Rye Research at the University of Minnesota

Contributors to this presentation include:

Deborah Allan, John Baker, Melissa Wilson, Erik Krueger and Adam Herges

Cover Crops

- Why use cover crops?
  - Increase organic matter
  - reduce erosion and runoff
  - reduce nitrate leaching
- Why winter rye?
  - Hardy in MN
  - excellent N scavenger
  - provides cover in early spring when growth resumes

Kaisi and Helmers. 2008. Iowa State Extension.

Zumwinkle M. 2008. MDA.

Projects

- 1. Modeling water use and biomass production
  - John Baker
- 2. Aerially seeding winter rye
  - Melissa Wilson, John Baker, and Deborah Allan
- 3. Paired watershed study to measure sediment and nutrient loading
  - Adam Herges, Erik Krueger, and John Baker
- 4. Rye as a catch/cover crop in continuous corn silage on a large dairy farm
  - Erik Krueger and John Baker

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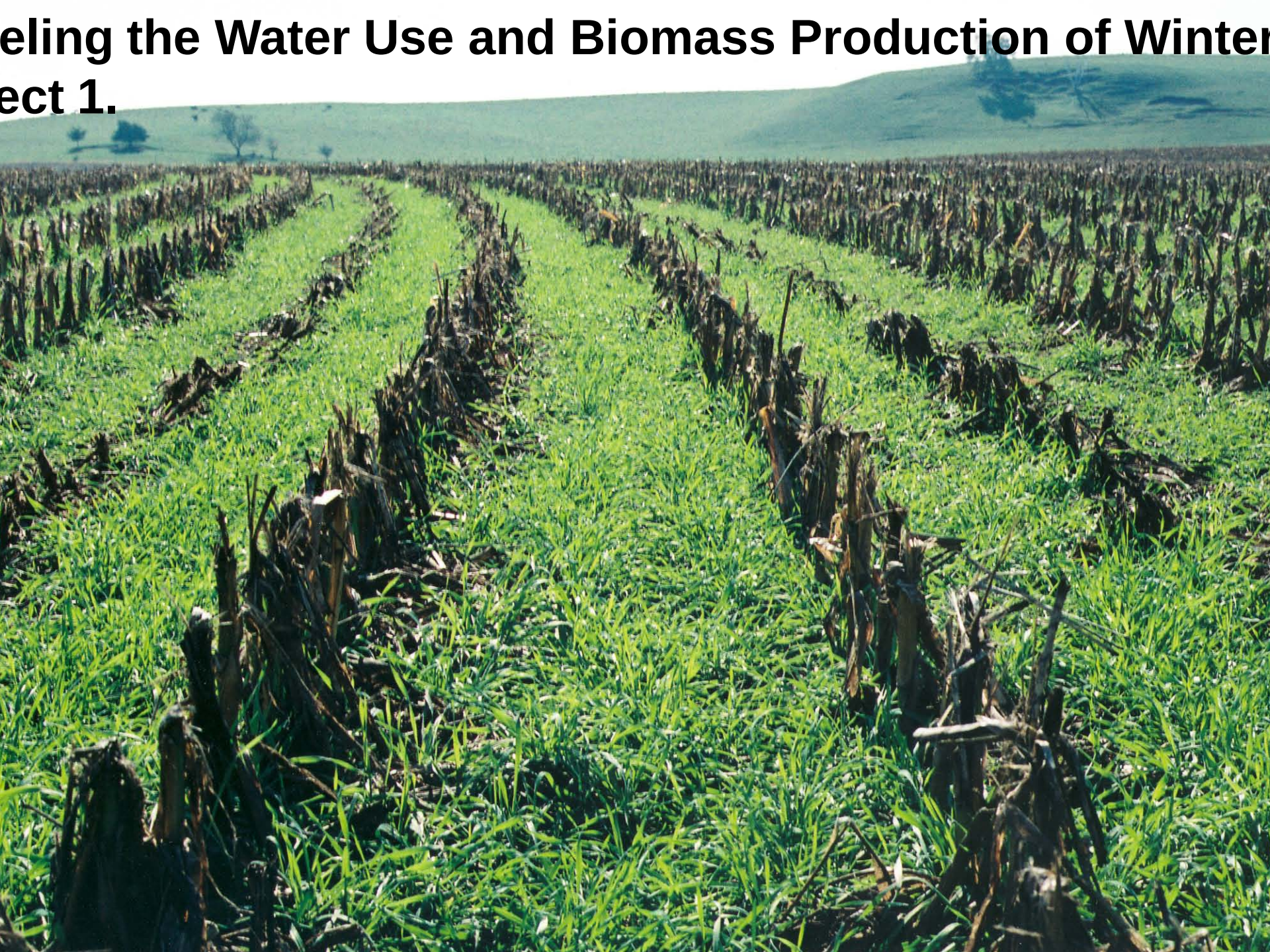
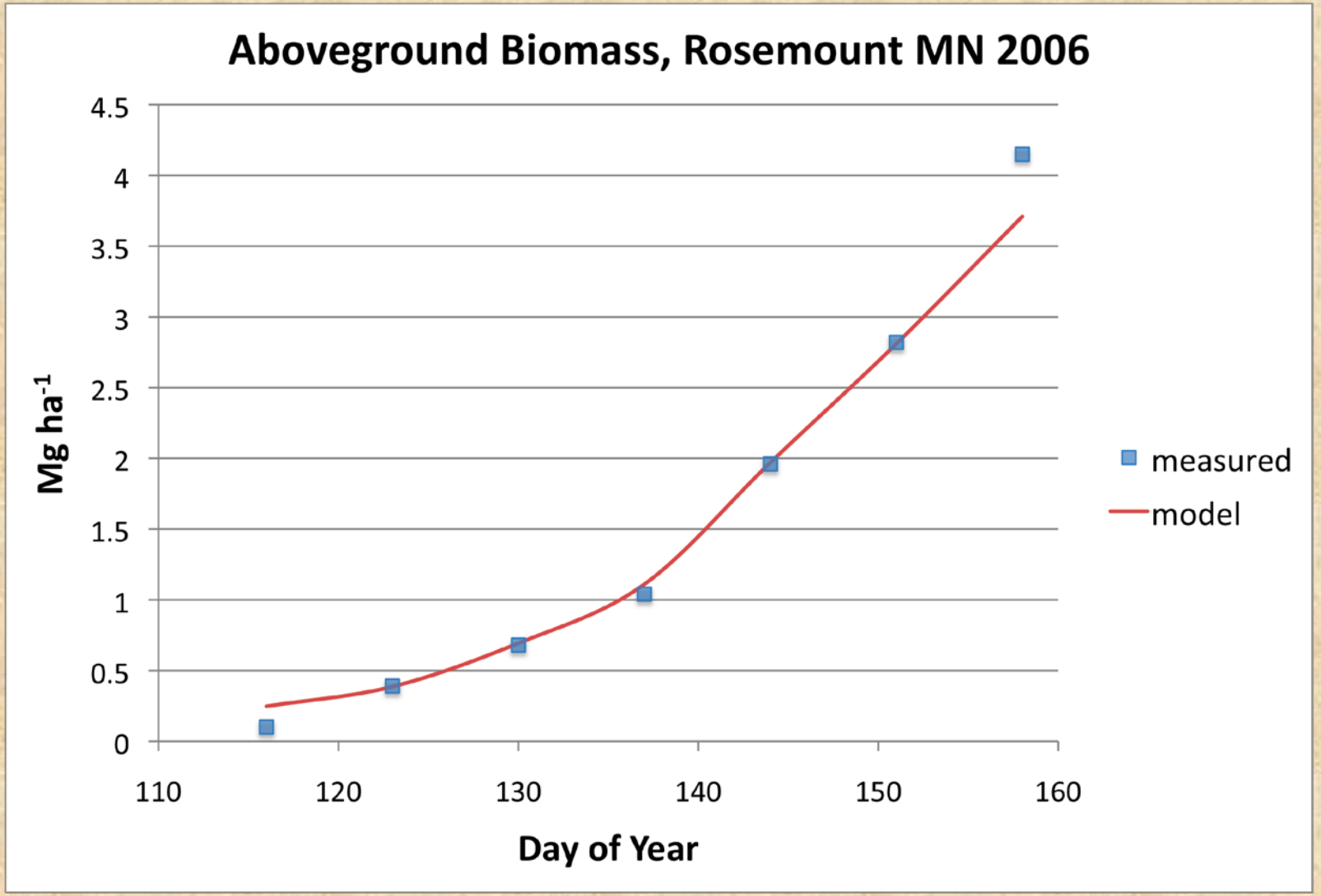
ect 1.

