Floodplain restoration as a nutrient management strategy in the agricultural Midwest

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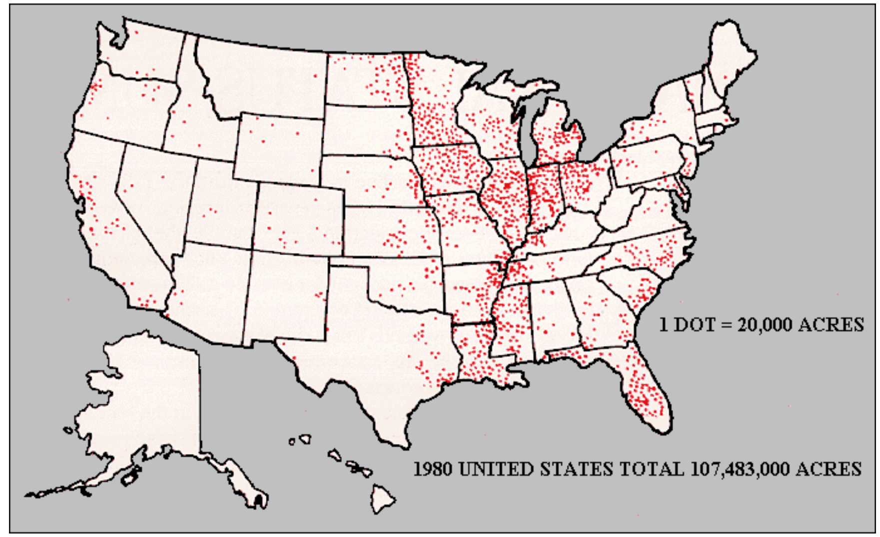
Artificial drainage in the agricultural Midwest

Photo credit: Natalie Griffiths

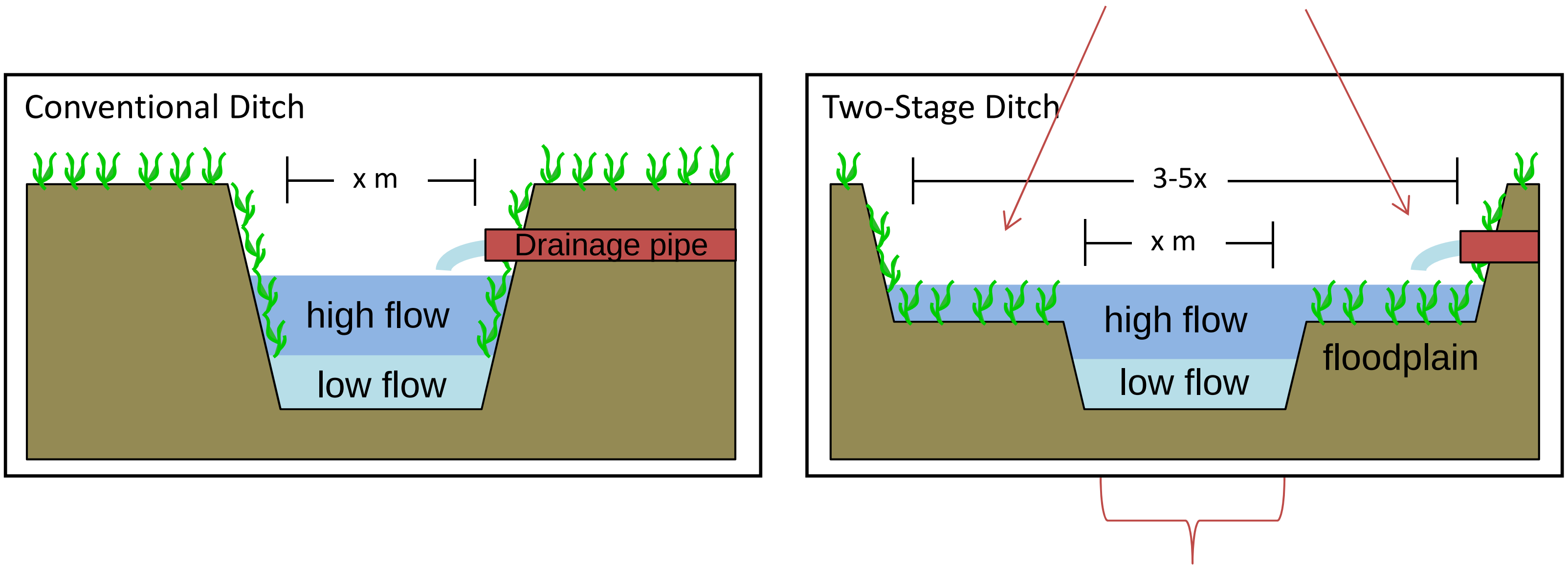


Dahl 1990

Can we restore ecosystem services by adding floodplains?

