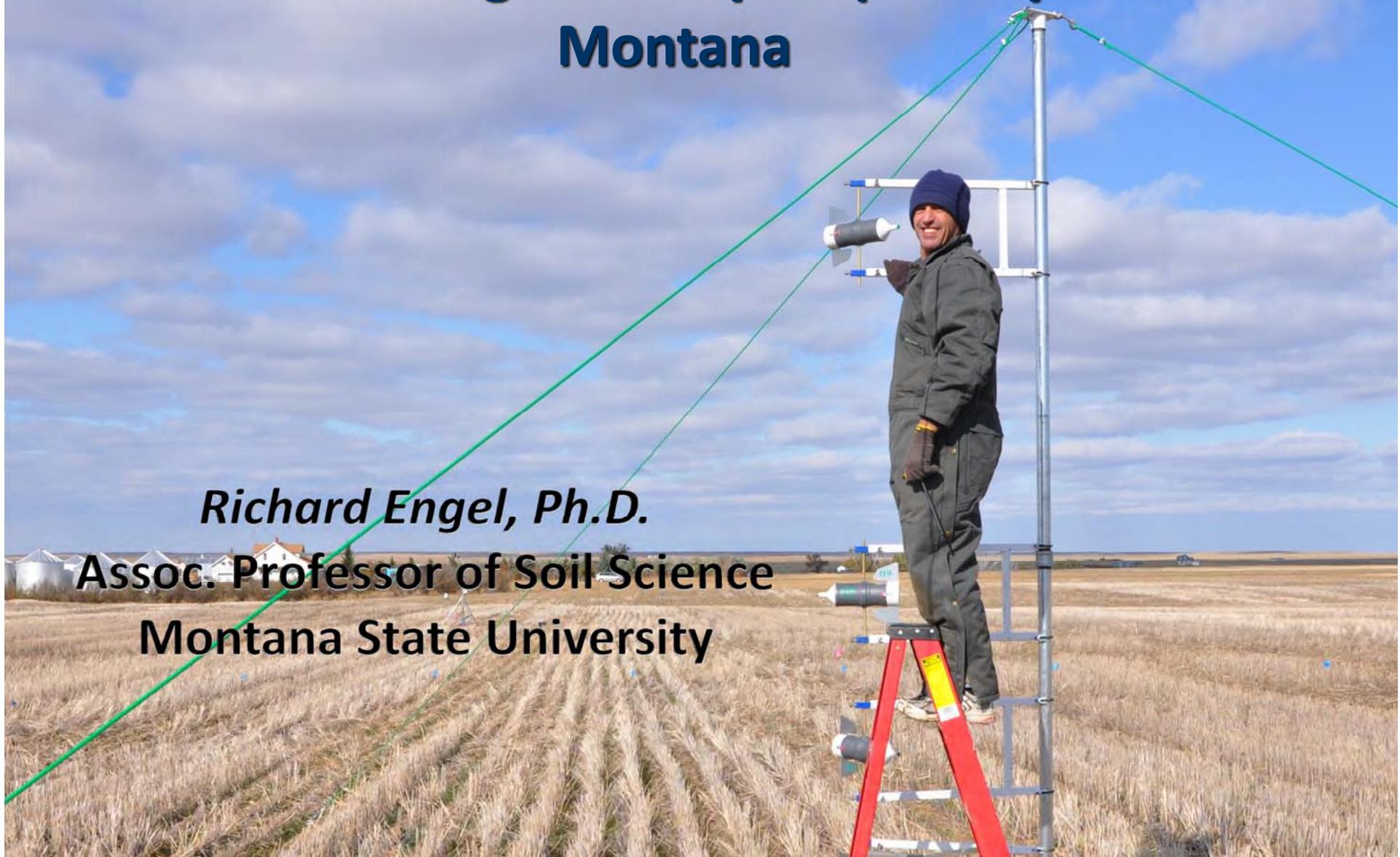


# **Volatility losses of N from surface-applied urea: A micrometeorological study to quantify losses in Montana**

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MONTANA AGRICULTURAL EXPERIMENT STATION



NORTHERN  
AGRICULTURAL  
RESEARCH CENTER

Cooperator: Jeff Whitmus, Research Assistant

# Winter wheat production in Montana

- ▶ large farms, no till has become norm
- ▶ seeded in September
- ▶ N fertilizer applications deferred to until fall, winter, and early spring (cold weather months)
- ▶ surface-applied urea - susceptible to volatility losses
- ▶ How much N are we losing?



# Surface-applied urea & volatilization



pH↑  
*micro-site*



# **Factors affecting volatilization**

- 1. Soil pH**
- 2. Soil moisture and humidity**
- 3. Wind**
- 4. Precipitation following fertilization**
- 5. Surface residue and vegetation**
- 6. Soil texture (sandy more susceptible than clay soils)**
- 7. Temperature**

***Bottom line → large number of soil & environmental factors make N losses variable and difficult to predict***



# Objectives

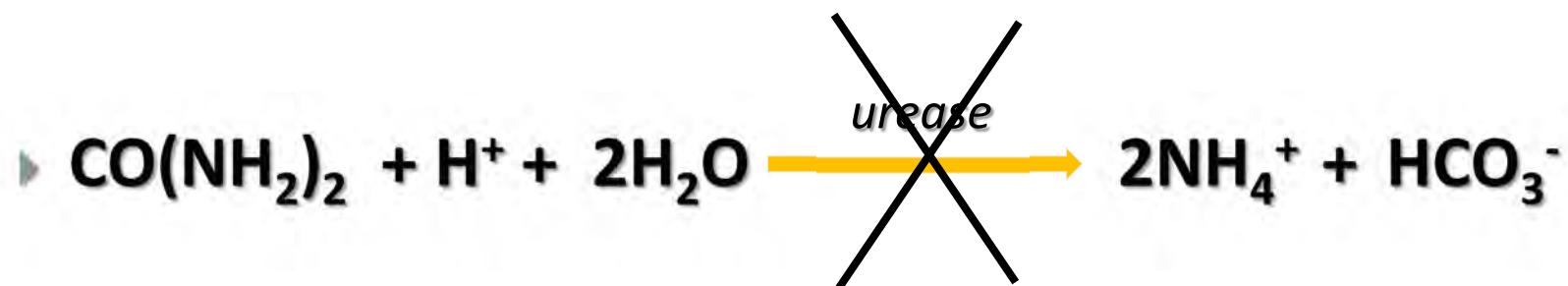
- ▶ How much N as NH<sub>3</sub> are we losing from surface-applied urea (fall, winter, and early spring)?

*Do cold temperatures (< 5°C or 41°F) provide protection against volatility losses?*

- ▶ How do we mitigate losses (particularly when significant) ?
  - *Enhanced efficiency N products (NBPT or Agrotain)*
  - *Incorporation & subsurface urea applications*



## NBPT - urease inhibitor





**surface-applied urea prior to seeding**

# Integrated horizontal flux approach

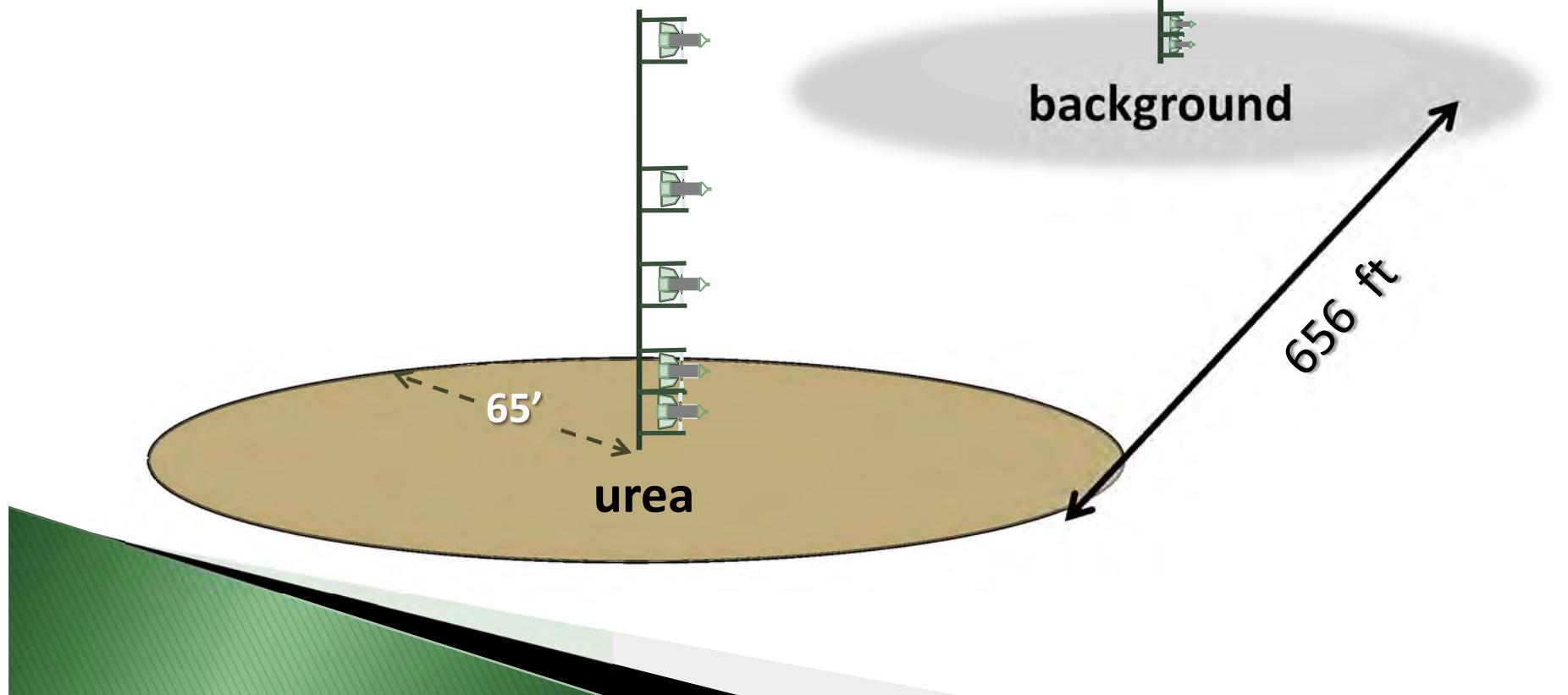
- ▶ micrometeorological - mass balance (Ryden and McNeil, 1984)
- ▶ does not disturb the soil-atmosphere environment
- ▶ moderate size plots (~0.3 acre) > larger footprint than enclosures
- ▶ continuous measurement of gas loss over time

mast and shuttles ➔



# On-farm studies

- urea (90 lbs N/acre)
- urea + NBPT  
(Agrotain 4 qt/ton = \$55)



