World Sustainability Forum

USING FUZZY COGNITIVE MAPPING AS A PLANNING TOOL FOR URBAN WATER QUALITY: A CASE STUDY OF URBAN PHOSPHORUS FLOWS

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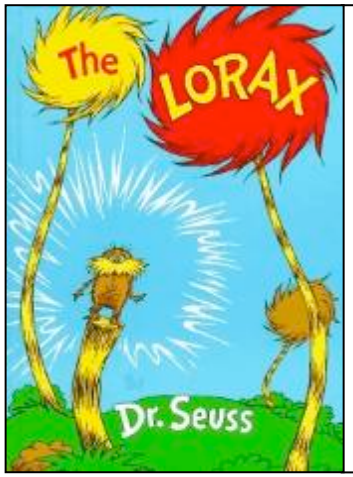
The Great Lakes Water Quality Agreement – *centerpiece of action*



"You're glumping the pond where the Humming-Fish hummed!
No more can they hum, for their gills are all gummed.
So I'm sending them off. Oh, their future is dreary.
They'll walk on their fins and get woefully weary
in search of some water that isn't so smeary.
I hear things are just as bad up in Lake Erie."

— The Lorax, by Dr. Seuss

GLWQA Annex 4 Nutrients Commitments

- Lake Ecosystem Objectives
- Establish phosphorus objectives, loading targets and allocations for each lake
- Implement programs and other measures to manage excess phosphorus
- Identify priority watersheds for nutrient control and develop management plans for these watersheds
- Develop phosphorus reduction strategies and domestic action plans

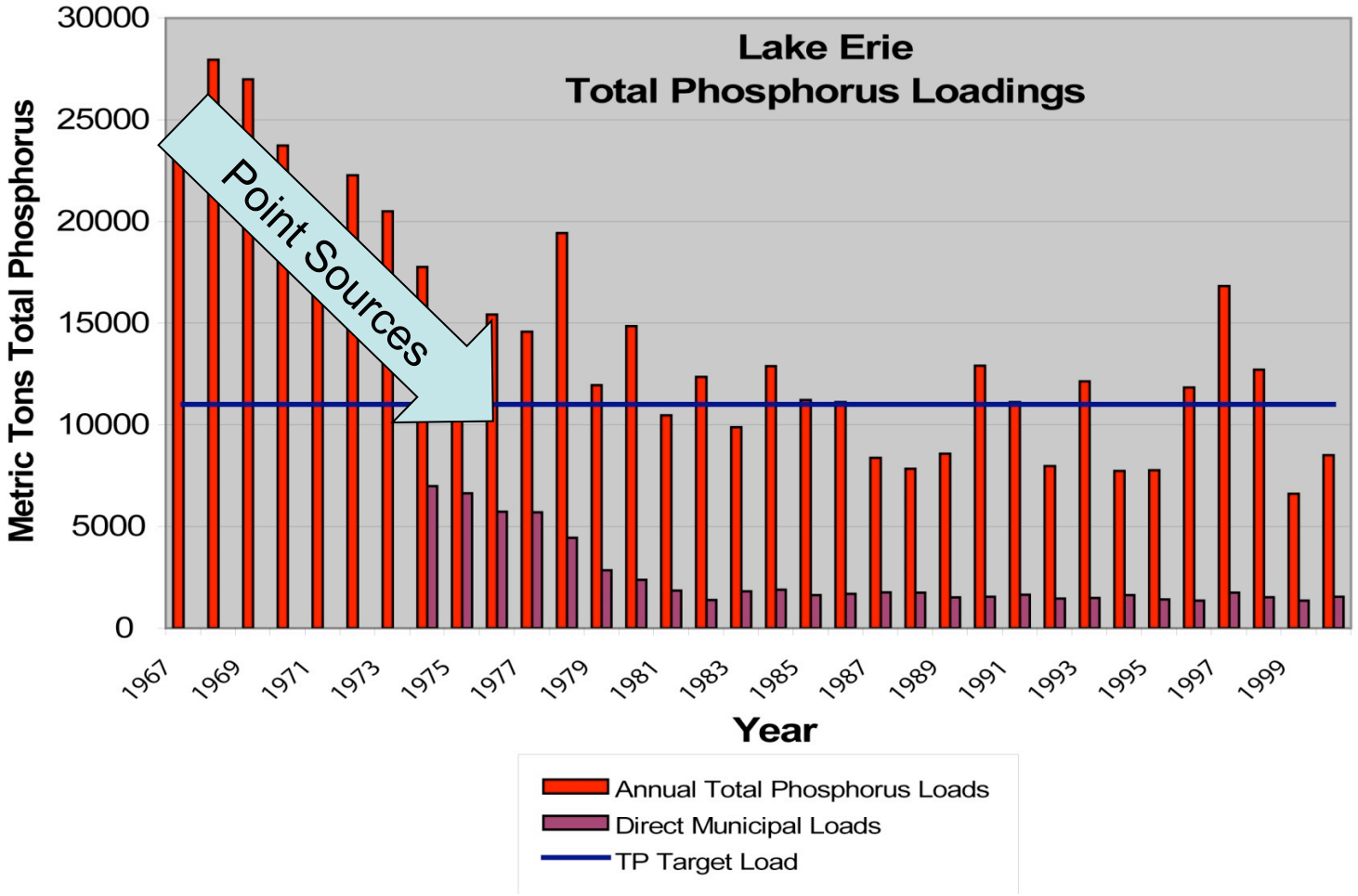


Phosphorus Essentials

- Essential for life, crucial for global food supply
- We contain approx. 1.5 kg of P
- No known substitute
- Cannot be manufactured, cannot be destroyed
- We excrete 3-4 grams daily in urine
- Cows, hogs excrete 15 – 20 times that amount
- 95% of high quality, economically recoverable P in 5 countries, a group that does not include Canada

