The Benefit of Gypsum for Crop Production in Wisconsin

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What is Gypsum?

- Soft mineral - calcium sulfate
- Other names: plaster or plaster of Paris
- Calcium sulfate dihydrate – $CaSO_4 \cdot 2H_2O$
- Different sources: Mined gypsum, flue-gas desulfurization (FGD) gypsum, recycled gypsum (wallboard & casting), and phosphogypsum

Canadian Institute of Mining, Metallurgy and Petroleum

Calcium in Wisconsin Soils

- Not likely to be deficient if liming recommendations followed (pH < 5.0 for calcium deficiency to show for most crops in WI).

- Response to calcium application unlikely even in soils testing low or very low, except when growing potatoes.

- Calcium recommendations for potato production:
  - Soils with: low – 100 lb/ac; very low – 200 lb/ac (no lime req.)
  - If lime is required, 50-100 lb/ac recommended in addition to lime in very low soils

(A2809-Laboski & Peters, 2012)

Sulfur in Wisconsin Soils

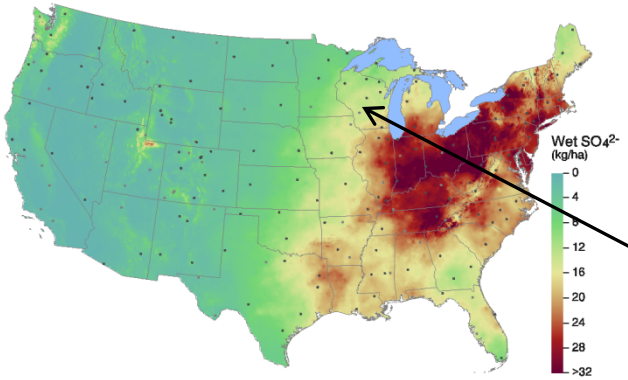
- Some sulfur deficiencies have been reported recently in WI.

- Most likely to occur in crops with a high S demand (alfalfa, canola and brassicas), in sandy soils and soils low in organic matter.

- Soils with low or medium potential for sulfate retention (sands and loamy sands), and with no recent manure applications, would benefit from sulfur application if growing plants with medium or high sulfur needs.

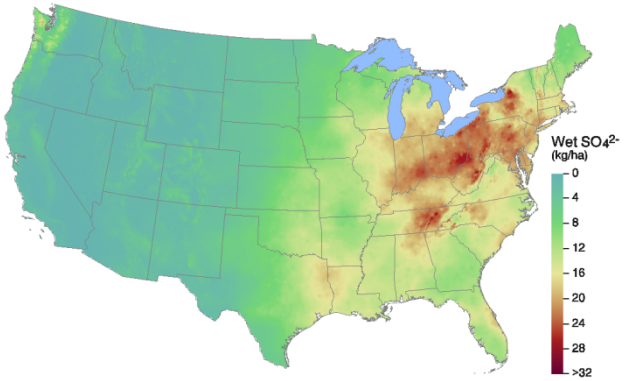
(A2809-Laboski & Peters, 2012)

Sulfur Deposition Trends

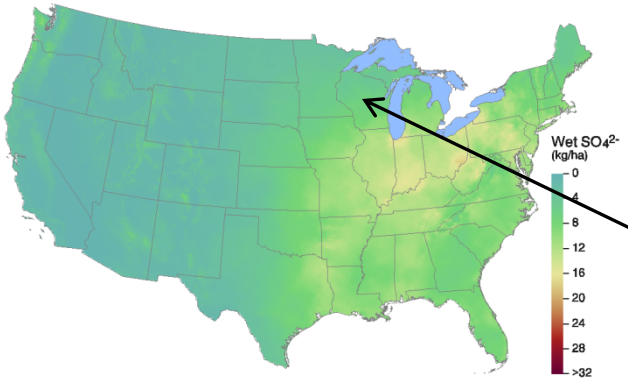


1989-1991

7 – 18 lb/ac



1999-2001



2009-2011

0 – 8 lb/ac

Source: NADP/NTN & PRISM

USEPA/CAMD 10/11/12

US EPA-Clean Air Status and Trends Network

A Look at Some Research Data in Wisconsin

1. Soil physical properties work by Buckley and Wolkowski
2. Crop productivity projects
3. Soil phosphorus losses work

Soil Physical Properties

- Watersheds draining to Lake Michigan and Lake Superior
  (9 sites Brown Co & 2 Douglas Co)
- Eleven private farm fields, six in 2010 and five in 2011
- Medium to heavy textured soils with high soil test P
- FGD gypsum surface broadcast after planting (not incorporated) at 0, 1.1, 2.2 and 4.4 Mg/ha (0, 1/2, 1, and 2 tons/acre)
- Soil sampled 12-weeks after application

Buckley, M. E., & Wolkowski, R. P. (2014). In-season effect of flue gas desulfurization gypsum on soil physical properties. Journal of environmental quality, 43(1), 322-327.

Soil Physical Properties (cont.)

Table 2. Tests of fixed effects for soil physical properties in the Wisconsin flue gas desulfurization gypsum studies, 2010–2011.

Fixed effect	Bulk density	MWD†	AS 2010‡	AS 2011§	Infiltration	Cone index
Site (S)	***	***	ns¶	ns	***	**
Gypsum (G)	*	*	ns	ns	ns	ns
S × G	**	ns	ns	ns	ns	ns
Aggregate size (A)	–	–	***	***	–	–
S × A	–	–	***	***	–	–
G × A	–	–	*	*	–	–
S × G × A	–	–	ns	ns	–	–
Depth (D)	–	–	–	–	–	***
S × D	–	–	–	–	–	***
G × D	–	–	–	–	–	ns
S × G × D	–	–	–	–	–	ns

* Significant at the 0.10 probability level.

