MANAGEMENT PRACTICES TO MINIMIZE NITRATE LEACHING

Crop Pest Management School
Bozeman, MT
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MONTANA STATE UNIVERSITY

MSU Soil Fertility Extension

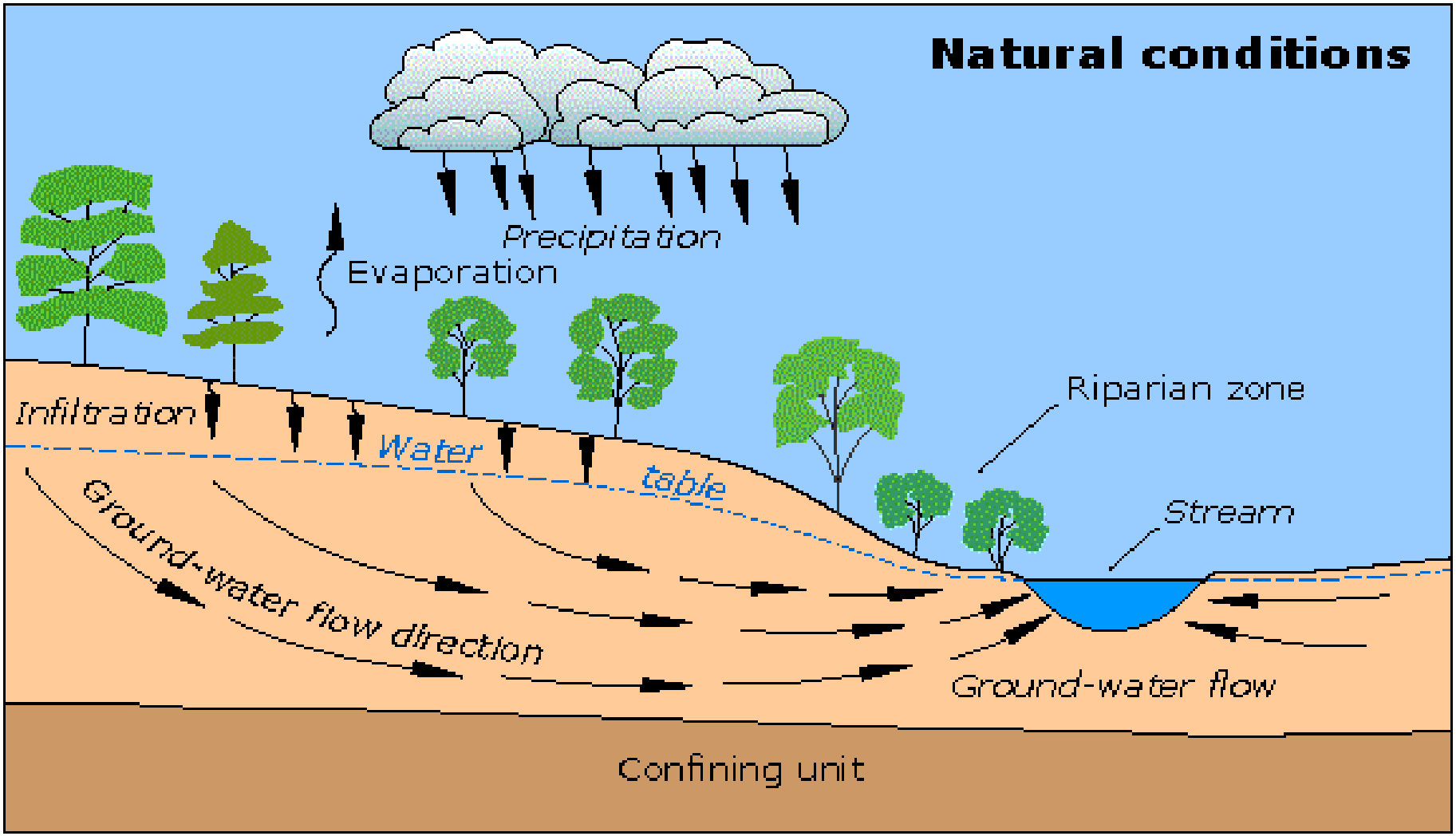
Objectives

- Briefly explain why nitrate leaching is an issue
- Show groundwater nitrate concentrations
- Discuss options to minimize leaching
- Present research results from central Montana on effects of management on leaching and economics

Problems with nitrate leaching

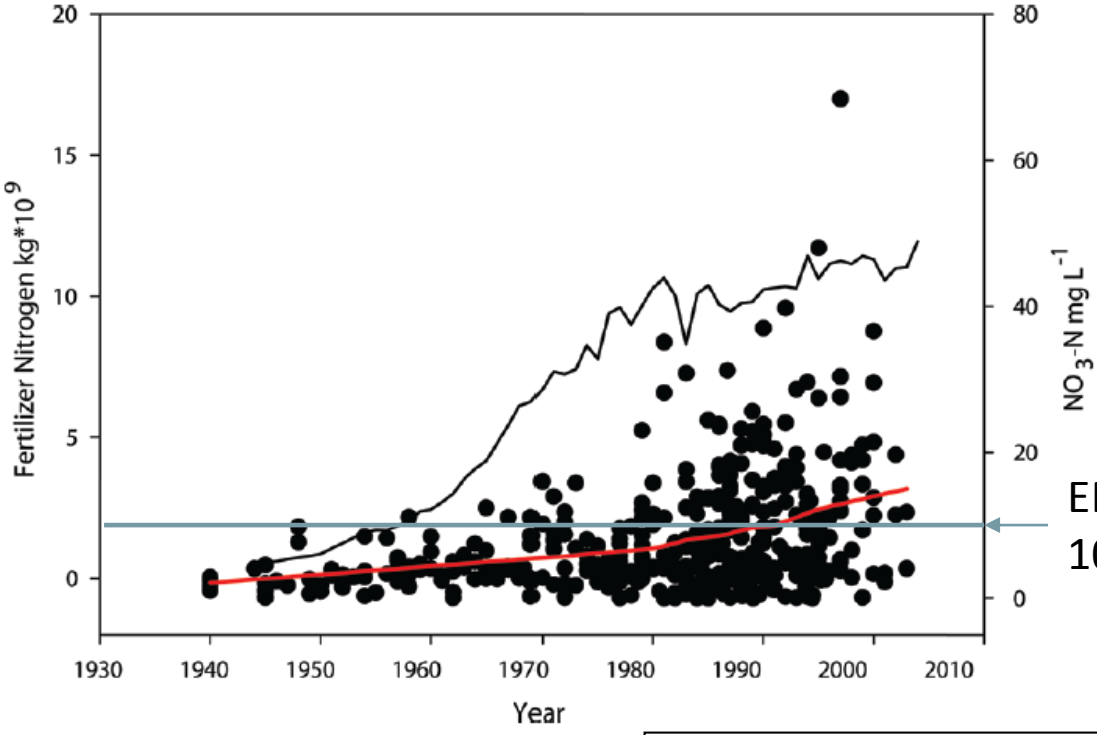
- N ends up below root zone rather than in crop
- Blue baby syndrome if nitrate in drinking water is high
- Nitrate often ends up in surface water: possible high algae growth

