# Practical implications of a 20-year poultry manure application study

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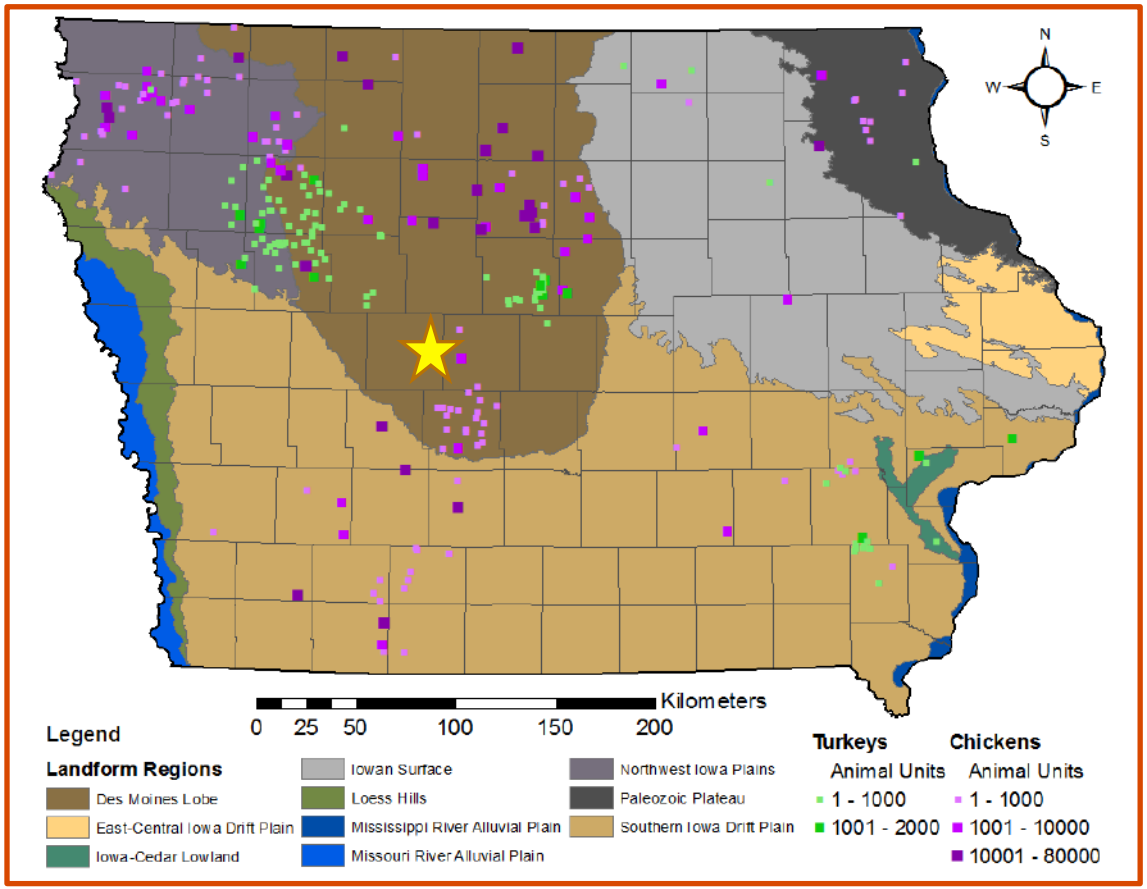
# Goal: Long-term assessment of the environmental and economic impact of poultry manure application in tile drained agricultural systems

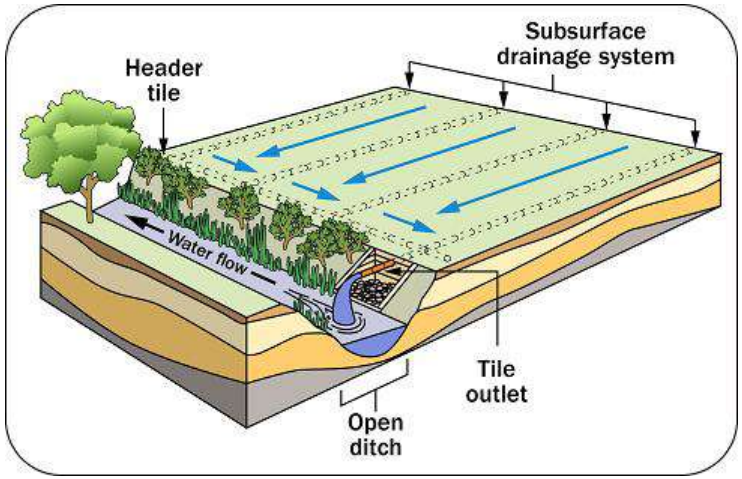
- Compare the impact of commercial fertilizer (UAN) and poultry manure (PM) applied to corn-soybean and corn-corn cropping systems on:
  - soil quality
  - crop yield
  - production cost of corn and soybeans
  - water quality

# When properly managed, poultry manure is a great source of fertilizer to enhance crop production.

- Poultry manure is generated annually in Iowa to land apply to 7% of all row crop acres, or 40% of Iowa's continuous corn acres at an agronomical recommended rate.
- This is a great resource for farmers in Iowa
- Iowa has very hydric soils and approximately half of Iowa's cropland is artificially drained



