Vertical stratification of soil phosphorus as a concern for dissolved P runoff in the Lake Erie Basin

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Supplementary Materials:
- Supplemental Fig. S1
- Supplemental Fig. S2
- Supplemental Table S1
- Supplemental Equations S1
- Supplemental Information Sheet

Excel file for Tables 2 and 3 (Separate file)
Supplemental Fig. S1. Location of the Maumee River Watershed and the Sandusky River Watershed in Ohio’s Western Lake Erie Basin Agricultural Subregion. Soil test data for the Western Lake Erie Basin include the Ohio portion of the Maumee Watershed eastward through the Sandusky Watershed.
Supplemental Fig. S2 Relationships between field size and (A) agronomic soil test levels and (B) stratification increments calculated as environmental STP (0-5 cm) minus agronomic STP (0-20 cm).
Supplemental Table S1

Table S1. Data on soils, land use, tillage practices and fertilizer application for the stratified sampling program, the Sandusky Watershed, and the Western Lake Erie Basin.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Stratified sample set</th>
<th>Sandusky Watershed</th>
<th>Western Lake Erie Basin</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Land Use</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cropland</td>
<td>(100%)</td>
<td>65.9</td>
<td>66%</td>
</tr>
<tr>
<td>Forest</td>
<td>11.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban, Suburban</td>
<td>13.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>9.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Soils, Drainage Class</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Well Drained</td>
<td>8%</td>
<td></td>
<td>2%</td>
</tr>
<tr>
<td>Moderately well drained</td>
<td>21%</td>
<td></td>
<td>11%</td>
</tr>
<tr>
<td>Somewhat poorly drained</td>
<td>64%</td>
<td></td>
<td>45%</td>
</tr>
<tr>
<td>Poorly to very poorly drained</td>
<td>7%</td>
<td></td>
<td>41%</td>
</tr>
<tr>
<td><strong>Slope</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-2%</td>
<td>57%</td>
<td></td>
<td>80%</td>
</tr>
<tr>
<td>2-6%</td>
<td>40%</td>
<td></td>
<td>16%</td>
</tr>
<tr>
<td>6-12%</td>
<td>3%</td>
<td></td>
<td>4%</td>
</tr>
<tr>
<td>&gt;12%</td>
<td>0%</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Crops (percent of cropland)</strong></td>
<td></td>
<td></td>
<td>Western Lake Erie Basin</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Tillage survey NRCS</td>
</tr>
<tr>
<td>Corn</td>
<td>36%</td>
<td>33%</td>
<td>35.7%</td>
</tr>
<tr>
<td>Soybeans</td>
<td>39%</td>
<td>54%</td>
<td>50.2%</td>
</tr>
<tr>
<td>Wheat</td>
<td>22%</td>
<td>13%</td>
<td>14.0%</td>
</tr>
<tr>
<td>Hay</td>
<td>1.8%</td>
<td>0.5%</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>1.5%</td>
<td>0.5%</td>
<td></td>
</tr>
<tr>
<td><strong>Tillage (Corn, Soybean, Wheat)</strong></td>
<td>C/S/W</td>
<td>C/S/W- NRCS</td>
<td></td>
</tr>
<tr>
<td>No-till or strip till</td>
<td>9%/68%/83%</td>
<td></td>
<td>19%/64%/71%</td>
</tr>
<tr>
<td>Mulch, &gt; 30% residue</td>
<td>14%/18%/12%</td>
<td>12%/9%/19%</td>
<td></td>
</tr>
<tr>
<td>Reduced, &lt;30% residue</td>
<td>72%/12%/5%</td>
<td>69%/27%/24%</td>
<td></td>
</tr>
<tr>
<td>Inversion (moldboard plow), &lt;5% residue</td>
<td>6%/2%/0%</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Inorganic fertilizer, application method</strong></td>
<td>From dealer survey</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Broadcast, incorporated within 1 week</td>
<td>14%</td>
<td>15%</td>
<td></td>
</tr>
<tr>
<td>Broadcast, incorporated after 1 week</td>
<td>22%</td>
<td>18%</td>
<td></td>
</tr>
<tr>
<td>Broadcast, not incorporated</td>
<td>21%</td>
<td>31%</td>
<td></td>
</tr>
<tr>
<td>Strip tilled</td>
<td>-</td>
<td>4%</td>
<td></td>
</tr>
<tr>
<td>Banded with corn planter</td>
<td>40%</td>
<td>33%</td>
<td></td>
</tr>
</tbody>
</table>
Supplemental Materials: Selected Equations

These equations were used to calculate a 0-2.5 cm E-STP value for each of the 0-5 cm values of the 2-part studies, so that the 2-part and 4-part data sets could be merged.

