COVER CROP AND UREA VOLATILIZATION RESEARCH RESULTS

NEW TRENDS WINTER SEMINAR, SHELBY

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MONTANA STATE UNIVERSITY

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I have some good news and bad news on MSU cover crop research

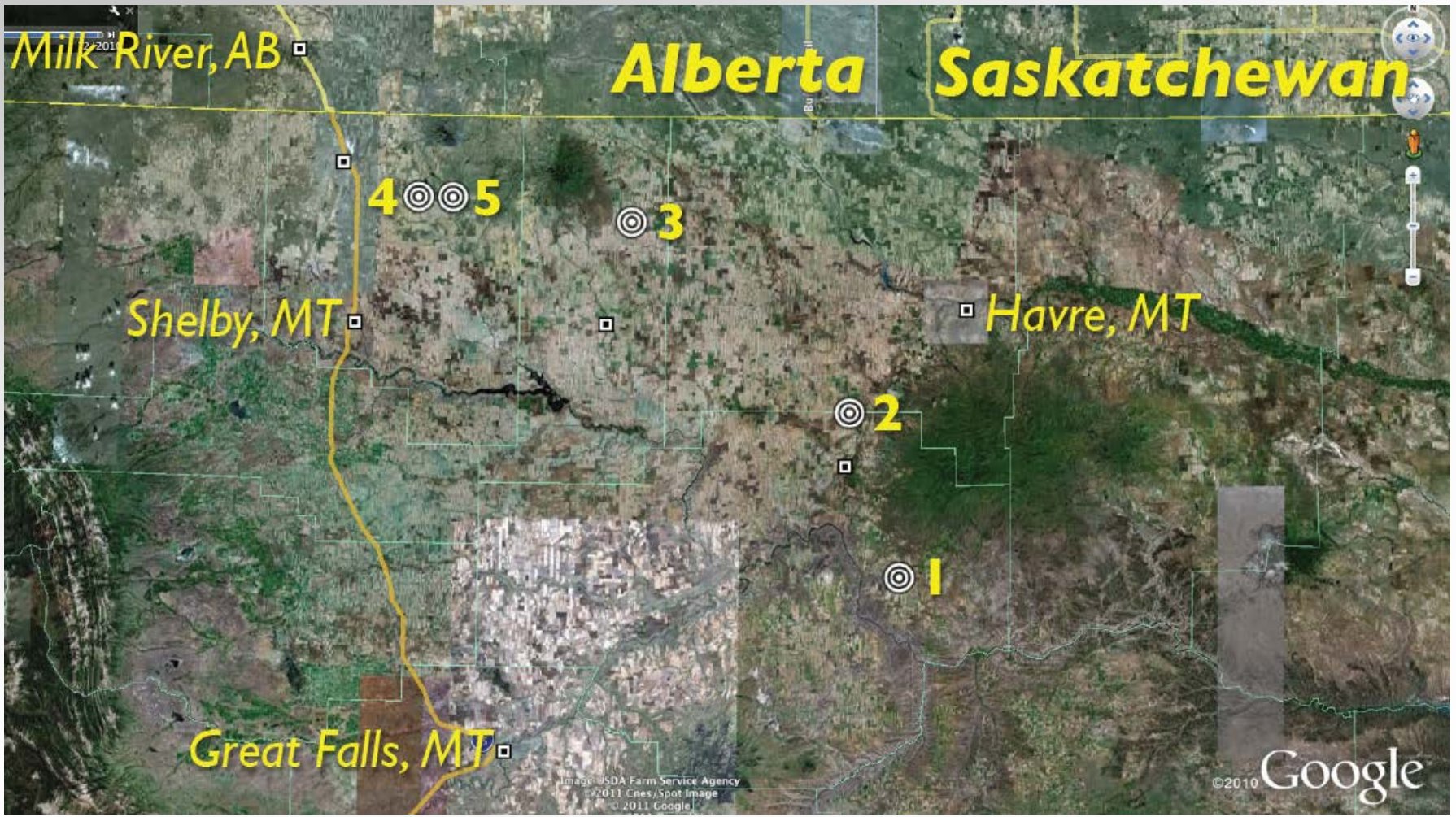
- Good news: This year, MSU received a 3 year grant from USDA to study the effects of mixed cover crops on soil quality and grain yield
- Bad news: The first field season will be 2012
- Good news: Perry Miller and others have been studying single species cover crops (green manures) for over a decade
- I'll show research results from single species cover crops first and finish with preliminary results from cover crop cocktails

What we think we know about cover crops in Montana

- Replacing fallow with cover crops should reduce nitrate leaching, saline seeps, organic matter loss, and soil erosion.
- Legumes as forage or green manure crops are promising fallow replacements because of their N fixing capability.
- Water and nitrogen use by cover crop may reduce yield of following crop in some years

Field Study: Legume green manure (LGM) vs fallow

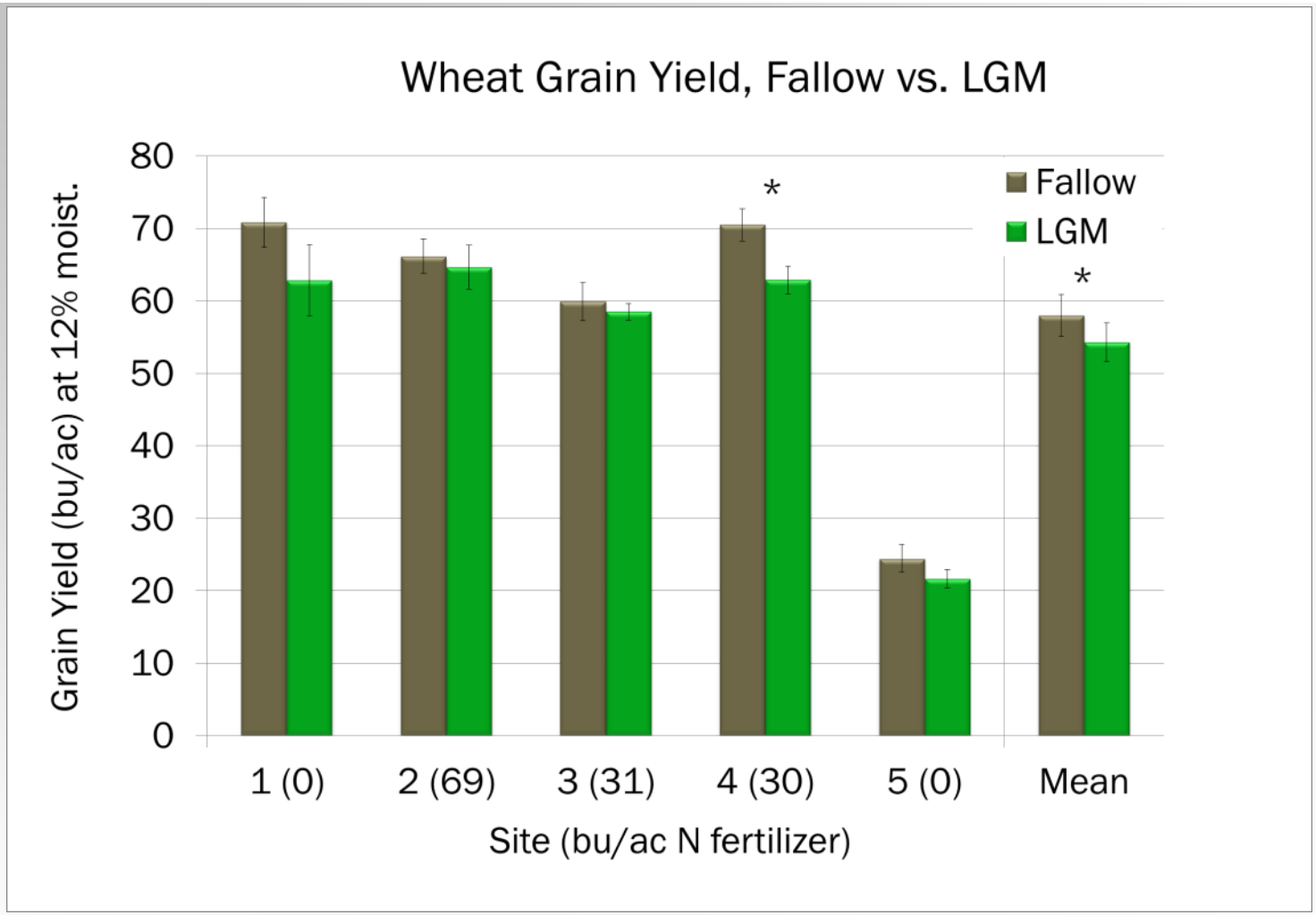
5 no-till producer-collaborators



Experimental Design

- *LGM (legume green manure - mainly pea) vs. summer fallow*
- LGM grown in 2009 and sprayed out at first flower
- 6-12 paired samples/site
- 500-1200 yard transect lengths
- Wheat grown in 2010

How did LGM affect the following wheat grain yield?



Wheat grain yield was about 4 bu/ac higher after fallow than after LGM

Questions…

- Was water use by LGM responsible?

