Research Needs Workshop Series 4
Watershed-based nutrients and nearshore ecosystem behaviour

Lake Erie Land and Water - Clarifying the Agriculture - Eutrophication Linkage
LEMN Research Needs Workshop 4.4
Tuesday March 23, 2010 - Stoneridge Inn, London, ON

Sponsored by the Ontario Great Lakes Program of
Ontario Ministry of Agriculture, Food and Rural Affairs

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Agenda

8:30   Coffee; informal gathering

9:00   Welcome and Introductions - Jan Ciborowski

9:10   Introduction to the problem - Pamela Joosse

9:30   Introduction to the exercise - Jan Ciborowski

9:45   FCM creation - part I

10:00   Working Break

11:30   Reporting out & clarification of terms

12:00   Working Lunch - Brief presentations and research interest summaries (5 min each)

1:00   FCM creation part II

2:00   Reporting out - key map elements by group
                most important links
                most variable links
                least understood links
                greatest data needs

2:30   Discussion - key elements of a consensual map

2:45   Break

3:00   Opportunities for collaboration

3:45   Next steps

Lake Erie Millennium Network (LEMN)

http://www.uwindsor.ca/erie2001

Binational Network - formed November 1998

Convening Organizations:

F.T. Stone Lab - Ohio State University (Jeff Reutter)
NWRI - Environment Canada   (Chris Marvin)
Large Lakes Research lab - US EPA   (Russ Kreis)
GLIER - University of Windsor   (Jan Ciborowski)

Sponsors: Federal, State, Provincial, Regional organizations

Collaborators: Groups active in research/information exchange

Supporting Groups

Sponsors
(funds for meetings, publications, etc.)

Essex Region Conservation Authority
Great Lakes Fishery Commission
International Joint Commission
Lake Erie Lakewide Area Management Plan
  through Environment Canada & US EPA
Michigan Sea Grant
Lake Erie Protection Fund
New York Sea Grant
Ontario Ministry of the Environment
Ontario Ministry of Natural Resources
Pennsylvania Dept. Environmental Protection
Pennsylvania Sea Grant
**US Geological Survey - Gt. Lakes Sci. Ctr.**

Campbell Scientific
DTE Energy, Inc.
Hoskin Scientific

Collaborators
(contribute to data needs, etc.)

Citizens Environment Alliance
Cornell University Biological Station
Ducks Unlimited
Essex County Stewardship Network
Great Lakes Commission
Great Lakes Environ. Res. Lab - NOAA
Great Lakes Research Consortium
Great Lakes Lab Fisheries & Aquatic
 Sci. - Fisheries & Oceans Canada
 Ontario Commercial Fishery Assoc.
 Ontario Fed. of Hunters & Anglers
 Ohio Dept. Natural Resources
 Ohio Environ. Protection Agency
 Ontario Ministry Agriculture & Food
 Water Environment Federation

3. forming collaborative groups (open to all)
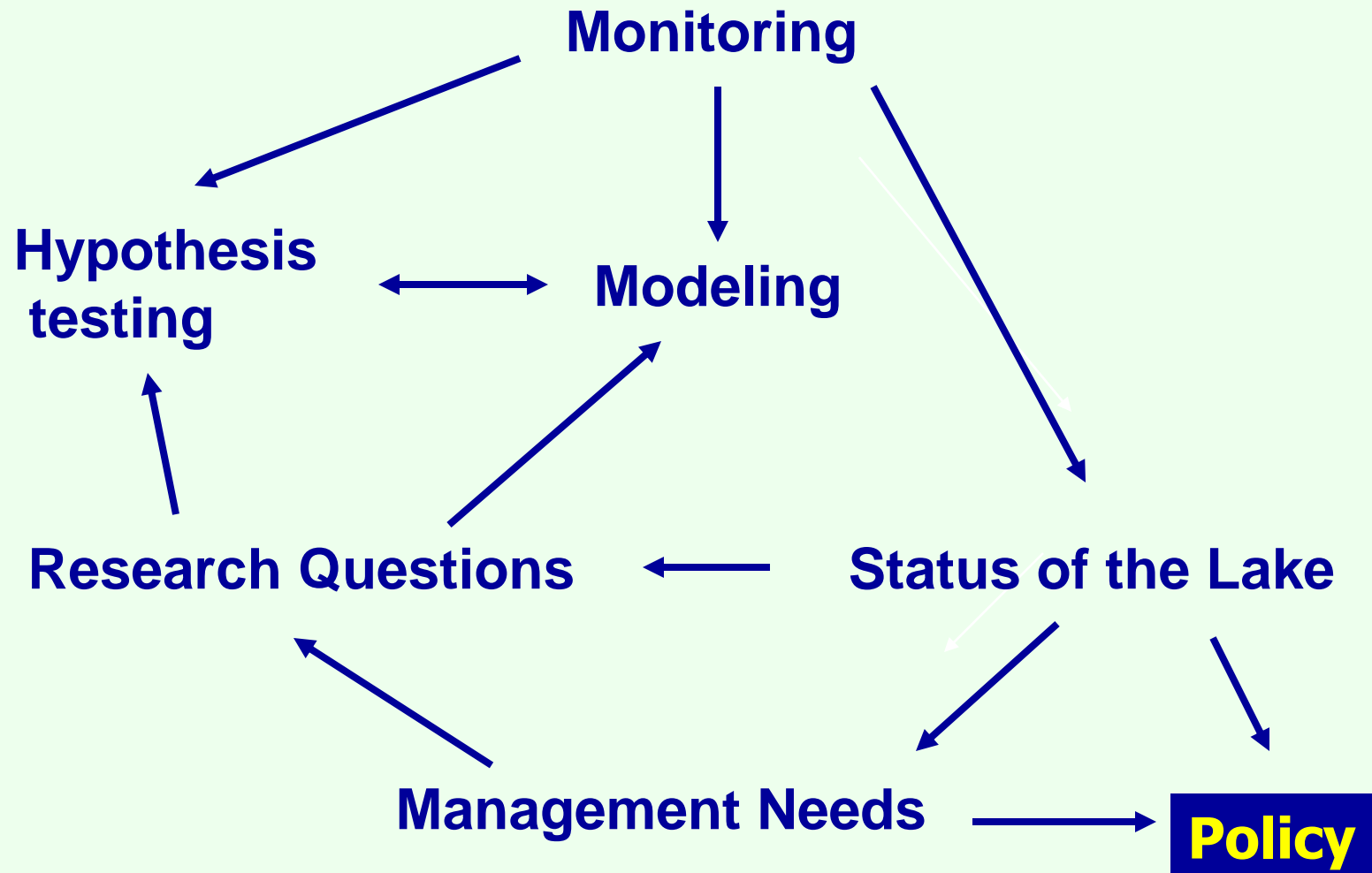
Relationship among management, research, & monitoring needs within LEMP.

