Nutrient objectives for small streams in agricultural watersheds of Alberta

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Funding

Project Team

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Faculty: Suzanne Tank; Rolf Vinebrooke
M.Sc. Students: Nikki van Klaveren; Emily Barrie; Sydney Huculak

Stakeholders

Alberta Agriculture and Forestry
University of Alberta
Alberta Agriculture and Agri-Food Canada
North Saskatchewan Watershed Alliance
ILWG Intensive Livestock Working Group
Project Objectives

1. Generalized nutrient management targets on a natural region basis

2. Compare to site-specific nutrient management targets

3. Assess achievability of recommended targets using watershed-scale modeling of agricultural BMPs
Project Scope

- **Natural region focus**
  - Parkland (26 sites)
  - Grassland (30 sites)

- **Seasonal focus**
  - Spring (April – May)
  - Summer (June – August)

- **Small streams**
  - 3rd and 4th Strahler Order
Aquatic Ecosystem Responses

Structural
- Attached Algae
  - Pigments
  - Biomass

- Suspended Algae
  - Community Composition

Functional
- Metabolism
  - Oxygen Cycling

- Nutrient Uptake
  - Decomposition

http://microbiologyonline.org/about-microbiology/introducing-microbes/algae
1. Composite data into seasons
2. Calculate 35 metrics of aquatic ecosystem health
3. Determine if threshold responses to nutrients exist for each metric
4. Obtain bootstrap threshold estimates for each applicable metric
5. Create distribution of thresholds used to define numeric targets
Phosphorus Uptake Velocity

Water column Chlorophyll a
Metrics with Threshold Response to Nutrients

Structural Metrics

- Water column Chl a
- Periphyton Chl a
- Cyanobacteria Abundance
- Diatom Abundance
- Motile Diatom Abundance
- Diatom Pigment Index
- Green Algae Pigment Index
- Generic Diatom Index
- Generic Evenness
- Generic Richness

Functional Metrics

- Net ecosystem productivity
- Daily minima of dissolved oxygen
- Decomposition rate: Total
- Decomposition rate: Microbial
- Nitrogen uptake velocity
- Phosphorus uptake velocity
- Areal uptake of nitrogen
Semi-Quantitative Weighting of Metrics

- Intent: promote the influence of more important metrics
- Survey of Government of Alberta employees
  - Restricted due to Elections Communications Policy
- Scored 35 aquatic ecosystem metrics on importance for defining numeric nutrient management targets
Nutrient Objectives = Boundaries of Aquatic Ecosystem Health Impairment (AEHI) Risk Zones

Central Value
Transition from Moderate to High Risk of Impairment states

Lower Error Bound
Transition from Low- to Moderate Risk of Impairment States

Nutrient Concentration Increase

Upper Error Bound
Transition from High to Very High-Risk of Impairment states

Low Risk of Impairment
Most ecosystem components are likely be performing well

Moderate Risk of Impairment
Aquatic ecosystem is in fair condition, but some ecosystem components may be stressed

High Risk of Impairment
Some ecosystem components may be operational, but most are likely to be altered

Very High Risk of Impairment
High degree of alteration in most ecosystem components
Boundaries of AEHI Risk Zones

Weighted Threshold Distribution: Parkland Summer TP

- **Lower**: Transition from Low-to-Moderate AEHI Risk
  - 10th Percentile
- **Central**: Transition from Moderate-to-High AEHI Risk
  - 50th Percentile
- **Upper**: Transition from High-to-Very High AEHI Risk
  - 80th Percentile
Preliminary Total Nitrogen Objectives

**Grassland**

- **Spring**
  - 0.68 mg/L
  - 0.87 mg/L
  - 1.18 mg/L

- **Summer**
  - 0.47 mg/L
  - 1.44 mg/L
  - 2.47 mg/L

**Parkland**

- **Spring**
  - 1.34 mg/L
  - 1.96 mg/L
  - 2.42 mg/L

- **Summer**
  - 0.61 mg/L
  - 1.44 mg/L
  - 2.03 mg/L
Preliminary Total Phosphorus Objectives

