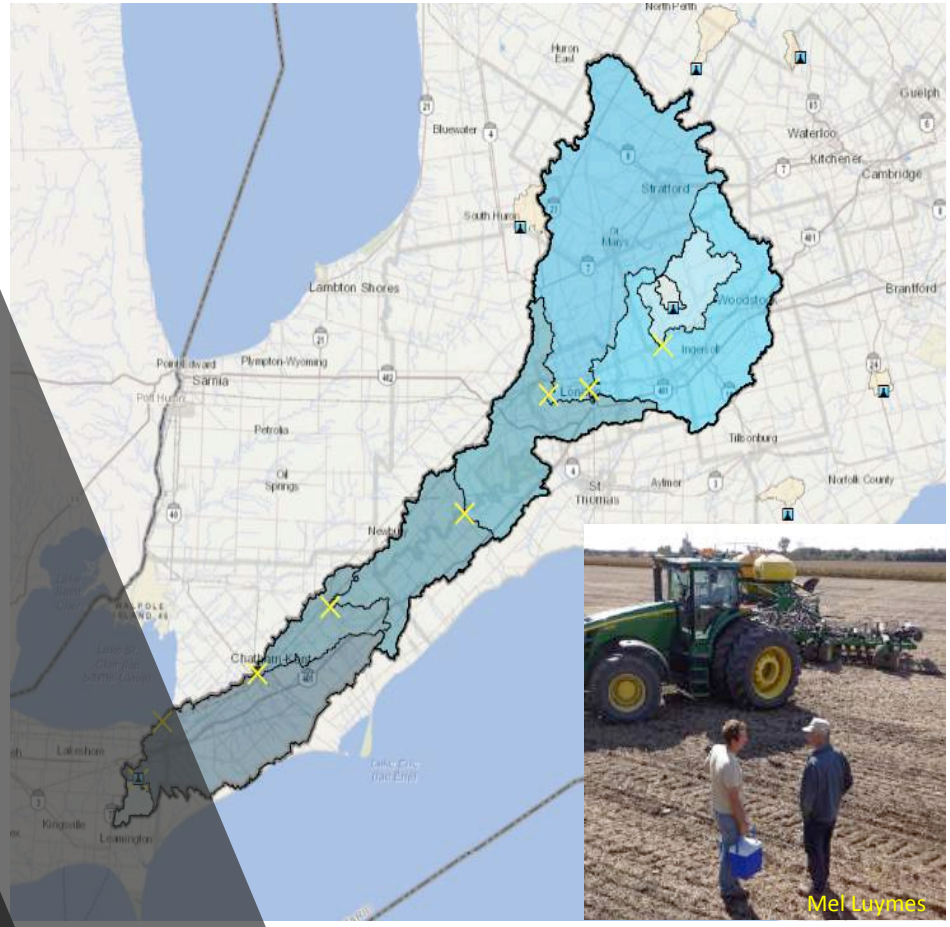
Understanding Sources and Transformations of Nutrients in Agricultural Landscapes from Headwaters to the Great Lakes



- Multi-Watershed Nutrient Study (MWNS)
  Mo Mohamed, Research Scientist, Water Monitoring, MOECC
  MWNS lead, mohamed.mohamed2@ontario.ca)
- Thames River Phosphorus Transformations
  Chris Parsons, Research Assistant Professor, Univ. Waterloo
  Chris.Parsons@uwaterloo.ca
- Agricultural Land Management Survey and Regional Watershed Modelling
  Christopher Wellen, Research Assistant Professor, Univ. Windsor
  Christopher.Wellen@uwindsor.ca

Presentation to the Agriculture Sector Working Group Meeting

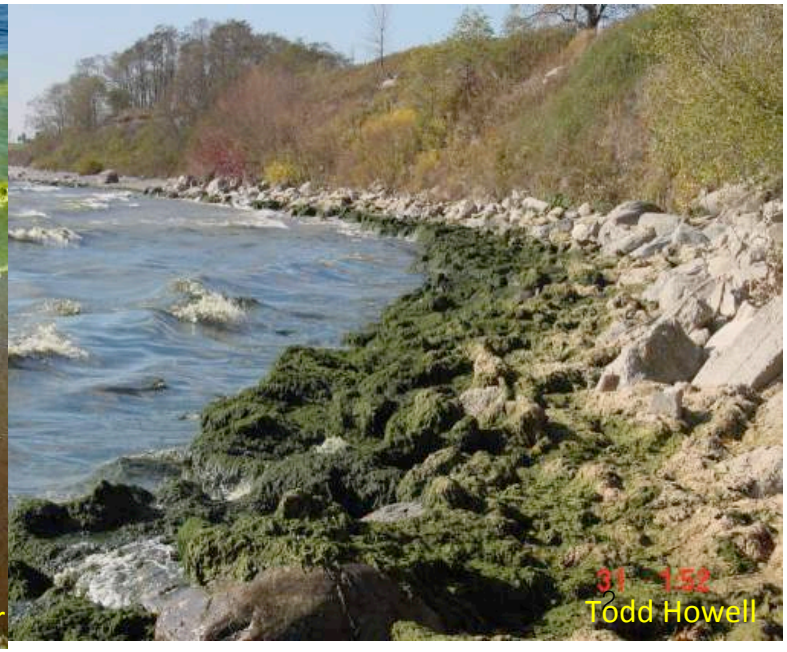
June 16, 2017

Eutrophication in the Great Lakes

- Near shore eutrophication in all lower Great Lakes

- Widespread eutrophication of W. Basin Erie

  → 40% reduction in tributary phosphorus loading



Eutrophication in the 70's

We've been here before… (sort of)

