Tile Drainage and Nutrient Loss: Are We Losing Fertilizer Down the Drain?

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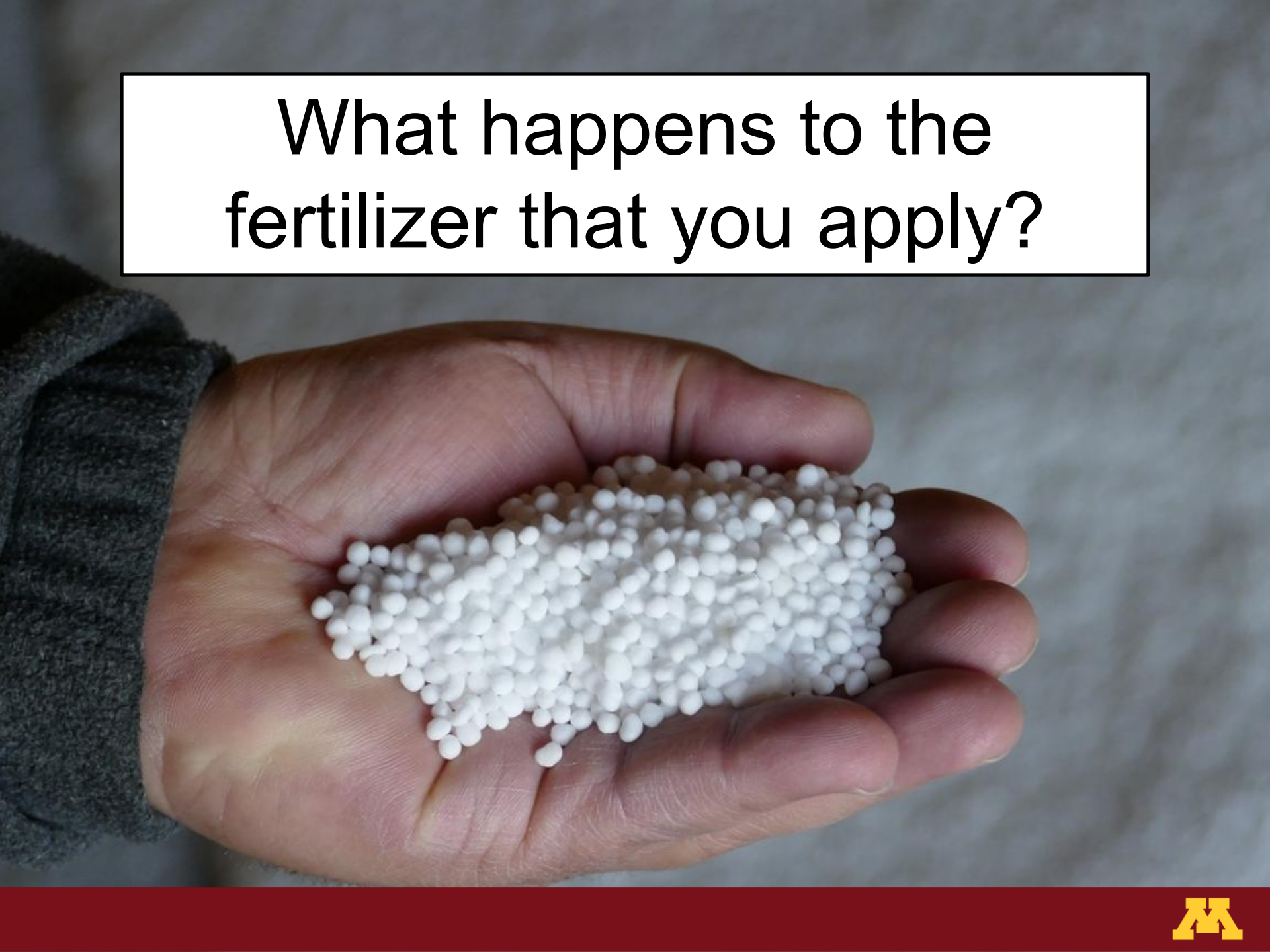
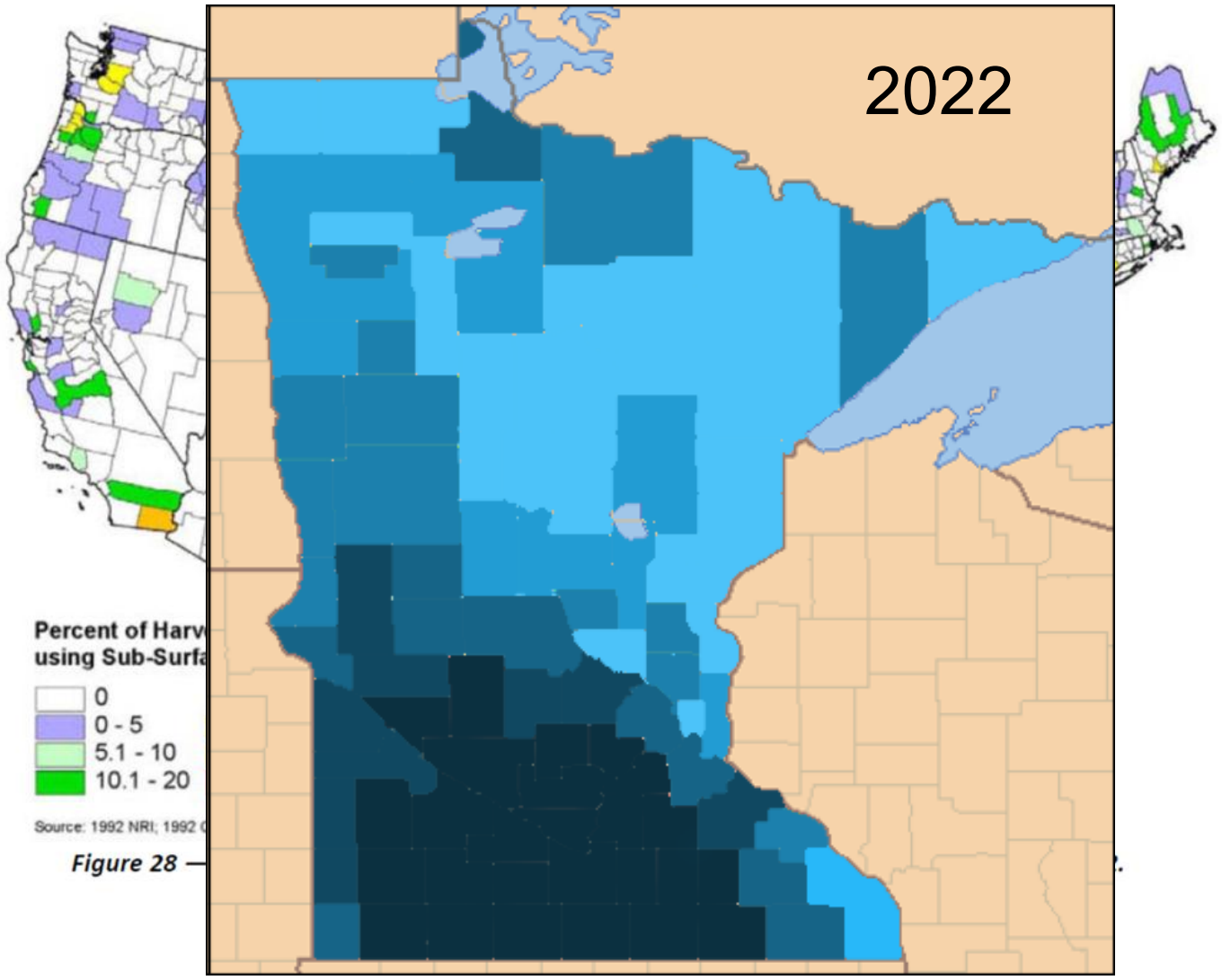
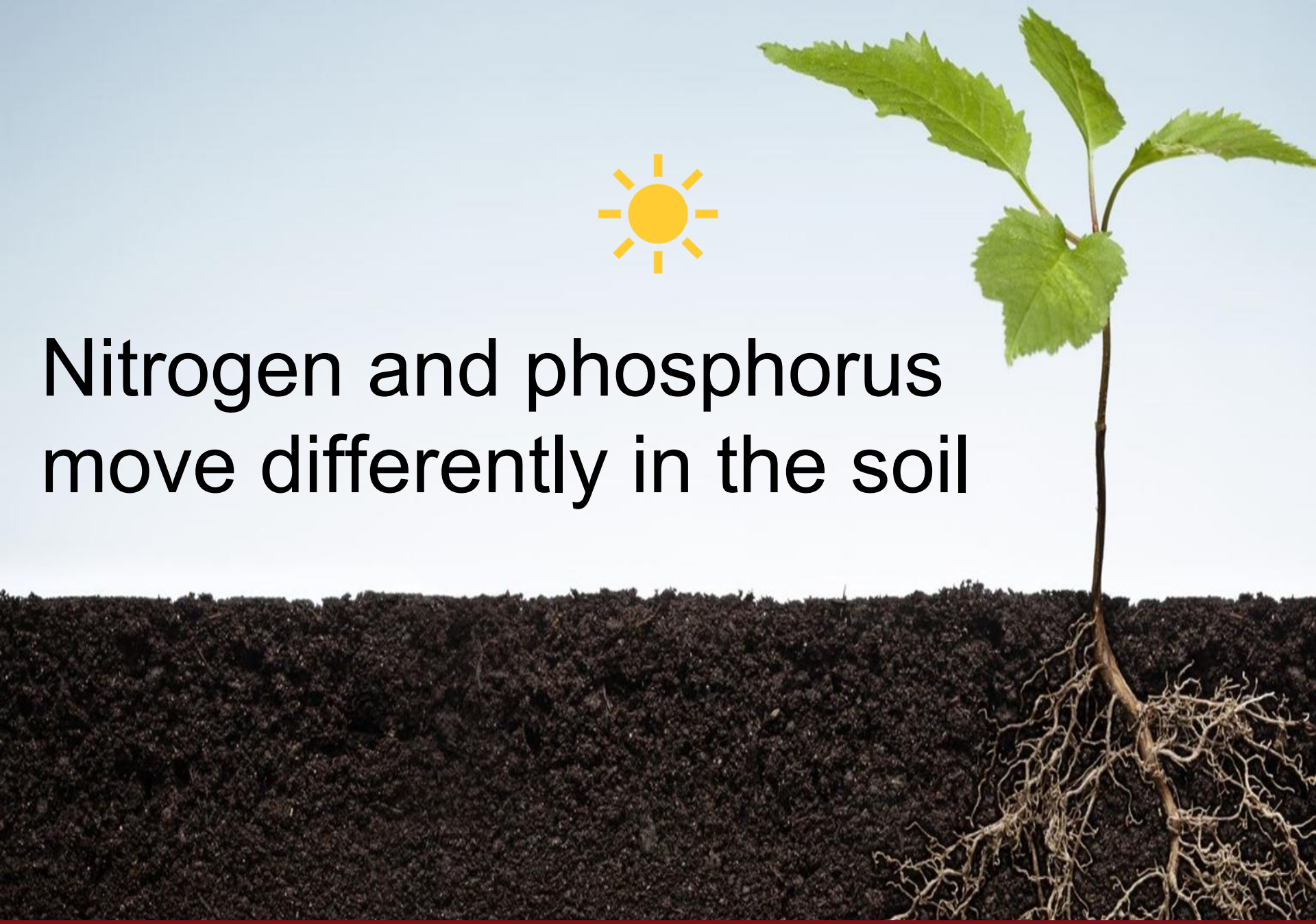
What happens to the fertilizer that you apply?



