TILE DRAINAGE RESEARCH IN WISCONSIN

Matt Ruark
Dept. Soil Science
University of Wisconsin-Madison
University of Wisconsin-Extension

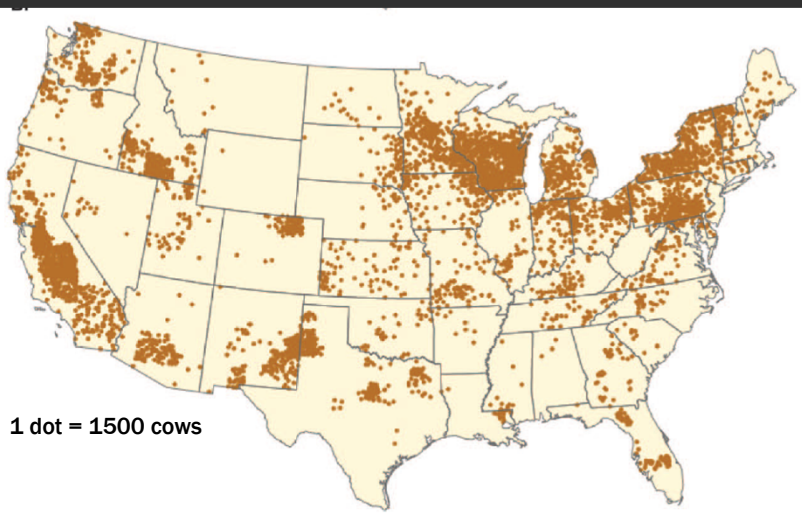
Eric Cooley – UWEX & UW-Discovery Farms
John Panuska – UW-BSE & UWEX

DEPARTMENT OF SOIL SCIENCE
University of Wisconsin-Madison

OUTLINE

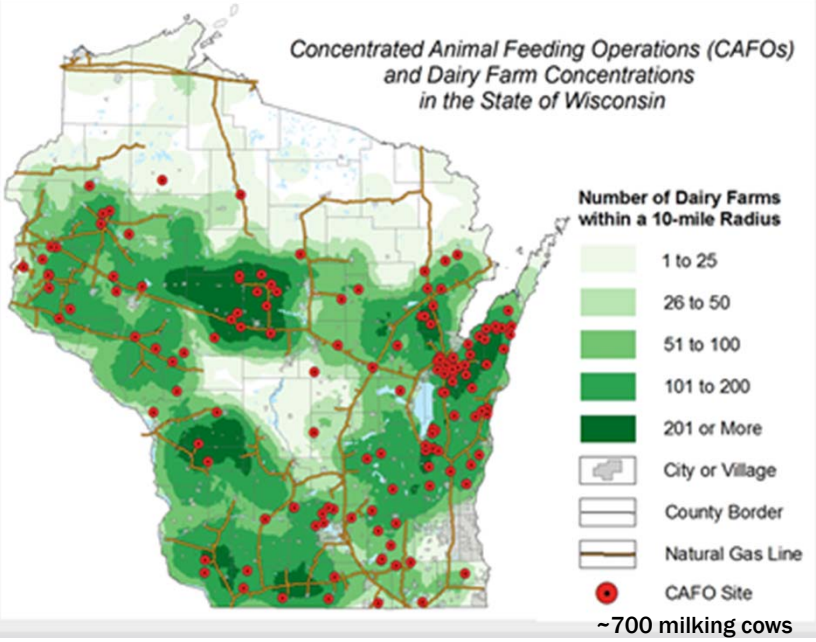
- Review tile drainage, cropping systems, and soils of Wisconsin.
- Discuss our on-going efforts with field-level measurements through our Discovery Farms program.
- Water data
- Phosphorus data

