The Great Lakes Indicator Suite: Changes and Progress 2004

Draft for Comment and Discussion at SOLEC 2004

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1. Preface

This document presents information to SOLEC participants about the development of Great Lakes indicators since the release of the *State of the Lakes Report 2003*. Included are changes to the organizing framework as well as to the indicators themselves.

Background

During 2003 and early 2004, external and internal peer reviews were conducted to objectively identify strengths and weaknesses of the process, products and indicators of SOLEC. The external peer review was conducted by a panel of experts on indicator monitoring and reporting systems outside the Great Lakes basin. They examined SOLEC on a broad scale by evaluating overall SOLEC efficiency, the Parties' approach to science-based reporting on Great Lakes assessments, and the SOLEC approach compared to other regional, national and international indicator efforts.

The second, internal peer review workshop consisted of a review and evaluation of the suite of Great Lakes basin indicators by an independent, knowledgeable group of data generators and information users from the Great Lakes basin. The objectives of this second session included evaluating the entire suite of indicators for their utility, success and effectiveness in reporting and influencing decision makers. Suggestions for improvement as well as positive validations emerged from both of these peer reviews. A full description and record of the proceedings and results of the SOLEC Peer Reviews is being prepared by U.S. EPA and Environment Canada, and will be available in early 2005.

In the months preceding SOLEC 2004, specific recommendations originating from the peer reviews and from SOLEC 2002 were recognized and where possible, incorporated. For example, steps were taken to reduce or consolidate existing indicators into a more manageable presentation by "bundling" groups of related indicators together. This was a suggestion made at both peer review sessions. Additionally, the indicators themselves underwent review and revision resulting in the deletion, combination, replacement or proposal of indicators and their descriptions. These and other changes are documented for review by SOLEC 2004 participants in this paper.

2. Revised Great Lakes Indicator Framework

A strong message that emerged from both Peer Review sessions was the need to reduce the overall number of indicators by identifying and eliminating those indicators that may be unnecessary or redundant. An additional and related comment was that in order to accomplish this reduction, categorical groupings of indicators by topic, issue or theme could be developed. Based on these recommendations, SOLEC organizers grouped related indicators into the following categories and sub-categories (or "bundles" and "sub-bundles") for ease in and presentation of related information and understanding of the larger issue:

1. **Contamination**
   a. Nutrients
   b. Toxics in Biota
   c. Toxics in Media
   d. Sources and Loadings

2. **Biotic Communities**
    a. Fish
    b. Birds
    c. Mammals
    d. Amphibians
    e. Invertebrates
    f. Plants
    g. General
3. **Invasive Species**
    a. Aquatic
    b. Terrestrial
4. **Coastal Zones**
    a. Nearshore Aquatic
    b. Coastal Wetlands
    c. Terrestrial
5. **Aquatic Habitats**
    a. Open Lake
    b. Groundwater
6. **Human Health**
7. **Land Use - Land Cover**
    a. General
    b. Forest Lands
    c. Agricultural Lands
    d. Urban/Suburban Lands
    e. Protected Areas
8. **Resource Utilization**
9. **Climate Change**

In this approach, many indicators are relevant to more than one category. For example, "Contaminants in Sport Fish" is included in both "Contamination: Toxics in Biota" and "Human Health." All of the indicators within a category, however, contribute to a more complete evaluation of environmental conditions pertaining to that category.

Other categories are possible, and they may of greater usefulness in the future. Likewise, the "old" categories previously used for reporting Great Lakes indicators may still be relevant for some users. As originally conceived, the Great Lakes suite of indicators was developed around the topics of open and nearshore waters, coastal wetlands, nearshore terrestrial, land use, human health, societal, and unbounded. Each indicator was associated with one primary category, but all the indicators were also evaluated for relevancy to other SOLEC categories and to other major environmental groupings (e.g., land, water, air, biota), issues (e.g., contaminants, invasive species, urban sprawl), or indicator systems (e.g., IJC Desired Outcomes, Great Lakes Water Quality Agreement Impaired Beneficial Uses).

The categories currently listed are incomplete, and others may be incorporated in the future. For example, under "Aquatic Habitats," indicators have yet to be identified and developed for inland surface waters, including tributaries, inland lakes, and inland wetlands. The category "Resource Utilization" is also very incomplete and will require quite extensive consideration of socio-economic indicators relevant to the assessment of Great Lakes ecosystem components. Likewise, "Human Health" could be expanded to "Human Health and Well Being" and include indicators to assess social values of residents in the Great Lakes basin.

3. Changes to the Indicator Assessment Process

In response to suggestions from the peer reviews that the SOLEC process for the assessment of indicators was not sufficiently transparent or standardized, some changes were made to make assessments more credible and internally consistent. Previously, the available assessment options were restricted to Good, Mixed Improving, Mixed, Mixed Deteriorating, and Poor. These were not always sufficient or helpful. For SOLEC 2004, a system is being used to better express the relative condition and trend for all indicators. Authors have provided a qualitative assessment as they have done in the past, but the assessment categories are now less ambiguous. Specifically, authors have provided a "condition" of the ecosystem related to their indicator by selecting a "good, fair, poor or mixed" status and then assigning a "direction" of "improving, unchanged, deteriorating or undetermined" to each indicator.

Four broad ranking categories were used to characterize the assessments:

Good. The state of the ecosystem component(s) is/are presently meeting ecosystem objectives or otherwise is in acceptable condition.

Fair. The ecosystem component(s) is/are currently exhibiting minimally acceptable conditions, but it is not meeting established ecosystem objectives, criteria, or other characteristics of fully acceptable conditions.

Poor. The ecosystem component(s) is/are severely negatively impacted and it does not display even minimally acceptable conditions.

Mixed. The ecosystem component(s) displays both good and degraded features.

In addition, four ecosystem trajectories (or trends over time) were recognized:

Improving. Information provided by the report shows the ecosystem component(s) to be changing toward more acceptable conditions.

Unchanging. Information provided by the report shows the ecosystem component(s) is/are neither getting better nor worse.

Deteriorating. Information provided by the report shows the ecosystem component(s) to be changing away from acceptable conditions.

Undetermined. Data are not available to assess the ecosystem component(s) over time, so no trend can be identified.

4. 2004 Great Lakes Indicator Suite and Status of Descriptions

The current 2004 Great Lakes indicator suite is organized under the "bundle" structure. Each of the indicators has been reviewed relative to its status in 2002, including possible changes in the descriptions of the indicators **(full descriptions for all indicators in the Great Lakes Suite can be viewed in Appendix 1 to this report)**. Some indicators have been modified or added, and new descriptions have been developed. In some cases, modifications have been suggested, but one or more experts have not yet reviewed the indicator description in the context of the suggested changes. Indicators that have been deleted since 2002 are listed in the next section of this report. The following definitions were applied to the "Status" of each indicator:

New Indicator, New Description — This indicator was not part of the 2002 suite, but it was developed through a process that included a SOLEC-recognized group,

	e.g., Great Lakes Coastal Wetlands Consortium, Groundwater Indicator Group, and Great Lakes Forestry Indicators Group
No Action Taken	This indicator is currently on the Great Lakes indicators suite, but some change has been suggested; to bring the description in line with the current monitoring data, to revise the metrics being reported, or some other action; but no action has yet occurred on this indicator, and no report was prepared for 2004.
No Change	No change has been suggested in the indicator description from 2002, and no change is required.
Proposed at 2002	This indicator was proposed at SOLEC 2002, and it was accepted during the SOLEC stakeholders review workshop of the indicator suite. A description has been provided.
Replaces #xxx	This indicator improves the suite of Great Lakes indicators by replacing another that was being used in 2002.
Revised Description	The indicator was part of the Great Lakes indicators suite in 2002, but the description has been revised.
Revised Description Needed	This indicator remains part of the Great Lakes indicators suite, but revisions are needed to the description/definition of the indicator. The revisions have not yet been achieved, but a report was prepared for 2004 based on the old description.

Table 1. Great Lakes indicators included in SOLEC 2004 suite of indicators with status information.

Indicator Number	Bundle	Status
	CONTAMINATION	
	Nutrients	
111	Phosphorus Concentrations and Loadings	No change
4860	Phosphorus and Nitrogen Levels (Coastal Wetlands)	No change
7061	Nutrient Management Plans	Proposed at 2002
	Toxics in Biota	
114	Contaminants in Young-of-the-Year Spottail Shiners	No change
115	Contaminants in Colonial Nesting Waterbirds	No change
121	Contaminants in Whole Fish	Proposed at 2002. Revised description
124	External Anomaly Prevalence Index for Nearhore Fish	Proposed at 2002. Replaces 101
4177	Biologic Markers of Human Exposure to Persistent Chemicals	New title. Revised description
4201	Contaminants in Sport Fish	New indicator. Replaces 113 & 4083. New description
4506	Contaminants in Snapping Turtle Eggs	Revised description
8135	Contaminants Affecting Productivity of Bald Eagles	Revised description needed
8147	Contaminants Affecting the American Otter	Revised description needed
	Toxics in Media	
117	Atmospheric Deposition of Toxic Chemicals	No change

118	Toxic Chemical Concentrations in Offshore Waters	No change
119	Concentrations of Contaminants in Sediment Cores	No change
4175	Drinking Water Quality	Revised description
4202	Air Quality	New indicator. Replaces 4176. New description
9000	Acid Rain	No change
	Sources and Loadings	
117	Atmospheric Deposition of Toxic Chemicals	No change
4202	Air Quality	New indicator. Replaces 4176. New description
9000	Acid Rain	No change
	BIOTIC COMMUNITIES	
	Fish	
8	Salmon and Trout	No change
9	Walleye	No change
17	Preyfish Populations and Communities	New title
93	Lake Trout	Revised description
125	Status of Lake Sturgeon in the Great Lakes	Proposed at 2002
4502	Coastal Wetland Fish Community Health	Revised description
	Birds	
115	Contaminants in Colonial Nesting Waterbirds	No change
4507	Wetland Dependent Bird Diversity and Abundance	New title. Revised description
8135	Contaminants Affecting Productivity of Bald Eagles	Revised description needed
8150	Breeding Bird Diversity and Abundance	No change
	Mammals	
8147	Contaminants Affecting the American Otter	Revised description needed
	Amphibians	
4504	Coastal Wetland Amphibian Diversity and Abundance	New title. Revised description
7103	Groundwater Dependent Animal and Plant Communities	Proposed at 2002. Revised description
	Invertebrates	
68	Native Freshwater Mussels	No change
104	Benthos Diversity and Abundance	No change
116	Zooplankton Populations	Revised description needed
122	Hexagenia	No change
123	Benthic Amphipod (Diporeia spp.)	No change
4501	Coastal Wetland Invertebrate Community Health	Revised description
	Plants	
109	Phytoplankton Populations	Revised description needed.
4862	Coastal Wetland Plant Community Health	New indicator. Replaces #4513. New description
8162	Health of Terrestrial Plant Communities	Proposed at 2002.
8500	Forest Lands - Conservation of Biological Diversity	New indicator. Description available
	General	
8114	Habitat Fragmentation	No change
8137	Nearshore Species Diversity and Stability	No action taken
8161	Threatened Species	No change
8163	Status and Protection of Special Places and Species	Proposed at 2002. No action taken
	INVASIVE SPECIES	
	Aquatic	
18	Sea Lamprey	No change
9002	Non-Native Species (Aquatic)	New indicator. Need description
	Terrestrial	
9002	Non-Native Species (Terrestrial)	New indicator. Need description
	COASTAL ZONES	
	Nearshore Aquatic	

6	Fish Habitat	No action taken
4860	Phosphorus and Nitrogen Levels (Coastal Wetlands)	No change
4861	Effect of Water Levels Fluctuations	No change
4864	Human Impact Measures (Coastal Wetlands)	New indicator. New description
8131	Extent of Hardened Shoreline	No change
8142	Sediment Available for Coastal Nourishment	No action taken
8146	Artificial Coastal Structures	No change
	Coastal Wetlands	
4501	Coastal Wetland Invertebrate Community Health	Revised description
4502	Coastal Wetland Fish Community Health	Revised description
4504	Coastal Wetland Amphibian Diversity and Abundance	Revised description
4506	Contaminants in Snapping Turtle Eggs	Revised description
4507	Wetland Dependent Bird Diversity and Abundance	New title. Revised description
4510	Coastal Wetland Area by Type	Revised description
4511	Coastal Wetland Restored Area by Type	Revised description
4516	Sediment Flowing into Coastal Wetlands	No action taken
4860	Phosphorus and Nitrogen Levels	No change
4861	Effect of Water Levels Fluctuations	No change
4862	Coastal Wetland Plant Community Health	New indicator. Replaces #4513. New description
4863	Land Cover Adjacent to Wetlands (Coastal Wetlands)	New indicator. New description
4864	Human Impact Measures	New indicator. New description
	Terrestrial	
4861	Effect of Water Levels Fluctuations	No change
4864	Human Impact Measures	New indicator. New description
8129	Area, Quality, and Protection of Special Lakeshore Communities - Alvars	Revised description needed
8129	Area, Quality, and Protection of Special Lakeshore Communities - Islands	Revised description needed
8129	Area, Quality, and Protection of Special Lakeshore Communities - Cobble Beaches	Revised description needed
8129	Area, Quality, and Protection of Special Lakeshore Communities - Sand Dunes	Revised description needed
8131	Extent of Hardened Shoreline	No change
8132	Nearshore Land Use	No action taken
8136	Extent and Quality of Nearshore Natural Land Cover	No action taken
8137	Nearshore Species Diversity and Stability	No action taken
8142	Sediment Available for Coastal Nourishment	No action taken
8149	Protected Nearshore Areas	No action taken
	AQUATIC HABITATS	
	Open Lake	
6	Fish Habitat	No action taken
111	Phosphorus Concentration and Loadings	No change
118	Toxic Chemical Concentrations in Offshore Waters	No change
119	Concentrations of Contaminants in Sediment Cores	No change
8131	Extent of Hardened Shoreline	No change
8142	Sediment Available for Coastal Nourishment	No action taken
8146	Artificial Coastal Structures	No change
	Groundwater	
7100	Natural Groundwater Quality and Human-Induced Changes	Proposed at 2002. Revised description
7101	Groundwater and Land: Use and Intensity	Proposed at 2002. Revised description
7102	Base Flow due to Groundwater Discharge	Proposed at 2002. Revised description
7103	Groundwater Dependent Plant and Animal Communities	Proposed at 2002. Revised description
	HUMAN HEALTH	
4175	Drinking Water Quality	Revised description
4177	Biologic Markers of Human Exposure to Persistent Chemicals	New title. Revised description
4179	Geographic Patterns and Trends in Disease Incidence	No change

4200	Beach Advisories, Posting and Closures	New indicator. Replaces 4081. New description
4201	Contaminants in Sport Fish	New indicator. Replaces 113 & 4083. New description
4202	Air Quality	New indicator. Replaces 4176. New description
	LAND USE- LAND COVER	
	General	
4863	Land Use Adjacent to Wetlands (Coastal Wetlands)	New indicator. New description
7002	Land Cover - Land Conversion	Revised description needed
7101	Groundwater and Land: Use and Intensity	Proposed at 2002. Revised description
8114	Habitat Fragmentation	No change
8132	Nearshore Land Use	No action taken
8136	Extent and Quality of Nearshore Natural Land Cover	No action taken
	Forest Lands	
8500	Forest Lands- Conservation of Biological Diversity	New indicator. New description
8501	Maintenance and Productive Capacity of Forest Ecosystems	New indicator. Description needed
8502	Maintenance and Forest Ecosystem Health and Vitality	New indicator. Description needed
8503	Forest Lands- Conservation and Maintenance of Soil and Water Resources	New indicator. Description needed
	Agricultural Lands	
7028	Sustainable Agriculture Practices	No action taken
7061	Nutrient Management Plans	Proposed at 2002
7062	Integrated Pest Management	Proposed at 2002
	Urban/Suburban Lands	
7000	Urban Density	Revised description needed
7006	Brownfield Redevelopment	Revised description needed
7054	Ground Surface Hardening	Revised description needed
	Protected Areas	
8129	Area, Quality, and Protection of Special Lakeshore Communities - Alvars	Revised description needed
8129	Area, Quality, and Protection of Special Lakeshore Communities - Cobble Beaches	Revised description needed
8129	Area, Quality, and Protection of Special Lakeshore Communities - Islands	Revised description needed
8129	Area, Quality, and Protection of Special Lakeshore Communities - Sand Dunes	Revised description needed
8149	Protected Neashore Areas	No action taken
8163	Status and Protection of Special Places and Species	Proposed at 2002. No action taken
	RESOURCE UTILIZATION	
3514	Commercial / Industrial Eco-Efficiency	Proposed at 2002
3516	Household Stormwater Recycling	Proposed at 2002
7043	Economic Prosperity	Revised description needed
7056	Water Withdrawal	No change
7057	Energy Consumption	No change
7060	Solid Waste Generation	Revised description needed
7064	Vehicle Use	Proposed at 2002. Replaces 7012. No action taken
	CLIMATE CHANGE	
4858	Climate Change: Ice Duration on the Great Lakes	No change
9003	Climate Change: Effect on Crop Heat Units	Proposed at 2002

5. Deleted or Replaced Indicators

One of the expected outcomes from the external peer review of SOLEC processes and products and the stakeholder's review of the Great Lakes suite of indicators is a recognition that some changes would strengthen the biennial evaluation of the conditions of Great Lakes. Some indicators were unnecessary and redundant, some indicator topics were over-represented, and some indicators did not add value to making better management decisions. The suggestions to delete or replace an indicator came from the two peer reviews of the indicators, from recognized groups developing indicators for a particular ecosystem component (e.g., wetlands, forest lands, groundwater), or from some other recognized authority on the ecosystem component being assessed by the indicators.

The following table presents those indicator titles that have been removed from the active Great Lakes suite of indicators since 2002. The indicator status and/or rationale for removal from the suite is also provided.

Table 2. Great Lakes indicators removed from the suite during 2003 – 2004, with Status and Rationale for the changes.

