Water on the Landscape; A Holistic View

Indiana Farm Bureau Drainage School

Laura Bowling

Department of Agronomy, Purdue University

8/26/25

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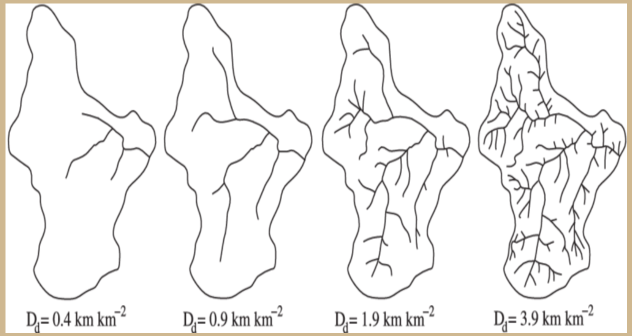
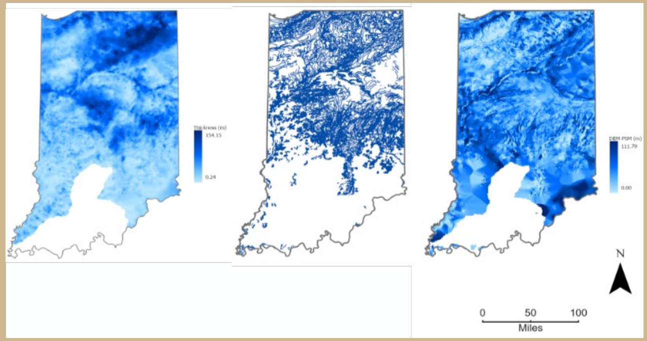
Today's topics

Watershed
drainage density



Storage in the
landscape

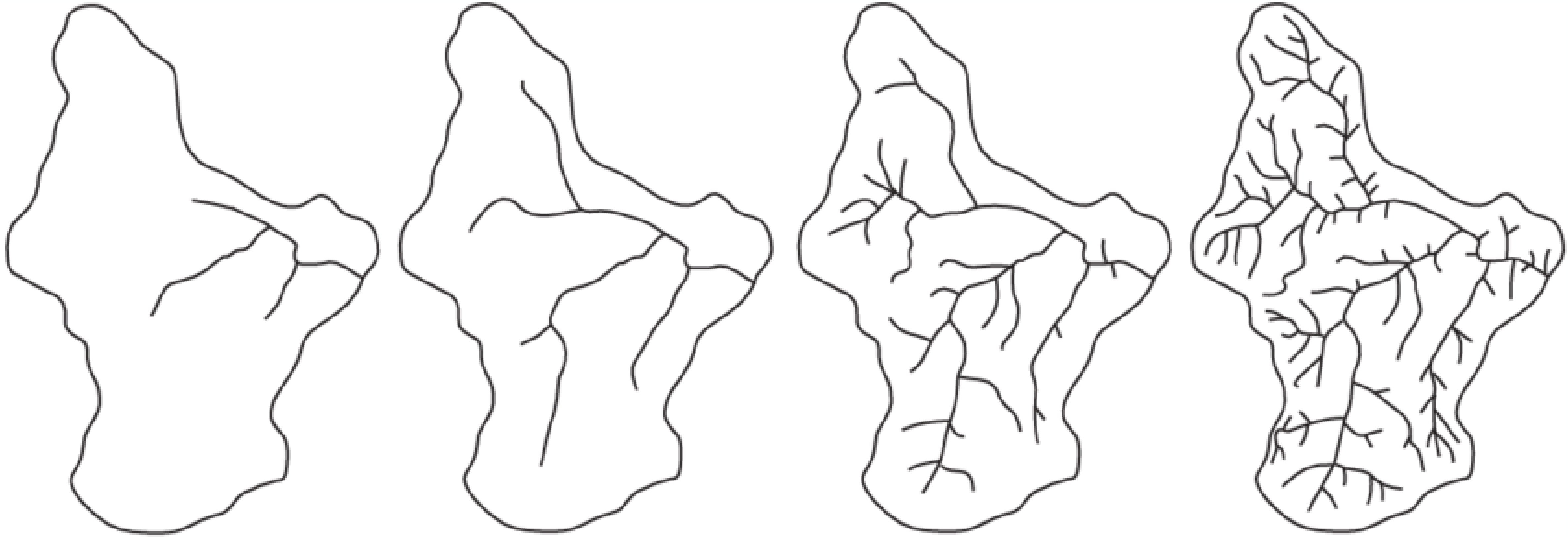
**Groundwater
supply & use**



Appalachian Mtns, WV

The Badlands, SD

Drainage Density, total length of streams per watersh

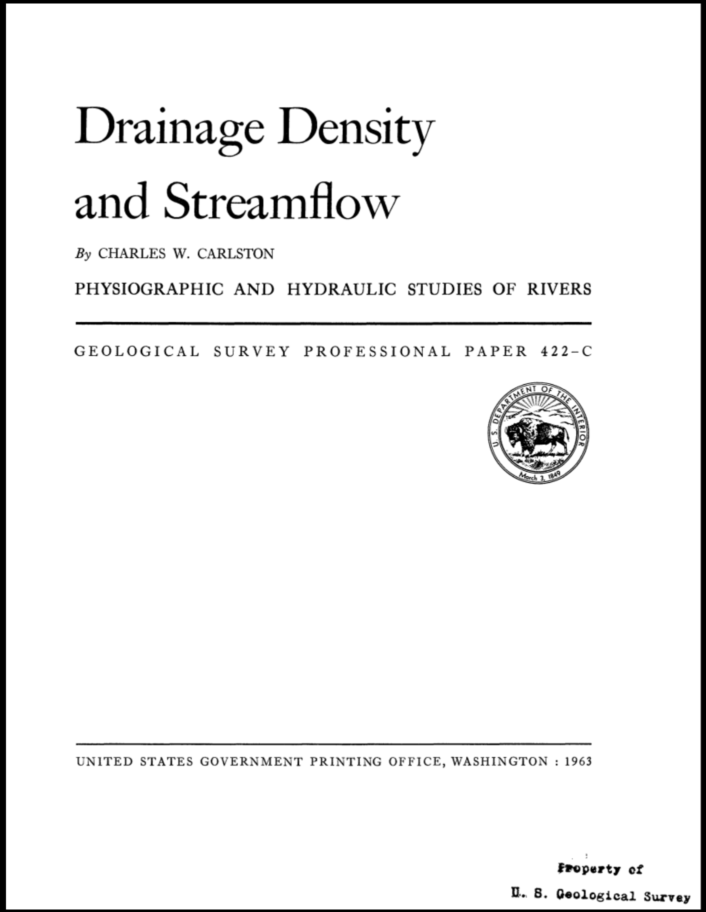


Appalachian Mtns, WV

- D ~ 3 mi/mi^2

The Badlands, SD

- D ~ 400 mi/mi^2



Drainage Density and Streamflow

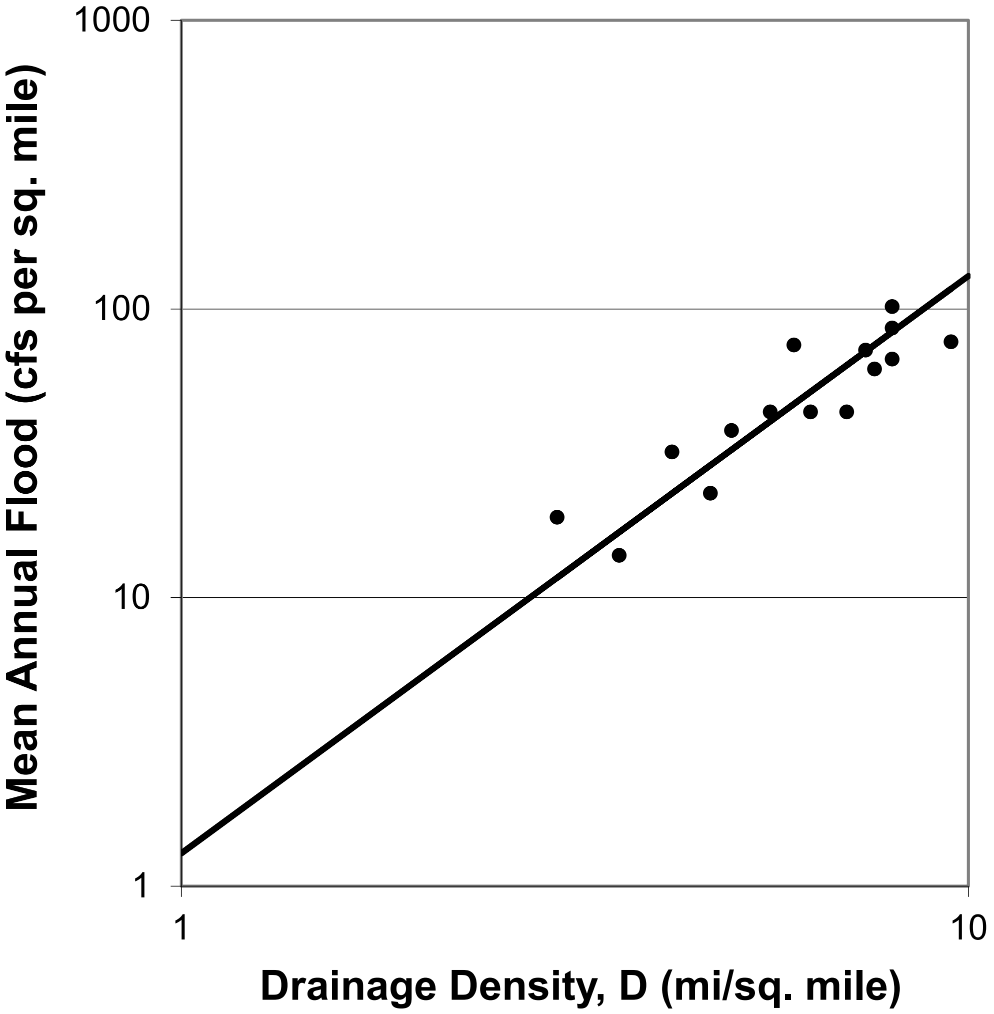
By CHARLES W. CARLSTON

PHYSIOGRAPHIC AND HYDRAULIC STUDIES OF RIVERS

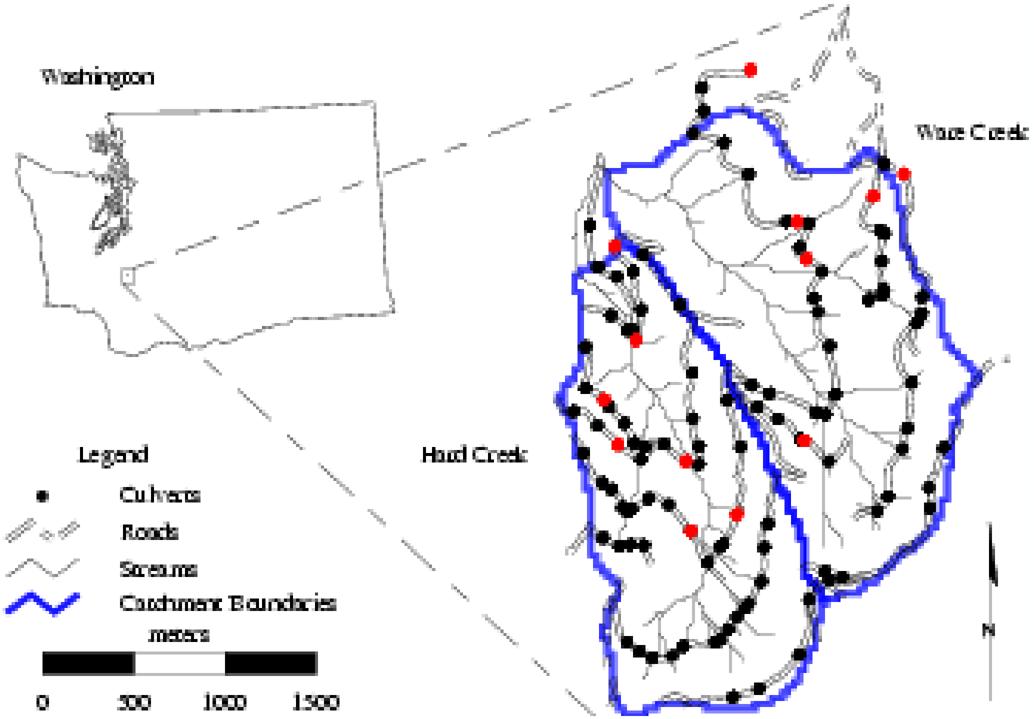
GEOLOGICAL SURVEY PROFESSIONAL PAPER 422-C

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1963

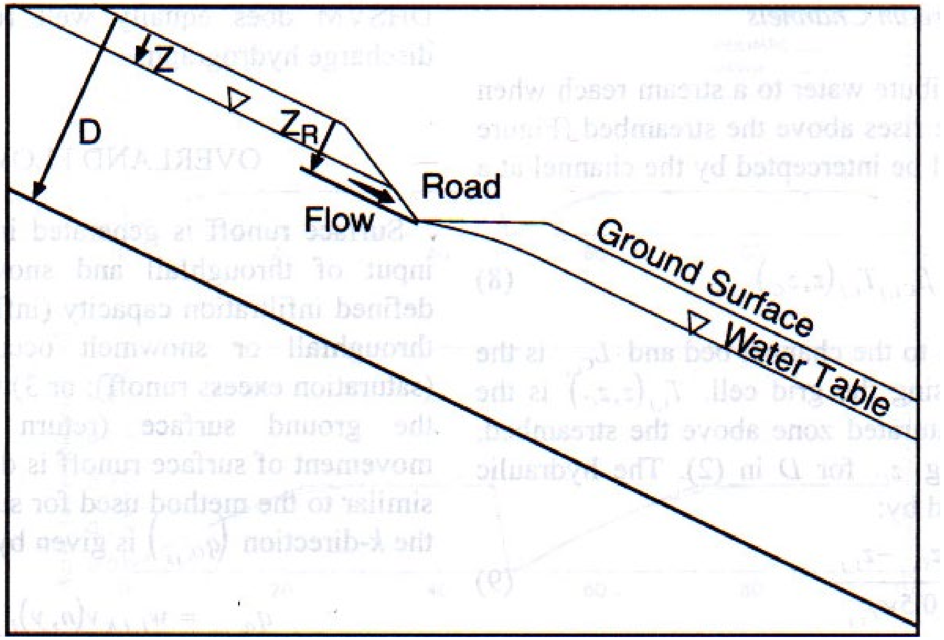
Carlston (1963), Drainage Density and Streamflow, Geological Survey and Professional Paper C.422



