays. Their thought provoking work was key to the overall success of the conference and essential to our understanding of the current status of the Huron-Erie Corridor.

In addition, we would like to thank all those who attended the conference, including local citizens, environmental and conservation organizations, researchers, students, and government and industry representatives who all played an important role in the success of the conference.

A special thank you is extended to Meg Castro, Eastern Michigan University Event Planning Office, and the student volunteers from Eastern Michigan University's Institute for Geospatial Research and Education for their assistance with the conference.

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Preface

Acknowledgements

1.0 Executive Summary

The fifth biennial State of the Strait Conference was held on November 2, 2011 at Eastern Michigan University in Ypsilanti, Michigan. The theme of the 2011 conference was "Use of Remote Sensing and Geographical Information Systems (GIS) to Better Manage the Huron-Erie Corridor." More than 200 people attended to learn about existing projects that utilized GIS and remote sensing technologies, and to disseminate information on best practices for use in future projects.

Remote sensing and geographic information systems (GIS) are advanced technologies or tools used to identify problems and provide managers, planners, and decision-makers with data and information to solve problems and track responses. Although these tools can help make better policy and management decisions, their full potential has not yet been realized in ecosystem-based, natural resource management within the Huron-Erie Corridor. Therefore, it is recommended that environmental and natural resource managers incorporate GIS and remote sensing tools in their assessment programs or add GIS and remote sensing capabilities (available from universities, organizations with GIS/remote sensing expertise, or consulting firms) to help support sound science-based decision-making.

Environmental and natural resource managers day-to-day are confronted with high levels of uncertainty and, despite such uncertainty, are required to make decisions. Adaptive management (i.e., assess, set priorities, and take action in an iterative fashion for continuous improvement) is a tool that can help managers makes decisions in the face of uncertainty. Therefore, it is recommended that environmental and resource managers plan actions and evaluate the ecological response of their actions through an adaptive management process, investing appropriately in GIS, remote sensing, and other tools to help effectively inform both professionals and the public, and to improve future decisions.

Today, modeling is used to test hypotheses based on known information about the ecosystem. To fully realize the benefits of modeling to managers, it is recommended that management agencies place a high priority on integrating modeling with GIS and remote sensing to better facilitate science-based decision-making and practice adaptive management. Further, such integration will help treat management actions as experiments, in an adaptive management mode, that promote learning and will help ensure that hypotheses are developed and tested using scientific rigor.

There is growing interest in measuring the benefits of environmental and natural resource management, and in measuring ecosystem services. Ecosystem services are the societal benefits derived from ecosystems. They include providing clean water and food, regulating floods, controlling diseases, providing recreational and cultural benefits, and supporting nutrient cycling that maintains the conditions for life on Earth. Measurement of ecosystem benefits and services helps manifest the social and economic advantages of ecosystem-based management. Therefore, it is recommended that spatial decision support systems include the ability to estimate both economic and ecosystem costs and benefits to allow fully-informed decision-making and facilitate discovery of novel solutions to management problems.

In summary, the Huron-Erie Corridor is an economically and environmentally important region within the Great Lakes basin. It is subject to multiple environmental stresses, many of which act over wide spatial and temporal scales. Environmental regulations and effective management have led to several notable improvements, but numerous challenges remain. Expanded use of remote sensing and GIS technologies, and their improved integration with scientific, social, and economic analyses, can help resolve ongoing challenges.

2.0 Introduction

The State of the Strait is a one-day conference held every two years that brings together government managers, researchers, students, environmental and conservation organizations, and concerned citizens from the United States and Canada to assess ecosystem status and provide advice to improve research, monitoring and management. Themes explored by past conferences include: rehabilitating and conserving Detroit River habitats (1998 – Tulen et al. 1998), best management practices for soft engineering of shorelines (1999 – Caulk et al. 2000), status and trends of the Detroit River ecosystem (2001 - Read et al. 2001), monitoring for sound management (2004 – Eedy et al. 2005), status and trends of key indicators (2006 – Hartig et al., 2007), and the ecological benefits of habitat modification (2009 – Hartig et al., 2010).

The fifth biennial State of the Strait Conference was held on November 2, 2011 at Eastern Michigan University in Ypsilanti, Michigan. More than 200 people attended. The theme for the 2011 conference was "Use of Remote Sensing and GIS to Better Manage the Huron-Erie Corridor." The goal of the conference was to summarize the results of existing projects and to disseminate best practices for future projects. In comparison to previous conferences, this one was the most specific on scientific technology and tools and the broadest geographically.

Past State of the Strait Conferences focused on the Detroit River and western Lake Erie. However, for the 2011 conference, the spatial scope was expanded to include the entire Huron-Erie Corridor, which is comprised of the St. Clair River, Lake St. Clair, the Detroit River, and the western basin of Lake Erie. Located at the center of the Great Lakes (Figure 1), the Huron-Erie Corridor connects the upper and lower Great Lakes and is significant both ecologically and economically.

Figure 1. The Huron-Erie corridor (Photo credit: NASA)

The Huron-Erie Corridor ecosystem provides habitat for over 65 species of fish, and serves as a major fish migration corridor (Corkum 2010). It is part of an internationally-important migration corridor for waterfowl and other migratory birds, and contains some of the largest and most diverse wetlands remaining in the region. The St. Clair Delta is one of the most biologically diverse ecosystems in North America and has been designated part of a wetland of international importance by the United Nations. At the same time, the Huron-Erie Corridor is one of the busiest navigation corridors in the United States, a major international trade route, and a center of industrial development. The Corridor is home to the highest density of commercial ports anywhere in the Great Lakes and is a major source of drinking water for over six million residents of Michigan, Ohio and Ontario.

Conflicting uses of Huron-Erie Corridor waters for waste disposal, water withdrawals, shoreline development, shipping, recreation, and fishing have resulted in numerous environmental stresses to the system, including contaminated sediments, the introduction of non-native species from ballast water discharges and other pathways, hardening of shorelines and infilling of coastal wetlands, construction of shipping channels, and urban sprawl. This has resulted in the designation of six Areas of Concern (AOC) within the Corridor, the highest density of AOCs anywhere in the Great Lakes.

Due to the ecological significance of the Huron-Erie Corridor and as a result of the often-conflicting economic uses, it is an area requiring active management. There is a need for quantitative information to form the basis of good decision-making and ecological management within the Corridor. Remote sensing and geographical information systems (GIS) have become important tools for environmental management since they facilitate data collection over large spatial scales and provide an orderly way to visualize and analyze spatially-structured information. In the spirit of past State of the Strait conferences, the information from this one is essential to support partnerships between resource managers, citizens and policymakers for the continued protection and restoration of the Huron-Erie Corridor ecosystem and the binational economic prosperity it supports.

This report summarizes the presentations and key findings from the 2011 State of the Strait conference. A total of eleven speakers and twelve poster presentations (see conference program in Section 7) highlighted some of the current uses of GIS and remote sensing and their importance in ecosystem management. Extended abstracts for oral presentations (Section 5) and poster abstracts are presented (Section 6), as well as recommendations for enhancing the future use of GIS and remote sensing in the management of the Huron-Erie Corridor developed by the State of the Strait Steering Committee (Section 3).

3.0 Synthesis and Recommendations

GIS and Remote Sensing Tools Can Help Strengthen the Science-Policy Linkages

Geographic Information Systems (GIS) and remote sensing are technological tools that can help make better policy and management decisions, but the full potential of these tools has not been realized in ecosystem-based and natural resource management within the Huron-Erie Corridor. Some current examples of science-policy linkages involving GIS mapping tools include:

- Making contaminated sediment management decisions in the Trenton Channel of the Detroit River;
- Providing an early warning signal to Cleveland of *Microcystis* blooms coming from Maumee Bay; and
- Targeting areas for conservation and restoration of habitats in the Detroit River and western Lake Erie.

There is great potential for further use of geospatial tools to strengthen science-policy linkages. ***It is recommended that environmental and natural resource managers incorporate GIS and remote sensing tools in their assessment programs or add GIS and remote sensing capabilities (available from universities, organizations with GIS/remote sensing expertise, or consulting firms) to help support sound science-based decision-making.*** One practical example of a university-management partnership is the linkage of Eastern Michigan University research on spatial and temporal changes of *Phragmites* with the work of the Detroit River-Western Lake Erie Cooperative Weed Management Area and *Phragmites* Strike Team. The Weed Management Area and *Phragmites* Strike Team are a cooperative effort among BASF, DTE Energy, Ducks Unlimited, Eastern Michigan University, Huron-Clinton Metropolitan Authority, International Wildlife Refuge Alliance, Michigan Department of Natural Resources, Monroe Conservation District, Southeast Michigan Council of Governments, The Stewardship Network, The Nature Conservancy, U.S. Fish and Wildlife Service, and Wildlife Habitat Council to assess/monitor, prevent, and manage invasive species. A steering committee is used to cooperate among organizations and take management actions. The Detroit River-Western Lake Erie Cooperative Weed Management Area and *Phragmites* Strike Team create efficiencies among the partners and lead to improved effectiveness in managing invasive species. The Eastern Michigan University research on *Phragmites* is helping set priorities for *Phragmites* control efforts and helping evaluate the effectiveness of herbicide treatments.

GIS and Remote Sensing Empower Adaptive Management

Today's environmental issues are as complex as ever. Ecosystems are changing very quickly in response to human disturbance, invasive species, and climate change, and are exhibiting novel characteristics. Managers are therefore confronted with high levels of uncertainty, and the necessity to make today's decisions despite the presence of this uncertainty. The process of adaptive management is a deliberate, science-based process for decision-making in the face of uncertainty. Natural resource managers need real-time information on the spatial distribution of and relationship between many elements of ecosystems. Different kinds of geographical information technology (GIT), including GIS and remote sensing, help meet these needs by enabling analysis of large amounts of information. Sometimes, effective display of spatial information to policy-makers and stakeholder communities with straightforward and complete analysis is all that is required to initiate the necessary policy changes to make environmental improvements.

It is recommended that managers plan actions and evaluate the ecological response of their actions through an adaptive management process, investing appropriately in GIT to ensure the appropriate data analysis to inform and improve future decisions.

GIS and Remote Sensing are Made More Powerful When Incorporated with Other Tools like Modeling

Some of the most pressing environmental questions require data collection and analysis over large geographic scales. Datasets incorporating lakewide or even corridor-wide information are not only difficult and expensive to collect, but landscape-scale changes may happen over long periods of time, further inhibiting experimentation at this scale. Therefore, modeling is used to test hypotheses based on known information about the ecosystem. Especially important to natural resource managers are models that are spatially explicit, where the consequences of different alternative actions are able to be seen impacting the real landscape.

It is recommended that modeling be coupled with spatial decision support systems (SDSS) that are readily available to managers, such as those produced by the Great Lakes Commission's Leveraging Geospatial Resources - Making the Case for Geo-Enabling Decision Processes in the Great Lakes and the Institute for Geospatial Research and Education at Eastern Michigan University's GIS-based SDSS for the Detroit River International Wildlife Refuge. These systems should integrate datasets that span jurisdictional boundaries so that solutions are effective for the entire landscape. They should also be bolstered by long-term investment in populating spatial datasets with new information, so that changes on the landscape can be quantified and communicated effectively to the public.

Modeling is often used in the assessment and priority-setting phases to help understand how ecosystems function and what services they provide, and to make predictions for better ecosystem-based management. Good examples of integrating modeling with GIS and/or remote sensing include:

- Using GIS data on diving duck abundance and factors affecting diving duck distribution (e.g., recreational boat disturbance) to develop predictive models of diving duck distribution;
- Using RADAR (SAR) to map *Phragmites*, identify environmental drivers affecting distribution, and develop a decision support system to predict and prioritize control of *Phragmites*; and
- Using remote sensing and GIS to model and predict priority natural features for setting management priorities under Essex Region Conservation Authority's Natural Heritage System Strategy.

Clearly, better and more robust management decisions can be made by integrating such tools. Therefore, ***it is recommended that management agencies place a high priority on integrating modeling with GIS and remote sensing to better facilitate science-based decision-making and practice adaptive management.*** Further, such integration will help treat management actions as experiments that promote learning and will help ensure that hypotheses are developed and tested using scientific rigor.

GIS and Remote Sensing Tools Can Help Measure Ecosystem Benefits and Services

There is growing interest in measuring ecosystem benefits of environmental and natural resource management, and in measuring ecosystem services. Ecosystem services are the societal benefits derived from ecosystems. They include providing clean water and food, regulating floods, controlling diseases, providing recreational and cultural benefits, and supporting nutrient cycling that maintains the conditions for life on Earth. Such measurement of ecosystem benefits and services helps manifest the social and economic advantages of ecosystem-based management.

In the Rouge River watershed in southeast Michigan, the Southeast Michigan Council of Governments, Wayne County Department of the Environment, and Detroit Water and Sewerage Department used GIS to quantify storm water benefits of green infrastructure. As a result, $50 million of green infrastructure over a two-year timeframe was included in the most recent Detroit Water and Sewerage Department National Pollutant Discharge Elimination System Permit, saving hundreds of millions of dollars in highly-engineered combined sewer overflow controls (e.g., massive underground retention basins). Such economic benefits and ecosystem services can also provide compelling rationale for investing in green infrastructure. Further, such “return on investment” information can be a catalyst for accelerating ecological design work, pollution prevention, cleanup, and restoration work.

It is recommended that spatial decision support systems include the ability to estimate both economic and ecosystem costs and benefits to allow fully-informed decision-making and facilitate discovery of novel solutions to management problems.

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5.1 Keynote Address: Technologies for Better Decisions in the Huron-Erie Corridor

Introduction

Advancements in an array of observing technologies have provided powerful tools to improve environmental assessment and to aid in decision-making. The full potential of technologies for environmental assessment has not yet been realized, particularly in combining or integrating various tools. We have come a long way from aerial over-flights combined with routine water quality sampling in providing a regional picture of a particular issue. Many segments of our life have been moved into a global arena, and environmental matters are no different. Our environmental issues are global, national, regional, local, and sub-local, and many of the technologies can be applied in the broadest view and then down to highly-resolved small scales to determine relationships across spatial scales (Figure 1).

A great deal of insight has been gained from remote sensing, Geographical Information Systems (GIS), wide-scale and multi-layered mapping, and hydro-acoustic devices, and such insights have progressed to a point where management can better evaluate priorities for conservation and remedial actions on varying spatial and temporal scales. Integration of these tools, together with conventional sampling and monitoring, sensors and data loggers, trend analysis, risk assessment, and mathematical modeling are pushing the envelope even further to meet the complex issues of the day.

Figure 1. Satellite Image of the St. Lawrence Great Lakes (photo credit: NASA).

The Huron-Erie corridor has been subjected to multiple environmental alterations and threats for over a century. Numerous Areas of Concern occur throughout the corridor, including international Areas of Concern. To the north, the St. Clair River has been impacted by chemical industries for years, but substantive progress has been made. Lake St. Clair has possessed good water quality, but is temporally impacted by wastewater discharges, tributary inputs, non-point source runoff, and nearshore problems. The Detroit River has been particularly impacted and has a large number of impaired beneficial uses (IJC 1997). It is the only Great Lakes Area of Concern that has another Area Concern as a major tributary (i.e., Rouge River). The western basin of Lake Erie receives the cumulative discharge of the corridor and has similar problems to Lake St. Clair with respect to point and nonpoint source discharges. Oxygen depletion and nutrient over-enrichment of Lake Erie and its dead zone are well-documented. Fortunately, high quality water enters the corridor from southern Lake Huron, and together with various mitigative and remedial actions, water quality has great potential for resilience and continues to improve in the corridor. I would like to provide three examples of how technologies are being used in the Huron-Erie Corridor for scientific inquiry and to meet the needs of corrective actions.

Technologies for Analyzing the Huron-Erie Corridor

There have been numerous successes in the corridor to remove contaminants from the system and reduce potential downstream contaminant movement into Lake Erie by remedial dredging of sediments. These include the St. Clair River south of Sarnia, Conner Creek, Monguagon Creek, and more recently the Black Lagoon under the Great Lakes Legacy Act (USEPA 2011). Sediment remediation will continue and further remediation is being planned for the Detroit River. Sediment dredging has never been an exacting operation; however, the use of technologies is reducing error and yielding cost savings. Arial over-flights, together with Google Maps and Global Positioning Systems (GPS), are providing greater spatial resolution for operations. Make no mistake; Google maps have made a distinct impact within the suite of technologies. Supplemented with sediment coring and analysis for source data and ground-truthing, GIS mapping and subsurface modeling, using extrapolation techniques such as kriging, provide three-dimensional representations of contaminant deposits. These further depict where contaminants are above and below target concentrations and guide decisions for cost-effective removal (Figure 2).

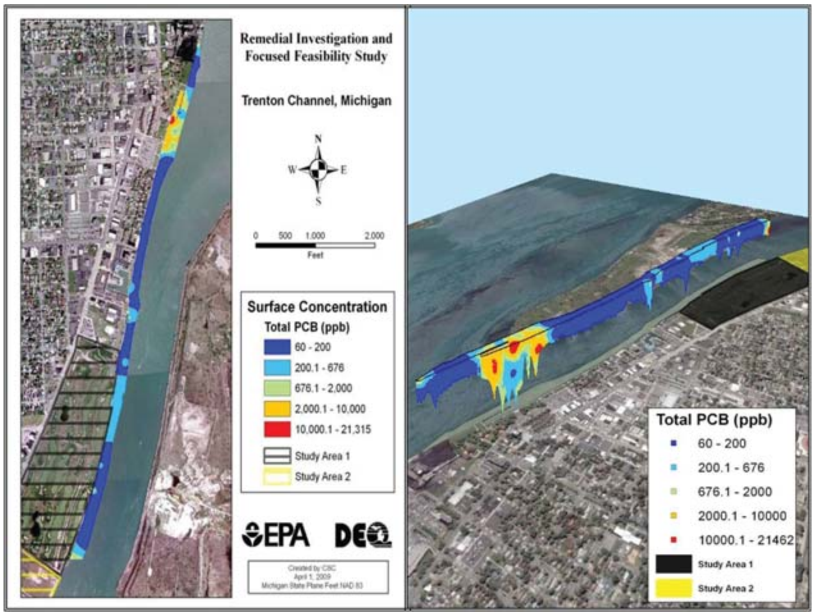
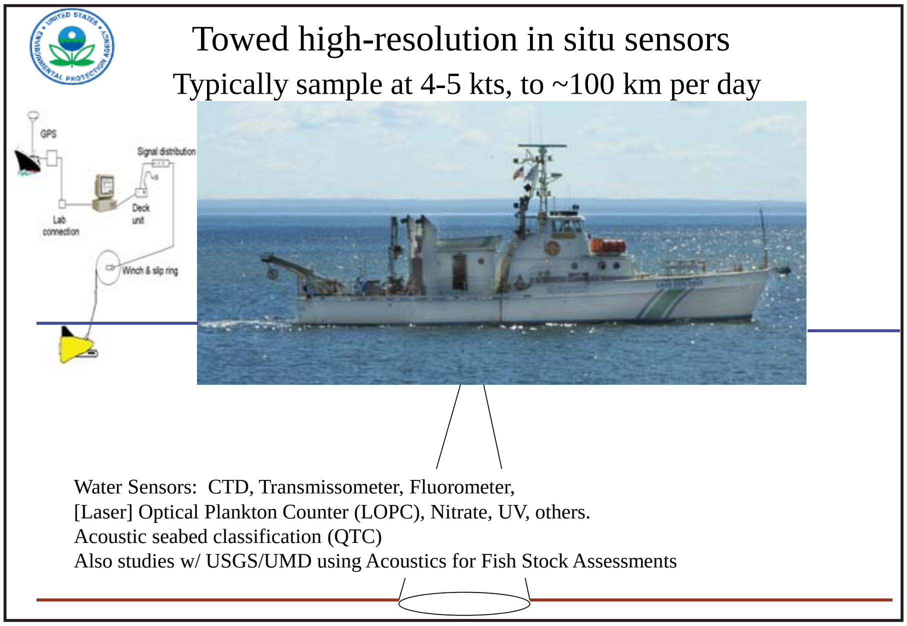


Figure 2. Mapping and Modeling in the Trenton Channel, Detroit River (photo credit: USEPA Great Lakes National Program Office).

Lake Erie has had a long history of high nutrient concentrations, nuisance algal blooms, and oxygen depletion. These conditions appeared to relax in the 1980s and early 1990s; however the impacts of dreissenid mussels and an influx of nutrients have, in part, exacerbated recovery. Although a complete understanding and direct cause-and-effect relationships among zebra mussels, and subsequent quagga mussels, and concurrent water quality, are not established, technologies are aiding in the characterizations of the phenomenon. Hazardous blooms of the toxic cyanobacterium *Microcystis* are being observed and monitored through remote sensing, aerial over-flights, and conventional sampling. In addition, model forecasting is being applied to predict distributions, and in a number of cases, protect drinking water supplies. The concurrence of *Microcystis* and increased dissolved phosphorus have been casually associated, but the availability of these real-time density data has been afforded by automated samplers and could not have been obtained through conventional tributary sampling methods. Better characterization of water quality associated with landuse is being afforded by high-resolution, towed sensors which provide multiple measurements in the nearshore zone over a lakewide scale (Figure 3).

World-wide, wetland communities have decreased as a result of human activity along shorelines. In the Huron-Erie corridor, areas such as the Detroit River, over 95% of the shoreline wetlands have been lost. The remaining wetlands are so few that it is paramount that they be protected and managed over space and time. GIS and mapping technologies have advanced to a point where they are being effectively used to determine the wetland type and community composition with high spatial resolution. Although there are numerous threats, it is apparent that invasion by *Phragmites* is extremely aggressive and extirpates the other species resulting in *Phragmites* monocultures. In application, high resolution maps are being generated to direct different mitigation strategies, generally spray, treat, or burn *Phragmites*, in order to protect proximal communities (Figure 4).