** Significant at the 0.01 probability level.

*** Significant at the 0.001 probability level.

† Mean weight diameter.

‡ Aggregate stability in 2010.

§ Aggregate stability in 2011.

¶ Not significant.

Buckley, M. E., & Wolkowski, R. P. (2014). In-season effect of flue gas desulfurization gypsum on soil physical properties. Journal of environmental quality, 43(1), 322-327.

Soil Physical Properties (cont.)

Bulk Density

Table 3. Effect of flue gas desulfurization gypsum on soil bulk density at each study site, 2010– 2011.

FGD gypsum	Bulk density									
	D-1	D-2	B-6	B-11	B-13	B-15	B-16	B-17	B-18	B-20
kg ha^{-1}	g cm^{-3}									
0	1.05c†	1.04a	1.29a	1.31a	1.44a	1.40ab	1.37a	1.22a	1.44a	1.34b
1120	1.27a	0.99a	1.29a	1.27a	1.46a	1.46a	1.39a	1.23a	1.32b	1.49a
2240	1.19b	1.02a	1.31a	1.29a	1.47a	1.35b	1.38a	1.21a	1.36b	1.35b
4480	1.23ab	1.03a	1.35a	1.29a	1.50a	1.41ab	1.31b	1.23a	1.42a	1.39b

† Different letters after means indicate significant treatment differences at $P \leq 0.10$ for that site.

Average Hydraulic Conductivity (p-value = 0.87)

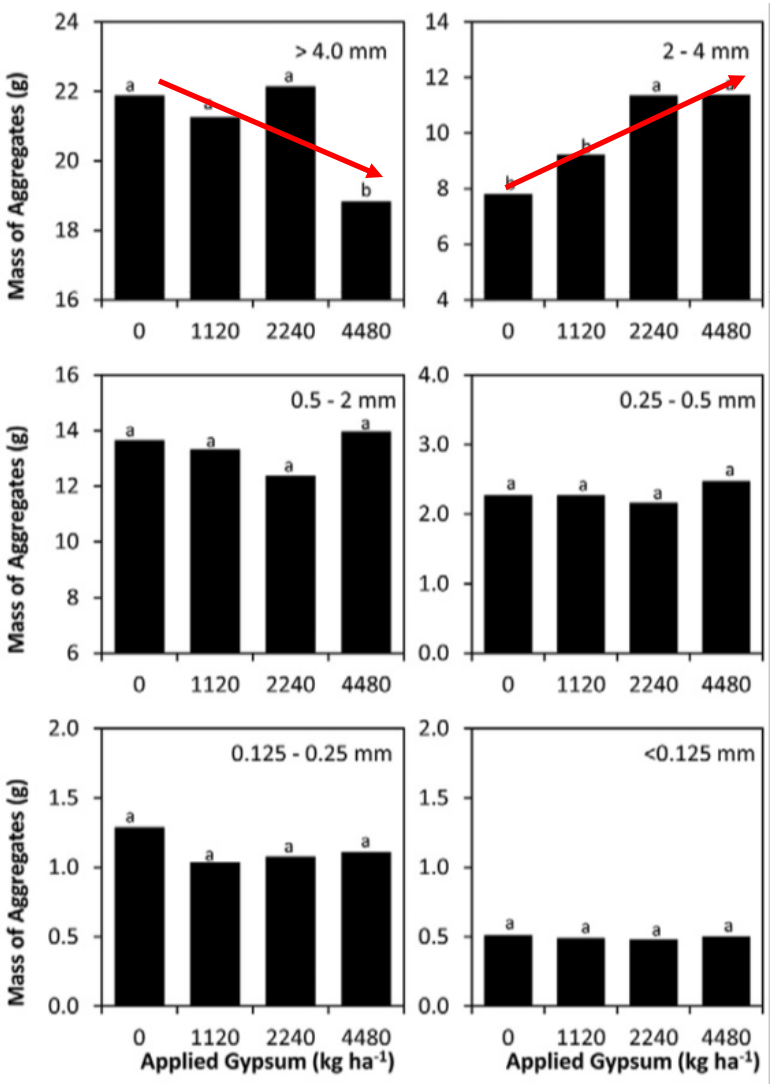
FGD Gypsum Rate, tons/acre			
0	1/2	1	2
---------- cm/hr (inches/hr) ----------			
0.75 (0.30)	0.73 (0.29)	0.74 (0.29)	0.78 (0.31)

Buckley, M. E., & Wolkowski, R. P. (2014). In-season effect of flue gas desulfurization gypsum on soil physical properties. Journal of environmental quality, 43(1), 322-327.