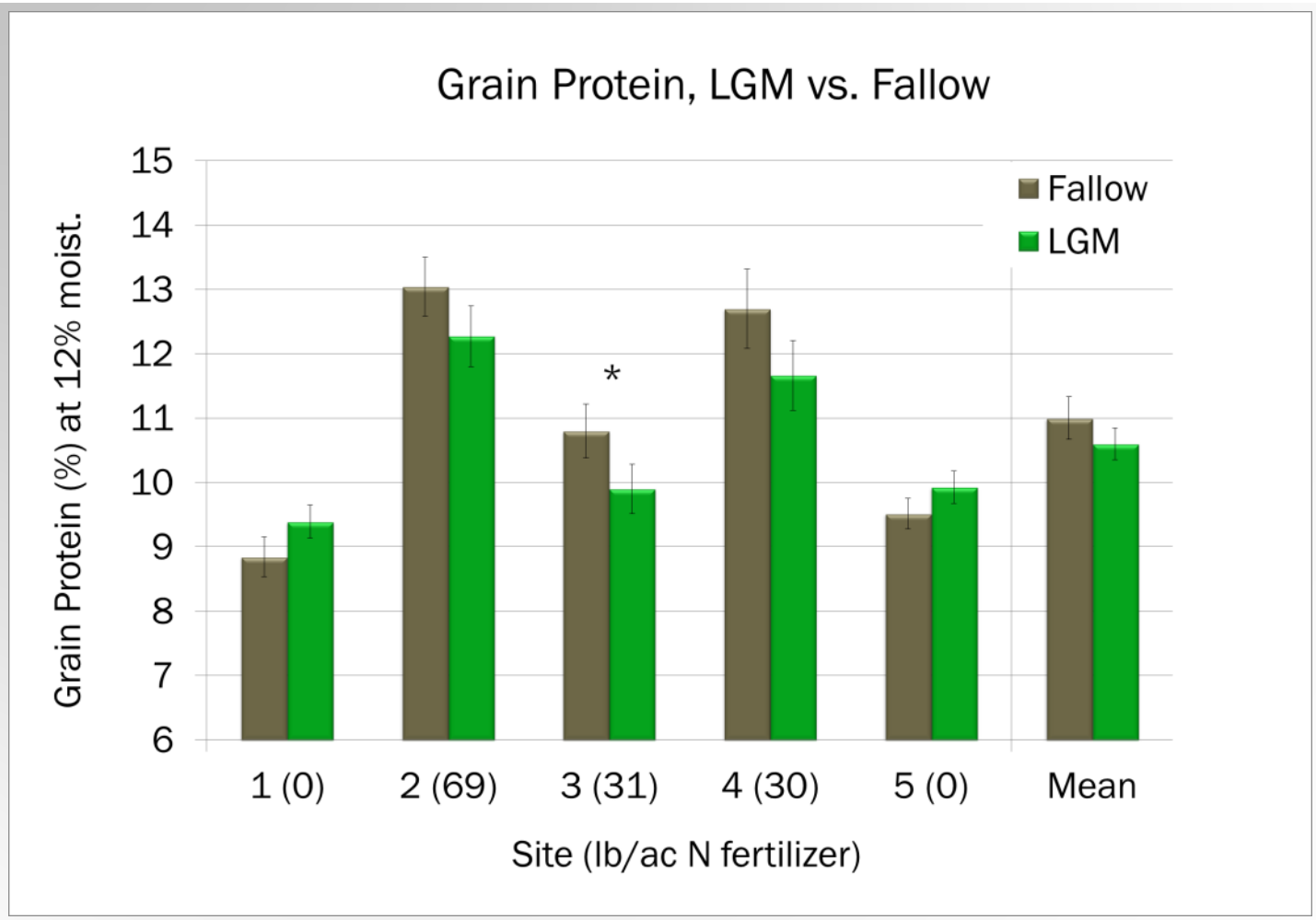
  Likely not – 2010 had near record high precipitation

- Was lower nitrogen availability after LGM responsible?

  Likely – LGM soil had ~18 lb N/ac less nitrate than after fallow at wheat seeding

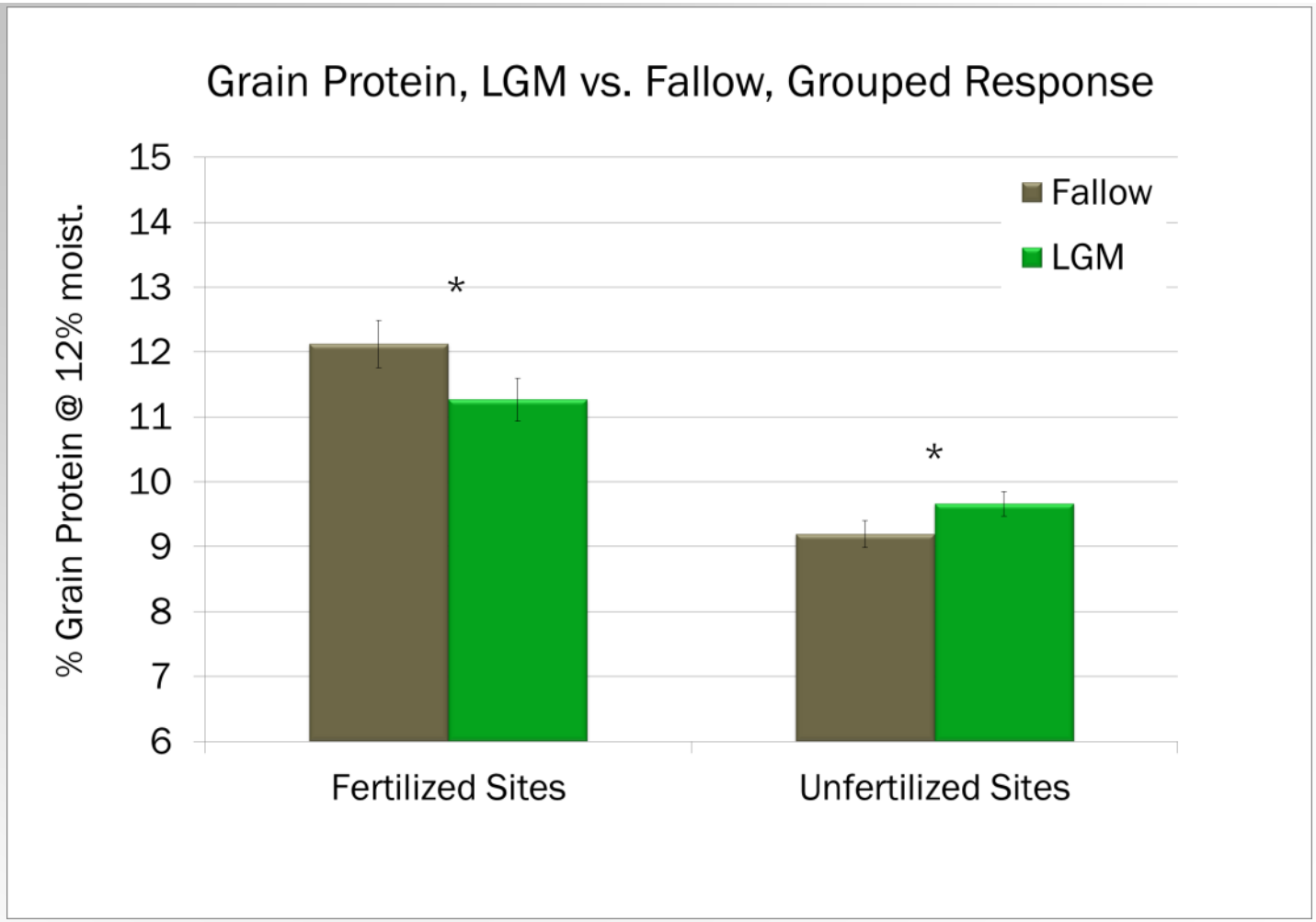
- How possible?
  - Legumes will use some nitrate even if fixing N.
  - Lower soil water after LGM than fallow (2009 was dry) - lowers release of N from soil organic matter and residue.

How did LGM affect the following wheat grain protein?



Grain protein was not different between LGM and fallow when averaged across sites

How did LGM affect grain protein at fertilized vs unfertilized sites?

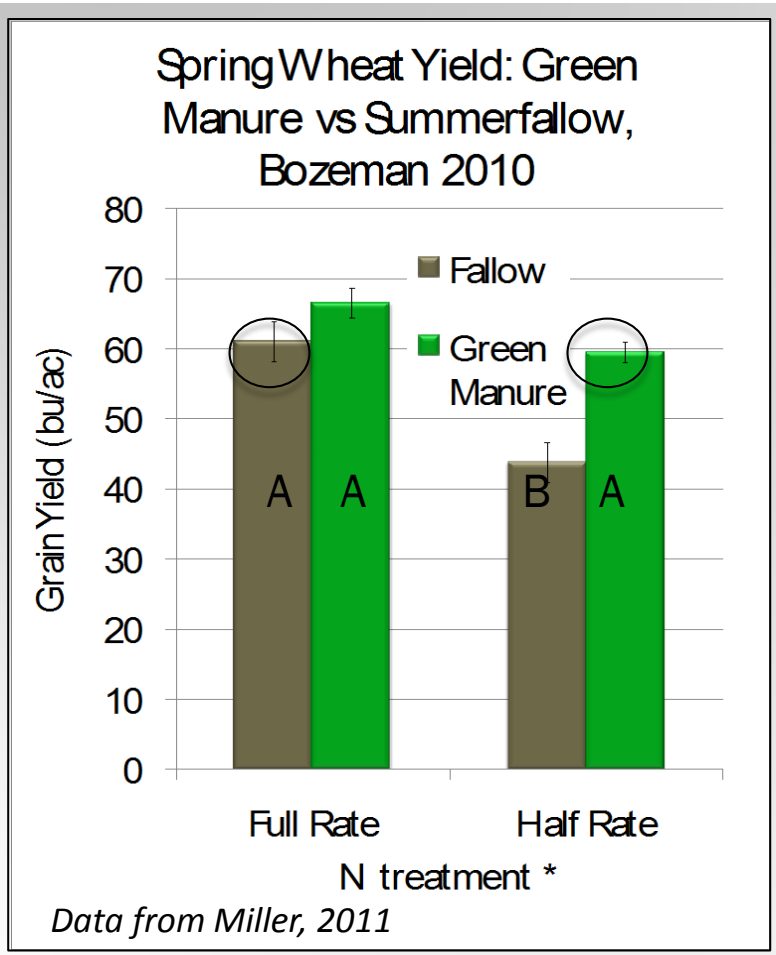


LGM decreased grain protein at fertilized sites and increased protein at unfertilized sites