DAIRY COWS IN THE US



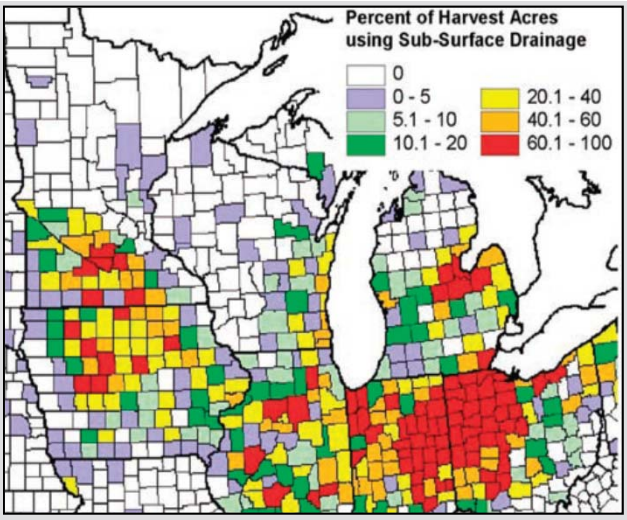
1 dot = 1500 cows

von Keyserlingk et al. 2012



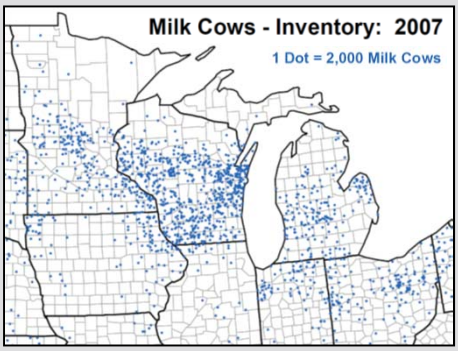
~700 milking cows

MAP OF TILE DRAINAGE IN US

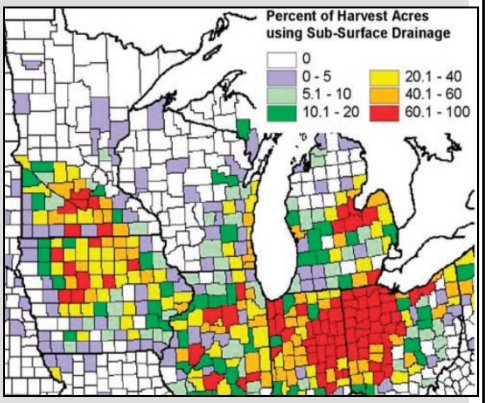


U.S. Census of Agriculture, 1992

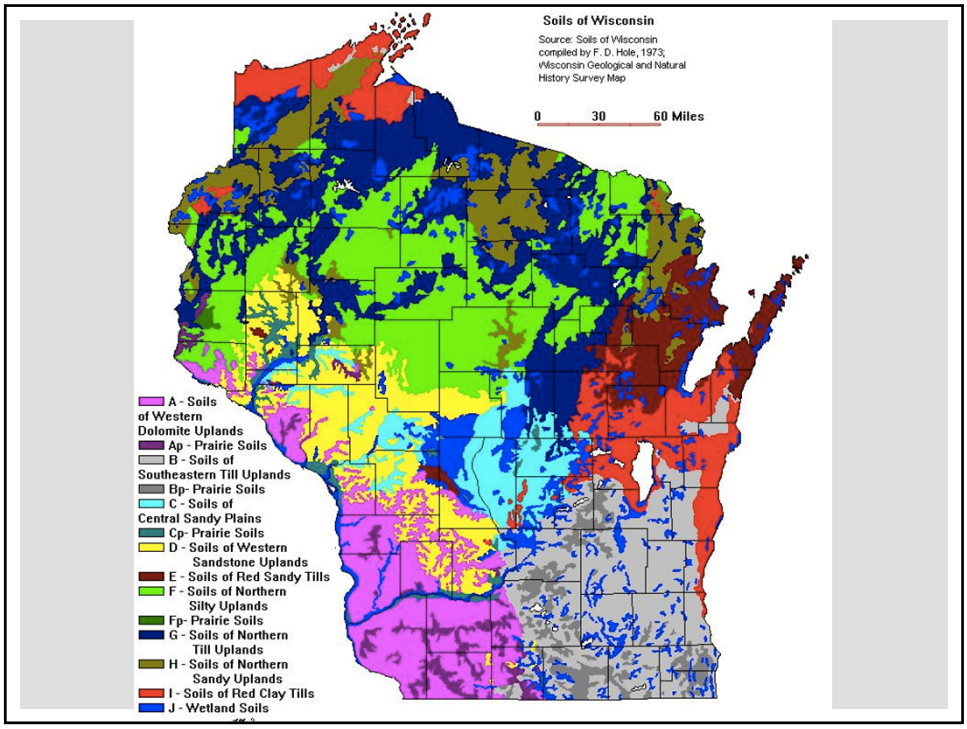
DRAINAGE AND COWS



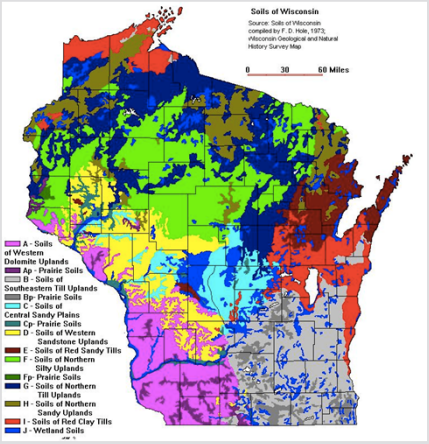
U.S. Census of Agriculture, 2007

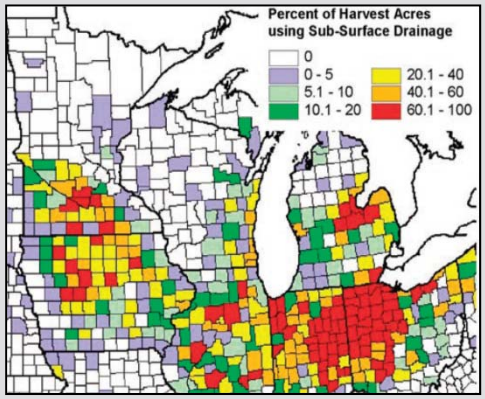


U.S. Census of Agriculture, 1992

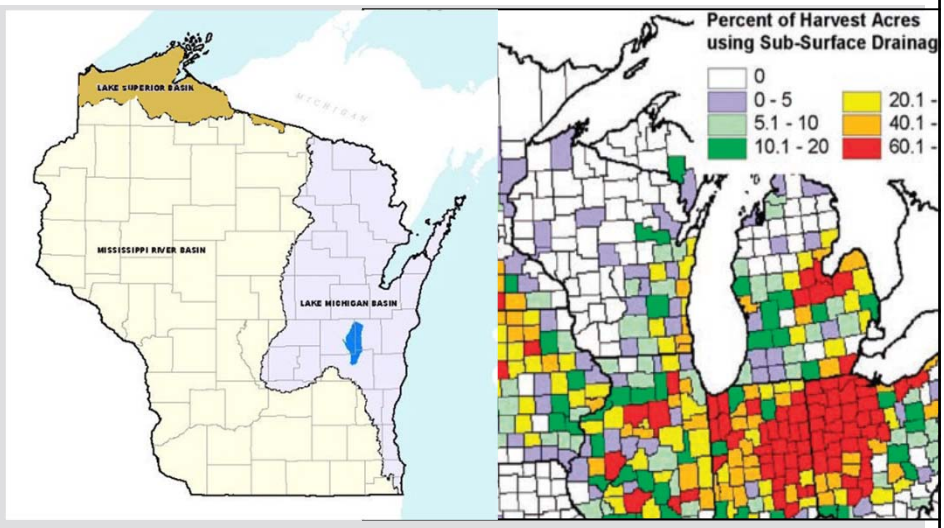


DRAINAGE AND SOILS





WATERSHEDS & DRAINAGE



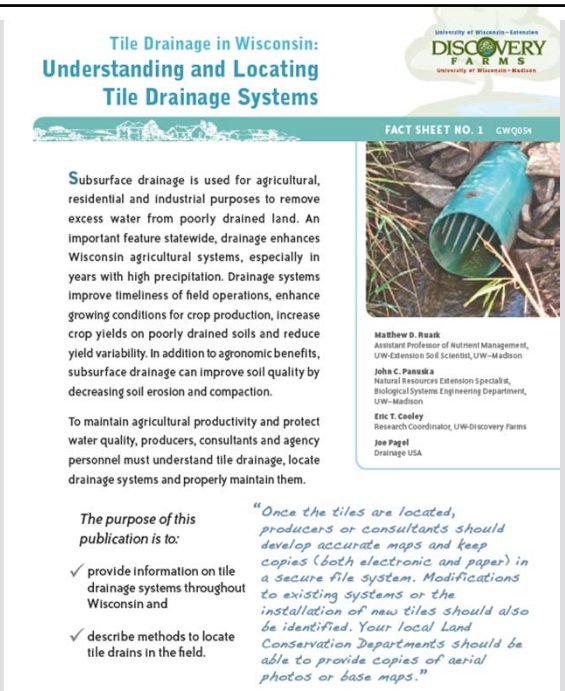
UW-DISCOVERY FARMS

UW-DISCOVERY FARMS

- Cooperative program between Wisconsin farmers, UW-Extension, and UW-Madison
- Began in 2001
- Mission:
  - Develops on-farm research
  - Evaluates environmental and economic effects
  - Educates and improves communication among the agricultural community, researchers, and policy-makers
- Run by two co-directors (UW-Extension) and Steering Committee (farmer representatives of agricultural industry groups in the state).

UW-DISCOVERY FARMS PROGRAMS

1. Winter manure application
2. In-field conservation practices
3. Agricultural tile drainage



Tile Drainage in Wisconsin:
Understanding and Locating Tile Drainage Systems

University of Wisconsin–Extension DISCOVERY FARMS University of Wisconsin–Madison

FACT SHEET NO. 1 GWQ05H

Subsurface drainage is used for agricultural, residential and industrial purposes to remove excess water from poorly drained land. An important feature statewide, drainage enhances Wisconsin agricultural systems, especially in years with high precipitation. Drainage