Managing Nitrogen Losses from Agricultural Drainage

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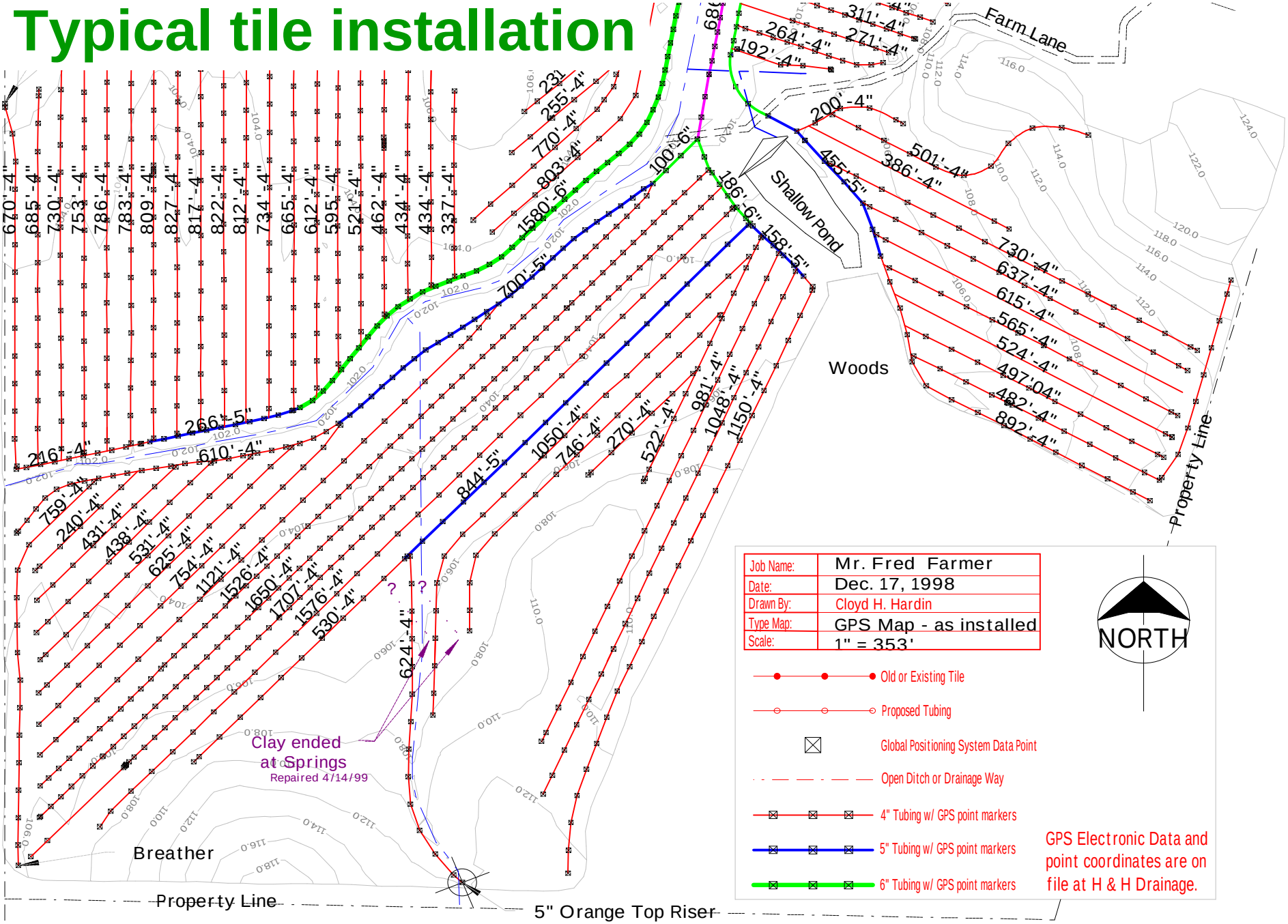
Subsurface or " tile" drainage

A key component of Midwestern agriculture

Soil conditions where crops benefit from artificial drainage

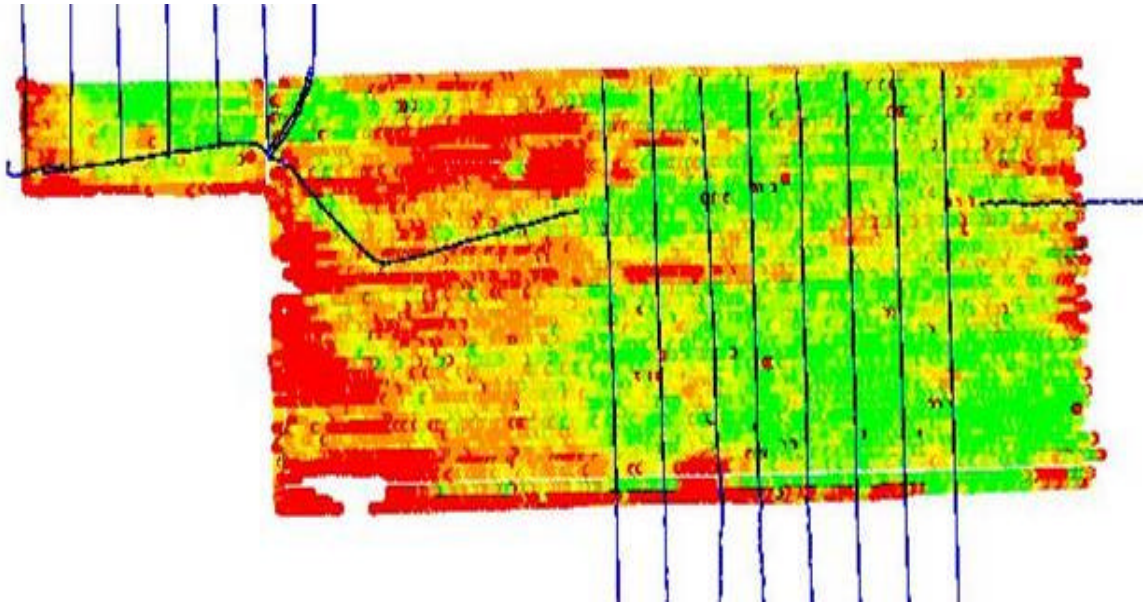
- Lack of topography for natural drainage
- Shallow restricting soil layers (dense till, fragipan, bedrock)
- Lack of natural outlet or slow soil permeability

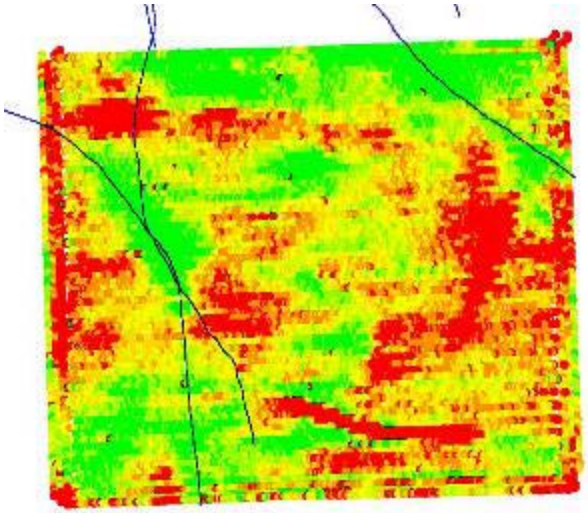
Typical tile installation



Site-specific agriculture has increased interest in drainage

Yield monitors show effect of poor drainage on yield.