Hard and Ware Creeks, WA



Water table interception

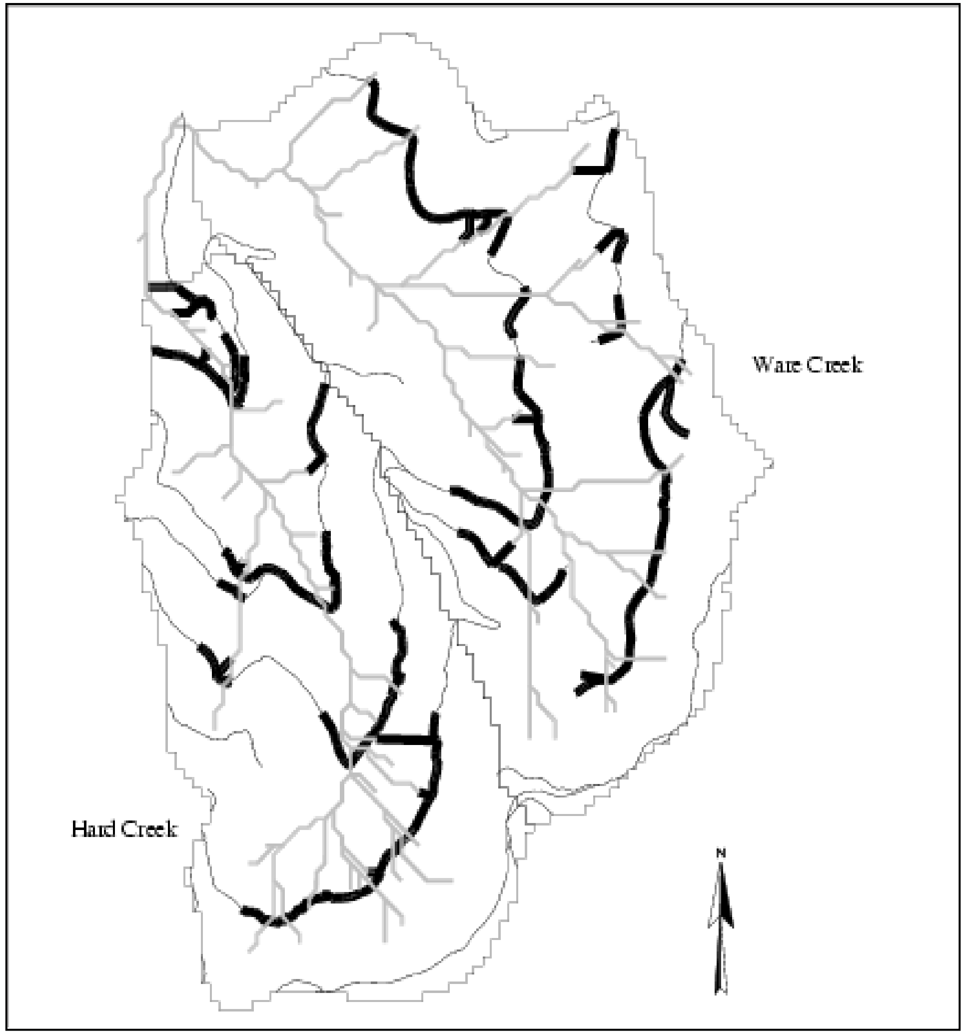


Stream Network Extension

(grey line)	Stream network
(black line)	Extended network due to roads

Stream Drainage Density:
3.6 & 3.7 km/km^2

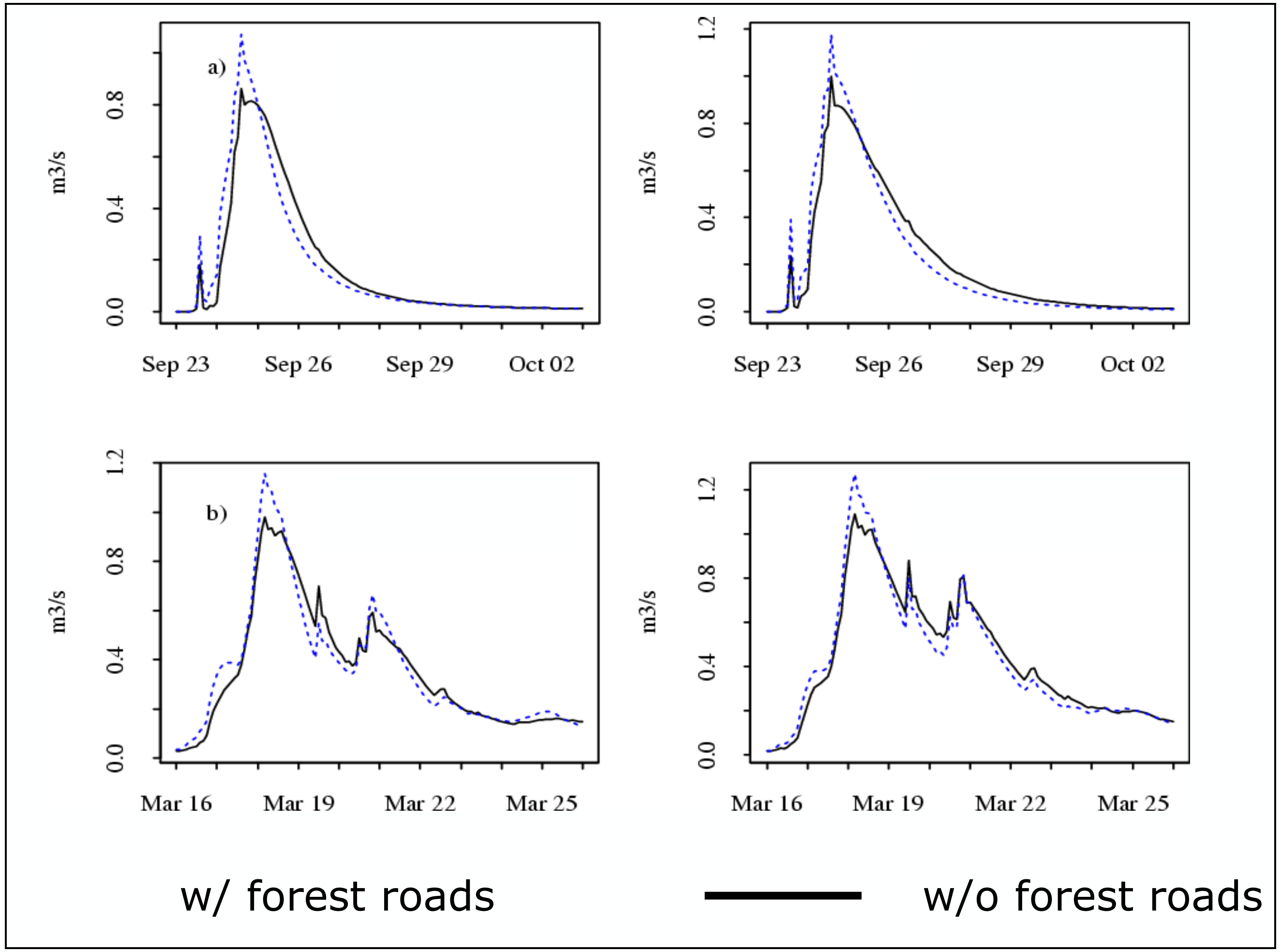
Stream and Road Drainage Density:
5.9 & 5.6 km/km^2



Simulated streamflow
w/ and w/o forest roads

17% increase

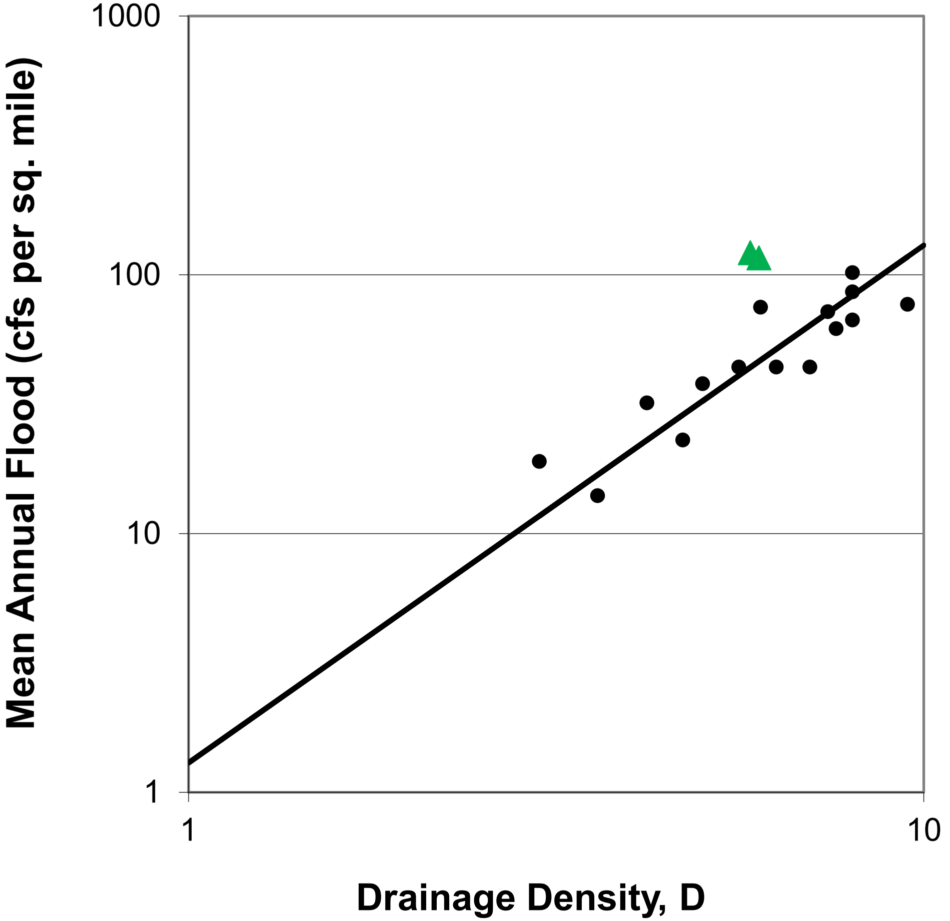
14% increase



Bowling and Lettenmaier (2001), The effects of forest roads and harvest on catchment hydrology in a mountainous maritime environment

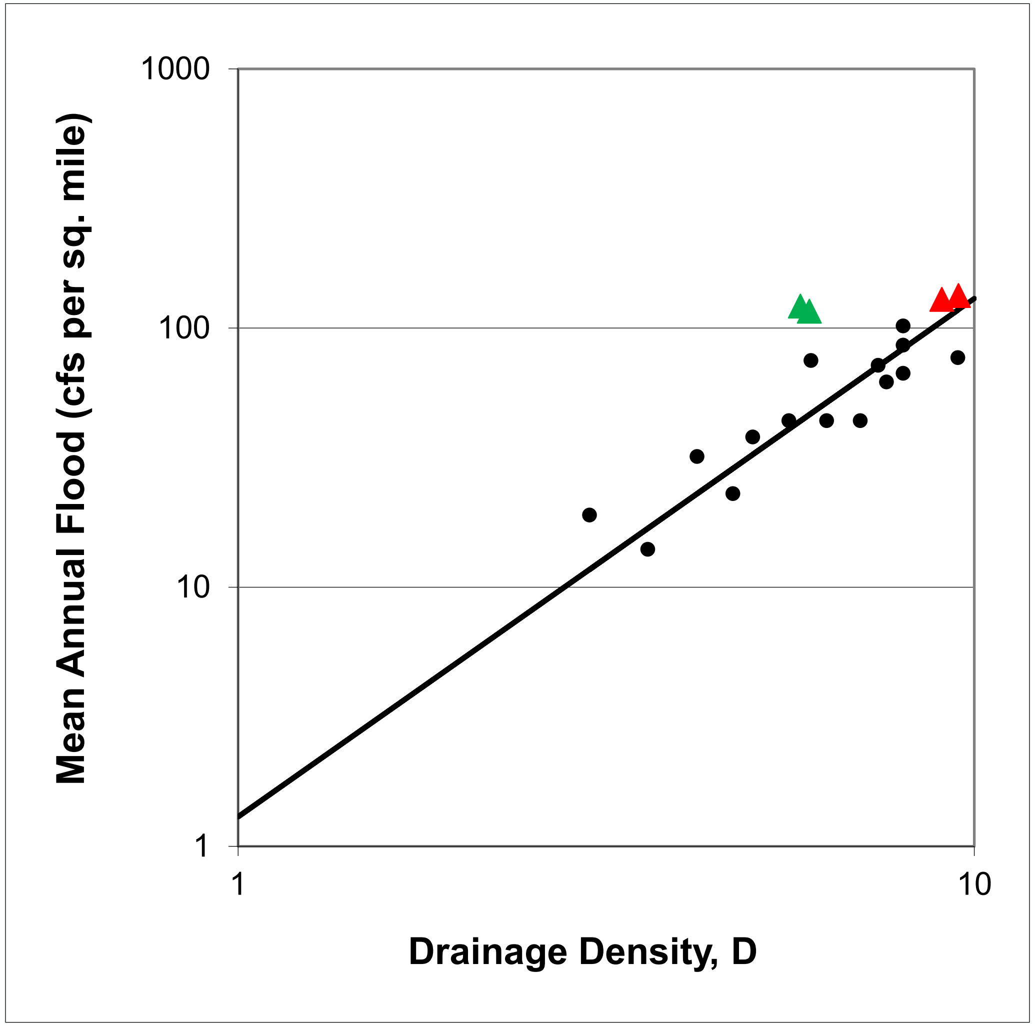
Hard and Ware Creeks, observed floods & drainage dens

Drainage density of streams only



Hard and Ware Creeks, simulated floods

Stream + road density



Midwest Agricultural Drainage

River Witham

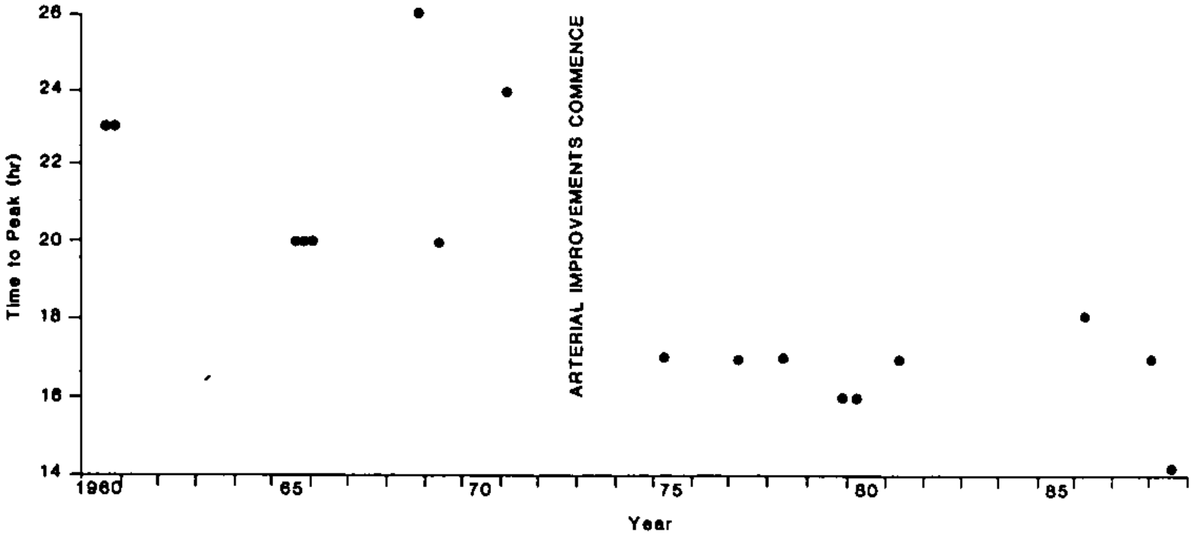


Figure 6.4 Unit hydrograph time to peak values at Claypole, for large events in the period 1960-88

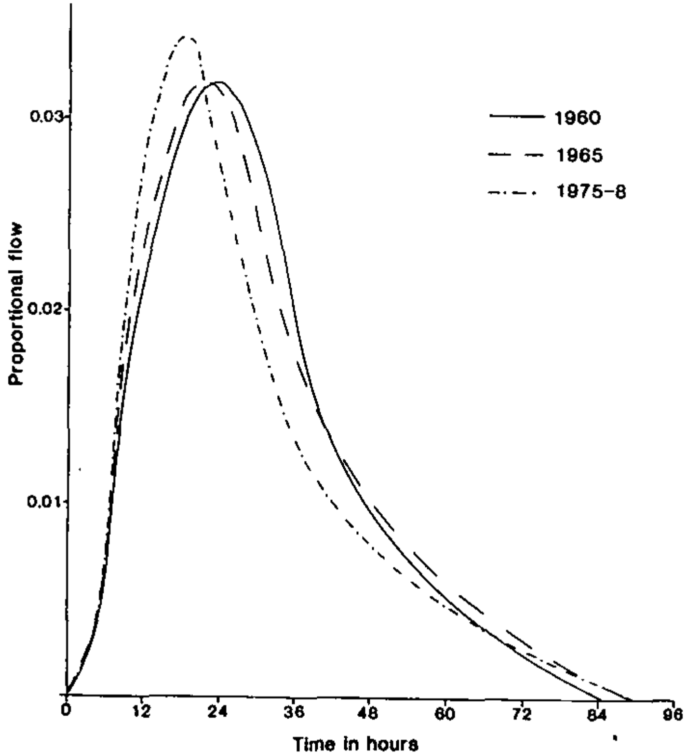
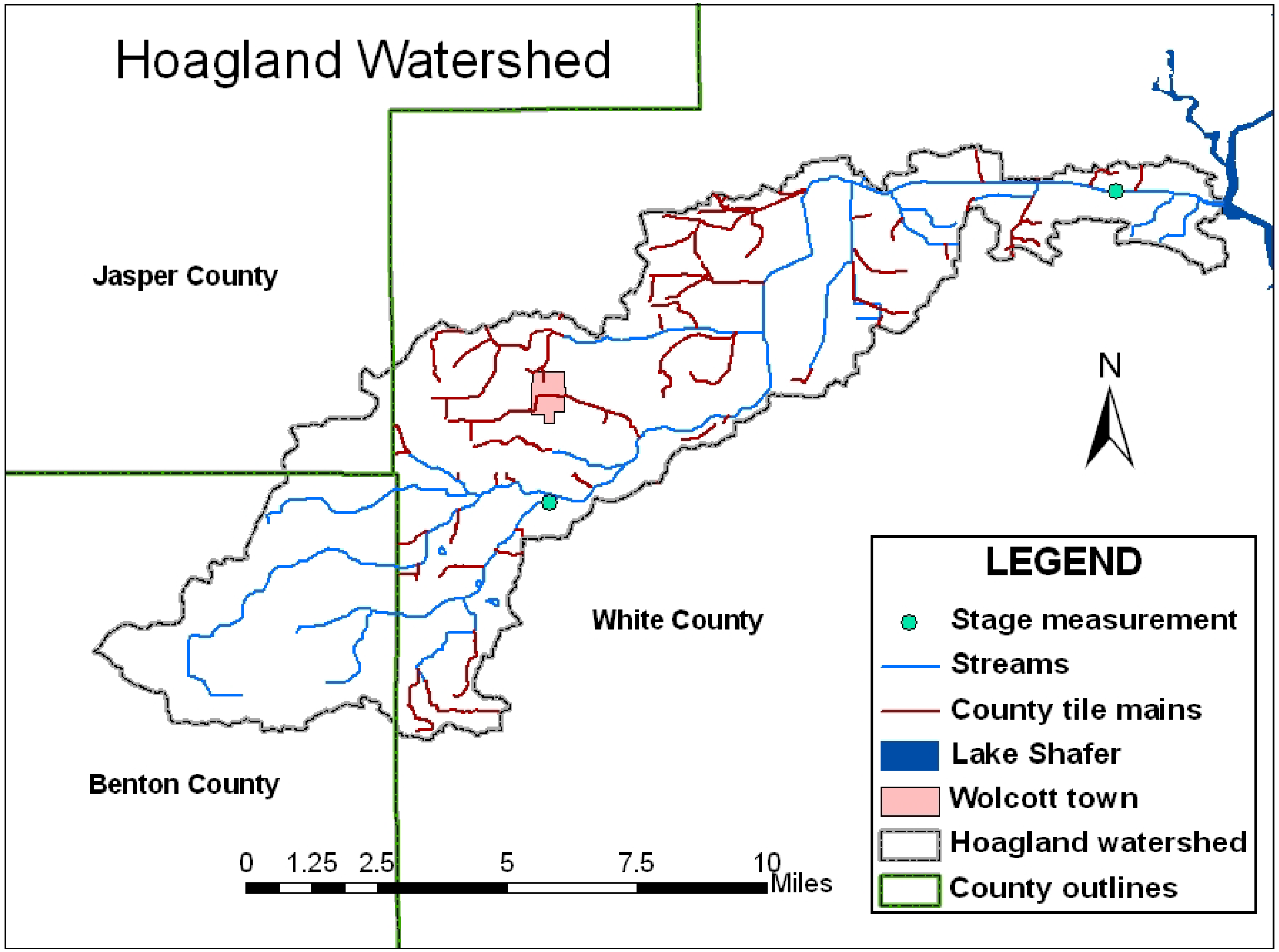


Figure 6.6 Average three-hour unit hydrographs, at Claypole, showing the increase in flow response over time