Workshops and Research Arising

1. Limits on Energy Transfer in the Lake Erie Ecosystem -
   Critical Tests of Hypotheses
        EPA-funded Lake Erie Trophic Status project (2002):
           -28 PI's funded by US EPA ($500K)
           -all agency collaboration → $2M in kind support
           - *Journal of Great Lakes Research* special issue (June/06)

2. Contaminant Processes in Lake Erie (2000)
        - Part I. *Loadings, Spatial Patterns, and Temporal Trends*
        - **Part II.** *Mechanisms and Processes*
        - **Part III.** *Ecosystem Implications* [review papers]

3. Habitat Structure, Function, and Change
   Anticipating effects of water level changes on habitat distribution & quality
       in the Huron-Erie Corridor
        - funded by GLFC; 5 PI's & cooperators; models proposed (2004)
   Binational Mapping Strategy for Lake Erie watershed
          - funded by US EPA & Envir. Cda. (2005/06)
          -12 PI's & cooperators
          - all agency collaboration

Workshops and Research Arising

4. Land-Lake Loadings

     IJC & OMAFRA Sponsored workshops (2008-2010):

          -28 PI's funded by US EPA ($500K)

          -all agency collaboration → $2M in kind support

   **-** *Journal of Great Lakes Research* special issue (June/06)

5. Understanding Causes of Nearshore Eutrophication (2009)

          - BEC Intensive monitoring year (EPE, EC, MOE, OMNR, etc.)

          - 7 integrated projects funded by US EPA & LEPF

          - parallel studies in Ontario

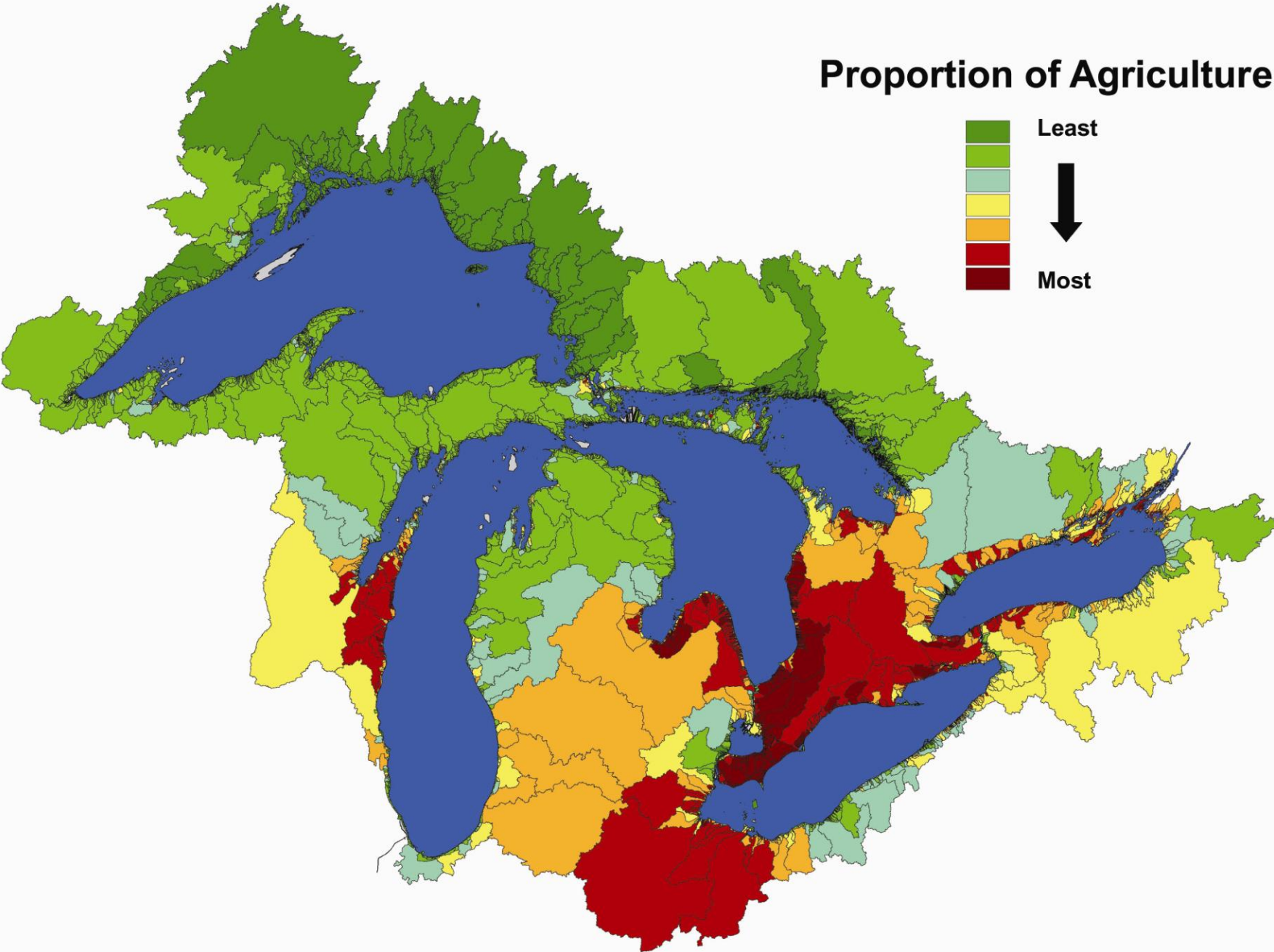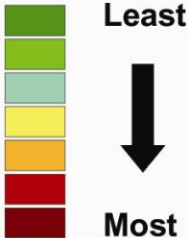   - SERA 17 Phosphorus forum

6. Collaborative Research under GLRI (& EC support)

          - update landuse/landcover for habitat classification

          - continuing nearshore research

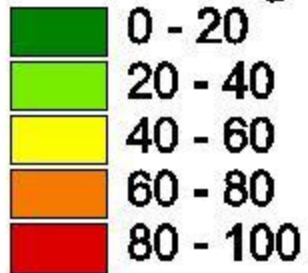   - monitoring wetland condition & ecological services

