Biofuels in Wisconsin: What we know and what we don't

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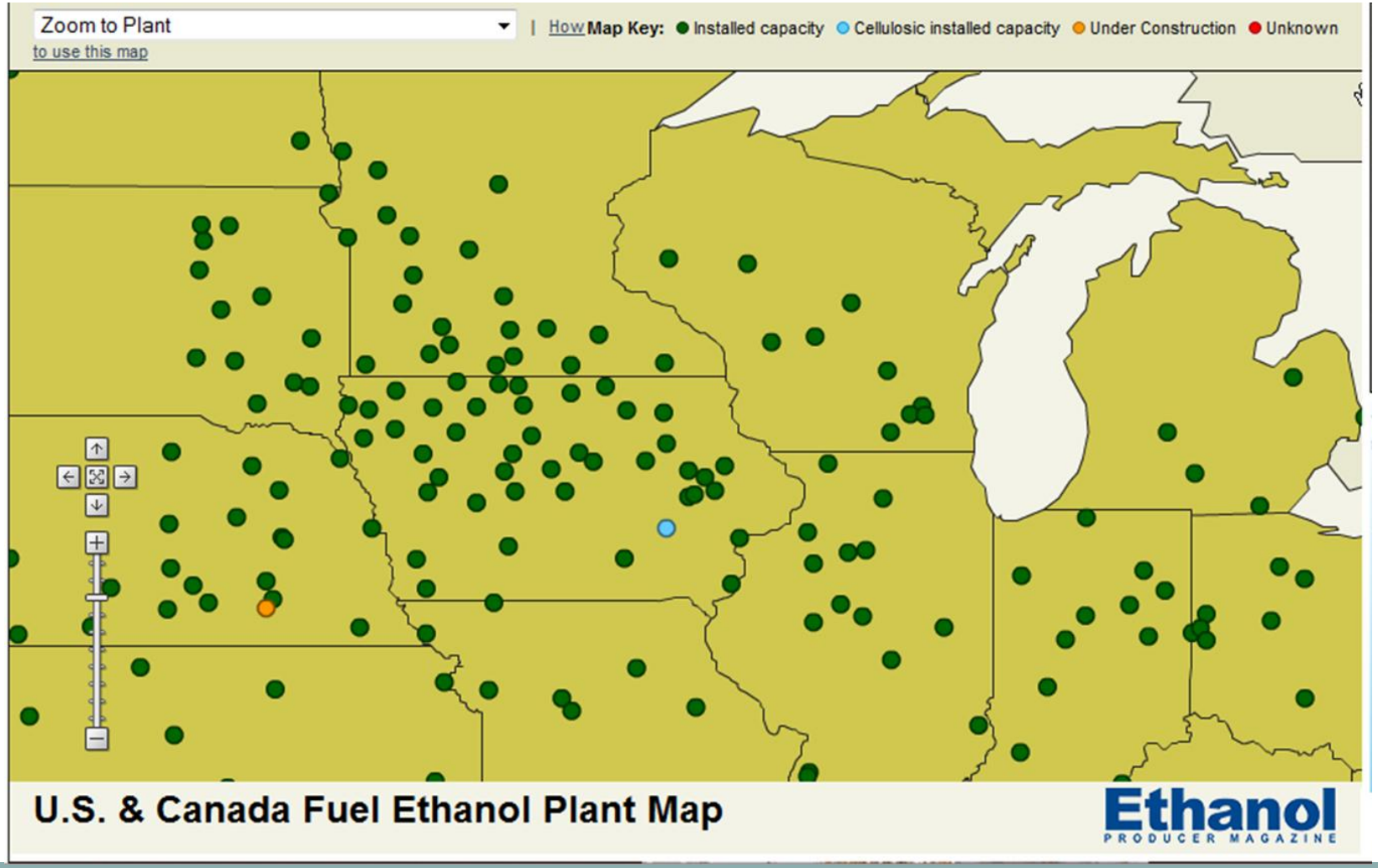
Outline

- What's the latest with biofuels?
- Biofuel opportunities for Wisconsin
- What we can learn from biofuel studies
  - Grassland management
  - Residue management

What are biofuels?

- Corn grain for ethanol production (1st generation)

Location of Ethanol Plants



http://www.ethanolproducer.com/plantmap/

What are biofuels?

- Corn grain for ethanol production (1st generation)
- Plant material for cellulosic ethanol production (2nd generation biofuels)
- Algae (3rd generation biofuel)

- Plant material for burning with (or in place of coal) to generate electricity (solid biofuels)
  - Woody biomass
  - Corn stover
  - Grasses (switchgrass, miscanthus)

Biomass Crop Assistance Program (BCAP)

Section 9001 of the 2008 Farm Bill established the Biomass Crop Assistance Program (BCAP) with the purpose of:

- Assisting agricultural and forest land owners and operators with the **collection, harvest, storage and transportation** of eligible material for use in a biomass conversion facility; and
- Supporting the **establishment and production** of eligible crops for conversion to bioenergy in selected BCAP project areas.

BCAP provides two broad categories of payments:

- **Matching payments** that may be available for the delivery of eligible material to qualified biomass conversion facilities by eligible material owners.
- Establishment and annual payments that may be available to producers who enter into contracts with the Commodity Credit Corporation (CCC) to produce eligible biomass crops within BCAP project areas.

http://www.apfo.usda.gov/Internet/FSA_File/bcap2010.pdf

Switchgrass vs. coal

- 14.4 million Btu/ton of switchgrass (DM)
- 26 million Btu/ton of bituminous coal
- Power utilities may soon have to incorporate "renewables" into feedstock stream
  - 10% by 2015; 25% by 2025;
- Gov. Doyle declared that the state-owned power plant would switch from burning coal to a mix of natural gas and biomass
  - Will require an estimated 250,000 tons of biomass per year
  - …where to get it?
  - Corn stover, switchgrass and woody biomass

USDA Fuel Value Calculator
http://www.fpl.fs.fed.us/documnts/techline/fuel-value-calculator.pdf

In Wisconsin

Questions for biofuel production in Wisconsin:

- Can we grow switchgrass them on marginal lands?
  - Too wet; too dry
  - Too steep; too shallow
  - Poor fertility
  - Estimated 6 million acres of “marginal” land in WI (of 40 million)
  - 600,000 of CRP in WI, half of which to expire in next few years.
- Does switchgrass require fertilizer inputs?
- How much corn stover removal can soils handle?