Groundwater Connections to Surface Water



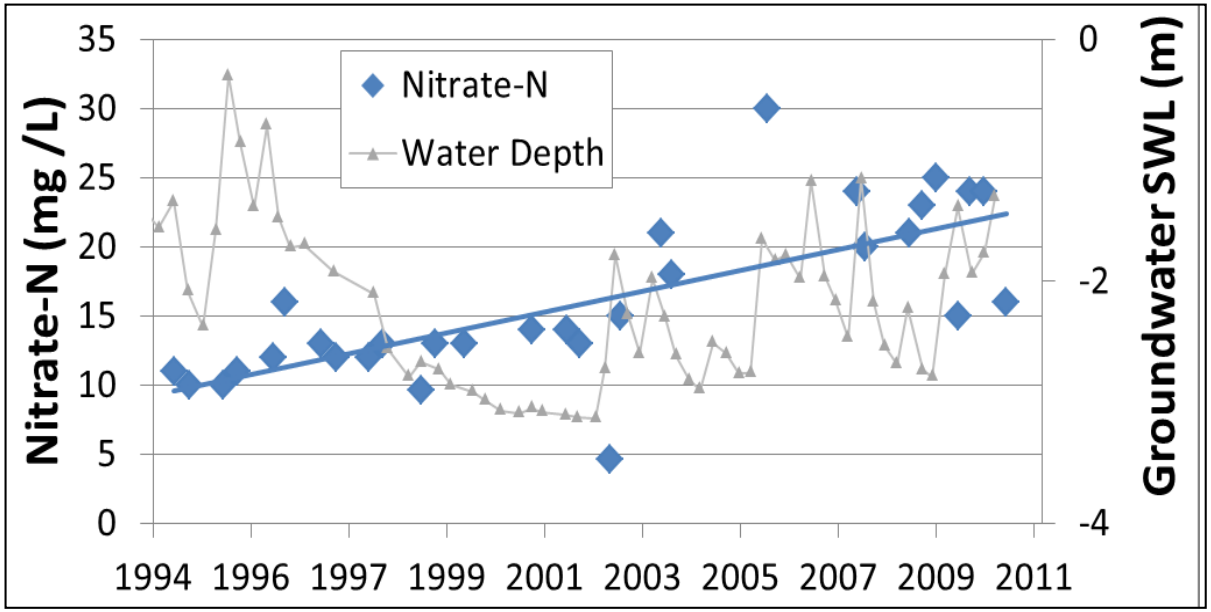
1. Nuisance algae growth
2. Challenges for users downstream

In grand scheme (Mississippi River Basin), MT role is small



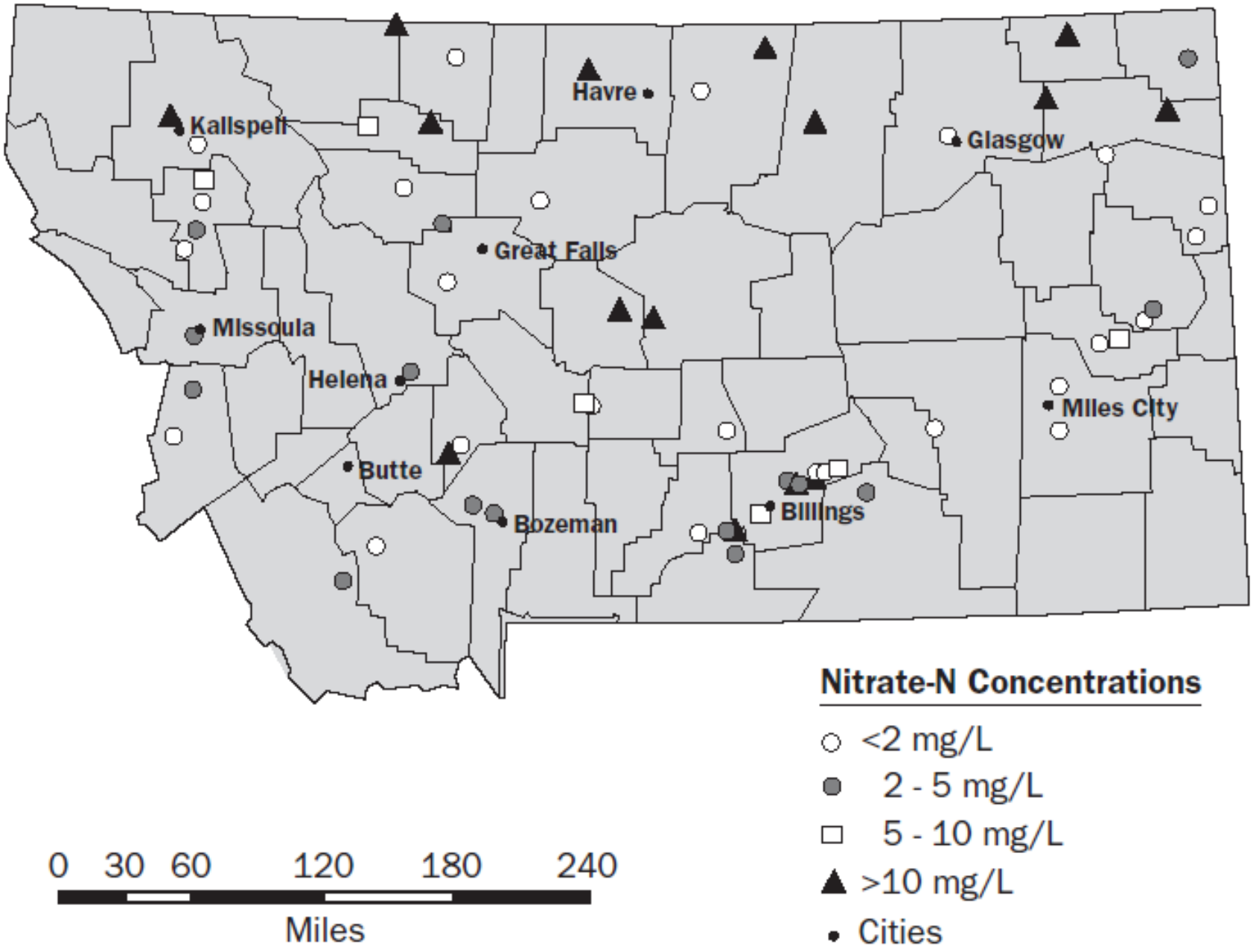
Nitrate in shallow groundwater in U.S. (Puckett et al., 2011)