Nutrient concentrations in Great Lakes coastal wetlands

Total N
r=0.62

Total P
r=0.50
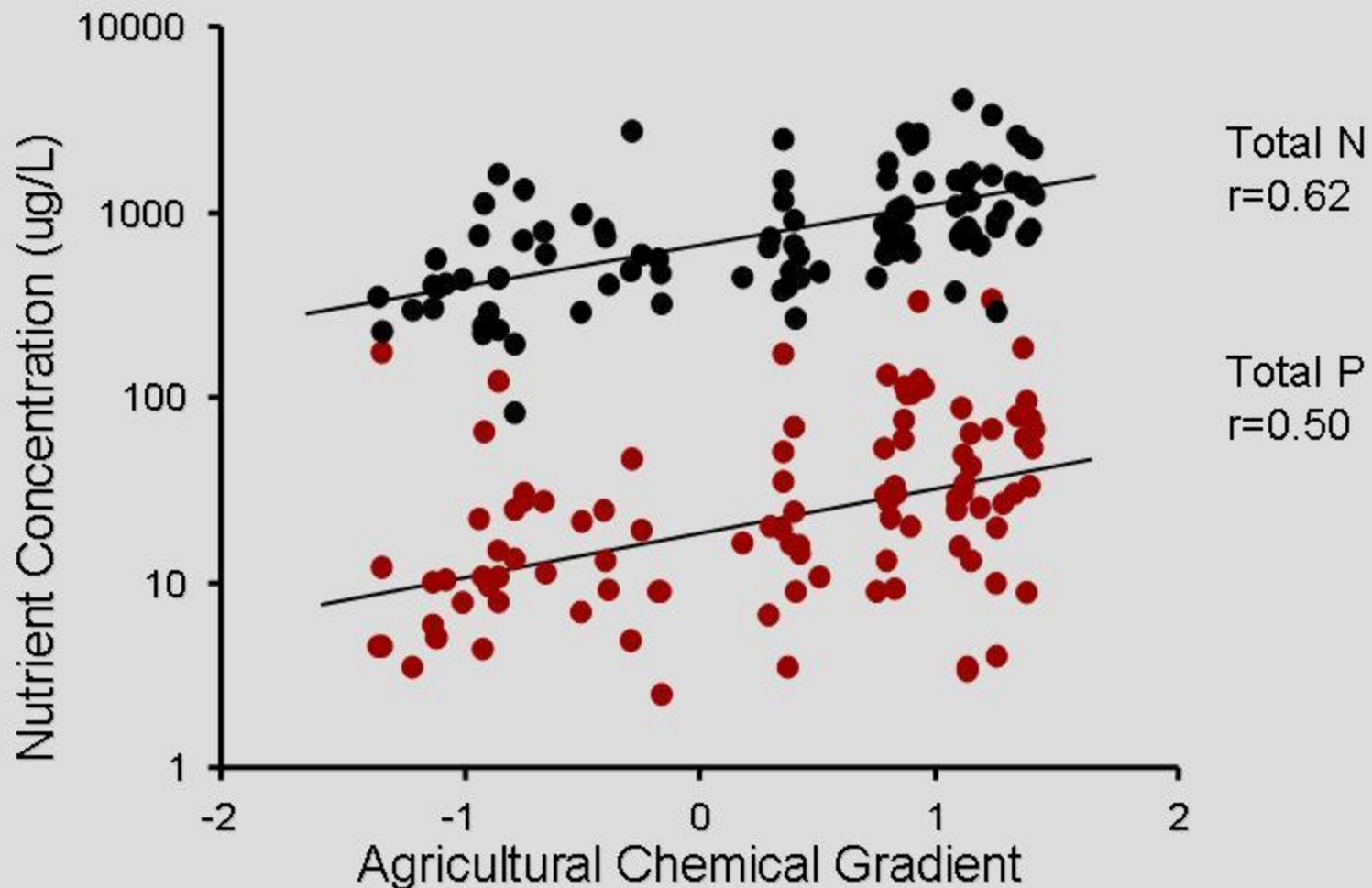
Proportion of Agriculture

Least

Most

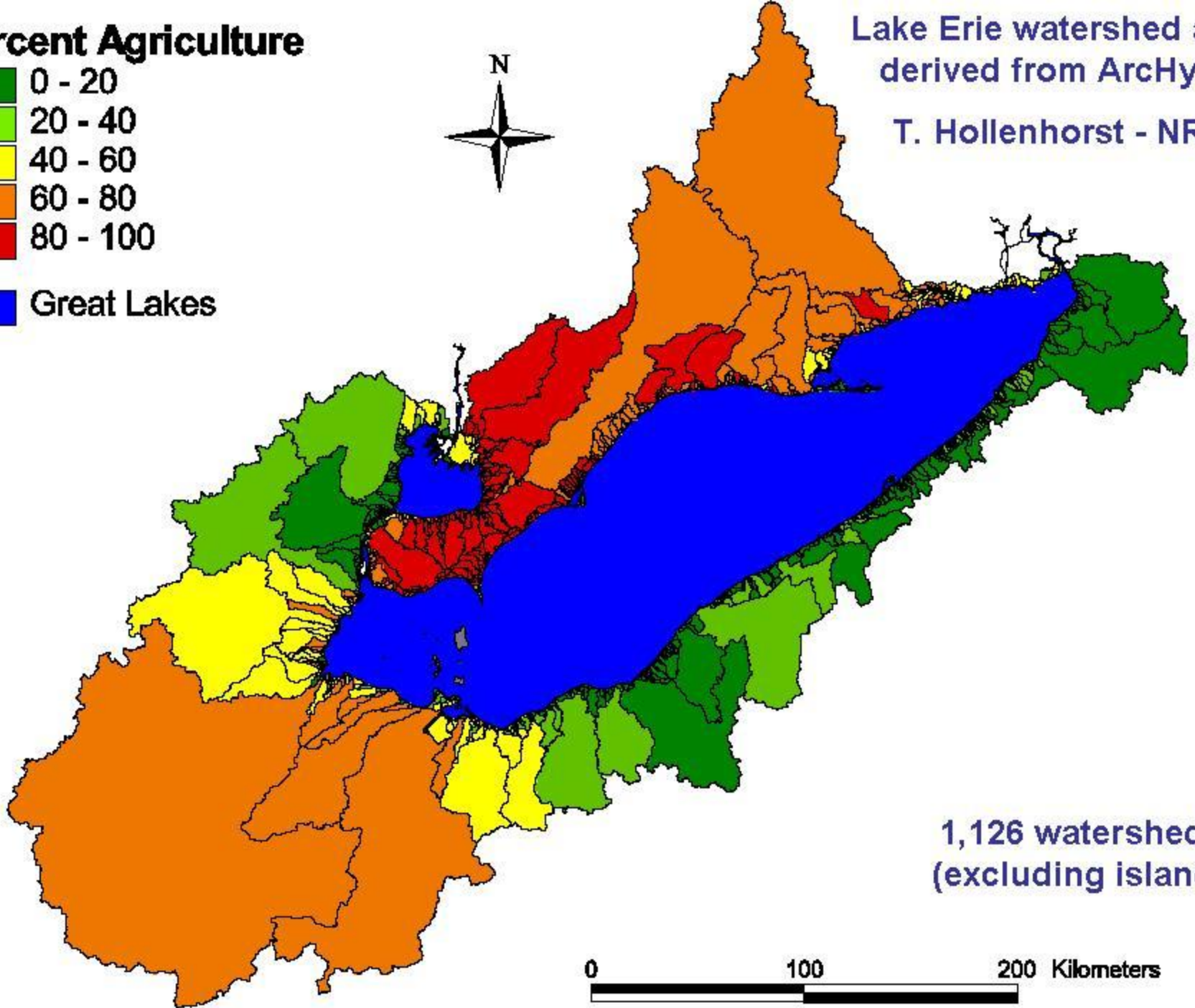**Percent Agriculture**
- 0 - 20
- 20 - 40
- 40 - 60
- 60 - 80
- 80 - 100