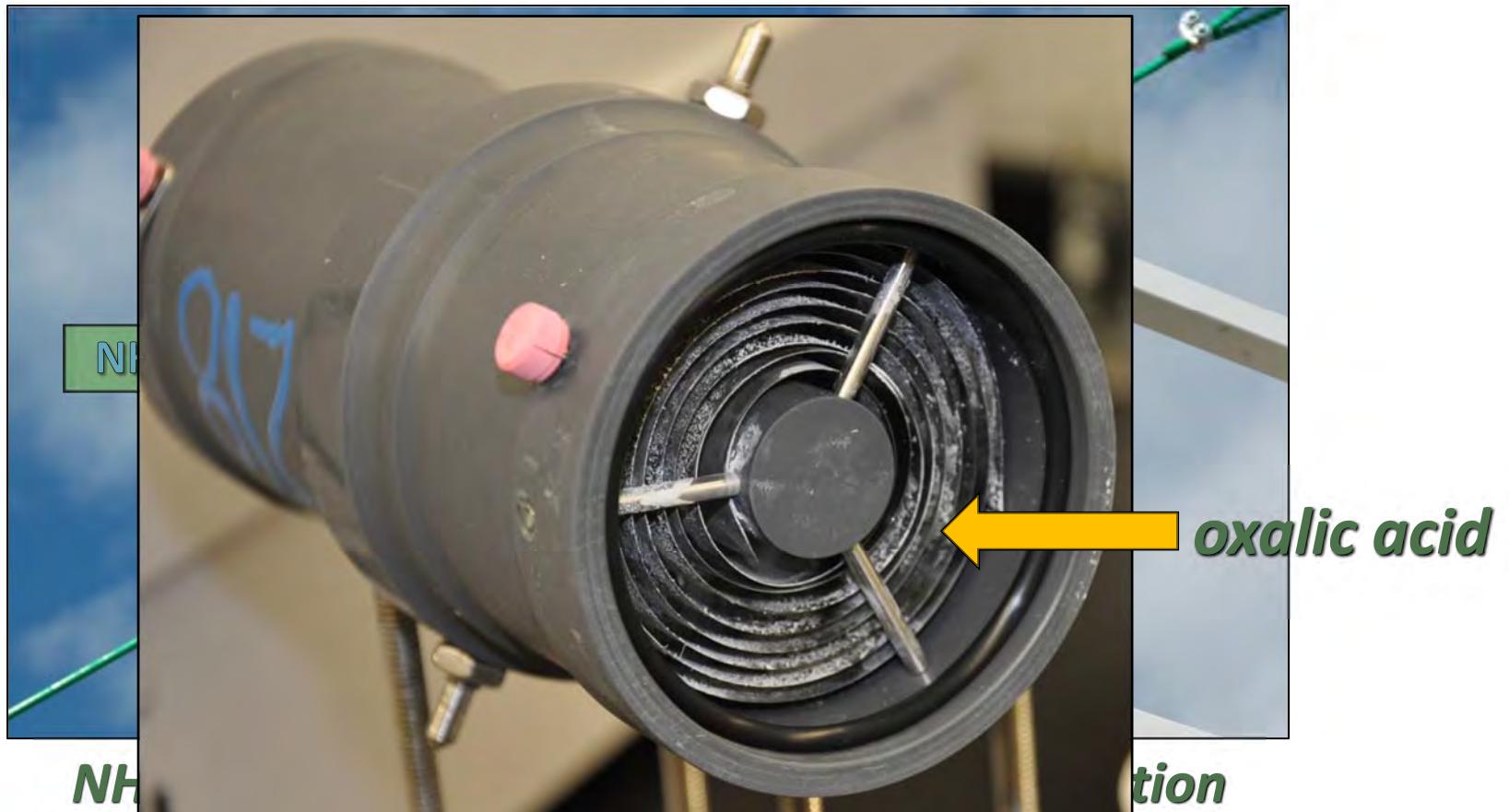


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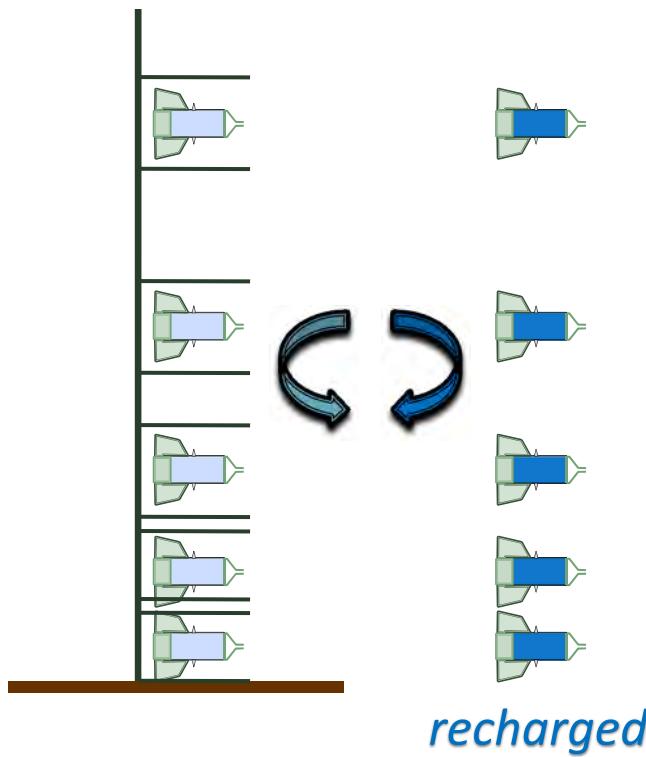
# Shuttles

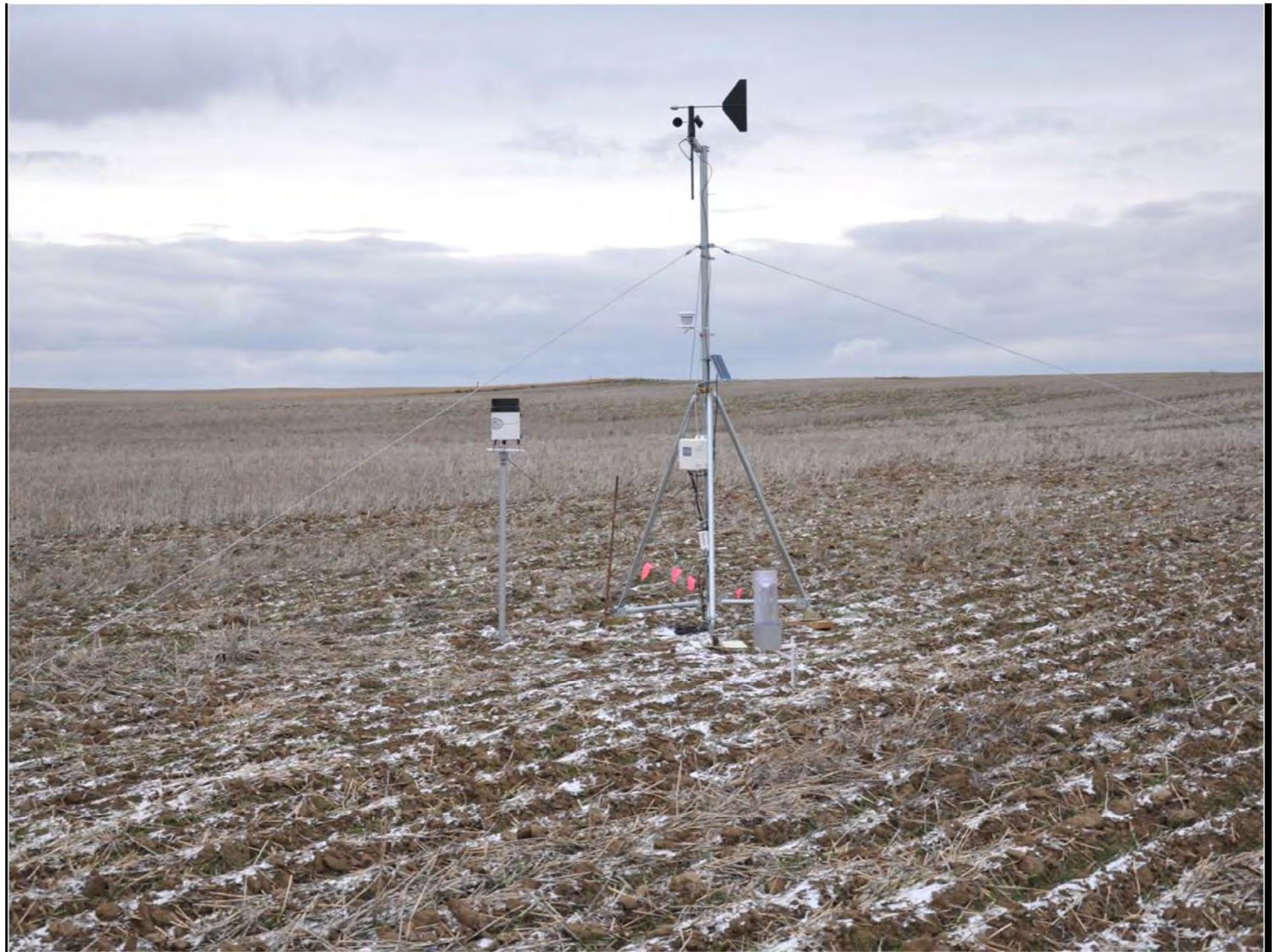
- traps for collecting ammonia, idea & design developed in Australia (Leuning et al., 1985. Atmos. Environ)



# Continuous measurements

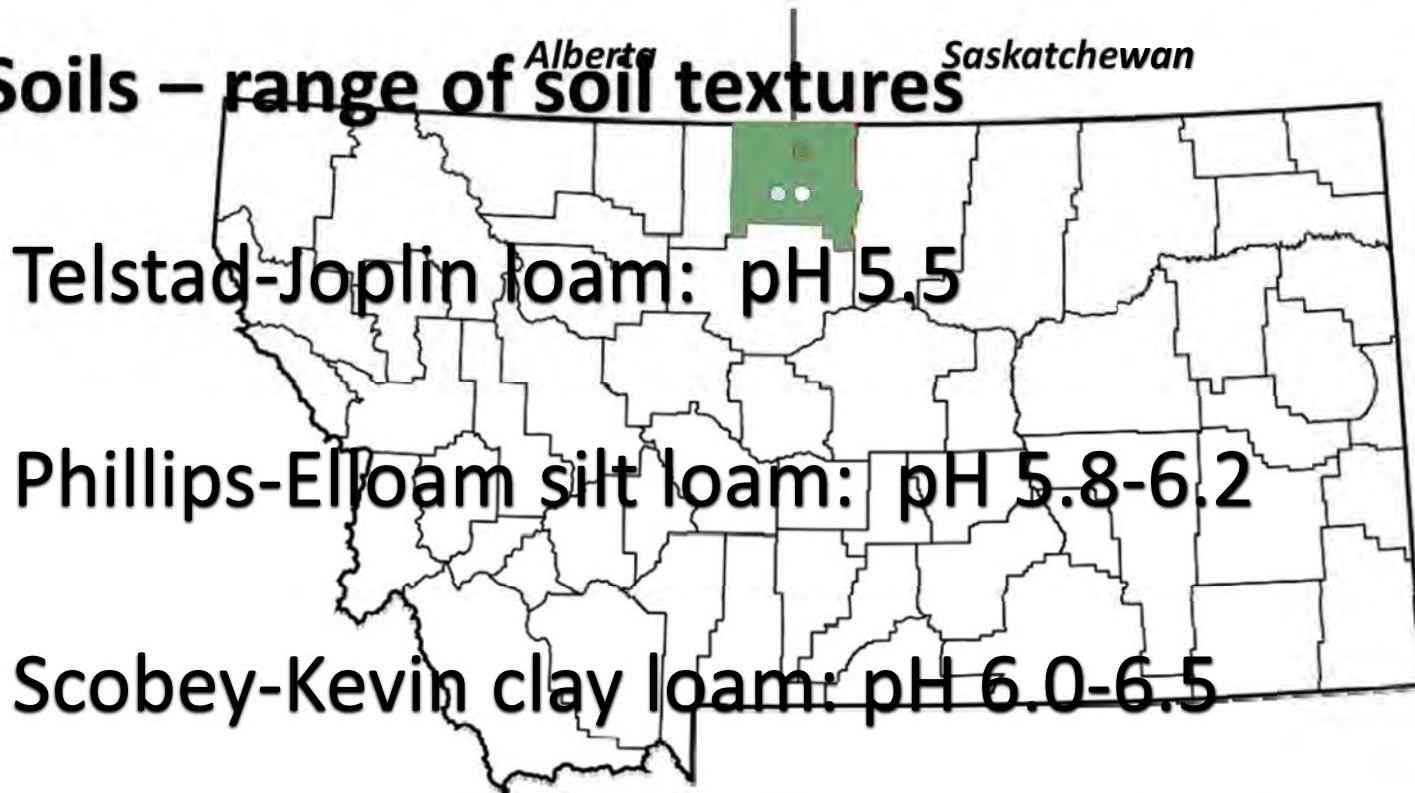
- spent shuttles exchanged with recharged shuttles weekly over 6-10 week campaign following fertilization