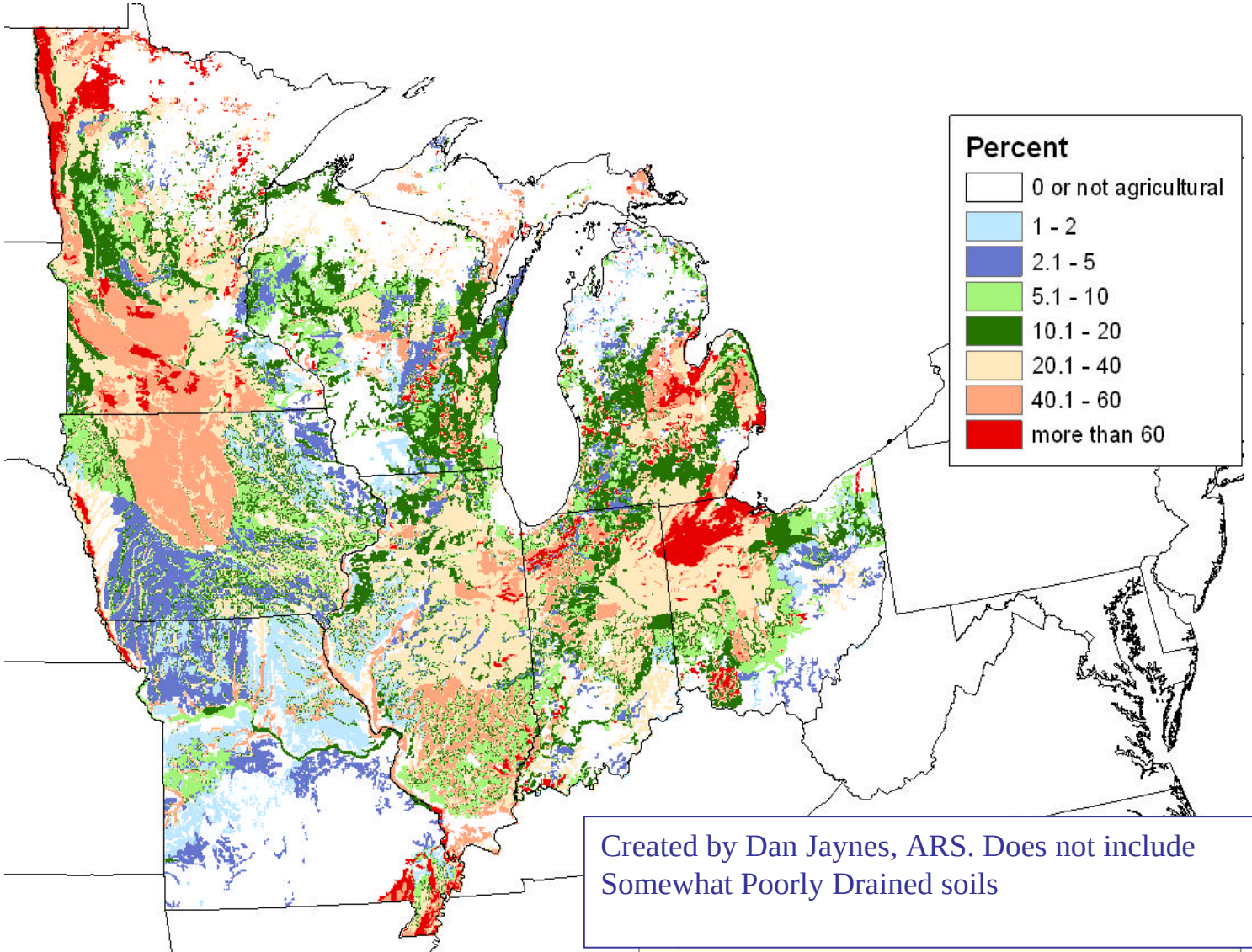




- Green = higher yield; Tile lines in blue

Image: Jeff Boyer

Drainage is common in much of the Midwest



Created by Dan Jaynes, ARS. Does not include Somewhat Poorly Drained soils

Water quality impacts of subsurface drainage

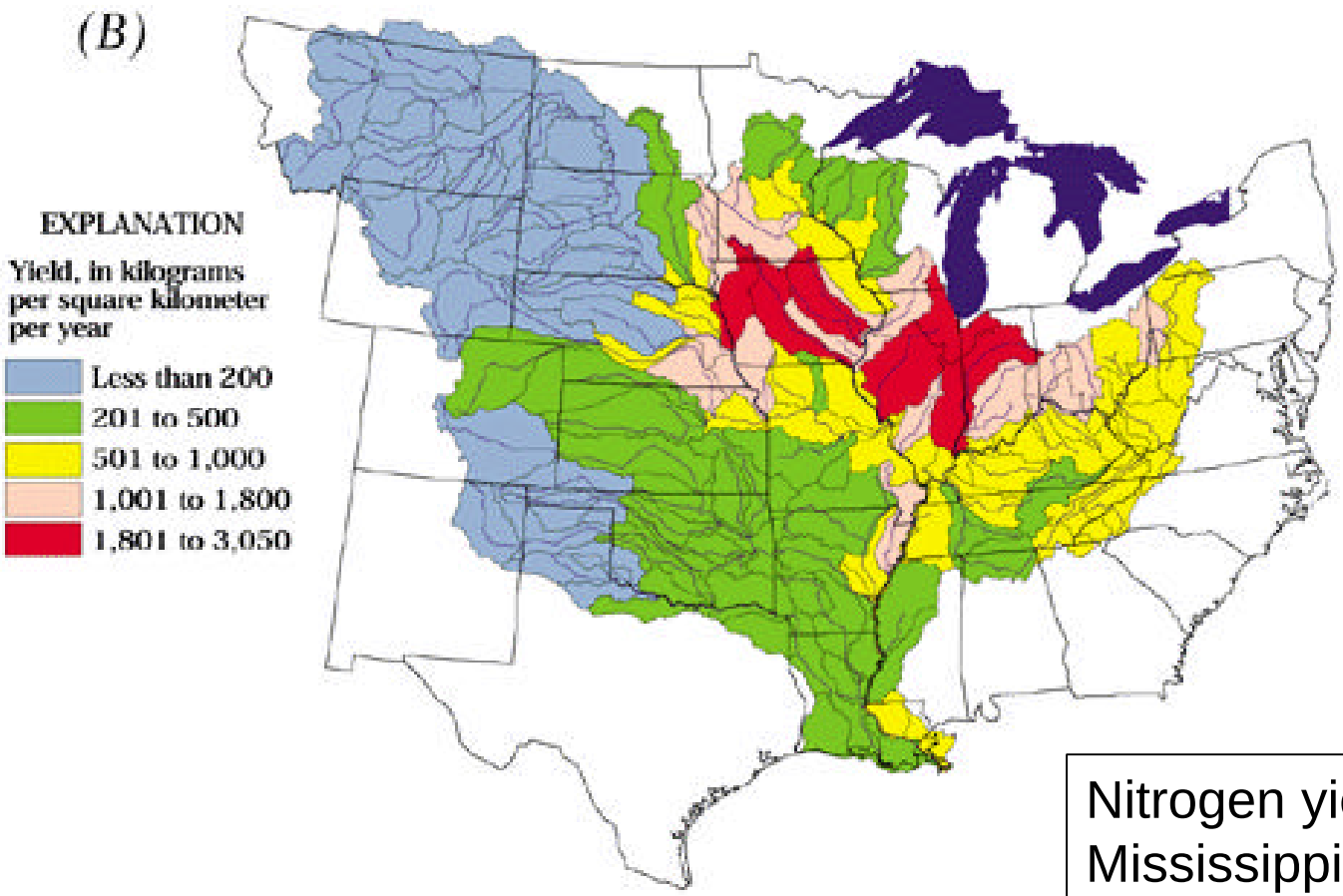
- **Positive**:

  Decreased runoff, soil erosion, and phosphorus loss

- **Negative:**

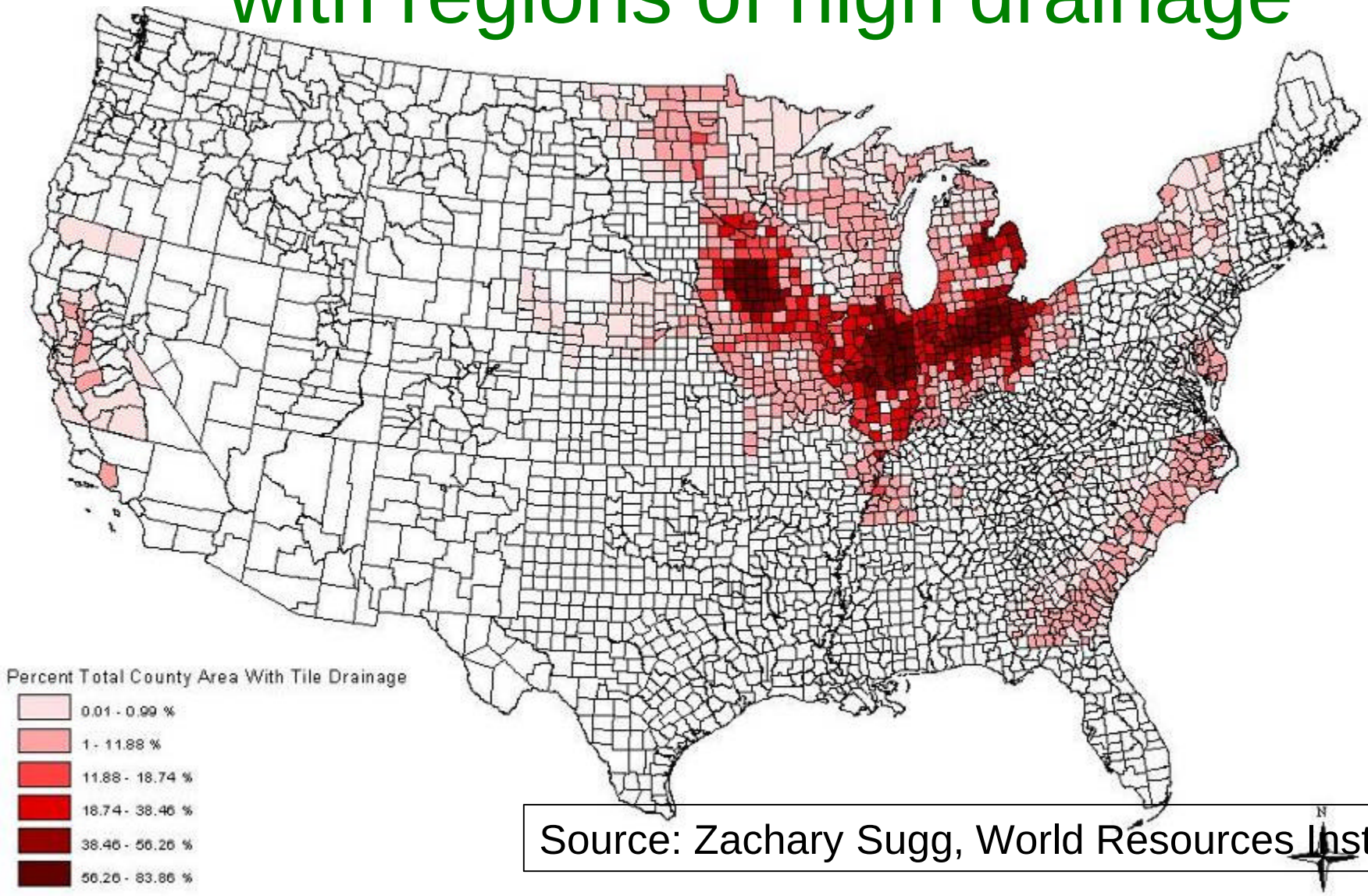
  Increased nitrate

Nitrate from drainage is a cause of low oxygen in the Gulf of Mexico



Nitrogen yield in Mississippi Basin (Source: USGS)