# Tile drainage artificially lowers the water table to enable or enhance crop production



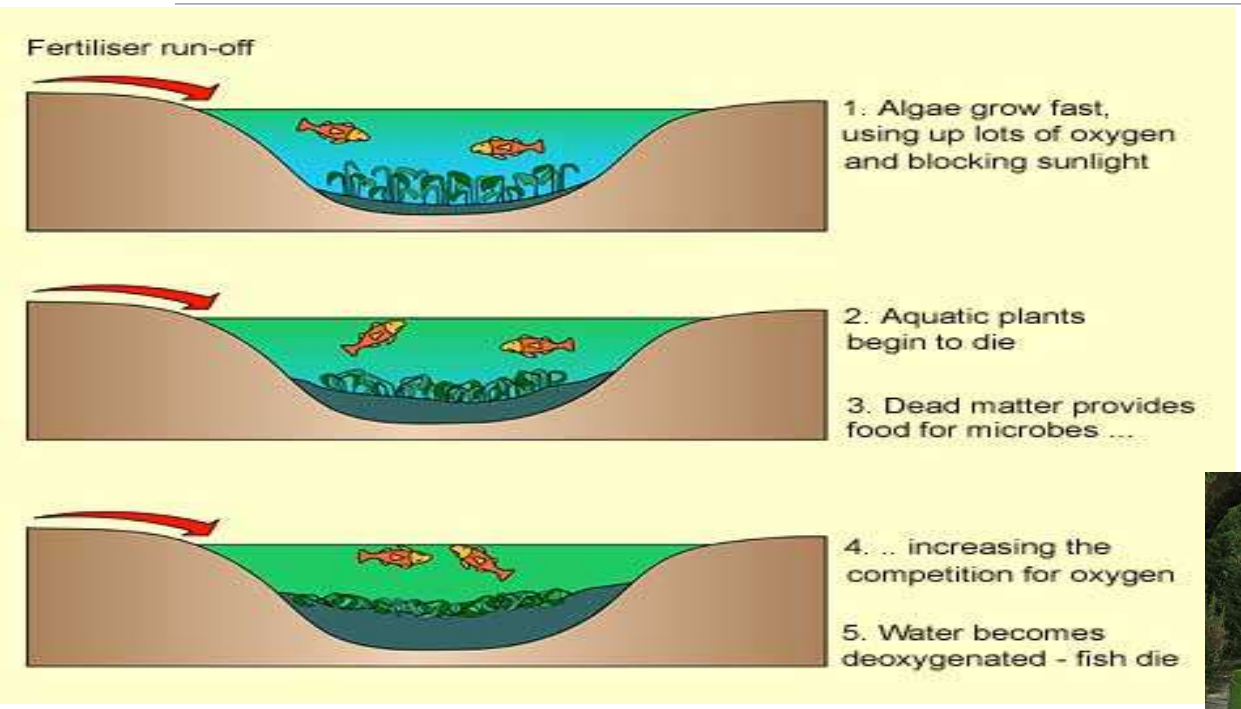

http://www.omafra.gov.on.ca/english/engineer/facts/10-091.htm

**Subsurface drainage has the potential to increase transport of contaminants to surface waters**

http://www.gpsdrainage.com/

http://blog.nature.org/science/2013/10/02/wetlands-conservation/

# High nutrient export from drainage can lead to eutrophic surface waters.




http://www.zo.utexas.edu/faculty/sjasper/images/eutrophication.jpg

http://greenliving.about.com/od/greenlivingbasics/a/Eutrophication-Algal-Blooms.htm

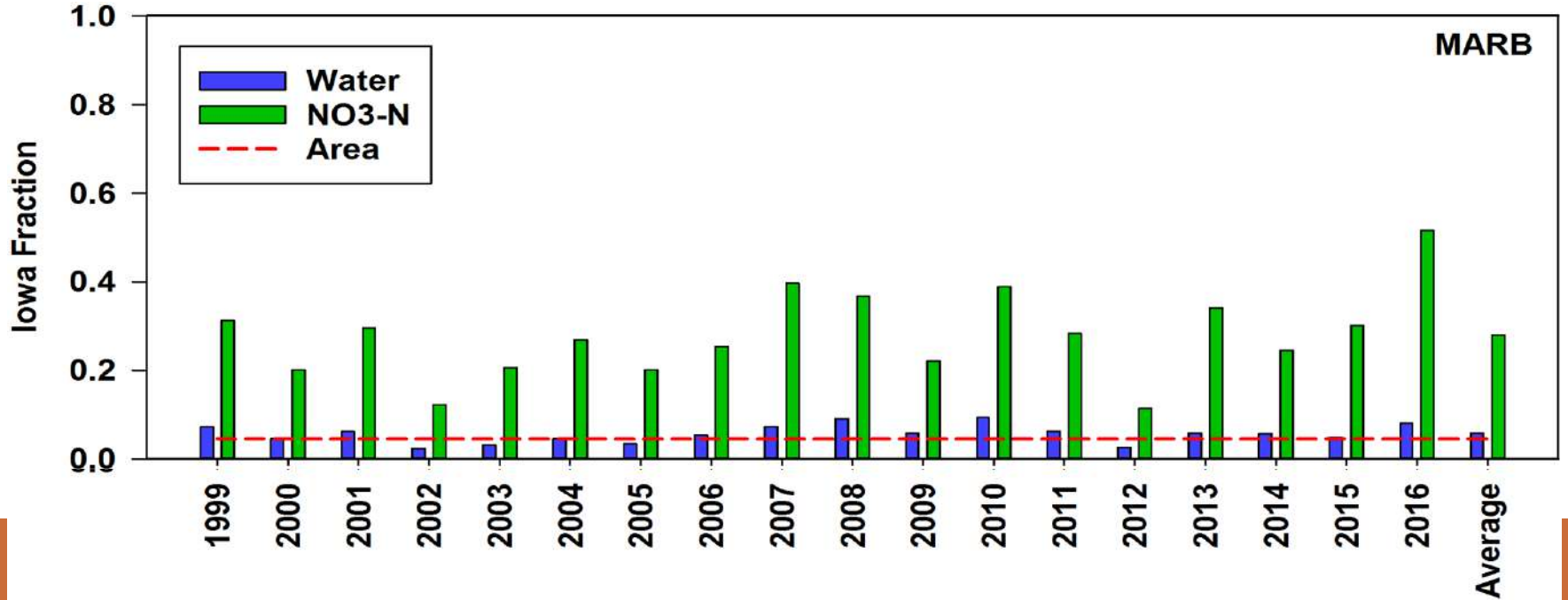
http://www.lakescientist.com/usda-initiative-to-reduce-agricultural-runoff/

# Water quality trends in Iowa show that implementing BMPs will have high impact on Gulf water quality

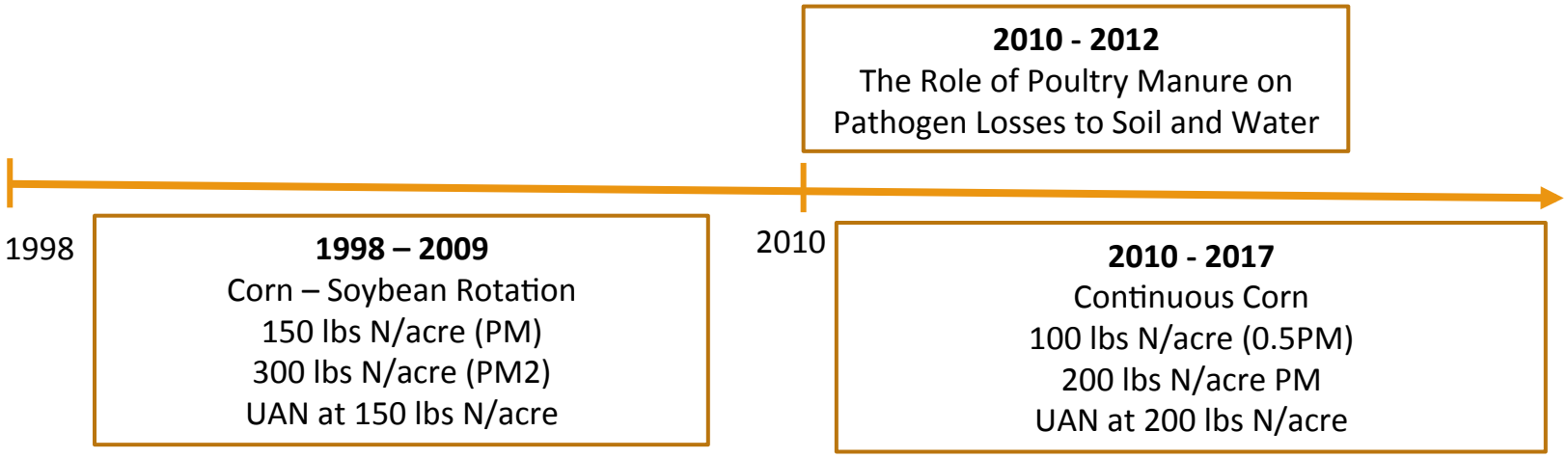
Iowa contributes 10 – 52% of long-term $NO_3$-N loading to the MRB