# Field sites

- ▶ 3 dryland farms in northern Montana, no till mgmt
- ▶ Soils – range of soil textures



# High NH<sub>3</sub> loss campaigns (>30%)

Campaign	Fertilization date	% urea-N volatilized
3 - north Havre	Nov. 14, 2008	31.5
4 - north Havre	March 25, 2009	35.6
5- west Havre	March 26, 2009	39.9



# High NH<sub>3</sub> losses – Campaign 4 (TJ loam)

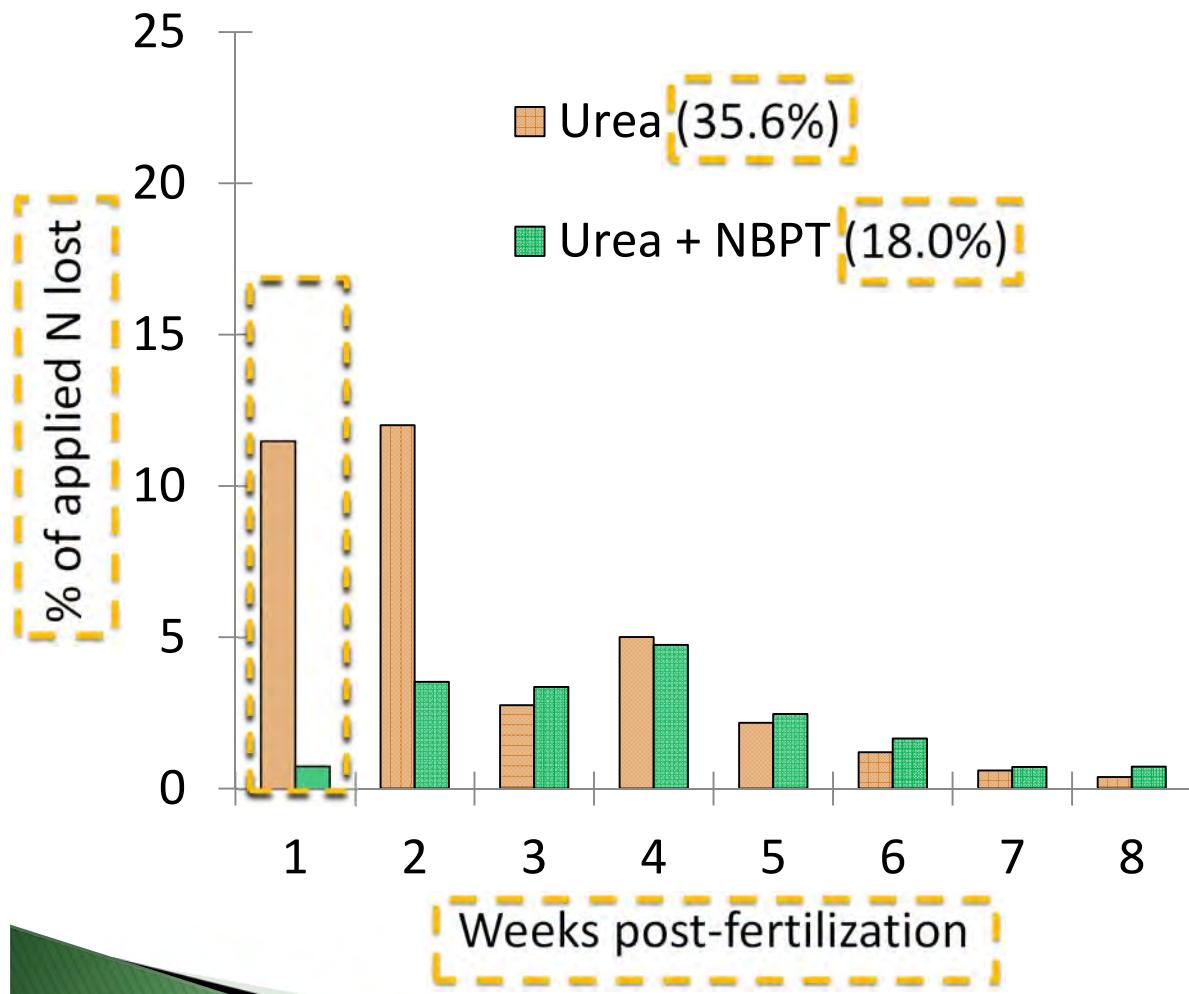


Fertilized applied – March 25, 2009  
“light snow & air-temp. 31°F”