Towed high-resolution in situ sensors

Typically sample at 4-5 kts, to ~100 km per day

Water Sensors: CTD, Transmissometer, Fluorometer,
[Laser] Optical Plankton Counter (LOPC), Nitrate, UV, others.
Acoustic seabed classification (QTC)
Also studies w/ USGS/UMD using Acoustics for Fish Stock Assessments

Figure 3. High-Resolution Sensing System in the Nearshore of Lake Erie (photo credit: USEPA Office of Research and Development, Jack Kelly)

Conclusions

Technologies are very powerful tools that have great potential and I hope to have demonstrated that their application is making a difference in the Huron-Erie Corridor. The horizon is infinite for satisfying scientific inquiry and aiding environmental management decisions and actions.

I contend that the greatest power is obtained through integration of multiple technologies and disciplines. This is consistent with a monitoring, mapping, modeling, and management paradigm. The younger scientists with us today will be our scientific leaders and managers for the next several decades. You will find the environmental challenges will become even more complex and environmental assessment to determine the human footprint on ecology and the various tradeoffs regarding supply and demand that will be encountered must be addressed. The need and competition for land, food, water, energy, and resources will continue to increase. In October 2011 there were seven billion people in the world, eight billion by the year 2025, and a projected nine billion by the year 2050. But scientific inquiry and discovery will not be enough because there will be an inherent push and pull among the environment and resources, policy, societal values and growing the economy and jobs. But with the technologies, integration, and in fact, trans-disciplinary science, you will be able to "step to the plate" and meet the challenges to protect, preserve, and sustain our environment and human health.

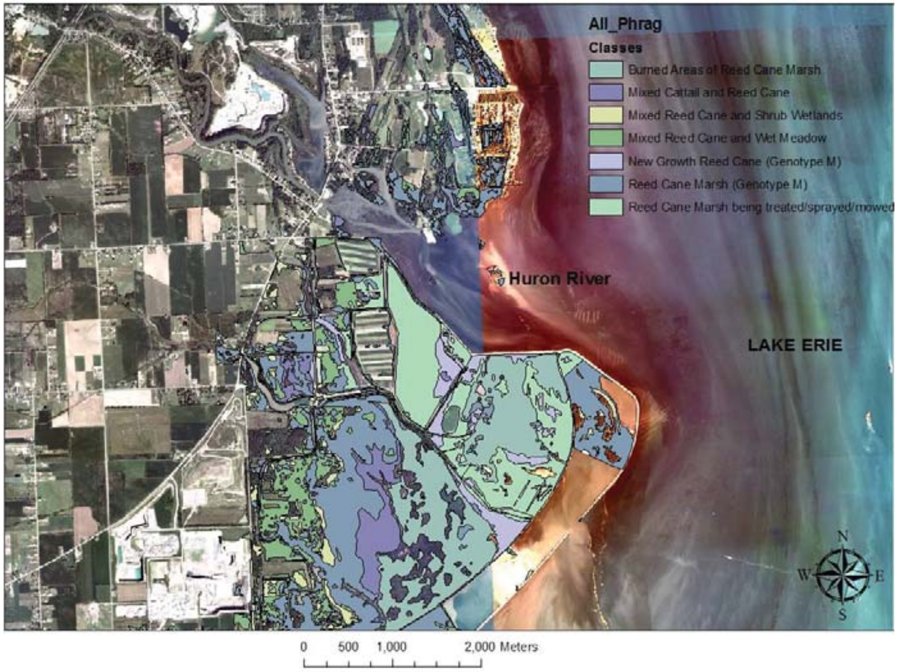


Figure 4. Satellite Image and Mapping of Lake Erie Wetlands for Management Strategies (photo credit: IGRE)

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5.2 Stopover Sites for Migratory Birds in the Western Lake Erie Basin, Ohio and Michigan: A Spatial Analysis Using Geographic Information Systems

Introduction

Conservation of migratory birds is challenging because they occur in geographically separated areas, up to thousands of kilometers apart, during their annual life cycle. Ecological conditions and threats to the habitats used by migratory birds vary dramatically between the breeding and winter seasons and during spring and fall migration. In addition, factors affecting condition of birds, survivorship and/or productivity in one season influence fitness of birds in following seasons (Marra et al. 1998). Stopover sites, areas used during migration between breeding and wintering areas, provide critical resources for birds to feed and rest and thus may influence fitness of birds subsequently. Mortality of adult birds, such as some species of landbirds, may be highest during the migration period (Sillett and Holmes 2002). Consequently, identifying important stopover habitat, areas used by large numbers of migrants, is needed to implement comprehensive conservation programs for migratory birds.

Large numbers of many species of all bird groups (defined here as landbirds [e.g., songbirds, including raptors], shorebirds [e.g., sandpipers, plovers and allies], waterfowl [ducks and geese] and waterbirds [e.g., loons, grebes, cormorants, cranes, and rails]) migrate through the western Lake Erie basin and some sites are considered to be of global or regional importance (Western Hemisphere Shorebird Reserve Network, Ontario Important Bird Area Network). As a result, this region was considered a top priority in the Great Lakes region to develop spatial models of stopover sites using Geographic Information Systems (GIS).

The goals of this project were to: (1) identify and summarize ecological and spatial attributes of migratory bird stopover sites in the Ohio and Michigan portions of the western Lake Erie basin based on a synthesis of the literature and unpublished sources, (2) develop a system for ranking or scoring the relative conservation importance of migratory bird stopover sites in the western Lake Erie basin, (3) use GIS data layers to depict areas by score and by bird group to prioritize where conservation could be implemented to protect migrating birds in the western Lake Erie basin, and (4) use results to inform broad biodiversity conservation strategies such as those developed in the Lake Erie Blueprint for Conservation of Biodiversity.

Methods

The study site included the Michigan and Ohio portions of the western Lake Erie basin. We reviewed peer-reviewed and gray literature and interviewed experts familiar with stopover sites in the western Lake Erie basin to identify spatial and ecological attributes associated with sites where migrating landbirds, shorebirds, waterfowl, and waterbirds are known to concentrate. Based on this information, we then determined which attributes could be mapped with GIS data layers, such as land cover or wetlands, common to both Ohio and Michigan, or which could be cross-referenced. Experts then assigned scores to these attributes, or combinations of attributes for each bird group which were then mapped at a 30 meter pixel resolution. This resulted in the creation of maps displaying the predicted relative importance of areas in the western Lake Erie landscape to migrants based on the criteria we used for the analysis. Scores ranged from very high priority (score of 5) to very low priority (score of 1) for each bird group; scores can be summed across all bird groups at each location to identify sites or areas particularly important for migrants generally in the western Lake Erie basin landscape.

The GIS analysis was completed with the best available and current data. The study area covered 2,832,800 hectares (7,000,000 acres) in Michigan and Ohio, including Lake Erie islands. We used the following sources for mapping: National Wetlands Inventory, Ohio Wetlands Inventory (where National Wetlands Inventory was not available), Landsat ETM+ imagery (1999-2001, to identify hydric soils on agricultural lands), USGS Digital Elevation Model, and CCAP and NLCD (for land cover). Much of the data was pieced together from several sources which can result in some error. Other sources of error may include inaccurate classification of satellite or aerial photos and changes in ground conditions since the original photography was taken. Some files contained more than 100,000 records which pushed our technology to its limits. The analyses should be combined with on-site observations and expert assessments to most accurately characterize stopover sites.

Other ecological or landscape features which may influence distribution of migrants, such as vegetation structure or species composition of a site, are described in the narrative of Ewert et al. (2005) but could not be mapped because GIS data layers are inadequate to map these features at the scale of desired resolution.

An important assumption of our work is that areas with high concentrations of birds are the most important sites for conservation work. There are insufficient data to evaluate sites across the western Lake Erie basin based on changes of condition of birds, predation rates, or other sources of mortality, although some recent work (e.g., Craves 2009; MacDade et al. 2011) is addressing factors affecting condition of birds. Other assumptions and caveats associated with our scoring system for each bird group, as well as research needed to fill the most important information gaps, are described in Ewert et al. (2005).

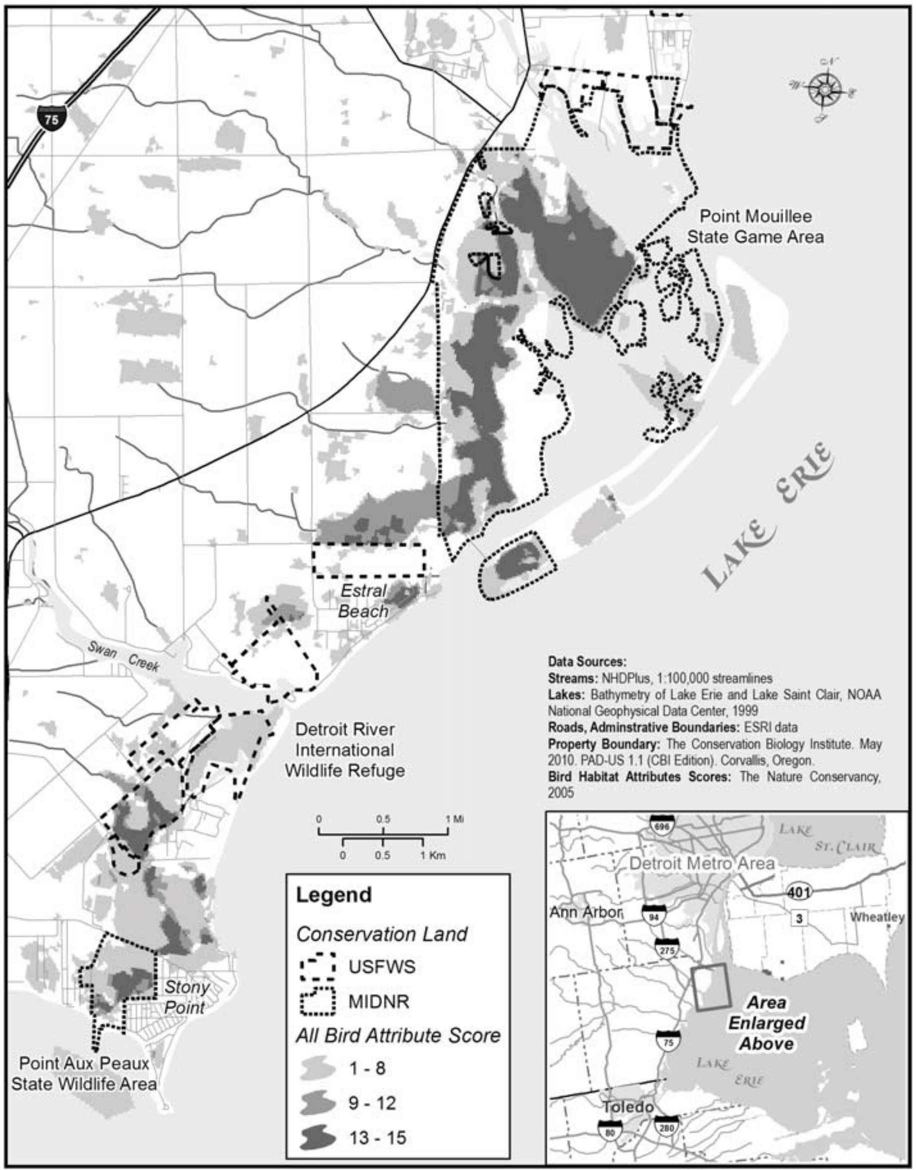
Results and Discussion

Even though migrants in different bird groups select different landscape features in the western Lake Erie landscape, our assessment indicates that habitats close to Lake Erie support larger numbers of waterfowl, shorebirds and landbirds than inland areas and therefore scored relatively high (Ewert et al. 2005). For illustrative purposes, characteristics of important stopover sites for landbirds depicted by our GIS analyses are shown in Table 1; this table and analogous information for waterfowl and shorebirds provides the basis for the GIS products. For illustrative purposes, we depict the summed scores for landbird, shorebird and waterfowl near Point Mouillee, Michigan in Figure 1.

Table 1. Expert-based scores assigned to landbird/raptor attributes available as digital, spatial data.

Attribute	**Score**	**GIS Layer**
Undeveloped cover <0.4 km from Lake Erie	**5**	**Landcover**
Undeveloped cover >0.4 km and <1.6 km from Lake Erie	**4**	**Landcover**
Undeveloped cover >1.6 km from Lake Erie and <200 m from rivers, lakeshores, and wetlands	**3**	**Landcover**
Undeveloped cover >1.6 km from Lake Erie and >201-400 m from rivers, lakeshores, and wetlands	**2**	**Landcover**
Undeveloped cover >1.6 km from Lake Erie and >4 km from other cover	**2**	**Landcover**
Undeveloped cover >1.6 km from Lake Erie and <4 km from any other habitat	**1**	**Landcover**

We recognize that species within each bird group have different habitat requirements but there were insufficient data and resources to portray known or projected species-specific relative abundance in the western Lake Erie



Data Sources:
Streams: NHDPlus, 1:100,000 streamlines
Lakes: Bathymetry of Lake Erie and Lake Saint Clair, NOAA National Geophysical Data Center, 1999
Roads, Adminstrative Boundaries: ESRI data
Property Boundary: The Conservation Biology Institute. May 2010. PAD-US 1.1 (CBI Edition). Corvallis, Oregon.
Bird Habitat Attributes Scores: The Nature Conservancy, 2005

Figure 1. Distribution of predicted high-use stopover sites in the Pointe Mouillee region, Michigan by rank score summed for landbirds, shorebirds and waterfowl.

basin during migration. In the narrative of Ewert et al. (2005) we provided qualitative descriptions of species-specific habitats during migration for some species and thus set the stage for more refined analyses as resources and new GIS data layers become available.

Metadata describing the data layers were summarized by August Froehlich and included in Ewert et al. (2005). Metadata and GIS data layers are available for viewing, exploring and printing maps with ArcReader.

Conclusions

The western Lake Erie basin stopover models have provided information that can inform: (1) ongoing land acquisition and restoration, (2) lake-wide basin planning efforts, and (3) wind energy siting guidelines and recommendations (Ewert et al. 2011). The effort has also been the impetus to develop stopover models for other portions of the Great Lakes basin by others: (1) Great Lakes shorelines of Wisconsin, (2) Chicago Wilderness region, (3) Green Bay and Saginaw Bay regions of Michigan, (4) Lake Ontario shoreline of New York, and (5) the eastern shore of Lake Huron and northern shore of Lakes Ontario and Erie in Ontario, Canada.

Recommendations and Lessons Learned

- A thorough review of the literature and recruitment of experts on stopover sites in the western Lake Erie basin and a dedicated staff expert in spatial modeling were essential to providing a disciplined, evidence-based approach to develop the stopover models.
- Conversion of results from stopover studies to GIS products requires considerable time and a core team to ensure appropriate interpretations/applications of stopover studies and GIS takes place.
- Revisions of models will be required as new information and GIS data layers become available. Well-focused research is needed to increase the resolution of the models.

Acknowledgements

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5.3 Developing Spatially-Explicit Models to Guide Conservation of Diving Ducks During Migration

Introduction

Historically, Lake St. Clair and western Lake Erie hosted an estimated 250,000 to 750,000 diving ducks during peak fall migration and is a location of continental significance to waterfowl as depicted in the North American Waterfowl Management Plan (NAWMP 2004; Bookhout et al. 1989; Soulliere et al. 2000). Prominent diving ducks during migration include canvasbacks (*Aythya valisineria*), lesser scaup (*A. affinis*), greater scaup (*A. marila*), and redheads (*A. americana*). Both canvasbacks and lesser scaup have been listed as species of priority by the Upper Mississippi River Great Lakes Region Joint Venture (UMRGLJV 2007).

Little research has been conducted on factors affecting distribution and abundance of diving ducks during migration, and understanding these factors for the Great Lakes region is important within the context of system-wide impacts of coastal wetland losses, reduced water quality, contaminant discharge, and invasions by exotic species. Poor water quality historically reduced abundance of submerged aquatic plants that were important foods for migrating diving ducks. Invasion by zebra (*Dreissena polymorpha*) and quagga mussels (*D. bugensis*) into Lake St. Clair during the 1980s created a new food source for some species of diving ducks and these invasions may have indirectly affected abundance of important diving duck plant foods as the filtering effects of mussels can improve water clarity. Also, Lake St. Clair is among the most heavily used areas of the Great Lakes by recreational boaters with over 200 marinas (Snider 1999) and this has implications for use by diving ducks as disturbance from boaters can displace birds from preferred feeding areas (Knapton et al. 2000). There is also concern that nearshore and offshore wind energy structures may displace diving ducks from important use areas if land use planners do not consider potential affects on diving ducks.

Feedback is a key component of adaptive conservation planning and the goal of our research is to address UMRGLJV and Michigan Department of Natural Resources (MDNR) needs related to monitoring priority waterfowl species during migration. We hope to improve conservation planning by identifying factors affecting temporal and spatial dynamics of diving duck populations during migration. To meet these information needs on our study area, we are analyzing data collected during historical aerial surveys conducted by MDNR. In addition, we are developing aerial survey protocols using distance sampling methodology that we hope will improve our understanding of diving duck distribution and abundance on Lake St. Clair and western Lake Erie.

Methods

Lake St. Clair and western Lake Erie are shallow, highly productive lake basins and our study area is dominated by open water less than ten meters deep. Lake St. Clair encompasses an area of 1150 km^2. The international border divides Lake St. Clair with the western third of the lake in the United States and the eastern two thirds in Canada. Historic diving duck surveys (1983–2008) included only the U.S. portion of Lake St. Clair while our contemporary surveys include transects across the entire lake;

in addition, we now survey portions of western Lake Erie extending southward from the lower Detroit River to Maumee Bay near Toledo, Ohio.

Historical Surveys

Historical surveys (1983–2008) were flown to monitor diving duck abundance within the U.S. waters of Lake St. Clair during fall migration. All surveys were flown on east-west transects spaced three kilometers apart. Pilots flew approximately 150 km/h at a height 100 m above the water. We estimated diving duck flock size by species, and recorded flock locations on paper maps of Lake St. Clair. During these surveys, no attempt was made to estimate detection probability of flocks, which was assumed to be near 1.0. In addition, we recorded locations of boats observed during aerial surveys as diving ducks are intolerant of boats in close proximity. We digitized flock and boat locations and georectified paper maps to a base Geographic Information System (GIS) layer using ArcGIS (ESRI 2006). All flocks were represented by a single point located at their center.

We used a bathymetric GIS layer with pixel resolution of 15 m by 15 m (NOAA 2011) to associate duck observations with water depth in four categories and adjusted estimated water depths at flock locations to account for deviations in Lake St. Clair water levels from the long-term average lake level. We modeled temporal changes in diving duck abundance by species using generalized linear models and implemented these analyses in SPSS (2009). We used the number of birds of each species counted on individual surveys as the response variable and broke the fall migration season into six weekly intervals for inclusion as a categorical explanatory variable. We also created a year categorical explanatory variable using three, 6-year intervals (1983–1988; 1989–1994, and 1995–2000) and one 8-year interval (2001–2008). We included number of boats counted during each survey as a covariate in our linear models to account for potential effects of disturbance on diving duck abundance. We estimated marginal means for effects of week and year using linear models fit to each diving duck species with the covariate for boat counts held at the mean over all surveys. We used ArcGIS to map distributions of diving ducks using the same 4-year periods used in our linear modeling. We fit kernel density models for each species and year interval and mapped model estimates using the spatial modeling feature in ArcGIS (ESRI 2006).

Current Surveys

Prior to our first fall field season we used ArcGIS to establish a systematic east-west oriented line transect survey with a random start point (ESRI 2006). Historic surveys were expanded to cover all of Lake St. Clair (1149 km^2) and parts of western Lake Erie (621 km^2). We established 26 transects from the northern end of Lake St. Clair to the southern shore of Lake Erie. We established five distance categories extending from the transect line out to 50, 125, 225, 425, and 825 m from the aircraft. We used our target flight altitude and a clinometer to establish declinations from horizontal to associated distance bands and placed visible markings on windows and struts of the airplane to allow observers to record ducks by distance categories. Observers aligned window and strut marks and recorded the appropriate distance category at the center of each flock. All distance data were analyzed using the software *Distance 6.0* (Thomas et al. 2010).

Each of two observers was responsible for recording birds on one side of the aircraft. All flights were conducted at a target altitude of 91 m using an amphibious DHC-DeHavilland Beaver. We recorded flock locations using a Global Positioning System (GPS) with audio recording capability. Due to GPS failures during the first field season, two different GPS systems were used. One observer used a Nomad unit connected to a Garmin 10.0 wireless GPS, while the other observer used a Columbus V-900 data logger. We recorded GPS locations of diving ducks, offshore boats, and hunting parties. Our research plan includes conducting five aerial surveys during both spring and fall migration for two-years, and we have completed the first year of aerial surveys. We plan to use the spatially explicit data collected during these surveys to evaluate variables predictive of diving duck abundance.

Results

Historical Surveys

MDNR staff completed 99 diving duck surveys of the U.S. portion of Lake St. Clair during fall migrations from 1983–2008. Linear models predicting diving duck abundance by species supported seasonal effects as well as an effect of boating traffic on abundance for all species (F-values > 6.0; p-values < 0.01). The only species for which linear models did not support year effects was the model predicting redhead abundance. Parameter estimates for the effect of boating activity indicated an expected 648, 178, and 312 fewer canvasbacks, redheads, and scaup observed for each additional boat counted during the surveys (95% confidence intervals: + 393, + 122, and + 202).

Lake St. Clair supported more diving duck use in recent years (i.e., after invasion by Dreissenid mussels) compared to the 1980s (Figure 1). For example, estimates of total annual fall use-days, with a use-day equal to one duck spending one day on the study area, by canvasbacks in U.S. waters increased from 500,550 use-days/year (95% confidence interval + 202,445) prior to 1989 to 1,048,972 use-days/year (95% confidence interval + 271,342) during 1989–2008. Total annual fall use-day estimates for scaup increased from 176,975 use-days/year (95% confidence interval + 54,235) prior to 1989 to 599,321 use-days/year (95% confidence interval + 133,381) during 1989–2008. In contrast, total annual fall use-day estimates for redheads in U.S. waters were relatively stable with 413,015 use-days/year (95% confidence interval + 113,500) prior to 1989 and 430,575 use-days/year (95% confidence interval + 95,371) during 1989–2008.