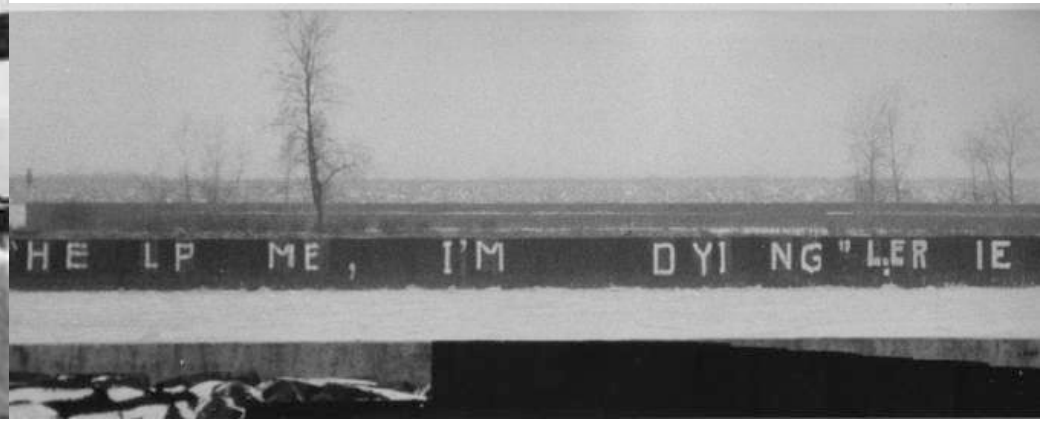
Control of point sources and reductions in P in detergents to address eutrophication

Massive investments in agricultural BMPs

Michael Rotman, "Lake Erie ," *Cleveland Historical*, accessed April 23, 2017, https://clevelandhistorical.org/items/show/58

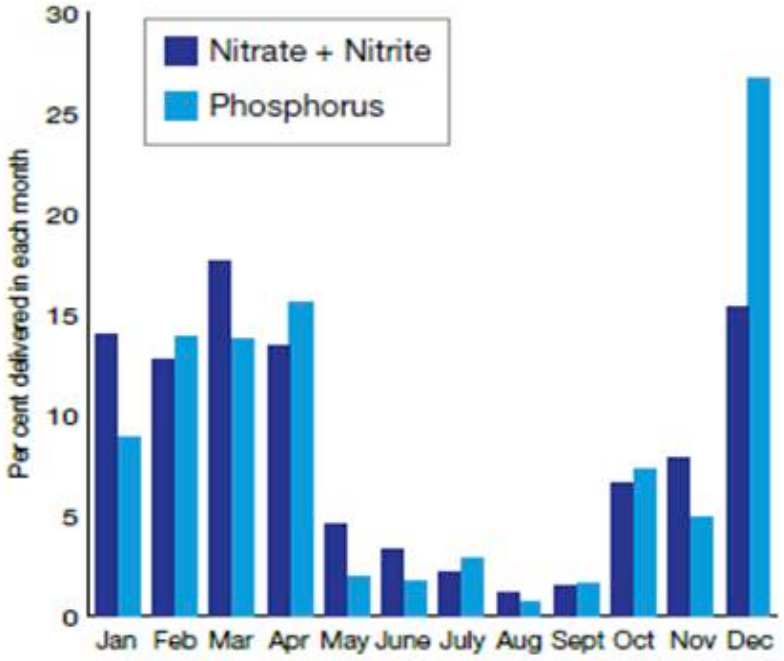
"You're glumping the pond where the Humming-Fish hummed!
No more can they hum, for their gills are all gummed.
So I'm sending them off. Oh, their future is dreary.
They'll walk on their fins and get woefully weary
in search of some water that isn't so smeary.
I hear things are just as bad up in Lake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

— *The Lorax, by Dr. Seuss*



What is causing current eutrophication?…

- Climate change?
- Food web changes?
- Tributary nutrient loads?
  - Magnitude
  - Form and proportions
  - Timing



MOECC Water Quality in Ontario Report 2012;
M. Rosamond et al. J. Soil and Water Conservation (in review)

…but, tributary loadings are the only ‘dial’ that we have

MWNS Project goals

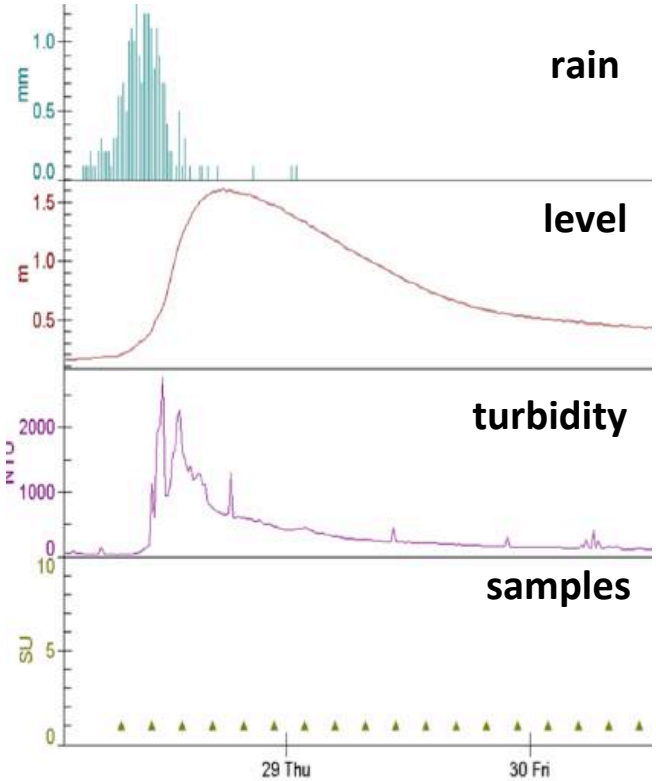
1) Have agricultural NPS **nutrient loadings changed since ~40y ago (PLUARG Study)**?

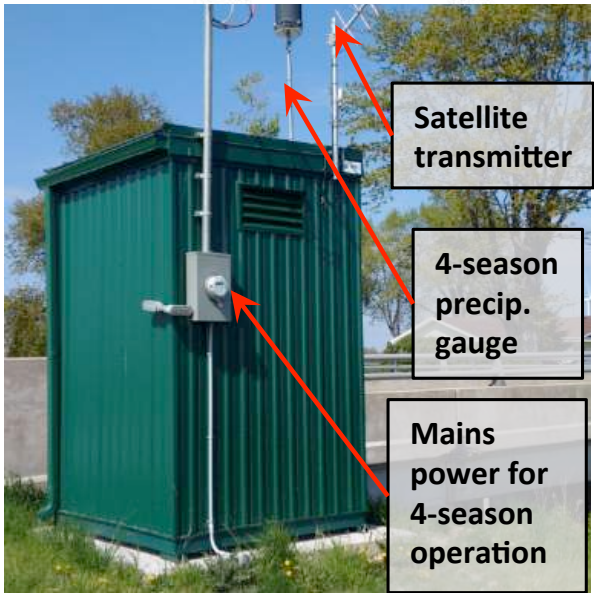
2) Has the **relationship between agricultural land use/ management** and nutrient loadings changed?