systems improve timeliness of field operations, enhance growing conditions for crop production, increase crop yields on poorly drained soils and reduce yield variability. In addition to agronomic benefits, subsurface drainage can improve soil quality by decreasing soil erosion and compaction.

To maintain agricultural productivity and protect water quality, producers, consultants and agency personnel must understand tile drainage, locate drainage systems and properly maintain them.

Matthew D. Ruark
Assistant Professor of Nutrient Management, UW-Extension Soil Scientist, UW–Madison
John C. Panuska
Natural Resources Extension Specialist, Biological Systems Engineering Department, UW–Madison
Eric T. Cooley
Research Coordinator, UW-Discovery Farms
Joe Pagel
Drainage USA

The purpose of this publication is to:

- ✓ provide information on tile drainage systems throughout Wisconsin and
- ✓ describe methods to locate tile drains in the field.

"Once the tiles are located, producers or consultants should develop accurate maps and keep copies (both electronic and paper) in a secure file system. Modifications to existing systems or the installation of new tiles should also be identified. Your local Land Conservation Departments should be able to provide copies of aerial photos or base maps."

TILE DRAINAGE IN WISCONSIN

- We do believe there is has been a dramatic increase in tiled fields in the past six years (2008 had a lot of flooding).
- Most of these fields are likely patterned tiled.
- We believe most of the fields in Wisconsin are not pattern tiled.
- Mostly random tiled, following depressional areas, or a combination of pattern and random.

