

# Tile Drainage: Basics and Current Research in Vermont

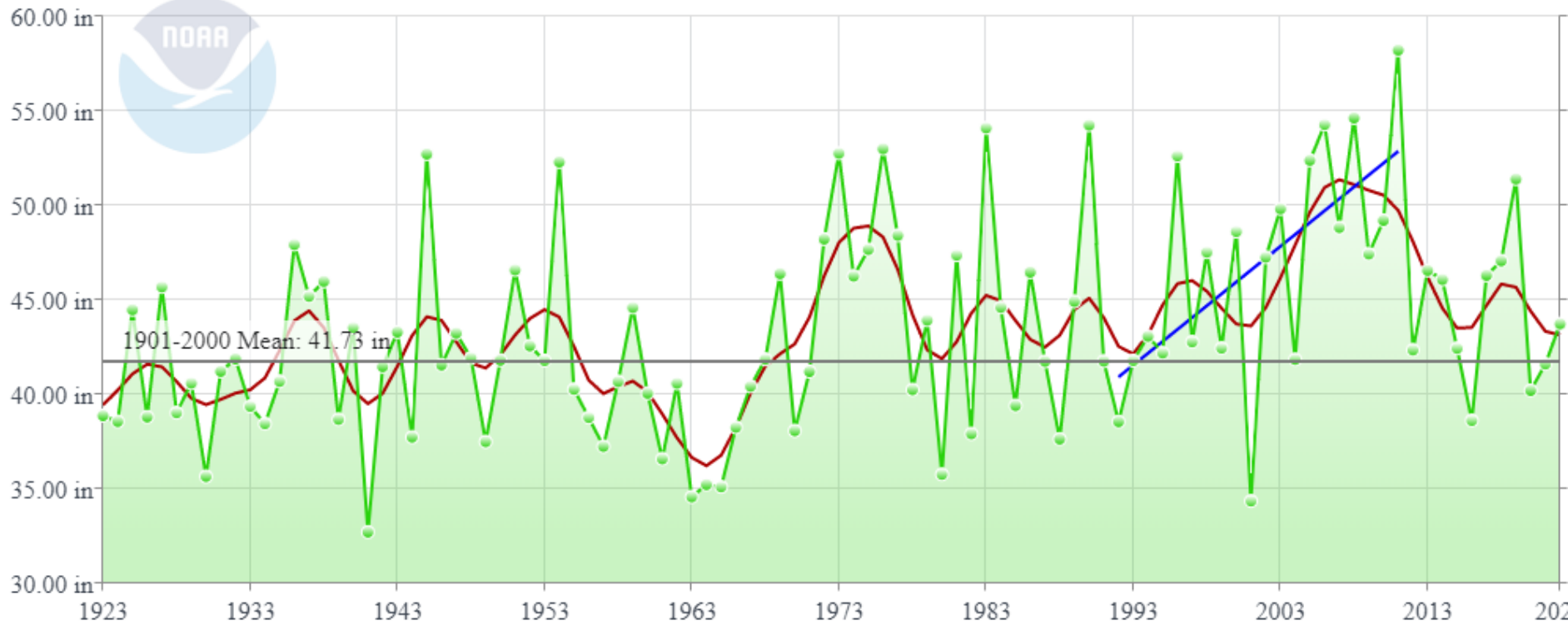
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April 1, 2026



THE UNIVERSITY OF VERMONT  
**EXTENSION**

Vermont Precipitation  
January-December

Vermont Annual Precip.: +62.86"/century  
(1992-2011)



# 2023: A year for the record books...

## Addison County, Vermont Precipitation

July-August, 1895-2023

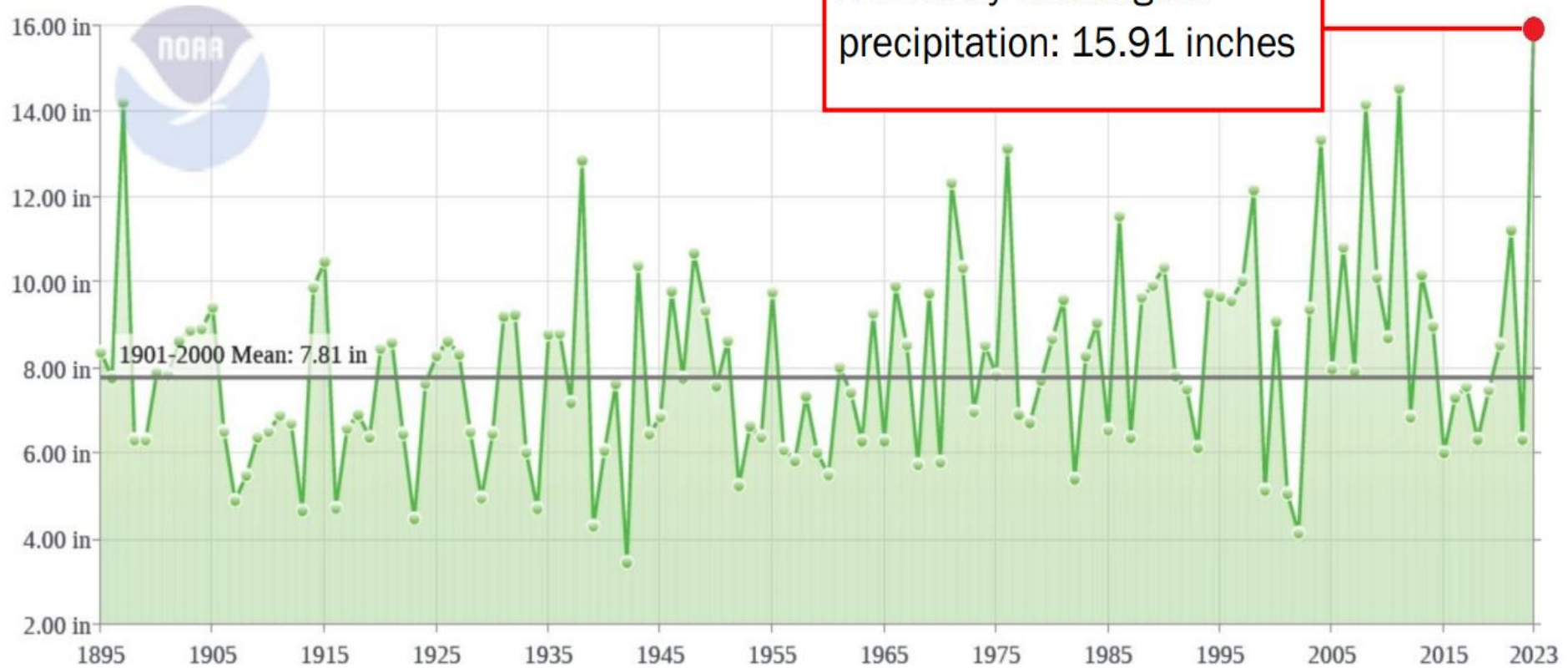
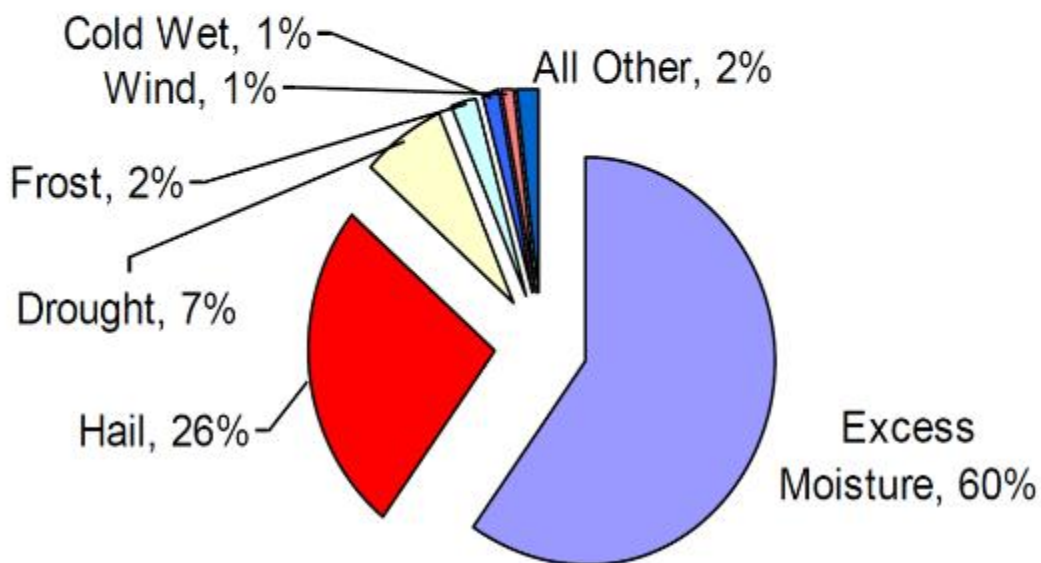