In addition to changes in abundance, we observed different spatial use patterns of Lake St. Clair by diving ducks among years. Canvasback distribution in U.S. waters of Lake St. Clair changed with a relatively broader distribution during the period 1989–2000 when canvasbacks were most abundant. Canvasbacks used the western side of Anchor Bay north of the mouth of the Clinton River extensively during 1983–2000, but this area received relatively less use during 2001–2008. Redhead distribution was relatively stable over time compared to changes in canvasback distribution. The near-shore waters along the western side of Anchor Bay were used extensively by redheads in all periods; however, there was a notable shift away from the shore after 1994. Changes in scaup distribution were similar to those of canvasbacks, except after 2000 when scaup use of offshore waters of Anchor Bay remained relatively high. Like canvasbacks, scaup used deeper waters later in the study, but change in water depth use was less dramatic after 2000 resulting from persistence of scaup in the relatively shallow Anchor Bay. Distributional shifts in canvasbacks and scaup resulted in increased use of intermediate water depths (2-4 and 4-6 m) and reduced use of shallow water depths (0-2 m) over time.

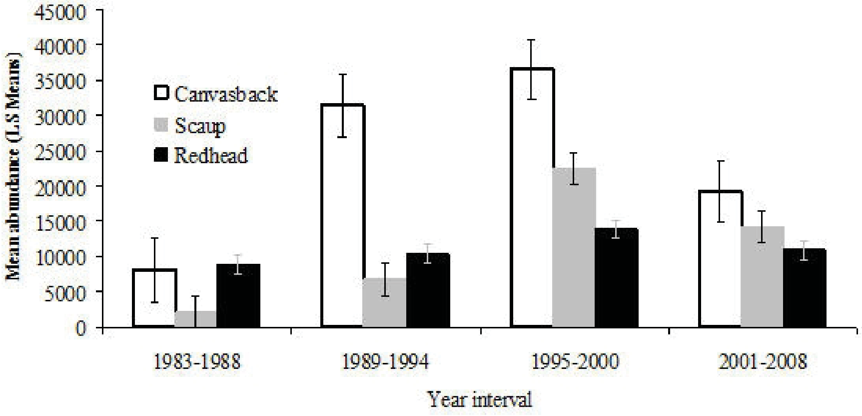

Figure 1. Mean (+ 1 SE) abundance of diving ducks on U.S. waters of Lake St. Clair by year interval, 1983-2008. Estimates are marginal means from species-specific linear models predicting abundance from week and year intervals and numbers of boats observed held at the mean over all surveys.

Current Surveys

We completed five surveys during fall of 2010 and five surveys during spring of 2011. The pilot flew a total of 531.5 km of transect on each survey. The total number of observed flocks on individual flights ranged from 65 to 204, and flock size ranged from a 1 to 45,000 birds. The total number of GPS-referenced flocks ranged from 43 to 97 (Table 1). The detection probability on individual surveys ranged from 20% to 28% and expected flock size ranged from a low of seven birds to a high of 536 (Table 1). The coefficient of variation (CV) ranged from 13% to 38% with CV's generally being higher during fall migration due to inherent variation in flock size (Table 1). Population estimates obtained with distance sampling methods were generally higher during fall migration than during spring with a peak estimate of 470,190 birds (Table 1).

Table 1. Summary statistics of current aerial diving duck surveys conducted using distance sampling techniques over Lake St. Clair and western Lake Erie.

Flight Date	Detection Probability	Expected Flock Size	Population Estimate	CV	Model Fit	Number of Flocks with GPS Location
10/29/2010	0.238	**536**	**310,270**	0.277	*<.05	**na (GPS failures)***
11/08/2010	0.261	**266**	**260,600**	0.338	0.219	**70**
11/16/2010	0.196	**319**	**470,190**	0.379	* <.05	**43***
12/03/2010	0.236	**135**	**194,650**	0.317	* <.05	**78**
03/25/2011	0.229	**67**	**120,550**	0.205	0.294	**48***
04/01/2011	0.284	**53**	**67,377**	0.183	0.236	**81**
04/13/2011	0.216	**17**	**23,424**	0.154	0.571	**97**
04/21/2011	0.231	**9**	**15,409**	0.172	0.519	**94**
04/29/2011	0.201	**7**	**26,263**	0.132	0.386	**94**

Discussion

Historical analyses revealed an increase over the course of the study period in scaup and canvasback abundance while redhead abundance remained approximately the same. In addition, both canvasbacks and scaup had a shift in distribution from shallow water depths (0-2 m) to intermediate water depths, while redheads remained closely tied to shallow water throughout the study period. We also found that abundance of all three diving ducks species was inversely related to recreational boating pressure within U.S waters of Lake St. Clair.

We believe that increases in scaup and canvasback abundance, as well as distributional shifts to deeper water, may indicate increased food availability on Lake St. Clair. One possible explanation for increasing amounts of food during our study period could be the invasion of dreissenid mussels in the mid 1980s. Dreissenids became a new and abundant food source for the more carnivorous scaup as found by researchers who documented 80% of scaup on Lake St. Clair contained dreissenids (Custer and Custer 1996). In addition, dreissenids may have had indirect impacts on more herbivorous diving ducks like canvasbacks and redheads. Although not targeted as a new food resource, dreissenids were the likely cause of a two-fold increase in water clarity documented on Lake St. Clair from 1986–1994 (Nalepa et al. 1996). This two-fold increase in water clarity led a resurgence in submergent vegetation documented anecdotally by MDNR biologists, and subsequently may have resulted in more food distributed over a wider geographical range for canvasbacks and redheads (Ernie Kafcas pers. communication).

Current survey methodology has improved the quality of spatial data because we now are no longer dependent on paper maps and observer judgment to locate diving duck flocks. Instead, we are able to record GPS locations for all diving duck flocks allowing us to perform more rigorous spatial analyses of factors influencing diving duck distribution within our study area. In addition to obtaining spatially-explicit distribution data, it appears distance sampling is a viable survey option for open water scenarios although not commonly used for waterfowl surveys. Historical surveys focused solely on large flocks (>250 birds) and assumed a detection probability of near 1.0; however, during some surveys, large numbers of small flocks of birds may have gone undetected. Distance sampling allows us to more appropriately account for small groups and likely generates a more accurate measure of abundance. Our second year of distance sampling research will focus on determining the most appropriate means for analyzing extremely large flocks of ducks (>10,000 birds) that cover multiple distance bands within a distance sampling framework.

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5.4 Innovative Techniques to Map *Phragmites australis* in the Lake St. Clair Watershed

Introduction

Phragmites australis (Phragmites) is a highly invasive grass that has the ability to become a monoculture in habitats ranging from uplands to freshwater marshes. *Phragmites* is creating dense monocultures throughout the Great Lakes, reducing plant and animal diversity in the process. It has a strong capacity to spread and recent low water levels in the Great Lakes appear to be favoring the expansion of *Phragmites* in the Lake St. Clair watershed. Mapping of *Phragmites* was undertaken in order to determine the current location of stands, predict future spread and develop a long-term control strategy. This project mapped 4,909 hectares (12,130 acres) of *Phragmites* in a 123,774 hectare (305,853 acre) project area, encompassing the Lake St. Clair watershed and surrounding townships. The photo interpretation was completed in ESRI's ArcMap software, using Southeast Michigan Council of Government's (SEMCOG) 0.6 meter resolution true color 2005 spring imagery. Other imagery, such as the two meter 2005 National Agriculture Imagery Program (NAIP), Bing Maps oblique Bird's Eye imagery, and Google Street View, was used as ancillary data.

Project Area

The project area consists of 123,774 hectares (305,853 acres) located in the southeast Michigan counties of St. Clair, Macomb, and Wayne (Figure 1). The area encompasses the entire Lake St. Clair watershed and extends to the boundaries of Clay, Cottrellville, Ira, Chesterfield, Harrison, St. Clair Shores and Grosse Pointe townships.

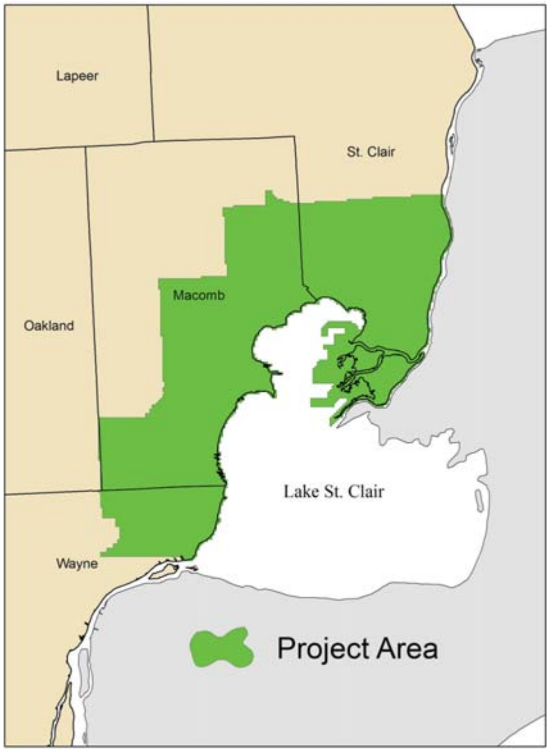


Figure 1. Project Area

Methods

ESRI's ArcMap software was used to digitize stands of *Phragmites* from the 2005 SEMCOG 0.6 meter resolution imagery at an approximate scale of 1:1200. True color 2005 NAIP two meter resolution imagery was also used to help determine vegetation types, as *Phragmites* shows up with a bluish "cotton candy" look. Also, very helpful in identifying stands of *Phragmites* were Bing and Google image sources.

Bing Maps oblique Bird's Eye imagery was available for a majority of the mapping area. This imagery is not only high resolution, but is also at an oblique angle that makes the height of *Phragmites* more prominent than surrounding vegetation. Also, in many areas the point of view can be rotated, helping to see around obstructions like trees or buildings.

Google Street View provided the ability to virtually drive up and down the roads and find very small stands of *Phragmites*, such as along ditches. It also was a valuable verification tool for many areas.

Once the mapping was completed, a roadside survey was conducted to verify a sampling of mapped stands of *Phragmites*, and to note any omitted stands, or areas incorrectly identified as *Phragmites*. Field verification sites were selected based on the amount of *Phragmites* mapped in the area, and taking into account traffic and safety concerns. Since the verification involved frequent stops and very slow driving, main roads were avoided. The field crew compared the actual *Phragmites* observed with the mapped *Phragmites* to confirm its presence or absence.

Results and Discussion

In total, 4,909 hectares (12,130 acres) of *Phragmites* were mapped in the 123,774-hectare (305,853-acre) project area (Figure 2). Of the 4,909 hectares (12,130 acres), 1,267 (3,130) have been field verified, of which 29 hectares (71 acres) were missed during the initial mapping and two hectares (four acres) were called *Phragmites* that were incorrectly identified.

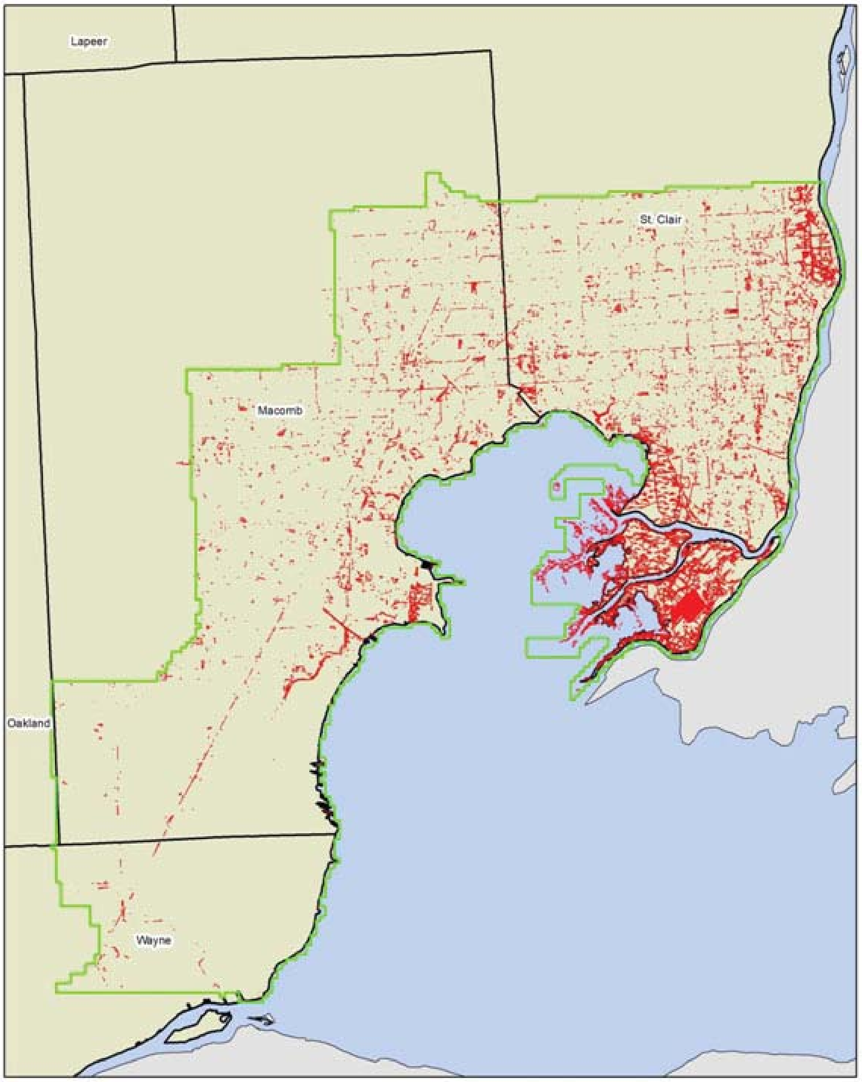
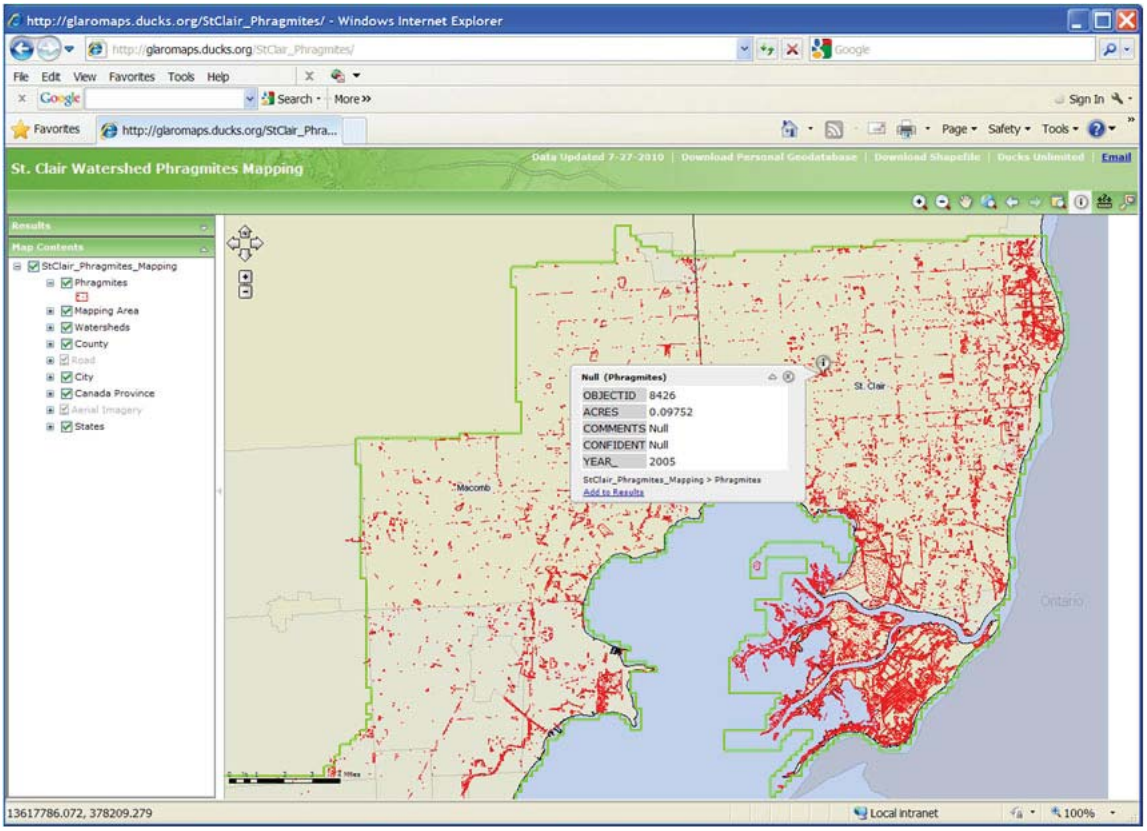


Figure 2. Phragmites *digitized in the mapping area.*

Although we did not quantify the results, the use of Bing high resolution oblique and Google Street View imagery was very helpful in the mapping process.There was a higher level of uncertainty and smaller stands of *Phragmites* were probably missed more often in mapping areas where these images were not available. The original work plan for this project included identifying historic stands of *Phragmites* from rectified 1978 imagery. Due to the scale of the 1978 imagery and the lack of historic location data, stands of *Phragmites* were very difficult to identify from the imagery. Therefore, funding allocated for the identifying historic stands of *Phragmites* was allocated to the design and building of an internet map viewer: http://glaromaps.ducks.org/StClair_Phragmites/.This viewer (Figure 3) allows the data to be viewed over aerial imagery and downloaded in shapefile or personal geodatabase format.



Null (Phragmites)

OBJECTID	8426
ACRES	0.09752
COMMENTS	Null
CONFIDENT	Null
YEAR_	2005

StClair_Phragmites_Mapping > Phragmites

Add to Results

Figure 3. Phragmites *map viewer.*

Acknowledgements

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5.5 Mapping Invasive *Phragmites* with Satellite Imaging Radar in the Coastal Great Lakes

Introduction

Throughout the past two centuries, the Great Lakes region has witnessed a variety of non-native (exotic) species permeate its boundaries. These species often remain unnoticed and are not detrimental to the habitat in which they reside. However when these exotic species become established in a given ecosystem and begin to cause economic, human health, or environmental damage in that ecosystem, they are termed invasive (U.S. Environmental Protection Agency, 2009).

Figure 1. Photo of large Phragmites *stand near Muskegon in coastal Lake Michigan.*

One species in particular, a fast-growing invasive reed, has begun to plague the Great Lakes region. The common reed, *Phragmites australis* (Figure 1), has recently been labeled an **extreme threat** to native ecosystems due to its aggressive ability to dominate a variety of ecosystems once introduced. There is a native species of *Phragmites* throughout the Great Lakes region; however, the invasive form is quickly displacing the native variety, as well as many other native types of vegetation. Invasive *Phragmites* is most prevalent in emergent wetlands throughout the Great Lakes region. This is due to rapid water level changes and the vast areas of exposed habitat. *Phragmites* can become well-established quickly because it propagates through underground rhizomes.

Within 10 km of the Great Lakes coastline, over 121,406 hectares (300,000 acres) of freshwater emergent wetlands exist. These areas, which are home to many endangered and threatened fish and wildlife species, are at risk of being invaded by dense stands of *Phragmites*. Once established, *Phragmites* is difficult to control and requires repeated applications of herbicide, cutting and/or burning. This regimen, however effective, also kills any native vegetation that remains after the initial invasion of *Phragmites*.

Currently there is no comprehensive map or documentation of the status/extent of *Phragmites* infestation in the Great Lakes region. There are, however, numerous environmental organizations attempting to locate and record the location of *Phragmites*, but their surveys usually cover small areas of land. A comprehensive map is needed to aid in effective management and control efforts across the Great Lakes basin.

Using a combination of dual polarization, L-band (23 cm wavelength), ALOS PALSAR data, as well as field documentation, known and potential *Phragmites* monoculture locations are being identified for the entire United States Great Lakes coastal basin within 10 km of shore (Figure 2). This is the first U.S. basin-wide map to be produced on this invasive plant. Advanced Land Observing Satelite (ALOS) is a Japanese satellite platform, which has an L-band (23 cm wavelength) imaging radar sensor, PALSAR, on board. Imaging radar (Synthetic Aperture Radar or SAR) is an active system that interacts differently with vegetative ecosystems based upon biomass, structure and moisture characteristics. It can also detect phenological changes in vegetation biomass and flood conditions which aid in wetland classification. Since L-band imaging radars are sensitive to differences in plant biomass and inundation patterns, it allows for the extraction of these tall (up to 5 m or 16.6 ft), high-density, high-biomass *Phragmites* stands.