The biofuel debate

1st Generation

- Food vs. Fuel debate

2nd Generation

- Removing vegetative biomass removes carbon and crop nutrients (N, P, K, S, micros) as well as soil cover
- What happens to soil erosion, nutrient management and soil organic matter?
- Are we trading one problem for another?

What we can learn from biofuel research

- Grassland management
- Corn residue management

- Over the past two years have conducted studies on:
  - N management of switchgrass
  - N management with rates of stover removal

Switchgrass Research

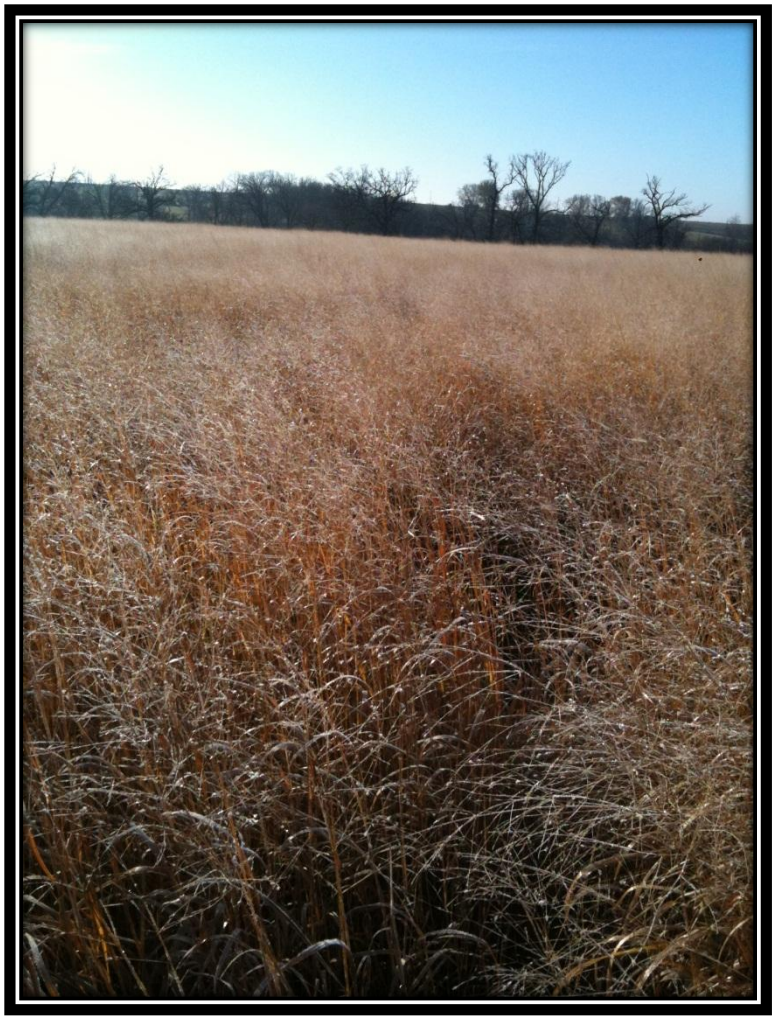
Switchgrass

- N rate studies
  - 3 large scale field studies to evaluate effect of weed management, N management and landscape position
  - 3 small plot studies to evaluate N management and N, P and K removal over time
- Cave-in-Rock variety
- Established 2008, sprayed with herbicides
- Harvest in 2009 and 2010

Funding provided by Focus on Energy

Very weedy at beginning of year 2

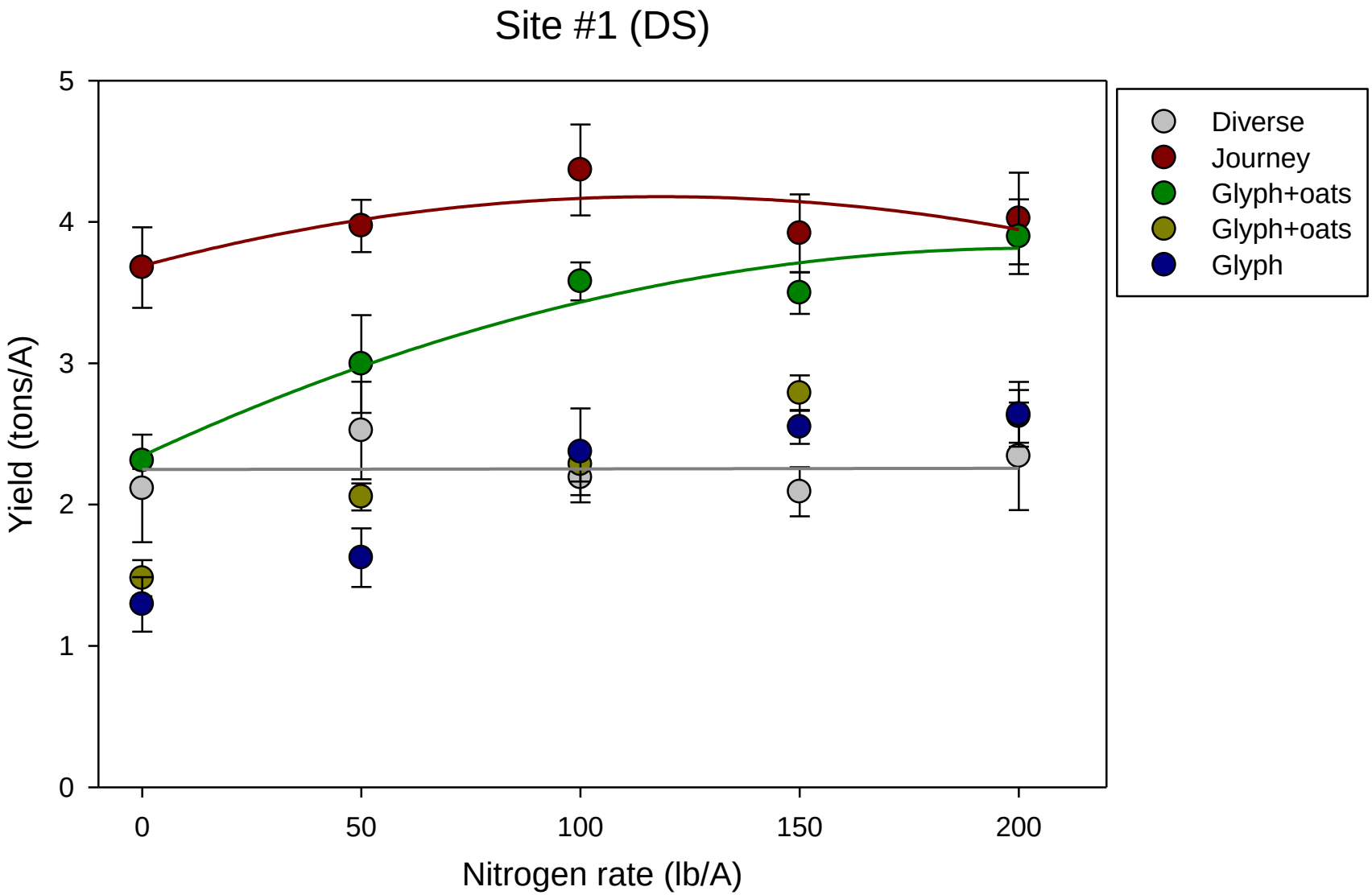
Bunchgrass, provides good cover later in season