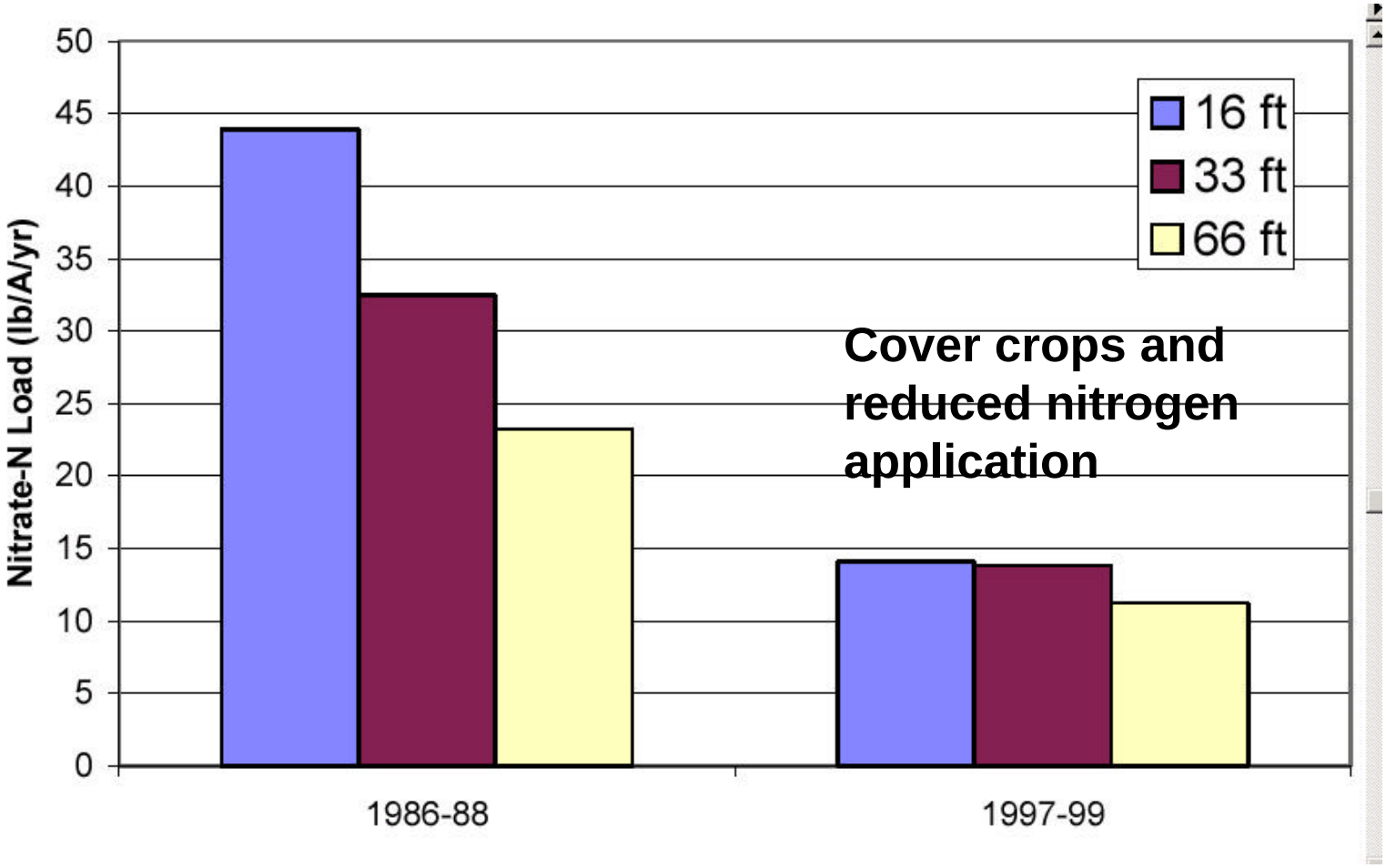
Regions of high nitrate loss coincide with regions of high drainage



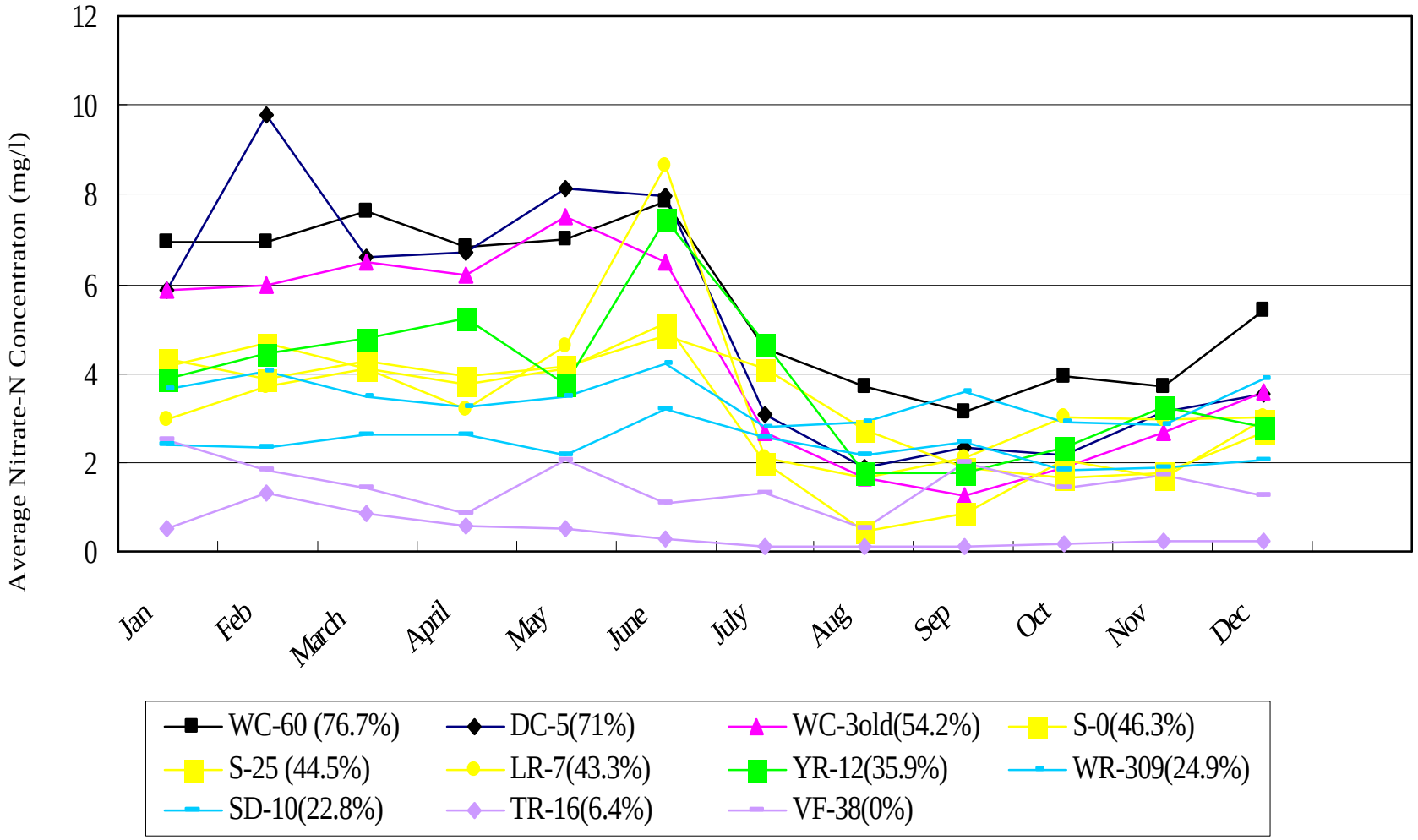
Source: Zachary Sugg, World Resources Institute