These loads have consistently remained above 2003 levels

Opportunity to have real impact on Gulf of Mexico hypoxic zone by implementing conservation practices in Iowa (Jones et al., 2018. *PLoS ONE*)



# Project Timeline

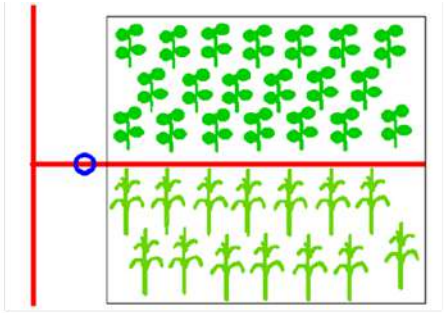



**1998-2017**

Poultry manure applied **in spring** at crop rotation recommended rate

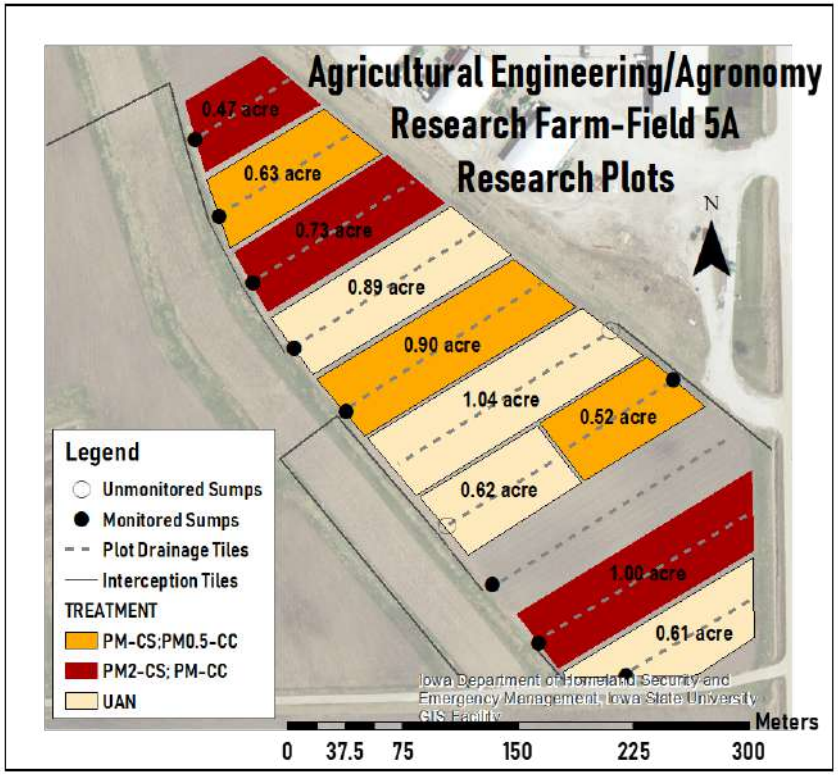
UAN applied at crop rotation recommended rate

# Phase 1 Corn- soybean



Corn-Soybean Rotation

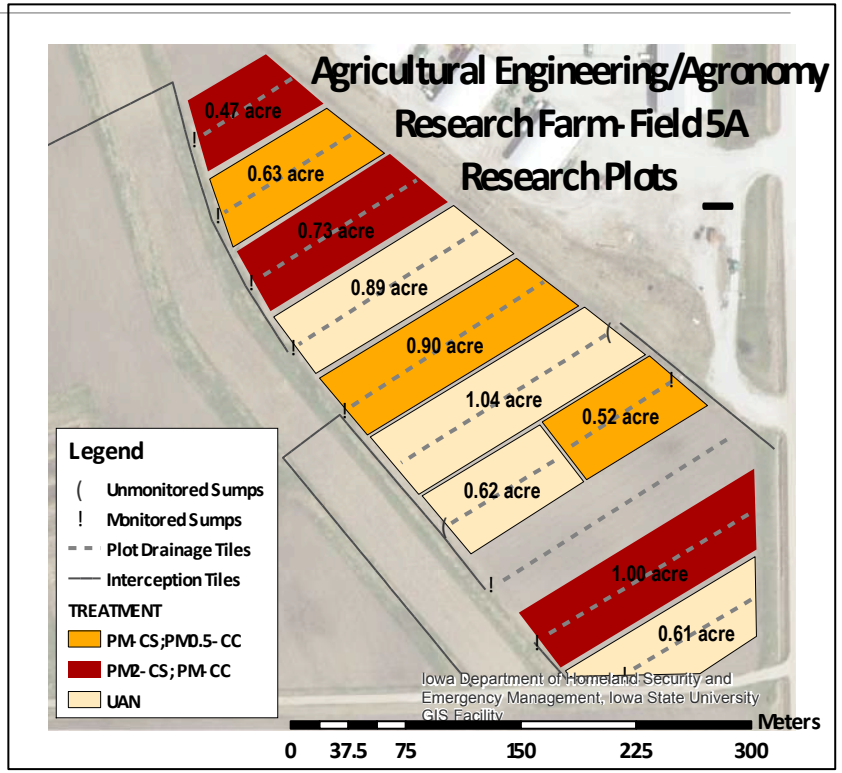
- 1998-2009
  - UAN 150 lbs N per acre
  - Low PM 150 lbs N per acre
  - High PM 300 lbs N per acre