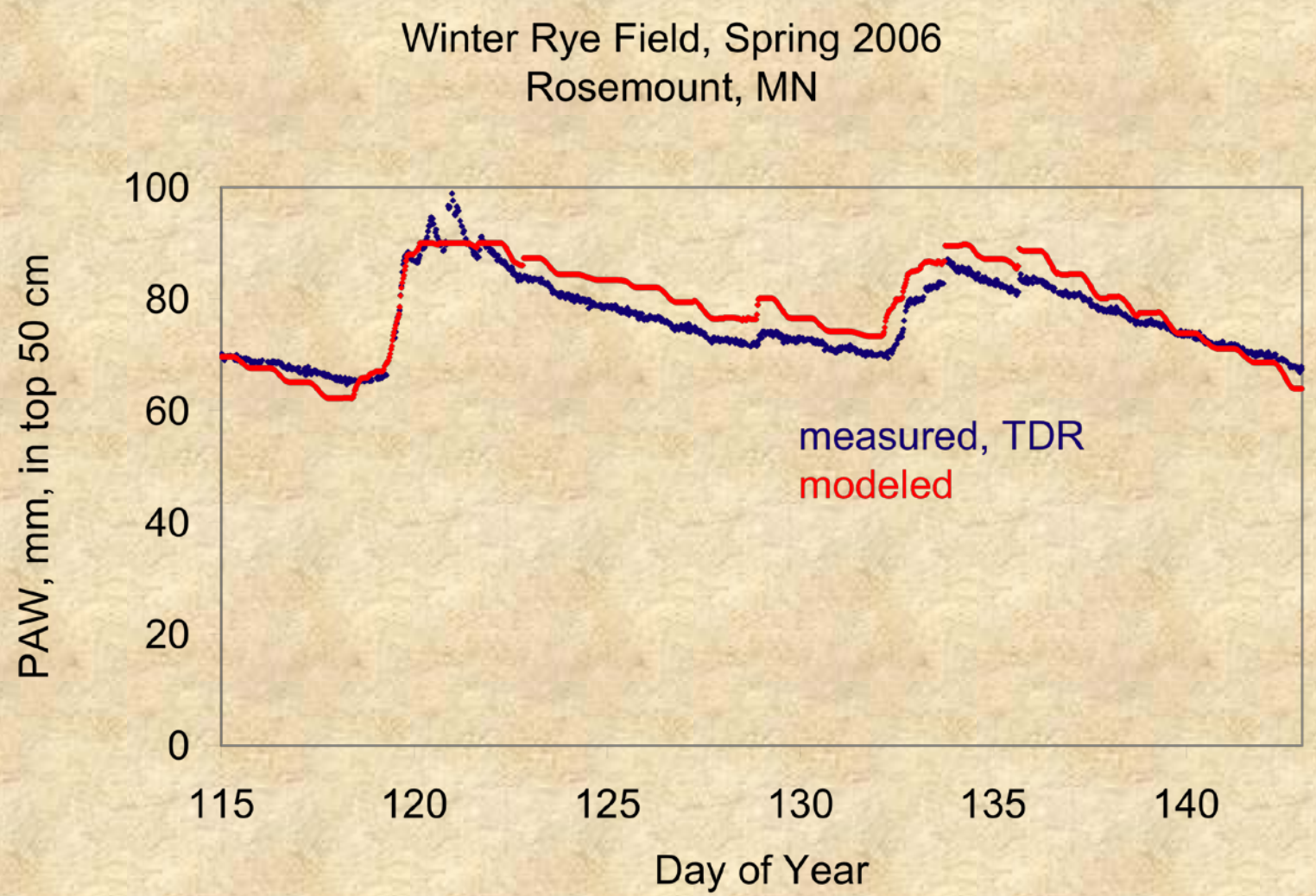


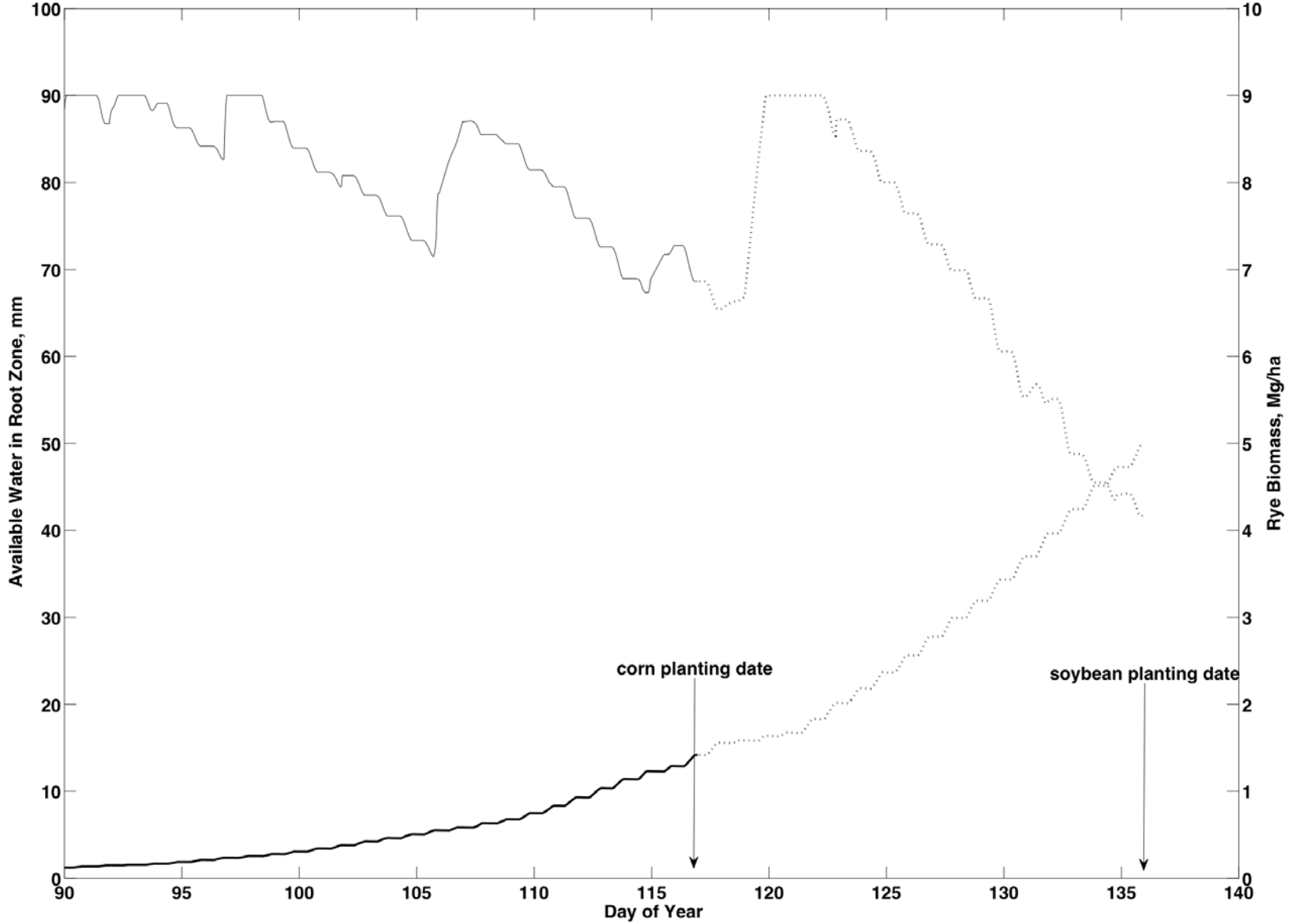
Biophysical model:

- **developed**
- **tested against MN field data**
- **applied across the corn belt**
  - **using weather data from ag weather networks**

Baker, J.M., and T.J. Griffis. 2009. Evaluating the potential of winter cover crops in corn-soybean systems for sustainable co-production of food and fuel. *Agric. Forest Meteorol*. 149:2120-2132.


Aboveground Biomass, Rosemount MN 2006
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Mg ha-1
110
120
130
140
150
160
Day of Year
measured
model


Winter Rye Field, Spring 2006
Rosemount, MN
PAW, mm, in top 50 cm
100
80
60
40
20
0
115
120
125
130
135
140
Day of Year
measured, TDR
modeled


Available Water in Root Zone, mm
Rye Biomass, Mg/ha
Day of Year
corn planting date
soybean planting date
100
90
80
70
60
50
40
30
20
10
0
10
9
8
7
6
5
4
3
2
1
0
90
95
100
105
110
115
120
125
130
135
140

Project 1 Conclusions

It appears possible to produce substantial biomass with winter rye in corn-soybean rotations across much of the corn belt, ***if*** there is sufficient N.

Growing season length is a serious constraint in the northern portion (MN,WI) of the region