EPA Drinking Water Standard = 10 mg/L



Nitrate-N and groundwater level in monitoring well near Moccasin (M-1; MT Dept. of Ag.)

Nitrate-N concentrations from random Montana Dept. Ag monitoring wells (2006-2010)



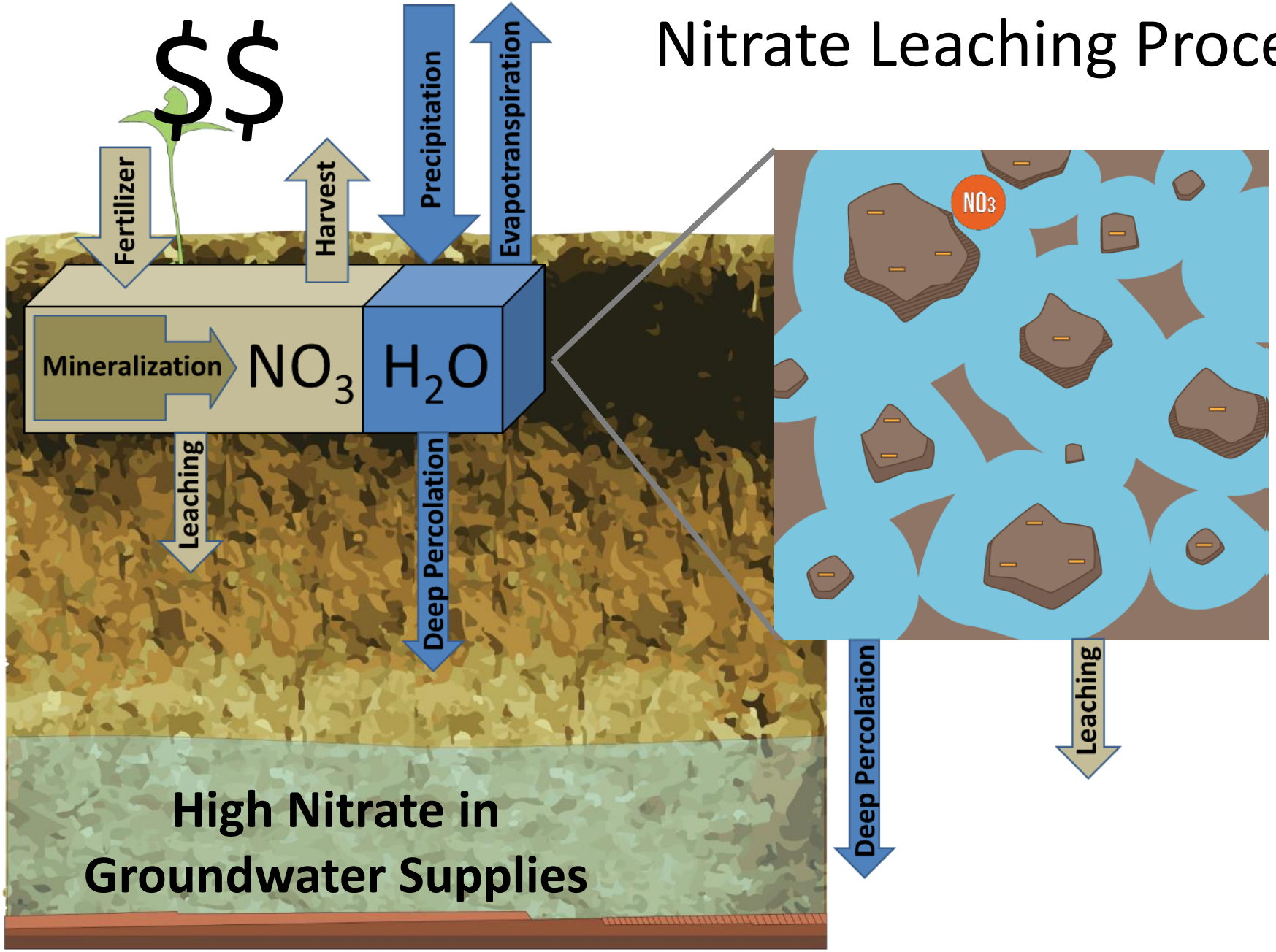
Water Quality Testing - When

- Every year for nitrate and bacteria
- After flooding
- After service
- If a change is noticed

Water Quality Testing - How

- Test kits will work for a rough value (screening)
- Certified drinking water testing labs

What is leaching? & Why we care



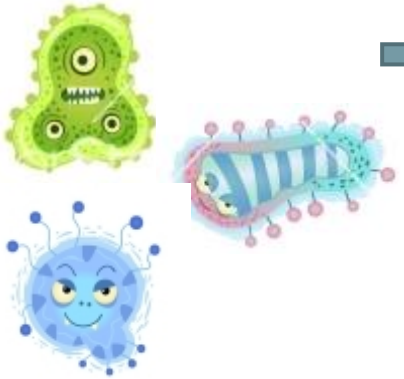
Nitrate Leaching Process

Mineralization = decomposition of soil organic matter to form ammonium

N in soil organic matter

+

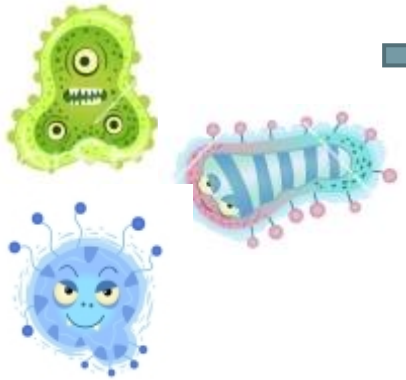
Microbes



→ Ammonium

- High SOM requires less fertilizer N, but can lead to more leaching (esp if fertilizer not reduced)

Nitrification = conversion of ammonium to nitrate (by microbes with oxygen)

NH_4^+ (ammonium) **+** Microbes + oxygen  → NO_3^- (nitrate)

Questions?