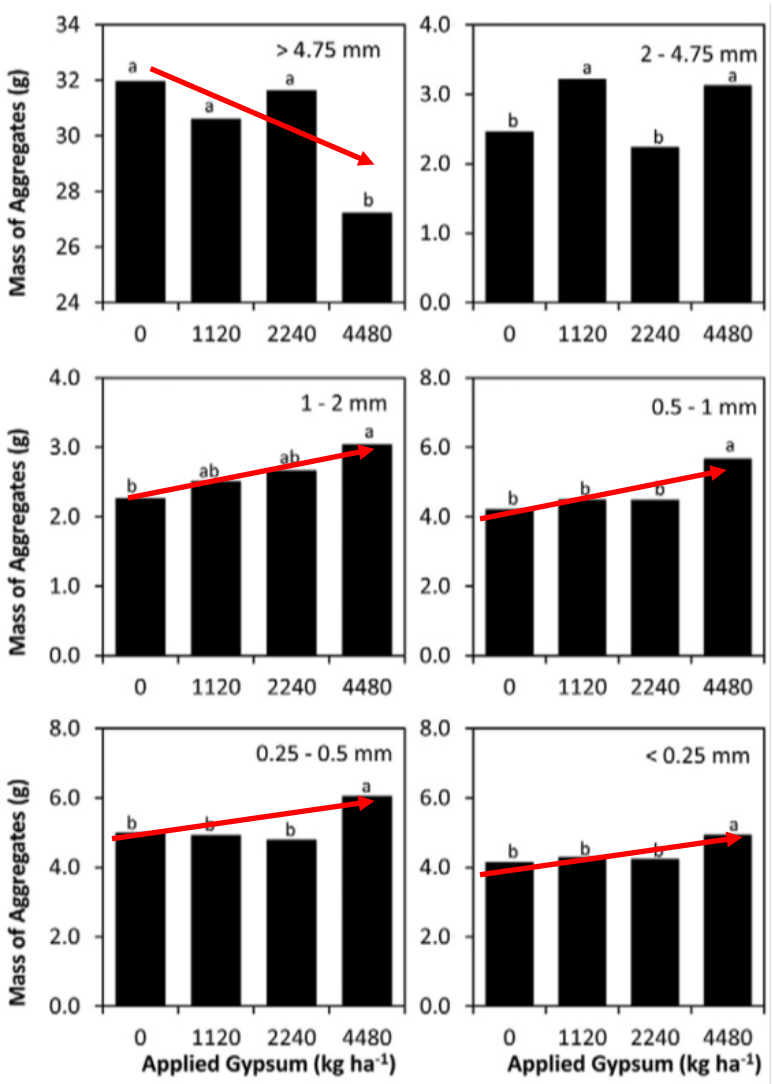
Soil Physical Properties (cont.)

Aggregate Sizes (MWD)

2010 – Five Sites



2011 – Five Sites



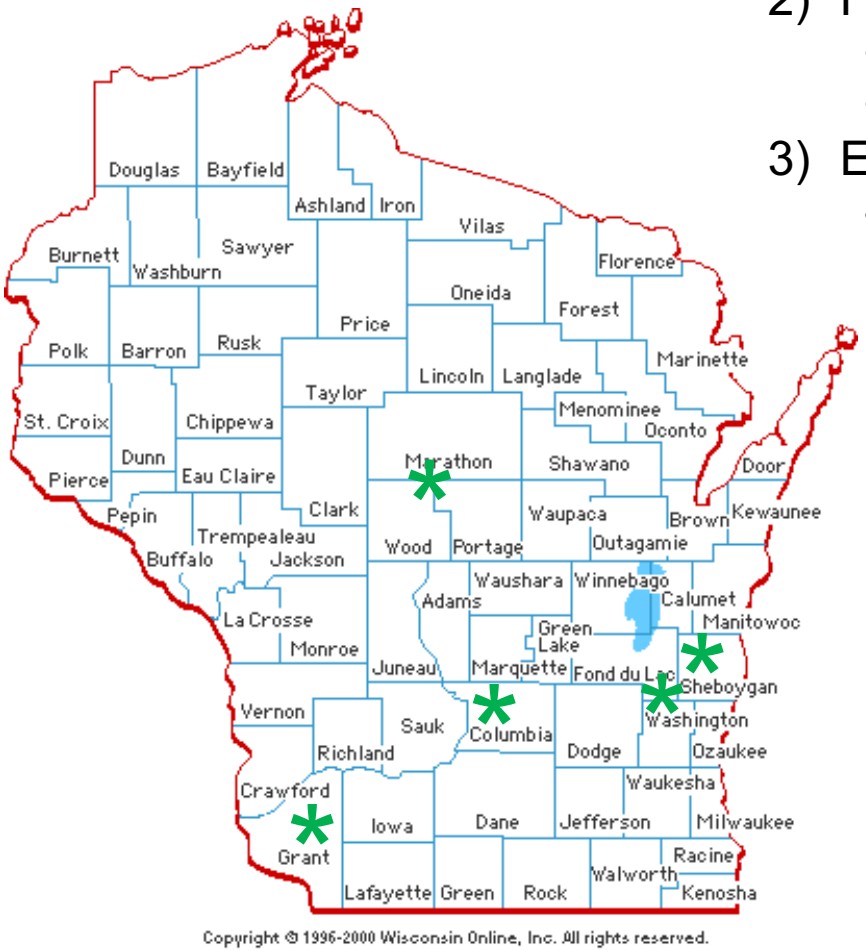
Buckley, M. E., & Wolkowski, R. P. (2014). In-season effect of flue gas desulfurization gypsum on soil physical properties. Journal of environmental quality, 43(1), 322-327.

