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

Goal of workshop

In 2009, a series of flow charts (fuzzy cognitive maps (FCMs))) was created by participants in an IJC-sponsored workshop, as well as a Lake Erie LaMP workshop, dealing with the issue of re-eutrophication in the Great Lakes (see **http://www.ijc.org/en/priorities/2009/reports/2009-eutrophication.pdf**). The diagrams are designed to help us represent our understanding of the causes of recent increases in eutrophication that seem to be appearing in the Great Lakes.

Among the findings of that workshop, two points were evident. Although the problem is affected by both external forces (changes in the land) and internal processes (changes in lake ecosystem structure), "agricultural activities" appeared to be one of the main external drivers of the reappearance of eutrophication. Limited time, and a desire to work at the scale of the whole Great Lakes basin meant that the role of agricultural impacts on eutrophication could not be assessed to the degree of detail that was warranted.

We recognize that

- agricultural activities likely play a major role in eutrophication, especially in the Lake Erie ecosystem, and
- practices related to agriculture are likely more amenable to 'no regrets' management actions than other possible causes of the eutrophication issue.

This workshop will further develop our understanding of the causes and consequences of the reappearance of eutrophication of portions of the Great Lakes, with emphasis on the role of agricultural activities in Lake Erie. The goal will be to develop a detailed fuzzy cognitive map that focuses on the agriculture-related, land-based pathways and variables that have the potential to drive eutrophication in Lake Erie

Fuzzy cognitive maps (FCMs) are a way of representing the causal structure of a system. Flow charts (the "maps") consist of two elements: "concepts" (represented by boxes or ellipses) and "relationships" (directed arrows that link two or more concepts). A 'consensual' map combines the information from individuals who contribute information from a variety of backgrounds and perspectives.

We hope that the consensus FCM, derived from the individual FCMs produced at this workshop will better help us represent the land-based activities contributing to the Lake Erie eutrophication problem.

Workshop activities

Before the workshop. Activities at two earlier FCM workshops generated a list of the key terms (concepts) that seem to describe most of the possible causes, pathways and endpoints of agriculture-related nutrient contribution to Lake Erie. The words in this list will be the 'building blocks' from which we'll work to build the maps. We will distribute the list to conference participants before the workshop.

Activity 1 (Prior to the workshop) During a conference call approximately one week before the workshop, we'll review the concepts and methodology, and poll participants on the completeness of the list.

Activity 2. (***Morning of the workshop)***

- Working from the list, or a deck of labeled cards, participants will select the terms they believe are necessary to develop their own FCM (the terms are the FCM "concepts"). Additional terms that are proposed will be reviewed by the group to ensure that everyone is aware of the common set of concepts.

- Participants will work alone or in groups, as preferred, to arrange their personal lists of key terms into a flow chart (FCM). Participants will draw arrows between the concepts, representing the relationships (cause & effect) between variables.

- Participants will then assign 'values' that indicate the direction and estimated strength of the relationship. Where possible, other attributes of the relationship will be assessed - spatial extent, temporal extent, certainty of understanding, and amenability to management (see Table 1).

Activity 3. (Afternoon of the workshop) Once individual FCMs have been drawn, we will work as a group to review the information in the individual maps and assess the most important relationships.

By the end of the workshop, we hope to have a single, consensual fuzzy cognitive map that depicts

- our understanding of the role of agricultural activities in driving eutrophication
- the key pathways that are well understood, and those that need more assessment
- the pathways that are most likely to be responsive to "no regrets" management actions
- the potential for no regrets management actions to reduce eutrophication in Lake Erie

Table 1. Arc attributes, rank, description and potential attribute values/scores.