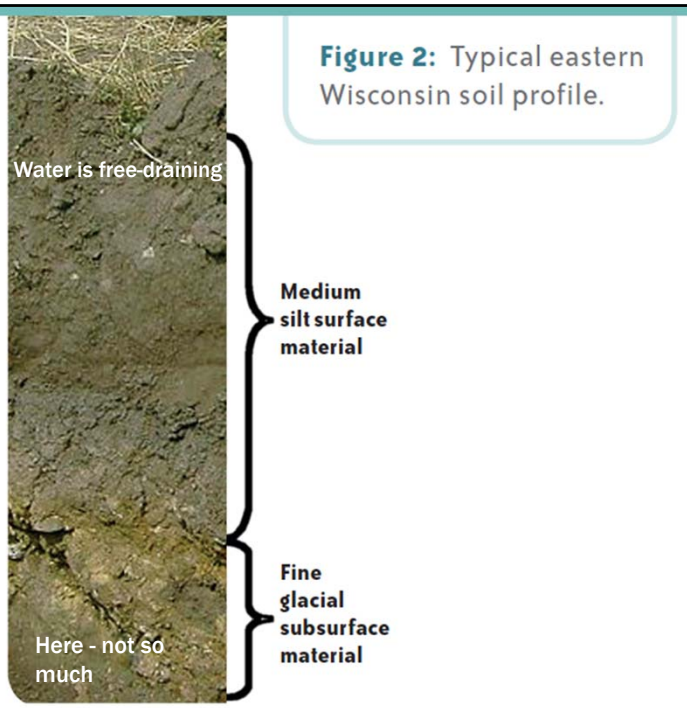


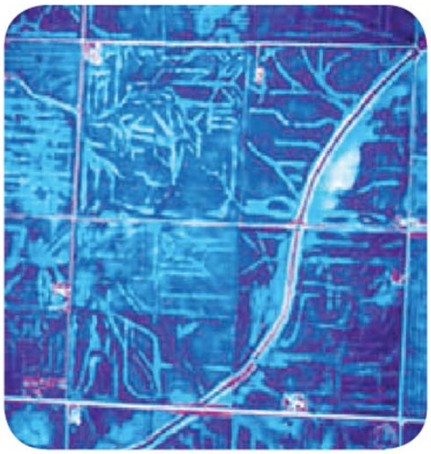
Figure 2: Typical eastern Wisconsin soil profile.

Field Locating Tile

- Crop Growth Patterns -

Hay field in Brown County at the end of September.

Source: USDA-NRCS Web Soil Survey



Source: Verma, A., R. Cooke and L. Wendte. 1996. Mapping subsurface drainage systems with color infrared aerial photographs. *In Proc. of the America Water Resources Association Symposium on GIS and Water Resources.* AWRA. Ft. Lauderdale, Fl.

Tile Drainage in Wisconsin:
Maintaining Tile Drainage Systems

University of Wisconsin–Extension DISCOVERY FARMS University of Wisconsin–Madison

FACT SHEET NO. 2 GWQ056

Tile drains play an important role in Wisconsin's agricultural production systems. Drains alleviate saturated soil conditions, maintaining optimal root zone moisture for plant growth. Saturated soils can kill or damage crops by depriving roots of oxygen. Saturated soils also delay field access and can increase soil compaction if fields are worked. Water-logged soils can cause denitrification, the process where soil bacteria convert nitrate to nitrogen gas, thereby decreasing available nitrogen for plants. Regular maintenance of tile drains is an important management practice to ensure agricultural productivity on tile-drained land in Wisconsin.

Figure 1: Tile outlet with a rodent guard.

John C. Panuska
Natural Resources Extension Specialist, Biological Systems Engineering Department, UW-Madison

Matthew D. Ruark
Assistant Professor of Nutrient Management, UW-Extension Soil Scientist, UW–Madison

Eric T. Cooley
Research Coordinator, UW-Discovery Farms

The purpose of this publication is to:

- ✓ provide information on inspecting and maintaining tile drainage systems and
- ✓ present issues to consider when modifying existing tiles or installing new drains.

"Tile drainage systems should be inspected annually, preferably at peak flow times that typically occur during spring melt and after heavy rainfall events."

BLOWOUTS

Figure 2: Sinkholes caused by tile blowout.

Figure 3: Sequence of steps forming a sinkhole from a tile blowout.

Tile Drainage in Wisconsin:

Managing Tile-Drained Landscapes to Prevent Nutrient Loss

University of Wisconsin–Extension DISCOVERY FARMS University of Wisconsin–Madison

FACT SHEET NO. 3 GWQ064

Subsurface drainage of agricultural land has the ability to improve yields and reduce surface runoff and erosion losses. However, with a reduction in surface runoff, more water infiltrates the soil and percolates through the soil profile. This is of particular importance to farmers, as this water can also transport essential plant nutrients, specifically nitrogen and phosphorus, out of the root zone. Once nutrients reach the tile drain, they have a direct conduit to surface waters.

Tile-drained agricultural land must be well-managed to reduce the loss of nutrients to surface waters. Nutrient management practices must be carefully followed to minimize the risk of nutrient loss and to maximize fertilizer use efficiency. Additional considerations need to be taken with manure applications on tile-drained land to both minimize nutrient loss and prevent manure entry into tile drains.

Eric T. Cooley
Co-Director, UW-Discovery Farms

Matthew D. Ruark
Assistant Professor of Nutrient Management, UW-Extension Soil Scientist, UW–Madison

John C. Panuska
Natural Resources Extension Specialist, Biological Systems Engineering Department, UW–Madison

The purpose of this publication is to:

- ✓ provide information on nutrient management concerns in tile-drained agricultural landscapes, and
- ✓ present management and treatment practices to reduce the loss of nutrients from tile systems to surface water.

"Proper management of crop nutrients on tile-drained landscapes is the key to reducing nutrient loss and maximizing nitrogen use efficiency."