Courtesy of D.S. Mavinic, UBC

Phosphorus Loads Have Decreased



Total Phosphorus loads to Lake Erie from 1967 – 2001. Estimated direct municipal loads are also presented for the period of record (1974 – 2001).

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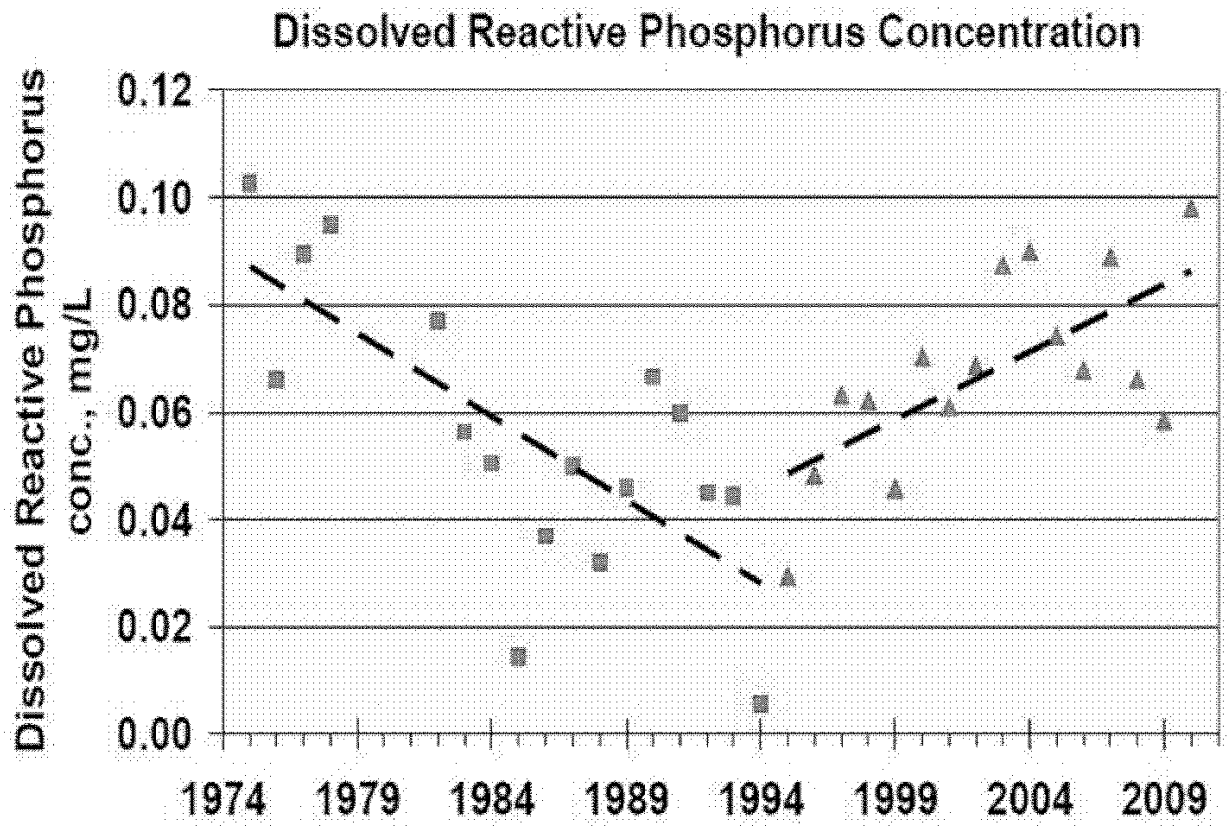
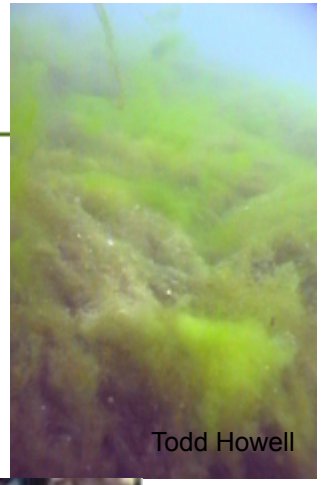
Figure prepared by Annex 3 Technical sub-group

Canada

What changed?



Excessive Nutrients


Todd Howell

Efforts in the 1970s to reduce phosphorus loadings were largely successful. However, an increase in dissolved phosphorus has led to a re-emergence of excessive algae and cyanobacteria blooms in the Great Lakes.

