Spatially Explicit Modelling for Examining Water Quantity and Quality Effects of Individual Wetlands at Site, Field, Farm, and Watershed Scales

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Agricultural Conservation Practices

Conservation Tillage

Nutrient Management

Cover Crop

Water & Sediment Control Basin

http://www.mda.state.mn.us/protecting/conservation/practices/bufferforested.aspx
**BMP Assessment in Space and Time**

- **CanSWAT**: Canadian Version of Soil and Water Assessment Tool – Adapted from U.S.
- **IMWEBs**: Integrated Modelling for Watershed Evaluation of BMPs – Canada
IMWEBs Model Workflow

- Data Preparation
- Watershed Delineation
- Model Setup
- Scenario Design
- Model Execution
- Result Analysis
- Model Calibration
The Broughton’s Creek Watershed
## Wetlands in the Broughton’s Creek Watershed

<table>
<thead>
<tr>
<th>Type</th>
<th>Count</th>
<th>Area (ha)</th>
<th>Avg. area (ha)</th>
<th>% of wetland area</th>
<th>% of watershed area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Altered</td>
<td>2,656</td>
<td>370</td>
<td>0.139</td>
<td>9.24</td>
<td>1.48</td>
</tr>
<tr>
<td>Intact</td>
<td>2,238</td>
<td>974</td>
<td>0.435</td>
<td>24.33</td>
<td>3.91</td>
</tr>
<tr>
<td>Drained consolidated</td>
<td>308</td>
<td>960</td>
<td>3.12</td>
<td>23.98</td>
<td>3.85</td>
</tr>
<tr>
<td>Drained altered</td>
<td>1,297</td>
<td>1,059</td>
<td>0.816</td>
<td>26.46</td>
<td>4.25</td>
</tr>
<tr>
<td>Drained lost</td>
<td>1,968</td>
<td>640</td>
<td>0.325</td>
<td>15.99</td>
<td>2.57</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>8,467</strong></td>
<td><strong>4,003</strong></td>
<td><strong>0.473</strong></td>
<td><strong>100</strong></td>
<td><strong>16.06</strong></td>
</tr>
</tbody>
</table>
Zoom in – Upper EC-9 Station
Flow Attenuation at EC9 Station for All Wetland Restoration
TP Reduction at EC9 Station for All Wetland Restoration
Flow Attenuation of Individual Wetlands

Individual wetland flow attenuation
TP Reduction of Individual Wetlands

Individual wetland TP reduction
Wetland TP Analysis Based on Modelling Results

- Average isolated wetland TP concentration from 2008 to 2013 is 0.019 mg/L with standard deviation of 0.014 mg/L

- Existing wetlands have reduced 4,975 kg/yr of on-site TP loading or 3,447 kg/yr of TP at the watershed outlet
Wetland Ranking Based on TP Reduction Efficiency

TP reduction efficiency
(kg ∆TP per ha per year)

\[ \text{Annual wetland TP reduction (kg/yr)} / \text{Wetland area (ha)} \]
On-site TP Change in Response to Wetland Loss/Restoration

Current status
Spatial Targeting of Wetland Retention and Restoration

- Retention: Identify the top 10 wetlands with the highest TP increase if lost

- Restoration: Identify the top 10 wetlands with the highest TP reduction efficiency if restored
Top 10 Wetlands for Retention and Top 10 Wetlands for Restoration

- All 249 existing wetlands – Average TP reduction 1.1 kg/ha/yr
- Top 10 wetlands for retention – Average TP reduction 6.7 kg/ha/yr
- Top 10 wetlands for restoration – Average TP reduction 7.9 kg/ha/yr
Wetland Loss and Restoration Scenarios
(Subbasin with Outlet at EC9 Station)