Indicator Number	Deleted or Replaced Indicators	Status and Rationale Change
101	Deformities, Eroded Dins, Lesions and Tumors (DELT) in Nearshore Fish	Replaced by #124, External Anomaly Prevalence Index for Nearshore Fish (new) which is more inclusive and representative.
113	Contaminants in Recreational Fish	Combined with #4083. Replaced by #4201, Contaminants in Sport Fish (new)
120	Contaminant Exchanges between Media: Air to Water and Water to Sediment	Deleted. Too research oriented; contaminant presence in the media is already covered under #117, #118, and #119.
3509	Capacities of Sustainable Landscape Partnerships	Proposed for deletion, January 2004 Workshop.
3510	Organizational Richness of Sustainable Landscape Partnerships	Proposed for deletion, January 2004 Workshop.
3511	Integration of Ecosystem Management Principles Across Landscapes	Proposed for deletion, January 2004 Workshop.
3512	Integration of Sustainability Principles Across Landscapes	Proposed for deletion, January 2004 Workshop.
3513	Citizen/Community Place-Based Stewardship Activities	Proposed for deletion, January 2004 Workshop.
New-3515	Cosmetic Pesticide Control	Proposed for deletion, January 2004 Workshop. (In the future this indicator will be replace by an indicator called: Residential and Commercial Pesticide Consumption and Application)
New-3517	Commercial/Industrial Environmental Management Systems	Replaced/incorporated into #3514, Commercial / Industrial Eco-efficiency.
New-3518	Community Engagement in Great Lakes Protection & Decision Making	Proposed for deletion, January 2004 Workshop.
New-3519	Environmental Education	Deleted. Difficult to establish a solid connection between education and the level of commitment to environmental issues.
New-3520	Household Solid Waste Minimization	Replaced/incorporated into Solid Waste Generation indicator #7060.
New-3521	Taxes on Energy/CO2	Proposed for deletion, January 2004 Workshop.
4081	E. coli and Fecal Coliform Levels in Nearshore Recreational Waters	Replaced by #4200, Beach Advisories, Postings and Closures (new).
4083	Contaminants in Edible Fish Tissue	Combined with #113. Replaced by #4201, Contaminants in Sport Fish (new).
4088	Chemical Contaminant Intake from Air, Water, Soil and Food	Proposed for deletion, January 2004 Workshop. Ambiguous and difficult method of data collection and weak connection human health impact.
4176	Air Quality	Replaced by #4202, Air Quality (new)
4178	Radionuclides	Deleted. Difficult to measure and limited in its usefulness to policy makers and regulatory agencies.
4503	Deformities, Eroded Dins, Lesions and Tumors (DELT) in Nearshore Fish	Replaced by #124, External Anomaly Prevalence Index for Nearshore Fish (new) which is more inclusive and representative.
4513	Presence, Abundance and Expansion of Invasive Plants	Replaced by #4862, Coastal Wetland Plant Community Health which is more inclusive and representative.
4519	Climate Change: Number of Extreme Storms	Deleted. Questioned for its usefulness, especially when other climate change indicators might be more useful such as depth,

		amount and duration of snow cover.
4857	Climate Change: First Emergence of Water Lilies in Coastal Wetlands	Proposed for deletion.
7012	Mass Transportation	Replaced by #7064, Vehicle Use.
7042	Aesthetics	Deleted. Needs a clearer description; will be covered within other indicators.
7053	Green Planning Process	Proposed for deletion, January 2004 Workshop.
7055	Habitat Adjacent to Coastal Wetlands	Replaced by #4863, Land Cover Adjacent To Wetlands
7059	Wastewater Pollution	Combined with #7063: Municipal Wastewater Treatment. To be replaced by Wastewater Treatment (proposed).
New-7063	Municipal Wastewater Treatment	Combined with #7059: Wastewater Pollution. To be replaced by Wastewater Treatment (proposed).
8134	Nearshore Plant and Animal Problem Species	Deleted. Covered by #104 Benthos Diversity and Abundance (revised), #8137 Nearshore Species Diversity and Stability and #8129 Area, Quality and Protection of Special Lakeshore Communities.
8139	Community / Species Plans	Deleted. Programmatic indicator that does not help with the understanding of the ecosystem.
8140	Financial Resources Allocated to Great Lakes Programs	Deleted. Programmatic indicator that does not help with the understanding of the ecosystem.
8141	Shoreline Managed Under Integrated Management Plans	Deleted. Programmatic indicator that does not help with the understanding of the ecosystem.
New-8164	Landscape Ecosystem Health	Deleted. Too similar to #7002, Land Conversion.

6. Proposed Indicators with Descriptions and Sample Reports

SOLEC is a continually evolving process and proposals for new indicators are accepted throughout the SOLEC cycle for presentation, critique and potential acceptance into the full suite of Great Lakes indicators. For SOLEC 2004, sample descriptions and/or sample reports for the proposed indicators in the table below were submitted to SOLEC organizers. The descriptions and reports themselves are included here. Please provide any comments back to SOLEC organizers.

Proposed Indicators	**Status**
Wastewater Treatment	sample description and report; proposed to replace #7059 & #7063
The following indicators are grouped under the new proposed *Well Being* Indicator Suite:	
Value of the Great Lakes to Basin Residents	sample description
Sense of Place: Indian Tribes Around the Great Lakes Basin	sample description and report
National Park Visitation	sample description and report
Capacity of Federal Program for Great Lakes Priorities	sample description
Public Recreational Access to the Great Lakes	sample description
Access to Information about the Great Lakes	sample description
Research/Educational Opportunities	sample description
Population and Income Distribution	sample description

Wastewater Treatment and Pollution

New Indicator; (Proposed sample report available)

Measure:
Proportion of the population served by municipal sewage treatment facilities, percent of collected wastewater that is treated, level of municipal treatment provided (primary, secondary, tertiary, and/or advanced treatment technologies), and the loadings of metals, phosphorous, BOD, and organic chemicals that are released by sewage treatment plants and industrial discharges into water courses of the Great Lakes basin.

Purpose:
This indicator will assess the scope of municipal sewage treatment and the commitment to protecting freshwater quality in the Great Lakes basin. The quality of wastewater treatment in terms of the loadings of pollutants discharged into the Great Lakes basin will be used to infer the potential adverse impacts to human and ecosystem health.

Ecosystem Objective:
To reduce the pressures induced on the ecosystem by insufficient wastewater treatment networks and procedures and further progression towards sustainable development.

Endpoint:
To provide municipal sewage treatment facilities to the greatest portion of the population and to treat all wastewater to a quality that ensures waters released back into the ecosystem approach the ambient quality of the area they are being discharged to.

Features:
This indicator measures progress toward safe and innocuous wastewater releases to the environment. In particular, this indicator provides information on how well local governments are managing wastewater generated in their communities. Measuring the level and type of treatment used provides additional information on the quality of the water returned to the environment. Measures of the percent of population connected to the municipal treatment facilities (over a select time period) can be used as an indicator of sprawl, since greenfield development may not supported by municipal infrastructure services.

Illustrations:
- Percent of population connected to sewage treatment systems over specific time period (by basin?) - bar
- Percent of wastewater treated vs. percent of wastewater collected - line
- Level of treatment based on type of treatment - pie
- Loadings over time (by jurisdiction / by basin / overall?) – multi bar

Limitations:
Though most municipalities produce wastewater treatment data, it may require considerable effort to collect all the information, particularly in smaller or more rural communities. Wastewater treatment technologies vary by municipality and, in some cases, may be difficult to classify. Although data are largely available, they are not collected on a necessarily comparable fashion for both the U.S. and Canada. Some work is required to ensure that Ontario data is consistent with the U.S. Since much industrial wastewater flows to municipal sewage treatment facilities the efficiency of these in reducing waste can be hidden.

Interpretation:

Wastewater treatment is dependent on the quality of the incoming wastewater, the state of the technology used to process the wastewater, and other factors such as fugitive leaks that can increase volumes dramatically at certain times resulting in a deterioration of the quality of wastewater. This indicator can also be used to monitor progress toward more comprehensive wastewater treatment in terms of quality and scale of the treatment system.

Wastewater Treatment and Pollution - Proposed Sample Report
New Indicator

Assessment: N/A

Purpose
This indicator will assess the scope of municipal sewage treatment and the commitment to protecting freshwater quality in the Great Lakes basin. The quality of wastewater treatment in terms of the loadings of pollutants discharged into the Great Lakes basin will be used to infer the potential adverse impacts to human and ecosystem health.

Ecosystem Objective
Wastewater refers to the contents of sewage systems –liquid wastes from municipal, institutional, and industrial sources as well as stormwater. Wastewater effluent is what is released into the environment after treatment.

Wastewater contains a large number of potentially harmful pollutants, including some that are the result of biological activity others such as the over 200 identified chemicals from industries, institutions, households, and other sources.

Wastewater systems are designed to collect and treat wastes, however, wastewater receives various levels of treatment to remove pollutants prior to discharge, ranging from no treatment to very sophisticated and thorough treatments. Wastewater effluent is released into different environments: lakes, ponds, streams, rivers, and estuaries. Despite treatment, effluents released from wastewater systems can still contain pollutants of concern since even advanced treatment systems cannot remove all pollutants and chemicals. Some sewer collection and treatment systems are combined with stormwater collection systems, and they can become overloaded during heavy rainfalls, resulting in the release of partially treated effluent directly into the waterways.

According to Environment Canada's publication *The State of Municipal Wastewater Effluents in Canada*, municipal wastewater effluents can contain:

- *grit, debris, and suspended solids*, which can discolour the water, make it unfit for recreational, domestic, and industrial use, and eventually smother and contaminate plant and animal life on the bottom of the receiving water body;
- *disease-causing pathogens (e.g., bacteria and viruses)*, which can make the water unfit for drinking, swimming, and other recreational uses and can contaminate shellfish;
- *decaying organic wastes*, which use up the water's dissolved oxygen and threaten the survival of fish and other aquatic life;
- *nutrients*, which overstimulate the growth of algae and other aquatic plants, giving rise to odours and other aesthetic problems, diminished biodiversity, and, in some cases, toxic contamination of shellfish; and
- *about 200 different identified chemicals*, many of which may be either acutely or chronically toxic to aquatic organisms and may pose a health risk to humans. Many of these chemicals may have long-term environmental effects, as they are not easily broken down and tend to accumulate in aquatic or terrestrial organisms through the food chain.

Concentrations of these contaminants can be high in untreated sewage, stormwater, and combined sewer overflows (CSO), but even treated sewage may contain smaller quantities of these harmful substances.

The goals of wastewater treatment are to reduce the pressures induced on the ecosystem by insufficient wastewater treatment networks and procedures and further progression towards sustainable development.

State of the Ecosystem

The concentration and type of effluent released into the receiving body of water depends heavily on the type of sewage treatment used. The three most common types of sewage treatment, are primary, secondary, and tertiary.

Primary Sewage Treatment

To prevent damage to pumps and clogging of pipes, raw wastewater passes through mechanically raked bar screens to remove large debris, such as rags, plastics, sticks, and cans. Smaller inorganic material, such as sand and gravel, is removed by a grit removal system. The lighter organic solids remain suspended in the water and flow into large tanks, called primary clarifiers. Here, the heavier organic solids settle by gravity. These settled solids, called primary sludge, are removed along with floating scum and grease and pumped to anaerobic digesters for further treatment.

Secondary Sewage Treatment:

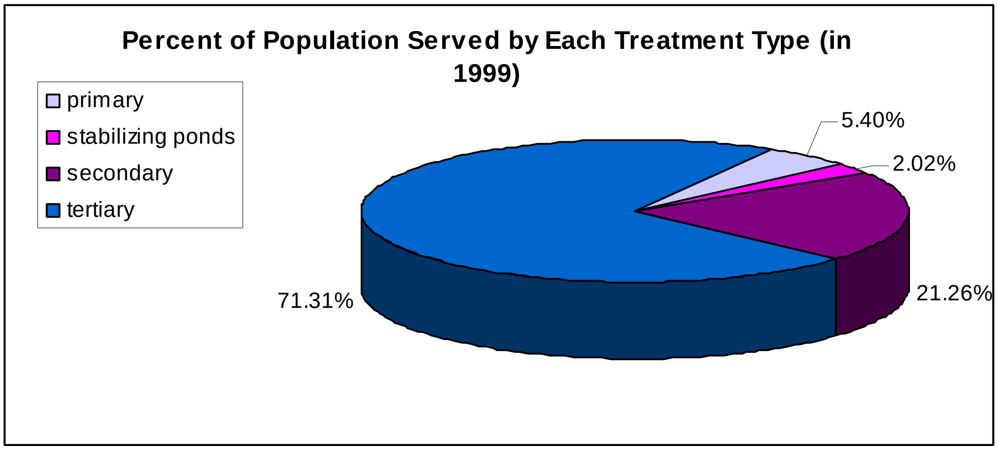
The primary effluent is then transferred to the biological or secondary stage. Here, the wastewater is mixed with a controlled population of bacteria and an ample supply of oxygen. The microorganisms digest the fine suspended and soluble organic materials, thereby removing them from the wastewater. The effluent is then transferred to secondary clarifiers, where the biological solids or sludges are settled by gravity. As with the primary clarifier, these sludges are pumped to anaerobic digesters, and the clear secondary effluent may flow directly to the receiving environment or to a disinfection facility prior to release.

Tertiary Sewage Treatment:

Advanced wastewater treatment is the term applied to additional treatment that is needed to remove suspended and dissolved substances remaining after conventional secondary treatment. This may be accomplished using a variety of physical, chemical, or biological treatment processes to remove the targeted pollutants. Advanced treatment may be used to remove such things as colour, metals, organic chemicals, and nutrients (phosphorus and nitrogen).

Source: The State of Municipal Wastewater Effluents in Canada (http://www.ec.gc.ca/soer-ree/English/soer/MWWE.pdf)

Within the Great Lakes basin tertiary treatment is the most common type of sewage treatment, as is illustrated in figure one.



Source: Municipal Water Use Database Web site: (http://www.ec.gc.ca/water/en/manage/use/e_data.htm)

After treatment the concentration of harmful contaminants is reduced, but the following constituents, mostly associated with human waste, are present in all sewage effluent.

- biodegradable oxygen-consuming organic matter (measured as biochemical oxygen demand or BOD);
- suspended solids (measured as total suspended solids or TSS);
- nutrients, such as phosphorus (measured as total phosphorus and/or ortho-phosphates) and nitrogen-based compounds (nitrate, nitrite, ammonia, and ammonium, which are measured either separately or in combination as total nitrogen);
- microorganisms (which are usually measured in terms of the quantity of representative groups of bacteria, such as fecal coliforms or fecal streptococci, found in human wastes); and
- sulphides.

Acknowledgements

Author: Erin Clark, Environment Canada

HUMAN HEALTH AND WELL BEING
A Proposed Suite of Societal Indicators

For the last several years State of the Lakes Ecosystem Conferences (SOLECs) participants have attempted to scope out a potential suite of "societal" or "human response" or "well being" indicators. Thus far, we have succeeded in illuminating the topic but have not managed to succinctly state and define indicators that would make up the suite. There are several reasons for this. First, in general, SOLEC participants are scientists and managers, not social scientists. Societal indicator development requires a group of economists and social scientists to work together much as the coastal wetlands scientists developed the current coastal wetlands indicator suite. Second, SOLEC participants have been occupied with developing chemical, biological, and physical indicators of ecosystem health, including human health, and have had little time to focus on the other factors associated with the well being of people.

Proposed below is a suite of eight "well being" indicators. It is our intention that these indicators complement the human health indicator "bundle" or category. We recommend that the "Human Health" category be renamed "Human Health and Well Being" once the following indicators are vetted in the SOLEC process.

Each indicator below is followed by a draft indicator description. Two—Sense of Place: Indian Tribes Around the Great Lakes Basin and National Park Visitation—have been analyzed with available data in order to demonstrate that there is data available and that societal indicator analyses are possible within our current SOLEC process. Both of the analyzed indicators need review by social scientists and other experts in order to edit to proper language and eventually provide valuable information as Great Lakes indicators.

We recommend a new working group of social scientists to review the following indicators, revise them, and present a suite of "well being" indicators at SOLEC 2006.

DRAFT
Well Being Suite of Indicators:

1. **Value of the Great Lakes to Basin Residents**
2. **Sense of Place: Indian Tribes Around the Great Lakes Basin**
3. **National Park Visitation**
4. **Capacity of Federal Programs for Great Lakes Priorities**
5. **Public Recreational Access to the Great Lakes**
6. **Access to Information about the Great Lakes**
7. **Research/Educational Opportunities**
8. **Population and Income Distribution**

Value of the Great Lakes to Basin Residents

New Indicator

Measure

Survey of representative number of Great Lakes Basin residents about responsibility for and awareness of the Great Lakes as a vital resource.

Purpose

To explore the connections, values, attitudes and general knowledge which residents of the Great Lakes basin hold about the Lakes.

Ecosystem Objective

Provide Great Lakes educators and managers information about the importance of the Great Lakes to the region's residents.

Endpoint

All Great Lakes basin residents will act responsibly in managing Great Lakes resources because the Great Lakes are a vital resource.

Features

A representative population of the Great Lakes basin will be surveyed by telephone to elicit responses in the following areas:

- Sense of personal responsibility for the Great Lakes
- Impressions of the Great Lakes
- Awareness of present or potential threats to the Great Lakes
- Support for water exports
- Reasons for caring about the Great Lakes
- Effectiveness of government actions to protect the Great Lakes

Illustration

An analysis of percentages of responses to the survey questions will be graphed.

Limitations

An independent group such as the Biodiversity Project must initiate any survey on the US side due to the constraints of the Government Paperwork Reduction Act which limits surveys by US government agencies to nine without OMB permission.

Interpretation

The responses to the survey questions will indicate a qualitative measure of Great Lakes residents' awareness and understanding of Great Lakes resources and issues.

Comments

In January 2003, The Biodiversity Project (Madison, Wisconsin) with the Joyce Foundation, released a report based on a survey conducted by Belden, Russonello & Stewart. The report that resulted from the survey is called *Great Lakes: Responsibility and Awareness about a Vital Resource, Summary Analysis of Public Opinion in Great Lakes States.* The report contains information that is continuing to inform Great Lakes education and outreach programs. The survey results can be found at http://www.biodiversityproject.org/GLSummaryAnalysis.PDF. A similar report is found in Canada.

Unfinished Business

The indicator requires scrutiny and refinement by the originators of the reports and by social scientists.

Relevancies
Indicator Type: Human response
Environmental Compartment: Societal
Related Issue(s):
SOLEC Grouping: Social Values
GLWQA Annex(es):
IJC Desired Outcome(s):
GLFC Objectives:
Beneficial Use Impairment(s):

Last Revised
September 2004

Sense of Place: Indian Tribes Around the Great Lakes Basin

New Indicator; (Proposed sample report available)

Measure

Importance of the Great Lakes ecosystem to Great Lakes Indian Tribes/First Nations.

Purpose

To assess how and why Indian Tribes/First Nations value natural resources, how natural resources are managed on Indian reserves, and how Indian Tribes/First Nations are affected by natural resources management decisions.

Ecosystem Objective

Human impacts to Great Lakes natural resources continue to degrade ecosystems.
Recognition by the Great Lakes community that many Great Lakes Indian Tribes/First Nations embrace an ecosystem approach to management of natural resources and that this approach provides a model for management in other areas of the basin.

Endpoint

To be determined.

Features

A variety of Indian Tribe/First Nation ideas and practices with regard to natural resource management (traditional ecological knowledge or TEK) could be analyzed to contribute to ecosystem management throughout the Great Lakes basin.

Illustration

A distribution map of the different Indian tribes around the Great Lakes Basin is the starting point for the study of TEK practices. Narratives of natural resource management practices need to be collected.

Limitations

American Indians do not view themselves as a “special interest” group. In fact, there are close to 100 different Indian Tribes/First Nations in the Great Lakes basin, all with differing histories, natural resource holdings, and cultural needs. In the US, Indian Tribes retain a status equal to states. Also, Tribal lands contain natural resources important to the culture and Indian Tribes/First Nations are not likely to readily share information about either the resources or cultural practices associated with them (i.e., medicinal plants). In addition, the past and current history of Indian Tribe/First Nation lands in both the US and Canada is contentious.