- The increasing proportion of the total phosphorus is dissolved and thus biologically available to fuel nearshore algal blooms.
- *Cladophora* fouling of shoreline has been reported for Lakes Huron, Michigan, Erie and Huron.
- Cyanobacteria blooms occurring in Lakes Michigan, Huron, Erie, and Ontario.
- *Plectoma Lyngbya* blooms identified in the western basin of Lake Erie.

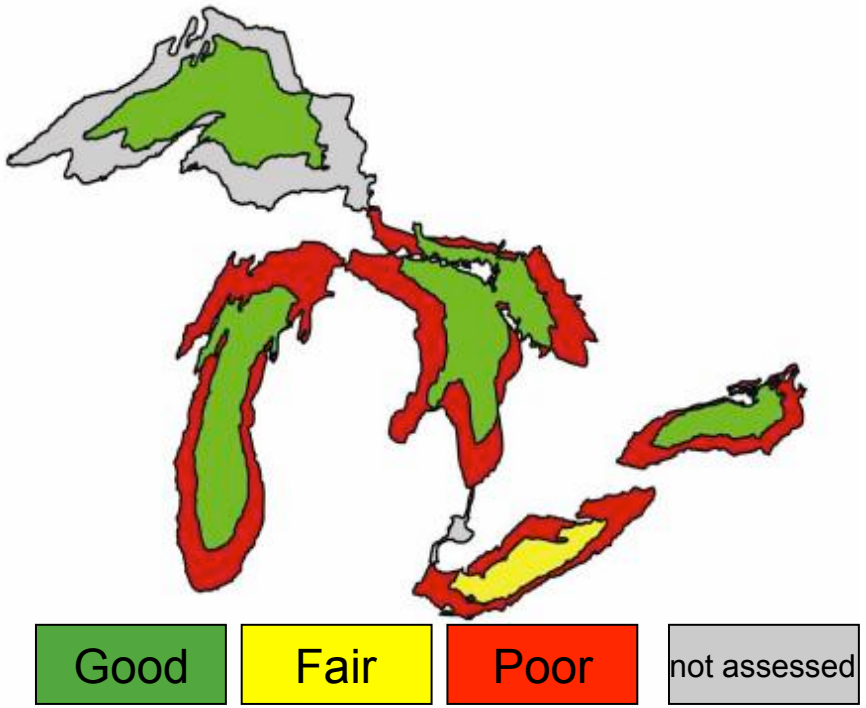

Scott Higgins

Phosphorus Stress in the Great Lakes

Total Phosphorus in the Nearshore

Lake Huron and Lake Ontario: some nearshore areas and embayments experiencing elevated levels

Lake Erie: extensive lawns of *Cladophora* are common place over the Eastern nearshore lakebed



Status of phosphorus can be quite different between the nearshore and offshore waters of each lake

Urban Land-Eutrophication Linkage

Land cover

Agriculture

Population density

Atmospheric deposition

Point source discharge

Shoreline modification

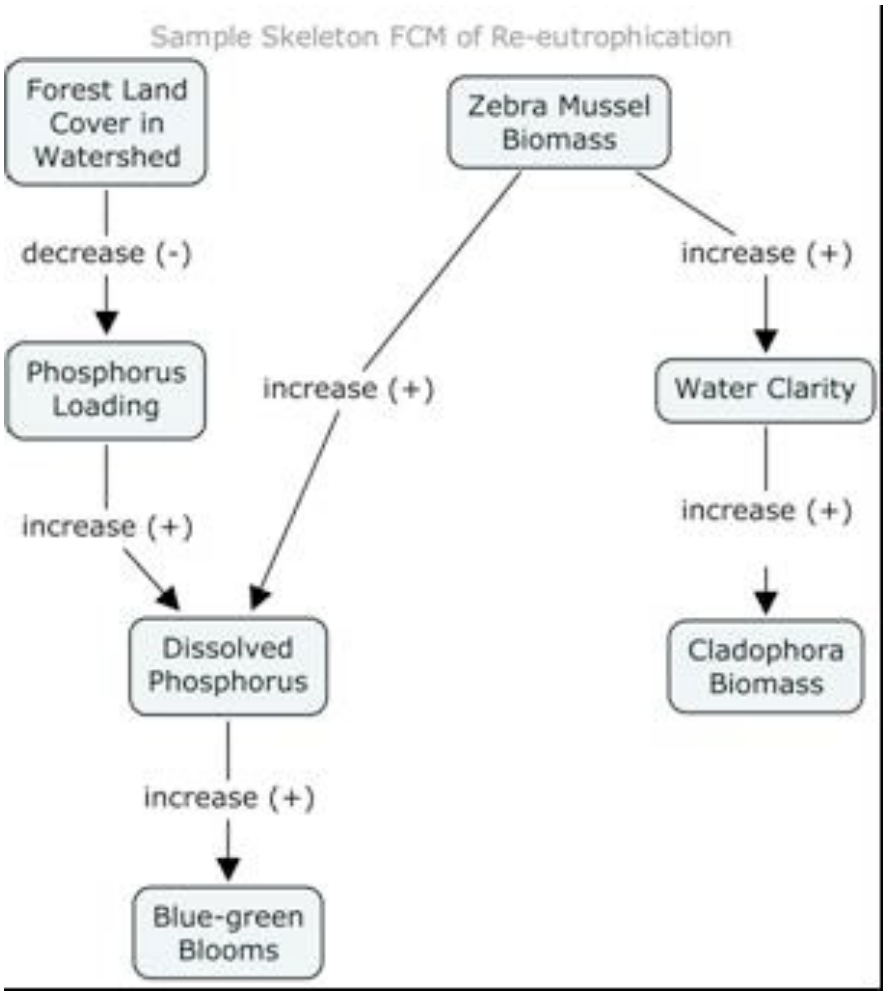
How do we Account for Stress Types?