# Phase 2- Continuous Corn

- 2010-2017


- ❖ UAN 200 lbs N per acre
- ❖ Low PM 100 lbs N per acre
- ❖ High PM 200 lbs N per acre



# An aerial view of the two phases of the study

1998-2009 (Corn-soybean Rotation)

2010-2017 (Continuous Corn)

# Manure was applied in the spring to chisel plow managed fields.

www.microbialearth.com

# Soil Health Properties were analyzed

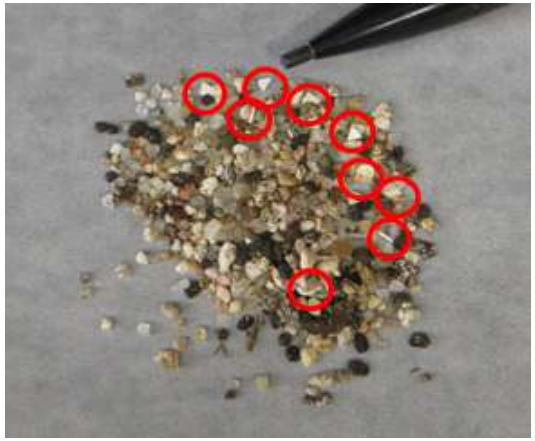
Cores collected in October 2017

Properties measured include:

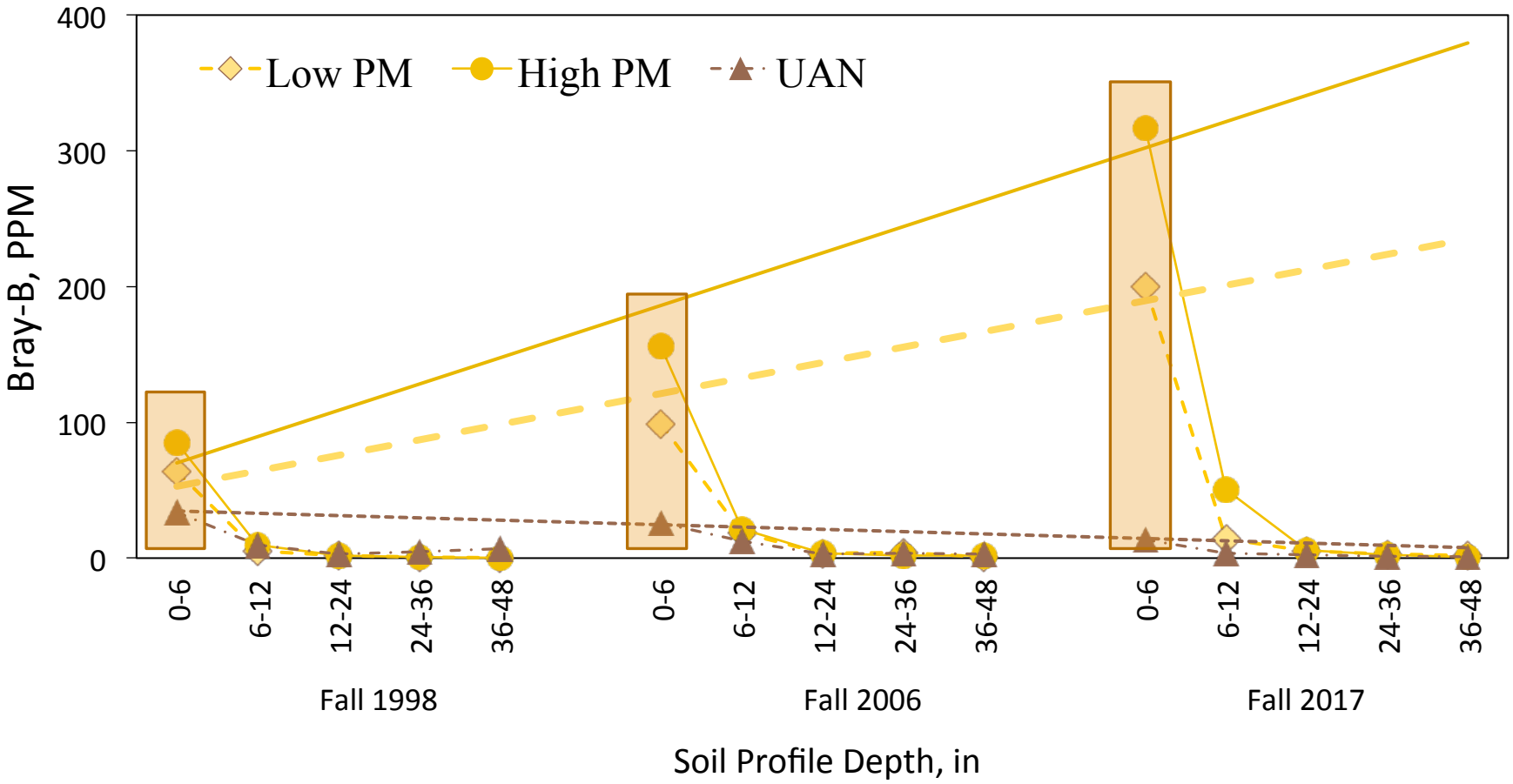
- Bulk density
- Aggregate size distribution
- Particulate Organic Matter (POM)
  - POM is 0.053-2 mm in size
- POM Carbon and Nitrogen
- Soil Organic Carbon and Nitrogen