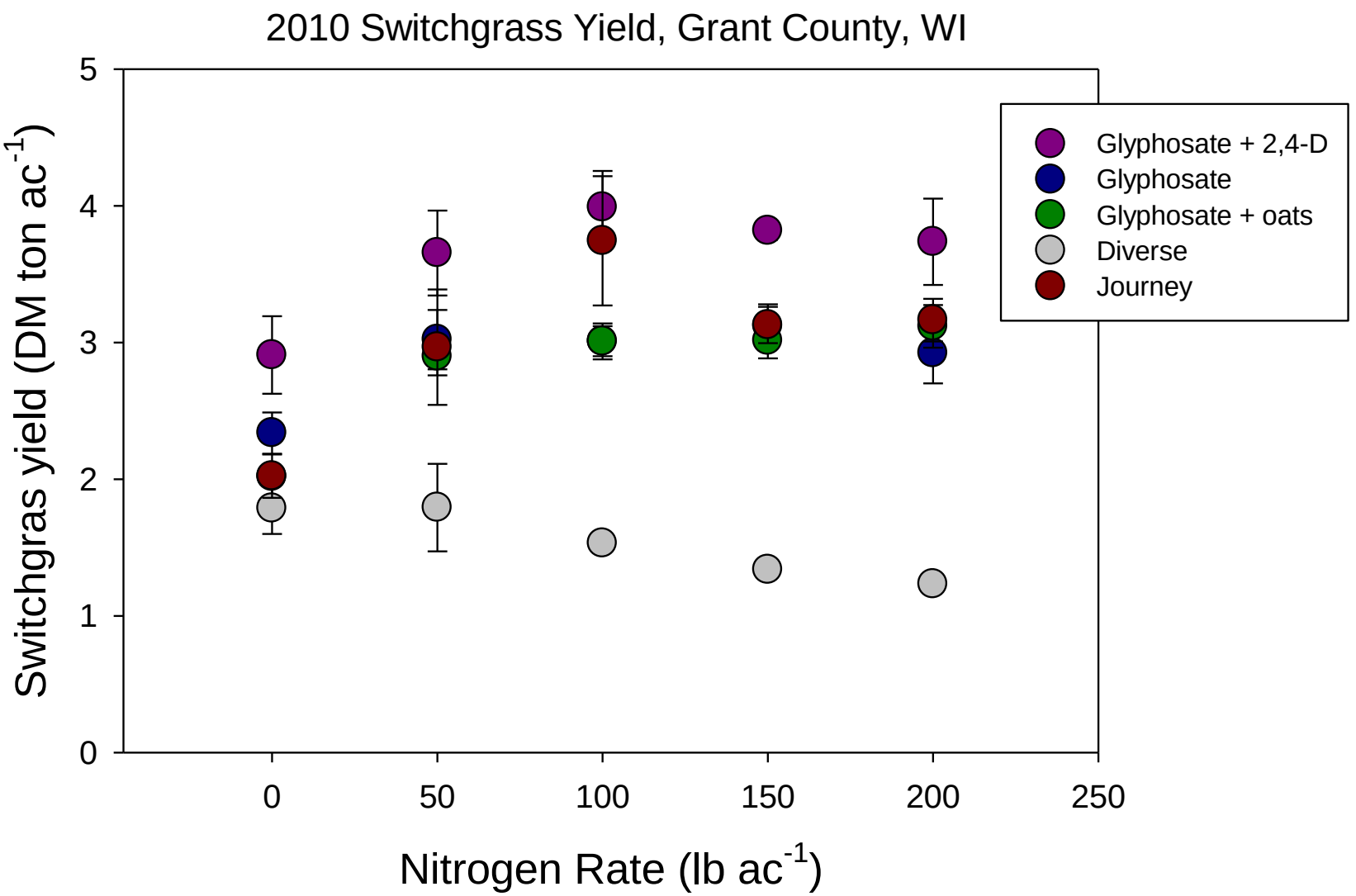
Creation of habitat

In-season observable response

Switchgrass response to N



2010 yield


2010 Switchgrass Yield, Grant County, WI
Switchgras yield (DM ton ac-1)
0
1
2
3
4
5
0
50
100
150
200
250
Nitrogen Rate (lb ac-1)
Glyphosate + 2,4-D
Glyphosate
Glyphosate + oats
Diverse
Journey