Figure 1 NOAA National Centers for Environmental Information.

# Effects of Increased Precipitation are Clear

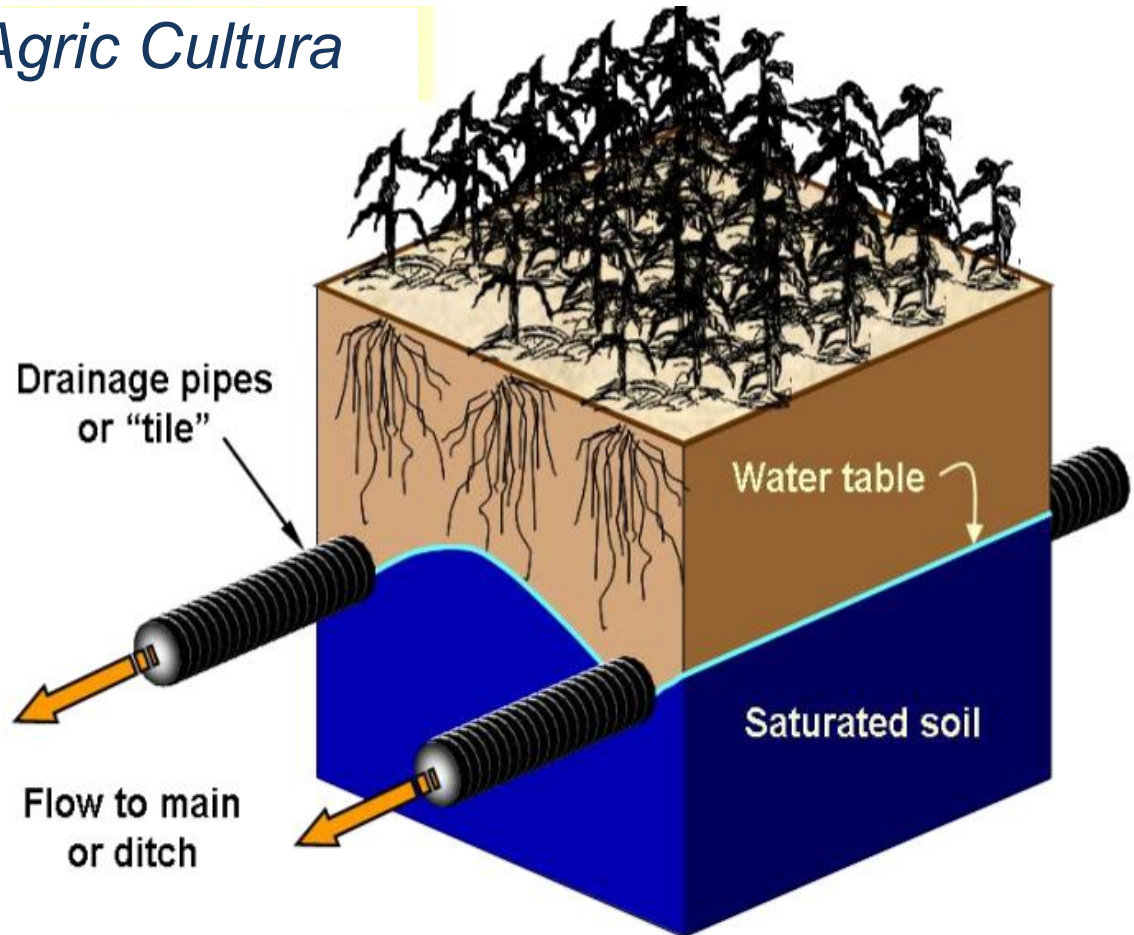
## Why Vermont Crops Fail (2001-10)

Since 1988, Crop Ins. provided  
\$213 Bil. of Protection and Paid \$15 Million  
in Loss Payments to VT Farmers



# Tile Drainage 101

- Artificial drainage first described by Cato in 200 BC in *De Agric Cultura*

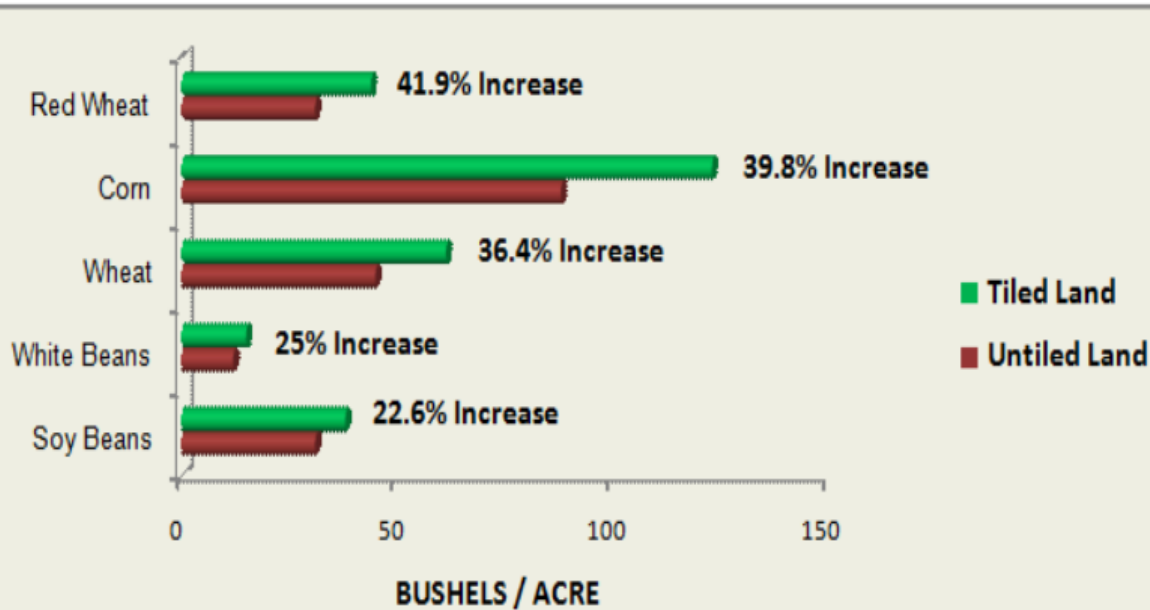


(Source: G. Sands, UMN)

