Watershed Nitrogen Reduction Planning Tool

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GOALS

• Assess nonpoint source nitrogen contributions to Minnesota rivers from a) the primary land use sources, and b) the primary hydrologic pathways under dry, average and wet climatic conditions.

• Determine the watersheds which contribute the most nitrogen to the Mississippi River, and combination of land uses and hydrologic factors having the greatest influences on the elevated nitrogen.

• What BMPs and goals for nitrogen reductions to surface waters are effective and economically feasible?
Baseline N Loss to Surface Waters

- Estimated nonpoint source nitrogen contributions to Minnesota rivers from agricultural, forest, and urban sources through drainage, groundwater discharge or runoff under dry, average and wet climatic conditions
  - Agricultural N loss estimates were based on precipitation, N inputs to system (e.g. fertilizer, manure, soil mineralization), N concentrations and discharges in numerous field and plot experiments conducted over many decades at different locations in Minnesota
  - Forest and Urban N loss estimates were based on export coefficients derived from an extensive literature review
- Point source losses were estimated based on an extensive permit database
Baseline N Loadings to Surface Water

- Cropland tile drainage: 37%
- Cropland groundwater: 30%
- Atmospheric: 9%
- Point Sources: 9%
- Forests: 7%
- Septic: 2%
- Urban Stormwater: 1%
- Feedlot runoff: <1%
- Cropland Runoff: 5%
The 15 red/orange-colored watersheds generate a majority of N losses to surface waters for the state of Minnesota.
Comparison between Predicted and Measured N Loads in an Average Climatic Year

Modeled vs Monitored Average TN Loads (millions lb)

\[ y = 1.33x - 631,920 \]
\[ R^2 = 0.69 \]
Effect of Climate on N Loadings

NPS N Loads (millions lb)

- Ag. Groundwater
- Ag. Drainage
- Ag. Runoff
- Forest
- Urban NPS
- Septic
- Feedlot

Legend:
- Dry
- Average
- Wet

Millions lb

0
25
50
75
100
125
150
175
200
225
Conclusions – Nonpoint Source N Loadings to Surface Waters

- Total nonpoint source N loadings to Minnesota surface waters were estimated at 254 million lb during an average climatic year. This is about 6% of the total inputs of N on all Minnesota cropland.

- Statewide, losses of N to surface water from agricultural sources represent 72% of total losses.
  - Agricultural N loadings to surface waters from groundwater and drainage are about equal and each far exceed runoff losses.
Watershed N Reduction Decision Tool

- How can non-point source N losses be reduced?
- What goals for nitrogen reductions to surface waters are feasible?
- The Decision Tool is an Excel spreadsheet linked to a database of Minnesota soils, landscapes, cropping systems, management practices and crop enterprise budgets
- Estimates of N reductions are based on research meta-data and BMP specific reduction coefficients
- Estimates are tied to site specific characteristics such as soil, slope, climate, and baseline farm management practices and cropping systems
N Reduction Decision Tool BMPs

- Rate and timing of N fertilizer
- Controlled drainage
- Bioreactors
- Planting cover crops
- Planting perennial grass
- Installing riparian buffer strips
- Installing wetlands

- Effects of individual BMPs as well as combinations of BMPs can be evaluated
Suitable Acres for BMPs

- Fertilizer rate reductions are only possible in areas where existing application rates exceed University recommendations.
- Controlled drainage and bioreactors can be installed on tile drained land with slopes of 0.5%, 1% or 2%.
- Perennial grass can be planted on ag land with crop productivity ratings of 60% or less (marginal land).
- Riparian buffers can be installed on ag land within 30 m of waterways.
- Wetlands can be restored on tile drained land with hydric soils and high Compound Topographic Index values.
Watershed Nitrogen Reduction Planning Tool

Screen Capture Image Results
Main Input Screen: Area Selection

<table>
<thead>
<tr>
<th>Watershed</th>
<th>% suitable</th>
<th>% adoption</th>
<th>% treated</th>
<th>% treated, combined</th>
</tr>
</thead>
<tbody>
<tr>
<td>Statewide</td>
<td>26.2%</td>
<td>90%</td>
<td>23.6%</td>
<td>23.6%</td>
</tr>
<tr>
<td>Corn grain &amp; spread</td>
<td>10.5%</td>
<td>45%</td>
<td>4.7%</td>
<td>4.7%</td>
</tr>
<tr>
<td>Fall N application</td>
<td>10.5%</td>
<td>45%</td>
<td>4.7%</td>
<td>4.7%</td>
</tr>
<tr>
<td>Fall N switch</td>
<td>5.8%</td>
<td>70%</td>
<td>4.0%</td>
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</tr>
<tr>
<td>Riparian buffer</td>
<td>5.3%</td>
<td>50%</td>
<td>2.7%</td>
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</tr>
<tr>
<td>Restored wetlands</td>
<td>4.5%</td>
<td>20%</td>
<td>0.9%</td>
<td>0.9%</td>
</tr>
<tr>
<td>Tile line bioretention</td>
<td>4.5%</td>
<td>50%</td>
<td>2.3%</td>
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</tr>
<tr>
<td>Controlled drainage % of suitable</td>
<td>4.5%</td>
<td>50%</td>
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</tr>
<tr>
<td>Corn &amp; soybean acres</td>
<td>50.1%</td>
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<tr>
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Weather scenario: Average weather - all of preplant N is available