Urban Land-Eutrophication Linkage

Fuzzy Cognitive Map (FCM)

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

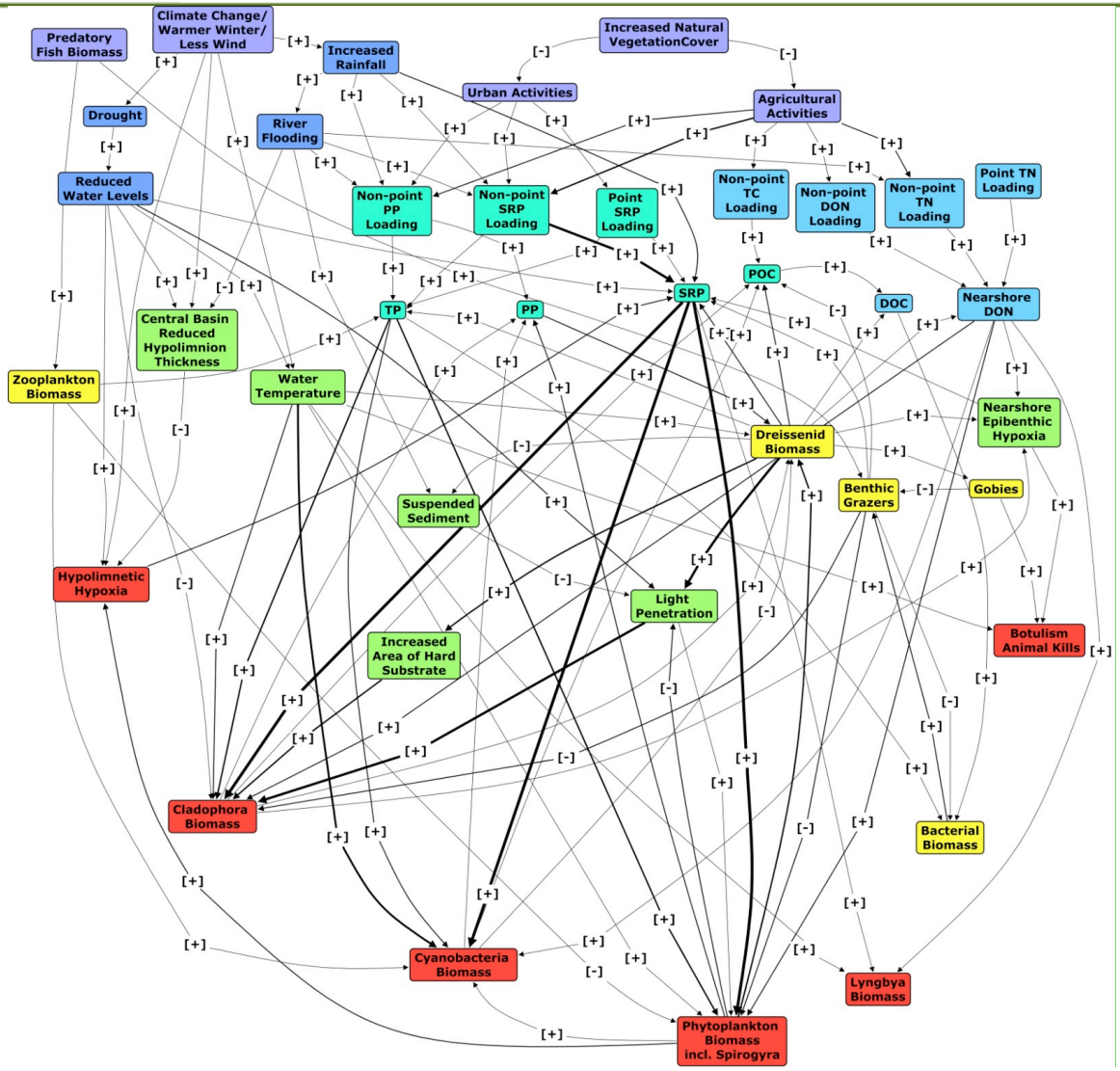
  – S. Findlay



IJC-Sponsored Workshop
February 2009

Lake Erie Consensual Map

IJC-Sponsored Workshop February 2009



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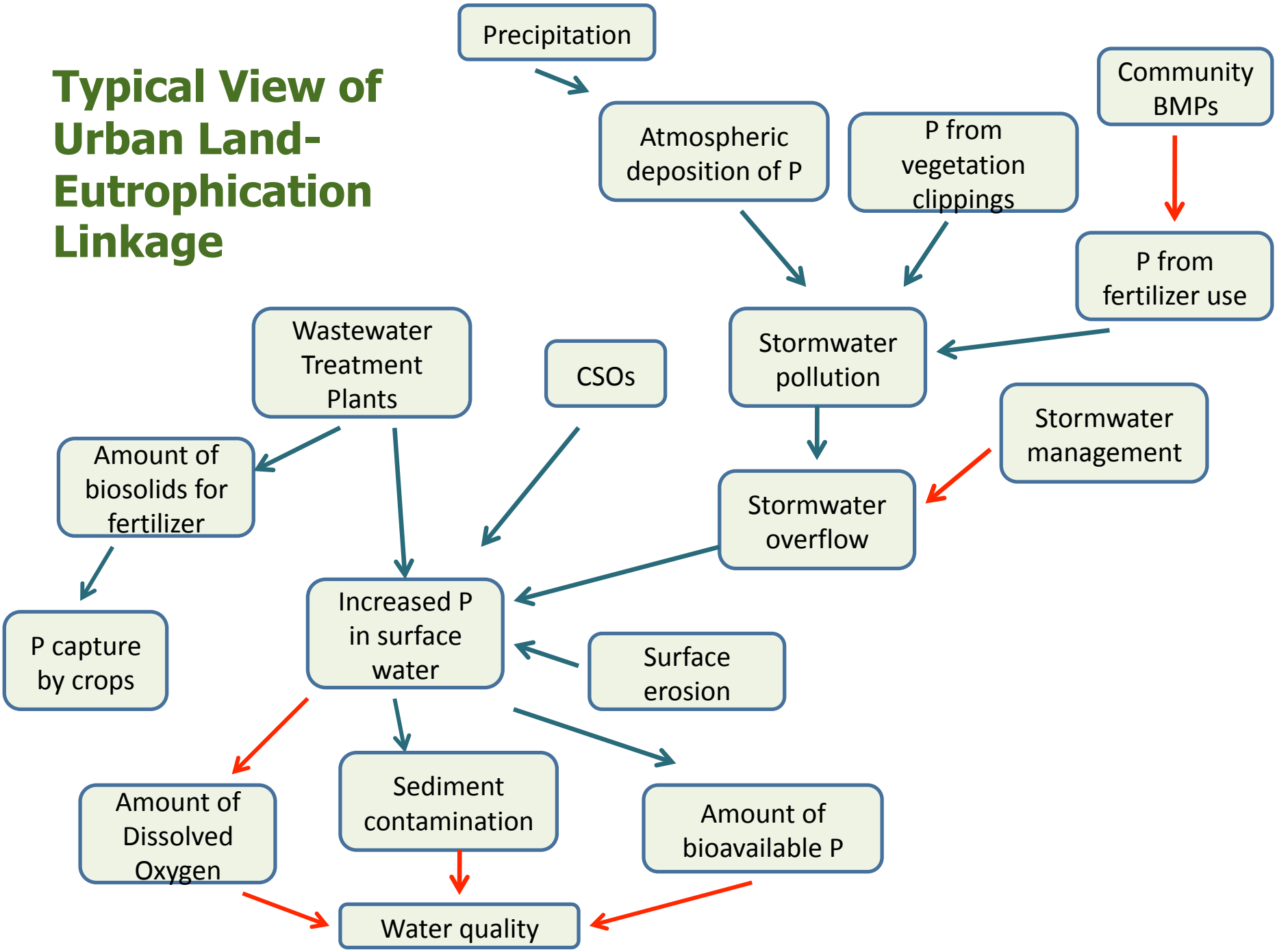
Typical View of Urban Land-Eutrophication Linkage

