# A Systems Approach to Setting Nutrient Standards & Loading Targets

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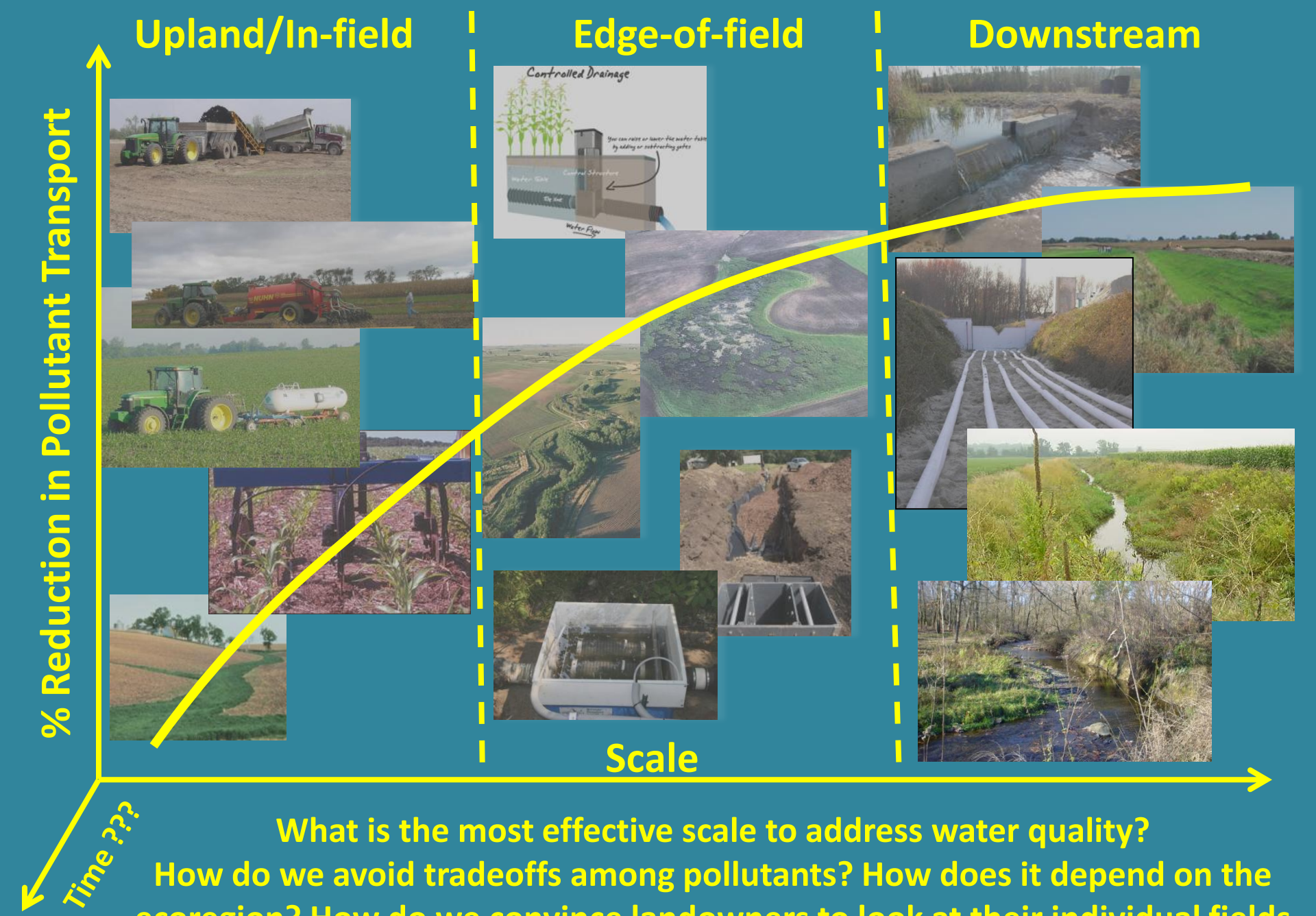
http://image-base.blogspot.com/

