# Proceedings of the 10th Annual Nutrient Management Conference



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# Discovery Farms – Edge-of-Field Phosphorus Losses in Surface Waters and Tile Drainage

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10th Annual Nutrient Management Conference

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# Discovery Farms is a farmer led water quality research and educational program, provides credible research, and communicates results


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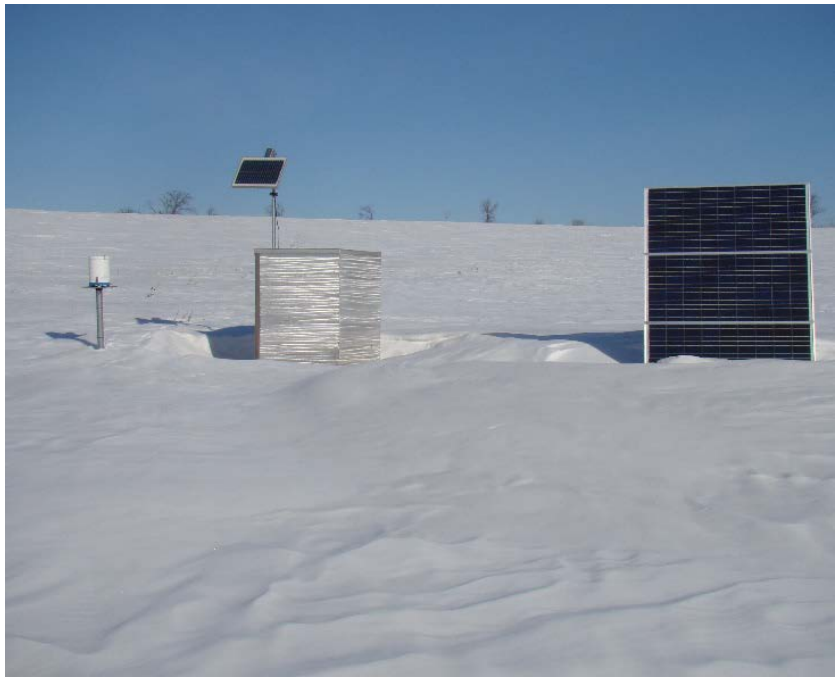
# Edge-of-field surface runoff and tile drainage data is collected 365 days a year

Weather • Soil

Flow • Sediment

Nitrogen • Phosphorus



Flow Volume X Concentration (ppm) = Loss (lb/ac)

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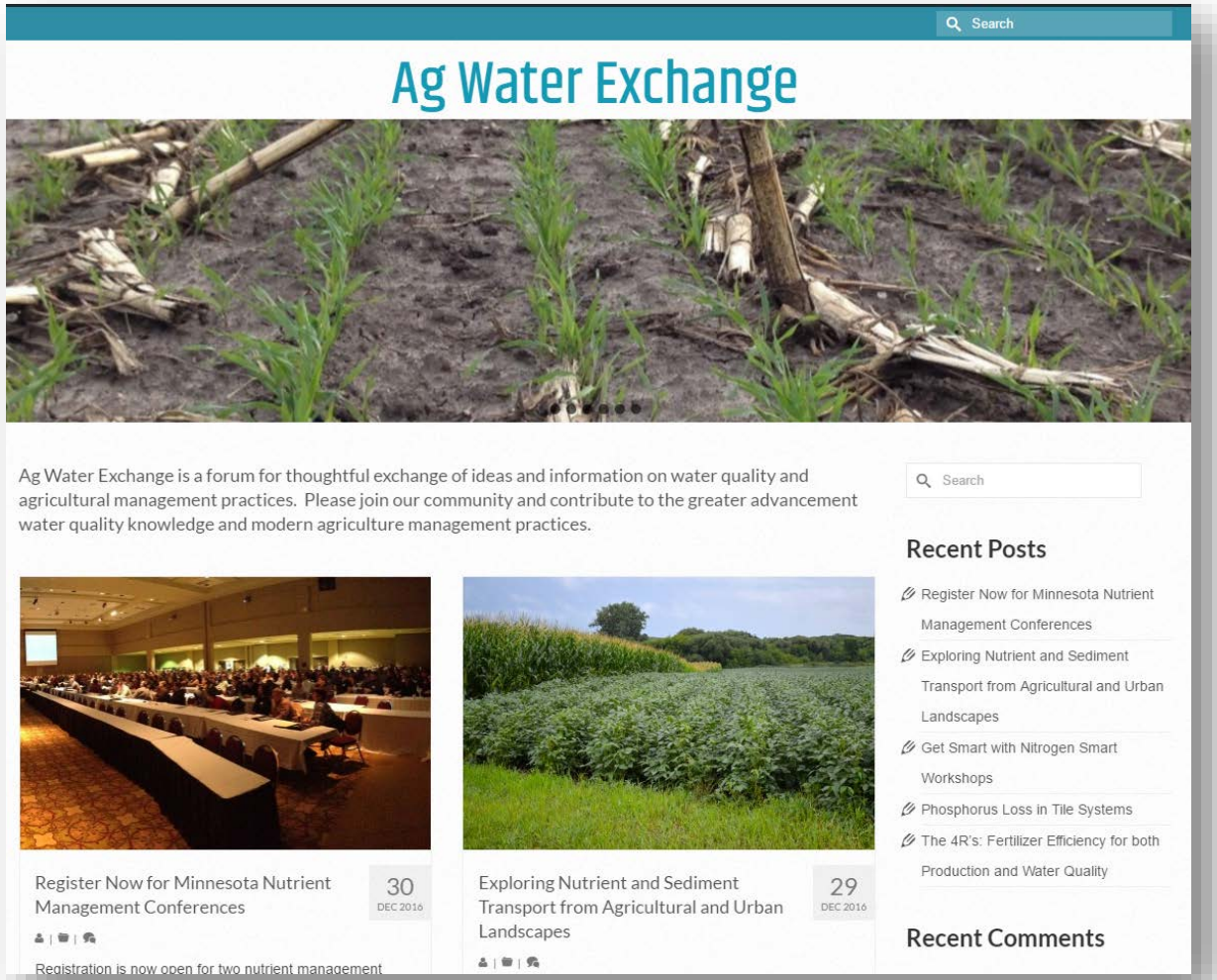
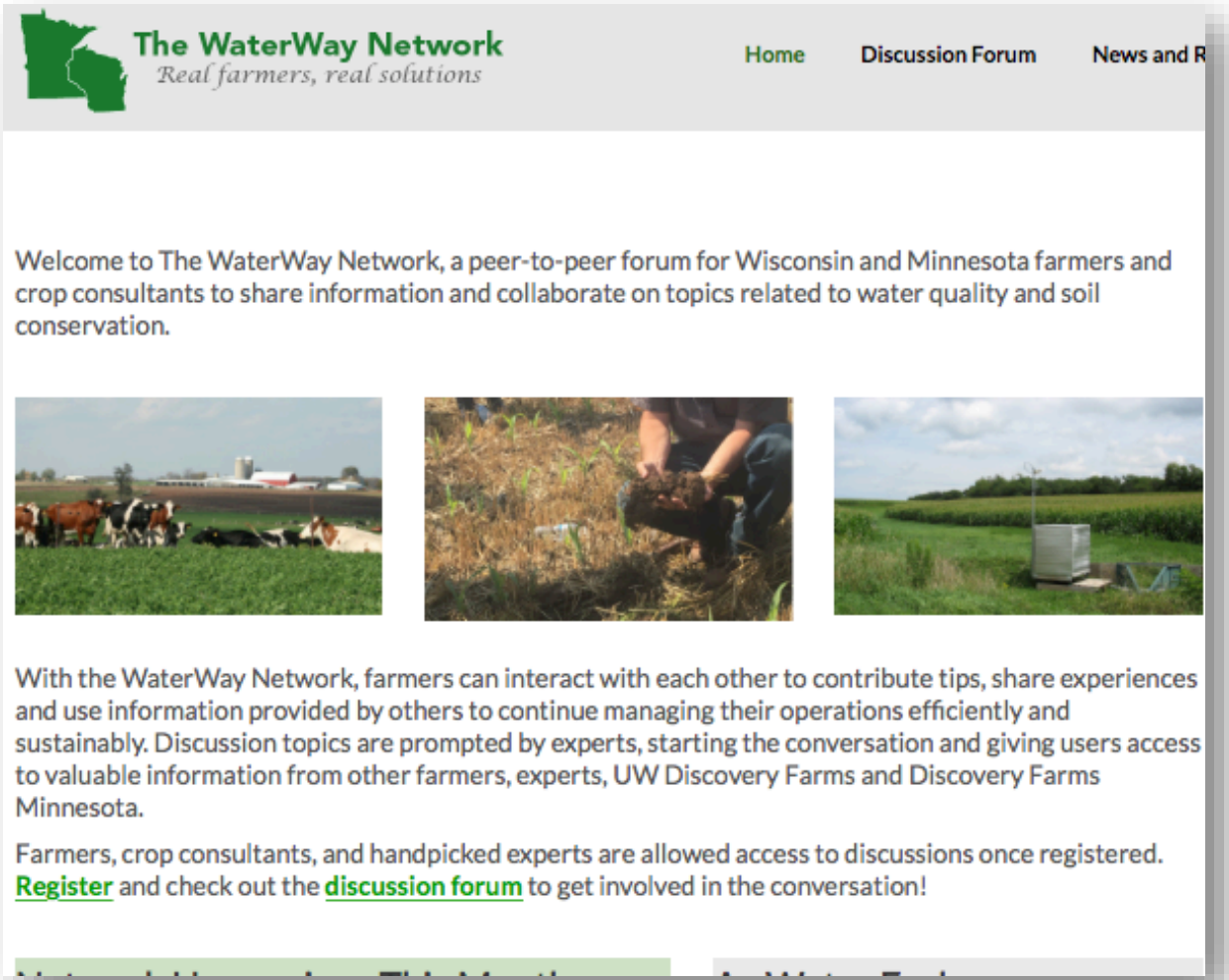
# AgWaterExchange.com