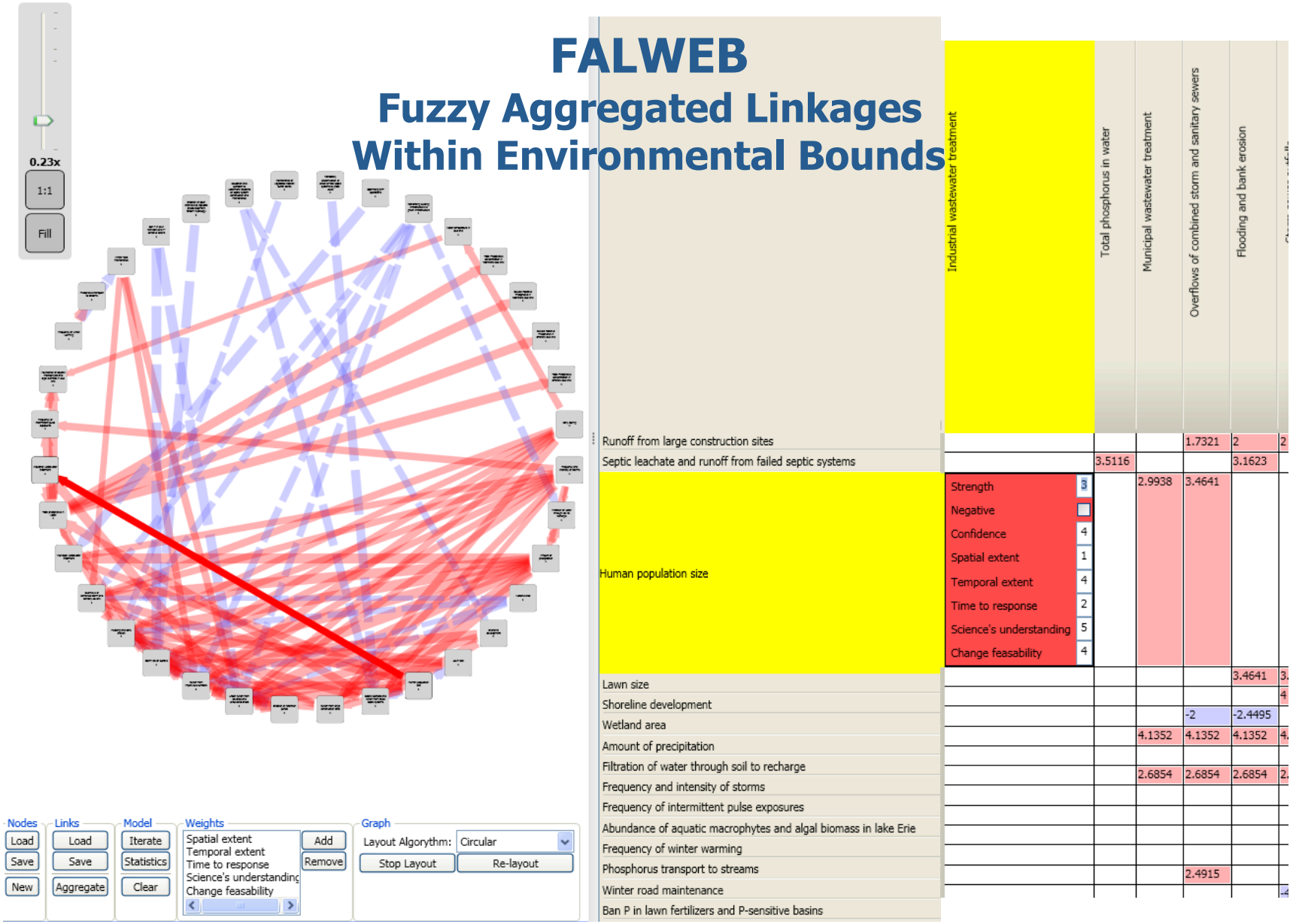


Urban Land-Eutrophication Linkage

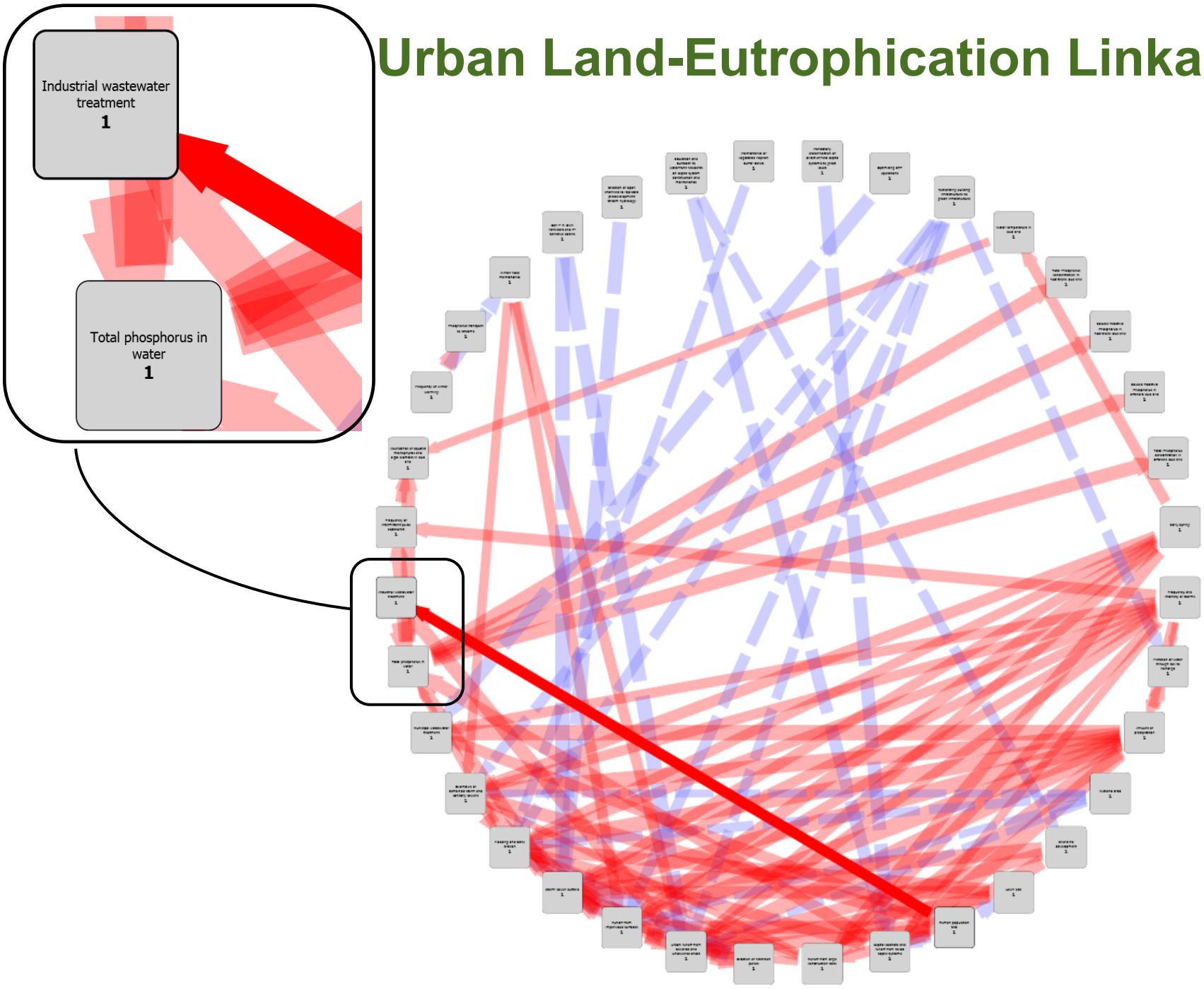
Variable Class	Number of Candidate Urban FCM Variables
Runoff Sources	17
Urban Attributes	18
Environmental Covariates	8
Measures/ Sources of Urban-Derive… Phosphorus	
Measures of Urban A…	20
Urban Manag… …actices	25
Biologica… …ures in Lake Erie	7
Environmental Covariates in Lake Erie	5
Measures of Phosphorus in Receiving Waters	12

