

Dealing with “weather whiplash” in Wisconsin’s croplands: a soil and water perspective

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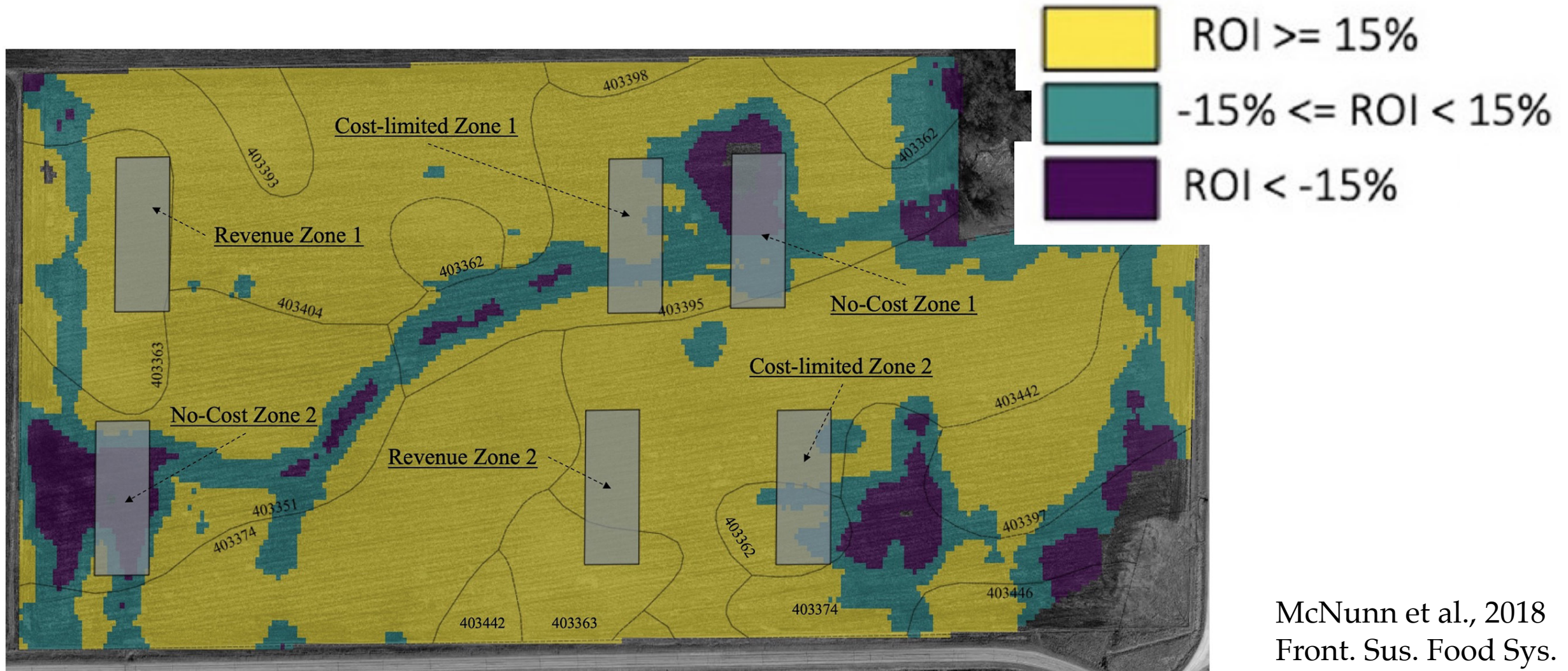




How to deal with increasing weather variability?

- A. Don't change practices: good years and bad years average out over time.
- B. Precision management, precision conservation:
 - Manage nutrients and crops at the sub-field scale
 - Consider taking the “money pits” out of production
- C. Engineer our way out of the problem: more drainage and irrigation!

Poorly drained field areas can have disproportionate economic impact

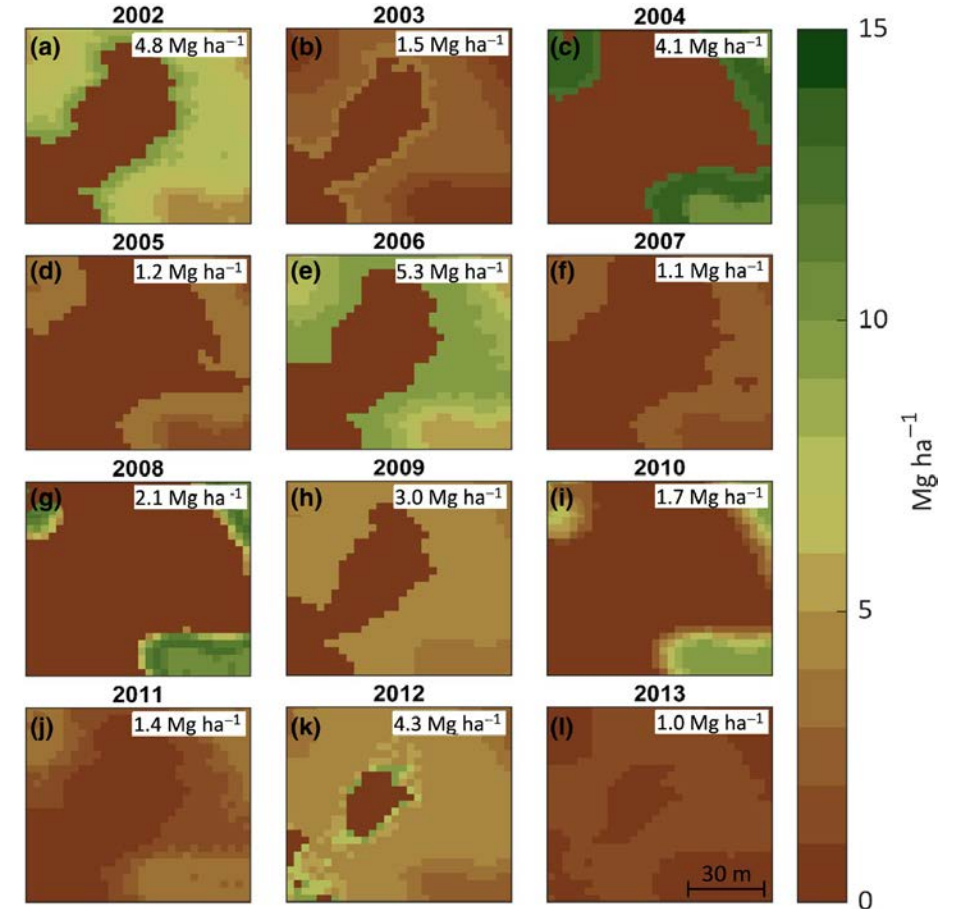


McNunn et al., 2018
Front. Sus. Food Sys.

Poorly drained field areas can have disproportionate economic impact



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- 10-year average loss of \$400 / ac / y!

Edmonds et al. 2021, GCB-Bioenergy

Poorly drained field areas can have disproportionate environmental impact



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- Lower living plant cover
- Lower nitrogen-use efficiency
- Greater nitrate leaching
- Greater soluble phosphorus leaching



Halle et al. 2023 JEQ, Lawrence and Hall 2024 JEQ, Lawrence et al. 2021 PNAS

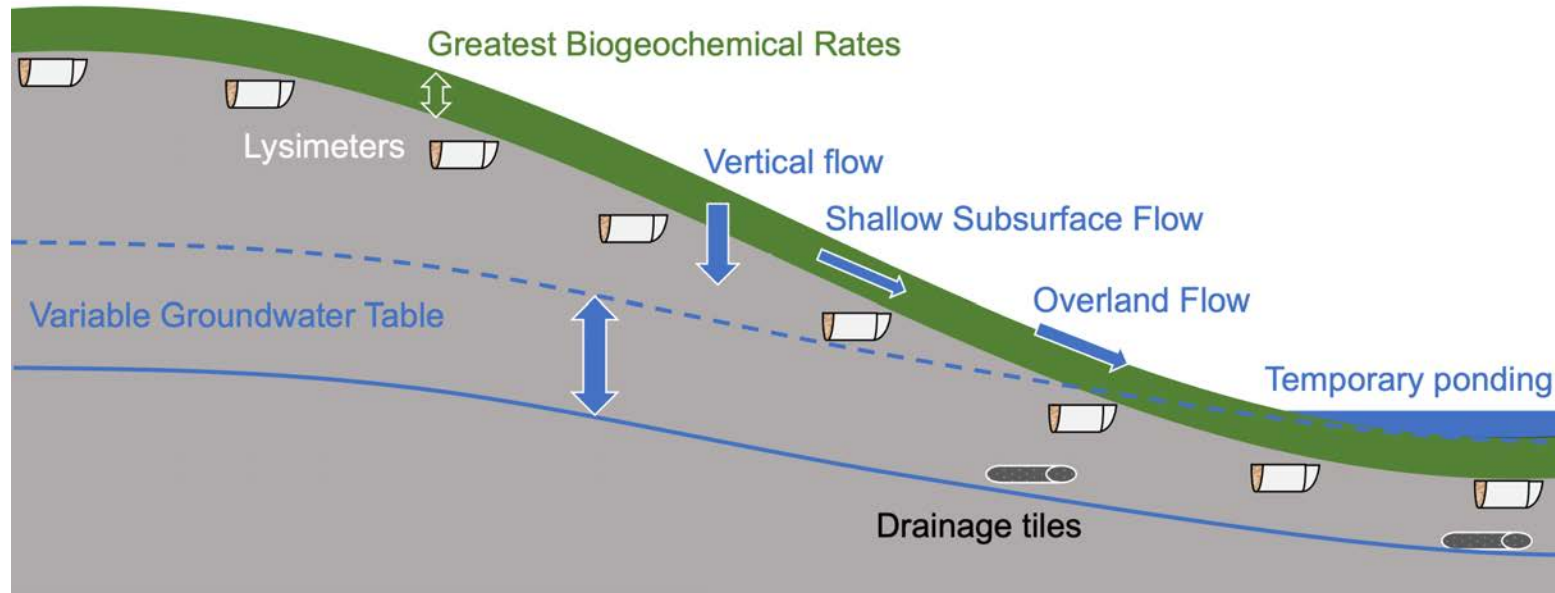
Poorly drained field areas can have disproportionate environmental impact