Potential rye production is much lower in continuous corn.

Water depletion is a serious problem in some years, but may become a more manageable risk as long-term weather forecasts improve.

Project 2.
Aerially Seeding Winter Rye

- What factors affect successful establishment?
  - Focusing on seeding rye into grain and silage corn

- Initial Study – 2008/2009
  - Large scale plots located on cooperator farms in southeast MN
  - Looked at seeding date
  - Measured:
    - Emergence, stand establishment, soil moisture, soil organic matter, total C and N, soil water nitrate, etc

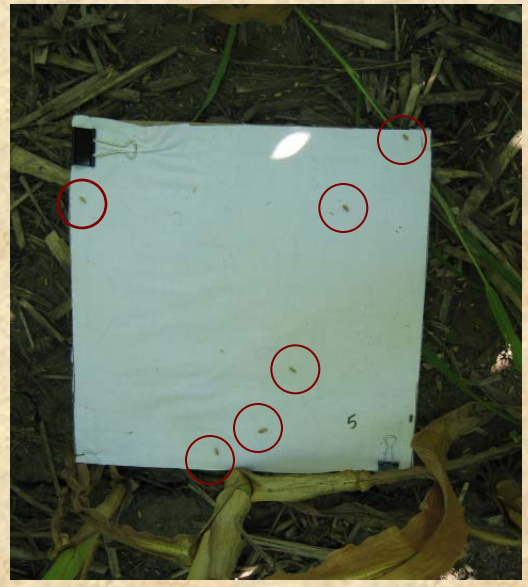
Aerially seeded winter rye

- 2008-2009 Cover crop season
  - Aerial seeding
    - Seeded on three dates: Aug 18, Sept 9, Sept 24
    - MDA seeded Aug 18th
      - Seeded 100 acres in 40 minutes
        - » A lot less time than drilling 100 acres!

Aerially seeded winter rye

Aerially seeded winter rye

- 2008-2009 Cover crop season
  - Aerial seeding
    - Seeded at 75 lb/A
      - Estimated there should be ~36 seeds per square foot
      - In reality, there were on average 3.02 (± 2.97) seeds per square foot (8.2 lb/A)