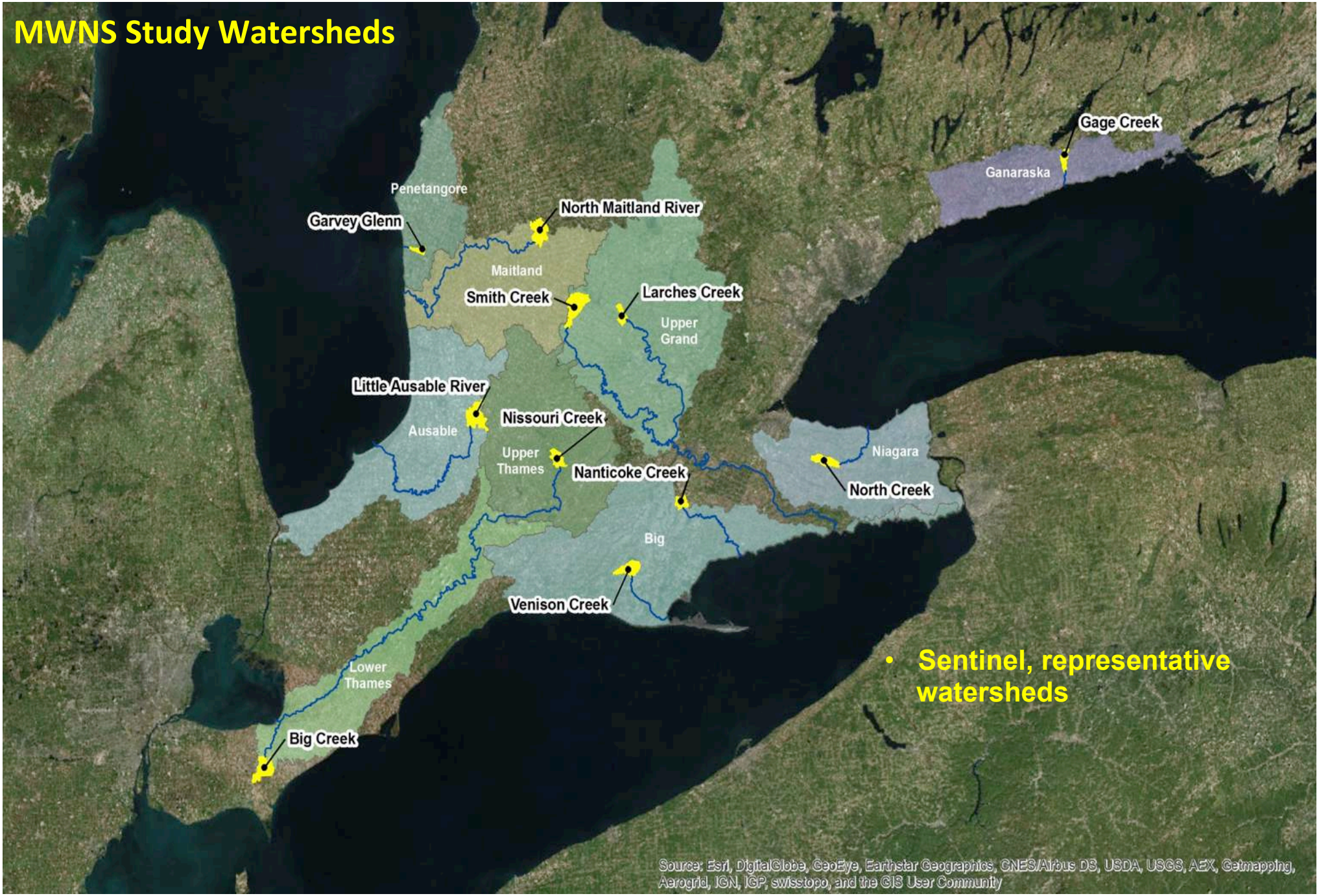
3) Has the **seasonal pattern** of stream nutrient loadings changed between now and those found in past studies?

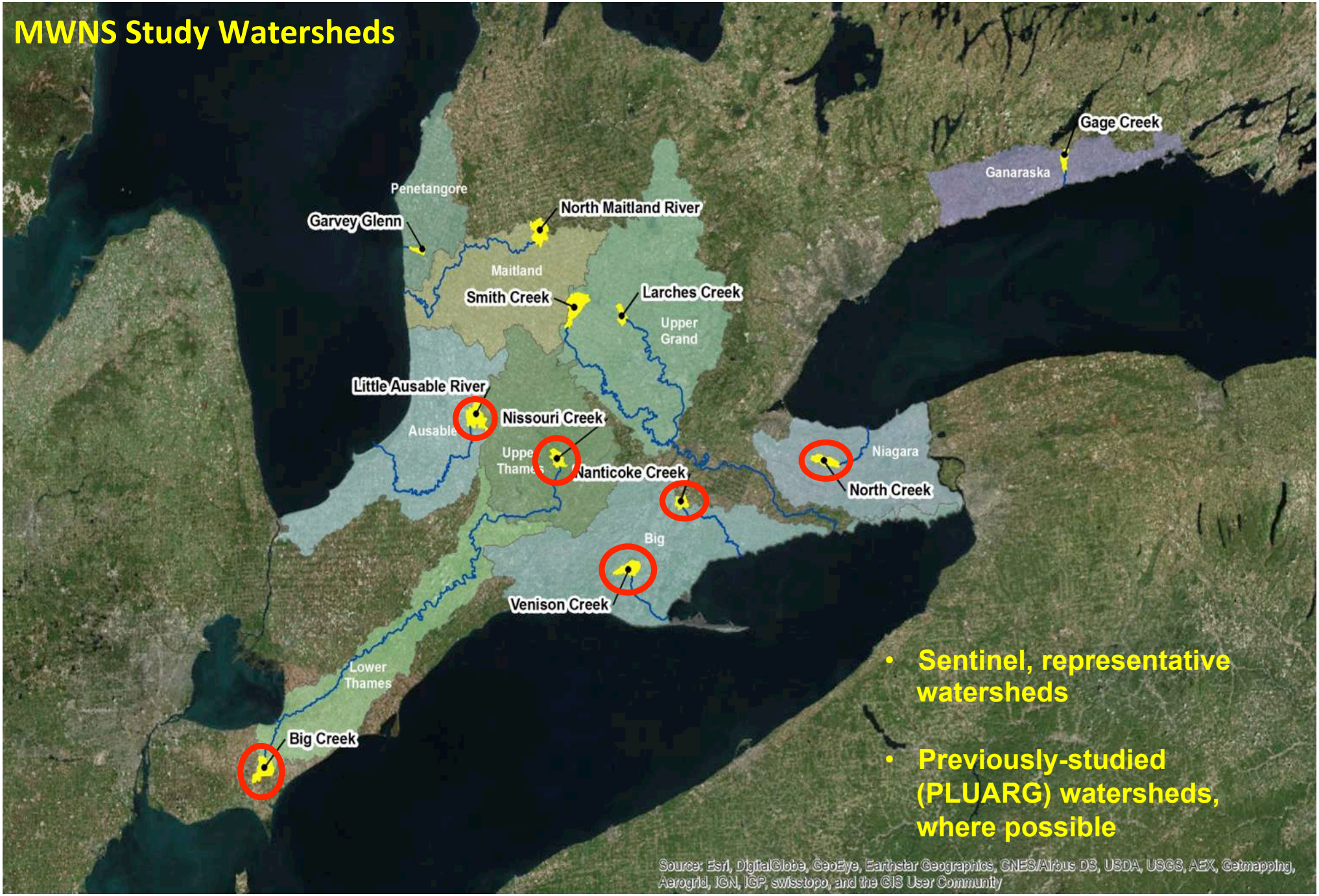
4) What are the **relevant fractions of P** delivered by agricultural watersheds? Has this **changed over time**?