Two-stage ditch floodplains

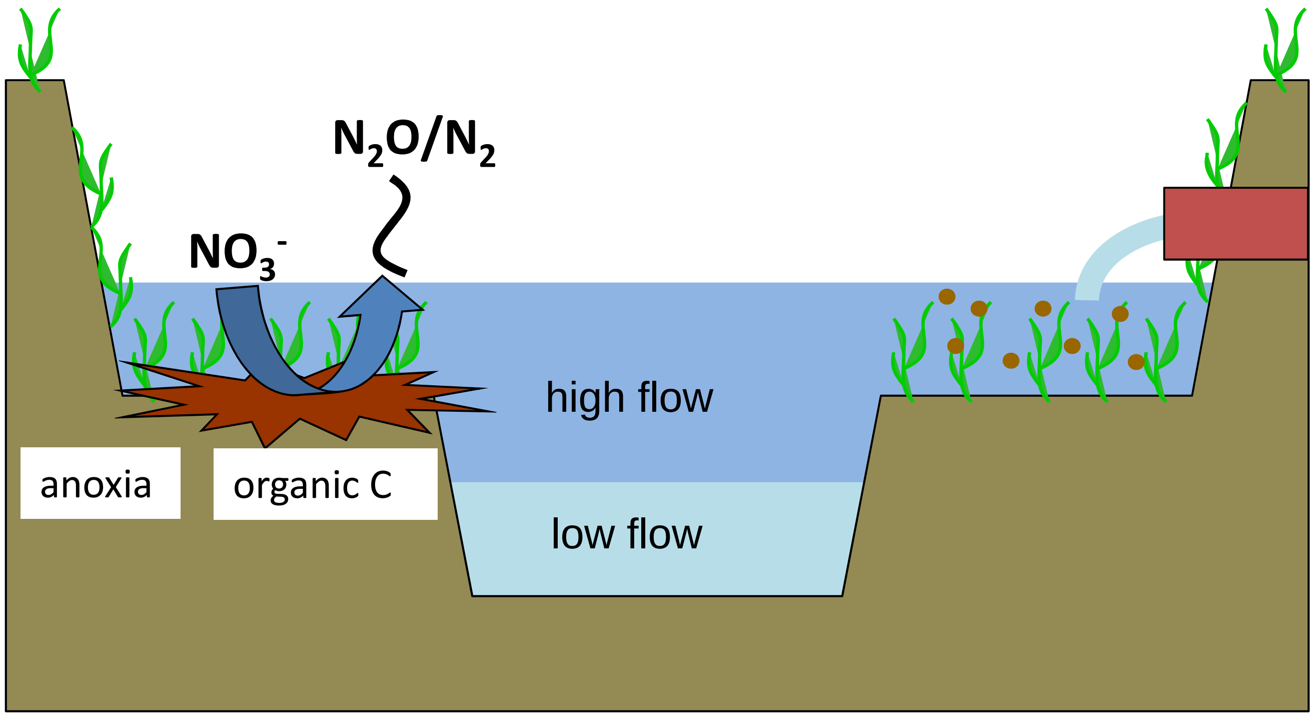
Each floodplain is 1-2.5 x the width of the main channel



Main channel left intact

During high flows: ↓ water velocity,↓ shear stress = greater stability (Powell et al. 2007)