soil surface frozen 18 °F  
 $\Theta_v = 35\%$

# High NH<sub>3</sub> losses – Campaign 4 (TJ loam)



## Precipitation

0.01" = 0-2 wks

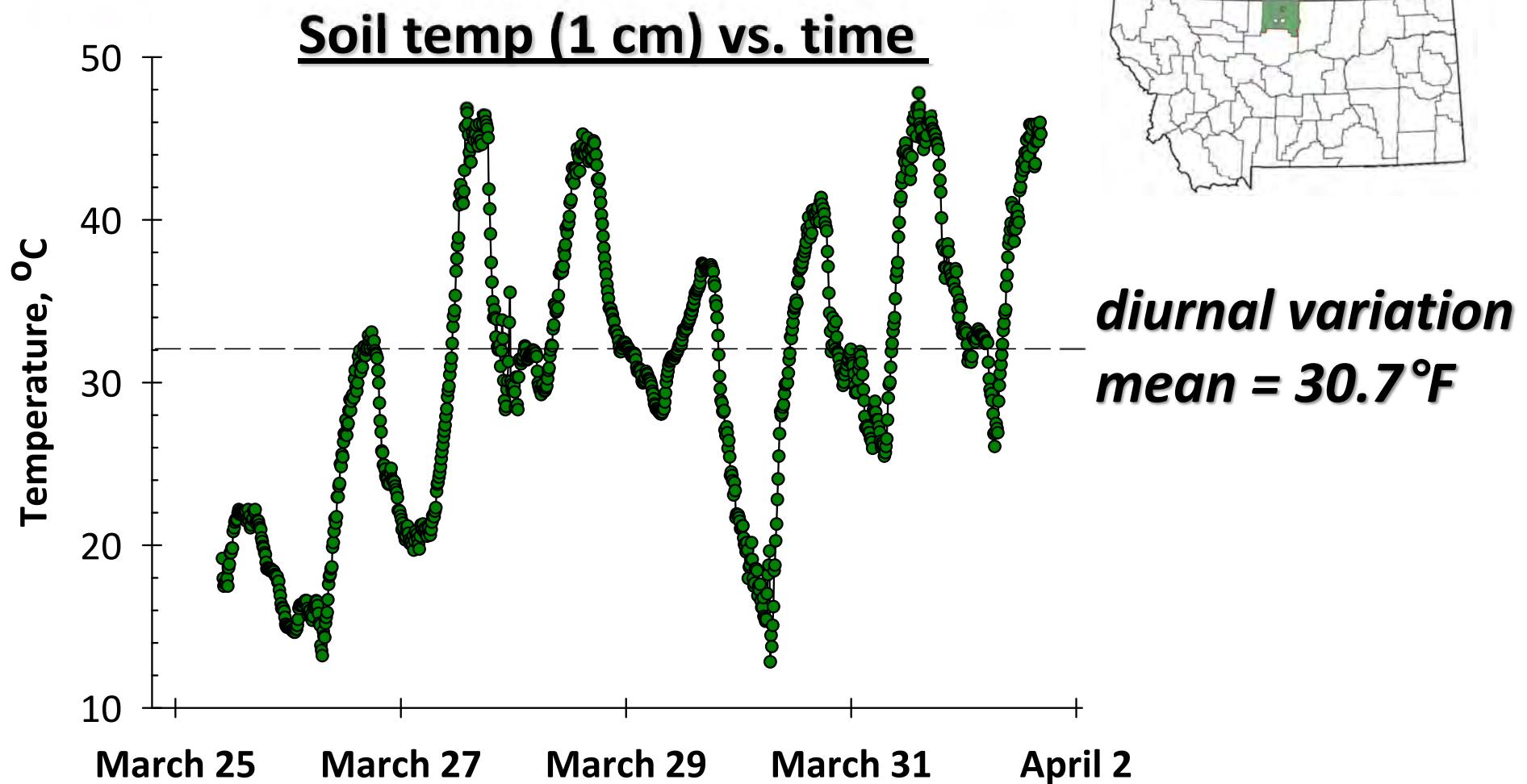
0.89" = 2-8 wks

## Temperature

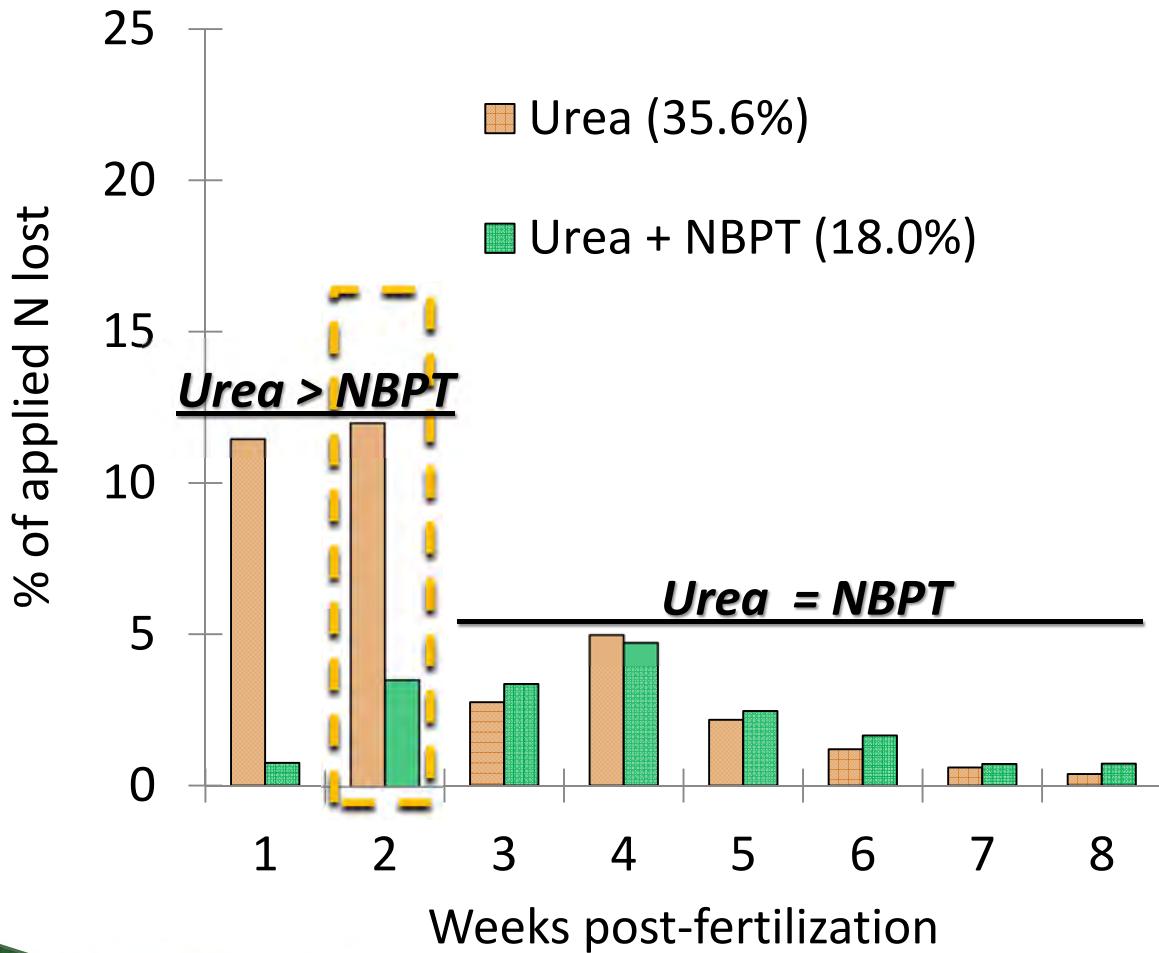
Soil = 30.7 °F

Air = 33.4 °F

# High NH<sub>3</sub> losses – Campaign 4 (TJ loam)



# High $\text{NH}_3$ losses – Campaign 4 (TJ loam)



## Precipitation

0.25" = 0-2 wks

0.89" = 2-8 wks

## Temperature

Soil = 38.0 °F

Air = 41.5 °F

# High NH<sub>3</sub> losses - Campaign 5(PE silt loam)

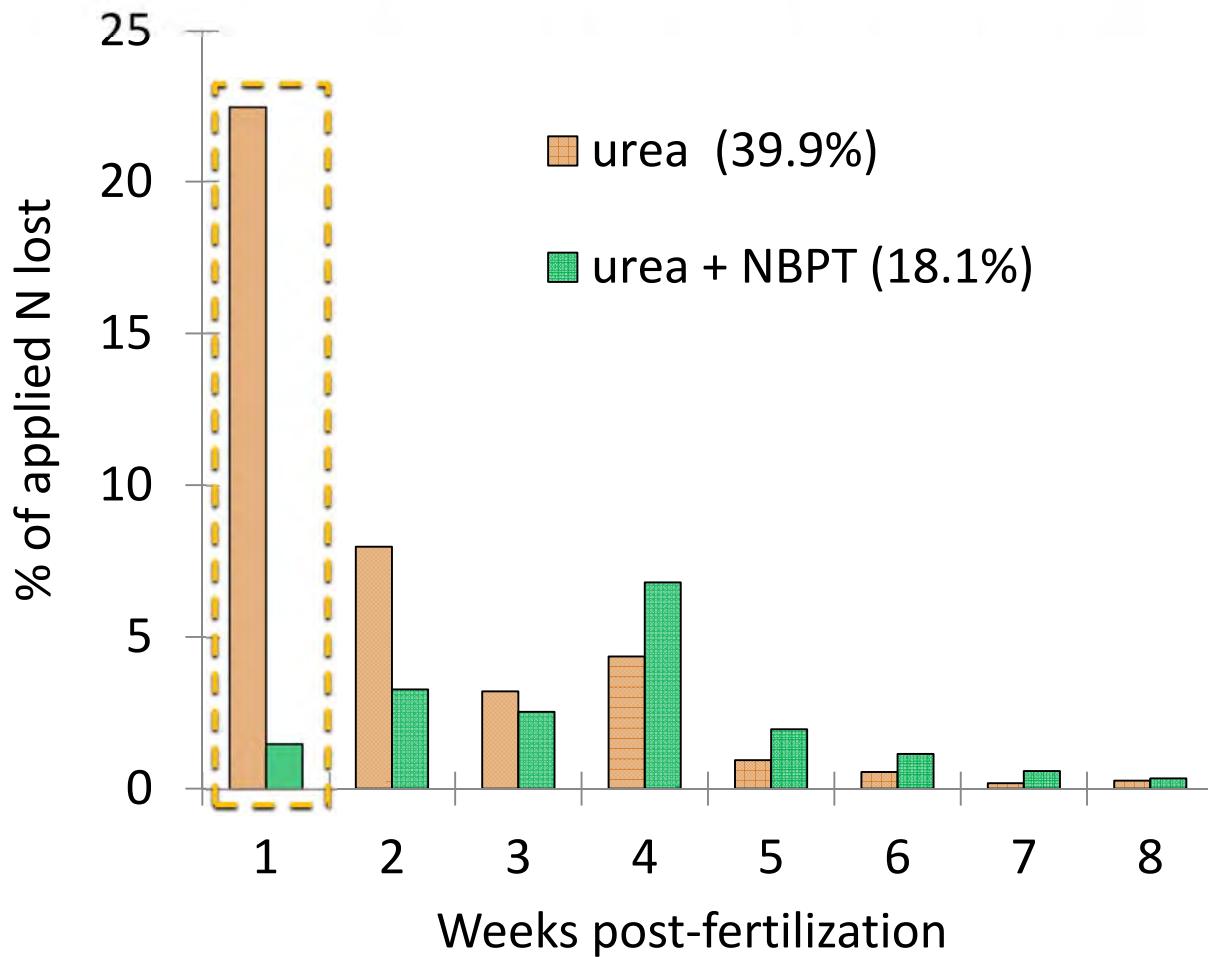


Fertilized applied – March 26  
“light snow on soil surface &  
air-temp. 21 °F”



soil surface with fertilizer  
prills beginning to dissolve  
32 °F

# High NH<sub>3</sub> losses - Campaign 5(PE silt loam)



Precipitation  
no rain 0-2 wks  
1.54" 2-8 wks

Temperature  
Soil = 34.3 °F  
Air = 33.1 °F

# High NH<sub>3</sub> losses – Campaign 3 (TJ loam)



*Surface damp from melting 2" snowfall event  
November 14, 2008*

# **High NH<sub>3</sub> losses -Campaign 3 - Summary**

- ▶ **0-6 days post-fertilization**
  - N loss 12.3%
  - Soil temperature (1 cm) - 33.4 °F \*
- ▶ **6-21 days post-fertilization**
  - N loss 17.0%
  - Soil temperature ( 1 cm) - 28.9 °F
- ▶ **precipitation – scattered events – often as snow**



# High NH<sub>3</sub> losses – Campaign 3 (TJ loam)



*December 4, 2008*

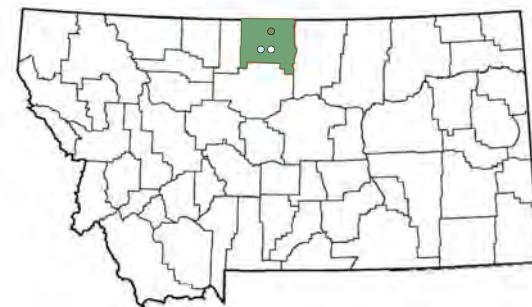
# High NH<sub>3</sub> losses – Campaign 3 (TJ loam)



winter arrived December 7

# High NH<sub>3</sub> loss campaigns (>30%)

Campaign	Fertilization date	% urea-N volatilized
3 - north Havre	Nov. 14, 2008	31.5
4 - north Havre	March 25, 2009	35.6
5- west Havre	March 26, 2009	39.9



# Moderate NH<sub>3</sub> loss campaigns (10-20%)

- ▶ urea applied to dry soil surface

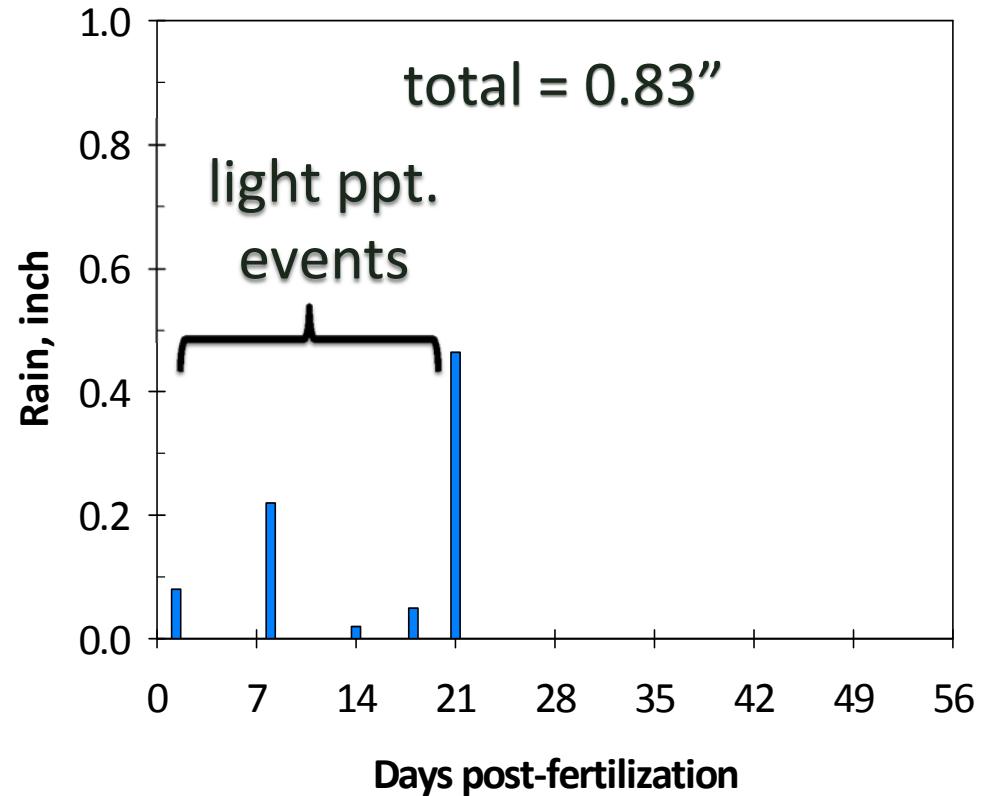
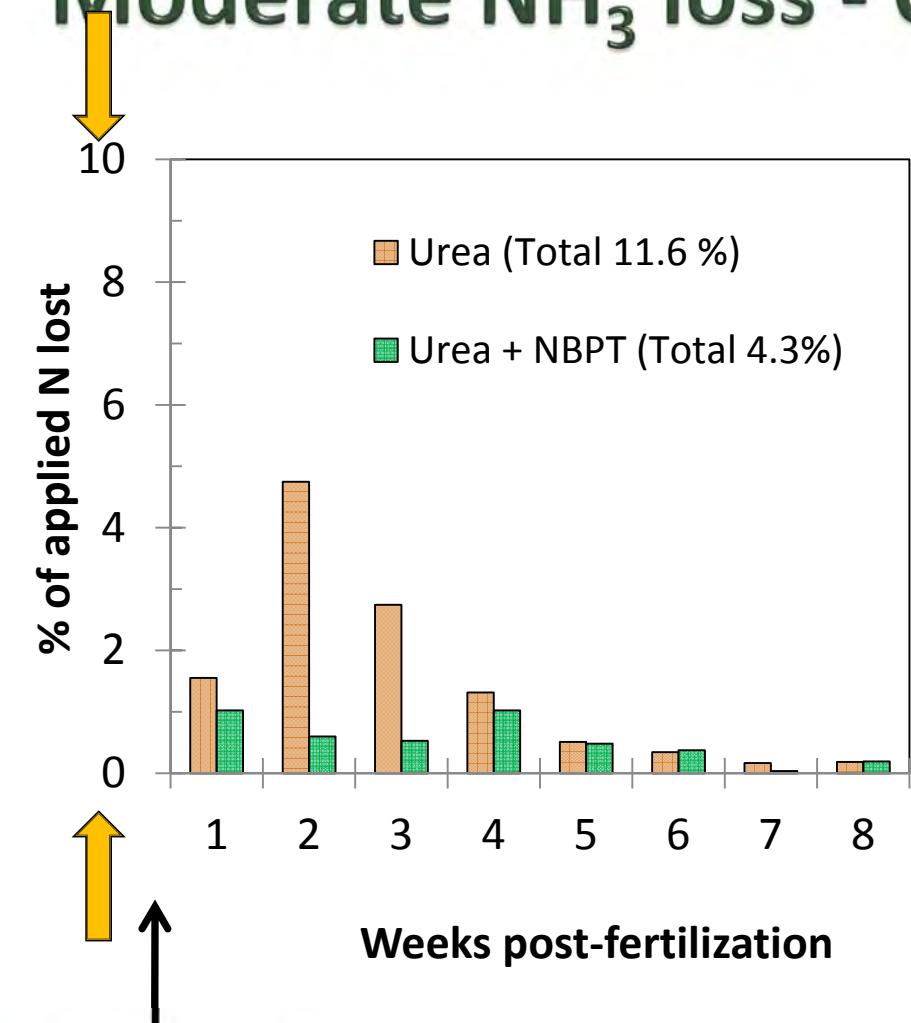