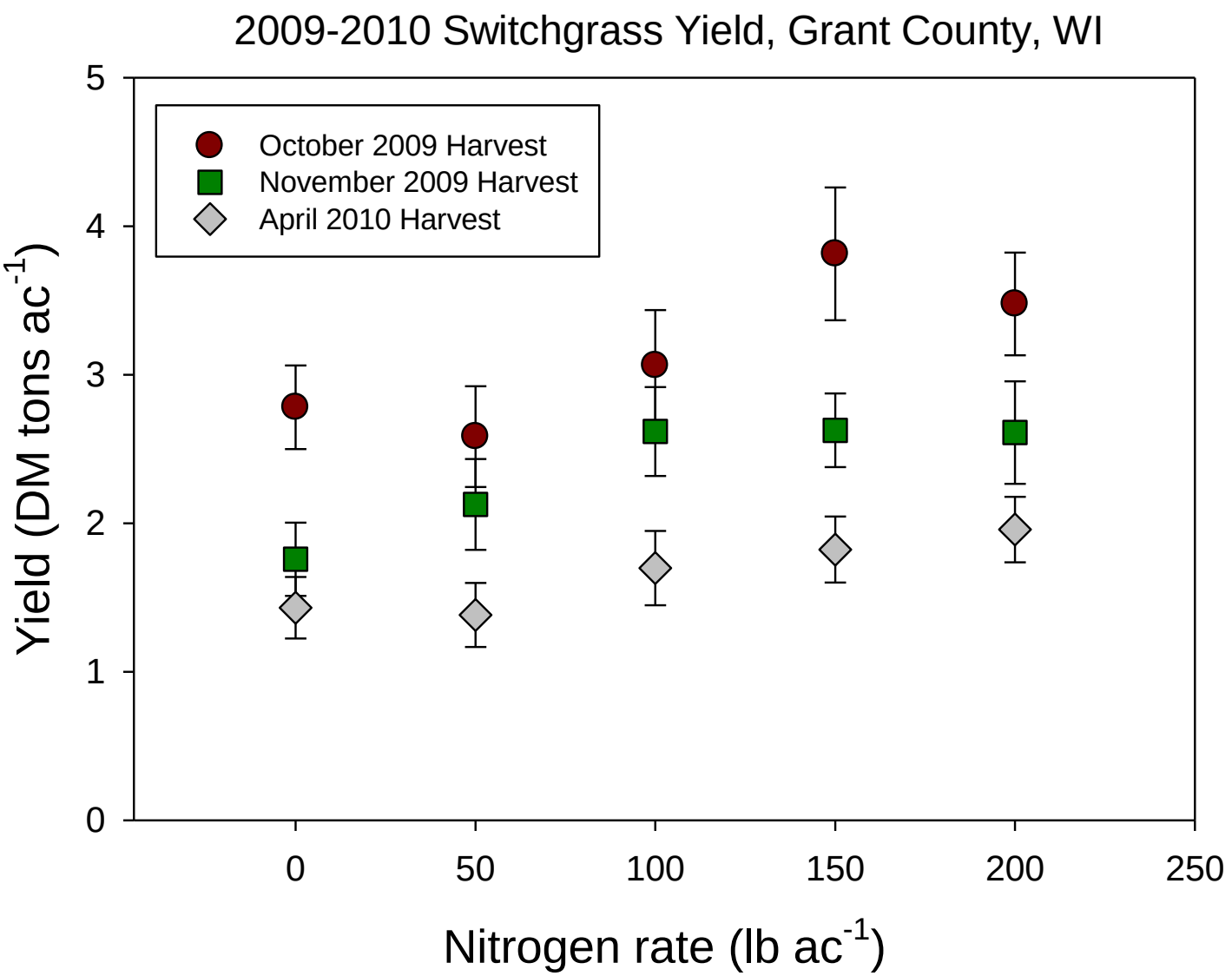
Switchgrass Yields

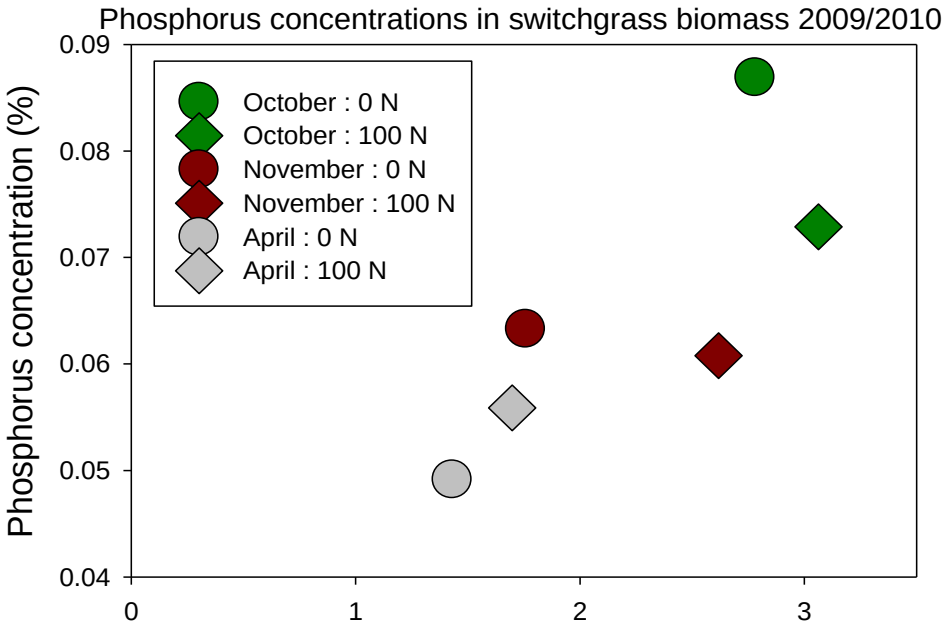
- Switchgrass yields are enhanced by N fertilizer (up to 100 lb ac^{-1}) on these high-sloping, marginal soils.
- Switchgrass produces more biomass than a diverse prairie grass mixture.
- However, switchgrass also appears to be influenced by weed management (i.e. weed control) and hillslope position.
- Year 3 (2^{nd} year of harvest) had less weeds or was overrun with weeds