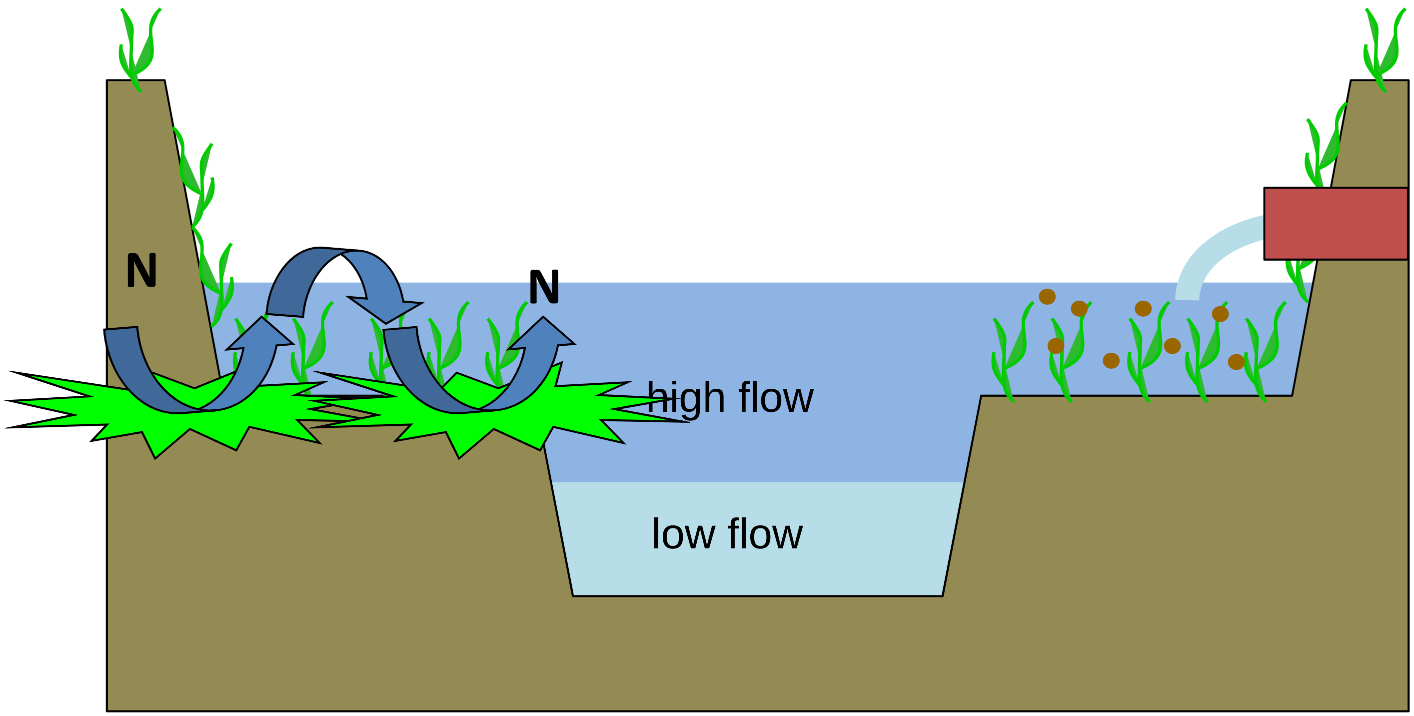
Potential ecosystem services



Denitrification: permanent N removal

Particle settling: retain sediment and TP

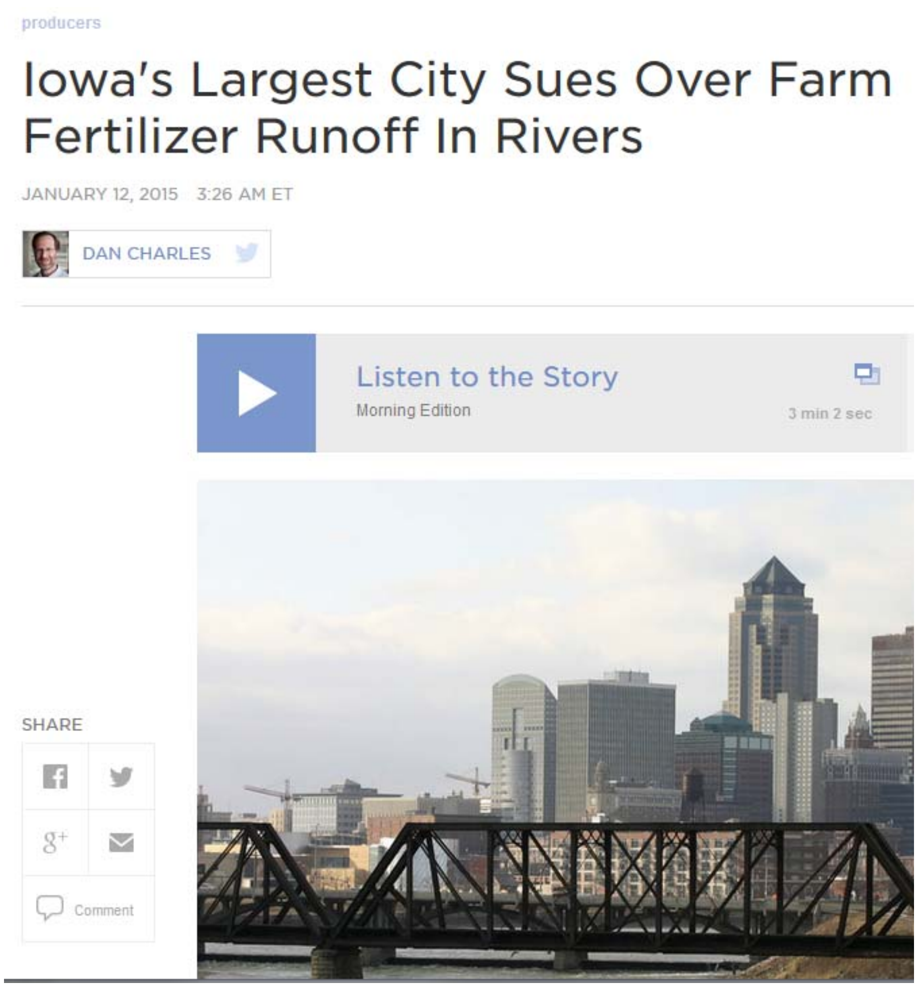
Potential ecosystem services



Assimilatory uptake: temporary removal of N