*Campaign 6*  
*Oct. 6, 2009*



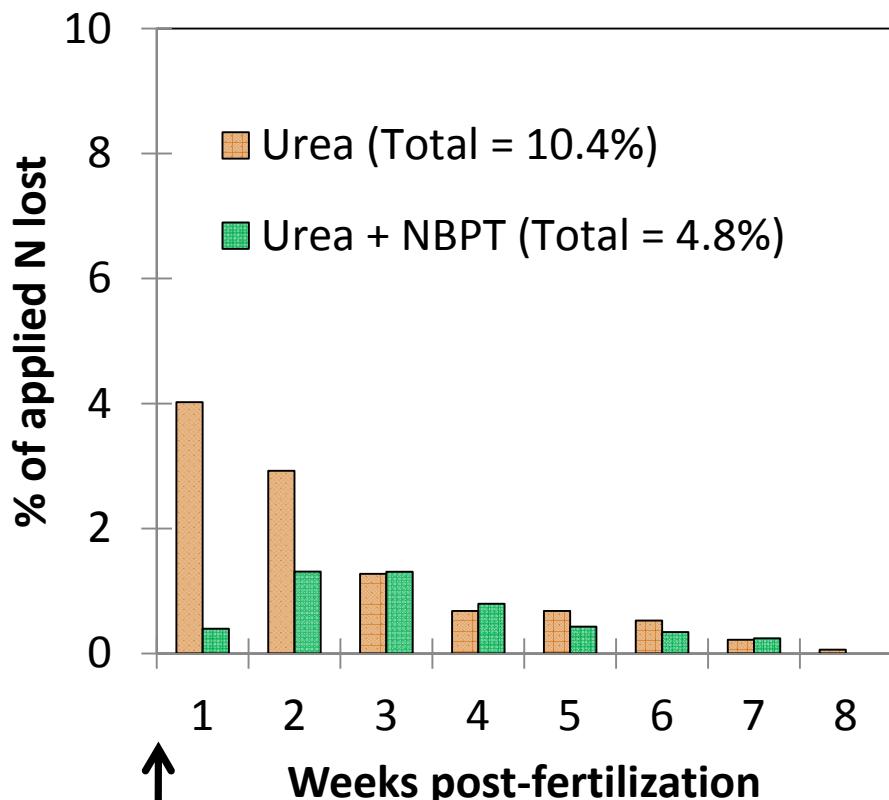
*Campaign 7*  
*Oct. 13, 2009*

# Moderate NH<sub>3</sub> loss - Campaign 6 (clay loam)

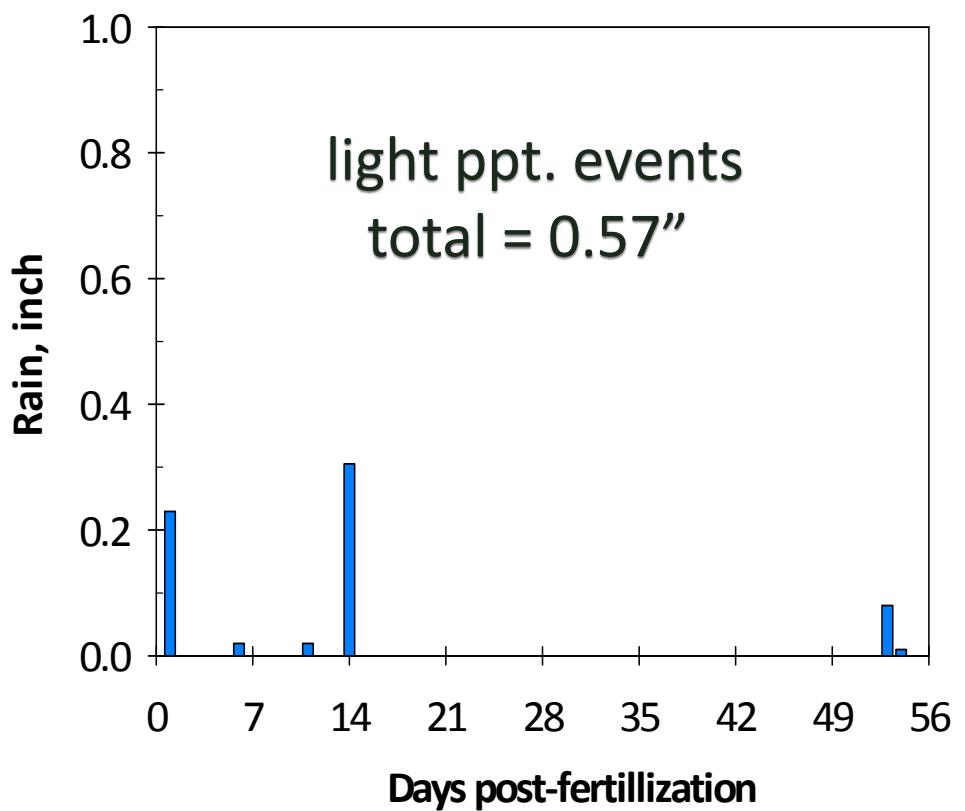


October 6

# Moderate NH<sub>3</sub> loss – Campaign 7 (PE silt loam)



October 13



**Light ppt events ( $\leq 0.4"$ ) are common**



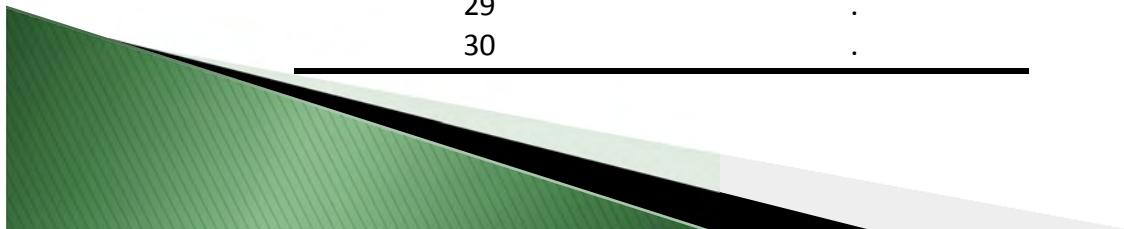
**along the Highline**

# What is meant by a precipitation event ?

Day	November 2010
7	.
8	0.14
9	.
10	.
11	.
12	.
13	.
14	0.02
15	0.01
16	0.29
17	.
18	0.04
19	.
20	0.22
21	0.02
22	0.16
23	0.19
24	0.01
25	0.03
26	.
27	.
28	0.08
29	.
30	.

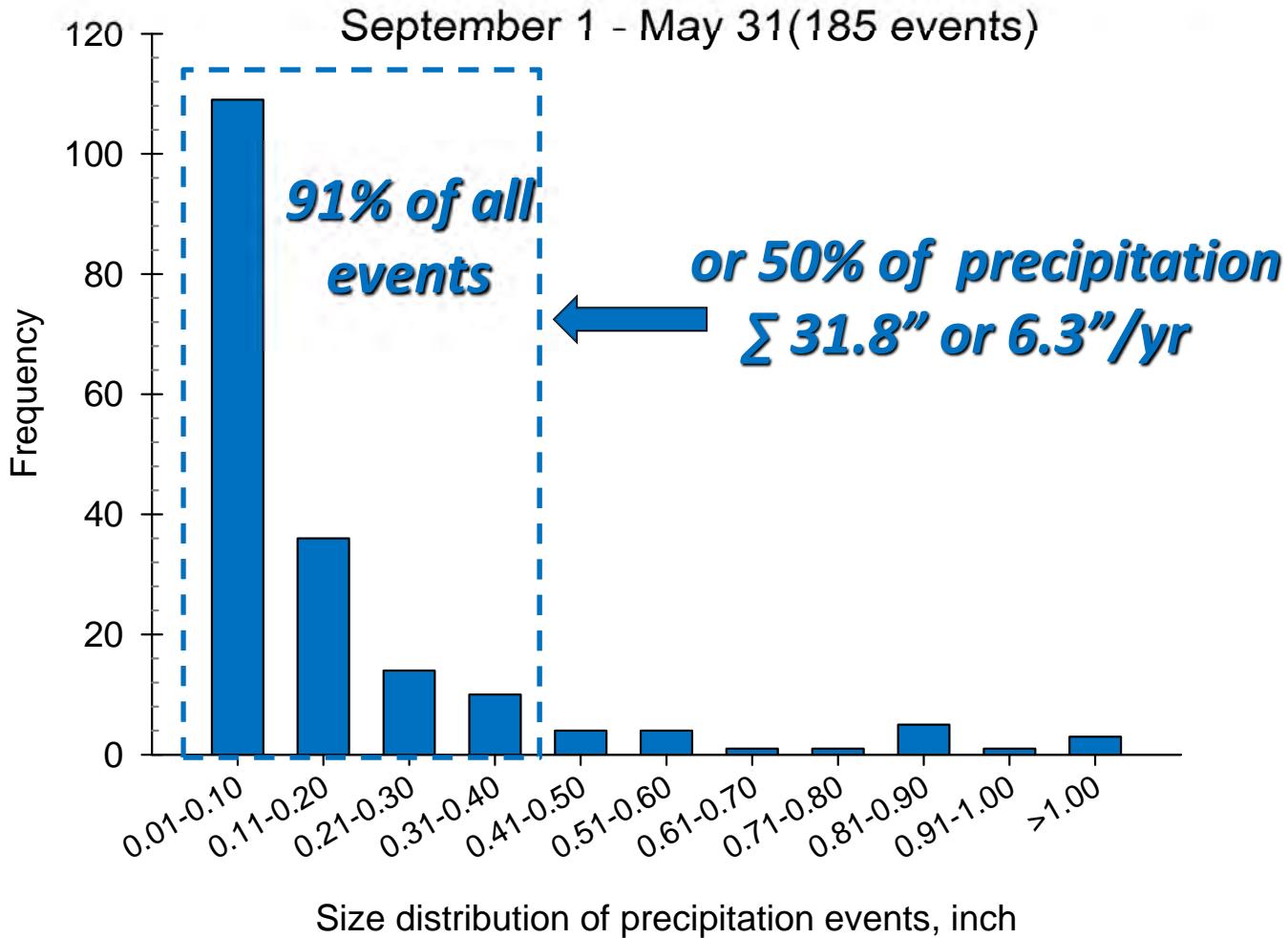
} **0.32"**

} **0.63"**



# Size and frequency of precipitation events

## Havre Airport ( last 5 years)



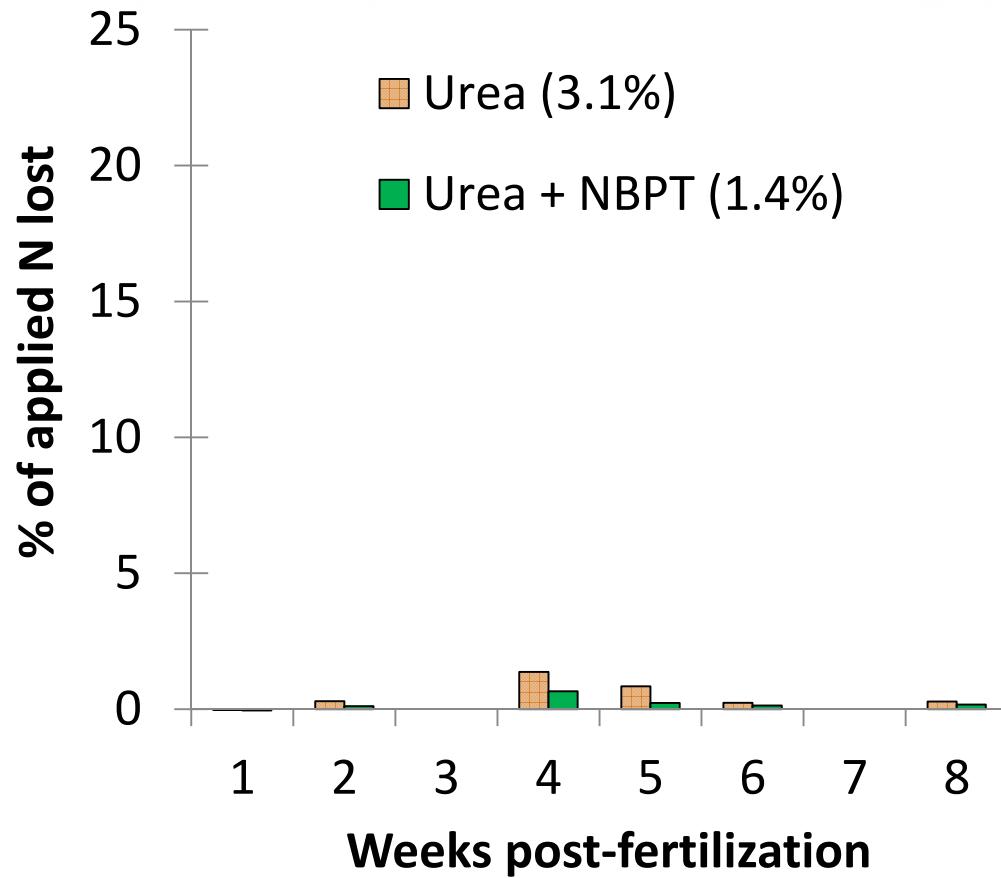
# Campaign 2 – low NH<sub>3</sub> losses (<10%)

