GLOBAL WATER ISSUES

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U N I V E R S I T Y

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Global trends in the era of the Anthropocene

- Urbanization
- Population Growth
- Regional Growth
- Travel and Tourism
- Global Corporate Growth
- Global Food Market
- Water Recycling, Reuse

Global Water Consumption 1900 - 2025
(by region, in billion m³ per year)

Legend:
- World
- Europe
- North America
- South America
- Africa
- Asia
- Australia & Oceania
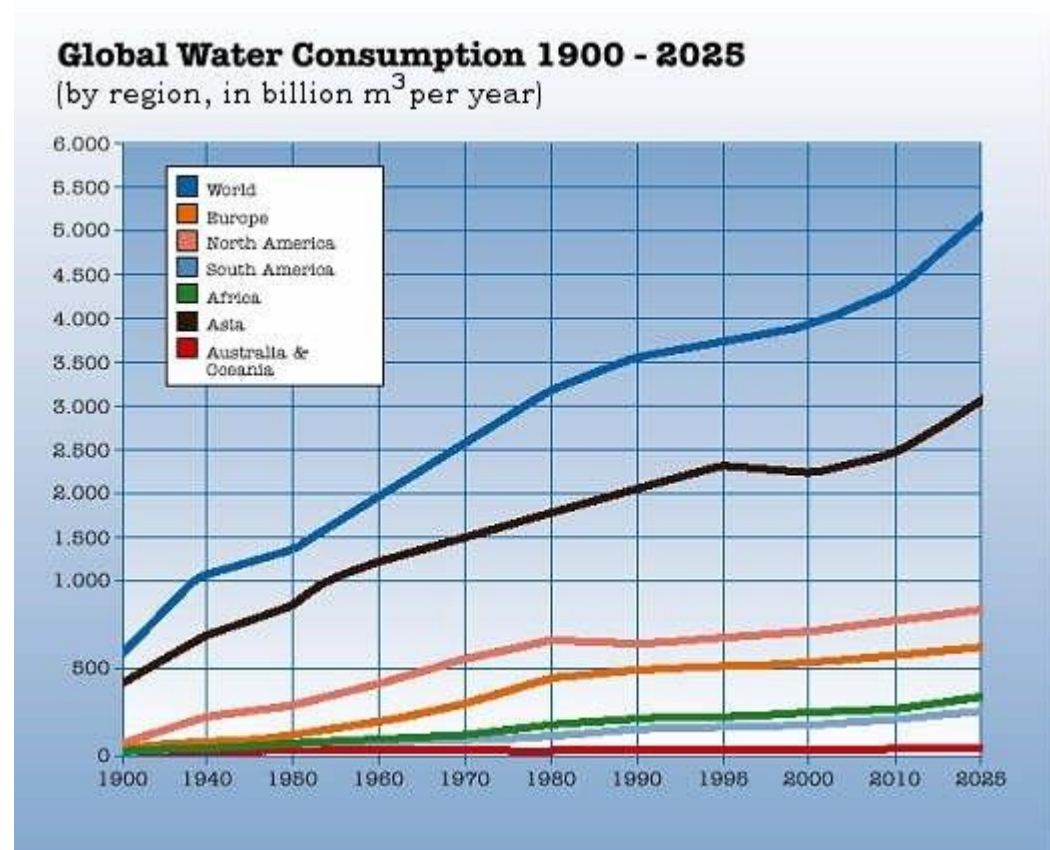
THE CHANGING LANDSCAPE IS CONTRIBUTING TO THE RISK

Cultivated areas of the world. Brown regions indicate areas in which at least 30% of the landscape is cultivated. Reproduced from the Millennium Ecosystem Assessment 2005 (http://www.MAweb.org), UNEP.
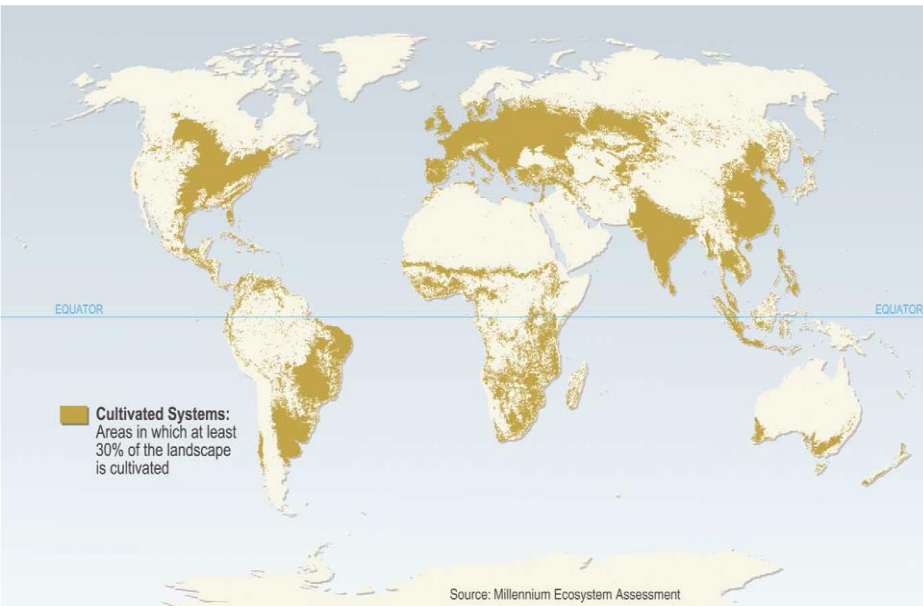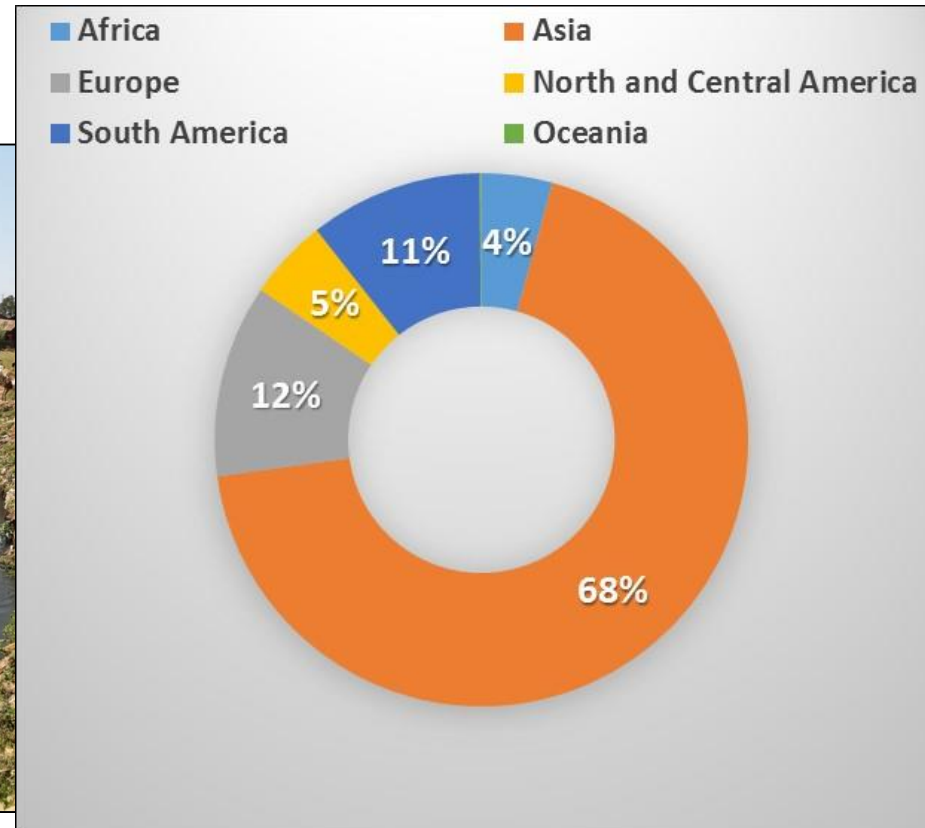
Loss of wetlands   (km^2) from 1950s to 1990s in the US