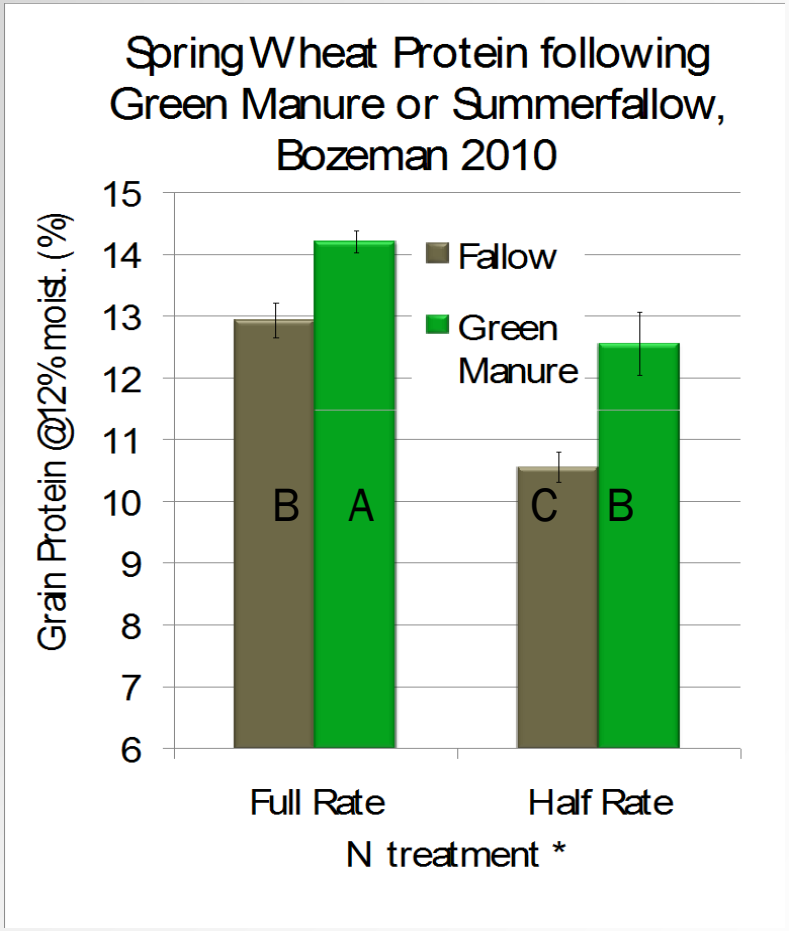
Questions…

- Do legume green manures increase yield and protein in LONG TERM?
- Is soil quality enhanced by legume green manures?
  - Compared to fertilized wheat
- Effects of legume N vs. fertilizer N?

8 year study near Bozeman: LGM-wheat vs. Fallow-wheat systems



Data from Miller, 2011



* N fertilizer rates	*Fallow-Wheat*	*LGM-Wheat*
Full N rate (lbs/ac)	124.00	83.00
Half N rate (lbs/ac)	39.00	0.00

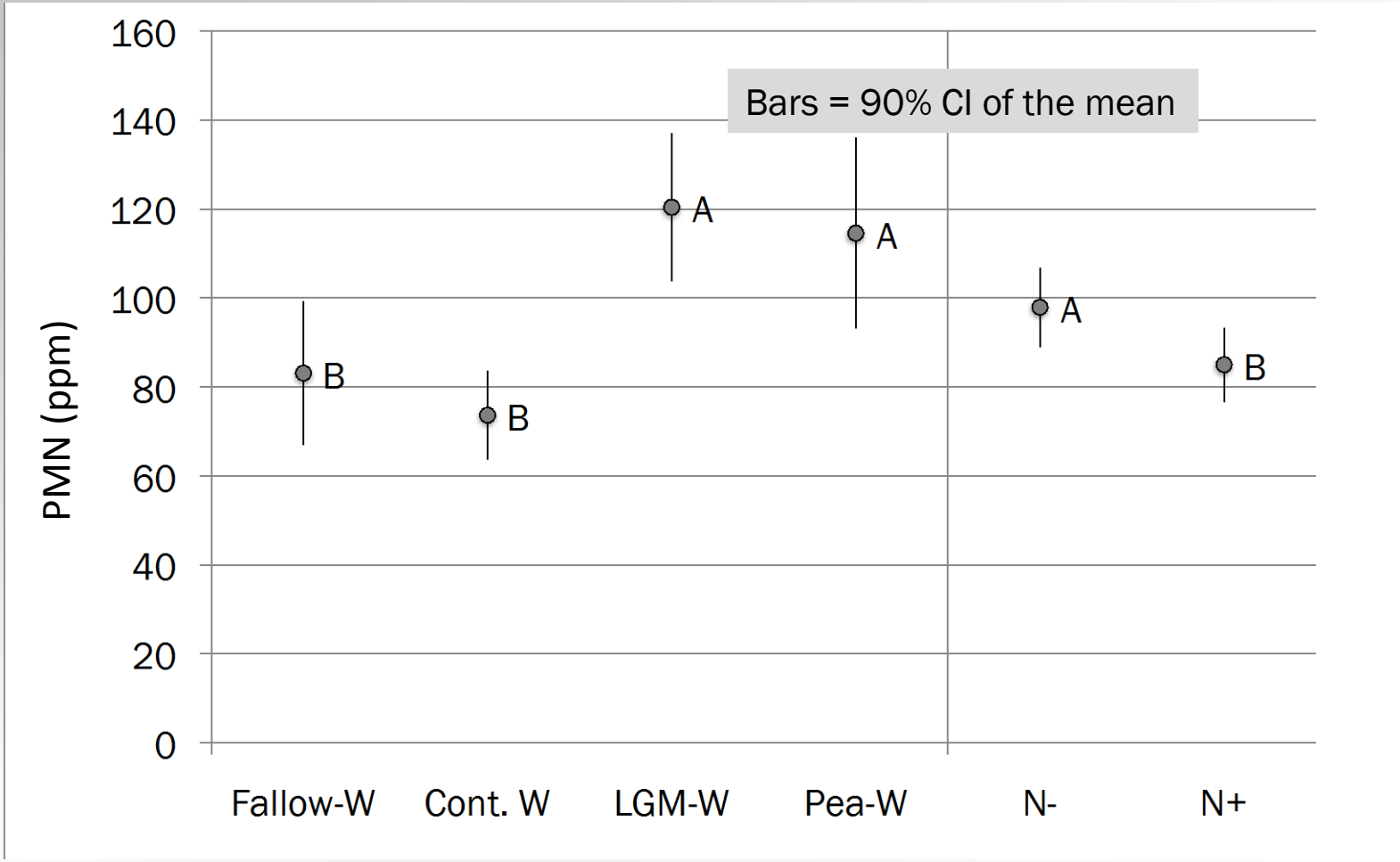
Pea green manure after 4 LGM-wheat rotations saved 124 lb N/ac COMPARED TO FALLOW!

Did LGMs affect soil quality in this long term study?

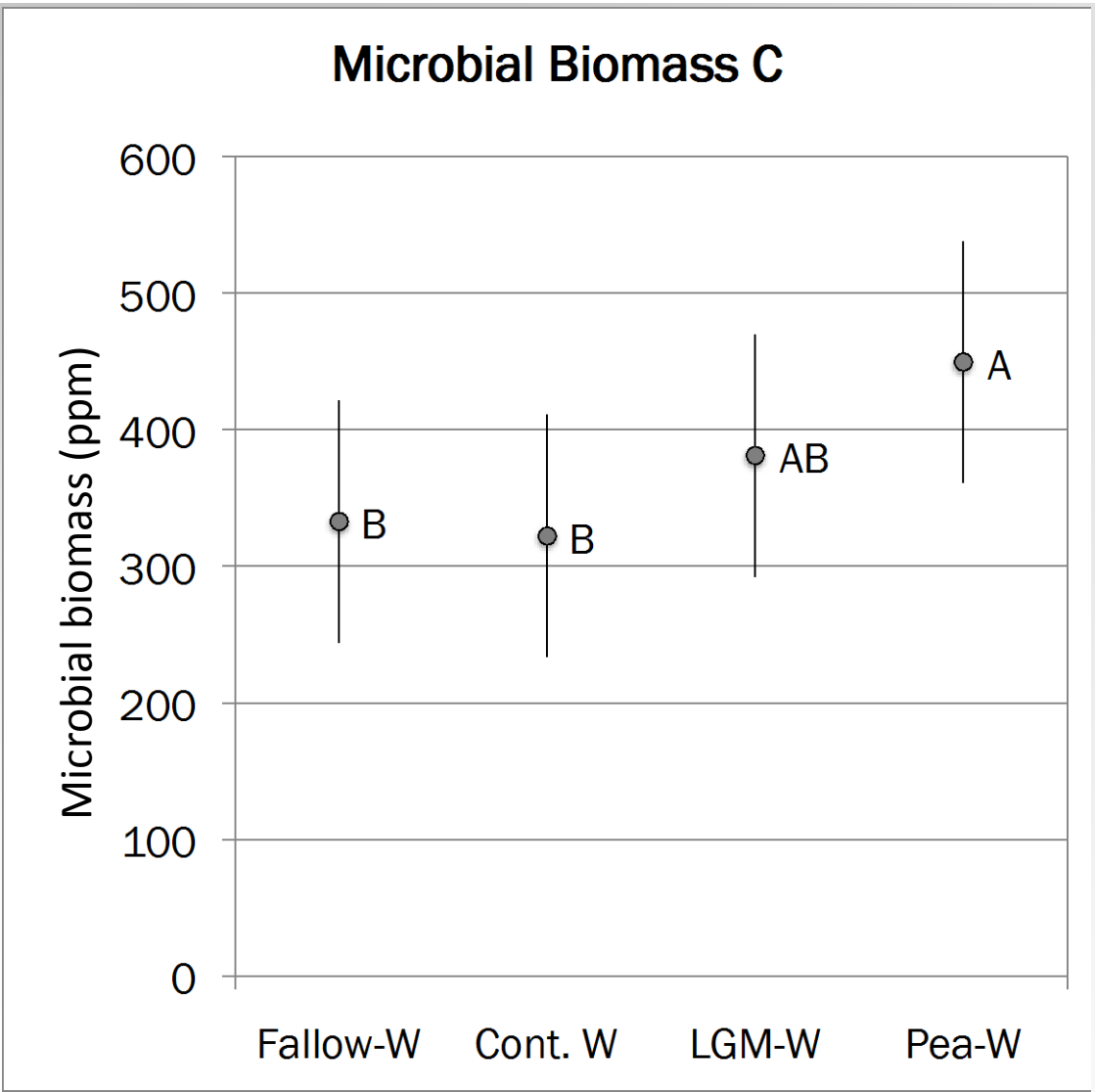
- *Bozeman, MT*: 8 year old Rotation Study
- 4 systems compared
  - NT Fallow – Wheat (F)
  - NT Continuous Wheat (CW)
  - NT Legume (pea) Green Manure – Wheat (LGM)
  - NT Pea – Wheat (P)
- Sensitive indicators of soil quality change (0-15 cm)
  - Potentially mineralizable N (PMN)
  - Microbial biomass C (MB-C)
  - Wet aggregate stability (WAS)

