Experimental Manipulation of Entire Watersheds through BMPs: Nutrient Fluxes, Fate and Transport and Biotic Responses

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Goals

1. To demonstrate, through the experimental watershed approach, that implementation of BMPs in agricultural dominated watersheds will preserve soil and reduce nutrient loss from a series of sub-watersheds.

2. To evaluate the impact of instituted BMPs by considering the impacts on the downstream lake community on the watershed scale.

3. To evaluate the fate and transport of nutrients over space and time.
Pre-Management Background

Sand Point Gully
Figure 1. Percentage of land within the Conesus Lake watershed in agriculture

Legend
- Subwatersheds
- Town Boundaries
- Land Use in Agriculture
  - >70%
  - 40 to 70%
  - <40%
High Losses
NO₃, SRP, TKN, TP
Soil, Na

Sub-watersheds heavily in Agriculture

Baseline (g/ha/d)  Event (g/ha/d)
Excessive growth of filamentous algae on or around milfoil beds is related to loss of nutrients from watersheds heavily used in agriculture. The surface area measurements we obtain by GPS are multiplied by biomass quadrat measures to estimate the standing crops of milfoil at each site.

Area near stream mouths dominated by algae species **Zygnema** and **Spirogyra** which grow on Eurasian milfoil.
The loading of total and soluble reactive phosphorus were good predictors of the standing crop of milfoil beds in areas near the mouths of streams.

![Graph of standing crop vs total and soluble reactive phosphorus loads](image)
Metaphyton

- Defined as: littoral algae, neither strictly attached to substrata nor truly suspended
- In Conesus Lake, metaphyton exists in close association with Eurasian Water Milfoil, *Zygnema* & *Spirogyra*

Metaphyton at the mouth of the stream draining the Graywood watershed
Percent Growth of Metaphyton versus Agricultural Activity in the Watershed

\[ R^2 = 0.76 \]
\[ P = 0.026 \]
What Effects Metaphyton Growth?

Stream Loading Contributes to Increased Algae Biomass.

Nested ANOVA

% Metaphyton Growth in Stream and Lake Water

Reference
**E. coli** contamination is a well documented problem around Conesus Lake with several reports of elevated **E. coli** levels in the watershed.

**WHAT IS THE SOURCE?**

- Generally was believed to be due to agricultural practices in the watershed – especially dairy cattle.

- Quantification by traditional methods provides little understanding of the particular sources (Cows? Humans?) contributing to poor bacterial water quality.

- Bacterial Source Tracking using PCR (Polymerase Chain Reaction) provides a tool to identify sources of **E. coli** contamination based on genetic fingerprinting.
• **Created a Library:** A total of 150 *E. coli* isolates were PCR amplified and an average of 30 isolates per source group were used for comparison with unknown samples.

• **Analyzed Unknowns:** A total of 153 *E. coli* isolates were identified from stream water during spring of 2003 and 2004.
  – 62 isolates from Graywood Gully Experimental Watershed
  – 34 isolates from Southwest Creek Experimental Watershed
  – 38 isolates from Long Point Control Watershed
  – 19 isolates from North McMillan Control Watershed
**E. coli** Source Distribution in Conesus Lake Sub-watersheds

Winter and Spring

![Graph showing the distribution of E. coli isolates in Conesus Lake sub-watersheds.](image)

- **Graywood Gully**
  - Dairy: 12.9%
  - Geese: 52.9%
  - Cows: 11.8%
  - Deer: 11.8%
  - Reference: 7.9%

- **Southwest Creek**
  - Dairy: 16.1%
  - Geese: 11.8%
  - Cows: 11.8%
  - Deer: 7.9%
  - Reference: 10.5%

- **Long Point**
  - Dairy: 21.0%
  - Geese: 18.4%
  - Cows: 7.9%
  - Deer: 5.3%
  - Reference: 10.5%

- **North McMillan**
  - Dairy: 14.5%
  - Geese: 5.3%
  - Cows: 18.4%
  - Deer: 7.9%
  - Reference: 10.5%

Reference
Agricultural Contribution of *E. coli* During Event and Non-Event Periods

<table>
<thead>
<tr>
<th>Source</th>
<th>Graywood Non-Events</th>
<th>Graywood Events</th>
<th>Long Point Non-Events</th>
<th>Long Point Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural</td>
<td>14%</td>
<td>52%</td>
<td>45%</td>
<td>50%</td>
</tr>
<tr>
<td>Non-Agricultural</td>
<td>86%</td>
<td>48%</td>
<td>55%</td>
<td>50%</td>
</tr>
</tbody>
</table>

Dairy Farm

Row Crops
Pre-BMPs Results

*Greater loss of nutrients and soils from agricultural watersheds – especially during hydrometeorlogic events

*Elevated levels of NO₃, SRP, TP, TKN and soil in streams

*Macrophyte beds in lake associated with watersheds in agriculture at stream mouths

*Macrophyte biomass highly correlated with phosphorus loading

*Algae biomass at stream mouths stimulated by water (e.g. phosphorus) from watershed