- Lower living plant cover
- Lower nitrogen-use efficiency
- Greater nitrate leaching
- Greater soluble phosphorus leaching
- Potentially greater erosion and particulate phosphorus loss
- Potentially greater greenhouse gas emissions

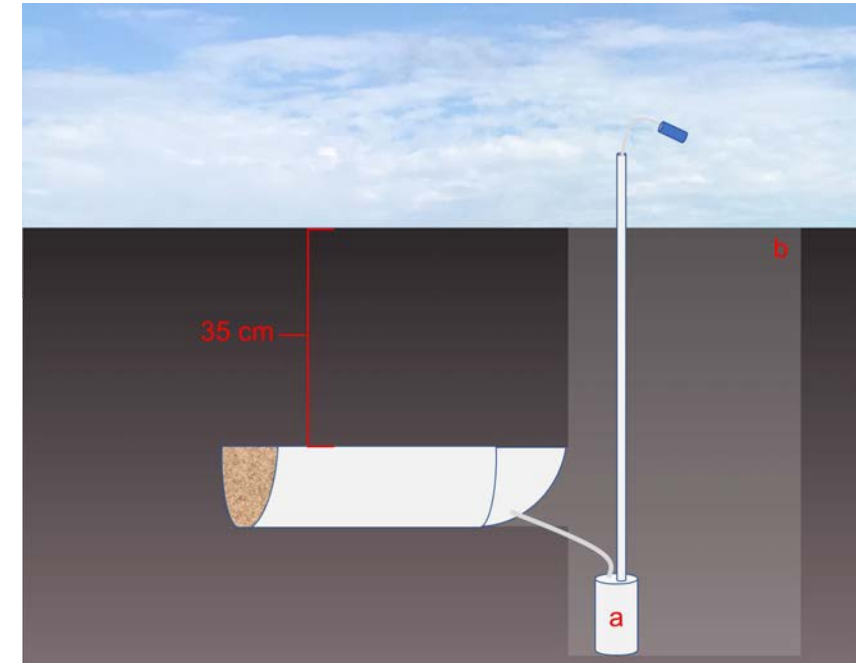
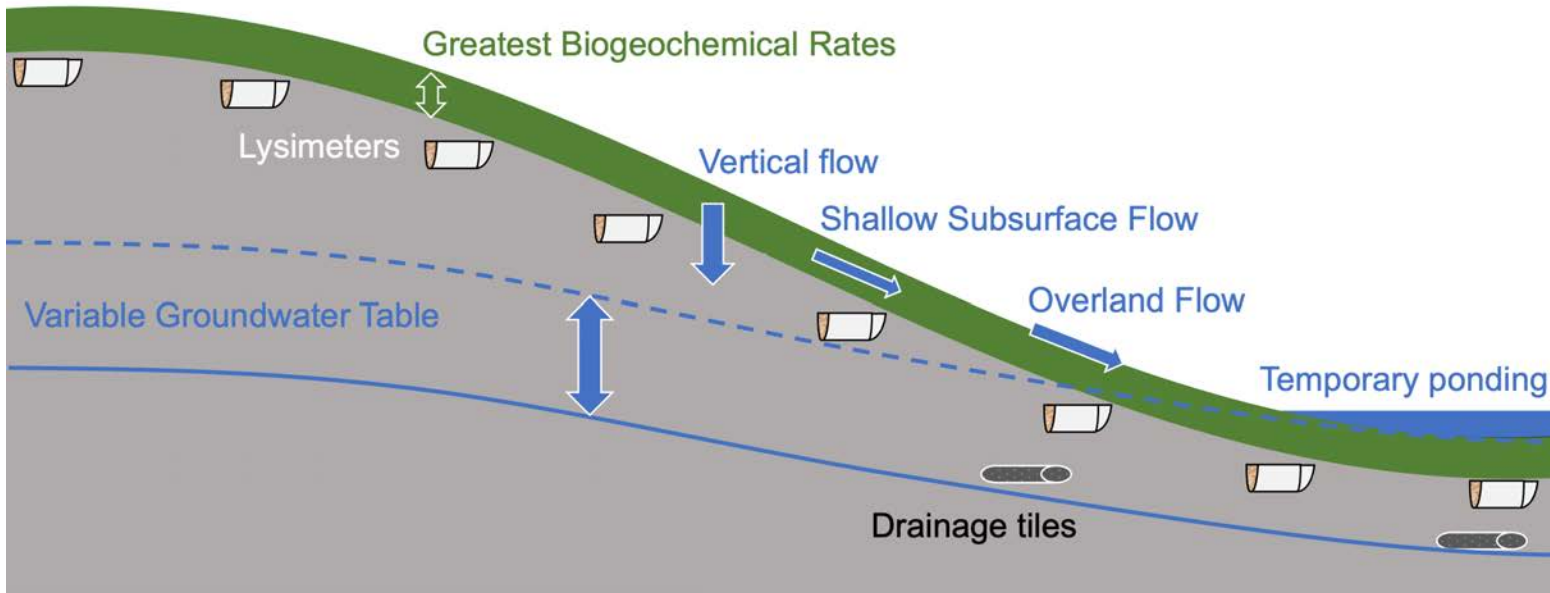


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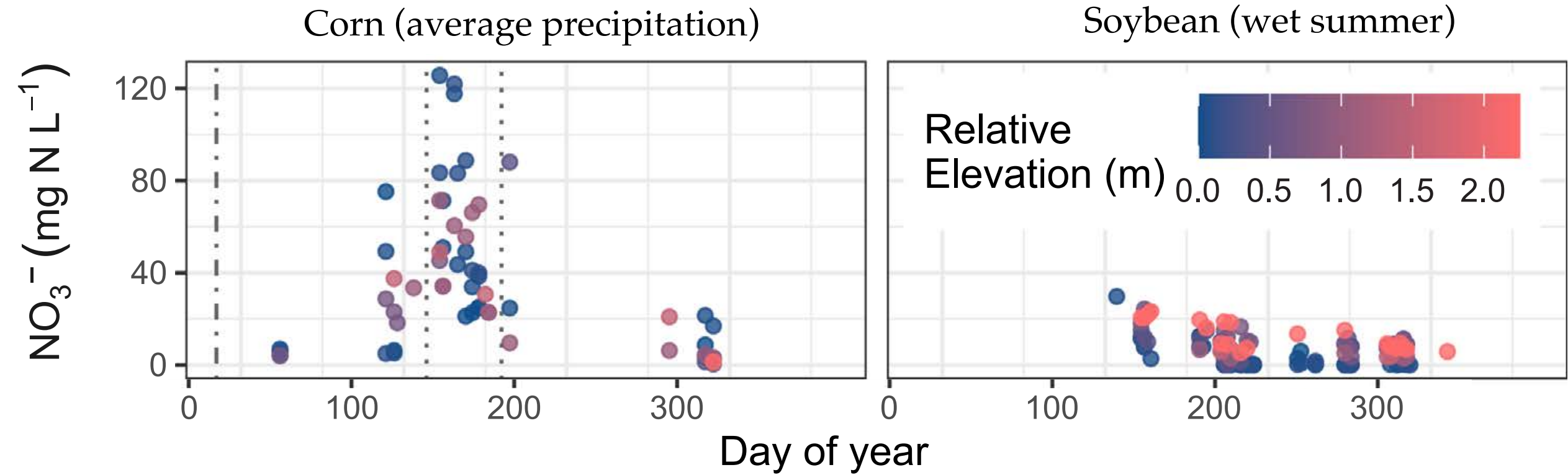
Approach: measure the chemistry of infiltrating water along a topographic gradient