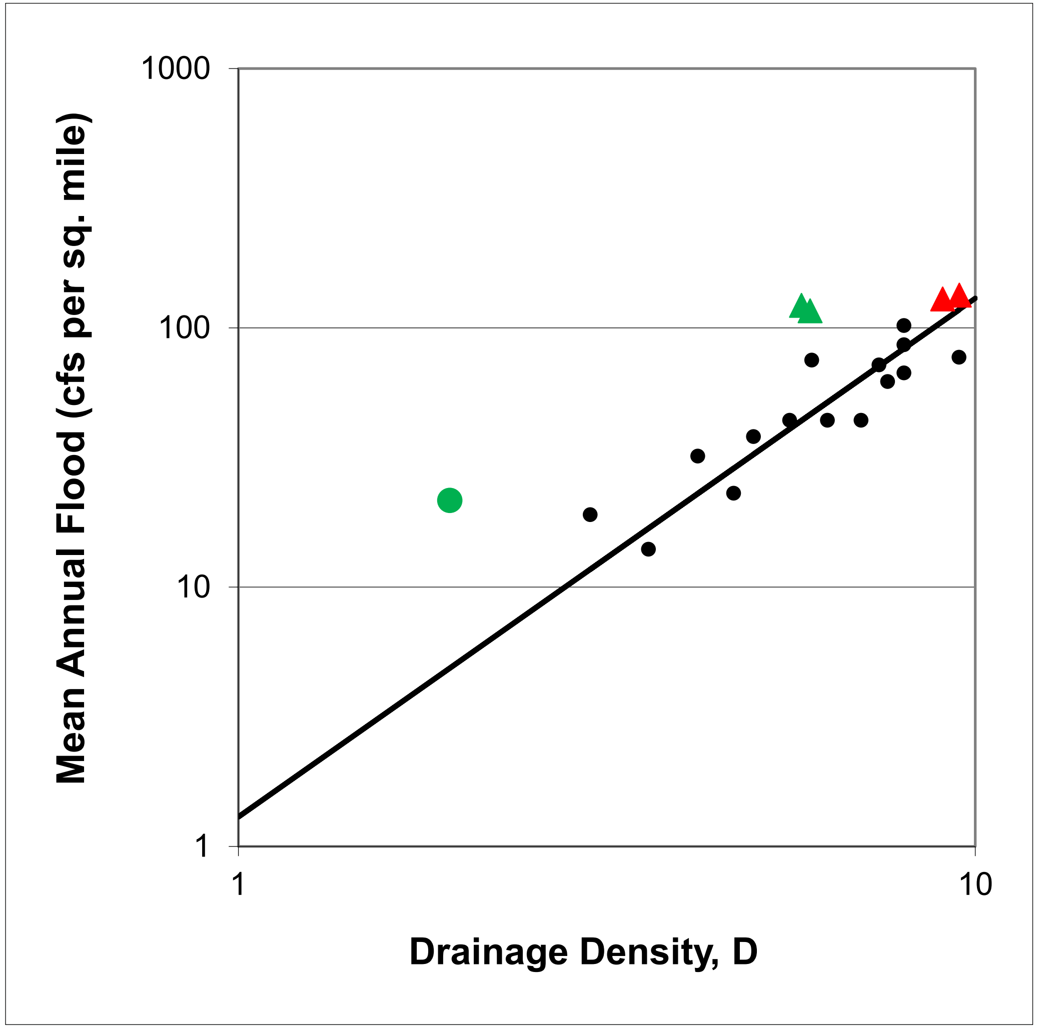
Arterial Expans

- Watershed area: 70.2 mi^2
- Stream length 67.4 mi
- D = .96 mi/mi^2

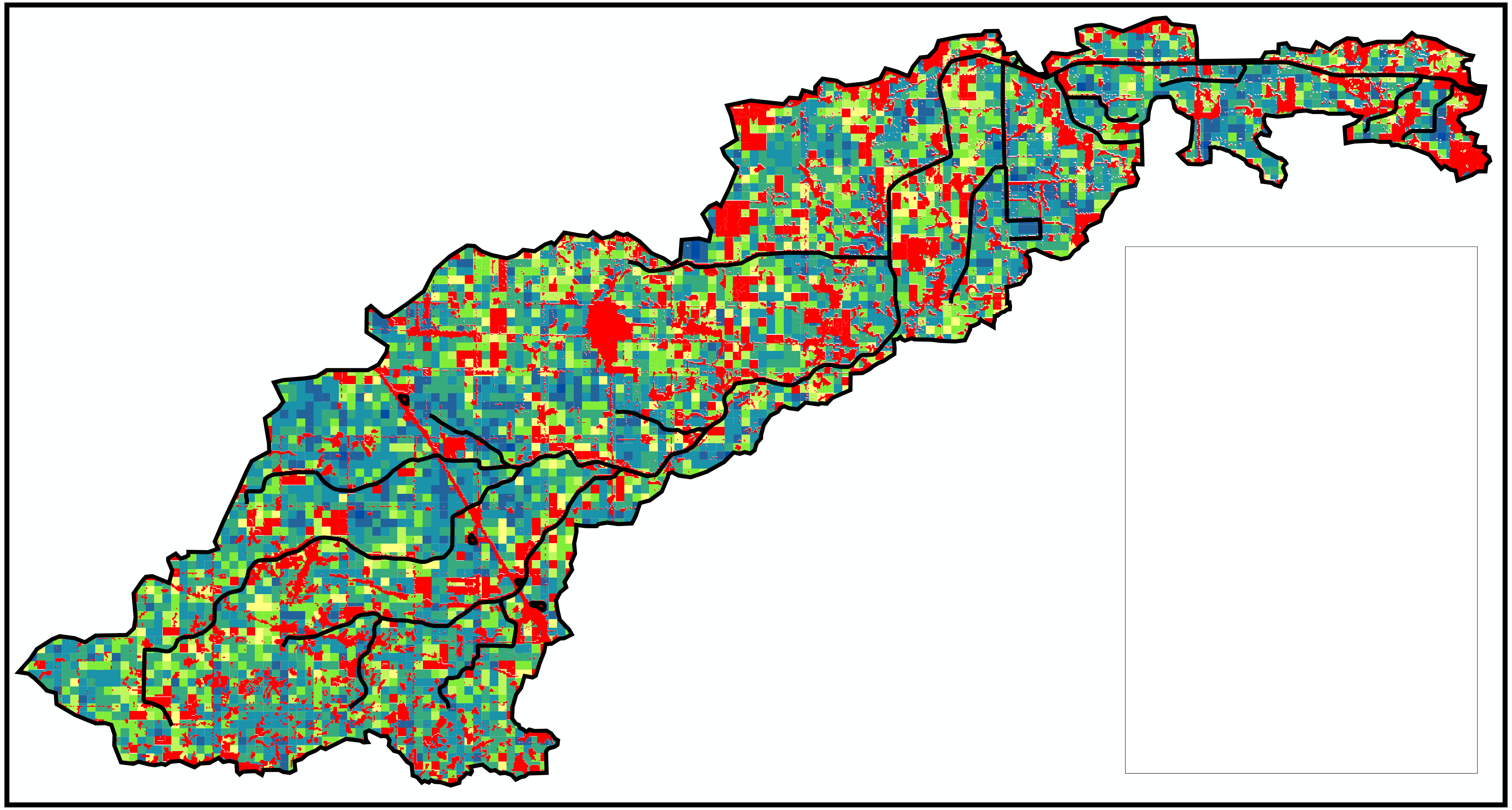
- Length of county mains 68.6 mi
- D = 1.94 mi/mi^2



Effect on Drainage Density

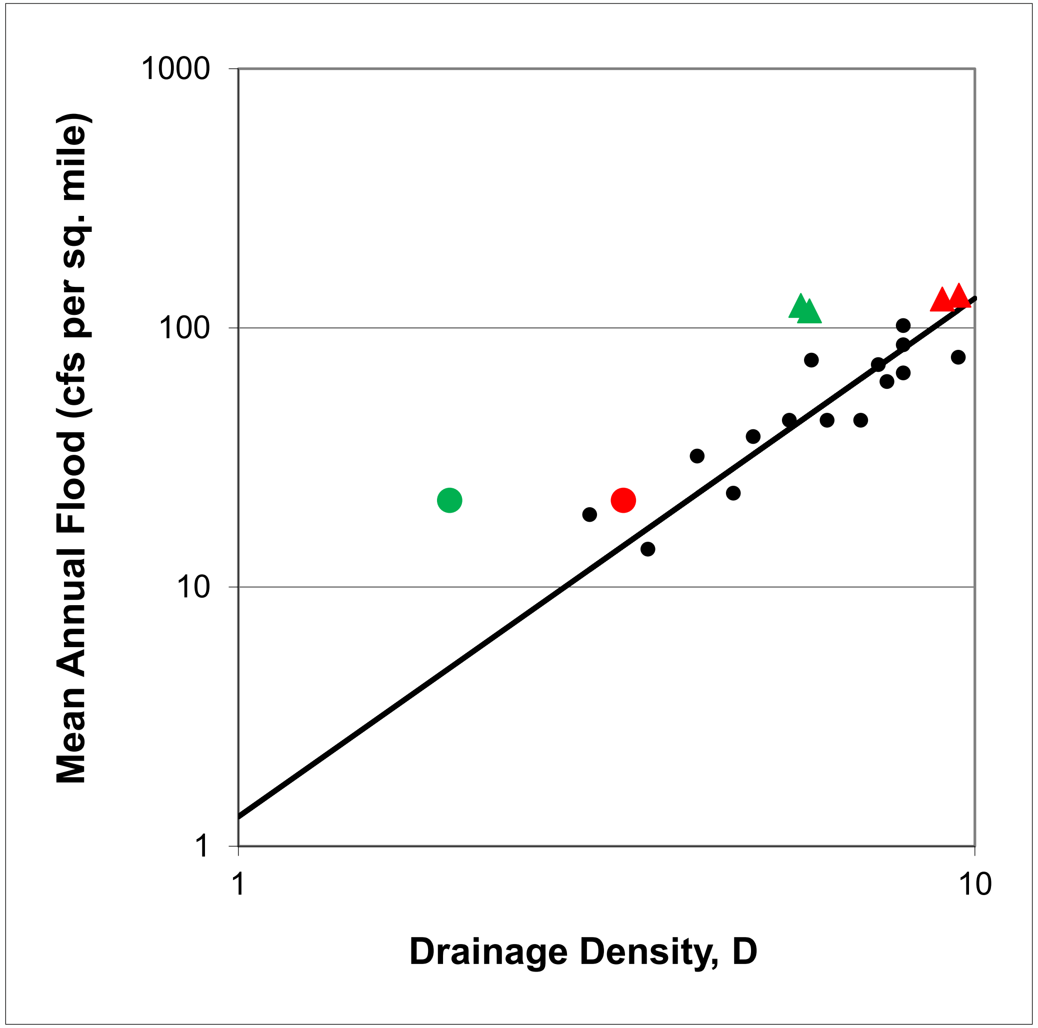


Predicted Tile Spacing in Hoagland Watershed



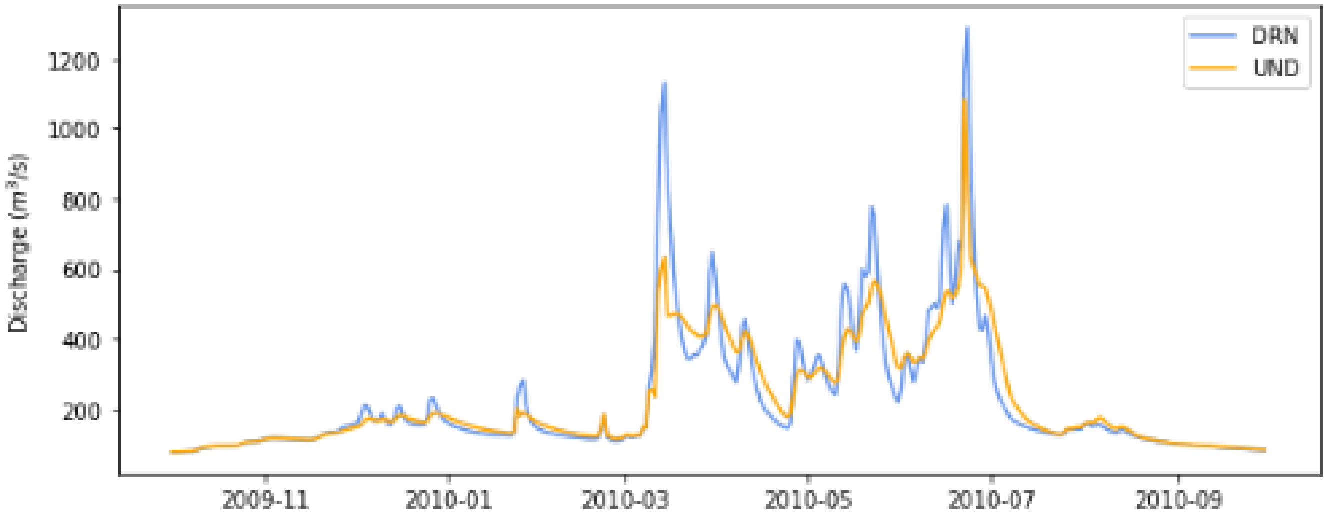
Ale et al. (2007) “Mapping of Tile Drains in Hoagland Watershed for
Simulating the Effects of Drainage Water Management

Effect on Drainage Density

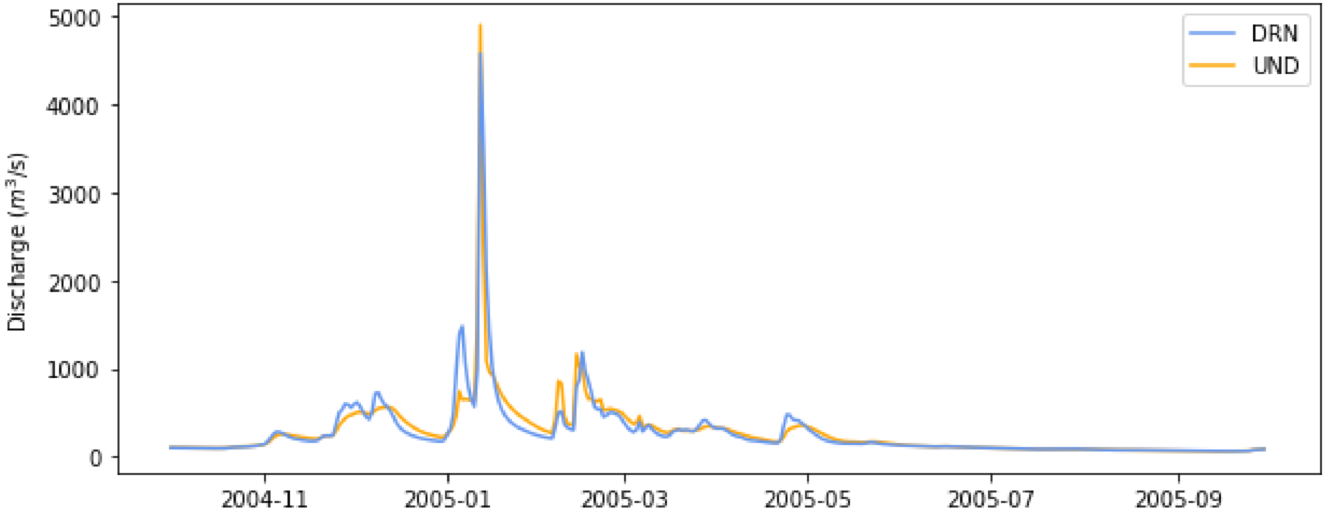


Wabash River @ Covington

Hydrologic model simulations



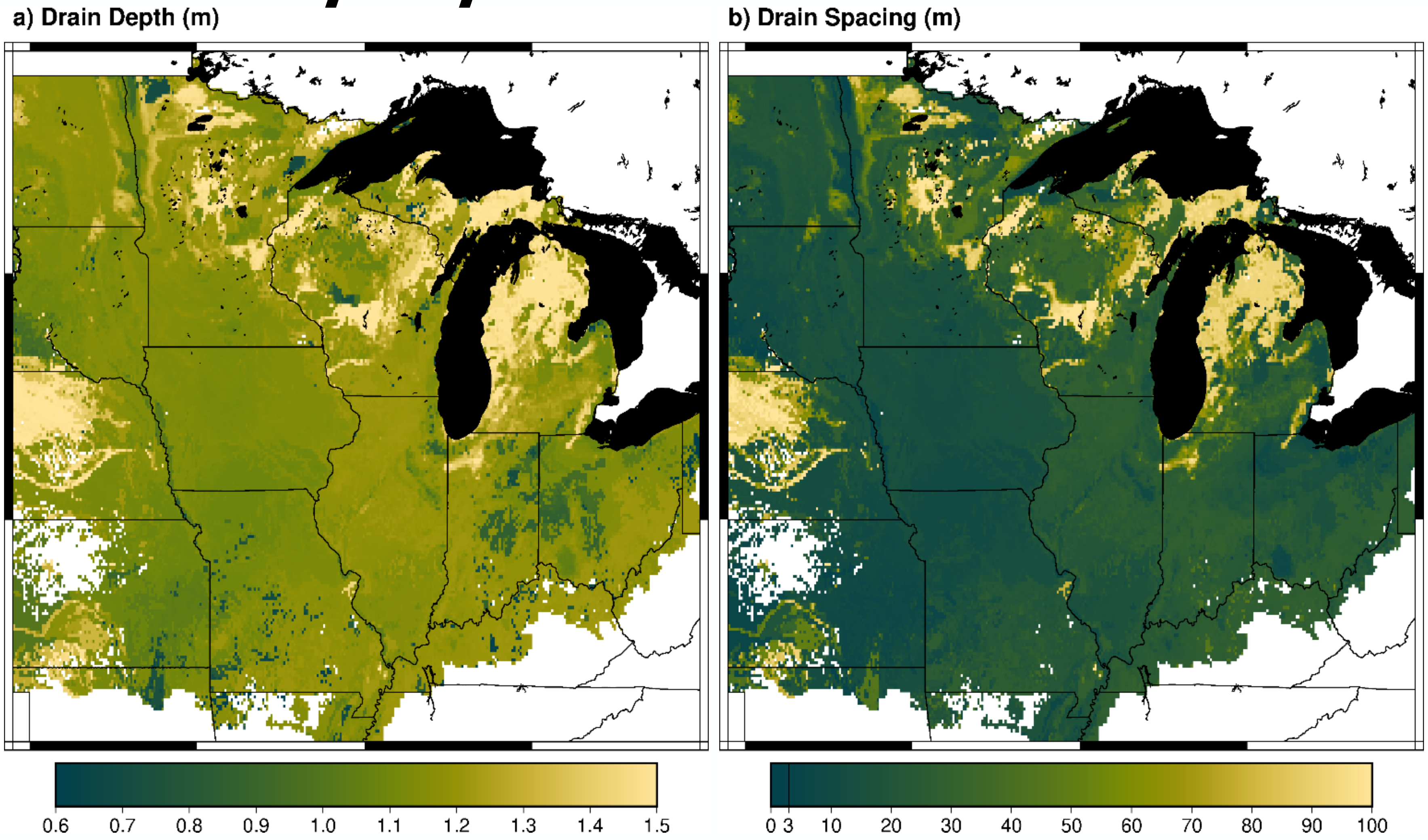
Moderate floods, > 3 x median flow
Subsurface drainage increases the peaks



Large flood, > 7 x median flow
Subsurface drainage decreases the peaks

Lee, Charlotte (2023), Evaluating Subsurface Drainage Hydroclimatology and Impacts on Streamflow Across the Corn Belt. Doctoral Dissertation, Purdue University, West Lafayette, IN.