Great Lakes

N

Lake Erie watershed areas
derived from ArcHydro

T. Hollenhorst - NRRI

1,126 watersheds
(excluding islands)

0   100   200 Kilometers

Fuzzy Logic Model: Nutrient Dynamics
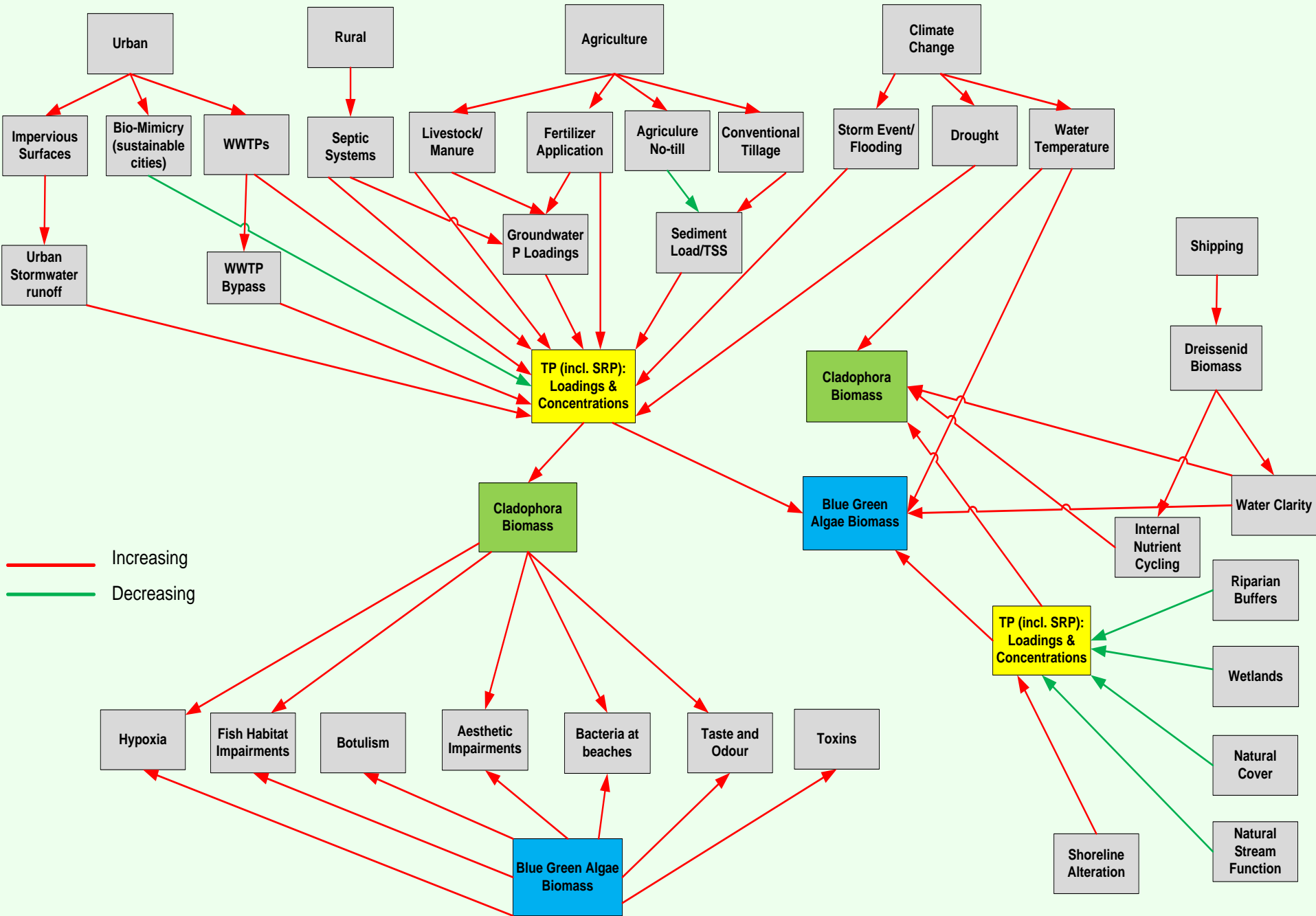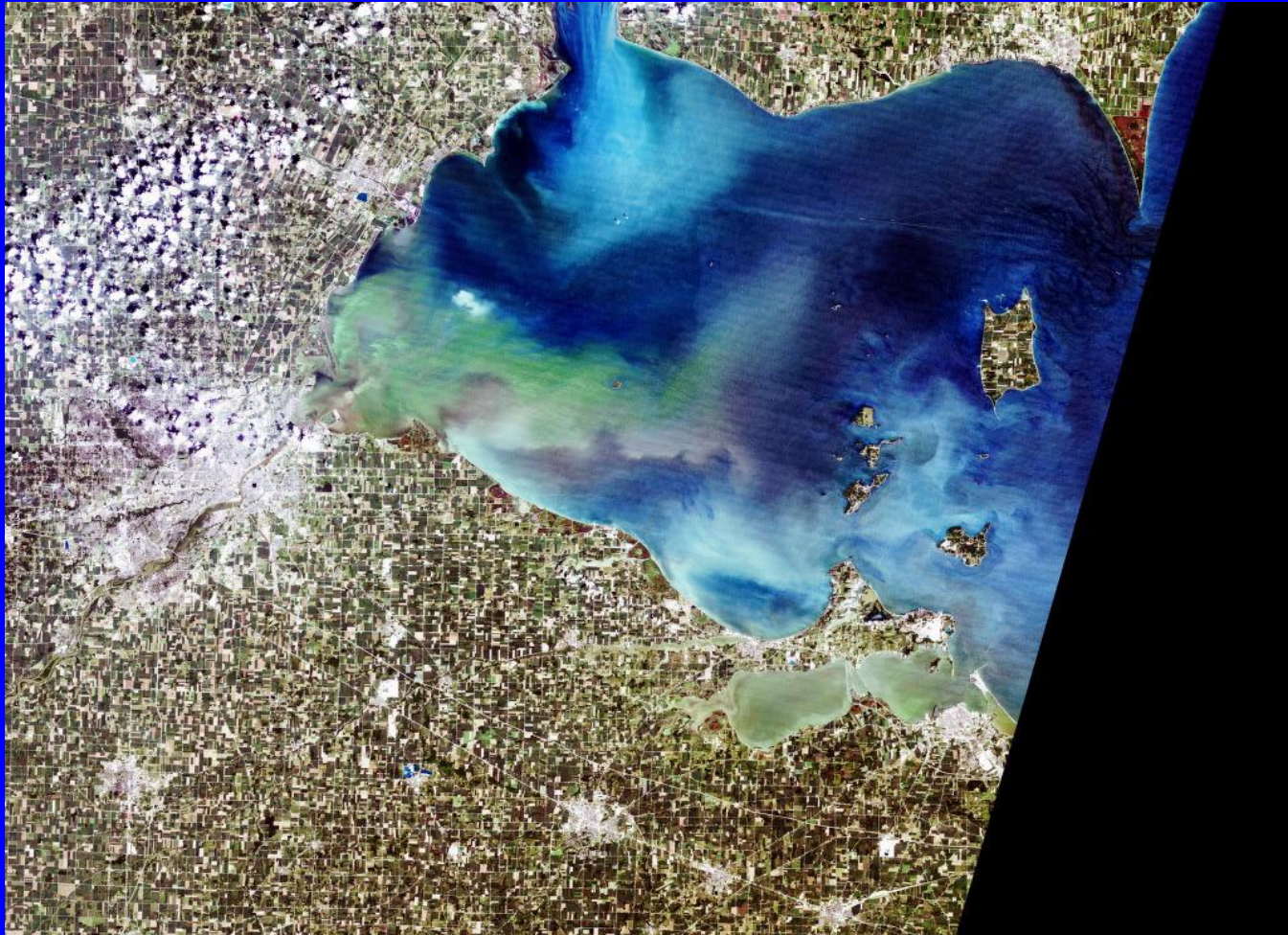
Western L. Erie 10 days after power failure; August 2003)