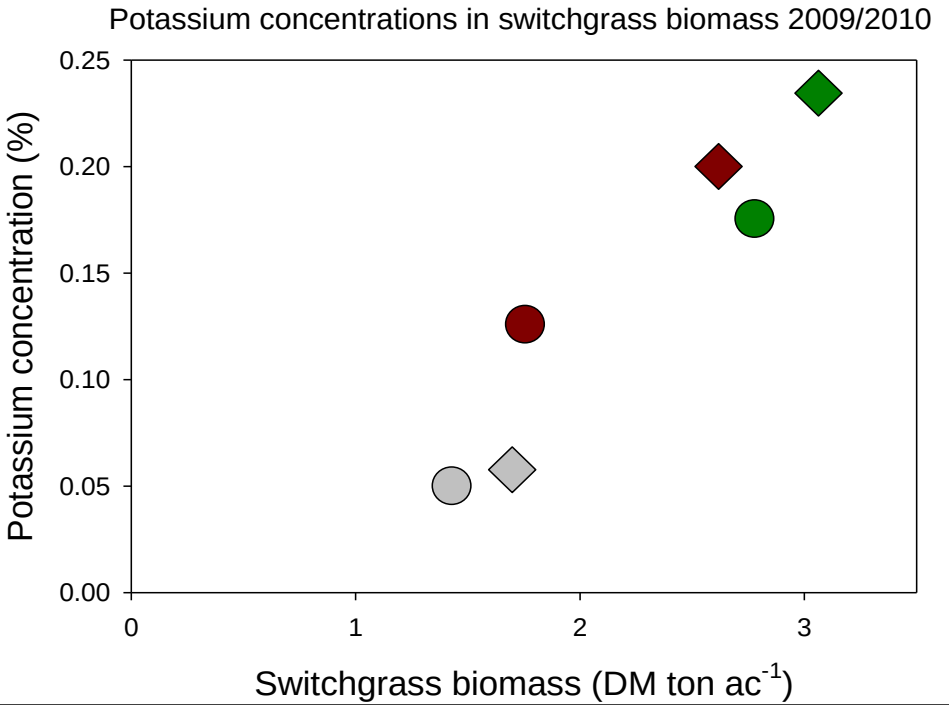
Giant ragweed can overtake switchgrass

Which one got fertilizer?

Yield vs. N rate and harvest timing







P & K concentrations in biomass

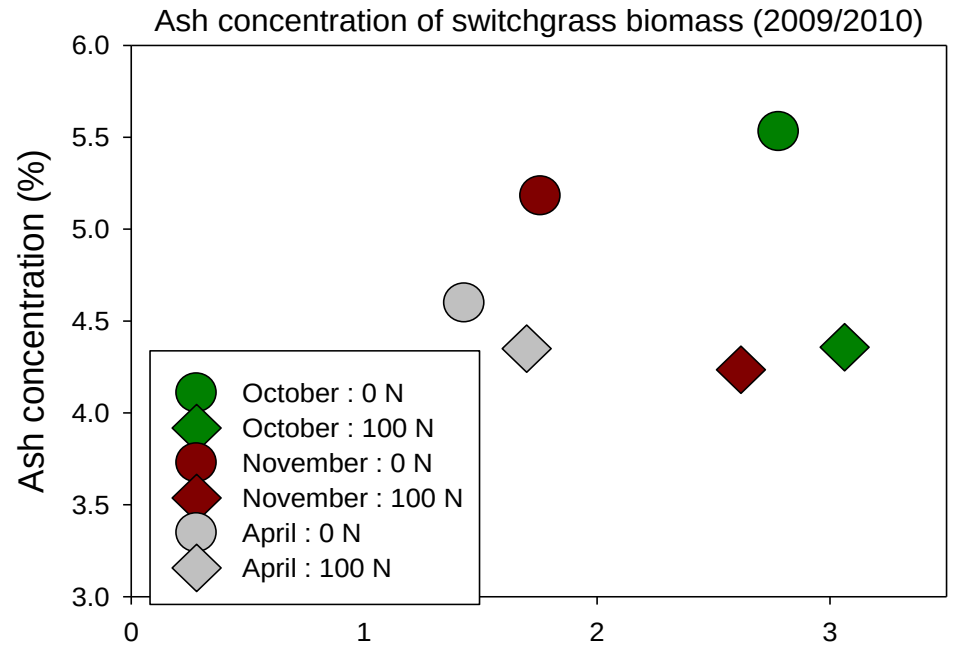
- Phosphorus concentrations not really affected by N rate (error bars too large to put on graph), but concentrations decreased over time