For wet spring scenario 2, fertilizer & manure N lost 30%

N load reduction with these adoption rates: 21.3%
Main Input Screen: BMPs

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Main Input Screen: Suitable Area

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For wet spring scenario 2, fertilizer & manure N lost 30%

N load reduction with these adoption rates: 21.3%
# Main Input Screen: Adoption Rate

- **Corn grain & silage acres receiving the target N rate**: 26.2% suitable, 90% adoption, 23.6% treated, 23.6% treated, combined.
- **Fall N applications switched to spring, % of fall-app. acres**: 10.5% suitable, 45% adoption, 4.7% treated, 4.7% treated, combined.
- **Fall N switch to split spring/sidedressing, % of fall acres**: 10.5% suitable, 45% adoption, 4.7% treated, 4.7% treated, combined.
- **Riparian buffers % of suitable acres**: 5.8% suitable, 70% adoption, 4.0% treated, 4.0% treated, combined.
- **Restored wetlands % of suitable acres**: 5.3% suitable, 50% adoption, 2.7% treated, 2.7% treated, combined.
- **Tile line bioreactors % of suitable acres**: 4.5% suitable, 20% adoption, 0.9% treated, 0.9% treated, combined.
- **Controlled drainage % of suitable acres**: 4.5% suitable, 50% adoption, 2.3% treated, 2.3% treated, combined.
- **Corn & soybean acres planted w/cereal rye cover crop**: Marginal only, 10% adoption, 5.0% treated, 4.6% treated, combined.
- **Perennial crop % of corn & soybean area**: 5.8% suitable, 10% adoption, 0.6% treated, 0.3% treated, combined.

For wet spring scenario 2, fertilizer & manure N lost 30%

N load reduction with these adoption rates: 21.3%
### Main Input Screen: Treated Area

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**Weather scenario**

- Average weather - all of preplant N is available: 30%
- For wet spring scenario 2, fertilizer & manure N lost: 30%

**N load reduction with these adoption rates:** 21.3%
Main Input Screen: Weather Scenario

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Weather scenario

- Average weather - all of preplant N is available
- Average weather - all of preplant N is available
- Wet year - 30% of preplant N is lost, yield reduced
- Dry year - low N leaching losses
“Effectiveness” is expressed as the N load reduction compared to the baseline. “Cost” is expressed per pound of N removed.
"Effectiveness" is expressed as the area normalized N load reduction. "Normalized Cost" is expressed per acre.
The “Efficient Frontier” of practice combinations.

BMPs appear from left to right in order of their cost effectiveness.
Reducing N to Waters from Cropland Statewide

- Optimal fertilizer rate and timing: $53 Million
- Fert. mgmt + tile drainage BMPs: $53 Million
- Fert. mgmt + tile drainage BMPs + vegetation: $879 Million

Cost savings:
- Tile drainage BMPs: $52 Million
- Fertilizer mgmt. optimized: $52 Million

Categories:
- Vegetation changes
- Tile drainage BMPs
- Fertilizer mgmt. optimized
MITIGATING AGRICULTURE’S IMPACT ON WATER AND AIR QUALITY

- **Watershed Nitrogen Reduction Planning Tool - Overview Paper** (pdf), **NBMPxls spreadsheet**, and two tutorial videos. Note: This is a watershed-scale tool intended for an audience of local water resource managers, not a farm-level decision tool. Click here to link to the Minnesota Pollution Control Agency’s recent study of nitrogen in surface waters and ways to reduce it. Click here to view their June press conference discussing the study. The videos shown below were recorded in May 2012. A number of small changes have been made in the spreadsheet since then, so you will see that the actual spreadsheet now looks slightly different from what is shown in the videos but they still provide a general overview of how it is organized.

**INSTRUCTIONAL VIDEOS ON USING THE WATERSHED NITROGEN REDUCTION PLANNING TOOL SPREADSHEET:**

**Part 1**

Spreadsheet: z.umn.edu/nbmp
Documentation: z.umn.edu/nbmpdoc
Conclusions

- An N Reduction Planning Tool was developed for Minnesota.
- The Tool estimates reductions in N losses to surface waters for combinations of agricultural BMPs based on the area suitable for implementation of these BMPs.
- Users can specify which BMPs to evaluate and the rate of adoption of these BMPs.
- The Tool estimates the costs associated with the selected BMPs and their economic impact on crop yield.
- The most cost-effective BMPs include optimal N rates, fall to spring/preplant timing, controlled drainage and wetlands.
- Costs increase substantially with BMPs that take cropland out of production (riparian buffers and perennial crops).
Thank you!

Questions?

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David Mulla  mulla003@umn.edu

Spreadsheet:  z.umn.edu\nbmp
Documentation:  z.umn.edu\nbmpdoc,