Interpretation

Human values, beliefs, and attitudes, including those of resource professionals, are part of social and institutional environments, which support management decisions or create restraints on what managers accomplish.

The identity associated with that community does not occur automatically; rather, identity centers around the interactions devoted to constructing a sense of place and commitment to the surrounding environment called home. However, community identity encompasses interrelated components centering on social interaction, including personal commitment, professional obligation, civic duty, and leisure.

Comments
Documents cited and analyzed are *Exposure assessment and initial intervention regarding fish consumption of tribal members of the Upper Great Lakes Region in the United States*' Environmental Research, Volume 95, Issue 3, July 2004, Pages 325-340
John A. Dellinger. And the other document cited is *Linking Traditional Ecological Knowledge and SOLEC: Summary and Final Recommendations*, prepared by Environment Canada –Ontario Region and Chiefs of Ontario by Deborah McGregor July 2001.

Relevancies
Indicator Type: Human Response
Environmental Compartment: Societal
Related Issue(s):
SOLEC Grouping: Social Values
GLWQA Annex (es):
IJC Desired Outcomes:
GLFC Objectives
Beneficial Use Impairment(s):

Last Revised
September 2004

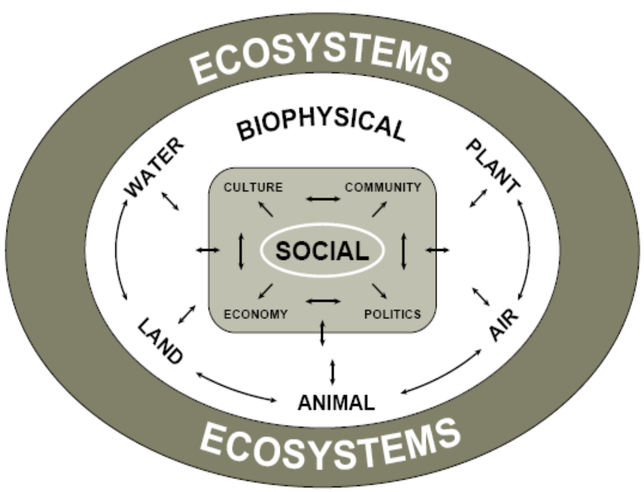
Sense of Place: Indian Tribes around Great Lakes Basin - Proposed Sample Report

Assessment
Status: Mixed; Trend: Undetermined
Indians are experiencing cultural, economic, and political shifts in local community development efforts. The intense interest of Indian peoples and their tribal governments in the region's ecosystems and natural resources is founded in their long-term relationship with and spiritual attachment to the land. As a Tribe chooses a particular development strategy, it must also "negotiate" the accompanying social identities associated with these efforts. Factors including length of residence, feeling accepted or welcomed within the community, and values placed on environmental protection and economic development are evaluated in relation to community identity.

Purpose
To assess how and why Indian Tribes/First Nations value natural resources, how natural resources are managed on Indian reserves, and how Indian Tribes/First Nations are affected by natural resources management decisions.

State of the Ecosystem
Human dimensions refer to how and why humans value natural resources, how humans want resources managed and how humans affect or are affected by natural resources management decisions. It covers a variety of ideas and practices including cultural, social, and economic values, individual and social behavior, demographics, legal and institutional frameworks of management, communication and education and decision making process of ecosystem management.

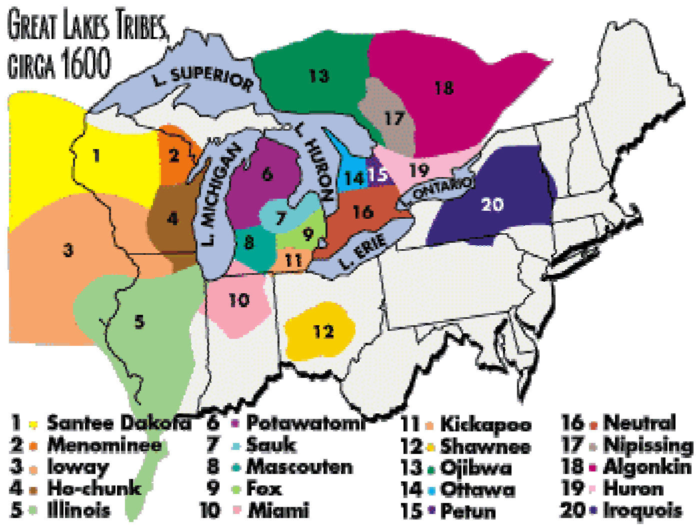
Ecosystems are places where biophysical and social components interact as a whole. All ecosystems have flows of energy, organisms, water, air, and nutrients and each element is affected by other elements. All ecosystems change over space and time.



Aboriginal people contribute to the Great Lakes ecosystem, providing valuable insight as how current society might reestablish more harmonious ways of relating to the Great Lakes basin.

First nations collectively hold thousands of years of knowledge and understanding of the Great Lakes ecosystem. This knowledge, referred to as Traditional Ecological Knowledge (TEK), has allowed aboriginal people to live, prosper from and contribute to the Great Lakes ecosystem. (Ref. *Linking Traditional Ecological Knowledge and SOLEC: Summary and Final Recommendations*, prepared by Environment Canada –Ontario Region and Chiefs of Ontario by Deborah McGregor July 2001).

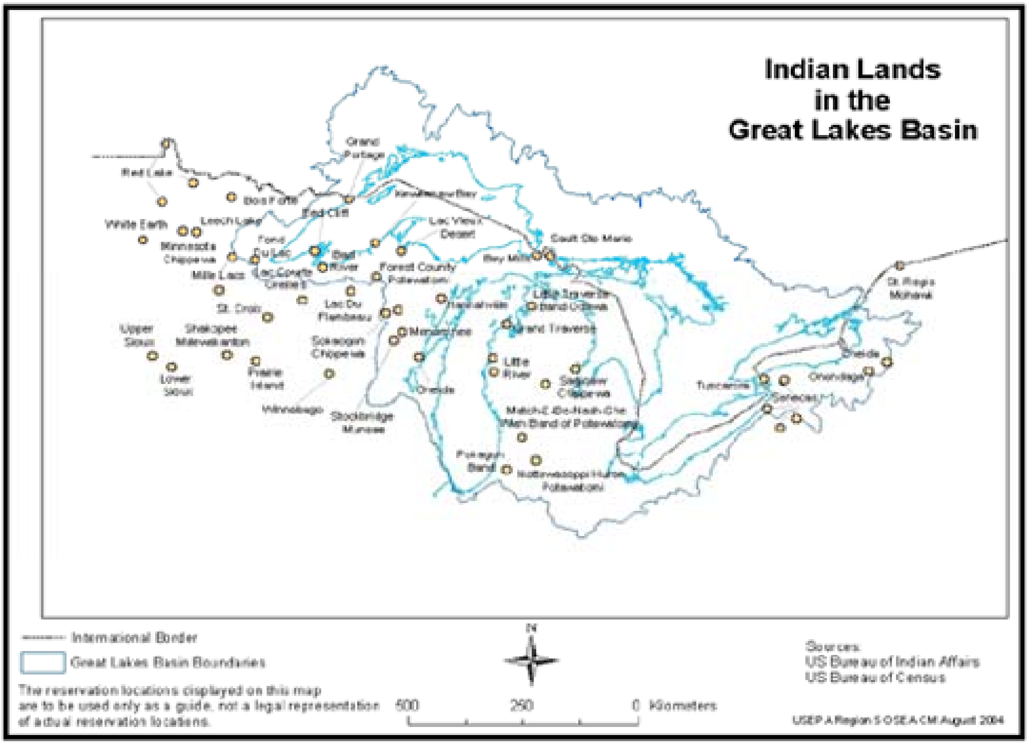
Indian Tribes settlements in 1600:



Indian Tribes in the present around the Great Lakes Basin-Canada:

In this map, Canadian communities with a significant Aboriginal population and currently producing mines are geographically displayed. Aboriginal communities, for purposes of these maps, are defined as those Canadian communities with a self-identified population of 20% or more Aboriginal people, as enumerated by the 1996 Census. For more information on the 1996 Census, visit the Statistics Canada web site at www.statcan.ca.

Note: The communities of Caldwell and Sand Point do not currently have a land base.



Pressures

- ✓ American Indians do not view themselves as another “special interest” that needs to be factored in (or trade off) with other interests when Federal agencies develops a management plan.
- ✓ In addition to environmental complexity, cultural and political boundaries in the Great Lakes Basin create one of the most complex resource management situations in the world. Two nations, two provinces, eight states, a growing number of Indian tribes, and scores of local institutions formally participate in basin management.
- ✓ Resource acquisition activities such as fishing, hunting, and plant and mineral gathering are usually done within the context of traditional socio-cultural and economic systems. These native foods are collected usually from a tribe’s or traditional community’s homeland and its socially and /or traditionally significant ecological places-typically places on reservation or public lands.
- ✓ Research is needed that integrates knowledge about the human and environmental dimensions to aid decision-making about the Great Lakes ecosystem.

Management Implications

- ✓ A framework for ecosystem management is a description of steps and components necessary to achieve desired goals. Steps and components to establishing a framework using TEK might include criteria, principles, concepts, processes, interactions, fundamentals, relationships, methods, and rules. Such a framework would place planning procedures within a broader, proactive process that considers the social, economic, and biophysical components of Tribal/First Nation ecosystems at the earliest stages of policy design. Specifically a framework based on an ecosystem approach and using TEK would:
  - o Strive to maintain the integrity of ecosystems;
  - o Include long-term ecosystem health and the resiliency and vitality of social and economic systems in its construct;

    - Recommend procedures for examining relations between the biophysical (land, air, water, plant, and animal) and social (community, economic, cultural, and political);
    - Consider people's expectations, management and ecological capabilities, scientific methods, and current scientific literature;
    - Describe temporal and spatial dimensions for planning and risk assessment, assessment approaches, monitoring and evaluation needs, and stakeholder participation processes; and,
    - Identify ecosystem principles that can be used to develop agency procedures for interagency coordination, planning, stakeholder involvement, and management.
- ✓ Meaningful dialogue through an effective consultation process is an important issue among tribes. Consultation is not a single event but a process that leads to a decision. Even though consultation means different things to different tribes: it can be a formal process of negotiation, cooperation and policy level decision government and the Federal government or a more informal process. Developing a consistent approach to consultation that meets tribal needs is one of the challenges of Great Lakes ecosystem management.
- ✓ The intimacy with and length of attachment to the land and the totality of landscape importance has contributed to a strong sense of place for Indian people. Places of significance are created by an intersection of nature, cultural uses, social system and cultural meanings.
- ✓ Most managers, as well as biological and social scientists recognize an urgent need for integration of biological and human dimensions in management as practiced in the Great Lakes ecosystem. Systematic evaluations are necessary to determine which techniques have been successful and why, what are impediments for adoption o these innovative and what are human dimensions research priorities to improve management.
- ✓ The human dimensions theme seeks to promote research into the value humans place on natural resources, the expectations people have for management, how and why governance structures have emerged the way they have and how stakeholders relate to the management process.

Further Work Necessary

- ✓ Management of the Great Lakes ecosystem is difficult because there is no single overarching management authority. Nevertheless, Indian Tribes/First Nations need to be included in natural resource management planning wherever appropriate.
- ✓ An evaluation of current human dimensions information and processes used in ecosystem management, and impediments to adoption of more effective decision processes, is needed.

Acknowledgments:

Authors: Yamille Cirino-Santana, REM (Registered Environmental Manager), ORISE Research Specialist on contract to USEPA Region 5- Great Lakes National Program Office. Karen Rodriguez, Program Specialist, USEPA, Great Lakes National Program Office.

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USEPA Great Lakes National Program Office: Mark Elster
USEPA Region 5: Tom Brody, Carmen Masó, John Haugland, Noel Kohl,
Environment Canada: A; Jamal

Sources:

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National Park Visitation

New Indicator; (Proposed sample report available)

Measures:

Number of acres (US) and square kilometers (Canada) of Great Lakes National Parks compared to national totals.

Number of recreational visitors each year to US and Canadian Great Lakes National Parks compared to national totals.

Proposed National Parks taken into consideration for an analysis are:
US Parks: Apostle Islands National Lakeshore, Cuyahoga Valley National Park, Grand Portage National Monument, Indiana Dunes National Lakeshore, Isle Royale National Park, Pictured Rocks National Lakeshore, Sleeping Bear Dunes National Lakeshore.
Canada Parks: Bruce Peninsula National Park, Georgian Bay National Park, Point Pelee National Park, Pukaskwa National Park, St. Lawrence Islands National Park.

Purpose

The purpose is two-fold: 1) To compare acreage and visitation to Great Lakes National Parks and to other National Parks in the US and Canada in order to assess their values as recreational resources; 2) To assess the human impacts of recreation on the resources of the Great Lakes.

Ecosystem Objective

National Parks in the Great Lakes region protect in perpetuity fragments of the original landscape. They often protect unique features or remnant populations of plants and wildlife. They also serve as important reference sites to compare changes in the landscape due to increasing human use. Great Lakes National Parks will continue to be recreational destinations for thousands of visitors to the Great Lakes region and are important assets to the economies of both the US and Canada.

Endpoint

The US and Canada increase total acres (square kilometers) of National Park lands within the Great Lakes region. The trend for Great Lakes National Park recreational visits is maintained over time or increases to year 2000 numbers.

Features

Total acreage (square kilometers) of Great Lakes National Parks and annual visitation will be compared to the national US and Canada totals. In the US, historical visitation records are available since 1990. In Canada, visitation records are available beginning in 1998.

In the US, visitation is defined as the number of days (1 person for four days equals 4 visits) or the number of visits (1 person visits a park, stays four days but it is still one visit).

Illustration

A pie chart or graph will illustrate number of acres (square kilometers) for each Great Lakes National Park and the total number of acres (square kilometers) for the country. A pie chart or graph will also illustrate visitation totals for each park and totals for the countries.

Limitations

National Parks are only one of numerous recreational opportunities available to Great Lakes residents and visitors. This indicator will provide a beginning to our understanding of Great Lakes recreational values.

Currently, data on visitation may not be consistently collected for a given park and the data are not necessarily comparable between parks because of the different methods of estimating visitation.

Interpretation
Proportional acreage preserved and the number of annual visits can measure the value of National Parks in a very simplistic way. Acreage of National Park lands in the Great Lakes is expected to remain more or less constant, though some new parks may be added and the total acreage could increase through time. This indicator will track the number of parks, total acreage, and visits so that we can assess relative use. Visitor use per park and per acre in the Great Lakes will enable us to test whether visitation in the region stays constant, increases or decreases through time. By comparing these numbers with national averages we can assess the relative economic impact as well as the resolve of the citizens, communities and public servants of the Great Lakes region to preserve the natural resources.

Comments:
If visitation decreases proportionally nationally, then decreased visitation to Great Lakes National Parks may be attributed to general attitudes and not necessarily degradation of the resources.

Relevancies
Indicator Type: Human response
Environmental Compartment: Societal
Related Issue(s):
SOLEC Grouping: Social Values
IJC Desired Outcome:
GLFC Objectives:
Beneficial Use Impairment(s):

Last Revised
September 2004

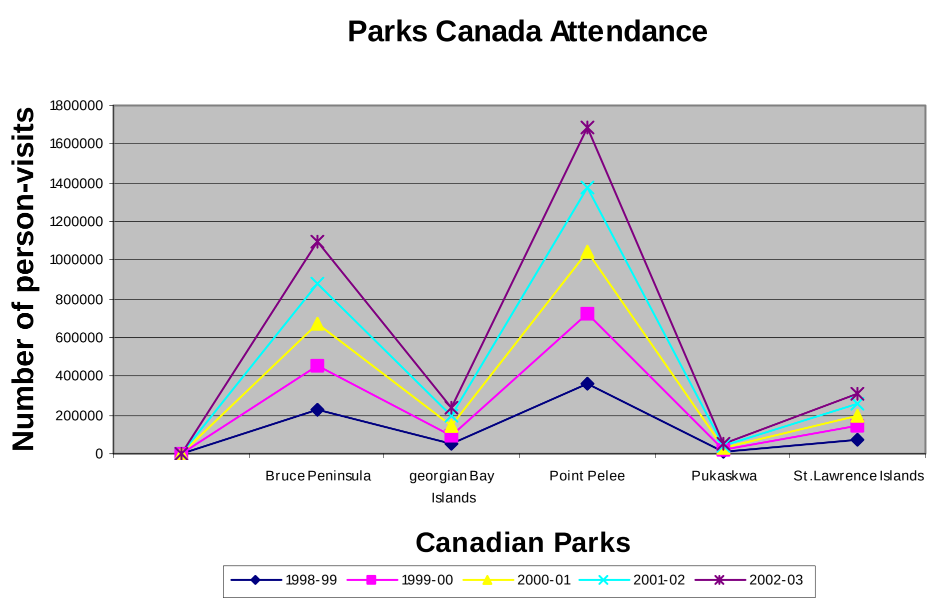
National Park Visitation - Proposed Sample Repor:

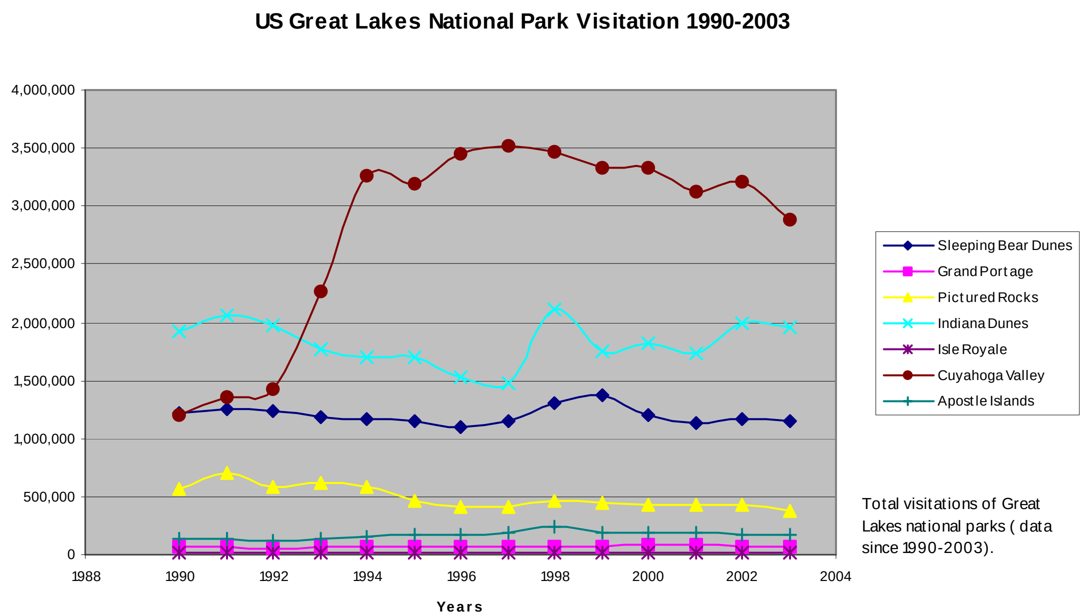
Assessment
Status: Fair; *Trend: Improving*
Visitor counts represent an inexact portrayal of the actual number of visitors to an area, as well as an attraction's impact on the community. To ensure that existing sites are conserved for the use and enjoyment of present and future generations, management, in conjunction with state leadership and user groups, should develop consensus on criteria and methods to systematically assess existing sites and proposed new sites. This assessment should be made to determine whether the site is of statewide significance and whether adequate resources exist to operate and maintain the site.