Verhoeven et al. TRENDS in Ecology and Evolution Vol.21 No.2 February 2006

Cultivated Systems: Areas in which at least 30% of the landscape is cultivated

Source: Millennium Ecosystem Assessment
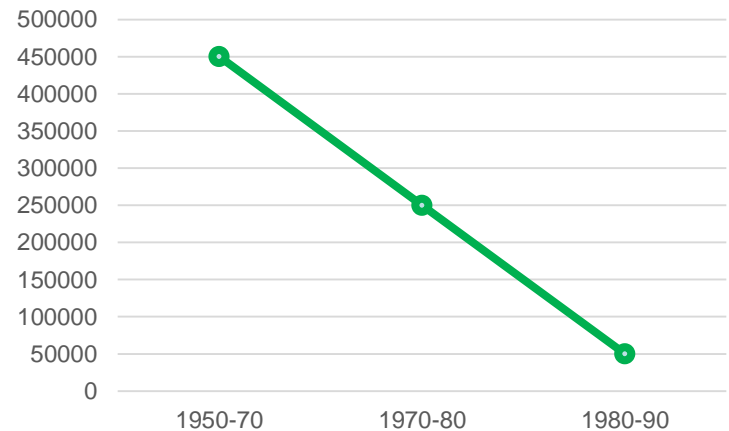
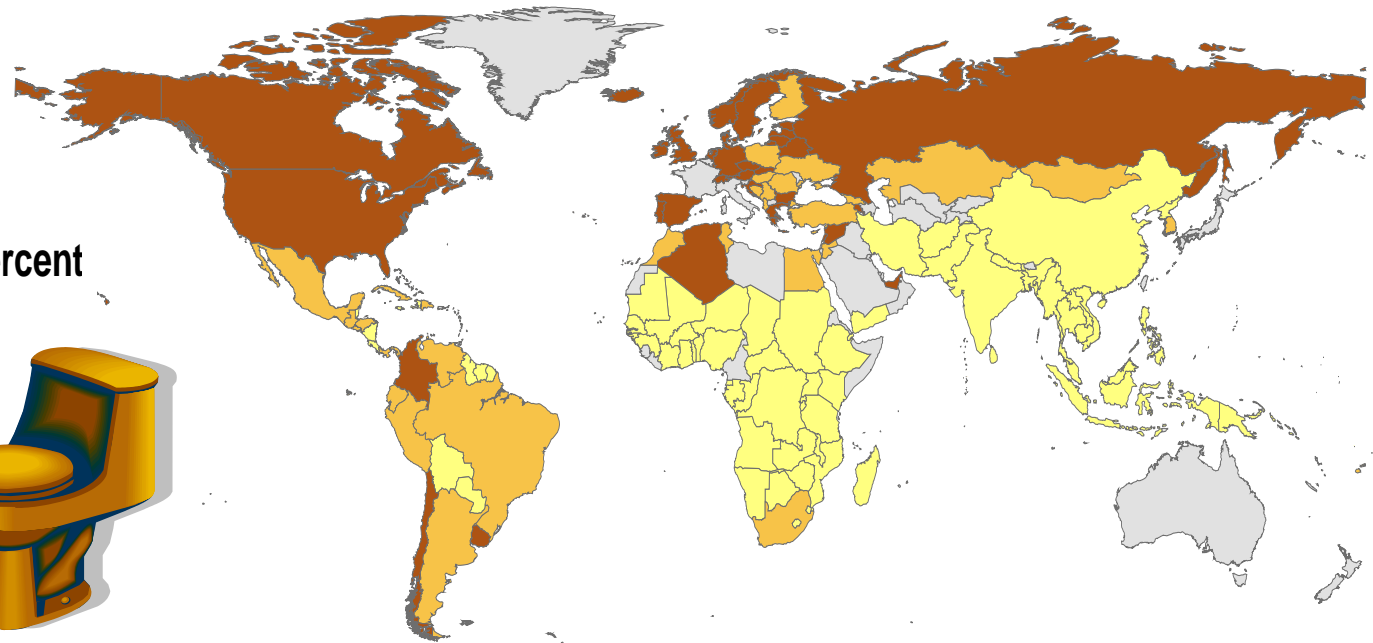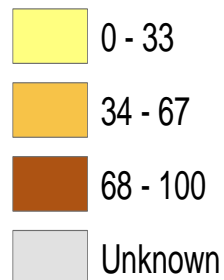# Billions lack effective sewage treatment

Distribution of the 1.5 billion people by continent whose sewage is discharged without treatment
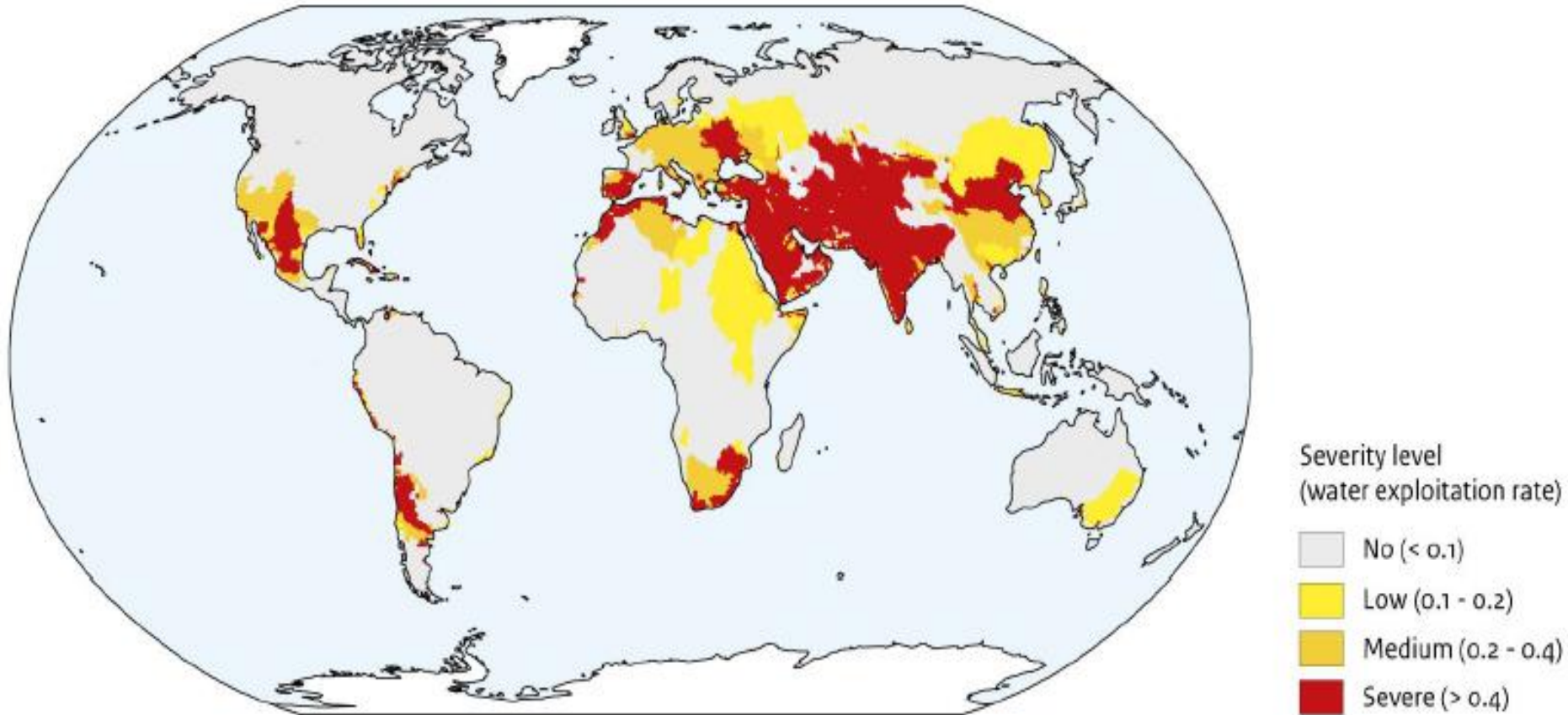
44% of the World's global population (7 billion people) lives within 150 km (93 miles) of the coastline (that is 3 billion people who flush or dispose daily and send fecal pollution into the environment and eventually into waterways). The world's rivers (ten of the longest rivers = 55,734 km or 34,629 miles) are so badly affected by human activity that the water security of 5 billion people are impacted.
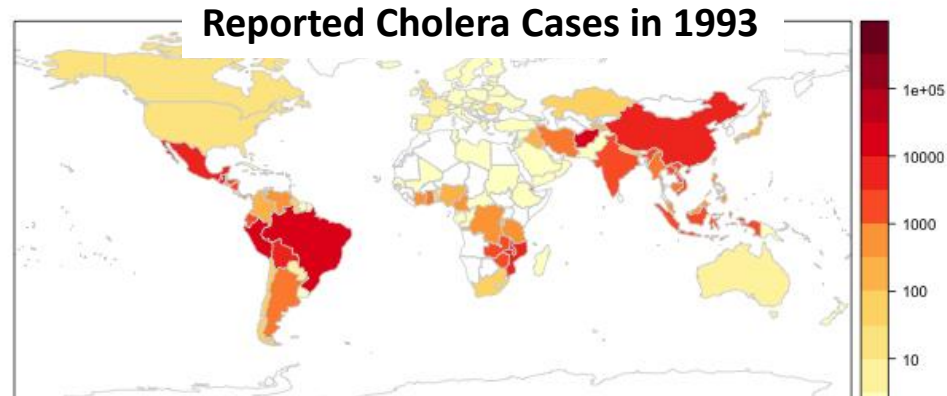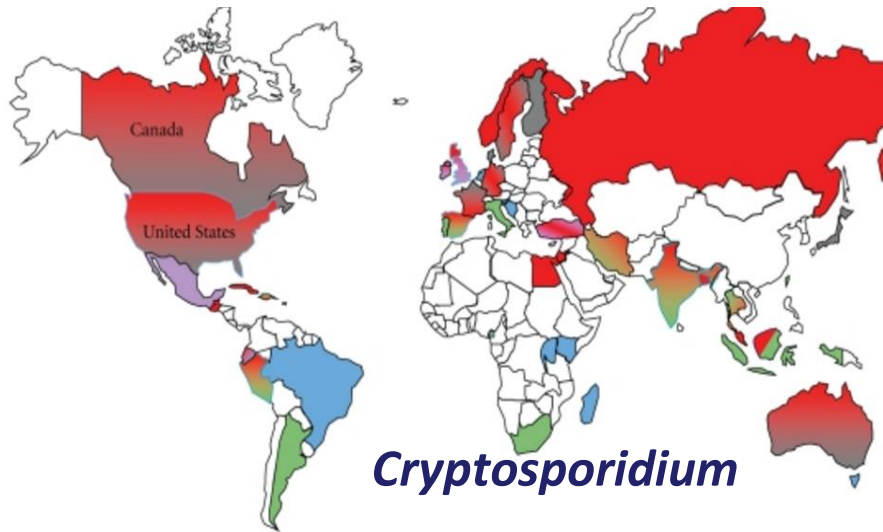
World Sanitation