Potentially Mineralizable N

model results

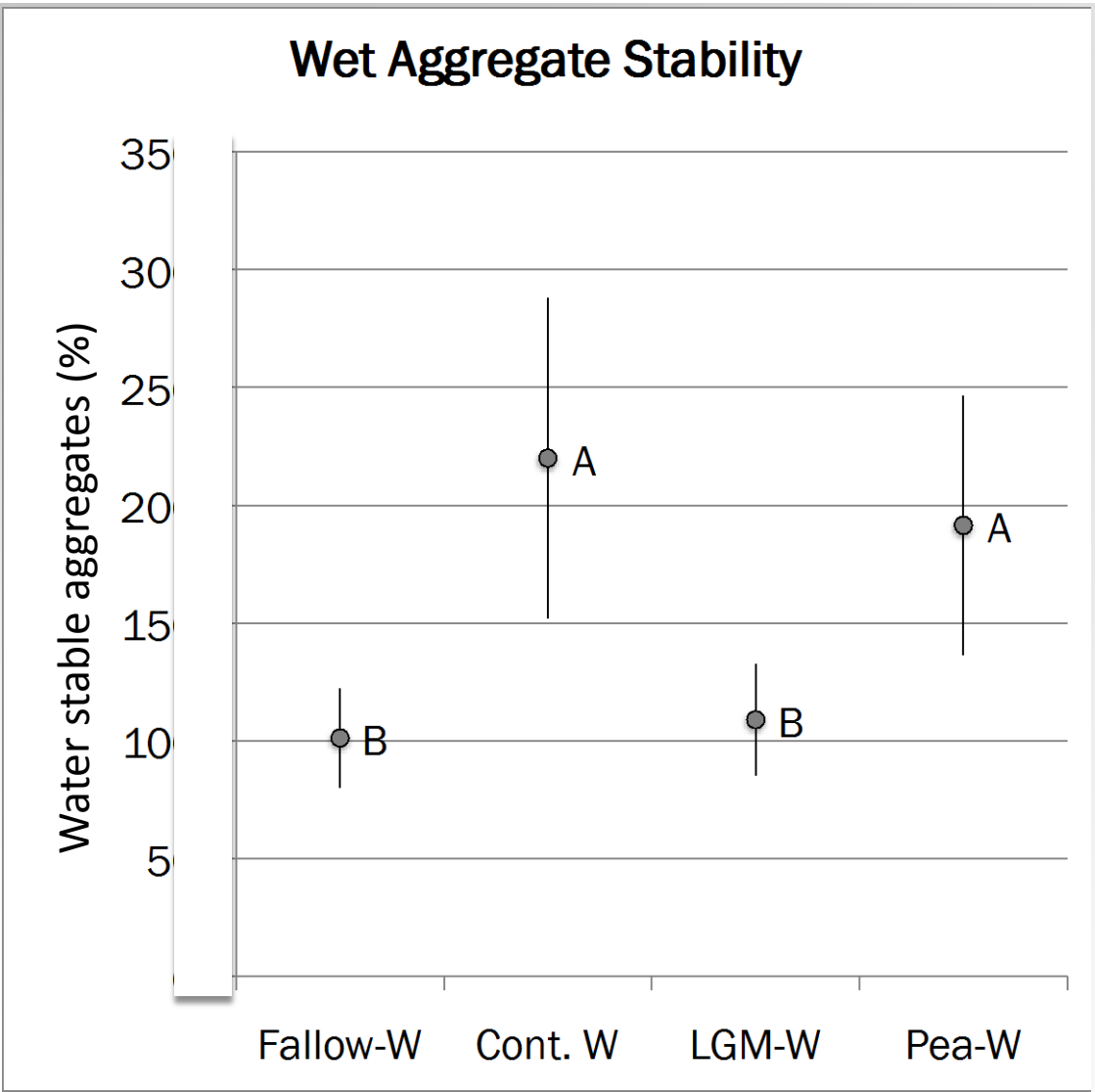


Microbial Biomass



MB: Legume > Wheat systems (P = 0.03)

Wet Aggregate Stability

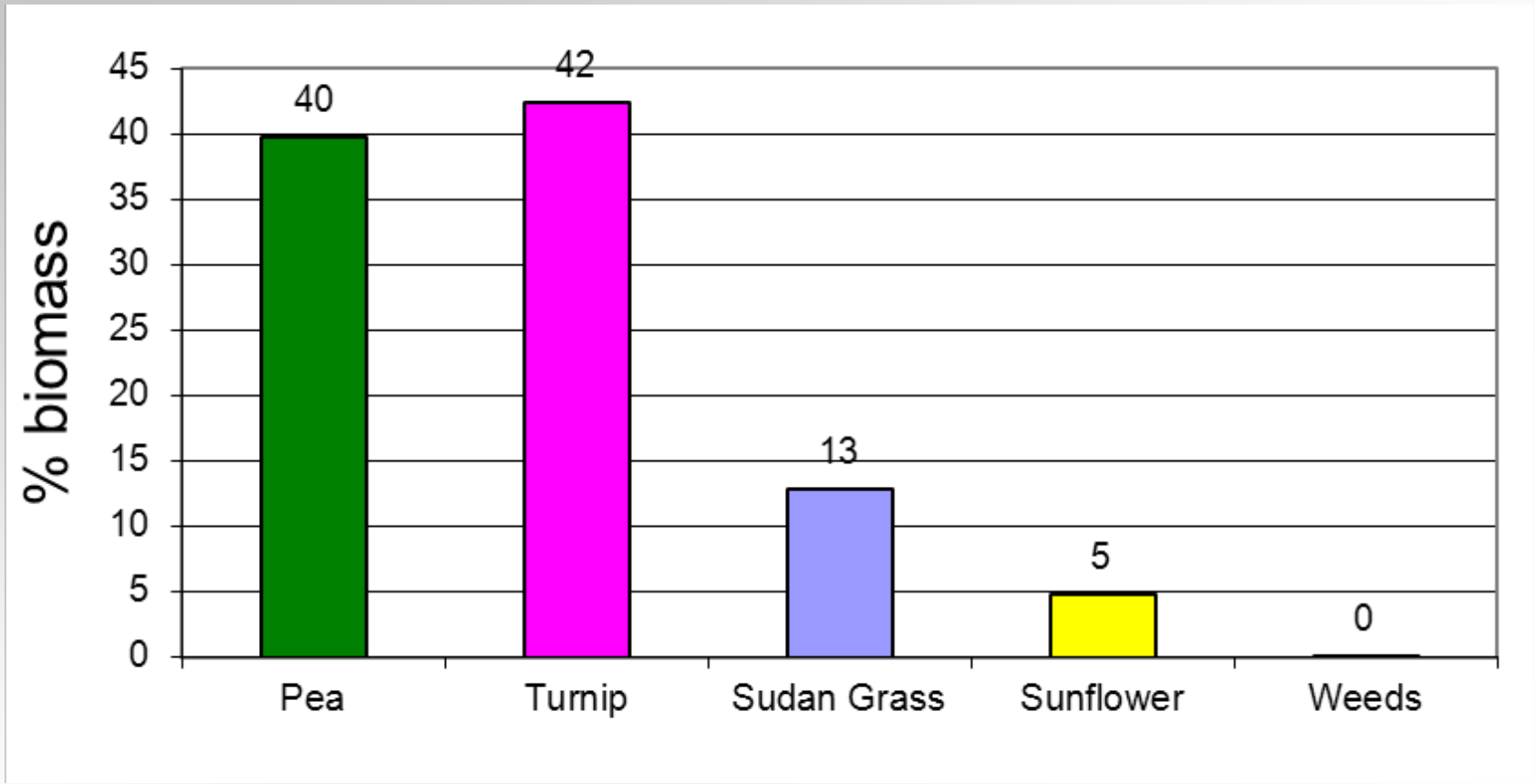


Cover Crop Cocktails – Preliminary Research Results

- Farmer's field near Willow Creek (as dry as Shelby!)
- Four species: pea, turnip, sudangrass, and sunflower
- Summer planted

Biomass production - 2010

~1.5 ton/acre total



Miller, unpub data

Cover Crop Cocktails – Preliminary Research Results

Soil water was only 3/4 inch less after cover crops than after fallow at wheat seeding.