On to management

Crop management factors to decrease leaching of N (and pesticides)

- Carefully manage irrigation, especially on coarse soils
- Consider sprinkler instead of flood irrigation
- Recrop rather than fallow
- Reduce tillage
- Include perennial and/or deep rooted crops
- Consider legumes since don't need to fertilize w/ N
- Space crops for optimal yields to optimize resource use; ex. SW in 6" rows and 30 plants/ft^2
  (Fertilizer Fact # 37)

N management factors to decrease N leaching

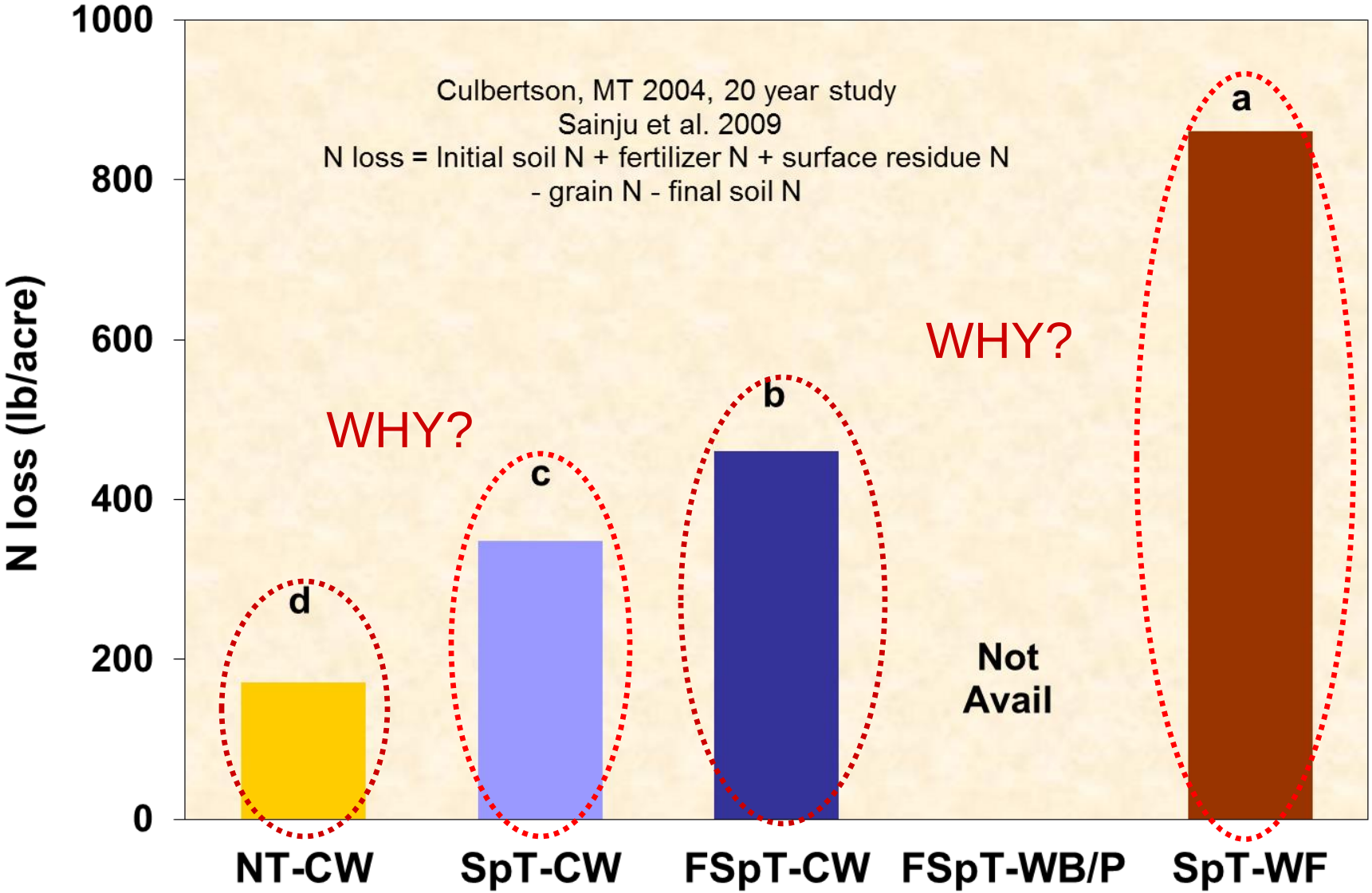
- Apply N based on spring soil test ESPECIALLY if have > 50 lb N/acre in fall AND soils less than 2 ft deep
- Split N application to match plant needs
- Avoid fall application on shallow and/or coarse soils
- Consider applying less N in areas that yield less or have shallow soils (variable rate application)
- Use an enhanced efficiency fertilizer?

Questions so far?