Distribution of *Dreissena bugensis* in Lake Erie

D. bugensis Density (No./m^2)

- ⬛ 0 - 10
- 🟦 10 - 100
- 🟩 100 - 1,000
- 🟧 1,000 - 10,000
- 🟥 > 10,000

N
W — E
S

0 12.5 25   50   75   100
Kilometers
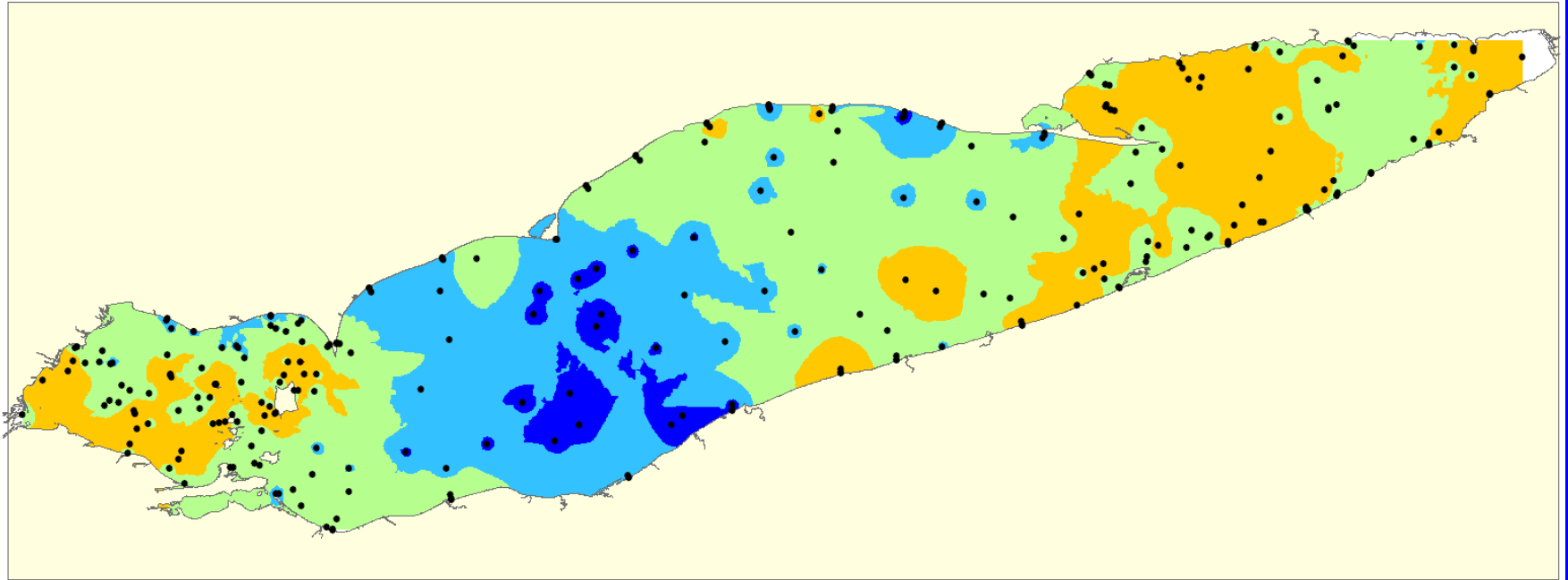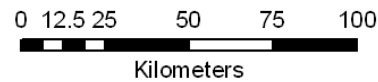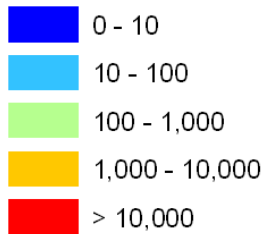
2004

"Management interventions and causal structure"

- To solve a problem, we have to understand the cause

- Successful management also requires understanding the causes

- Different management strategies can be seen as experiments to assess causes

Fuzzy Cognitive Map (FCM)

- A tool for representing the causal structure of a system
- Elements includes concepts (vertices) and relationships among concepts (arcs)
- The resulting FCM is (formally) a graph, and can be analyzed using various graph-theoretic techniques.

