Development of a GIS-Based Application for Mapping Phosphorus Risk in the Coastal Bays

Jay Morgan, Phil Reese, and Rick Kutz
PHOSPHORUS SITE INDEX (P INDEX)

- Allows nutrient management planners to associate a risk for P loss with every field
- Provides a basis for changes in management to reduce risk
- Components (2002 P Index)
  - Site and Transport (Part A)
    - Soil erosion (RUSLE)
    - Runoff class
    - Subsurface drainage
    - Leaching
    - Distance to water
    - Receiving water priority
  - Management and Source (Part B)
    - Soil Test P
    - P fertilizer rate \((0.6 \times P_2O_5)\)
    - P fertilizer method
P INDEX (CONTINUED)

- Organic P rate \( (PSC \times P_2O_5) \)
- Organic P method
### Table 1. The Maryland Phosphorus Site Index, April 2005.

**Part A: Phosphorus loss potential due to site and transport characteristics**

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Phosphorus Loss Rating</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil Erosion (tons/acre)</td>
<td>2 × tons soil loss/acre/year</td>
<td></td>
</tr>
<tr>
<td>Soil Runoff Class</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Negligible or Very Low 0</td>
<td>Low 2</td>
<td>Medium 4</td>
</tr>
<tr>
<td>Subsurface Drainage</td>
<td>Very Low 0</td>
<td>Low 2</td>
</tr>
<tr>
<td>Leaching Potential</td>
<td>Low 0</td>
<td>Medium 2</td>
</tr>
<tr>
<td>Distance From Edge of Field to Surface Water (feet)</td>
<td>&gt; 100 feet</td>
<td>&lt; 100 feet AND &gt; 50 feet vegetated buffer OR &lt; 100 feet AND &gt; 25 feet vegetated buffer AND &gt; 25 feet additional no P application zone</td>
</tr>
<tr>
<td>Priority of Receiving Water</td>
<td>Category 2 0</td>
<td>Category 3, Selected 2</td>
</tr>
</tbody>
</table>

**Sum of Site and Transport Characteristics:**

- **Scaling Factor:** $x \times 0.02$
- **Total Site and Transport Value:** ________
### Part B: Phosphorus loss potential due to management practice and source characteristics

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Phosphorus Loss Rating</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil Test P Fertility Index Value</td>
<td>0.2 X FIV</td>
<td></td>
</tr>
<tr>
<td>P Fertilizer Application Rate (lbs P₂O₅)</td>
<td>0.6 X (lbs P₂O₅ / acre)</td>
<td></td>
</tr>
<tr>
<td>P Fertilizer Application Method</td>
<td></td>
<td></td>
</tr>
<tr>
<td>None applied</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Injected/Banded below surface at least 2”</td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td>Incorporated within 5 days of application</td>
<td></td>
<td>45</td>
</tr>
<tr>
<td>Surface applied March through November</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incorporated more than 5 days after application</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surface applied December through February</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organic P Application Rate (lbs P₂O₅)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>None applied</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Injected/banded below surface at least 2”</td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td>Incorporated within 5 days of application</td>
<td></td>
<td>45</td>
</tr>
<tr>
<td>Surface applied March through November</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incorporated more than 5 days after application</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surface applied December through February</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Total Management and Source Value:**
PROJECT BACKGROUND

- The Geospatial Research and Education Laboratory at Towson University has developed a method to approximate Part A of the Maryland Phosphorus Site Index using geographic information systems (GIS).
- A variety of digital geographic data were assembled for the Maryland Coastal Bays watershed.
- Data were converted to raster format for spatial analysis purposes:
  - The resolution of the raster data was 10 meters x 10 meters.
  - Each pixel represented an area of 0.01 hectares (0.025 acres).
- The geographic data were used to map the factors to calculate phosphorus loss potential due to site and transport characteristics:
  - Factors derived from the Maryland Phosphorus Site Index Technical Users Guide, SFM-7 (March, 2008).
PROJECT BACKGROUND (CONTINUED)

- ArcGIS 10 was used to assemble the vector data for the project in shapefile format
- IDRISI Selva was used to rasterize the Esri vector shapefiles
- Spatial analysis of the raster data was performed using IDRISI Selva
DIGITAL GEOGRAPHIC DATA