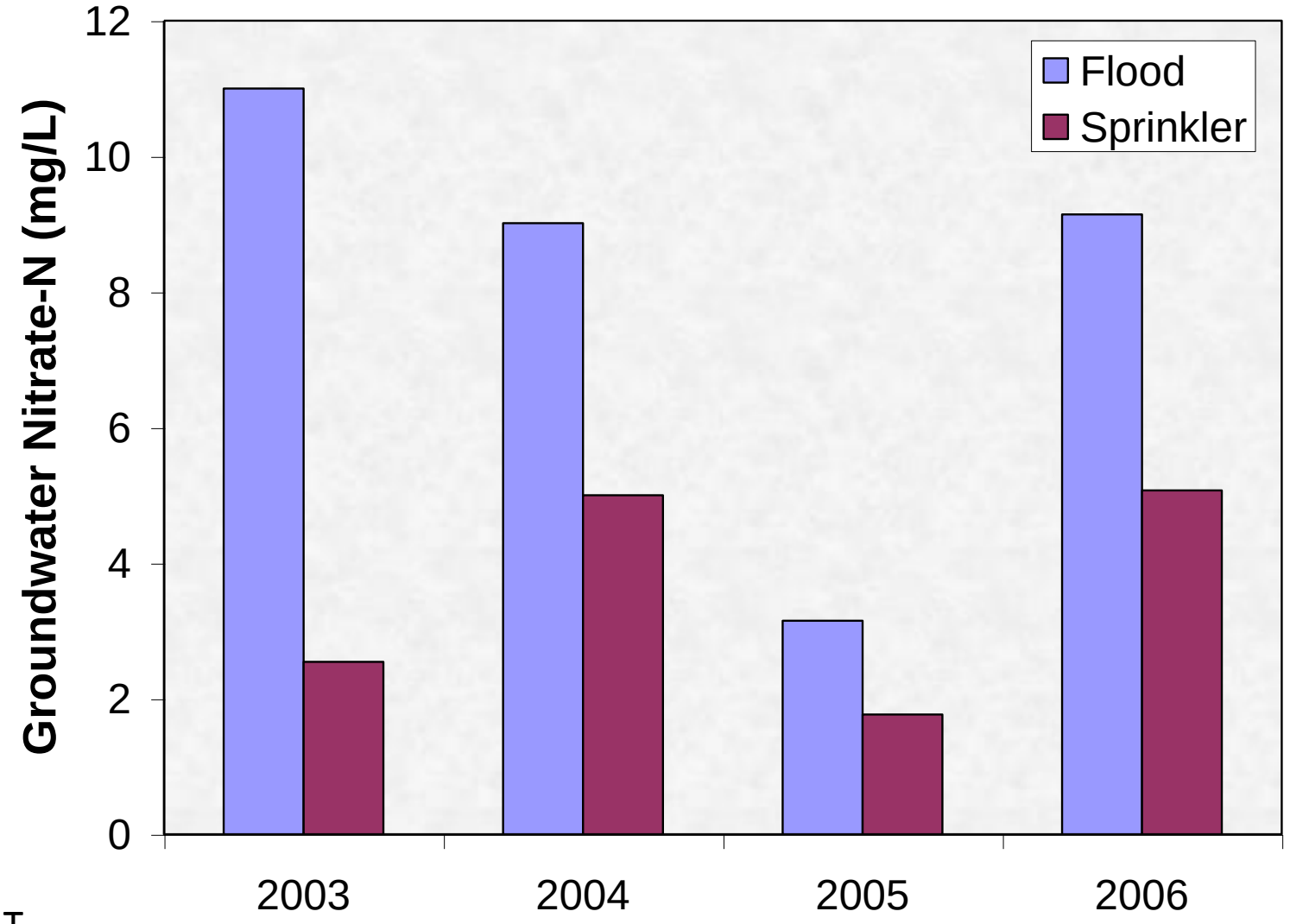
Long-term effect of cropping system on soil N

- 1983 to 2004 near Culbertson, MT
- Comparing tillage and crop
  - NT-CW : No Till-Continuous Spring Wheat
  - SpT-CW: Spring Till-Continuous Sp. Wheat
  - FSpT-CW: Fall & Spring Till – Continuous Sp. Wheat
  - FSpT-WB/P: Fall & Spring Till – Wheat/Barley (17 years), Wheat/Pea (4 years)
  - SpT-WF: Spring Till – Sp. Wheat/Fallow

Estimated N loss: Spring 1983 to Fall 2004

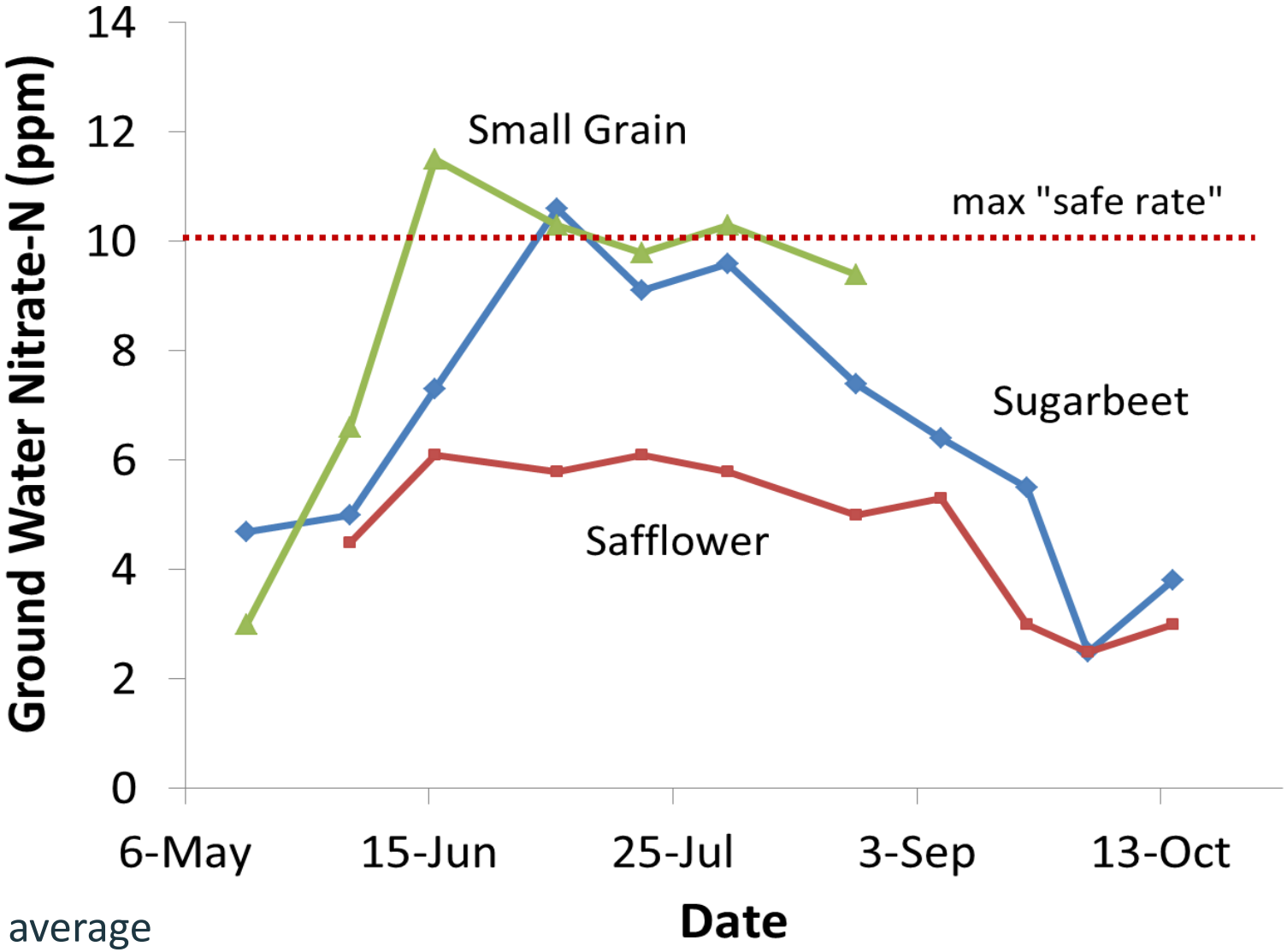


Sprinkler irrigation leads to less groundwater NO_3 than flood irrigation on lower Yellowstone