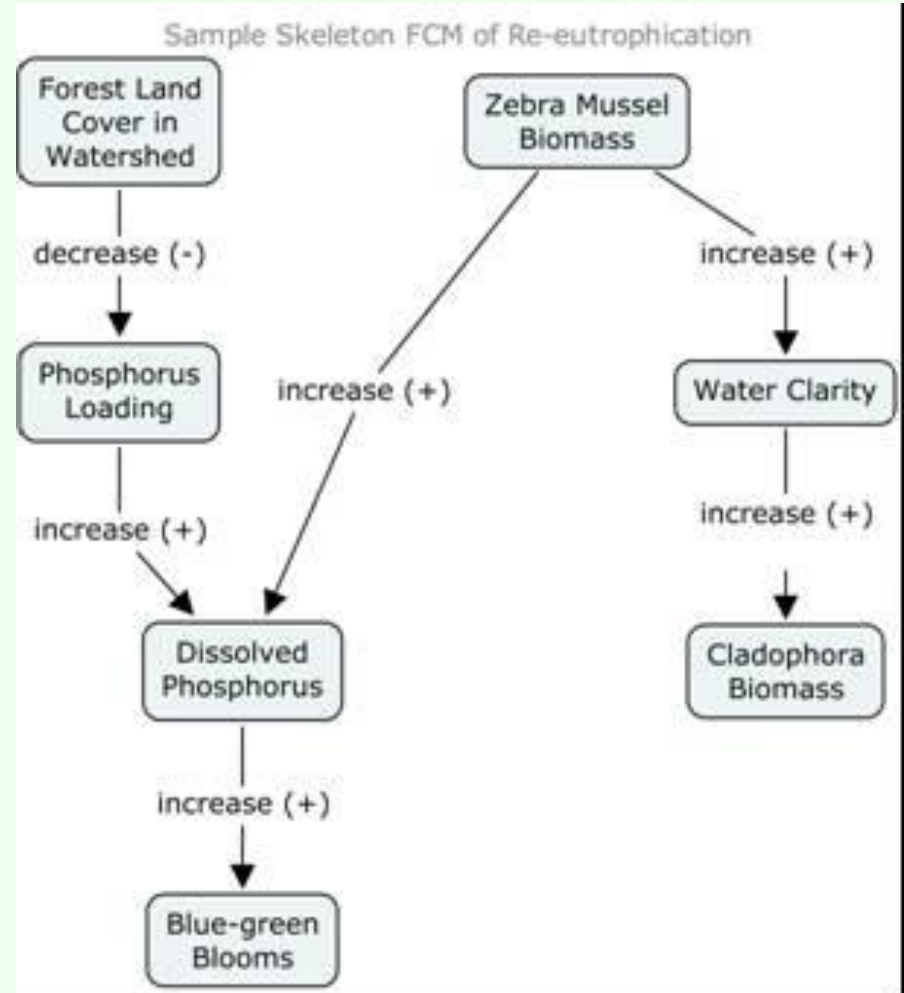 – S. Findlay

IJC-Sponsored Workshop February 2009

Sample Skeleton FCM of Re-eutrophication

Forest Land Cover in Watershed → decrease (-) → Phosphorus Loading → increase (+) → Dissolved Phosphorus

Zebra Mussel Biomass → increase (+) → Dissolved Phosphorus

Zebra Mussel Biomass → increase (+) → Water Clarity → increase (+) → Cladophora Biomass

Dissolved Phosphorus → increase (+) → Blue-green Blooms

Characteristics of "The Hairball"

Total number of approved FCMs contributing to the consensual map: **10**

After combining all unique propositions from each submitted FCM to form the consensual map, we have a final map (i.e. "the hairball"; Fig.1) comprised of:

62 concepts
forming
193 propositions

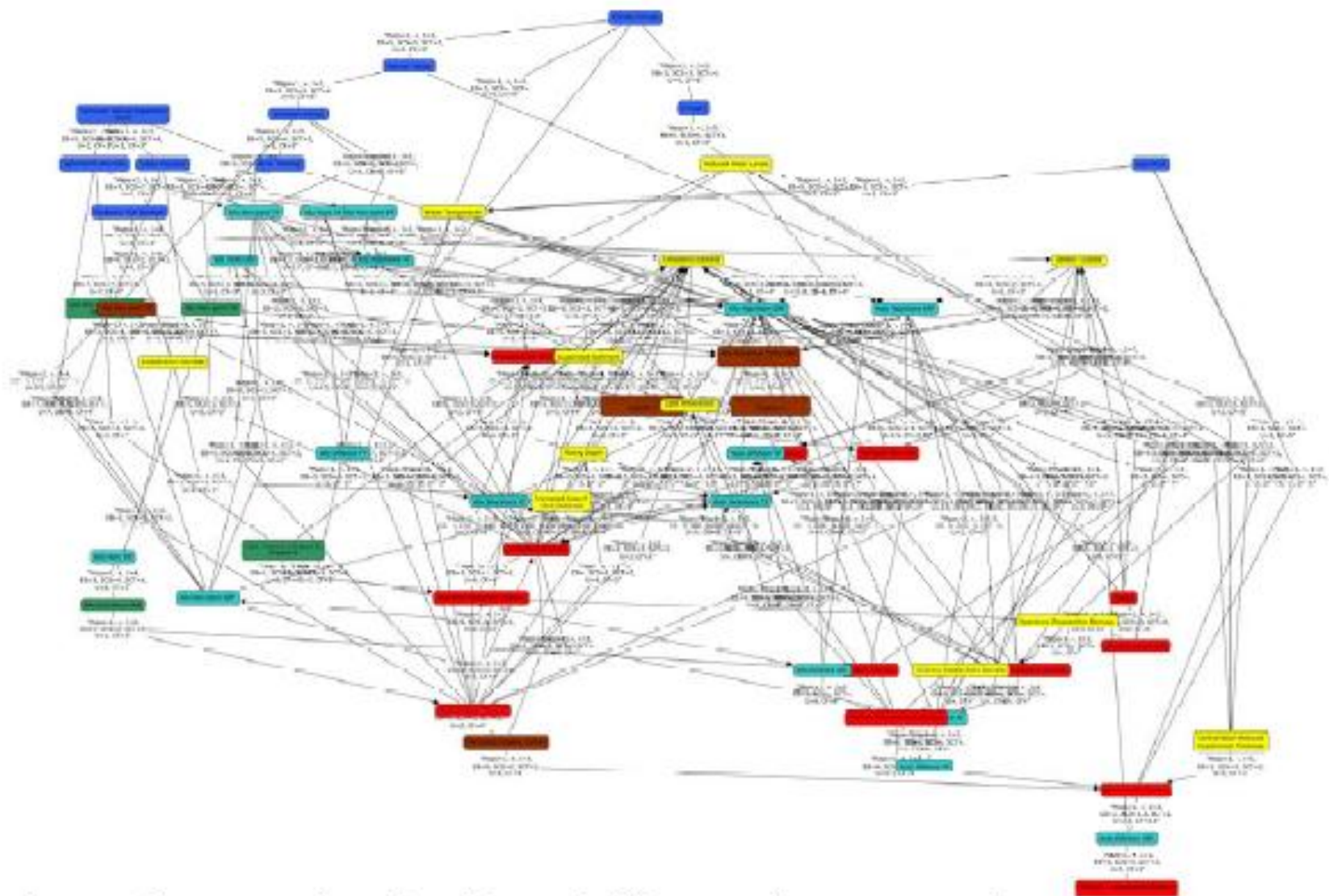**Figure 1.** The consensual map (i.e., "The Hairball"). Arc attributes represent the averages in situations when more than one map had that particular relationship. "Maps" = Number of maps that relationship was present on. Blue="Emitter"; Aqua=Phosphorus-related; Greenish=Nitrogen-related; Brown=Carbon-related; Red="endpoint"; Yellow=1 directly upstream from Endpoint and not already corresponding to another colour. See also CXL file.