# Benefits of Drainage

1. Improve crop production and less year-to-year variability
2. Allows earlier and later field operations

Crop Yield Increase Measured in Bushels/Acre

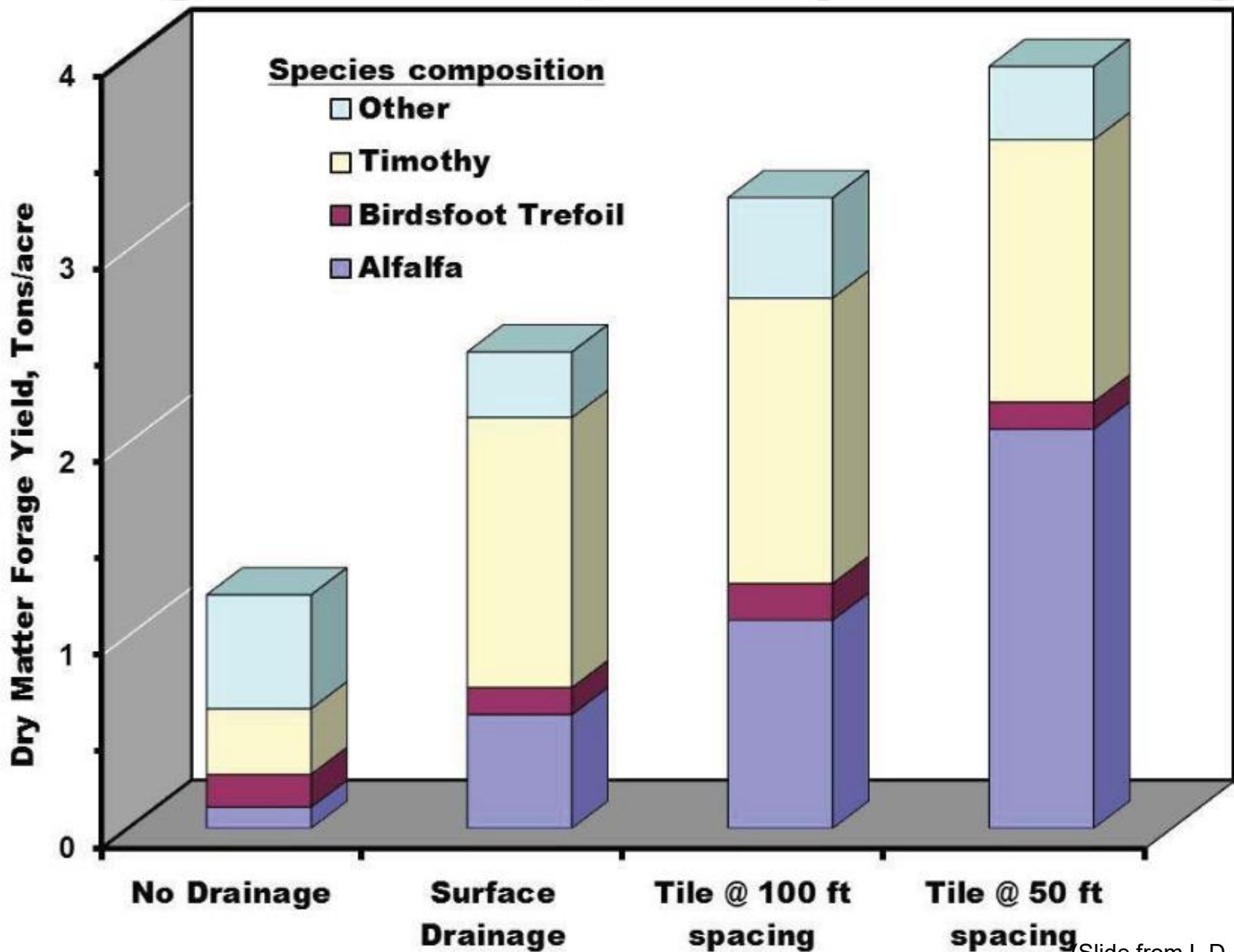


*Average of 30% yield increase in corn and soybeans due to drainage over 25 years in Ohio (Reeder et al., 2011)*



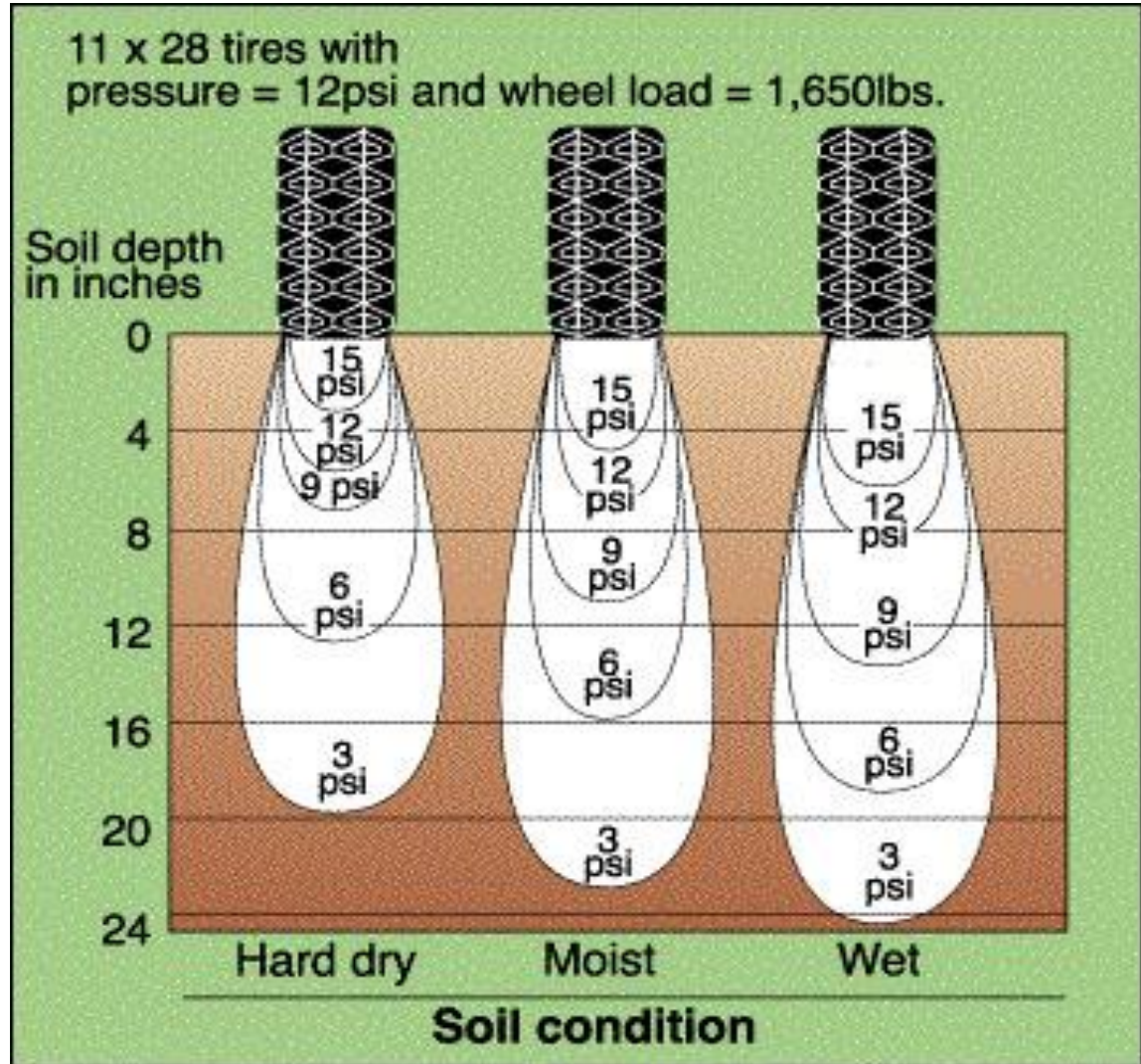
Sources: The Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA), and the National Crop Insurance Services (NCIS) program