Summary - Soil Physical Properties

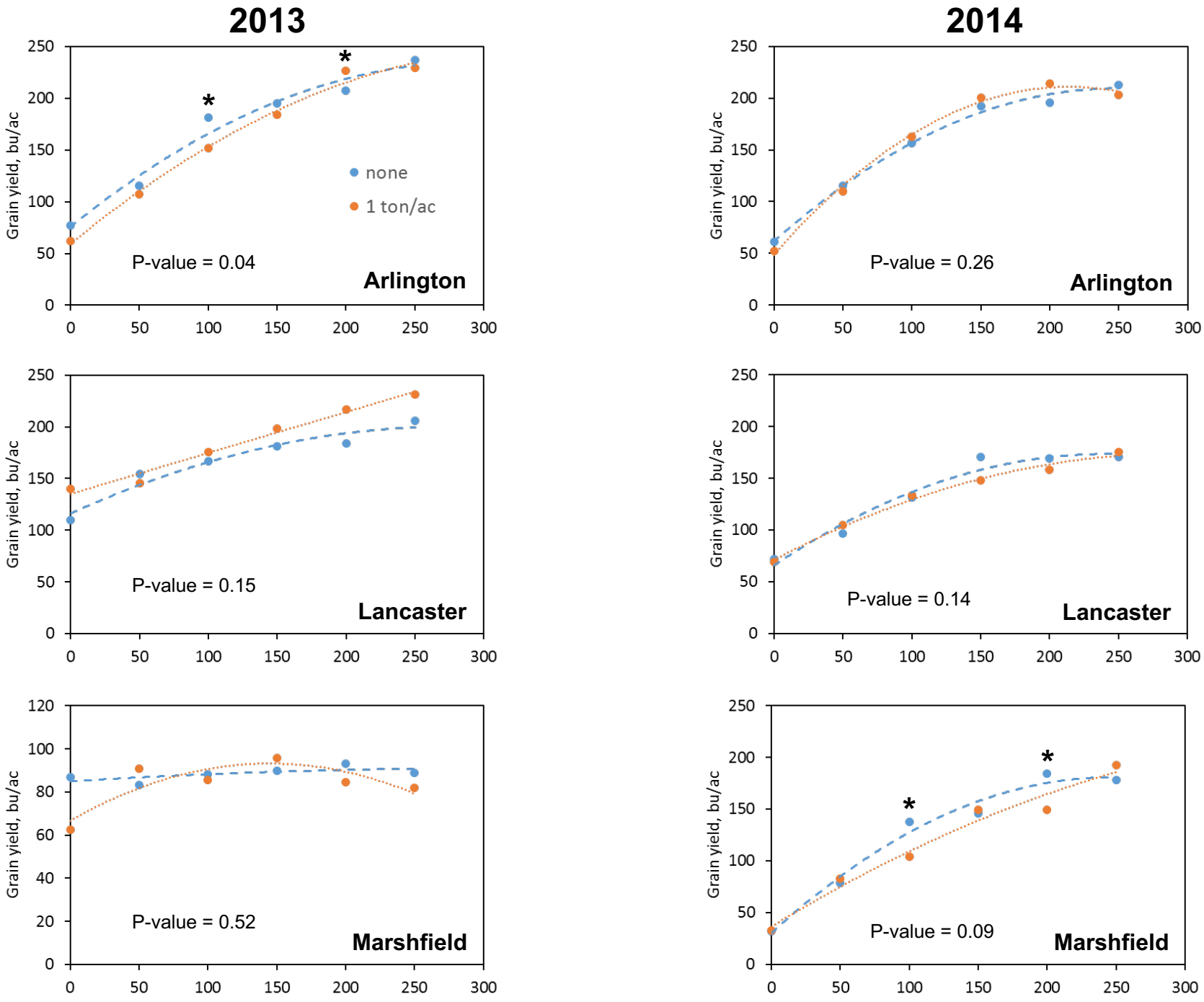
- Soil bulk density improved in 2 out of 10 sites, and negatively affected in 1 (high clay)
- High FGDG rates reduced large aggregate fractions (>4.0mm) but increased smaller fraction aggregates
- Hydraulic conductivity/infiltration not affected
- Authors conclude that FGDG doesn't have the ability to improve soils the year of application and suggest rates be kept below 2 tons/acre

Buckley, M. E., & Wolkowski, R. P. (2014). In-season effect of flue gas desulfurization gypsum on soil physical properties. Journal of environmental quality, 43(1), 322-327.