Drain depth and spacing datasets for the US Co based on soil properties



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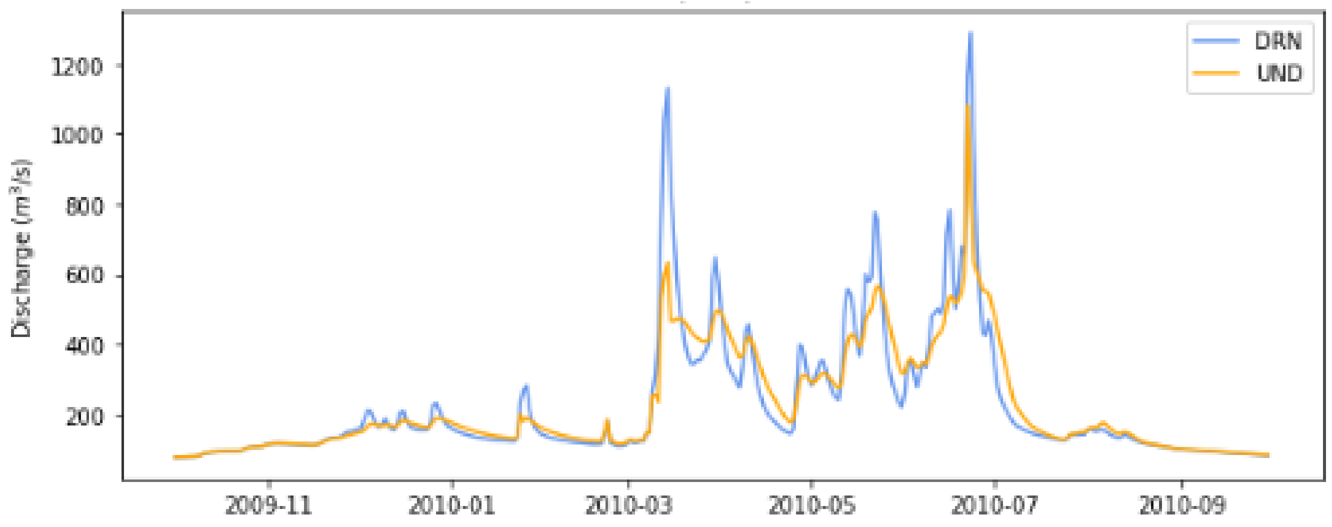
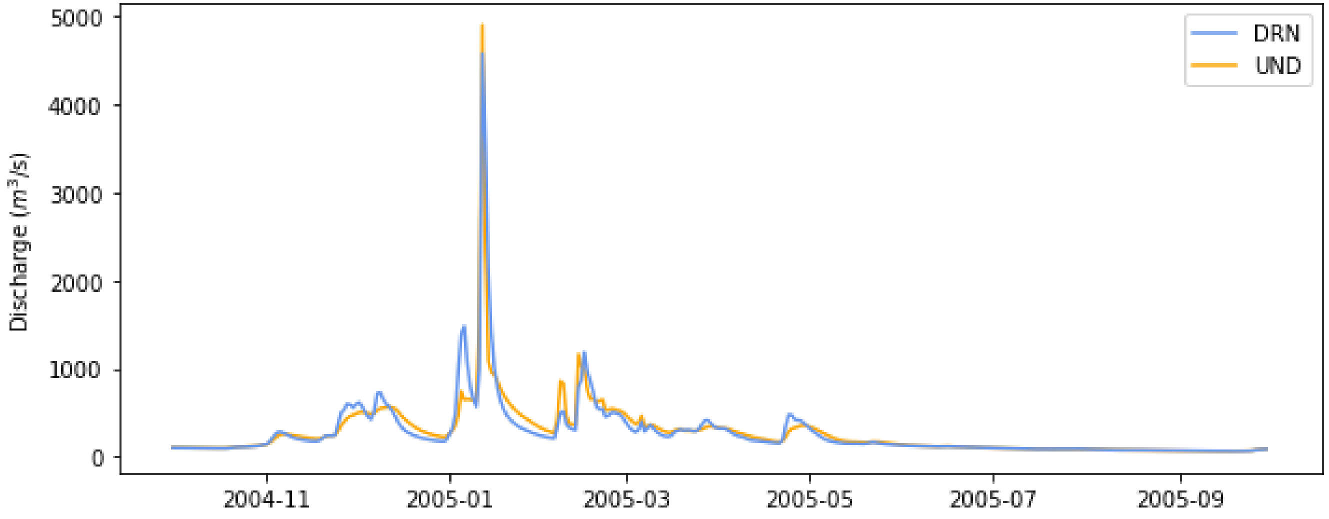
Wabash River @ Covington

Hydrologic model simulations

Moderate floods, > 3 x median flow
Subsurface drainage increases the peaks

Soil or depressional storage is still available in the undrained case.



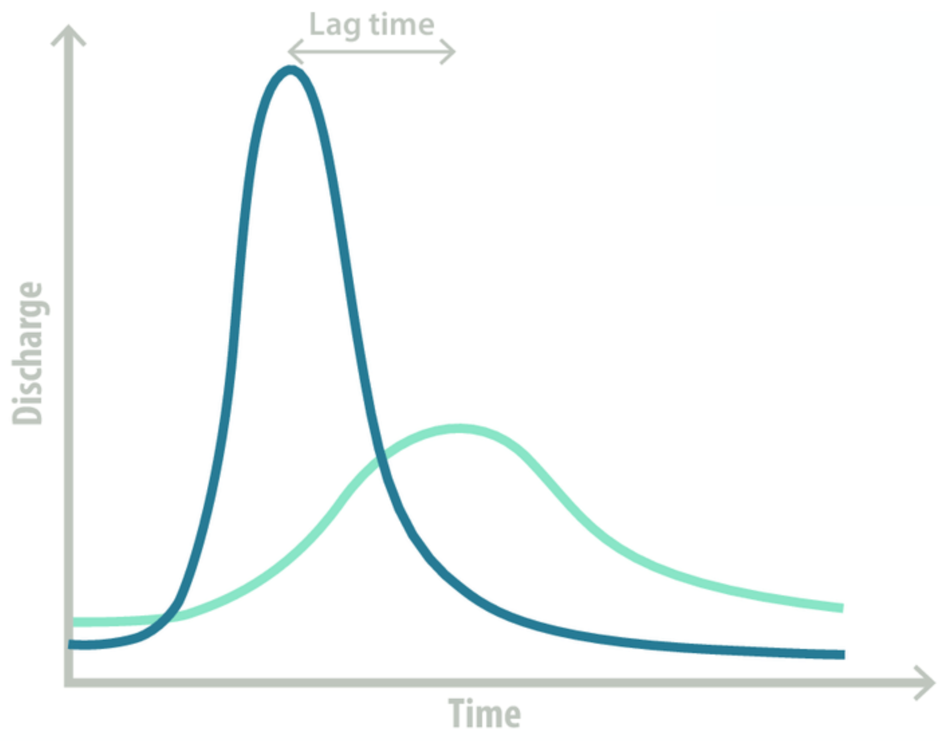


Large flood, > 7 x median flow
Subsurface drainage decreases the peaks

All the storage is filled in the undrained case.

My holistic view

- More channels in the landscape, whether natural streams, ditches or pipes:
  - ➢ Decrease the travel time to the basin outlet or downstream point;
    - ➢ Compressing the travel time means that more water gets to the outlet at the same time;
      - ➢ This increases peak flows downstream.

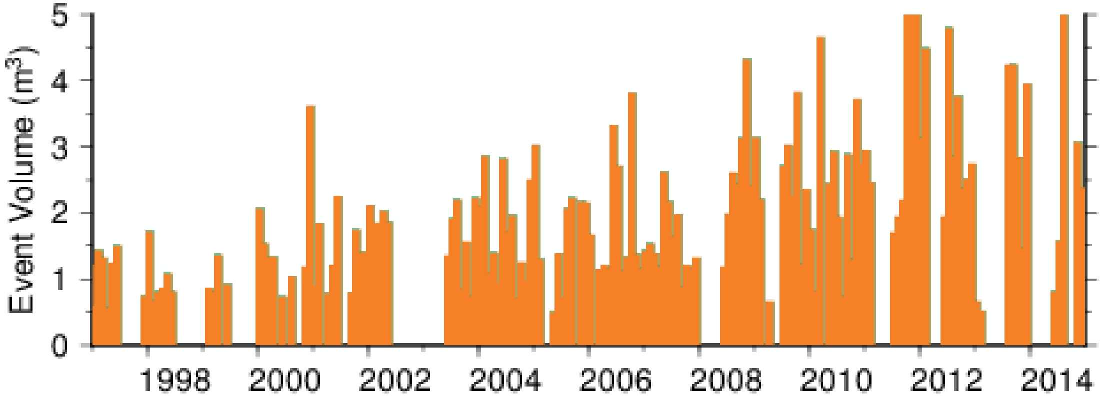


Slowing down water and increasing watershed storage can flatten the curve, while still protectin

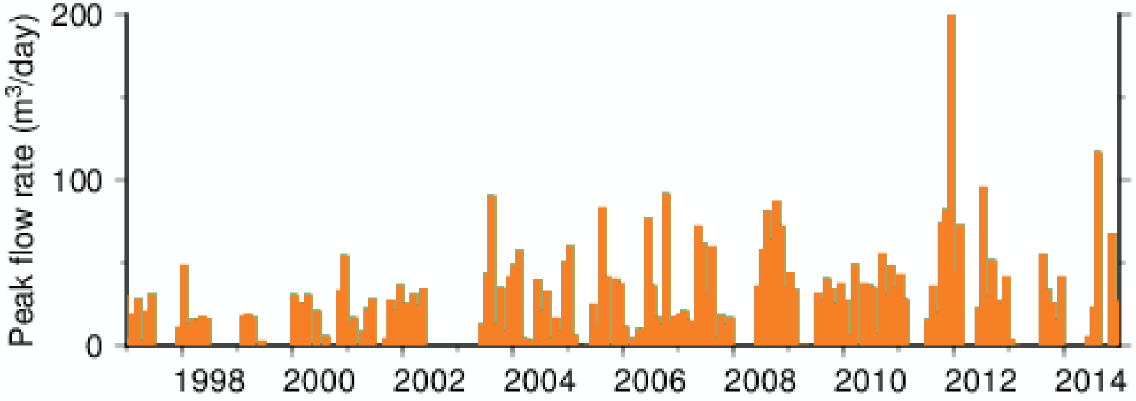
Drainage events are getting larger over time

SE Purdue Agricultural Center Long-term Drainage Study

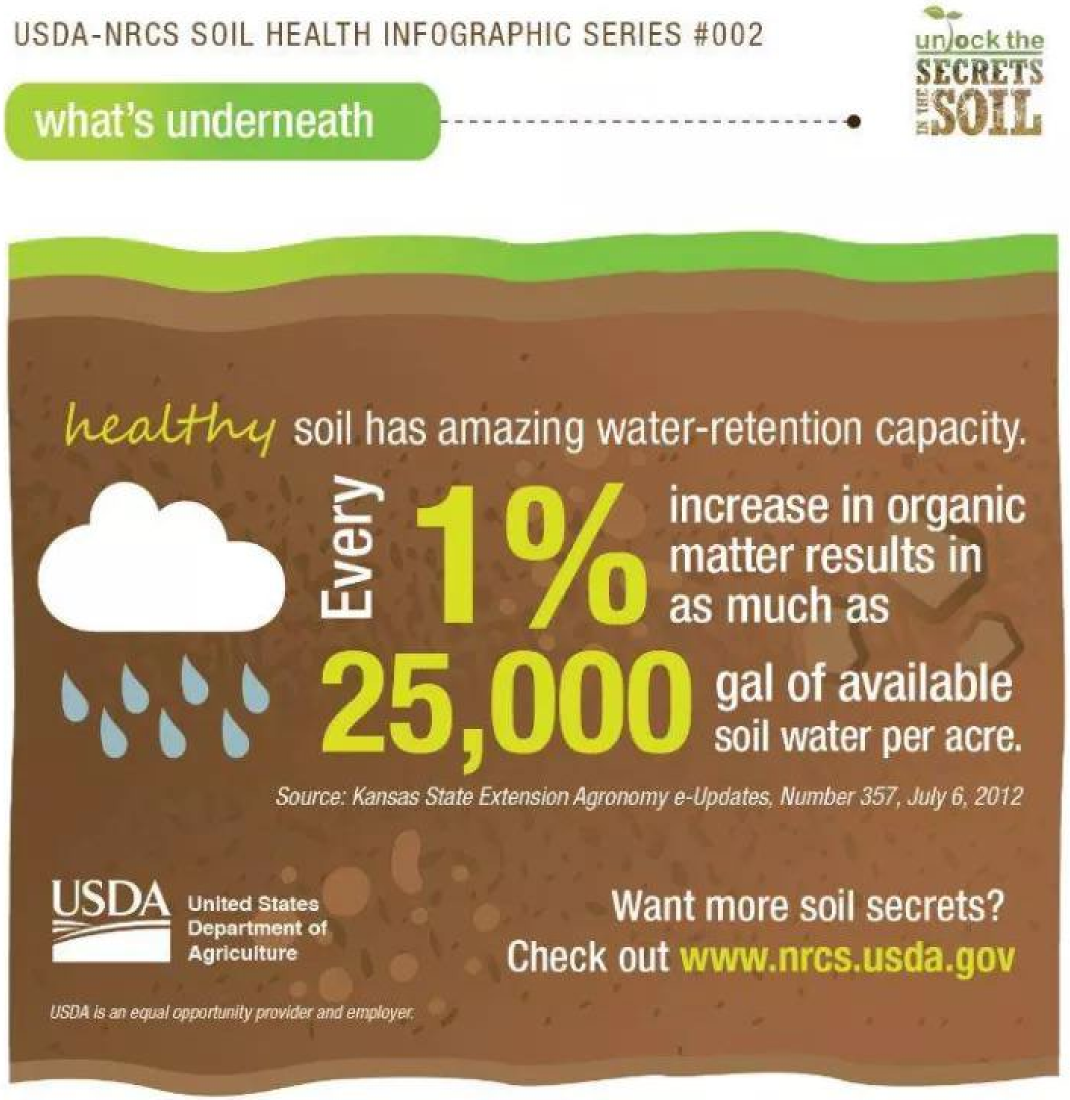
- Monthly mean storm volume
  - Significant increase for all 6 drains
  - Trend rates of 376–1600 L/yr



- Monthly mean peak flow rate
  - Significant increase for all 6 drains
  - Trend rates of 84–122 L/hr/yr