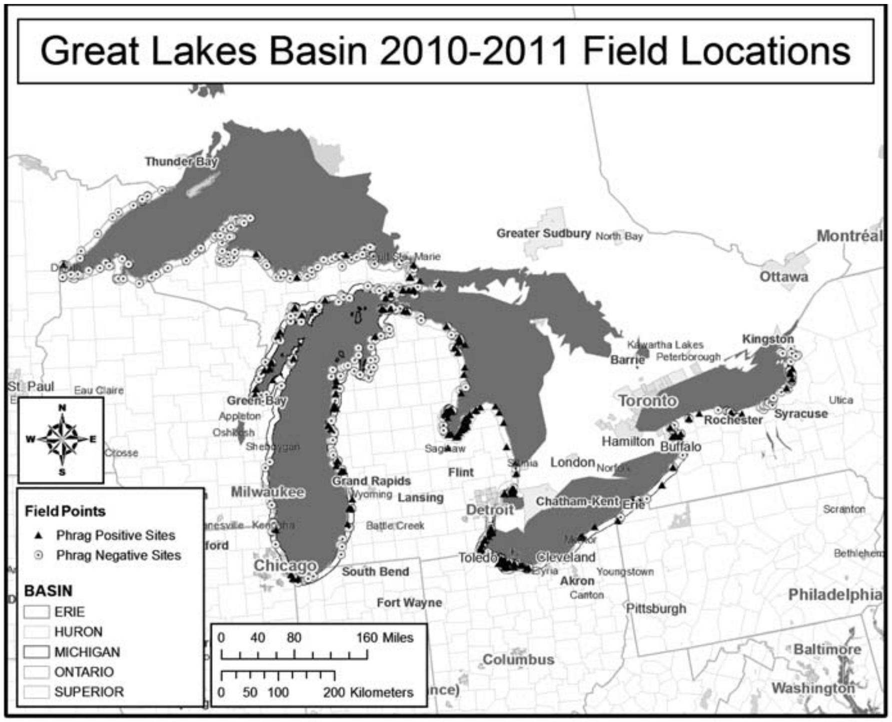

Figure 2. Phragmites *and non-*Phragmites *1/2 acre field collection locations.*

Methods

Field Data Collection

In the spring of 2010, a large field campaign was initiated to collect information on wetland type at randomly selected locations within coastal emergent wetlands of the entire US coastal Great Lakes basin. To match the minimum mapping unit (mmu) of the satellite data (0.2 hectare or 0.5 acre) all sites were sampled to this extent. Both training data and validation data, which were reserved for accuracy assessments of the map products, were collected from May to October of 2010 and 2011.

For each basin, a spatial query was performed in order to generate random points for validation data collection. The National Wetlands Inventory (NWI) emergent class was merged with the Great Lakes Coastal Wetlands geomorphology map (http://www.glc.org/wetlands/inventory.html) to include all wetlands from the coast to 10 km inland in the selection. Using a NOAA Sampling Design Tool in ArcGIS, points were randomly generated within these emergent wetlands for field collection. Field collection occurred throughout the summer of 2010 and will continue through the fall of 2011. To date, 1047 sites (693 validation and 354 training sites) have been visited and extensively documented. This field work, conducted by graduate and undergraduate students, helps to provide accurate identification of ecosystem types when classifying the PALSAR imagery and accurate validation information upon the completion of the mapping process. Information gathered at the 0.2 hectare (0.5 acre) sites such as, ecotype, percent cover, dominant species, and water level are used to help train the mapping algorithm.

Mapping

PALSAR data spanning three seasons (spring, summer, and fall) were utilized to aid in discriminating various other wetland cover types from *Phragmites*. More than 200, 70 x 70 km, 20 meter resolution PALSAR images were acquired over the U.S. side of the Great Lakes basin for mapping. The fine beam dual polarization (FBD) PALSAR data provide two polarizations: horizontal send and receive (HH polarization) and horizontal send and vertical receive (HV polarization). The HV polarization is more sensitive to variations in biomass across cover types while the HH polarization is most sensitive to inundation changes and interactions with the vegetation.

Each 70 x 70 km PALSAR area was mapped separately using field data and air photo comparison for training. The three season triplicats were used to improve discrimination of *Phragmites australis* by taking advantage of the phenological changes that occur in vegetation and inundation patterns over the seasons. Unlike many other herbaceous species, the dead stalks of *Phragmites* remain standing in spring and exhibit different patterns of radar scattering than most other herbaceous wetland cover types over the seasons.

Mapping was conducted through maximum likelihood, unsupervised classification of the triplicats, followed by a series of clusterbusting masks in ERDAS IMAGINE to identify the *Phragmites*. Once the classification was complete, agricultural confusion pixels were filtered using NOAA C-CAP and Cropland Data Layer products in ArcGIS. These confusion classes often occur due to the effect of row structure on SAR backscatter. The classification maps were then run through the clump and eliminate model in ERDAS IMAGINE to group like-pixels and eliminate small groupings. Both of these steps helped to rid the final maps of small areas of confusion throughout the upland areas.

Results

Initial first run results were delivered to the U.S. Geological Survey (USGS) in the spring of 2011. Additional analyses and more field training data were collected in May and June of 2011 to improve the mapping. Final products have since been delivered for Lakes Ontario, Michigan and Erie with Huron expected to be completed by the end of October.

Large monotypic *Phragmites* stands were identified throughout the Great Lakes basin with the most dense and tallest stands found on the southwest shore of Lake Erie and the northern portion of Lake St. Clair, as seen in Figures 3 and 4, respectively. 9,500 hectares (23,475 acres) of *Phragmites* were identified within 10 km of the coast from Sandusky, Ohio to the north side of Lake St. Clair. Of the 1,047 field sites visited, over 31% of them had *Phragmites* presence at some level. Only Lake Erie has a completed accuracy assessment (Table 1) due to ongoing field collections for the other lake basins. For Lake Erie, the overall accuracy was 86%.

The completion of the mapping phase of the *Phragmites* distribution study is set for December 2011, at which point focus will shift completely to the ecological niche models and analysis of coastal wetlands and stream corridors that the USGS Great Lakes Science Center is conducting. The corridor network that provides the framework for vulnerability assessment is composed of NWI wetlands, NHD flow lines and water bodies, and coastal corridors based on simulated reduced lake level scenarios. An online map-based decision support tool hosted by the USGS Center for Integrated Data Analytics will allow depictions of current *Phragmites* distribution at user-defined scales, and a variety of approaches for assessing vulnerability to future invasions. The vulnerability assessment approaches available to users will be based on proximity to existing *Phragmites* populations, a habitat suitability index, or a cost-distance analysis that integrates these two concepts.

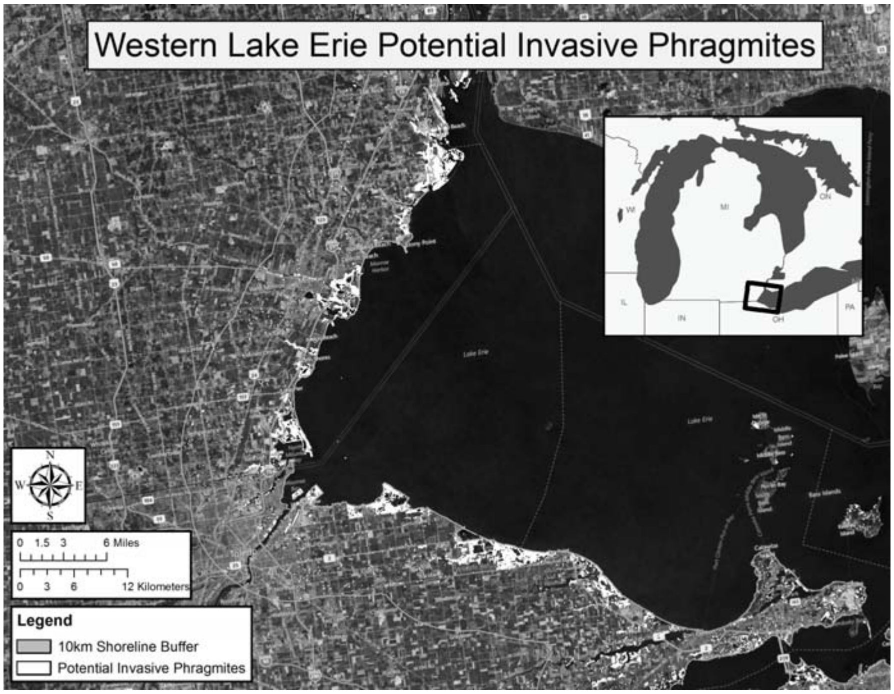

Figure 3. PALSAR derived map of invasive Phragmites *in Western Lake Erie.*

Figure 4. PALSAR derived map of invasive Phragmites *map of Northern Lake St. Clair.*

Invasive *Phragmites* treatment and control operations are underway across the Great Lakes region, most often through small operations limited in geographic extent. The Michigan departments of Environmental Quality and Natural Resources, in cooperation with the Great Lakes Commission, have been holding stakeholder meetings to develop a Strategic Framework for the Management and Control of Invasive *Phragmites* in Michigan (http://glc.org/ans/initiatives.html#phrag). It is through these regional and basin-wide scale mapping, monitoring, modeling and management efforts that such a widely distributed and problematic species as *Phragmites australis* can be controlled.

Table 1. Lake Erie Invasive Phragmites *Classification vs. 2010 Field Data:* Phragmites *> 90% cover, mmu ½ acre*

		Ground Truth Classes			
		Phrag	**Other**	***Total***	**User's Accuracy**
SAR Classes	***Phrag***	**22**	6	28	78.57%
	Other	3	**34**	37	91.89%
	Total	25	40	**65**	
	Producer's Accuracy	88.00%	85.00%		**Overall Accuracy: 86.15%**

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5.6 Development of Remote Sensing Methods for Detection of Invasive Wetland Plants

Introduction

Phragmites australis (giant reed grass) is an invasive species of special concern in the wetlands of the North American Great Lakes Basin (Marks et al., 1994; Galatowitsch, et al., 1999). It is a cosmopolitan species of wetland grass native to every continent but Antarctica (Pengra et al., 2007). In the context of *Phragmites* invasion, scientists and land managers need effective methods to detect and appraise the severity and progression of *Phragmites* infestation (Byers et al., 2002). Thus, the development of applicable methodologies to analyze spatio-temporal dynamics of *Phragmites* invasion is one of the most important issues in policy-making for controlling *Phragmites* infestation (Bruzzone et al., 2003).

Temporal analysis, integrated with spectral and spatial dimensions in terms of image processing, provides essential information concerning vegetation dynamics (Lhermitte et al., 2008). Vegetation change detection with Landsat images has a history as long as the Landsat program itself (Heller, 1975). The approaches based on remotely-sensed data have been increasingly applied in vegetation transition studies (Zhao et al., 2009; Proulx et al., 2008; Xie et al., 2010). Airborne platforms offer effective means of collecting contemporary data over vast areas and in short periods of time (Moreau, et al., 2003; Nordberg, et al., 2003). However, most current literature has focused on three to ten years, or long time intervals, or one or two Landsat scenes (Singh, 1989; Coppin, et al., 1994; Lunetta et al., 2004). Some studies have processed large numbers of Landsat scenes, but are limited to relatively coarse time intervals (Skole, et al., 1993; Cohen, et al., 2001; Masek, et al., 2008). Few studies have analyzed annual or near-annual datasets (Kaufmann, et al., 2001; Healey, et al., 2006; Schroeder, et al., 2006). In the case of *Phragmites* research, most studies have focused on how to identify different vegetation types, or on the distributions and habitat mapping of invasive *Phragmites*, but very few tackled spatiotemporal changes with a time series dataset.

The Study Area, the Image Sources, and the Research Methodology

The study area, the Detroit River International Wildlife Refuge (DRIWR), is situated 41°43´–42°16´N and 83°06´–83°30´W. The DRIWR occupies 48 miles of the Detroit River and western Lake Erie shoreline and contains thousands of acres of wetlands. The DRIWR is well vegetated with *Phragmites*, grass, shrubs, trees, cattail (*Typha*), marshland, cropland, and various other vegetation types. Many of these wetlands have been invaded by *Phragmites* in recent years. Previous studies and onsite survey showed that the invasion of *Phragmites* presents a severe threat to the indigenous plants of the wetland ecosystem. Collection of the present and historical vegetation cover through remote sensed images could provide critical information to support the study of dynamic trajectories of *Phragmites* invasion.

The biggest challenge associated with processing time-series images is the lack of comparable ground truth data. It is essential to get a sufficient number of high–quality reference points in order to obtain training signatures and to validate classification results. Lack of coincident ground information with which to either establish discrete land cover classes or assess the accuracy of their identification has been demonstrated to be a serious limitation for effective use of remotely sensed imagery (Xie, et al., 2010). The solution we developed in this project is called Synthetic Approach of Ground Reference Extraction (SAGRE).

SAGRE is implemented on the basis of two publically-available image sources with the integration of two image processing techniques. The two image sources are USDA National Agriculture Imagery Program (NAIP) imagery and USGS Digital Orthophoto Quarter Quads (DOQQ) data. Beginning in 2003, NAIP was acquired on a 5-year cycle. Two thousand eight was a transition year, and a three-year cycle began in 2009. Since 2009, NAIP imagery was acquired at a one-meter ground sample distance with four bands of data: Red Green Blue (RGB) and Near Infrared. NAIP imagery has a high spatial resolution, but a coarse spectral resolution. DOQQ has been available since 1998 in most states with a spatial resolution of 1-2 meters either in Color Infrared (CIR), True Color (TC), or Black and White (B&W) format.

Two image processing techniques were adopted to extract ground reference points, including the supervised classification that applies to NAIP images and the traditional aerial photo interpretation that is often suitable for DOQQ. In other words, with a limited number of field sampling sites (ground reference points), a NAIP image could be effectively classified to create a vegetation map with a good accuracy level because of its high spatial resolution and four spectral bands. The same approach works for DOQQ. With a small number of field samples, a DOQQ image could be easily interpreted to generate a vegetation map due to its high spatial resolution. In comparison, the former process (NAIP) is much quicker and less labor-intensive than the latter process (DOQQ) because it contains spectral information. These vegetation maps could be resampled to extract a set of ground truth points for training and validating Landsat image classifications. In combination, NAIP and DOQQ could provide a reliable ground reference dataset with a time-series of at least 11 years.

For constructing the ground reference points, field validation data were collected in July 2010 and July-September 2011. In total, 22 vegetation/soil transects were staked and the data were collected over 11 DRIWR units and two Michigan Department of Natural Resources' units, including: Humbug Marsh (3), Strong (1), Gibraltar Bay (2), Gibraltar Marsh (2), Fix (1), Burke (1), Pte. Aux Peaux (1), Plum Creek (1), Lady of the Lake (1), Brancheau (2), Lake Erie Metropark (3), Ford Marsh (2), and Pt. Mouillee (2). The locations of transect stakes, vegetation community boundaries, soil samples, and field photos were geo-referenced using GPS. Detailed transect field data collection forms were devised and implemented by the data collection team. All data were compiled into fully digital forms after conclusion of the field season and were quality checked.

The field transect sample was an important source of ground reference data for developing training signatures. However, due to the limitations of the spatial distribution, the quantity of the field transects and the acquisition time, additional ground reference data especially for the years 1998, 2005, 2008, 2009 and parts of 2010 were extracted through classifying and interpreting NAIP and DOQQ images as previously discussed. More than 50 samples per class, with a minimum of 30 samples for rare classes, were targeted in order to achieve satisfactory accuracy. Cattail was the only class with fewer than 30 samples, because not enough pixels of cattails could be found. The extraction of the samples was done by using ArcGIS 10 and ENVI 4.8.

Pilot Applications of the Integrated Spatiotemporal Image Processing in Studying the Dynamics of *Phragmites* Invasion in DRIWR

Considering the available time-series Landsat images and ground-reference datasets, three pilot applications were developed to demonstrate and test the applicability of the integrated spatiotemporal image processing approach in studying the dynamics of *Phragmites* invasion in DRIWR. The first looked into the spatiotemporal dynamics of *Phragmites* invasion in Grassy Island and the Strong Unit of DRIWR in 1998, 2005, 2008, 2009, and 2010 based on NAIP and DOQQ images. The second investigated the spatio-temporal dynamics of *Phragmites* invasion over the entire study area of DRIWR with Landsat TM5 images from 2000 to 2010. The third explored the spatiotemporal dynamics of *Phragmites* invasion over the entire study area of DRIWR with NDVI derived from Landsat TM5 images from 1985 to 2010 without the ground reference points.

In the context of the accuracy assessment of three pilot studies, the first has more field observation data and involves images with higher spatial resolutions. Hence, the accuracy is better and more reliable (>90%). The second has three years of training and validation datasets, and the overall accuracy levels are about 86% percent, except for 2002 and 2003 (Figure 1). However, the third pilot is designed to study invasive plant evolution in a longer time-series that does not have corresponding ground reference datasets. The accuracy is the lowest of the three pilot studies, although it is still pretty good and seems promising (Table 1).

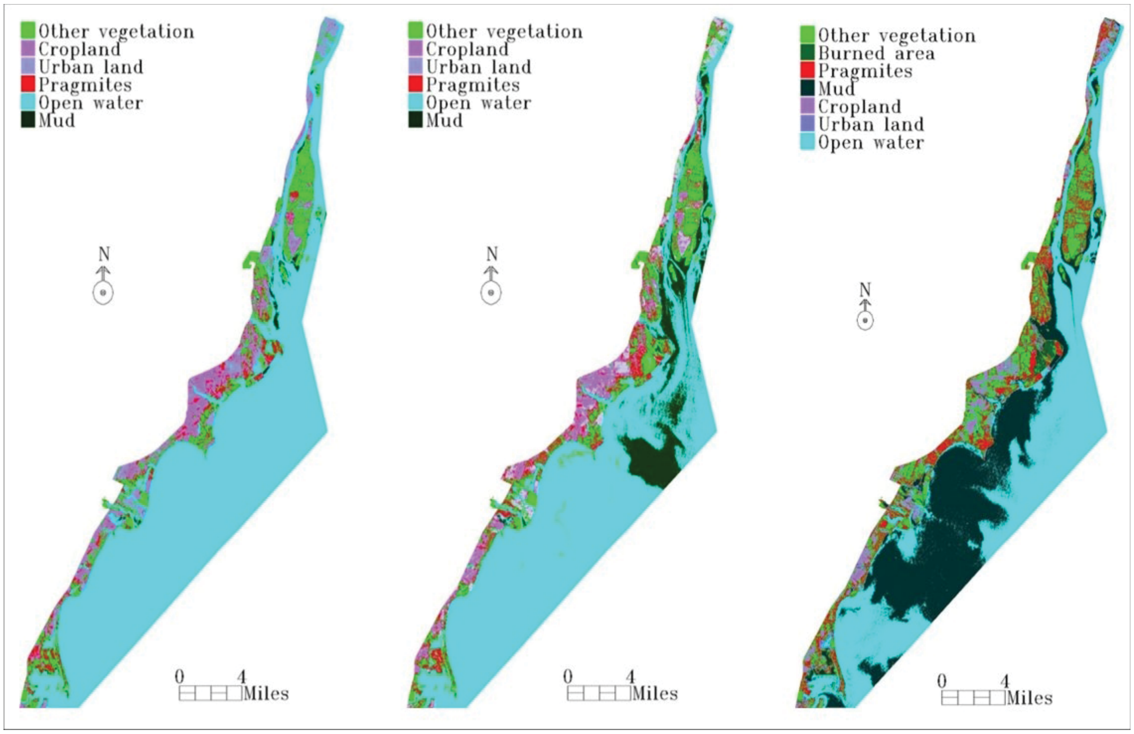

Figure 1. Phragmites *invasion over DRIWR from 2000 to 2010 (Left 2000, Middle 2005, Right 2010).*

Table 1. Comparison of NDVI and Support Vector Machine (SVM) Classifications

Year	NDVI (Acres)	SVM Classifier (Acres)	Overa Accu
1985	3014.99		
1987	3493.36		
1989	2929.15		
1990	3641		
1995	3521.49		
2000	**5025.21**	**5038.77**	
2001	5087.48	5938.36	
2002	6459.84	8858.61	
2003	6035.32	10658.89	
2004	6045.33	8442.05	
2005	**4617.78**	**5873.2**	
2006	4475.65	6011.3	
2007	6780.13	7977.71	
2008	5526.93	6857.42	
2009	Covered by cloud		
2010	**6292.98**	**6178.1**	

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5.7 Remote Sensing- and GIS-Facilitated Biological Monitoring of DRIWR Wetlands

Introduction

Applications of remote sensing and geographic information systems (GIS) for environmental monitoring and decision support systems to assist environmental managers are increasingly expanding. Mapping habitat characteristics at the landscape level can provide mangers with a useful tool for monitoring environmental change, such as the spread and control of invasive plant species, especially over large regions or in difficult to access areas. In addition to directly detecting changes in plant communities, remote sensing can be used to quantify and map ecosystem services that are linked with specific plant communities. Here we describe an ongoing study using hyperspectral remote sensing and biological monitoring of coastal wetland ecosystems in the Detroit River International Wildlife Refuge (DRIWR) to assess the spread and control of invasive species and the impacts of these changes in plant communities on wetland ecosystem services. First, we describe temporal and spatial biological monitoring of wetland communities. We then provide an example of how these data can be integrated with remotely-sensed imagery to quantify effects of an invasive plant, *Phragmites australis*, on ecosystem services and discuss future applications of this approach.

Linking biological monitoring and remote sensing is potentially a powerful tool for scaling up measurements of ecosystem services and assessing impacts of invasive species. Ecosystem services refer to various components of ecosystem structure and function that support, provide, or regulate ecological processes and biota considered valuable to humans or the maintenance of intact natural systems. For example, common ecosystem services attributed to coastal wetlands include biodiversity support, regulation of flooding and erosion, sediment and nutrient uptake, water purification, and nutrient cycling. Wetlands may also play an important role in carbon storage, because of high plant productivity and low rates of decomposition in saturated soils. However, these saturated soils can result in carbon (C) release to the atmosphere in the form of methane gas, a greenhouse gas that is 21 times more potent than CO_2. The specific services provided by a given wetland and the balance of C storage and release depend on a number of factors, including anthropogenic impacts. Ecologists typically measure ecosystem services at the plot level. While this approach is useful for comparing services among different treatments or vegetation types, determining the degree to which a given wetland provides specific services requires scaling up to the landscape level.

Biological Monitoring

In an ongoing project at the DRIWR, we are combining biological monitoring with GIS and remote sensing to better understand how the spread of *Phragmites australis* and its management are impacting ecosystem services. Monitoring occurred at two spatial scales: transect studies covered large spatial scales and a wide range of plant communities, and intensive monitoring was carried out at the plot-level to compare sites with and without *Phragmites*.