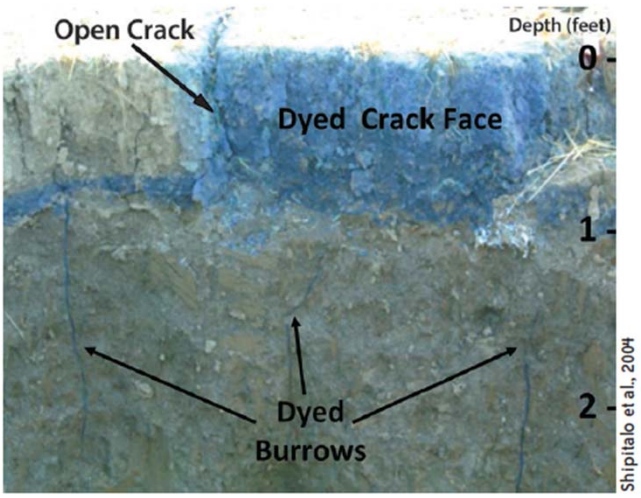


Figure 1. Methylene blue dye flowing through preferential flow paths in the soil.

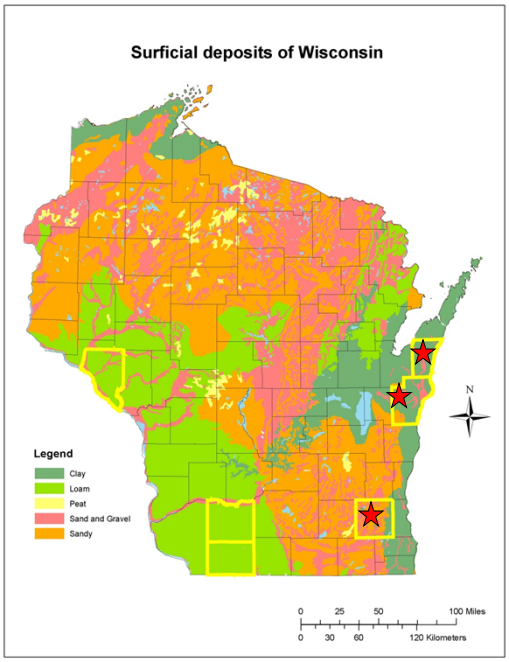
Figure 3: Cracks in clay soils with high shrink-swell capacity.

Discovery Farms Tile Research (26 site years)

1 - Kewaunee County
- Two tile line sites (2004 – 2009)

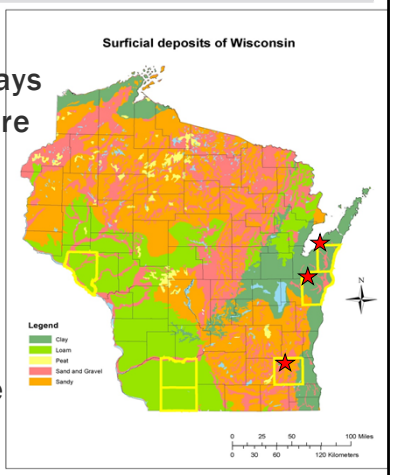
2 - Manitowoc County
- Two tile line sites
- (2004 – 2007, 2007 – 2011)

3 - Waukesha County
- Two tile line sites (2004 – 2009)



STUDY LOCATIONS

1. Kewaunee Co.
   - 6” ceramic tile
   - Random under grass waterways
   - Grain cropping, annual manure
2. Manitowoc Co.
   - 12” cement tile, random
   - Grazed pasture
3. Waukesha Co.
   - 6” PVC, patter & random
   - No-till grain, biennial manure

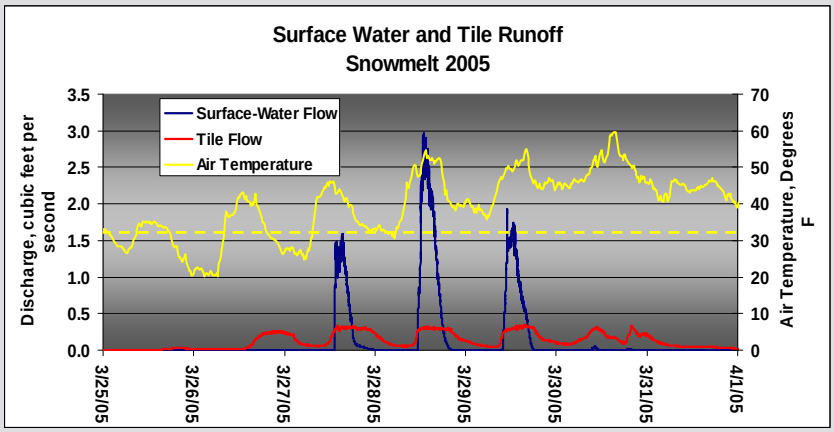


USGS MONITORING

Methods of Data Collection, Sample Processing, and Data Analysis for Edge-of-Field, Streamgaging, Subsurface-Tile, and Meteorological Stations at Discovery Farms and Pioneer Farm in Wisconsin, 2001–7