# WaterWayNetwork.org

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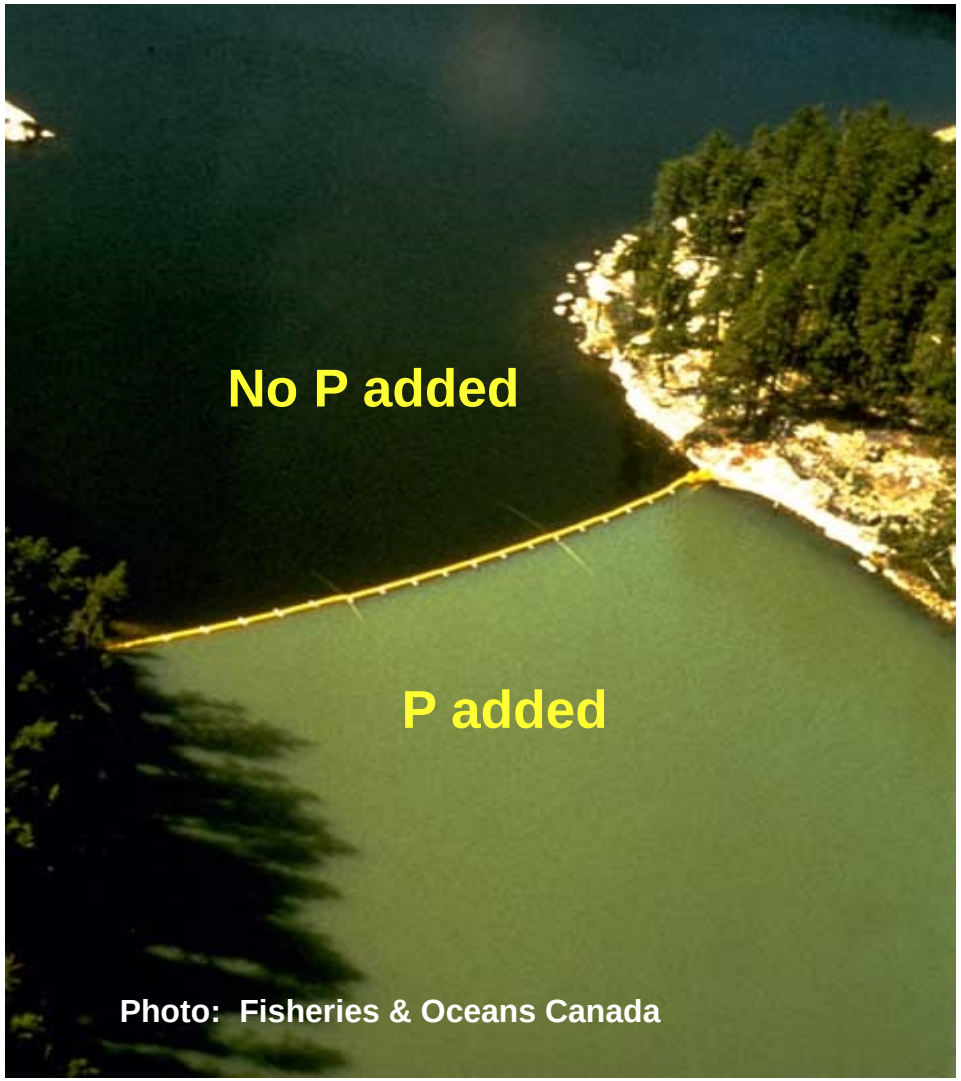
Phosphorus and nitrogen are nutrients needed for plant growth and are natural parts of aquatic ecosystems

Too much in water can cause excessive algae growth

# The problem with excessive phosphorus loss – algae blooms.




## Eutrophication

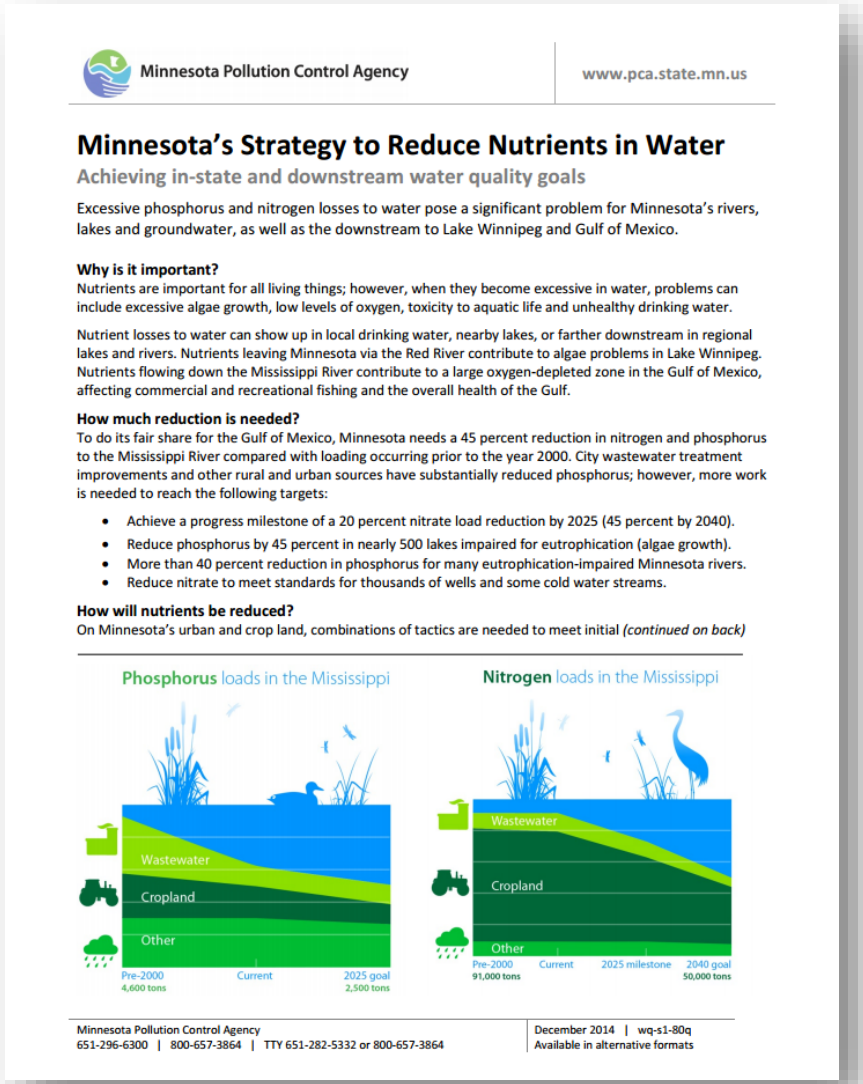
- Excessive richness of nutrients in a lake or water body
- Occurs at very low concentrations of P (20-50 ppb)