Transect monitoring

Vegetation/soil transects were established in thirteen DRIWR management units. Data were collected for 22 transects, including the start and end of wetland plant communities, basic soil diagnostics at selected points, digital photography, and GPS ground control. Each transect was plotted to bisect plant communities of interest, particularly wetlands infested to varying degrees with *Phragmites*, but also included non-invaded landscapes for comparison. Certain transects were located in the vicinity of the intensively sampled plots, though care was taken not to trample or otherwise interfere with these experiments. Our intent was to use the transects as a means of linking intensive sample plot data to a more spatially-extensive scale via assumptions of similarity between plant community and soil type. Also, the transects allow us to monitor changes in plant community boundaries over time, including the documentation of the effects of treatment and control of invasive species. Finally, each transect serves as a source of ground truth for the calibration of remote sensing image analyses. Future research will demonstrate the results and use of transect data. This presentation focuses on the integration of hyperspectral remote sensing imagery with the intensive sample plots.

Intensively-sampled plots

Many of the measurements required to monitor ecosystem services are time consuming and/or require repeated sampling throughout the year. We therefore conducted plot-level studies in areas with and without *Phragmites* to quantify ecosystem services related to biodiversity support, nutrient cycling, and carbon storage. We used a before-after, control-impact (BACI) design, taking measurements for one year before one set of plots was treated with herbicide (and later burned). We measured a number of water, plant, and soil characteristics to allow us to assess shifts in ecosystem services with changes in plant community, either through invasion or removal. Water quality measurements were taken throughout the ice-free season to capture seasonal changes and inter-annual variability. These measurements included pH, conductivity, dissolved nutrients (nitrogen in ammonium and nitrate and soluble reactive phosphorus), organic carbon, CO_2 and methane. Other measurements, such as water depth and soil moisture, were also regularly monitored. Once each year we identified all plant species in our plots and measured annual biomass production. We also analyzed above ground vegetation to determine the quantity of carbon, nitrogen, and phosphorus sequestered in plant material each year. Soils provide a number of critical ecosystem services, and while direct sensing of soils remotely is difficult, soil processes are closely linked with plant communities. We measured several soil characteristics, including pools of carbon and nutrients, microbial communities, and microbial processes, such as CO_2 and CH_4 release.

Our results indicate that invasion by *Phragmites* has significant effects on plant diversity and carbon and nutrient cycling. Compared to *Typha* stands, plant diversity was reduced by *Phragmites* invasion (Figure 1). Biomass production and nutrient uptake were greater in *Phragmites* stands (Figure 2), while soil CO_2 and methane release were lower (Figure 3). These results suggest that wetlands become more of a sink for carbon and nutrients following *Phragmites* invasion.

Remote Sensing

This project is primarily utilizing remote sensing imaging devices that measure electromagnetic energy in the reflected-optical range, typically sub-divided into the visible (400nm to 700nm), the near-infrared (700nm to 1100nm), and the short-wave or middle-infrared (1100nm to 2500nm) wavelength regions. From the standpoint of green vegetation, each of the above wavelength regions has a special significance. Within the visible wavelengths, sunlight falling on plants is selectively absorbed by leaf pigments, including chlorophyll, to be used during photosynthesis. Reddish (600nm to 700nm) and bluish (400nm to 500nm) wavelength regions are considered the chlorophyll absorption bands, with the greenish region (500nm to 600nm) being more reflected relative to the other two. Hence, healthy, growing vegetation appears to us in shades of green, and the visible wavelength region contains information about the vigor and condition of plants. If something occurs that affects photosynthesis,

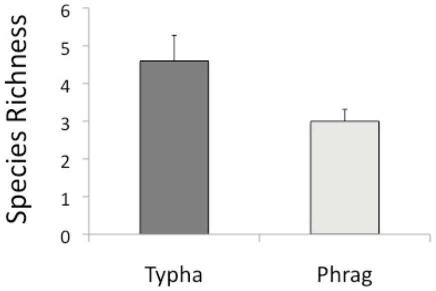

Figure 1. Plant species richness in 1 m^2 *plots dominated by* Typha *and* Phragmites *plots (n = 5). Bars indicate standard error.*

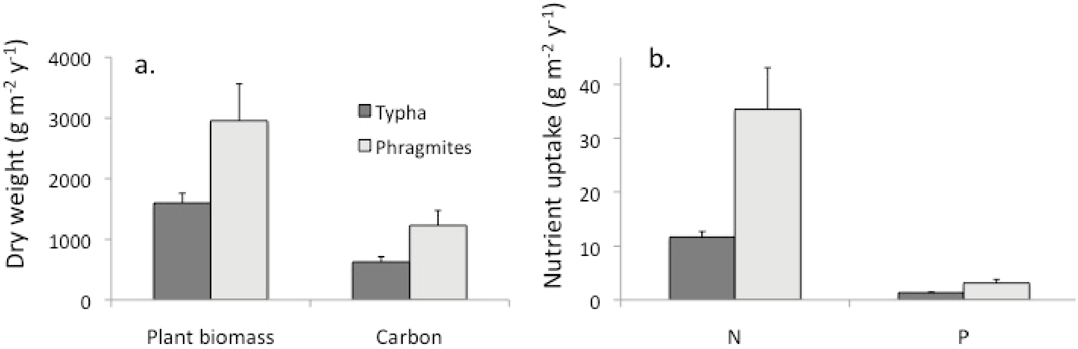

Figure 2. Annual above ground plant biomass and carbon production (a) and nutrient uptake (b) in Typha *and* Phragmites *stands (n = 5). Bars indicate standard error.*

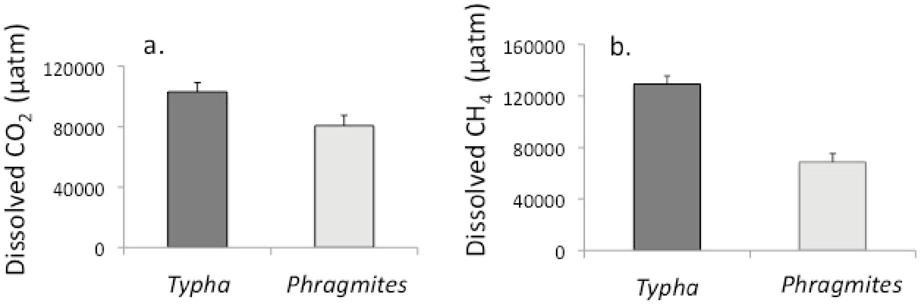

Figure 3. Dissolved soil water CO_2 *(a) and* CH_4 *(b) concentrations in* Typha *and* Phragmites *stands (n = 5).*

such as drought or senescence, the spectral pattern of reflected visible energy changes. Within the near-infrared region, the structure of the plant leaf (spongy mesophyll) acts to scatter the incident electromagnetic radiation. Hence, this wavelength region contains information about type of vegetation as expressed by leaf structure, such as discrimination between deciduous versus evergreen trees. Finally, reflection and absorption by plants of solar energy within the middle-infrared wavelength region is controlled by leaf water content (turgidity), and as such can provide information about drought stress, for example.

By analyzing the *spectral signatures*, remotely sensed imagery can be used to distinguish between different types of vegetation, and under the right conditions, to determine some of their biophysical properties. A spectral signature can be defined quantitatively as: $SS = [(x_1,y_1), (x_2,y_2),\ldots(x_n,y_n)]$, where: x is the wavelength region, y is the percent reflectivity, and it is assumed $x_1 < x_2 < \ldots x_n$. Understanding that different types of plants and other land cover have varying and oftentimes distinct spectral signatures is essential to grasping the importance of remote sensing for invasive plant species research and monitoring.

Optical remote sensing systems are designed to measure the spectral reflectance patterns within the instantaneous field of view (IFOV) of the device. Basically, the IFOV is analogous to the ground sample area of the intensively sampled plots discussed above, and determines the source pixel dimension. The detector collects reflected electromagnetic energy within the IFOV within a certain continuous wavelength region (e.g. 400nm to 1100nm), then the energy is subdivided into smaller regions (often referred to as spectral *bands*), and undergoes an analog-to-digital conversion. The result is a digital image comprised of *n-by-m* arrays of pixels stacked into sequential spectral bands. In *multispectral* remote sensing, there are typically only a few bands of relatively wide regions of the electromagnetic spectrum that comprise a given image. National Agricultural Imagery Project (NAIP) imagery has four bands (blue, green, red, and near-infrared), for example. Hence, a NAIP pixel has four measurements of reflected electromagnetic energy corresponding to one (pure) or more (mixed) types of land cover that were within the IFOV. The spectral signature for the pixel, if graphed, would only have four data points.

Thus, a limitation of multispectral remote sensing for the study of vegetation is the coarse spectral resolution of the imagery. For example, *Phragmites* and *Typha* are spectrally similar, even though we can easily tell them apart when viewed in the field or on a photograph. To address this limitation, we are employing *hyperspectral imagery* (HSI), which has many more bands and much narrower wavelength regions than multispectral remote sensing devices. To this end, we contracted with NASA-Glenn in Cleveland, Ohio, to conduct primary data acquisition over much of the DRIWR between August 15 and September 15, 2010. Scientists at NASA have designed and built a hyperspectral imaging device with 179 bands, 3nm wide, ranging from 400nm to 930nm. The NASA HSI device was mounted on a single-engine plane and flown at a height that resulted in approximately 1.2meter pixel size. The HSI data provides much more detailed spectral signature for the various vegetation and land cover types found within our study area. We are now processing and experimenting with this recently-acquired imagery as a means of integrating intensive plot scale biological variables and scaling up the variables based on their (assumed) relationship to vegetation and soil spectral properties.

Our research design involves selecting the HSI pixels that correspond to the ground locations of each of the eight intensive-sampling plots and their adjacent replicates (i.e., a total of five points per plot, times eight plots, totaling 40 points/pixels). Next, we select the adjacent pixels to each of the 40 plots within a 3x3 pixel neighborhood, then repeat for a 5x5 pixel area, and so on, until the pixel neighborhoods around each of the plots coalesces into a single region. A spectral signature will be collected from the HSI for each pixel associated with the eight sampling plots. Individual signatures will be compared using the Transformed Divergence (TD) and Jeffries-Matusita (JM) indices of spectral similarity. Our intent is to determine how far from the intensive-sampling plot the spectral signature, and hence the assumed determinant vegetation properties, remain constant. Ultimately, we hope to be able to infer plot-scale properties and associated ecosystem services to the entire landscape as a function of hyperspectral image signatures and GIS modeling.

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5.8 A GIS for Remediation of Fish Spawning Habitat in the Huron-Erie Corridor

Introduction

Habitat-related Beneficial Use Impairments (BUIs) within designated Areas of Concern are system-level issues that require macro scale spatial modeling to address. Petts et al. (1989) noted that “It is now clear that river management should address problems at a scale larger than that of a short reach of main channel” and it was the intention of this study to look at potential fish spawning habitat on a system-wide spatial scale. Historically, the Huron-Erie Corridor (HEC) supported large commercial fisheries for lake whitefish and lake sturgeon (Roseman et al. 2007, 2011). Construction of shipping channels greatly altered the hydraulic structure within the HEC and disturbed large areas of river bottom through dredging and spoil disposal (Bennion and Manny 2011). A U.S. Fish Commission report (Smith 1917) directly attributed the loss of the lake whitefish fishery near Grassy Island in the Detroit River to shipping channel construction. In addition to the loss of mid-channel fish habitats, other major fish habitat alterations within the HEC have been extensive shoreline armoring and a loss of coastal wetlands (Manny et al. 1988).

In recent years, man-made fish spawning habitat in the Detroit River has been used as a spawning ground by walleye lake whitefish, lake sturgeon and white sucker (Caswell et. al. 2004; Roseman et al. 2007; Manny et al. 2010; Roseman et al. 2011). Past evaluation of fish spawning habitat construction projects have demonstrated that native species of fish spawn concurrently or sequentially on spawning habitat constructed for lake sturgeon by adding suitable spawning substrates to the Detroit River (Lyttle 2008; Manny 2010).

The goal of this study was to locate areas of acceptable water depth and velocity as possible sites for remediation of lost fish spawning habitat for a particular guild of large bodied, migratory, lithophilic, benthic, broadcast spawning fishes represented by walleye, lake whitefish, and lake sturgeon. The focus of our study was on the mid-channel spawning habitat lost or altered by past shipping channel construction projects and changes to hydraulic function from the construction of water level compensating structures. The assumptions of this approach are that lack of spawning habitat is a limiting factor for these fish populations, and lack of suitable bottom substrate in areas that the fish are naturally drawn to is a limiting habitat component. Threader (1998) concluded that for lake sturgeon “the spawning variables were more important in determining the overall Habitat Suitability Index for a particular study area than variables associated with the food life requisite”. Four main physical habitat parameters, (i.e. water depth, flow velocity, substrate, and water temperature) were identified as important to spawning walleye, lake whitefish, and lake sturgeon (Threader 1998, Lyttle 2008). From these habitat parameters, water depth and flow velocity were singled out to form the basis of our analysis because fish respond to both of these variables in seeking places to spawn in the HEC (Roseman et al. 2011) and data sets for these two variables were available with complete coverage of the HEC. We assumed that river bottom, rock-rubble substrate was the limiting factor to be remediated and that changing the temperature regime in a large unregulated river system is largely outside the scope of remediation efforts. This summary outlines a spatial modeling investigation designed to integrate data on two variables (water flow velocity and water depth) that many riverine fish respond to in selecting where to spawn in these waters.

Methods

Our study area was the entire 117 kilometer (73 mile) channel connecting lakes Huron and Erie, between Michigan and Ontario, Canada, including the St. Clair River, Lake St. Clair, and the Detroit River. Bathymetric data and three discrete sources of modeled water flow velocity were obtained and interpolated to create continuous raster surfaces. To facilitate the assignment of relative habitat rankings, the created raster surfaces representing water depth and flow velocity were reclassified. Our selection of reclassified values placed a premium on the highest available water flow velocities, while also acknowledging that lake sturgeon spawning has been documented in areas exhibiting a wide range of water velocity values. The reclassified depth and flow velocity rasters were combined and the presence of maintained dredged shipping channels was accounted for to produce ranking surfaces that contained relative scoring values with higher values considered acceptable fish spawning habitat. To account for variation in the rankings produced by each individual hydraulic model input, a further step of combining each output surface by adding all results together was performed. This process created a final ranking surface for each river. Model validation was achieved by comparing areas identified by the model with the locations in this connecting channel where fish spawning habitat is either known, or has been remediated and fish are spawning there. All known and postulated lake whitefish and lake sturgeon spawning areas in the HEC were selected as acceptable fish spawning habitat by our model. Our analysis revealed areas in each river, in addition to the known and postulated sites, that possessed suitable water velocity and depth, and therefore theoretically could be remediated by the addition of rock-rubble spawning substrate.

Results

The final ranking surface for the Detroit River contained a total area of potential habitat of roughly 15,000,000 m^2. The final ranking surface for the St. Clair River, including the delta, indicated a total potential habitat area of roughly 19,000,000 m^2. These areas predicted by the model comprise less than 5% of the total area of the HEC. This calculation is the result of comparing all acceptable habitat areas to the total area of the Huron-Erie Corridor, including Lake St. Clair. Considering sites already selected for remediation, those that should not be altered due to current use as spawning habitat and those which have a lower remediation potential, a subset of sites was selected as good candidates for further assessment.

Discussion

The indicated sites should not be considered the only possible areas for habitat remediation, but represent the most likely areas for spawning habitat remediation for our target species, when considering the HEC on such a large spatial scale. Because of the selection of depth and velocity as our model parameters, the model favors the riverine environments over Lake St. Clair. It is not unreasonable that some spawning by our target species may occur in Lake St. Clair on wave-washed rocky shorelines and rocky shoals, but it is expected that the bulk of suitable spawning habitat for these species is located within the Detroit and St. Clair Rivers.

The known spawning areas represent a small portion of the overall indicated potential habitat in the HEC, suggesting that larger populations of our guild of fish should be possible, if lack of suitable spawning grounds is the limiting factor. This assumption is supported by historic reports and modern scientific studies. Bowers (1897) related the success of the Detroit River lake whitefish population to the high quality spawning habitat that was found in the river and notes the destruction of a fishery at Fort Wayne by land fill.

This study was designed to address the overall fish spawning habitat remediation potential for native fish species on a large spatial scale and was meant to provide a guide for further meso and micro scale habitat analysis on a site by site basis. Next steps would include assessment of these indicated areas and to determine whether or not they are currently being utilized by spawning fish. If coarse substrate is not the limiting factor in these areas, other issues, such as substrate contamination, local thermal disturbances or water quality issues could be considered. The influence of freighter traffic on fish is largely unstudied in the HEC. Propeller hits on the fish themselves and regular short term alterations to hydraulic function created by prop wash could play a role in the ultimate productivity of some of these indicated fish spawning habitat areas.

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5.9 Using Remote Sensing and GIS Tools to Model and Prioritize a Natural Heritage System

Introduction

The Essex Region Conservation Authority (ERCA) is currently preparing the "County of Essex Natural Heritage System Strategy" (CENHSS) for the Corporation of the County of Essex. The overall purpose of the CENHSS study is to assist the County of Essex in determining an appropriate strategy to protect natural heritage features and their functions as part of the update to their Official Plan process. The objectives of the technical GIS portion of this exercise were to: 1) *prioritize existing natural areas*; and 2) *prioritize restoration opportunities* within the project area. The deliverables that would result from this exercise include "heat" maps and associated GIS datasets that can be used at a screening level to aide upper and lower tier municipal partners, as well as staff at the Conservation Authority, in identifying the relative significance of existing natural heritage features and areas of potential restoration opportunities.

In technical terms, the project is an exercise in the GIS fundamentals of overlay and proximity. To execute this exercise, GIS tools such as ESRI's ModelBuilder and IDRISI's Andes remote sensing software where used.

In order to prioritize features, a list of defined input criteria (i.e., input datasets) had to be decided on. These inputs were created by using GIS and remote sensing software packages and techniques, and were then geoprocessed in ModelBuilder using customized models.

Remote Sensing

A watershed health assessment using remote sensing was envisioned for ERCA. Land use type and vegetation status were considered as the two most important watershed condition indicators. The assessment included deriving a watershed health index, including land cover and overall biomass (spatio-temporal) and vegetation vigor class (weighted as either very poor, poor, moderate, good, or very good).

Eight landsat images spanning 17 years (1979–2006) were used in creating the following datasets: 1) land cover type in ERCA, and its 27 subwatersheds; 2) vegetation vigor classes using the Normalized Difference Vegetation Index (NDVI) for ERCA, and its 27 subwatersheds; and 3) average NDVI using a 200-meter buffer along 12 major streams. The NDVI was the lone remote sensing parameter used in the CENHSS study (input #7 in Table 1).

Model Builder

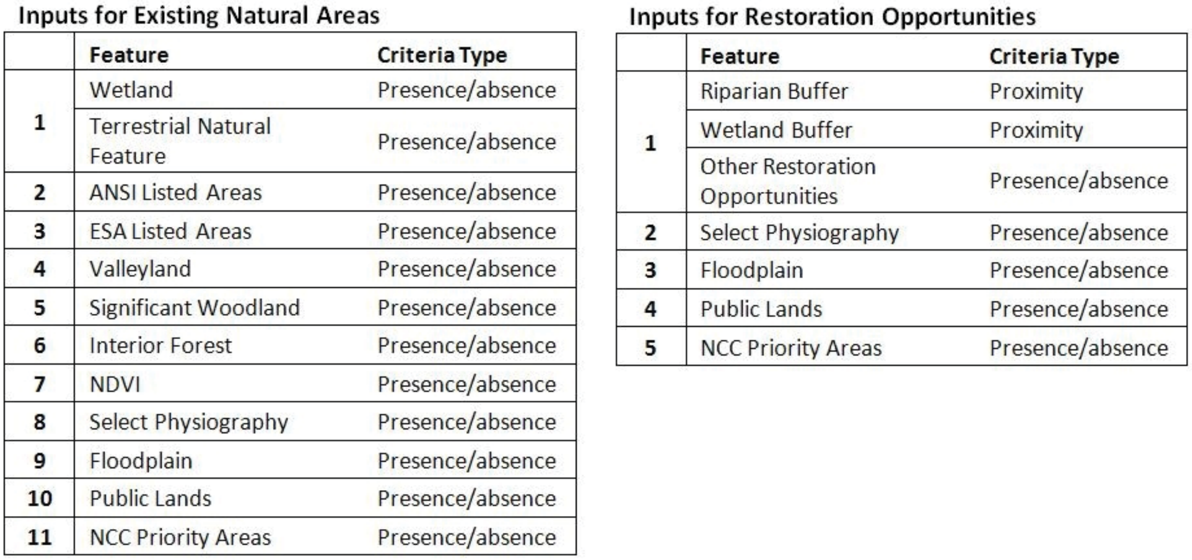
ESRI's ArcGIS software was used to compile, manage and analyse the digital data. Geoprocessing was used for manipulating the data (e.g., using overlay and proximity tools) in defined workflows. ESRI's ModelBuilder was used to manage these geoprocessing workflows.

ModelBuilder is a visual programming language that can be used as a tool to encapsulate workflows into a model. The benefits of using ModelBuilder include their reusability, automation, and use as a visual representation of analysis operations.

Prioritization

The input criteria (i.e., input datasets) were geoprocessed by the models in ModelBuilder to create the final maps and data deliverables. For the prioritization of the *existing natural areas* and the *areas of potential restoration opportunities*, criteria 11 and 5 were used respectively (Table 1). These input data sets are the results of various natural heritage evaluations and studies. These criteria were felt to capture the full range of environmental variables considered within all known assessments completed within the region.

Table 1. Input criteria (datasets) that were consumed by the models. The listed inputs are not in any order of significance. Full criteria descriptions can be found in the CENHSS. ANSI = Area of Natural or Scientific Interest. ESA = Environmentally Significant Areas. NDVI = Normalized Difference Vegetation Index. NCC = Nature Conservancy of Canada.