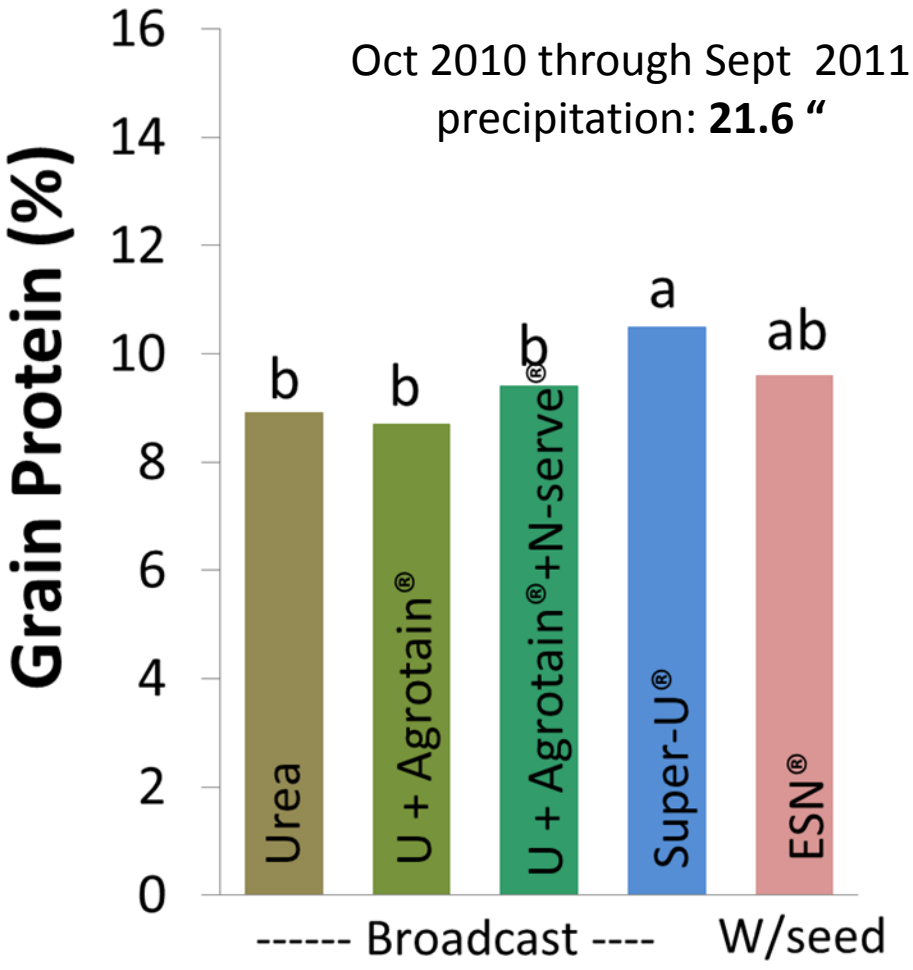
Sidney, MT,
Eckhoff, Fertilizer Fact 43

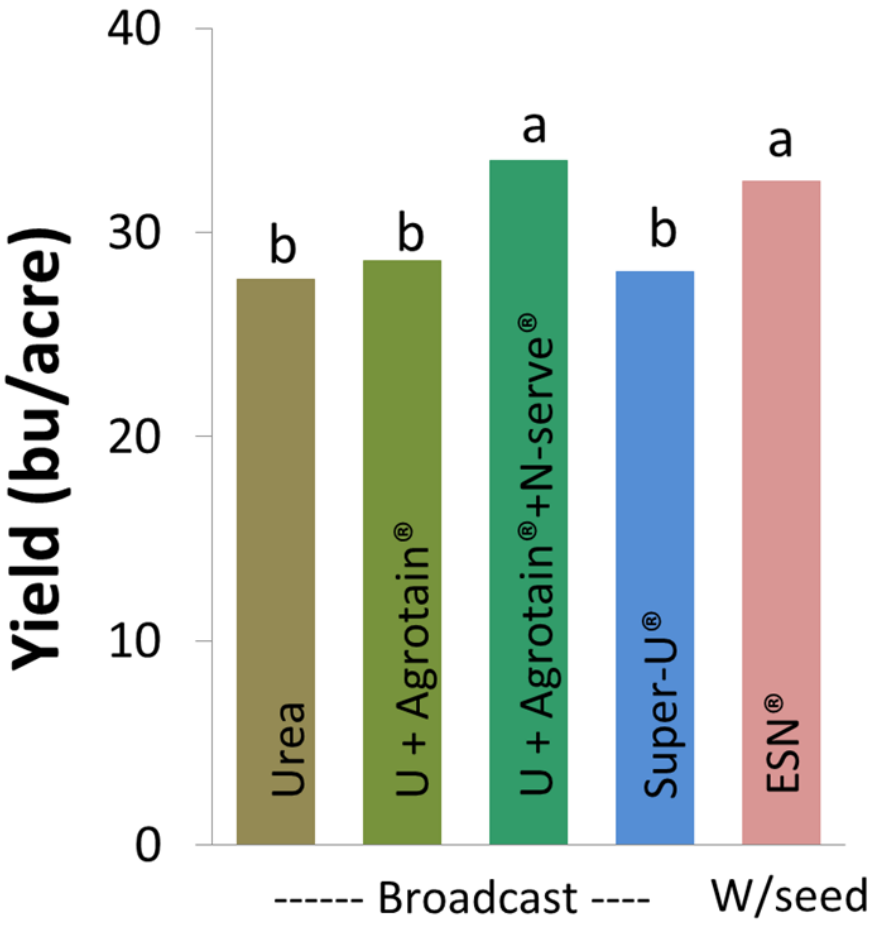
Deep rooted crops dig deep for N and help keep NO_3 out of groundwater