Question 2. *Which concepts are most prevalent/interconnected within the consensual map? i.e. Which factors are connected to many other factors and processes in terms of the problem of re-eutrophication?*

Table 1. Number of propositions each concept appears in, within the consensual map. Concepts are ordered from most propositions to least; darker shading indicates more propositions.

| Concept	Total Number of Links
Dreissenid Biomass	25
Cladophora Biomass	22
Allo Nearshore SRP	20
Auto Nearshore TP	15
Cyanobacteria Biomass	14
Allo Non-point TP	13
Allo Non-point SRP	11
Phytoplankton Biomass	11
Auto Nearshore SRP	11
Benthic Grazers	11
Allo Nearshore TP	10
Nearshore Phytoplankton Biomass	10
Light Penetration	10
Water Temperature	10
Allo Nearshore Particulate Organic C	8
Offshore Phytoplankton Biomass	8
Auto Nearshore PP	8
Agricultural Activities	8
Reduced Water Levels	8
Nearshore Cyanobacteria Biomass	7
Hypolimnetic Hypoxia	6
Bacterial Biomass	6
Allo Non-point PP	6
Allo Non-point TN	6
Allo Offshore SRP	5
Nearshore Epibenthic Hypoxia	5

Question 4. Which concepts are primarily emitters?

Table 4. Concepts that are primarily "emitters" (i.e. those concepts that have few or no links in). There are 58 concepts that appear in the FROM column, in total. Ten of them appear only in the FROM column (i.e. not in the TO column).

Concepts that only have links OUT	Number of Links OUT
Allo Point SRP	5
Climate Change	4
Allo Point TP	3
Increased Natural Vegetation Cover	3
Less Wind	3
Predatory Fish Biomass	2
Allo Point TN	1
Nearshore Zooplankton Biomass	1
Offshore Zooplankton Biomass	1

Concepts that have only one link IN	Number of Links OUT
Agricultural Activities	7
Reduced Water Levels	7
Increased Rainfall	4
River Flooding	4
Allo Non-point Dissolved Organic N	3
Urban Activities	3
Zooplankton Biomass	3
Mixing Depth	2
Warmer Winter	2
Allo Nearshore Dissolved Organic C	1
Allo Non-point TC	1
Auto Nearshore Dissolved Organic C	1
Drought	1
Increased Area of Hard Substrate	1
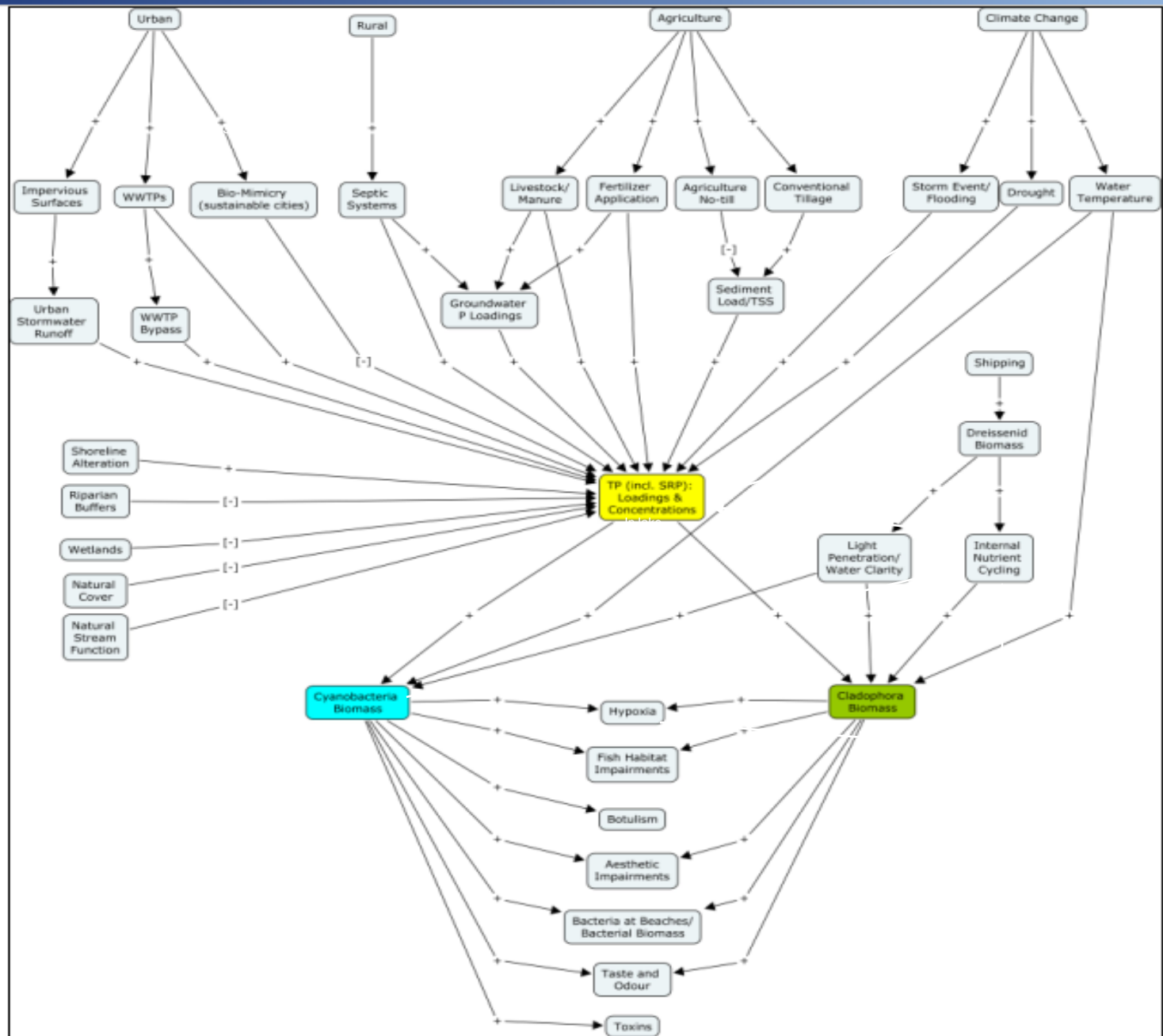
Concepts ('boxes'): Descriptors of the system.