Inputs for Existing Natural Areas

	Feature	Criteria Type
1	Wetland	Presence/absence
	Terrestrial Natural Feature	Presence/absence
2	ANSI Listed Areas	Presence/absence
3	ESA Listed Areas	Presence/absence
4	Valleyland	Presence/absence
5	Significant Woodland	Presence/absence
6	Interior Forest	Presence/absence
7	NDVI	Presence/absence
8	Select Physiography	Presence/absence
9	Floodplain	Presence/absence
10	Public Lands	Presence/absence
11	NCC Priority Areas	Presence/absence

Inputs for Restoration Opportunities

	Feature	Criteria Type
1	Riparian Buffer	Proximity
	Wetland Buffer	Proximity
	Other Restoration Opportunities	Presence/absence
2	Select Physiography	Presence/absence
3	Floodplain	Presence/absence
4	Public Lands	Presence/absence
5	NCC Priority Areas	Presence/absence

All input criteria were weighted equally as to not introduce any further bias (i.e., all datasets had the default weighted value of "1"). During the overlay process, the input data sets were considered on their presence or absence only and no additional scoring or weighing was allotted to them. In some cases where input datasets where composed of a range of values (such as in the inclusion of the NDVI index), an educated cut-off value was determined to represent which areas to include as "present".

The resulting dataset prioritized features relative to one another with respect to natural heritage significance. This was done through the summation of overlapping input data sets (e.g., an area having three overlapping inputs had a final value of "3").

Results and Discussion

The resulting datasets from the prioritization methods are shown on the heat maps in Figures 1 and 2. The highest priority areas are shown in black on both maps. Figure 1, showing the prioritization of existing natural areas, depicts the relative significance of these areas in a range from 1 to 11 (i.e., the number of input datasets that are coincident, or overlaying, at a spatial location). You can then get a sense of the spatial distribution of the significant features within the project area. Figure 2 shows the results for the areas of potential restoration opportunities in a range from 1 to 5 (representing the 5 input datasets).

As a spatial product, these datasets are "raw." By bringing them together in a report with local context and knowledge base, they become a powerful tool for decision makers in natural heritage and planning.

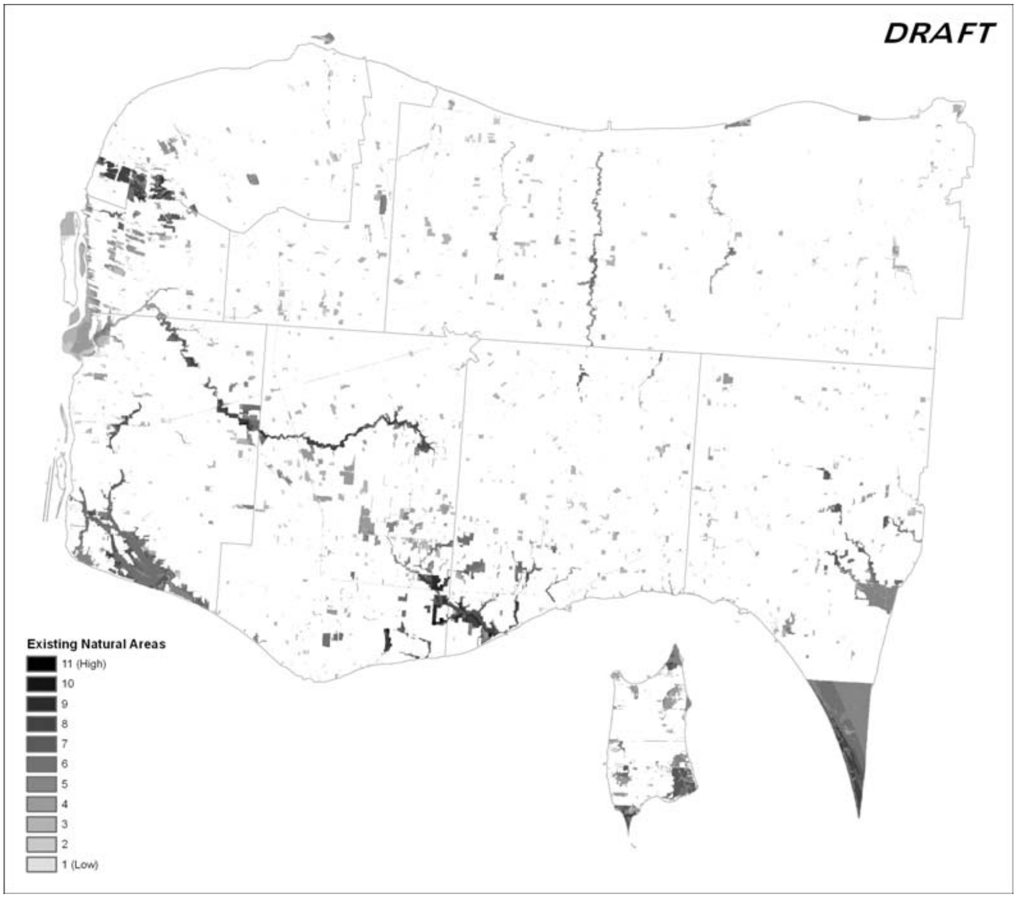


Figure 1. Prioritization of Existing Natural Areas

Furthermore, the two resultant datasets are mutually exclusive and do not overlap. By merging them together you get a third product showing how the area would look with all existing natural areas along with if all restoration opportunities were implemented.

Leveraging the methods and intermediate datasets used to create the final deliverables, other valuable by-products were also calculated. These included updated statistics of natural areas coverage by municipality and by subwatershed within our region. As well, by using the Model Builder framework, updates to this project can be re-run when new and/or more accurate data becomes available.

Conclusions

By using existing GIS and remote sensing tools along with GIS fundamentals of overlay and proximity, the two main objectives of this project were met. The *existing natural areas* and *areas of potential restoration opportunities* have been prioritized at a screening level within the project area. This will enable decision makers at the municipal level and at the Conservation Authority to compare these features and opportunities relative to one another with respect to planning and management matters.

The biggest key to the success of this and any GIS project is the communication between team members regarding expected deliverables and project scope. GIS is a technical discipline that depends on input from other staff including, planners and biologists in this case. In the same sense, GIS professionals must be brought to the table at the early stages of planning a project so that they may communicate their input to ensure the project meets expectations and is a success in the end.

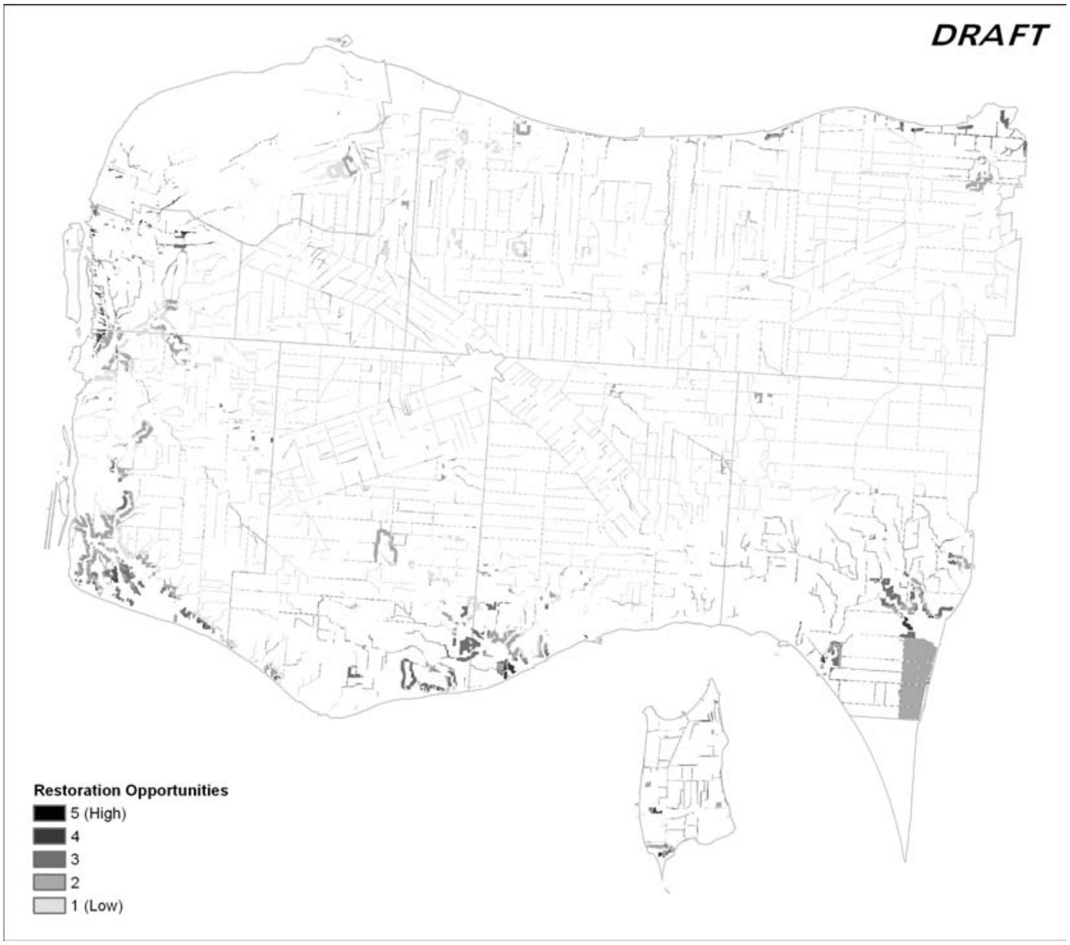


Figure 2. Prioritization of Areas of Potential Restoration Opportunities

Technically, the use of ModelBuilder represented a front end investment of time due to the associated learning curve. The workflow documentation and reusability of the models have made this a good investment. Future work with ModelBuilder can be further enhanced by the use of iterations and Python scripting that has become more user friendly and powerful with newer releases of the software.

With regards to remote sensing, the watershed health assessment project that was started five years ago was designed to develop a rapid remote sensing based watershed health appraisal that would be repeatable on an annual basis. Along with NDVI, other algorithms were explored such as the Soil Adjusted Vegetation Index (SAVI), Normalized Difference Water Index (NDWI), and eCognition software. However, due to lack of resources, only the NDVI was included as an input criterion in the CENHSS. Much more could have been included in the model, and what was included could have been fine-tuned to better suit the project's needs. At a Conservation Authority level, the need for collaboration with other agencies, especially universities, is an ongoing need.

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5.10 Using Technology to Quantify Stormwater Benefits of Green Infrastructure

Introduction

Geographical Information System (GIS) technology combined with applications that estimate stormwater runoff benefits have been used in a variety of applications across southeast Michigan to evaluate and prioritize green infrastructure opportunities. By combining data such as land use, land cover and parcel details, environmental restoration and enhancement opportunities are identified and prioritized. Technology applications used in concert with GIS include both CITYgreen© (American Forests 2004) and i-Tree©(i-Tree 2011) which identified tree planting locations and solved more complex problems in evaluating the benefits of green infrastructure for meeting environmental regulatory requirements. In addition, significant efforts are underway to create a Green Infrastructure Vision for southeast Michigan that will rely on numerous GIS analyses. Benefits of using these technological approaches are wide ranging, but include the following:

- Combining various data sources to more effectively make decisions benefitting multiple goals;
- Saving staff time by reducing data collection efforts in the field; and
- Demonstrating ability to meet regional environmental goals and objectives that are identified in restoration plans.

What is Green Infrastructure?

The U.S. Environmental Protection Agency (EPA) describes green infrastructure as an approach to wet weather management that is cost-effective, sustainable, and environmentally-friendly. Green infrastructure methodologies and techniques are designed to infiltrate, evapotranspire, capture and reuse stormwater to maintain or restore the natural hydrologic process. Examples of green infrastructure techniques include tree planting, porous pavement, rain gardens/bioswales, tree planter boxes, and rain barrels.

Multiple Benefits of Green Infrastructure

EPA's Green Infrastructure Action Strategy

This strategy identifies the many benefits achievable through the design and implementation of green infrastructure (U.S. EPA 2008). Multiple community, regional and national goals are identified, including the following:

Cleaner Water – Vegetation, green space and water reuse reduce the volumes of stormwater runoff and, in combined systems, the volume of combined sewer overflows, and reduce concentrations of pollutants in those discharges.

Community Benefits – Trees and plants improve urban aesthetics and community livability by providing recreational and wildlife areas. Studies show that property values are higher when trees and other vegetation are present.

Cost Savings – Green infrastructure saves capital costs associated with paving, creating curbs and gutters, building large collection and conveyance systems, and centralized stormwater ponds; operations and maintenance expenses for treatment plants, pumping stations, pipes, and other hard infrastructure; energy costs for pumping water; cost of treatment during wet weather; and costs of repairing the damage caused by stormwater, such as streambank restoration.

Cleaner Air – Trees and vegetation improve air quality by filtering many airborne pollutants and can help reduce the amount of respiratory illness. Transportation and community planning and design efforts that facilitate shorter commute distances and the ability to walk to destinations will also reduce vehicle emissions (American Forests 2004).

Creating Success in Southeast Michigan

Sustainability in southeast Michigan means improving economic opportunity, social equity and environmental quality while experiencing a decline in population, employment and fiscal capacity. Over the past several years, the Southeast Michigan Council of Governments (SEMCOG), with active participation from its members, has developed plans for a number of initiatives supporting sustainability as outlined in our regional sustainability plan: *A Framework for Sustainability in Southeast Michigan*. These collective efforts support six common outcomes for Creating Success in southeast Michigan:

- Economic prosperity;
- Desirable communities;
- Reliable, quality infrastructure;
- Fiscally sustainable public services;
- Healthy, attractive environmental assets; and
- Access to services, jobs, markets, and amenities.

Green infrastructure has a role in achieving all six outcomes in Creating Success in southeast Michigan. This can range from green infrastructure's direct impacts on the quality of our environmental assets in the region, to the economic benefit associated with green infrastructure, to green infrastructure as one solution for desirable communities. While large or small, green infrastructure plays a part in our success as a region.

Regional Projects Using Technology for Green Infrastructure Analysis

Detroit Water and Sewerage Department (DWSD) Green Infrastructure Program

Background and Regulatory Partnerships

GIS and other similar technologies were fundamental in demonstrating achievable stormwater runoff reductions for DWSD in negotiating an updated regulatory permit. These technologies were used to demonstrate reductions in stormwater runoff entering the combined sewer system through green infrastructure implementation in the Upper Rouge Tributary (URT) area. DWSD, in partnership with the City of Detroit, SEMCOG and the Michigan Department of Environmental Quality worked cooperatively to demonstrate that this revised approach will save $600 million. The revised Combined Sewer Overflow Control Program and subsequent issuance of the National Pollutant Discharge Elimination System (NPDES) permit by the MDEQ now includes a green infrastructure component addressing multiple land uses.

It is important to note that the approach moves towards achieving economic, social and environmental sustainability while considering multiple outcomes representing various needs. The strategy for implementation coordinates with other Detroit programs, including the Detroit Works Project which is focused on realigning the City by adjusting from a population of almost two million to the latest census at just over 700,000. DWSD's new Green Infrastructure Program works towards achieving the following goals:

- Establishing a more affordable program based on current financial capabilities;
- Meeting regulatory requirements established by MDEQ;
- Demonstrating infrastructure cost savings and energy efficiencies; and
- Enhancing community property values and aesthetics.

Technical Planning Analysis

In order to better understand the potential benefits of DWSD's green infrastructure plan for the URT area, land cover and parcel data were utilized in conjunction with CITYgreen© to estimate stormwater runoff volume reductions. GIS is also utilized to determine the priority of green infrastructure locations, demolition and greening locations, as well as potentially tracking short- and long-term implementation.

The URT area is approximately 96 square kilometers (37 square miles) and contains over 100,000 individual parcels. The largest land use coverage is residential, followed by roads, alleys and respective rights-of-way. The City of Detroit has jurisdiction of approximately 10% of the area. SEMCOG utilized City of Detroit parcel information combined with the land cover data from the Urban Ecosystem Analysis Southeast Michigan and City of Detroit (May, 2006) to identify various green infrastructure opportunities. Using the technical stormwater runoff methodology of TR-55 within CITYGreen©, runoff volume was estimated for existing and proposed conditions based on installing green infrastructure. This was possible by combining both the land use and parcel data with the land cover data (impervious, open space, tree canopy, water and barren land) across the URT area. Then, by altering the land cover for each of the land use classes, future runoff conditions were predicted resulting in an estimated reduction in runoff entering the combined sewer system.

Applying this methodology for each land use type within the URT area resulted in an estimated 10-20 percent reduction in stormwater runoff volume. Subsequently, the resulting green infrastructure techniques included in the revised permit comprise 1) tree planting in underutilized parks and along streets, 2) demolition of abandoned homes and greening vacant property, 3) greening municipally-owned property, 4) constructing green streets and streetscapes, and 5) disconnecting downspouts.

Table 1 provides a sampling of parcel/land use types, corresponding area and a breakdown of the land cover (e.g., impervious, open space, tree canopy, bare and water) by land use type.

Table 1. City of Detroit Upper Rouge Tunnel Tributary Area – Land Use and Impervious Area

Parcel Type	Number of Parcels	Total Area (Acres)	% of Total Tributary Land Area	Impervious (Acres)	% Impervious Cover by Land Use Type
Residential	**88,115**	**10,928**	**45%**	**3,154.0**	**29%**
Roads	**NA**	**6,744**	**28%**	**3405**	**50%**
City of Detroit Parks	**116**	**2,032**	**8%**	**95.2**	**5%**
Vacant Non-Tax Exempt	**7,678**	**826**	**3%**	**99.3**	**12%**
City Municipal/ Detroit Buildings	**30**	**55**	**0.23%**	**43.1**	**79%**
Total	**107,003**	**24,021**	**NA**	**8,813.7**	**44%**

Table 2 provides example scenarios modeled by land use type and the estimated reduction in runoff volume.

*Table 2. Green Infrastructure Scenarios and Stormwater Runoff Volume Reduction**

Parcel / Land Use Type	Proposed Long-Term Scenario	Storm Water Runoff Volume Existing (Future Scenario) MG	% Reduction of Storm Water Runoff Volume
City of Detroit Municipal Buildings	100% roof downspout disconnect; parking lots to bioswale; 50% grass cover to tree canopy with grass understory; 50% bare to tree canopy with grass understory	3 (2)	28%
Residential	100% roof downspout disconnection;100% bare to trees with grass understory	228 (130)	43%
Roads	33% impervious cover to tree canopy with impervious understory; 50% grass to tree canopy with grass understory	227 (170)	25%

**Stormwater runoff volume represented is based on a single 2-year, 24-hour rain event, equivalent to 2.25 inches of rainfall. This recurrence interval indicates that this intensity storm has a 50% chance of occurring in a single year.*
**MG = million gallons.*

Implementation

Early short-term implementation stages of this program include neighborhood stabilization in two primary pilot areas, Grandmont-Rosedale Park and Rouge-Cody Neighborhoods, through techniques such as demolitions, greening vacant property, and street tree planting. Over 1,000 trees have been planted through a partnership with The Greening of Detroit, a local not-for-profit agency "founded in 1989 to improve the quality of life in Detroit by guiding and inspiring the reforestation of Detroit's neighborhoods, boulevards and parks through tree planting projects and educational programs". Street trees, an urban stormwater forest demonstration project, and over six hundred abandoned home demolitions have been completed. The combined initial runoff reduction benefits of these tree plantings and demolitions are estimated at over 0.25 million gallons for a single 2-year, 24-hour event. These reductions were estimated using a combined approach with both CITYGreen© and i-Tree©.

Consistent with a long-term roadmap for the City, this program includes planning for large-scale green infrastructure techniques along roadways and on municipal properties, additional stormwater forests as well as community gardens/urban farming. For example, GIS is being used to map vacant properties across Brightmoor, a ten square-kilometer (four square-mile) inexpensive, residential housing area built in the 1920s for factory workers. The area is surrounded by green space, including Eliza Howell Park and Stoepel Park. One option for the vacant land within Brightmoor is to link these two parks together using green techniques with community partnerships.

The Green Infrastructure Program will continue to be implemented as a cooperative endeavor with multiple city agencies and departments, as well as private and nonprofit stakeholders. A $50 million budget has been established to fund Green Infrastructure projects from sewer revenues as an integral component of the CSO Control Program for the next twenty years.

U.S. Forest Service - Great Lakes Restoration Initiative: Tree Enhancements on Publicly-Owned Priority Urban Areas

This project includes implementation of recommendations outlined in existing management plans that are guiding the restoration of the Rouge River, Ecorse Creek and Combined Downriver Watersheds. Specific objectives include using GIS and CITYgreen© to analyze benefits of installing over 1,000 trees across the region. In Wayne County, planting areas are focused around Wayne County Public Services facilities. The combined parcel data with land cover data previously described is allowing County staff to prioritize tree planting locations.

First, Wayne County properties were identified in GIS within both the Rouge River Watershed and Downriver Watersheds. Second, these data were combined with the land cover data previously described.

Land Cover of Wayne County Facilities in the Rouge River Watershed ranks the sites by increasing quantities of open space (Table 3).

Table 3. Sample Wayne County Facilities for Selecting Tree Planting Locations.

Land Cover of Wayne County Facilites in ARC						
BUILDING	**Total (acres)**	**Open Space (acres)**	**Trees (acres)**	**Impervious (acres)**	**Percent OS**	**Percent Imperv.**
River Rouge CSO Basin	2.21	1.55		0.66	70.0%	30.0%
Warren Valley Golf Course	219.90	134.96	62.13	15.71	61.4%	7.1%
Merriman Yard	13.15	3.49	4.38	5.18	26.5%	39.4%
Salt Storage Yard-Dearborn St. Detroit	42.21	10.53	1.08	17.89	25.0%	42.4%
Field Engineering Office	2.99	0.75	0.03	2.22	24.9%	74.2%
Salt Storage Yard-8mile & Telegraph Detroit	3.74	0.82	2.17	0.61	21.9%	16.4%
Salt Storage Yard-Southfield Road	25.08	1.02	0.29	23.78	4.0%	94.8%
Total	**117.28**	**20.04**	**13.76**	**59.34**	**17.1%**	**50.6%**

Table 3 shows a sampling of Wayne County properties ranked by percent open space (OS) which gives an indication of the land area available for tree planting. As a further refinement, the decision tree will include proximity to water bodies, relative amount of imperviousness, and priority subwatersheds, all of which can be mapped through GIS. Without the GIS tool, it would be difficult to provide justification for tree planting locations in the prioritization process.