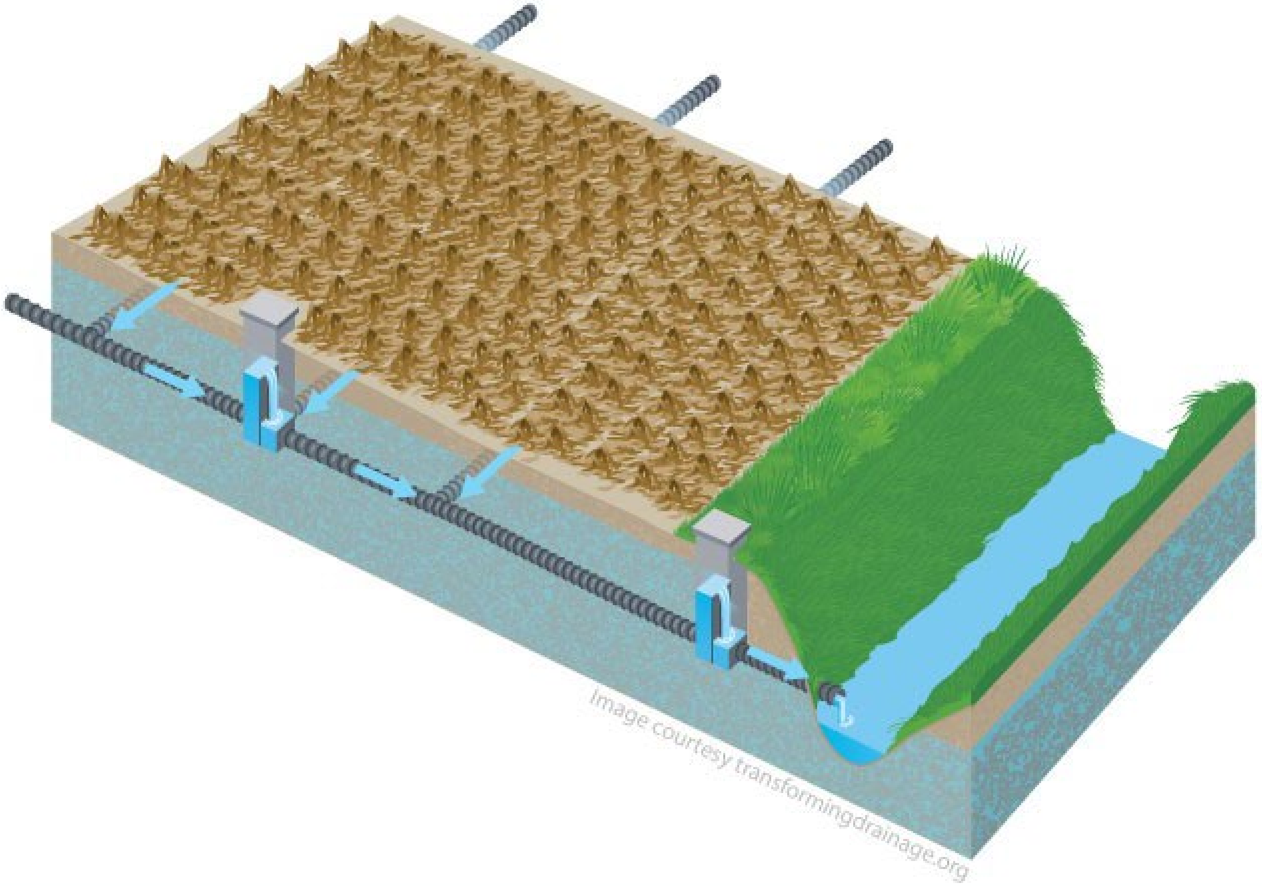


Healthy soils increase storage



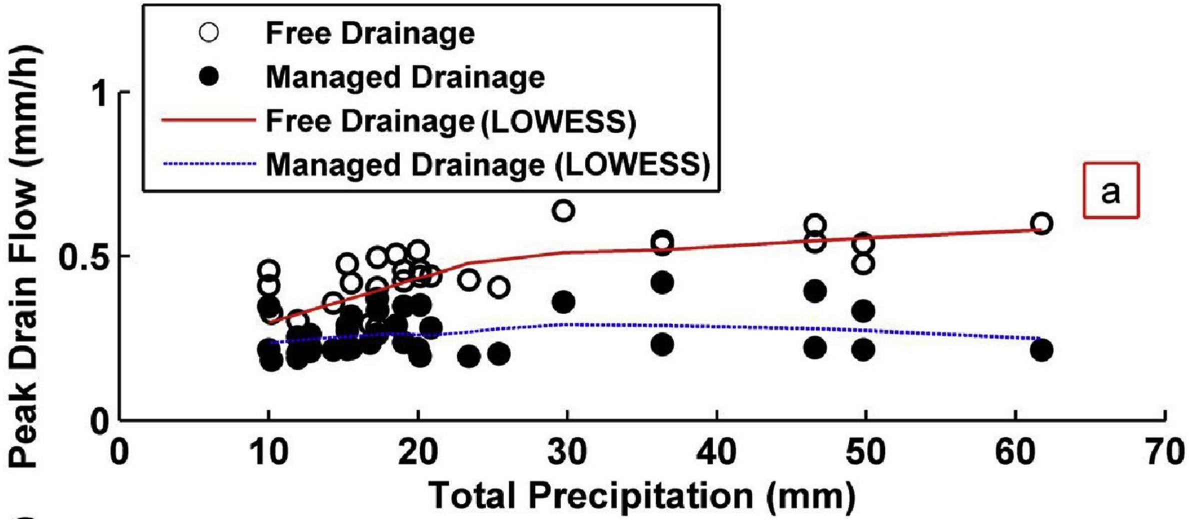
Controlled drainage can increase in-field storage when drainage is less needed

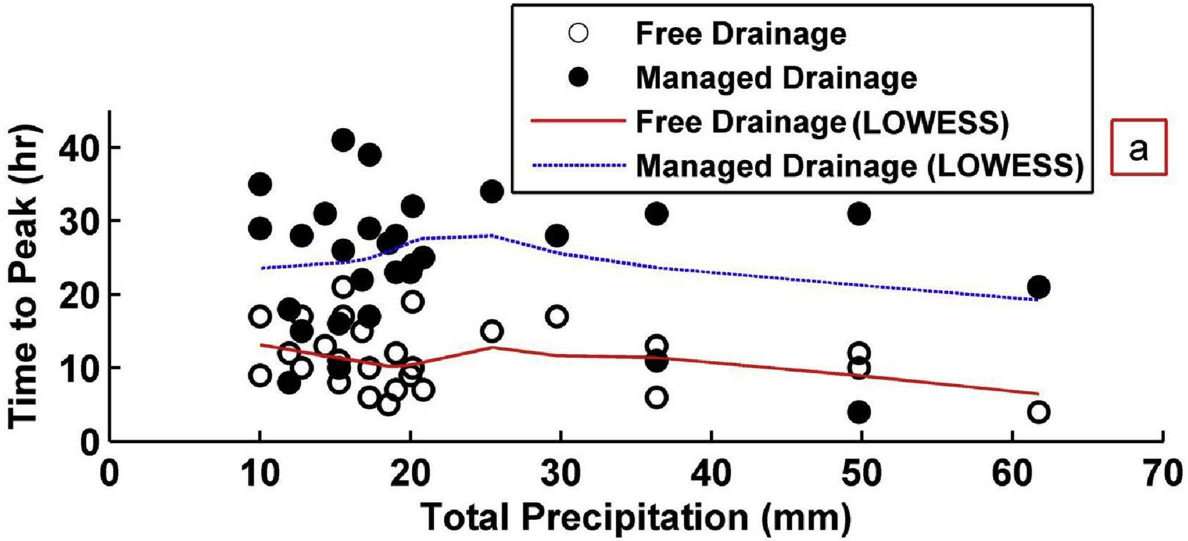
In controlled drainage, edge-of-field structures are used to prevent drainflow until the water table rises above the outlet control structure.



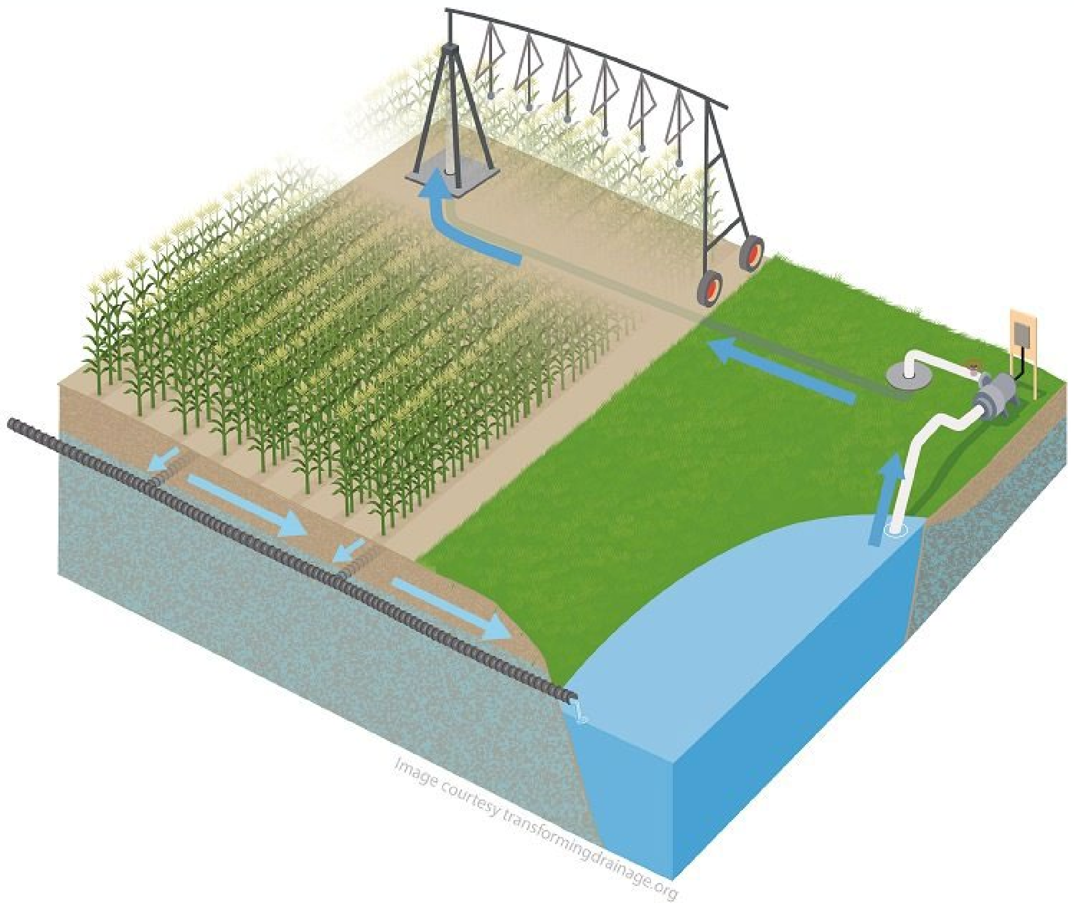
Controlled drainage increased lag time, decreas flow and total drainage volume during storm eve

- Davis Purdue Agricultural Center (DPAC)
- Controlled drainage reduced event drainage volume and peak flows by 22% ± 12% and 29% ± 16%.
- It increased the time to peak of drainage by 98% ± 52%.





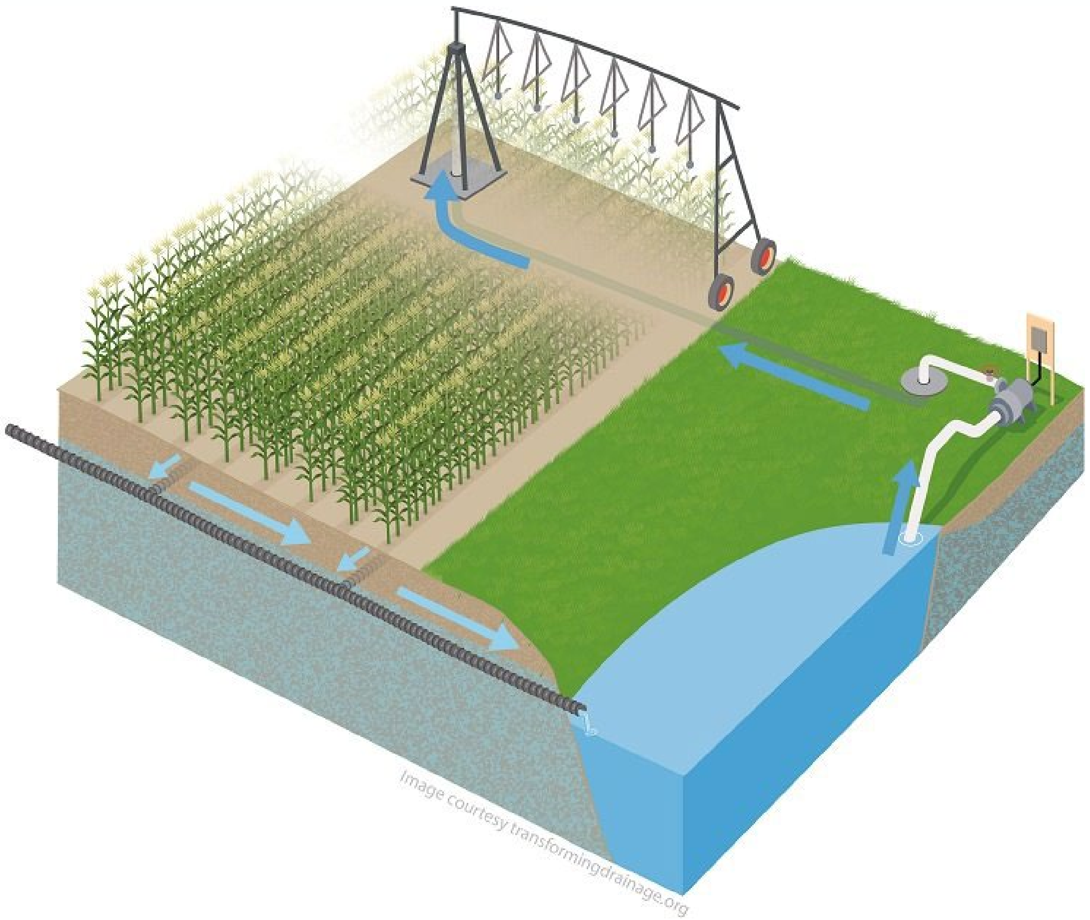
Drainage Water Recycling



In drainage water recycling, subsurface drainage water is captured in an on-farm reservoir and applied later in the season as supplemental irrigation.

ACRE Drainage Water Recycling Project

- Ecointensification using wetland water for fertigation
  - Climate adaptation
  - Water quality mitigation
  - Flood control
- In collaboration with:
  - *Dr. Shaun Casteel, Dr. Laura Bowling, D Quinn, Agronomy*
  - *Dr. Keith Cherkauer, ABE*
  - *Dr. Juan Sesmero, Ag Econ*



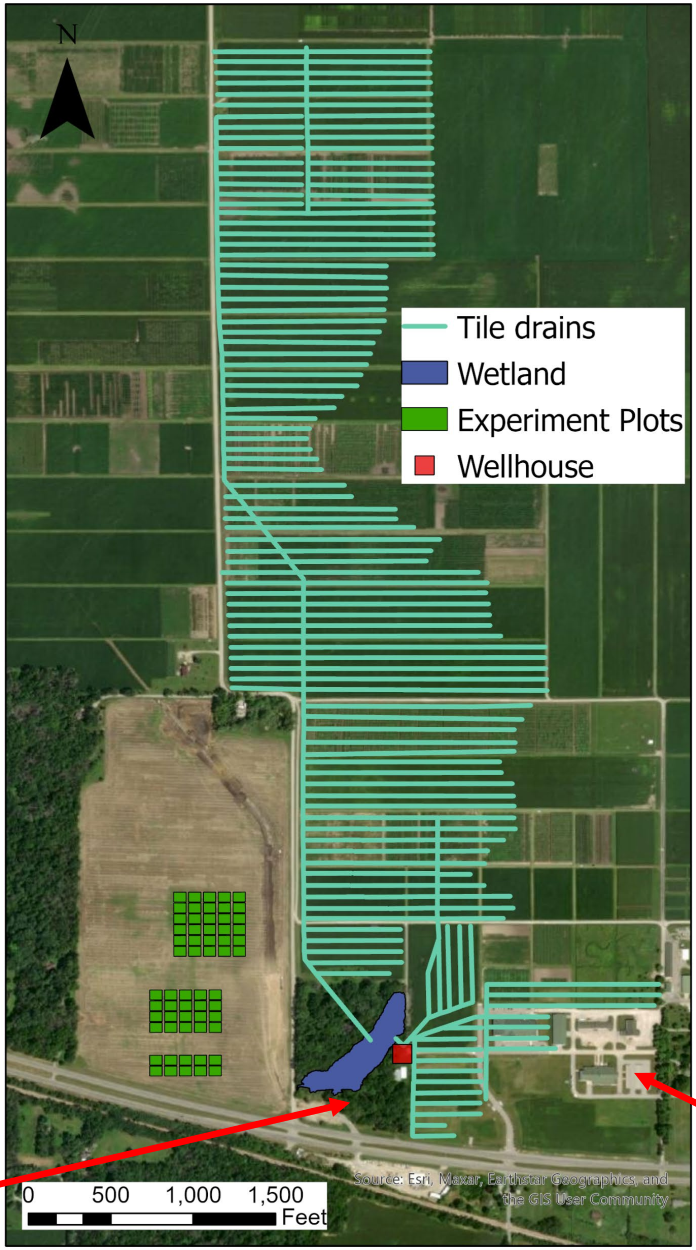
USDA NIFA

Water Control Structure at Wetland Outlet

- Custom AgriDrain Structure
- 6” removeable boards control water level within the wetland

During installation

Buried Structure



Beck Center

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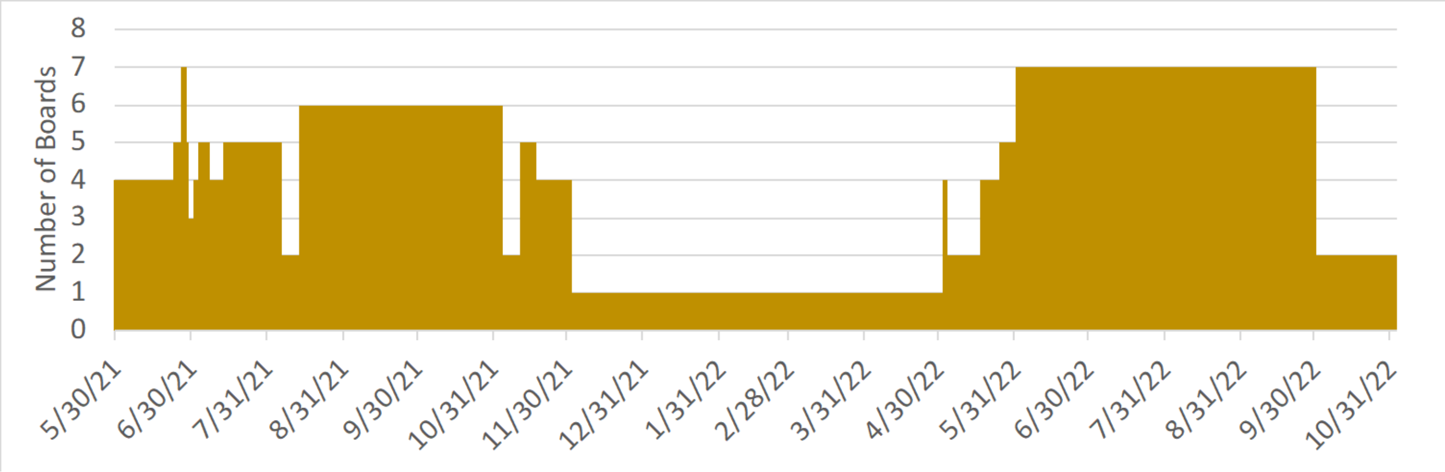
Operational Strategy