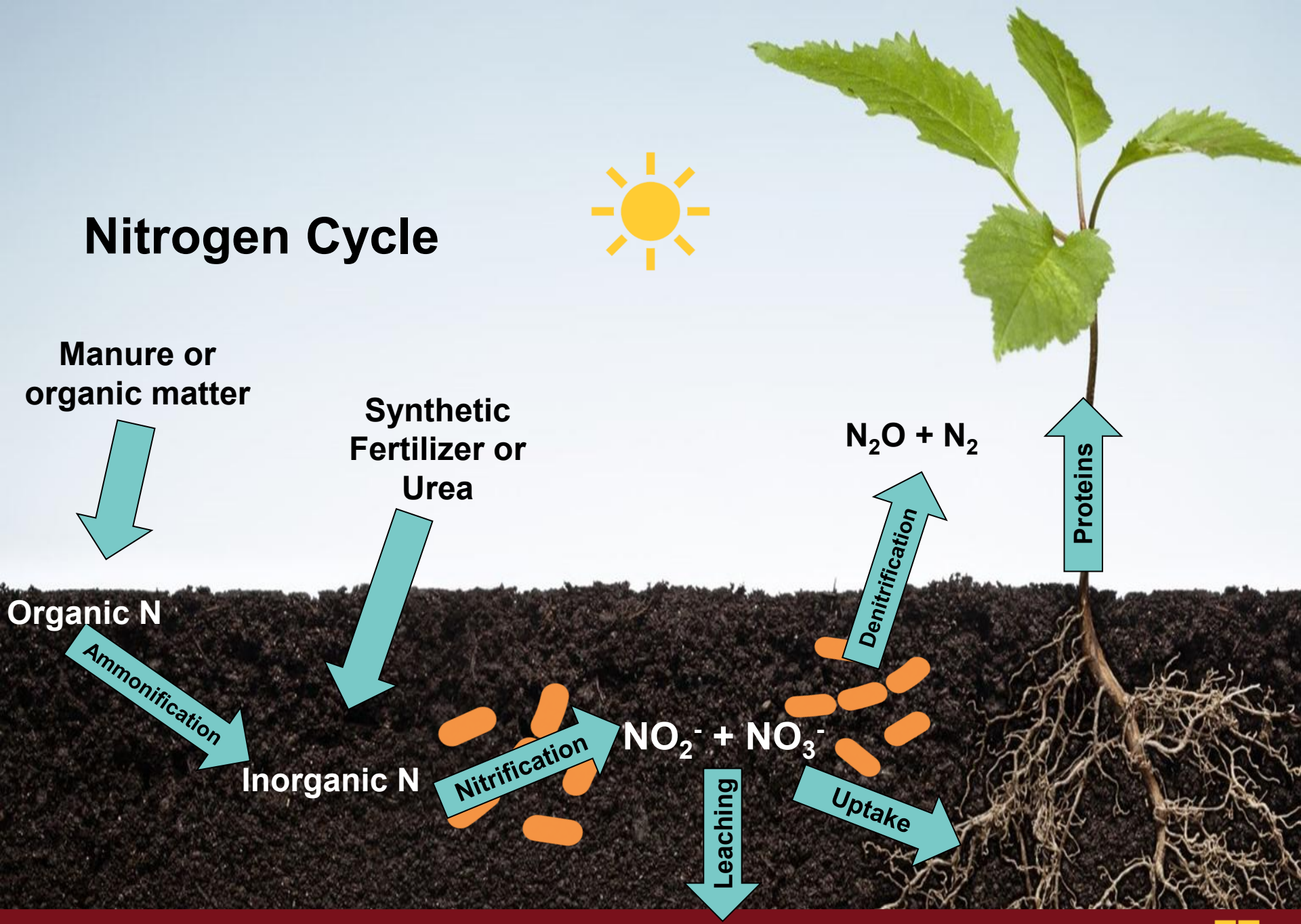

DITCH DOCTOR
DRAIN TILE SYSTEMS 218-201-8068

Minnesota farmers are installing tile





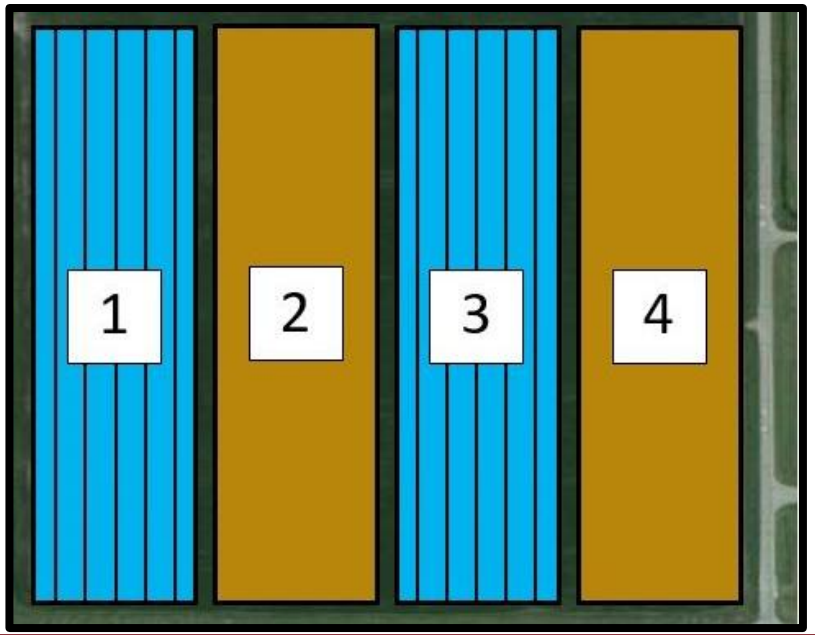
Nitrogen and phosphorus move differently in the soil


Nitrogen Cycle
Manure or organic matter
Synthetic Fertilizer or Urea
Organic N
Ammonification
Inorganic N
Nitrification
NO_2^- + NO_3^-
Leaching
Uptake
Denitrification
N_2O + N_2
Proteins

Measuring on-farm nitrogen cycling: Minnesota's Coolest Drainage Plots

Minnesota's Coolest Drainage Plots

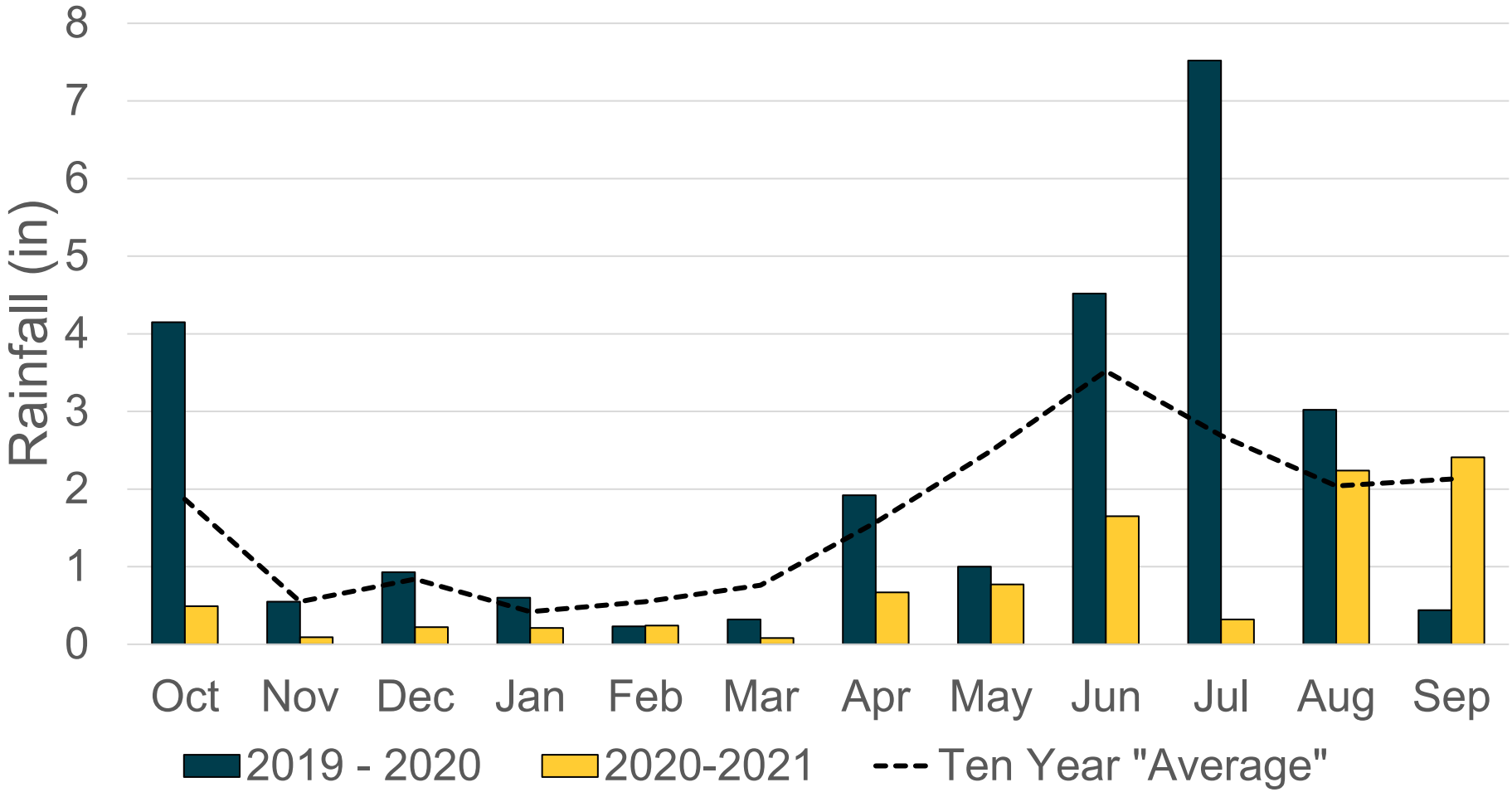
- Four large (15 ac) plots
- Tile installed 3 feet deep and 50 feet apart
- Silty clay loam soil
- Farmed as one unit
- Wheat-Soybean rotation with sugarbeets in 2024, back to wheat in 2025



Minnesota's Coolest Drainage Plots

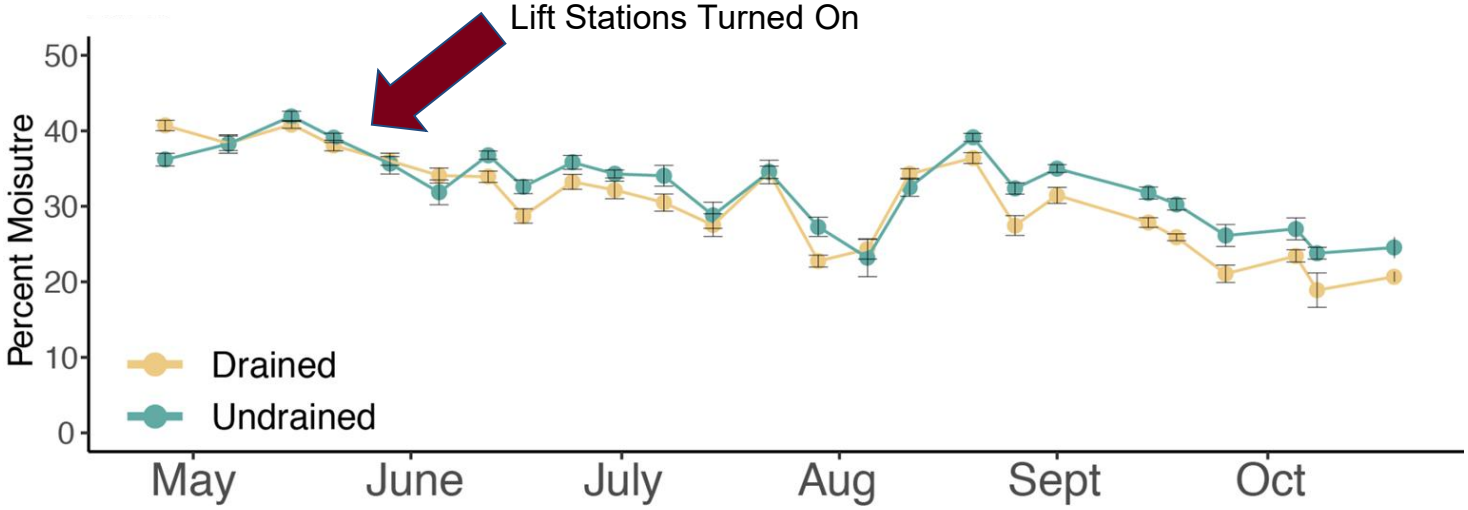
- Research
  - Measure surface runoff, tile discharge, and nutrient concentrations
  - Multiple large plots
  - Farmed commercially on station
- Outreach
  - Highly visible, easily accessible location
  - Place for discussion with growers AND the public