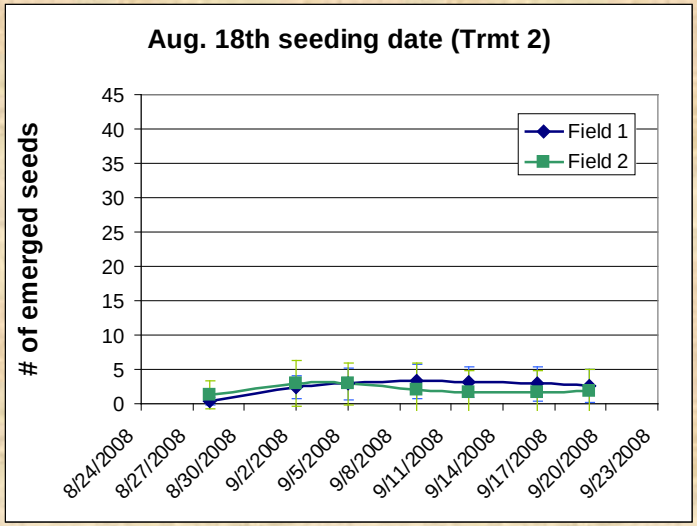


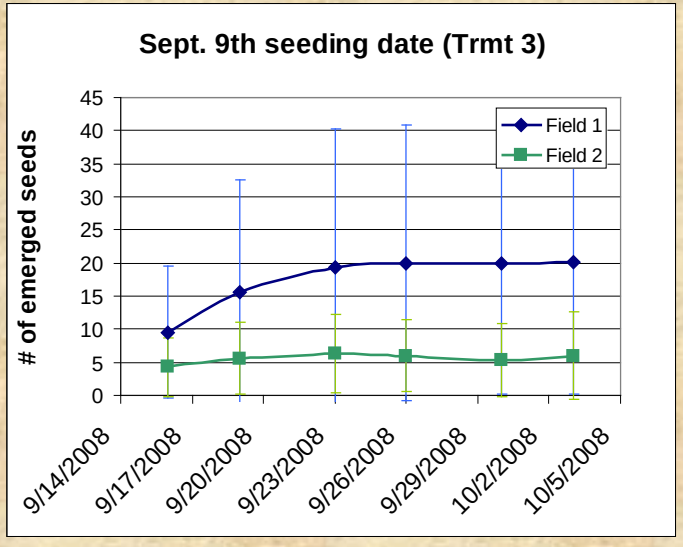
Aerially seeded winter rye

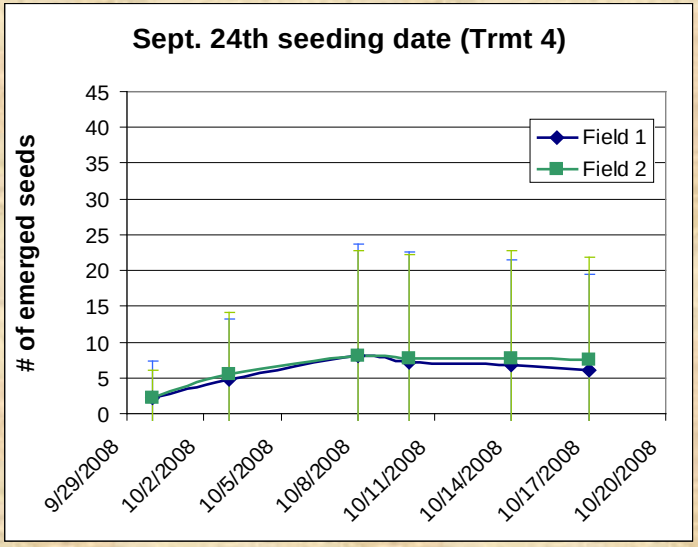
90% of seed caught in canopy?

Aerially seeded winter rye

- Emergence Counts
  - Counted emergence 2 times a week
  - Results varied drastically





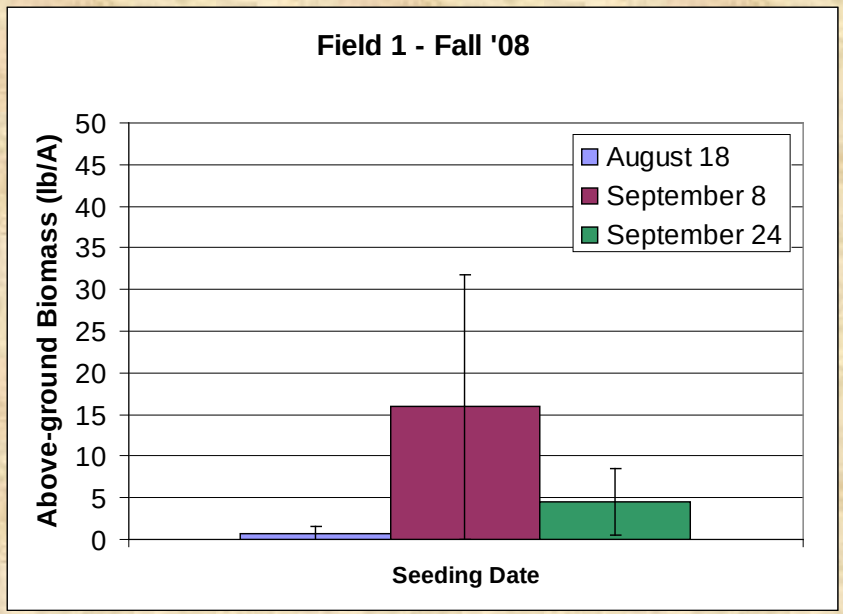


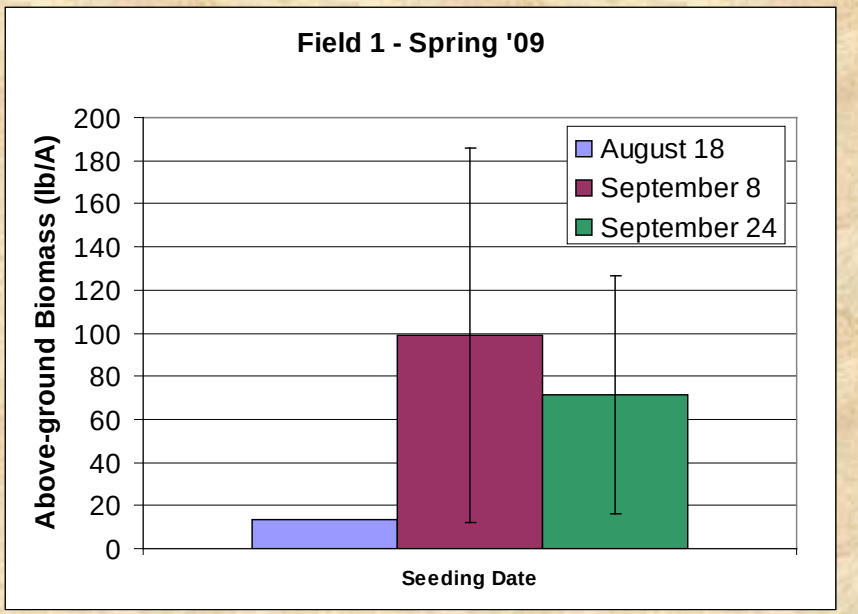
Aerially seeded winter rye

- Rye stand counts – Fall
  - Field 1:
    - Aug. 18th seeding date: 0.6 plants per ft^2
    - Sept. 9th seeding date: 6.7 plants per ft^2
    - Sept. 24th seeding date: 4.3 plants per ft^2
  - Field 2:
    - Only 1 plot had rye - it averaged 11.7 plants per ft^2
    - What happened?

Aerially seeded winter rye

- Above-ground rye biomass





Aerially seeded winter rye

Google Maps. 2008.

Aerially seeded winter rye

- MDA cooperator's farms

Zumwinkle M. 2008. MDA.

Aerially seeded winter rye

- MDA cooperator's farms

Zumwinkle M. 2008. MDA.

Aerially seeded winter rye

- MDA cooperator's farms

Zumwinkle M. 2008. MDA.

2008/2009 Conclusions

- Rye cover crops can be successful in Minnesota
  - As shown by the MDA
- More research is needed
  - Why does rye successfully establish in one field, but not another?
    - Soil organic matter content? Surface crusting? Insects?
  - What type of spreader is best for aerial seeding?
  - How much seed is caught up in corn canopy? At what rate should rye be seeded to overcome this?

