

Development of an Indicator Suite for Lake Erie

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Outline

1. Background
2. Framework
3. Indicators Matrix
4. Current Status/Next Steps
5. Research Needs

Background

- The Lake Erie LaMP has developed a Vision for the Lake Erie basin ecosystem

Where all people, recognizing the fundamental links among the health of the ecosystem, their individual actions, and their economic and physical well-being, work to minimize the human impact in the Lake Erie basin and beyond;

Where natural resources are protected from known, preventable threats;

Where native biodiversity and the health and function of natural communities are protected and restored to the greatest extent that is feasible;

Where natural resources are managed to ensure that the integrity of existing communities is maintained or improved;

Where human-modified landscapes provide functions that approximate natural ecosystem process;

Where land and water are managed such that water flow regimes and the associated amount of materials transported mimic natural cycles; and

Where environmental health continually improved due to virtual elimination of toxic contaminants and remedial actions at formerly degraded and/or contaminated sites.

Background

- Ecosystem Management Objectives provide targets for achieving the vision
 - Land Use
 - Nutrients
 - Chemical and Biological Contamination
 - Resource Use and Disturbance
 - Non-native Species

Background

- Ecosystem Management Objectives provide targets for achieving the vision
 - Land Use
 - Land use activities result in gains in the quantity and quality of natural habitat in order to support the maximum amount of native biodiversity and community integrity that can be achieved and be sustained for the benefit of future generations.
 - Nutrients
 - Chemical and Biological Contamination
 - Resource Use and Disturbance
 - Non-native Species

Background

- Ecosystem Management Objectives provide targets for achieving the vision
 - Land Use
 - Nutrients
 - Nutrient inputs from both point and non-point sources are managed to ensure that ambient concentrations are within bounds of sustainable watershed management and consistent with the Lake Erie Vision.**
 - Chemical and Biological Contamination
 - Resource Use and Disturbance
 - Non-native Species

Background

- Ecosystem Management Objectives provide targets for achieving the vision
 - Land Use
 - Nutrients
 - Chemical and Biological Contamination
 - Toxic chemical and biological contaminant concentrations within the basin must be virtually eliminated.**
 - Resource Use and Disturbance
 - Non-native Species

Background

- Ecosystem Management Objectives provide targets for achieving the vision
 - Land Use
 - Nutrients
 - Chemical and Biological Contamination
 - Resource Use and Disturbance
 - Natural resource use (e.g. commercial and sport fishing, hunting, trapping, logging, water withdrawal) and disturbance by human presence or activity be managed to ensure that the integrity of existing healthy ecological communities be maintained and/or improved, and provide benefits to consumers.**
 - Non-native Species

Background

- Ecosystem Management Objectives provide targets for achieving the vision

- Land Use
- Nutrients
- Chemical and Biological Contamination
- Resource Use and Disturbance
- Non-native Species

Non-native invasive species should be prevented from colonizing the Lake Erie ecosystem. Existing non-native invasive species should be controlled and reduced where feasible and consistent with other objectives.

Background

- Ecosystem Management Objectives provide targets for achieving the vision
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 - Resource Use and Disturbance
 - Non-native Species

- Recognized the need to measure progress toward achieving the EMOs
 - Indicators task group formed in November 2002

Framework for Indicator Development

- Lake Erie LaMP definition of an indicator:

A measurable feature that identifies the current state of the ecosystem relative to the desired state of the ecosystem, as described by the Lake Erie Vision and Ecosystem Management Objectives.

- The purpose of the indicator suite that is developed is to:

- (1) Assess overall ecosystem management integrity
- (2) Evaluate components contributing to change at component and basin levels
- (3) Evaluate important components for reporting and long-term trends
- (4) Provide predictive capacity (i.e., allow us to anticipate problems and adopt a proactive approach)

Framework for Indicator Development

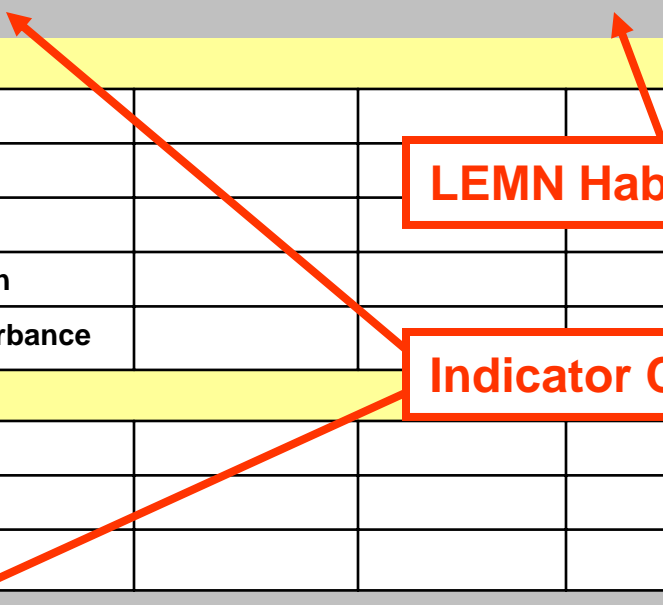
- Apply indicators to different habitat types using the Habitat Classes defined through the Lake Erie Millennium Network habitat workshops
 - Terrestrial
 - Tributaries
 - Coastal Wetlands
 - Nearshore
 - Offshore
- A set of indicator Selection Criteria was developed to ensure the selected indicators meet the purposes of the LaMP
- Wherever possible, build upon work that has already been done