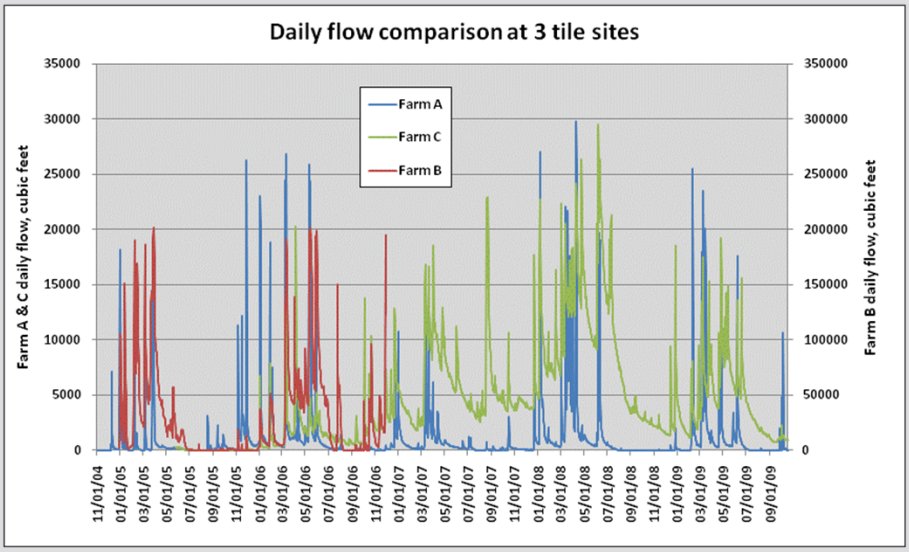
http://pubs.usgs.gov/of/2008/1015/

Surface and Tile Runoff Under Snowmelt Conditions

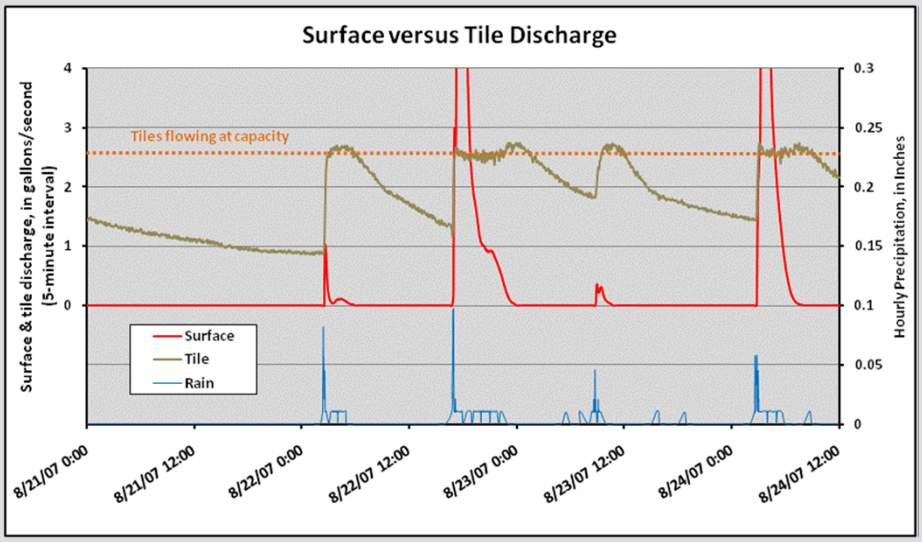


- Tile flow began before surface flow
- Relative volumes of water flowing in surface and tile were similar for this snowmelt period

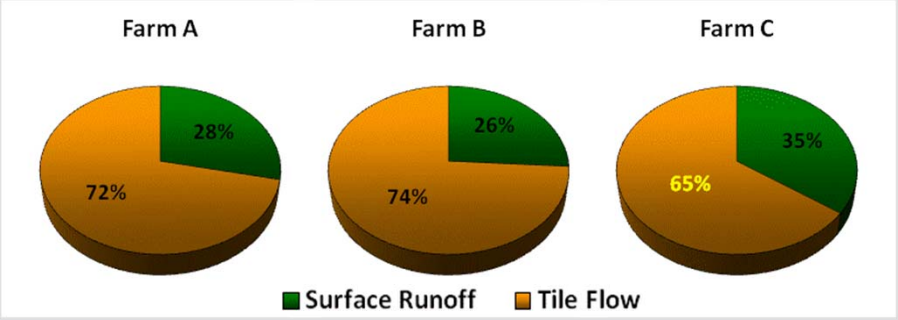
Tile Flow Periods



Efficiency of Tile Water Removal



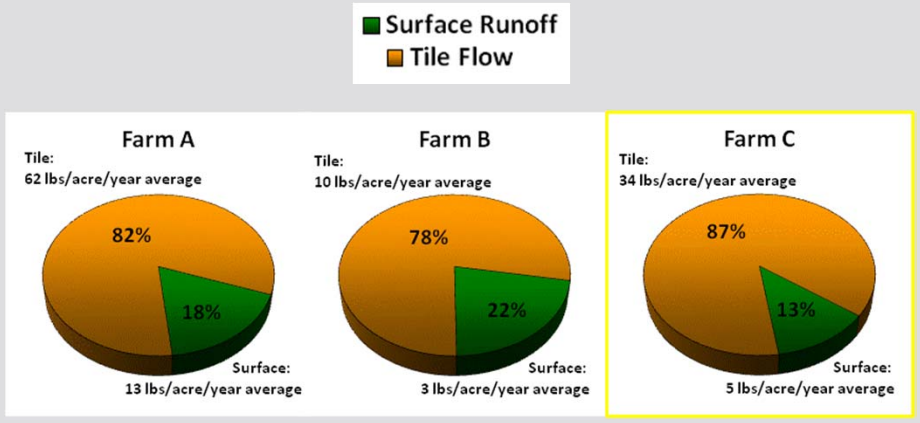
Water Budget



Percentage of total precipitation leaving the landscape as surface water

	Farm A	Farm B	Farm C
Surface runoff	10%	6%	9%
Tile flow	24%	16%	16%

Surface & Tile Nitrogen Loss



Farm A: Chisel plow, injected Farm B: grazed paddocks Farm C: no-till, surface

Nitrogen Loss Speciation

	Tile			Surface		
Total (lbs/acre)	WY05	WY06	WY07	WY05	WY06	WY07
Total Nitrogen	14.6	99.0	35.0	19.5	10.7	3.7
Nitrate	3.2	95.1	34.0	0.2	4.3	2.3
Ammonium	7.1	0.4	<0.1	13.8	0.4	<0.1
Organic Nitrogen	4.3	3.6	0.9	5.5	6.0	1.3