5) How does **P from headwaters translate** to potential impacts in the Great Lakes? Can we develop **novel mitigation strategies**?






MWNS Study Watersheds
Gage Creek
Ganaraska
Penetangore
Garvey Glenn
North Maitland River
Maitland
Smith Creek
Larches Creek
Upper Grand
Little Ausable River
Nissouri Creek
Ausable
Upper Thames
Nanticoke Creek
Niagara
North Creek
Big
Venison Creek
Lower Thames
Big Creek
• Sentinel, representative watersheds
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community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North Creek
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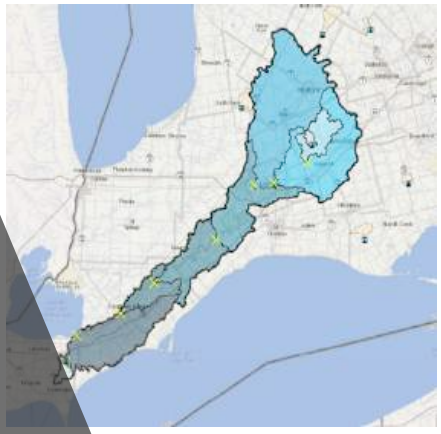
Venison Creek
Lower Thames
Big Creek
• Sentinel, representative watersheds
• Previously-studied (PLUARG) watersheds, where possible
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Thames River Phosphorus Forms and Transformations:

From Source to Lake (2017-2020)

Chris Parsons - University of Waterloo

Chris.Parsons@uwaterloo.ca 519 888 4567 ext 32820



UNIVERSITY OF WATERLOO

ecohydrology research group

Why do we care about the type of phosphorus?

1. Lots of different P forms in rivers but their distribution and importance isn't well known (lack of data).

2. Algae can assimilate some P forms more easily than others.

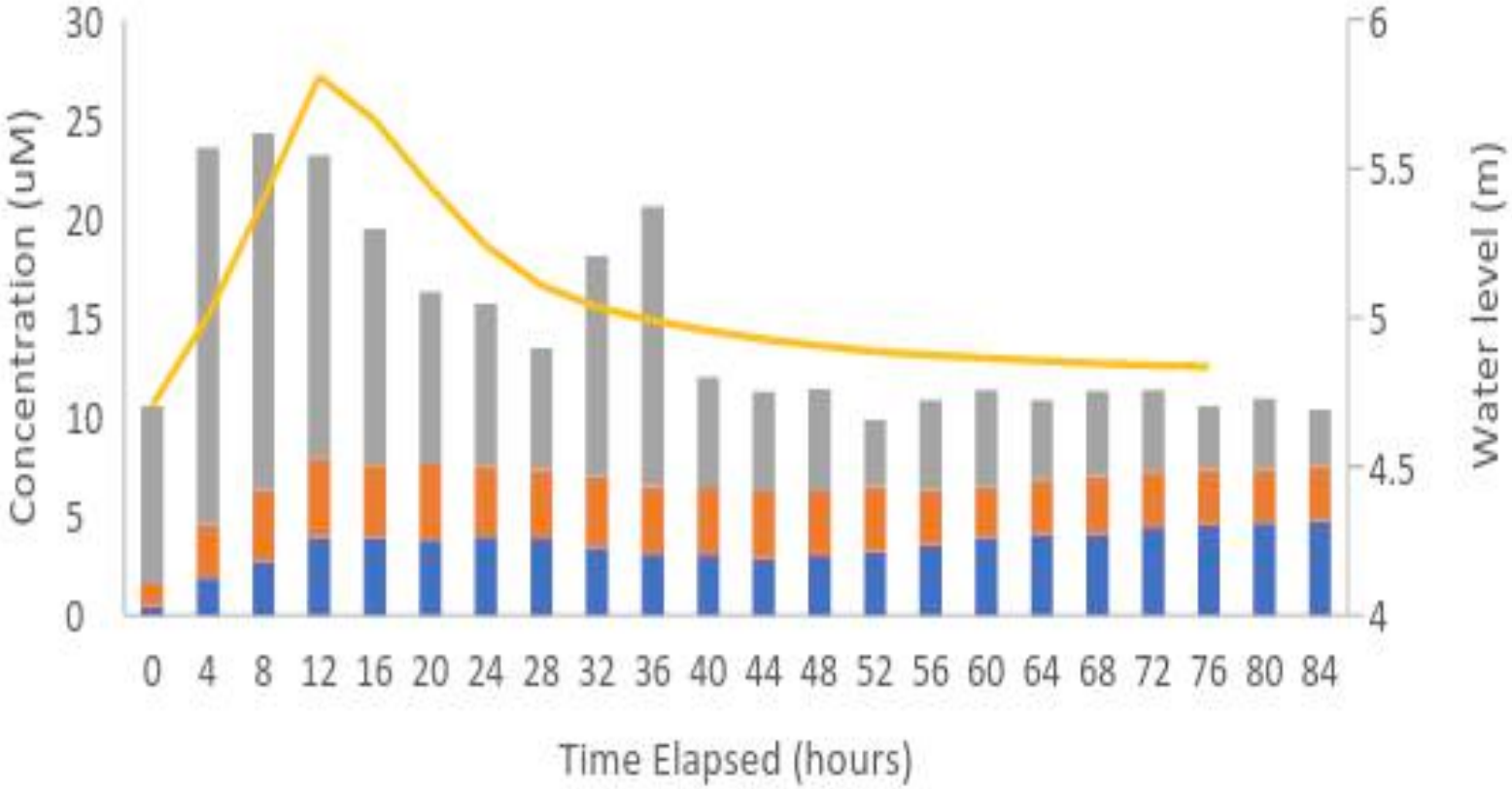
3. Different sources/areas release different P forms at different times of year and during different hydrological conditions