- October 9, 2008 application,  
air-temp. 45 °F, dry soil surface
- no rain for 24 days & then  
Nov 2-5 received 1.0" ppt.
- same field site as Campaign 5



*1 wk post-fertilization  
prills not dissolved*

# Campaign 2 – low NH<sub>3</sub> losses



# Campaign 9 - Willow Creek - Brocko silt loam

► calcareous soils, pH 8.3

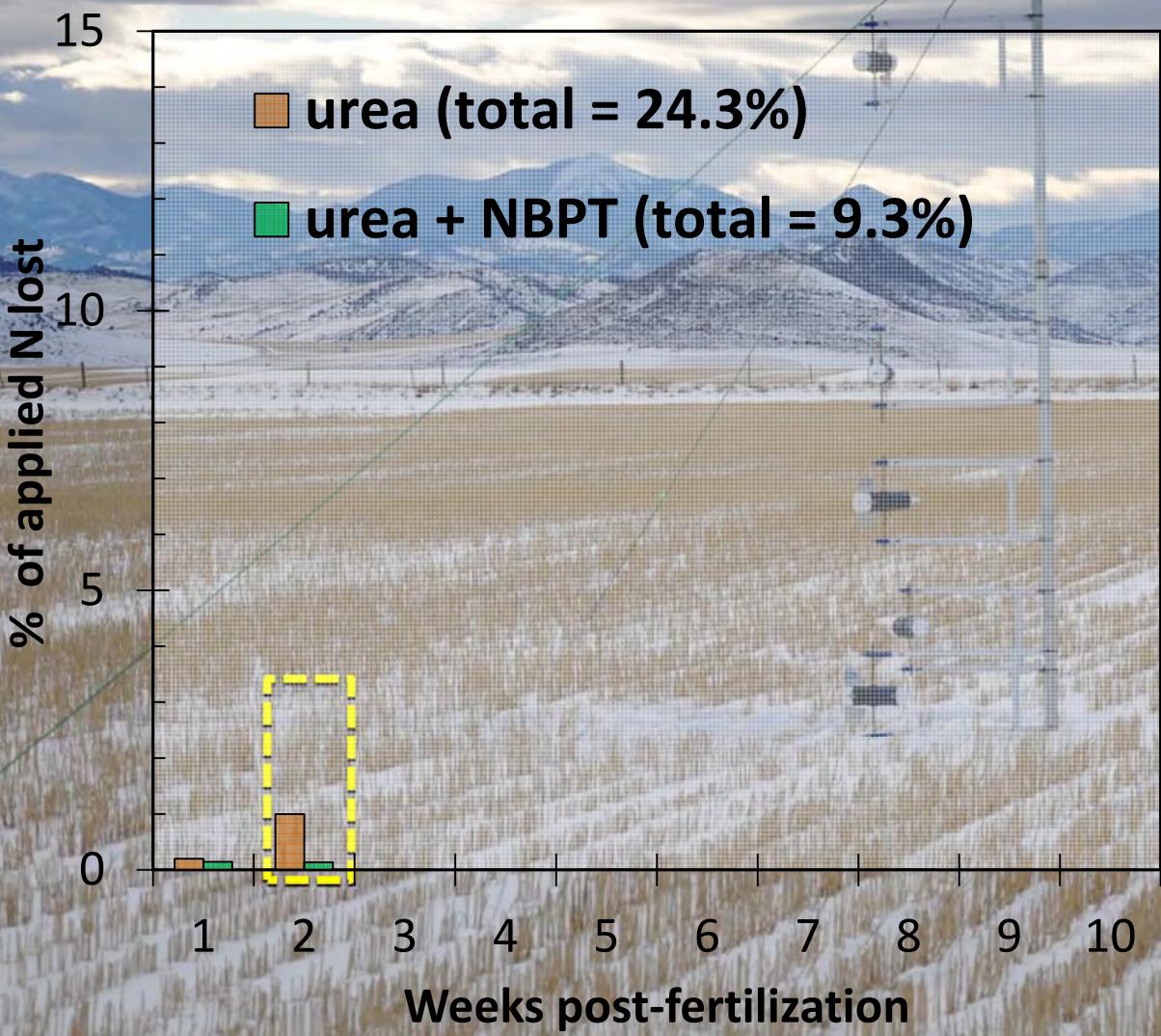


# What about urea on snow ?

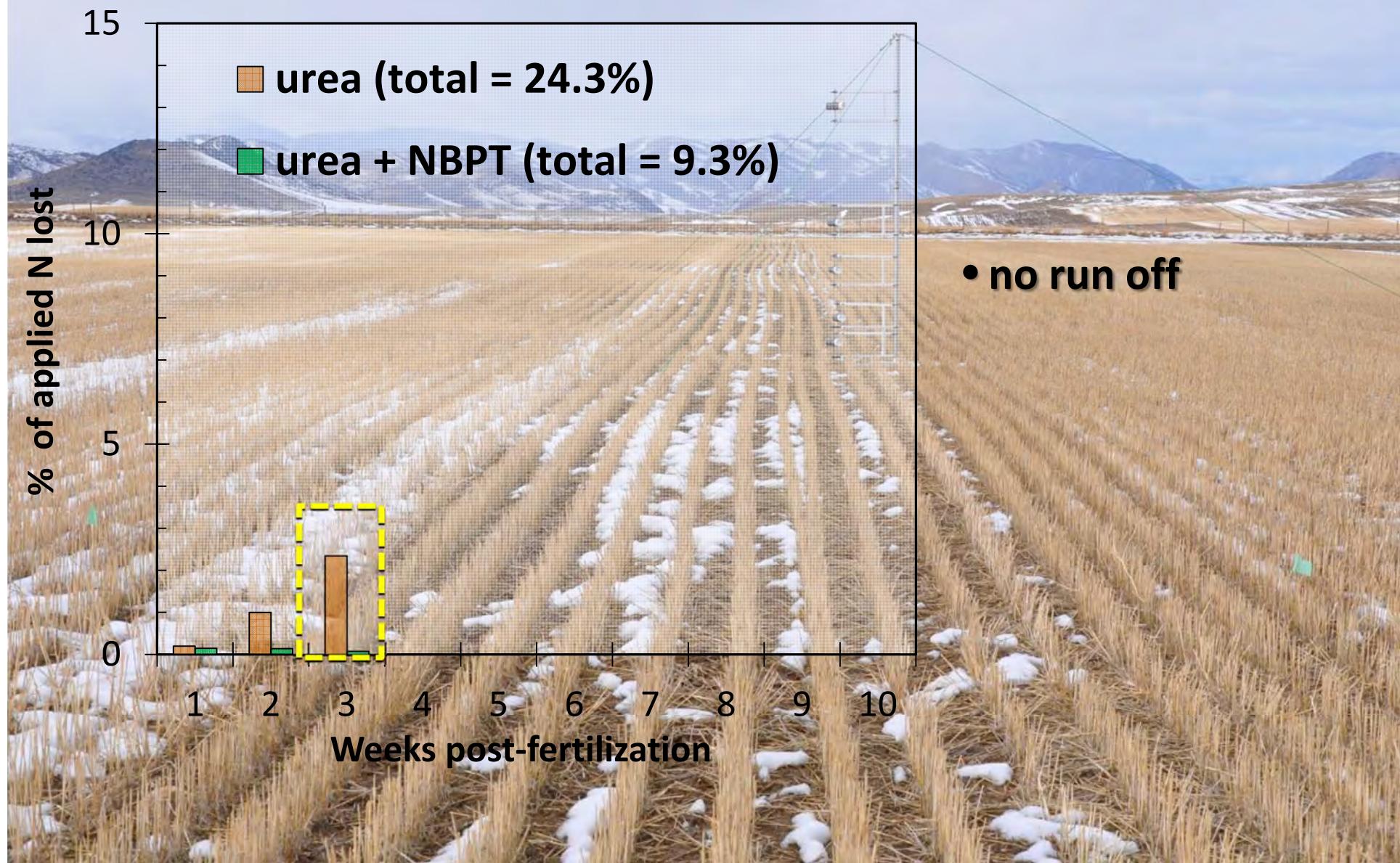
## Campaign 9 – Willow Creek – Jan 27, 2010