WY = Water Year (October 1 through September 30)

Nitrogen Loss Timing and Speciation

Total Nitrogen

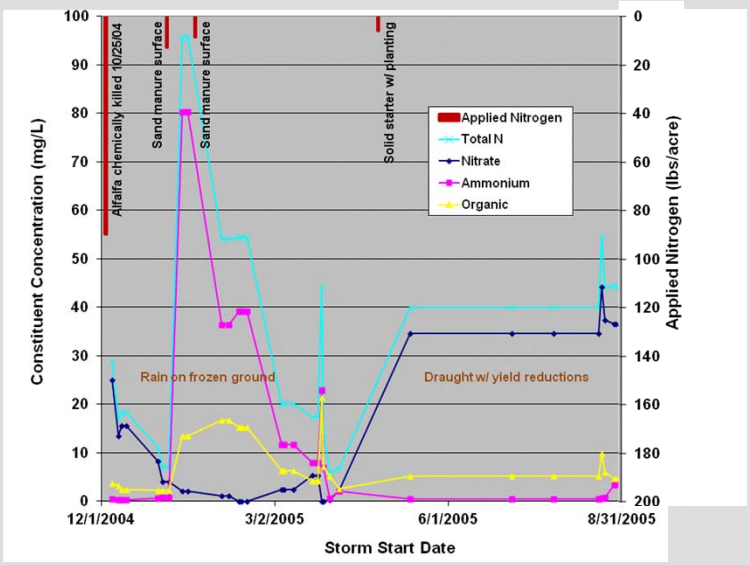
	Surface		Tile	
	Frozen	Non-frozen	Frozen	Non-frozen
Farm A	57%	43%	52%	48%
Farm B	42%	58%	46%	54%
Farm C	16%	84%	24%	76%

Farm A: Chisel plow, injected Farm B: grazed paddocks Farm C: no-till, surface

Nitrogen Speciation

	Surface			Tile		
	Nitrate	Ammonium	Organic	Nitrate	Ammonium	Organic
Farm A	45%	18%	37%	93%	2%	5%
Farm B	20%	38%	41%	50%	18%	32%
Farm C	22%	17%	61%	94%	1%	5%

NITROGEN LOSS SPECIATION

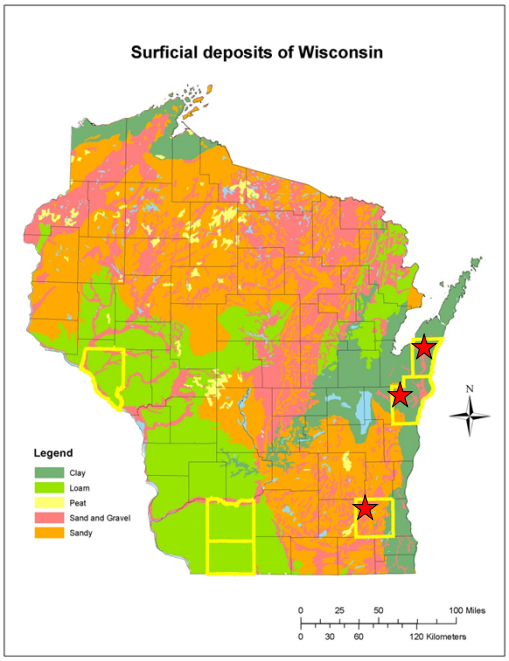


Discovery Farms Tile Research (26 site years)

1 - Kewaunee County
- Grain, annual manure
- 56 ppm Bray-P

2 - Manitowoc County
- Grazed pasture
- 108 ppm Bray-P

3 - Waukesha County
- No-till, biennial manure
- 85 ppm Bray-P



mdr3

ANNUAL TOTAL PHOSPHORUS LOADS

	2005		2006		2007		2008		2009	
Site	Tile	Surface	Tile	Surface	Tile	Surface	Tile	Surface	Tile	Surface
	---------- kg ha^{-1} ----------									
CP1	1.3	1.5	1.3	2.2	0.4	0.5	1.3	2.0		
CP2	0.2	1.0	1.3	4.1	0.3	1.9	1.4	1.3		
NT			0.4	2.0	0.5	0.9	2.4	6.2		
GP					1.1	3.7	2.3	8.7	0.2	3.9

State regulated losses = 6 lb-P / ac / yr (averaged across all years of rotation)

Slide 36

mdr3 Seems like a lot of "white space" - can you make font size larger?
Ruark, 4/28/2011