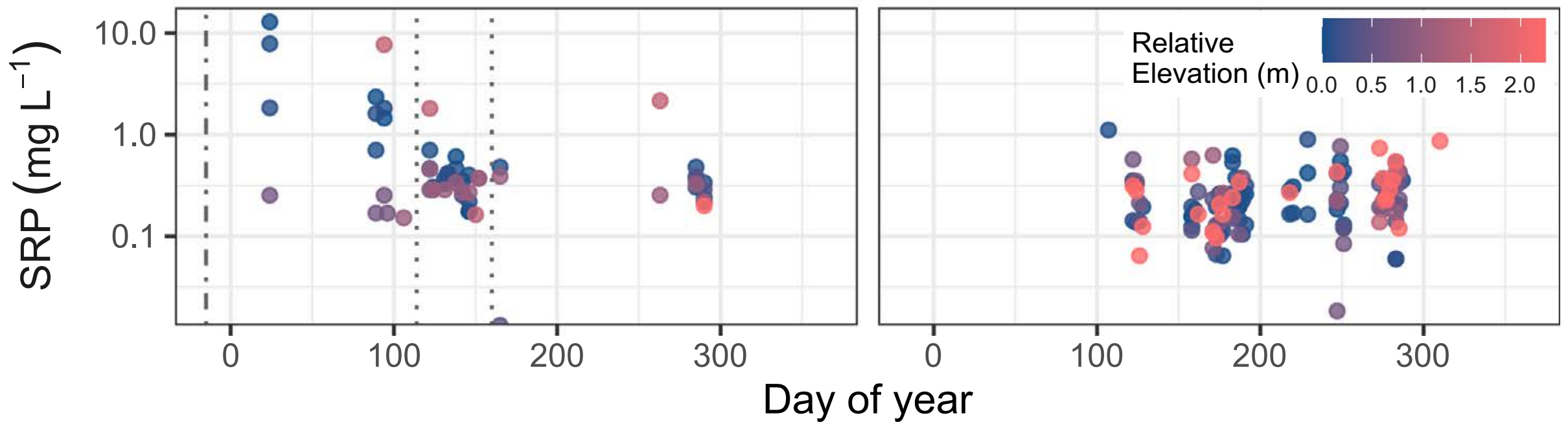
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Farmed depressions had the highest and lowest nitrate concentrations



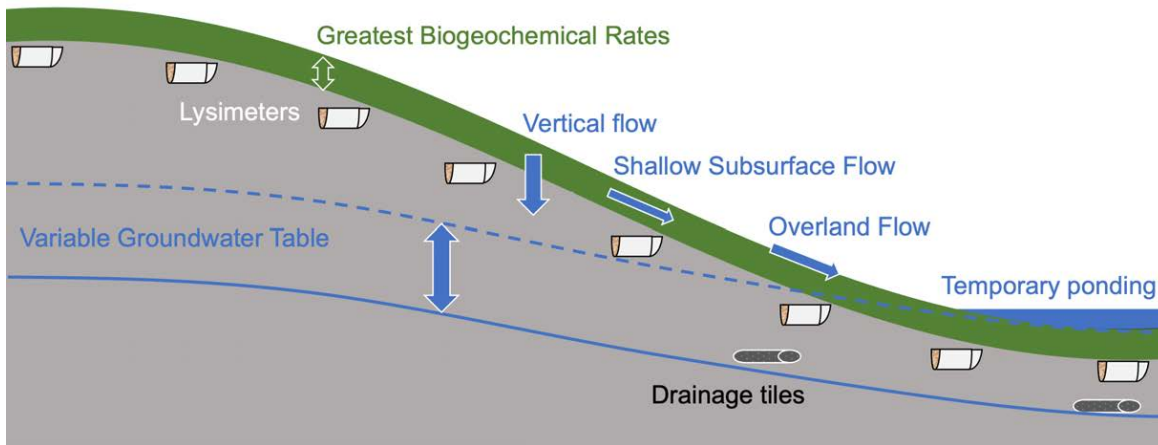
Farmed depressions had sporadically high soluble phosphorus concentrations



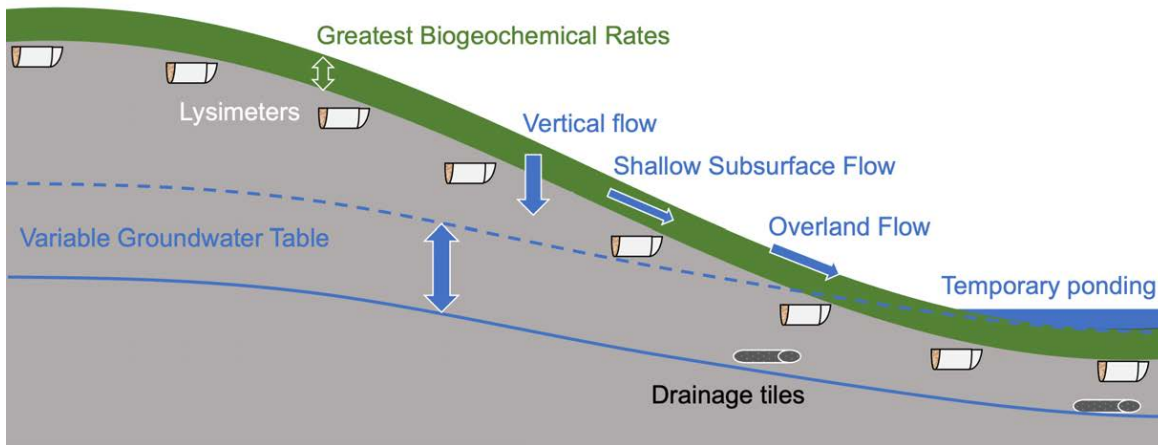
Nutrients don't always stay where we put them; they often move downslope!

Recommendations:

- Save money and improve water quality by decreasing N and P application to depressions and toeslopes



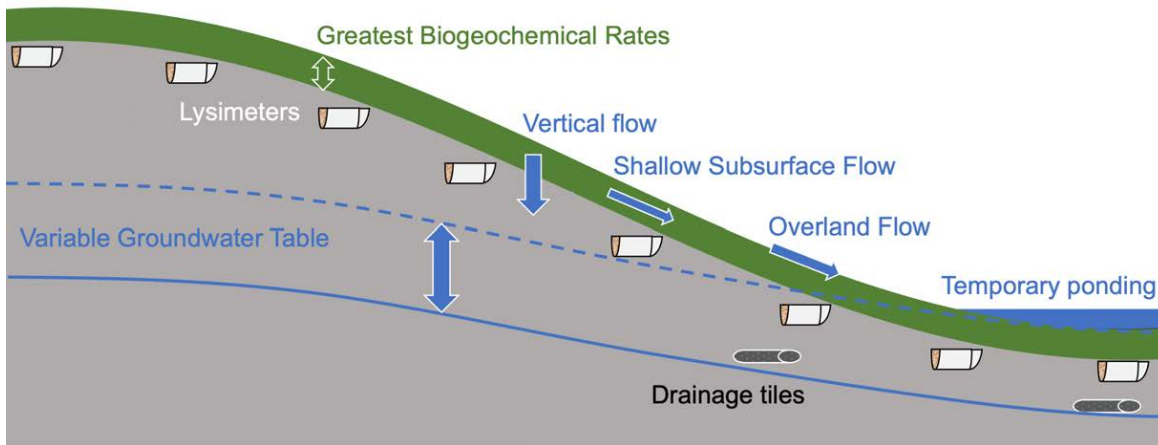
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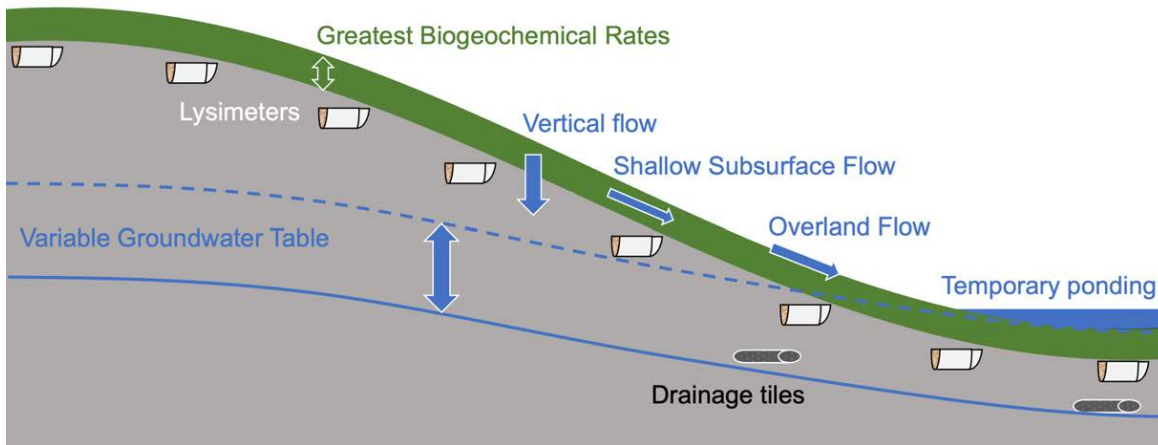
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- During “**normal**” years, nutrients are transported downslope
- During **wet** years, N is removed through denitrification
- During **dry** years, legacy nutrients and shallow groundwater may sustain plant growth

Precision conservation: taking the money pits out of production



Precision conservation: taking the money pits out of production



- Farm for profit, not for total yield
- Consider cost-share opportunities...