Household Connections Percent
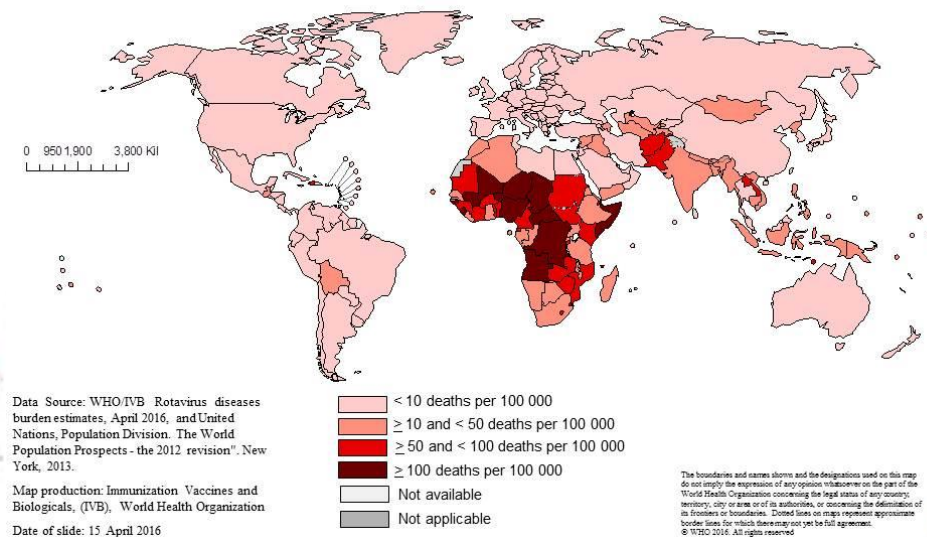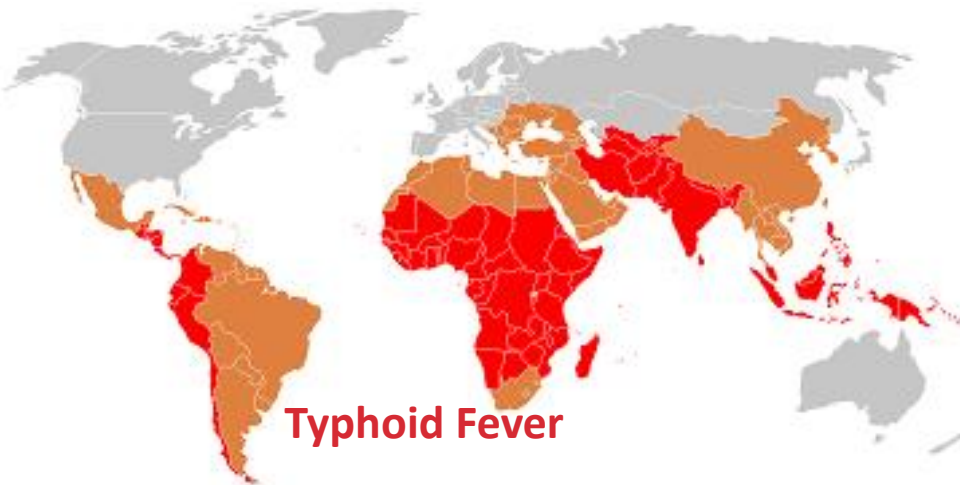
- 0 - 33
- 34 - 67
- 68 - 100
- Unknown

3.9 Billion People Projected to Live Under Severe Water Stress by 2050

Severity level
(water exploitation rate)

- No (< 0.1)
- Low (0.1 - 0.2)
- Medium (0.2 - 0.4)
- Severe (> 0.4)

Waterborne Diseases are a global problem

Cryptosporidium

Reported Cholera Cases in 1993

Rotavirus mortality rate in children younger than 5 years, 2013

Typhoid Fever

Data Source: WHO/IVB Rotavirus diseases burden estimates, April 2016, and United Nations, Population Division. The World Population Prospects - the 2012 revision". New York, 2013.

Map production: Immunization Vaccines and Biologicals, (IVB), World Health Organization

Date of slide: 15 April 2016

< 10 deaths per 100 000
≥ 10 and < 50 deaths per 100 000
≥ 50 and < 100 deaths per 100 000
≥ 100 deaths per 100 000
Not available
Not applicable

The boundaries and names shown and the designations used on this map do not imply the expression of any opinion whatsoever on the part of the World Health Organization concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Dotted lines on maps represent approximate border lines for which there may not yet be full agreement.
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Old & new pathogens threaten human health around the world

THE CONVERSATION
Academic rigor, journalistic flair

Arts + Culture   Economy + Business   Education   Environment + Energy   Health + Medicine   Politics + Society   Science + Techno

Brazil's sewage woes reflect the growing global water quality crisis

August 7, 2016   Joan Rose

Clostridium dificile Finland, 2007

*Campylobacter-*assoc rare paralysis Mexico & USA, 2011

Campylobacter, New Zealand, 2016

Polio, Nigeria, 2016

Cholera, Central African Republic, 2016

Sustainable Development Goals

At the United Nations Sustainable Development Summit on 25 September 2015, world leaders adopted the 2030 Agenda for Sustainable Development, which includes a set of 17 Sustainable Development Goals (SDGs) to end poverty, fight inequality and injustice, and tackle climate change by 2030.

THREATS TO THE COASTAL GL
Sewage;
Combine sewer overflows
Storm water;
non-point source pollution
Inadequate Infrastructure
Invasive species
Algal blooms
Climate change

Michigan's challenges

Waterborne pathogens threaten human health in the Great Lakes region

A sample glass of Lake Erie water is photographed near the Toledo water intake crib in Lake Erie. (Haraz N. Ghanbari/Associated Press)

E.Coli *0157H7 and* Campylobacter

Cryptosporidium

Norovirus

Legionella

Campylobacter, Arcobacter, Giardia

Toxic Algal blooms

©James A. Sullivan   www.cellsalive.com

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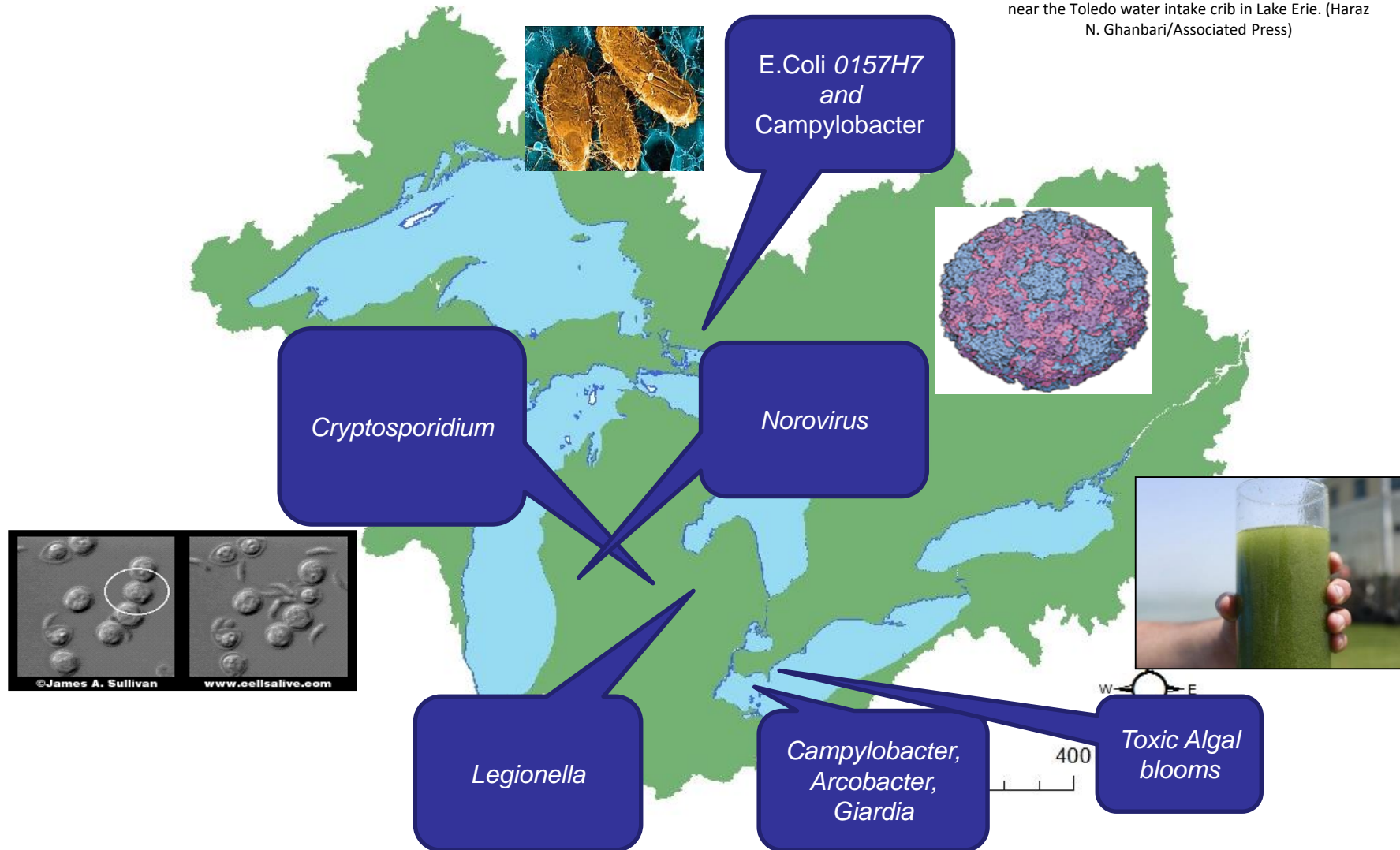
How do we solve the water pollution problems and protect water quality?