## Algal blooms

- Oxygen depletion and fish kills
- Nerve and liver toxins – livestock and wildlife mainly at risk
- Aesthetics and smell

Phosphorus is transported either attached to **soil particles** or **dissolved** in the water column

# Pressure to reduce nutrient losses is increasing.



Minnesota Pollution Control Agency | www.pca.state.mn.us

## Minnesota's Strategy to Reduce Nutrients in Water

### Achieving in-state and downstream water quality goals

Excessive phosphorus and nitrogen losses to water pose a significant problem for Minnesota's rivers, lakes and groundwater, as well as the downstream to Lake Winnipeg and Gulf of Mexico.

**Why is it important?**
Nutrients are important for all living things; however, when they become excessive in water, problems can include excessive algae growth, low levels of oxygen, toxicity to aquatic life and unhealthy drinking water.

Nutrient losses to water can show up in local drinking water, nearby lakes, or farther downstream in regional lakes and rivers. Nutrients leaving Minnesota via the Red River contribute to algae problems in Lake Winnipeg. Nutrients flowing down the Mississippi River contribute to a large oxygen-depleted zone in the Gulf of Mexico, affecting commercial and recreational fishing and the overall health of the Gulf.

**How much reduction is needed?**
To do its fair share for the Gulf of Mexico, Minnesota needs a 45 percent reduction in nitrogen and phosphorus to the Mississippi River compared with loading occurring prior to the year 2000. City wastewater treatment improvements and other rural and urban sources have substantially reduced phosphorus; however, more work is needed to reach the following targets:

- Achieve a progress milestone of a 20 percent nitrate load reduction by 2025 (45 percent by 2040).
- Reduce phosphorus by 45 percent in nearly 500 lakes impaired for eutrophication (algae growth).
- More than 40 percent reduction in phosphorus for many eutrophication-impaired Minnesota rivers.
- Reduce nitrate to meet standards for thousands of wells and some cold water streams.

**How will nutrients be reduced?**
On Minnesota's urban and crop land, combinations of tactics are needed to meet initial *(continued on back)*



Minnesota Pollution Control Agency
651-296-6300 | 800-657-3864 | TTY 651-282-5332 or 800-657-3864
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Available in alternative formats

- Do we know where the finish line is if we don't know the starting point?
- Perceptions seem to be getting worse

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# The problem with water controversies is that it rarely provides guidance for farmers to more effectively manage farm systems.


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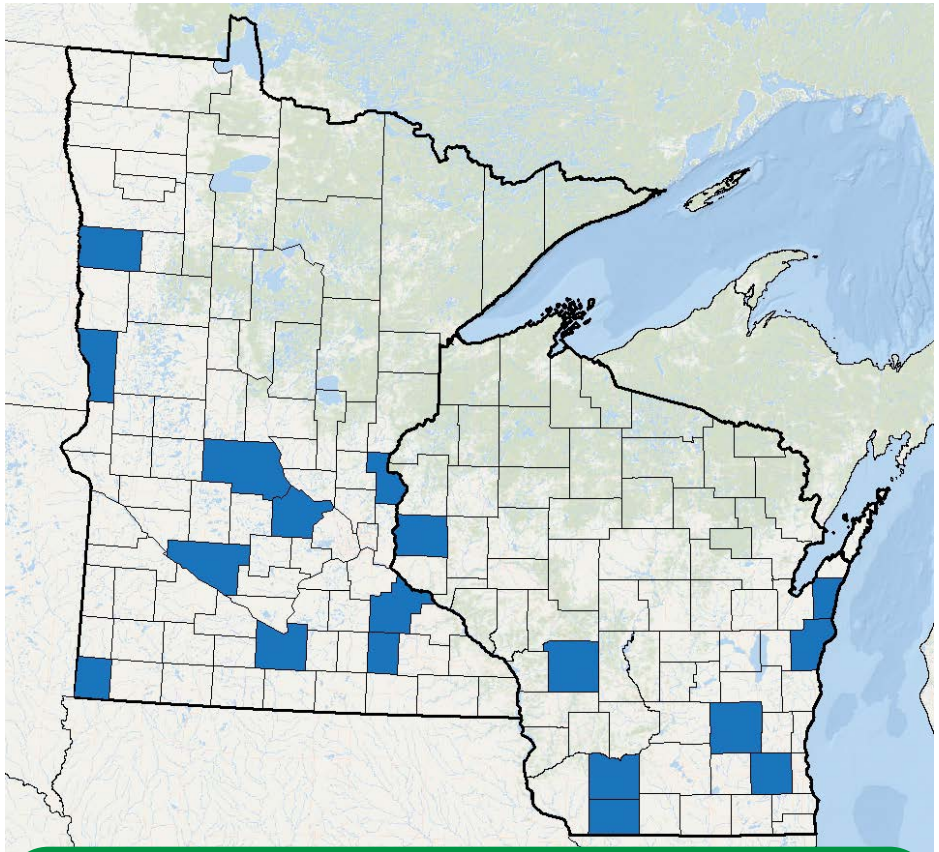
# We have been collecting edge-of-field water quality data in MN and WI for 10-20 years, what do we know?

Losses are different than expectations

There is no perfect farming system

There are no silver bullet solutions

# Discovery Farms has a large dataset with diverse farm systems and locations.



26 Farms
45 Fields
141 Surface Site Years
90 Tile Site Years

Diverse farm systems and landscapes across MN and WI

- Data collected from 2004-2017
- No tile and pattern and random tile at different spacing and depths
- Drainage areas from 5 to 650 acres
- Field slopes >1% to 9%
- Well drained to poorly drained soils
- Dairy, beef, swine, and grain operations
- Crops ranging from corn, soybean, alfalfa, sugarbeet, wheat, pasture

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# Runoff happens!