Crop looked worse on cover crop side, but farmer tells us yields were similar.

Cover Crop Cocktails – Preliminary Research Results

Seeded

Site: Post Farm, 6 miles west of Bozeman

Goal: Determine effects of species and seeding date on root to shoot ratios (important for soil quality?)
Species: radish, beets, turnips

Seedings: April, May, June

April seeded radish bolted and reduced root growth compared to May seeded.

Summary

- One time cover crops have potential to lower yields and/or protein of following crops
- After 4 cover crop cycles, available N, yield and protein of following crop can be much higher than following fallow.
- Less is known in Montana on cover crop cocktails, but likely also provide a long term, not short term benefit
- Stay tuned for more research in next couple years

Acknowledgements

- **Funding**:
  NRCS-Conservation Innovation Grant Program, Montana Wheat and Barley Committee, and USDA – Western Sustainable Agriculture Research and Education program

- **Questions on cover crops?**

Ammonia volatilization losses following surface urea applications to wheat in Montana

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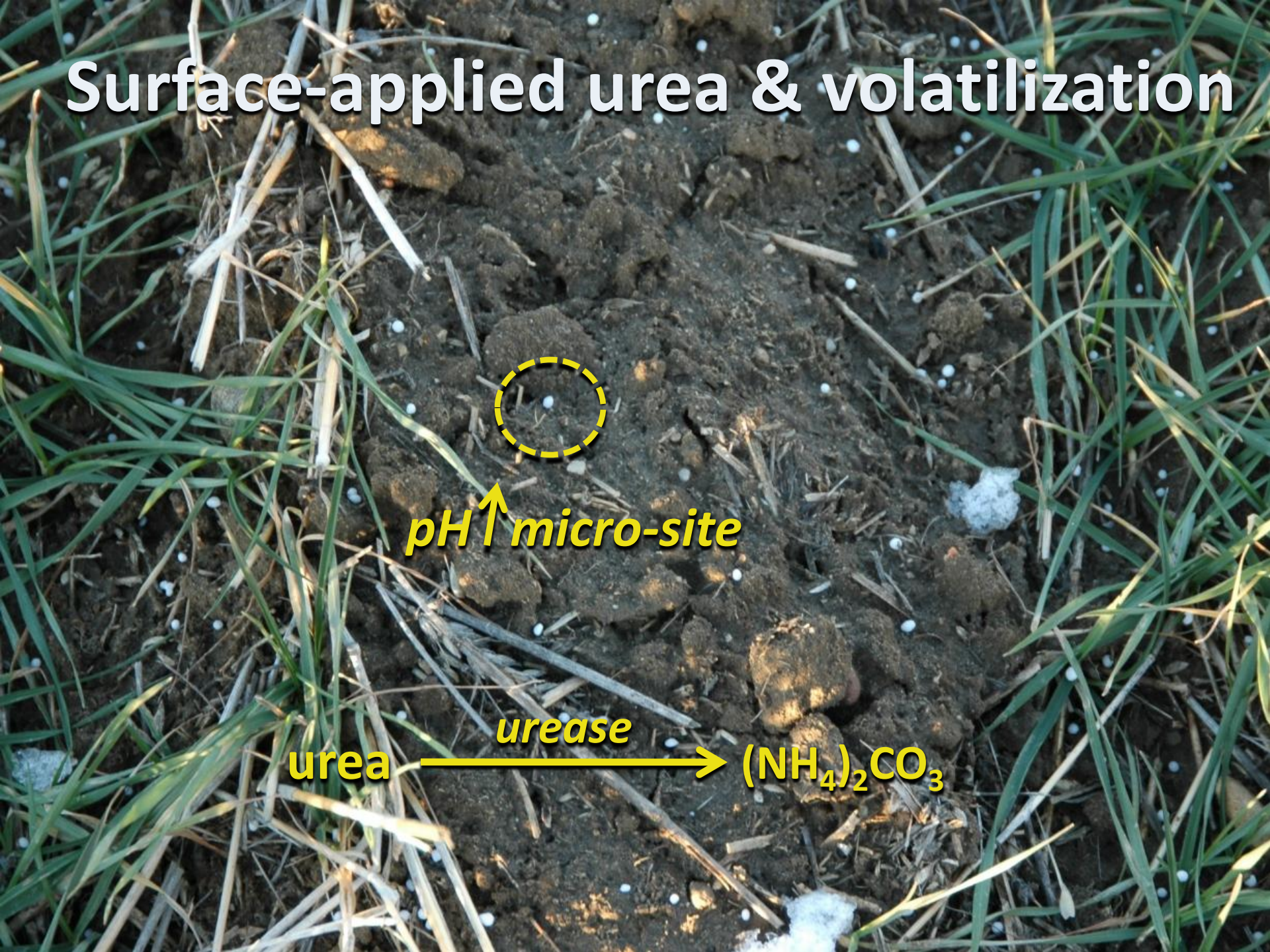
Urea and NH_3 volatilization

- susceptible to volatility losses once it undergoes hydrolysis; long known problem, but…..
  - volatility problems have been assumed to be minor if soil temperatures were cold, e.g. <40-50 °F
  - research says “volatilization losses are greater in warm weather”…. by inference losses minimized if applications are made in cold weather
- losses below 40 °F never measured in the field to our knowledge

Surface-applied urea & volatilization



Urease and residue

- enzyme lives in soil & found in high conc. in crop residue
- volatilization risks are often > with no till because of greater urease activity
- no till has become norm for wheat production

Goals

- How much N as NH_3 are we losing from surface-applied urea (fall, winter, and early spring)?

  Does this represent a large economic loss? If so, what are the conditions where the largest N losses are observed ?

  Do cold temperatures provide protection against losses (40 to 50 °F)?

Goals

- Defining mitigation strategies to minimize NH_3 loss ?
  - ***Timing***
  - ***Enhanced efficiency N products (NBPT or Agrotain)?***
  - ***Incorporation & subsurface urea applications***

Methods – On farm studies

Methods: Integrated horizontal flux

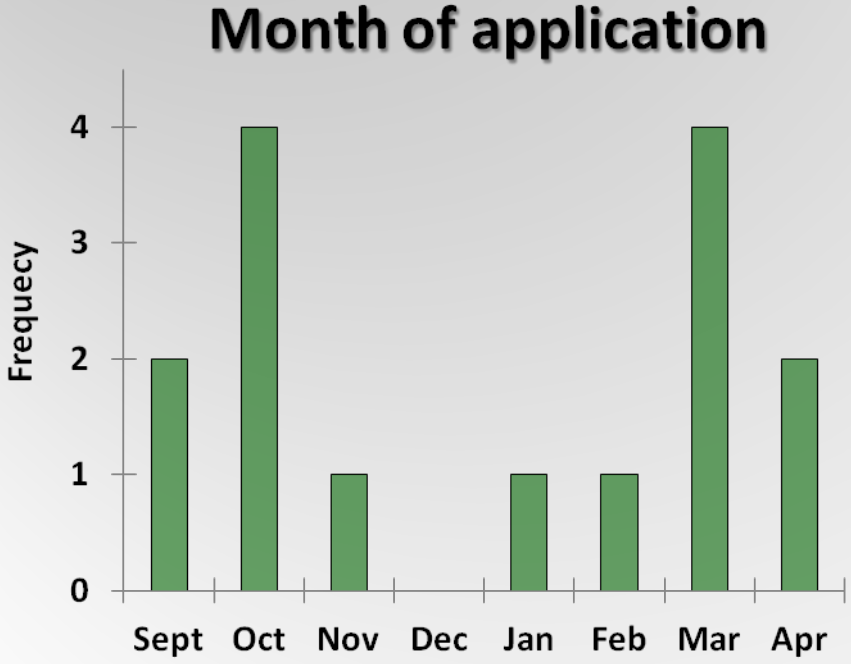
- micrometeorological - mass balance
- does not disturb the soil-atmosphere environment
- continuous measurement of gas loss over time

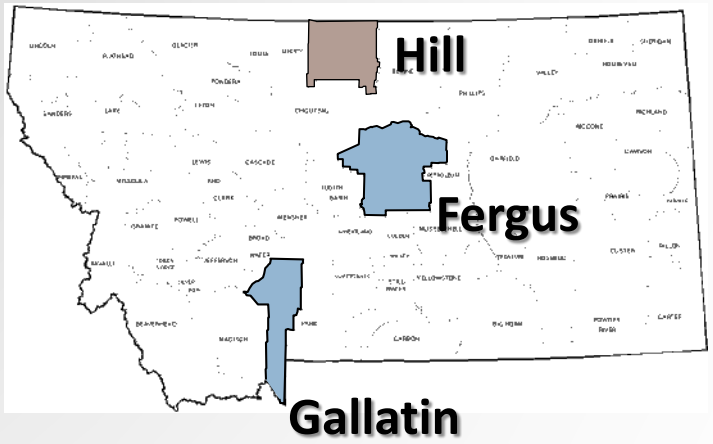
mast and shuttles

Summary of 15 trials

Mean NH_3 loss: 20.0 % of applied N

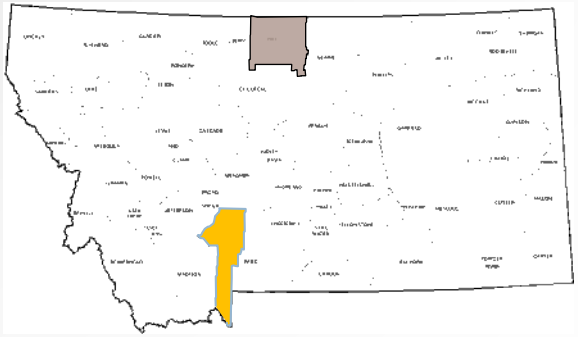
Range NH_3 loss: 3.1- 44.1% of applied N