TECHNOLOGY

⬇

ASSESSMENT

⬇

IMPROVED KNOWLEDGE & DECISION MAKING

Growth Based Methods: Common Fecal Indicator Organisms for measuring water quality

Filtering 100 ml water samples
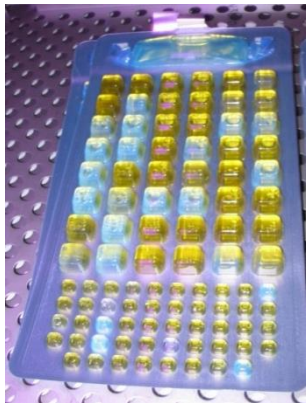
Total coliforms

MPN
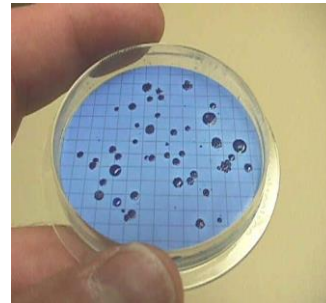
Fecal coliforms

Agar and colonies
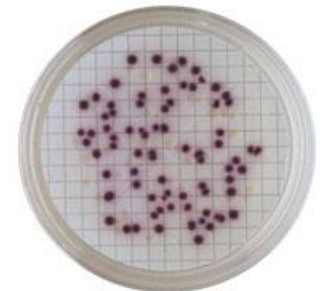
E.coli

MPN and colonies

Water Diagnostics

Polymerase chain reaction (PCR):

Small amount of DNA amplified in a thermal cycler

Amplified products are measured at the end point of amplification by agarose gel electrophoresis

Quantitative PCR (qPCR):

Amplified PCR products are detected real-time during the early phases of the reaction

DIGITAL DROPLET PCR

Metagenomic tools:

Understanding the Waterbiome

DNA Extraction

PCR

Real Time Detection

THE MICROBIOME

sources

microbiota

Community DNA

Metagenome library & sequence analysis
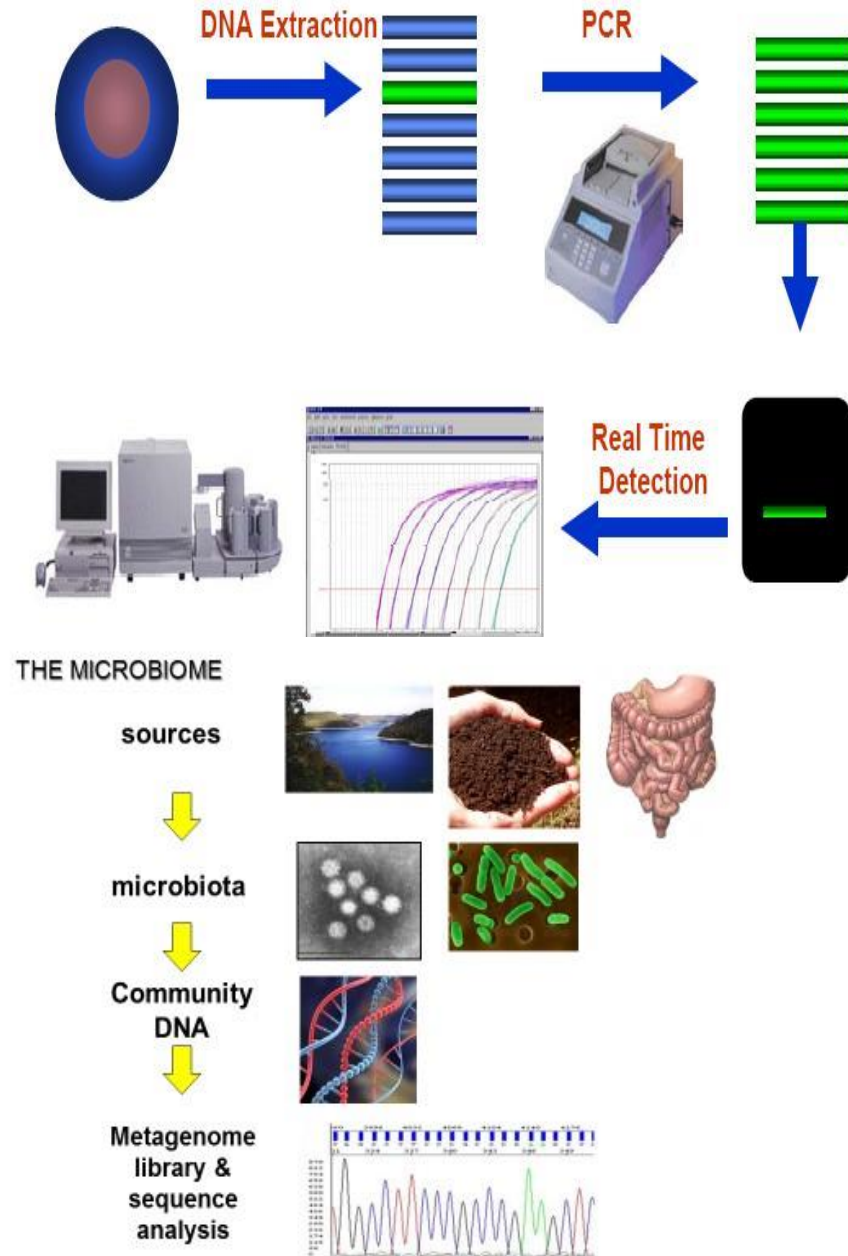
Water Diagnostics using digital droplet polymerase chain reaction
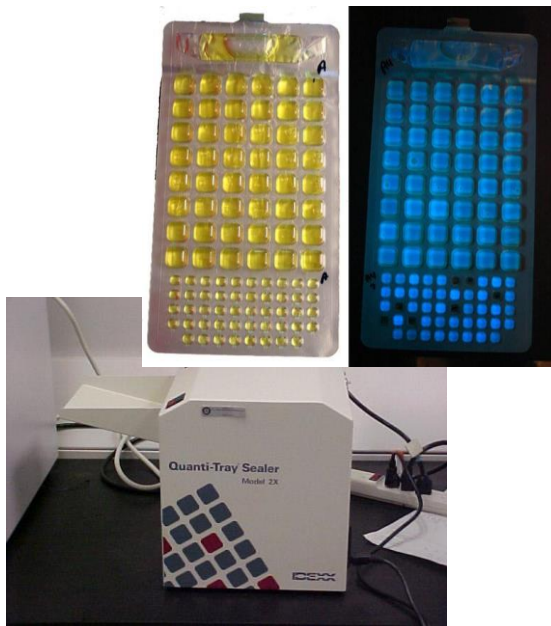
MPN cultivation TC/*E.coli* 24 hrs→ Rapid MPN genetic analyzer

Sources of *E.coli* and Pathogens

Septic systems

Waste water/Sewage treatment

Animal farming operations

Combined Sewer Overflow

Agricultural run-off

Wildlife
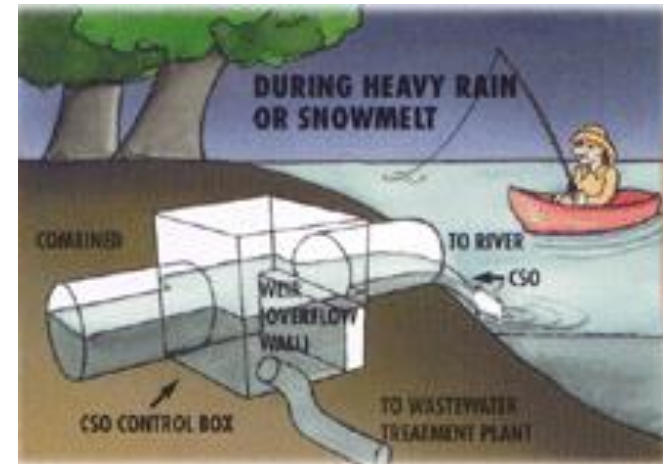
Source Tracking Study

1. Examine spatial distribution of *E. coli* and *B. theta* (Human) the M2 (Bovine) and pig2bac (Porcine) Markers in river systems under three flow conditions (baseflow, spring flow, summer flow)

2. Determine how key chemical, physical, environmental, hydrologic, and land use variables are linked to river water quality

Sampling

Baseflow (October 2010)
Spring thaw (March 2011)
Early summer rain (June 2011)