Precision conservation: taking the money pits out of production



State of Wisconsin

Department of Agriculture, Trade and Consumer Protection



Conservation Reserve Enhancement Program: Information for
Landowners

What land is eligible for CREP?



- Several cost-share programs focus on “wet spots”
- CREP is an especially generous one
 - Upfront payment, annual payment, and practice payment
 - Can be hundreds of \$ per acre per year
 - Contact your county land and water conservation office

Precision conservation: taking the money pits out of production

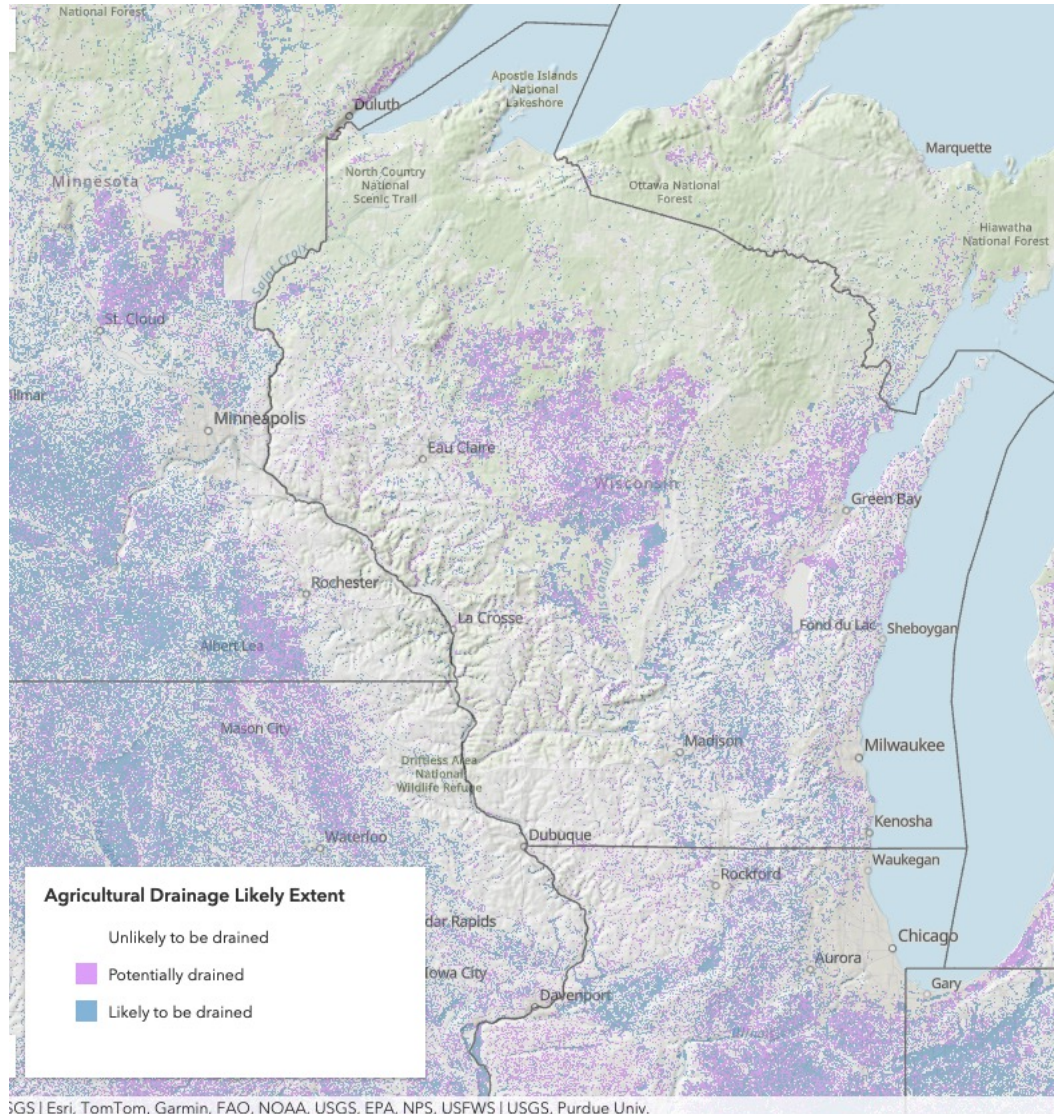
- In Wisconsin, Pheasants Forever provides a free precision conservation service: precision@pheasantsforever.com
- Evaluate sub-field profitability and cost-effective conservation opportunities



How to deal with increasing weather variability?

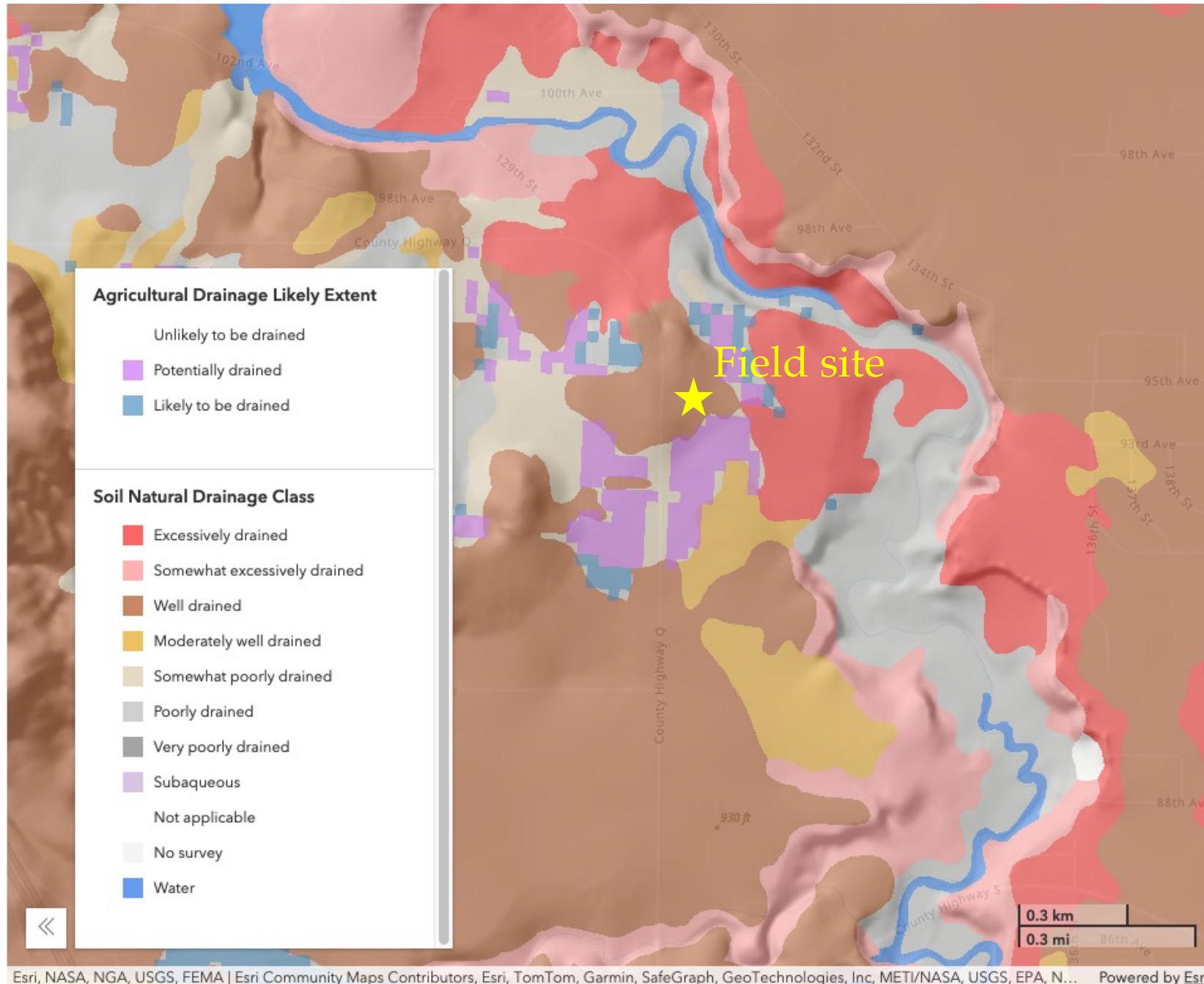
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Estimated extent of tile drainage in WI