*Non-agricultural sources of *E. coli* are prevalent during non-events. Geese, rather than dairy cattle, were predominant

*During events *E. coli* from cattle are prevalent.
Collaborative approach of local agencies, farming community and academics
Experimental and Reference Watersheds
What effect do the implemented management plans have on retaining soil and nutrients within the watershed?
Pre- and Post- BMP monitoring of stream sites (continuous flow and chemistry)
Gully Erosion - Loss of 133 tons per year

AEM Planning
*Total farm planning
  *Nutrient Reduction
  *Runoff reduction
  *Strip cropping
  *Buffer strips (alfalfa)
*Teracing
**Gully Plugs
**SOIL LOSS**

**ORGANIC NITROGEN LOSS**

**Phosphorus Loss**

Major decrease in particulates with “gully plugs”, not in reference watersheds

No change or an increase in dissolved fractions
Conesus Lake

Graywood Watershed, February 2003
AEM Planning (All Exp. watersheds)

*Total farm planning
  *Nutrient Reduction
  *Runoff reduction
  *Strip cropping

**Eliminated winter manure spreading in hydrologically sensitive areas (HSAs) and and highly erodible land (HEL)

* Reduced fertilizer use ($5,000 year 1) while maintaining yields

SRP = 210 mg SRP/L
TKN = 1000mg N/L
Effect of Management Practices on the Graywood Watershed

Winter

- **TP**
- **SRP**
- **NO₃**
- **TKN**
- **TSS**
- **Na**

**ug/L or mg/L**

2002 2003

Fall – Sig.TKN and TSS
Spring – no significance
Summer - no significance
Graywood Events

Rising Limb of Events

TKN (mg/L*10)  SRP (µg P/L)

** P(T<=t)= 0.008
*  P(T<=t)= 0.057
**Manure Lagoon

Soil Injection

No significant changes in chemistry in first two years.
50 tons of soil from Gully Erosion, Installation of Gully Plugs, surface inlets and underground outlets on the McClellan Farm.

**Grazing pens on steep sided pasture**

HEL
What effect did these management plans have on downstream biotic streams?

Macrophytes?
Bacteria?
Metaphyton?
Relative Coliform Abundance

Total Coliform Bacteria

***P(T<=t) = 0.005***
Metaphyton Cover (BMPs and Reference)

P(T<=t) = 0.032
Phosphorus Dynamics During Metaphyton Bloom

(July and August)
Summary (preliminary results)

*Able to better retain nutrients and soils in the watershed with management practices.

*Able to reduce nutrient (TP, SRP, NO₃, TKN) and soil loss to downstream systems by MPs.

*Metaphyton and coliform bacteria were reduced in streams and in the lake in managed watersheds.

*Macrophytes – some suggestions of a reduction but no significant statistical response yet.
Some Issues, Lessons, Suggestions

1. Funding agencies want adaptive management strategies. Takes time.
   The public wants instant results. No win situation.
2. Difference between “remediation” and “science” projects.
   Public does not understand the difference.
   Reference versus Experimental watersheds. Altria vs USDA
3. How to deal with the constant pressure to do something!
   Short-term (aquasol, Alum?, weevils, etc.) vs long-term solutions
4. Science Perspective: Not experimental watersheds controlled by an agency. At the mercy of the land users in and out of the watershed.
5. Liaison with the agricultural community. Generally will not believe an academic type. Nate Herendeen
Demonstrate to the Finger Lakes farming community, the utility and effectiveness of the implemented BMPs allowing regional policy makers and managers to develop optimal strategies for improving land usage in watersheds while significantly improving water quality and decreasing abundance of nuisance plant species in downstream ecosystems.

The collaborative approach provides a mechanism for the farming community to be proactive in watershed issues through education, implementation of BMPs, and by its traditional stewardship of the land it farms and is a logical step in the implementation of the Conesus Lake Watershed Management Plan.
## Monitoring Post- Best Management Plans

**SUNY Brockport**
- **Joe Makarewicz** – Organization, Nutrient and hydrologic data
- **Ted Lewis** - Web, Field and Laboratory work
- **Mark Noll** - GIS
- **Jim Zollweg** - Watershed Models
- **Sarah Wasson** - Graduate Student

**SUNY Geneseo**
- **Sid Bosch** - Macropytes and metaphyton
- **Bob Simon** - Bacterial abundance - coliforms, BST

**Rochester Institute of Technology**
- **Tony Vodacek** - Stream mouth modeling and imagery

**Cornell Cooperative Extension**
- **Nate Herendeen** – AEM, Soil analysis, soil nutrient assessment,
- **Nancy Glacier** outreach

**Livingston County SWCD**
- **Pete Kanouse** - Construction, liason

**Livingston County Planning**
- **David Woods** and **Heather Ferrero** - Liaison
AEM Planning
Agricultural Environmental Management

• Mandatory on all CAFO sized farms, over 1000 animal units

• Voluntary on dairy/livestock farms with 300 - 999 animal units

• Will be required (voluntary compliance) on all farms with animals by 2009