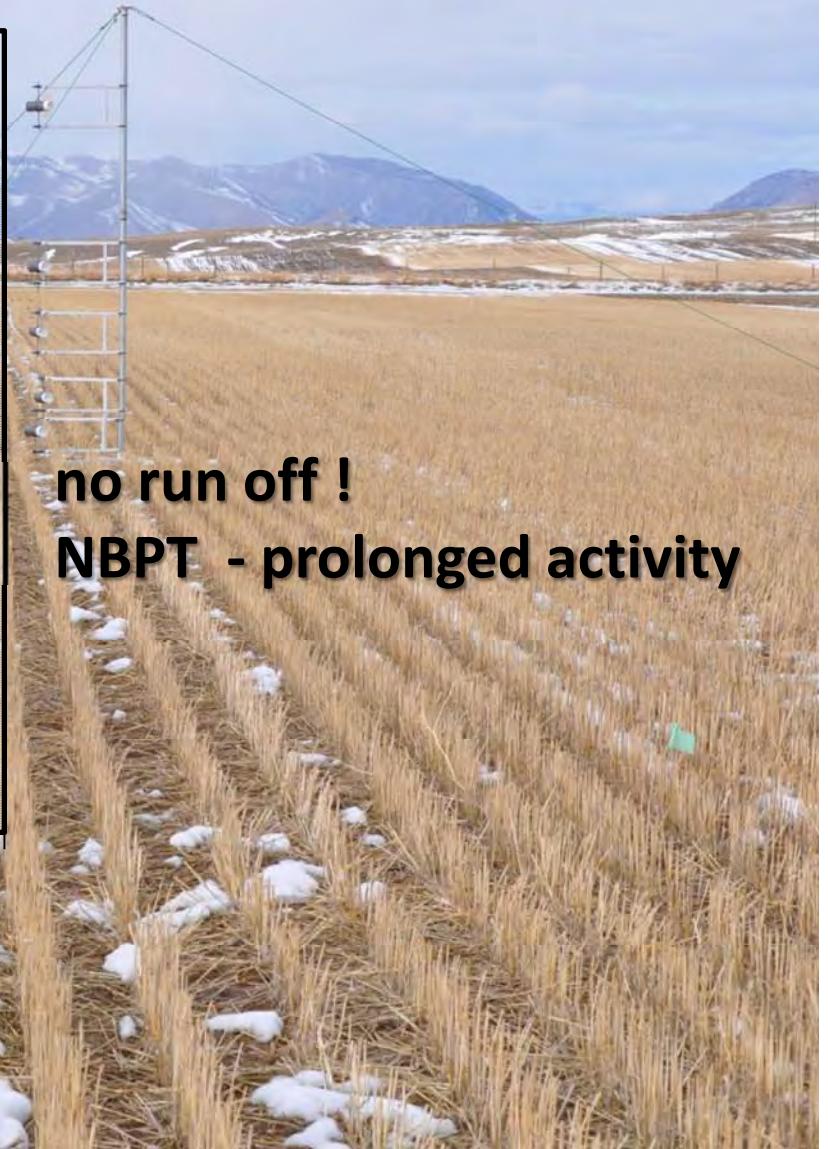
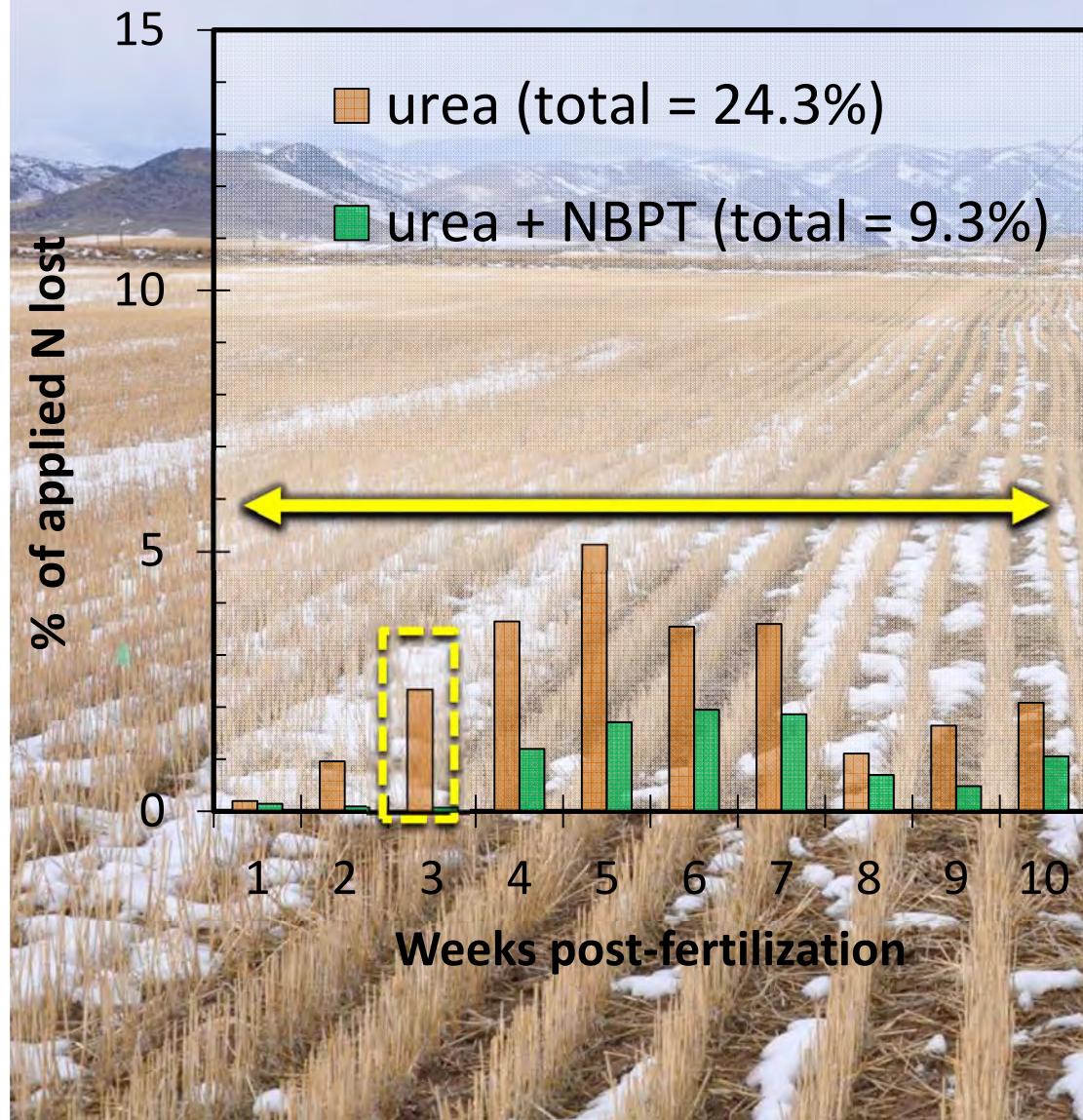
# Campaign 9 – Willow Creek – Feb. 10



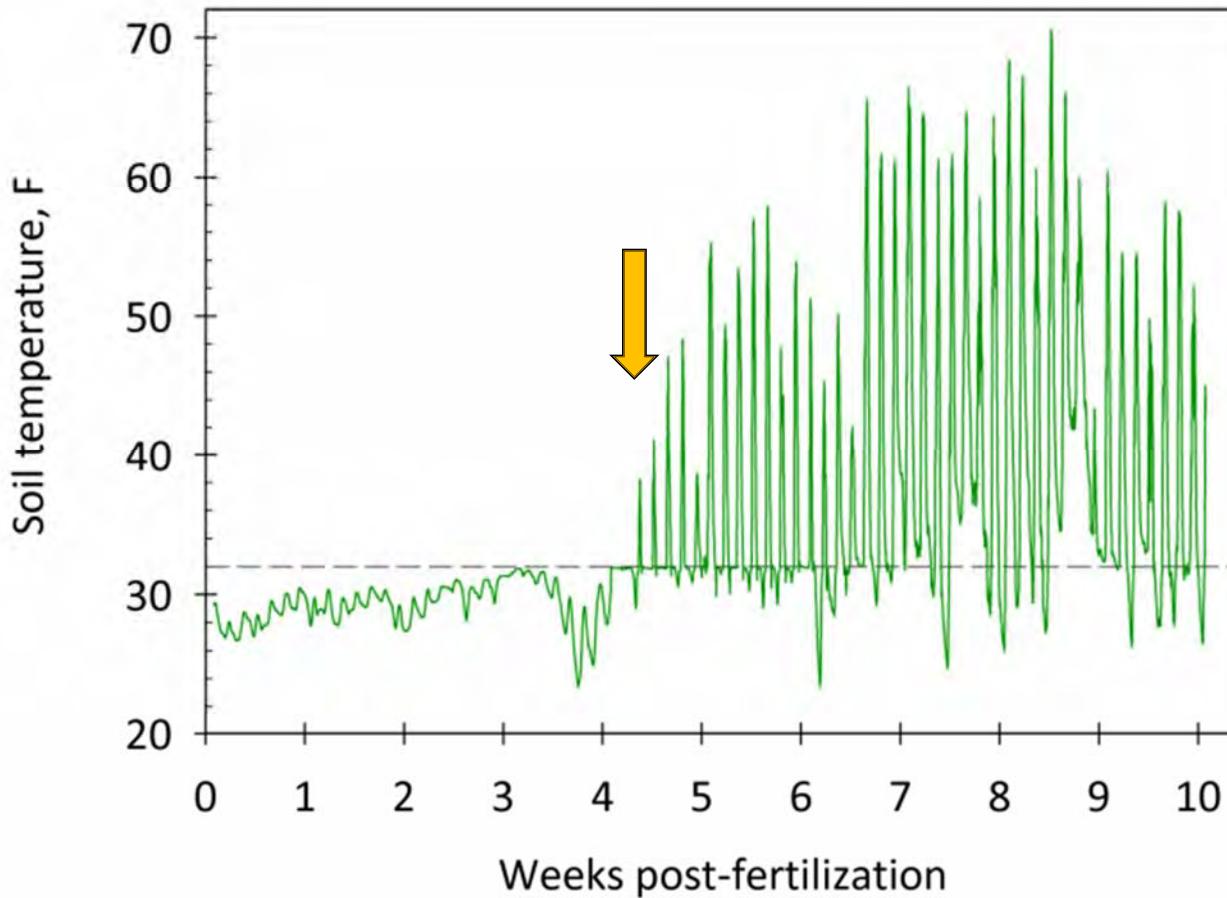
# Campaign 9 – Willow Creek – Feb. 17



# Campaign 9 – Willow Creek – Feb. 17



## Campaign 9 – Soil temperature ( 1 cm)



- ***12.3% applied N lost 0-5 wk***
- ***soil temp. 30.0°F***



# Campaign Summary (% N loss)

Campaign	Fertilization date	Urea	NBPT-urea
1	April 3, 2008	8.4	4.4
2	Oct 8, 2008	3.1	1.4
3	Nov 14, 2008	31.5	4.0
4	March 25, 2009	35.6	18.0
5	March 26, 2009	39.9	18.1
6	Oct 6, 2009	11.6	4.3
7	Oct 13, 2009	10.4	4.8
8	Oct 19, 2009	15.7	3.4
9	Jan 27, 2010	24.3	9.3
10	Feb 26, 2010	44.1	11.9
11	March 29, 2010	6.3	1.7
12	April 20, 2010	14.7	1.4
Average		20.4	6.8

*wide range in N loss amounts*

# What about applying urea in front of seeder?

## Three Campaigns this Fall

Fertilization date	Cooperator	Pre-seeding	Post-seeding
September 15	McIntosh- north Havre	18.7%	13.8%
September 27	McCormick - Kremlin	20.4%	24.4%
October 7	Peterson – north Havre	4.1%	5.2%