Two extreme years: 2020 and 2021

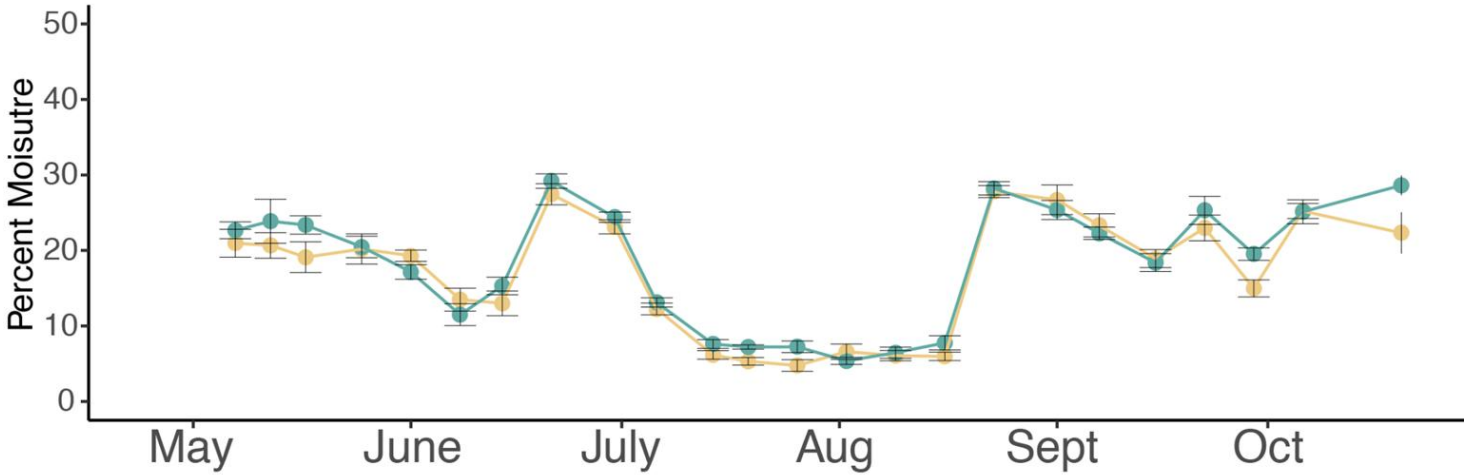


Soil Moisture

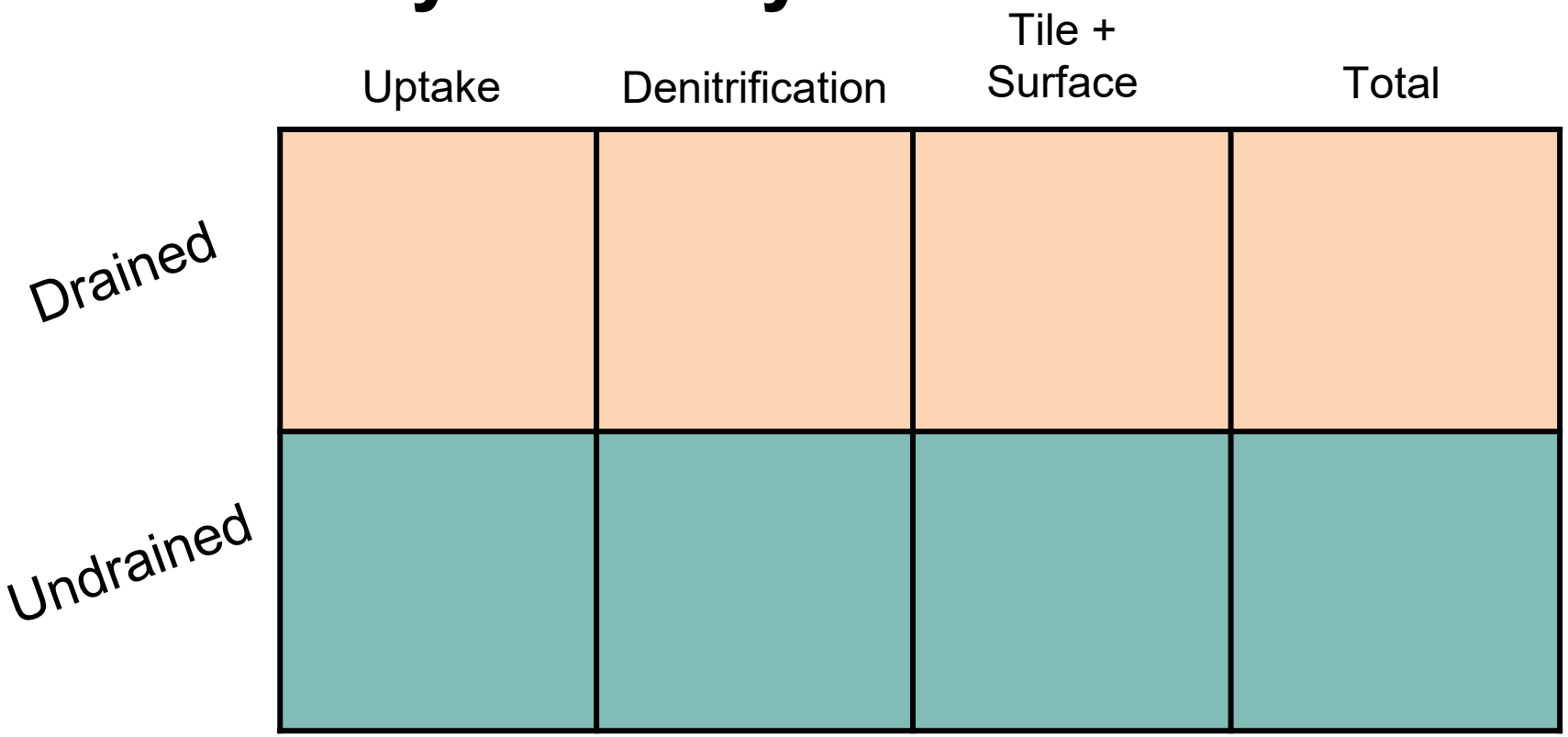
2020



2021



N Losses by Pathway



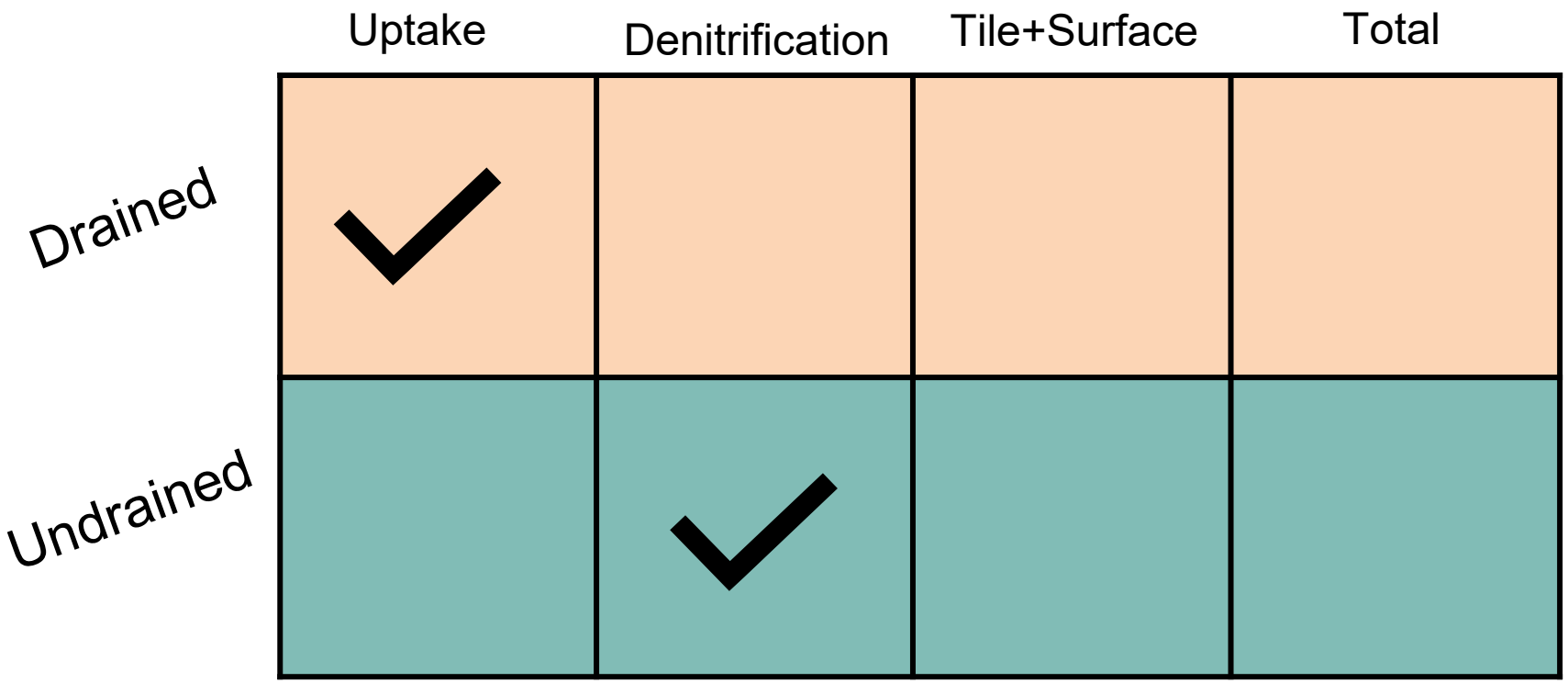
Soybean and Wheat Yields (bu/ac)

	2020	2021
	Soybeans	**Wheat**
Drained	40	54
Undrained	34	58

N uptake (lb/ac) estimated from yields

	2020	2021	Total
	Soybeans	**Wheat**	
Drained	129.3	65.7	195.0
Undrained	108.3	72.0	180.3

N Losses by Pathway



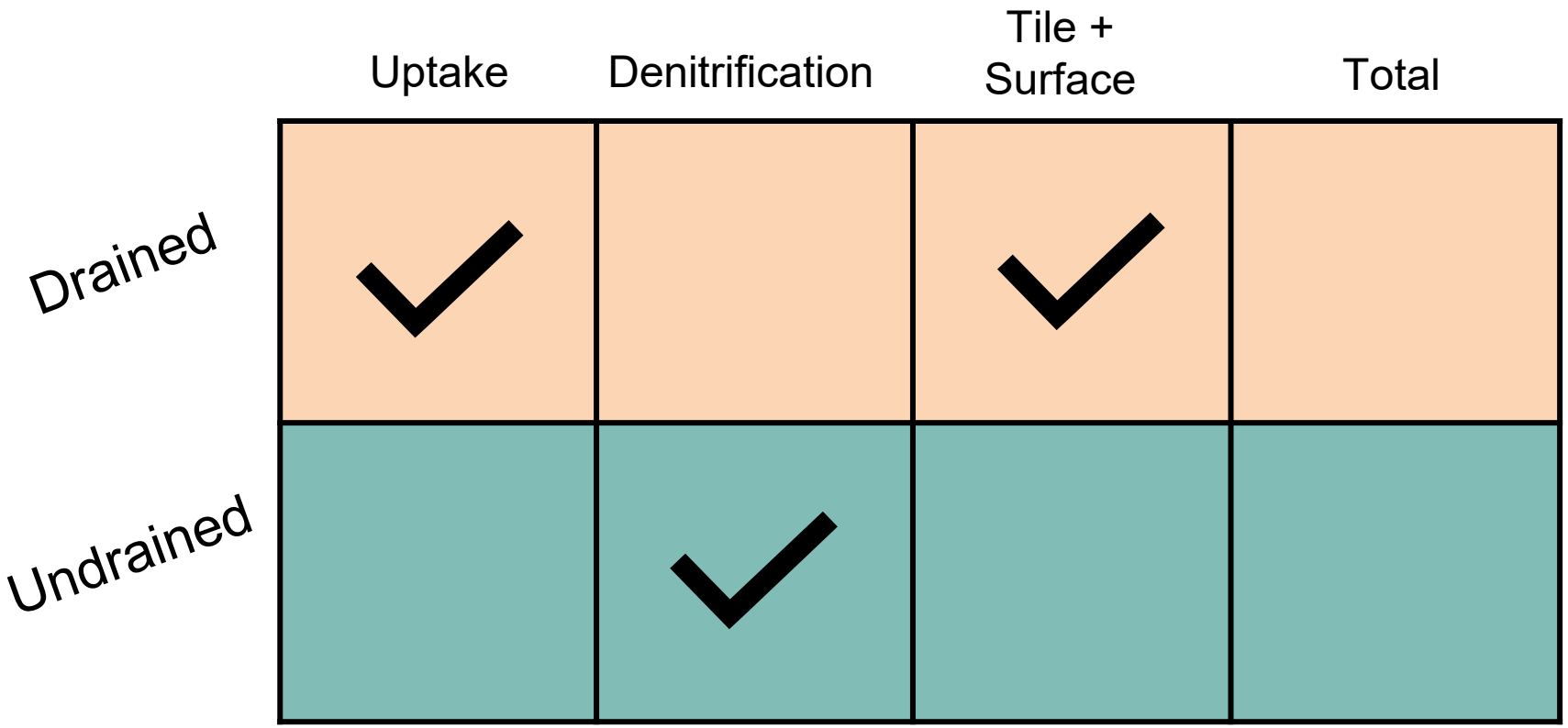

ELLINGSON
ELLINGSON

N loss in tile discharge and runoff (lb/ac)

