When it rains, it pours:
Conservation considerations for resiliency in a changing climate

Mark Williams
USDA – Agricultural Research Service
National Soil Erosion Research Laboratory
mark.williams2@usda.gov

@AgriH2O
Presentation roadmap

RAINFALL
Has rainfall amount and intensity changed over the past 40 years?

DISCHARGE
Have spatial and temporal patterns in discharge changed?

PHOSPHORUS
How, when, and where is P lost from tile-drained fields?

CONSERVATION
What are the challenges and opportunities for conservation?
The science


Why do we care about climate?

Rainfall and soil moisture control discharge

Williams et al. 2019
Assessments of changing precipitation are often at the regional- or national-scale. As a result, they lack detail on specific impacts at the watershed scale that have relevance for local agriculture management and conservation.
Evaluating rainfall patterns across the WLEB over the past 40 years

1975 – 2017 (daily data)

- 23 rain gauges
- 12 river monitoring locations

To be included:
>90% complete time-series

Rainfall data: www.ncdc.noaa.gov
Discharge data: waterdata.usgs.gov/nwis/rt

Williams & King. 2020
Changes in annual rainfall aren’t spatially uniform across the basin.

Change since 1975-1977

Moderate decrease

Small increase

Large increase

mm (in)

350 (13.8)
238
125
13
-100 (-3.9)

Williams & King. 2020
Increases in heavy rainfall (1-3 in) observed across the watershed

- Trace (< 2.5 mm) (< 0.1 in)
- Light (2.5 - 12.7 mm) (0.1-0.5 in)
- Moderate (12.7 - 25.4 mm) (0.5-1.0 in)
- Heavy (25.4 - 76.2 mm) (1.0-3.0 in)
- Very heavy (> 76.2 mm) (> 3.0 in)

14 ± 17 mm increase per 5-year period

Williams & King. 2020
Largest changes in heavy and total rainfall have occurred during spring
Spring is already the wettest season

Wet soil + Heavy rainfall = Discharge

Williams et al. 2019
Changes in tributary discharge follow spatial patterns in rainfall.
Spring high flows
(>90\textsuperscript{th} percentile)
at 7 of 12 tributaries

Summer low flows
(<10\textsuperscript{th} percentile)
at 4 of 12 tributaries

Williams & King. 2020
RAINFALL
Has rainfall amount and intensity changed over the past 40 years?

DISCHARGE
Have spatial and temporal patterns in discharge changed too?

PHOSPHORUS
How, when, and where is P lost from tile-drained fields?

CONSERVATION
What are the opportunities and challenges for conservation?
**USDA-ARS edge-of-field network**

Data collected from 2011-2016
35 fields with surface runoff (94 site-years)
34 fields with tile drainage (90 site-years)
Average time-series length = 3 years

**Field characteristics**
1.0 to 18.6 ha
<1 to 6% slope
Corn-soybean or corn-soybean-wheat
Field-scale phosphorus budget

- Atmospheric Deposition: 0.14±0.10
- Fertilizer or Manure Applied: 27.63±40.81
- Crop Removal: 23.39±7.84
- P Balance = Inputs - Outputs: 3.17
- Surface Runoff: 0.51±0.82
- Leaching/Tile Drainage: 0.69±0.54

~60% Dissolved reactive P
~40% Particulate P

Pease et al. 2018 [mean±stdev; kg TP ha⁻¹]
Phosphorus loading is event driven.

80% of P loading in runoff occurs during 10 days per year.

80% of P loading in tile drainage occurs during 45 days per year.

Williams et al. 2018
If rainfall patterns continue to change as predicted...

It is expected that the period over which P loading occurs will decrease.
Adaptation to changing rainfall is largely production focused

Survey of Iowa farmers indicates that:

• Most farmers (62%) recognize the need to adapt to increasing rainfall amount and intensity in order to protect their land

• 46% agreed that increased investment in drainage networks (tile drains, ditches) would be required to prepare for increasing rainfall

Arbuckle et al. 2013
The conservation dilemma

Do we try to target high flows?
Treat water for short intervals when loads are greatest

Do we try to target low flows?
Treat water for long periods of time when loads are much smaller

Williams et al. 2018
Conservation practices aren’t typically designed for large storm events

Large volumes of water tend to overwhelm most (if not all) conservation practices resulting in large nutrient loads reaching nearby waterways.

Evidence suggests that increases in rainfall amount and intensity have outpaced increases in storage on the landscape.
Conservation practice effectiveness is often greater at low flows – increased residence time, manageable volumes of water, increased nutrient removal rates

**BUT…**

They would need to be perfect (100% nutrient removal) for long periods to achieve modest nutrient reduction goals

**FOR EXAMPLE**

To achieve a 30-40% reduction in P loading in tile drainage at the edge-of-field, 100% of P would need to be removed during >75% of days with tile flow

Williams et al. 2018
Achieving water quality goals will be difficult with upland only conservation
Improving water quality in a changing climate

Decrease the supply of P available for rapid transport

Soil test and apply P based on recommended rates

Place P in the subsurface to maximize soil contact

Avoid application prior to large storm events
Practices that can help hold more water on the landscape

Wetland
Controlled drainage
Soil health

Opportunity for innovative drainage design to meet both production and environmental goals

These practices often come with trade-offs:

• wetlands can become a P source
• P release due to redox conditions with controlled drainage
• broadcast fertilizer applications associated with no-till
1. Upland field with nutrient management practices
2. Phosphorus removal structure
3. Constructed wetland

Stacking nutrient management and engineered practices for increased nutrient removal

Penn et al. 2020
Tools are available for designing and selecting sites for engineered practices

Agricultural Conservation Planning Framework

Nutrient Removal Wetland
Cover Type
- Wetland
- Buffer
- Contributing Area

Streams
Lakes
Watershed Boundary

0 1 2 4 Miles

Designing P removal structures

Mark Tomer, USDA-ARS
Dave James, USDA-ARS

Chad Penn, USDA-ARS
Extend conservation beyond field boundaries

Total = 14,467 Miles of Streams
Changes in rainfall aren’t uniform across the Lake Erie watershed (and neither are other soil and management factors)

Conservation practice recommendations can’t be “one size fits all”
Summary

Rainfall amount and intensity have increased over the past 40 years with patterns expected to continue to change in the future.

Phosphorus loss is event driven which poses a challenge for conservation efforts.

Innovative nutrient and water management practices can help decrease nutrient loss in a changing climate.

Conservation efforts must extend beyond field boundaries and into waterways.

Conservation implementation across the Lake Erie watershed should be regionally tailored and adaptive.
For more information on this presentation, copies of recent publications, or more information on hydrology and nutrient transport in drained landscapes

Mark Williams - USDA ARS NSERL
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