Purpose
The purpose is two-fold: 1) To compare acreage and visitation to Great Lakes National Parks and to other National Parks in the US and Canada in order to assess their values as recreational resources; 2) To assess the human impacts of recreation on the resources of the Great Lakes.

Ecosystem Objective
National Parks in the Great Lakes region protect in perpetuity fragments of the original landscape. They often protect unique features or remnant populations of plants and wildlife. They also serve as important reference sites to compare changes in the landscape due to increasing human use. Great Lakes National Parks will continue to be recreational destinations for thousands of visitors to the Great Lakes region and are important assets to the economies of both the US and Canada.

State of the Ecosystem
US and Canadian National Parks provide a unique resource for outdoor recreation opportunities. The presence of these parks in urban and rural areas is a significant natural resource that adds to the base of opportunities for recreation and leisure. In the US, National Park attendance seems to have remained steady or decreased over the last few years. In Canada, visitation has increased.





Total visitations of Great Lakes national parks (data since 1990-2003).

Pressures:

- ✓ In the US, racial and ethnic minorities are largely absent among visitors to national parks (Goldsmith 1994). Several visitor surveys at parks throughout the country support this observation. Without understanding the factors that may inhibit visitation among minority groups, it will be difficult to develop strategies to engender support for National Park programs among a broader and more diverse segment of the population.
- ✓ In the US, acreage of National Park lands in the Great Lakes is expected to remain more or less constant, or at least proportional to national acreages. A drop in visitation may be due to one or more of the following:
    - o The self-selection factor (when people choose activities they enjoy and locations they perceive to best provide for their chosen recreation experiences).
    - o Parks are not walking distance and sometimes are difficult to get to.
    - o Sagging economy or economic barriers: higher unemployment and high gas prices seem to be determining factors.
    - o Terrorism fears may have influenced travelers. (People are going to be sticking closer to home).
    - o A decrease in the value of the resource for recreational purposes.
    - o Competing recreational opportunities.
    - o Changes in recreational preferences.
    - o Degradation of the resources so that their attractiveness is lessened.
    - o Visitors are not satisfied with appropriate park facilities, services and recreational opportunities. Park visitors may not understand and appreciate the significance of the park they are visiting.
    - o Education about park resources has been scaled back.
    - o Adjacent development has changed historic view sheds, contributing to a lack of understanding of their significance.

- New recreations (e.g., snow mobiles) are incompatible with resource preservation.
- Minorities' park visitation seems to be increasing, so the approach to visitor's services, park history and interpretation are not well represented.

Management Implications:

- ✓ If visitation decreases proportionally nationally, then decreased visitation to Great Lakes parks may be attributed to general attitudes and not necessarily degradation of the resources.
- ✓ The disparity in National Park visitation between the majority and minority populations should be a major concern among National Park managers and policy-makers for at least two important reasons.
  - First, racial and ethnic minority populations, particularly Hispanic populations, have dramatically increased their share of the US population and will continue to increase over the next several decades. For the first time in history, the Hispanic population will soon supplant African Americans as the largest minority group in the US population.
  - Second, if current patterns of visitation persist into the future, along with current demographic trends, the probability of lower demand for National Park experiences increases. If this should result, where will National Park programs rank among other public policy priorities in a multi-ethnic and multi-cultural society?
    - Without greater visitation and interest from among those populations that are growing most rapidly, National Park programs, over time, are likely to be supported by a smaller and shrinking segment of the US population.

Further Work Necessary:

National Park managers in both the US and Canada are confronted with increasingly complex and challenging issues that require a broad-based understanding of the status and trends of park resources as a basis for making decisions and working with other agencies and the public for the benefit of park resources.

Acknowledgements:

ORISE Research Specialist on contract to USEPA Great Lakes National Program Office: Yamille Cirino-Santana

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USEPA Great Lakes National Program Office: Karen Rodriguez

Sources:

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Capacity of Federal Programs for Great Lakes Priorities
New Indicator

Measure
Annual budgets of key federal programs for Great Lakes priorities.
US: Department of Agriculture, Department of Commerce, Department of State, US Army Corp of Engineers, Department of Interior, Department of Transportation, Environmental Protection Agency (EPA), National Oceanic and Atmospheric Administration (NOAA)
Canada: Environment Canada, Ontario Ministry of Environment

Purpose
To assess the yearly overall funding for Great Lakes programs from US and Canada federal agencies.

Ecosystem Objective
To effectively allocate appropriate federal funding for Great Lakes environmental priorities.

Endpoint
To be determined. Must first run a cost exercise to determine the need.

Features
The budgets of key US and Canada federal programs with dollar amounts spent for key Great Lakes programs.

Illustration
A chart of the key federal programs in the US and Canada with dollar amounts spent for key Great Lakes programs.

Limitations
Data is available with interpretation by Northeast-Midwest Institute and a parallel organization in Canada.

Interpretation
The total of the Great Lakes funding by key US and Canadian federal programs will indicate the capacity of federal programs to manage these priorities. Baseline will be the *Great Lakes at the Millennium, Priorities for Fiscal 2001* report by the Northeast-Midwest Institute (Sturtevant and Cangelosi 2001) and a comparable report or reports for Canada.

Comments
This indicator would allow us to state what could be accomplished with full funding for particular programs.

Unfinished Business
The indicator requires scrutiny and refinement by the originators of the reports and by social scientists.

Relevancies
Indicator Type: Human response
Environmental Compartment: Societal
Related Issue(s):
SOLEC Grouping: Social Values
GLWQA Annex(es):
IJC Desired Outcome(s):

GLFC Objectives:
Beneficial Use Impairment(s):

Last Revised
September 2004

Public Recreational Access to the Great Lakes
New Indicator

Measure
Number of recreational boat access points, marinas, public beaches and public parks along the Great Lakes shoreline.

Purpose
To assess public recreational access to the Great Lakes shoreline.

Ecosystem Objective
To ensure recreational access to the Great Lakes shoreline by the public.

Endpoint
To maintain the recreational boat access points, marinas, public beaches and public parks along the Great Lakes shoreline in the numbers assessed in the baseline.

Features
Once the baseline is established, re-survey every five years.

Illustration
Bar chart for each access parameter by lake.

Limitation
Except for public parks and beaches, the information may be difficult to obtain. How many recreational access points are sufficient for the Great Lakes public is unknown.

Interpretation
The higher the number of access points, the greater the recreational opportunities for the public.

Comments
The next step might be to determine number of access points relative to population density.

Unfinished Business
This indicator needs a "champion" agency or agencies to establish the baseline and collect and interpret data.

Relevancies
Indicator Type: Human response
Environmental Compartment: Societal
Related Issue(s):
SOLEC Grouping: Social Values
GLWQA Annex(es):
IJC Desired Outcome(s):
GLFC Objectives:
Beneficial Use Impairment(s):

Last Revised
September 2004

Access to Information about the Great Lakes
New Indicator

Measure
Average number of Great Lakes Information Network (GLIN) visits, pages, files and hits to the GLIN Internet website per year.

Purpose
To interpret the degree of public access to electronic information about the Great Lakes ecosystem.

Ecosystem Objective
Information about the Great Lakes ecosystem will be readily available electronically through the Great Lakes Information Network.

Endpoints
Number distinct visits, average time each visit lasted, percentage of total visits that were repeat visits and hits to GLIN continue to increase yearly.

Features
Number of visits represents
Number of pages represents
Number of files represents
Number of hits represents

Illustration
Average yearly visits, pages, files and hits to the GLIN Internet website will be graphed and compared to GLNPO web server statistics.

Limitations
GLIN is only one media for retrieving information about the Great Lakes. The information is contained in web logs and can be extrapolated and interpreted but they cannot truly answer simple questions like "How many people visited site X last week?"

Interpretation
An increase in the average yearly visits, pages and files and hits to the GLIN Internet website will indicate access to information about the Great Lakes by an increasing number of Great Lakes public. This data will be selected randomly to state a trend in the variables.

Comments
The Great Lakes Information Network (GLIN) is a partnership that provides one place online for people to find information relating to the binational Great Lakes-St. Lawrence region of North America. GLIN offers a wealth of data information about the region's environment, economy, tourism, education and more. Based on a strong network of state, provincial, federal and regional partner agencies and organizations, GLIN provides a reliable source of information for those who live, work or have an interest in the Great Lakes region.

The GLIN model accommodates three different pathways to its information: geographic, subject and administrative. Analysis of GLIN usage statistics and feedback from users indicates that these pathways are the most likely routes to information that people follow. Examples of these pathways include:

- **Geographic**: Map-based or textual links to a locality, lake basin, pollution hotspot, tourist site, or other physical area in the region.
- **Subject**: Links based on a wide range of topics important to the sustainable development of the Great Lakes region, including agriculture, tourism, manufacturing, education, water levels, exotic species, pollution and more.
- **Administrative**: Organizational links, including an agency's home page, staff list, mission statement and newsletter.

Statistics also indicate that links buried several levels into a web site don't get as much attention. The most frequently hit pages are those linked directly from the home page. As a result, GLIN was carefully designed to provide more link options for people to pursue right off the top pages

Relevancies
Indicator Type: Human response Environmental Compartment: Societal
Related Issue(s)
SOLEC Grouping: Societal Values
GLWQA Annex (es):
IJC Desired Outcome(s):
GLFC Objectives:
Beneficial Use Impairments:

Last Revised
September 2004

Research/Educational Opportunities
New Indicator

Measure
Survey of Great Lakes colleges and universities that are integrating Great Lakes topics into their curricula or conducting Great Lakes-related research.

Purpose
To gauge interest by academic institutions in Great Lakes topics as topics for study and research.

Ecosystem Objective
Provide opportunities for students to learn about and research Great Lakes topics.

Endpoint
Students have an opportunity to study and research Great Lakes topics at academic institutions around the basin.

Features
Great Lakes academic institutions will be surveyed to determine a) what Great Lakes-related courses are offered, and b) research being conducted on Great Lakes topics.

Illustration
An analysis of responses will be characterized in a narrative.

Limitation
An independent group must initiate any survey on the US side due to the constraints of the Government Paperwork Reduction Act, which limits surveys by US government agencies to nine without Office of Management and Budget permission.

Interpretation
The responses will indicate interest in Great Lakes topics for both education and research.

Comments
No data currently exists.

Unfinished Business
Currently, there is no agency or organization in place to further develop this indicator.

Relevancies
Indicator Type: Human response
Environmental Compartment: Societal
Related Issue(s):
SOLEC Grouping: Social Values
GLWQA Annex(es):
IJC Desired Outcome(s):
GLFC Objectives:
Beneficial Use Impairment(s):

Last Revised - September 2004

Population and Income Distribution
New Indicator

Measure
Distribution of the population and income across the Great Lakes basin.

Purpose
To understand population densities relative to geography and income relative to geographic location.

Ecosystem Objective
Provide Great Lakes managers with information about Great Lakes population movements and income distribution across the basin.

Endpoint
To be determined.

Features
Use of US and Canada census data will provide a picture of distribution of both population and income.

Illustration
A map of the basin showing population and income.

Limitation
Although this information is important in understanding population movement and income distribution, it is not clear what the endpoint would be.

Interpretation
Tracking population density and income distribution over several years will indicate movement and contribute to our understanding of sprawl and natural resource use over time and the landscape.

Comments
Census data exists for both the US and Canada.

Unfinished Business
Currently, there is no agency or organization in place to further develop this indicator.

Relevancies
Indicator Type: Human response
Environmental Compartment: Societal
Related Issue(s):
SOLEC Grouping: Social Values
GLWQA Annex(es):
IJC Desired Outcome(s):
GLFC Objectives:
Beneficial Use Impairment(s):

Last Revised
September 2004

7.

Progress Indicator Reports

This section contains records of progress toward reporting on selected indicators. Some describe the available state of information while others report progress toward development of the indicator.

Number	Indicators	Status
7054	Ground Surface Hardening	Further research and revised report needed.
8129	Area, Quality and Protection of Great Lakes Islands	A group has been formed to pursue further work on this indicator for reporting at SOLEC 2006.
8129	Extent and Quality of Great Lakes Sand Dunes	Further research and revised report needed.
9002	Terrestrial Non-native Species	Further research and revised report needed.
8150	Breeding Bird Diversity and Abundance	Development Report including suggested future direction submitted by Save the Dunes Conservation Fund.

Ground Surface Hardening
Indicator 7054

Assessment
Not assessed - the available information are incomplete, or outdated.

Purpose
The purpose of this indicator is to indicate the degree to which development is affecting natural water drainage and percolation processes and thus causing erosion, and other effects through high water levels during storm events and reducing natural ground water regeneration processes. Ground surface hardening or imperviousness (the sum of area of roads, parking lots, sidewalks, roof tops and other impermeable surfaces of the urban landscape) is a useful indicator with which to measure the impacts of land development on aquatic systems (Center for Watershed Protection, 1994).

Ecosystem Objectives
A goal for the ecosystem is sustainable development. This would entail minimizing the quantities of impervious surface by using alternatives for replacement and future development.

State of the Ecosystem
Information on ground surface hardening in the Great Lakes basin is currently in the development stage. Different organizations are working towards developing effective systems of analyzing the status of this indicator. The use of technology such as Landsat imagery and Geographic Information Systems (GIS) applications are being utilized in efforts to evaluate the current state. The instruments on the Landsat satellites have acquired millions of images. These images form a unique resource for applications in agriculture, geology, forestry, regional planning, education, mapping, and global change research. This type of information will help illustrate the land use qualities of the Great Lakes basin.

In attempts to obtain information for this indicator many avenues were explored. Within Ontario, the Ontario Ministry of the Environment, conservation authorities and municipalities of different sizes were contacted for a random survey to see what information was available. Each organization had very little available information on impervious surfaces.

In the Great Lakes basin, data on ground surface hardening are rare. The Ministry of Natural Resources is in the process of implementing a project called Southern Ontario Land Resource Information System (SOLRIS). SOLRIS is a mapping program designed accurately measure the nature and extent of Southern Ontario’s natural resources and will be used to track changes to the natural, rural and urban landscape (Mussakowski, 2004). SOLRIS integrates existing base resource information and advanced GIS and remote sensing techniques to derive a comprehensive land cover database. SOLRIS is attempting to complete the assembly of all layers into comprehensive landcover/use mapping by 2006 and will continue to upgrade on 5 or 10 year intervals.

Recently, Christopher Elvidge of the National Oceanic and Atmospheric Administration's National Geophysical Data Center in Boulder, Colorado, along with colleagues from several universities and agencies produced the first national map and inventory of impervious surface areas (ISA) in the United States. The new map is important, because impervious surface areas affect the environment. The qualities of impervious materials that make them ideal for construction also create urban heat islands, by reducing heat transfer from Earth's surface to the atmosphere. The replacement of heavily vegetated areas by ISA reduces the sequestration of carbon from the atmosphere (Elvidge, 2004).

Pressures
Growth patterns in North America can be generalized, with few exceptions, as urban sprawl. As our cities continue to grow outwards there is a growing dependency on personal transportation.

This creates a demand for more roads, parking lots and driveways. Impervious surfaces collect and accumulate pollutants deposited from the atmosphere, leaked from vehicles or derived from other sources. Imperviousness represents the imprint of land development on the landscape (Center for Watershed Protection, 1994).

A long-term, adverse impact to water quality could occur as a result of the continued and likely increase of nonpoint-source pollution discharge to stormwater runoff from roads, parking lots, and other impervious surfaces introduced into the area to accommodate visitor use. If parking lots, roads, and other impervious surfaces were established where none currently exist, then vehicle-related pollutants and refuse may accumulate. This impact could be mitigated to a negligible level through the use of permeable surfaces and vegetated or natural filters or traps for filtering stormwater runoff (National Park Service, 2001).

Management Implications

Ground surface hardening is an important indicator in the Great Lakes basin that needs to be explored further. The information available for this indicator is incomplete, or outdated. With current technological advancements there are emerging methods of monitoring impervious surfaces, and hopefully within 5 years the data required for this report will be complete. Ground surface hardening has many detrimental effects on the environment; thus, it is essential to monitor and seek alternatives.

Acknowledgements

Lindsay Silk, Environment Canada, Downsview, Ontario

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Developing, Evaluating, and Selecting SOLEC Indicators for Area, Quality, and Protection of Great Lakes Islands

June 2004 Status Report

Submitted by Linda Wires, Karen E. Vigmostad and Megan Seymour on behalf of the Collaborative for the Conservation of Great Lakes Islands

Background

The 30,000 islands of the Great Lakes form the world's largest collection of freshwater islands and contribute significantly to the ecology of North America. The unique biodiversity of these islands includes endemic species such as the Lake Erie Watersnake, rare communities such as alvar, and some of the largest concentrations of colonial waterbirds in the world. As such, the biological diversity of the islands is globally significant (Crispin in Vigmostad 1999).

To work towards conservation of the biodiversity of species and communities on Great Lakes islands, a binational Collaborative for the Conservation of Great Lakes Islands formed in 1996. Recently, a small Science Advisory Team of the Collaborative received a habitat grant from the Environmental Protection Agency's Great Lakes National Program Office to develop a framework for the binational conservation of Great Lakes islands. With this funding, the Team is developing:

- An island assessment and ranking system (based on a subset of biodiversity parameters) that will provide a foundation to prioritize island conservation
- A freshwater island classification system
- A suite of indicators that can be monitored to assess change, threats, and progress towards conservation of Great Lakes islands biodiversity

These products are essential if we are to conserve the diversity of Great Lakes islands in perpetuity. Below we present a summary of progress we have made on developing the last item: a suite of indicators to inform and guide island conservation over time.

Developing Island Indicators

Work on indicator development formally began with a March 29-30, 2004 workshop in Chicago. Participants included the Collaborative's Science Advisory Team and two indicator experts, Drs. Lucinda Johnson and Paul Bertram. Dr. Johnson is a scientist with the Natural Resource Research Institute in Duluth, MN, and has a leading role in developing indicators for the Great Lakes near shore region. Dr. Bertram is a scientist with the U.S. Environmental Protection Agency, Great Lakes National Program Office, and has a leading role in developing indicators for use in the Great Lakes Ecosystem Basin. Dr. Johnson provided an overview of environmental condition, pressure, and response indicators and Dr. Bertram provided an update on the selection of indicators by the State of the Lakes Ecosystem Conference (SOLEC). During the workshop we began discussions of the special attributes and features of the Great Lakes islands—i.e., conservation targets—that need to be captured by a suite of indicators.

After the workshop, we reviewed relevant literature addressing the development, selection and evaluation of environmental indicators. Because there is a large body of scientific literature on indicator development and selection, during the initial consultation and workshop, we asked Drs. Johnson and Bertram to identify key indicator references and thus narrowed the body of literature for review specifically to the Collaborative's goal. Specifically, the process of developing island indicators was closely related to the island ranking and classification systems already under development. These systems provide a basinwide assessment of Great Lakes islands and biodiversity, and identify conservation targets. Thus indicators considered for island biodiversity conservation must apply directly to these targets.