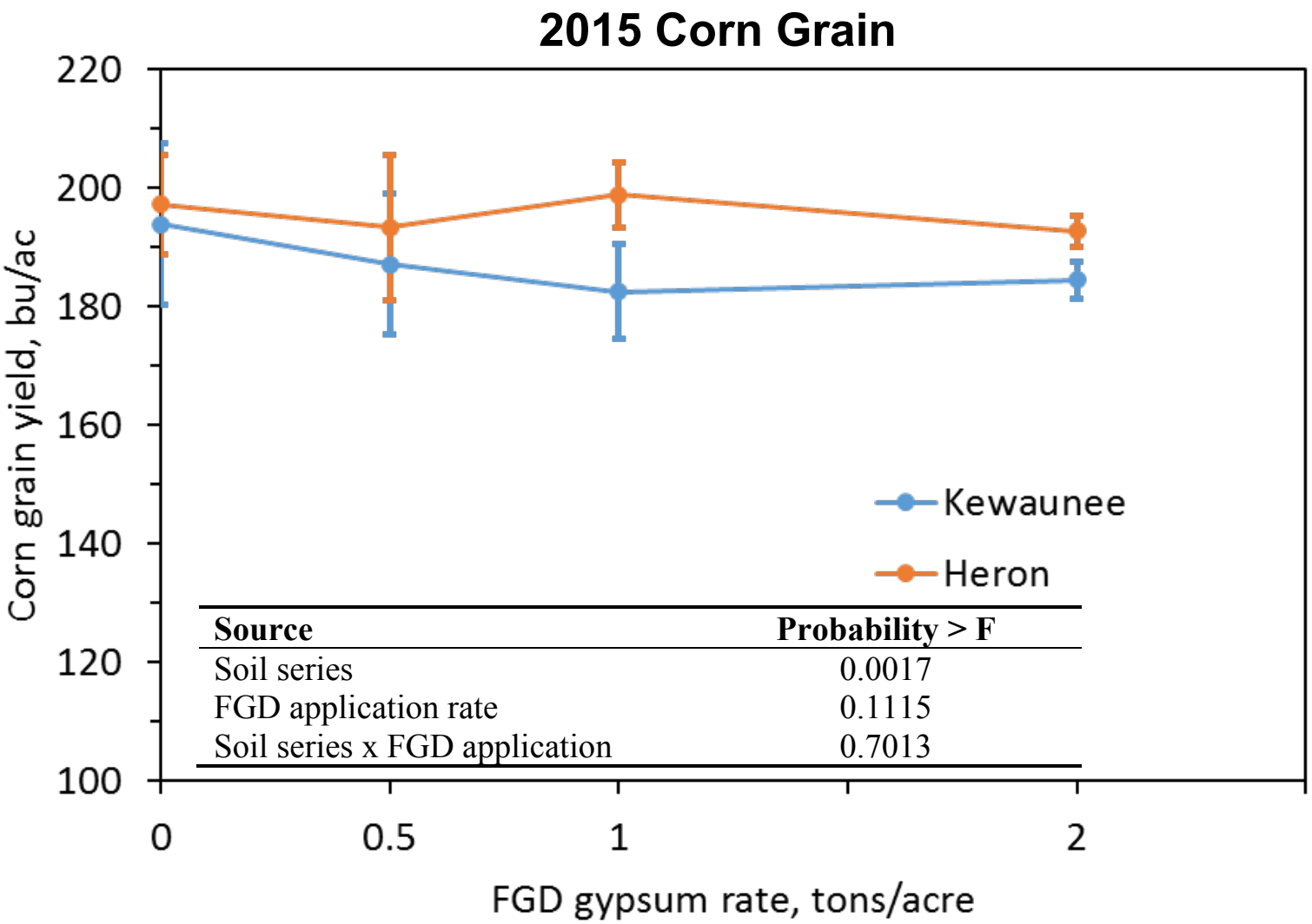
FGD gypsum Research in Wisconsin



1) Tillage and N rate (3 locations; 12 site-years)
   - Tillage (CT and NT)
   - N rate (0, 50, 100, 150, 200 & 250 lb N/ac)
   - FGD (0 & 1 ton/ac/yr)
2) FGD rate (TNC-Sheboygan Co; 4 site-years)
   - 0, ½, 1 & 2 ton/ac
   - Kewaunee silt loam & Hebron loam
3) Edge-of-Field (SCF; 3 site-years)
   - 3 paired field sites