64 River systems

84% Lower Peninsula
drainage area
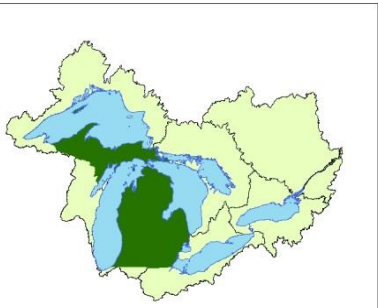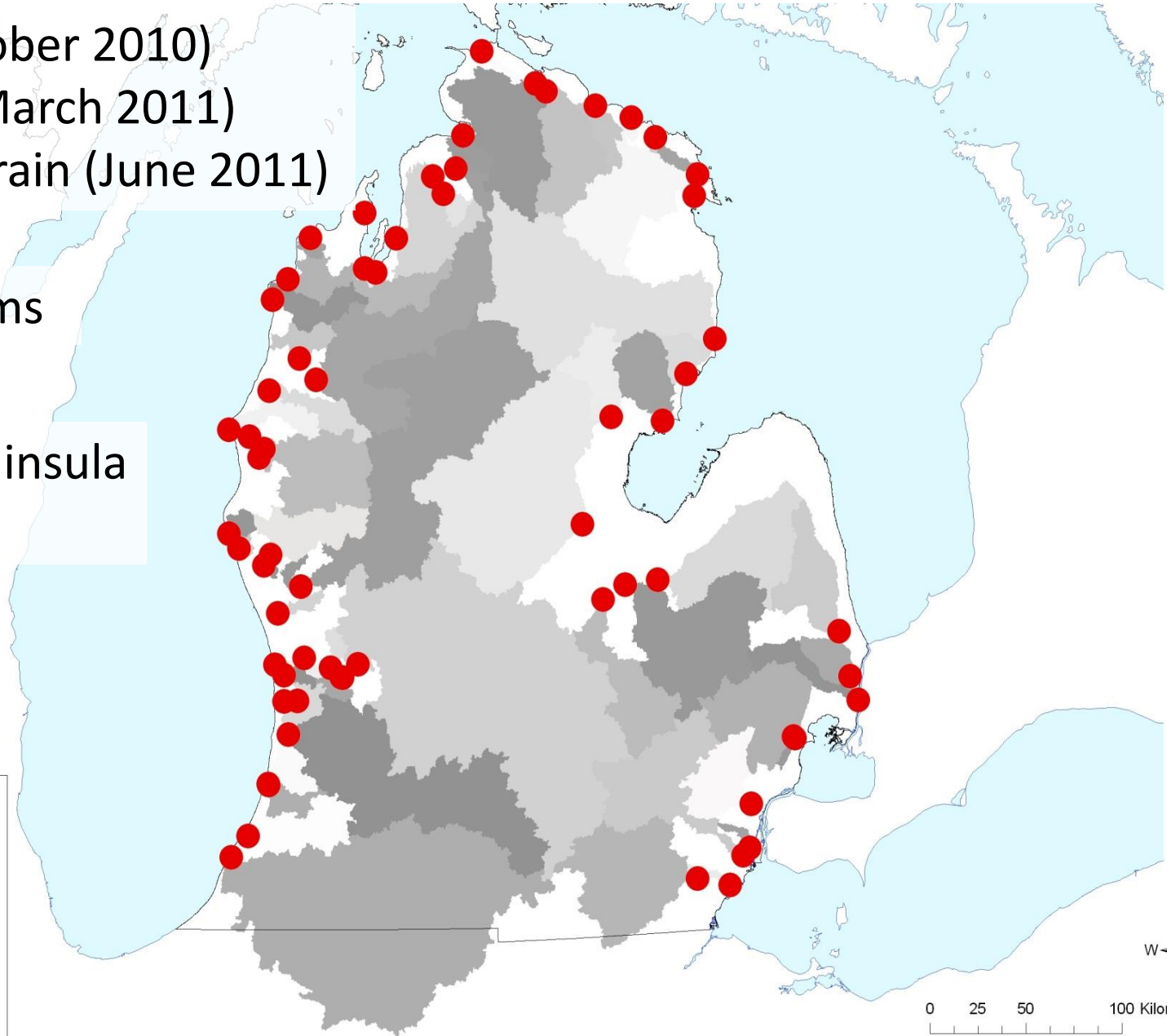
Improved Water Quality Diagnostics source tracking at large scale
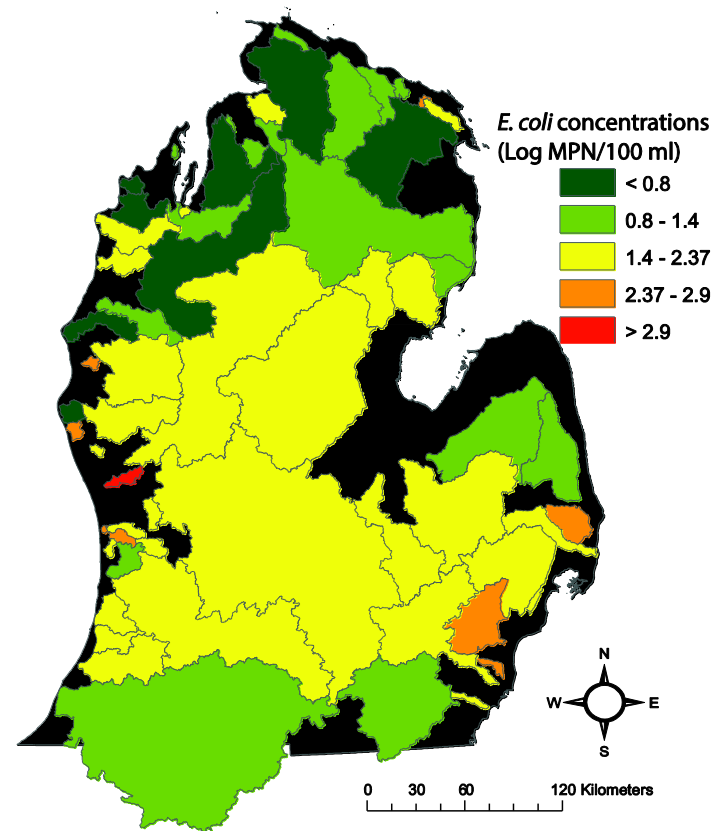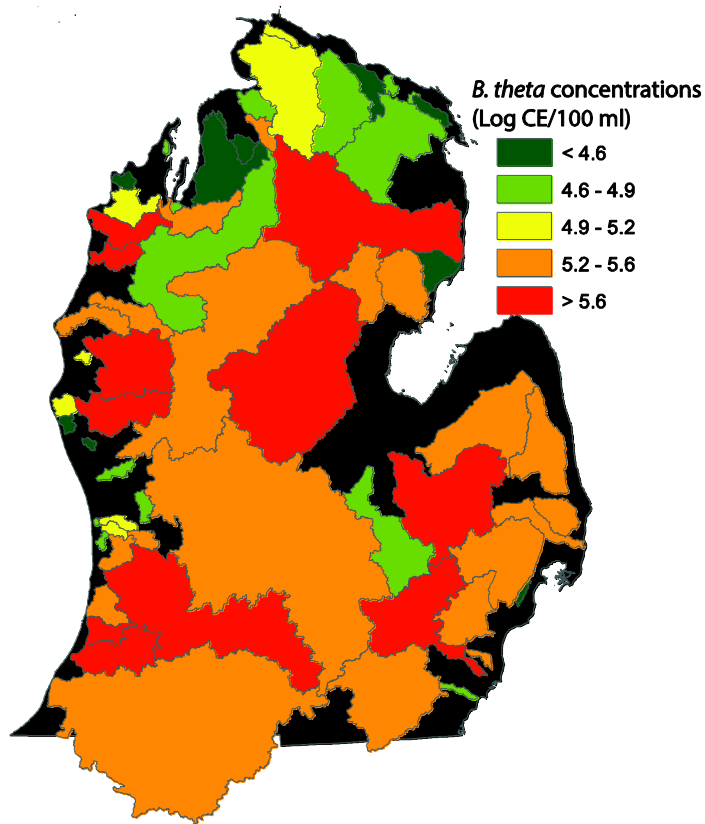
The distribution of the human sewage marker *Bacteroides*
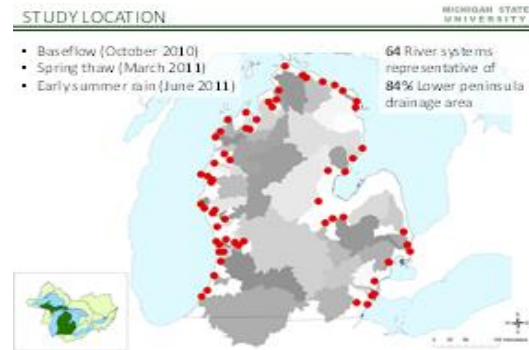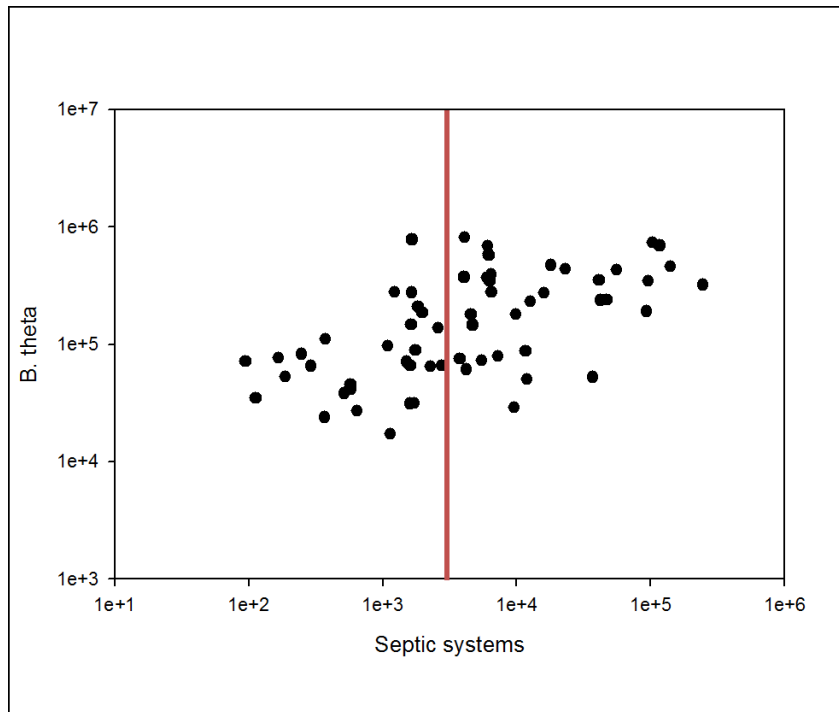
- Increasing *B. theta* related to more septic tanks
- *More E.coli* related to more total phosphorous and increasing stream temperature

What did we learn?