Runoff was measured in **140 out of 141** years of surface runoff data

Tile flow was measured in **90 out of 90** years of tile flow data

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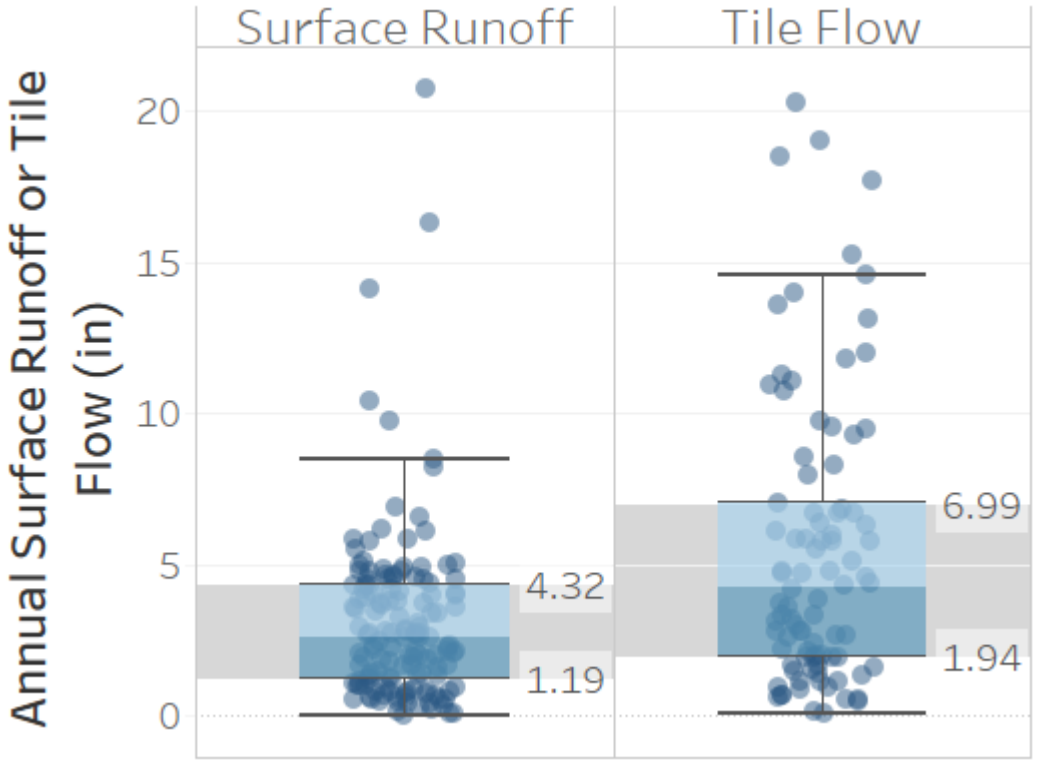
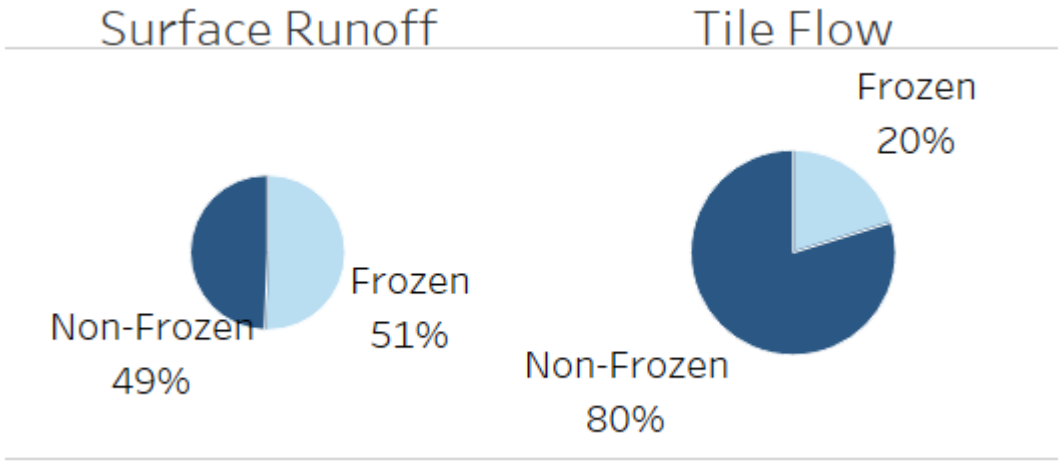
# The timing and intensity of surface runoff and tile flow is much different.




| Category | Surface Runoff | Tile Flow |
|---|---|---|
| Annual Range (inches) | 1.19 to 4.32 | 1.94 to 6.99 |
| Median annual days of flow | 8 | 174 |

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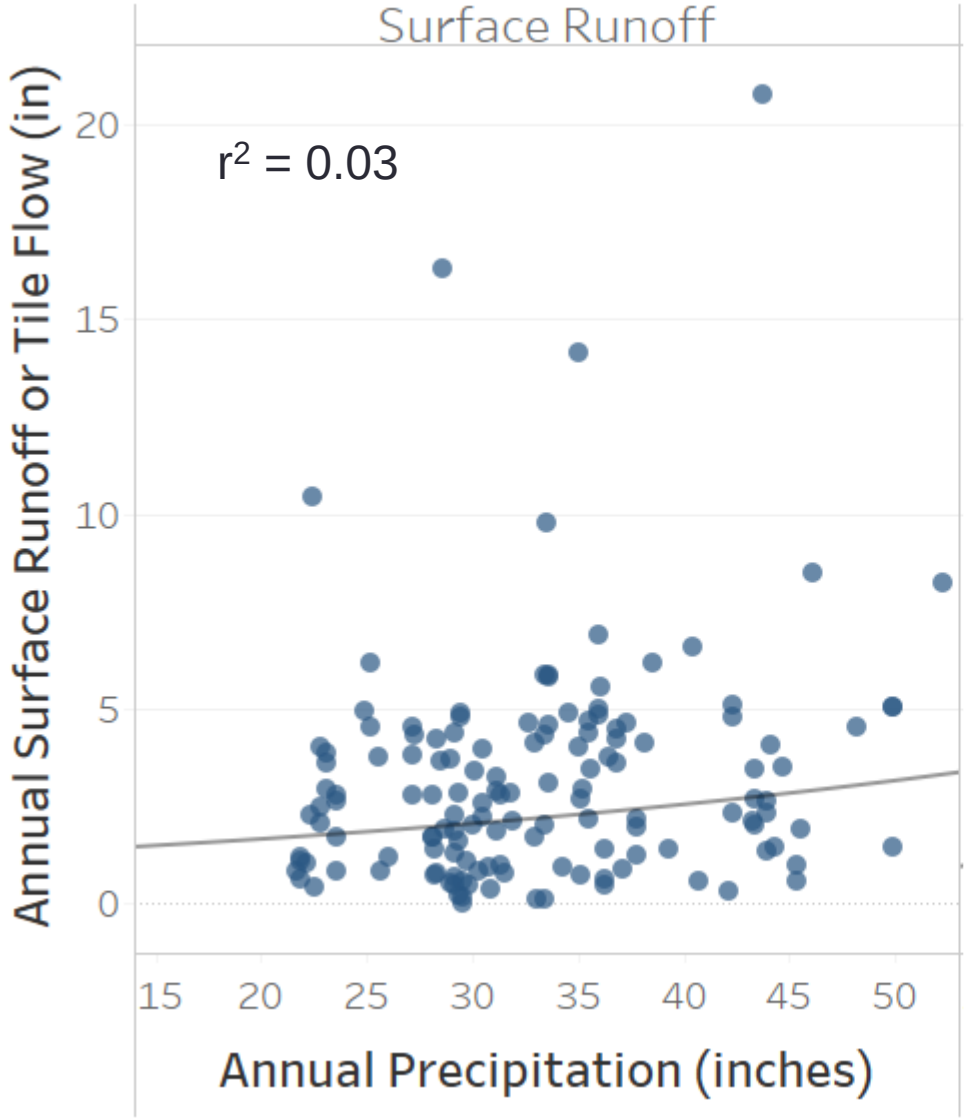
# The amount of annual precipitation has a large influence on the amount of tile flow, but not surface runoff.

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# Timing of precipitation matters for surface runoff.

| Site | Date | Precipitation (in) | Intensity (in/hr) | Runoff (in) |
|---|---|---|---|---|
| ST1 | 5/18/2012 | 1.03 | 1.37 | 0.17 |
| | 7/18/2012 | 1.03 | 1.37 | 0 |


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# Intensity of precipitation matters for surface runoff.



| Site | Date | Precipitation (in) | Intensity (in/hr) | Runoff (in) |
|---|---|---|---|---|
| CH1 | 7/6/2015 | 2.06 | 0.17 | 0.02 |
| | 8/22/2015 | 1.56 | 0.62 | 0.34 |