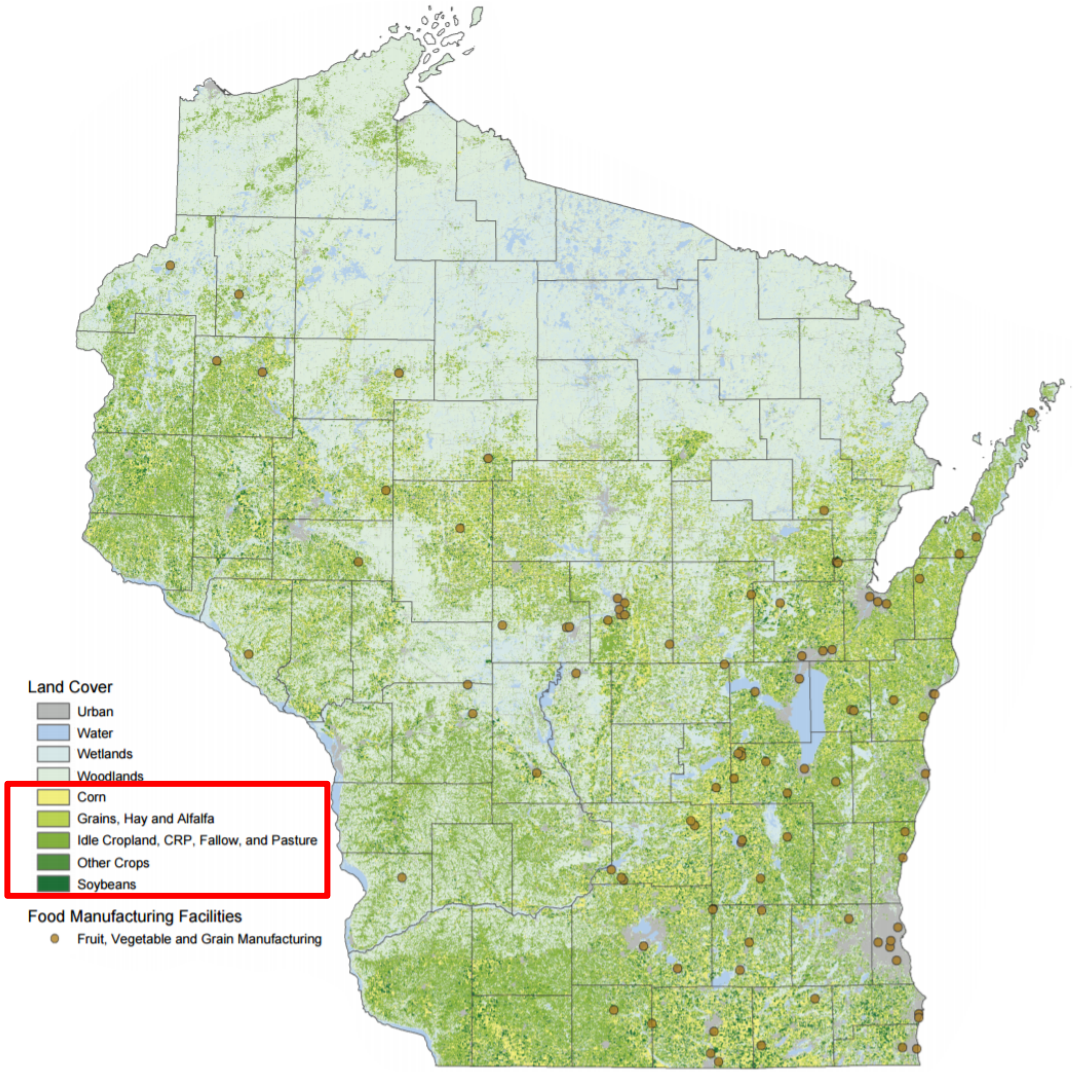

2013
2014
Grain yield, bu/ac
none
1 ton/ac
P-value = 0.04
Arlington
P-value = 0.26
Arlington
P-value = 0.15
Lancaster
P-value = 0.14
Lancaster
P-value = 0.52
Marshfield
P-value = 0.09
Marshfield
*

On-Farm Sheboygan Co



Source	Probability > F
Soil series	0.0017
FGD application rate	0.1115
Soil series x FGD application	0.7013

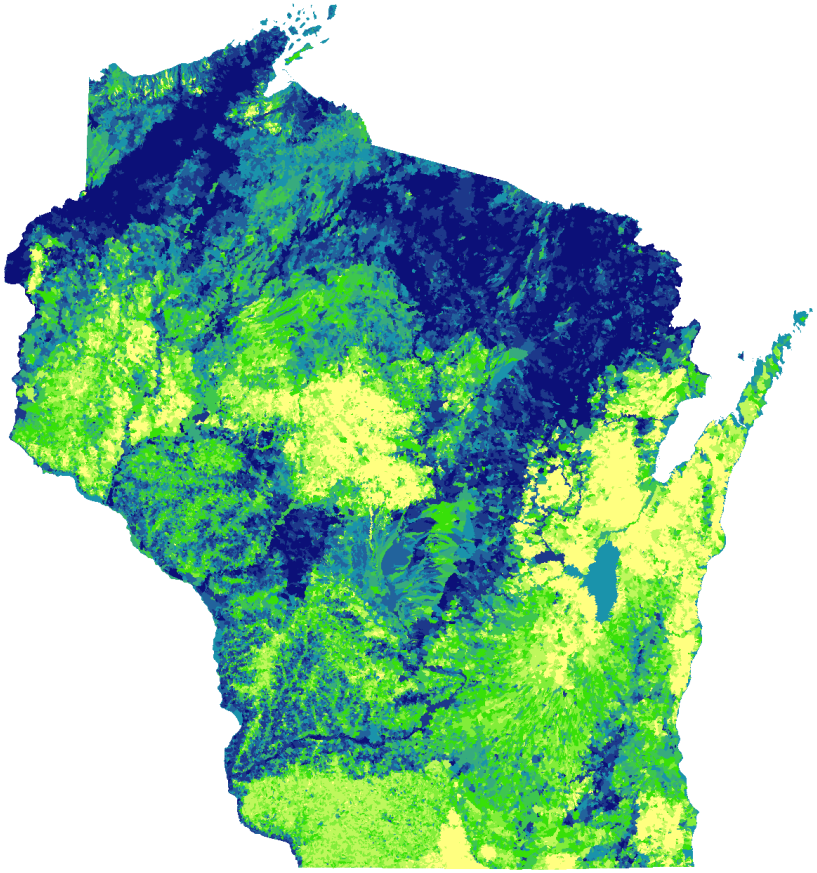
Soil Phosphorus Losses Background



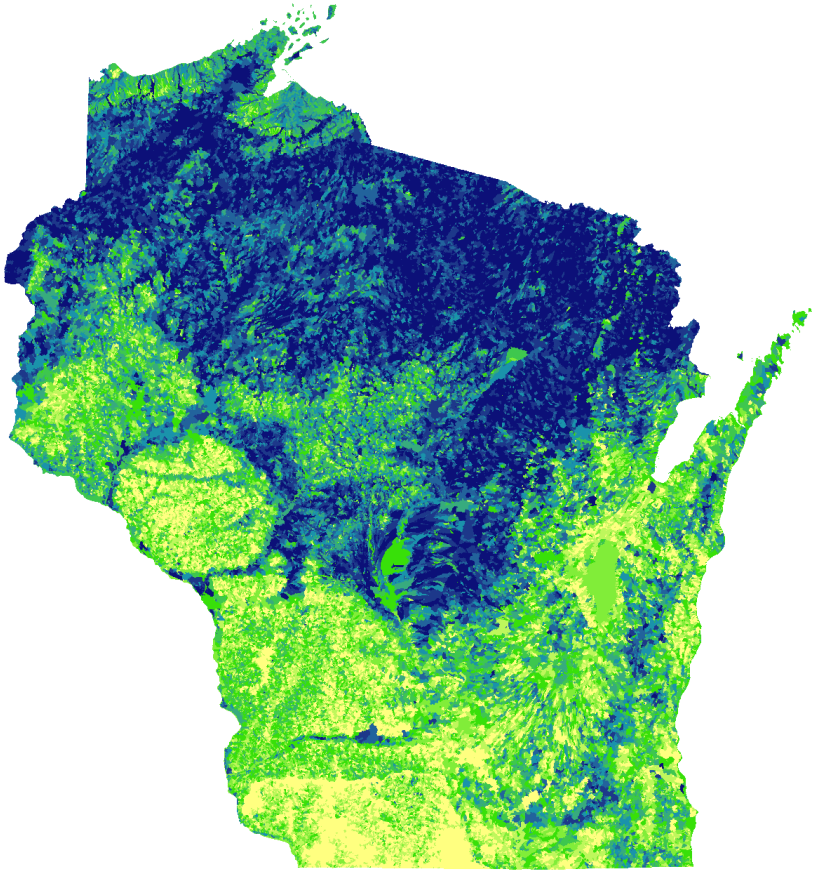
- 12,600 streams and rivers:
  ~88,000 miles