# Long term poultry manure application improves soil health

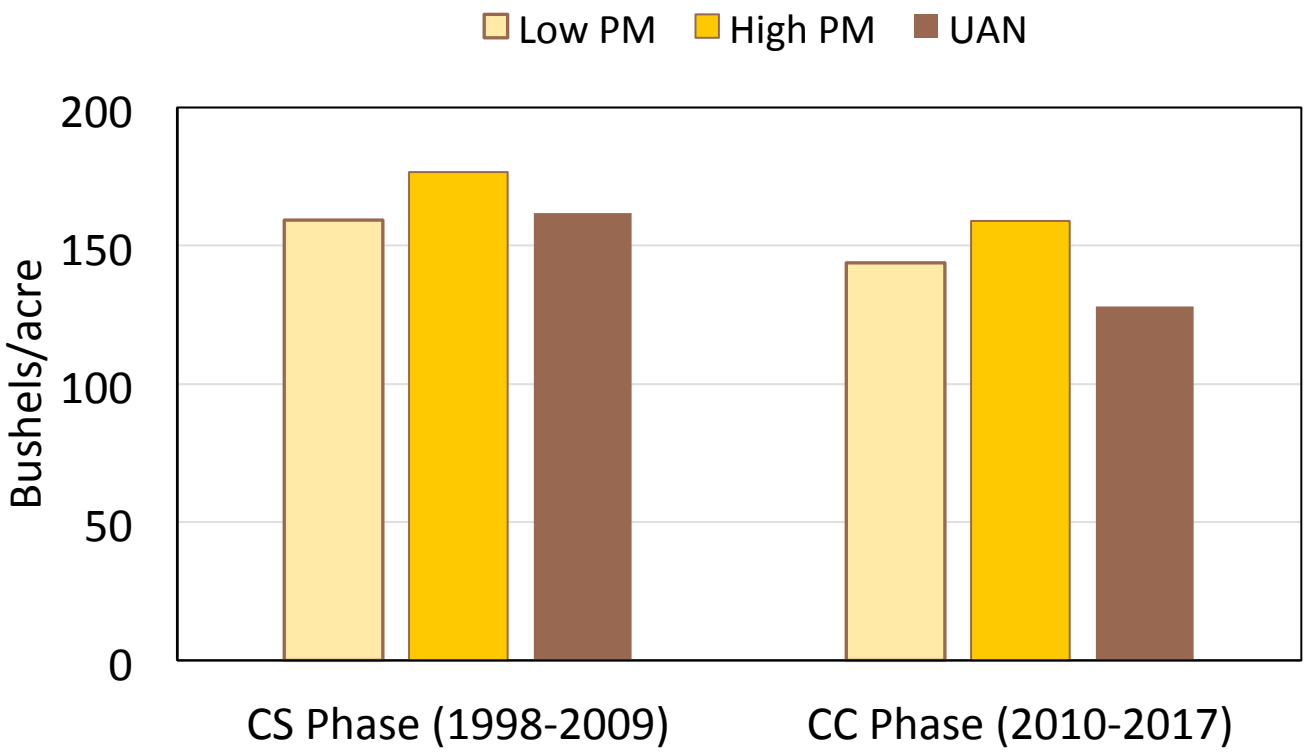
| Fertilizer | SOC (g C/kg soil) | Soil Nitrogen (g/kg soil) | POM content (g/kg soil) | POM C/SOC | Aggregates >0.21 mm | Large Aggregates (>2 mm) |
|---|---|---|---|---|---|---|
| High Poultry Manure | 23.0 A | 2.0 A | 6.7 A | 19% A | 87.5% A | 42.6% A |
| Low Poultry Manure | 21.9 A | 1.9 A | 3.6 A | 17% A | 83.0% AB | 45.9% A |
| UAN | 20.8 A | 1.8 AB | 2.5 B | 12% B | 82.0% AB | 41.6% A |
| No fertilizer | 17.9 A | 1.5 B | 1.7 B | 9% B | 75.3% B | 28.3% B |



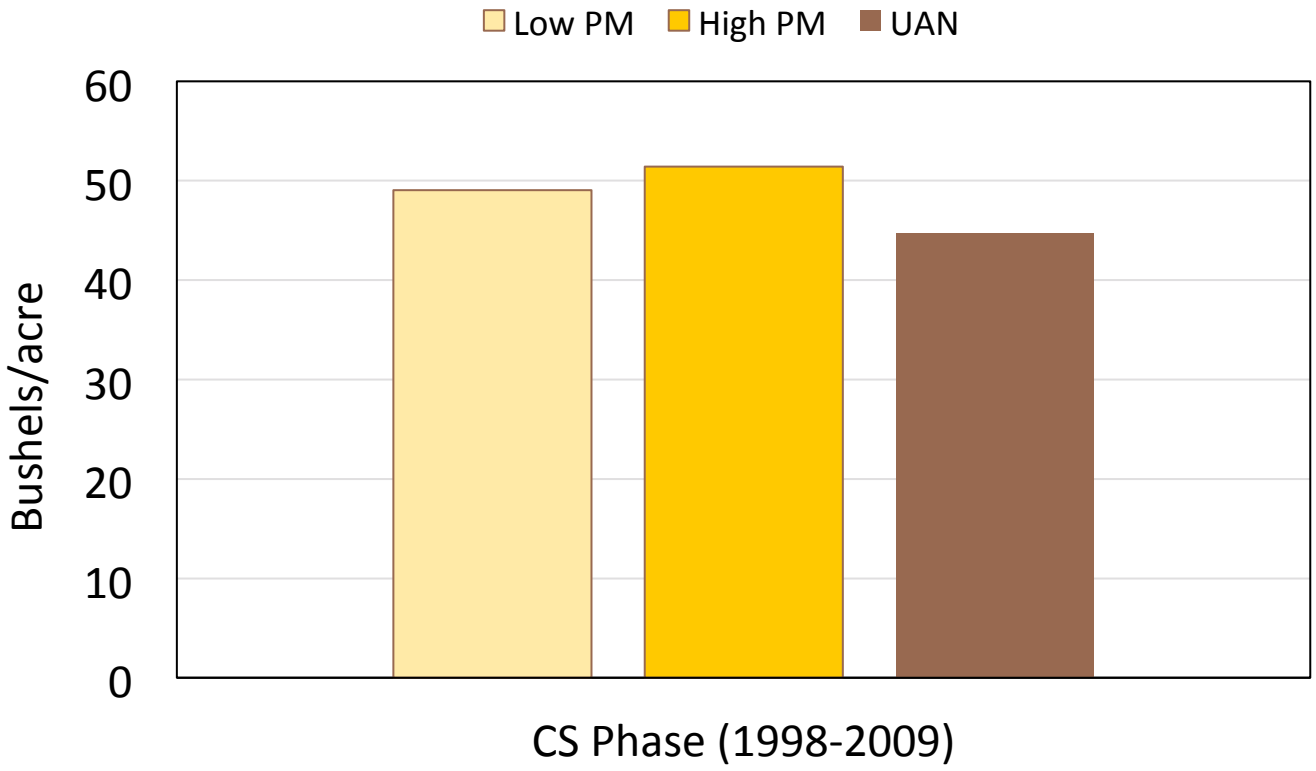
# Topsoil P increased with continued manure application



# Corn Yields


Low PM
High PM
UAN
200
150
100
50
0
Bushels/acre
CS Phase (1998-2009)
CC Phase (2010-2017)

# Soybean Yields



# Techno-economic Analysis (TEA): Inputs, Assumptions

| Input costs | Descriptions | % total input $ |
|---|---|---|
| Pre-harvest machinery | Chisel plow, tandem disk, N applicator, field cultivate, plant, cultivate, spray | 5-10% |
| Harvest machinery | Combine, grain cart, haul, dry (corn), handle | 15-20% |
| Land | Cash rent equivalent | 40-50% |
| Labor | 2 to 3 hours per ac depending on type of crop | 5% |
| Seed | | 10-20% |
| Lime | Yearly cost | < 3% |
| Miscellaneous | | < 3 % |
| Fertilizer | Manure or UAN fertilizer cost | 15-20% |