Attribute	Symbol #	Description	Attribute values/score (for all scaled attributes, 0 = NA)
Sign (S)	1	The sign (+ or -) of the relationship between A and B. A + sign on the arrow from A to B means that an increase (or decrease) in the level of A will result in an increase (or decrease) in the level of B. A - sign on the arrow means that an increase (or decrease in the level of A will cause a decrease (or increase) in B.	"+" or "– "
Strength of Association (A)	2	The degree to which A influences B	Scale from 1 -5; 1 = correlation is very weak, or seldom observed 3 = relationship may be statistically significant but is not very predictive 5 = correlation/cause-effect link is very strong
Spatial Extent (SE)	3	A low spatial extent means that the effects of the relationship of A on B are very localized; or the relationship between A and B is restricted to small areas A high spatial extent means that the relationship between A and B holds and can be observed in many places Examples: Winter ostrich manure spreading in winter → P concentration in stream (spatial extent = 1) Rainfall on land → volume of water in stream (spatial extent = 5)	Scale from 1 -5 1 = effect of A on B is very localized; or the relationship is relevant in only small parts of the basin 3 = relationship holds in many but not all places 5 = relationship holds wherever A and B are observed; and A is important everywhere in the basin
Temporal Extent (TE)	4	A low temporal extent means that the relationship between A and B rarely holds; or A rarely changes enough to have a meaningful effect on B A high temporal extent means that the relationship between A and B always holds and changes A almost always produced meaningful effect on B Examples: Conservation tillage → sediment in streams (sign = 1; Temporal extent = 5)	Scale from 1 -5, with 1 = changes in A causing an effect on B seldom occur [either A seldom changes; or changes in A seldom greatly influence B); 3 = changes in A are sometimes (but not always) great enough to cause a meaningful change in B; often but not always observed 5 = relationship holds whenever A and B are in a position to covary
Certainty/under-standing of relationship (C)	5	The extent to which we understand the relationship between A and B Examples: Strong wind events in fall → western basin algal blooms (1) No till conservation → sediment in streams (5)	Scale from 1 -5, 1 = empirical; no or weak explanation for the relationship 5 = certainty; B is a logical consequence of A, or mechanism of relationship is well-known
Potential for Management (M)	6	The ease with which the 'causal variable' (A) could be 'managed' or altered (with available technology) in a way that would meaningfully influence "B" Examples: Dreissenid density in nearshore → SRP excreted (1) Winter application of manure → winter P in streams (5)	Scale from 1 –5 1 = value of A cannot be managed in a way that will meaningfully influence B 5 = value of A can easily be managed/controlled in a way that will meaningfully influence B

All information pertinent to the workshop will be posted on the following website for invitees:

http://web2.uwindsor.ca/lemn/March2010AgFCMWorkshop4.4.htm

FCM Definitions and Terminology

Fuzzy Cognitive/Conceptual Map (FCM): A tool for schematically representing causal relationships within a system. A qualitative model of how a given system operates.

Concept (node, vertex): A "box" in a FCM. Represents a factor or process.

Arc: An "arrow" in a FCM. Depicts a causal relationship between two factors or processes.

Proposition (link): Two concepts connected by an arc, depicting the effect one concept has on another concept.

Arc attributes: Descriptors assigned to an arc, describing the relationship (e.g. directionality, strength). For this exercise, we will be using seven attributes: Sign, Importance/Strength, Evidence base, Spatial scale, temporal scale, Universality, and Change feasibility.

Consensual map: The union of individual maps.