Aerially seeded winter rye

- 2009/2010 Cover crop season
  - New approach
    - Used a different helicopter service with bucket spreader

Aerially seeded winter rye

- 2009/2010 Cover crop season
  - New approach
    - Aerially seeded multiple sites in Fillmore, Olmstead and Dakota Counties
      - 7 sites in Fillmore on August 17th
      - 11 sites in Olmstead on August 28th
      - 1 site in Dakota on September 9th
    - Measured multiple variables that potentially affect rye growth
      - Soil moisture, nutrient content, organic matter content and residue cover
      - Will determine which variables are most likely to predict rye growth

Aerially seeded winter rye

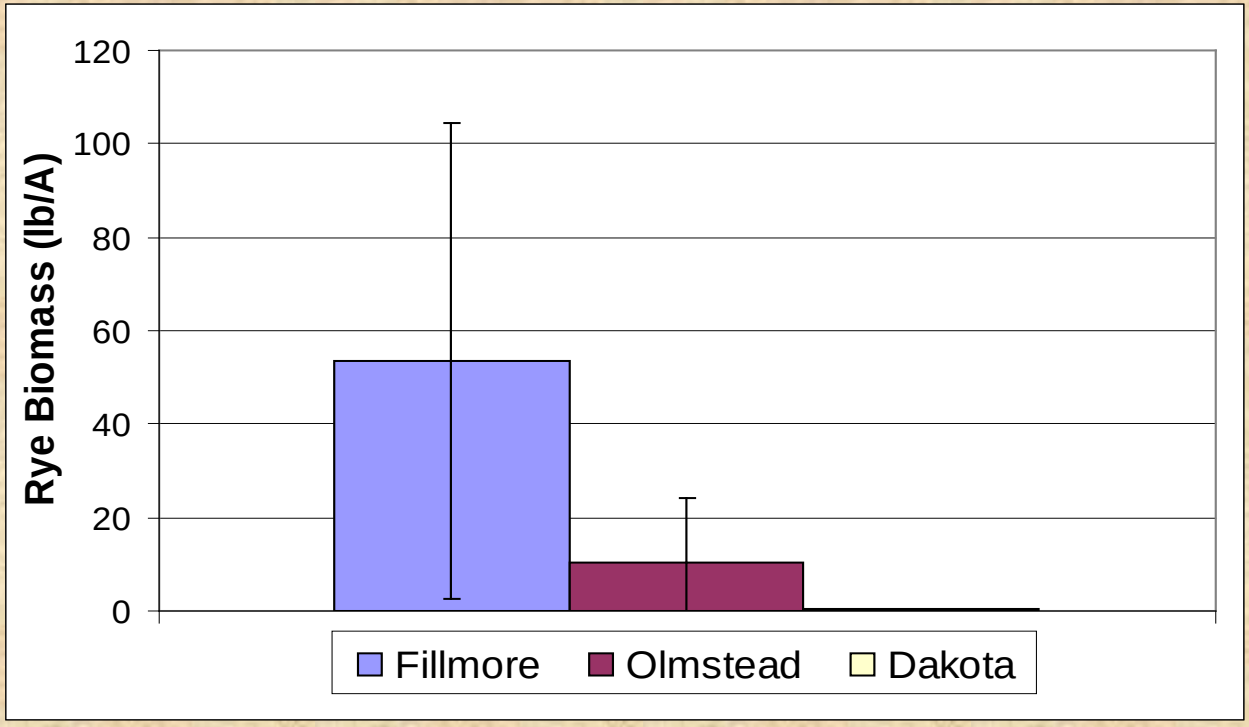
- Preliminary Results
  - Seeding rate
    - Again, seeded at 75 lb/A
    - On average had 33 lb/A on the ground at sites in Olmstead and Dakota Counties
      - Better than previous year but still needs more work

Aerially seeded winter rye

Rye growth 1 week after seeding in Fillmore County

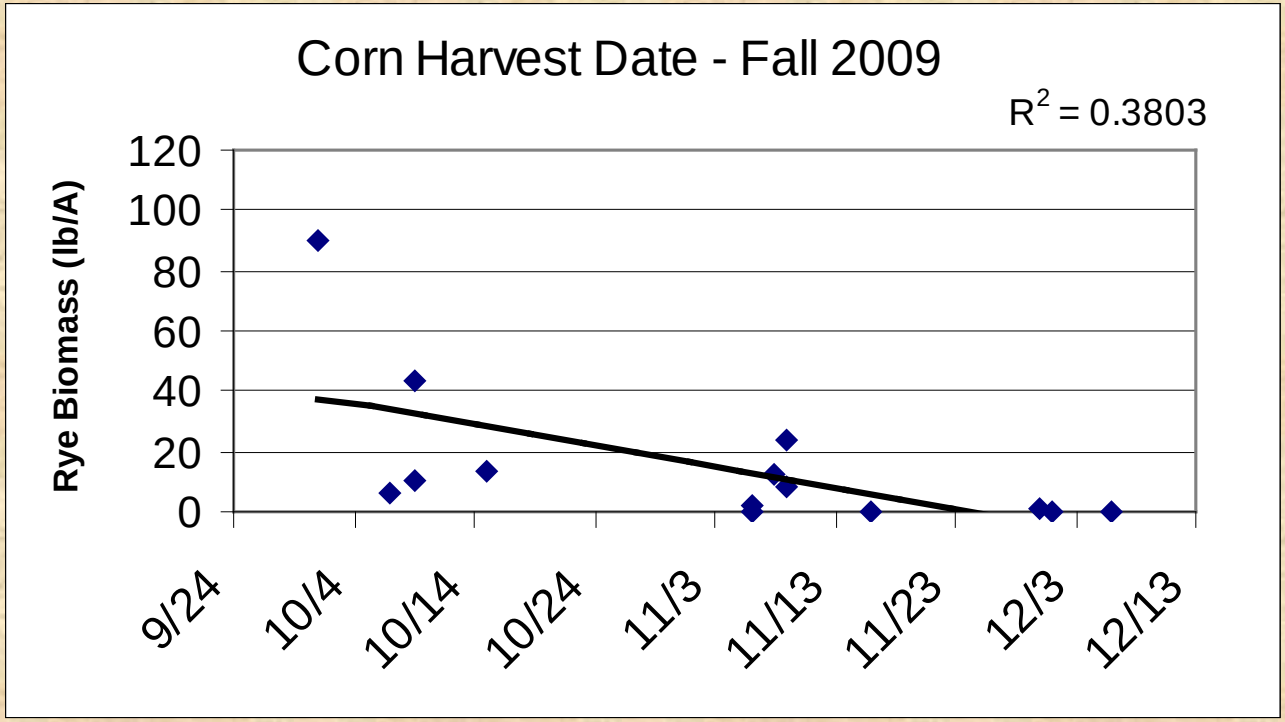
Aerially seeded winter rye

- Preliminary Results
  - Above-ground rye biomass
    - Collected early December