# The Problem

| River | January | July | November | 12 Month Mean Total |
|---|---|---|---|---|
| Honey Creek | | | | |
| 10/1/2010 - 9/30/2011 | 0.13 | 0.16 | 0.22 | 0.15 |
| 10/1/2005 - 9/30/2006 | 0.11 | 0.10 | 0.20 | 0.11 |
| Sandusky River | | | | |
| 10/1/2010 - 9/30/2011 | 0.06 | 0.11 | 0.08 | 0.10 |
| 10/1/2005 - 9/30/2006 | 0.11 | 0.11 | 0.12 | 0.09 |
| Maumee River | | | | |
| 10/1/2010 - 9/30/2011 | 0.10 | 0.01 | 0.01 | 0.07 |
| 10/1/2005 - 9/30/2006 | 0.09 | 0.08 | 0.12 | 0.08 |

**SRP concentrations in three Lake Erie rivers (flow weighted concentrations, mg/l)**

*Monthly means usually exceed 0.05 mg/l.*




What is the most effective scale to address water quality? How do we avoid tradeoffs among pollutants? How does it depend on the ecoregion? How do we convince landowners to look at their individual fields in a larger environmental context?

# Strategies for Addressing Agricultural Induced Nutrient Transport

Upland Management
- 4Rs
- Cover crops, variable rate technologies
- Interruption of connection to surface

Structural Hydrologic Control
- Water table management
- Blind inlets

Filtration
- End-of-tile and in-stream
- Enhanced bioreactors

Edge-of-field
- Buffers (vegetated and saturated)
- Wetlands

Ditch Design and Management
- Two stage, natural, and over-wide ditches
- Dredging
- Vegetated channels

# 4R Nutrient Stewardship

- 4R nutrient stewardship provides a framework to achieve **cropping system goals**, such as increased production, increased farmer profitability, enhanced environmental protection and improved sustainability.
- The 4R concept incorporates the:

**Right fertilizer source**

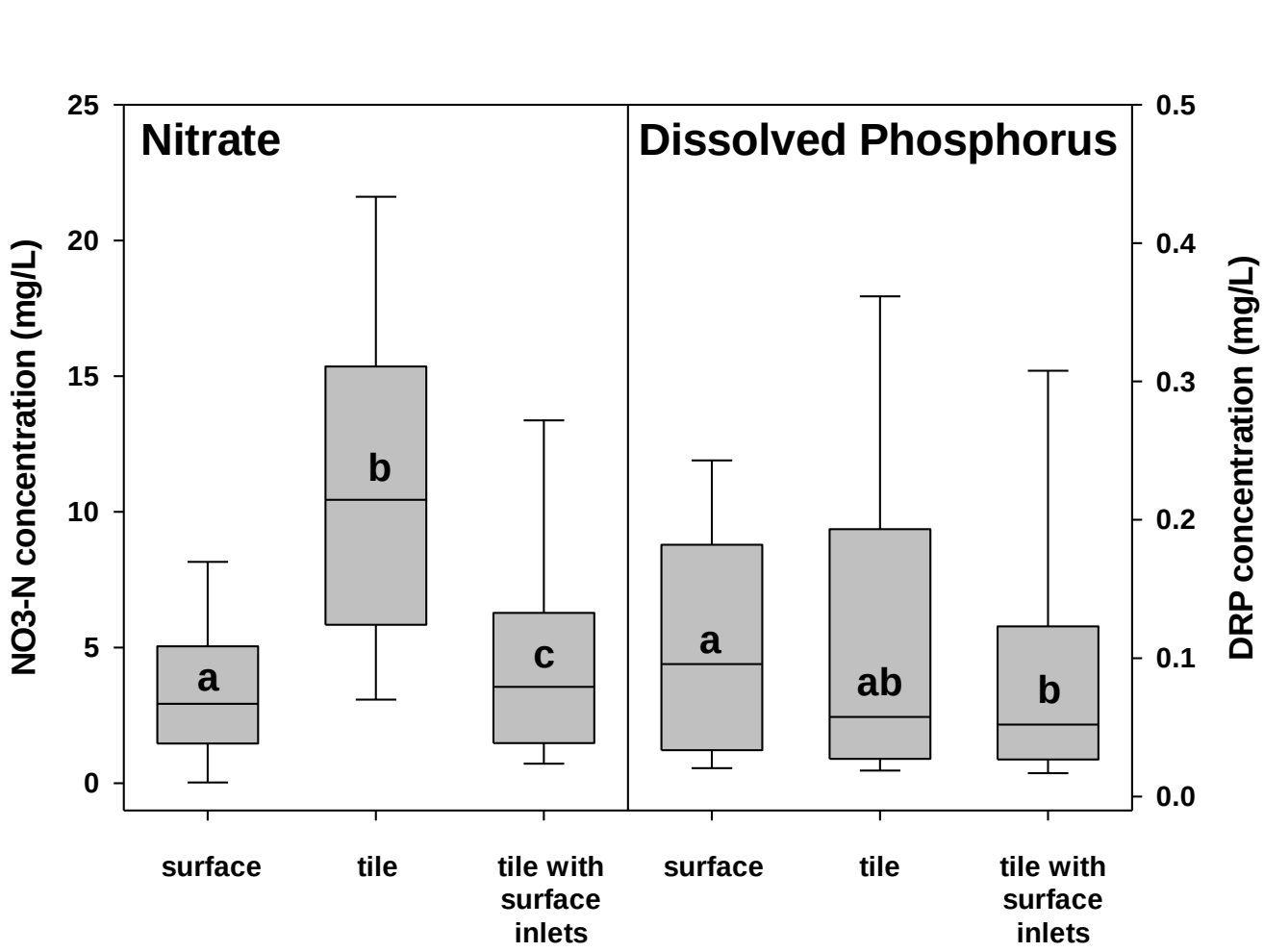
**Right rate**

**Right time**

**Right place**

**http://www.nutrientstewardship.com/what-are-4rs**

# Importance of Source

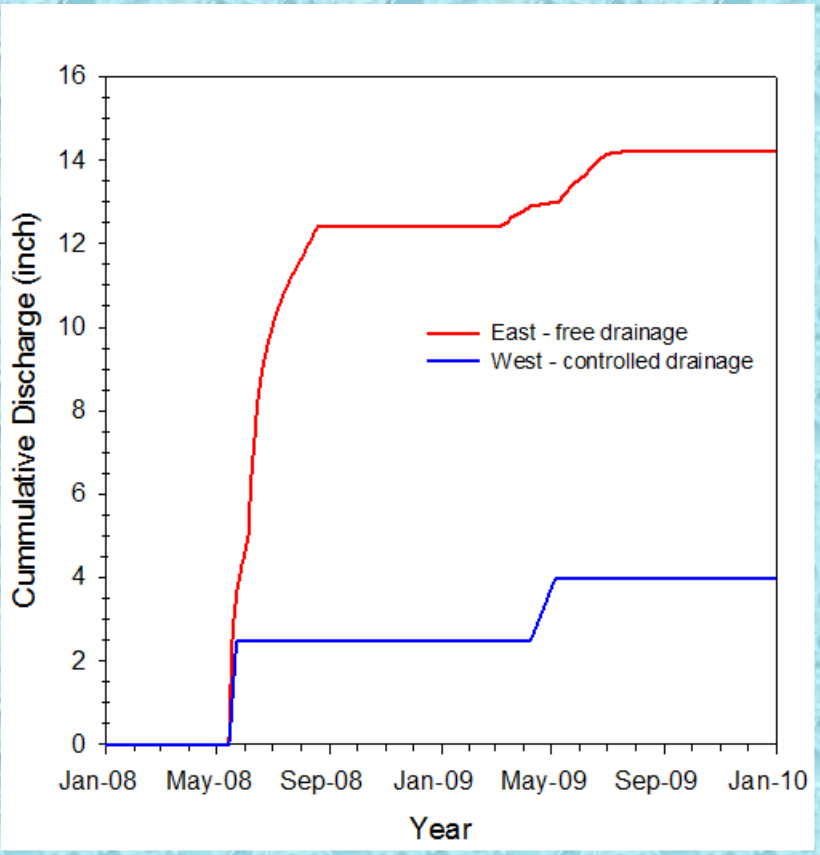


# Importance of Water Table Management

**30-60% reduction