- New microbial source-tracking tools elucidate important nonpoint sources of water quality degradation and potential need for further investigation of human health risks at large scales

- Pollution arising from septic system discharges likely more important than previously realized

- Identifying sources and providing reference levels for water quality provides a basis to assess water quality trends and remediate degraded areas

- While transport was linked to rain, changes in concentrations were not as clearly determine.

Significant Knowledge Gaps Exist for Septics

OUTSIDE
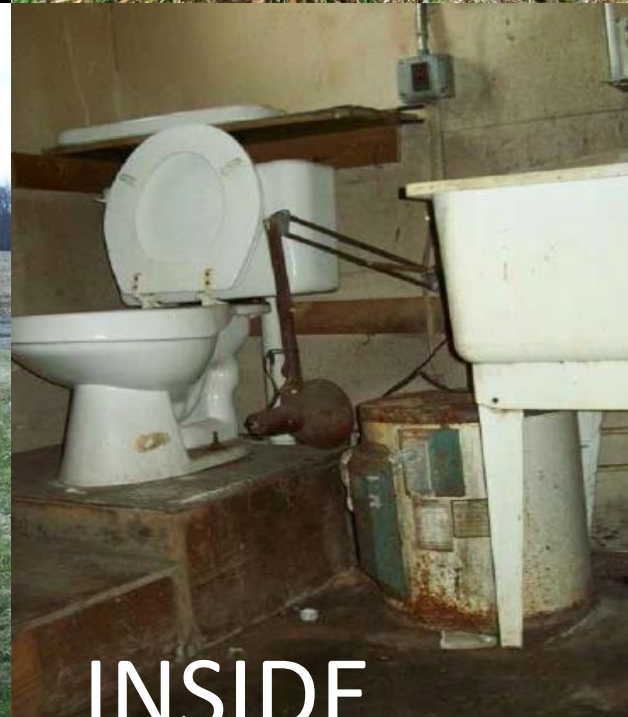
INSIDE
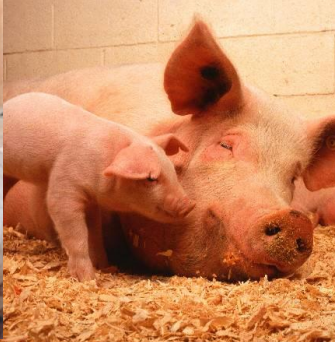
Agricultural Environments

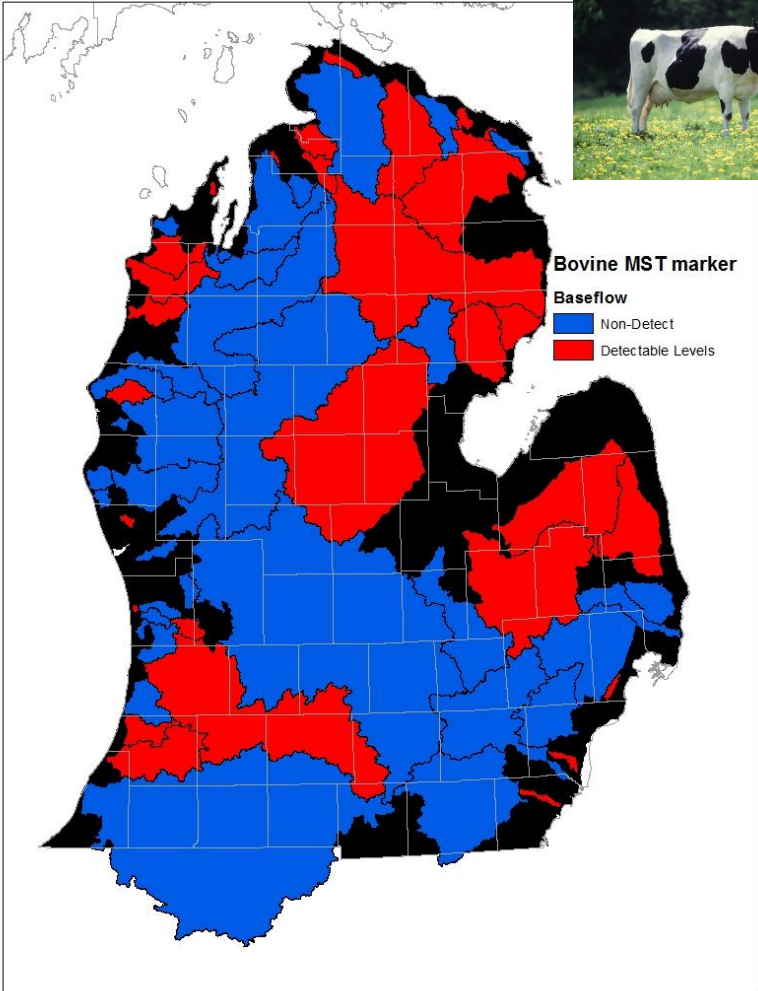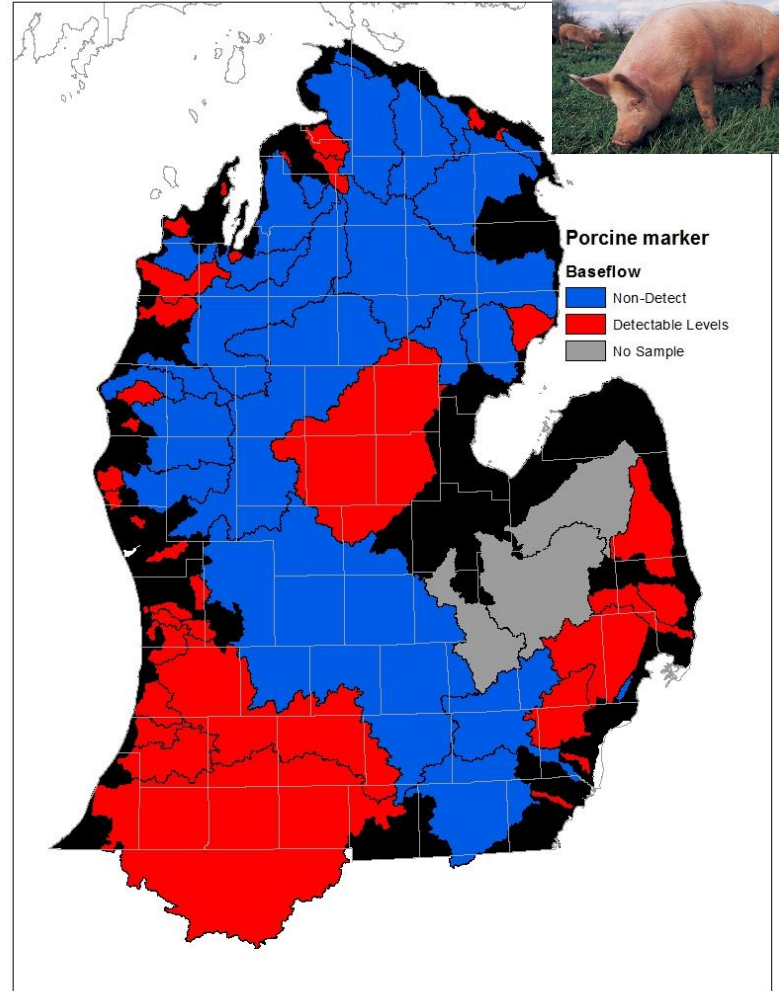**Bovine MST marker**

Baseflow
- Non-Detect
- Detectable Levels

Low flow

Porcine marker
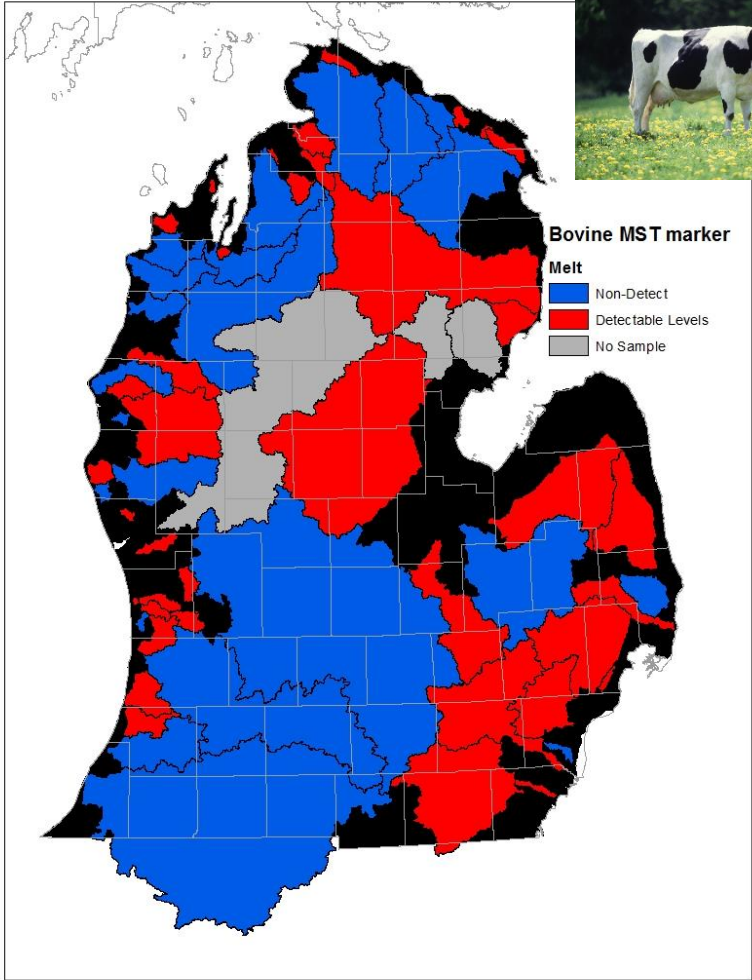
Baseflow
- Non-Detect
- Detectable Levels
- No Sample