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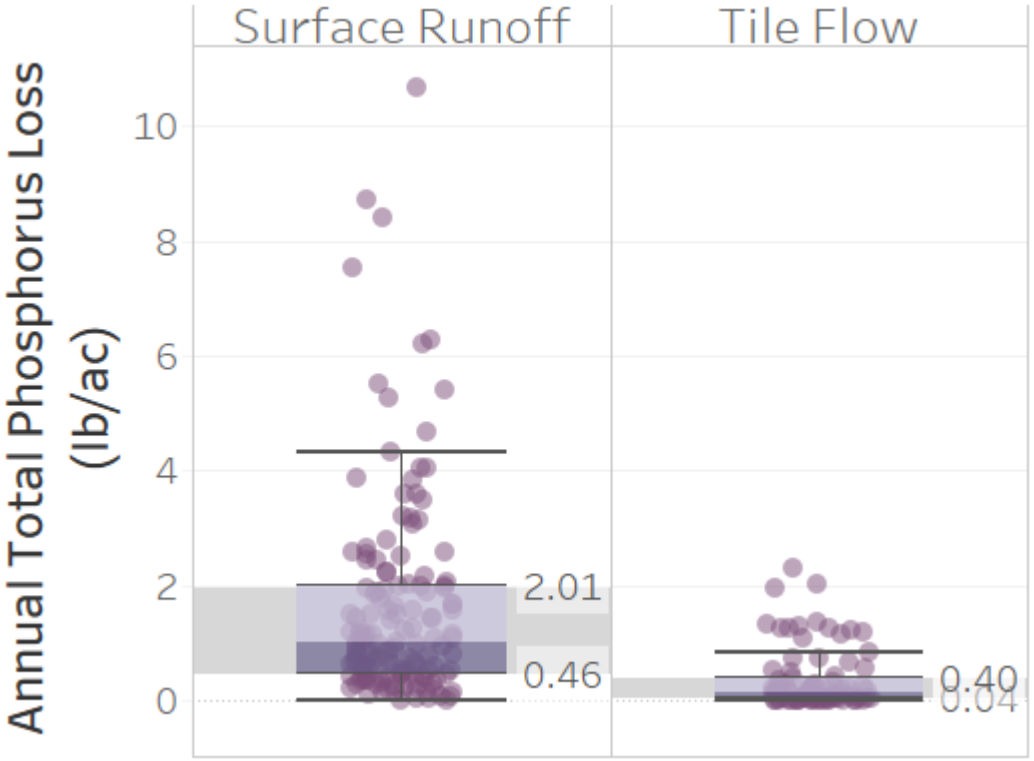
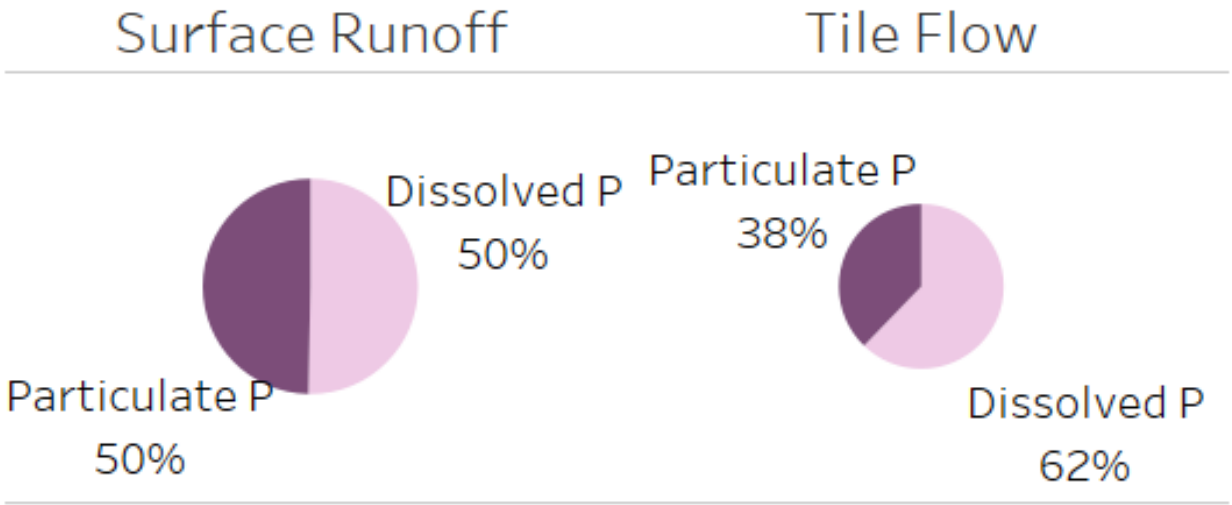
# Phosphorus loss mainly occurs with surface runoff, but a few tile sites have had elevated losses.




Typical Ranges:
Surface Runoff: 0.46 to 2.01 lb/ac
Tile Flow: 0.04 to 0.40 lb/ac

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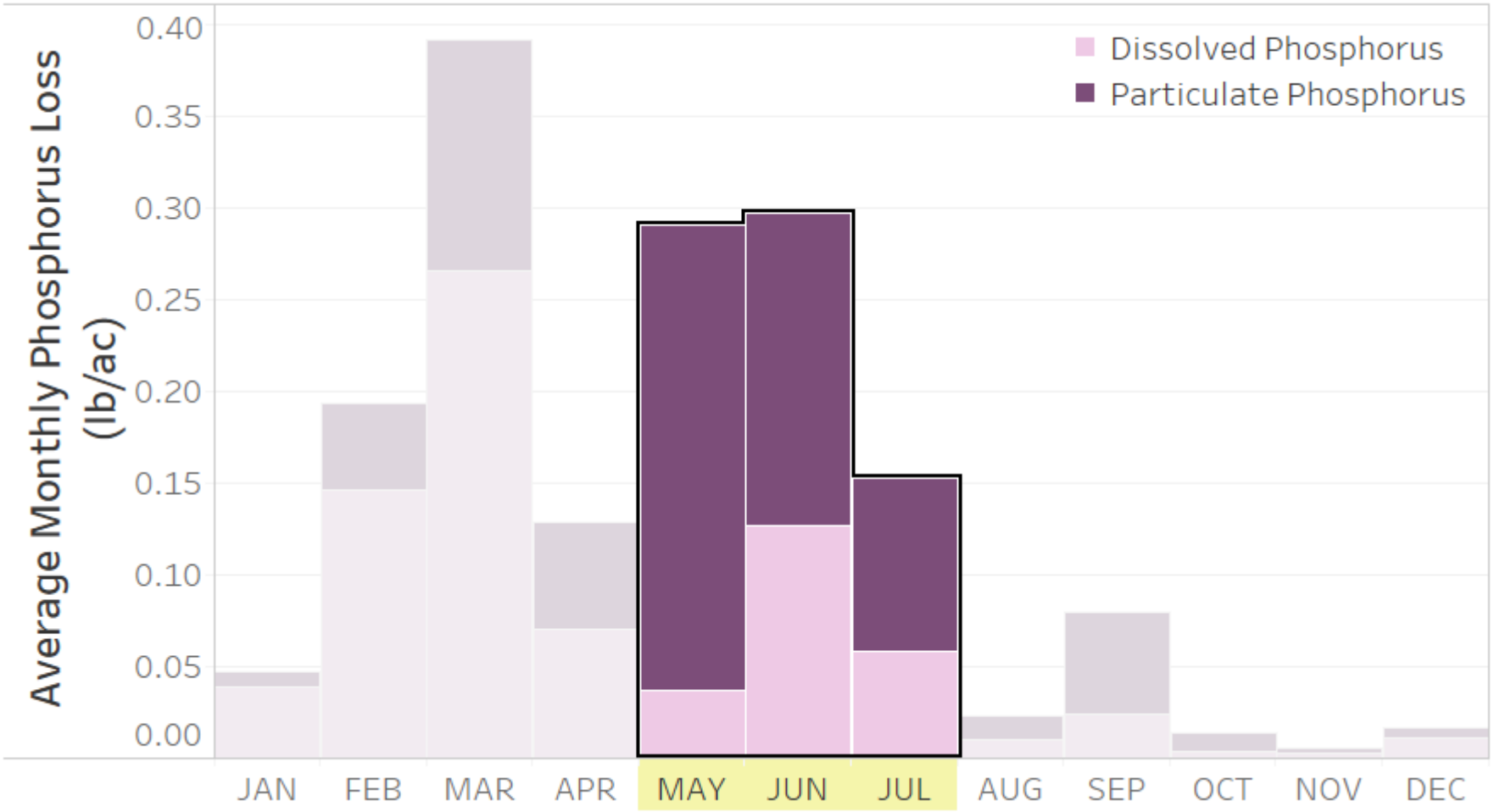
# There are two time periods for phosphorus loss – snowmelt and spring runoff.