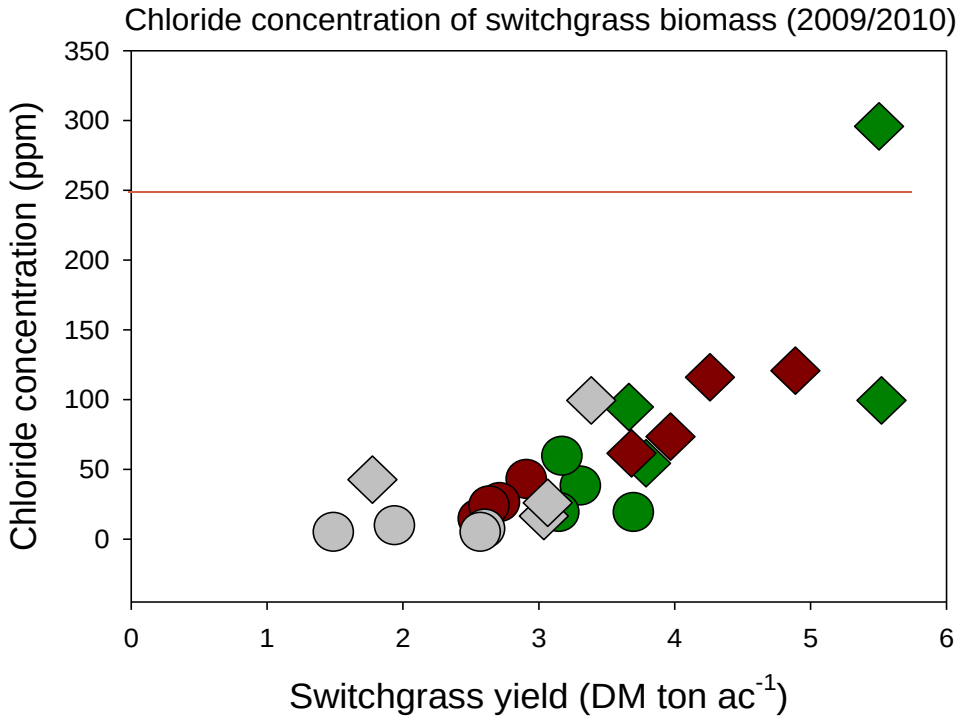
- Potassium concentrations increased with N rate and decreased over time

P removal: 1 to 1.7 lb per ton DM

K removal

- Fall (0 N): 2.5 to 3.5 lb per ton DM
- Fall (100 N): 4 to 5 lb per ton DM
- Spring: 1 lb per ton DM





Switchgrass quality

- Ash concentration decreases with harvest timing, and with N fertilizer application
- Chloride concentration decreases with harvest timing, and increases with N application

Switchgrass

- Immediate switchgrass harvest after first hard frost has greatest yield.
- Later harvest decreases yield, spring harvest not recommended
- Switchgrass quality for burning appears be adequate – but for one outlier…
- Harvesting later in the fall may be necessary to ensure switchgrass quality (especially when fertilized with N)

Corn stover removal

Issues with corn stover removal

- Nutrient cycling, yield decline
- Soil erosion
- Soil quality
  - Increases susceptibility to compaction and crusting
  - Reduces aggregate stability (carbon is glue!)
  - Greater soil temperature and moisture fluctuations

Stover removal and corn yield

- IA: removal of stover, no effect on NT yield in 10 of 13 years (silty clay loam) (Morachum et al., 1972)
- SC: 3 yr study, increase, decrease, no effect (sandy loam) (Karlen et al., 1984)
- NE: removal reduced yield in 2 of 4 years (Wilhelm et al., 1986)
- In Texas, removing sorghum stover decreased SOM over four years, but increased yields when no N was applied (Powell and Hons, 1991)
- In Ohio, removing 50% of biomass reduced corn yields by 26 bu/ac and removing 100% reduced corn yields by 50 bu ac^{-1}…but in only one of three sites. Ultisol, with 10% slope. (Blanco-Canqui and Lal, 2009)

Wisconsin research on No-till

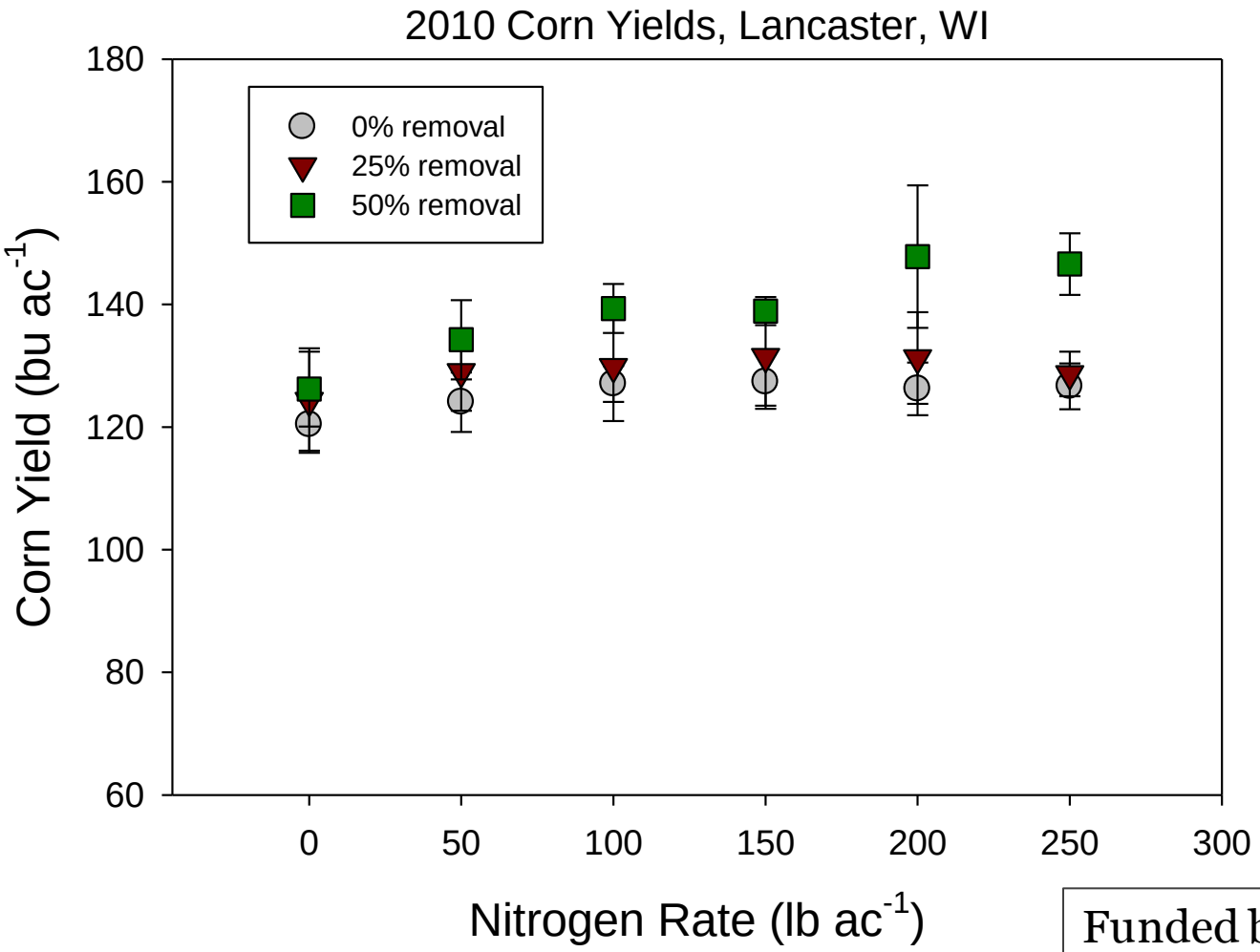
Seasonal (May through August) rainfall and yield[a] of corn grain at 155 g kg^{-1} water content as affected by 10-year crop residue treatments on non-glaciated silt loam soils near Lancaster, Wisconsin, USA