Bovine MST marker
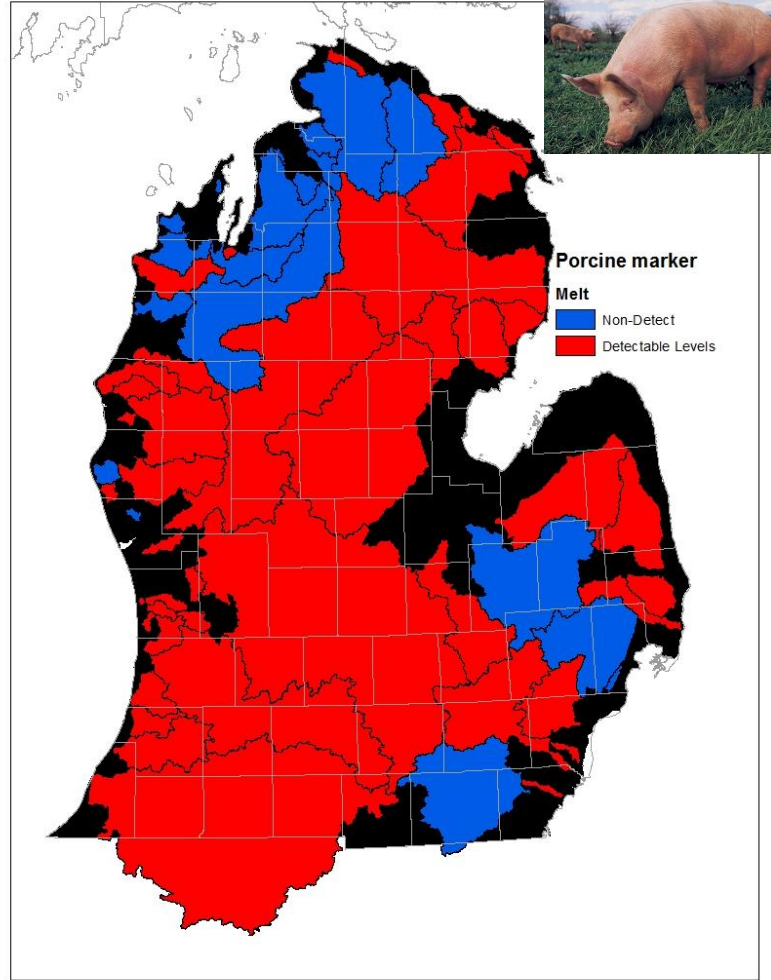
Melt
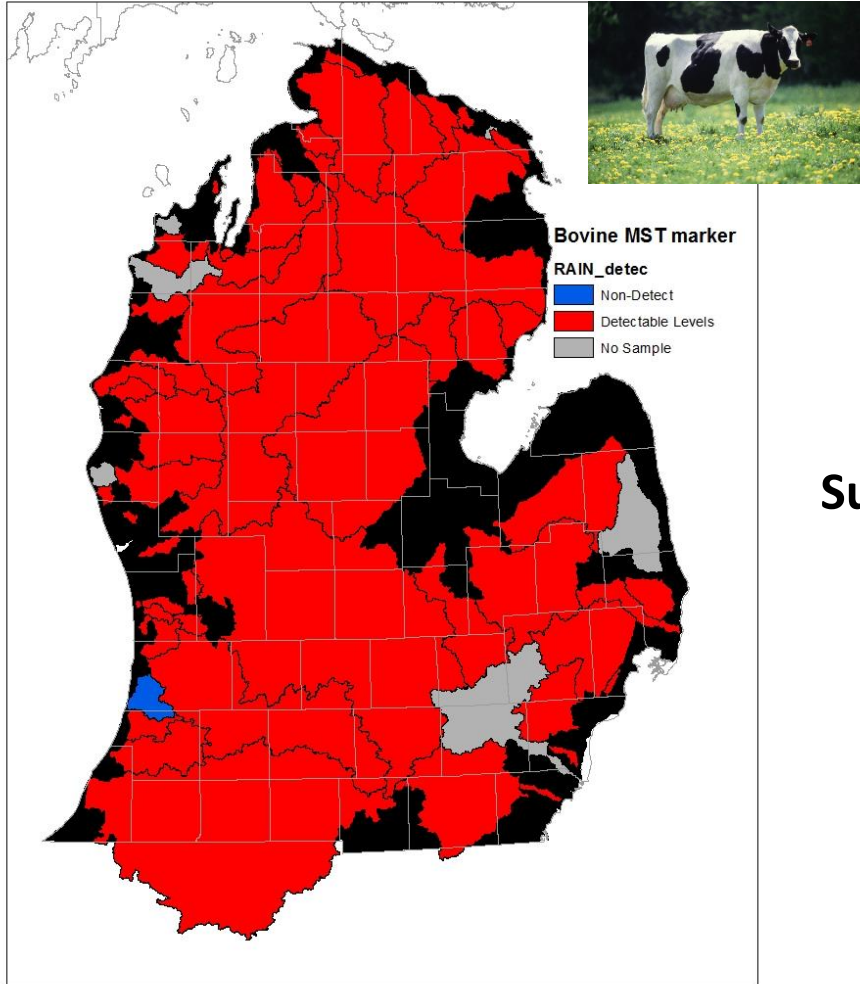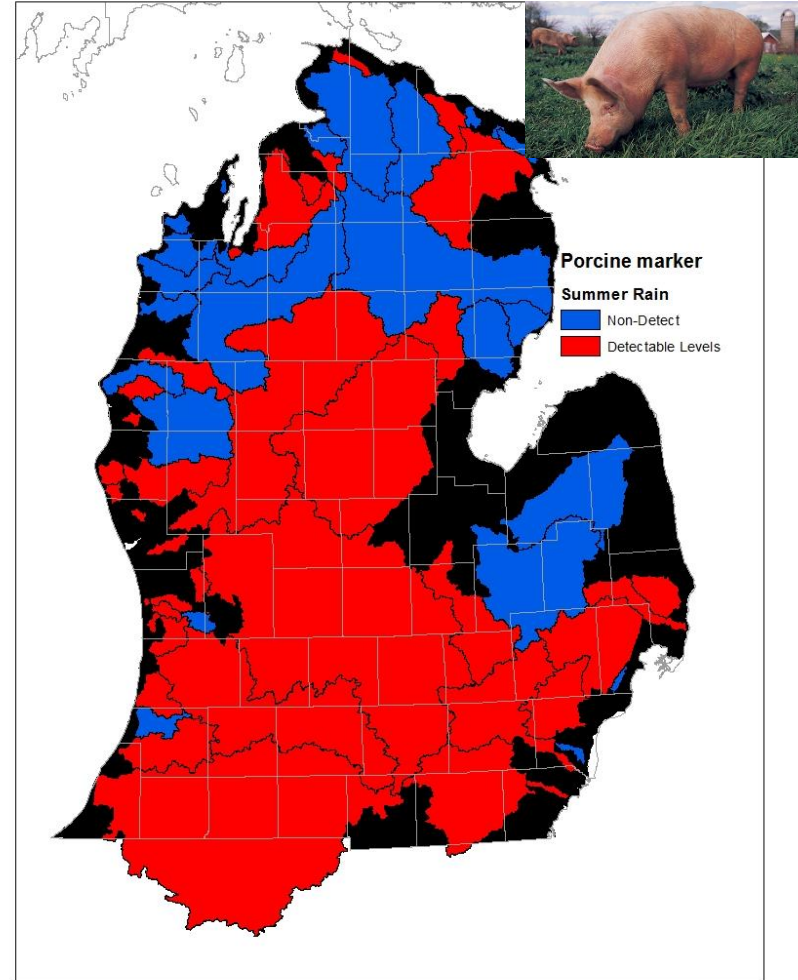- Non-Detect
- Detectable Levels
- No Sample