Note: 170 lb N/ac applied in wheat years

	2020	2021	Total (% of applied)
	Soybeans	**Wheat**	
Drained	0.7	0	0.7 (<1%)
Undrained	0	0	0 (0%)

N Losses across 2 Extreme Years



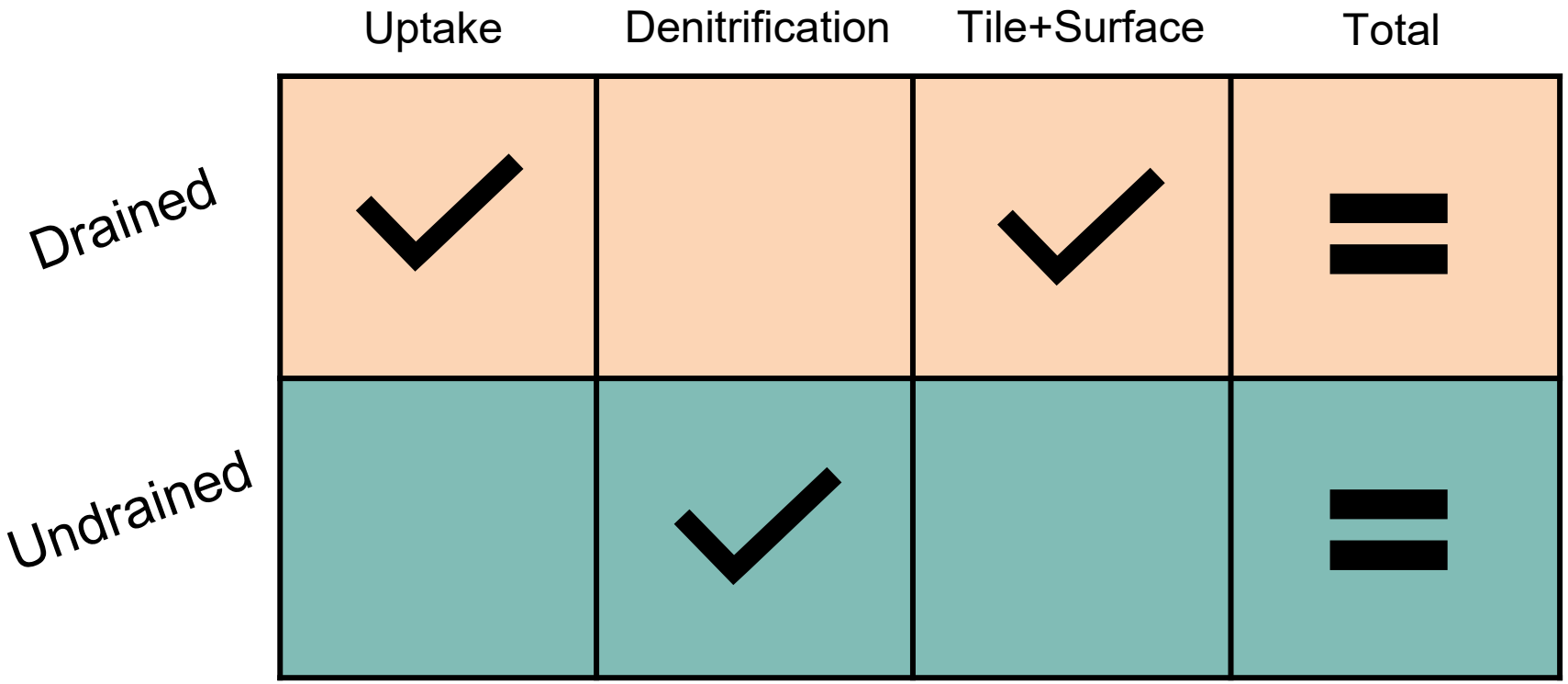
Wet July (2020): Drained > Undrained

	Denitrification	Uptake	Surface+Tile	Total Loss
Drained	4	120	1	**125 lb ac^{-1}**
Undrained	5	108	0	**113 lb ac^{-1}**

Extreme drought: Drained < Undrained

	Denitrification	Uptake	Tile+Surface	Total
Drained	5	71	0	**76 lb ac^{-1}**
Undrained	6	80	0	**86 lb ac^{-1}**

N Losses across 2 Extreme Years



Two-Year Average (lb N/ac):

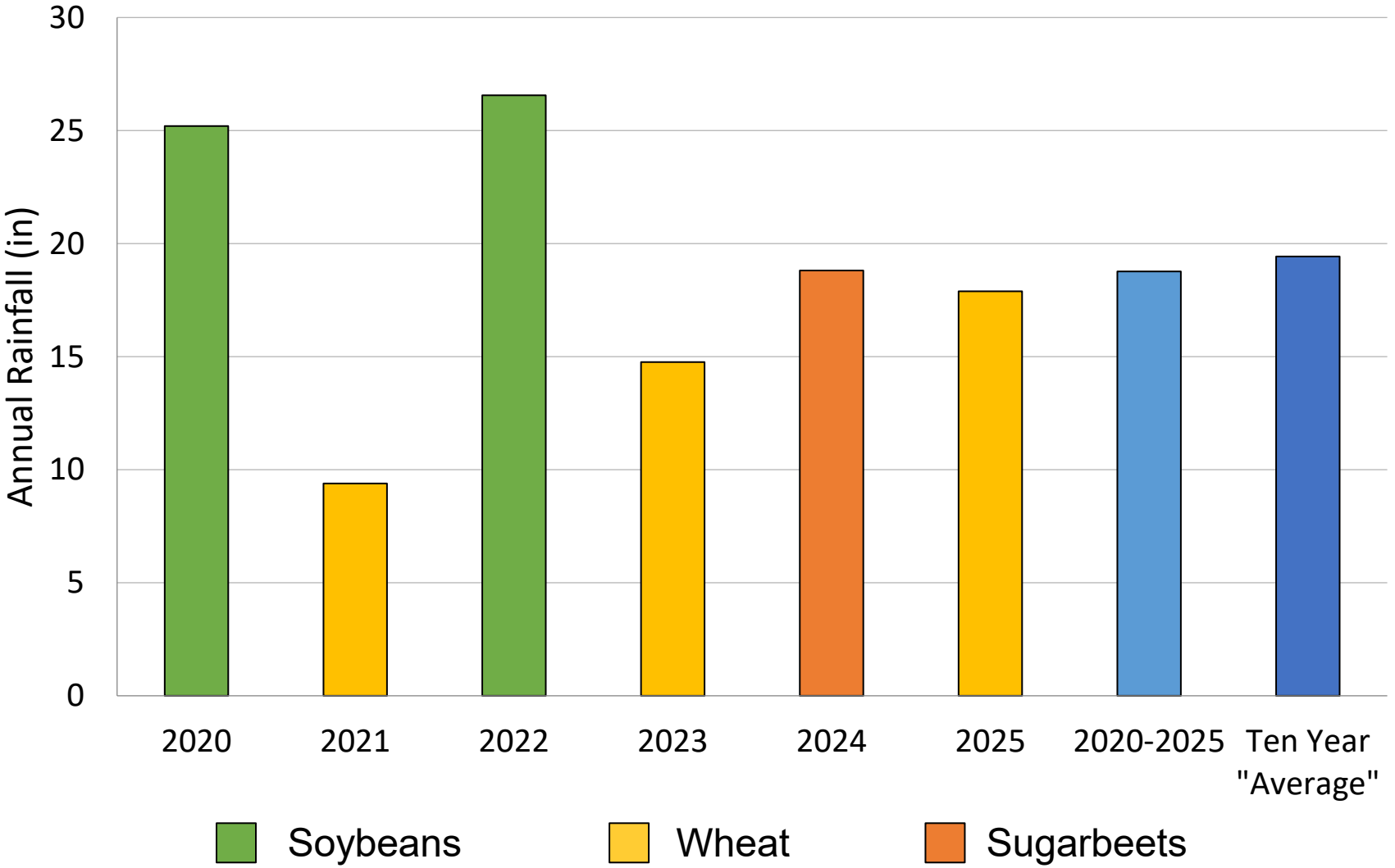
	Applied	Uptake	Denitrification	Tile + Surface	**N Loss**
Drained	85	96	5	1	**11%**
Undrained	85	94	6	0	**11%**

$3.90/ac

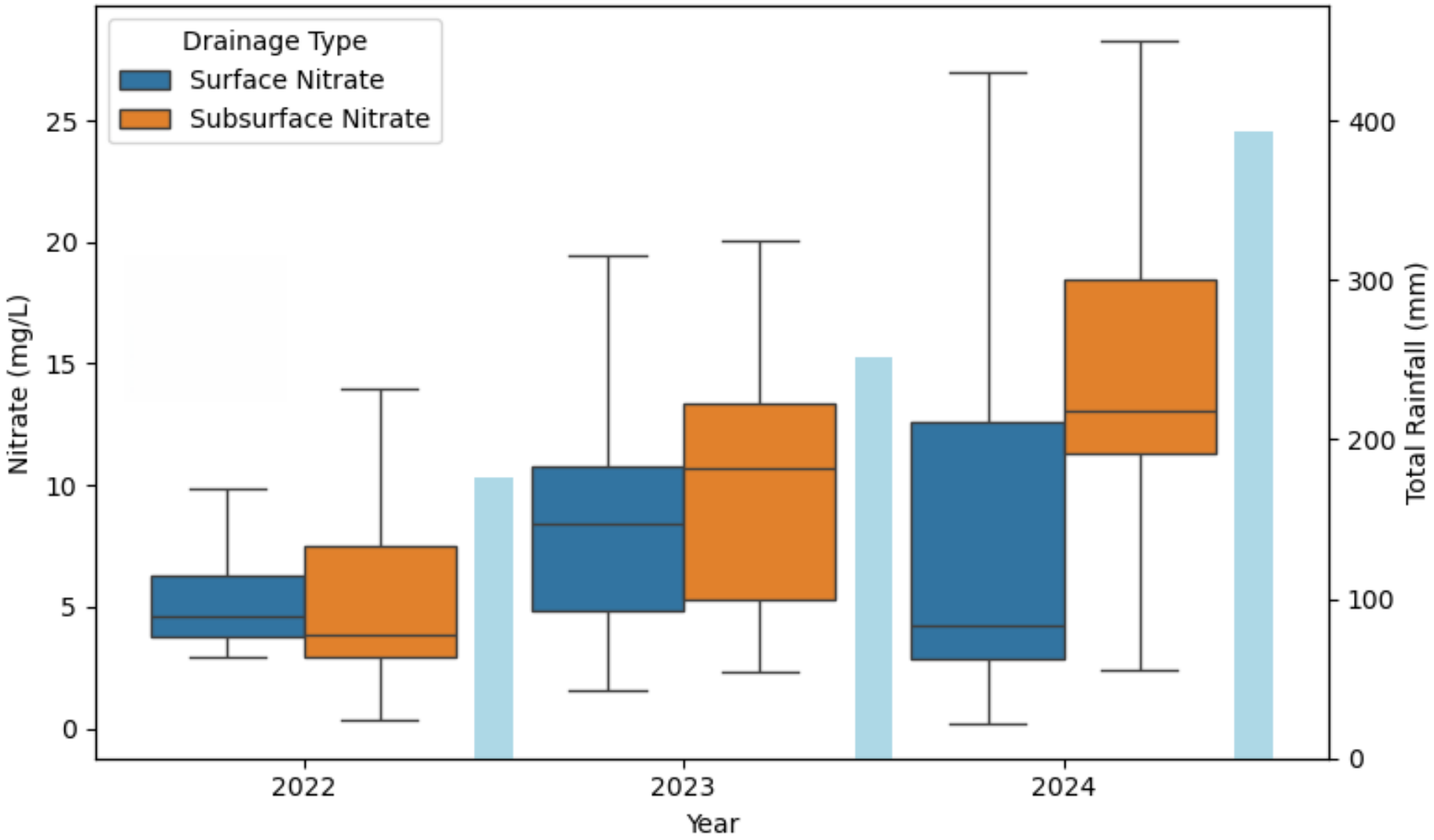
Haven’t seen dramatic improvements in yield since 2020, but have had less rain