- 10 meter resolution digital elevation model (USGS NED)
- April, 2010 Landsat 5 Thematic Mapper imagery
- SSURGO soils
  - Depth to seasonal high water table
  - Maryland NRCS leaching value
  - Permeability
  - Soil drainage class
- County boundaries
- Roads
- Streams and tax ditches
DIGITAL GEOGRAPHIC DATA

- Watersheds and subwatersheds (HUC 8, 10, and 12)
- Wetlands (NWI)
DATABASE CHARACTERISTICS

- Map extents of study area (in UTM-18N Meters)
  - MINX – 451995.0
  - MAXX – 505485.0
  - MINY – 4184415.0
  - MAXY – 4309815.0
- Number of columns – 5,349
- Number of rows – 12,540
- Total number of pixels – 67,076,460
- Pixel resolution – 10 Meters x 10 Meters
USGS NED DATA (WITH HUC 10 WATERSHEDS OVERLAY)
C FACTOR DERIVED FROM NDVI (WITH ROADS)
ASSUMPTIONS

- The LS factor was calculated using Wischmeier and Smith (1978) and steepest descent was used for the routing algorithm
- C factor values were derived from a Normalized Difference Vegetation Index calculated from Landsat 5 TM data for 2010 where

\[
C \text{ Factor} = \frac{(1 - \text{NDVI})}{2}
\]

- The P factor assumed to be 1.0 for the entire watershed
SOIL EROSION (TONS/ACRE)
SOIL RUNOFF CLASS
SUBSURFACE DRAINAGE CLASS
LEACHING POTENTIAL CLASS
DISTANCE FROM EDGE OF FIELD TO SURFACE WATER
TOTAL SITE AND TRANSPORT VALUE
Selected data will be summarized in tabular form by watershed.

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>Total</th>
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<tbody>
<tr>
<td>0</td>
<td>20457597</td>
<td>812987</td>
<td>1544237</td>
<td>2453087</td>
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<td>8388138</td>
<td>794023</td>
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<td>371931</td>
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<td>10025721</td>
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<td>334987</td>
<td>516316</td>
<td>13006</td>
<td>10076057</td>
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<tr>
<td>3</td>
<td>3523813</td>
<td>351459</td>
<td>296062</td>
<td>470589</td>
<td>7201</td>
<td>4688144</td>
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<tr>
<td>4</td>
<td>1907203</td>
<td>243024</td>
<td>245463</td>
<td>328615</td>
<td>3791</td>
<td>2728026</td>
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<tr>
<td>5</td>
<td>4611272</td>
<td>501697</td>
<td>664438</td>
<td>801803</td>
<td>7622</td>
<td>6586832</td>
</tr>
<tr>
<td>Total</td>
<td>47412556</td>
<td>3433203</td>
<td>3508317</td>
<td>4942341</td>
<td>7780041</td>
<td>67076456</td>
</tr>
</tbody>
</table>

Chi Square = 10598281.00000

df = 20

P-Level = 0.0000

Cramer's V = 0.1987

Proportional Crosstabulation

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.3050</td>
<td>0.0121</td>
<td>0.0220</td>
<td>0.0366</td>
<td>0.1148</td>
<td>0.4915</td>
</tr>
<tr>
<td>1</td>
<td>0.1251</td>
<td>0.0118</td>
<td>0.0063</td>
<td>0.0055</td>
<td>0.0007</td>
<td>0.1455</td>
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<tr>
<td>2</td>
<td>0.1271</td>
<td>0.0103</td>
<td>0.0050</td>
<td>0.0077</td>
<td>0.0002</td>
<td>0.1503</td>
</tr>
</tbody>
</table>
FUTURE

- Once the new version of the P Index is published, new P Index values can be readily calculated using the database
- Issue #1 – derivation of selected P Index values from soil tests
  - Fertility Index Value (FIV)
  - Dissolved P Risk Factor (DPR)
- Issue #2 – historically, soil tests were geocoded at the county level

Equation 2. Proposed calculation for the Maryland phosphorus site index.

\[
PSI = SUBSURFACE + RUNOFF + PARTICULATE
\]

Where

\[
SUBSURFACE = DF \times 0.1 \times SUBDRAIN \times DPR_{sub}
\]

\[
RUNOFF = DF \times 0.1 \times RUNOFF \times DPR
\]

\[
PARTICULATE = DF \times 0.1 \times SED \times FIV
\]
CONTACT INFORMATION

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