Institute of Ag Professionals

Proceedings of the

2015 Crop Pest Management Shortcourse &

Minnesota Crop Production Retailers Association Trade Show

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Productive Agriculture, Conservation and Water Quality: Opportunities and Challenges

Andrew Sharpley

Crop Pest Management Short Course
Dec. 9, 2015, Minneapolis, MN
What do we know?

- Unlike N, P rock is a finite resource that will become more expensive to extract.
- Implementing CPs must be precise & targeted.
- There are no “cure-all” CPs and there are tradeoffs.
- CP adoption has occurred mainly as a result of voluntary measures.
Where do we go from here?

- Need to set realistic goals
  - Or risk failure
  - After low-hanging CPs, it becomes more costly

- Phased-in approach
- System legacies can mask CP benefits
- Outreach & education at field to farm to watershed scales
P is a finite resource

65,000 million tonnes
USGS, 2010

Morocco, 76.9%
Other 3.7%
U.S., 2.2%
M. East, 5.4%
China, 5.7%
Africa, 6.3%
• Productive agriculture requires P inputs
• P also increases freshwater productivity
• Global issue
Soil erosion & particulate P
Crop P harvest 15%
Release of soil P dissolved P
P leaching is small
Tile flow
Subsurface flow
Soil P immobilization - 80%
Total P - 5%
The N cycle - is leaky

- Crop uptake: 50 - 60%
- Denitrification loss: small-moderate 10-20%
- Ammonia loss: small-moderate 5-20%
- Eroded organic & mineral N: small losses 1-5%
- Leaching loss: large 10-40%
- Soil N immobilization: 5-10%
- Nitrate leaching
- Days/wks
- Weeks/mo
- Years

Division of Agriculture Research & Extension
University of Arkansas System
Led to the 80/20 rule:
80% of P comes from
20% of land area
Appropriate rate, method timing, & placement of P can increase crop uptake & decrease runoff loss.

Soil & manure testing to tailor rates of P to apply

Subsurface injection reduces P runoff & N volatilization.
Rotational grazing reduces P runoff & N leached

Riparian buffers trap particulate nutrients

Stream bank fencing Decreases P deposition in streams

Conservation tillage reduces P runoff

Cover crops reduces P runoff

Riparian buffers

Transport BMPs

Cover crops

Conservation tillage

Rotational grazing

Stream bank fencing

University of Minnesota Extension
Uptake & release of P by sediments affects response time

Adoption of BMPs by farmers is variable

Soil processes

BMP response

Hydro-chemical response

System response

Decline in soil P with crop offtake is slow

Wetlands & buffers can trap then recycle P

Can eventually release P

Time for ground water to reach stream can vary from days to years

BMPs can take time to decrease P runoff

Uptake & release of P by sediments affects response time

Decline in soil P with crop offtake is slow

Wetlands & buffers can trap then recycle P

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BMPs can take time to decrease P runoff

Uptake & release of P by sediments affects response time
Conservation tradeoffs
Cover crops

- There are many cover crops available
- Can decrease runoff and erosion
- Management of the cover crop is important
- Decaying cover crop can release P to runoff
- In-field nutrient management should adapt
<table>
<thead>
<tr>
<th></th>
<th>No cover crop</th>
<th>Wheat cover crop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Runoff, inches</td>
<td>4.81</td>
<td>1.00</td>
</tr>
<tr>
<td>Erosion, tons/ac/yr</td>
<td>7.9</td>
<td>1.0</td>
</tr>
<tr>
<td>Dissolved P, lbs/ac/yr</td>
<td>0.13</td>
<td>0.04</td>
</tr>
<tr>
<td>Total P, lbs/ac/yr</td>
<td>5.26</td>
<td>0.82</td>
</tr>
</tbody>
</table>

Sharpley, 1991: Ft. Cobb, OK watersheds
Freezing releases biomass P

Repeated freezing & thawing of ryegrass, which is then extracted with water

Water extractable P, mg/g dry matter

Bechmann et al., 2005
• Tile drainage increases
  - Soil productivity
  - Critical source areas
  - Increase connectivity to streams
  - By-passes a large mass of reactive soil
Rainfall, runoff & tile flow

Smith et al., 2015; St. Joseph Watershed, IN

Flow, L/sec

Rainfall mm/hr

Surface runoff
Tile flow

Rainfall

Time, hours

14:00 16:00 18:00 20:00
Conservation tradeoffs

• No-till management
  ▪ Enhances macropore development
  ▪ Increases soil organic matter
Conservation tillage

No-till reduced erosion from wheat 95%

Total P, mg/L

Dissolved P, mg/L

Sharpley and Smith, 1994 - El Reno, OK
Riparian buffers

Outflow - kg/ha/yr - Inflow

Surface runoff
Subsurface flow

80%
75%

N
P
N
P
## Contribution of pathways, %

<table>
<thead>
<tr>
<th></th>
<th>Surface runoff</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discharge</td>
<td>10</td>
</tr>
<tr>
<td>Dissolved P</td>
<td>32</td>
</tr>
<tr>
<td>Particulate P</td>
<td>9</td>
</tr>
<tr>
<td>Total P</td>
<td>11</td>
</tr>
</tbody>
</table>

Sharpley et al., 1976; New Zealand
Buffer impacts are site specific

- They are most effective adjacent to sloping fields
- Less effective adjacent to tile-drained fields
- And where stream bank erosion is main source of sediment
Discovery Farms Program

- Private “real-world” farms: now have 9
- On-farm research & demonstration
- Demonstrate success stories
## Mean annual totals, kg/ha/year

<table>
<thead>
<tr>
<th>Flow</th>
<th>Diss. P</th>
<th>Total P</th>
<th>Total N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flume 1</td>
<td>693,722</td>
<td>4.5</td>
<td>5.3</td>
</tr>
<tr>
<td>Flume 2</td>
<td>80,542</td>
<td>0.9</td>
<td>1.0</td>
</tr>
</tbody>
</table>
Most important farmer involvement
.. and farmer empowerment
Are we expecting too much from “cure-all” CPs?

Panacea - a solution or remedy for all ailments

... many still assume that CPs work all the time, in all situations, & don’t have any undesirable side-effects
Should treat conservation management like human health

We’re all aware of the risks of medications
Get the **diagnosis** right

- Assess each site comprehensively
- Aim for reduced losses
- Is runoff or leaching the problem?
- Particulate of soluble losses?
- In-field or in-stream nutrient sources
- Anything that gets farmers on the conservation path is positive
Get the **treatment** right

- Make sure the “remedy” works
- Treat with precision
- Consider the benefits & risks
  - No-till & cover crops decrease runoff and erosion
- Look out for problems, then adapt & fine tune
  - No-till can increase surface soil P & leaching
  - Mgt. of cover crop termination is important
  - In-field nutrient mgt. should adapt
Dealing with the elephant
Blue water - green pasture paradox

Public has grown to expect blue waters & green pastures

With predicted population growth, 50 - 100% increase in crops yields

- Will increase pressure to intensify & maximize yields
- Likely on less suitable lands
- Economics will remain THE driver
Dealing with the elephant

- It’s a fan
- It’s a wall
- It’s a rope
- It’s a spear
- It’s a snake
- It’s a tree
Which do you prefer?

Photos courtesy of Colin Neal, Helen Jarvie & Ian Bateman
Which do you prefer?

Photos courtesy of Colin Neal, Helen Jarvie & Ian Bateman
We all view things differently

- I need a green lawn
- No, it’s from fertilizer
- I want cheap steaks
- No, it’s from manure
- I need my lake to be blue
- We need more trees