in drain flow**

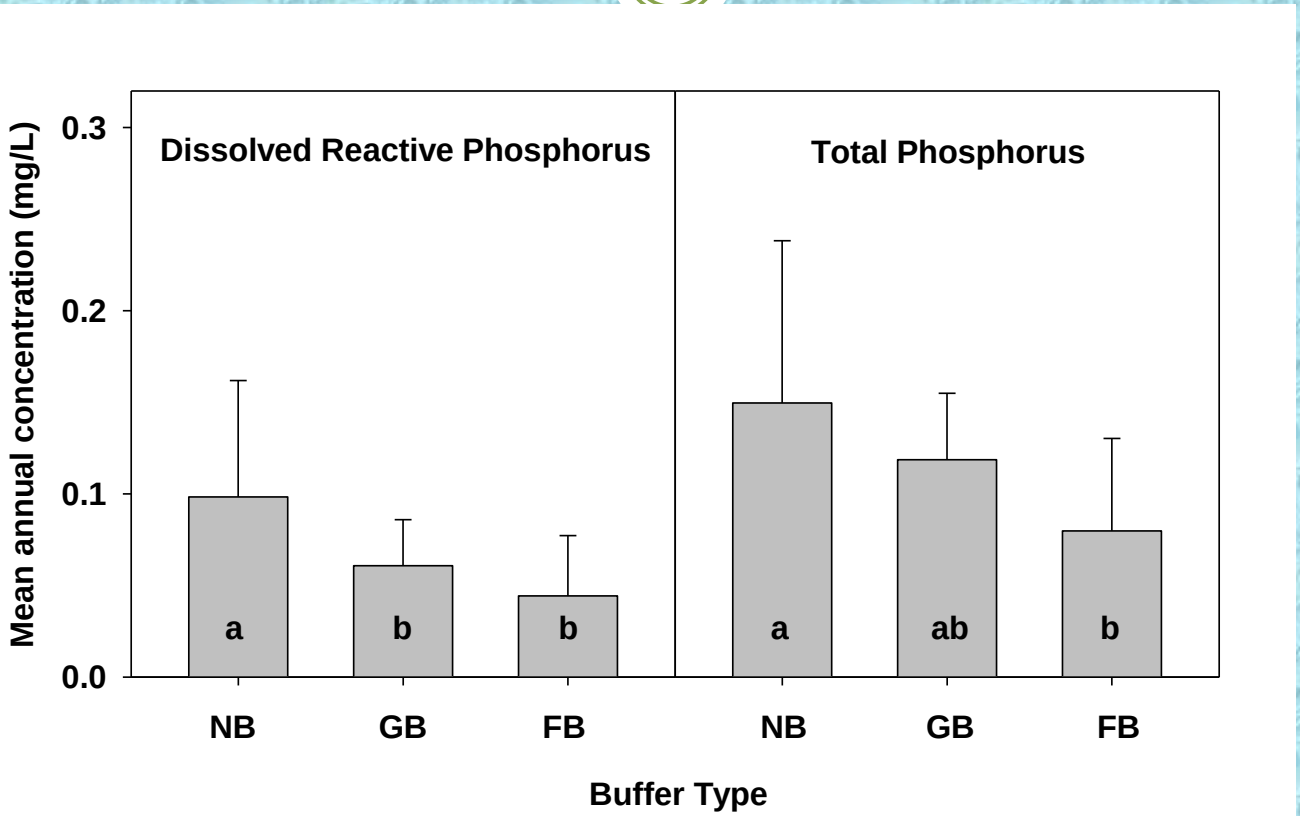
**30-50% reduction in nitrate load**

**30-40% reduction in TP and DRP load**




Provided by Jeff Strock

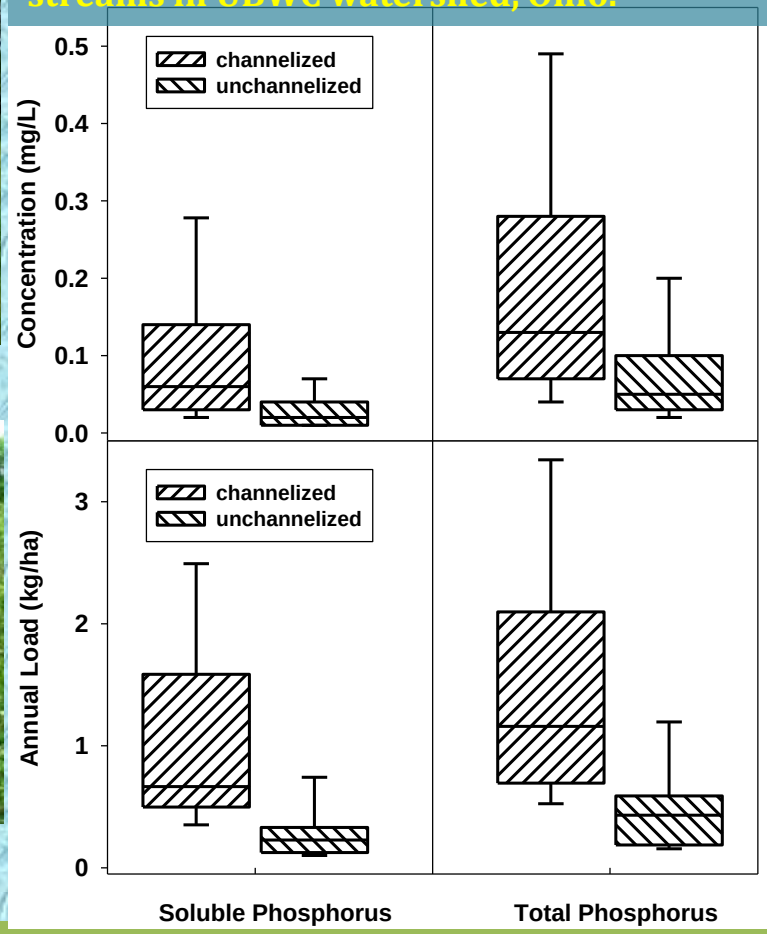
# Importance of Buffers




Mean annual (2006-2010) stream side nutrient concentrations for dissolved reactive phosphorus and total phosphorus for streams with no buffers (NB), grassed buffers (GB), and forested buffers (FB). Letters inside each box indicate significance; boxes with different letters indicates that mean values are significantly ($p < 0.05$) different.