Year	Rainfall	Corn grain yield (Mg ha^{-1}) under crop residue treatment			Significance
		Removal	Normal	Double	
1981	492	9.7	9.8	7.7	$P \leq 0.003$ (1.0)
1982	464	9.6	8.3	8.9	$P \leq 0.165$ (NS)
1983	379	5.8	5.3	4.8	$P \leq 0.001$ (0.3)
1984	397	7.3	6.8	6.8	$P \leq 0.318$ (NS)
1985	298	7.2	7.5	7.6	$P \leq 0.645$ (NS)
1986	378	9.7	10.4	10.1	$P \leq 0.156$ (NS)
1987	544	10.3	11.1	10.7	$P \leq 0.139$ (NS)
1988	153	3.6	3.7	4.2	$P \leq 0.360$ (NS)
1989	316	8.0	10.8	10.7	$P \leq 0.004$ (1.4)
1990	462	9.7	10.2	8.6	$P \leq 0.184$ (NS)

[a]All treatments were planted with a no-till planter equipped with a 50 mm offset fluted coulter ahead of double disk furrow openers. Yields are mean values for four replicates. Numbers in brackets are $LSD_{(0.05)}$ values.

Karlen et al., 1994

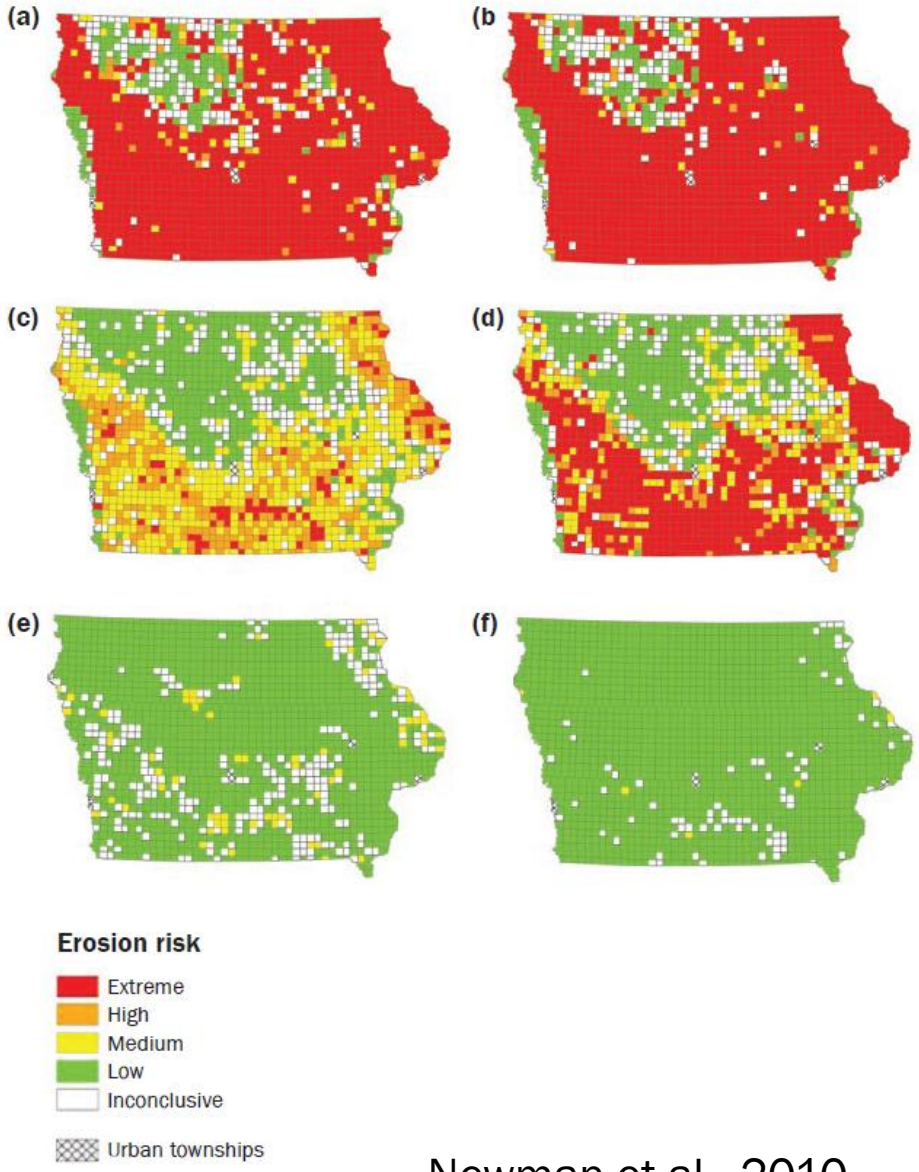
Stover removal study



- After one year of removal
- No trend was observed at other 2 sites

Funded by: Wisconsin Fertilizer Research Program

Figure 4
Soil erosion risk for corn stover removal based on 1/2 soil loss tolerance for (a) continuous corn under heavy tillage, (b) corn–soybean under heavy tillage, (c) continuous corn under intermediate tillage, (d) corn–soybean under intermediate tillage, (e) continuous corn under no-till management, and (f) corn–soybean rotation under no-till management scenarios.