Plot and field-scale studies also show high nitrate loss from tile drains

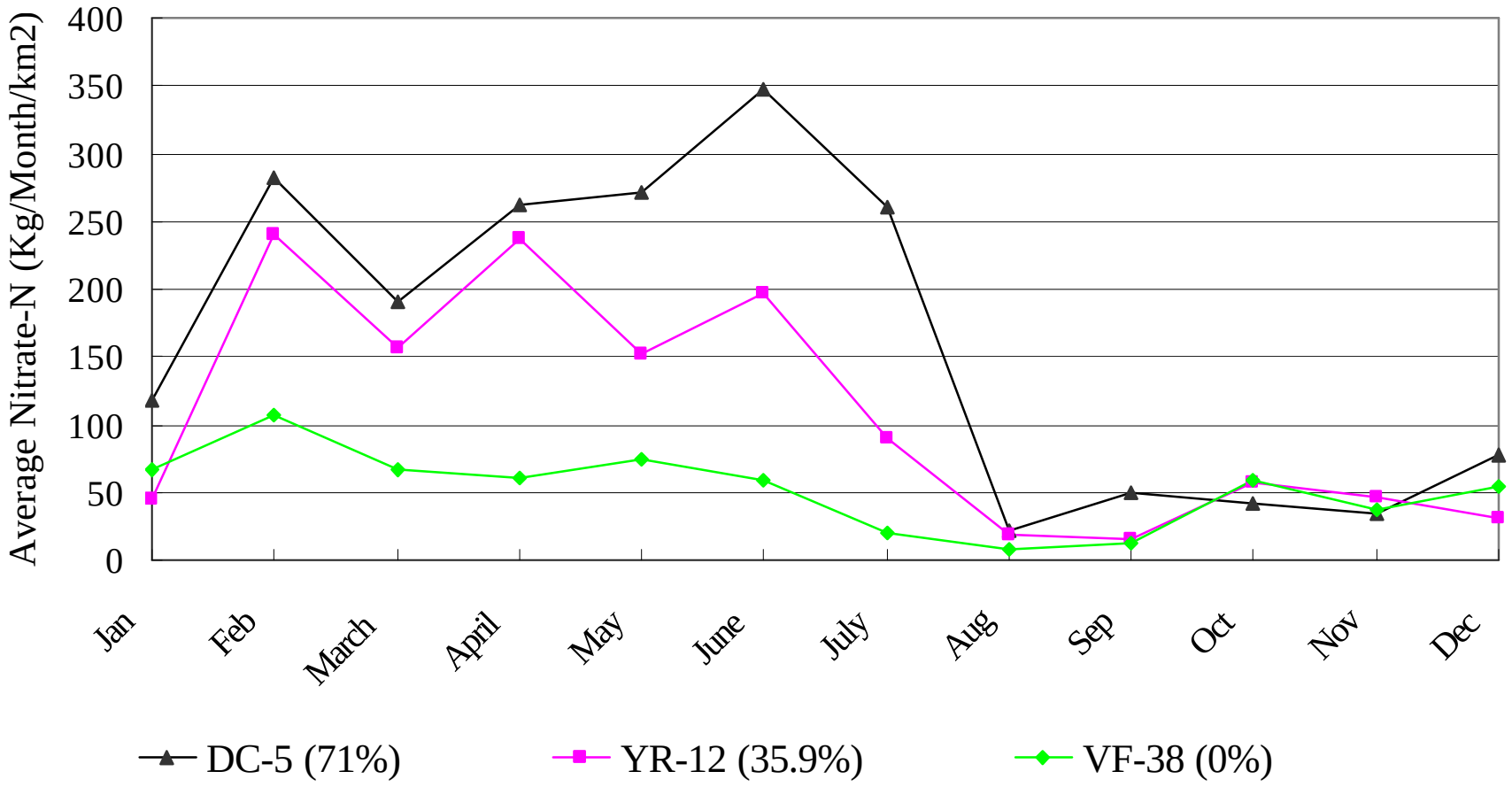
- For example, studies by Kladivko et al.at SEPAC:



Long term average nitrate concentration



Long term average nitrate load



What can be done to reduce nitrate losses

- In-field
  - Agronomic practices
  - Shallow drainage
  - Controlled drainage or drainage water management
  - Biocurtains or denitrification walls
- Edge of field
  - Bioreactors
  - Water recycling
  - Wetlands
- Downstream
  - Wetlands
  - Ditch management

Cropping practices can reduce nitrate loss to some extent

- Improve fertilizer application: reduce amount, apply later, use nitrification inhibitor
- Cover crops in winter
- Perennials or other crops that result in some uptake during winter and early spring

Photo: NRCS

Shallower drains

- Skaggs et al. found through DRAINMOD-N simulations that shallower drains can reduce nitrate loss by 60%
- Research in Minnesota (G. Sands) showed nitrate loss reduction in the range of 15%
- Shallower drains requires narrower spacing (and therefore higher cost) to achieve same drainage intensity)

Drainage Water Management

- Also called controlled drainage, managed drainage, conservation drainage
- Overall concept: Drain only what is needed for crop production

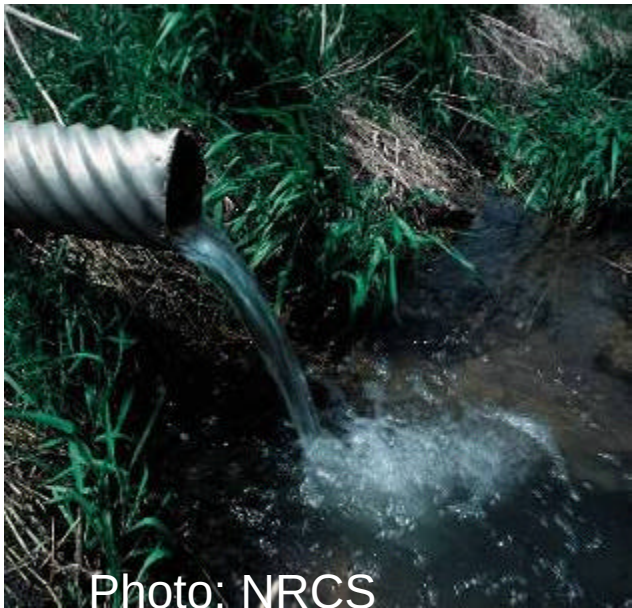
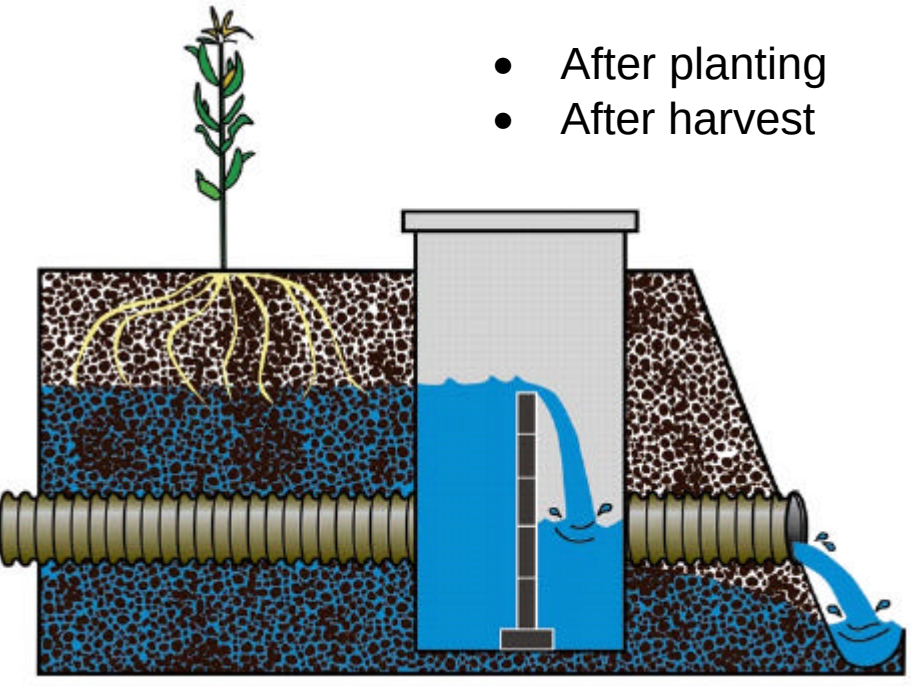
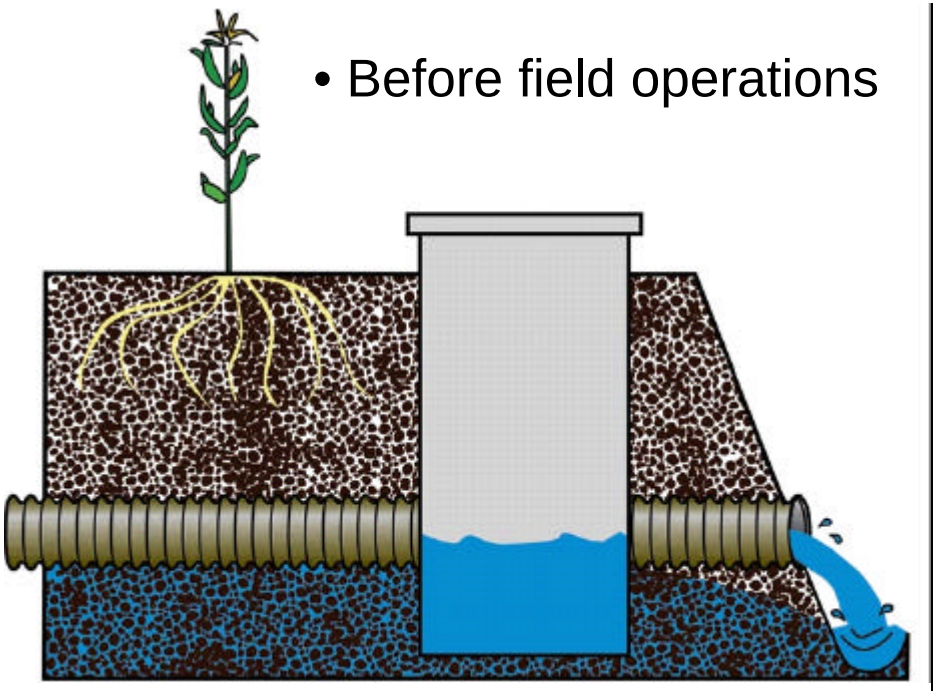


Photo: NRCS

Drainage water management
(Minimum drainage or conservation drainage)



Boards installed to hold water back when drainage not needed



Boards removed for full drainage capacity

AgriDrain control structure

Hancor control structure

Past studies show nitrate loss reduction from 15-50%

- Ontario, Canada (Tan et al): 14% (tilled), 25% no-till
- Illinois (Cooke et al): 32%-47%
- Ohio (Fausey et al): 45%-57%
- North Carolina (Skaggs, Evans, et al): many studies averaging 30% to 50%