With this in mind, several frameworks for indicator development and selection were considered and discussed via conference calls and an in-person meeting in May 2004. The Team with a few other members of the Collaborative primarily used the framework developed by the Scientific Advisory Board of the Environmental Protection Agency (EPA 2002). This framework identifies six Essential Ecological Attributes (EEAs) that summarize and logically organize the major ecological components of a system: Landscape Condition, Biotic Condition, Chemical and Physical Characteristics, Ecological Processes, Hydrology and Geomorphology, and Natural Disturbance Regimes. In this approach the focus is on ***condition measures*** because these relate directly to the ecological values we are interested in conserving, and they are considered a critical link in the information base upon which environmental reporting rests. This framework also incorporates parallel development of ***pressure indicators***, using the EEAs as a checklist to identify assessment endpoints that should be evaluated to detect adverse effects or threats to ecological condition (EPA 2002).

To date, the Team has tentatively proposed ten condition and five pressure indicators as summarized in Table 1 below. It is important to note that the indicators on this list are still being evaluated and are not final. Final selection of indicators will take place after peer review and discussions at SOLEC 2004, and will be based on relevance, feasibility, response variability, and interpretation and utility.

Table 1. Essential ecological attributes and suggested indicators for monitoring.

Essential Ecological Attribute	Condition Variable to Monitor (Indicator or Indicator Suite)	Pressure Variable to Monitor (Indicator or Indicator Suite)
Landscape Condition		
Extent of each ecological system	Total island area and island perimeter at ordinary high water mark (USACOE)	
	Percent of shoreline in natural cover within 500 m of water's edge (USACOE)	Extent of hardened lake shoreline
Landscape composition	Percent of landscape within 20 km in natural cover	Number of mainland marinas; distance from marinas; presence of safe harbor on island; roads; nearness to shoreline community
Biotic Condition		
Ecosystems and communities		
Community extent	Extent of native ecological communitites (target)	
Community composition	Native fish diversity, colonial waterbird diversity, neo tropical migrant diversity, vegetation diversity; monitor top 10 sites for each target	Percent non-native species
Trophic structure	Colonial waterbirds, bald eagle, diporeia	
Species and Populations		
Population size	Colonial waterbirds, piping plovers, L. Erie watersnake Endemics or near endemics	Abundance of non-native species
Habitat suitability (focal species)	Habitat for colonial waterbirds, piping plover, watersnakes, migrants, nearshore spawning fish	
Hydrology and Geomorphology		
Surface and ground waterflows	Water levels	Regulated water levels / water stability
Sediment and material	Transport	

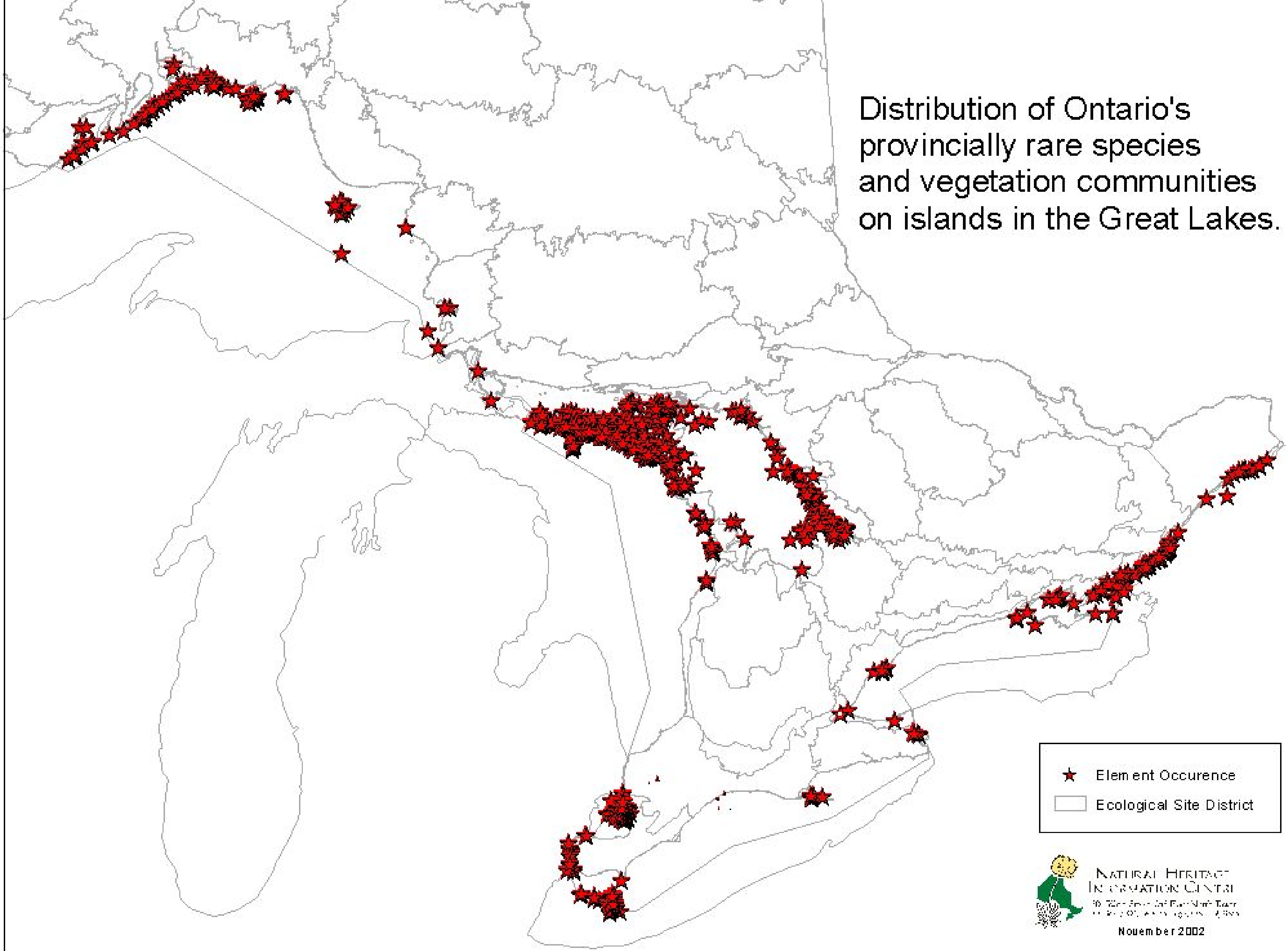
We also examined SOLEC indicators in this framework and incorporated those that were applicable. Indicators for only three EEAs have been developed; we may also incorporate indicators for the Chemical and Physical Characteristics and Ecological Processes attributes. Additional pressure indicators may include: transportation to and from islands; concentration of contaminants in sediment cores; contaminants in snapping turtle eggs; duration of ice on lakes; and extent habitat modified by non-native species.

Importantly, we will also include ***response indicators*** as measures of how well island protection programs are achieving conservation goals. Thus far two response indicators have been proposed and are being evaluated. These include: percent of island area and shoreline in protective status; and percent area of native communities (targets) in protection at priority sites. We anticipate developing additional response indicators and may be able to incorporate SOLEC response indicators.

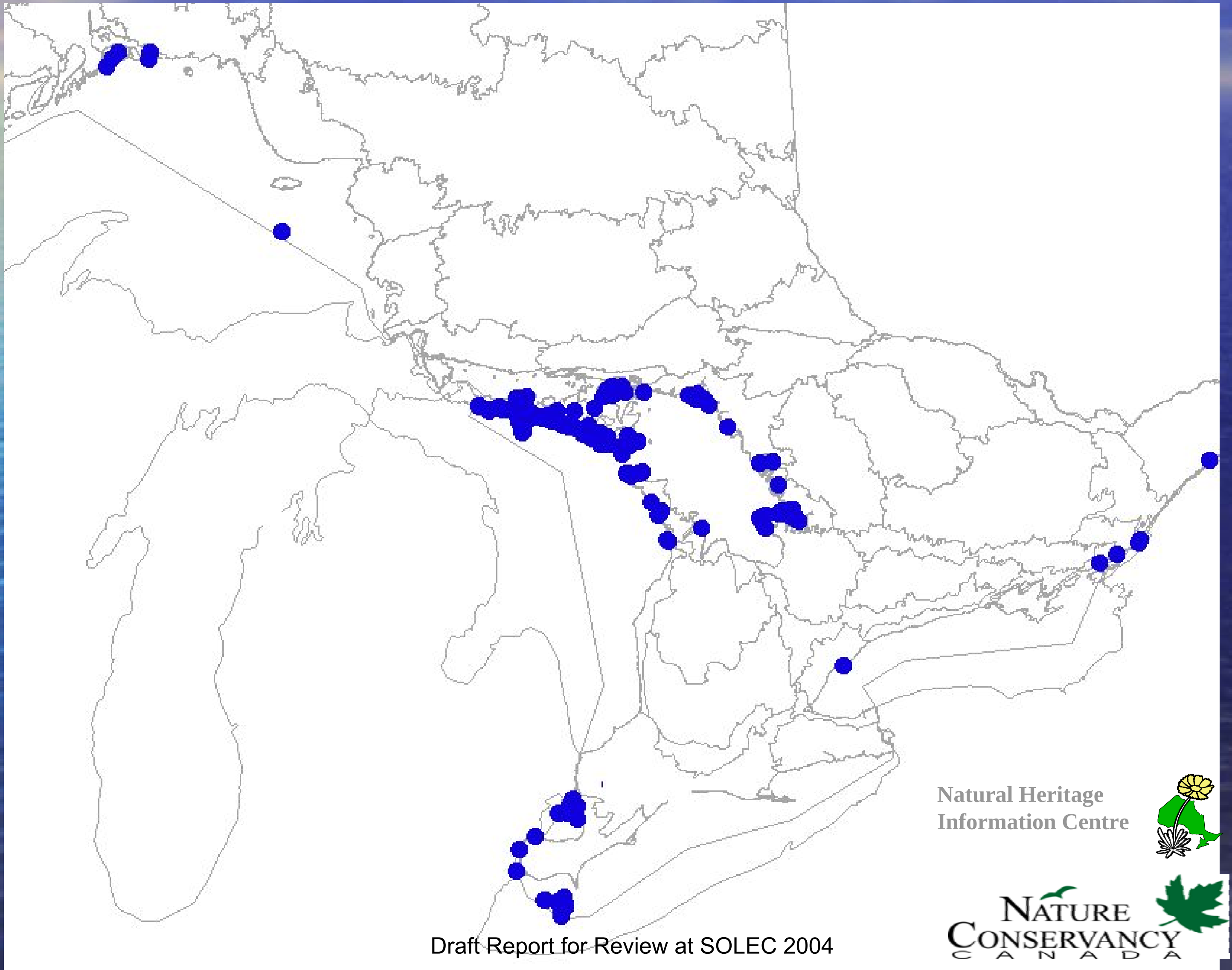
Next Steps

We are scheduling a conference call with members of the Collaborative's Science Advisory Team in the latter half of June 2004 to continue discussion and evaluation of these and other potential indicators. We also have planned an in-person meeting in mid-July 2004 to continue this work. We will present the island indicators at SOLEC 2004 for discussion. At that point, we will finalize a suite of island indicators for final submission to SOLEC and other relevant venues.

For further information	
Megan Seymour U.S. Fish and Wildlife Service Ecological Services Field Office 6950 Americana Pkwy., Suite H Reynoldsburg, OH 43068 (614) 469-6923 ext. 16 (614) 469-6919 fax	Karen E. Vigmostad, Ph.D. Northeast-Midwest Institute 218 D Street, SE Washington, DC 20003 (202) 464-4016 (202) 544-0043 fax www.nemw.org/islands.htm


Distribution of Ontario's provincially rare species and vegetation communities on islands in the Great Lakes.
Element Occurence
Ecological Site District
Natural Heritage Information Centre
November 2002

Distribution of globally rare species on islands in the Great Lakes



Extent and Quality of Great Lakes Sand Dunes (8129)

Assessment: Mixed Deteriorating

Purpose

To assess the extent and quality of Great Lakes sand dunes.

Ecosystem Objective

Maintain total a real extent and quality of Great Lakes sand dunes, ensuring adequate representation of sand dune types across their historical range.

State of the Ecosystem

Sand dunes continue to be lost and degraded, yet the ability to track and determine the extent and rate of this loss in terms of both area and quality in a standardized way is not yet feasible.

Great Lakes sand dunes comprise the world's largest collection of freshwater dunes. They are home to endemic, rare, endangered, and threatened species. Sand dunes can be found along the coasts of all the Great Lakes. Lake Michigan, however, has the greatest number of sand dunes with a total of 111,291 hectares, followed by Ontario with 8,910 hectares, Indiana with 6,070 hectares, New York with 4,850 hectares, and Wisconsin with 425 hectares. This information is not complete. No comprehensive map of Great Lakes sand dunes exists.

Degree of protection varies considerably among jurisdictions so it is difficult to assess the overall loss or status of sand dunes because although information about the quality of individual sand dunes is locally available, this information has not been collected across the entire basin. Nevertheless, conversations with local managers and environmentalists indicates a continued loss of sand dunes to development, sand mining, recreational trampling, and non-indigenous invasive species. The Lake Ontario Dunes Coalition, Michigan Dunes Alliance, and the Save the Dunes Council in Indiana are making some progress in both protecting and restoring sand dunes in their respective regions.

Pressures on the Ecosystem

Threats to sand dunes are numerous. Non-indigenous invasive species such as baby's breath (*Gypsophila paniculata*) and spotted knapweed (*Centaurea maculosa*) tend to spread rapidly if not controlled. Habitat destruction, however, is the greatest threat. In addition to sand mining, shoreline condominium and second home development level dunes. And recreational use by pedestrians and off road vehicle use destroys vegetation, thereby causing dune erosion.

Further Work Necessary

A group of sand dune managers and scientists is organizing to convene a conference for all persons involved in Great Lakes sand dune ecosystem ecology, management, research and education efforts. The purposes of the conference will be to compile information about sand dunes and sand dune research and management and to form the Great Lakes Sand Dunes Coalition. This group could work actively to collect available data about Great Lakes sand dunes and begin collaborative actions to protect them.

Management Implications

Many actions have been taken to protect Great Lakes sand dunes. For example, in Eastern Lake Ontario boardwalks and dune walkovers have been constructed to provide public access to beaches without compromising dune ecology. Native beach grasses have been planted to retard erosion. On the eastern shores of Lake Michigan, invasive plants have been systematically removed by dune stewards. Michigan has legislation in place to control or reduce sand mining impacts.

In order to protect sand dunes there is a need for improved communication between government agencies and stakeholders with regard to sand dune management. Public education would help alleviate stress to dunes cause by recreational trampling. Stronger legislation could limit some damaging activities. Local government creativity in managing dune areas through creative zoning would improve the protection of sensitive and irreplaceable areas.

Acknowledgments

Author: Lindsay Silk, Environment Canada, Downsview, Ontario

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Terrestrial Non-Native Species

Assessment: Unknown
Data from multiple sources not consistent

Purpose
This indicator reports the extent of cover by terrestrial non-native species (including plants, animals and other organisms, such as insects and microbes) in the Great Lakes watershed, and assesses the biological integrity of the basin ecosystem.

Ecosystem Objective
Only a small percentage of non-native species introduced into the ecosystem, primarily through human activity, pose a hazard to the economy, environment or human health. However, the lack of naturally-occurring predators allows some non-native species to become invasive by colonizing and proliferating unchecked. This destroys wildlife habitats, crowds out competitors and depletes prey, thereby threatening biodiversity.

Once established, terrestrial non-native species can also impact water quality, by changing water tables, runoff dynamics, fire frequency, and other watershed attributes that in turn can alter watershed conditions. Attempts to eradicate terrestrial non-native species could lead to greater use of pesticides and herbicides, in turn potentially increasing the amount of chemicals entering surface water through runoff.

State of the Ecosystem
The negative impact of a wide range of non-native species, such as reed canary grass, garlic mustard, common buckthorn and purple loosestrife, has been documented throughout the Great Lakes basin. However, the extent of invasion by terrestrial non-native species is not known. It is not clear what metric should be used to report on this indicator.

Federal and state agencies, tribal governments, nongovernmental organizations, and universities are actively collecting data on terrestrial non-native species. At this point, most projects focus on a single species on a local basis. Projects range from mapping where non-native species have been detected in a given jurisdiction, to measuring the actual population or extent of area covered by that species. This large body of research presents an opportunity to increase our understanding of the problem posed by terrestrial non-native species. Coordination of these data collection efforts may produce the comprehensive data necessary for assessment, not to mention monitoring, control and eradication.

Future Pressures
Growth in international trade and travel increases the risk that a larger number of terrestrial non-native species will become established in the Great Lakes region. The spread of microbes such as the West Nile virus and the SARS virus demonstrates the speed and ease in which non-native species can migrate on a global basis. Response efforts vary by species. It is believed that terrestrial non-native species that do not pose an immediate threat to agriculture, industry or human health may not prompt sufficient response to mitigate their impacts to the ecosystem.

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Developing a Breeding Bird Indicator for the Great Lakes Region

U.S. Environmental Protection Agency
Great Lakes National Program Office
Assistance Agreement GL-97523301-1

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24 September 2004

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Table of Contents

Developing a Breeding Bird Indicator for the Great Lakes Region

Introduction

The State of the Lakes Ecosystem Conferences (SOLEC) are hosted every two years by the U.S. Environmental Protection Agency and Environment Canada to fulfill the reporting requirement of the binational Great Lakes Water Quality Agreement (GLWQA). The purpose of the Agreement is "to restore and maintain the physical, chemical, and biological integrity of the Great Lakes Basin." The first SOLEC was held in 1994. For SOLEC 1998, a suite of indicators was developed to represent the condition of the Great Lakes ecosystem components. The indicator suite fulfills Annex 11 of the GLWQA (Surveillance and Monitoring) and is also used to address the monitoring and evaluation needs of the Lakewide Management Plans (LaMPs) and Remedial Action Plans (RAPs) for Areas of Concern identified in Annex 2 (http://www.epa.gov/glnpo/glwqa/1978/index.html).

The SOLEC Breeding Bird Diversity and Abundance Indicator (ID #8150) was developed to assess the status of breeding bird populations and communities and to infer the health of breeding bird habitat in the Great Lakes basin. This indicator is listed as unbounded because it could apply to more than one of the seven SOLEC ecological categories (open waters, nearshore waters, coastal wetlands, nearshore terrestrial, land use, human health, and societal). The SOLEC indicators are also classified according to the following types: State (of the Environment), Pressure (activities that affect environmental quality), and Human Activities (Response). The Breeding Bird Diversity and Abundance Indicator is a State indicator for assessing the state of the environment, the quality and quantity of natural resources, and the state of human and ecological health. These indicators reflect the ultimate objective of environmental policy implementation, and are chosen by considering biological, chemical, and physical variables and ecological functions (Paul Bertram and Nancy Stadler-Salt 2000).