6-yr average
Sidney, MT, Fertilizer Fact 9

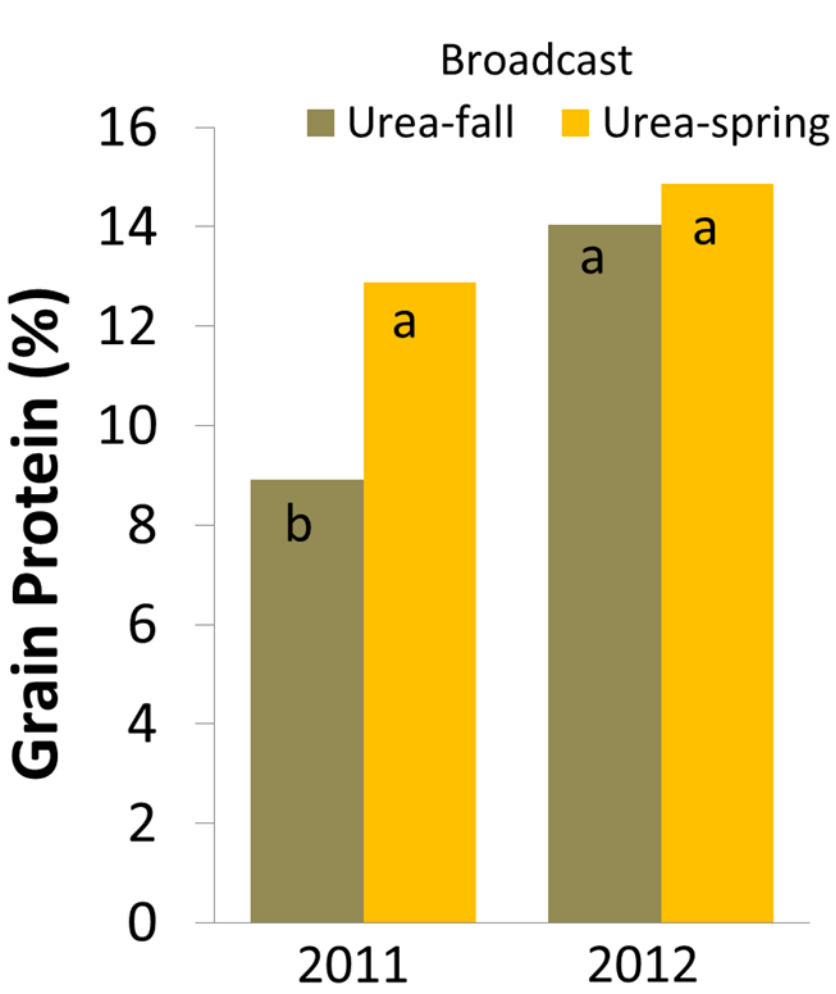
Effect of source and placement (fall applied) on grain yield under high risk leaching conditions

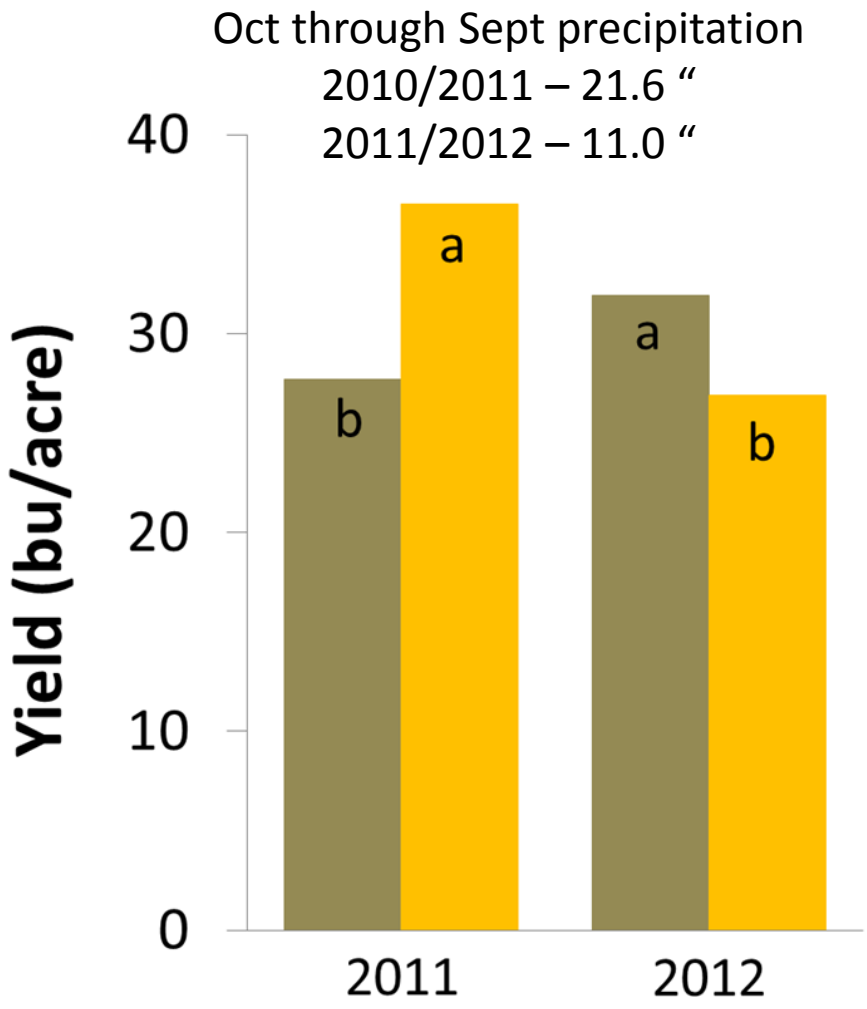




Fertilizer Fact 62, Moccasin, MT

Effect of **spring vs fall N application** on winter wheat grain protein and yield