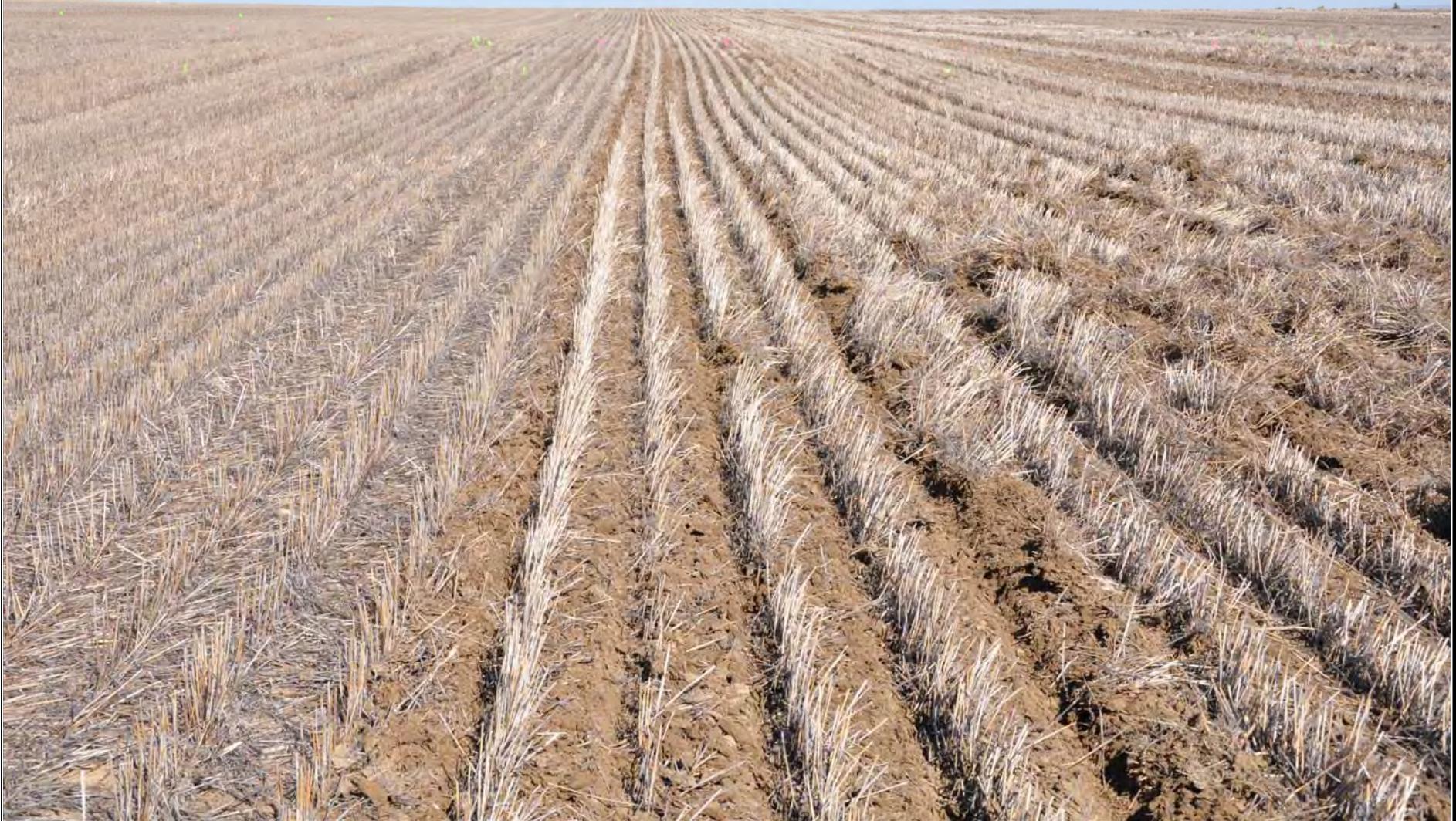


*McIntosh site*





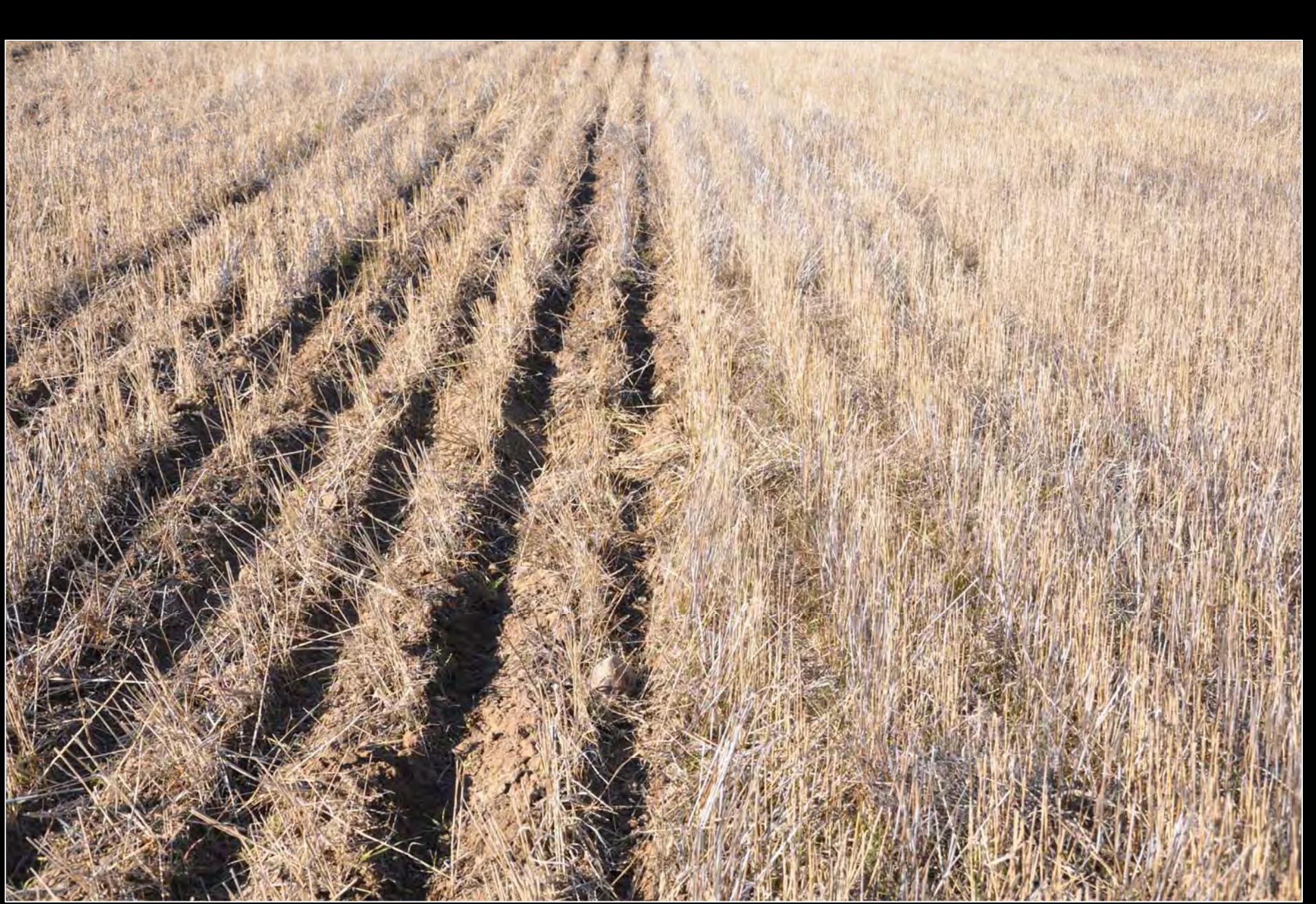
# *McCormick site*



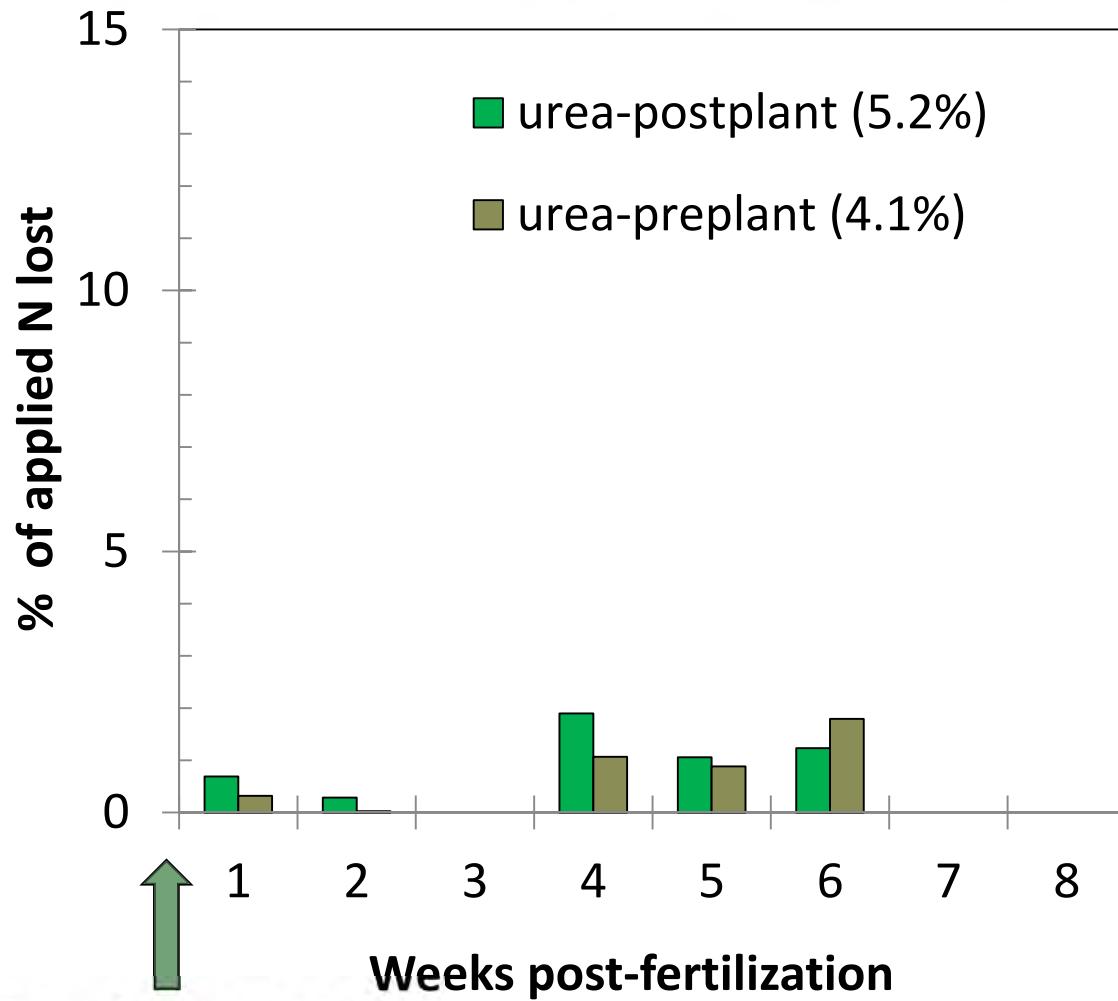


Peterson site





# Campaign 15 (in progress) – low N loss



**0-4 wks**  
*characterized by  
light precipitation  
events*

*October 7, 2010*





# Summary comments

- significant N losses as  $\text{NH}_3$  can happen in Montana when urea is surface-applied
- wet surface soil conditions w/o accompanying ppt → high risk for appreciable  $\text{NH}_3$  loss, even if soil temperatures 28 to 41°F
  - ✓ greater potential for these conditions in Montana during late fall, winter (thaw), early spring
  - ✓ throw urea prills on the ground. Do they dissolve ?
- surface-applying urea to a dry soil surface is best, then hope for rain and wet snow that infiltrates into soil; some loss of N (10-20%) appears likely based on results to date

# Summary Comments

- mid-winter urea on snow – 1 campaign on soil pH 8.3 (24.3% N loss) - may be problematic from NH<sub>3</sub> loss standpoint but we need to investigate further ??
- NPBT or Agrotain may have a role under the high loss potential conditions - longevity may be greater in calcareous soils
- surface-applying urea in front of air-seeder so far has not shown to be effective in suppressing volatility



# **Future Plans – evaluation form**

- ▶ **Winter applications**
- ▶ **Preplant N**
- ▶ **Goose Shooter – Kurt Kamberzell (Chester, MT)**
- ▶ **How are wheat yields and protein affected by N loss?**



# **Support**

- ▶ **WSARE**
- ▶ **MT Fertilizer Advisory Committee**
- ▶ **MT Wheat and Barley Committee**
- ▶ **NRCS-CIG program**
- ▶ **International Plant Nutrition Institute**
- ▶ **Agrotain International**



# Urea volatilization web site

<http://landresources.montana.edu/ureavolatilization>

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> College of Agriculture > Land Resources & Environ. Sci. > Urea Volatilization

## Ammonia volatilization and urea fertilizer

**A micrometeorological study to quantify volatilization losses of ammonia from surface urea applications to no-till wheat**

In Montana, farmers often fertilize wheat by applying urea to the soil surface during the fall, winter, or early spring. The question of how much nitrogen is lost from this application strategy seems to be raised by growers and fertilizer dealers every season. Surface urea applications are known to be susceptible to nitrogen losses as a result of ammonia volatilization (lost to the air). However, the importance of this process in cold soils is not known and is the focus of an investigation I am currently leading. To answer this question, I am using a micrometeorological system referred to as the integrated horizontal flux (pictured in photograph below) method to quantify ammonia losses from the soil. Micrometeorological are widely recognized as providing the most accurate measures of gas losses from soils. This method is not disruptive of the soil environment and provides for continuous collection of ammonia gas over time. This is a first of its kind study in Montana. Field studies are presently being conducted at two farms in northern Montana, with a third farm site to be added in the fall 2009. I have constructed this web site to keep people up-to-date on the progress of this study.



**Contact Us**

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