In its current preliminary state, the SOLEC Breeding Bird Diversity and Abundance Indicator does not address productivity or survivorship parameters. To address the second purpose of the indicator, to infer the health of breeding bird habitat in the Great Lakes Basin, demographic parameters must be measured. The diversity and abundance of birds in any given area do not provide sufficient data for evaluating the health of that habitat for supporting birds. Environmental factors may negatively affect reproduction or survival, but local population size and/or diversity can be maintained by immigration from other populations, with the result that local environmental problems may not be reflected in population trends until problems become severe (Conway and Martin 1999). A habitat may host a great diversity and abundance of birds, and yet serve as a population sink for one or several species. In addition, depending on the types of species present and the natural diversity of the target habitat, increased diversity is not always desirable (Howell et al. 2000). While point count surveys such as the Breeding Bird Survey are less expensive and easier to conduct, a breeding bird indicator must include demographic data to be effective and avoid misleading information. Estimating primary demographic parameters is essential to assessing the viability of populations, which indicates the health of the habitat.

The purpose of this project is to investigate established protocols for monitoring avian productivity and/or survivorship in habitats of interest; identify projects around the Great Lakes Basin that use these protocols; assess the applicability and feasibility of these protocols/projects for contributing to the breeding bird indicator; and develop a framework for integrating the most appropriate protocols into the breeding bird indicator.

Breeding bird indicator development

Birds are good indicators of ecosystem health for several reasons, including their high metabolic rate, abundance and distribution within and across habitats, and relatively high position in the food chain. Songbirds are sensitive to changes in food supply, vegetative cover, and predator densities (Gardali et al. 2001). Estimates of their productivity and survivorship can provide early warning signals of environmental problems, and can demonstrate environmental improvement to address delisting beneficial use impairments (BUIs) for Areas of Concern (AOCs) as well as fulfilling Lakewide Management Plan (LaMP) goals. In addition, demographic data can help determine whether population trends are related to breeding productivity or winter survival factors, and help identify habitat conditions associated with successful and failed breeding attempts (Martin et al. 1995, Phil Nott, pers. comm., Robinson and Morsel 1999). The breeding bird indicator as presented here can thus serve as both a State and Pressure indicator by providing information on what is happening in the environment and why.

As noted earlier, the goals of the breeding bird indicator are 1) to assess the status of breeding bird populations and communities and 2) to infer the health of breeding bird habitat in the Great Lakes basin. These goals may be applied at the local, landscape, or regional scale. In addition, as a SOLEC land use indicator, the breeding bird indicator should influence decision-makers in the Great Lakes basin to make environmentally informed development decisions (SOLEC 1998 Selection of Indicators for Great Lakes Basin Ecosystem Health, Version 3). These varied goals cannot be effectively addressed with a single monitoring approach.

At the regional level, MAPS and BBIRD data from existing and new sites in the Great Lakes Basin could be used in conjunction with Breeding Bird Survey data to reveal the health of bird populations using the Great Lakes Region. The British Trust for Ornithology's Integrated Monitoring program (http://www.bto.org/survey/ipm.htm) could serve as a model for integrating data on the numbers, breeding performance, and survival rates of birds. This program brings together data on several long-running monitoring schemes such as the Common Birds Census and Constant Effort Sites Scheme (constant effort mist-netting) to monitor population trends, identify which stage of the life cycle is affected, and provide data to assist with identifying causes of change.

Here we focus on applying the breeding bird indicator goals at the local level, i.e., assessing local bird populations and inferring the health of local habitats. In this capacity, the breeding bird indicator can serve the needs of some AOC RAPs and LaMPs by measuring progress toward delisting habitat-related beneficial use impairments and achieving goals such as ecosystem integrity. The three habitat-related beneficial use impairments are 1) degradation of fish and wildlife populations, 2) bird or animal deformities or reproductive problems, and 3) loss of fish and wildlife habitat. The breeding bird indicator is relevant to AOCs in which one or more of these impairments exists and includes a degraded, breeding songbird population(s). The status of the breeding bird population(s) may be known directly or indirectly by the degraded condition of the impaired habitat.

To estimate the vital rates (productivity and survivorship) of a bird population requires more resource-intensive protocols than are used for monitoring population size and diversity (census and survey techniques). The latter monitoring protocols provide measurements of abundance, density, and/or diversity that can reveal population composition and trends, but do not necessarily reflect the health of the local bird population or their habitat. Population size and diversity measurements are affected by varying emigration and immigration rates, and do not differentiate dysfunctional from functional demographic units (Conway and Martin 1999, Dias 1996, Smallwood 2001). Because of confounding effects of population sources and sinks, information on presence/absence or even relative abundance or population size can provide misleading indicators of habitat quality (Van Horne 1983, Pulliam 1988). There is also concern that some management strategies may attract high numbers of adults but create an "ecological trap" in which adult density is high but reproductive success is low (Reme 2003, Purcell and Verner 1998).

Several methods are available to measure survivorship and annual productivity. Monitoring breeding pairs by color banding (in addition to using the Fish and Wildlife Service aluminum band) and resight data is the most resource intensive method and can provide the most detailed information about a local population's productivity and survivorship. Banding (without the use of color bands and resight data) and nest monitoring are somewhat less resource intensive and provide the best methods available for estimating and assessing bird populations' demographic parameters. Existing protocols developed by the Institute for Bird Populations (Monitoring Avian Productivity and Survivorship or MAPS) and the Montana Cooperative Wildlife Research Unit of the US Geological Survey's Biological Resources Division (Breeding Biology and Research Monitoring Database or BBIRD) programs can provide data necessary for fulfilling the needs of the breeding bird indicator. The MAPS and BBIRD monitoring programs can also fulfill several of the criteria for delisting the three habitat-related beneficial use impairments as identified in the *Pathway for Delisting* (US EPA GLNPO 2004). These include determining that target habitat quantities are sufficient to support desired wildlife (bird) populations and that desired bird communities are showing signs of sustainable recovery. The cost and labor requirements should be feasible for most areas. Coordinating and combining the resources of federal, state, and local agencies, nonprofit organizations, and academic institutions is expected for implementing AOC RAPs, and should alleviate the burden on any one entity and improve the success of planning, monitoring, and implementation. The availability of the nationally standardized bird banding (MAPS) and nest monitoring (BBIRD) programs facilitate their use, repeatability, and interpretation of results. These protocols combined are recommended for monitoring abundance and breeding bird demography at Olympic National Park (Jenkins et al. 2003) and are also used by other long-term monitoring efforts such as those conducted by Point Reyes Bird Observatory. They are recommended for priority areas and species by the *Canadian Landbird Monitoring Strategy* (http://www.cws-scf.ec.gc.ca/birds/strat_e.cfm).

For the Great Lakes breeding bird indicator, we recommend the MAPS and/or BBIRD protocols for collection of demographic data, depending on the impairments and environmental goals of the AOC. These protocols are designed to measure the population demographics of small-medium sized songbirds. Reference information on protocols for marsh birds and waterbirds is included in Appendix 2. Descriptions of the MAPS and BBIRD programs are provided below and followed by a template for their application in AOCs. Cost estimates are provided, but will vary locally. We emphasize the importance of addressing costs for the full duration of the monitoring requirement as well as the training, data processing, evaluation, and reporting components for successfully contributing to delisting requirements. The BBIRD program is more labor intensive than MAPS, and is recommended for use in areas where contamination problems are known or suspected to affect songbird populations and/or where songbird productivity problems have been documented. (The latter can be determined by implementing the MAPS program.)

In addition to recommending the MAPS and BBIRD programs, we recommend pursuing the potential of contracting with Institute for Bird Populations (IBP) to conduct a pilot study. We also suggest consideration be given to contracting with a single entity to coordinate the initial stages of identifying target bird communities/habitats, restoration goals, and monitoring methodologies for the appropriate Areas of Concern.

If the breeding bird indicator is limited to measurements of diversity and abundance, we suggest that its purpose be limited to assessing the status of breeding bird populations and communities in the Great Lakes basin. Again, these data may or may not reflect the health of the habitat, and are insufficient to make any such determination.

Monitoring Avian Productivity and Survivorship (MAPS)

The Monitoring Avian Productivity and Survivorship (MAPS) program is a cooperative effort among public agencies, private organizations, and individual bird banders in North America to operate a network of over 500 constant-effort mist netting and banding stations during the breeding season. MAPS was established in 1989 by The Institute for Bird Populations (IBP) and was modeled after the British Constant Effort Sites (CES) scheme operated by the British Trust for Ornithology. A network of station operators uses a standardized constant-effort mist-netting protocol. Each station typically consists of about ten permanent net sites located within the interior eight hectares (ha) of a 20-ha study area (DeSante et al. 2001). Usually one 12-m, 36-mm mesh mist net is operated at each net site for six morning hours per day, for one day during each of six to ten consecutive 10-day periods. Starting dates vary between May 1 and June 10 (later at more northerly latitudes and higher elevations) and operation continues through the ten-day period ending August 8. All birds captured during the program are identified to species, age, and sex using criteria in Pyle (1997) and, if unmarked, are banded with a uniquely numbered aluminum band provided by the U.S. Geological Survey's Biological Resources Division (USGS/BRD) Bird Banding Laboratory or the Canadian Wildlife Service/Bird Banding Office.

MAPS protocols also require station operators to record the probable breeding status of all avian species seen, heard, or captured at each station using methods similar to those employed in breeding bird atlas projects, and to assign a composite breeding status for every species at the end of the season based on those records (DeSante et al. 2001). In addition, a station map and standardized quantitative habitat descriptions are prepared for each major habitat type contained in the station by means of the MAPS Habitat Structure Assessment protocol (Nott 2000). Finally, MAPS operators are able to enter or import, verify, edit, and submit all their data to IBP by means of MAPSPROG, a Windows-based computer program distributed free of charge for that purpose by IBP. MAPSPROG has four modules that deal, respectively, with banding, effort, breeding status, and habitat assessment data. The program includes within- and between-record verification algorithms that substantially improve the quality of the banding data, particularly age and sex determinations. Importantly, it allows the persons who actually collect the data to also verify and edit them. Moreover, this process can be carried out during the field season, allowing station operators to learn from their errors in a timely manner.

MAPS has grown from 16 to over 500 stations and has received the support and endorsement of many federal agencies and conservation groups, including USGS/BRD, the Department of Defense Legacy Resource Management Program, the National Audubon Society, and the international cooperative Neotropical Migratory Bird Conservation Initiative, Partners in Flight (PIF). The substantial growth of the Program is attributed in part to its endorsement by PIF and the involvement of various federal agencies in PIF, including the USDA Forest Service; the USDI National Park Service, Fish and Wildlife Service, and Bureau of Land Management; and the USDoD Department of the Navy, Department of the Army, and Texas Army National Guard. The National Park Service recommends MAPS protocols for monitoring landbirds in National Parks to aid in determining the causes of population trends and differences in abundance among species, habitats, and areas or to identify and evaluate management actions to reverse declining trends and increase low population sizes (Fancy and Sauer 2000). As noted earlier, the *Canadian Landbird Monitoring Strategy* recommends MAPS and BBIRD for priority areas and species. During 2000, IBP personnel operated 151 'agency' stations under federal contracts. Support for the operation of the remaining 356 'independent' stations (those not operated by IBP personnel) has come from a wide variety of federal, state, and private sources (http://www.birdpop.org/Eurinews/overview.htm).

A panel assembled by USGS/BRD reviewed and evaluated the MAPS pilot project. The review concluded that: (1) MAPS is technically sound and is based on the best available biological and statistical methods; (2) it complements other landbird monitoring programs such as the North American Breeding Bird Survey (BBS) by providing useful information on landbird demographics that is not available elsewhere; and (3) it is the most important project in the nongame bird monitoring arena since the creation of the BBS (Geissler 1996).

The online National Biological Information Infrastructure (NBII)/MAPS Avian Demographics Query Interface provides access to the annual reports of the MAPS program and MAPS information on adult populations and productivity, survivorship, station information, habitat information, and breeding status of each species captured, seen, or heard at each station (Institute for Bird Populations 2003). The data is currently limited to information on stations that operated between 1989 and 2000 and on annual productivity and survivorship data acquired between 1992 and 1998. The IBP partnered with USGS/BRD to create this web-based electronic information network, and plans regular updates. Data from 2001 and 2002 should be online by the beginning of 2005.

MAPS: Great Lakes sites

According to the IBP MAPS Roster for 2004, there are four MAPS sites operating in Ontario's Great Lakes Basin, one each on Lake Huron, Georgian Bay, Lake Ontario, and Lake Superior. Within the states, there are MAPS sites across most of the Great Lakes Basin: two in Illinois, two in Indiana, four in Michigan, two in Minnesota, one in New York, three in Ohio, and two in Wisconsin. Information on MAPS stations operating between 1989 and 2000 is available at http://www.birdpop.org/nbii/station/default.asp.

We surveyed those MAPS stations within the Great Lakes states by email to learn more about their efforts and how they may contribute to the breeding bird indicator. Of the six respondents, five stations are located in the Great Lakes Basin and three are in or near an AOC. Three are interested in contributing to the breeding bird indicator and one needed more information. Existing Great Lakes stations may offer valuable data for use in identifying reference conditions or other habitat comparisons, as well as contributing to the selection of target bird species and/or habitats. Such stations may also be helpful in identifying contacts for student, professional, and volunteer assistance and support. See Appendix 1 for a complete summary of the survey results.

MAPS: Applicability/limitations for contributing to the breeding bird indicator

In order for the MAPS protocol to yield data sufficient for meaningful analyses of both productivity and survivorship rates and trends in a single AOC, a cluster of six stations each using ten net lanes over approximately 20 ha is recommended (Phil Nott, pers. comm.). Ideally, the stations are situated 5-10 kilometers apart from each other. To meet these criteria, a fairly large tract or several tracts of very similar habitat are required (>= 5,510 ha or 13,615 acres total). In addition, reference sites would require the same area for equal evaluation. Not all target habitats of the AOCs will meet these size requirements. Use of private property(s) would obviously require consulting with the owner(s) for approval and access arrangements. If it is uncertain whether the size and/or contiguity of the habitat(s) targeted and available for monitoring is sufficient for effective implementation of the MAPS protocol, we recommend consulting with IBP (P.O. Box 1346, Point Reyes Station, CA 94956-1346; (415) 663-1436; http://www.birdpop.org/index.html).

Based on the dominant and sub-dominant habitat types recorded for the 516 current and/or former MAPS stations continent-wide, this protocol can be used in most Great Lakes habitats. The dominant and sub-dominant types represented at the 833 stations break down as follows (Nicole Michel, pers. comm.):

35.5% forest (crowns overlapping, forming 60-100% cover),
24.9% woodland (crowns not touching, forming 25-60% cover),
18.3% shrubland (shrubs >0.5 m tall, shrubs form >25% cover, trees <25% cover), and
20.8% herbaceous (herbs – graminoids, forbs, and ferns – form >=25% cover; trees, shrubs, and dwarf-shrubs with <25% cover and/or herbs exceed tree, shrub, and dwarf-shrub cover, respectively).

All habitat types are taken from the top two levels (Class and Sub-Class) of the National Vegetation Classification Standard (NVCS) Formation Codes list included in the MAPS Habitat Structure Assessment (HSA) Protocol (Nott et al. 2003).

Although MAPS may be implemented in all of these habitat types in general, mist netting is not the ideal method for surveying some species (those that prefer upper canopy habitats) and habitats. It is not recommended for closed canopy with little understory or grassland habitats. In addition, the MAPS protocol is not for monitoring larger species such as crows and raptors, and poorly samples several species that forage on the wing, such as swallows and nighthawks (Wang and Finch 2002). Mist netting is a superior method for bird species that frequently visit or nest in undergrowth and shrubby habitats, particularly secretive species and those that vocalize infrequently, which point count surveys typically underestimate.

Depending on the size of the target habitat and the surrounding land uses, high predation and/or parasitism rates associated with edge habitats may confound interpretation of productivity levels, particularly as related to habitat quality. Indicators intended to measure the quality of a habitat must consider the quantity of the habitat as it relates to the space needed to support a viable population (Smallwood 2001). This should include accounting for the edge affects that often lead to increased predation and brood parasitism. Predation is known to be the primary cause of nest mortality for many songbird populations, and landscape character affects predator populations (Howell et al. 2000, Rodewald and Yahner 2001, Knutson et al.

2004). Habitat patches may thus function as population sinks due to the affects of fragmentation and the surrounding land uses, and not necessarily the quality of the target habitat.

MAPS data have revealed that the productivity of birds is influenced by the surrounding landscape within a 2-4 km radius (DeSante and Nott 2000, Phil Nott, pers. comm.). It follows that if stations are situated such that there is less than a 2-km wide habitat buffer, productivity levels may be low due to high rates of predation and/or parasitism. Agricultural activities within a 3 km radius may increase nest parasitism (Stribley and Haufler 1997). In such situations, BBIRD nest monitoring protocols may be preferable to MAPS since MAPS data cannot distinguish the causes of low productivity. BBIRD data can reveal high levels of predation, and restoration ecologists could then manage for habitats with more interior and buffered edges to reduce nests' vulnerability to predation (Guepel and Elliot 2001). (This scenario presumes sufficient habitat availability for the prescribed restoration.) Likewise, if brood parasitism is identified as a primary cause of low productivity, a control plan for brown-headed cowbirds may be designed and implemented to reduce the problem. The rates of cowbird parasitism and impacts on local songbird productivity range from minimal to extreme (Ellison 1997, Greene 1997) depending on habitat and host species factors, and do not necessarily correlate with the number of cowbirds in an area (Muehter). Removal programs can be effective (De Groot et al. 1997. Eckrich et al. 1997), but are generally only recommended as short-term means to reduce parasitism of threatened or endangered host species at the local level (Muehter).

Other factors that must be considered when interpreting MAPS data include variation in juvenile dispersal, capture probabilities, and vegetation structure (Heath et al. 2002).

The absence or unavailability of a bird bander (USGS master permit holder or subpermit holder) could limit the use of the MAPS program, although contracting with IBP is an option that might resolve this issue (see below). Potential MAPS station operators (interns or otherwise) must possess or obtain the necessary permits from the appropriate state and federal authorities. To qualify at the federal level, persons at least 18 years of age must be able to safely trap, handle, and band the birds and identify all of the common birds in their different seasonal plumages. Applications are submitted to the Federal Bird Banding Laboratory in the USA or the Canadian Wildlife Service in Canada. The applicants must furnish the names of three well-known bird banders or ornithologists who can vouch for their expertise as a bird bander (http://www.pwrc.usgs.gov/BBL/homepage/whocan.htm). State permit requirements vary.