CSREES-Funded ***Project:***
Drainage Water Management Impacts on Nitrate Load, Soil Quality, and Yield

Jane Frankenberger, Roxanne Adeuya, Barry Gutwein,

Agricultural and Biological Engineering

Eileen Kladivko, Laura Bowling, Brad Carter, Sylvie Brouder

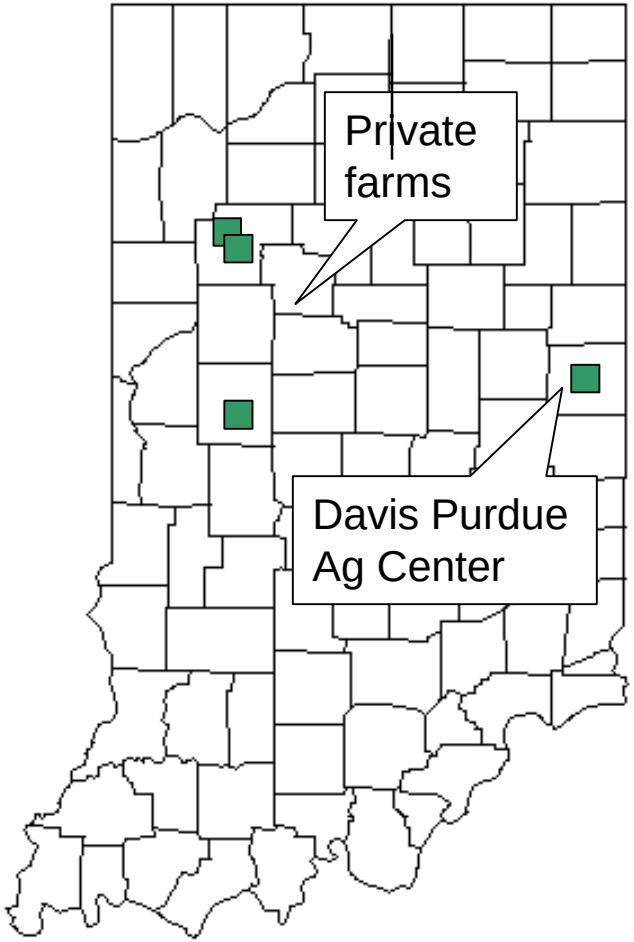
Agronomy

James Lowenberg-DeBoer and Jason Brown,

Agricultural Economics

Paired sites on four farms

- Purdue research farm (Davis Purdue Ag Center)
  - Installed as a field day with Land Improvement Contractors
  - Two pairs of controlled/uncontrolled drainage
- Three private farms



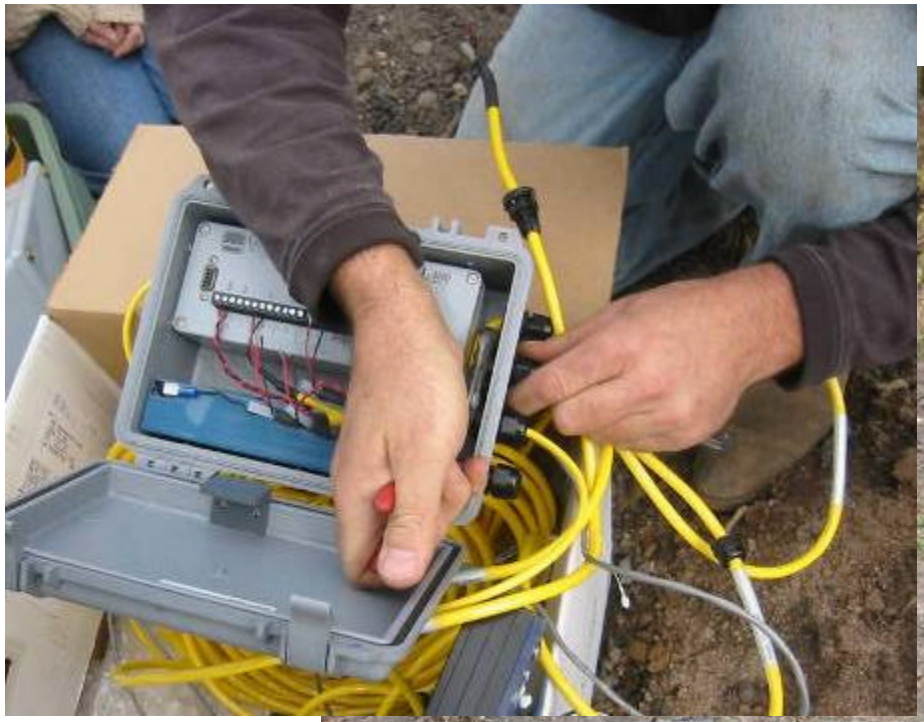
Installation Field Day allowed many people to find out about drainage water management

Photo: Steve Hawkins

Finished product: 4 research subfields (10 acres), and plenty of education

Private farm research/demonstration sites

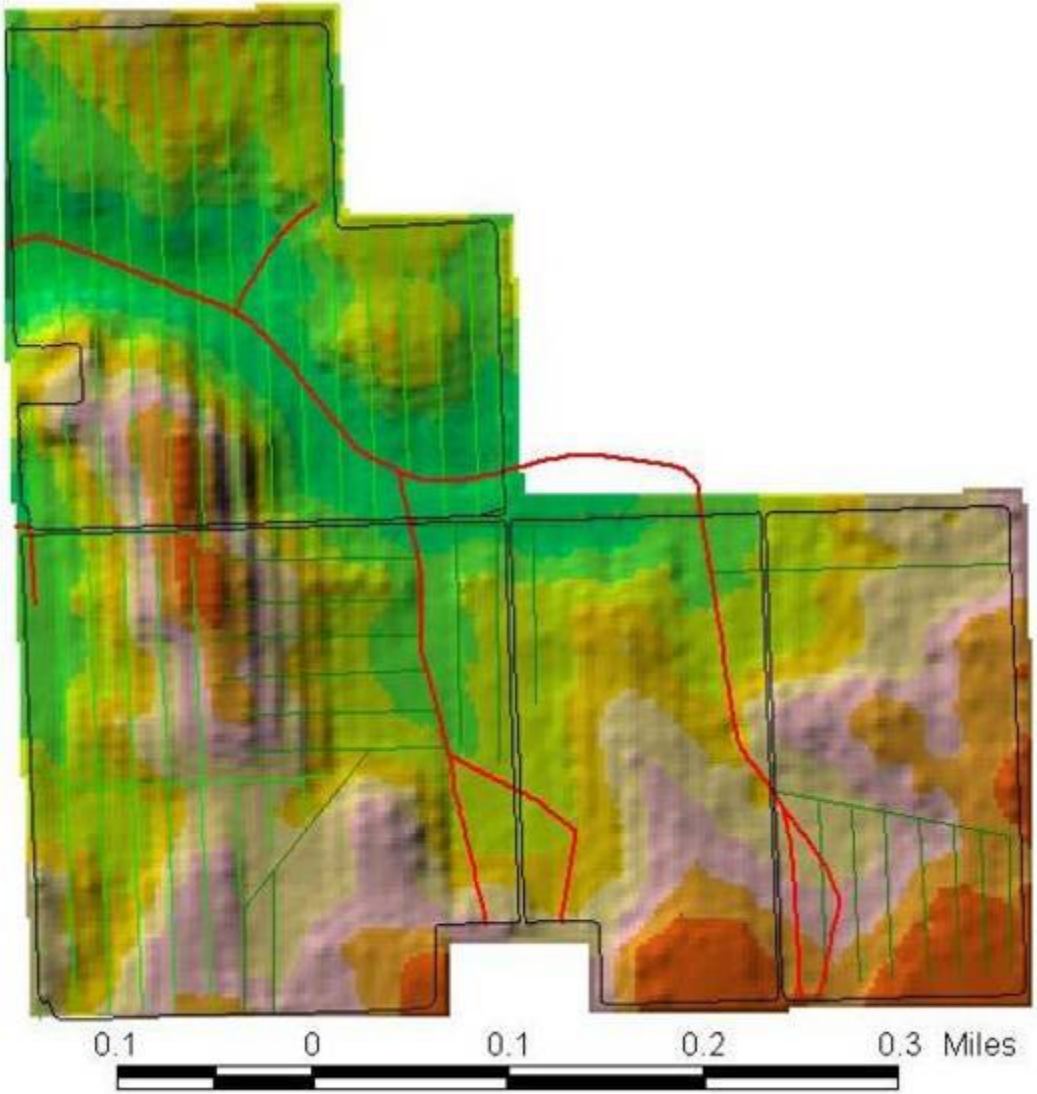
We are monitoring flow and nitrate concentration in paired fields