Green Infrastructure Vision

Southeast Michigan was recently awarded a Housing and Urban Development Sustainable Communities Regional Planning Grant effective February 15, 2011 – February 14, 2014. A key component of this grant is developing a Regional Green Infrastructure Vision to make green infrastructure a part of the fabric of the region to create healthy, attractive environmental assets. This requires development of a regionally-tailored vision for green infrastructure in southeast Michigan.

The vision will use GIS to conduct an analysis of existing green infrastructure components, identify green infrastructure targets of opportunity, develop ways to improve green infrastructure in these areas, and provide recommendations on how to implement them. Where applicable, these efforts will be combined with other projects under the grant (e.g., commercial/industrial redevelopment and housing) to reinforce the incorporation of green infrastructure as a means for economic prosperity and sustainable neighborhoods. GIS, combined with CITYgreen©, will also be used to estimate stormwater runoff benefits of existing infrastructure while also providing predictions of what may be achieved across the southeast Michigan region.

References

American Forests, 2004. CITYgreen for ArcGIS, American Forests, Washington D.C.,

I-Tree, 2011. Tools for Assessing and Managing Community Forests Web Site. www.itreetools.org.

U.S. EPA 2008. Managing Wet Weather with Green Infrastructure Action Strategy, from http://cfpub.epa.gov/npdes/greeninfrastructure/information.cfm#greenpolicy.

Contact Information

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5.11 Managing Water Quality Data in the Huron to Erie Corridor

Introduction

The Regional Water Quality Information Management System (www.rwqims.com) is a web-based application that provides access to a central repository of water quality information for southeast Michigan. The RWQIMS is intended to serve data from multiple water quality projects, past, present and future.

A vast amount of water quality data exist across Michigan in general, and within southeast Michigan in particular; however, the data are of variable quality and stored in a variety of formats across disparate sources, which makes obtaining and analyzing those data a challenge. Accordingly, RWQIMS was designed based on the concept of centralizing these disparate data sources into a standardized database structure, thereby allowing users to access and analyze a wealth of data more quickly and efficiently.

Fundamental to the design of RWQIMS is creating a user-friendly system that will not overwhelm people looking for information, however complex or simple. As such, the application offers multiple pathways to accessing the data (via map or via forms). Additionally, users can view metadata about each of the projects included in RWQIMS to help determine how each dataset can and should be use.

Basic Design

The fundamental driving design principle behind RWQIMS was to create a system that is user friendly. There are other web sites through which water quality data can be accessed, but the tendency of many sites is to attempt to create a single access point for all things related to water quality, which can be highly valuable and even necessary, but in most cases the result is that the data are difficult to find among all of the supplemental information. In contrast, RWQIMS is designed to strictly focus on data access, allowing a simplified design and a streamlined workflow.

Sticking to the user-friendly design principle has represented a challenge to RWQIMS. As the system went through the development process and even as it continued to mature, a desire to add additional functionality to the site had to be weighed against the desire for simplicity. In some cases, a potential enhancement that would appear to add analytical power and which seems intuitive to the project team may actually be one more "bell" or "whistle" to distract or overwhelm new users and detract from the value of the site.

Navigation

Essentially, RWQIMS is designed to allow users to view data with a minimum number of mouse clicks. Accordingly, navigation through the site is managed by only five buttons or icons that remain accessible along the left of every page (Figure 1). Each icon offers both graphical and text-based navigation. The navigation panel also allows users

Figure 1. RWQIMS icons.

to see the basic organization of the site. As mentioned, the simplicity of navigation and organization is possible in part because RWQIMS is focused on providing data access.

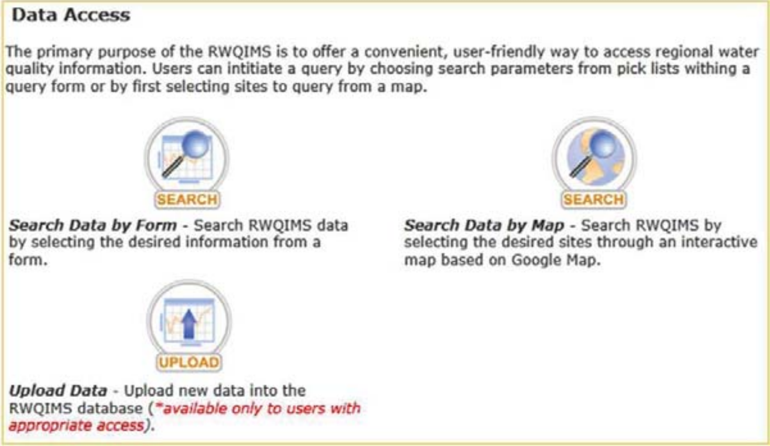
Consistent with an attempt to create an intuitive system, each icon also has a tool tip that appears as the user's mouse passes over the navigational icon to provide a more descriptive name for the category or link.

Core Functionality

The RWQIMS was built around data access, allowing users to quickly and conveniently access water quality data even on the first visit to the site. Users are able to view water quality data in as few as three clicks upon arriving at the website. For example, one click on the *Data* icon in the navigation panel, another click on one of the *Search* icons (e.g., search by form, Figure 2) and a third click on the *Return Results* button will launch a query.

Search Data by Form

One of the primary tools to access data within the RWQIMS is the main search form (Figure 3), which allows users to construct a search by manually selecting the desired search criteria (i.e., locations, parameters, dates, etc.). To make the search construction as user-friendly as possible, this form is broken into few simple steps. As users step through the process, each subsequent choice list is filtered accordingly, making selection that much easier.


Data Access

The primary purpose of the RWQIMS is to offer a convenient, user-friendly way to access regional water quality information. Users can intiitate a query by choosing search parameters from pick lists withing a query form or by first selecting sites to query from a map.

Search Data by Form - Search RWQIMS data by selecting the desired information from a form.

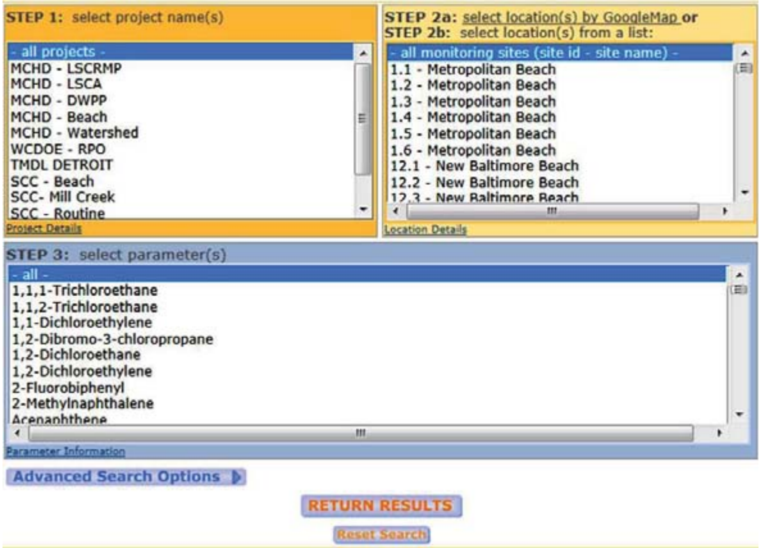
Search Data by Map - Search RWQIMS by selecting the desired sites through an interactive map based on Google Map.

Upload Data - Upload new data into the RWQIMS database (**available only to users with appropriate access*).

Figure 2. RWQIMS search selection screen.

After users have constructed a search and executed the query (by clicking the *Return Results* button), the search definition will be stored until the user makes a change. This feature allows users to navigate to other pages within the RWQIMS web site without having to re-create the search each time they return to the search form. There is also a quick reset button to allow users to start from scratch.

A set of *Advanced Search Options* is available to users who wish to create a more refined search, but this panel is minimized by default to avoid overwhelming new users. The advanced options allow users to specify three additional optional criteria that will help return more targeted results.


STEP 1: select project name(s)

- all projects -
MCHD - LSCRMP
MCHD - LSCA
MCHD - DWPP
MCHD - Beach
MCHD - Watershed
WCDOE - RPO
TMDL DETROIT
SCC - Beach
SCC- Mill Creek
SCC - Routine

Project Details

STEP 2a: select location(s) by GoogleMap **or**
STEP 2b: select location(s) from a list:

- all monitoring sites (site id - site name) -
1.1 - Metropolitan Beach
1.2 - Metropolitan Beach
1.3 - Metropolitan Beach
1.4 - Metropolitan Beach
1.5 - Metropolitan Beach
1.6 - Metropolitan Beach
12.1 - New Baltimore Beach
12.2 - New Baltimore Beach
12.3 - New Baltimore Beach

Location Details

STEP 3: select parameter(s)

- all -
1,1,1-Trichloroethane
1,1,2-Trichloroethane
1,1-Dichloroethylene
1,2-Dibromo-3-chloropropane
1,2-Dichloroethane
1,2-Dichloroethylene
2-Fluorobiphenyl
2-Methylnaphthalene
Acenaphthene

Parameter Information

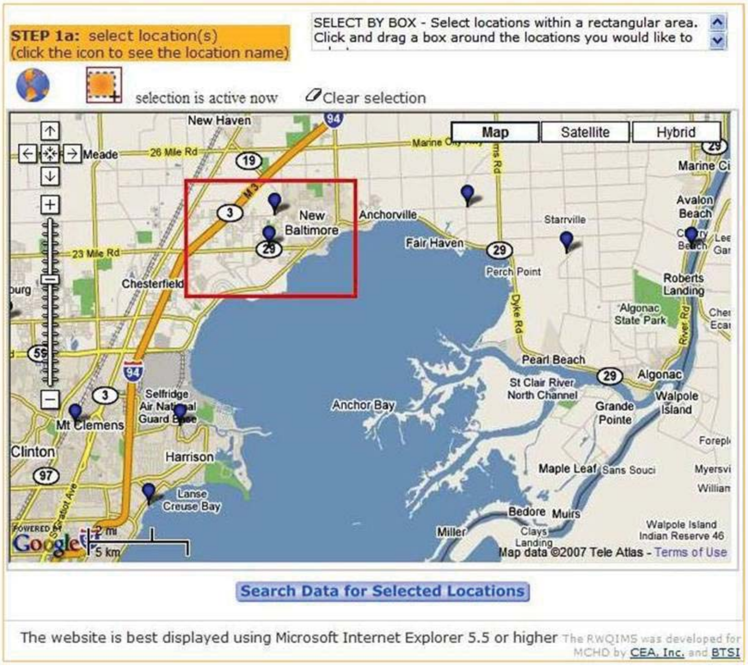
Figure 3. RWQIMS search screen.

Once a search is performed, users will be provided feedback regarding the results if zero records match the specified criteria or alternatively if more than one million records match the criteria, users will be prompted to refine their search. Once a successful search is executed, users will automatically see the results in a paginated tabular view.

Search Data by Map

As an alternative approach to the form based search definition, users may select the desired locations via an interactive map (Figure 4).

The map interface leverages Google maps and allows users to zoom in/out, pan around and then select sites from the map for which they would like to see data. RWQIMS is not a GIS-centric system, but geography clearly plays a key role in understanding the origin, destination and pattern of water quality information. This simple map interface offers users an intuitive and familiar interface to identify desirable sampling sites based on location from which they can perform more detailed analyses.



STEP 1a: select location(s)
(click the icon to see the location name)

SELECT BY BOX - Select locations within a rectangular area. Click and drag a box around the locations you would like to

selection is active now

The website is best displayed using Microsoft Internet Explorer 5.5 or higher The RWQIMS was developed for MCHD by CEA, Inc. and BTSI

Figure 4. RWQIMS interactive map.

Once the desired sites have been selected, users can simply click the *Search Data for Selected Sites* button, which will take them to the main search criteria form where the sites selected in the map are pre-selected and ready to be queried. From this point, users can further refine the query or simply click *Return Results* to retrieve a paginated tabular view of the results.

Search Results

Whether a query is initiated through the map or through the search definition form, a successful search will automatically switch the user over to the results tab where they can choose to view the results in a paginated tabular (Figure 5) or graphical (Figure 6) format. Additionally, users have the option of exporting the search results to a file that can be manipulated or analyzed locally.

Tabular View

By default, search results are returned as a table presenting raw data. The table includes fields to identify the project to which the records belong, location ID, parameter ID, sample date, parameter result, parameter units and any flags related to the record.

The tabular results can be sorted (ascending or descending) and the first several columns include links to more detailed information regarding the project and the location of the parameter (chemical or physical water quality characteristic).

Records/Page: 20 447 record(s) matched your query.

Project	Location ID	Parameter	Date	Time	Result	Units	FLAG
MCHD - LSCRMP	BE02	Aluminum	09/16/2004	01:30:00 PM	.04	mg/l	
MCHD - LSCRMP	BE02	Aluminum	04/12/2005	04:05:00 PM	.05	mg/l	<
MCHD - LSCRMP	BE02	Aluminum	05/04/2005	10:25:00 AM	.05	mg/l	<
MCHD - LSCRMP	BE02	Aluminum	05/11/2005	08:45:00 AM	.05	mg/l	<
MCHD - LSCRMP	BE02	Aluminum	06/03/2005	08:00:00 AM	.05	mg/l	<
MCHD - LSCRMP	BE02	Aluminum	06/21/2005	09:20:00 AM	.06	mg/l	
MCHD - LSCRMP	BE02	Aluminum	07/13/2005	11:20:00 AM	.10	mg/l	
MCHD - LSCRMP	BE02	Aluminum	08/04/2005	11:04:00 AM	.09	mg/l	
MCHD - LSCRMP	BE02	Aluminum	08/05/2005	11:35:00 AM	.05	mg/l	<
MCHD - LSCRMP	BE02	Aluminum	08/11/2005	10:30:00 AM	.05	mg/l	<
MCHD - LSCRMP	BE02	Aluminum	08/18/2005	10:30:00 AM	.05	mg/l	<
MCHD - LSCRMP	BE02	Aluminum	08/18/2005	10:30:00 AM	.05	mg/l	<
MCHD - LSCRMP	BE02	Aluminum	08/24/2005	09:22:00 AM	.08	mg/l	
MCHD - LSCRMP	BE02	Aluminum	10/10/2005	09:57:00 AM	.05	mg/l	<
MCHD - LSCRMP	BE02	Aluminum	10/21/2005	01:50:00 PM	.05	mg/l	<
MCHD - LSCRMP	BE02	Aluminum	10/21/2005	01:50:00 PM	.05	mg/l	<
MCHD - LSCRMP	BE02	BOD, Biochemical oxygen demand	09/16/2004	01:30:00 PM	2.00	mg/l	
MCHD - LSCRMP	BE02	BOD, Biochemical oxygen demand	09/28/2004	02:45:00 PM	7.00	mg/l	
MCHD - LSCRMP	BE02	BOD, Biochemical oxygen demand	10/12/2004	01:20:00 PM	35.00	mg/l	
MCHD - LSCRMP	BE02	BOD, Biochemical oxygen demand	10/28/2004	08:10:00 AM	7.10	mg/l	

Figure 5. RWQIMS tabular results.

Chart View

The RWQIMS provides the ability to create and view presentation quality charts of the search results at the click of a button.

If one or more records are returned by the search, the *View as Chart* tab will be enabled allowing you to view a chart of the data. Clicking the *View as Chart* button displays a chart of the data returned by the search. The parameter results are displayed on the y-axis with date as the x-axis. Additionally, wherever standard parameter limits have been defined, a dynamically generated marker (line or range) will be included in the chart.

Charting limits (i.e., number of locations, total number of records, number of sites, number of parameters, etc.) have been imposed to help ensure interpretability and to minimize server side-processing. If a data query returns more than 10,000 records, includes more than four locations or more than four parameters, then the *View as Chart* tab will be disabled (grayed out) and you will not be able to graph the data online.

Chart Type: Line 3-D ☐ Display Standard Limits ☑

Figure 6. RWQIMS graphical results.

Export Data

Searching, charting and mapping data through a browser provides RWQIMS users with a great deal of functionality. Additional quantitative analysis and customized charting requires that the capacity to extract the data for use in a desktop application. The results from any search performed within the RWQIMS may be exported to an Excel file that you can save to a local drive, which can then be used in any additional analyses.

After successfully executing a search, you may click the *Export Results* button to export the search results to an EXCEL file. The result of the export is a simple EXCEL file that contains the data returned by the data search. Basic table formatting is applied and a date stamp is appended to the top of the spreadsheet indicating when the export occurred.

Upload Data

One key aspect of the RWQIMS is the ability for registered users to load their data into the database. Once the monitoring sites have been defined along with the parameters that are being sampled, the data can be loaded into the RWQIMS database. A registered user logs into the RWQIMS web site (under *UPLOAD*) and then attaches an EXCEL (extension XLS) file containing the data to be imported into the database. Once uploaded into the RWQIMS, the data file is examined and verified with respect to format and viability (sites, parameters, units, etc.). If the uploaded file passes all the review criteria, the data are loaded into the database. This process occurs on a daily basis.

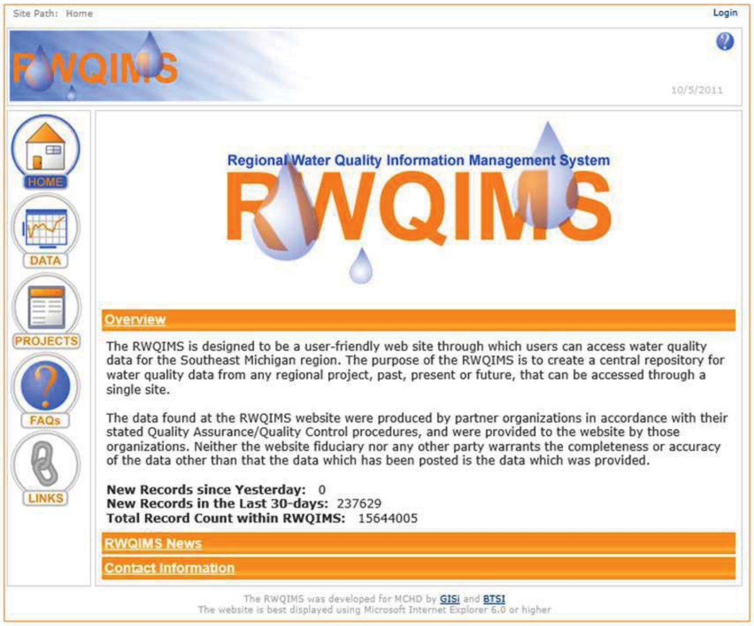
Additional Functions

Although the *Data* section of the RWQIMS web site represents the focal functionality of RWQIMS, as mentioned earlier, there are other sections of the web site that provide supplemental content and resources relevant to the water quality data users may query.

Home

The default page that users see when first arriving at the RWQIMS web site is the *Home* page (Figure 7), which contains several collapsible sections of information that provide users with general information regarding the system, such as an overview of the RWQIMS, news or events and contact information.

The RWQIMS *Home* page also display the total number of water quality records stored in the database as well as the number of records loaded within the last 24-hours and last 30 days. This allows frequent users of the RWQIMS web site to quickly determine if new information has been loaded.



Overview

The RWQIMS is designed to be a user-friendly web site through which users can access water quality data for the Southeast Michigan region. The purpose of the RWQIMS is to create a central repository for water quality data from any regional project, past, present or future, that can be accessed through a single site.

The data found at the RWQIMS website were produced by partner organizations in accordance with their stated Quality Assurance/Quality Control procedures, and were provided to the website by those organizations. Neither the website fiduciary nor any other party warrants the completeness or accuracy of the data other than that the data which has been posted is the data which was provided.

New Records since Yesterday: 0
New Records in the Last 30-days: 237629
Total Record Count within RWQIMS: 15644005

RWQIMS News

Contact Information

The RWQIMS was developed for MCHD by GISi and BTSI
The website is best displayed using Microsoft Internet Explorer 6.0 or higher

Figure 7. RWQIMS home page.

Projects

The *Projects* section of the RWQIMS web site (Figure 8) provides access to what is essentially metadata or information about the projects and the project partners that have data included within the RWQIMS.

Through the Project section, users can quickly view summary information about each project to determine potential relevance. Each project description includes contact information, date range for collection and a categorical quality metric or score along with a list of the locations and characteristics sampled by that project.

Partner Projects

This section will provide additional information on the RWQIMS partner projects that have uploaded data into the RWQIMS. If you would like to include a new project in the RWQIMS, please click here to access the request form.

The following
describing th

RWQIMS Project Page

Project Name: **LSCRMP**
Project Description: Lake St. Clair Regional Monitoring Project
Contact Name: Gary White
Company: Macomb County Health Department
E-mail Address: gary.white@macombcountymi.gov
Phone: ( ) -

Project Website: http://www.lakestclairdata.com
Date Range: 9/30/2007 to 9/30/2007
QAQC Score: 4: Formally documented SOP/FSP and QAQC process

Monitoring Locations (25)

Characteristics (20)

Figure 8. RWQIMS Projects section.

Unique to RWQIMS is the concept of a categorical quality metric or score, called QAQC Score, which allows users to quickly understand the quality of the data collected, which may in turn determine relevance or value to a specific type of analysis. The QA/QC Score allows RWQIMS to include data ranging from locally funded projects to Federally funded grants or initiatives in a single database.