	2020	2021	2022	2023	2024		2025
	Soybean	Wheat	Soybean	Wheat	Sugarbeet		Wheat
	---------- Yield (bu/ac) ----------				Yield (t/ac)	Recov. Sucrose (%)	Yield (bu/ac)
Drained	40 **A**	54 **B**	39	86	33.5	17.4% **A**	94
Undrained	34 **B**	58 **A**	40	88	34.6	17.0% **B**	92

Wheat years corresponded with drier years



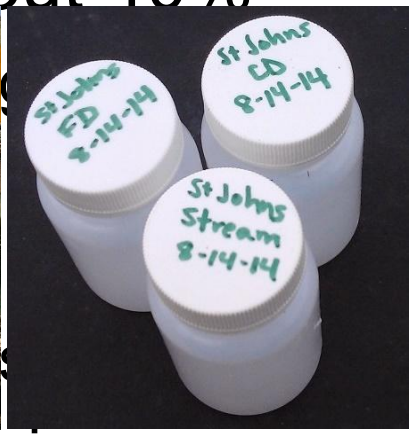
Nitrate loss is strongly tied to total rainfall



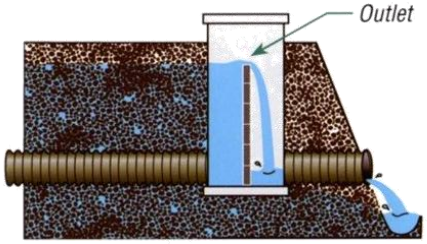
Controlled Drainage

- Reduces tile drainage discharge by about 40%

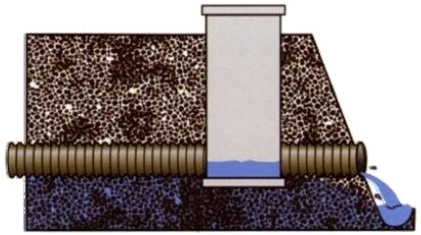


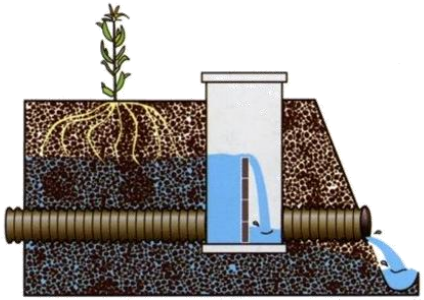



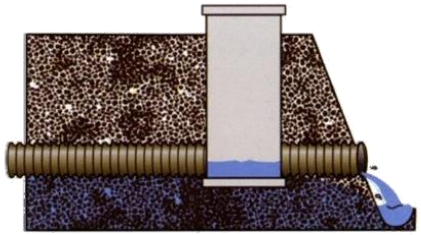
  - Sloped/rolling fields need more complex design



Non-Growing Season

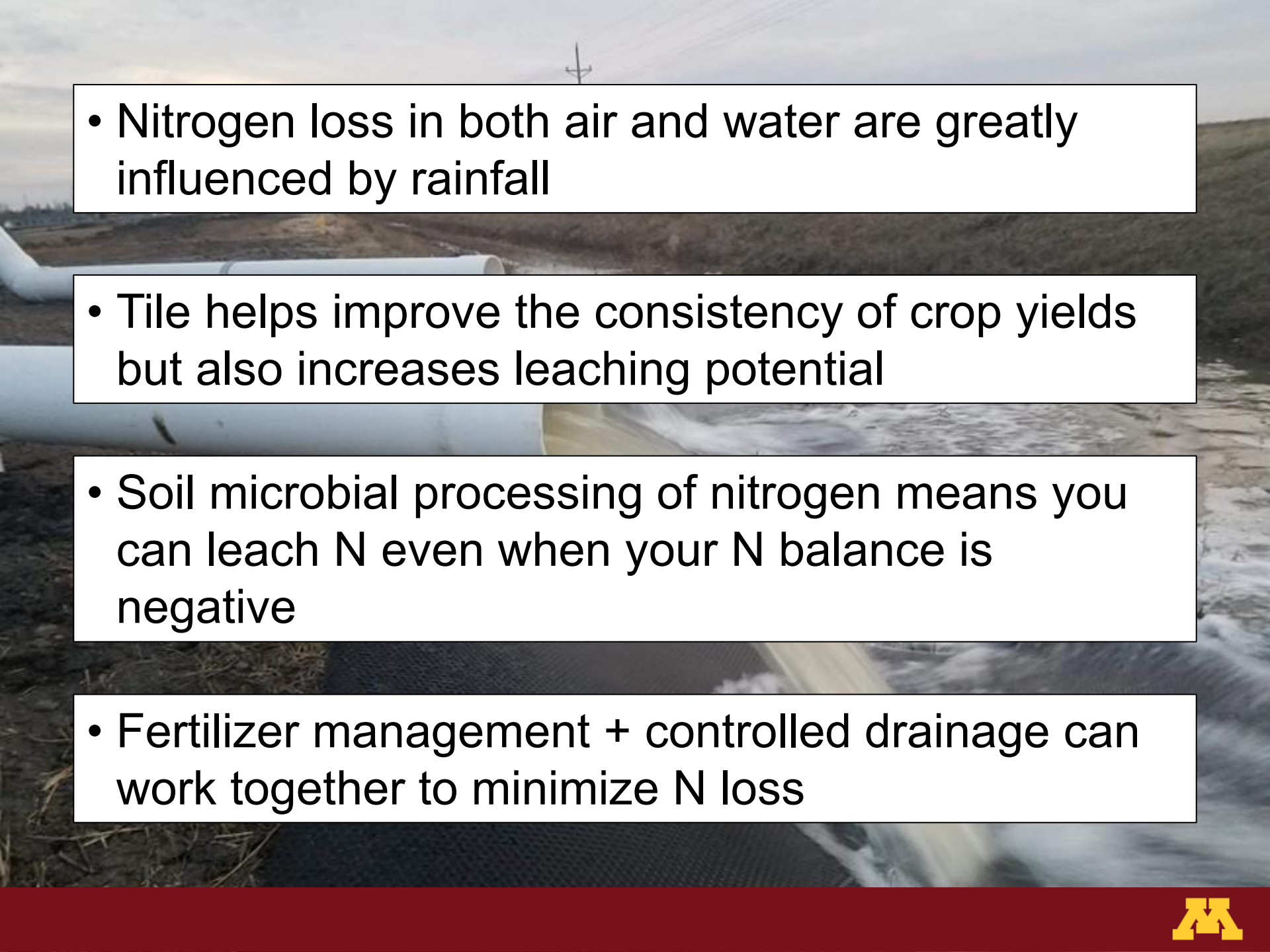

Planting


Growing Season

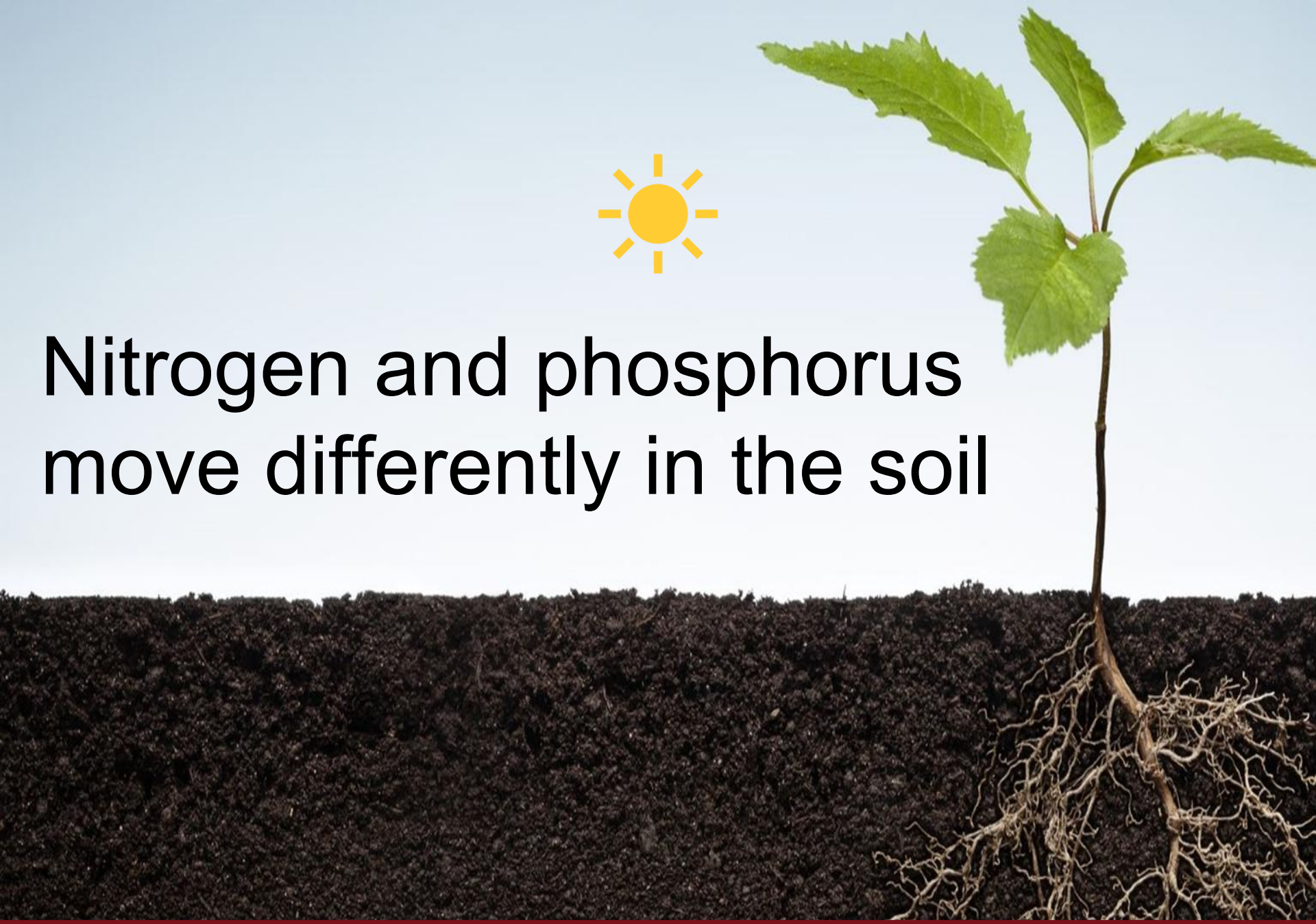

Harvest

Pease et al. (2018), Helmers et al. (2022), and Youssef et al. (2023)