Water table depth measurements will help show effectiveness

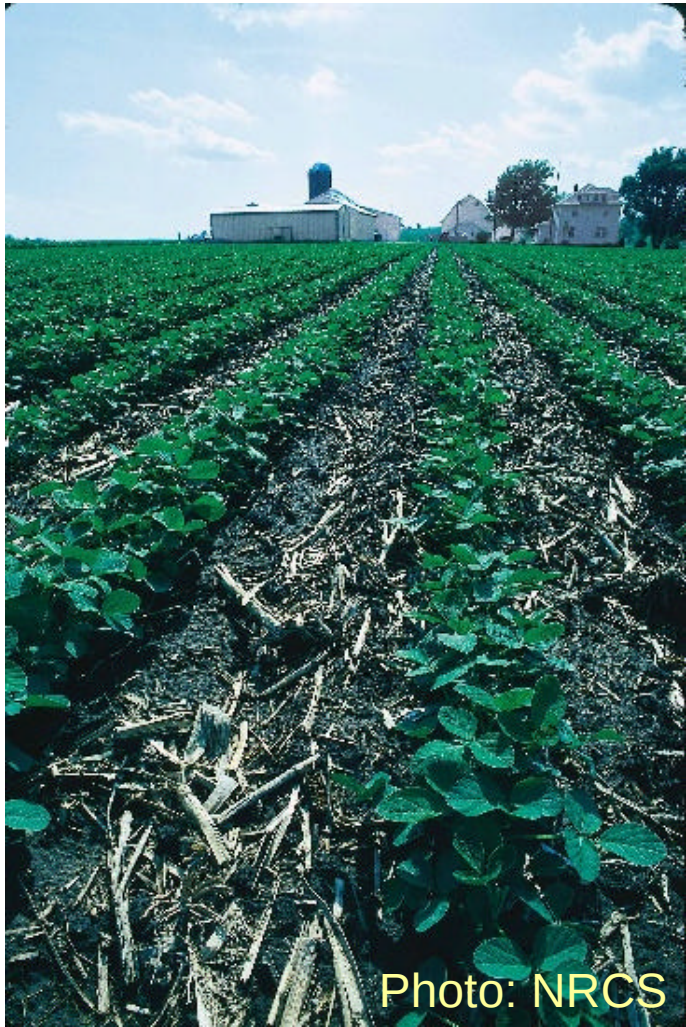
- Automated water table depth logger in each field
- Several additional manually read
- Water table rose 15 cm as soon as structure closed at one site

Topography assessed at each site using RTK (cm-accuracy) GPS



Soil quality

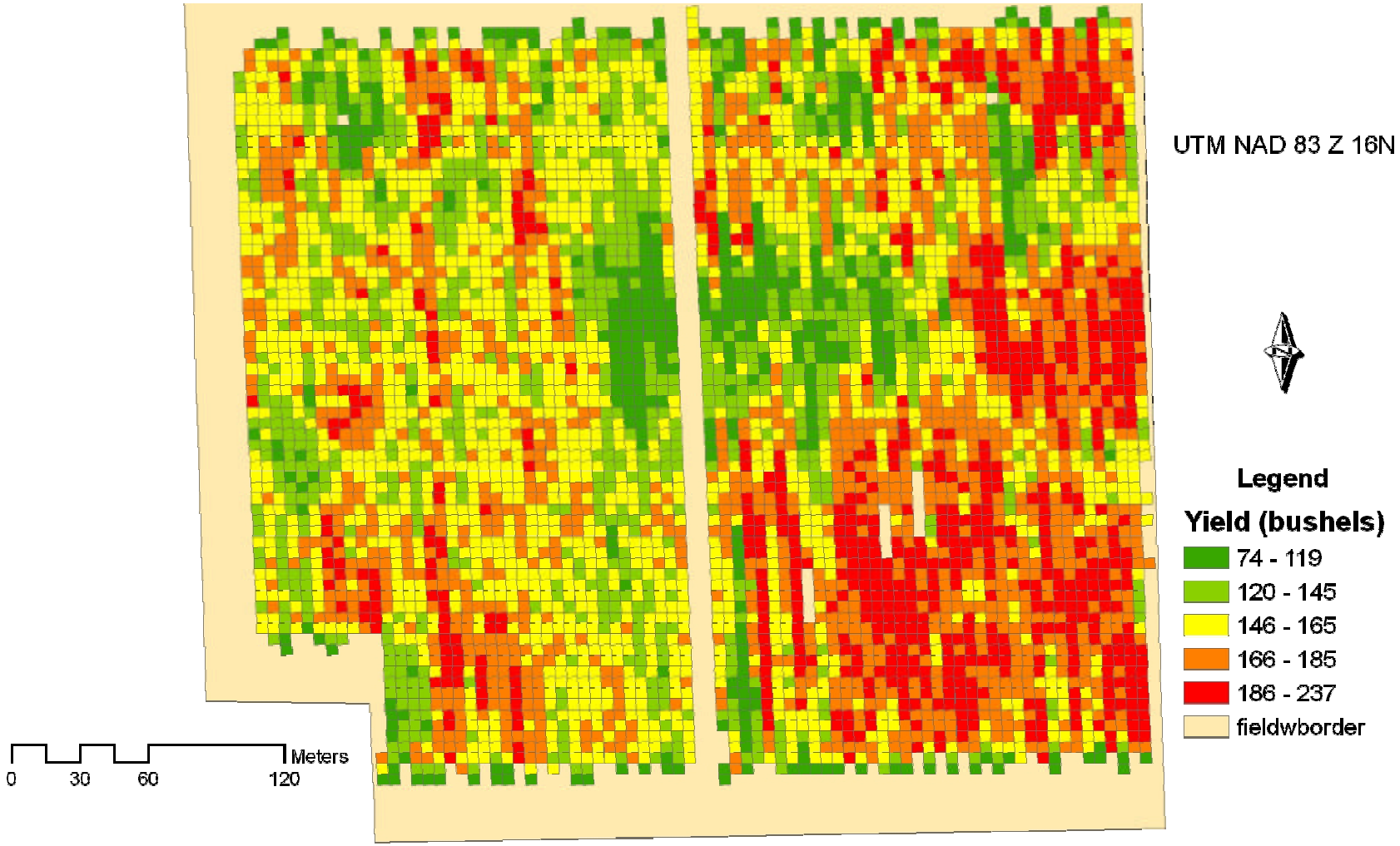
- Earthworm populations assessed
- Soil aggregation and bulk density
- Penetration resistance measured within four weeks after planting using a recording cone penetrometer



Crop growth and N use

- End-of-season stalk nitrate test used to indicate whether soil N supply to a corn crop limited yield
- Basal stalk segments analyzed for NH4-N, NO3-N and total N
- SPAD meter readings made on 10 corn leaves at growth stages V8 to V10, at tasseling and at the end of silking

2005 Yield Data – Davis Field “W”



Date: January 13, 2006
Prepared by: Jason P. Brown

2005 Yield Comparison

Location	Conventional Drainage Average yield (bu/ac)	Controlled Drainage Average yield (bu/ac)	% Yield Difference
Davis	155	161	3.8%
Site 1*	160	180	12.5%
Site 2**	41	43	4.9%
Site 3	173	175	1.2%

* Site 1 had two severe drought places in conventional drainage field which did not occur on controlled drainage field.

** Site 2 was planted in soybeans.

Source: Purdue University, M.S. Thesis – Jason P. Brown

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Denitrification walls treat drainage water as it flows through trenches filled with wood chips or other carbon sources.

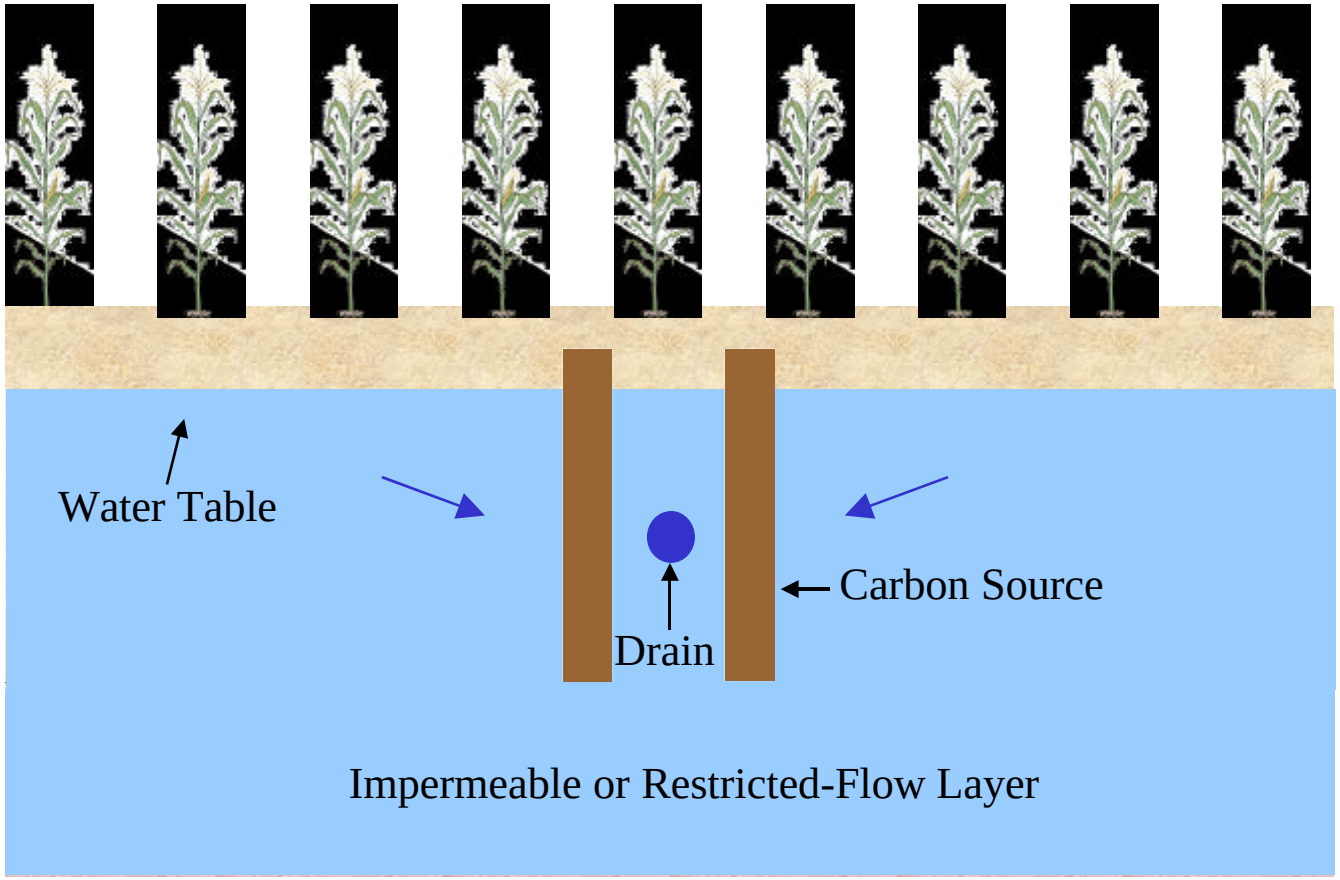


Image: Richard Cooke

Edge-of-field bioreactors treat drainage water by passing it through a subsurface trench filled with a carbon source iust before it leaves the drain

