Multiple Benefits

Sustainable Phosphorus Alliance

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@sustainP
P can runoff in stormwater and cascade downstream

Once downstream, P can have unintended impacts on the “goods and services” we receive from the natural environment – Ecosystem Services

Adapted from MacDonald et al 2017
Inputs and Outputs of Excess P are often Disconnected

We do not see decreased outputs in response to decreased inputs yet

Increased soil available P in China

**Average soil available Olsen-P, 1980**

7.4mg/kg

Soil Olsen-P <10 mg/kg accounting for 79.4%

**Average soil available Olsen-P, 2006**

20.7mg/kg

Soil Olsen-P <10 mg/kg accounts for 23.5%

(Li et al., 2011, Plant and Soil)
Not all P losses are from excess P applications (timing and placement)

Phosphorus loss associated with fertilizer application just prior to precipitation
Honey Creek in Ohio
Managing for Crop Productivity is not Enough...
Can we manage agriculture to achieve benefits aside from just productivity?

We need cost/benefit research to make this a reality.
**Ecosystem Services**
- Food-fiber-fuel
- Nutrient cycling
- C storage
- Water retention
- Landscape aesthetic

**Impacts of P**
- Crop productivity
- Biodiversity
- Water quality
- Fish
- Recreation
- Property value

*Adapted from MacDonald et al 2017*
Practices to Improve P Management

- Reuse organic P waste
- Draw down P in P saturated soils
- Water management
- Soil erosion control
- Improved fertilizer efficiency

Adapted from MacDonald et al 2017
Changes at the Small Scale can Benefit the Entire System

Adapted from MacDonald et al 2017

Anthropogenic P use and management

P input stewardship
Rate, source, timing, and placement of P use

P export to the coast
Example: Soil P Drawdown

- Soil P was sufficient to support crop P without added P for over 9 years.

- Soil P loss (tile) with P draw-down decreased by 35%, relative to continuous P addition.

- Tile drainage P loss accounts for ~85% of total soil P loss.
But, There can be Tradeoffs...
What does a holistic approach to P management look like?

• We can implement all aspects of the 4R nutrient stewardship at the farm scale to maximize crop productivity and water quality
  • Right source: use recycled sources of P fertilizer such as struvite
  • Right rate: use soil tests that incorporate soil buffering capacity to ensure proper application of P
  • Right time: match applications to crop demand and low risk of runoff
  • Right place: apply fertilizer below the surface of the soil to prevent unintentional losses

• Each point of stewardship comes with a cost
• Major challenge → what is the cost of maintaining water quality relative to benefit of high crop productivity?
## Possible Changes to Manage for Multiple Benefits (US)

<table>
<thead>
<tr>
<th>Component</th>
<th>Agronomic</th>
<th>Agronomic + water quality</th>
</tr>
</thead>
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<tr>
<td>Soil P test</td>
<td>Mehlich 3</td>
<td>Mehlich 3 + buffering capacity</td>
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<tr>
<td>Soil sampling</td>
<td>Single depth only</td>
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<tr>
<td>Interpretation</td>
<td>Agronomic optimum</td>
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<tr>
<td>Fertilizer sources</td>
<td>Standard fertilizer</td>
<td>Use struvite</td>
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<tr>
<td>Fertilizer application</td>
<td>Single rate application</td>
<td>Variable rate application</td>
</tr>
<tr>
<td>Crop system</td>
<td>Current varieties/rotations</td>
<td>Designer varieties/rotations to improve soil P acquisition efficiency</td>
</tr>
</tbody>
</table>
Conclusions

• This is a complex issue
  • P sources and impacts are not connected in time and space
  • P loss occurs without excess P application
  • Managing P often gets more complicated and expensive the further you get from its source
  • But benefits of small scale solutions cascade to the large scale

• Agricultural management should involve more than one ecosystem service (productivity), but this is limited by a lack of knowledge about cost/benefits of specific ecosystem services

• A holistic approach to P management will provide multiple benefits on a wide scale throughout the economy
Questions?