The STP value for the 0 - 5 cm portion of the 4-part studies was taken as the average of the 0-2.5 cm and 2.5 – 5 cm for each sample:

\[ \text{STP}_{0-5(4)} = \frac{\text{STP}_{0-2.5(4)} + \text{STP}_{2.5-5.0(4)}}{2} \]  
\[ \text{(1)} \]

where,

\[ \text{STP}_{0-2.5(4)} = \text{STP value for the 0 - 2.5 cm portion of the 4-part studies} \]

\[ \text{STP}_{2.5-5.0(4)} = \text{STP value for the 2.5 - 5 cm portion of the 4-part studies} \]

\[ \text{STP}_{0-5(4)} = \text{STP value for the 0 - 5 cm portion of the 4-part studies} \]

The mean of the 0 – 2.5 cm values (68.8 ppm) from all the 4-part samples was divided by the mean of their 0 – 5 cm values (63.5 ppm) to develop a factor (1.083) for converting the 0 - 5 cm values of the 2-part study to their estimated 0 – 2.5 cm values.

\[ \text{STP}_{0-2.5(2)} = \text{STP}_{0-5(2)} * \frac{\text{mean(STP}_{0-2.5(4)}))}{\text{mean(STP}_{2.5-5.0(4))}} \]  
\[ \text{(2)} \]

\[ \text{mean(STP}_{0-2.5(4)})) / \text{mean(STP}_{2.5-5.0(4)}) = 1.083 \]  
\[ \text{(3)} \]

where,

\[ \text{STP}_{0-2.5(2)} = \text{STP value for the 0 - 2.5 cm portion of the 2-part studies} \]

\[ \text{STP}_{0-5(2)} = \text{STP value for the 0 - 5 cm portion of the 2-part studies} \]
**The Sandusky River Watershed -- Stratified Soil Testing Program for Phosphorus**

**Supplemental Information Data Sheet**

Key for sample labels as provided by Heidelberg College:
- HC-xxxx-S = Standard Soil Test (0-8 inch cores)
- HC-xxxx-T = Top (0-2 inch) of stratified soil sample
- HC-xxxx-B = Bottom (2-8 inch) of stratified soil sample
- HC-xxxx-I = Supplementary Information sheet for this sample

1. Name (and company) of person collecting this sample ____________________________________________

2. Sample Collection Date: ___________ Month ___________ Day ___________ Year

3. How many acres does this sample represent? ________________ Acres

4. When was the last time soil testing was performed for this field? Check one:
   - _____ <3 years ago
   - _____ 3 to 5 years ago
   - _____ 5 to 10 years ago
   - _____ >10 years ago
   - _____ Unknown

5. Laboratory used for Standard Sample: ________________________________________________

<table>
<thead>
<tr>
<th>TEST</th>
<th>VALUE</th>
<th>UNITS (ppm, lbs/ac)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phosphorus (P)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cation Exchange Capacity (CEC)</td>
<td></td>
<td>meq/100g</td>
</tr>
<tr>
<td>Percent Organic Matter (OM)</td>
<td></td>
<td>percent</td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td>neg. log H</td>
</tr>
<tr>
<td>Potassium (K)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calcium (Ca)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magnesium (Mg)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6. Location: _________________ County _______________ Township ____ Section
   (Only omit section number where there is a heightened concern over confidentiality.)

7. What is the name of the predominant soil in this field? See County Soil Survey:
   ________________________________ (Example: Blount silt loam)

8. What is the slope class for the predominant soil? See County Soil Survey. Check one:
   - _____ 0 to 2% flat or nearly level
   - _____ 2 to 6% gently to moderately rolling
   - _____ 6 to 12% moderately rolling to steep
   - _____ >12% steep

Attach label for Supplementary Information sheet for this sample here.
9. What are common slope lengths for the predominant soil? Check one:
   ______ <50 foot lengths
   ______ 50 to 100 foot lengths
   ______ 100 to 150 foot lengths
   ______ 150 to 200 foot lengths
   ______ >200 foot lengths

10. What is the drainage class for the predominant soil? See County Soil Survey. Check one:
    ______ well to excessively well drained
    ______ moderately well drained
    ______ somewhat poorly drained
    ______ poorly or very poorly drained

11. Does the field experience flooding from a nearby stream or river? See County Soil Survey for flood prone soils. Check one:
    ______ never or rare  <5% chance of flooding in any one year
    ______ occasionally  5 to 50 percent chance of flooding in any one year
    ______ frequently  >50% chance of flooding in any one year

12. What is the extent of sub-surface tile drainage within field? Check one:
    ______ systematic or pattern tiled
    ______ random tile typically in draws or low areas
    ______ none

13. Are there surface inlets to existing sub-surface drains in the field? Check one or more:
    ______ constructed inlets (catch basins, metal or plastic pipe risers, etc.)
    ______ tile main breakdowns or "blowouts"
    ______ "French Drains" (tile trenches filled with stone or gravel)
    ______ none

14. Are there “sinkholes” or “limestone fractures” in the field that permit direct drainage of surface water to ground water? Check one:
    ______ Yes
    ______ No

15. What is the distance of the down slope field edge to the nearest watercourse (field ditch, stream or river)? Check one:
    ______ <150 feet
    ______ 150 to 250 feet
    ______ 250 to 500 feet
    ______ 500 to 1,000 feet
    ______ >1,000 feet

16. In a field <150 feet from a ditch or stream, are there existing grass or tree buffers along the watercourse?
    ______ Yes
    ______ No
17. In a field >150 feet from a ditch or stream, are there grassed waterways or other forms of surface drainage (surface drains, shallow ditches, water furrows, etc.) within the field that direct surface runoff to a stream or ditch?
   _____ Yes
   _____ No

18. What was the previous crop in this field?
   _____ Corn
   _____ Soybeans
   _____ Wheat/Oats
   _____ Hay
   _____ Other, list crop: ______________________

19. What is the planned crop for this field?
   _____ Corn
   _____ Soybeans
   _____ Wheat/Oats
   _____ Hay
   _____ Other, list crop: ______________________

20. Designate the form of tillage used for the type of crops typically planted in this field. Select the number representing an option below and place it in the blank before the crop name.