If you have a lift station, you can implement controlled drainage by switching the pump off or to manual

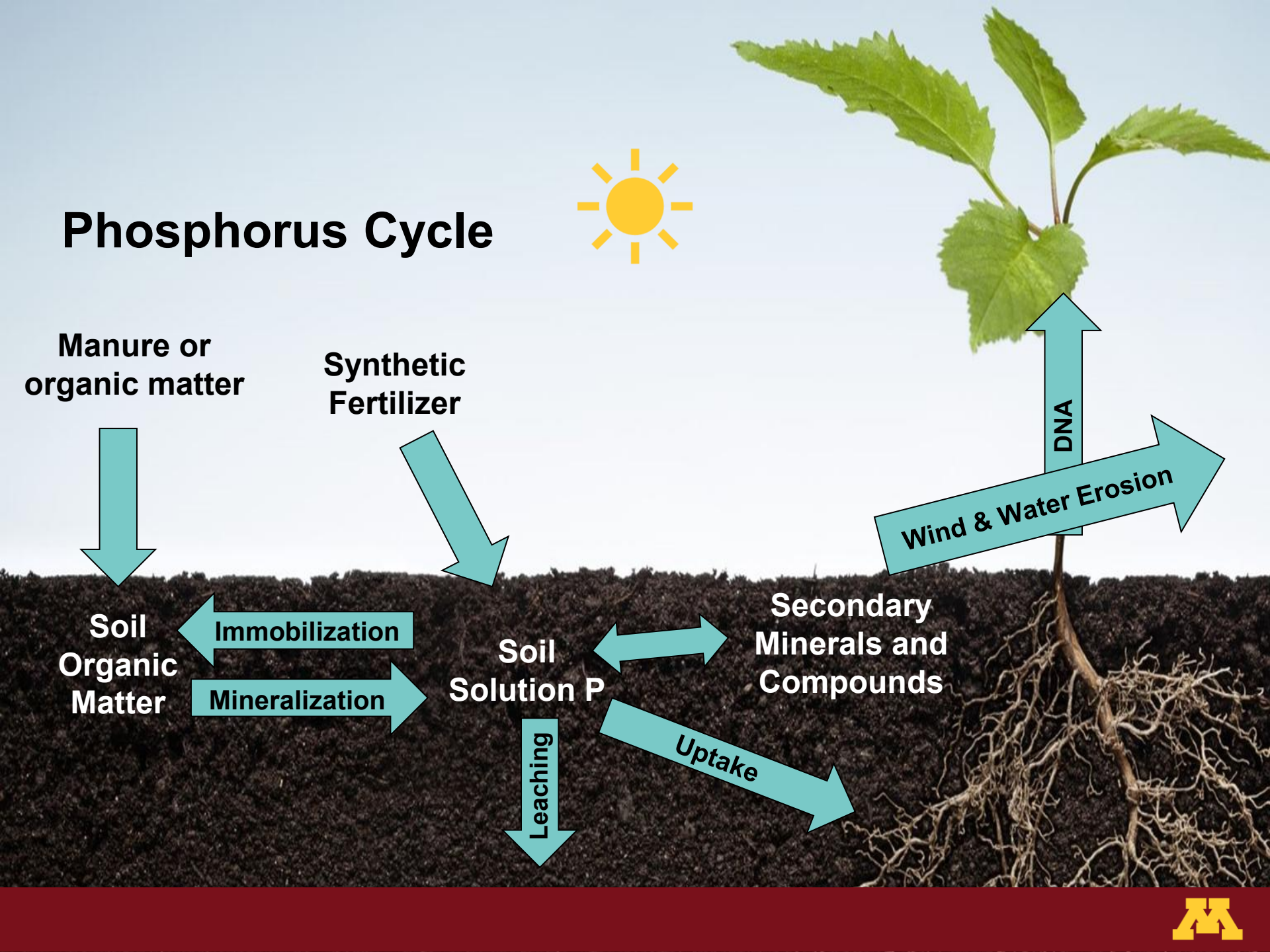


- Nitrogen loss in both air and water are greatly influenced by rainfall
- Tile helps improve the consistency of crop yields but also increases leaching potential
- Soil microbial processing of nitrogen means you can leach N even when your N balance is negative
- Fertilizer management + controlled drainage can work together to minimize N loss