Free-flowing (1 board + weir) during the non-growing season (part of our pe

Increase storage in early May, watch the weather

3 boards is “safe level” during extreme rain – flow rate limited by downstrea



Maximum water level
in May/June 2022

Irrigation Water Supply

Passes through water filtration system

Powered by a 6500 W portable generator

PVC elbow to 4” flexible hose to existing ACRE groundwater well for backup

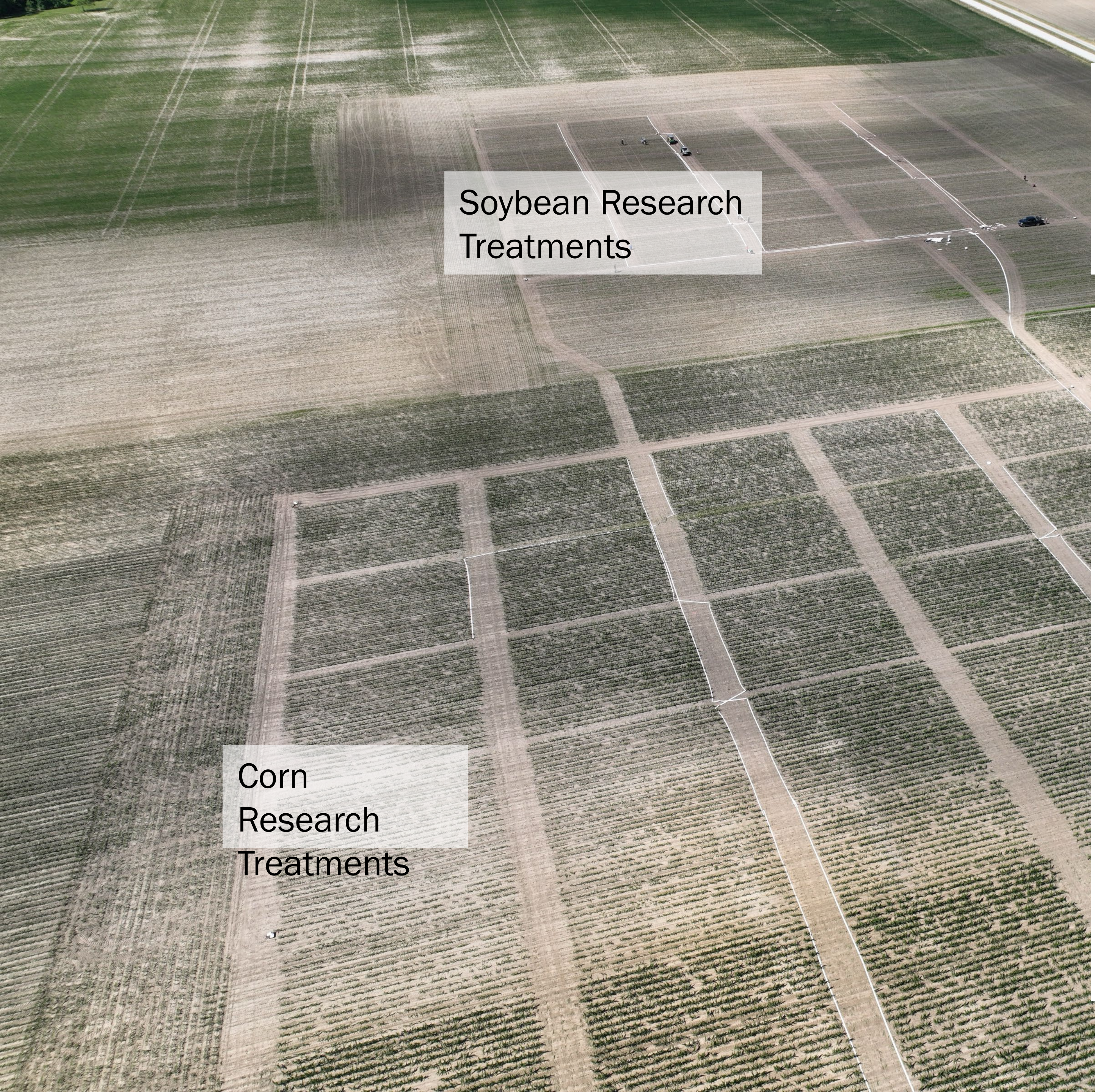
2 HP centrifugal pump, provides about 26 psi of pressure at 90 GPM

Inflow from wetland 10’ 2” intake hose with foot valve

Field Layout

- Buried 2” mains supply water to 24 zones:
  - 30" spacing for driplines
    - Every row in corn
    - Every other row in soybean
  - DripNet PC 636 15ml
    - Emitters every 27”
    - 0.16 gallons per hour flowrate
- Netaflex 3G multi-channel dosing channel for fertigation

Thank you to Netafim for supporting our research!



Established 2021

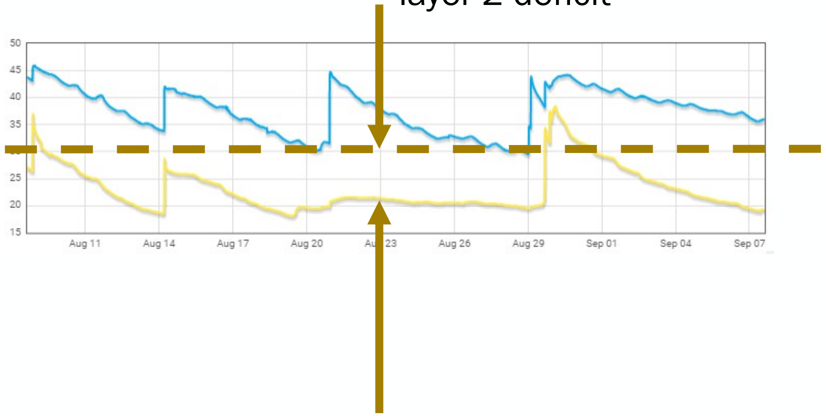
- Drip irrigation with Netafim materials:
  - Surface, 2021, 2022, 2023
  - Subsurface 2024-present
- Treatments
  - Water management:
    - Rainfed
    - Irrigated
    - Fertigated
  - Agronomic management:
    - Standard
    - Intense (seeding rate, S, K, fungicide)

When and how much do we irrigate?

- Both irrigation checkbook and soil moisture sensors are used to determine soil water deficits.
- Both methods are compared, and if soil moisture deficit of irrigated plots is greater than 30%, we irrigate.
- Irrigation depth is based on 3 day average ET losses

water balance "checkbook"

Date	Week Past Emer-	Penman Eto	Kc	Crop ET (ET)	Effective Rain ®
-	-	in		in.	in.
6/19/2022	2	0.65	0.23	0.15	0.00
6/20/2022	2	0.70	0.23	0.16	0.00
6/21/2022	3	0.78	0.33	0.25	0.00
6/22/2022	3	0.63	0.33	0.21	0.00
6/23/2022	3	0.72	0.33	0.24	0.00



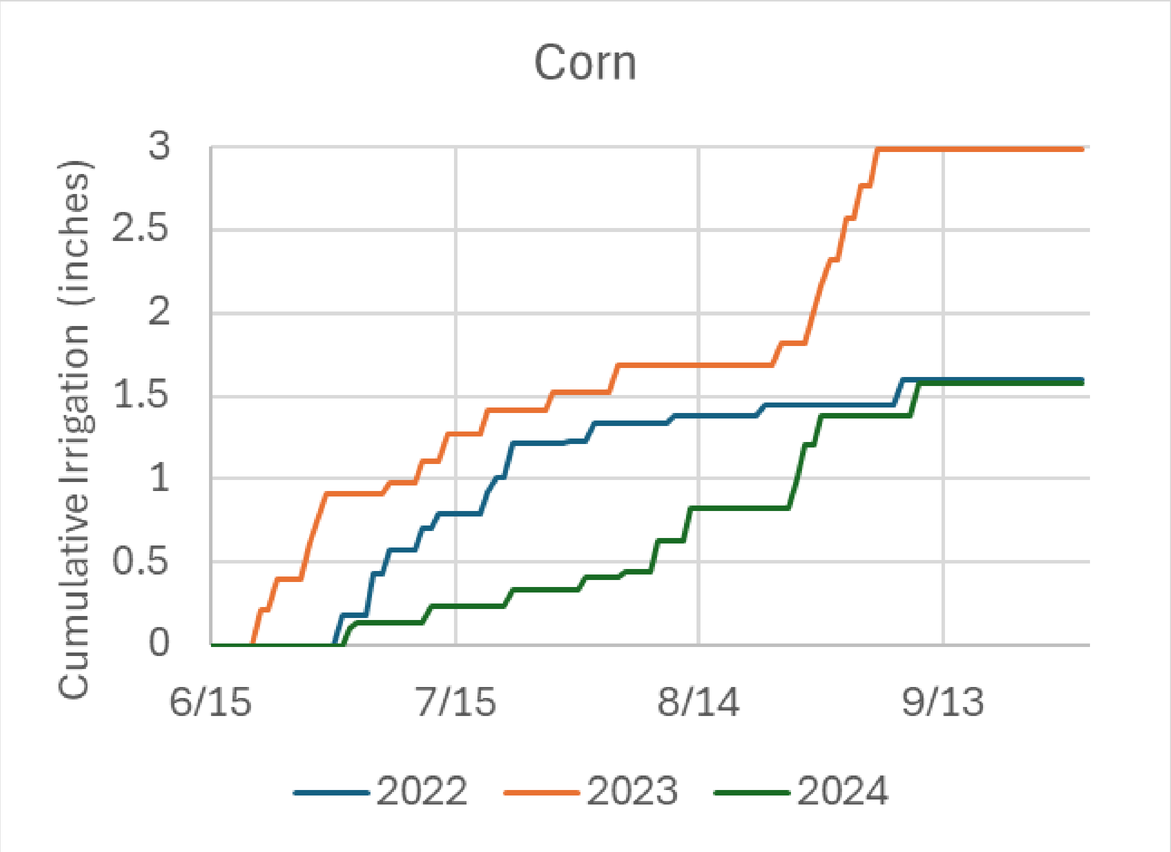
soil moisture data

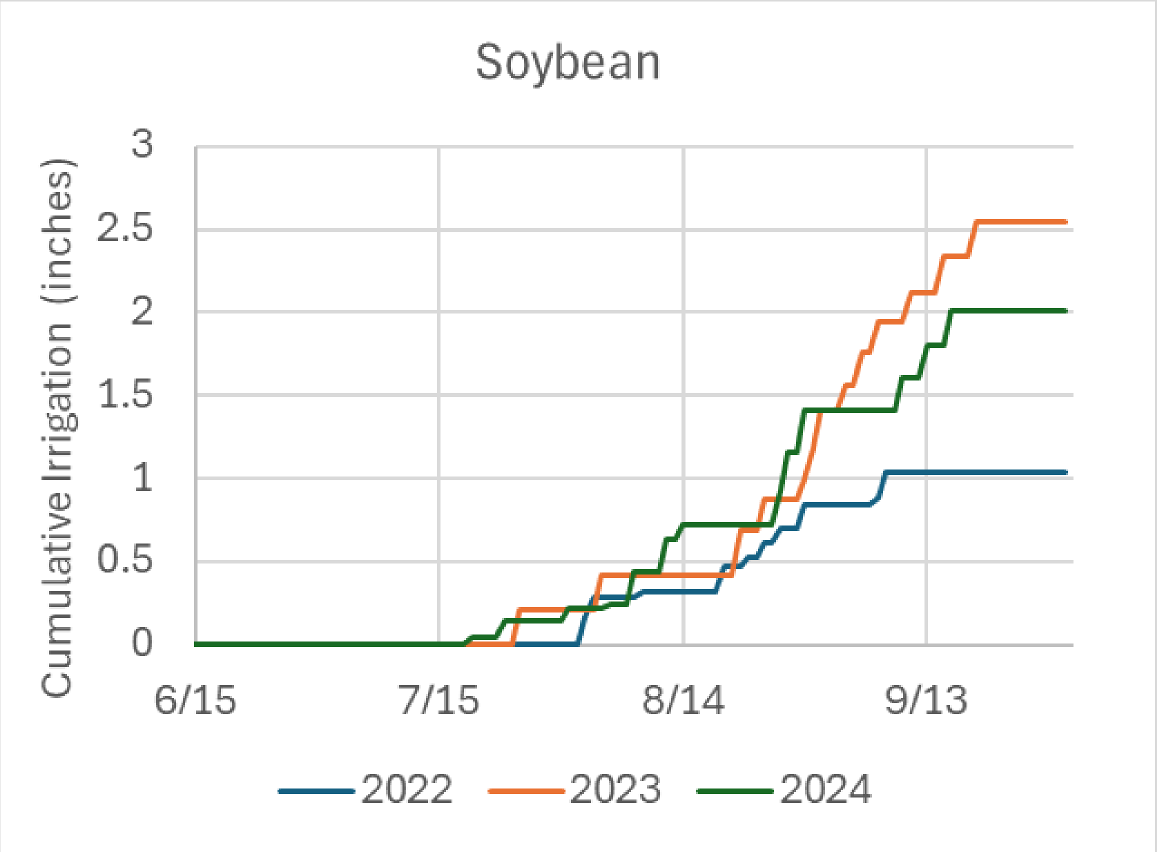
data dashboard

Observed Corn		
Date	Avg Rainfed Deficit	Average Irrigated Deficit
9/1/2022	65%	31%

Checkbook Corn		
Date	Avg Rainfed Deficit	Average Irrigated Deficit
9/1/2022	60%	35%