# Forage Yield Response (4-Yr. Average)



# Prevents Compaction

Especially tough-to-remedy deep compaction

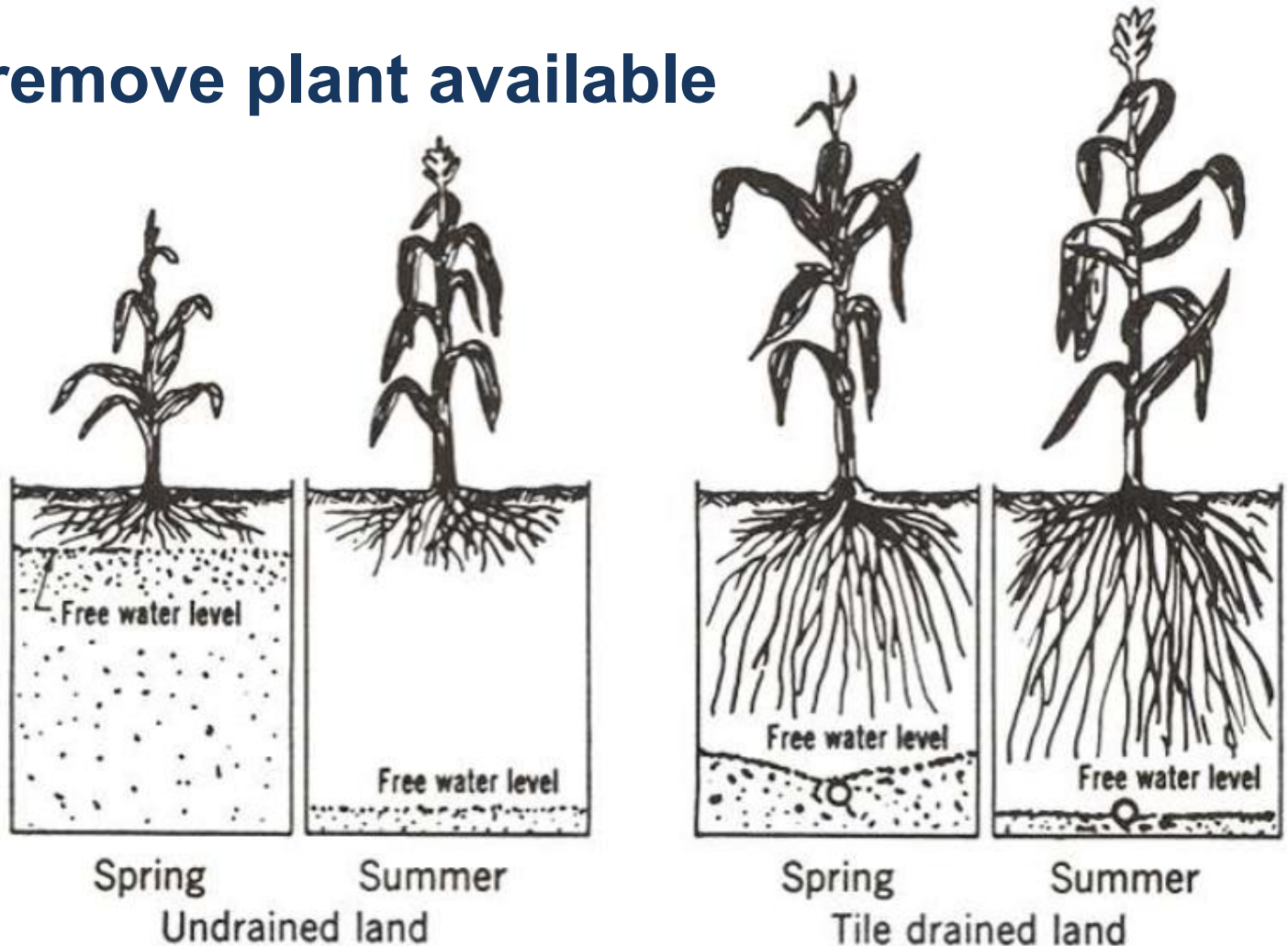


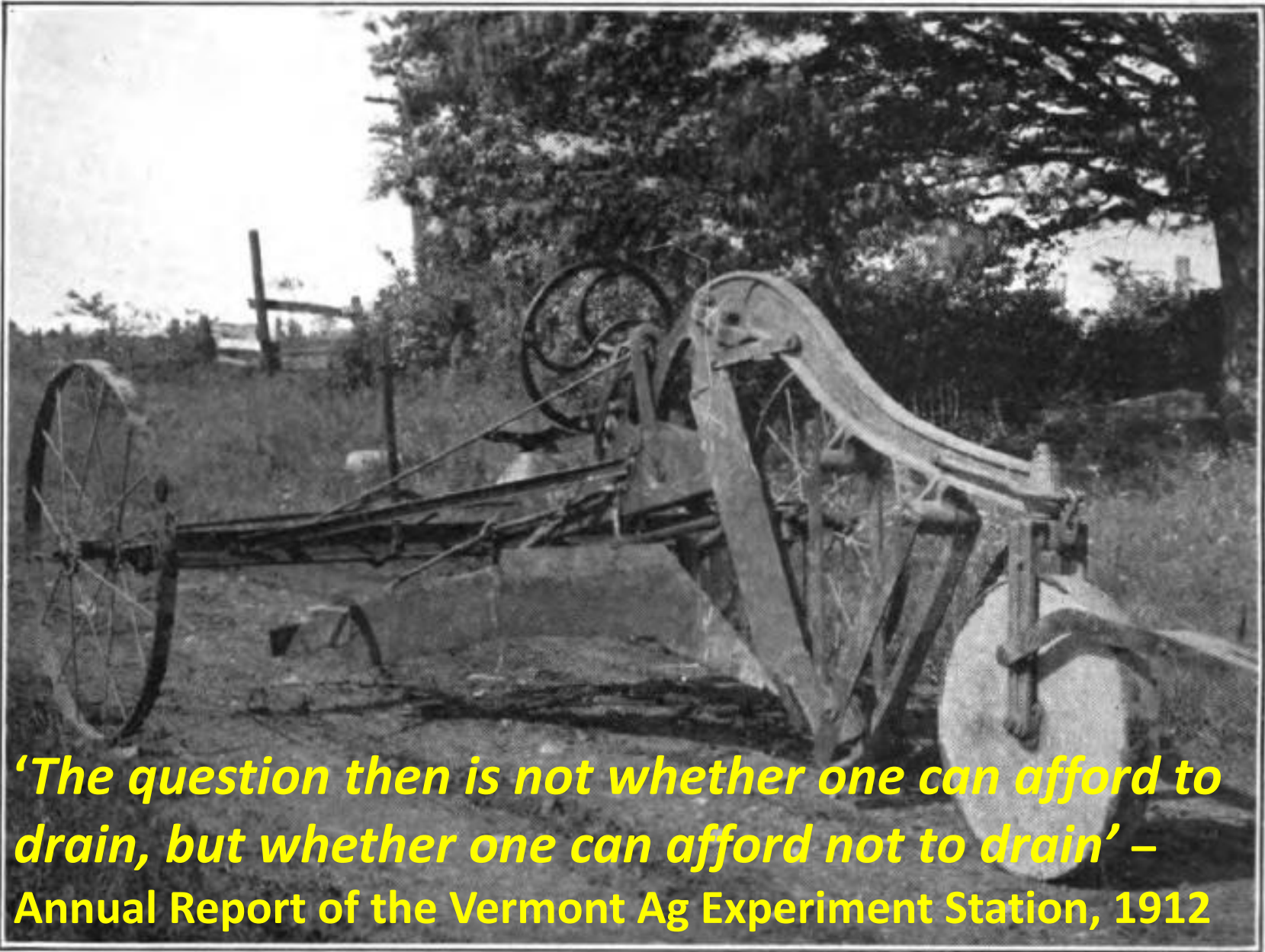
<http://stormwater.pca.state.mn.us/index.php>

