Potential accuracy of water quality estimates based on non-calibrated SWAT simulations

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Most parameters have a suggested range of values, not one definite value.

Their final value is determined during the calibration process by comparing measured and simulated flow values and pollutant concentrations.

Flow and water quality data are not always available.

Crop yields are estimated for all U.S. counties.
Question

Can we use SWAT to evaluate BMPs impacts at the watershed level when few data are available to calibrate the model?
Long Branch Watershed

- Grassland: 39%
- Crop land: 29%
- Forest: 27%
- 271 km²
- 17% ground water
- Average annual flow: 0.56 m³/s

Flow Gage
Weather Gage
Streams
Subbasins
SwatLandUseClass
Crop land
Grasslands
Urban
Water
Forest
Miami Creek Watershed

- Grassland: 66%
- Crop land: 26%
- Forest: 8%
- 350 km²
- Average annual flow: 0.90 m³/s
- 13% ground water
Process

- Develop a model with SWAT2000 using best estimates of parameter values.
- Yield calibration based on crop yields and regional runoff values.
- Run alternatives.
- Calibrate the model with flow data.
- Run alternatives again.
Comparisons

- Compare stream loadings from the yield and flow calibrated models.
- Compare load reductions from alternative management with both models.
- Compare concentration reductions from alternative management with both models.
Data Sources

- 30 m grid Digital Elevation Map
- 30 m grid soil map
- Soil survey (SSURGO) data for soil characteristics
- 30 m grid land use map (MoRAP)
- Stakeholder information for crop rotations and crop management
- Missouri Agricultural statistics for annual county crop yields from 92 to 2000
- Regional flow data
Yield Calibration

- Curve numbers
- ESCO
- Soil characteristics (Ks, BD, AWC)
- Groundwater parameters (REVAP and GWQMIN)
- Match average crop yields
- Match average total flow estimate based on downstream flow values and watershed size
Flow Calibration

- Previous parameters
- Groundwater alpha_bf
- Groundwater delay
- Snow melt parameters
- Soil crack potential
- Surface runoff storage parameter (SURLAG)
## Model Fit

<table>
<thead>
<tr>
<th></th>
<th>% error surf Q</th>
<th>% error GW</th>
<th>% error total Q</th>
<th>Monthly Nash-Sutcliffe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long Branch</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>yield calibrated</td>
<td>-26%</td>
<td>65%</td>
<td>-7%</td>
<td>0.78</td>
</tr>
<tr>
<td>Long Branch</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>flow calibrated</td>
<td>-8%</td>
<td>45%</td>
<td>6%</td>
<td>0.93</td>
</tr>
<tr>
<td>Miami yield</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>calibrated</td>
<td>9%</td>
<td>-24%</td>
<td>6%</td>
<td>0.56</td>
</tr>
<tr>
<td>Miami flow</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>calibrated</td>
<td>-4%</td>
<td>7%</td>
<td>1%</td>
<td>0.62</td>
</tr>
</tbody>
</table>
## 30-year Loadings to the Stream

<table>
<thead>
<tr>
<th></th>
<th>Water yield</th>
<th>Sediment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Long Branch yield</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>calibrated</td>
<td>206 mm</td>
<td>3.2 T/HA</td>
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<tr>
<td><strong>Long Branch flow</strong></td>
<td>211 mm</td>
<td>40%</td>
</tr>
<tr>
<td>calibrated</td>
<td></td>
<td>difference</td>
</tr>
<tr>
<td><strong>Miami yield</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>calibrated</td>
<td>275 mm</td>
<td>2.6 T/HA</td>
</tr>
<tr>
<td><strong>Miami flow</strong></td>
<td>204 mm</td>
<td>46%</td>
</tr>
<tr>
<td>calibrated</td>
<td></td>
<td>difference</td>
</tr>
</tbody>
</table>

Sediment: 46% difference

Water yield: 26% difference
## 30-year Nutrients to the Stream

<table>
<thead>
<tr>
<th></th>
<th>Org N KG/ha</th>
<th>Org P KG/ha</th>
<th>N SurQ KG/ha</th>
<th>SolP KG/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long Branch yield calibrated</td>
<td>7.3</td>
<td>2.3</td>
<td>1.3</td>
<td>0.26</td>
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<tr>
<td>Long Branch flow calibrated</td>
<td>7.9</td>
<td>2.7</td>
<td>2.4</td>
<td>0.26</td>
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<tr>
<td>Miami yield calibrated</td>
<td>7.3</td>
<td>1.62</td>
<td>2.65</td>
<td>1.64</td>
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<tr>
<td>Miami flow calibrated</td>
<td>4.2</td>
<td>1.66</td>
<td>2.43</td>
<td>1.23</td>
</tr>
</tbody>
</table>

- **20% difference**
- **35% diff.**
- **10% diff.**
- **40% difference**
- **8% diff.**
- **25% diff.**
Alternative Practices

- **Miami**
  - No-till practices on soybeans and wheat:
    Tillage operations before and during soybeans and wheat growth are removed, residue cover is increased, and soil properties are left the same.

- **Long Branch**
  - Two-pass herbicide application:
    Frontier is applied at planting, and a reduced atrazine application (50%) is applied in June.
Load Reductions in Miami Creek

<table>
<thead>
<tr>
<th></th>
<th>Sediment (Tons)</th>
<th>Total N (Tons)</th>
<th>Total P (Tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield Calibrated Model</td>
<td>-16%</td>
<td>-7%</td>
<td>+12%</td>
</tr>
<tr>
<td>Flow Calibrated Model</td>
<td>-14%</td>
<td>-6%</td>
<td>+14%</td>
</tr>
</tbody>
</table>
## Load Reductions in Long Branch

<table>
<thead>
<tr>
<th></th>
<th>Runoff</th>
<th>Atrazine (Kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield Calibrated Model</td>
<td>0%</td>
<td>-27%</td>
</tr>
<tr>
<td>Flow Calibrated Model</td>
<td>0%</td>
<td>-45%</td>
</tr>
</tbody>
</table>
Concentration Reductions in Long Branch

Yield calibrated model

Flow calibrated model
Conclusions

- Absolute results are different between the yield and flow calibrated models.
- Load reductions were similar when the BMP did not introduce a timing effect.
- Load reductions were different when the practice did introduce a timing effect.
- Concentration reductions were similar.
Recommendations

Calibrate with flow and water quality data when available.

Based on these results, a yield calibrated model can be adequate to estimate the impact of practices that are not season related.

In the absence of calibration data, a SWAT model may still be the best option to estimate the impact.