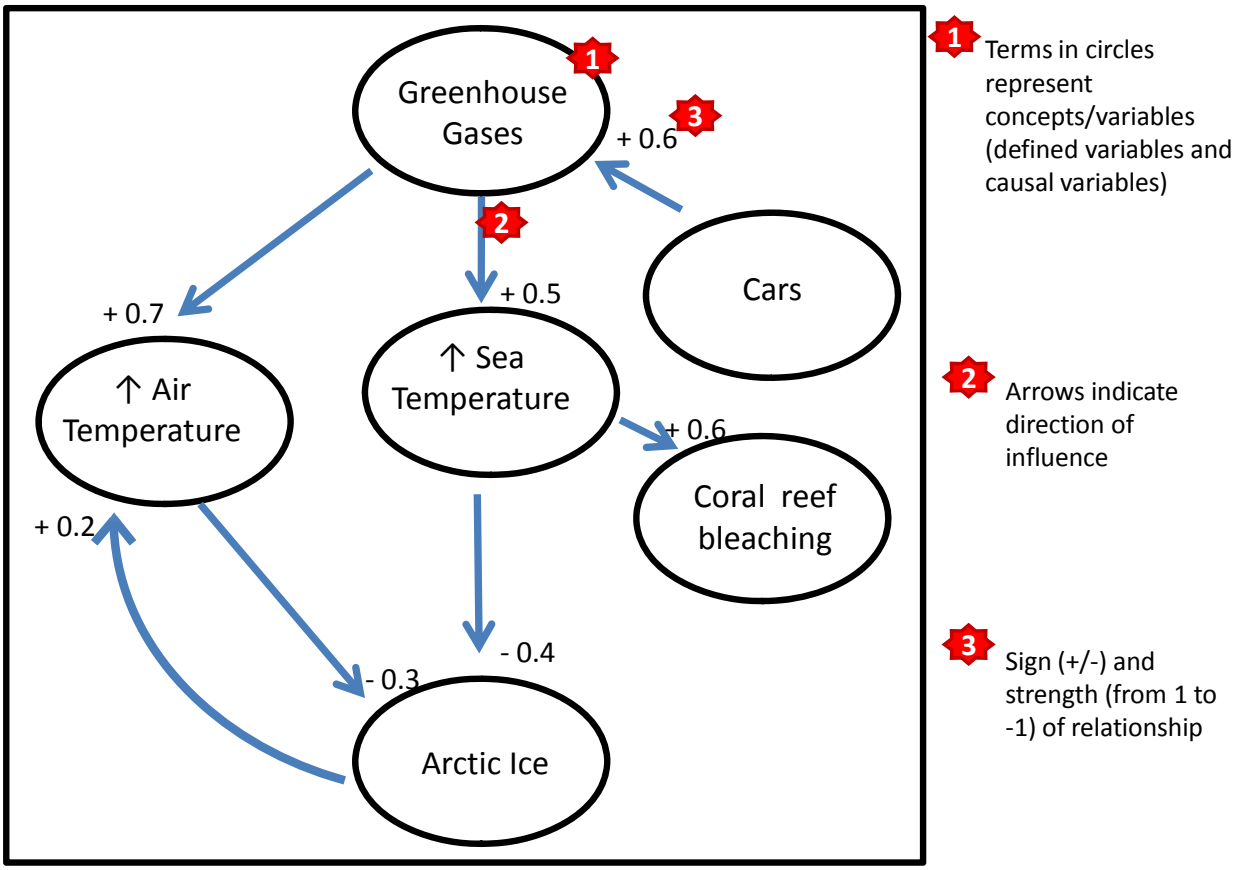
Fuzzy Cognitive Map: A simplified Example

Problem: What are the causes and effects of climate change?

Step 1: Choose a subset of terms from list of key terms

List of key terms provided	Subset of terms (ones selected in blue, ones discarded in grey)
Greenhouse Gases	**Greenhouse Gases**
Unicorns	Unicorns
Number of Cars	**Number of Cars**
Helium Balloons	Helium Balloons
↑ Sea Temperature	**↑ Sea Temperature**
Cats	Cats
Polka dancing	Polka dancing
↑ Air Temperature	**↑ Air Temperature**
Coral reef bleaching	**Coral reef bleaching**
Increased Commercial Fishing	Increased Commercial Fishing
Amount of Arctic Ice	**Amount of Arctic Ice**

Step 2: Create individual fuzzy cognitive map based on personal expert opinion



Next step: **Compare and discuss this map with other participants**

Final step: **Develop consensus map**