IBP offers training courses that cover MAPS protocols, including techniques for ageing and sexing the birds. In addition, the North American Banding Council has developed a bander certification program and provides resource materials and trainer contact information (http://www.nabanding.net/nabanding/). *Ample training is essential to ensure the integrity of the data collected and the safety of the birds captured.*

For IBP, the approximate annual cost of running the minimum recommended number of six MAPS stations at a single location in northern California, including two weeks intensive intern training, data analysis, and a final report, ranges from $24,000 - $28,000. The cost varies depending on intern housing (David DeSante, pers. comm.). The estimate includes a per diem ($18-$24) expense for a pair of interns to run the stations, which may not be sufficient in some areas. The stations are configured as efficiently as possible, such that three locations (six stations per location) are in reasonable proximity and one overseeing biologist can rotate among them. The qualifications of the overseeing biologist(s) are not included in the training expenses. The overseeing biologist in this instance is typically an IBP staff person; the position is usually seasonal, but many seasonal staff return. All interns are trained and help with station set up and operation. The interns (two per six MAPS stations) rotate between stations (banding once per 10-day period), and the overseeing biologists spend one week at a time supervising the stations.

Given the variables, we used the higher end of the IBP estimate ($28,000) and added $2,000 for interns/housing expenses to estimate an average cost of $30,000/MAPS location (six stations).

We suggest that consideration be given to contracting with IBP for implementing the MAPS protocol at several AOCs simultaneously. This arrangement could serve as a pilot study to evaluate the use of the MAPS protocols for the breeding bird indicator. It would ensure that all training and qualification needs are met, improve consistency in the effort, and reduce costs. IBP estimates that a network of three clusters (with six stations each) could be implemented for $65,000, including data analysis and reporting. To pursue this option requires a coordinated review of AOC impairments and habitats to determine appropriate station locations (see procedures below), agency involvement for each locality, identification and attainment of a funding source(s), and further discussion with IBP. Determining the details/logistics of implementing MAPS should be locally driven, with specific objectives identified and presented to IBP to ensure the program is designed to successfully address the objectives. It is recommended that IBP contribute to this process, particularly to the identification of target habitats, bird communities, and/or species for evaluation.

See Table 2 below for a summarized comparison of MAPS and BBIRD.

Breeding Biology Research and Monitoring Database (BBIRD)

University of Montana's Breeding Biology Research and Monitoring Database (BBIRD) program is a national, cooperative program that provides standardized field methodologies for studies of nesting success in birds. BBIRD monitors the nesting success, productivity, and habitats of nongame birds by finding and monitoring nests at sites across North America. Studies at each local site are administered by independent investigators. Point counts can be used to index population size at plots. Standardized vegetation sampling is conducted at nest sites, the locations at which point counts are conducted, and where individual investigators deem useful at "non-use" sites that are paired with locations of actual nests. Data from all sites are merged annually and maintained in a central database to allow overview analyses of national trends and patterns across sites. The BBIRD field protocols provide instructions to potential investigators for initiating BBIRD sites and maintaining standardized data collection. Ultimately, the goal of BBIRD is to enable scientists to identify relative population health and habitat requirements for a wide range of species, and to examine responses to land conversion processes and global change.

There are two types of BBIRD sites: funded and volunteer. Funded sites follow the protocol completely. Volunteer participants obtain their own funding and use BBIRD protocols to the extent possible. The minimum requirement for participation in the program is data on nesting productivity and sources of nesting mortality. Measurement of vegetation associated with nest sites is strongly encouraged. Point counts are included whenever possible to provide population trend information (Martin 1997).

An additional benefit to the BBIRD program is the ability to address local objectives at individual sites. Most monitoring programs require pooling data across a wide diversity of sites to provide statistical inference. The BBIRD protocols allow for strong statistical inference to evaluate effects of local management actions. Consequently, the program can address national and local goals simultaneously (Conway and Martin 1999).

For several years after its establishment in 1992, BBIRD was extremely successful and went beyond the objectives of the original four-year feasibility study (Conway and Martin 1999). More than 100 partners have provided funding for one or more BBIRD sites, including federal, state, and local government agencies, universities, non-governmental conservation organizations, industry, and private foundations. Unfortunately, funding has since dwindled. Nonetheless, substantial data for many species are available from multiple BBIRD sites, allowing for comparisons of nesting productivity across sites. The breeding bird data website provides land managers and researchers with summary data of breeding parameters such as nesting success, mean clutch size, mean number of fledged young, and proportion of nests parasitized by Brown-headed Cowbirds. Data for approximately 40,000 nests of 241 bird species from 42 sites located throughout the United States in a variety of habitats and fragmentation contexts are currently included (http://woodpecker.ornith.cornell.edu/BBird/).

BBIRD: Existing sites around Great lakes

Table 1 lists the previously active BBIRD sites across the Great Lakes states. Further information is available at http://pica.wru.umt.edu/BBIRD/datasite.htm. Funding has been cut for BBIRD, so far fewer sites are currently active and a list of such is not available (Thomas Martin, pers. comm.).

Table 1. Locations and years of operation for BBIRD sites in the Great Lakes states.

State	Location	Years
IN	Hoosier National Forest	91-97
MN	Chippewa National Forest	92-98
MN	Minnesota	97
MN	Minnesota	92
NY	Finger Lakes	92-93
OH	Beach City	93-00
OH	Ravenna Training Site, (Army/NG Ammo plant)	97-98
WI	Chequemegon National Forest	91-93
WI	Land O'Lakes	97-00
WI	Northern Highlands State Forest	96
WI	Nicolet National Forest	96
WI	Pewaukee	97-99
WI	Rosendale	98-00
WI	St. Croix River Valley	91-93

BBIRD: Applicability/limitations for contributing to breeding bird indicator

The labor requirements for BBIRD are greater than those of MAPS. Each BBIRD site typically has 4-10 volunteers, technicians, and graduate students working in the field each summer. Plots are searched for nests every two days, and individual nests checked every 3-4 days. Each full-time technician can effectively monitor two nests plots, visiting each plot every other day.

The size and number of replicate plots at each site vary with local objectives and the productivity of the habitat, but the overall land area requirement is much less than for MAPS. Nest plots must be sufficient to generate at least 20 nests per year in a single treatment/habitat type of each of the most common local species. Sites range from eight 35-50 ha (87-124 acres) plots in eastern hardwood forests to eight 10-20 ha (24-50 acres) sites in western riparian sites. Most BBIRD sites are in eastern hardwood forests (Conway and Martin 1999), but protocols for grassland habitat are now available (http://pica.wru.umt.edu/BBIRD/protocol/protocol.htm). Plots should be separated spatially to the extent possible such that they can be treated as independent sampling units, and be at least 200 x 200 m (4 ha) to accommodate fixed-radius point counts (Martin et al. 1997).

Hejl and Holmes (1999) demonstrated the budgetary and other logistic constraints inherent in nest monitoring studies. They found that one observer could monitor from 10 – 15 nests per day, and that old-growth forest required one person/50-ha plot to find most nests of focal species and to monitor those nests, resulting in the need for 16 field assistants for an ideal expanded study comparing nesting success in fragmented versus continuous forests (with the expectation of finding about 20 nests per treatment per year for each of five focal species). Hejl and Halmes (1999) recommended one to five focal species for using BBIRD methodology in order to focus effort.

Knadle et al. (2001) demonstrated the need for estimating annual reproductive output (versus nest success and/or number of young fledged) to account for different breeding strategies and the influence of renesting and multiple brooding on avian productivity. They caution against relying on nest success estimates that typically do not recognize these factors. However, nest success has been positively correlated with annual productivity (Thomas Martin, pers. comm.).

As with the MAPS protocol, one or two qualified and experienced biologist(s) must be available and committed to project oversight and intern training.

Conway and Martin (1999) reported that funding for 76 BBIRD sites exceeded two million dollars annually. Dividing by the number of sites, the approximate annual cost at the time was $26,300 per site. Again, given the variability in costs, we round up and add costs for intern/housing/travel to arrive at the same $30,000 figure for implementing BBIRD annually. The estimated cost of the BBIRD program is coarser than for MAPS because less information was available and costs will vary with habitat productivity and volunteer availability.

Table 2. Comparison of MAPS and BBIRD costs, requirements, and data products/limitations.

	MAPS	**BBIRD**
Resources		
Estimated cost per site	$30,000.00	$30,000.00
Personnel	2 field workers, 1 biologist	4-15 field workers, 1 biologist
Duration	3 months/yr	10 weeks/yr
Training time	two weeks	three weeks
Habitat		
Minimum area of habitat	5510 ha	320 ha
Habitat restrictions	closed canopy/grassland	variations in labor requirements
Data		
Productivity data	yes	yes - more detail/breeding stage
Survivorship data	yes - fledglings/adults only	yes - eggs/nestlings only
Uncontrolled variables:	*juvenal dispersal rates*	*renesting*
	capture probabilities	*multibrooding*

Local application of the breeding bird indicator using MAPS and/or BBIRD

Steps for developing indicators and indices of biological integrity have been widely proposed (USEPA 2002a, USEPA 2002b, Block et al. 2001, von Euler 1999, Andreasen et al. 2001, Dale and Beyeler 2001, International Joint Commission 1996). Dale and Beyeler (2001) identified three common problems with the use of indicators: 1) small number of indicators fail to consider full complexity of the ecological system; 2) vague long term goals and objectives confound the choice of indicators; and 3) lack of scientific rigor in management and monitoring programs due to undefined protocol used to identify indicators. The NPS Inventory and Monitoring program's Guidance for designing an integrated monitoring program provides a compilation of resources (http://science.nature.nps.gov/im/monitor/vsmTG.htm#Protocols), and the EPA's evaluation guidelines further facilitate the process of indicator selection (Kurtz 2001). Wherever possible, we attempt to address and incorporate the issues and recommendations identified in the existing literature.

Although the breeding bird indicator itself has been identified and approved through the SOLEC efforts, the specific methodologies, processes, and selection of any target species and/or groups have not been addressed. To further the use of this indicator, we present here a process for determining the applicability of the breeding bird indicator for use in AOCs (but generally applicable otherwise) and suggestions for methodology and indicator species. We have integrated components of the draft *Pathway for Delisting Three Beneficial Use Impairments in Great Lakes Areas of Concern* prepared by USEPA GLNPO (2004), and referenced these components.

1. Determine the applicability of the breeding bird indicator to the data needs for delisting the impairment(s). As stated earlier, if one or more of the habitat-related beneficial use impairments (BUIs)

exists in the AOC and includes breeding songbird populations that are definitely or potentially degraded, the breeding bird indicator may be useful. The three habitat-related BUIs are 1) degradation of fish and wildlife populations, 2) bird or animal deformities or reproductive problems, and 3) loss of fish and wildlife habitat. If none of these BUIs exist in the AOC, the breeding bird indicator is not likely ideal at the local level.

For most AOCs, the breeding bird indicator will probably be applicable primarily to the degradation of fish and wildlife populations impairment, since bird deformities and reproductive problems are often documented in waterbirds or raptors and assessment of the loss of fish and wildlife habitat is typically habitat-based (e.g., to acquire/maintain 2,000 ha of riparian forest.) If deformities and/or reproductive problems pertain to breeding songbird populations or if population-based objectives are preferred to ensure the quality of habitat, the breeding bird indicator could contribute to delisting these impairments as well.

2. Presuming that the species, habitat type, and area requirements for MAPS and/or BBIRD are addressed, consider what the breeding bird indicator (as presented here) can provide:

- data on the productivity and survivorship of local songbirds populations to demonstrate self sustainability and ecosystem integrity,
- if the population is impaired, data on what life stage is being affected by stressors, and
- data on habitat conditions associated with successful and failed breeding attempts.

Are such data necessary and sufficient to characterize the desired outcome (environmental goals and targets) and evaluate progress toward delisting the BUI(s)? The International Joint Commission (IJC)'s delisting guidelines may be referenced (Appendix 1), but are not recommended because of their vagueness. AOCs are expected to set their own guidelines with approval from the appropriate government agency (Bruce Kirschner, pers. comm.).

Are the costs feasible? It would be useful at this point, if not done previously, to determine the relevant agencies/organizations to be involved and/or responsible for monitoring and achieving the environmental targets.

The IJC's Indicators for Evaluation Task Force recommends the above criteria (data needs and feasible costs) for selecting indicators (1996). Presuming proper selection and implementation by the AOCs, the protocols proposed here (MAPS and BBIRD) for the breeding bird indicator fulfill the remaining criteria recommended by the Task Force:

- Data and information availability,
- Integrative capacity,
- Scientific validity,
- Certainty and quality of results,
- Understandability by technical and lay persons,
- Policy relevance, and
- Ability to establish reference values, or targets to achieve (International Joint Commission 1996).

If the breeding bird indicator is selected based on these criteria or further information is needed for the decision, proceed through the following steps.

1) Determine bird community/habitat targets

a) Consider the status/make-up of the current bird community(s). Conduct inventories if necessary.

b) Consider what bird communities were present historically (i.e., prairie, woodland, forest, wetland, riparian). Use the available data on bird occupancy patterns and habitats present just prior to the impacts leading to the fish and wildlife related impairments. Earlier data may be needed or useful, but the target community(s) must be restorable within the confines of the current landscape(s).

c) Consider the quality and quantity of current habitat types within and surrounding the AOC. Research pre-European settlement habitat and species in order to understand the magnitude of changes and the range of improvement possibilities (part of Pathway Step 1, pg 4).

   i) What is the extent of existing habitat?
   ii) What is the potential for restoring functional conservation areas? Functional can be defined as able to maintain the focal biotic and abiotic patterns and processes within their natural ranges of variability over time frames relevant to conservation planning and management (e.g., 100-500 years). Factors to consider include:

      (1) composition and structure of the focal ecosystems and species,
      (2) dominant environmental regimes, including natural disturbance,
      (3) minimum dynamic area, and
      (4) connectivity (Poiani et al. 2000).

d) Consider the stressors contributing to the impairment. To the extent possible, articulate the specific impairments to bird populations and habitats and their causes (part of Pathway Step 2, pg 5). Distinguish between the five key stresses (International Joint Commission, 1996) as follows:

   i) biological contamination: exotic species
   ii) chemical contamination: nutrients
   iii) chemical contamination: persistent toxic substances
   iv) physical alterations
   v) human activities and values

e) Given the current and historic conditions of the bird communities and habitat, identify the priority impaired bird community(s) with restoration potential relevant to the fish and wildlife impairment(s) and environmental goals of the AOC.

2) *Determine restoration target(s)*

a) Given the impairments, stressors, and restoration potential, determine objectives and timeline for the target bird community(s) (part of Pathway Step 3, pg 5).

   Usually data on existing bird productivity and survivorship is lacking and, therefore, specific productivity and/or survivorship targets will be difficult to determine. Approximately five years of monitoring is required to identify average productivity and/or survivorship levels at the restoration and/or reference site. This should not, however, prevent objectives from being set as specifically as possible, and progress toward them undertaken. Data on productivity and survivorship by species and location are available at IBPs NBII data interface (http://www.birdpop.org/nbii/NBIIHome.asp) and BBIRDs online database (http://cornell.birdsource.org/BBIRD/Reports). If local data are unavailable or insufficient, we recommend relying on the available literature and these online sources to estimate acceptable productivity and survivorship goals. Depending on the monitoring methodology selected, objectives should be identified in terms of percent average nesting success; the total number of juveniles caught, the proportion of juveniles in the catch (number of juveniles captured/total number of aged individuals captured), or the ratio of juvenile:adult captures; and annual adult survival rates. (See below for more information related to data analysis.) An example of a more general productivity objective would be above or equal to the minimum productivity required to sustain the target population without relying on immigration. Specific objectives are better to avoid any ambiguity that could lead to confusion and difficulty in evaluation. Objectives based on estimated figures can change as more data become available.

b) Choose reference sites for each habitat type to be restored (part of Pathway Step 3, pg 5).

Natural/sustainable reference conditions should help define the objectives while degraded reference conditions define the socially unacceptable state. Identifying each end of the metric enables development of its range and scale (Andreasen et al. 2001).

3) *Determine methodology(s)*

a) Review the size/connectivity of the target restoration area(s) and the stressor(s) impacting it or them. As described earlier, minimum size requirements for BBIRD and MAPS protocols are typically 320 ha (8 40 ha plots) and 5,510 ha, respectively. For BBIRD sites, the number and size of plots varies with the habitat productivity and target species, and should support a sufficient number of nest plots to find at least 20 nests per treatment/habitat type each year, for each of the most locally common species (Martin et al. 1997).

b) If productivity is known to be impaired and adult survivorship is not a primary concern, BBIRD protocols should be implemented to isolate the parameter of concern.

c) If chemical contamination is a known or potential problem, BBIRD protocols should be implemented to isolate any impacts at the various nesting stages (egg-laying, incubation, nestling).

d) MAPS and BBIRD protocols may be implemented together to obtain a comprehensive understanding of birds' productivity and survivorship, as well as any stressors affecting them. This requires a more substantial investment of resources consistently over 5-10 years, and caution must be taken to avoid and reduce disturbance impacts.

e) Both MAPS and BBIRD have habitat components that should be included in the monitoring program. In addition to considering habitat type and vegetational characteristics, it is important to consider landscape variables that may be affecting bird populations.

f) If MAPS protocols are implemented and productivity is found to be impaired and stable or declining (this conclusion would require at least five years of data), BBIRD protocols may be implemented to isolate the stressor(s). MAPS may then be continued or not, depending on remaining data needs.

4) *Select target species*

Based on the habitat, bird community, and impairment information, select indicator species for targeted evaluation. Five focal species are recommended for both BBIRD and MAPS programs (Hejl and Holmes 1999, Phil Nott, pers. comm.). The following steps should be used to select target species.

a) Make a list of all species in the area capable of reflecting the impaired habitat/ecosystem (specific attributes, if known) and with adequate baseline information available on biology, taxonomy, and tolerance levels.

Habitat assemblages are recommended versus foraging or nesting guilds (secondary consideration). Habitat assemblages allow direct evaluation of community responses to the modification of vegetation structure and likely integrate multiple effects of disturbance such as changes in foraging and nesting substrates and scale-dependent fragmentation effects. In addition, multiple habitat assemblages can be considered for evaluating entire communities (Canterbury et al. 2000). Habitat association data are readily available for most species in the literature as well as through online sources, including the Partners in Flight Species Management Synthesis (http://www.partnersinflight.org/birdacct.htm), NatureServe Explorer (http://www.natureserve.org/explorer), USGS Habitat Suitability Indices (http://www.nwrc.usgs.gov/wdb/pub/hsi/hsiindex.htm), Forest Birds of the Western Great Lakes Species Accounts (http://www.nrri.umn.edu/mnbirds/accounts.htm) and Bird Conservation, Western Great Lakes Basin (http://www.uwgb.edu/birds/greatlakes/index.htm). Local data and expertise must also be considered, since species' habitat associations can vary geographically.

i) If cowbirds, starlings, or other exotic bird species are problems targeted for resolution, select common host/victim species. If exotic vegetation is a stressor identified for restoration, identify species sensitive to alteration of the habitat structure caused by the exotic(s).

ii) If chemical contamination is a problem, consider the material(s) impacted and identify species that utilize or depend on this material in a part of their life cycle. Since contamination problems in the AOCs are typically associated with water bodies, delisting this type of impairment will most likely require monitoring fish-eating species for which MAPS and BBIRD methods are not appropriate. See Appendix 2 for information on marsh bird, waterbird, and shorebird monitoring programs.