Spring melt

Porcine marker

Melt
- Non-Detect
- Detectable Levels

Bovine MST marker

RAIN_detec
- Non-Detect
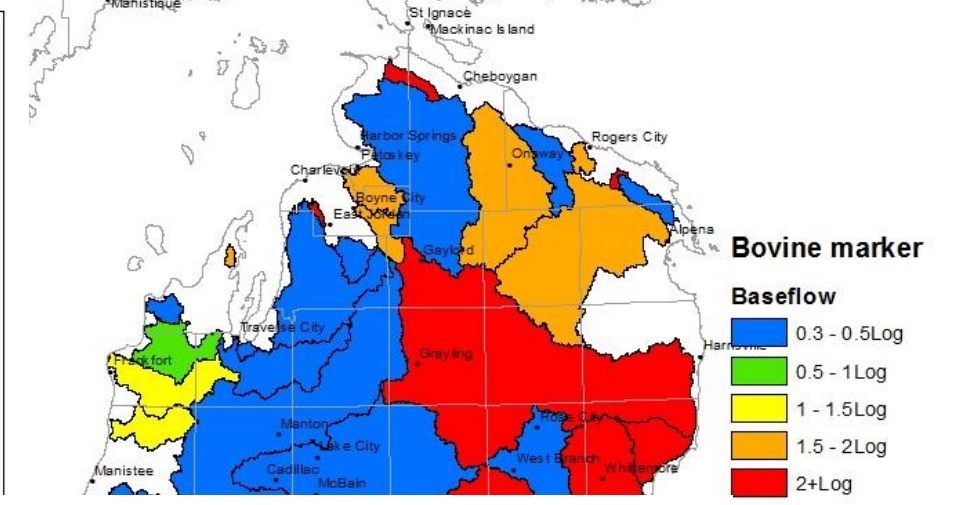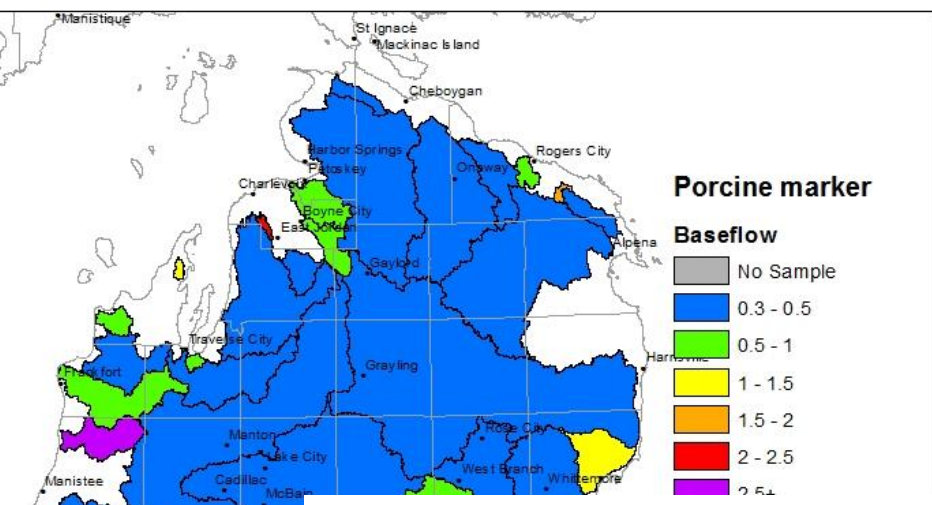- Detectable Levels
- No Sample

Porcine marker

Summer Rain
- Non-Detect
- Detectable Levels

Summer rain

Porcine marker

Baseflow
- No Sample
- 0.3 - 0.5
- 0.5 - 1
- 1 - 1.5
- 1.5 - 2
- 2 - 2.5
- 2.5+

Bovine marker

Baseflow
- 0.3 - 0.5Log
- 0.5 - 1Log
- 1 - 1.5Log
- 1.5 - 2Log
- 2+Log

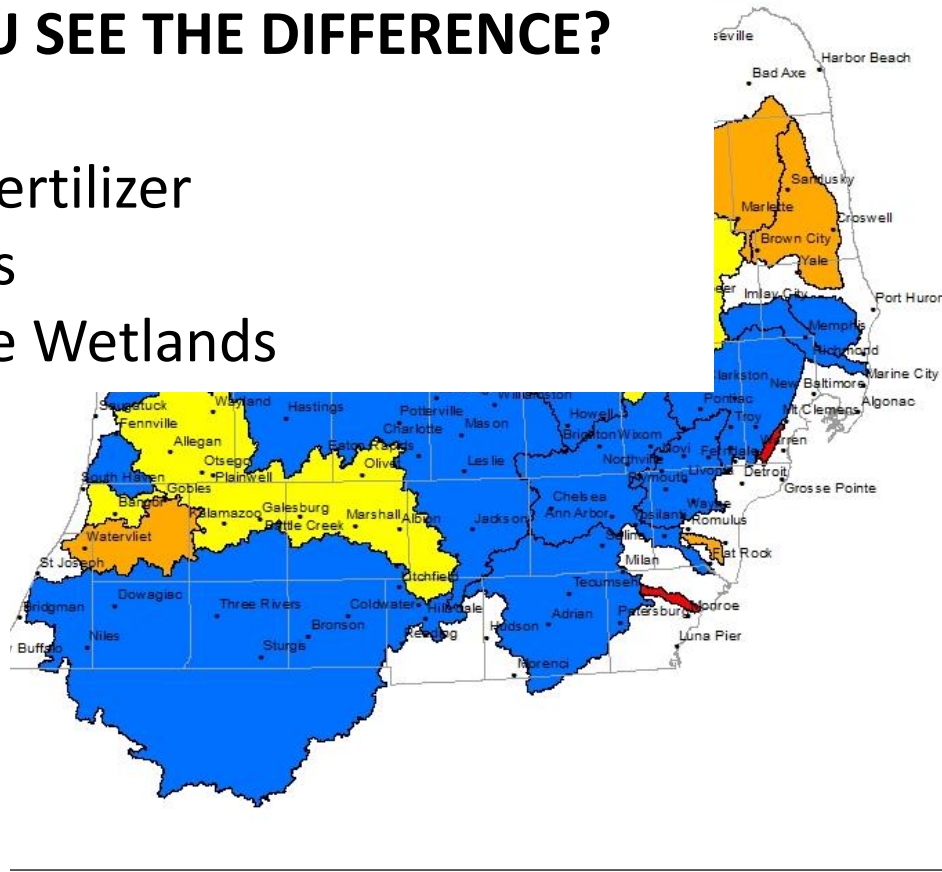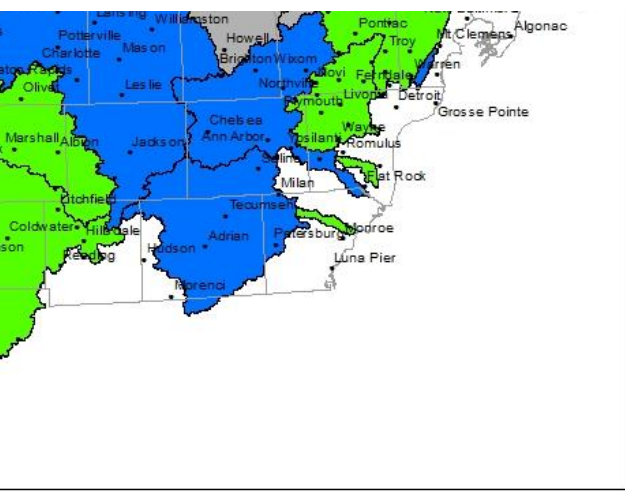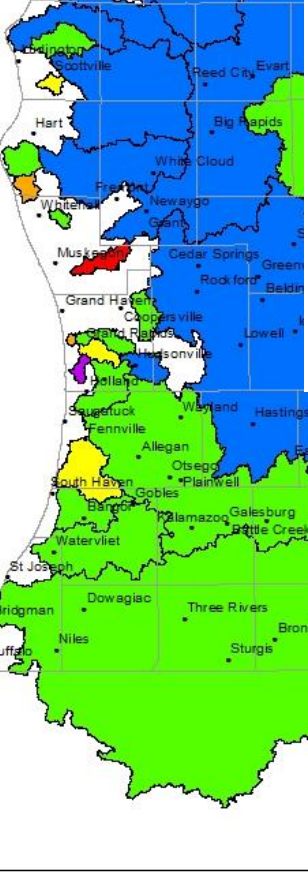## AT WHAT SCALE DO YOU SEE THE DIFFERENCE?
Till versus No Till

Manure versus Fertilizer
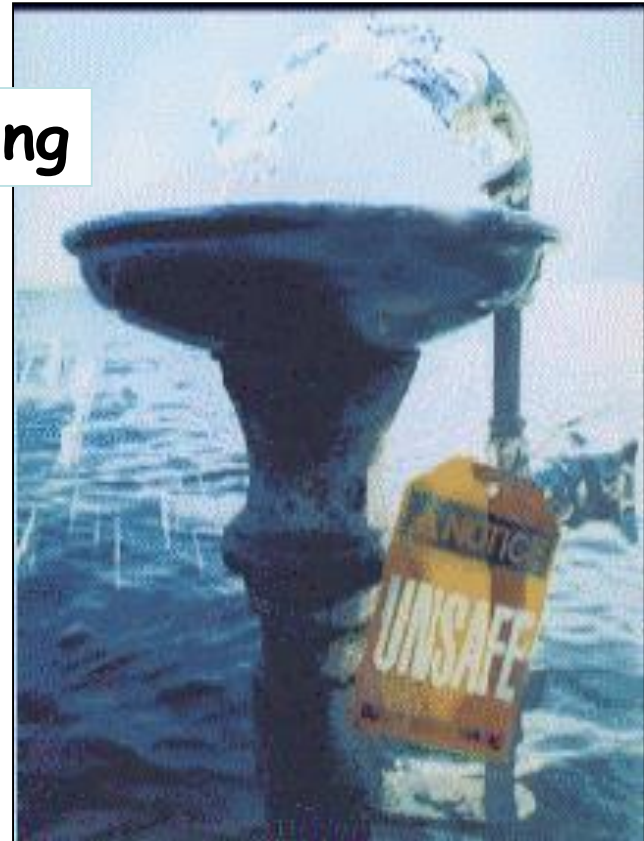
Use of Tile Drains

Buffers and More Wetlands

FRESH WATER RESOURCES ARE DEGRADING

Quality/Quantity issues

Irrigation

Recreational

Drinking

Algal blooms

Ecosystems

In waters used for drinking, fishing, recreation

Recommendations

- To achieve an understanding of water quality, fresh water resources and "Safe Water".
  - Use new water diagnostic molecular tools
  - Address the distribution of fecal pollution and sources under different land use and climate regimes at regional scales
  - Use sampling strategies to understand large scale processes.
  - Examine at smaller scale best management strategies

Thank You!

Any Questions??

Major contributors:
- **Dr. Marc Verhougstraete**,
- **Dr. Sherry Martin,**
- **Dr. Anthony Kendall,**
- **Dr. David Hyndman,**
- **Dr. Tiong Aw,**
- **Mr. Matthew Flood**

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