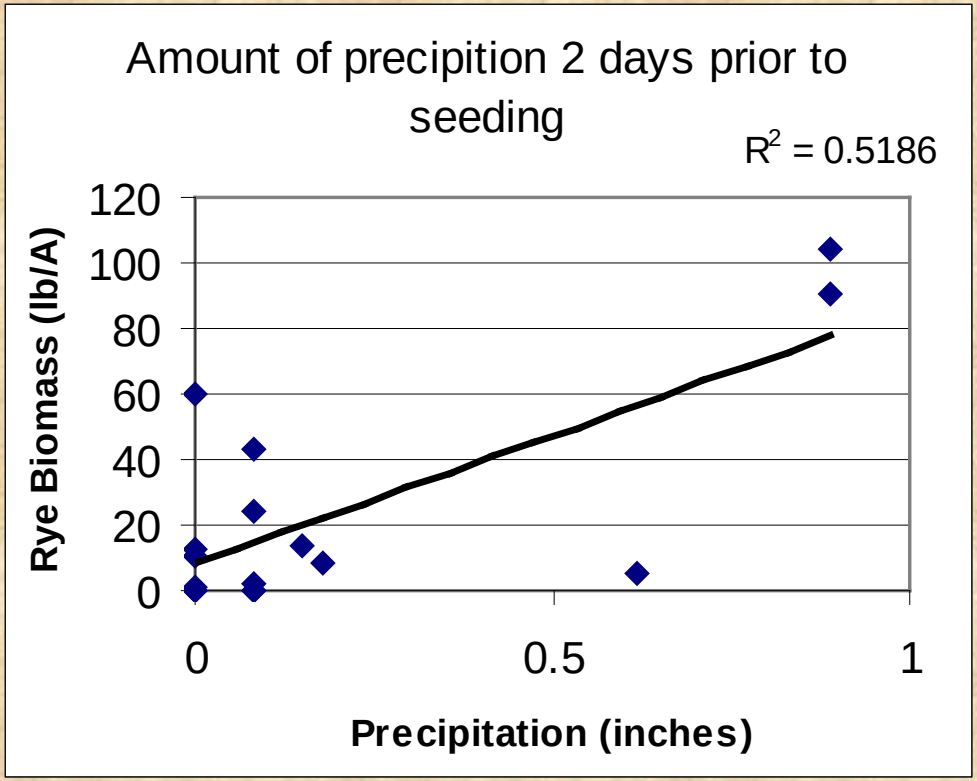
Aerially seeded winter rye

- Preliminary Results
  - Correlations



Aerially seeded winter rye

- Preliminary Results
  - Correlations



Aerially seeded winter rye

- Preliminary Results
  - Correlations
    - Other variables seem to have little to no correlation
      - Soil organic matter
      - Soil pH
      - Inorganic nitrogen
      - Total nitrogen
      - Total carbon
      - Extractable K

Aerially seeded winter rye

- Future plans
  - Germination and Growth Experiments
    - Soil moisture at the soil surface
    - Rainfall pattern and distribution variations
  - Mechanical Aspects of Seeding
    - How much seed actually gets caught in the corn canopy?
    - Will some of the seed caught in the canopy eventually fall to the ground?

Project 3. Winter rye BMPs to reduce sediment and nutrient loading of Minnesota surface waters

- Funded by the Minnesota Clean Water Act

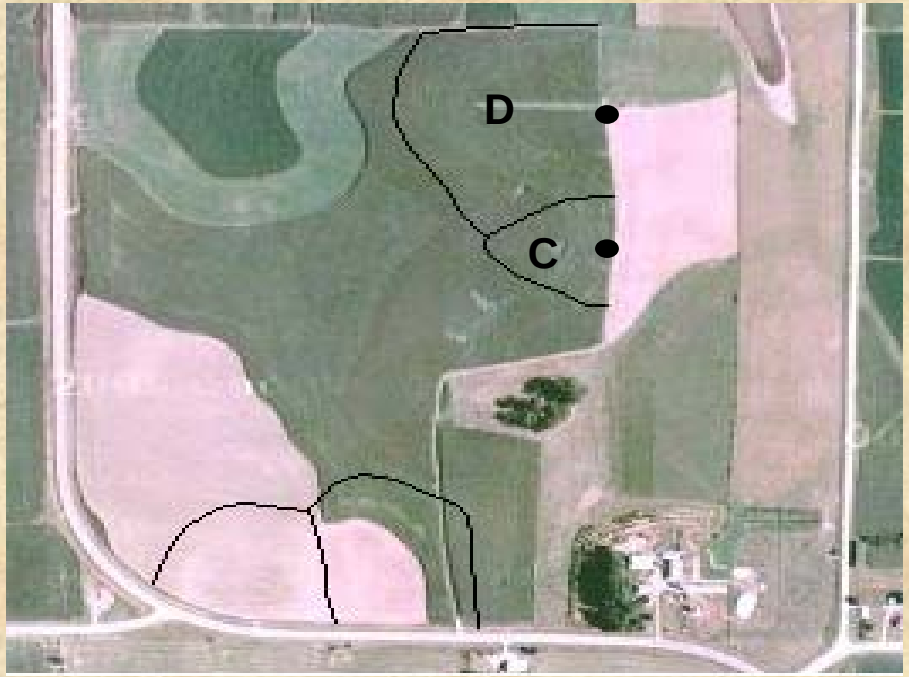
Research Team

- Adam Herges, GRA, UM Dept. of Soil, Water, and Climate, (herge010@umn.edu, 612-625-1798)
- Erik Krueger, GRA, UM Dept. of Soil, Water, and Climate
- John Baker, USDA-ARS and UM Dept. of Soil, Water, and Climate
- Gary Feyereisen, USDA-ARS and UM Dept. of Soil, Water, and Climate
- Paul Porter, UM Dept. of Agronomy
- Mark Zumwinkle, MN Dept. of Agriculture

Research Objectives:

- **To evaluate surface runoff from 2 paired watersheds (in corn silage and corn grain systems)**
- **Use rainfall simulations (plot scale) to evaluate grazed vs. harvestable winter rye for BMPs.**

Aerial photograph representing the paired watersheds at the two SE MN locations



200 m

N

Approx. Monitoring Site

Approx. Watershed Boundary

200 m

N

Approx. Monitoring Site

Approx. Watershed Boundary

The letter D represents the control (field left fallow over winter) and the letter C represents the treatment (winter rye seeded in fall of growing season)

Lewiston, MN location – corn silage field

Constructing the plywood barrier for edge-of-field monitoring, October 2009.

Installing H-flume into position at the lowest point on the field edge, January 2010.