# Wet years, and dry years

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Does not remove plant available water



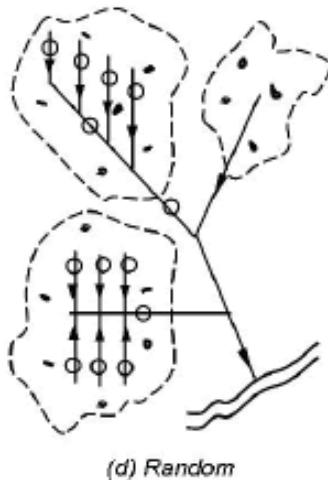
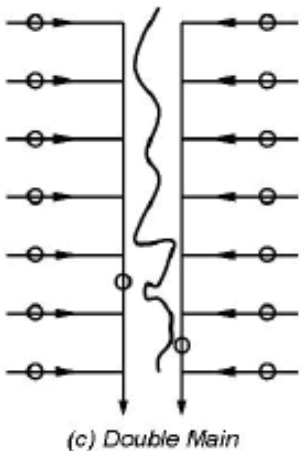
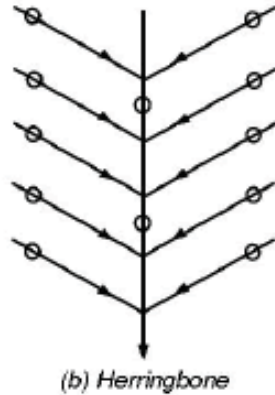
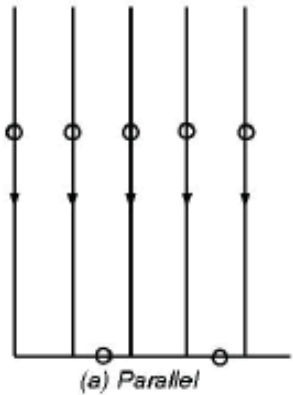


***'The question then is not whether one can afford to drain, but whether one can afford not to drain' – Annual Report of the Vermont Ag Experiment Station, 1912***

**PLATE III. Cyclone Ditcher, drawn by six horses. (Courtesy Hon. E. S. Brigham, St. Albans.)**

# Tile Drainage 101

- Configurations of 'laterals' varies, but all feed 'main'



# Tile Drainage Environmental Concerns

- King et al. (2015) monitored eight tile outlets in central Ohio over an 8-yr period, and nearly half of the dissolved P and 40% of the total P load measured at the watershed outlet was attributed to runoff delivered by tile drains.



# Preferential Flow

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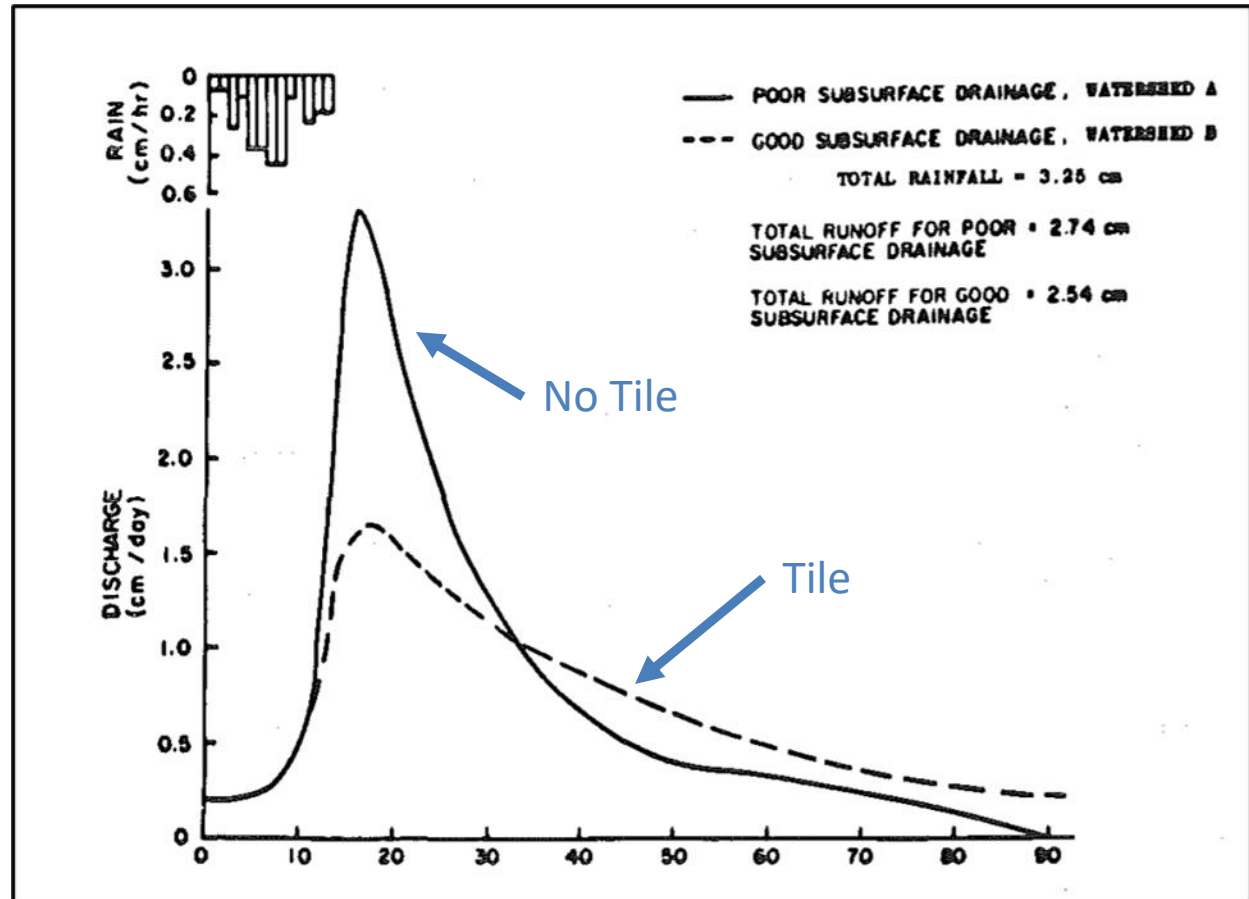


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(Source: <http://soilandwater.bee.cornell.edu>)