Mechanism: ↓ turbidity = ↑ photosynthesis

Particle settling: retain sediment and TP

Excess N an important resource concern



producers

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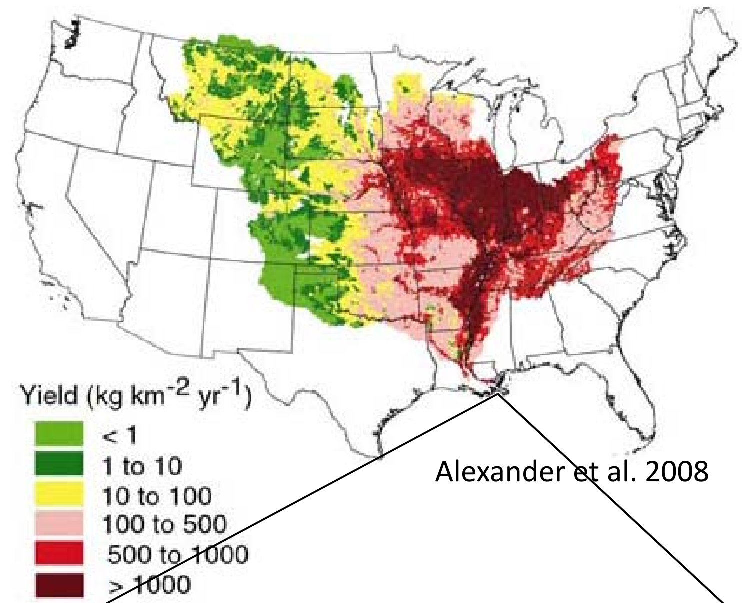
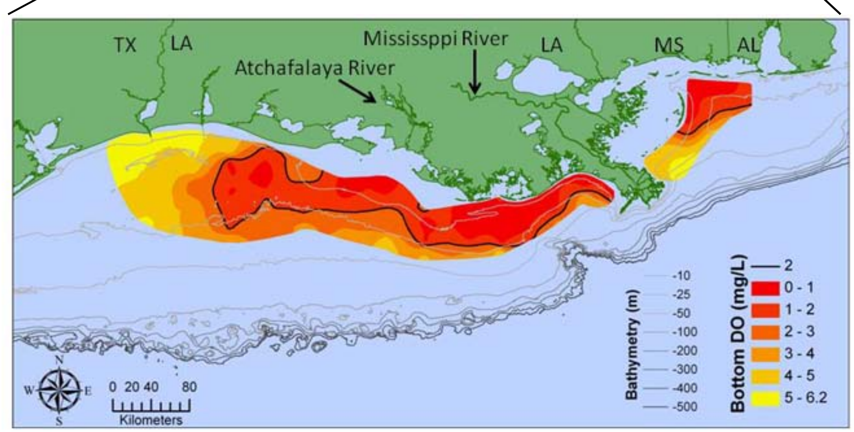