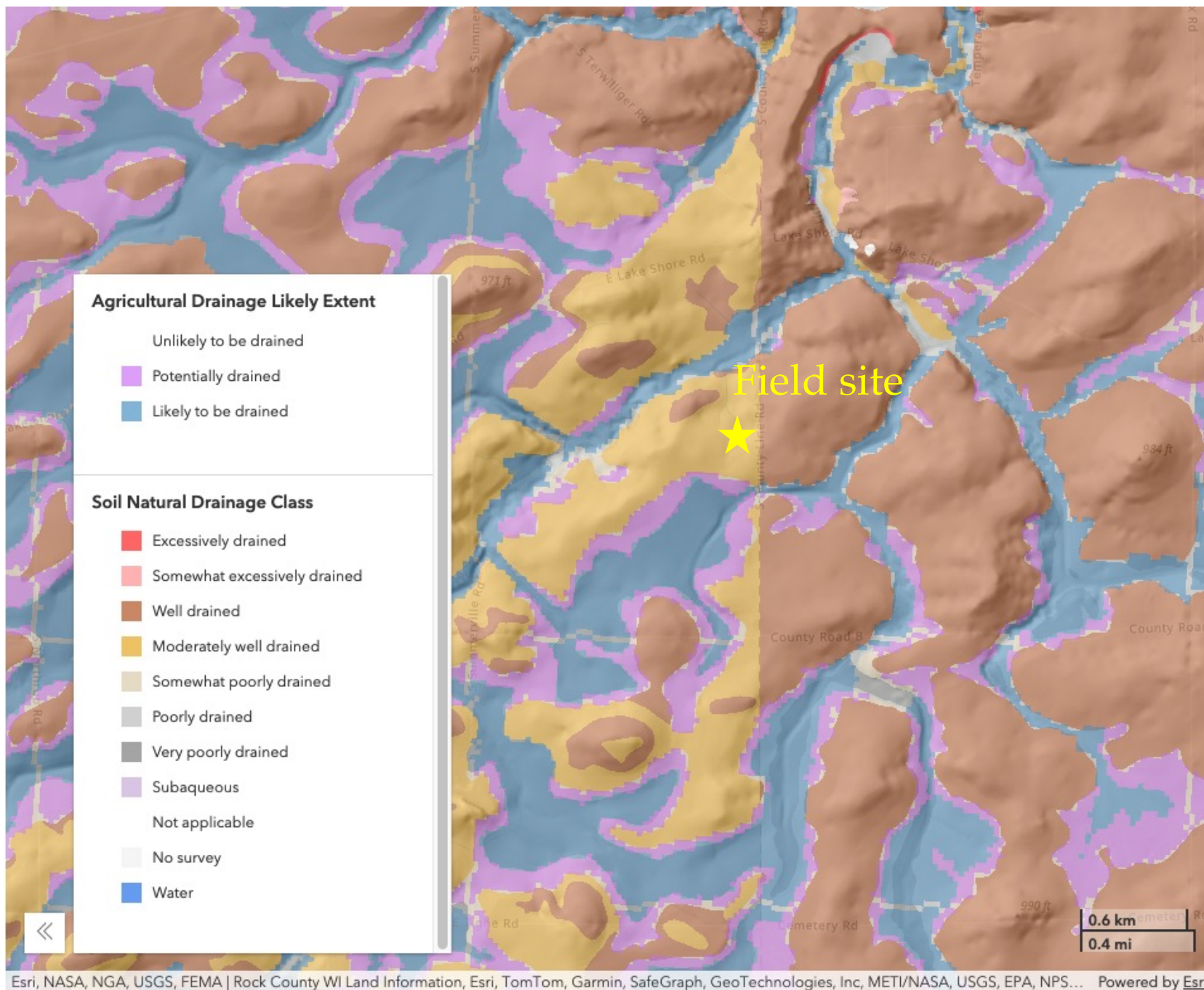
- Useful tool from Purdue University:
 - Frankenberger, J., Reinhart, B., Hancock, B. (2022). Likely Extent of Agricultural Drainage in the U.S. Midwest. Transforming Drainage Tools, <https://transformingdrainage.org/tools>.
- Uses soil drainage class to estimate likelihood of drainage
- Percent of WI agricultural land *likely to be drained*: **10.5%**
- Percent of WI agricultural land *likely/potentially drained*: **25.7%**
- As with any tool, caution is needed...

Tile drainage is more common in WI than often assumed



- The yellow star shows a field site on soils mapped as “well-drained”
- Yet, there is a tile running through the middle of the site, and a shallow groundwater table

Tile drainage is more common in WI than often assumed



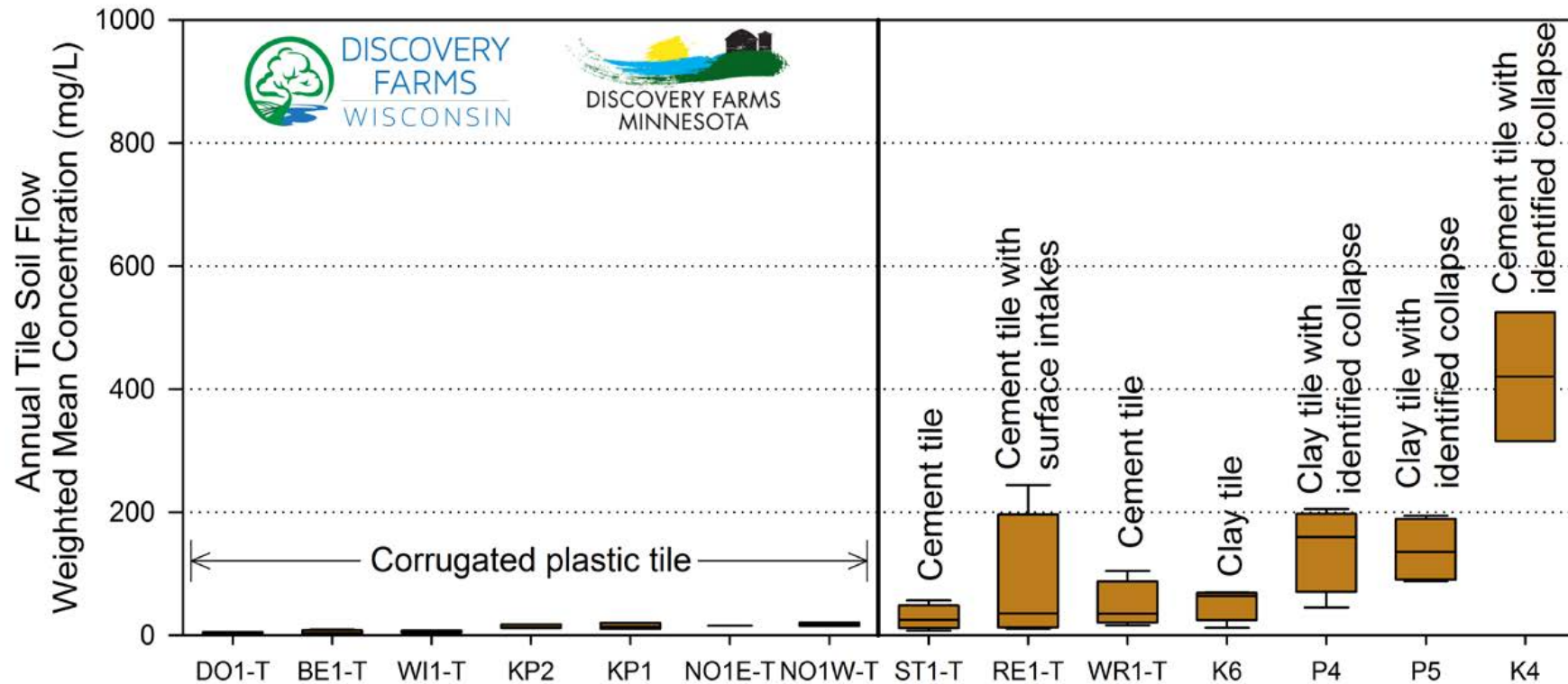
- The yellow star shows a field site on soils mapped as “well-drained”
- Yet, there is a tile in this field...

Our tile systems are often many decades old and need renovation



- Clay tile discovered during tile replacement...
- Photo credits: Jane Frankenberger, Chris Hay

Our tile systems are often many decades old and need renovation



- Replacing clay or cement tile with modern corrugated plastic tile can decrease phosphorus losses while improving water removal