<table>
<thead>
<tr>
<th>Area</th>
<th>Season</th>
<th>0.05 mg/L</th>
<th>0.13 mg/L</th>
<th>0.25 mg/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grassland</td>
<td>Spring</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Summer</td>
<td>0.04 mg/L</td>
<td>0.18 mg/L</td>
<td>0.32 mg/L</td>
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<tr>
<td>Parkland</td>
<td>Spring</td>
<td>0.07 mg/L</td>
<td>0.29 mg/L</td>
<td>0.41 mg/L</td>
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<tr>
<td></td>
<td>Summer</td>
<td>0.05 mg/L</td>
<td>0.25 mg/L</td>
<td>0.47 mg/L</td>
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</tbody>
</table>
Achievability of AEHI Risk Boundaries as Nutrient Management Targets

Simulating In-Stream Nutrient Reductions using Watershed-scale Agricultural BMP Modelling
Simulates nutrient load reduction due to agricultural practices

Calculated reduction in monthly flow-weighted mean concentration (FWMC)

Simulated cumulative land-use scenarios on 25-year time series (1987 – 2011)
Parkland – Threehills Creek

Grassland – Indianfarm Creek
<table>
<thead>
<tr>
<th>BMP type</th>
<th>Number of fields</th>
<th>Watershed affected area (%)</th>
<th>Fields selection criteria for BMP application</th>
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</thead>
<tbody>
<tr>
<td><strong>Indianfarm Creek watershed</strong></td>
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<td></td>
</tr>
<tr>
<td>Scenario #1: Baseline+Filter Strip</td>
<td>19</td>
<td>23.2</td>
<td>TP &gt; 1.6 mg l(^{-1}), Cultivated</td>
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<tr>
<td>Scenario #2: SCEN1+Dugout (Pond)</td>
<td>17</td>
<td>9.3</td>
<td>TP &gt; 2.0 mg l(^{-1}), Area &gt; 20 ha, Pasture</td>
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<tr>
<td>Scenario #3: SCEN2+Wetland</td>
<td>3</td>
<td>6.1</td>
<td>Area drained during 1991-2010 period</td>
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<tr>
<td>Scenario #4: SCEN3+Stream Fencing</td>
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<td>29.8</td>
<td>TP &gt; 1.6 mg l(^{-1}), Pasture</td>
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<tr>
<td>Scenario #5: SCEN4+Rotational Grazing</td>
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<td>39.4</td>
<td>TP &gt; 0.8 mg l(^{-1}), Area &gt; 9 ha</td>
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<tr>
<td>Scenario #6: SCEN5+Soil P</td>
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<td>17.4</td>
<td>STP &gt; 200 ppm, Manured</td>
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<tr>
<td><strong>Threehills Creek watersheds.</strong></td>
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<td>Scenario #1: Baseline+Filter Strip</td>
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<td>Scenario #3: SCEN2+Wetland</td>
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<td>Drain during 1991-2000 period</td>
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<td>Scenario #5: SCEN4+Rotational Grazing</td>
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<td>8.3</td>
<td>TP &gt; 0.8 mg l(^{-1}), Area &gt; 9 ha</td>
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<td>Scenario #6: SCEN5+Soil P</td>
<td>134</td>
<td>37.1</td>
<td>STP &gt; 200 ppm, Manured</td>
</tr>
</tbody>
</table>
Simulated TN Reduction: Indianfarm Creek

Scenario #6
Simulated TP Reduction in Indianfarm Creek

Scenario #6

[Chart showing box plots for TP Pesticide Reduction (%) by month from March to September.]
Next Steps: Phase 2

• Conduct stressor-response studies in Boreal natural region
  – Complete provincial agricultural zone
• Derive AEHI Risk Zones (i.e., nutrient objectives) according to watershed classification
  – Better identifies inherent differences in flow conditions, water chemistry, etc.
  – Potentially leads to more meaningful values
• Consider evaluating the AEHI bounds using different model that better simulates in-stream concentrations
Questions?