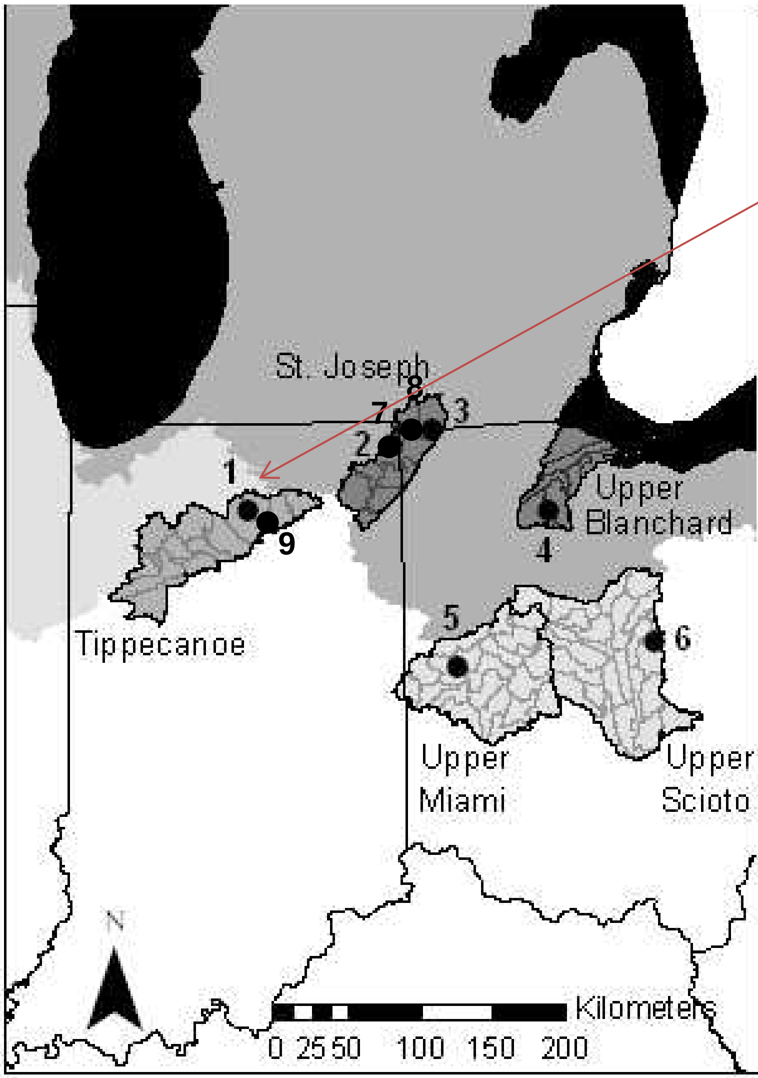
Alexander et al. 2008



LUMCON 2011

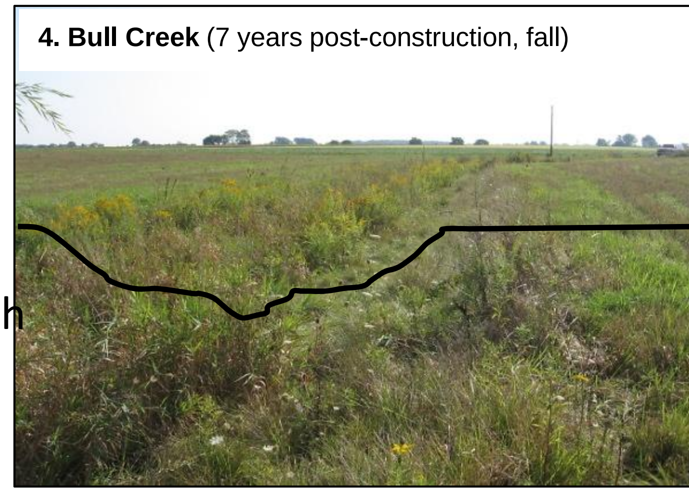
Study Sites

Most extensive study on Shatto



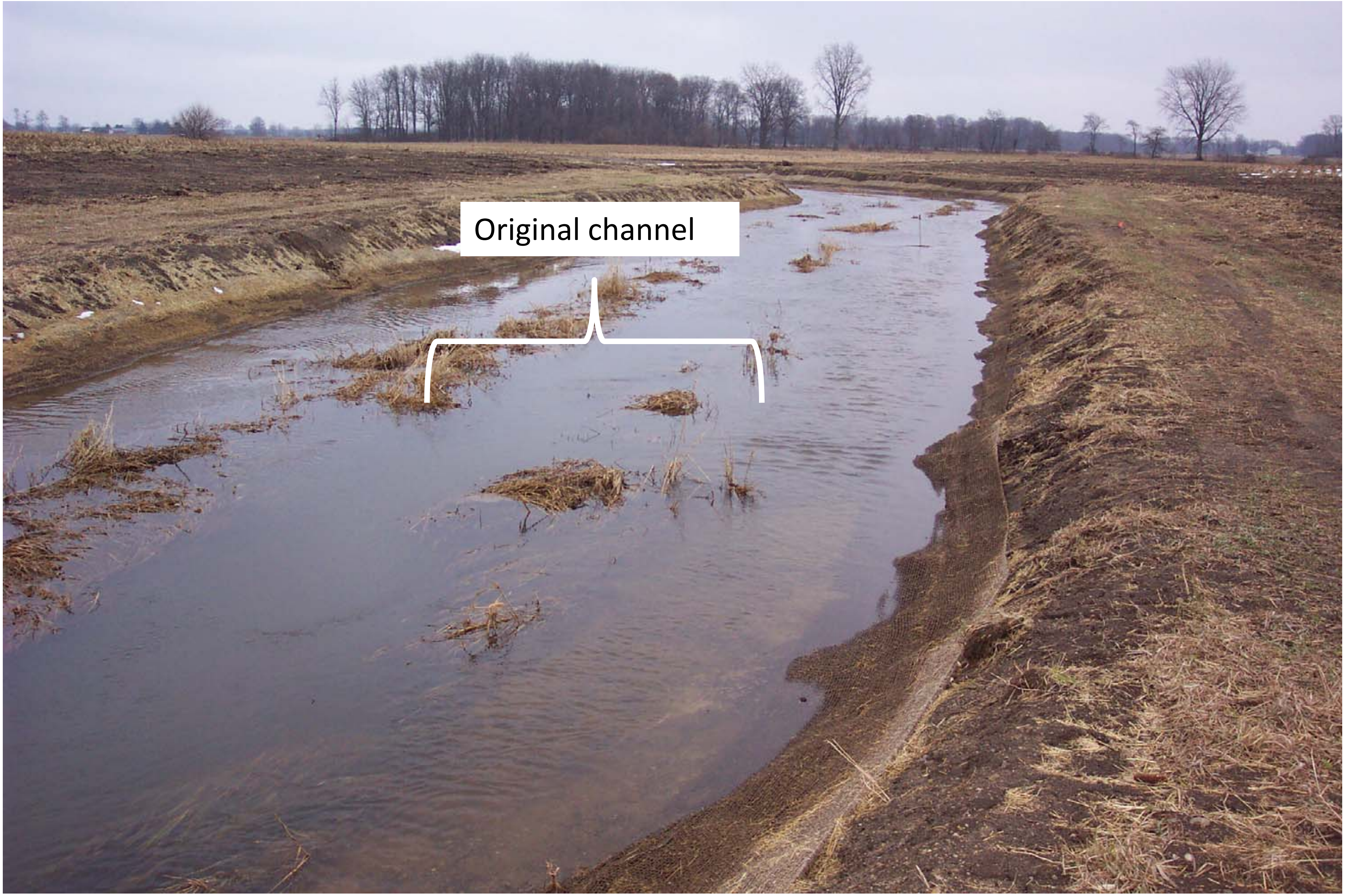
- > 70 % row-crop agriculture
- History of conventional ditch maintenance
- Abundant nutrients


