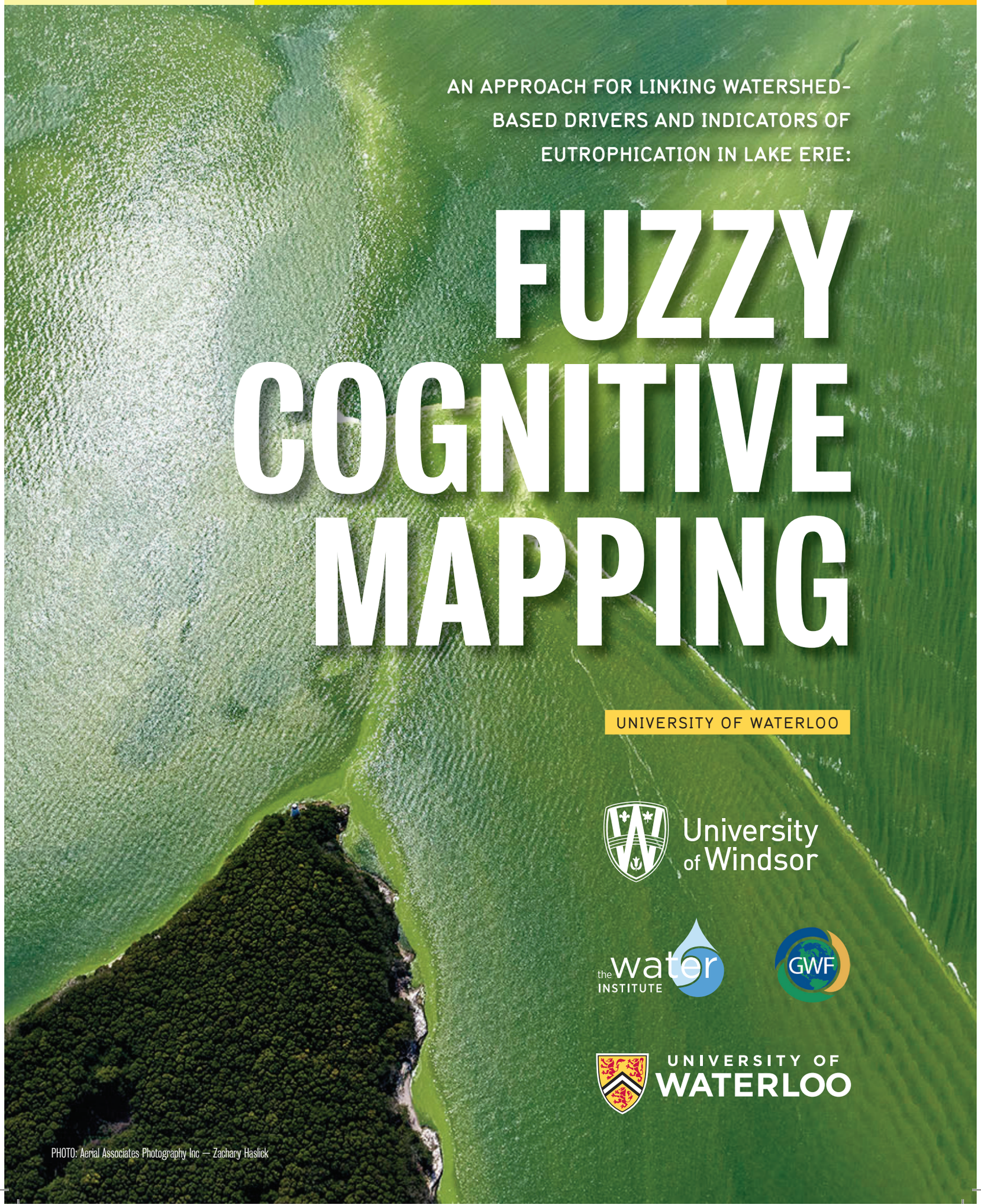


AN APPROACH FOR LINKING WATERSHED-BASED DRIVERS AND INDICATORS OF EUTROPHICATION IN LAKE ERIE:

FUZZY COGNITIVE MAPPING

UNIVERSITY OF WATERLOO

University of Windsor

the water INSTITUTE

GWF

UNIVERSITY OF WATERLOO

PHOTO: Aerial Associates Photography Inc — Zachary Haslick

FUZZY COGNITIVE MAPPING

EUTROPHICATION IN LAKE ERIE

Eutrophication in Lake Erie is a complex phenomenon about which we have limited information. Understanding how human actions in the watershed affect biological aspects of the lake is riddled with unknowns. Here we use best professional judgement from a range of experts around the Lake Erie basin to develop a **fuzzy cognitive map** of the current understanding of eutrophication.

WHAT IS FUZZY COGNITIVE MAPPING?

Fuzzy cognitive maps (FCMs) are semi-quantitative models made up of nodes (concepts) connected by directional relationships (- or +). A positive relationship from concept A to concept B means that an increase in A leads to an increase in B, while a negative relationship means increasing A leads to decreasing B. Relationships can be weighted to show relative importance.

Individual FCMs can be compared to describe how different groups perceive an issue, or they can be combined to form a consensual FCM that describes the issue from a broader perspective.

Concepts can be categorized into three types: transmitters, receivers, and ordinary variables. Transmitters have only outgoing relationships, influencing other concepts but not being influenced (e.g., "Point Source Total Phosphorus" in Fig.1). Receivers only have inputs, and don't influence other concepts (e.g., "Cladophora Biomass" in Fig.1). Ordinary variables both influence and are influence by other concepts.

POTENTIAL APPLICATIONS:

- Key use: Identifying important indicators of conditions and processes within a system.
- Visualizing expert understanding of a topic to determine research and management priority areas.
- Comparing differing perceptions of an issue.
  - E.g., Bosma et al. (2017) found that different user groups (farmers, government workers, fishermen, etc.) perceived the value of a Ugandan wetland very differently. They concluded that effective management of the wetland required an integration of perspectives.
- Assisting in the communication of complex systems to the public.
- Understanding how the public views a complex issue.
  - Understanding perceptions of what is known and unknown about management issues could improve communication between managers and stakeholders.

STRENGTHS:

- Quantitatively use expert knowledge
- Intuitive interpretation
- Visually engaging
- Allow comparisons of perceptions of an issue among groups

LIMITATIONS:

- Imperfectly defined concepts can be interpreted differently by users
- Important viewpoints can be missed if initial FCM creation excludes key players
- Complex systems can produce complex maps that are difficult to difficult to understand

AN APPROACH FOR LINKING WATERSHED-BASED DRIVERS AND INDICATORS OF EUTROPHICATION IN LAKE ERIE:

PHOTO: NOAA Great lakes Environmental Research Laboratory

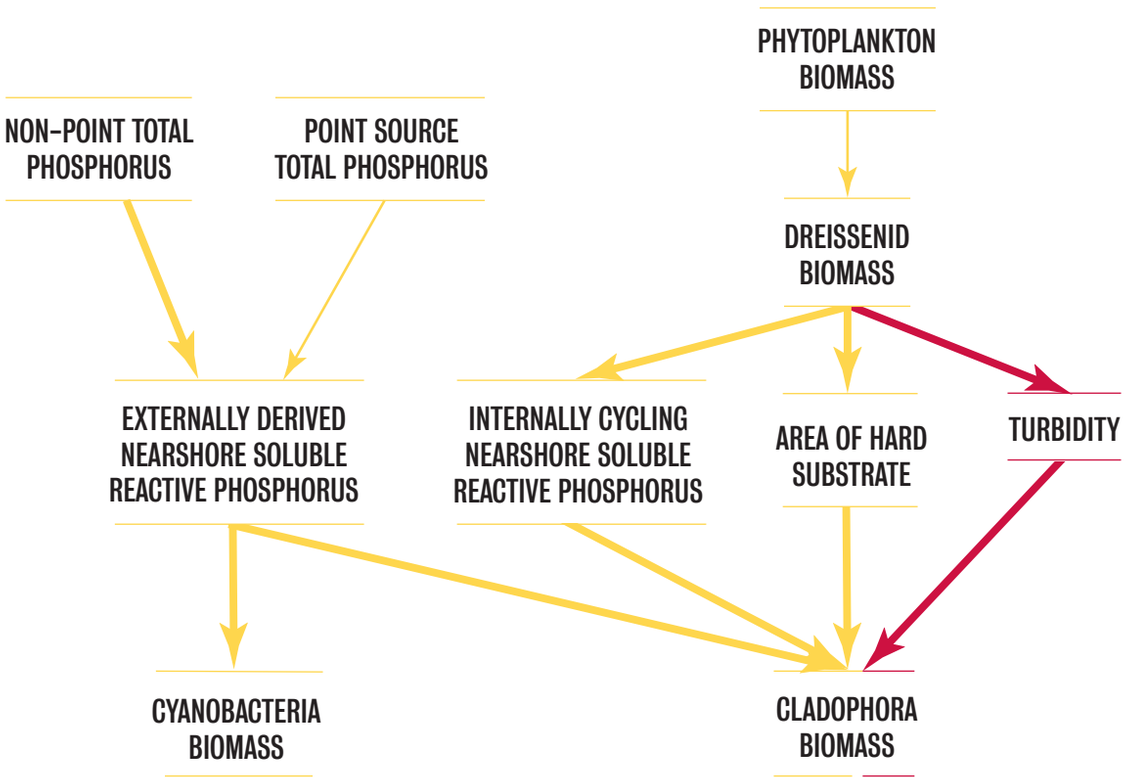
HOW TO BUILD A FUZZY COGNITIVE MAP:

1. Decide on the viewpoint(s) you want the FCM to describe – this will determine who you ask to contribute (e.g., researchers, stakeholders, managers)
2. Create a list of relevant and clearly defined concepts (via literature search, survey of experts, etc.)
3. Educate key contributors about the FCM exercise.
    - Contributors can either work together to create one FCM, or break into smaller groups and individual FCMs can be ultimately combined.

Following creation, the FCM can be analyzed to find the most important relationships and concepts, as defined by combined best professional judgement of your chosen contributors.

FIGURE 1. BELOW

Example FCM examining concepts related to Cladophora biomass in Lake Erie. Arrows represent directional positive (yellow) or negative (red) relationships between concepts. Arrow width denotes relationship strength.



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SUGGESTED CITATION:

Ives, J., Ciborowski, J., and Rooney, R. (2018) An Approach for Linking Watershed-base Drivers and Indicators of Eutrophication in Lake Erie: Fuzzy Cognitive Mapping [Fact sheet]. Retrieved from **https://uwaterloo.ca/lake-futures/**

RESOURCES:

Turney, S. and Bachhofer, M. (2016). FCMapper: Fuzzy Cognitive Mapping. R package version 1.1. **https://CRAN.R-project.org/package=FCMapper**

Özesmi, U., & Özesmi, S. L. (2004). Ecological models based on people's knowledge: a multi-step fuzzy cognitive mapping approach. Ecological modelling, 176(1-2), 43-64.

Bosma, C., Glenk, K., & Novo, P. (2017). How do individuals and groups perceive wetland functioning? Fuzzy cognitive mapping of wetland perceptions in Uganda. Land Use Policy, 60, 181-196.

FOR MORE INFORMATION, OR
CONTACT INFORMATION FOR FCM EXPERTS,
PLEASE CONTACT JAN CIBOROWSKI

cibor@uwindsor.ca

UNIVERSITY OF WATERLOO
200 UNIVERSITY AVE. W., WATERLOO, ON, CANADA N2L 3G1

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