JAN/FEB/MAR:
39% of Annual
71% Dissolved

MAY/JUN/JUL:
45% of Annual
70% Particulate

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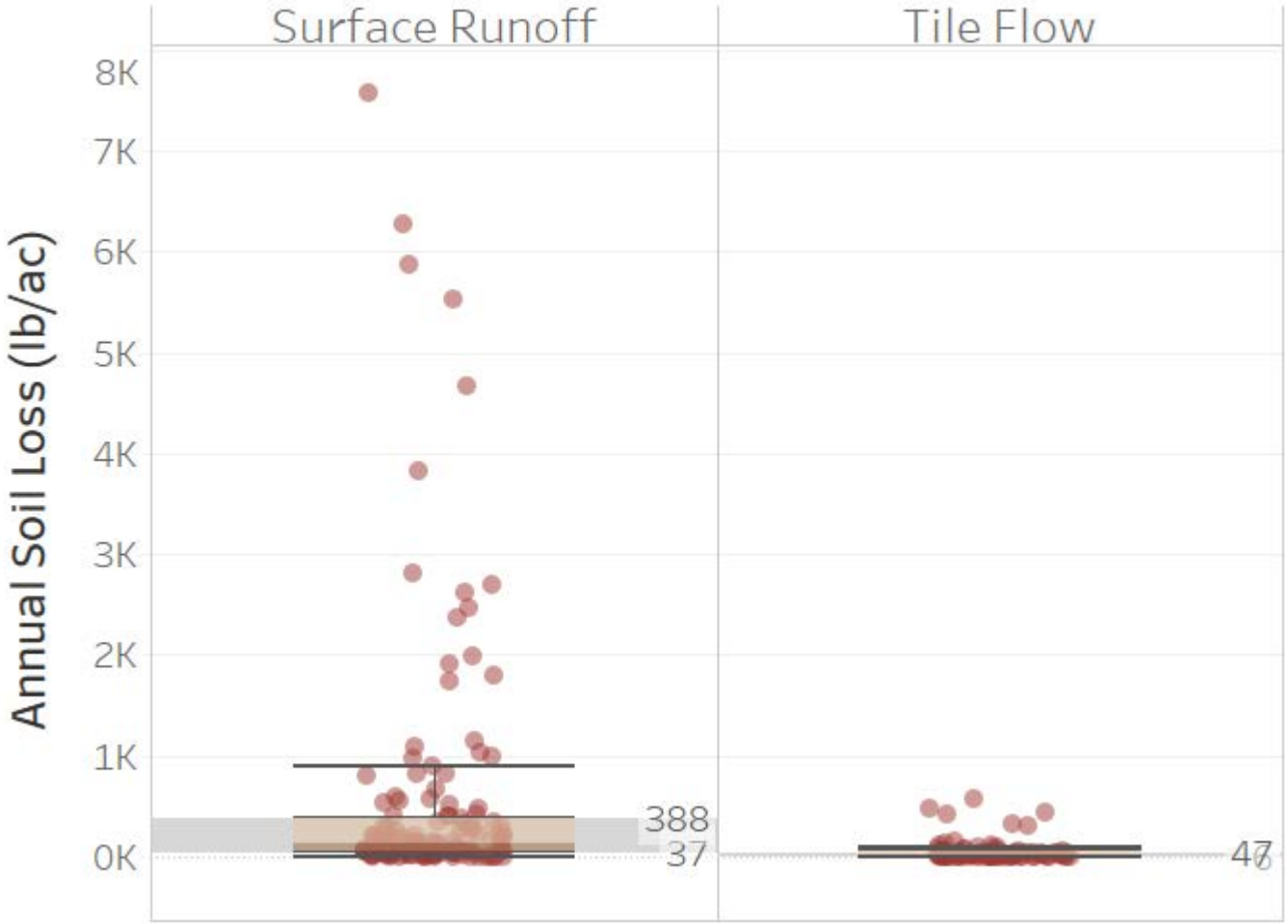
# Soil loss mostly occurs with surface runoff.




Typical Ranges:
Surface Runoff: 37 to 388 lb/ac
Tile Flow: 6 to 47 lb/ac

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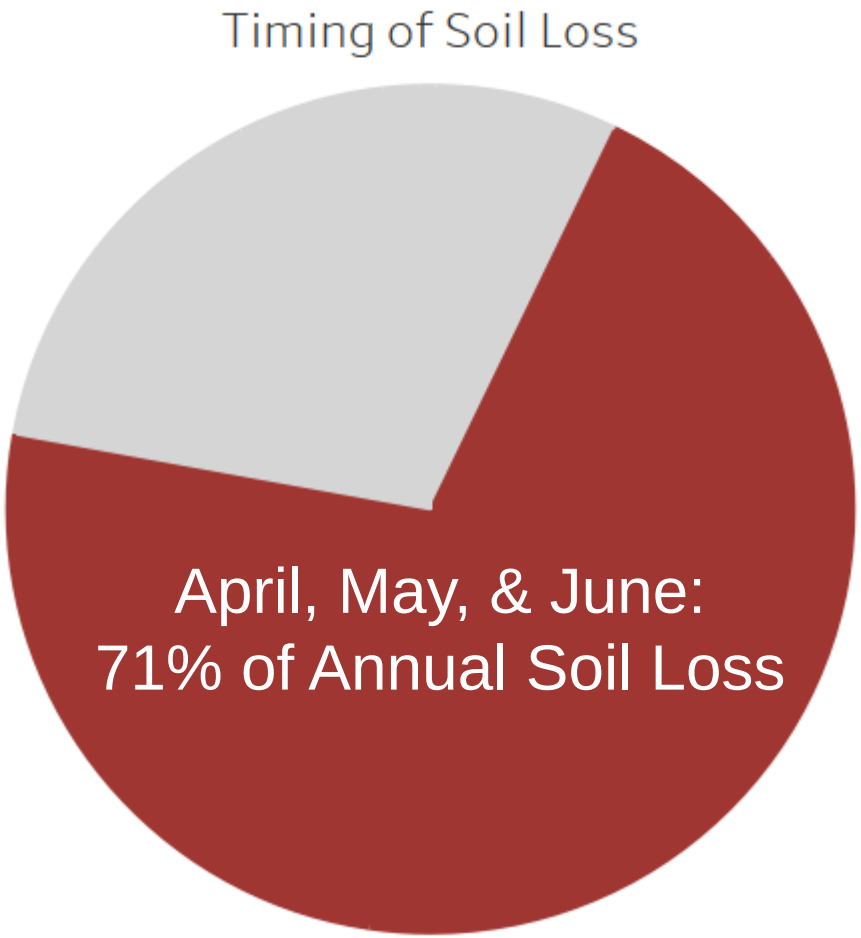
# Controlling soil losses is the first step to managing phosphorus loss.




April, May, and June: Combination of vulnerable fields and intense storm events.

Reduce soil losses by providing protection during this critical time period.

Level of protection needed is site specific.

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# Controlling soil losses is the first step to managing phosphorus loss.

Level of soil protection needed is site specific.

How do we know whether we have enough protection?