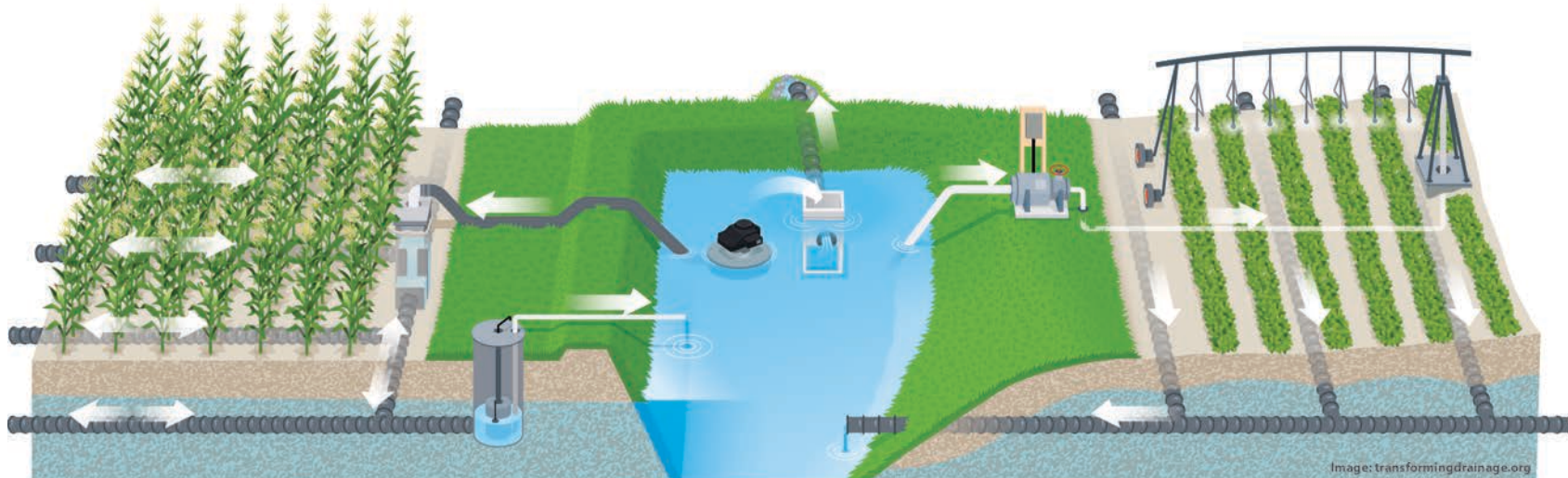
Drainage modernization can improve environmental and agronomic performance



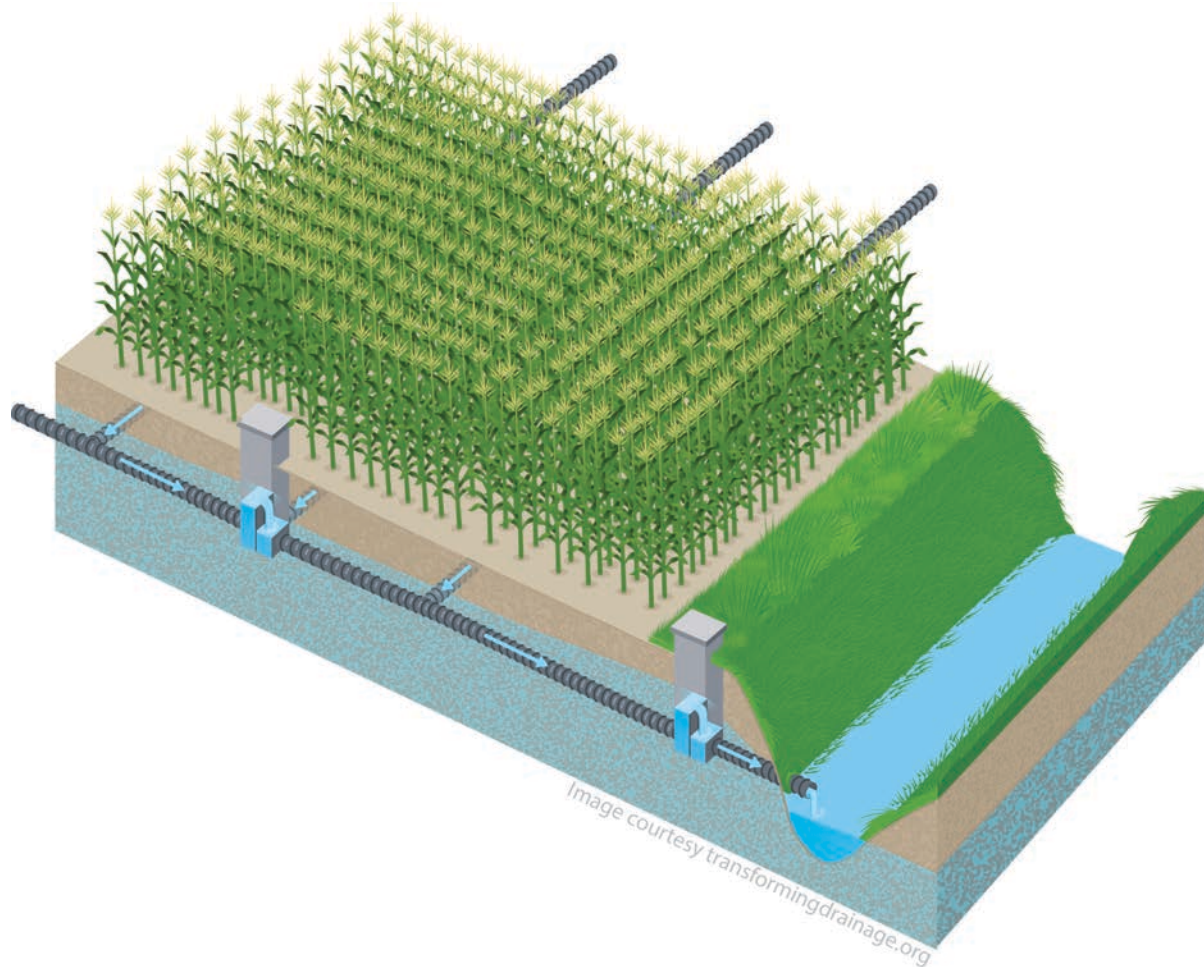
- *Conservation drainage* includes a range of in-field and edge-of-field infrastructure and practices

Conservation drainage practices include...

- Drainage water management
- Woodchip bioreactor (a.k.a. denitrifying bioreactor)
- Saturated buffer
- Blind inlet and / or P trap
- Water quality wetland
- Drainage water recycling



Drainage water management (controlled drainage)



- Install control structure(s) with movable weirs
- Hold water back after the crop is established
- Capture the benefits of drainage with less risk of moisture stress later in the season

Drainage water management (controlled drainage)

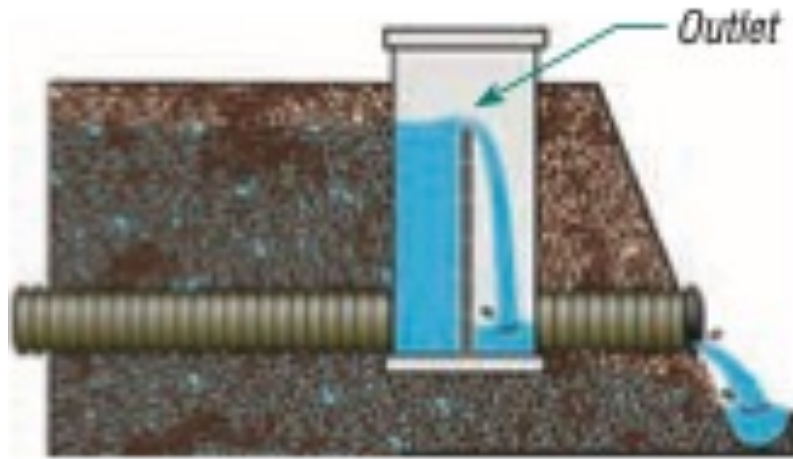


Figure 1. The outlet is raised after harvest to reduce nitrate delivery.

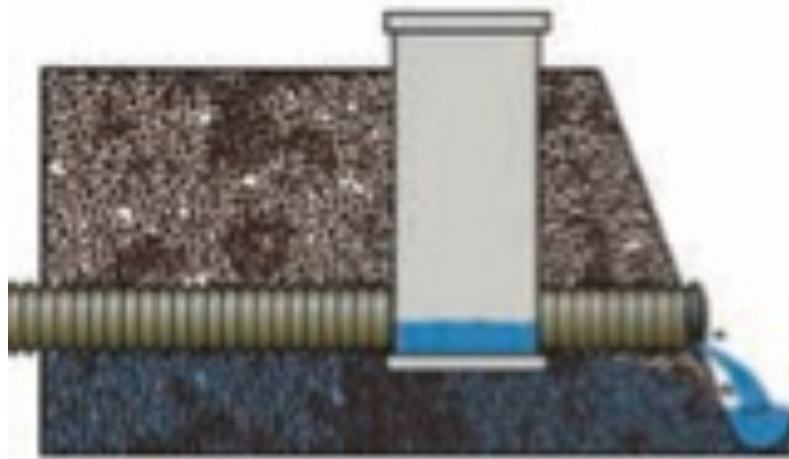
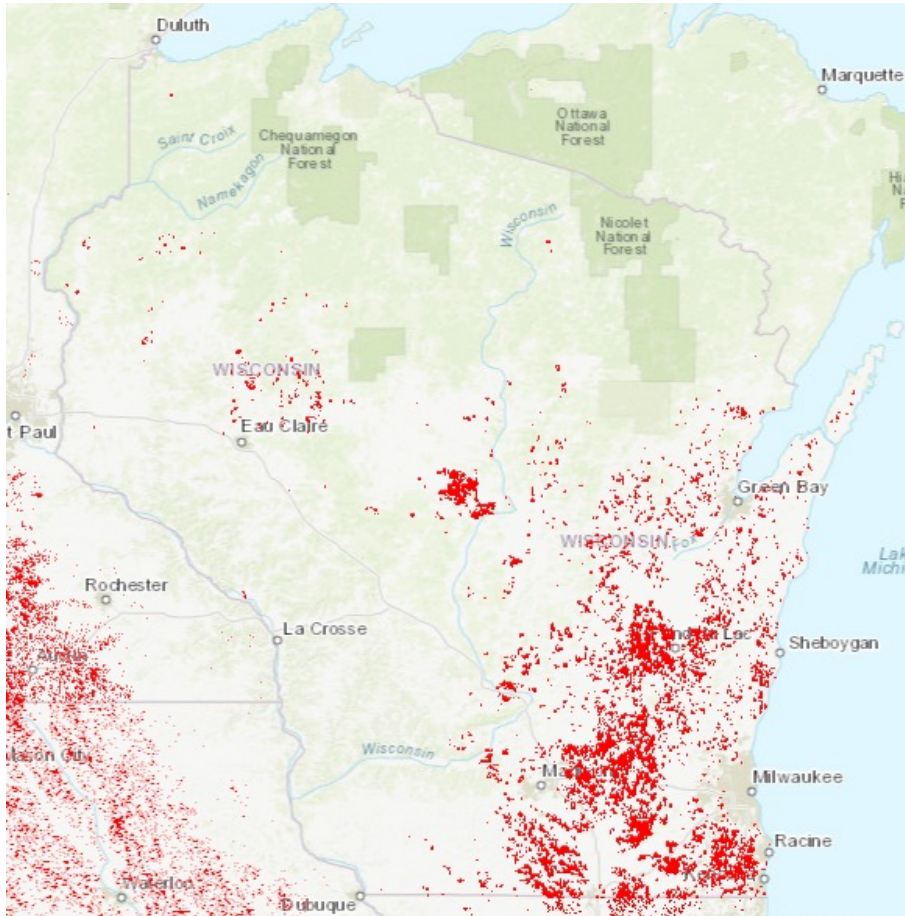