# Importance of In-Stream Processes

**2005-2010 phosphorus concentration and loading for channelized and unchannelized streams in UBWC watershed, Ohio.**



# In-Ditch Filtration

- Can use industrial waste materials to help remove contaminants
- Treating ditches may have benefits to fields, since multiple fields drain into ditches
- Works best during small storms (bypass flow during big storms)

# In-stream or End-of-Tile Treatment Summary

-Approximately 70% reduction in DRP over 2 years in New Zealand (McDowell et al., 2008)

- > 70% of DRP in milkhouse wastes removed with steel slag (Bird and Drizo, 2010)

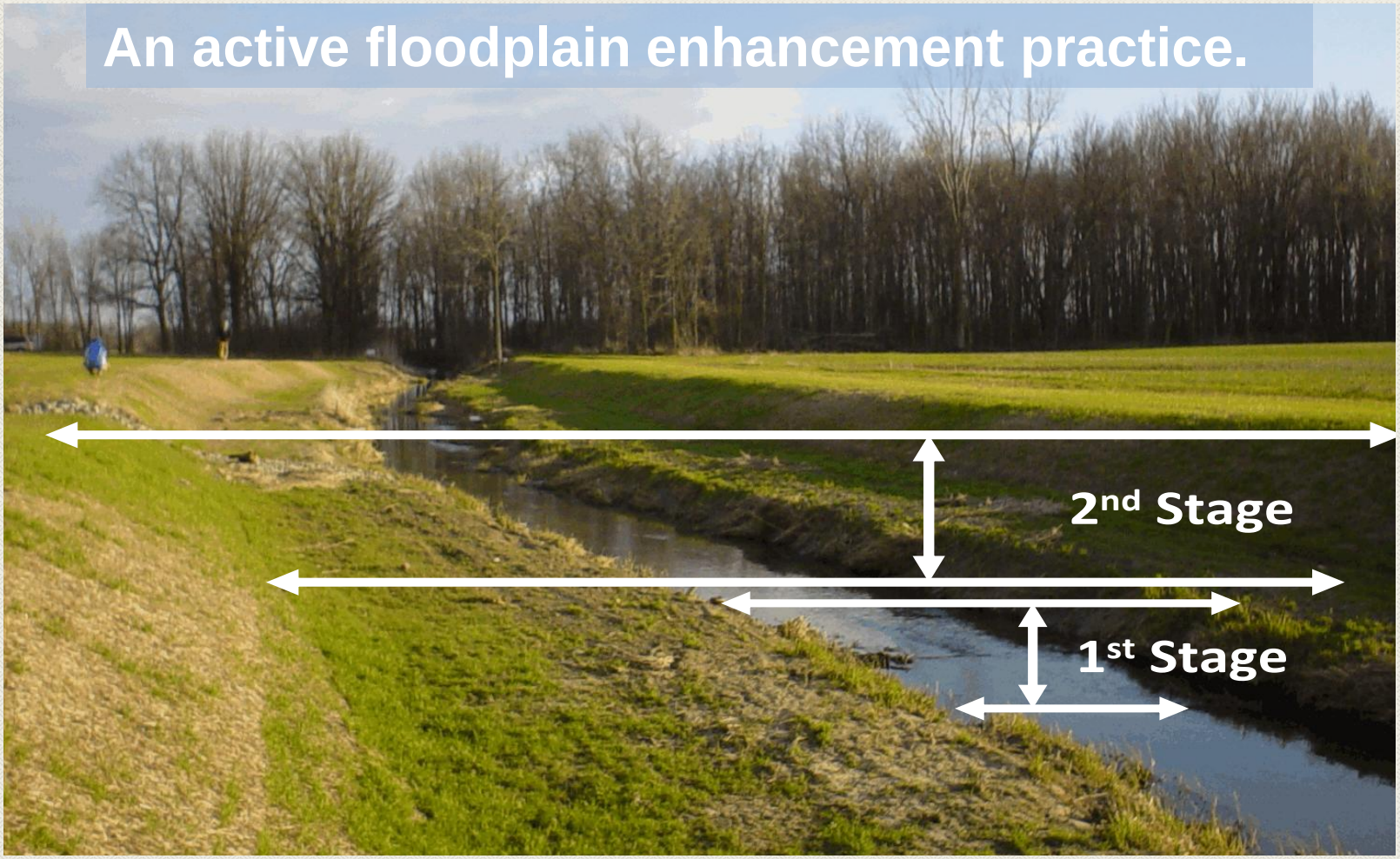
- DRP concentrations reduced by 50 to 99% using in-stream gypsum (Penn et al., 2010)