1. Shatto Ditch (immediately after construction)

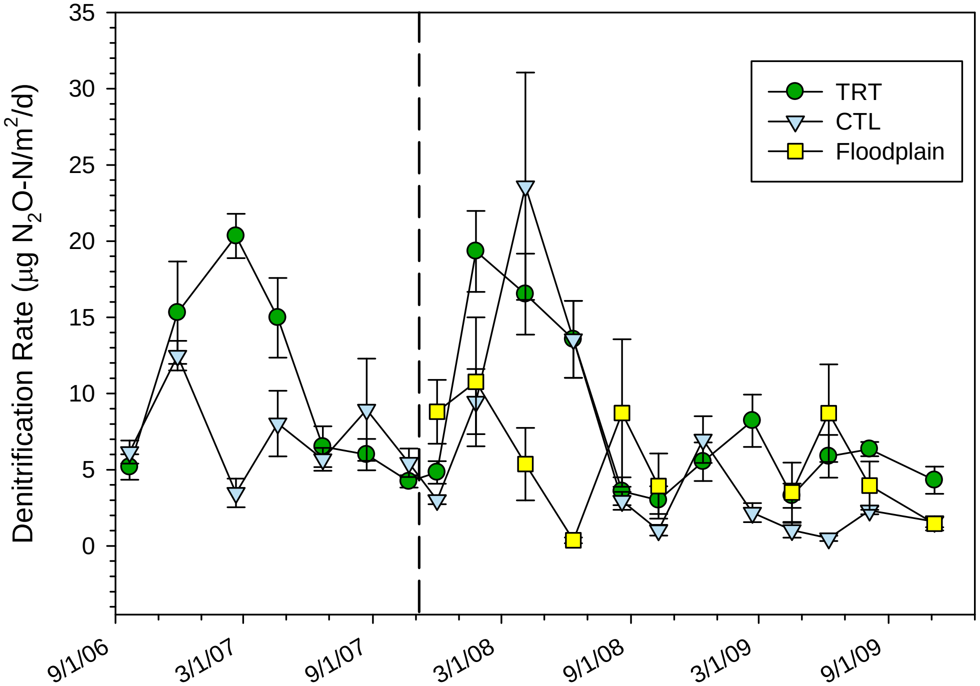

4. Bull Creek (7 years post-construction, fall)


3. Crommer Ditch (5 years post-construction, fall)

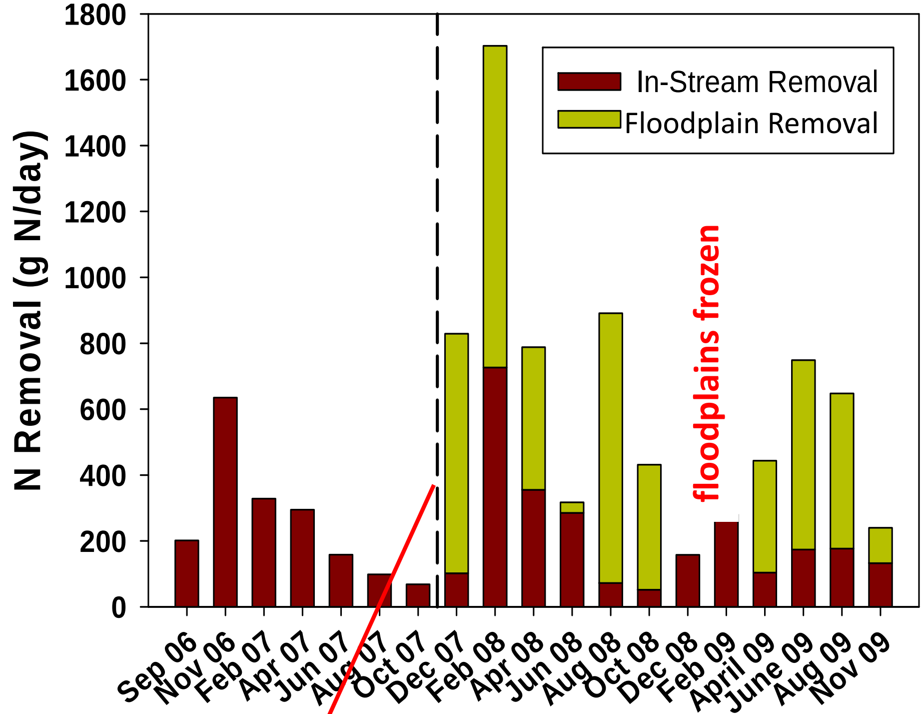
Shatto Ditch - January 2008 flood (2 months post-construction)



Seasonal patterns at Shatto



No effect on in-stream rate; seasonal variation (temp, [NO_3^-])



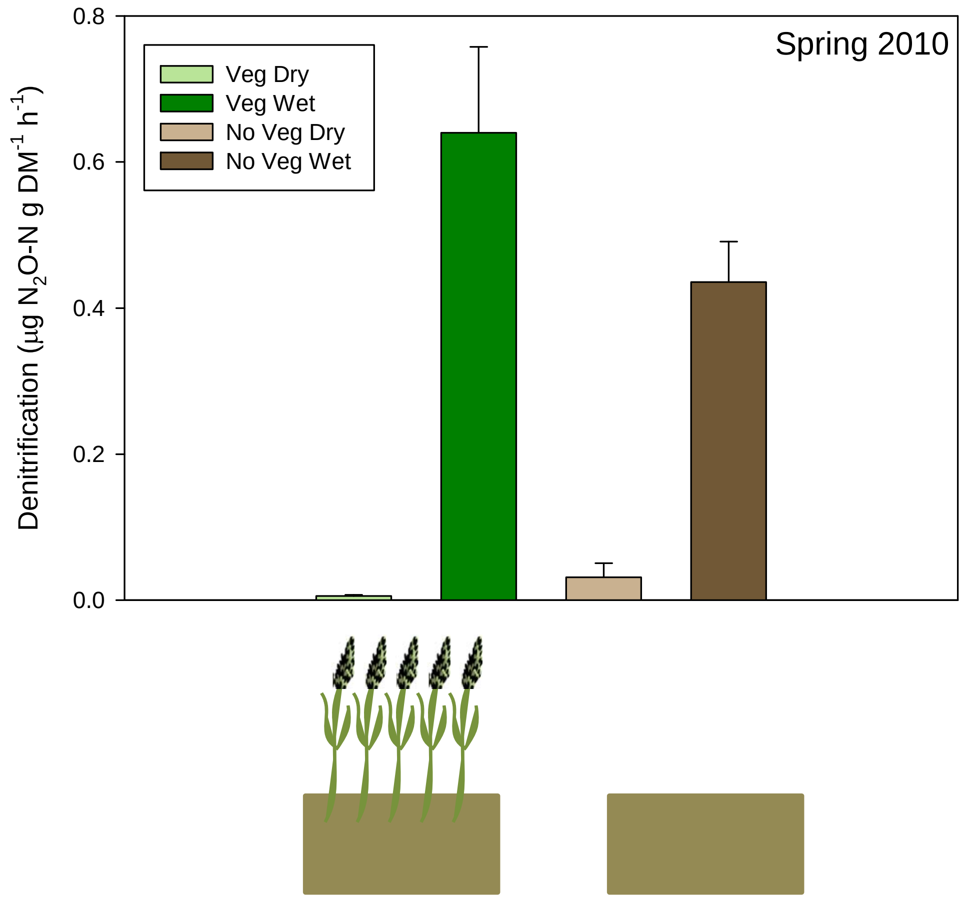
During inundation, N removal 0-12 times higher with floodplains (mean=3x higher)