**Manure and UAN prices 2010-2017:**

UAN: $233 - $395/ton (avg. $112/ac)

PM: N(55%) P(60%) K(60%); avg. $33/ton ($160/ac for PM)

Source: https://www.extension.iastate.edu/agdm/crops/html/a1-20.html

# Techno-economic Analysis (TEA): Calculations

Manure price calculation and assumptions

- N, P, K content
  - TKN: 43±10 lb/ton
  - $P_2O_2$: 52±25 lb/ton
  - $K_2O$: 34±12 lb/ton
- Assumed 55%, 60%, 60% availability
- Commercial N, P, K fertilizer cost
- Assumed 20 miles transportation distance
- Manure price ($/ton) = actual test N (or P, K) content (lb/ton) * assumed N (or P, K) availability (%) * commercial fertilizer cost ($/lb) + transportation cost ($/ton)

- Total production cost per bushel ($/bu)

  = Production costs ($/ac) / average crop yield (bu/ac)

- Total revenue ($/ac)

  = cash price ($/bu) * average crop yield (bu/ac)

- Revenue per dollar of input ($/$, unitless)

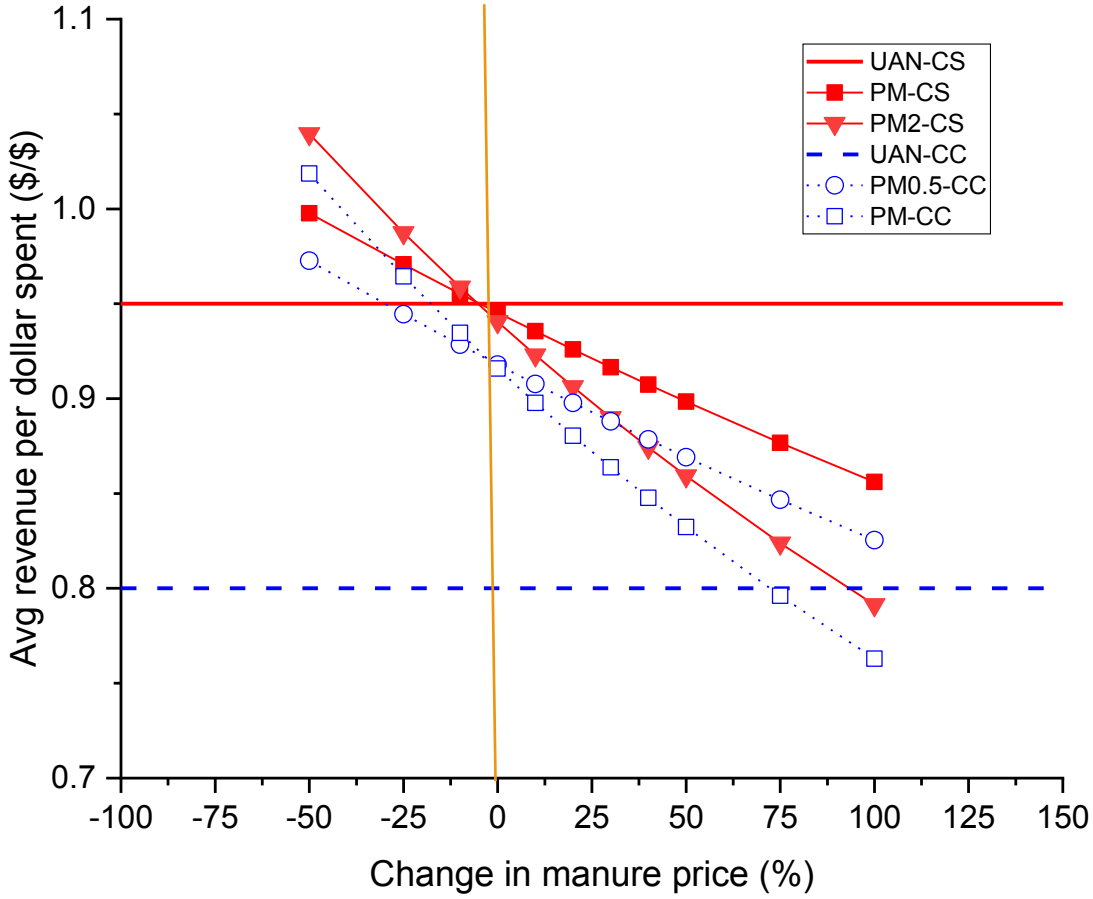
  = crop revenue ($/ac) / total input cost ($/ac)

# Relative comparison of production cost and revenue per $ input

| Cost per Bushel ($/bu) | | | | | | |
|---|---|---|---|---|---|---|
| Phase | Crop | Years | PM0.5 | PM | PM2 | UAN1 |
| CS | Corn | 2000-2009 | --- | $3.00 | $3.09 | $2.74 |
| CS | Soybean | 2000-2009 | --- | $6.66 | $6.45 | $7.65 |
| CC | Corn | 2010-2017 | $5.62 | $5.54 | --- | $6.88 |