Total of 125 variables

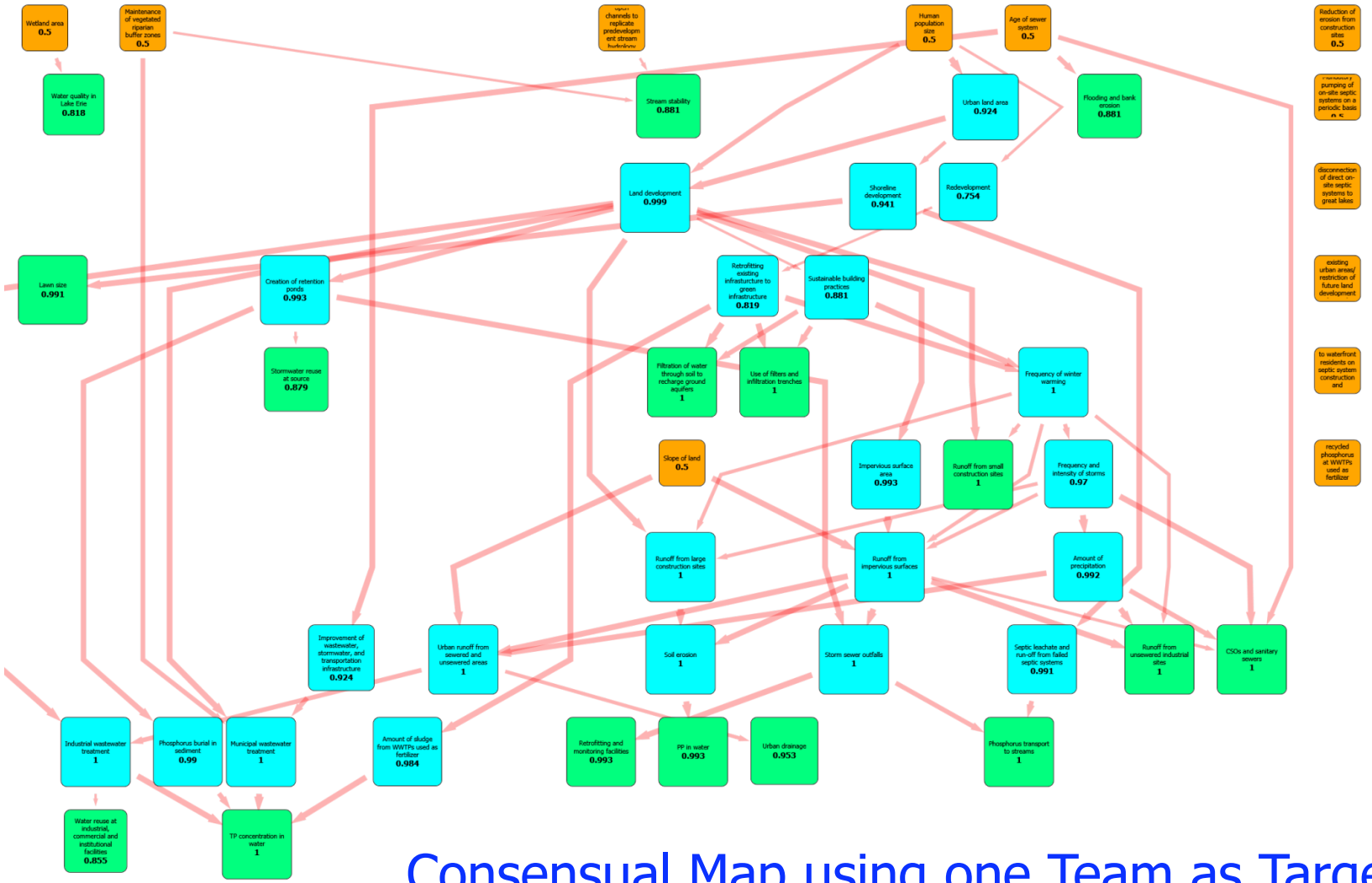
Urban Land-Eutrophication Linkage



Urban Land-Eutrophication Linkage

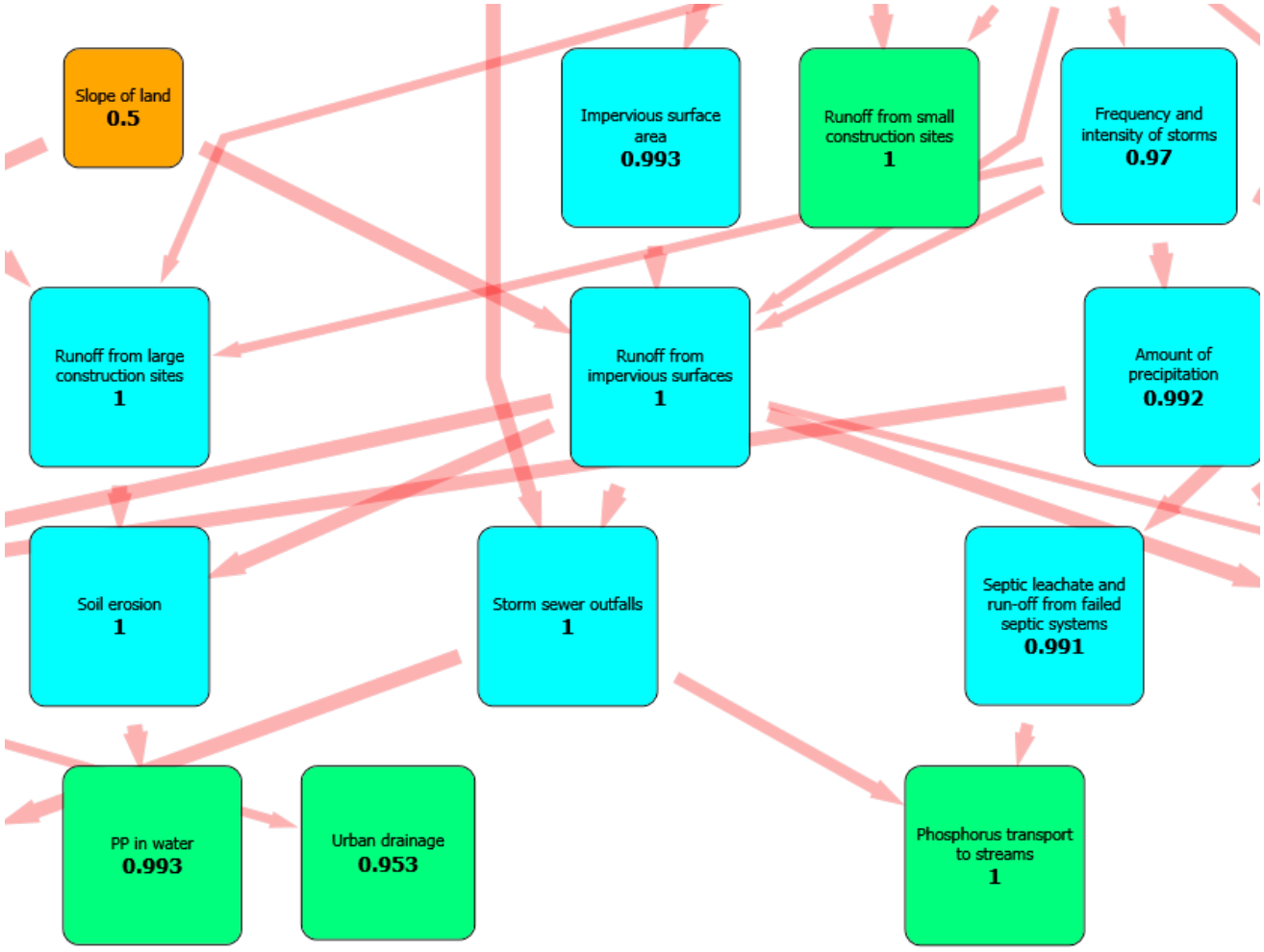


Urban Land-Eutrophication Consensual Map



Consensual Map using one Team as Target

Urban Land-Eutrophication Linkage Enlarged Consensual Map



Enlarged Portion of Consensual Map using one Team as Target

Urban Land-Eutrophication Linkage

Key Findings:

- The processes that link cities to eutrophication are extremely complex
- There are insufficient data sources for each concept and linkage
- Maps of the process can be constructed through expert opinion elicitation
- The is called exercise called fuzzy cognitive mapping
- The consensual maps can assist in identifying the most important contributions or linkages to the process of urban phosphorus flows
- The consensual maps indicate that the conventional thinking about phosphorus management have little impact on the phosphorus loadings

Next Steps:

- Compare targeted maps to a non-targeted aggregate of all four maps to identify the degree to of divergence within the participants
- Use the maps to assess the impact of different BMPs on the whole system.

Urban Land-Eutrophication Linkage

Acknowledgements:

- Igor Yeremin – development of FALWEB
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