- 50% reduction in DRP concentrations & loads using end-of-tile filters (King et al., 2010)

- bioreactors enriched with steel slag (Brown et al., in progress)

- flow rate is limiting factor both in-stream and end-of-tile systems

# Two-Stage Channel Design



# Effect of the two-stage ditch on sediments and nutrients in Midwestern agricultural streams

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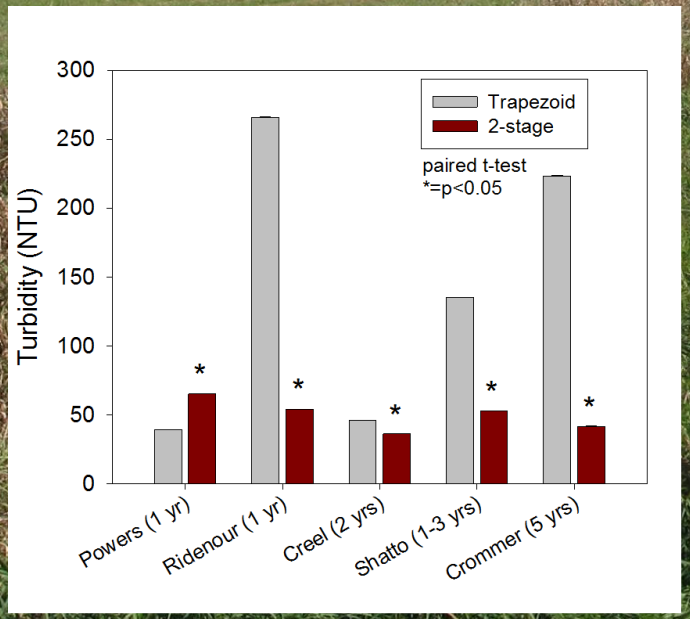


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# Benefits of Two-Stage Ditches

1. **Reduce water column turbidity, sediment and P export**

   **Turbidity was lower in properly-constructed two-stage ditches; TSS, TP, and SRP were also lower in two-stage.**

2. **Increase particle size of benthic sediments**

   **Substrate effect takes time to appear, evident in two-stage ditches ≥ 4 years old.**

3. **Increase reach-scale N removal**

   **Two-stage denitrification was 2-14 times higher; but nitrate was not lower due to very high N loadings.**

Roley, S. S., J.L. Tank, M.L. Stephen, L.T. Johnson, J.J. Beaulieu and J.D, Witter. 2012. Floodplain restoration enhances denitrification and reach-scale nitrogen removal in an agricultural stream. Ecological Applications. 22: 281–297.

Roley, S. S., J.L. Tank, and M.A. Williams. 2012. Hydrologic connectivity increases denitrification in the hyporheic zone and restored floodplains of an agricultural stream. J. Geophys. Res- Biogeosciences.. doi:10.1029/2012JG001950

# Ditch Design and Management

## Nutrient Reductions in Vegetated Drainage Ditches

Over 2 years from cotton fields:
Phosphorus: 43% of dissolved P
and particulate / total P