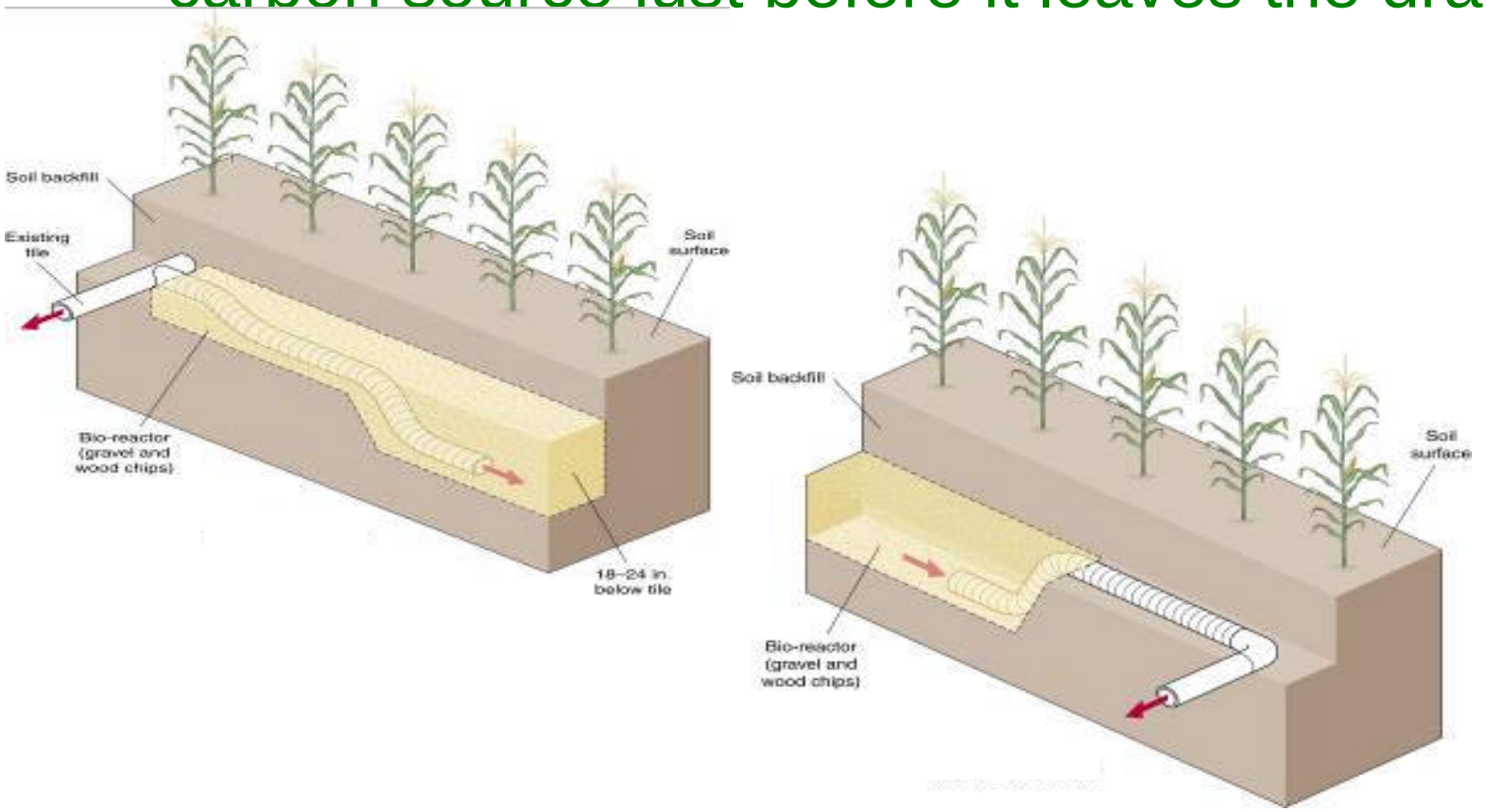


Image: Richard Cooke

Restoration or creation of wetlands downstream of drainage outlets

- Wetlands provide extensive areas for denitrification and biological uptake to occur

Water recycling

- Reservoir to store water, combined with subirrigation

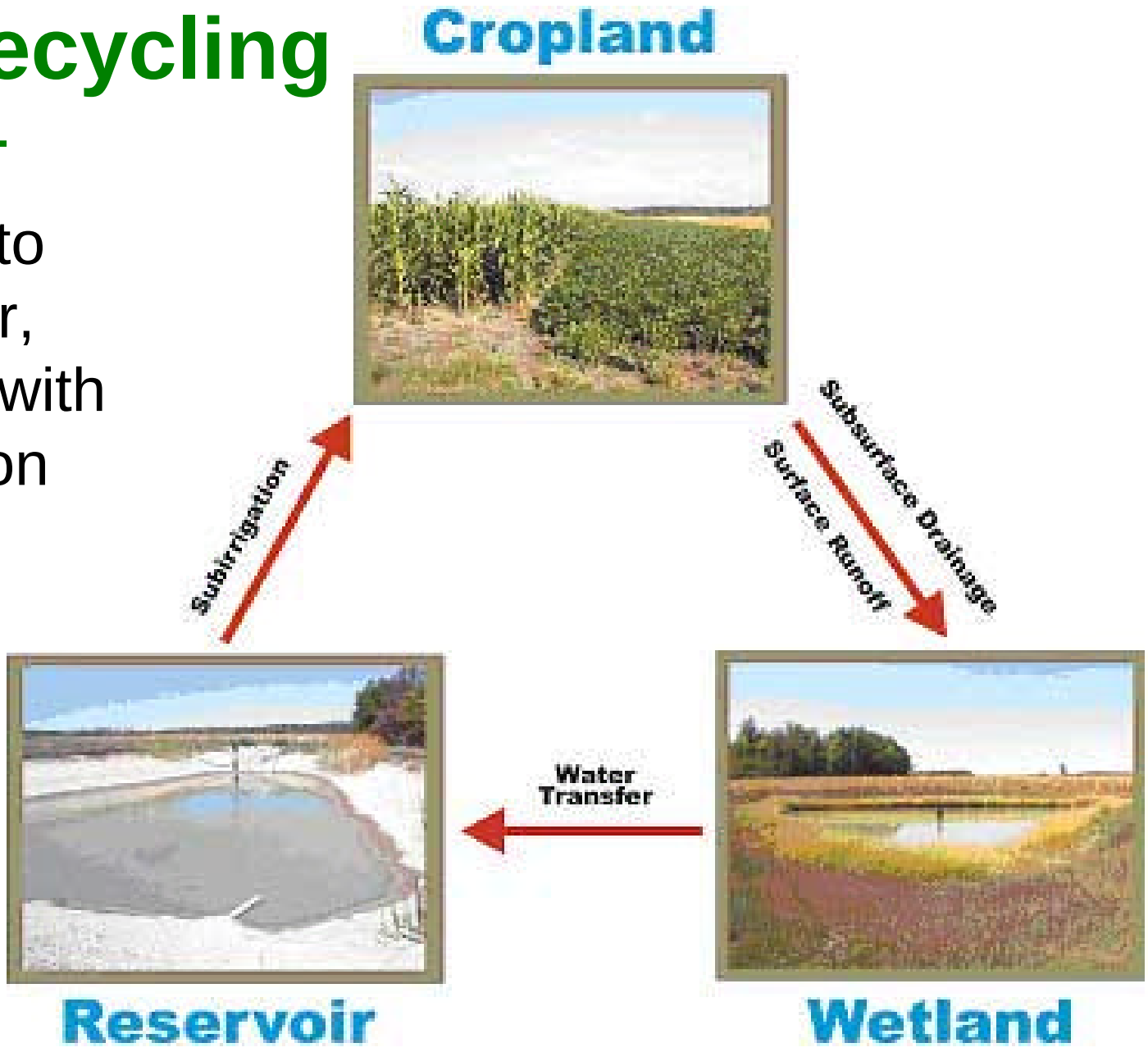
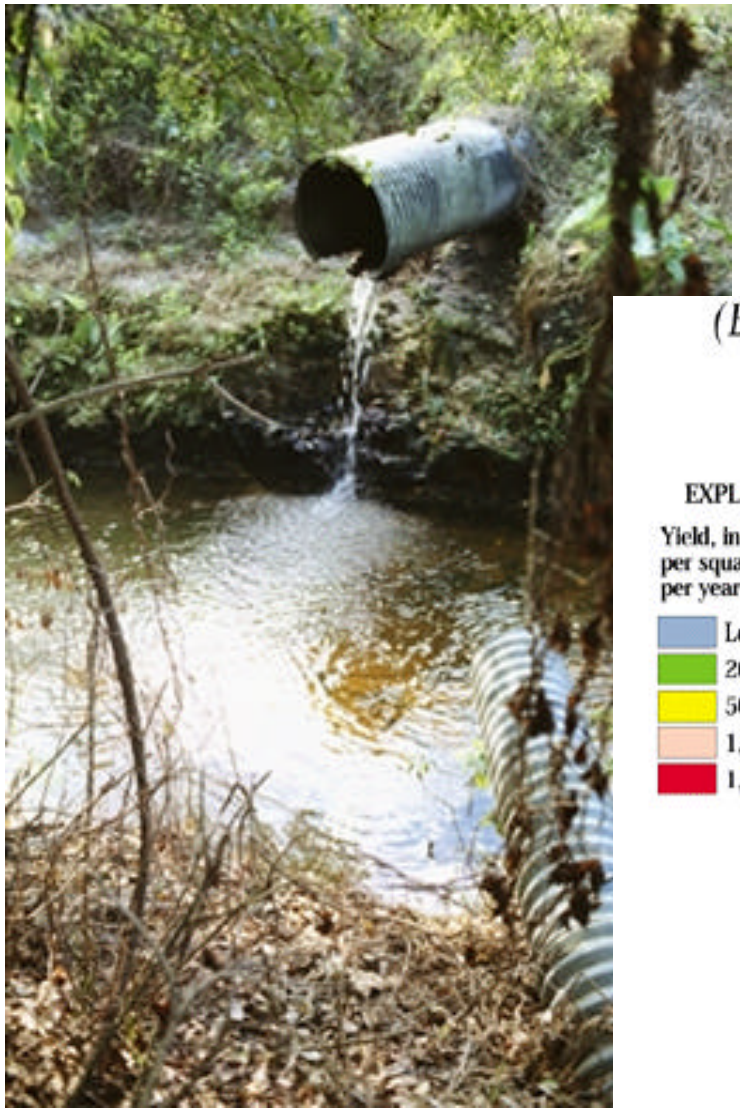