Figure 2. The outlet is lowered a few weeks before planting and harvest to allow the field to drain more fully.



Figure 3. The outlet is raised after planting to potentially store water for crops.

Drainage water management (controlled drainage)



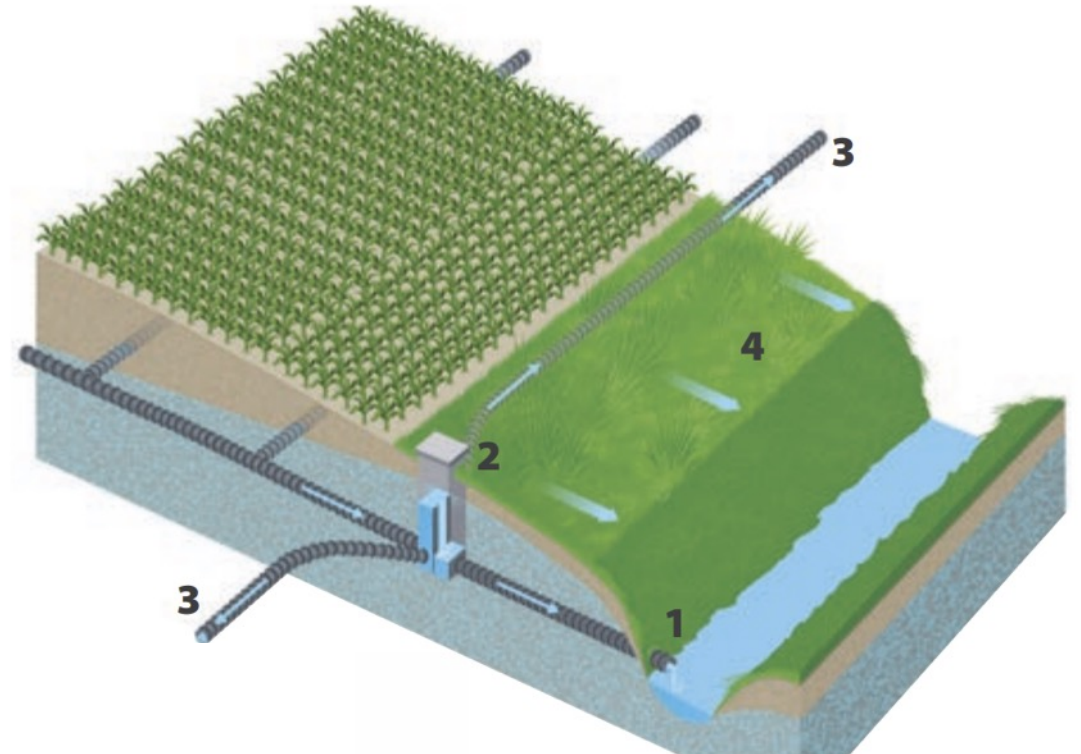
- Constraints: need a relatively level field (~0.5% slope is best)
- Nevertheless, this practice could be implemented in many areas of WI
- Can potentially benefit crop yields during dry years
- Decreases nitrate losses to downstream waters

Red areas: suitable for controlled drainage, according to Purdue's site suitability tool

Key risk of tile drainage: Increased nitrate and soluble P losses



Saturated riparian buffer



- Divert tile drainage through a buffer planted with perennial vegetation
- Removes almost all the diverted nitrate!



