Using the SWAT Model for BMP implementation and diffuse source phosphorus reductions in the Pike River Watershed, southern Quebec, Canada:

Isabelle Beaudin, Aubert Michaud, Julie Deslandes, Jacques Desjardins & Flora Umuhire
Outline

- Context
- Site Description
- SWAT’s set-up (Brochets, Walbridge, Castor)
- Results
- Scenarios
- Transfer to SWAT-2005
- Tile drainage
- Modification to the code
- Conclusion
Context

Diffuse pollution sources

Support decision making

↓ **Loads**
97.2 t/yr by 2009
41% reduction

VT: 60%
Qc: 40%

Study site

Upstream of Bedford (Ag. Area = 13 265 ha)

- Dairy: 36%
- Beef: 39%
- Hog: 8%
- Poultry: 5%

Dairy: 18 828 AU (1.01 AU/ha)
Beef: 18 828 AU (1.01 AU/ha)
Hog: 5 877 AU (0.44 AU/ha)
Poultry: 5 877 AU (0.44 AU/ha)

Downstream of Bedford (Ag. area=18 640 ha)

- Dairy: 36%
- Beef: 35%
- Hog: 24%
- Poultry: 5%

Dairy: 18 828 AU (1.01 AU/ha)
Beef: 18 828 AU (1.01 AU/ha)
Hog: 5 877 AU (0.44 AU/ha)
Poultry: 5 877 AU (0.44 AU/ha)
Data Integration

Hydrography/Topography

Pedology

Land use

Base unit: HRU

Elevation

Land use

Soil

HRU - Homogenous Response Unit

99 sub-bassins
3885 HRU

- Cultures/rotations
- Fertilization
- Tillage
- Conservations practices
Gauging stations

Brochets downstream:
- 563 km²
- Forest 44%
- Grassland 20%
- Corn 16%

Castor:
- 12 km²
- Corn 44%
- Grassland 28%
- Cereals 20%

Walbridge intervention & témoin:
- 15 km²
- Corn 36%
- Forest 26%
- Grassland 20%

Brochets upstream:
- 386 km²
- Forest 54%
- Grassland 20%

<table>
<thead>
<tr>
<th>Location</th>
<th>Calibration</th>
<th>Validation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brochets upstream</td>
<td>1999-2000</td>
<td>---</td>
</tr>
<tr>
<td>Brochets downstream</td>
<td>2002</td>
<td>2003</td>
</tr>
<tr>
<td>Walbridge</td>
<td>2002</td>
<td>2003</td>
</tr>
<tr>
<td>Castor</td>
<td>1998-1999</td>
<td>2000</td>
</tr>
</tbody>
</table>
Results
Spatial Variability

10% of cropped lands contribute to 50% of the total P exports.
Modelling results
Temporal variability

Corn on a Milton badly drained sandy loam

78% of P exports happened during 6% of the study period
(62 days between 2001 et 2003)
Scenarios

Reference Scenario

Alternative Scenarios

- Mode and period of fertilizer application
  - Optimization of the period and mode of fertilizer application

- Conservation tillage
  - No-Till
  - Reduced tillage

- Cover crops
  - Perennial crops
  - Small grains + intercrop (leguminous crop)
  - Small grains + late season cover crop (cruciferous crop)

- Hydro-agricultural structures
  - Buffer strips
  - Tile inlets
Phosphorus exports in relation to increasing adoption of BMPs

Cumulative reduction in total P export (%)

- Intercropping
- Perrenial crop
- Late season cover crop
- Conservation tillage

% of cropped area affected by the scenario
Sediment and phosphorus reductions obtained with varying level of BMP implementation

Effect of 10% targeted = 50% random

- Perennial crop
- Small grains + Leguminous crop (inter-cropping)
- Small grains + Brassicaceae (late cover crop)
- Conservation tillage
# Résultats

## Mixed Scenarios

### Basic scenarios

<table>
<thead>
<tr>
<th>Scenarios</th>
<th>Late Season Cover Crops</th>
<th>Reduced Tillage or Intercropping</th>
<th>Immediate Incorporation</th>
<th>Perennial Crops</th>
<th>Buffer Zones</th>
<th>Structures Hydro-agricoles</th>
<th>Reductions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Sediments %</td>
</tr>
<tr>
<td>Reference Scenario</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>30.5 t/ha</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1%</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0%</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>9%</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>16%</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1%</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>25%</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>10%</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>26%</td>
</tr>
</tbody>
</table>