   1. Moldboard plow – soil inverted, <5% residue remains on soil surface
   2. Reduced tillage – soil heavily mixed, <30% residue remains on soil surface
   3. Mulch tillage – soil lightly mixed, >30% residue remains on soil surface
   4. No or strip tillage - soil not inverted by tillage, >30% residue remains on soil surface
      _____ Corn
      _____ Soybeans
      _____ Wheat/Oats
      _____ Hay
      _____ Other, list crop: ______________________

21. What is the total planned fertilizer P rate for this field? _____________ lbs/ac P2O5

22. If this fertilizer P rate is for more than the planned crop, list subsequent crop(s) for which phosphorus fertilizer is planned: _____________________________________

23. In general, what type of recommendation do these rates follow? Check one:
   _____ Soil buildup rates
   _____ Crop maintenance rates
   _____ Soil drawdown rates

24. How will the majority of phosphorus fertilizer be applied to this field? Check one:
   _____ Broadcast and unincorporated
   _____ Broadcast and incorporated within one week
   _____ Broadcast and incorporated after one week or more
   _____ Banded with a corn planter
   _____ Banded more than 2 inches deep with a coulter/knife injection tool
25. **When** will the majority of phosphorus **fertilizer** be **applied** to this field? Check one:
   - _____ In spring (April – June) prior to planting
   - _____ In spring (April - June) at planting
   - _____ In late summer or fall (August – November) after wheat or hay harvest
   - _____ In fall (September – November) after soybean harvest
   - _____ In fall (September – November) after corn harvest
   - _____ In winter (December – March)
   - _____ In winter (December – March) on snow covered or frozen soils

26. What is the **manure application history** for this field? Select from below:
   - _____ No known manure applications
   - _____ Manured historically but no recent applications
   - _____ Recent but infrequent manure applications
   - _____ Recent and frequent manure applications

27. What **types of manures** were recently applied in this field? Select from below:
   - _____ Dairy
   - _____ Cattle
   - _____ Hogs
   - _____ Poultry
   - _____ Sheep
   - _____ Treated manures/bio solids

28. Are **manure or bio solid P applications planned** to complement commercial P fertilizers?
   - _____ Yes
   - _____ No

29. If yes, what **type of manure** will be applied? Select one:
   - _____ Dairy
   - _____ Cattle
   - _____ Hogs
   - _____ Poultry
   - _____ Sheep
   - _____ Treated manures/biosolids

30. If this **manure/bio solid P rate is for more than the planned crop**, list subsequent crop(s) for which phosphorus fertilizer is planned: ______________________________

31. **How** will the majority of **manures or bio solids** be **applied** to this field? Select one:
   - _____ Broadcast and unincorporated
   - _____ Broadcast and incorporated within one week
   - _____ Broadcast and incorporated after one week or more
   - _____ Injected more than 2 inches below the soil surface

32. **When** will the majority of **manures or bio solids** be **applied** to this field? Check one:
   - _____ In spring (April – June) prior to planting
   - _____ In summer (June – September) on fallow ground
   - _____ In late summer or fall (August – November) after wheat or hay harvest
   - _____ In fall (September – November) after soybean harvest
   - _____ In fall (September – November) after corn harvest
   - _____ In winter (December – March)
   - _____ In winter (December – March) on snow covered or frozen soils
33. Prior to application of manures or bio solids, \textbf{P nutrient values} will be estimated using:

- Laboratory testing of manure/bio solid samples
- Book values for manure/bio solid P concentrations

\textbf{Directions for submitting this form and requesting payment}

1. Submit this form, together with the Payment Request Form and other completed information forms, to Nancy Miller, NCWQR, Heidelberg College, 310 East Market Street, Tiffin, OH 44883.

2. Group several of these information forms together for mailing to Heidelberg, placing the ID numbers for each completed form on the Payment Request Form. Although the Payment Request Form has room for 50 Information Sheet IDs, it is not necessary to have completed 50 samples in order to submit information forms and request payment. If possible, we would like to submit payment checks no more frequently than once per month.

\textbf{Directions for requesting additional forms and sample label sets}

1. To obtain additional payment request forms and Supplementary Information Data Sheets contact Dave Baker (dbaker@heidelberg.edu - 419 448-2941) or Nancy Miller (nmiller@heidelberg.edu - 419 448-2198). Alternatively, you may make copies of either of these forms. Eventually these materials will be available on a project website.

2. To obtain additional sample label sets, contact Nancy Miller at the above e-mail or phone number.