Newman et al., 2010

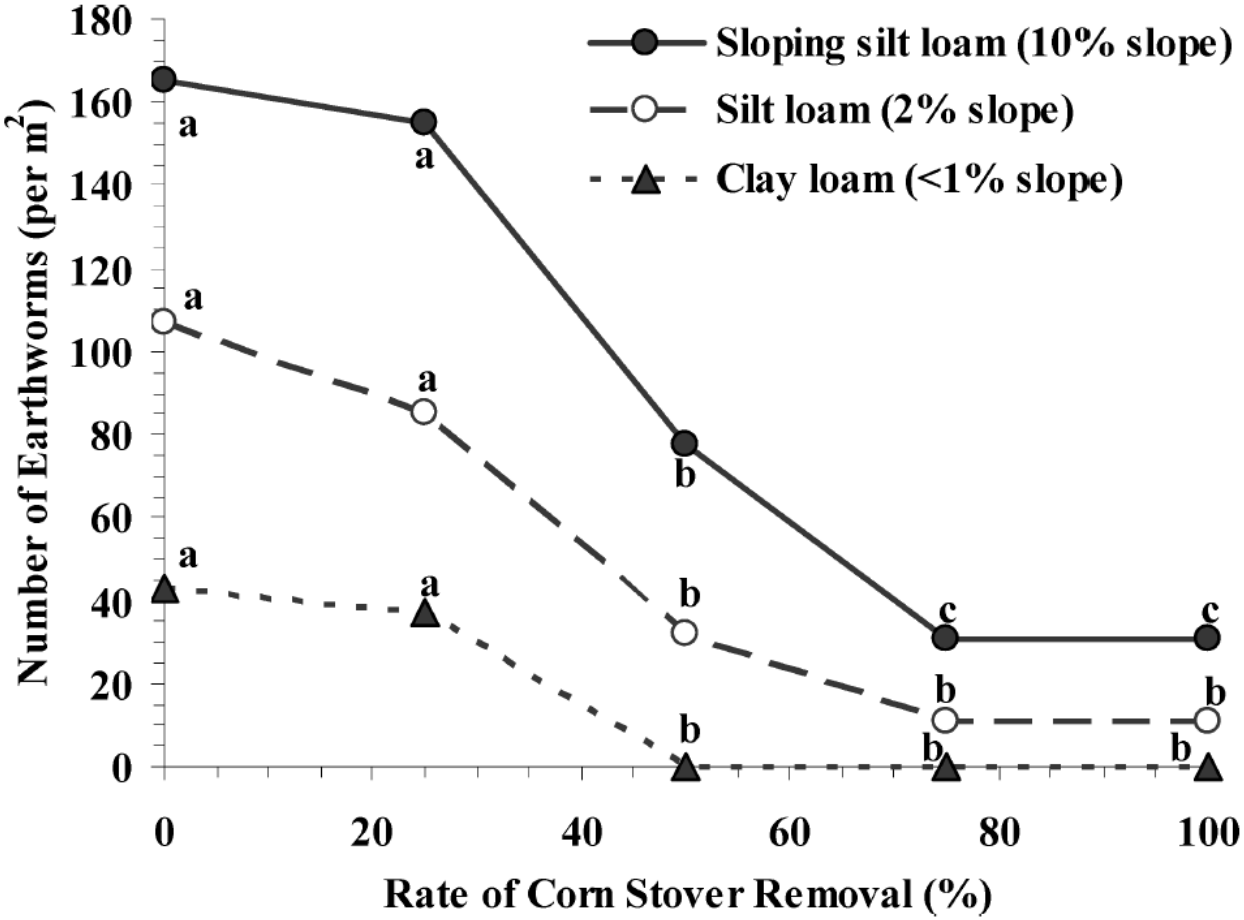
Soil erosion

- A reduction in tillage intensity can alleviate erosion losses
- Cover cropping would also provide value

Corn cobs as biofuels

- Cob removal –NE, cob removal with stover retained did not negatively affect erosion or nutrient runoff (Wienhold and Gilley, 2010)
- Recent research by UW Researchers (Avila-Segura, Barak, Hedtcke and Posner; in press Biomass and Bioenergy)
  - 4.4 tons ac^{-1} of DM as grain
  - 3.2 tons ac^{-1} of DM as stover
  - 0.5 tons ac^{-1} as DM as cob
- Most of nutrients and alkalinity are in stalks and leaves, not cob.
- Removal of stover: \$580 ac^{-1} yr^{-1}
- Removal of cob: \$ 49 ac^{-1} yr^{-1}

Effects on soil quality



(Blanco-Canqui and Lal, 2009)

Conclusions

<u>What we know</u>

- Maximize switchgrass production with 100 lbs of N per acre
- Weed management is critical for switchgrass production
- Most highly productive soils can handle short-term stover removal
- Greater concern with erosion rather than productivity in short-term

<u>What we don't</u>

- How much switchgrass or stover should cost (cost beyond nutrients!)
- What are the long-term effects of stover removal (+10 yrs)


Thoughts?
Questions?
Concerns?
Complaints?

Additional Resources

- Considerations for Corn Residue Harvest in Minnesota (DeJong-Hughes and Coulter) http://www.extension.umn.edu/distribution/cropsystems/M1243.html
- Crop Residue Removal For Energy Production: Effects on soils and recommendations (NRCS, Tech. Note 19) http://soils.usda.gov/sqi/management/files/sq_atn_19.pdf
- Potential biofuels influence on nutrient use and removal in the US (Fixen, IPNI) http://www.ipni.net/ppiweb/bcrops.nsf/$webindex/BD81AB2128ECC7D2852572DE005B4364/$file/07-2p12.pdf
- Switchgrass as a Bioenergy Crop (ATTRA, 2006) http://attra.ncat.org/attra-pub/switchgrass.html