©IRDA
# Mixed Scenarios

## Conservation Practices

<table>
<thead>
<tr>
<th>Scenarios</th>
<th>Late season cover crops</th>
<th>Reduced tillage or intercropping</th>
<th>Immediate Incorpo.</th>
<th>Perennial crops</th>
<th>Buffer zones</th>
<th>Hydro-agricultural structures</th>
<th>Sediments %</th>
<th>Total P %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference Scenario</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>30.5 t/ha</td>
<td>46.1 kg/ha</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>47%</td>
<td>35%</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>100%</td>
<td>100%</td>
<td>Flood Plain</td>
<td>100%</td>
<td></td>
<td>53%</td>
<td>40%</td>
</tr>
<tr>
<td>11</td>
<td></td>
<td>T10%</td>
<td>100%</td>
<td>Flood Plain</td>
<td>100%</td>
<td></td>
<td>25%</td>
<td>19%</td>
</tr>
<tr>
<td>12</td>
<td></td>
<td>T 10%</td>
<td>100%</td>
<td>Flood Plain</td>
<td>100%</td>
<td>100%</td>
<td>38%</td>
<td>29%</td>
</tr>
<tr>
<td>13</td>
<td></td>
<td>R50%</td>
<td>100%</td>
<td>Flood Plain</td>
<td>100%</td>
<td></td>
<td>31%</td>
<td>25%</td>
</tr>
<tr>
<td>14</td>
<td></td>
<td>R50%</td>
<td>100%</td>
<td>Flood Plain</td>
<td>100%</td>
<td>100%</td>
<td>43%</td>
<td>34%</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td>T50%</td>
<td>100%</td>
<td>Flood Plain</td>
<td>100%</td>
<td></td>
<td>44%</td>
<td>32%</td>
</tr>
<tr>
<td>16</td>
<td></td>
<td>T50%</td>
<td>100%</td>
<td>Flood Plain</td>
<td>100%</td>
<td>100%</td>
<td>53%</td>
<td>40%</td>
</tr>
<tr>
<td>Scenarios</td>
<td>Late Season Cover Crops</td>
<td>Reduced Tillage or Intercropping</td>
<td>Immediate Incorporation</td>
<td>Perennial Crops</td>
<td>Buffer Zones</td>
<td>Hydro-agricultural Structures</td>
<td>Reductions Sediments %</td>
<td>Total P %</td>
</tr>
<tr>
<td>-----------</td>
<td>-------------------------</td>
<td>----------------------------------</td>
<td>-------------------------</td>
<td>----------------</td>
<td>-------------</td>
<td>------------------------------</td>
<td>------------------------</td>
<td>-----------</td>
</tr>
<tr>
<td>Reference Scenario</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>30.5 t/ha</td>
<td>46.1 kg/ha</td>
</tr>
<tr>
<td>17</td>
<td>T 10%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>27%</td>
<td>21%</td>
</tr>
<tr>
<td>18</td>
<td>T 10%</td>
<td></td>
<td>100%</td>
<td>Flood Plain</td>
<td>100%</td>
<td></td>
<td>35%</td>
<td>29%</td>
</tr>
<tr>
<td>19</td>
<td>T 10%</td>
<td>R 45%</td>
<td>100%</td>
<td>Flood Plain</td>
<td>100%</td>
<td></td>
<td>49%</td>
<td>39%</td>
</tr>
<tr>
<td>20</td>
<td>T 10%</td>
<td>T 45%</td>
<td>100%</td>
<td>Flood Plain</td>
<td>100%</td>
<td></td>
<td>53%</td>
<td>42%</td>
</tr>
<tr>
<td>21</td>
<td>T 10%</td>
<td>R 45%</td>
<td>100%</td>
<td>Flood Plain</td>
<td>100%</td>
<td>T10%</td>
<td>51%</td>
<td>41%</td>
</tr>
<tr>
<td>22</td>
<td>T 10%</td>
<td>R 45%</td>
<td>100%</td>
<td>Flood Plain</td>
<td>100%</td>
<td>100%</td>
<td>58%</td>
<td>46%</td>
</tr>
<tr>
<td>23</td>
<td>T 50%</td>
<td></td>
<td>100%</td>
<td>Flood Plain</td>
<td>100%</td>
<td></td>
<td>63%</td>
<td>51%</td>
</tr>
<tr>
<td>24</td>
<td>T 50%</td>
<td>+ 50%</td>
<td>100%</td>
<td>Flood Plain</td>
<td>100%</td>
<td></td>
<td>73%</td>
<td>59%</td>
</tr>
<tr>
<td>25</td>
<td>T 50%</td>
<td>+ 50%</td>
<td>100%</td>
<td>Flood Plain</td>
<td>100%</td>
<td>100%</td>
<td>78%</td>
<td>63%</td>
</tr>
</tbody>
</table>
Publications


Premilinary Conclusion

SWAT:
- A good tool for reproducing the transport dynamics of water, sediment and phosphorus from agricultural lands;
- Allow to identify the most sensitive zones in terms of P exports in watersheds in order to target these for BMP applications;
- Allow to model agri-environmental scénarios with BMP;
- Allow to identify some scenarios that enable to reach the target loads;
- Allow to establish realistic P export goals;
- Not a regulation tool;
Transfer to SWAT-2005

- Almost no water in the drains
- Tile drainage routines were modified
- Revert to old routines*
  - Bring back code based of SWAT-2000
  - Change order of operations
    1. Tile drainage
    2. Lateral flow
    3. Seepage
  - Tile drainage based on soil LAYER water, not soil profile

* In collaboration with U. Laval and UNESCO-IHE
Roughly 80% of the water drained from these two fields exits through tile drains.

### Volume of water (mm)

- **Surface runoff**
- **Tile drains**

#### 2002/2003
- GAGNON: 320.821
- MARCHAND: 378.860
- Surface: 96.351
- Tile drains: 75.260
- Total: 417.172

#### 2003/2004
- GAGNON: 426.505
- MARCHAND: 520.076
- Surface: 80.707
- Tile drains: 21.880
- Total: 507.212

#### 2004/2005
- GAGNON: 357.759
- MARCHAND: 191.346
- Surface: 157.041
- Tile drains: 55.871
- Total: 514.800

#### 2005/2006
- GAGNON: 737.340
- MARCHAND: 527.679
- Surface: 246.689
- Tile drains: 78.115
- Total: 984.029

©IRDA
Flow Separation with multisonde

Beaver Brook 2004-2006
- Subsurface flow (mm): 42%
- Surface runoff (mm): 58%

531 mm/yr.

Walbridge Creek temoin 2004-2006
- Subsurface flow (mm): 26%
- Surface runoff (mm): 74%

601 mm/yr.

Walbridge Creek intervention 2004-2006
- Subsurface flow (mm): 30%
- Surface runoff (mm): 70%

515 mm/yr.
Measurements and sampling of surface and subsurface runoff
Thank you!