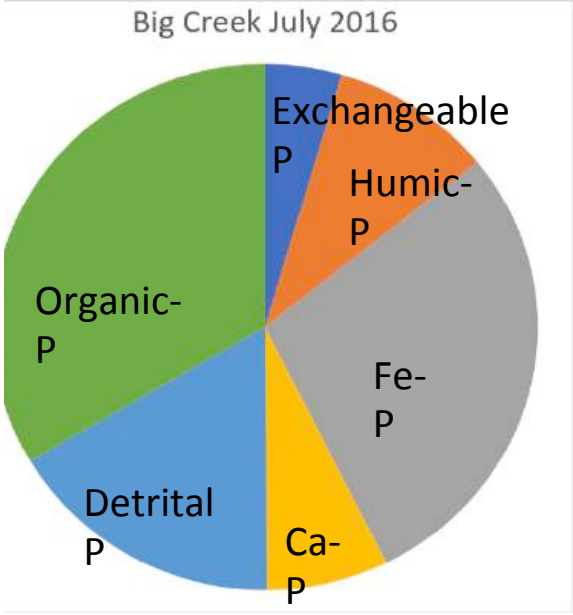
4. P forms can change during in river transport.

P speciation work within MWNS (2015-2016)

- Seasonal differences in P speciation.
- P speciation and loading depend on hydrological conditions.
- Bioavailability of P species determined with algal assays.