High NH_3 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
10 -Willow Creek	Feb. 26, 2010	44.1

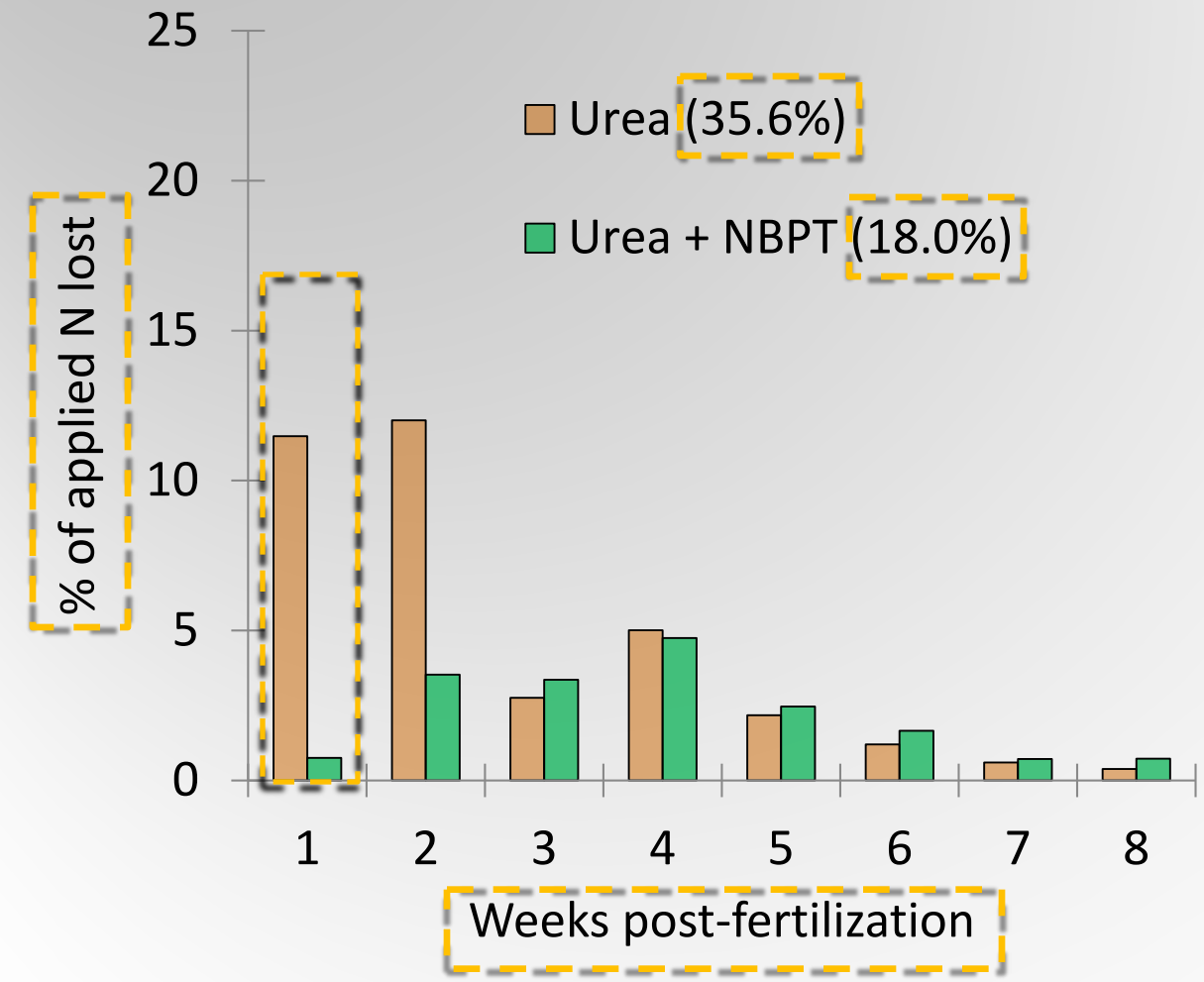


High NH_3 losses – Campaign 4 (TJ loam)

Fertilizer applied – March 25, 2009
"light snow & air-temp. 31°F"

soil surface frozen 18 °F
Soil water content = 35%

High NH_3 losses – Campaign 4 (TJ loam)



Precipitation

0.01” = 0-2 wks

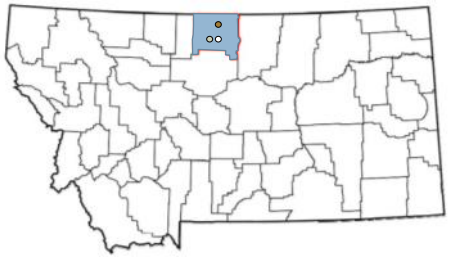
0.89” = 2-8 wks

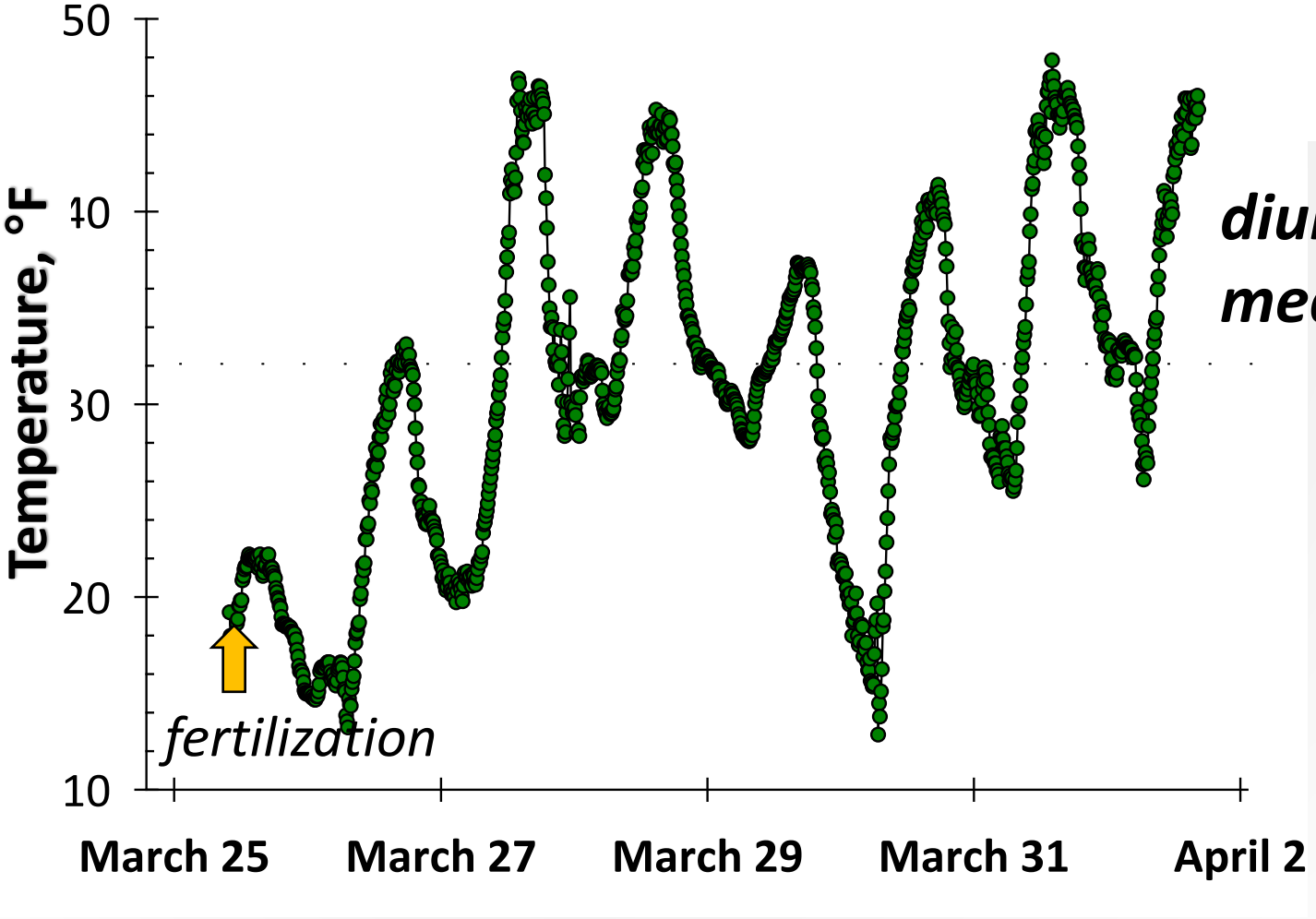
Temperature

Soil = 30.7 °F

Air = 33.4 °F

High NH_3 losses – Campaign 4 (TJ loam)