Lake Erie Indicators Matrix

Indicator Category	Terrestrial	Streams	Coastal Wetlands	Nearshore	Offshore
PRESSURE INDICATORS					
<i>Management Objectives :</i>					
Natural Lands					
Nutrients					
Chemical Contamination					
Biological Contamination					
Resource Use and Disturbance					
<i>Processes :</i>					
Flow Disruption					
Energy Disruption					
Economic Disruption					
STATE INDICATORS					
Plant Cover					
Food Web Base					
Lower Food Web (benthic inverts)					
Lower Food Web (pelagic)					
Middle Food Web (fish)					
Upper Food Web (fish)					
Upper Food Web (herps/birds)					

LEMN Habitat Zones

Indicator Categories



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Flow Disruption					
Energy Disruption					
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STATE INDICATORS					
Plant Cover					
Food Web Base					
Lower Food Web (benthic inverts)					
Lower Food Web (pelagic)					
Middle Food Web (fish)					
Upper Food Web (fish)					
Upper Food Web (herps/birds)					

Measuring progress toward the five Lake Erie ecosystem management objectives

Measuring impacts on important

... evaluate components contributing to change at component and basin levels, evaluate important components for reporting and long-term trends, and provide predictive capacity.

components of the Lake Erie ecosystem

Populating the Matrix

- List of potential indicators compiled via a questionnaire to the wider scientific and management community in July 2004
- Purpose was to get an idea of indicators already are already available or in development
- The Lake Erie Vision was used as a guide for selecting indicators for the portion of the matrix linked to the management objective indicators

Using the Vision to Populate the Matrix

Indicator Category	Terrestrial	Streams	Coastal Wetlands	Nearshore	Offshore
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<i>Management Objectives :</i>					
Natural Lands					
Nutrients					
Chemical Contamination					
Biological Contamination					
Resource Use and Disturbance					

Indicator Category	Tactical Objective (LE LaMP 2004)	Habitat Class				
		<i>Terrestrial</i>	<i>Streams</i>	<i>Coastal Wetlands</i>	<i>Nearshore</i>	<i>Offshore</i>
Natural Lands	Land use activities result in gains in the quantity and quality of natural habitat in order to support the maximum amount of native biodiversity and community integrity that can be achieved and be sustained for the benefit of future generations.	Protect and restore terrestrial habitats. Reduce the extent of imperviousness in the Lake Erie basin. Increase extent of natural lands through changes in land use that represent a return to more natural landforms. Create and maintain habitat corridors for wildlife.	Protect and restore natural stream & associated watershed function. Ensure that flow regimes and associated amounts of materials transported mimic the natural cycle. Use BMPs whenever possible to maintain and restore more natural conditions.	Increase total basin coastal wetland area. Protect and restore coastal wetland area and function.	Protect and restore natural nearshore function. If shoreline protection is needed, ensure that appropriate design is employed to mimic natural current and material transport.	Adopt land use practices throughout the watershed to minimize impacts on offshore waters and habitat.

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Current Status

- The matrix has been populated with candidate indicators (“grocery list”)