Stream Total P and Suspended Sediment

Stream Total P



Stream Suspended Sediment

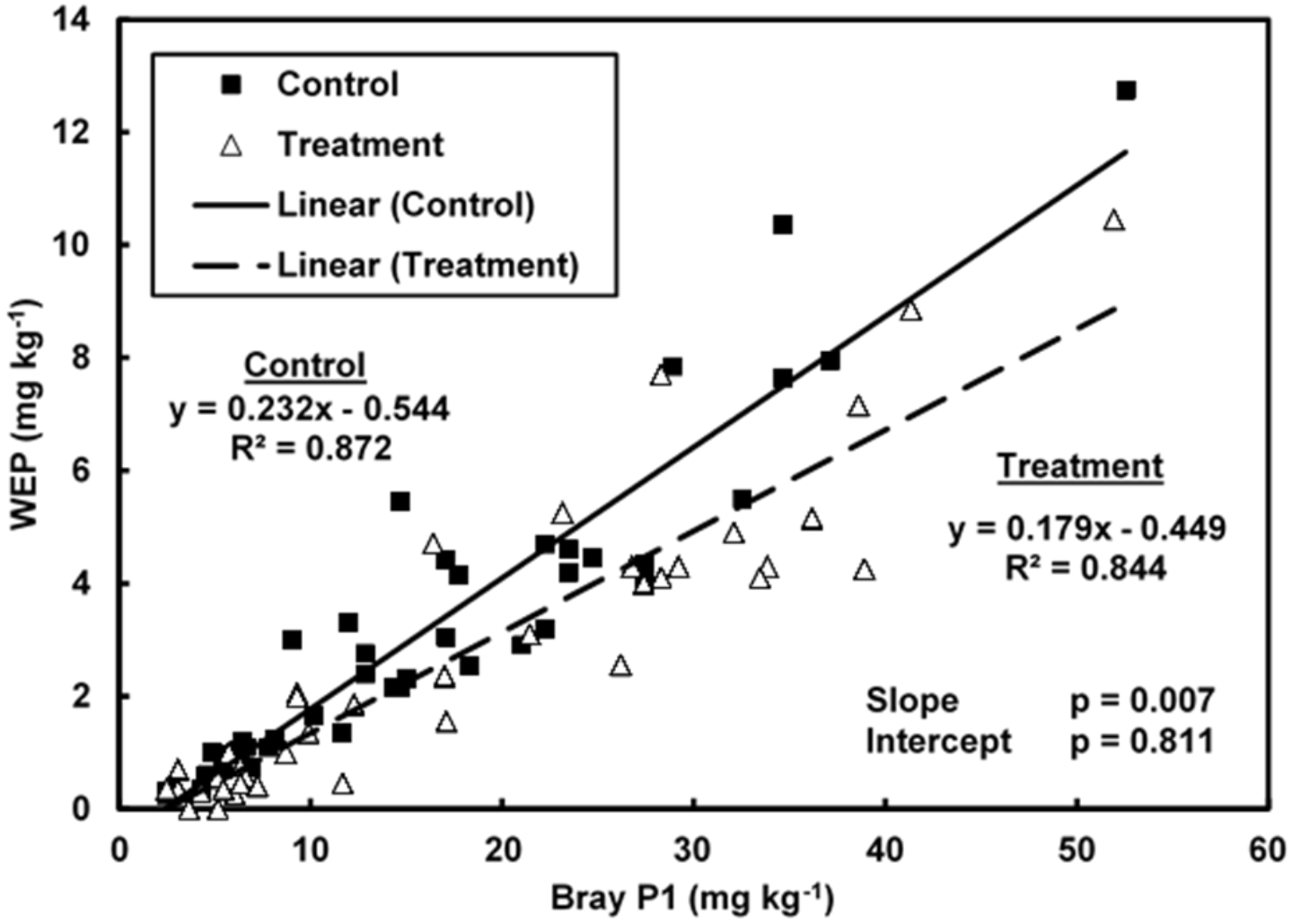


WI Integrated Assessment of Watershed Health, March 2014

WEP versus Bray P

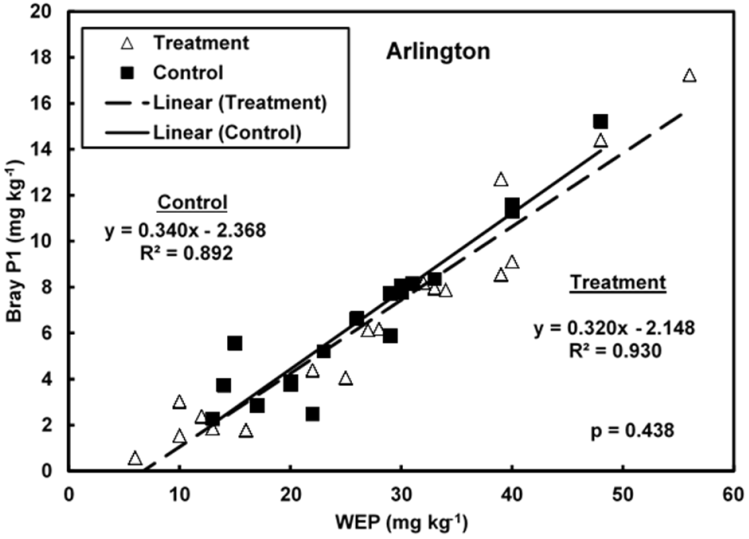
- Water extractable phosphorus (WEP)
  - 50:1 with DI water
  - 0.45 um filtrate analyzed colorimetrically
- Soil test phosphorus (Bray P)
  - Samples from 0-15 cm
  - Bray P as routine soil testing

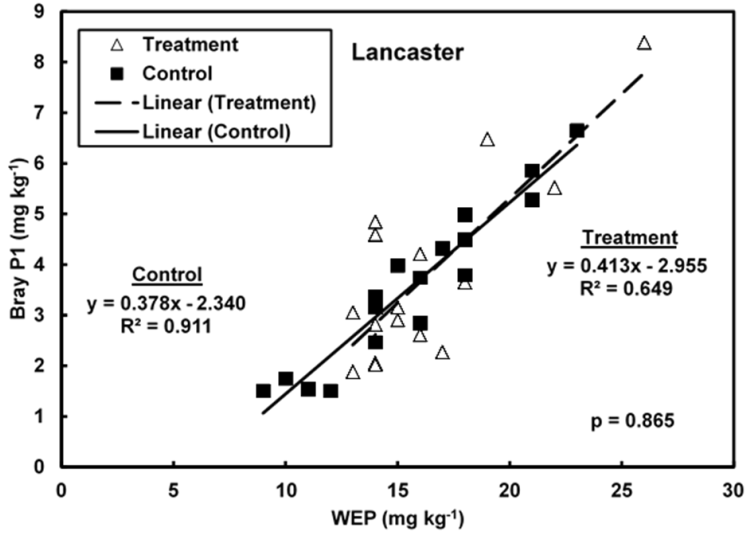
Water Extractable P (WEP) vs. Bray P

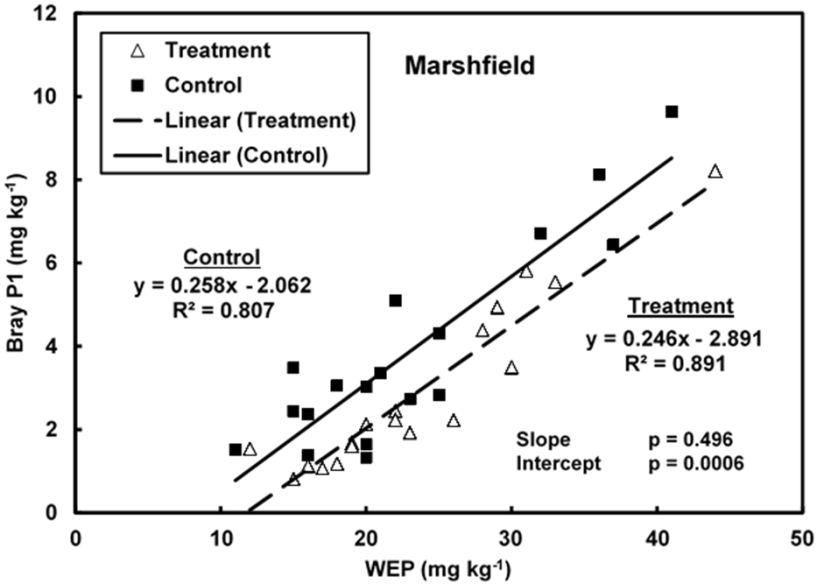


Water Extractable P (WEP) vs. Bray P

Tillage/N rate Study (200 lb N/ac)







Estimated Annual Reductions in DP

Soil Test P	DP in Runoff			Reduction in DP
	Control	Treatment	Difference	-- *lb year^{-1}*
--- *mg kg^{-1}* ---	------ *lb acre^{-1} year^{-1}* ------			*per 1,000 ac* --
5	0.0041	0.0029	0.0012	1.2
10	0.0083	0.0058	0.0025	2.5
20	0.0166	0.0117	0.0049	4.9
30	0.0249	0.0175	0.0074	7.4
40	0.0332	0.0234	0.0099	9.9
50	0.0416	0.0292	0.0123	12.3
60	0.0499	0.0351	0.0148	14.8
70	0.0582	0.0409	0.0172	17.2

Estimated reduction in dissolved P (DP) with FGD gypsum application to soil with different soil test P values from two farm sites in Fond du Lac and one site from Washington counties. Values were calculated assuming an average 3 inch annual runoff volume using equations to estimate soluble P losses in SNAP-Plus and data from figure previous slide.

Closing Thoughts

- Gypsum is a good source of sulfur and calcium.
- Research data from Wisconsin thus far doesn't show a clear benefit to soil properties and crop yields from gypsum application.
- FGD gypsum application shows good potential to reduce P losses in some Wisconsin soils. The main effect thus far is related to a reduction in DRP.
- On-going and future research aims to determine which soils/regions within the state might benefit from FGD gypsum applications.

Picture courtesy of Greg Olson

Thank You

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