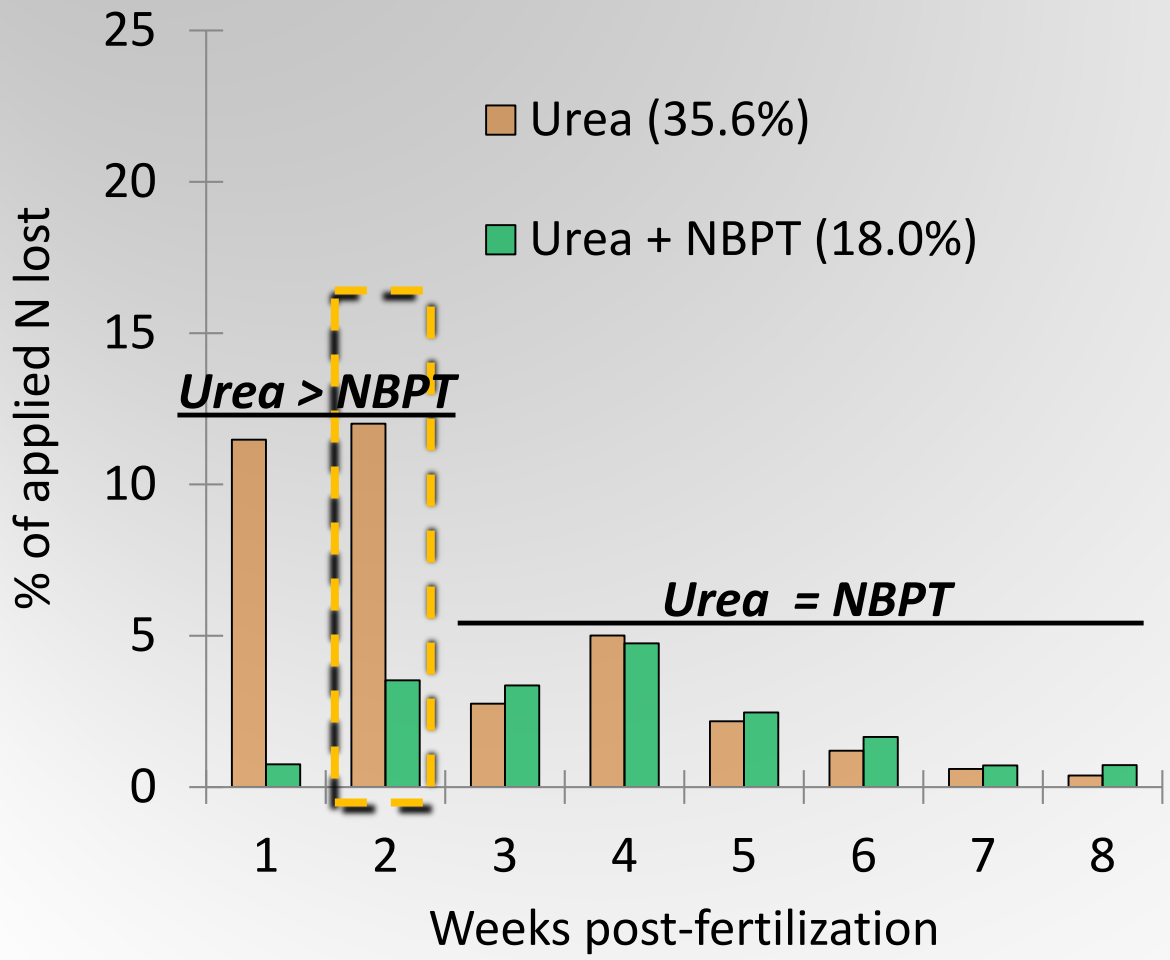




diurnal variation

mean = 30.7°F

High NH_3 losses – Campaign 4 (TJ loam)



Precipitation

0.25” = 0-2 wks

0.89” = 2-8 wks

Temperature

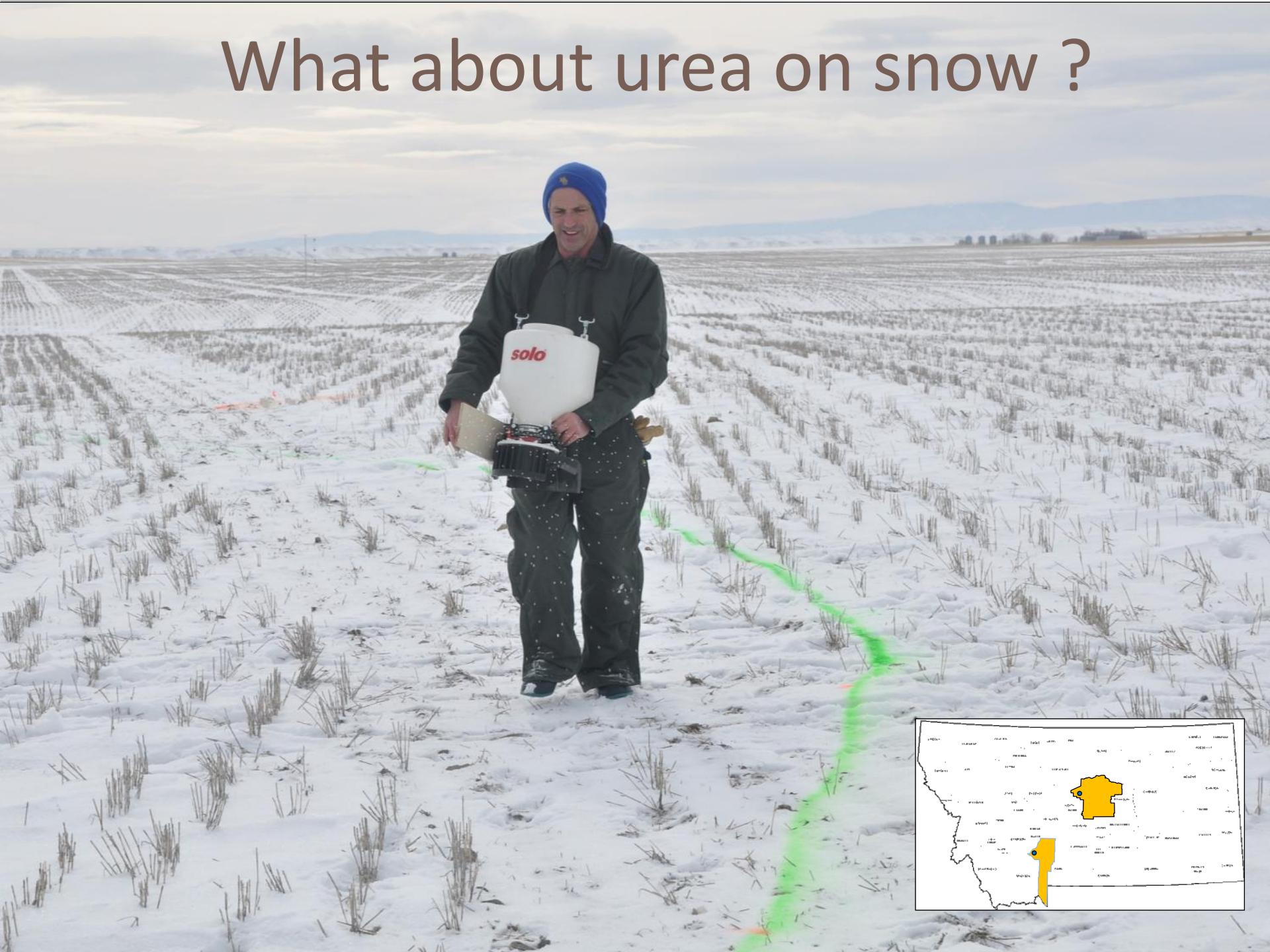
Soil = 38.0 °F

Air = 41.5 °F

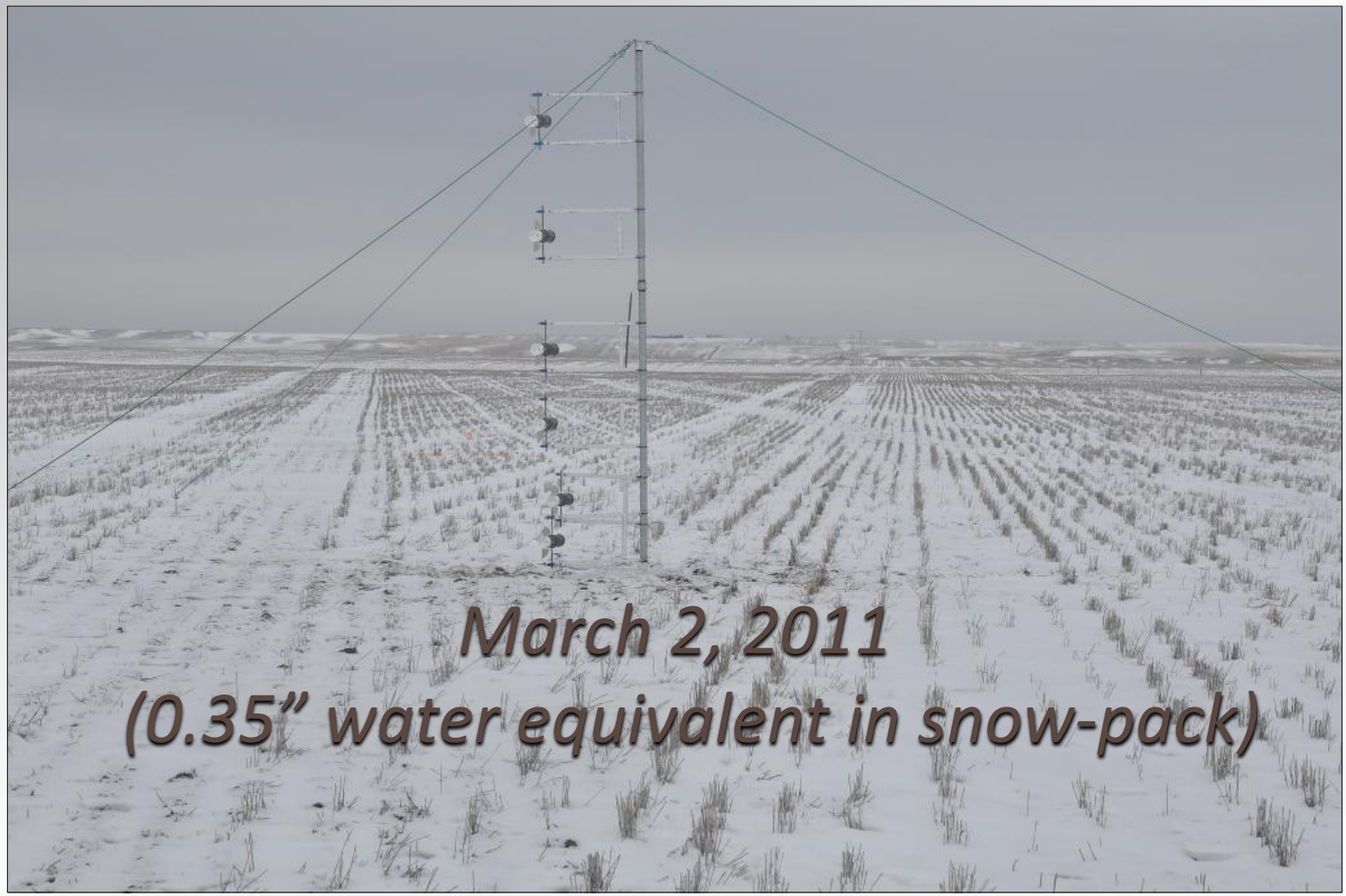
High NH_3 losses from urea -what to avoid -