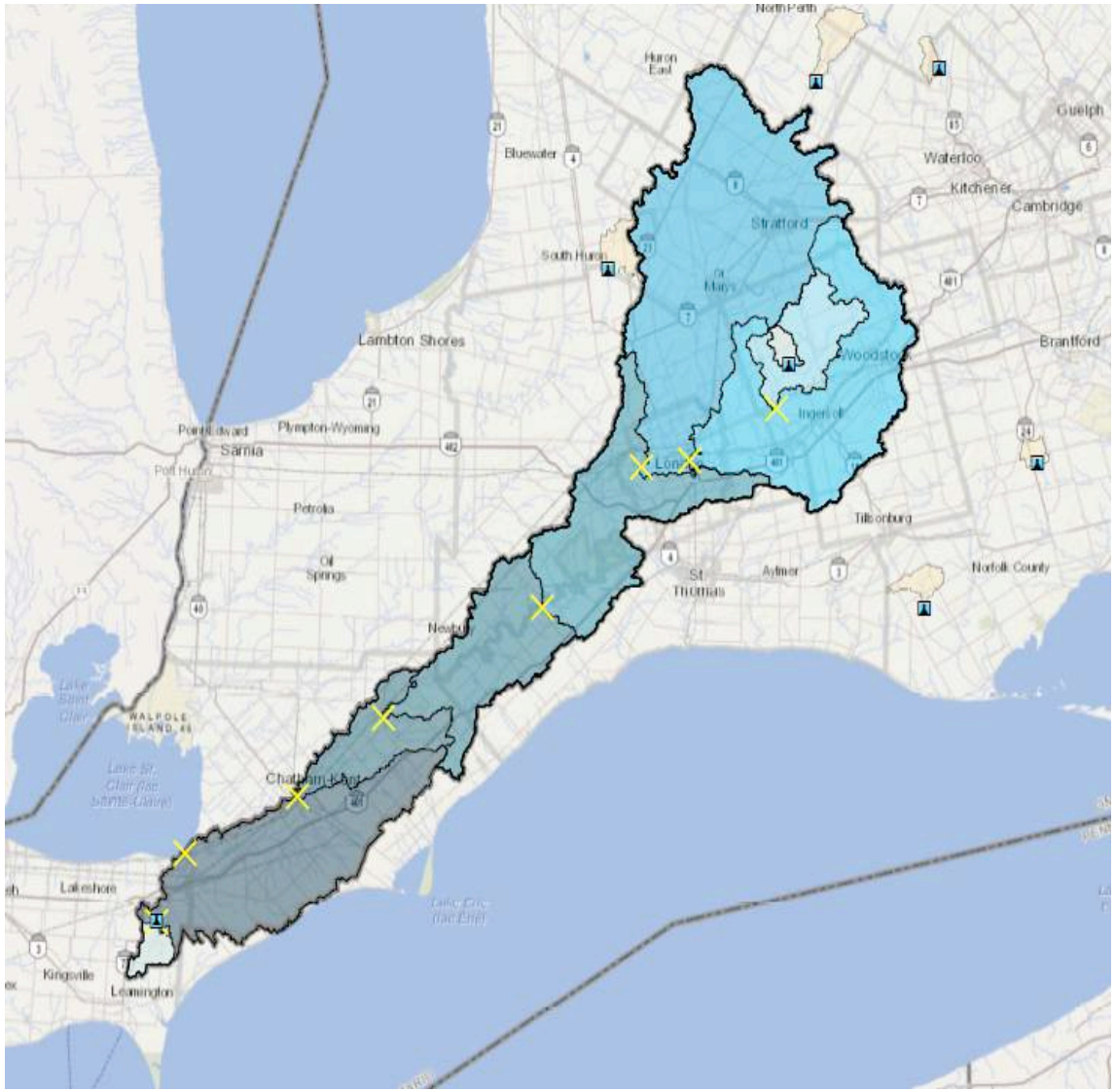
Big Creek – July 8-11 2016 (110cm



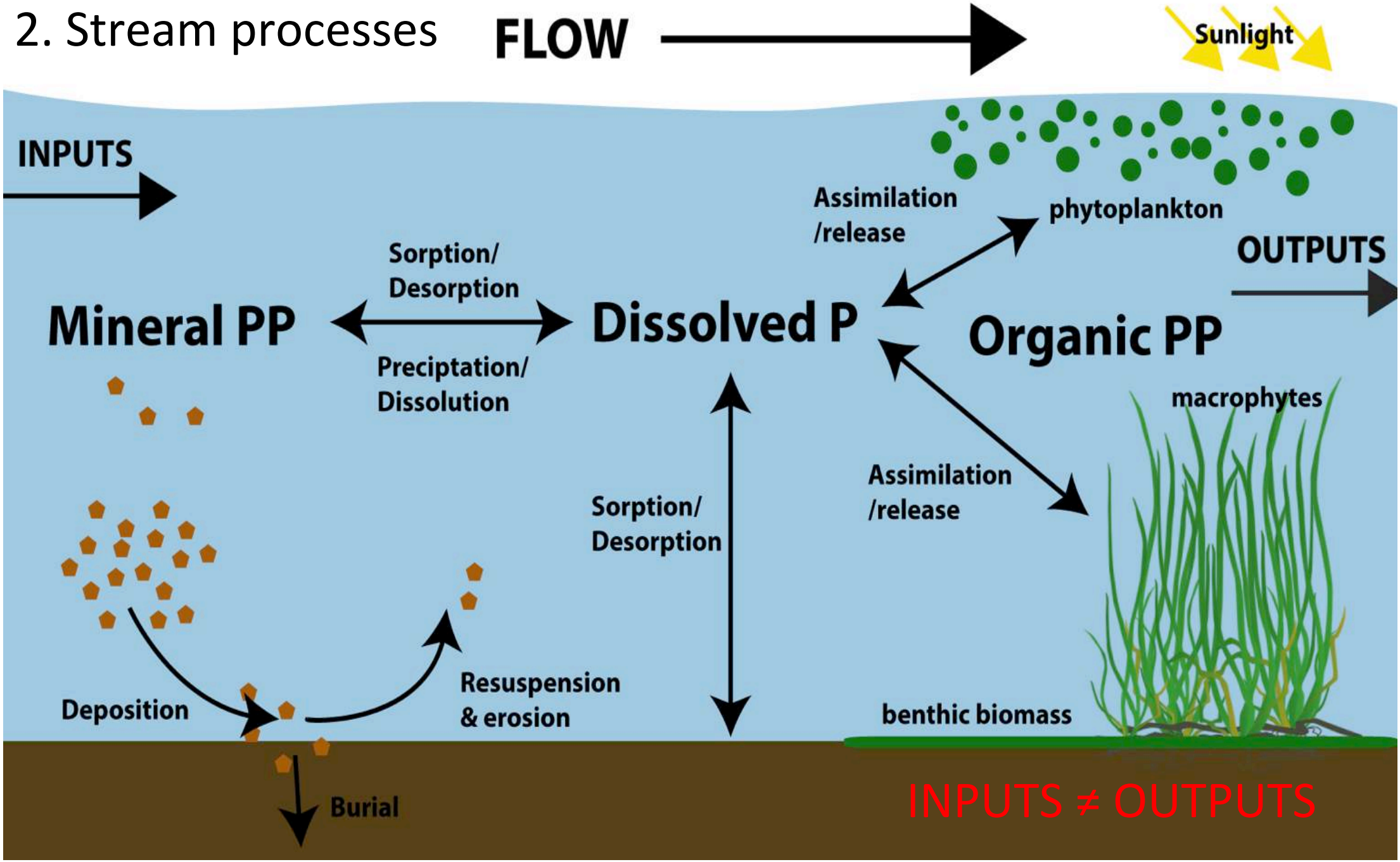


1. P Load assessment - Nested Watershed Approach

- 13 Sampling locations from headwaters to river mouth – 2017 - 2020
- Point and non-point P loads from **agricultural**, **suburban** and **urban** areas
- Quantify loading of different P forms
- Identify areas of significant P removal and/or transformation