# Tile Drainage Hydrology: What the scientific literature says...

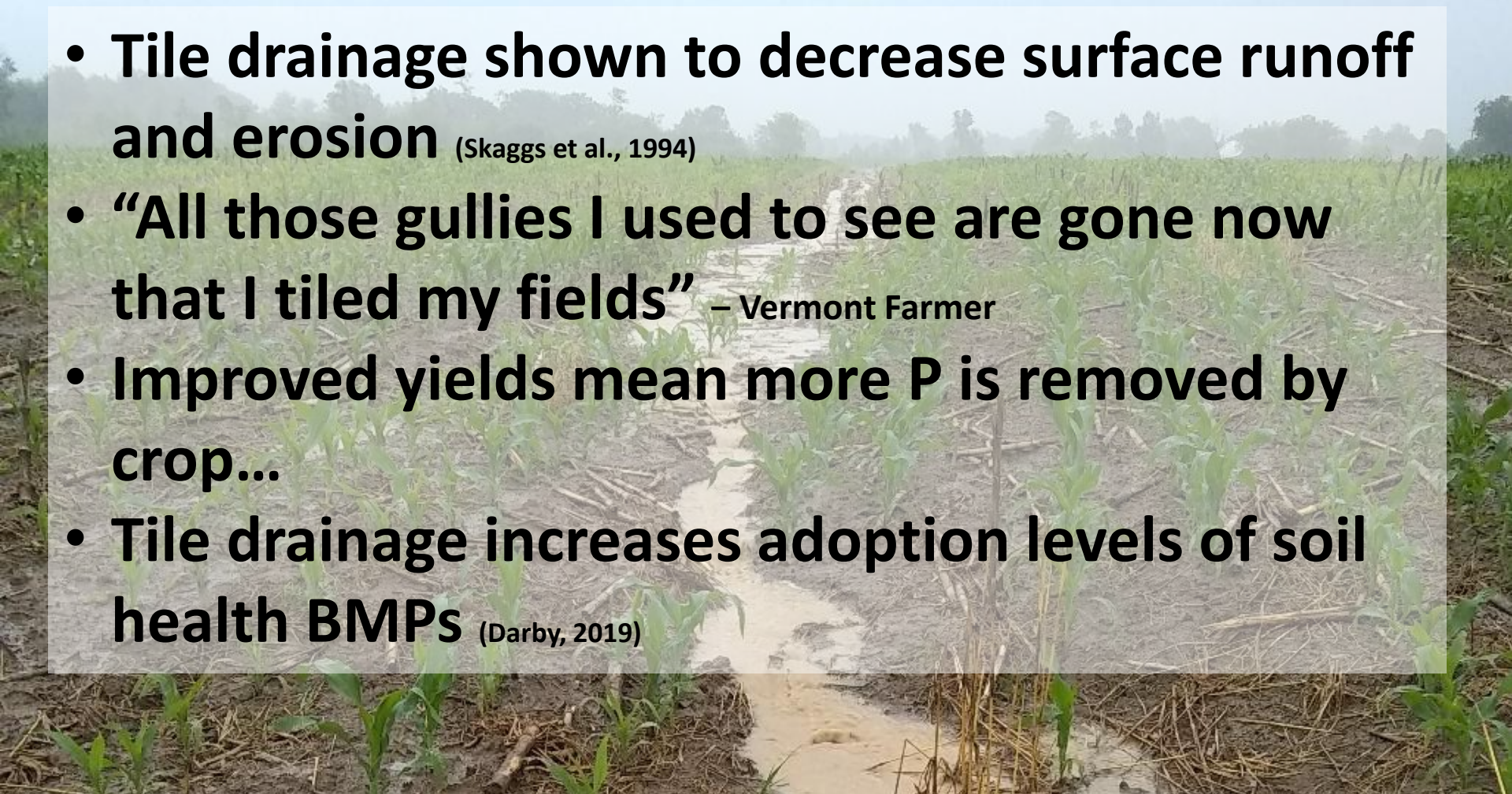
- Skaggs and Broadhead (1982) found peak flows were reduced by 20% due to tile when soils were wet before a storm
- When soils were dry, tile reduced peak flows by up to 87%
- Robinson (1990) found a reduction of peak flows due to tile drainage specifically for clay-textured soils
- Increases overall watershed discharge volume by 10-20% (increases baseflow, between storms)



(Gilliam and Skaggs, 1986)

# Relationship Status: It's complicated...

- **Tile drainage shown to decrease surface runoff and erosion** (Skaggs et al., 1994)
- **“All those gullies I used to see are gone now that I tiled my fields”** – Vermont Farmer
- **Improved yields mean more P is removed by crop...**
- **Tile drainage increases adoption levels of soil health BMPs** (Darby, 2019)



# DC Study: Total Phosphorus Loss (2020 & 2021)

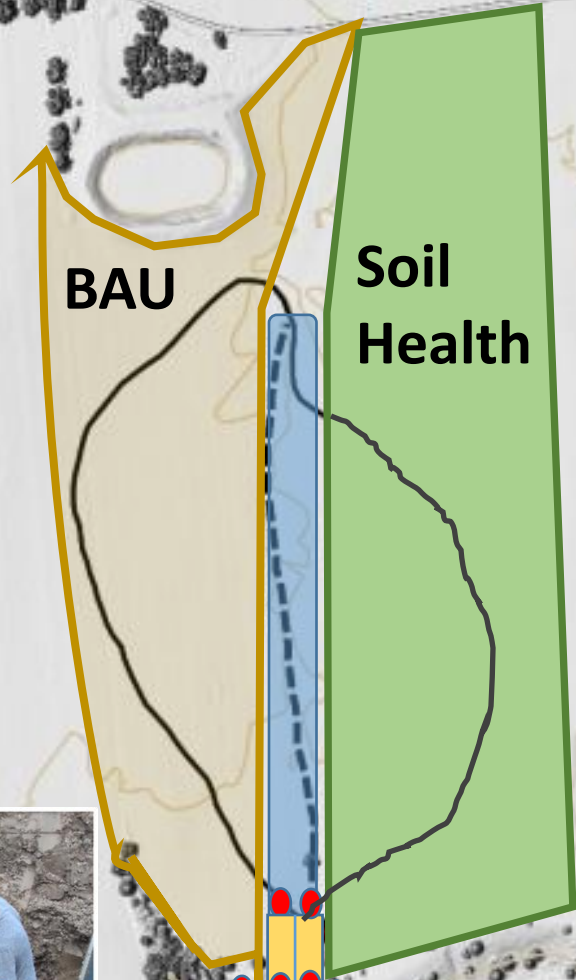
- Dry conditions: 56% (2020) and 68% (2021) of typical precipitation

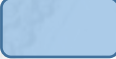





**Table 1: Total Phosphorus Loss from Dead Creek Fields (lb/ac)**

Field	2020			2021		
	Growing Season	Non-Growing	Total	Growing Season	Non-Growing	Total
DC-North	0.07	0.67	<b>0.74</b>	0.58	0.54	<b>1.12</b>
DC-South	0.42	0.28	<b>0.70</b>	0.39	0.28	<b>0.67</b>

- TP loss was generally within ranges reported elsewhere in the country (**0.35 – 1.4 lb/ac/yr**) (King et al., 2015)

# Bridport Study Field



-  : Existing ditch
-  : Tile treatment
-  : Ditch Filter
-  : Monitoring station
-  : Surface watershed
-  : Ditch divider

**Tile system outlet:  
Treatment Side**

**Tile system outlet:  
Control Side**



**Tile P Removal Structure**



## Tile Phosphorus Filters

- Remove dissolved P
- Use pea gravel and iron shavings
- Act like big water filters at edge-of-field
- Currently an NRCS-VT Interim Conservation Practice

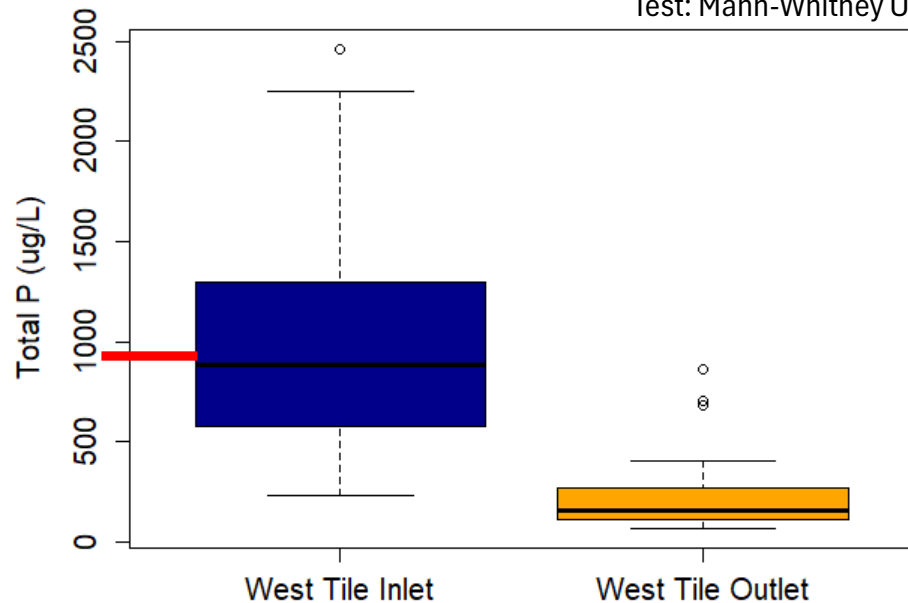
# West Tile Filter (Business as Usual) – Total Phosphorus