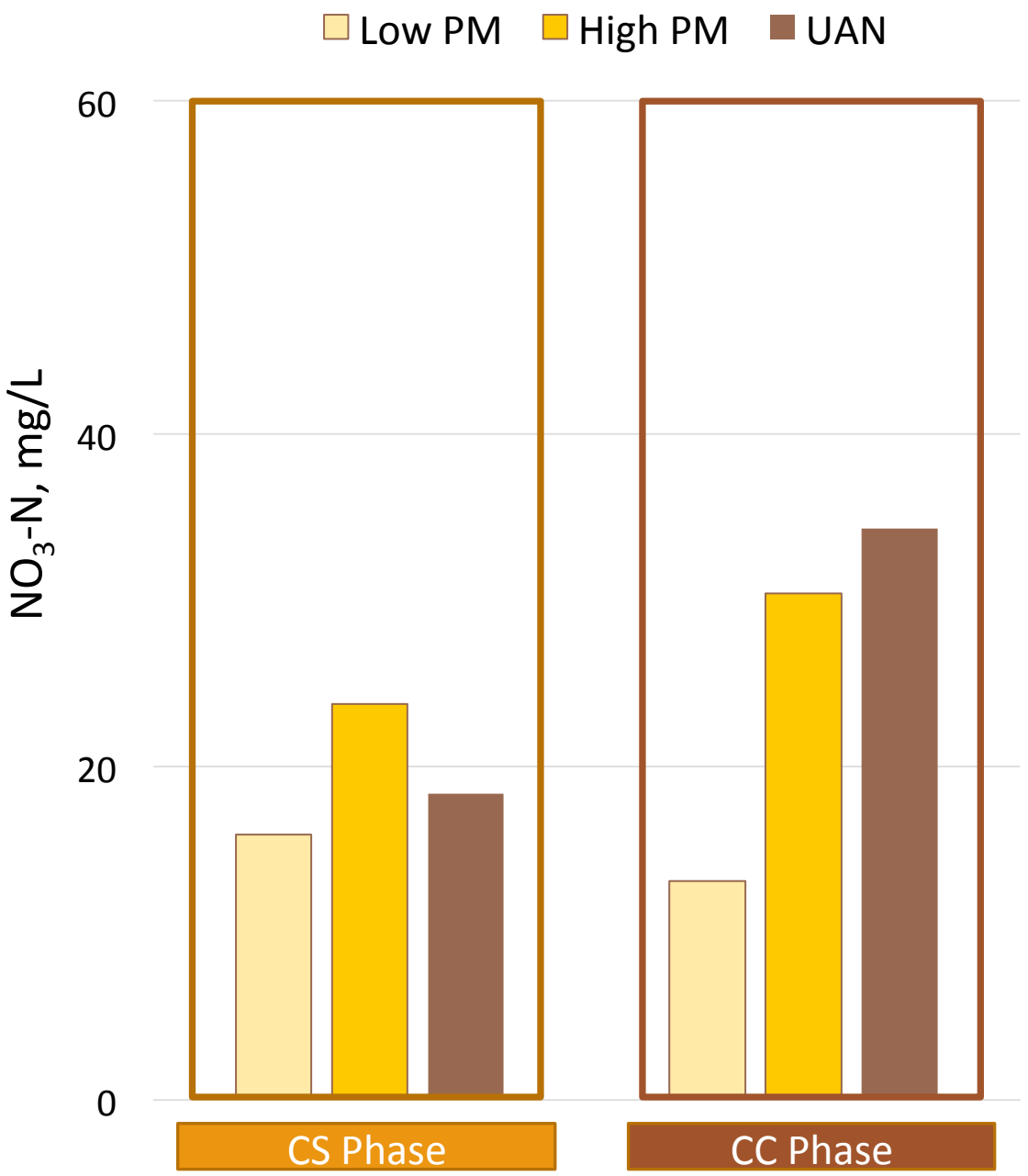
| Revenue per dollar of input ($/$) | | | | | | |
|---|---|---|---|---|---|---|
| Phase | Crop | Years | PM0.5 | PM | PM2 | UAN1 |
| CS | Corn | 2000-2009 | --- | 0.88 | 0.86 | 0.97 |
| CS | Soybean | 2000-2009 | --- | 1.04 | 1.09 | 0.92 |
| **CS** | **Combined** | 2000-2009 | | 0.95 | 0.94 | 0.95 |
| **CC** | **Corn** | 2000-2017 | 0.92 | 0.92 | --- | 0.80 |