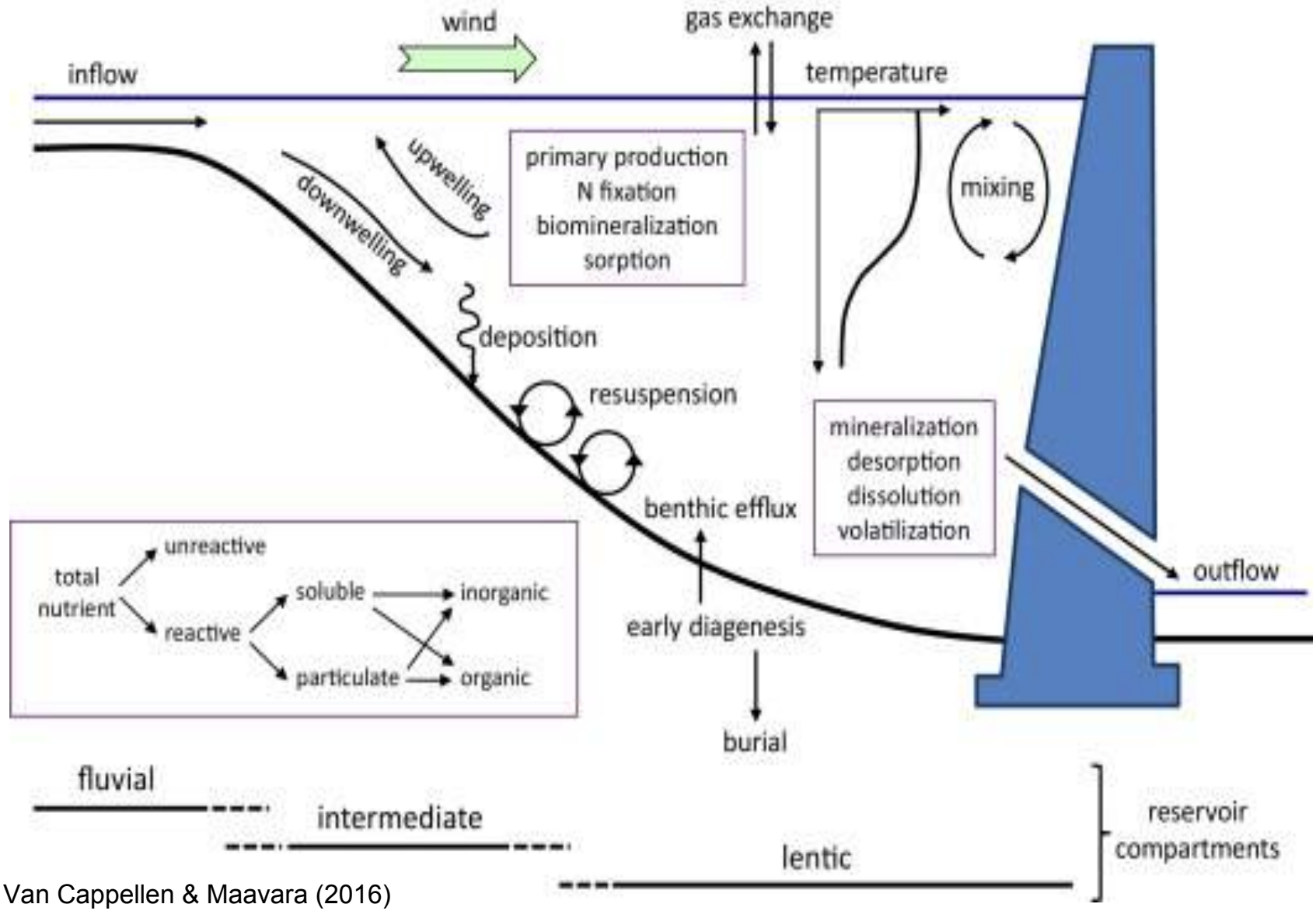


2. Stream processes



3. Influence of reservoirs and floodplains

- Measurement of floodplain and reservoir sediment deposition
- Measurement of P remobilisation
- Diagenetic modelling to quantify permanent vs temporary P removal



Van Cappellen & Maavara (2016)

Agricultural Land Management Survey and Regional Watershed Modelling: Grounding the Science (2016 – 2020)

Christopher Wellen - University of Windsor, Ryerson University

Christopher.wellen@uwindsor.ca
Christopher.wellen@Ryerson.ca

647-239-5138

Project objectives

1. Conduct a detailed **land management survey:** base knowledge on real data, not assumptions

2. Assemble a **regional scale model** of the major agricultural watersheds draining into the Great Lakes: incorporate knowledge of farmer practices and in-stream processing.

3. Conduct a **landscape sensitivity analysis:** assess sensitivity of nutrient losses to changes in **land use/management, climate, and drainage practices**.

Land Management Survey

Why a comprehensive land management survey?

- Example of model input file for SWAT (.mgt file) from Wellen et al. (2014 JGLR).

```
Operation Schedule:
          0.09    6 2
          0.100  1    2          1200.65200   0.00      0.00000 0.00    0.00   0.00
          0.200 10    1  3  1       0.99000 0.99   5.0          0.01
          0.200  3   56            100.00000 0.50     900.00000 1.30    0.20   0.00
          0.600  3   56            100.00000 0.50     900.00000 1.30    0.20   0.00
          1.200  5       1      0.5           0.9
          1.21   6 1
```

- I had to assume ‘reasonable’ values using OMAFRA’s guidelines for corn.
- <u>If we are to use models to recommend how land management can improve water quality we need to do better</u>!

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          0.200   3    56             100.00000 0.50      900.00000 1.30    0.20   0.00
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AGRI-MODEL

1 hour survey
400 farmers
11 sub-watersheds
70,000 soil tests
18 months

www.agri-model.com

Led by Melisa Luymes

Land Management Survey

What do farmers actually do with respect to:

- Crop rotation, varieties & yields
- Nutrient placement, timing & rates
- Tillage type & timing
- Drainage installation
- Cover crops, tree planting, buffer strips, etc.
- Soil testing, liming, irrigation, etc.

Data comparable w/ OSCIA's GLASI priority sub-watershed surveys.

Land Management Survey

Not just what, but <u>what has changed and why</u>:

- Comparison with mgmt 15-20 years ago
- Farmland rental – relationships, lengths of term
- Decision making for nutrient application
- Precision agriculture – definition and barriers
- Changes in community & local ag infrastructure
- Getting feedback for the model

All data kept private with coding process & only shared as averages.