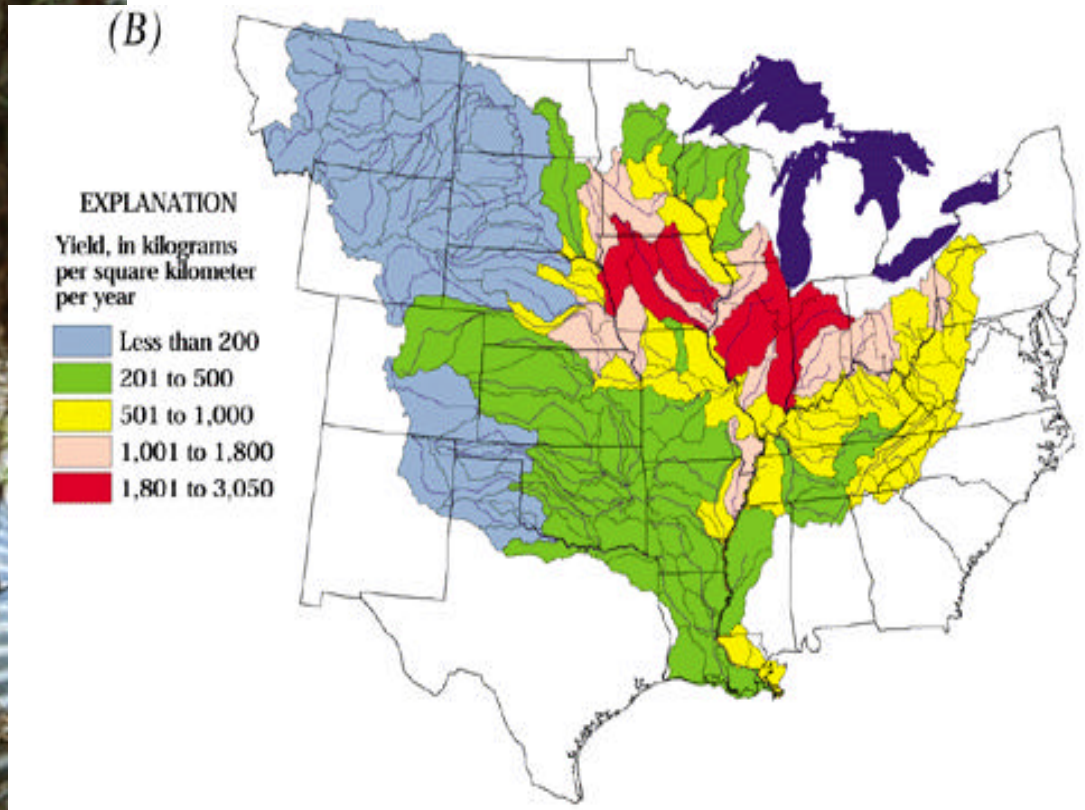
Image: ARS drainage unit

Ditch design to improve water quality

Research needed to quantify impacts and effects of channel shape, vegetation, etc.

Moving forward to meet the drainage challenges





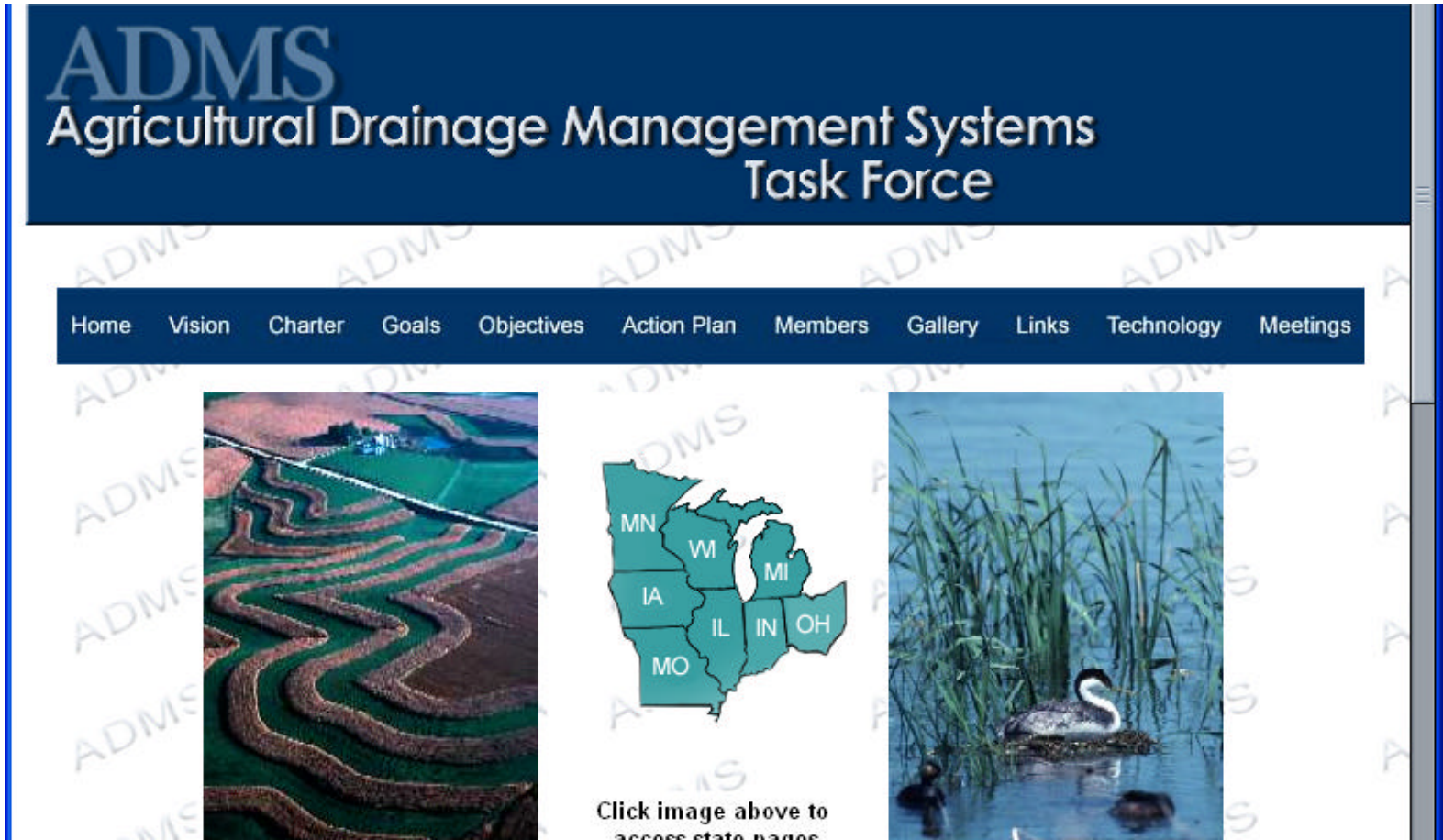
Integration among disciplines

- Engineers, agronomists, soil scientists, economists, ecologists need to be involved

Integration of research, education, and extension

- The land-grant university tradition

Integration across state lines

Integration among agencies

Agricultural Drainage Management Systems Task Force: Partnership of ARS, NRCS, CSREES, and Land-Grant Universities