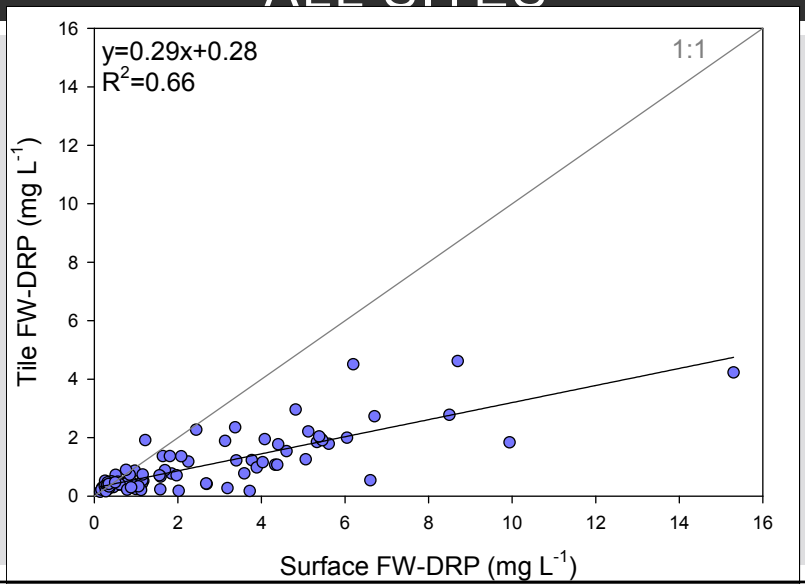
mdr4

Soil Test Phosphorus

Site	Bray P1	Tile FW-TP	Tile TP Average	Tile TP Range
	mg kg^{-1}	mg L^{-1}	kg $ha^{-1}yr^{-1}$	
1a	54	0.70	1.19	0.60-1.47
1b	57	0.50	0.91	0.24-1.53
3-NT	85	0.22	1.25	0.49-2.73
2-GP	108	1.31	1.38	0.27-2.63

Eutriphication threshold = 0.1 mg L^{-1} (ppm)

EVENT P CONCENTRATIONS: ALL SITES



Slide 37

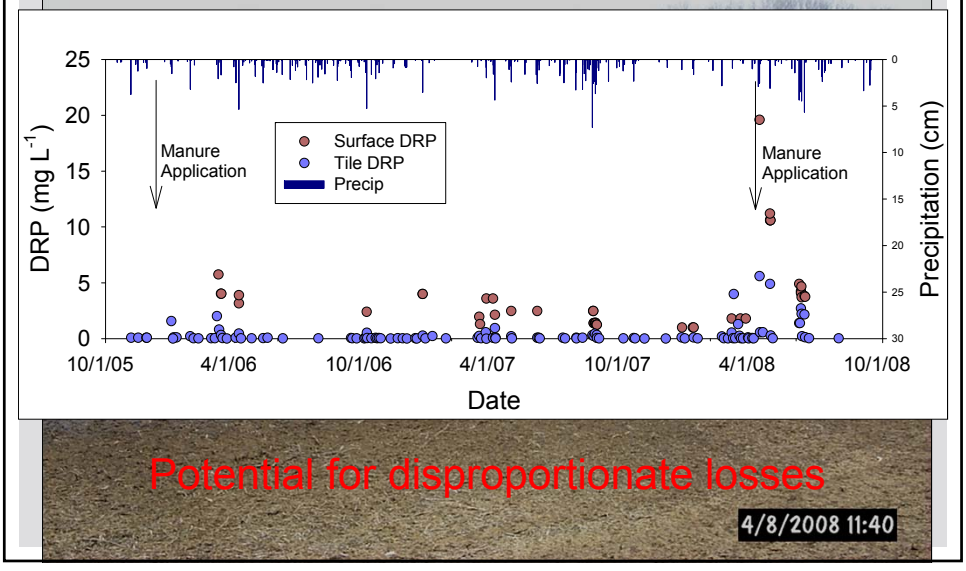
mdr4 What are you going to say about this data?
Ruark, 4/28/2011

Soil Test Phosphorus

Location	Bray P1 equiv.	Tile FW-TP	Tile TP
	mg kg^{-1}	mg L^{-1}	kg ha^{-1} yr^{-1}
1a	54	0.70	1.2
1b	57	0.50	0.9
3	85	0.22	1.3
2	108	1.31	1.4
IL[1]	NA	0.09-0.19ŧ	0.1-0.2ŧ
Quebec[2]	29	0.30	1.6
Quebec[2]	58	0.08	0.4
Denmark[3]	NA	0.02-0.11ŧŧ	0.1-0.6ŧŧ
MN[4]	NA	>0.02	0.1
UK[5]	42	1.11	1.9

[1]Algoazany et al, 2007; [2]Eastman et al, 2008; [3]Grant et al, 1996; [4]Oquist et al, 2007; [5]Withers et al, 2009;
ŧSP; ŧŧselective sampling (weekly and storms)

MANURE APPLICATIONS



SATURATED MACROPORE THEORY

- These soils have a lot of macropore flow (preferential flow pathways). It is likely that the P concentration on the inside of the pathways are very high are are quickly dissolving (desorbing) into the flowing water.
- Or – there's so much labile P unaffiliated with the clay that it can leach out every time it rains.

WHAT CAN WE DO?

- All of our past efforts have been to quantify.
  - Which is good – it's step #1
- Now we need to evaluate mitigation methods
  1. Agronomic solutions
     1. Manure application methods
     2. Cover cropping
     3. Stop applying P? For how long?
  2. Engineering solutions
     1. Capturing the P after it gets to the tile drain

SUMMARY

- In eastern WI we have clay soils, soils with an affinity for preferential flow, lots of dairy, high STP, and tile drainage.
- We can lose a lot of N
- We can lose a lot of P
- The drivers of N loss are more closely tied to management (application of N or manure).
- The drivers of P loss are not as closely tied to timing of manure application and may be a function of the high STP.
- As of right now, its not clear what the political ramifications are of this, but tile drainage in WI is not getting the attention that tile drainage in IA, IL, IN, and OH are getting.

QUESTIONS?
COMMENTS?
CONCERNS?