## TP Concentrations

n=36

p=8.51e-14

Test: Mann-Whitney U

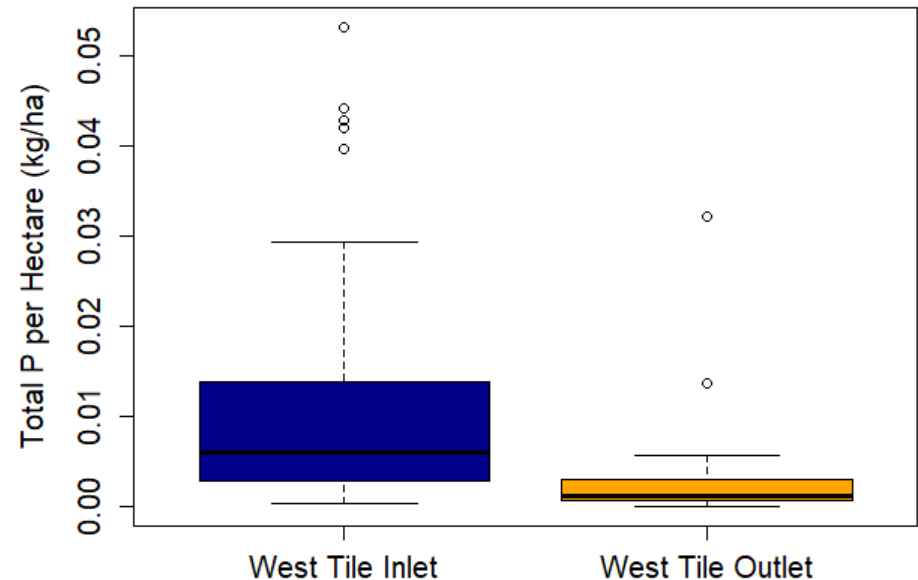


## TP Loads per Hectare

n=36

p=1.75e-06

Test: Mann-Whitney U

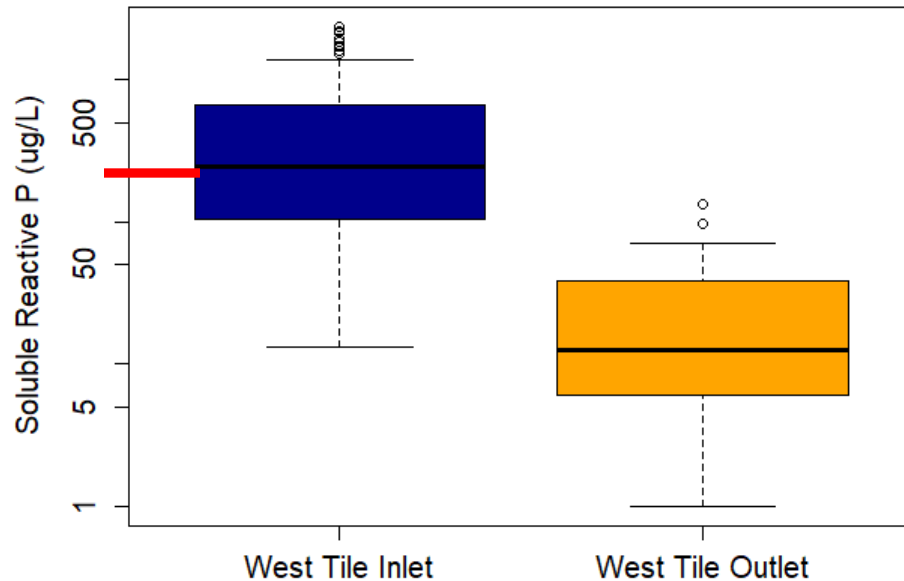


**Removed 69% of  
cumulative TP load**

# West Tile Filter (Business as Usual) – Soluble Reactive Phosphorus

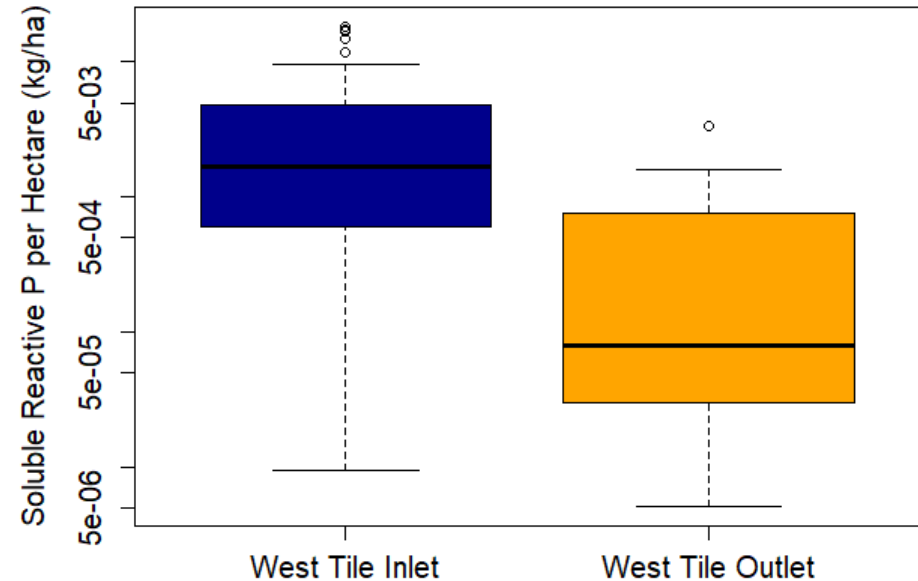
## SRP Concentrations

n=35  
p=3.25e-13  
Test: Mann-Whitney U



## SRP Loads per Hectare

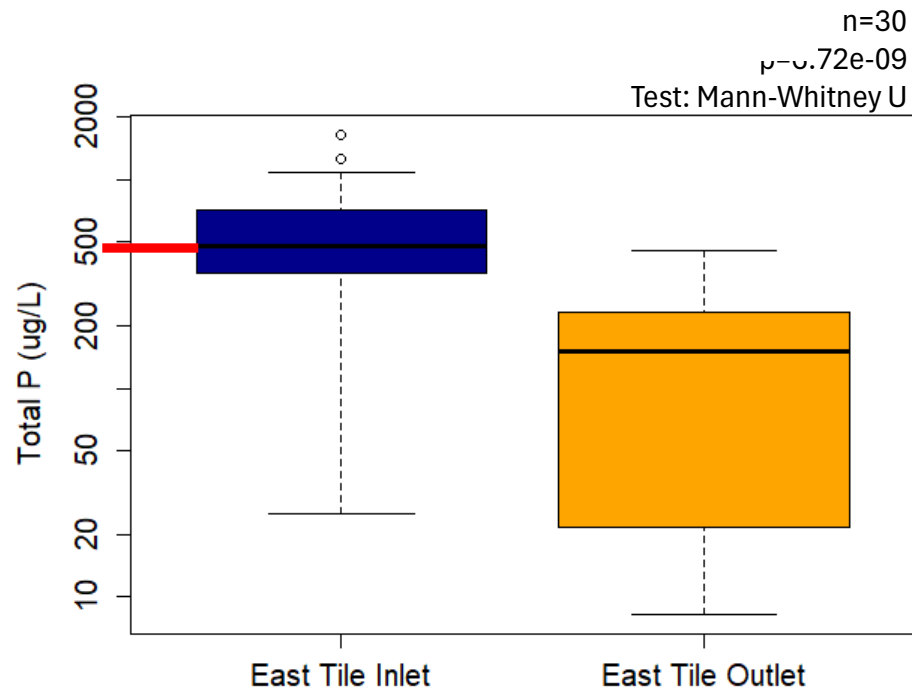
n=35  
p=1.22e-07  
Test: Mann-Whitney U