Nitrogen and phosphorus move differently in the soil

Phosphorus Cycle



- Phosphorus loss is most visible after storms, heavy rainfall, and snowmelt

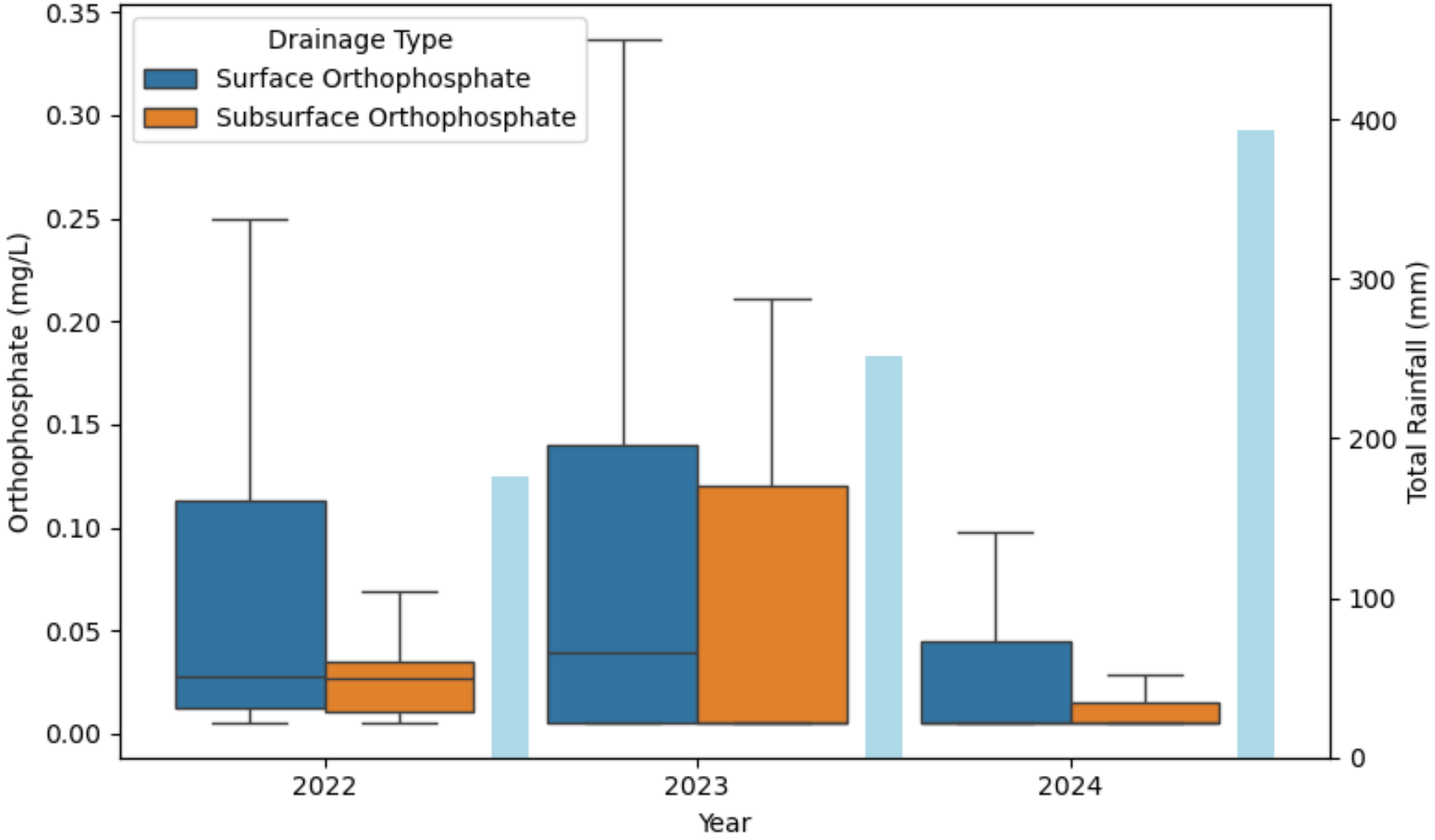
- Can also move in tile

Surface Runoff vs Tile Drainage

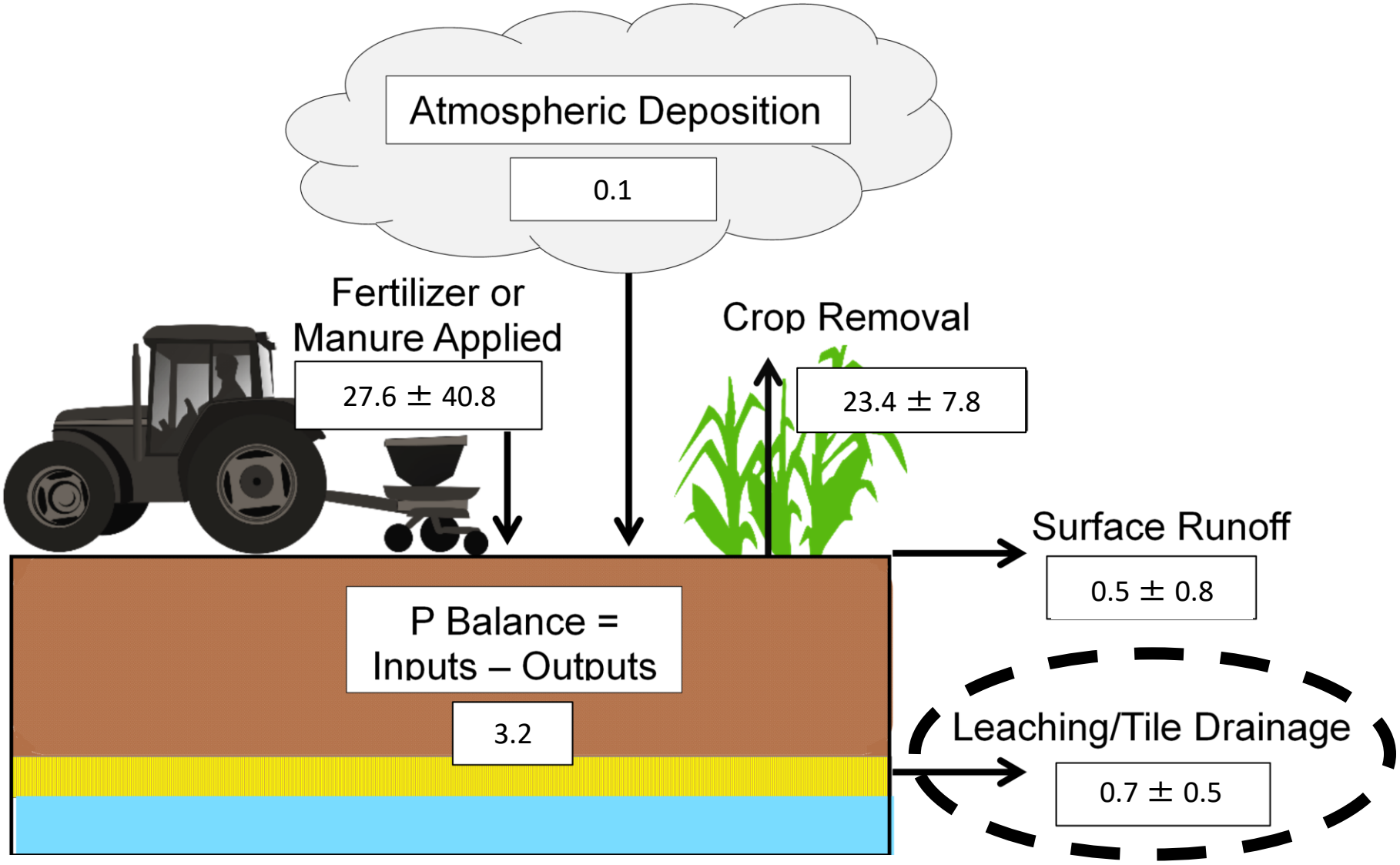
Fast & Intense

Slow & Steady

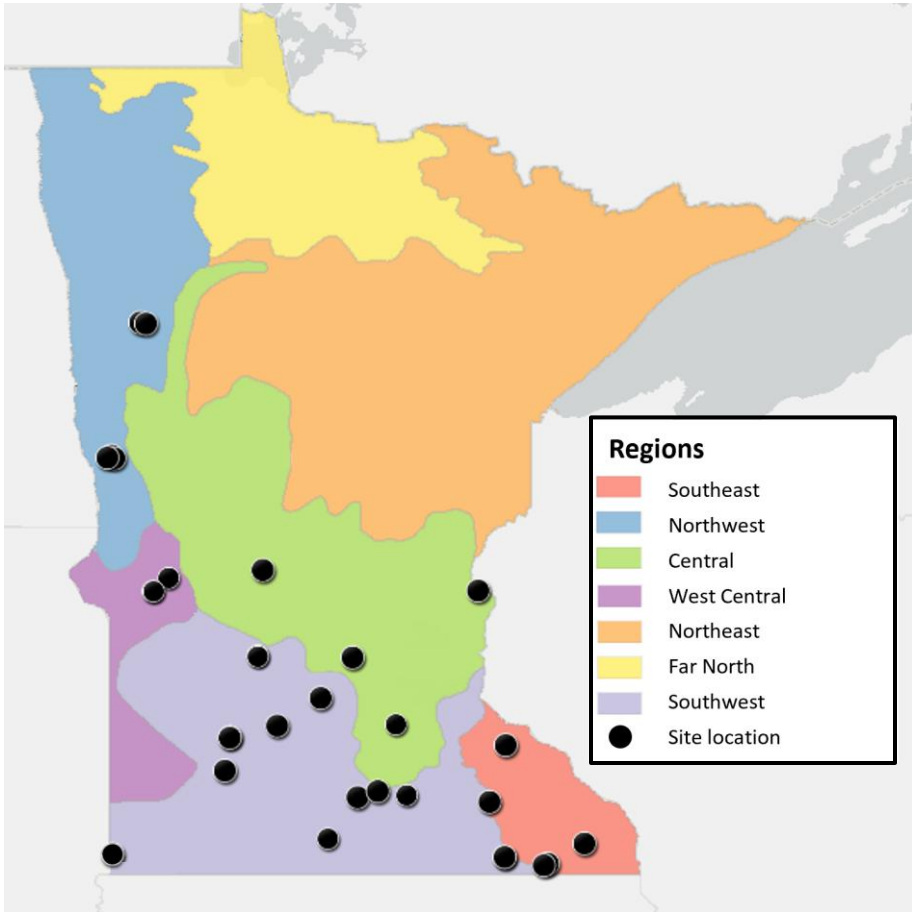
P concentration: Surface runoff > subsurface runoff



Ohio: Average Total Phosphorus Budget (lb/ac)