Indicator Category	Habitat Class				
	Terrestrial	Streams	Coastal Wetlands	Nearshore	Offshore
PRESSURE INDICATORS					
Management Objective Indicators:					
Natural Lands	<ul style="list-style-type: none"> % natural lands % impermeable surfaces GLEI land cover 	<ul style="list-style-type: none"> % altered stream length Relative TSS/sediment loads Altered hydraulic flow? 	<ul style="list-style-type: none"> Total area of coastal wetlands GLCWC coastal wetland IBI 	<ul style="list-style-type: none"> % vegetated shoreline 	<ul style="list-style-type: none"> Integrated measure of effects of land condition Model process results and flow disruptions
Nutrients	<ul style="list-style-type: none"> TP/TN production (fertilizer, livestock, population density) Groundwater contamination 	<ul style="list-style-type: none"> TP, SRP, TN 	<ul style="list-style-type: none"> TP, TN 	<ul style="list-style-type: none"> TP, SRP, TN DOC 	<ul style="list-style-type: none"> TP, SRP, TN DOC
Chemical Contamination	<ul style="list-style-type: none"> Point-source discharge Atmospheric deposition Groundwater contamination (persistent chemicals) GLEI ag-chem 	<ul style="list-style-type: none"> Sum of persistent and non-persistent chemicals in water and substrate Benthos/mussel contaminant levels Fish tissue contaminant levels 	<ul style="list-style-type: none"> Biota tissue contaminant concentration (snapping turtles, mudpuppies, etc) 	<ul style="list-style-type: none"> Sum of persistent and non-persistent chemicals in water and substrate Benthos/mussel contaminant levels Fish tissue contaminant levels Herring gull eggs contaminants levels 	<ul style="list-style-type: none"> Sum of persistent and non-persistent chemicals in water and substrate Benthos/mussel contaminant levels Fish tissue contaminant levels
Biological Contamination	<ul style="list-style-type: none"> Introduced diseases 	<ul style="list-style-type: none"> Beach E. coli levels Frequency/extent of hazardous algal blooms 	<ul style="list-style-type: none"> Frequency/extent of bird and fish kills (botulism) Frequency/extent of hazardous algal blooms 	<ul style="list-style-type: none"> Beach E. coli levels Frequency/extent of bird and fish kills (botulism) Frequency/extent of hazardous algal blooms 	<ul style="list-style-type: none"> Frequency/extent of bird and fish kills (botulism) Frequency/extent of hazardous algal blooms
Non-Native Invasive Species	<ul style="list-style-type: none"> Non-native arrivals Non-native domination 	<ul style="list-style-type: none"> Non-native arrivals Non-native domination 	<ul style="list-style-type: none"> Non-native arrivals Non-native domination 	<ul style="list-style-type: none"> Non-native arrivals Non-native domination Dresseinid abundance 	<ul style="list-style-type: none"> Non-native arrivals Non-native domination Dresseinid abundance
Resource Use and Disturbance	<ul style="list-style-type: none"> Footprint of extractions GLEI population and disturbance indicator 	<ul style="list-style-type: none"> Water taking Amount of water treated and returned Total recreational fishing effort 	<ul style="list-style-type: none"> Waterfowl hunting Trapping Disturbance indicator (eg, % emergent cover) 	<ul style="list-style-type: none"> Walleye & yellow perch production:extraction Density of artificial structures (e.g., wind power, well heads, pipelines, shipwrecks) 	<ul style="list-style-type: none"> Walleye & yellow perch production:extraction Density of artificial structures (e.g., wind power, well heads, pipelines, shipwrecks)
Process Indicators:					
Flow Disruption	<ul style="list-style-type: none"> Inter-basin water transport % tile drained % impermeable surfaces 	<ul style="list-style-type: none"> Indices of hydrologic alteration Hydrological flashiness index 	<ul style="list-style-type: none"> % (# and area) of wetlands that are dyked 	<ul style="list-style-type: none"> Density of artificial structures (piers, jetties, groynes) % of shoreline altered Water level patterns 	<ul style="list-style-type: none"> Regional climate patterns (# of intense storms, ice cover, 10 yr flood/drought frequency) Water level patterns Density of artificial structures (e.g., wind power, well heads, pipelines, shipwrecks)
Energy Disruption	<ul style="list-style-type: none"> Net assimilation efficiency, # trophic levels, connectivity 	<ul style="list-style-type: none"> Net assimilation efficiency, # trophic levels, connectivity 	<ul style="list-style-type: none"> Net assimilation efficiency, # trophic levels, connectivity 	<ul style="list-style-type: none"> Net assimilation efficiency, # trophic levels, connectivity 	<ul style="list-style-type: none"> Density of artificial structures Net assimilation efficiency, # trophic levels, connectivity
Economic Disruption	<ul style="list-style-type: none"> Canadian wellness index Genuine progress indicator EMERGY 			<ul style="list-style-type: none"> Model of process and impacts to fishery (Jeff) 	<ul style="list-style-type: none"> Model of process and impacts to fishery (Jeff)