Wetland loss and restoration scenarios for the EC9 subbasin in the BRC watershed

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Wetland number</th>
<th>Wetland surface area (ha)</th>
<th>Storage ($10^4$m$^3$)</th>
<th>Flow (mm/yr)</th>
<th>Sediment (t/yr)</th>
<th>TN (t/yr)</th>
<th>TP (t/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing</td>
<td>249</td>
<td>266</td>
<td>94.8</td>
<td>275</td>
<td>9.4</td>
<td>5,806</td>
<td>1,268</td>
</tr>
<tr>
<td>Loss all</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>326</td>
<td>10.5</td>
<td>6,504</td>
<td>1,562</td>
</tr>
<tr>
<td>Restore all</td>
<td>456</td>
<td>515</td>
<td>192</td>
<td>258</td>
<td>4.07</td>
<td>4,424</td>
<td>1,101</td>
</tr>
<tr>
<td>Loss 10</td>
<td>239</td>
<td>233</td>
<td>81.0</td>
<td>279</td>
<td>9.57</td>
<td>6,017</td>
<td>1,312</td>
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<tr>
<td>Restore 10</td>
<td>259</td>
<td>298</td>
<td>108</td>
<td>271</td>
<td>6.31</td>
<td>4,555</td>
<td>1,187</td>
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</tbody>
</table>

Evaluation results of wetland loss and restoration scenarios for the EC9 subbasin

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Flow (mm/yr)</th>
<th>Sediment (t/yr)</th>
<th>TN (kg/yr)</th>
<th>TP (kg/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(%)</td>
<td>(%)</td>
<td>(%)</td>
<td></td>
</tr>
<tr>
<td>Loss all</td>
<td>51</td>
<td>18.5</td>
<td>1.13</td>
<td>12.0</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>697</td>
<td>12.0</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>294</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>23.2</td>
</tr>
<tr>
<td>Restore all</td>
<td>-17</td>
<td>-6.10</td>
<td>-5.33</td>
<td>-56.9</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>-1382</td>
<td>-23.8</td>
</tr>
<tr>
<td></td>
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<td>-168</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-13.2</td>
</tr>
<tr>
<td>Loss 10</td>
<td>4</td>
<td>1.35</td>
<td>0.17</td>
<td>1.86</td>
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<td></td>
<td></td>
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<td>211</td>
<td>3.63</td>
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<td></td>
<td></td>
<td>44</td>
</tr>
<tr>
<td></td>
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<td>3.44</td>
</tr>
<tr>
<td>Restore 10</td>
<td>-4</td>
<td>-1.51</td>
<td>-2.25</td>
<td>-23.9</td>
</tr>
<tr>
<td></td>
<td></td>
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<td>-814</td>
<td>-14.0</td>
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<td>-93</td>
</tr>
<tr>
<td></td>
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<td>-7.33</td>
</tr>
</tbody>
</table>
Conclusions

- The cell-based IMWEBs model was developed and applied to a representative watershed to evaluate the water quantity and quality effects of wetland loss and restoration.

- The IMWEBs is a unique watershed model that is capable of evaluating agricultural BMPs including wetlands at site, field, farm, and watershed scales.

- The IMWEBs model can be further developed to support decision making in landscape conservation programs.
Although many tools and models were reviewed that have the potential to evaluate water purification as a wetland ecosystem service, limited options were available, with the model that has the most potential (i.e., IMWEBs) currently in development. With respect to climate regulation, there were limited options...
**IMWEBs Supported BMP List**

**General BMPs**
- Crop management
- Tillage management
- Fertilizer management
- Grazing management
- Irrigation management
- Reservoir

**Wetland restore BMPs**
- Isolated wetland restoration

**Livestock BMPs**
- Manure incorporation
- Manure setback
- No application on snow
- Fall application
- Apply base on soil N level
- Apply base on soil P level
- Feedlot management
- Manure storage design
- Catch basin management
- Dugout
Livestock BMPs

Riparian and surface water management
- Manage access including fencing
- Vegetated filter strip
- Riparian buffer strip
- Grassed waterway

Wintering site management
- Changing location and area of wintering site
- Alternating wintering site annually
- Vegetation adjacent to wintering site

Pasture management
- Rotational grazing
- Timing and density of stocking
- Plant species in tame pasture
- Conservation and sustainable use of natural areas

Marginal crop land management
- Conservation to tame perennials
- Conservation to native perennials
Contact Information

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