Floodplain restoration date

Roley et al. 2012 Ecological Applications

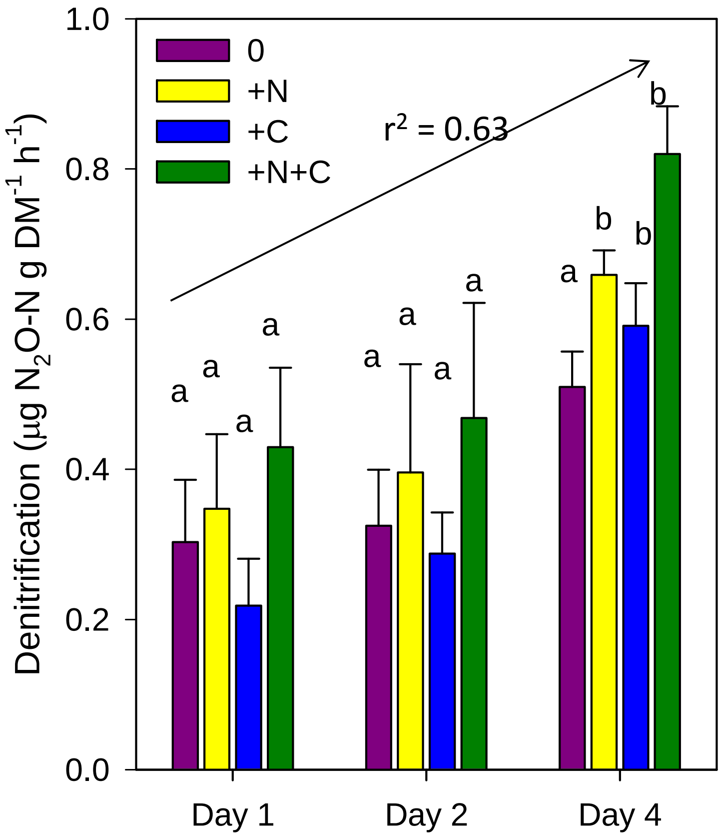
Controls on floodplain denitrification - vegetation

Vegetation facilitates denitrification response to floodplain inundation.



Roley et al. 2012 JGR-Biogeosciences

Controls on floodplain denitrification - inundation time

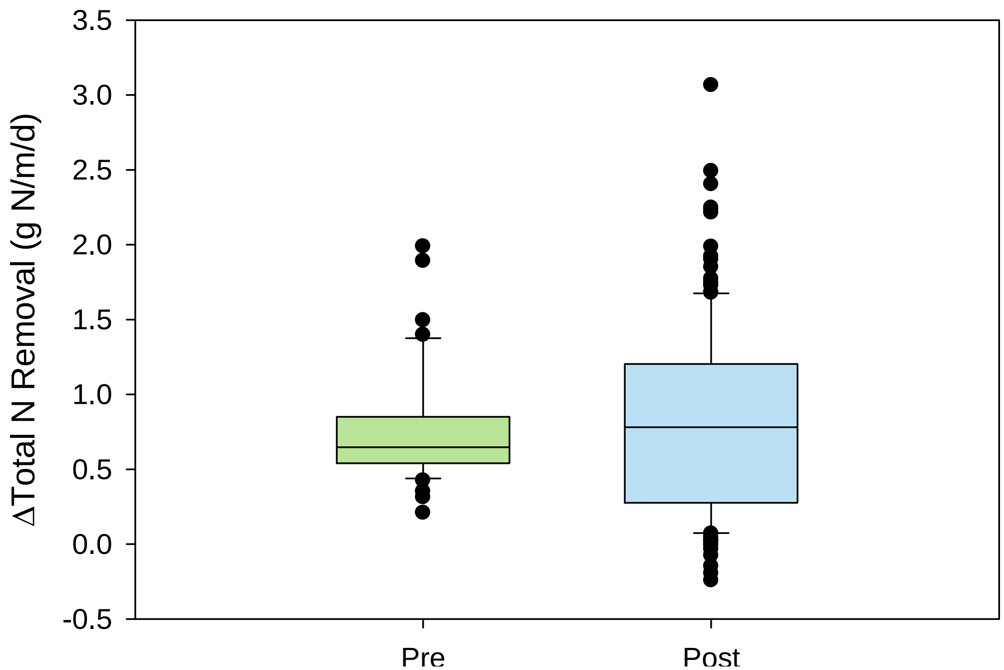


Within an event:
↑ inundation time = ↑ denitrification rate

Floodplain height should be low enough to allow regular inundation

Mahl et al., in review; Roley et al. 2012 JGR-Biogeosciences

Assimilatory N Uptake During Storms



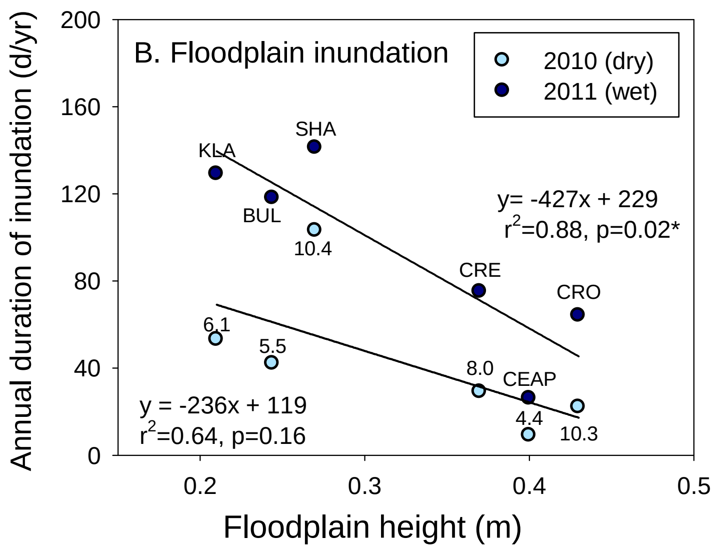
Approach:
Convert photosynthesis and respiration measurements to N uptake
- autotrophic (algae)
- heterotrophic (bacteria)