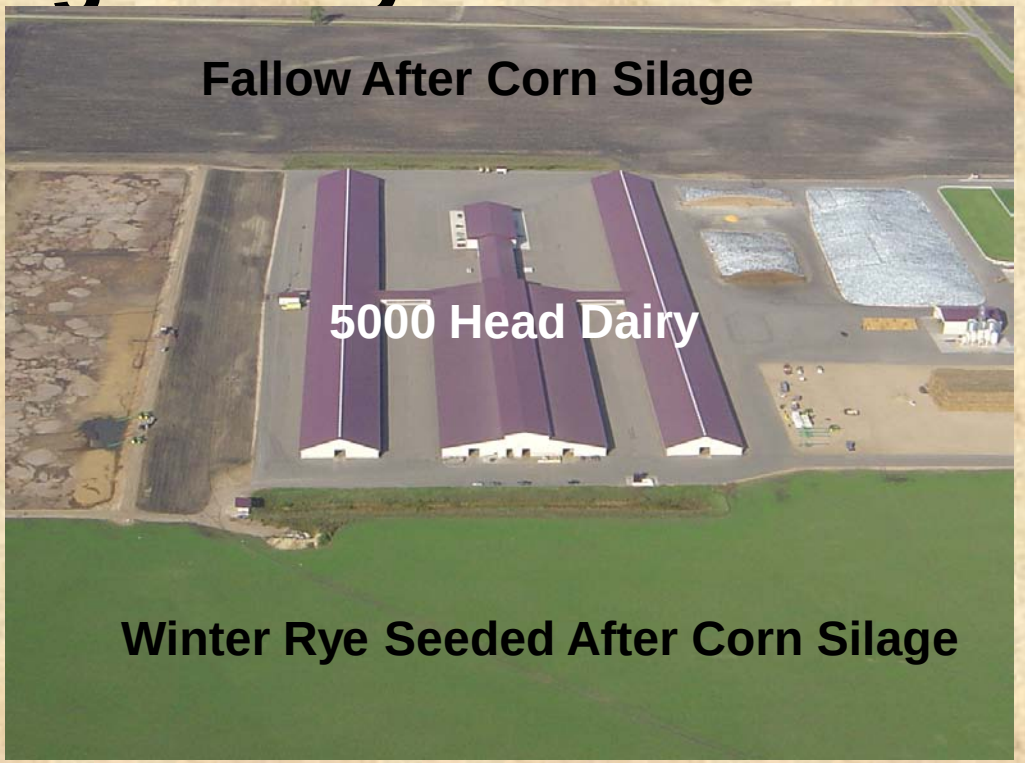
Plainview, MN location – corn grain field

Constructing platform for ISCO equipment: 4230 Bubbler Flow Meter and 3700 Portable Samplers, November 2009.

Completed 3 foot plywood wall, November 2009. (Took 1 day to complete with 6 people)

Project 4. Rye in continuous corn silage on large dairy farm

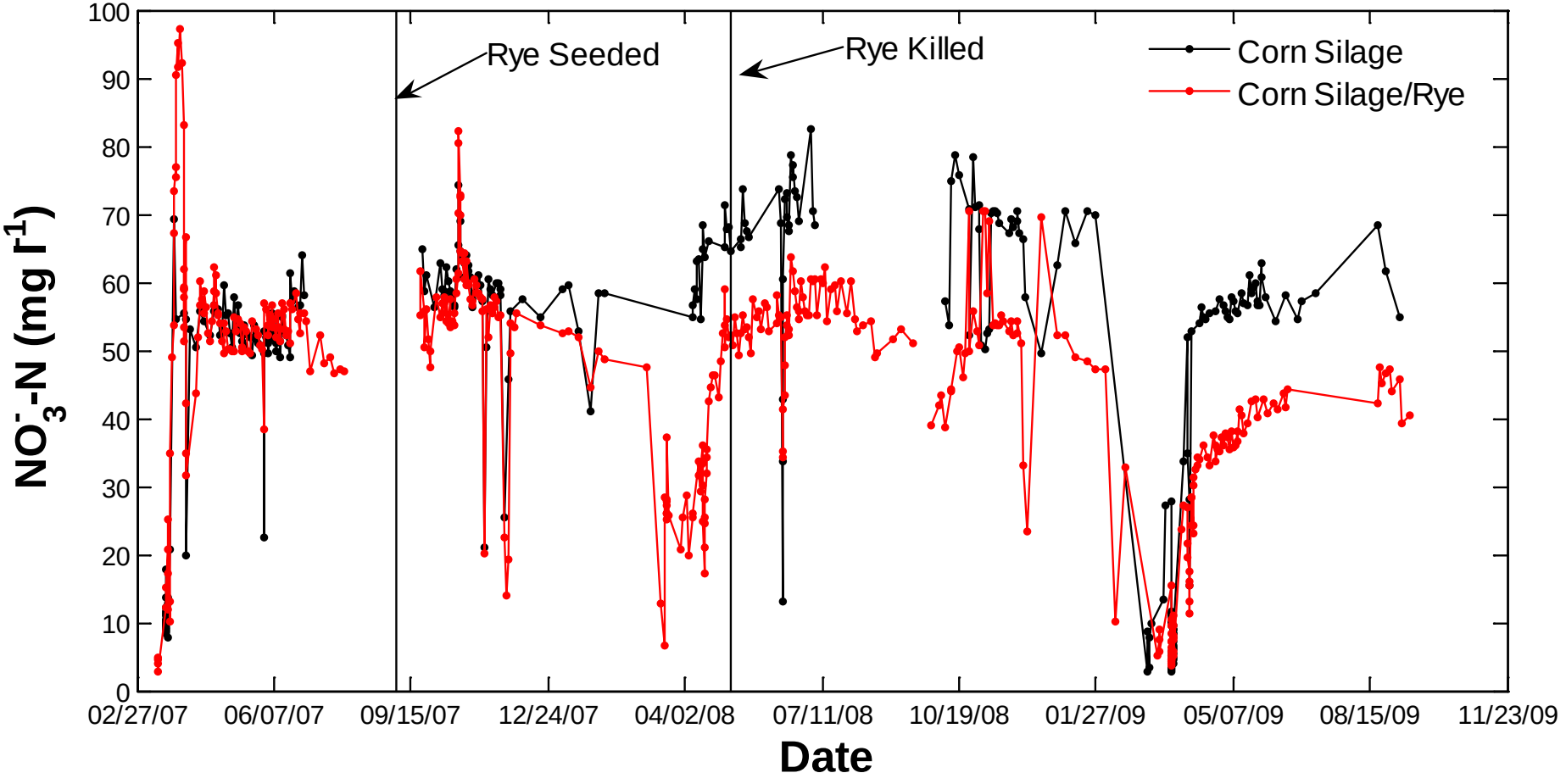
- **Concerns with Large Dairies**
  - **Continuous corn silage**
    - **Short growing season, OM removal, erosion potential**
  - **Large volume of manure**
    - **Nutrient buildup and transport**



Objectives:

- Determine the effectiveness of the rye at reducing N and P losses
- Monitor the influence of rye cover crop on soil erosion
- Address the effects of the rye cover crop on subsequent corn yield
- Estimate N balance by measuring N applied, removed in biomass, leached, and changes in soil N content

NO_3 Concentration in Subsurface Drainage



- NO_3 concentration was similar in 2007 prior to rye seeding
- A decrease in NO_3 concentration of 23% was observed in 2008
- Rye was not seeded in fall 2008, but a residual effect of the single year of cover cropping was observed in 2009

Biomass Production and Nitrogen Capture

	2006-2007				2007-2008[⁋]				2008-2009			
	Biomass Mg ha^{-1}		N Captured Kg ha^{-1}		Biomass Mg ha^{-1}		N Captured Kg ha^{-1}		Biomass Mg ha^{-1}		N Captured Kg ha^{-1}	
Trt.	Rye	Corn	Rye	Corn	Rye	Corn[‡]	Rye	Corn[‡]	Rye	Corn	Rye	Corn
C-CS[†]	-----	10.6	-----	107.1	-----	17.1	-----	175.5	----	21.2	----	214.1
T-R/CS	-----	11.1	-----	112.2	2.28	14.4	79.1	143.4	----	20.9	----	211.1