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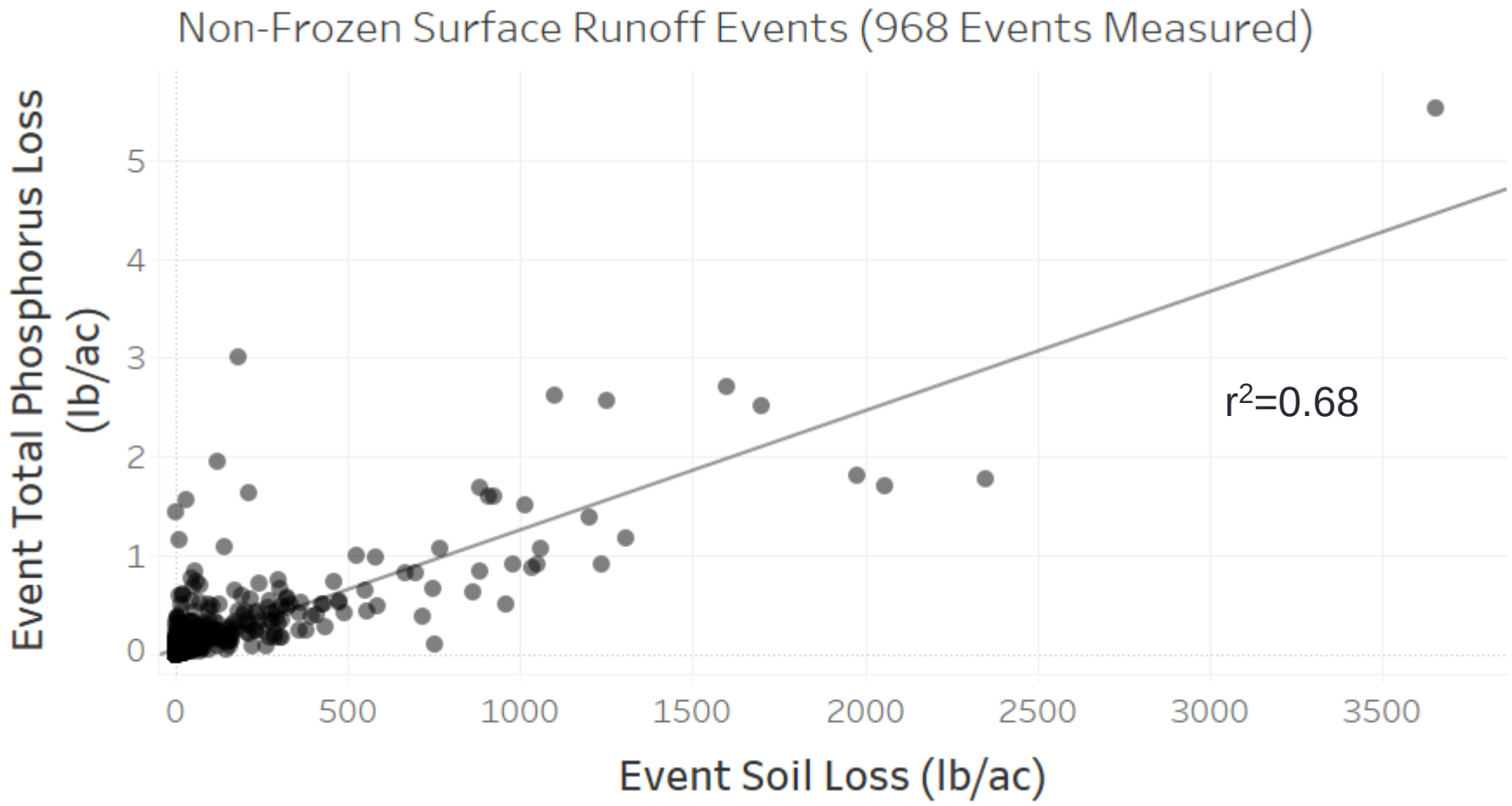
# Controlling soil losses is the first step to managing phosphorus loss.

<u>Surface Runoff:</u>
Phosphorus loss is driven by soil loss during the growing season.

Limiting soil erosion will reduce phosphorus losses

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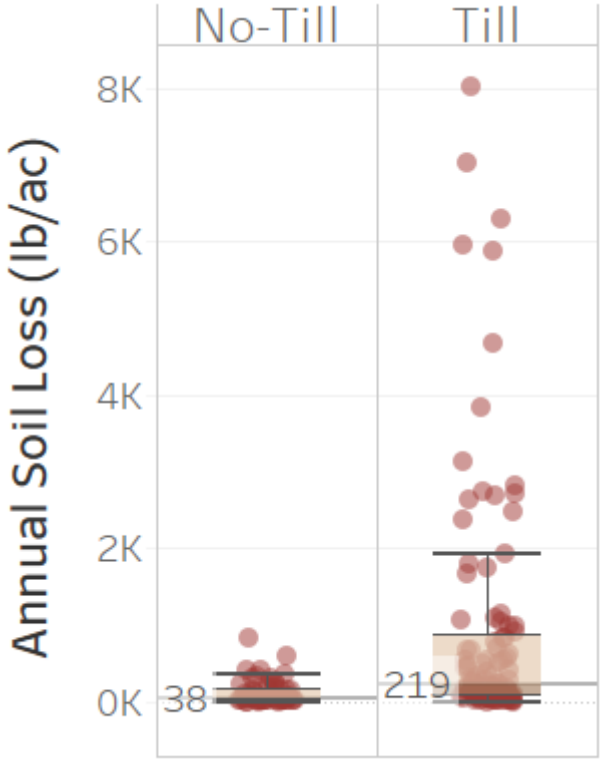
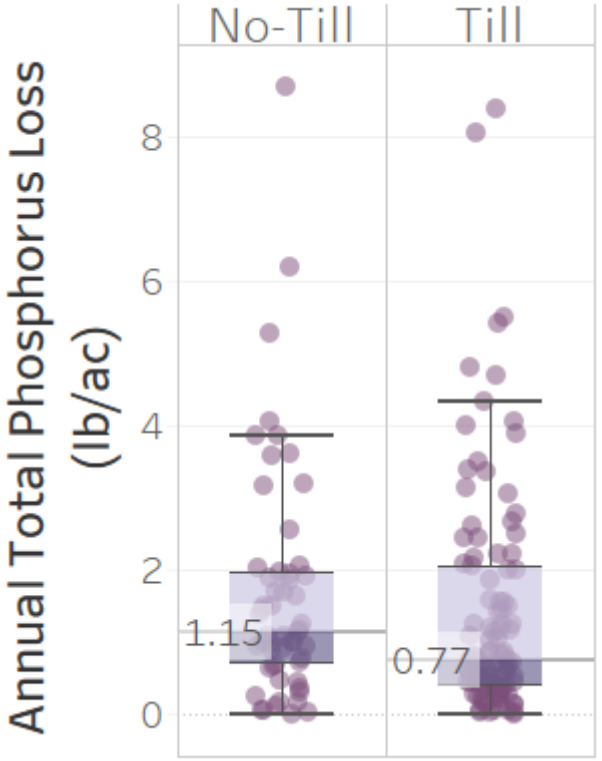
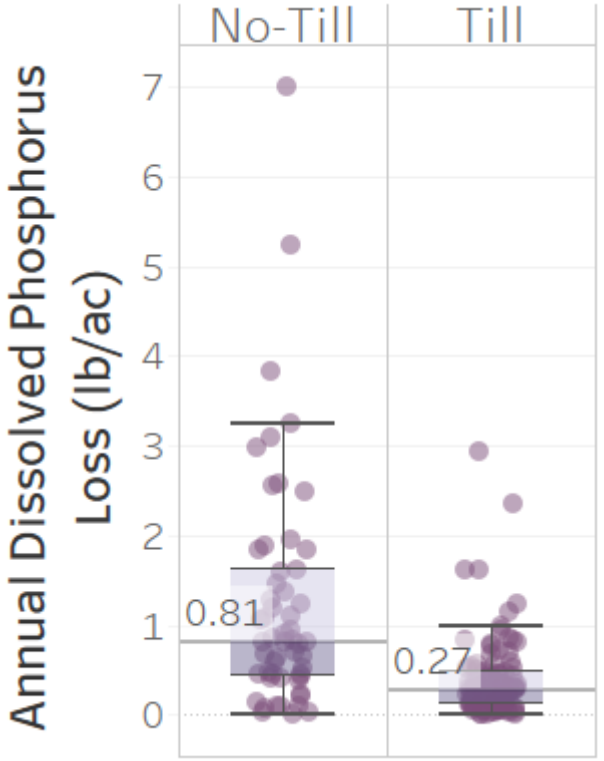
# But, controlling soil losses is **JUST** the first step to managing phosphorus loss.