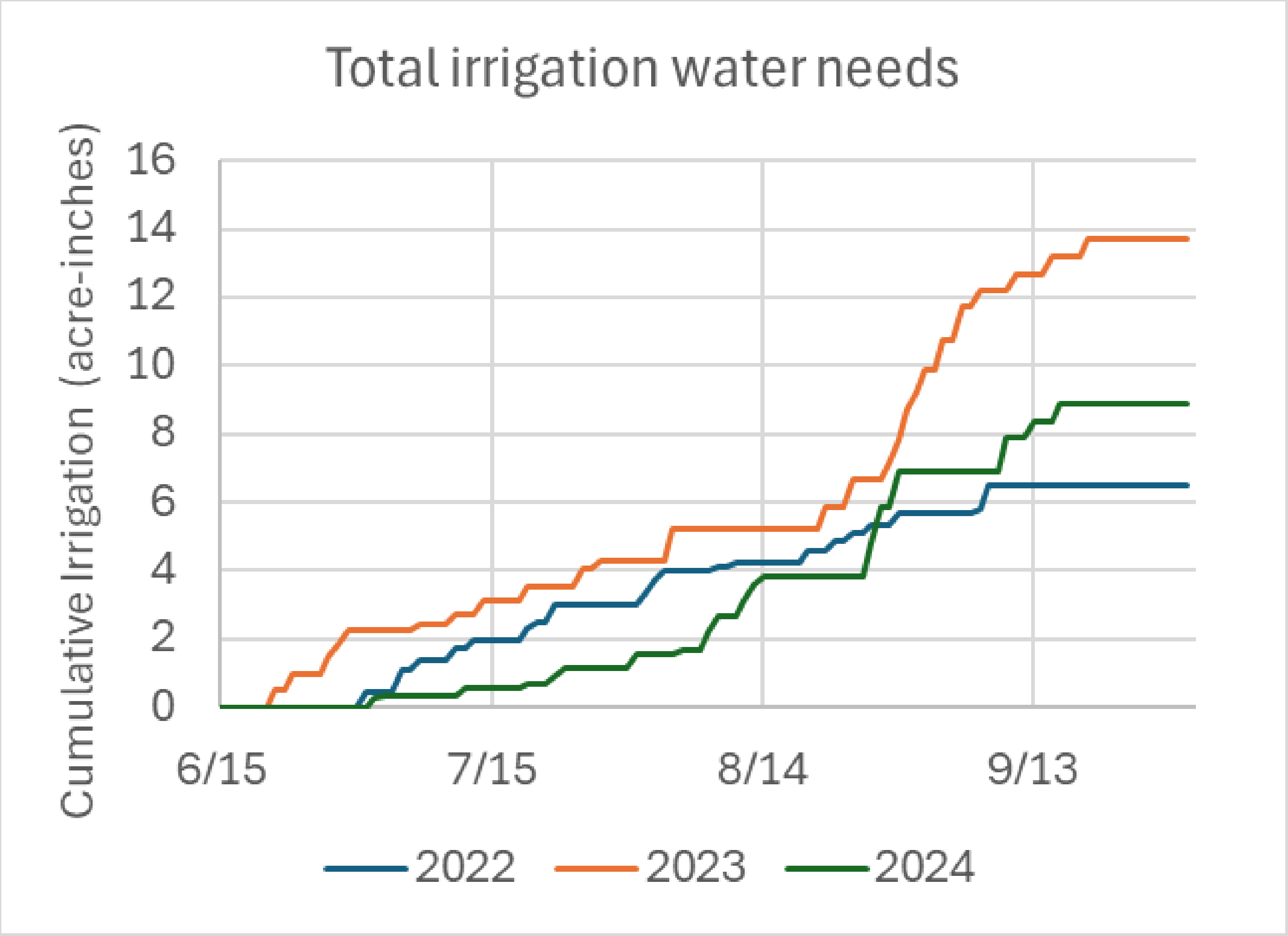
Three-year irrigation depths



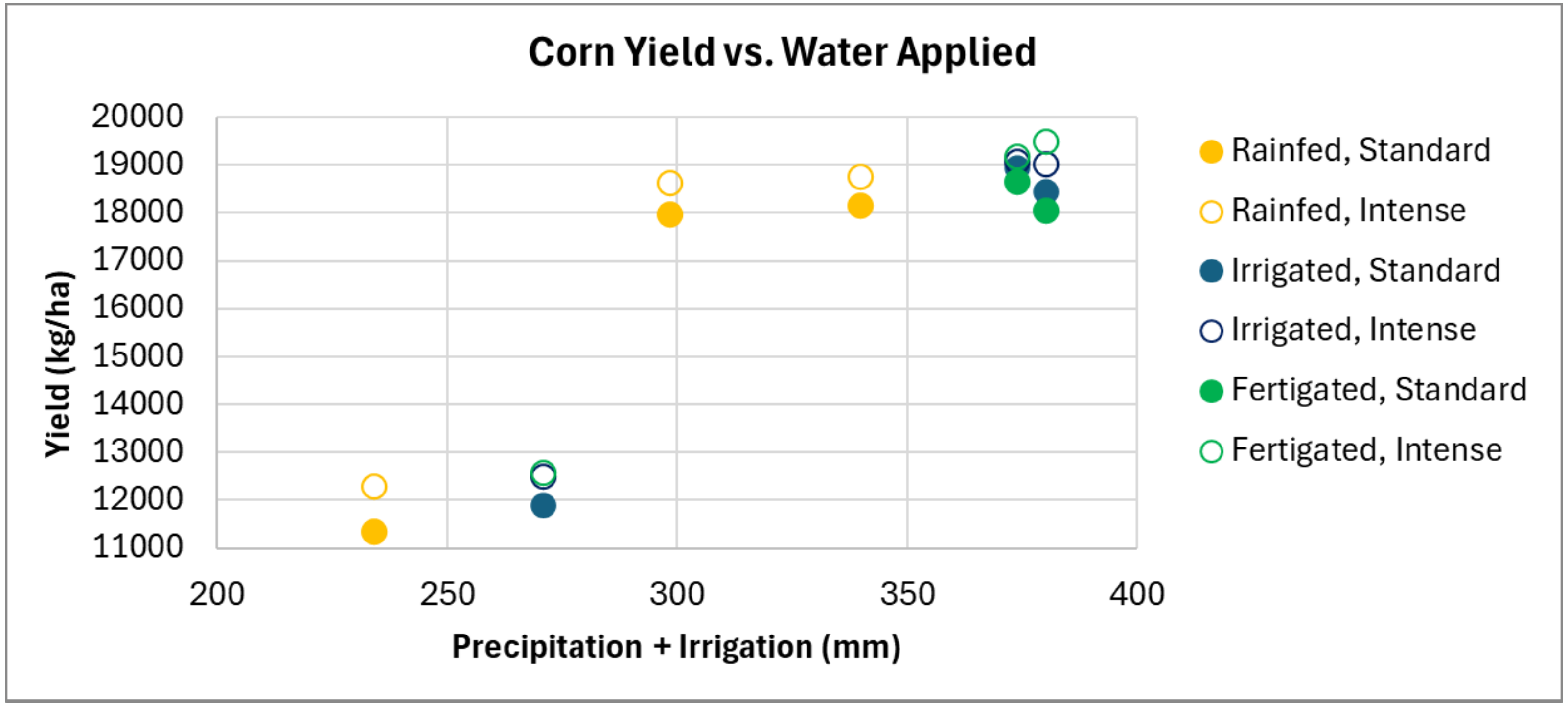


Irrigation demand versus supply

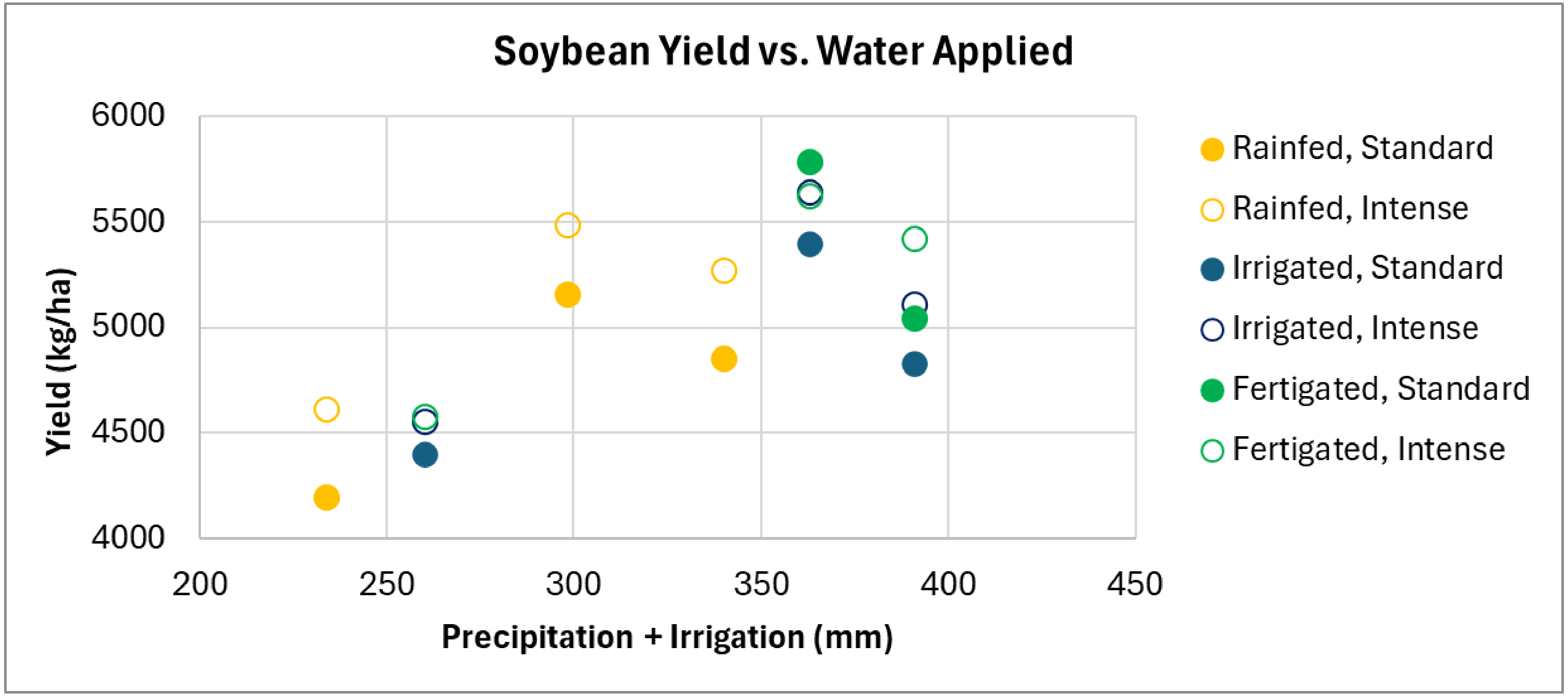
Water Supply and Demand Basics	
Tile drained area	175 acres
Spring 2022 drainage depth	6.0 inches
Spring 2022 drainage volume	1040 acre-inches
Wetland storage volume	31.7 acre-inches
2022 irrigation applied	8.3 acre-inches
Evapotranspiration losses	19.1 acre-inches
Seepage losses	3.0 acre-inches



Maize Yield results,-2024

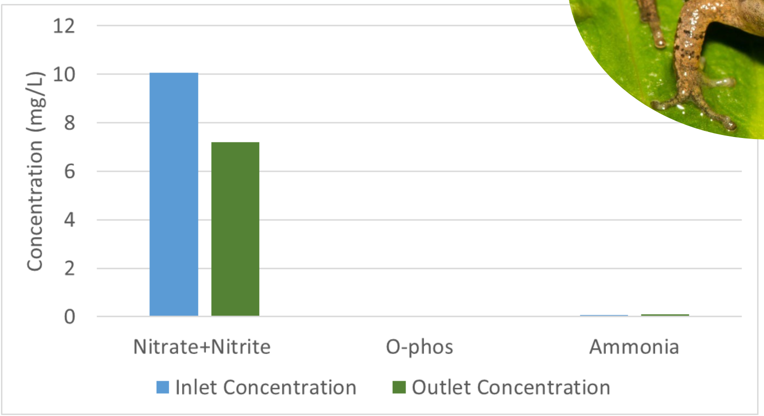


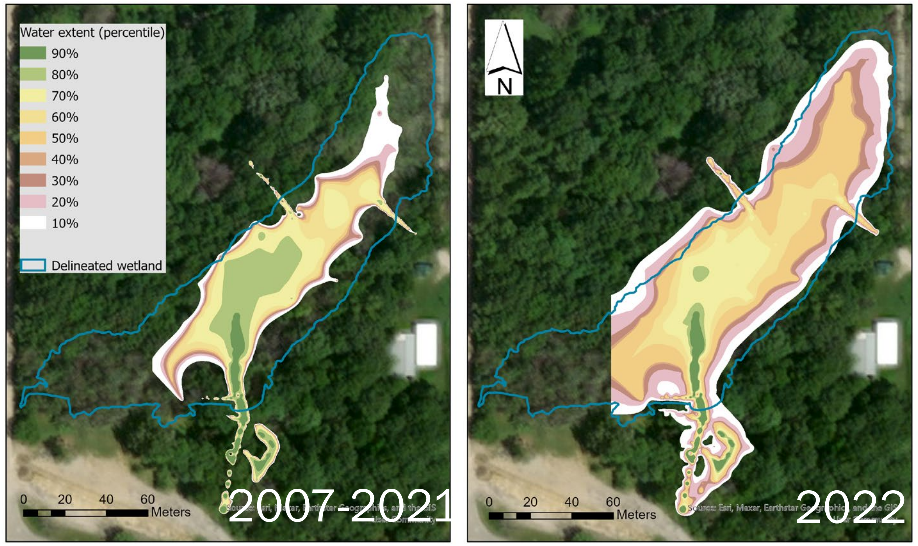
Soybean Yield, 2024



Ecosystem benefits of wetland control

- Existing wetland with Reed Canary Grass (2007-2021):
  - 28% reduction in mean nitrate concentration
  - Nitrate reduction of about 1
    96 kg/year or 2.8 kg/ha/yr
- Expansion of breeding habitat
- Potential for watershed –scale flood control