FAQs

This section of the RWQIMS is where you will find a categorized list of frequently asked questions (FAQs) regarding water quality, the RWQIMS project and this application. In large part, the RWQIMS Administrator will provide the list of questions and associated answers that will comprise this section.

Links

As with any web site, this section of the RWQIMS contains numerous links to other relevant web sites where users can find more detailed information. Although the RWQIMS is not a one-stop-shop for water quality information, this section of the website is intended to provide links to the wealth of web-based information and resources that already exists on other water quality oriented sites.

The links are organized as intuitively as possible and a brief description of the target location is available as the mouse passes over the link. All links open in a new browser window, thus allowing users to keep the current session within the RWQIMS active (i.e., search definitions and results will persist).

Help

Consistent with the desire to make the RWQIMS user-friendly, an integrated help system is accessible throughout the application. Each page has a small question mark icon that can be clicked to provide context or page specific help. Additionally, a question mark icon is also accessible at all times that will launch the general help page.

Contact Information

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6.0 State of the Strait Poster Presentations with Abstracts

State of the Strait Conference- Poster Presentations
November 2, 2011
Eastern Michigan University, Ypsilanti, Michigan

Geographic Mapping and Hydrodynamic Modeling to Support Fish Spawning Habitat Rehabilitation in the Huron-Erie Corridor

David Bennion, U.S. Geological Survey
Bruce Manny, U.S. Geological Survey

Abstract: Quantity and quality of available habitats determines fish and wildlife population production capacity. The U.S. Environmental Protection Agency has designated the St. Clair River and Detroit River Areas of Concern (AOC) and as noted in 2004, project design for Michigan AOCs, including maps, was largely nonexistent. This poster summarizes a project that addresses AOC delisting goals for beneficial use impairments number 3 (degradation of fish and wildlife populations) and number 14 (loss of fish and wildlife habitat) by mapping major physical components of select fish spawning habitat. Information from recent spawning habitat construction projects and spawning and larval fish studies is combined with spatial overlays of depth and water velocity to identify and rank potential sites for future fish spawning habitat construction projects.

U.S. Army Corps of Engineers Surveying and Mapping along the Huron-Erie Corridor

Molly Reif, U.S. Army Corps of Engineers/Engineer Research and Development Center

Abstract: The U.S. Army Corps of Engineers (USACE) Joint Airborne Lidar Bathymetry Technical Center of eXpertise (JALBTCX) executes the National Coastal Mapping Program (NCMP) by providing surveying and mapping of the coastal U.S. on a recurring basis. Since the inception of the NCMP in 1994, high-resolution bathymetric and topographic lidar elevation data, as well as hyperspectral and RGB aerial imagery, have been collected along a 1-mile swath for over 15,000 kilometers of shoreline along the Gulf, Atlantic, Pacific, and Great Lakes coasts. These data are developed into a suite of Geographic Information Systems (GIS) products, including seamless bathymetric/topographic digital elevation models (DEMs), bare earth DEMs, building footprints, shoreline vectors, basic land cover classification, seafloor reflectance, and RGB and hyperspectral image mosaics. Consequently, the data are used to support a myriad of activities in the coastal zone, such as regional sediment management, construction, operations, and regulatory functions. More recently the data are used to support environmental and coastal engineering applications, ranging from habitat and invasive species mapping to shore protection and geomorphic feature extraction. Along select shorelines of lakes Erie and Huron, data were collected from 2006 to 2008, and again in summers 2011 and 2012. In addition to these data, analytical tools and methods are developed to support specific environmental and coastal engineering studies in the Great Lakes, including: 1) development of a semi-automated procedure for bluff edge detection, 2) image and lidar data fusion for detection and monitoring of invasive species, such as *Phragmites australis*, 3) and time series capabilities to illustrate changes in the landscape and tracking progress of shore protection projects, such as on Presque Isle, PA. Furthermore, these data are available to support other research and project activities through free access to lidar point data, by accessing the JALBTCX website, www.jalbtcx.org, to explore NCMP coverage and via the National Oceanic and Atmospheric Administration's Digital Coast website, www.csc.noaa.gov/digitalcoast.

LIDAR Feature Extraction: Skip the Overhead of Grids and Extract Information Directly from Your LAS File

Trevor Floyd, St. Clair County GIS

Abstract: Staff at St. Clair County have pioneered a method of extracting feature information directly from the point file. Our two meter post spacing LAS with identified ground classifications has provided enough of a baseline to harvest features. A recursive process of selective data point elimination and re-grouping has provided some impressive results. After sorting the points into probable groups, data can be compared against other known information sources to help improve accuracy and precision. Why pay a consultant to replicate information you may already have available?

Visualizing Our Coordinated Response. *Phragmites australis*: An Invasive Species in the St. Clair River delta

Charles Miller, Clay Township Phragmites Advisory Board
Ernest Kafcas, Clay Township Phragmites Advisory Board
Trevor Floyd, St. Clair County GIS

Abstract: Determining locations and ownership can be a difficult task when working in an area such as the River Delta; this study includes large acreage assemblages of state property and small ownership lots as narrow as eight meters. The changing landscape of disappearing cuts and increasing marsh islands dot the watery landscape. Complicate the issue with three meter invasive grasses and the task becomes all the more difficult. Using the tools of GIS, residents, and community leaders are able to identify, explore, track, demonstrate, and manage progress. A range of mapping resources from Microsoft Bing to an enterprise ArcGIS Deployment have been leveraged in this program. Some benefits of this cooperative effort have been unified permitting and volume purchase of chemicals and equipment. GIS has been an invaluable tool; stop by and talk with local representatives regarding this program!

Cooperative Approaches for Soil Erosion and Sediment Control in the Great Lakes Basin

Laura Kaminski, Great Lakes Commission
Gary Overmier, Great Lakes Commission
Michael Schneider, Great Lakes Commission
Thomas Crane, Great Lakes Commission

Abstract: Science, public outreach, and technical support for conservation practices are combined in the Great Lakes Commission's (GLC) nonpoint source pollution (NPS) program. Two federal programs, facilitated in part by the GLC -- the Great Lakes Tributary Modeling (GLTM) Program and the Great Lakes Basin Program for Soil Erosion and Sediment Control (GLBP) ñ promote partnerships and a coordinated approach to modeling sediment transport and implementing erosion and sediment control practices.

Soil erosion from urban, agricultural, and forested landscapes is a priority issue facing the Great Lakes region and a focus area of the Administration's Great Lakes Restoration Initiative (GLRI). Soil erosion and sedimentation have adverse environmental and economic impacts. Sediment loadings to tributaries can be a major source of nutrients, which increases algal blooms and can accelerate eutrophication (or the development of dead zones) within the

Lakes. The introduction of sediment to water bodies reduces water depths in harbors and shipping channels and increases the need for dredging and the costs to navigation users. The loss of soil from the land can also reduce farmland productivity and contribute to stream channel and bank instability, decreased enjoyment of recreational uses, and diminished flood control.

The GLTM program (authorized through Section 516(e) of the Water Resources Development Act of 1996) addresses sediment production and delivery in critical watersheds around the Great Lakes basin through the development of customized watershed and sediment transport models. The program is a joint initiative between the U.S. Army Corps of Engineers, agency and university partners, and the Great Lakes states. Together, the Corps and its partners develop modeling tools that can be used by state and local agencies and other stakeholders to help plan and implement soil conservation and nonpoint source pollution implementation programs. This work is helping to reduce the need for and costs of navigation dredging, while promoting actions to delist Areas of Concern (AOCs) and enhance Great Lakes water quality. More than 25 models have already been completed for tributaries to the Great Lakes and are being used by local, state, and federal agencies for watershed and ecosystem planning, forestry management, navigation maintenance planning, and water quality compliance evaluations. Additional information on the GLTM program can be found on the project website at: http://glc.org/tributary.

The GLBP is coordinated by the GLC in partnership with the U.S. Department of Agriculture & Natural Resources Conservation Service (NRCS), the U.S. Environmental Protection Agency, the U.S. Army Corps of Engineers, and the Great Lakes states to promote the improvement of Great Lakes water quality through financial assistance, technical support, education, and outreach at the local level. Initiated in 1991 and authorized in the 2002 and 2007 Farm Bills, this partnership has supported more than 400 grants to implement soil erosion and sediment control projects throughout the Great Lakes region. In 2010, nine watershed scale sediment reduction projects were awarded funding in priority areas in the basin through the GLRI. A selection of completed projects can be viewed at: http://glc.org/basin.

Organic Matter Decay, Greenhouse Gas Evasion, and Microbial Activity in Invaded and Historic Wetlands in the Detroit River International Wildlife Refuge

Shawn Duke, Eastern Michigan University

Abstract: Invasive species can substantially alter vital ecosystem functions, such as carbon and nutrient cycling. One emergent macrophyte, the common reed (*Phragmites australis* subsp. *australis*), is currently overtaking many Great Lakes wetlands. Invasion has resulted in the displacement of historic plant species such as *Typha x glauca*. This transition may result in increased carbon accumulation in freshwater wetlands. Reeds form monocultures, exhibit high primary productivity, contain large proportions of recalcitrant biomass and produce compounds that are potentially allelopathic and antimicrobial. These traits enhance *Phragmites* ability to dominate large areas. This study compares organic matter decay, carbon dioxide and methane evasion, and the effects of plant derived leachates on microbial activity in invaded and historic wetlands. We hypothesized that *Phragmites* invasion decreases rates of organic matter turnover, decreases evasion of both carbon dioxide and methane and inhibits microbial activity. Litter decay, soil incubation and leachate addition experiments were conducted to determine the effects of *Phragmites* on carbon transformations in a Lake Erie marsh. The results of this study suggest that carbon is stored in *Phragmites* biomass for longer periods than *Typha* biomass and that less carbon dioxide and methane are emitted from *Phragmites* invaded wetlands regardless of saturation level. However, our data indicated that *Phragmites* leachates do not inhibit total microbial respiration. Despite minor fluctuations in carbon output, invasive *Phragmites* could be impacting wetland function by acting as a temporary sink.

A Profile Depiction of Transect Communities in the Detroit River International Wildlife Refuge

Greg Stevens, Eastern Michigan University

Abstract: The aim of this poster is to depict the landform and vegetation profiles for the research transects set up in the summer of 2011 for the Detroit River International Wildlife Refuge. Among the data collected for the 2010 season by Dr. Gene Jaworski, Lisa Denys, and Greg Stevens, was observations of the vegetation species. The vegetation profile will place these observations and seek to establish the plant associations to which these species belong. There will also be produced a profile that suggests what those associations would normally be composed of. These idealized landscapes will be in comparison to what was observed. This will serve as indicators on the state of the lands that are being managed. The depictions will be a profile "slice" through the landscape revealing aspects of elevation, observed water level and location of vegetation. The use of ArcMap GIS and AutoCAD 3-D will be used to construct these representations. The software representation files will be linked to the database for the DRIWR so that clarification of observations may take place, as well as allow the database to show temporal studies as to the degree of succession. Instances of past and perspective land management techniques will also be noted, to allow for visual comparison.

Effect of Non-Native *Phragmites australis* and its Control Measures on Microbial Community Composition and Abundance in a Freshwater Wetland

Jennifer Kirk, Eastern Michigan University

Abstract: *Phragmites australis* is an invasive plant that has strong negative impacts on wetland ecosystems. To control *Phragmites*, a combination of the broad-spectrum herbicides glyphosate and imazapyr are often applied. While the toxicity effect on macroorganisms and specific model microorganisms has been well researched, effects on microbial community structure have not. Because microbes are important regulators of nutrient cycling in wetlands, and changes in their composition can alter this function, the purpose of this study was to determine whether differences in microbial community structure and abundance occur after glyphosate treatment. A series of soil samples were collected from a local wetland prior to and following a large-scale glyphosate application by the Michigan Department of Natural Resources at a wetland within the Detroit River International Wildlife Refuge (DRIWR). Additionally, soil samples were taken from wetlands dominated with invasive *Phragmites australis* and native vegetation. Using terminal restriction fragment length polymorphism (T-RFLP), a DNA fingerprinting technique, and quantitative polymerase chain reaction (Q-PCR) analysis, a bacterial community profile was constructed through time and by vegetation type. I hypothesized that an overall shift in the microbial community composition and abundance would be seen, and that some microbial groups would be enriched based on their ability to use glyphosate as a nutrient source. Furthermore, I expected that microbial communities and abundance would differ between soils under different vegetation types. Analysis using principal component analysis (PCA) indicated distinct differences between vegetation type and exhibited changes in microbial structure after herbicide application through time. Given microbes' central involvement in nutrient cycling, these changes are important to understanding how they relate to the function of freshwater wetland ecosystems.

Juvenile Lake Sturgeon Habitat Use in the Detroit River near Fighting Island

Margaret Hutton, University of New England
Justin Chiotti, US Fish and Wildlife Service
Ashlee Horne, US Fish and Wildlife Service
James Boase, US Fish and Wildlife Service
Charles Tilburg, University of New England

Abstract: The Detroit River contains one of the largest populations of lake sturgeon, *Acipenser fulvescen*s in the Great Lakes. However, habitat degradation due to channel dredging, pollution, and overharvest has played a role in reducing the number of lake sturgeon in this system. In order to protect and restore this population, the critical habitat of all life stages needs to be identified. In the summer of 2010, three young-of-year lake sturgeon were collected during bottom trawl assessments along the east side of Fighting Island. To gain a better understanding of juvenile lake sturgeon habitat use in this section of the Detroit River, side-scan sonar, ponar grabs, and bottom trawl assessments were conducted during the summer of 2011. Over 1700 images were taken using an 1197 series HumminbirdÆ Side Imaging System which were georeferenced in ArcGIS creating a mosaic of the sonar images. Forty-five petite ponar samples were taken throughout the sample area to verify specific substrate types (e.g. silt, clay, cobble, etc.) seen in the sonar images. Preliminary results from ponar grabs have shown the substrate as a mixture of silt, clay, sand, small gravel, and/or zebra mussels with one substrate dominating the mixture. Forty-five bottom trawls were conducted to assess juvenile lake sturgeon distribution. Together, this information will assist managers when protecting and restoring the lake sturgeon population in the Detroit River.

Current and Historical Mapping of Reed Cane (*Phragmites australis*, Genotype M), in Detroit River International Wildlife Refuge Units

Eugene Jaworski, Eastern Michigan University
Jacque Alessi, Eastern Michigan University

Abstract: Since the late 1970s the introduced genotype M variant of the tall, invasive grass, *Phragmites australis*, has been rapidly colonizing large areas of the coastal emergent marshes of Lake St. Clair, Detroit River, and western Lake Erie. Also known by its common name, Reed Cane, this cosmopolitan polyploid species is displacing the natural marsh vegetation on all 17 Detroit River International Wildlife Refuge (DRIWR) units. The displacement has occurred primarily in cattail (*Typha* sp.) communities, as well as in wet meadow areas (*Carex* spp., and amid *Calamagrostis canadensis*), and even among more aquatic plant species such as broad-leaf arrowhead (*Sagittaria latifolia*). Spreading initially by seed per coastal earth-moving work including berm building, local road construction, dredge and fill, along with lake level fluctuations, once established this invasive expands its patches several meters a year by way of rhizome extension. Genotype M of Reed Cane is now a dominant plant community type on all the Detroit River International Wildlife Refuge units. Tolerant of burning and mowing, the current preferred control method is herbicide treatment, followed by burning to remove the standing stock of dead culms. On some DRIWR sites, early results show that spraying and burning is facilitating the seed bank in the wetland soils in regenerating rather diverse marsh communities representative of the pre-1970s coastal wetland vegetation. The detailed mapping efforts of Institute for Geospatial Research and Education at EMU are assisting the DRIWR in targeting units for restoration.

Developing Biodiversity Conservation Strategies for Lake Erie: Preliminary Assessments of Viability and Threat, with Emphasis on the Huron-Erie Corridor

Douglas R. Pearsall, The Nature Conservancy
John Paskus, Michigan Natural Features Inventory

Patrick J. Doran, The Nature Conservancy
Dan Kraus, Nature Conservancy Canada
Anthony Sasson, The Nature Conservancy
Cindy Chu, Nature Conservancy Canada
Matt Herbert, The Nature Conservancy
Mary Khoury, The Nature Conservancy
Dave Ewert, The Nature Conservancy
Sagar Mysorekar, The Nature Conservancy
Tia Bowe, The Nature Conservancy
Rebecca Hagerman, The Nature Conservancy

Abstract: The Nature Conservancy, Michigan Natural Features Inventory, and Nature Conservancy Canada, are developing strategies for conservation of the biodiversity of Lake Erie. Our intent is that these strategies will complement and be incorporated into the Lake Erie Lakewide Management Plan (LaMP). Using the Conservation Action Planning (CAP) process, we are midway through this 2-year project and have identified the focal biodiversity conservation targets (the aquatic systems of the lake and connecting channels, associated coastal and wetland systems, islands, native migratory fish, and aerial migrants) and completed preliminary assessments of the viability (health) of biodiversity and threats to biodiversity. We are reporting these preliminary results for the lake, with a focus on the St. Clair River – Detroit River System (aka Huron – Erie Corridor). Our assessment incorporates indicators that align with those of the Lake Erie Millennium Network, as well as others, and we have taken an additional step of assigning ratings of Poor, Fair, Good, or Very Good to each indicator.

Forecasting *Phragmites* Invasion Patterns and Habitat Suitability in the Huron-Erie Corridor

David M. Galbraith, USGS Great Lakes Science Center
Martha L. Carlson Mazur, USGS Great Lakes Science Center
Kurt P. Kowalski, USGS Great Lakes Science Center

Abstract: Wetland habitats and transportation corridors in the Great Lakes are being invaded by a tall exotic plant called common reed (*Phragmites australis*). This plant forms dense stands and impairs wetland functions, reduces biodiversity and property values, limits human uses of beaches and recreational areas, and is extremely difficult and costly to eradicate once established. In partnership with Michigan Tech Research Institute, radar data were used to create a distribution map of *Phragmites* extent within the Great Lakes basin and allow the assessment of habitat suitability using observed and modeled environmental conditions. The resulting habitat suitability index was used in conjunction with proximity to areas dominated by *Phragmites* in order to produce an online geospatially-based decision support tool. When complete, this tool will assist resource managers with efforts to prioritize invasive species control actions and strategically plan applied restoration projects that target this invasive species within the Great Lakes basin.

7.0 State of the Strait Conference Program

State of the Strait Conference
November 2, 2011
Eastern Michigan University, Ypsilanti, Michigan

8:00-9:00	**Registration and Refreshments**
9:00-9:05	**Introductory Remarks** Steve Francoeur, Eastern Michigan University
9:05-9:15	**Opening and Welcome** Susan Martin, President, Eastern Michigan University
9:15-9:45	**Keynote Address - Technologies for Better Decisions in the Huron-Erie Corridor** Russell Kreis, U.S. Environmental Protection Agency
9:45-10:05	**Stopover Sites of Migratory Birds in the Western Lake Erie Basin, Ohio and Michigan: A GIS Analysis** David Ewert, The Nature Conservancy August Froehlich, The Nature Conservancy
10:05-10:40	**Coffee Break and Viewing of Posters and Displays**
10:40-11:00	**Developing Spatially-Explicit Models to Guide Conservation of Diving Ducks during Migration** Brendan Shirkey, Michigan State University David Luukkonen, Michigan Department of Natural Resources Scott Winterstein, Michigan State University
11:00-11:20	**Innovative Techniques to Map *Phragmites* and Wetlands in the Lake St. Clair Watershed** Robb Macleod, Ducks Unlimited Rob Paige, Ducks Unlimited
11:20-11:40	**Mapping Invasive *Phragmites* with Satellite Imaging Radar in the Coastal Great Lakes** Laura L. Bourgeau-Chavez, Michigan Tech Research Institute Kirk A. Scarbrough, Michigan Tech Research Institute Liza K. Jenkins, Michigan Tech Research Institute Colin N. Brooks, Michigan Tech Research Institute Richard B. Powell, Michigan Tech Research Institute Elizabeth Banda, Michigan Tech Research Institute

	Zach Laubach, Michigan Tech Research Institute Kevin Riordan, General Dynamics Martha L. Carlson Mazur, U.S. Geological Survey Kurt Kowalski, U.S. Geological Survey
11:40-12:00	**Development of Remote Sensing Methods for Detection of Invasive Wetland Plants** Yichun Xie, Eastern Michigan University Bill Welsh, Eastern Michigan University Anbing Zhang, Eastern Michigan University Eugene Jaworksi, Eastern Michigan University
12:00-1:40	**Lunch and Poster Session/Vendor Exhibits**
1:40-2:00	**Remote Sensing- and GIS-Facilitated Biological Monitoring of DRIWR Wetlands** Bill Welsh, Eastern Michigan University Kristi Judd, Eastern Michigan University Yichun Xie, Eastern Michigan University Steve Francoeur, Eastern Michigan University Eugene Jaworksi, Eastern Michigan University Gary Hannan, Eastern Michigan University Anbing Zhang, Eastern Michigan University
2:00-2:20	**Using GIS to Identify Potential Fish Spawning Habitat Remediation Areas in the Huron-Erie Corridor** David Bennion, U.S. Geological Survey
2:20-2:40	**Using Remote Sensing and GIS Tools to Model and Prioritize a Natural Heritage System** Tom Dufour, Essex Region Conservation Authority Roger Palmini, Essex Region Conservation Authority
2:40-3:15	**Coffee Break and Viewing of Posters and Displays**
3:15-3:35	**Using Technology to Quantify Storm Water Benefits of Green Infrastructure** Amy Mangus, SEMCOG Kelly Karl SEMCOG
3:35-3:55	**Managing Water Quality Data in the Huron-Erie Corridor** Charles R. Bristol, Bristol Technical Services, Inc. Sean Savage, Geographic Information Systems, Inc. Gary White, Macomb County Health Department
3:55-4:10	**Closing Remarks** Luca Cargnelli, Environment Canada
4:10-5:00	**Post-Event Reception**