CODE # FAKE DATA

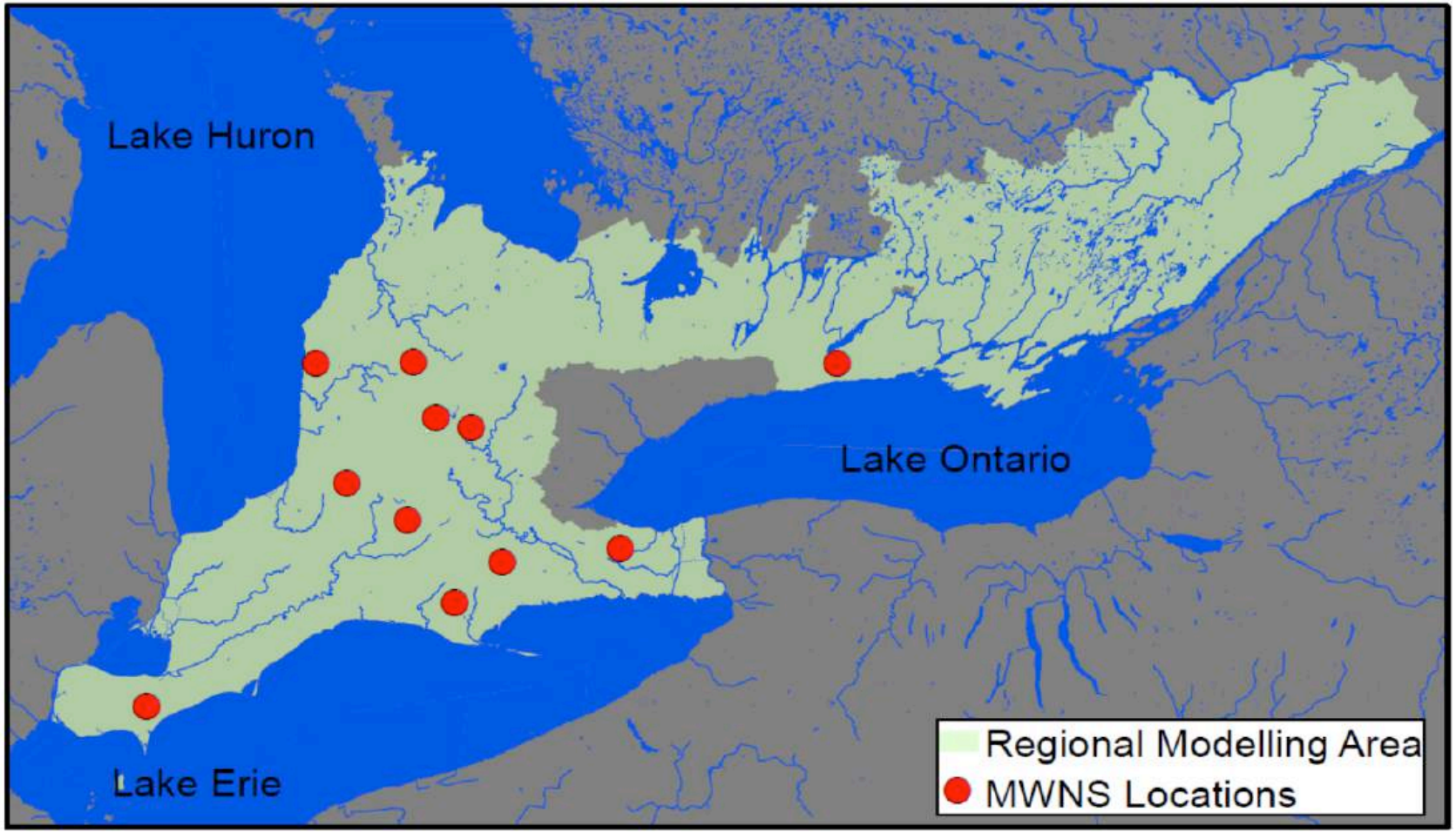
Field ID (if applicable): 01

Notes: This is fake data

Starting what year at planting? (if applicable): 2015

Crop				Fertility						Tillage			
Variety	Plant/ Harvest Timing	Cover	Yields	When	L D	B I	N-P-K-S □ variable rate?	Product / Manure Source	Rate (unit/ac)	When	Equipment	X	% res
May 15 Corn				May 1 June 14	**D** **L**	**I** **I**	**30-20-20-10** **30-20-20-10**	**Fake Stuff** **Fake Stuff**	**20 lbs** **20 lbs**	**May 1**	**Disk Cultivator**	**2**	**20**
Nov 1			180 Bu										
May 15 Soy				May 1 June 14	**L** **L**	**I** **I**	**5-20-20-10** **5-20-20-10**	**Fake Stuff** **Fake Stuff**	**20 lbs** **20 lbs**	**May 1**	**Disk Cultivator**	**2**	**20**
Oct 15			60 Bu										

Regional Scale Model



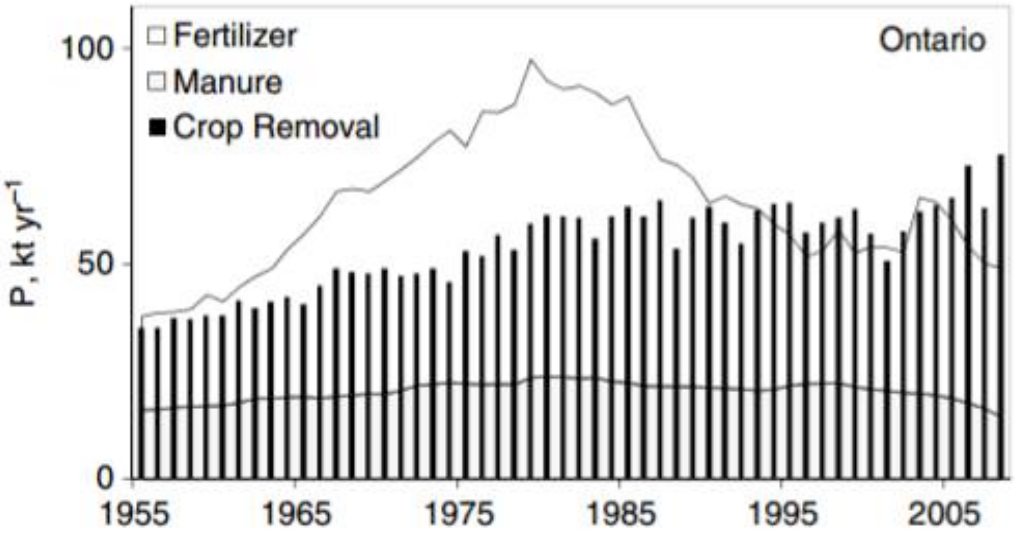
Landscape Sensitivity Analysis

How might nutrient loading change with future states of climate, land use, and land management?

What have been the individual effects of changes to climate, land use, and land management that have already taken place?

How to involve stakeholders (including farmers) in the design of the sensitivity analyses?

This is not a BMP evaluation exercise.



Bruulsema et al., 2011

Project Partnerships

Partnerships are key aspect of these studies

Key partners include:

- Conservation Authorities
  - Ausable Bayfield, Credit Valley, Ganaraska Region, Grand River, Essex Region, Long Point Region, Lower Thames, Maitland Valley, Niagara Peninsula, Toronto and Region, Upper Thames
- Agriculture and Agri-Food Canada
- Environment and Climate Change Canada
  - Science and Technology Branch
  - Water Survey of Canada
- University of Waterloo
- University of Windsor
- Ministry of Agriculture, Food, and Rural Affairs
- Ministry of Natural Resources and Forests
- Ministry of the Environment and Climate Change
  - West Central Region, South West Region, Environmental Monitoring and Reporting Branch

Feedback requested

- **Are we asking the right questions?**
  - **Measuring the right things?**
  - **Sampling in the right ways (events, places, etc.)?**
  - **Asking the right questions of farmers?**
  - **Looking into the right types of scenarios?**

  Synergies with existing programs?
  - **Is it important we talk to or involve someone specific?**
  - **Are there key contacts we need to talk to?**
- **Are there important data sources or existing work that we should know about?**
- **Would you be interested in regular updates on the work? Would you know who would be?**