Controlled drainage can be readily combined with a saturated buffer

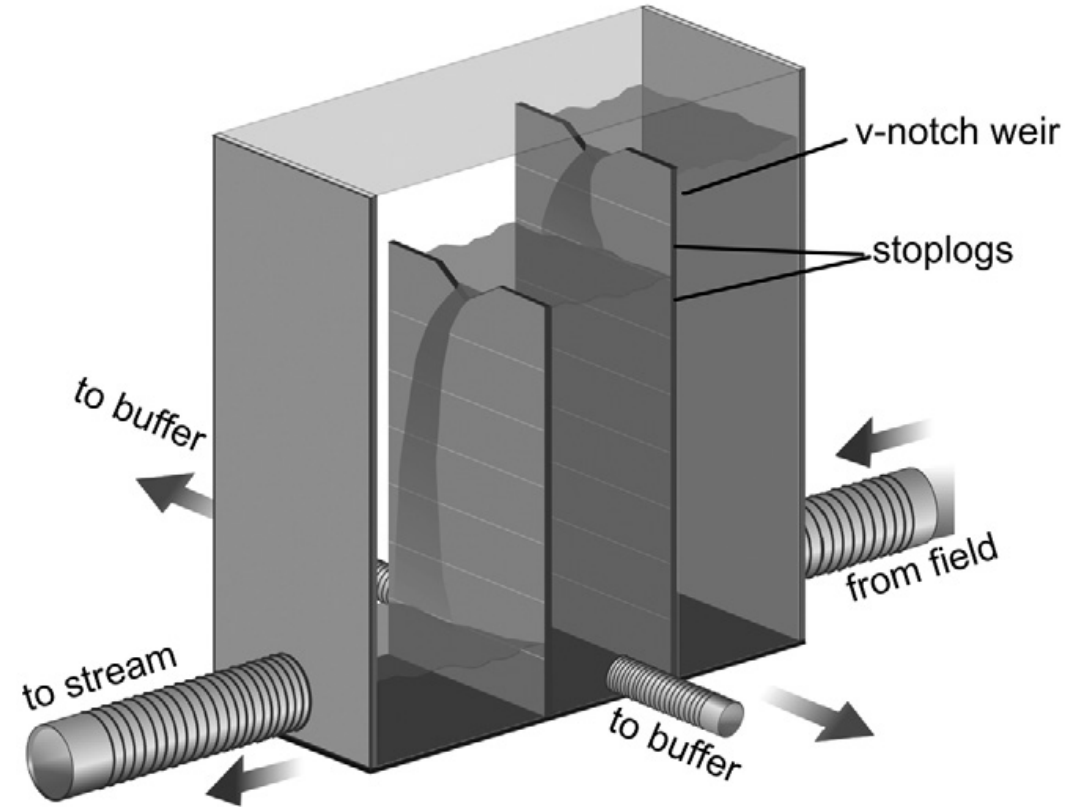
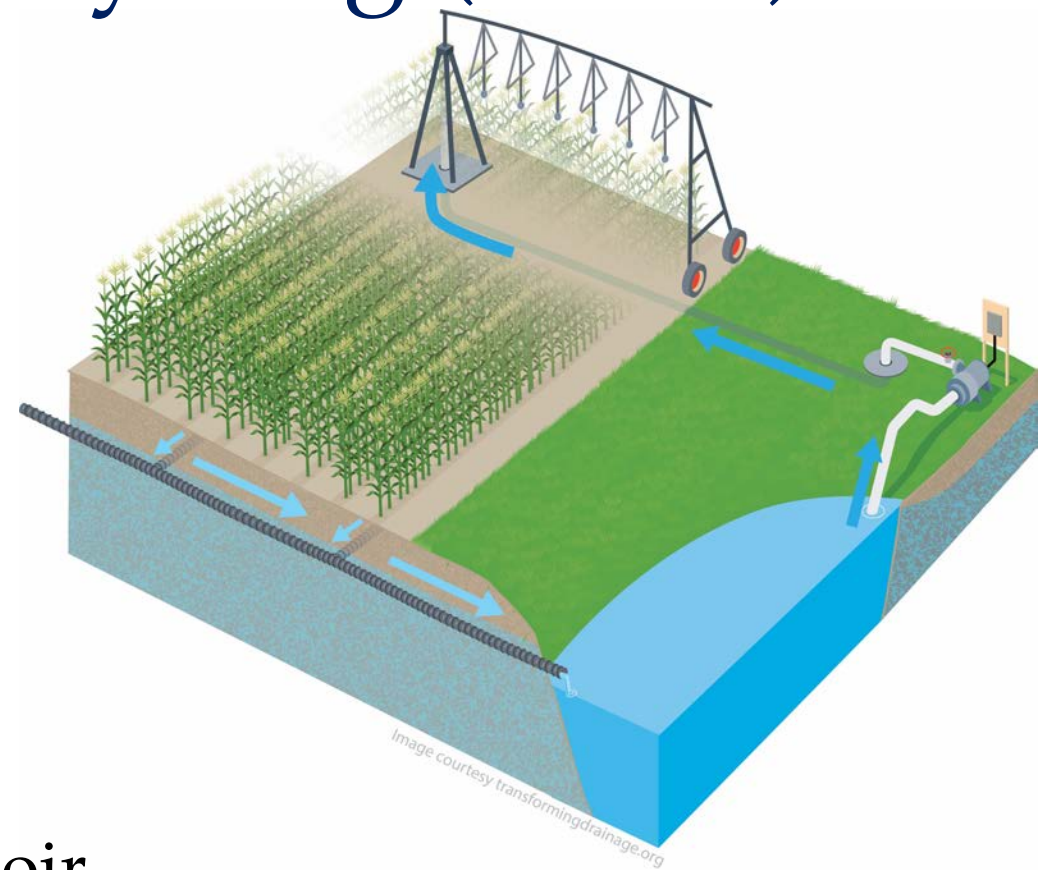
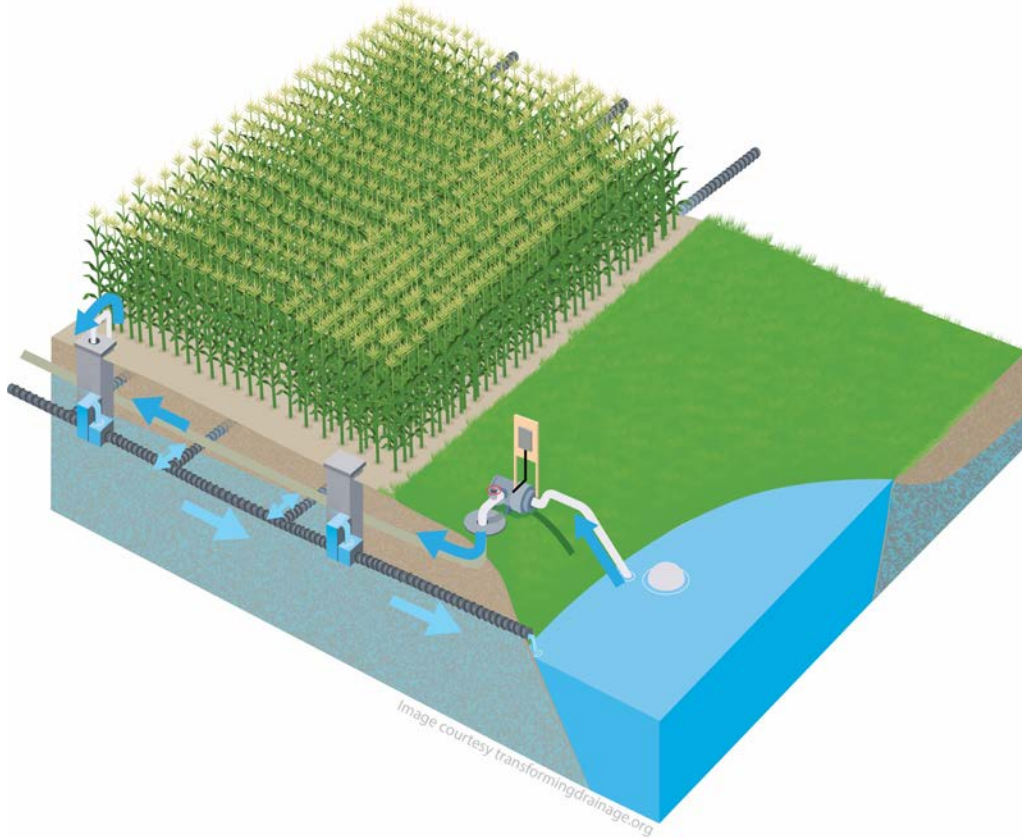


Fig. 2. Schematic of the control box used to redirect tile flow showing the three chambers separated by two sets of stoplogs, each topped with a v-notch weir (not drawn to scale).

Jaynes and Isenhardt 2014,
JEQ

Drainage water recycling (DWR)



- Capture drainage water in a reservoir
- Use the water for irrigation during periods of water stress
- Average corn yield increase of 19 bu/ ac across Midwest.
(Willison et al. 2021 Ag. J)

Drainage water recycling (DWR)

- **Downside:**

- Need to take land out of production to construct a reservoir
- Large up-front costs

- **Upsides:**

- Can pay back the investment in less than 10 years with increased yields (Dean Lemke, personal communication)
- Can achieve benefits of drainage in basins without an outlet
- Wisconsin has already been doing DWR for many decades in one key industry...

Blind inlet



Images: Ehsan Ghane,
MSU

- Replace slotted surface inlet (Hickenbottom riser) with perforated pipe buried underneath gravel
- Can improve drainage in depressional areas
- Improves water quality by decreasing sediment and phosphorus loss through tile
- Can be combined with other materials (woodchips and steel slag) to remove additional N and P

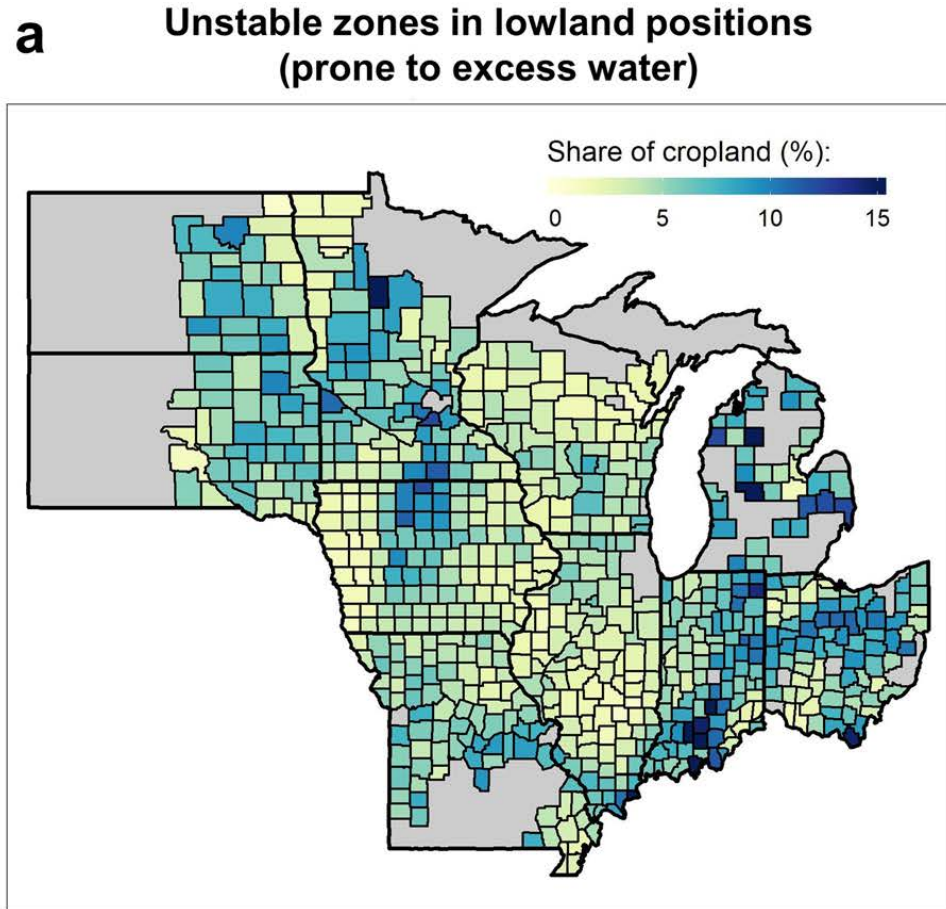
Take-home points

- Our cropping systems need to withstand very wet and very dry conditions within the same season
- A combination of sub-field management, precision conservation, and conservation drainage can help us deal with these “new normal” conditions
- Feel free to contact me: **steven.hall@wisc.edu**

But I thought wetlands were effective at removing and retaining nutrients?



Prevalence of wet and droughty field zones across the Midwest



Prevalence of wet and droughty field zones across the Midwest