No-till median: 38 lb/ac
Till median: 219 lb/ac
Rank sum p value: <0.0001




No-till median: 1.15 lb/ac
Till median: 0.77 lb/ac
Rank sum p value: 0.122




No-till median: 0.81 lb/ac
Till median: 0.27 lb/ac
Rank sum p value: <0.0001

Till Count: 104; No-till Count: 55

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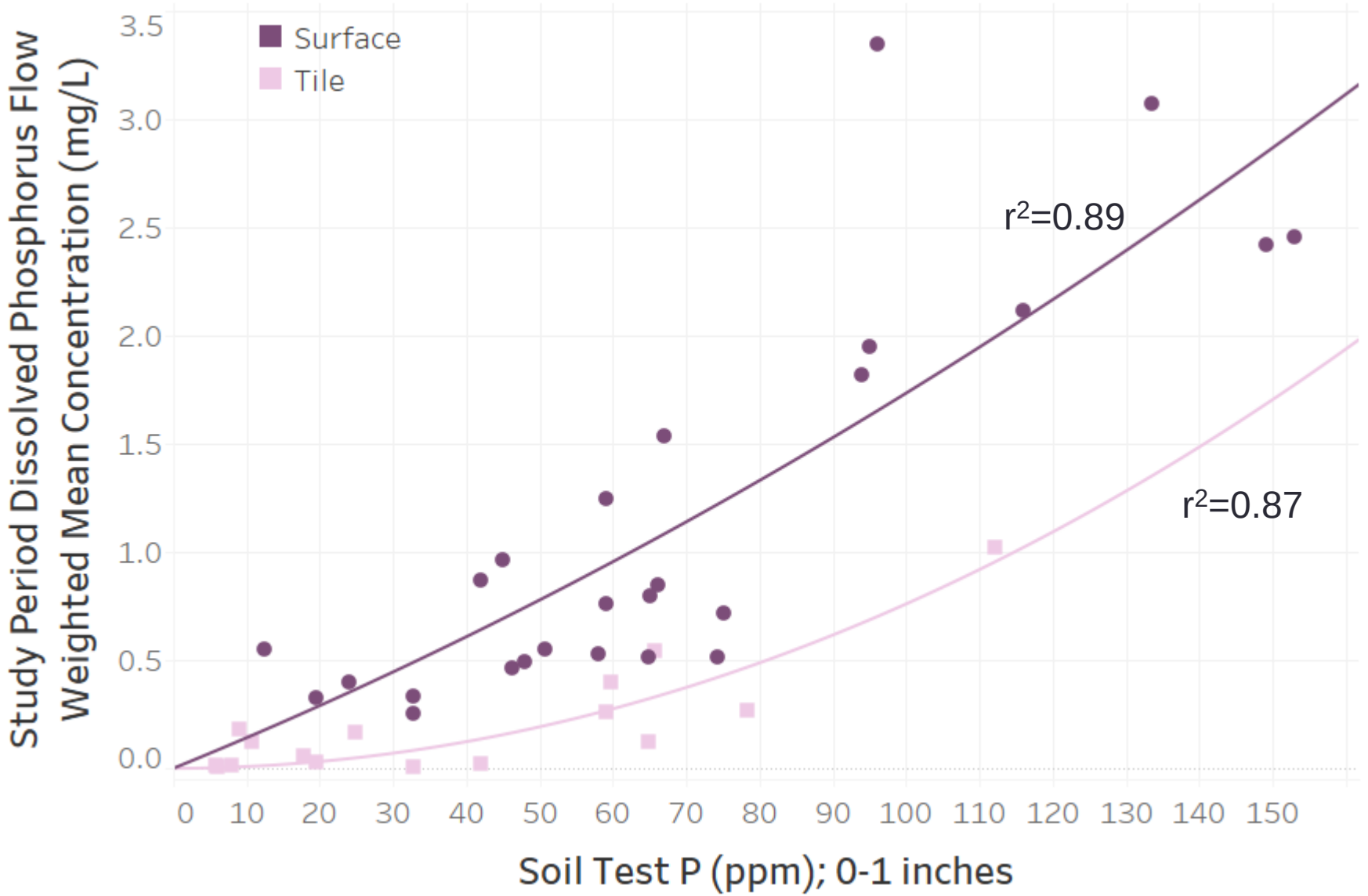
# Managing soil test phosphorus levels in the top of the soil profile is just as important.

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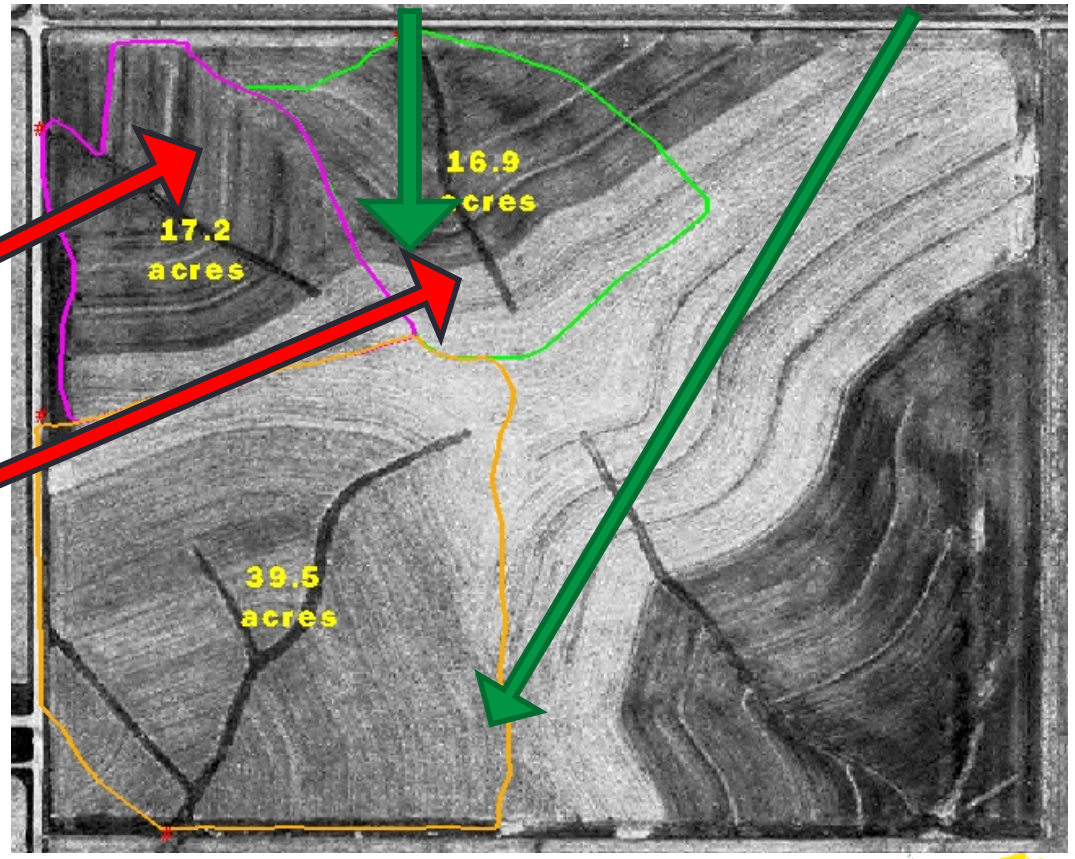
# Consider timing of manure or fertilizer application.

## Winter 2004 SW WI

- Mid-Feb runoff
- 5” snowpack
- Rain on snow

**Fall/Early Winter applications**

**Sep: 6,000 gal/acre  Nov: 7,000 gal/acre**




**Feb. 14: 4,300 gal/acre**

**Feb. 13: 7,000 gal/acre**

**Winter applications- during or shortly preceding runoff**

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# Consider timing of manure or fertilizer application.

## The Outcome

Samples from basins with only November manure application

Samples from basins with February manure application

Management decisions matter - late winter manure applications increased phosphorus losses by 3-4 times at this farm!

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# Keys to reduce phosphorus loss from the edge of field.

**#1** Controlling soil losses is the first step to managing phosphorus loss.

**#2** Limit buildup of phosphorus in the top inch of soil by considering placement and rate of applications.

**#3** Consider timing of manure and fertilizer application.

Tim Radatz - radatz@mawrc.org

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