- Do not apply urea to damp or wet soil surfaces. Wet + slow drying is ideal for seeing large NH_3 losses.
- Example – early spring or late winter; ground may be wet; soil frozen at night, but thaws during the day

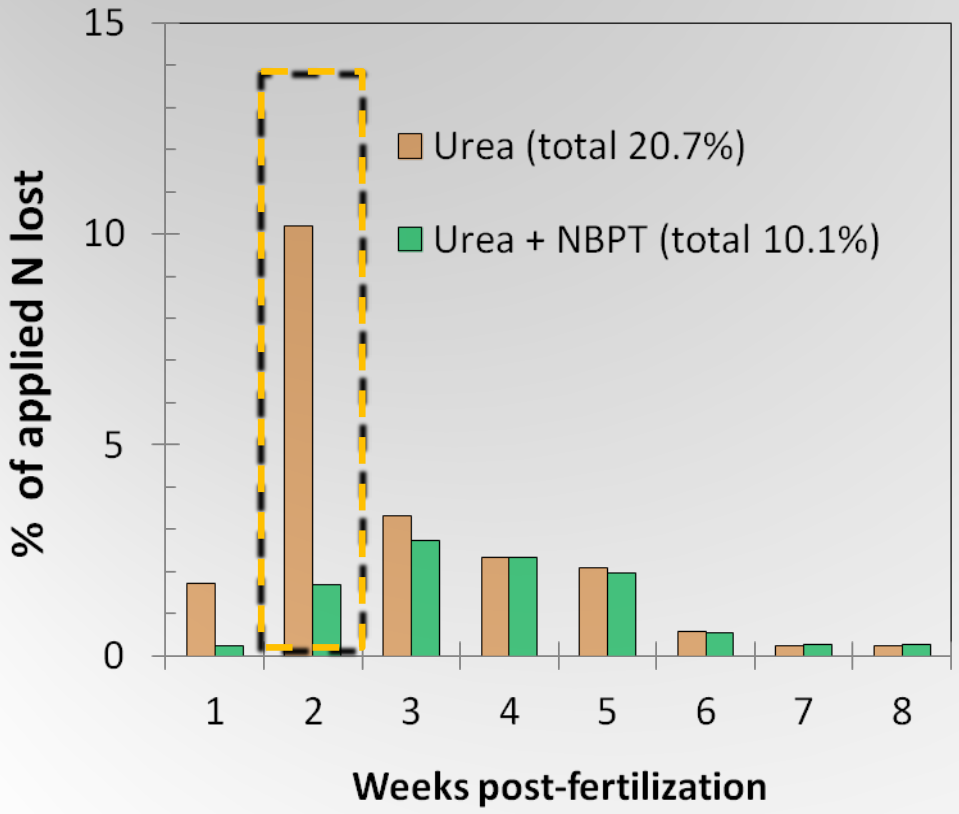
What about urea on snow ?



Campaign 16 - Denton - winter application



Campaign 16 – Denton – winter application



Summary points

- Danvers clay loam, pH 7.0
- snow pack disappeared 2nd wk
- largest NH_3 occurred during 2nd wk, mean surface temp = 36˚ F (6-13 dpf)
- precipitation light wks 1,2, & 3

Campaign 16 – Denton – winter application

6 d post-fertilization

13 d post-fertilization

snow-pack disappeared during 2nd week

Urea on snow

- early results showed significant NH_3 losses after snow-pack disappeared, not as large as urea onto wet soil surface w/o snow
- soil drying (wet → dry); particularly slow drying is when largest losses observed
- mean daily surface temperature can be cold; e.g. 22˚F 0-6 d; 36˚F 6-13 d

Reducing NH_3 loss from surface-applied urea

- apply urea to dry soil surfaces only
- NH_3 losses do not occur until after urea dissolves

undissolved urea prills

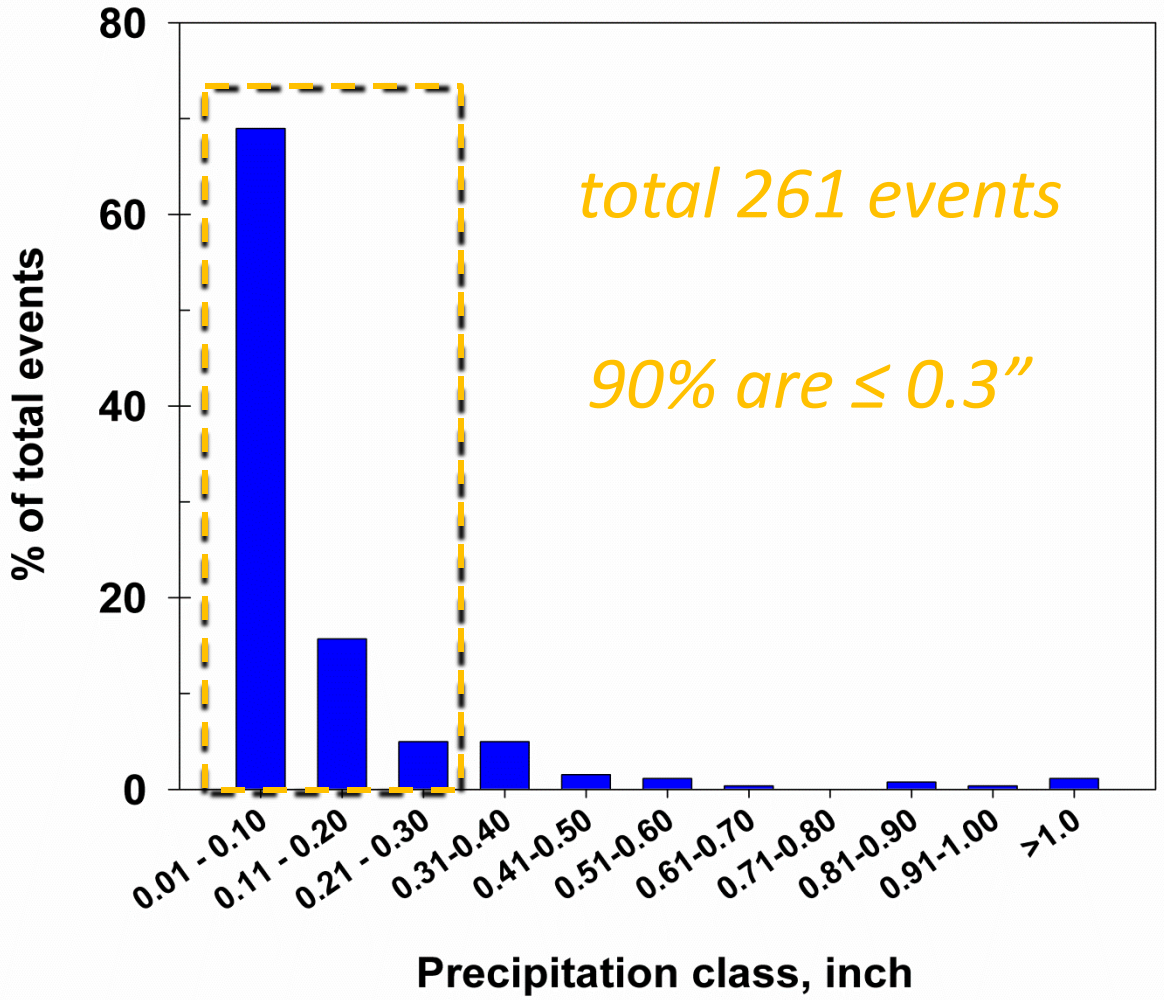
……. then hope for rain (more the better)

Size and frequency of precipitation events between Oct – April (last 10 years)

Havre Airport

7 month ppt. ave. 3.1”

~50% falls as ≤ 0.3” events



Low NH_3 loss campaigns (<10% of applied N) What happened?

Campaign	Fertilization date	% urea-N volatilized
1 - west Havre	April 3, 2008	8.4
2 - north Havre	Oct 8, 2008	3.1
11 – west Havre	Oct. 9, 2009	6.3

same field location as Campaign 5 (39.9% loss), but 1" ppt event occurred 4 days after fert

Summary comments

- significant N losses as NH_3 can happen in Montana when urea is surface-applied
- wet surface soil conditions w/o accompanying ppt → high risk for appreciable NH_3 loss, even if soil temperatures less than 40°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 – 2 campaigns to-date (20.7 and 24.3 % N losses observed) - may be problematic from NH_3 loss standpoint but we need to investigate further ?
- NBPT or Agrotain may have a role under the high loss potential conditions - longevity may be greater in calcareous soils
- double-shoot urea to minimize volatility losses

Agencies supporting

- USDA - Western Sustainable Agric. Research & Education program
- MT Fertilizer Advisory Committee
- MT Wheat and Barley Committee
- NRCS-CIG program
- International Plant Nutrition Institute
- Agrotain International
- AG Wise - Kremlin, Montana

Questions?

For More Information

Soil Fertility Website:
http://landresources.montana.edu/soilfertility

Contains links to my presentations including this one, economic N rate calculator, fertilizer facts, press releases, Extension publications, etc.