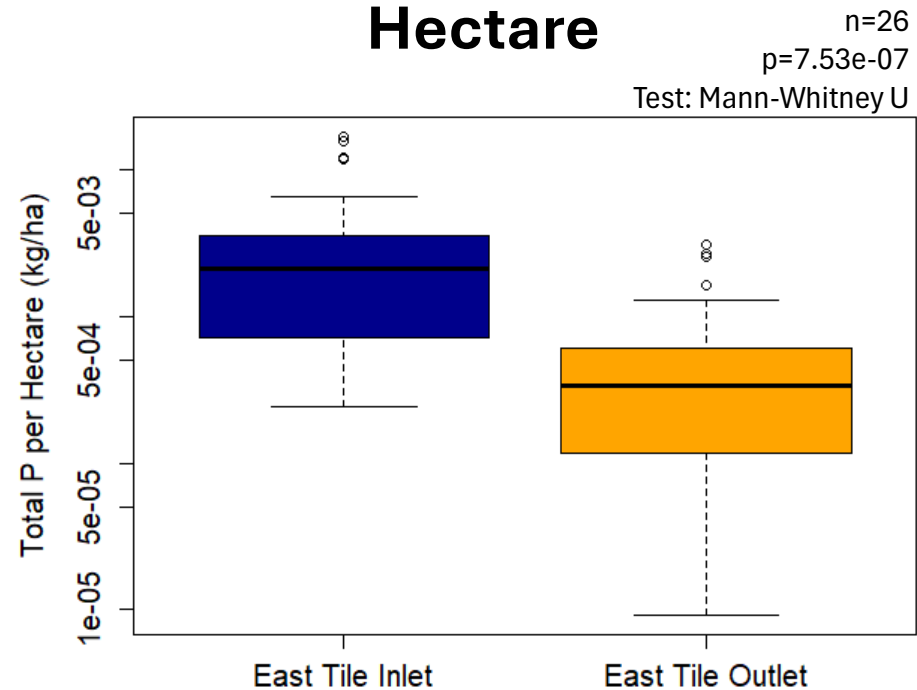
**Removed 87% of  
cumulative SRP load**

# East Tile Filter (Soil Health Practices) – Total Phosphorus

## TP Concentrations



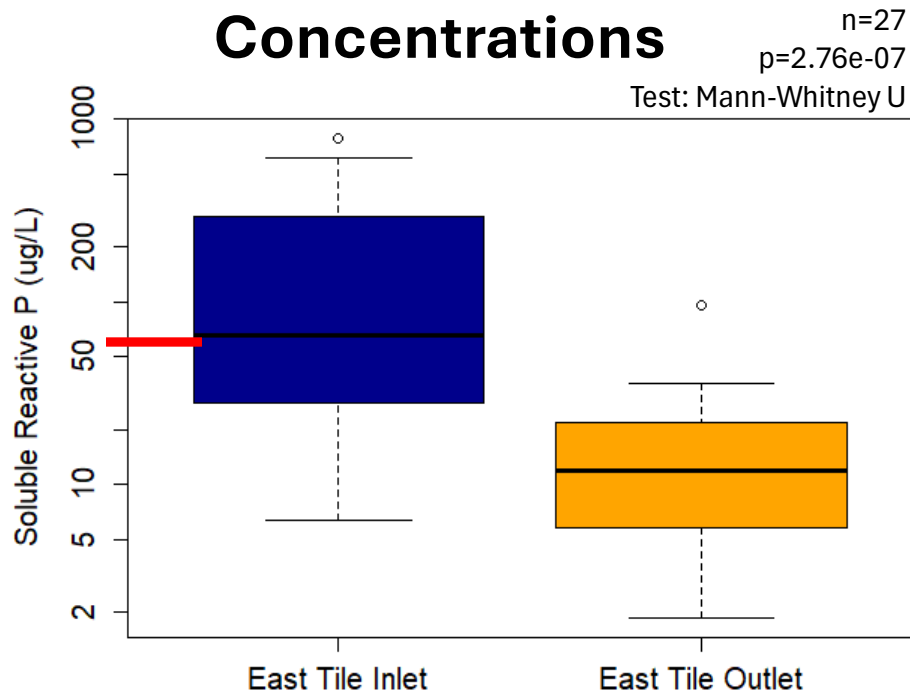
## TP Loads per Hectare



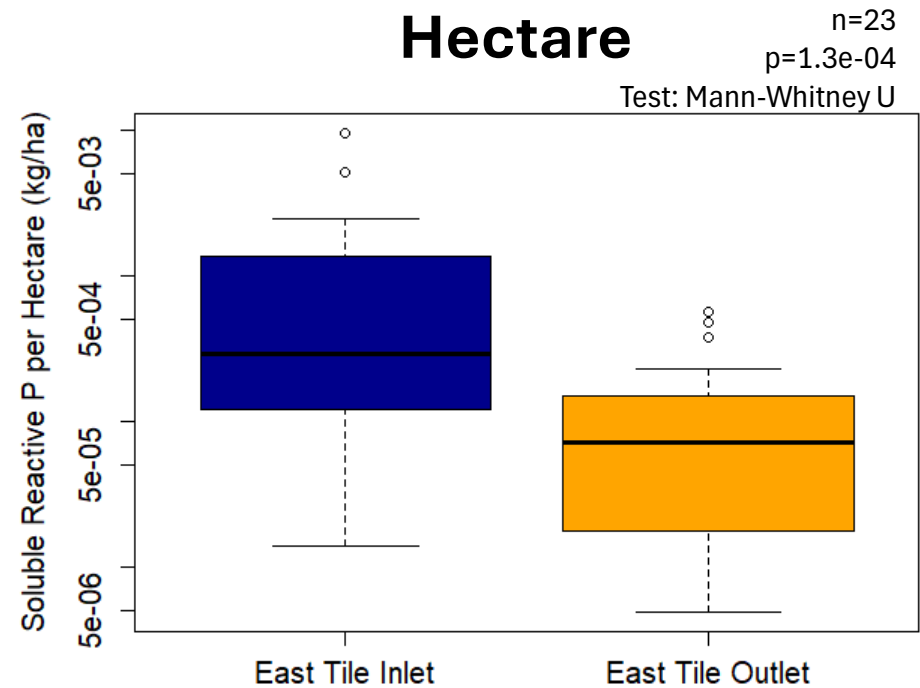
**Removed 54% of  
cumulative TP load**

# East Tile Filter (Soil Health Practices) – Soluble Reactive Phosphorus

## SRP Concentrations





## SRP Loads per Hectare





**Removed 51% of  
cumulative SRP load**

# Tile vs. No Tile: Discovery Farms, VT


Existing Ditches: 


Plastic 'curtain': 


System #1: 

System #2: 

System #3: No drainage

Watershed boundary: 

Surface Runoff Station: 

Tile Station: 

Study Area Boundary: 