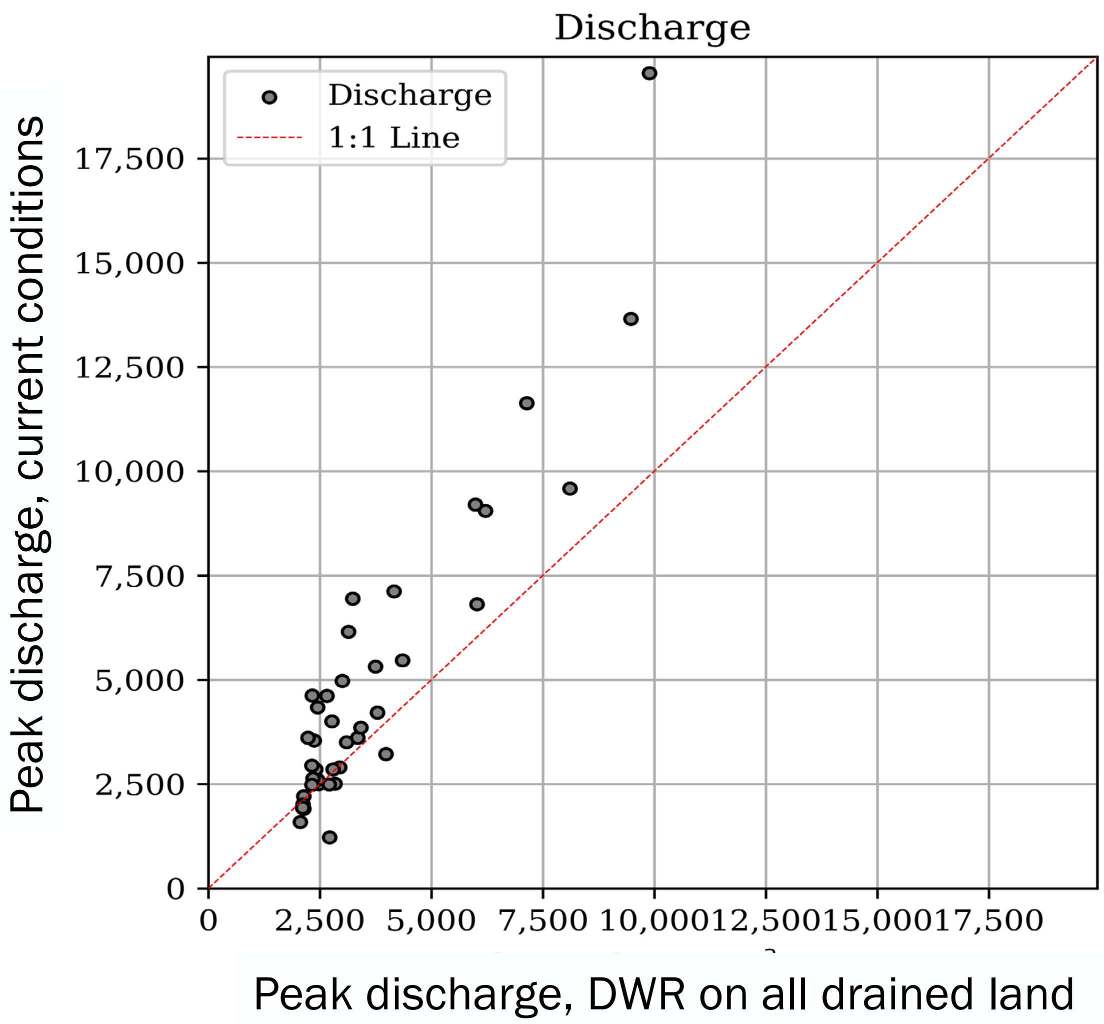




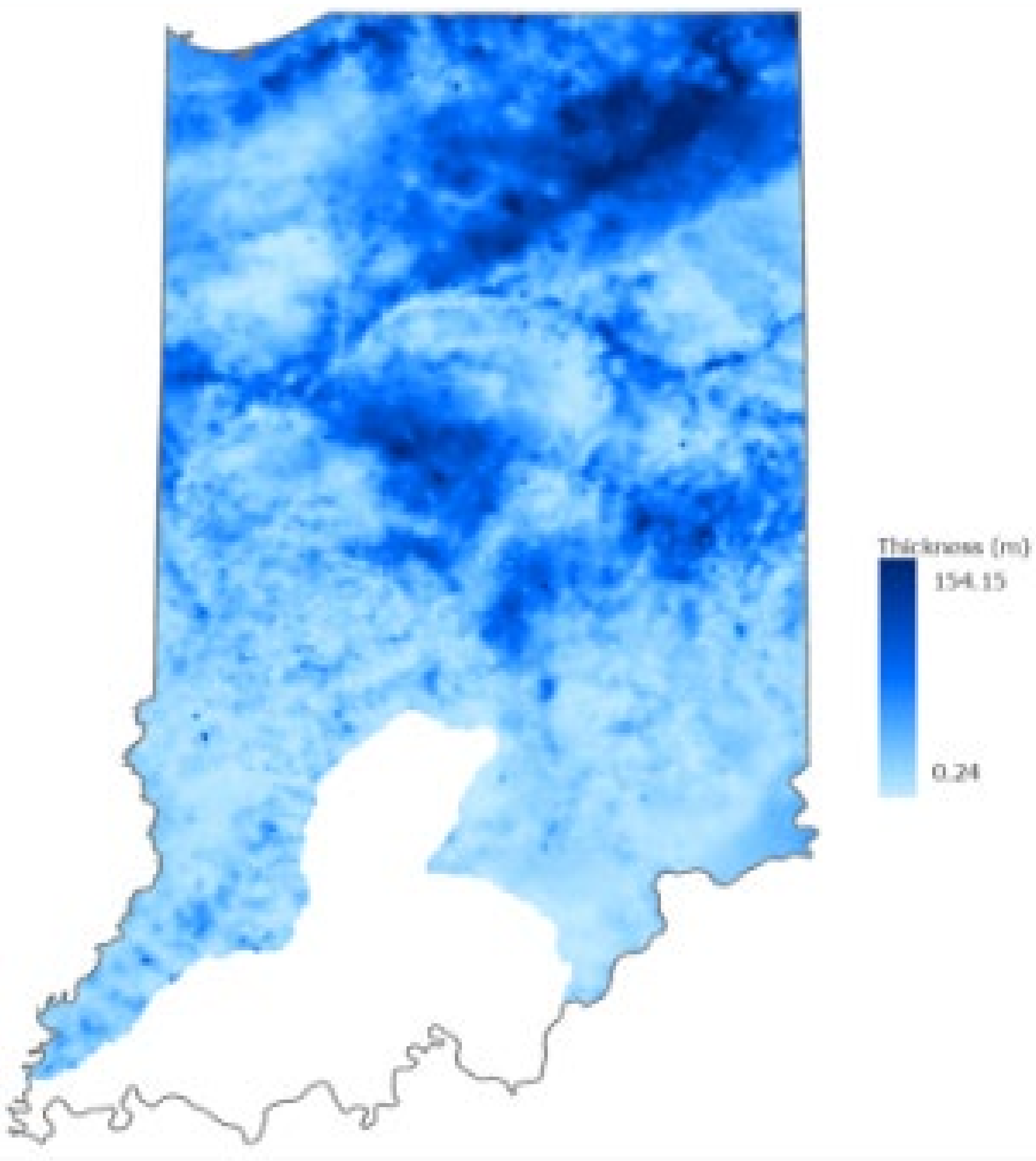
Potential for flood control with DWR

Model simulations for the Wabash River @ Covington

Preliminary results, still needs some quality control

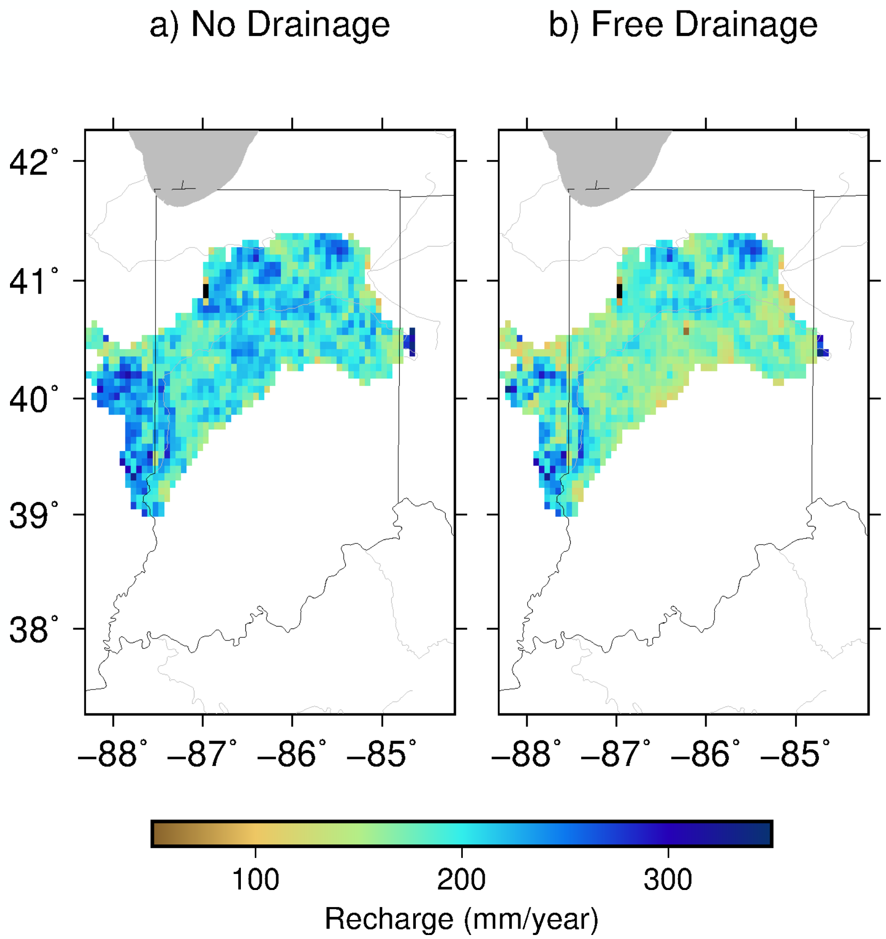


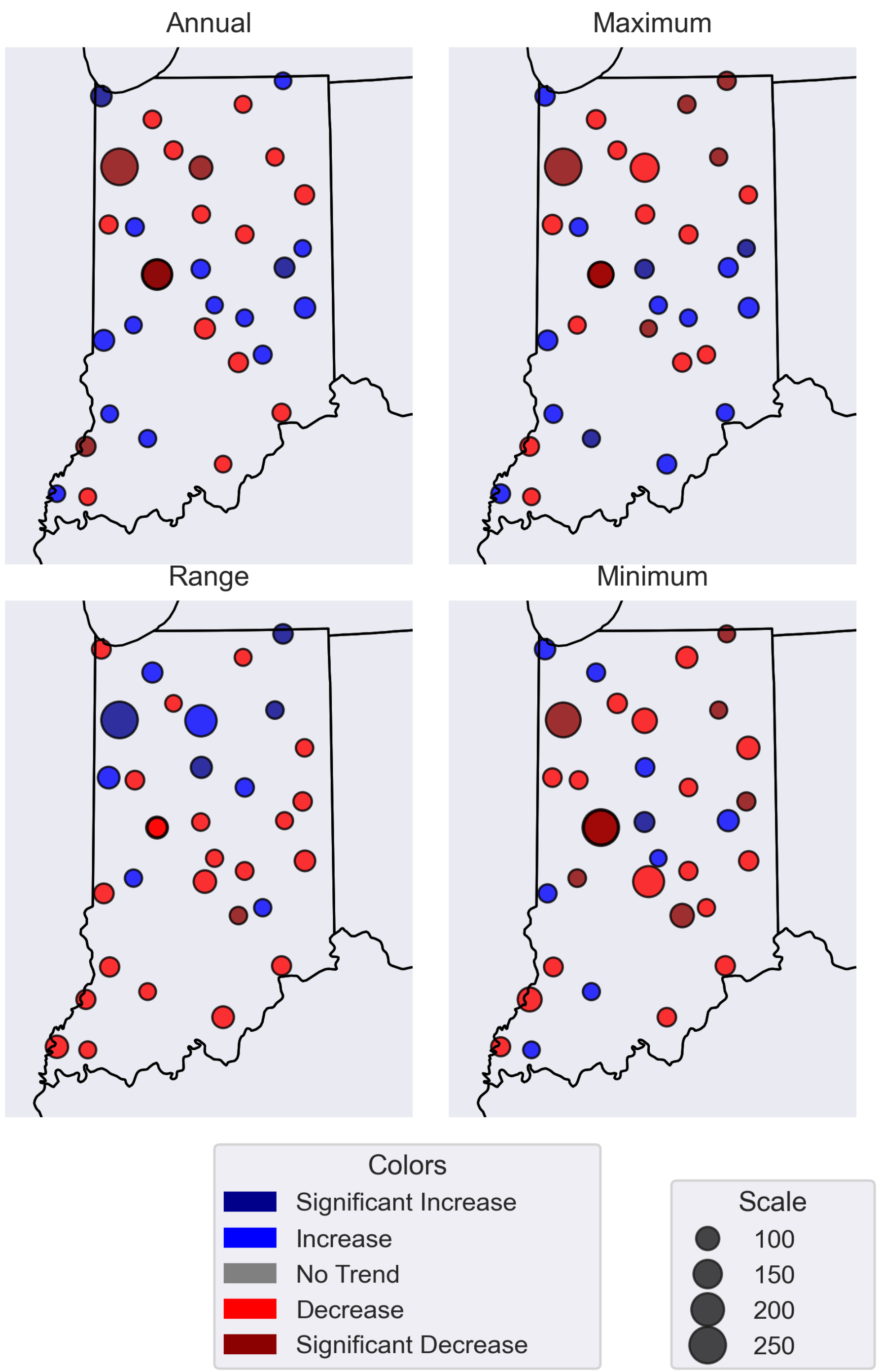
Aquifer Storage



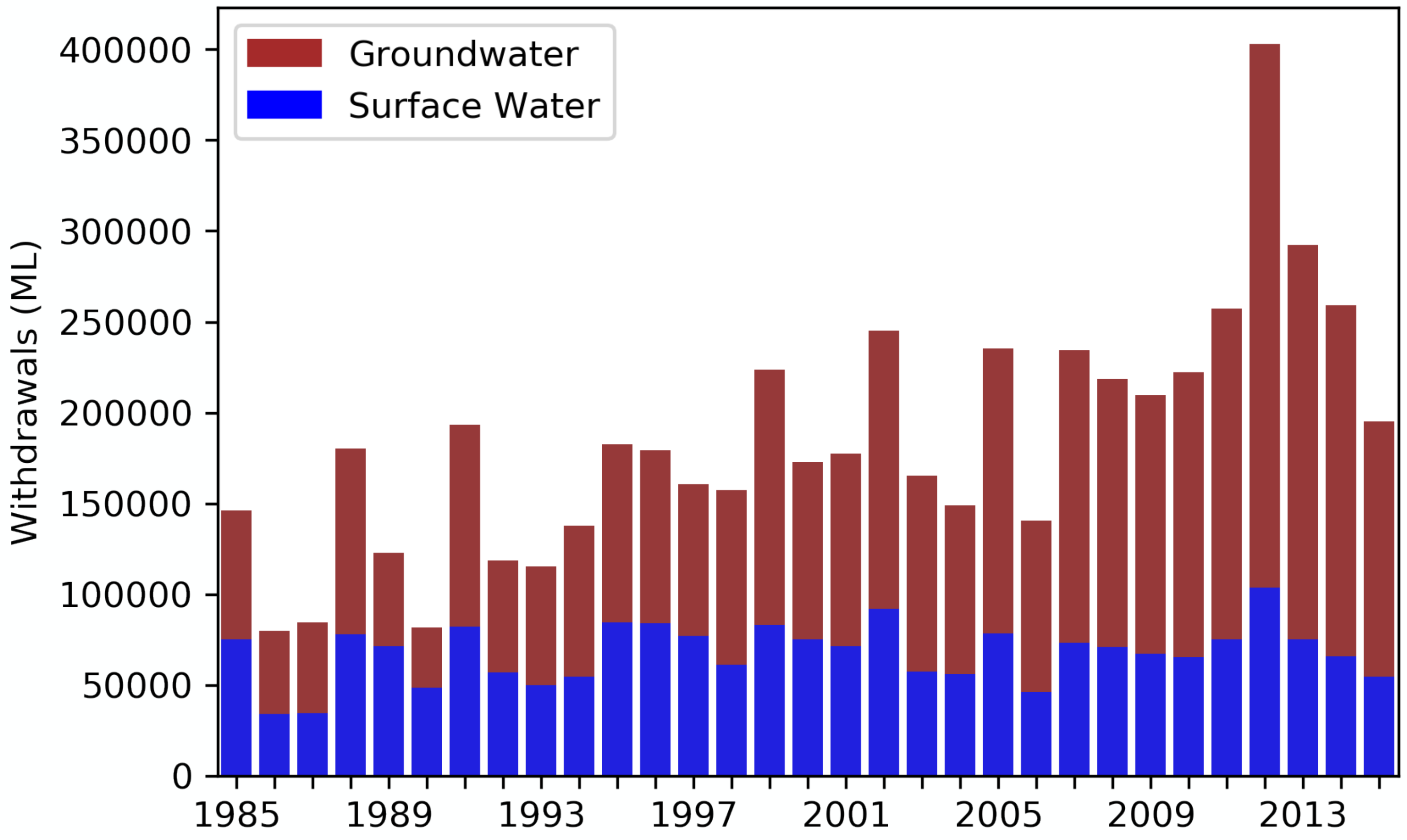
Thickness of glacial aquifer deposits in IN

Observed trends in groundwater level in IN

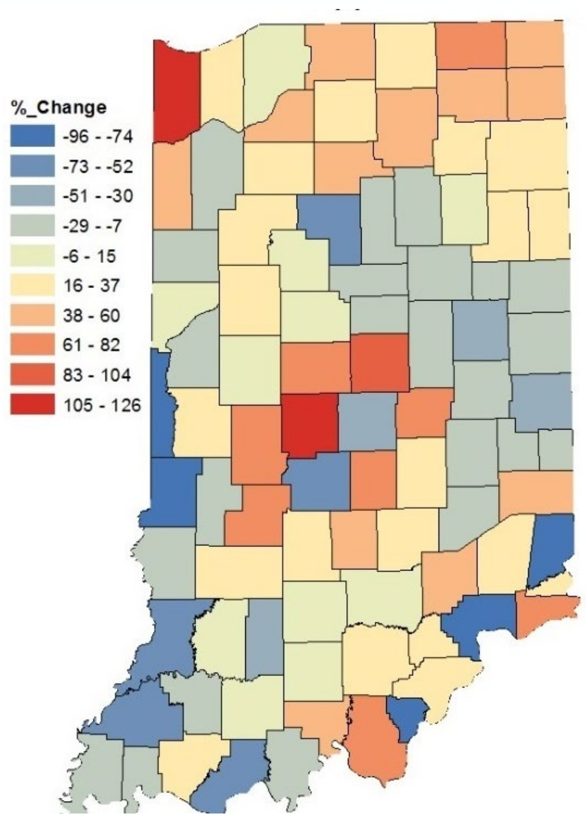




Irrigation withdrawals in Indiana



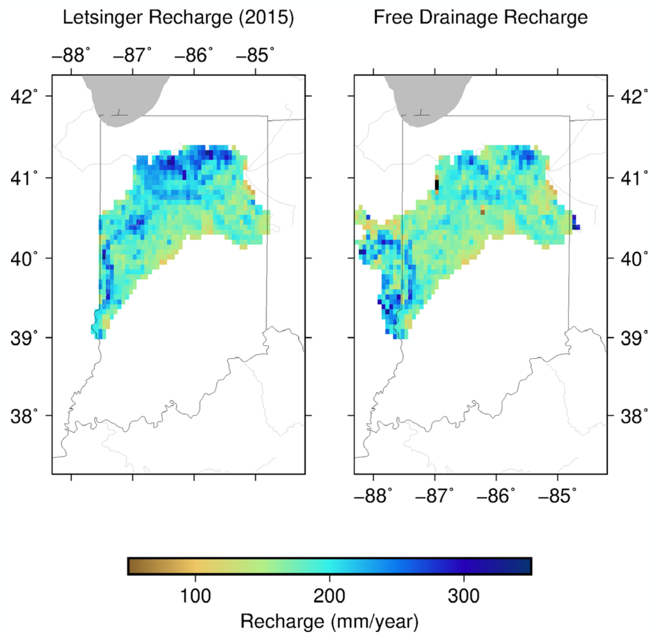
Future Change in Demand

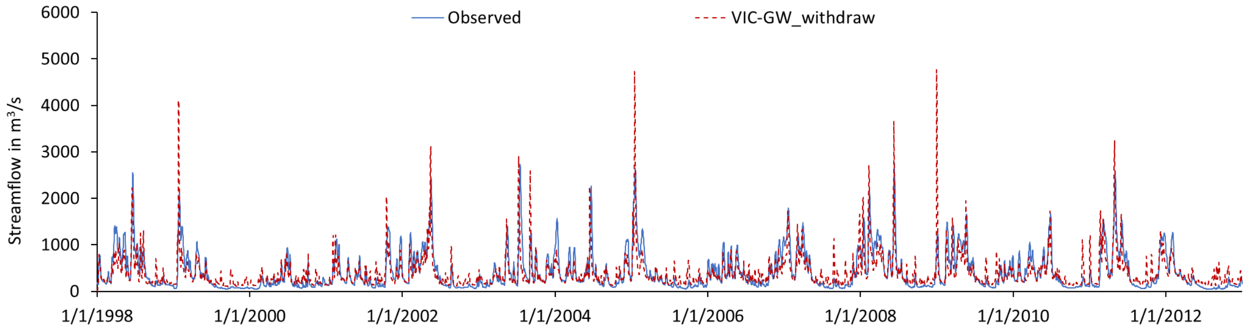


GW Stress Simulation System

Hydrologic model construction for the Wabash River Basin

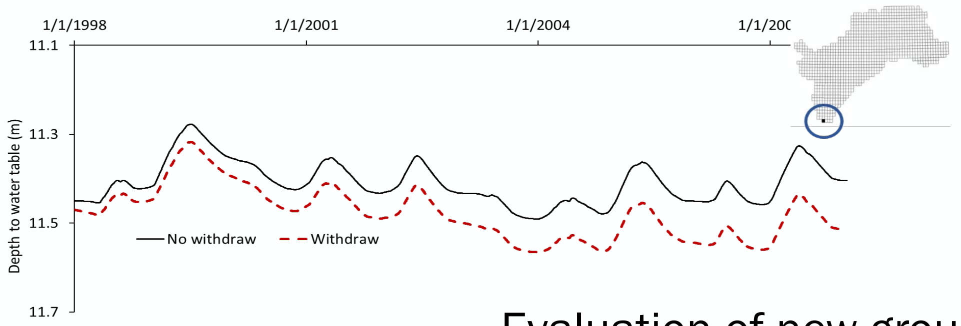
Evaluation of groundwater simulation



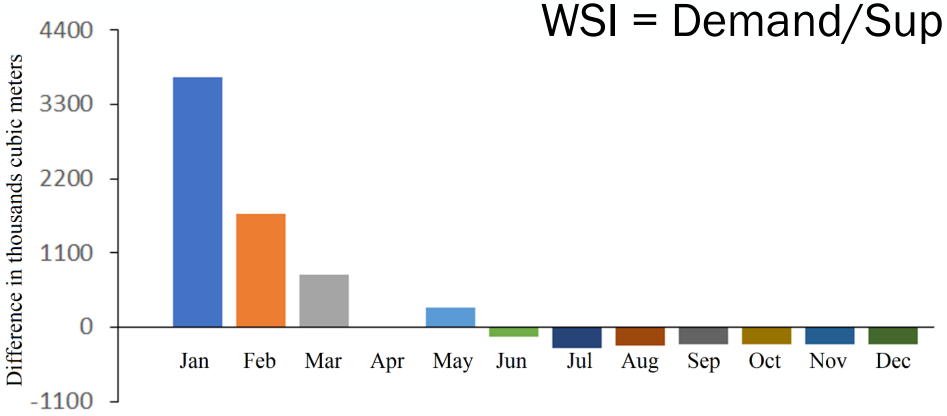


Evaluation of surface water simulation

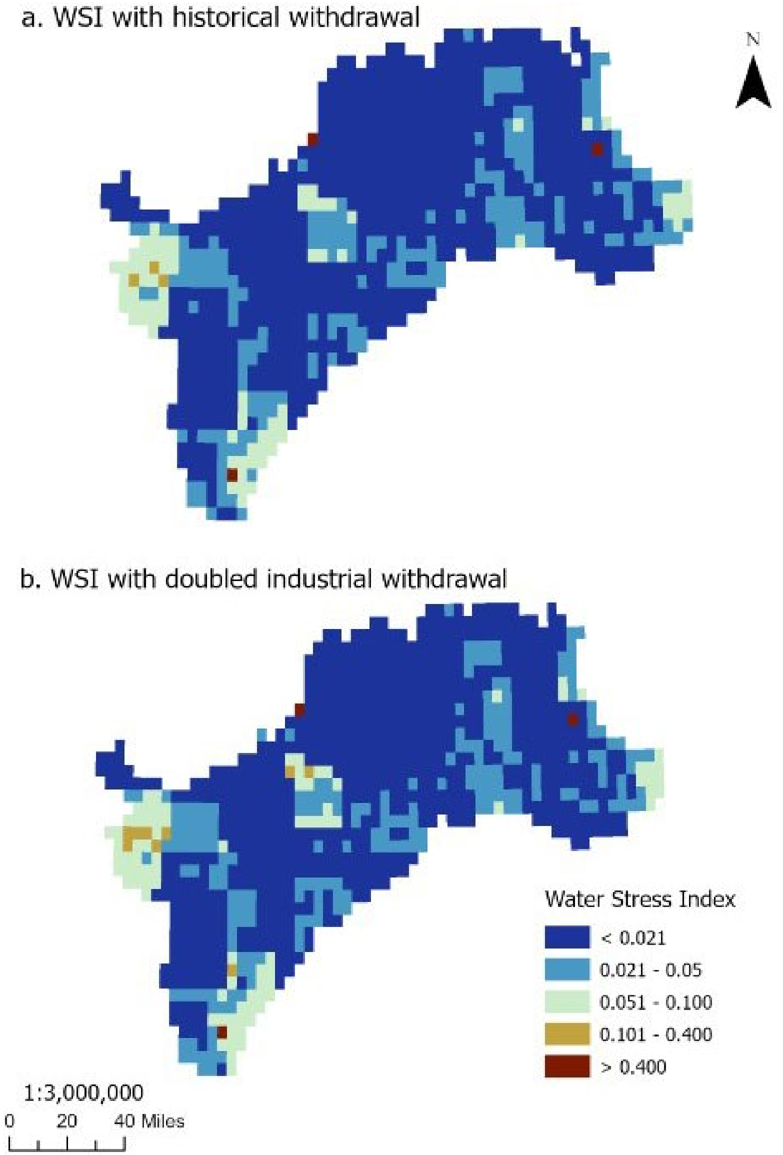
Model Scenarios to View the Surface and Groun Impact of Proposed Withdrawals



Evaluation of new groundwater withdrawals, relative to renewable supply
WSI = Demand/Supply



And subsequent impact to surface water downstream



Closing thoughts

Drainage infrastructure is an integral part of our Indiana landscape, allowing for crop production in our poorly drained soils.

Changing precipitation patterns exacerbate the drainage trade-offs.

Distributed storage in soil and unfarmable ground can help.

Recent trends have increased scrutiny on groundwater use.

New tools can help quantify impact of new uses.

Water storage can both increase gw recharge and decrease irrigation demand.

Thank You

Laura Bowling, Head, Department of Agronomy, bowling@purdue.edu

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