The Contaminant Exposure and Effects-Terrestrial Vertebrates database (CEE-TV) contains contaminant exposure and effects information for terrestrial vertebrates (birds, mammals, amphibians and reptiles) that reside in estuarine and coastal habitats along the Atlantic, Gulf and Pacific Coasts including Alaska and Hawaii and in the Great Lakes Region (http://www.pwrc.usgs.gov/contaminants-online/). This site also provides a template for ranking the suitability of terrestrial vertebrate species as potential sentinels of exposure to contaminants.

iii) If fragmentation (or another physical alteration) is a stressor targeted for restoration, select species that depend on that component of the habitat most affected. For example, if the size of habitat patch is limiting and management plans include expanding or linking habitats, chose an area-dependent species that utilizes the target habitat. As noted earlier, fragmentation can also result in increased predation. If this is a problem targeted for resolution, select species that are common prey of the predator(s) at issue.

b) Preference should be given to year-round species. Demographic data on migratory birds are complicated by factors beyond those existing on the breeding grounds and must be interpreted with caution. In addition to populations being limited by nonbreeding habitats, migratory species typically disperse far from natal areas and have the capacity to recolonize even very poor habitats (Robinson and Morse 1999). However, depending on the habitat and impairments and with due caution, it may be useful or necessary to choose a migratory species as part of an indicator group. Most resident species are considered generalists, and thus may be more difficult to relate to a specific impairment(s).

c) Consider species identified as priorities for the region by authorities on bird conservation, but see caution below regarding the use of uncommon species as indicators. Bird priority lists include those published by Partners in Flight (http://www.partnersinflight.org/), the Fish and Wildlife Service (http://midwest.fws.gov/pdf/priority.pdf), and Partners in Flight - Canada (http://www.cws-scf.ec.gc.ca/publications/clms/app3_e.cfm). Also, Bird Studies Canada has published *Conservation Priorities for the Birds of Southern Ontario* (http://www.bsc-eoc.org/conservation/conservmain.html). The American Bird Conservancy's Green List identifies the highest priority birds for conservation in the continental United States and Canada, building on the species assessments conducted by Partners in Flight on landbirds and expanded to include species of all taxa (http://www.abcbirds.org/greenlist.htm).

d) Very uncommon or rare species are not recommended because they will be difficult to monitor in numbers sufficient for meaningful analyses. In addition, if a species is uncommon in the area, its absence from a given habitat would not necessarily indicate inferior quality. If, on the other hand, an uncommon species is documented in an area and monitoring reveals a decline or disappearance, a reduction in habitat quality should be investigated. Information on BBS trends by Bird Conservation Region is available online http://www.mbr-pwrc.usgs.gov/bbs/bbsbcr2003.html. In their study of breeding birds in Great Lakes National Forests, Lind et al. (2003) found highly significant declines for short-distance migrants and ground nesting birds in all study areas, while other birds groups (long-distance migrants, permanent residents, shrub, sub-canopy, canopy, and cavity nesters showed mixed results, increased, or were mostly stable.

e) To the extent possible, rank the species by their ability to meet the following criteria:

   i) Measurable. Give preference to those species that can be easily detected and monitored with available funds (Vora 1997, Linty et al. 2000, Dale and Beyeler 2001, Hilty and Merenlender 2000). Each target species must be one that MAPS and/or BBIRD would adequately sample within resource limitations. Table 3 lists species that are regularly captured at MAPS sites throughout the Midwest/Northeast and thus should provide adequate samples. Table 4 lists the five most common species monitored at BBIRD sites in Great Lakes states, and Table 5 breaks these species down by site.

Table 3. Species commonly captured at Midwest/Northeast MAPS stations with general migratory status/seasonal occurrence status for Great Lakes populations (the status rankings vary within the Great Lakes region for some species).

Alpha Code	Common Name	Scientific Name	Migratory Status*	Seasonal Occurrence
TRFL	Traill's Flycatcher	*Empidonax alnorum/traillii*	N	summer resident/migrant
REVI	Red-eyed Vireo	*Vireo olivaceus*	N	summer resident
BCCH	Black-capped Chickadee	*Poecile atricapilla*	R	permanent resident
HOWR	House Wren	*Trolodytes aedon*	S/N	summer resident
VEER	Veery	*Catharsus fuscescens*	N	summer resident
WOTH	Wood Thrush	*Hylocichla mustelina*	N	summer resident
AMRO	American Robin	*Turdus migratorius*	S	summer resident
GRCA	Gray Catbird	*Dumetalla carolinensis*	S/N	summer resident
YELL	Yellow Warbler	*Dendroica petechia*	N	summer resident
CSWA	Chestnut-sided Warbler	*Dendroica pensylvanica*	N	summer resident
MAWA	Magnolia Warbler	*Dendroica magnolia*	N	summer resident/migrant
MYWA	Myrtle Warbler	*Dendroica c. coronata*	S/N	summer resident/migrant
WPWA	Yellow Palm Warbler	*Dendroica p. hypochrysea*	S/N	summer resident/migrant
BWWA	Black-and-White Warbler	*Mniotilta varia*	S/N	summer resident
AMRE	American Redstart	*Setophaga ruticilla*	N	summer resident
OVEN	Ovenbird	*Seiurus aurocapillus*	N	summer resident
NOWA	Northern Waterthrush	*Seiurus noveboracensis*	N	summer resident/migrant
CONW	Connecticut Warbler	*Oporornis agilis*	N	summer resident
MOWA	Mourning Warbler	*Oporornis philadelphia*	N	summer resident
COYE	Common Yellowthroat	*Geothlypis trichas*	N	summer resident
HOWA	Hooded Warbler	*Wilsonia citrina*	N	summer resident
WIWA	Wilson's Warber	*Wilsonia pusilla*	N	summer resident/migrant
FISP	Field Sparrow	*Spizella pusilla*	S	summer resident
SOSP	Song Sparrow	*Melospiza melodius*	S	summer resident
LISP	Lincoln Sparrow	*Melospiza lincolnii*	S	summer resident
WTSP	White-throated Sparrow	*Zonotrichia albicollis*	S/N	summer resident/migrant

***Migration Status Key**
R=Resident (winters in Great Lakes region)
S=Short-distance migrant (winters in S. USA)
N=Neotropical migrant (winters south of the Tropic of Cancer)
R/S=Resident to Short-distance migrant
S/N=Short-distance migrant to Neotropical migrant

Table 4. Summary of top five species most commonly monitored at Great Lakes states BBIRD sites with general migratory and seasonal occurrence status (the status rankings vary within the Great Lakes region for some species).

Alpha Code	Common Name	Scientific Name	Migratory Status*	Seasonal Occurrence
MALL	Mallard	*Anas platyrhynchos*	S	summer/perm. resident
RTHU	Ruby-throated Hummingbird	*Archilocus colubris*	N	summer resident
YBSA	Yellow-bellied Sapsucker	*Sphyrapicus varius*	S	summer resident/migrant
EAWP	Eastern Wood Pee-Wee	*Contopus virens*	N	summer resident
ACFL	Acadian Flycatcher	*Empidonax virescens*	N	summer resident
LEFL	Least Flycatcher	*Empidonax minimus*	N	summer resident
REVI	Red-eyed Vireo	*Vireo olivaceus*	N	summer resident
BLJA	Blue Jay	*Cyanocitta cristata*	R	permanent resident
BRCR	Brown Creeper	*Certhia americana*	S	winter/perm. resident
HOWR	House Wren	*Troglodytes aedon*	S	summer resident
SEWR	Sedge Wren	*Cistothorus platensis*	S	summer resident/absent
BGGN	Blue-gray Gnatcatcher	*Polioptila caerulea*	S/N	summer resident/absent
WOTH	Wood Thrush	*Hylocichla mustelina*	N	summer resident/absent
HETH	Hermit Thrush	*Catharus guttatus*	N	summer resident/migrant
AMRO	American Robin	*Turdus migratorius*	R/S	summer/perm. resident
GRCA	Gray Catbird	*Dumetella carolinensis*	S/N	summer resident
NAWA	Nashville Warbler	*Vermivora ruficapilla*	N	summer resident/migrant
CSWA	Chestnut-sided Warbler	*Dendroica pensylvanica*	N	summer resident
BTNW	Black-throated Green Warbler	*Dendroica virens*	N	summer resident
AMRE	American Redstart	*Setophaga ruticilla*	N	summer resident
PROW	Prothonotary Warbler	*Protonotaria citrea*	N	summer resident/absent
OVEN	Ovenbird	*Seiurus aurocapillus*	N	summer resident
COYE	Common Yellowthroat	*Geothlypis trichas*	S/N	summer resident
HOWA	Hooded Warbler	*Wilsonia citrina*	N	summer resident/absent
SCTA	Scarlet Tanager	*Piranga olivacea*	N	summer resident
SOSP	Song Sparrow	*Melospiza melodia*	S	summer/perm. resident
WTSP	White-throated Sparrow	*Zonotrichia albicollis*	S	summer resident/migrant
NOCA	Northern Cardinal	*Cardinalis cardinalis*	R	permanent resident
RBGR	Rose-breasted Grosbeak	*Pheucticus ludovicianus*	N	summer resident
BOBO	Bobolink	*Dolichonyx oryzivorus*	N	summer resident
RWBL	Red-winged Blackbird	*Agelaius phoeniceus*	S/R	summer/perm. resident
BAOR	Baltimore Oriole	*Icterus galbula*	N	summer resident

***Migration Status Key**
R=Resident (winters in Great Lakes region)
S=Short-distance migrant (winters in S. USA)
N=Neotropical migrant (winters south of the Tropic of Cancer)
R/S=Resident to Short-distance migrant
S/N=Short-distance migrant to Neotropical migrant

Table 5. Top five species per BBIRD sites of the Great Lakes states. See Table 4 for species alpha code key.

State	Location	5 Most Common Species
IN	Hoosier National Forest	ACFL,WOTH,REVI,WEWA,OVEN
MN	Chippewa National Forest	LEFL,OVEN,YBSA,REVI,HETH
MN	Minnesota	BGGN,AMRE,EAWP,AMRO,SCTA
MN	Minnesota	HOWR,YBSA,AMRE,PROW,BRCR
NY	Finger Lakes	AMRO, OVEN, REVI, YBSA, COYE
OH	Beach City	ACFL,HOWA,WOTH,REVI,NOCA
OH	Ravenna Training Site, (Army/NG Ammo plant)	ACFL,REVI,WOTH,AMRE,RTHU
WI	Chequemegon National Forest	OVEN,LEFL,REVI,WOTH,HETH
WI	Land O'Lakes	NAWA,WTSP,YBFL,CSWA,RBGR
WI	Northern Highlands State Forest	OVEN,HETH,BTNW,SCTA,REVI
WI	Nicolet National Forest	LEFL,OVEN,HETH,REVI,BTNW
WI	Pewaukee	BLJA,NOCA,GRCA,AMRO,BAOR
WI	Rosendale	BOBO, SEWR, RWBL, SOSP, MALL
WI	St. Croix River Valley	OVEN,WOTH,REVI,AMRO,LEFL

ii) Sensitive to identified stressor(s) (Linty et al. 2000, Hilty and Merenlender 2000). Sufficiently high signal strength (when compared with natural or seasonal variation) to allow detection of ecologically significant changes within a reasonable timeframe (2% linear trend over a region within 10 years, with a 0.20 probability of a Type I error and a power of 70% (Vora 1997)).

iii) Responds to identified stressor(s) in a known, predictable manner, with an established correlation to the ecosystem change. Reflects differences in ecological condition, pollutant exposure, or habitat condition and responds to stressors across most pertinent habitats within a region (Vora 1997, Dale and Beyeler 2001, Linty et al. 2000).

iv) Predicts changes that can be averted by management goals/targets. Is related unambiguously to the assessment endpoint (Vora 1997, Dale and Beyeler 2001).

v) Low variability in response (Linty et al. 2000, Dale and Beyeler 2001, Hilty and Merenlender 2000).

vi) If possible, remove species that may respond to changes occurring outside the system of interest (Hilty and Merenlender 2000).

vii) Select a set of complementary indicator taxa from different taxonomic groups so that all selection criteria are met by more than one taxon (Hilty and Merenlender 2000).

5) Evaluation

a) For MAPS, patterns in productivity may be calculated by analysis of 1) the total number of juveniles caught; 2) the proportion of juveniles in the catch (number of juveniles captured/total number of aged individuals captured); and 3) the ratio of juvenile:adult captures. Because of differences inherent in juvenile versus adult captures, the use of juvenile captures per net hour is recommended where breeding population size is relatively stable. Where breeding density fluctuates greatly, adult captures should be considered (Nur et al. 1999b). (Breeding density can be measured roughly using the number of adult captures and/or with supplemental monitoring.) IBP estimates annual adult survival rates and adult capture probabilities with modified Cormack-Jolly-Seber mark-recapture models that account for between- and within-year length-of-stay transients. The models permit estimation of the proportion of residents among newly captured birds and provide survival rate estimates that are unbiased with respect to transient individuals (DeSante and Nott 2000). The software, however, is proprietary and not available for distribution (Phil Nott, pers. comm.). Nur et al. (1999a) suggest manual criteria for distinguishing transients and provide other recommendations for data analysis. Nur et al. (1999b) review and offer guidance and examples on methods and software for statistical analysis of data from bird banding and other bird monitoring programs. This publication is available for download at http://www.prbo.org/tools. The IBP website also offers publications that may assist in data analysis (http://www.birdpop.org).

b) For BBIRD data, the Mayfield method (Mayfield 1975, Hensler and Nichols 1981) is used to estimate daily nest mortality rates and percent nests lost to mortality due to all causes or due only to predation. Also, Pease and Grzybowski (1995) present a mathematical model for measuring the consequences of brood parasitism and nest predation on seasonal fecundity, since measuring the impacts on individual nesting attempts may not reflect the impact on seasonal fecundity due to renesting efforts.

c) A minimum of five years' data is required to establish baseline information on target species/community(s).

d) Ten to twenty years has been suggested as an appropriate range of intervals to evaluate overall restoration or management plans, depending on how immediate a response is expected from the activities. Assessment of population response(s) to restoration/management activities should occur subsequent to annual monitoring throughout the process (Donovan et al. 1999).

Appendix 1: MAPS stations Survey – Summary of Responses

MAPS Location/Station						
Survey Questions	**Chicago Bird Observatory**	**MELC/MLFS & MLWM**	**PITS/PIFI**	**BMAC/BAAR**	**KJOS**	**STBR/STBR**
Nearest Town	Illinois-GSU	Goshen, IN	Vicksburg, MI	Java, NY	Lena, WI	Republic, OH
Great Lakes Basin	-	Lake Michigan	Lake Michigan	Lake Erie	Lake Michigan	Lake Erie
Located in AOC	no	no	nearby	no	yes	nearby
Habitat(s)	shrubland	shrubland, grassland	woodland, old field, gravel pit	shrubland, grassland	northern hardwood swamp/scrub	2nd older growth hardwoods, remnant/farmed orchard, bottomland, etc.
Impact	-	moderate	moderate	moderate	-	moderate
Management	-	active	active	active	minimal	minimal
Area of habitat	28 acres	1150 acres	900 acres	324 acres	122 acres	-
Duration	-	2002-?	1990-?	2002-?	1993-2003, 2005-?	1992-1997; 2004-2009
					(permit probs)	
Costs	-	>$5,250	>$5,000	training/equip only (all volunteer)	equipment only (all volunteer)	equipment only (all volunteer)
Interst in contributing to the BBInd	-	Yes	Yes	need more info	No	Yes

Appendix 2: IJC Listing and Delisting Guidelines for Habitat-related Beneficial Use Impairments

Degradation of fish and wildlife population (BUI 3)
Listing guideline: When fish and wildlife management programs have identified degraded fish or wildlife populations due to a cause within the watershed. In addition, this use will be considered impaired when relevant, field-validated; fish or wildlife bioassays with appropriate quality assurance/quality controls confirm significant toxicity from water column or sediment contaminants.

Delisting guideline: When environmental conditions support healthy, self-sustaining communities of desired fish and wildlife at predetermined levels of abundance that would be expected from the amount and quality of suitable physical, chemical and biological habitat present. An effort must be made to insure that fish and wildlife objectives for Areas of Concern are consistent with Great Lakes ecosystem objectives and Great Lakes Fishery Commission fish community goals. Further, in the absence of community structure data, this use will be considered restored when fish and wildlife bioassays confirm no significant toxicity from water column or sediment contaminants.

Rationale: Emphasizes fish and wildlife management program goals; consistent with Agreement and Great Lakes Fishery Commission goals; accounts for toxicity bioassays.

Bird or Animal Deformities or Reproductive Problems (BUI 5)
Listing guideline: When wildlife survey data confirm the presence of deformities (e.g. cross-bill syndrome) or other reproductive problems (e.g. egg-shell thinning) in sentinel wildlife species.

Delisting guideline: When the incidence rates of deformities or reproductive problems in sentinel wildlife species do not exceed levels in inland control populations.

Rationale: Emphasizes confirmation through survey data; makes necessary control comparisons.

Loss of fish and wildlife habitat (BUI 14)
Listing guideline: When fish and wildlife management goals have not been met as a result of loss of fish and wildlife habitat due to a perturbation in the physical, chemical, or biological integrity of the Boundary Waters, including wetlands.

Delisting guideline: When the amount and quality of physical, chemical, and biological habitat required to meet fish and wildlife management goals have been achieved and protected.

Rationale: Emphasizes fish and wildlife management program goals; emphasizes water component of Boundary Waters.

Appendix 3: Monitoring programs for other habitats/bird groups

The Marsh Monitoring Program monitored wetland habitats in Great Lakes AOCs from 1995-2002, and produced a series of reports on the status of breeding marsh bird and amphibian communities and recommendations for future monitoring (http://www.bsc-eoc.org/MMP-AOCreports.html). These data and this program should be considered, but the protocol does not currently address demographic parameters.

Building on the MMP, the *Development and Assessment of Environmental Indicators based on Birds and Amphibians in the Great Lakes Basin* is part of a multi-disciplinary investigation involving scientists from seven academic institutions, the Minnesota Department of Natural Resources, and US EPA Mid-Continent Ecology Division. The final product will include a suite of wetland bird, shorebird, and amphibian indicators of ecological condition in the Great Lakes basin and recommendations for a long-term monitoring strategy that minimizes costs while maximizing statistical power for discriminating degraded vs. high quality ecosystems (http://glei.nrri.umn.edu/default/birds.htm).

International Shorebird Survey (ISS), Program for Regional & International Shorebird Monitoring (PRISM), US Shorebird Plan, and Canadian Conservation Shorebird Plan can all be accessed at http://www.manomet.org/WHSRN/monitoring.htm.

Information on the Waterbird Monitoring Partnershp is at http://www.pwrc.usgs.gov/cwb/, and the *Breeding Season Population Census Techniques for Seabirds and Colonial Waterbirds Throughout North America* is available at http://www.pwrc.usgs.gov/cwb/manual/.

With regard to contributing to delisting AOC impairments, it should be noted that a major challenge in linking the health of waterbird populations such as gulls, terns, and herons to water quality conditions is identifying the specific feeding locations associated with breeding areas. Also, most waterbird and shorebird populations are migratory throughout the Great Lakes, adding substantially to the variables that affect productivity and survivorship.

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