[†]Control Corn Silage (C-CS), Treatment Rye/Corn Silage (T-R/CS)

[⁋] Rye seeded 9/4/2007 and killed 5/6/2008

[‡] Corn seeded 5/16/2008 after fallow and 5/22/2008 after rye

- **Corn yield and N capture were similar for 2007 and 2009 when no rye was seeded**
- **In 2008, N capture improved with cover cropping, but corn yield was suppressed**
- **Late planting due to wet conditions and poor seedbed preparation after rye may be the cause of the reduced yield**

This research demonstrates that cover cropping with winter rye can <u>reduced NO_3</u> in subsurface drainage but may also <u>reduce corn yield</u>

Plot Scale Double Cropping

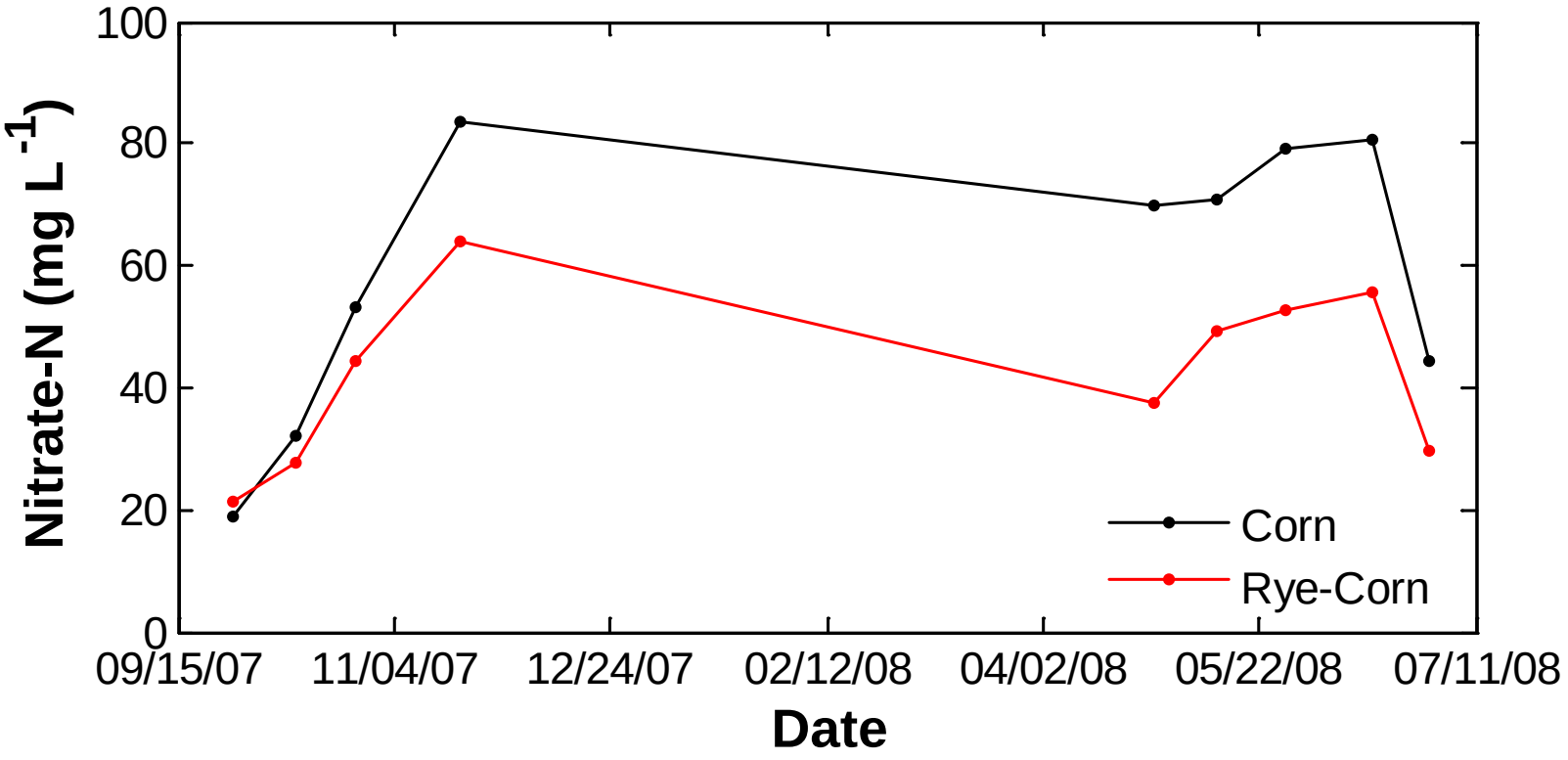
Designed as a companion project to the on farm research
Allows for replication and multiple management schemes

- **Four treatments and four reps**
  - EC: Corn Planted Early May
  - LC: Corn Planted Mid May
  - ER: Corn after Rye, Mid May
  - LR: Corn after Rye, Early June

Photos Taken 6/23/2009

Objectives similar to on farm experiment, but possibility of rye forage production also examined

NO_3 Concentration in Subsurface Drainage



- **Suction cup water samplers were used to determine NO_3 concentration in subsurface drainage**
- **Leachate data are limited, but a decrease in NO_3 concentration of 37% was observed in one year of data**

Biomass Production and Nitrogen Capture

	2006-2007						2007-2008					
	Yield (Mg ha^{-1})			N Captured (Kg ha^{-1})			Yield (Mg ha^{-1})			N Captured (Kg ha^{-1})		
	Rye	Corn	Total	Rye	Corn	Total	Rye	Corn	Total	Rye†	Corn†	Total†
EC	----	18.0^{a}	18.0^{a}	----	241^{a}	241^{a}	----	17.5^{a}	17.5^{a}	----	235	235
LC	----	16.8^{a}	16.8^{a}	----	231^{a}	231^{a}	----	17.7^{a}	17.7^{a}	----	243	243
ER	0.15^{a}	15.3^{a}	15.5^{ab}	6.82^{a}	212^{ab}	219^{a}	1.43^{a}	13.7^{b}	15.1^{a}	63.4	190	253
LR	1.39^{b}	12.5^{b}	13.9^{b}	31.3^{b}	181^{b}	212^{a}	2.77^{b}	14.0^{b}	16.8^{a}	76.0	203	279

Same letter within column indicates no significant difference ($p < 0.05$)

† N capture estimated using forage quality data from 2007

- **Late planting and low rye yield in 2007 resulted in both reduced total biomass production and N capture in the double crop treatments**
- **In 2008, N capture was increased in the double crop treatments, but biomass yield was greater in monocrop corn silage**
- **Soil data indicate that soil moisture and N depletion likely cause decreasedcorn yield**

As with the on farm study, this research demonstrates that cover cropping with winter rye can <u>reduce NO_3</u> in subsurface drainage but may also <u>reduce both corn yield and total biomass production</u>