# Changes in manure prices impact average revenue per $ spent

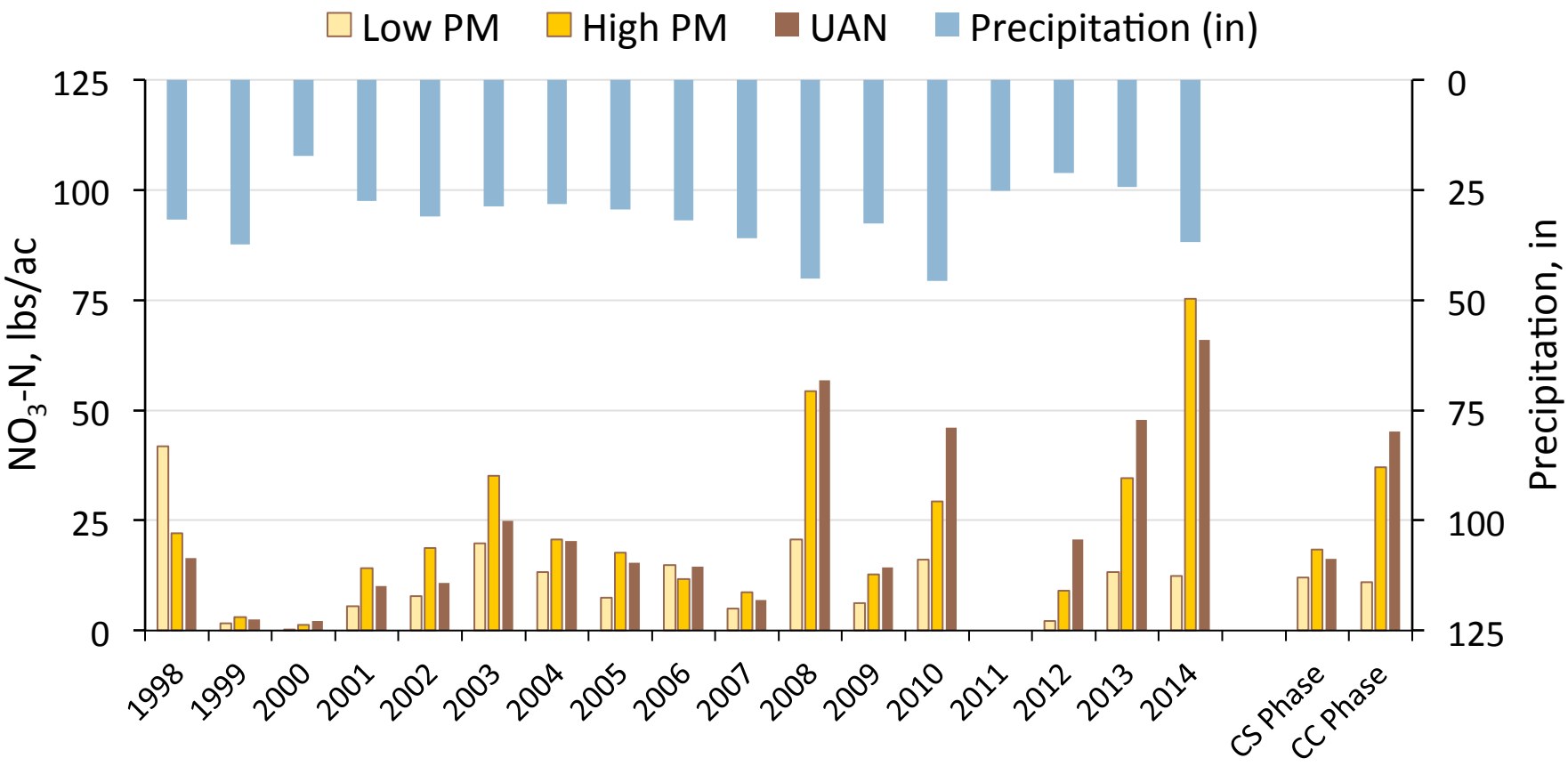


# Lower average drainage $NO_3$-N was measured with manure

- CS Phase- 11% lower
- CC phase- 13% lower

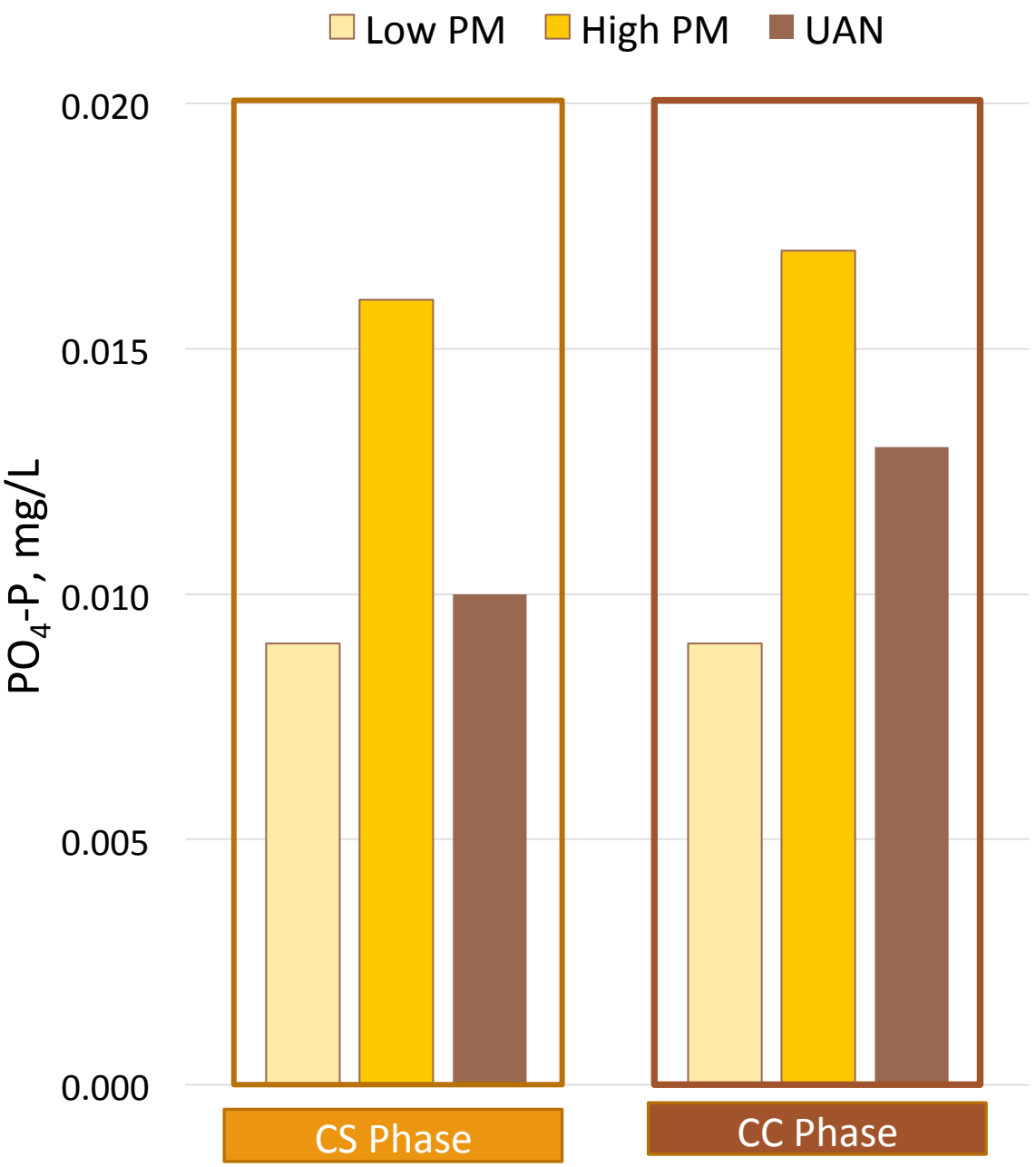


# $NO_3$-N losses are related to precipitation



# Drainage phosphorus concentrations remained relatively low throughout the study

- Similar $PO_4$-P concentrations with manure compared to UAN at the same rate during the CS Phase.
- 0.004 mg/L higher $PO_4$-P concentrations with poultry manure compared to UAN



# Major Findings: Yield benefit of poultry manure also agrees with other studies

Soybean yields 10% higher with poultry manure applied at the same rate as chemical fertilizer (UAN)

Corn yields similar (2% lower) with poultry manure applied at the same rate as UAN during the CS Phase.

Corn yields 24% higher with poultry manure applied at the same rate as UAN during the CC Phase.

# These yield benefits mean that poultry manure application provides an economic benefit to the farmer

http://www.dreams.metroeve.com/wp-content/uploads/2017/03/dreams.metroeve_corn-field-dreams-meaning-1024x821.jpg

# Practical Implications: Poultry manure improved soil health but conservation practices are still important

- Soil health indicators show ***long term soil health benefits of poultry manure application***
- Soil P was higher in the topsoil (0-6”) for all poultry manure treatments
- Soil P was immobile, with accumulation limited to the ***Conservation practices important to prevent P movement with surface runoff***

# Practical Implications: Nitrate levels in drainage were lower from poultry manure plots

- Lower nitrate concentrations and losses to drainage were measured with poultry manure applied ***at rates equal to or less than UAN***.
- Phosphorus drainage concentrations remained low throughout the study

# Study results are based on spring manure application, one example of many existing practices

Additional studies are need to confirm a wider range of standard industry practices and their impact on water quality

Suggestions include: fall manure application, different tillage options, balanced manure (200A ~ every 3 years, etc…)

The benefits of lower nitrate in drainage from poultry manure amended plots ***will likely not be observed if supplemental nitrogen is applied***.

***Smarter manure application is needed*** to make sure sufficient nutrients are applied at the right place and time

# Acknowledgements


- ABE-Water Quality Research Lab- Loren Shiers, Leigh Ann Long
- Agricultural Engineering Research Farm- Richard Vandepol, Nathan Meyers, Mike Fiscus
- Iowa Agriculture and Home Economics Experiment Station







Questions?

# Average Annual Drainage Phosphorus (lbs/ac)