Results: autotrophic N uptake ↑; heterotrophic N uptake unchanged

Total assimilatory N uptake (autotrophic + heterotrophic) unchanged

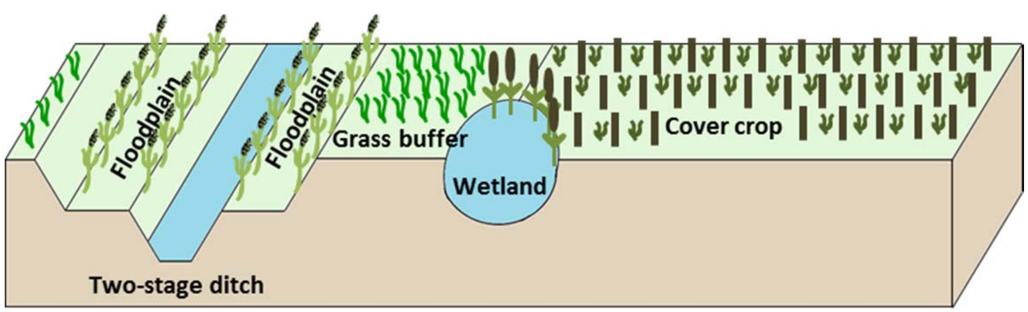
Roley et al. 2014 Freshwater Science

Design considerations



1. Floodplain height – low enough for multiple inundation events per year

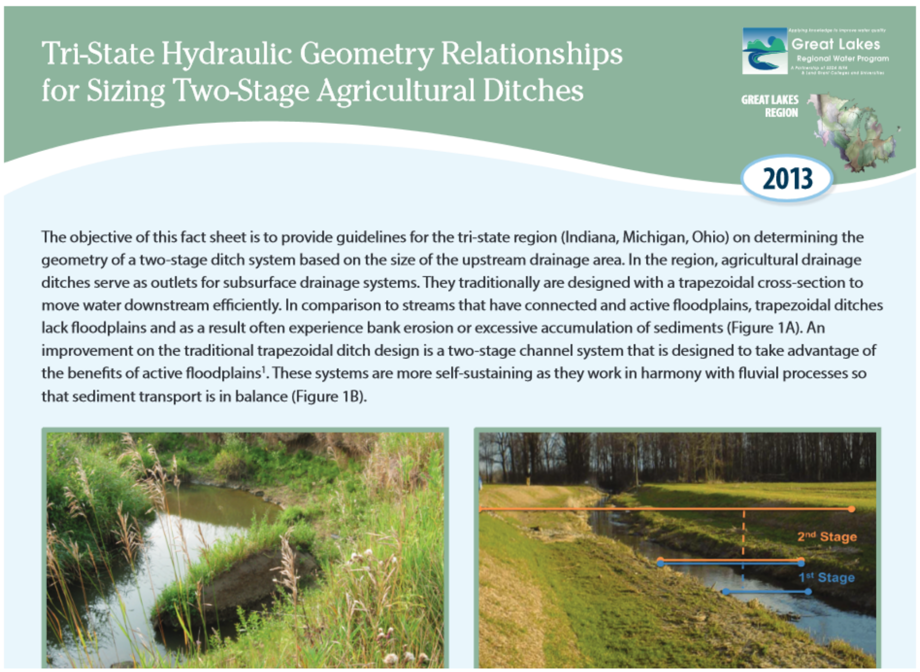
2. Encourage growth of vegetation



3. Combine with other practices to achieve greatest N removal benefit

Resources for two-stage ditch design

http://agditches.osu.edu/Publications


Tri-State Hydraulic Geometry Relationships for Sizing Two-Stage Agricultural Ditches

Great Lakes Regional Water Program

GREAT LAKES REGION

2013

The objective of this fact sheet is to provide guidelines for the tri-state region (Indiana, Michigan, Ohio) on determining the geometry of a two-stage ditch system based on the size of the upstream drainage area. In the region, agricultural drainage ditches serve as outlets for subsurface drainage systems. They traditionally are designed with a trapezoidal cross-section to move water downstream efficiently. In comparison to streams that have connected and active floodplains, trapezoidal ditches lack floodplains and as a result often experience bank erosion or excessive accumulation of sediments (Figure 1A). An improvement on the traditional trapezoidal ditch design is a two-stage channel system that is designed to take advantage of the benefits of active floodplains[1]. These systems are more self-sustaining as they work in harmony with fluvial processes so that sediment transport is in balance (Figure 1B).

Summary

- Floodplains increase N removal via denitrification
- Denitrification optimized with:
  - Soil OM
  - Length of floodplain inundation
  - Presence of established vegetation
- Turbidity and [SRP] reduced by floodplain restoration; [NO_3^-] sometimes reduced
- Two-stage ditch cost-effective

Acknowledgements

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The Nature Conservancy

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