Drivers ('from' concepts)   and Recipients ('to' concepts)
Restriction for FCM: Ordinal concepts (must have a "size")

Problem Term: "Soil Type"
**   (important variable, but categorical)**

Solution: Describe ordinal attributes
**   - Soil permeability**
**   - Soil carbon content**

"Arcs" (Arrows): Relationships within the system

Attributes: Describe the strength of the <u>relationship</u>,
(not the importance of the driver or the recipient)

Sign:	**+ = positive**	**= negative**
Importance/strength	**1 = unimportant**	**5 = very important**
Certainty	**1 = not sure about**	**5= very sure about**
Spatial extent	**1 = rel. is local**	**5 = relationship holds everywhere**
Temporal extent	**1= rel. rarely occurs**	**5 = relationship always hold**
Change_feasibility	**1 = uncontrollable**	**5 = very controllable**

Procedure for Drawing FCMs

1. review deck of concept cards
2. select cards (words) deemed relevant to your map.
3. Using pencil and paper or concept cards, arrange cards (keywords) to form a flow chart
4. (If no card/key word exists for a concept, please tell a facilitator, and we'll create one or suggest an equivalent term)
5. Write your team number prominently in a corner of the map
6. Draw lines/arrows/pathways from each card (keyword) "to" other cards (keywords) that are directly influenced. The 'from' card is considered a 'driver' or 'emitter'. The 'to' card is considered to be a 'recipient' or 'receiver'.
7. Draw an arrowhead indicating direction of influence.
7a. If you think there is a feedback loop between two cards, draw two lines; one going from A to B, and the other going from B back to A.
8. Provide information on relationships. for each line,

> Identify the card: indicate
>> team number,
>> "Driver" card number
>> "Receiver" card number
> Place a value in each box on the card (see diagram)
>> **sign** of the relationship;
>> **strength** of association,
>> **spatial** extent,
>> **temporal** extent,
>> our **understanding** of relationship,
>> potential for **management**

9. When the map is complete, tell a facilitator, who will photograph or scan your map.

The Nearshore and Offshore Lake Erie Nutrient Study (NOLENS) (EPA GLNPO funded)

Sources & transport of bioavailable phosphorus (Winston et al.)

Central & eastern basin studies of nearshore/offshore nutrient pools, fluxes and their interactions (Pennuto et al.)
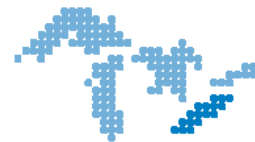
Movement of phosphorus from agricultural fields (Mullen et al.)

Linking soil test phosphorus with agricultural runoff phosphorus (Dayton et al.)

Connecting phosphorus load, transport, and biological use: how does *Microcystis* use phosphorus and where is the bloom trigger point? (Conroy et al.)

Lake Erie Algal Source Tracking (LEAST) (Bridgeman et al.)

http://www.LEMN.org

Lake Erie Regional Research and Information Network

2001

Lake Erie Millennium Network | The Network | Workshops | Conferences | Resources

Welcome to the new Lake Erie Millennium Network website...click here to find out about the network.

The Lake Erie Millennium Network is a series of events dealing with Lake Erie environmental issues. It is a cooperative approach, benefiting from the expertise and concerns of the public, regulatory agencies and the academic community.

Our goal is to define and understand Lake Erie's most pressing problems, propose solutions, and track the changes.

The Lake Erie Millennium Plan (LEMP), was initiated in 1998 by scientists at the University of Windsor, National Water Research Institute - Burlington, F.T. Stone Lab of Ohio State University, and US-EPA Large Lakes Lab at Grosse Ile, MI, to foster and coordinate research that will identify and solve basic ecological questions relevant to the Lake Erie Ecosystem through a binational, collaborative network.

Lake Erie News

State plans to offer quieter experience at 2 Lake Erie islands - Akron Beacon Journal

Wildlife Officials, Residents Concerned About Major Lake Erie ... - WIVB

Lake Erie vs Waynesburg (Sep 01, 2006) - Waynesburg College Athletics

Lake Erie helicopter rescue for Michigan family members - WLNS

Boaters rescued during trip to cross Lake Erie - Toledo Blade

GLRC News

WETLANDS TO SLOW OR GROW GLOBAL WARMING?

TREES UNDER THE INFLUENCE OF OZONE AND CO2

STEERING CARS OUT OF NATIONAL PARKS

CALI OUT FRONT ON GREENHOUSE GAS REGS

FISH-EATING BIRD DISRUPTING FOOD CHAIN

GLIN News

GLIN Daily News

Wisconsin mute swans are safe until January

Isle Royale: island wilderness

Could bills lead way to oil drilling in the Great Lakes?

Safety equipment slow to appear on waterfronts