STATE INDICATORS					
Plant Cover	<ul style="list-style-type: none"> GLEI land cover Terrestrial vegetation IBI? 	<ul style="list-style-type: none"> Dominant benthic algae or plant (diatom: cladophera:macrophyte) Stream bank plant cover index (% of stream length in forested cover, width of buffer) 	<ul style="list-style-type: none"> GLCWC wetland IBI GLEI wetland indicators 	<ul style="list-style-type: none"> Cladophora/macrophyte index (benthic and planktonic combined) LEQI plankton IBI Total chlorophyll 	<ul style="list-style-type: none"> Total chlorophyll LEQI plankton IBI
Food Web Base	<ul style="list-style-type: none"> Average depth of top soil Insect invaders 	<ul style="list-style-type: none"> Day-night minimum DO ratio (net community respiration) Productivity of streams Water column DOC TSS 	<ul style="list-style-type: none"> Planktonic:macrophyte primary production ratio Water column DOC TSS 	<ul style="list-style-type: none"> Benthic vs. pelagic primary production and respiration LEQI plankton IBI Substrate organic content Water column DOC TSS 	<ul style="list-style-type: none"> Benthic vs. pelagic primary production and respiration LEQI plankton IBI Substrate organic content Water column DOC TSS
Lower Food Web (benthic inverts)	N/A	<ul style="list-style-type: none"> Benthic biomonitoring program (CAS, TMDL) LEQI benthic inv. IBI Benthic invertebrate contaminant burdens 	<ul style="list-style-type: none"> GLCWC wetland benthic invertebrate indicator GLEI wetland benthic invertebrate metric Benthic invertebrate contaminant burdens 	<ul style="list-style-type: none"> Barton indicator GLEI benthic invertebrate indicator Hexagenia Benthic invertebrate contaminant burdens 	<ul style="list-style-type: none"> Diporeia ECCS benthic invertebrate indicator Benthic invertebrate contaminant burdens
Lower Food Web (pelagic)	N/A	<ul style="list-style-type: none"> Zooplankton index 	<ul style="list-style-type: none"> Zooplankton index 	<ul style="list-style-type: none"> Zooplankton index 	<ul style="list-style-type: none"> Zooplankton index
Middle Food Web (fish)	N/A	<ul style="list-style-type: none"> Benthic fish IBI Benthic:pelagic ratio Exotic:native ratio Contaminant burdens 	<ul style="list-style-type: none"> Wetland fish IBI Benthic:pelagic ratio Exotic:native ratio Contaminant burdens 	<ul style="list-style-type: none"> Round goby abundance Benthic fish IBI (GLEI) Benthic:pelagic ratio Exotic:native ratio Mill's index of planktivory Contaminant burdens 	<ul style="list-style-type: none"> Round goby abundance LEQI benthic fish IBI Benthic:pelagic ratio Exotic:native ratio Mill's index of planktivory Smelt index (east basin) Forage fish index Contaminant burdens
Upper Food Web (fish)	N/A	<ul style="list-style-type: none"> Stream fish IBI Contaminant burdens 	<ul style="list-style-type: none"> Wetland fish IBI (GLEI, GLCWC, LEQI, Chow-Frasier WFI) Contaminant burdens 	<ul style="list-style-type: none"> Fish population index Nearshore fish IBI GLFC objectives index Contaminant burdens 	<ul style="list-style-type: none"> Fish population index LEQI offshore fish IBI GLFC objectives index Contaminant burdens
Upper Food Web (herps/birds)	<ul style="list-style-type: none"> Nesting colonies (cormorants, gulls, etc.) Christmas bird count GLEI bird IBI 	<ul style="list-style-type: none"> Marsh monitoring program (stream wetlands) Snapping turtle contaminant burdens? 	<ul style="list-style-type: none"> Marsh monitoring program (coastal wetlands) Snapping turtle contaminant burdens? Tree swallow contaminant burdens Waterfowl assessment 	<ul style="list-style-type: none"> SOLEC bald eagles Great blue herons Waterfowl assessment Colonial waterbird contaminants 	N/A
Economics	<ul style="list-style-type: none"> Total value of mining, gravel, timber extractions 		<ul style="list-style-type: none"> Total value of waterfowl hunting 	<ul style="list-style-type: none"> Total value of fishery (nearshore and offshore combined) 	<ul style="list-style-type: none"> Total value of fishery (nearshore and offshore combined)

Current Status

- Next step is to refine the list (selection criteria)
- Workshop: getting feedback regarding the choice of indicators
- Categories:
 - (1) Ready to be implemented
 - (2) Not ready
 - (a) Indicator requires further development, program exists
 - (b) Indicator needs to be developed, program exists

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Research Needs

- Indicator scaling (targets, endpoints) – 2a
- Indicator development – 2b

Lake Erie LaMP Indicators Task Group

- Members:

Luca Cargnelli, Jennifer Vincent, Janet Planck (Environment Canada)
Jan Ciborowski (University of Windsor)
Mike Bur (United States Geological Survey)
Jeff Tyson (Ohio Department of Natural Resources)

- Past Members:

Roger Knight
Phil Ryan
Roger Thoma