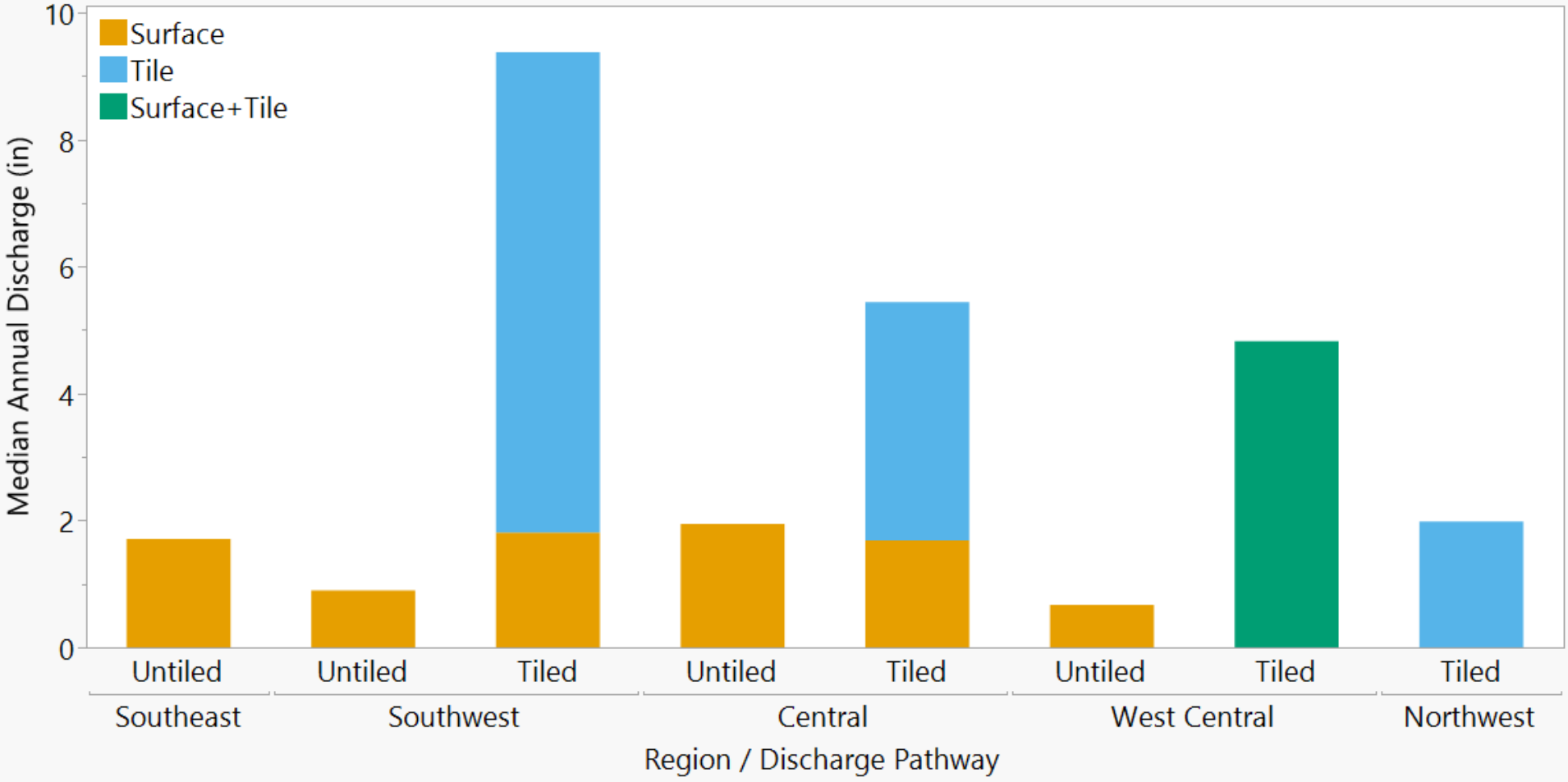


Edge-of-Field P Loss Data in MN: 1994-2021

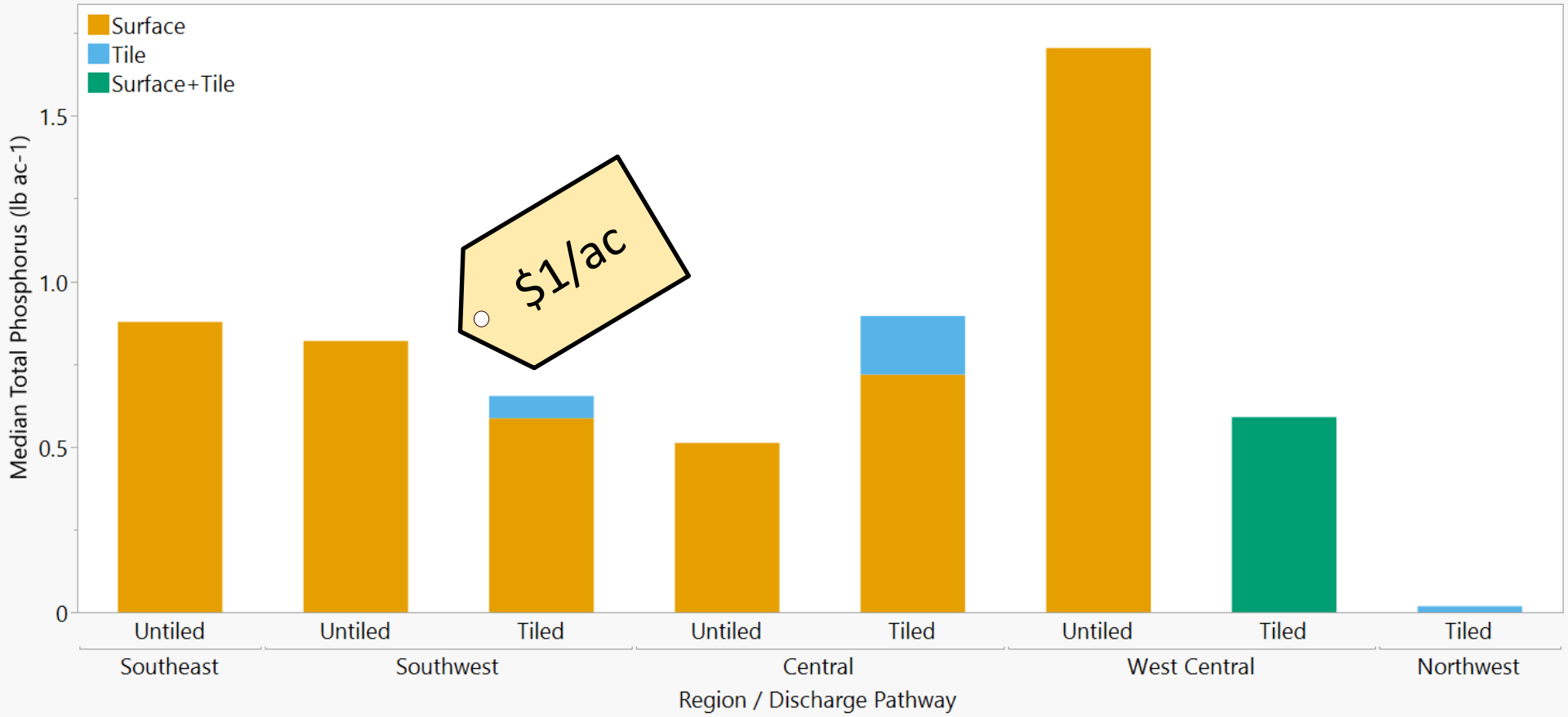


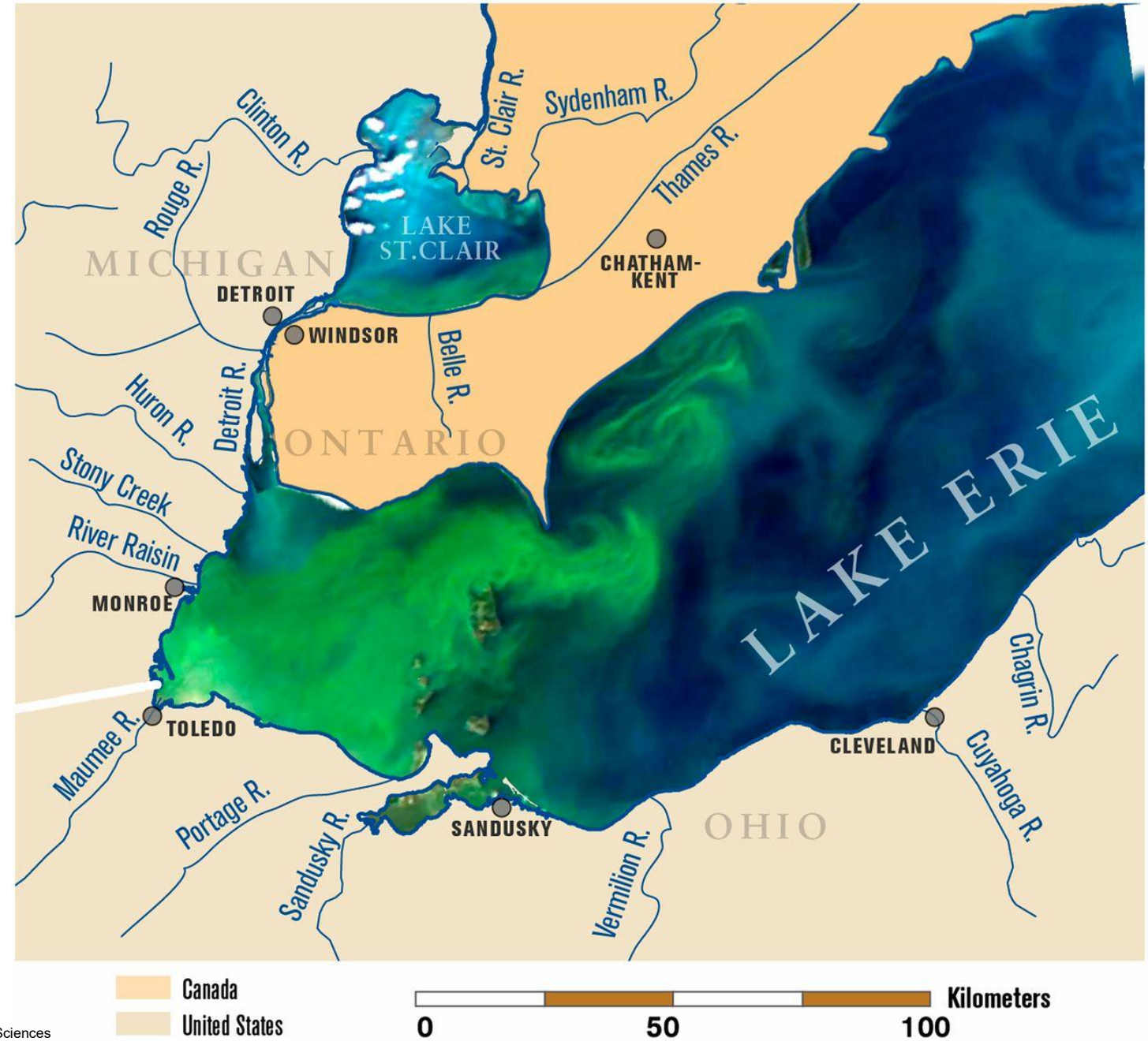
- Data Sources:
  - Discovery Farms MN (2011-2021)
  - MN Dept of Agriculture (2010-2021)
  - University of Minnesota, various studies (1994-2012)

Greater discharge from tiled fields



Greater P load from surface runoff

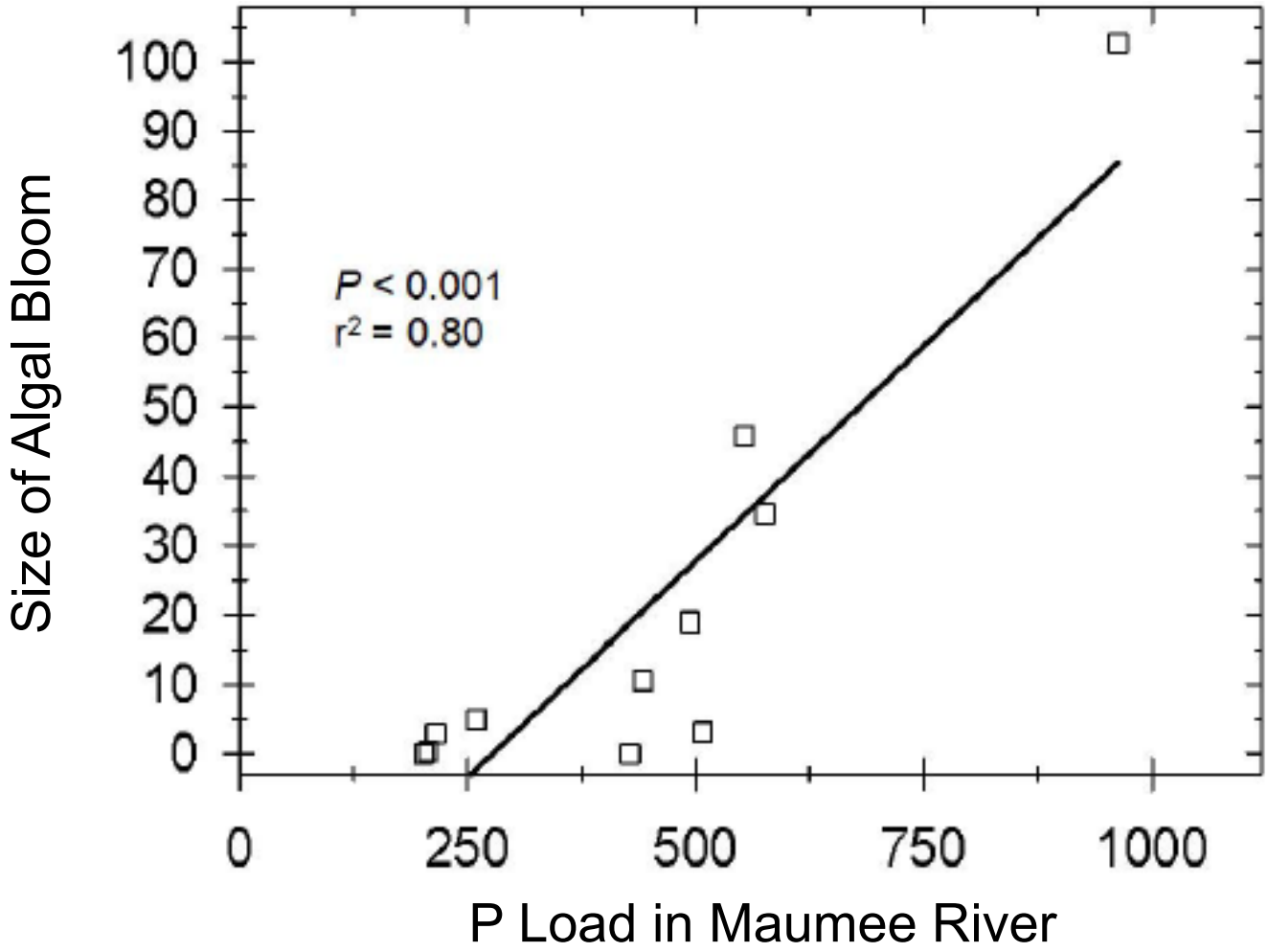




Michalak A M et al. PNAS 2013;110:6448-6452

MODIS satellite Image of Lake Erie on September 3, 2011

Dissolved Phosphorus Load Predicts Lake Erie Algal Bloom Size



Kane et al. 2014

600,000 people rely on this Lake Erie intake for drinking water


DANGER
AVOID ALL CONTACT WITH THE WATER
ALGAL TOXINS AT UNSAFE LEVELS HAVE BEEN DETECTED
FOR MORE INFORMATION GO TO:
WWW.OHIOALGAEINFO.COM
OR CALL 1-866-644-6224
Have fun on the water, but know that blue-green algae are in many Ohio lakes. Their toxins may be, too.
Be Alert! Avoid water that:
• looks like spilled paint
• has surface scums, mats or films
• is discolored or has colored streaks
• has green globs floating below the surface
Avoid swallowing lake water.
For more information, visit ohioalgaeinfo.com or call 1-866-644-6224.


Toguchi Beach
Okinawa, Japan
Credit: Okinawa Soba (Rob)(2012)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Manitoba

Algae covers stretch of beach on Lake Winnipeg

Beachgoers say Grand Beach was covered in green sludge on Monday

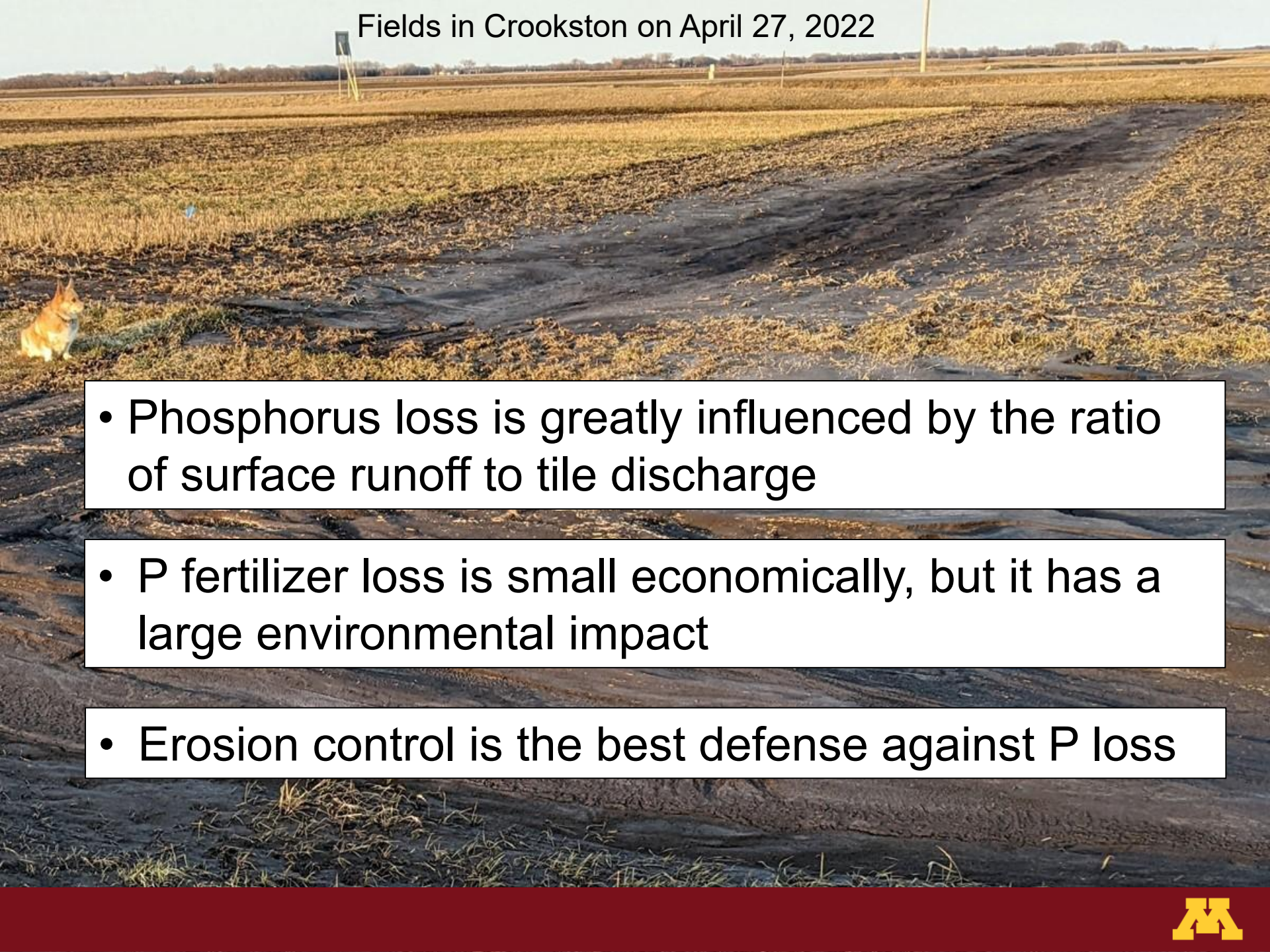
Holly Caruk · CBC News · Posted: Aug 15, 2016 9:59 PM CT | Last Updated: August 15, 2016

Photo: Harley Hudon

Photo: Monique Andrew

Photo: Gabie Tolkmitt

In Minnesota: Reduce potential for P loss with erosion control



- Phosphorus loss is greatly influenced by the ratio of surface runoff to tile discharge
- P fertilizer loss is small economically, but it has a large environmental impact
- Erosion control is the best defense against P loss

Are we sending fertilizer down the drain?

- Yes, but probably less than you think (economically)
- Rainfall is the most important variable for how much you lose each year
- Fertilizer management (placement) is a good first defense against nutrient loss
- N Loss: Consider conservation drainage practices like controlled drainage
- P Loss: Consider erosion control practices

Acknowledgements

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DISCOVERY FARMS MINNESOTA

USDA Agricultural Research Service

MAWRC Minnesota Agricultural Water Resource Center

MinnesotaCorn Research & Promotion Council

Department of Agriculture

Minnesota Wheat Research & Promotion Council

AFREC Agricultural Fertilizer Research & Education Council

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