Water / nutrient / sediment mixture amendment flow:
600 gallons/minute for 7 hr

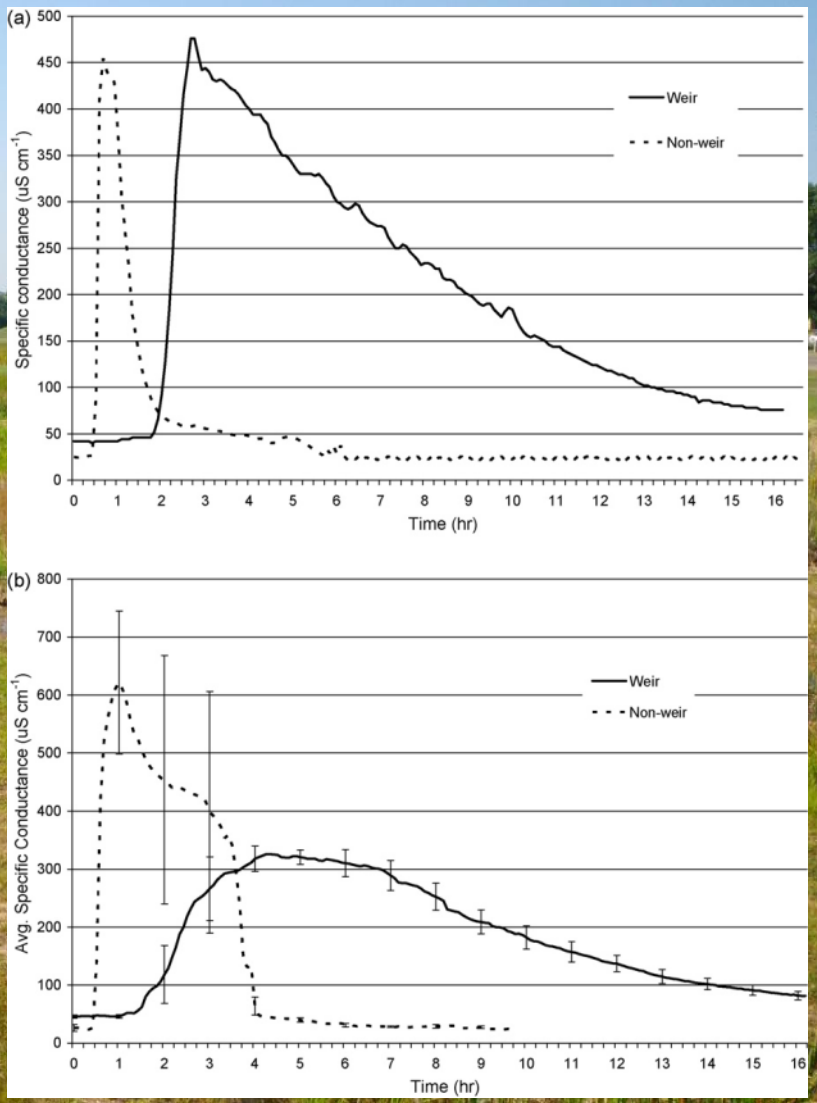
| | Load Reduction (%) |
|---|---|
| | Vegetated |
| DIP | 99 |
| TOP | 60 |
| TP | 86 |

Provided by Robbie Kroger (MSU)

**Repeated Measures: significant time x treatment interaction (F=3.285; P=0.042)**
**Significantly higher concentrations in no-weir treatments (P = 0.001) at t = 120mins**

Weir
0.156 mg/L

No-Weir
0.205 mg/L




What's the ultimate purpose of low grade weirs?

- ✓Increase Hydraulic Capacity
- ✓Promote biogeochemical wetland like conditions
- ✓Increase source nutrient reductions

# RECOMMENDATIONS

1. Solutions should be based on system specific knowledge and consideration of the causes and pathways of sediment and nutrients movement within fields, from fields, through systems such as ditches and streams, and into lakes.
2. A process based systems approach that incorporates a combination of methods should be used.
3. The focus should not just be on soluble reactive phosphorus (SRP).
4. Practices that are field specific are likely to be the most practical, beneficial and affordable but might not always provide adequate reductions in flow, nutrient, and sediment exports.
5. Edge-of-field and in-stream treatment practices will be needed in some settings.
6. Historically, voluntary approaches that provide incentives to adopt BMPs have been the most successful.

***A societal goal should be to seek affordable and sustainable targets that enhance agricultural production while protecting downstream ecosystems.***

**Thank You!**