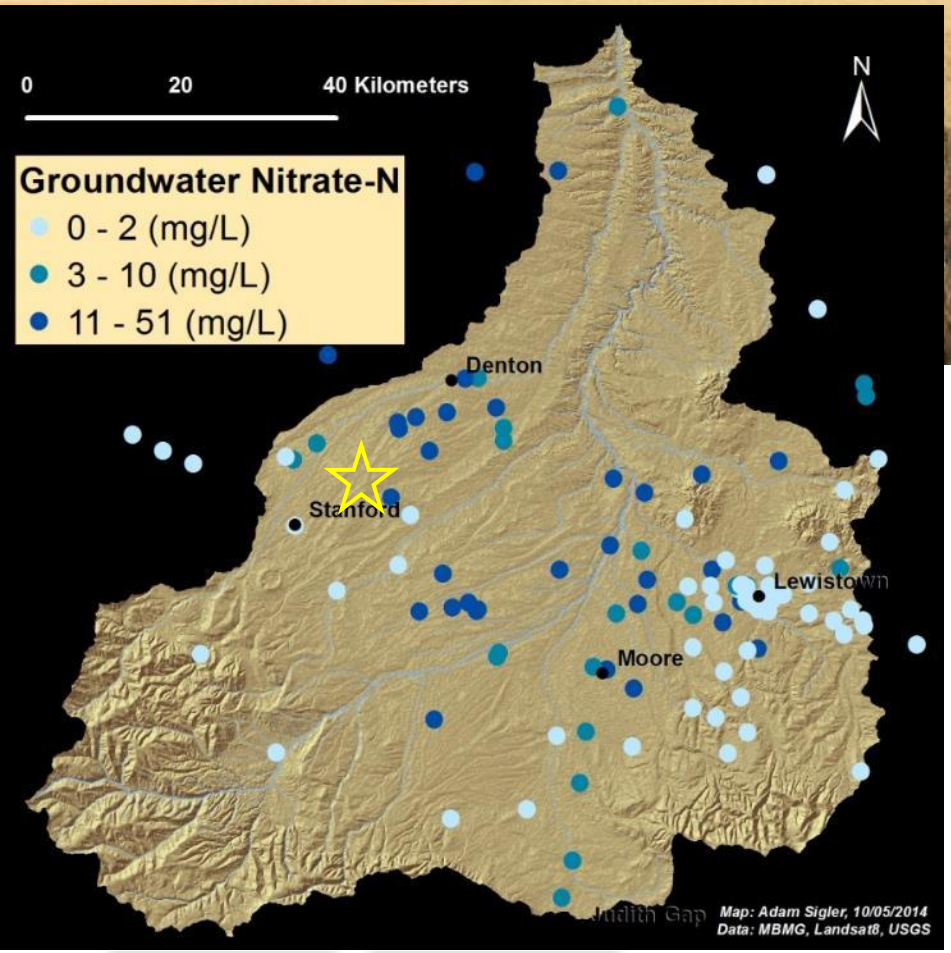


Fertilizer Fact 62, Moccasin, MT (very shallow soils)

Questions?

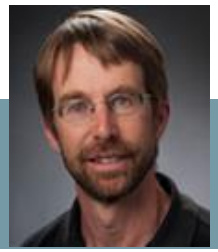
On to JB Nitrate Leaching Project

JUDITH BASIN NITROGEN PROJECT



Stephanie Ewing – MSU
Clain Jones – MSU
Doug Jackson-Smith – USU
Adam Sigler - MSU

http://waterquality.montana.edu/judith/index.html

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UtahStateUniversity

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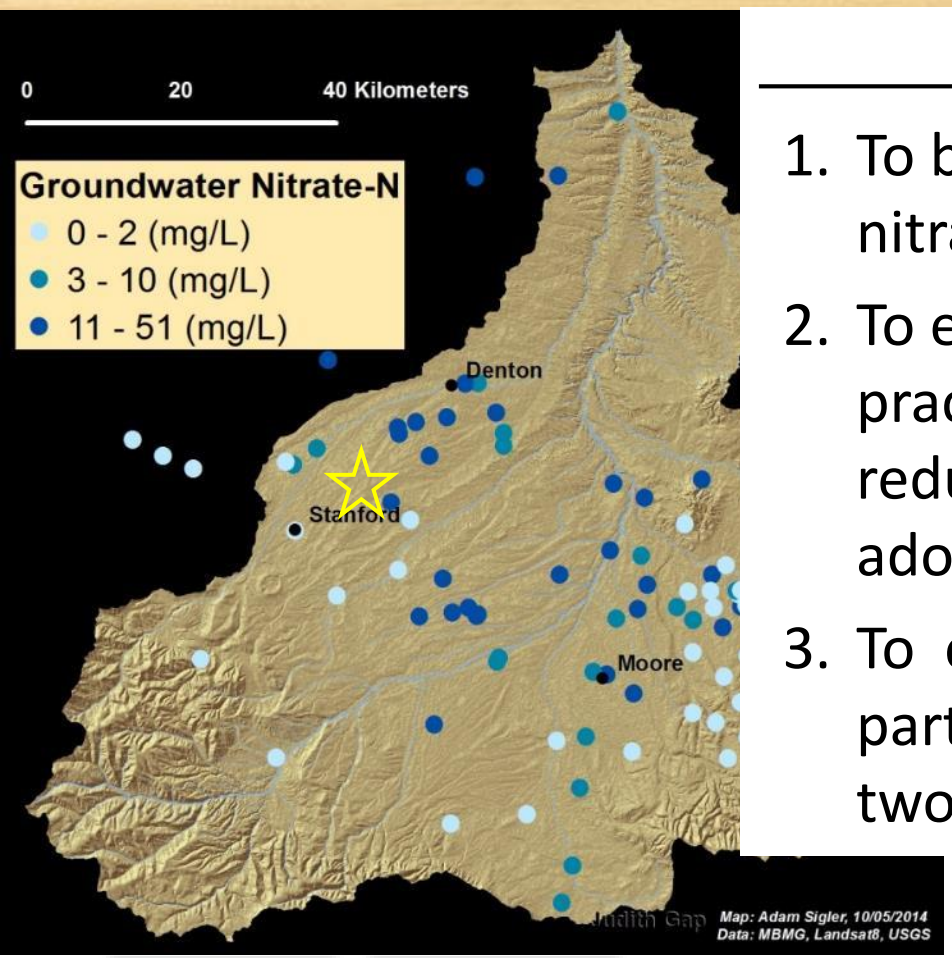
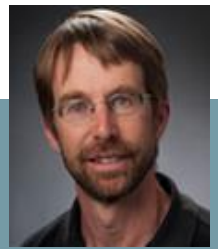


Broader Project Goals

1. To better understand the sources of nitrates in ground and surface water
2. To evaluate which management practices are likely to be effective to reduce nitrate leaching and to be adopted
3. To engage the local community in participatory research to meet the first two goals

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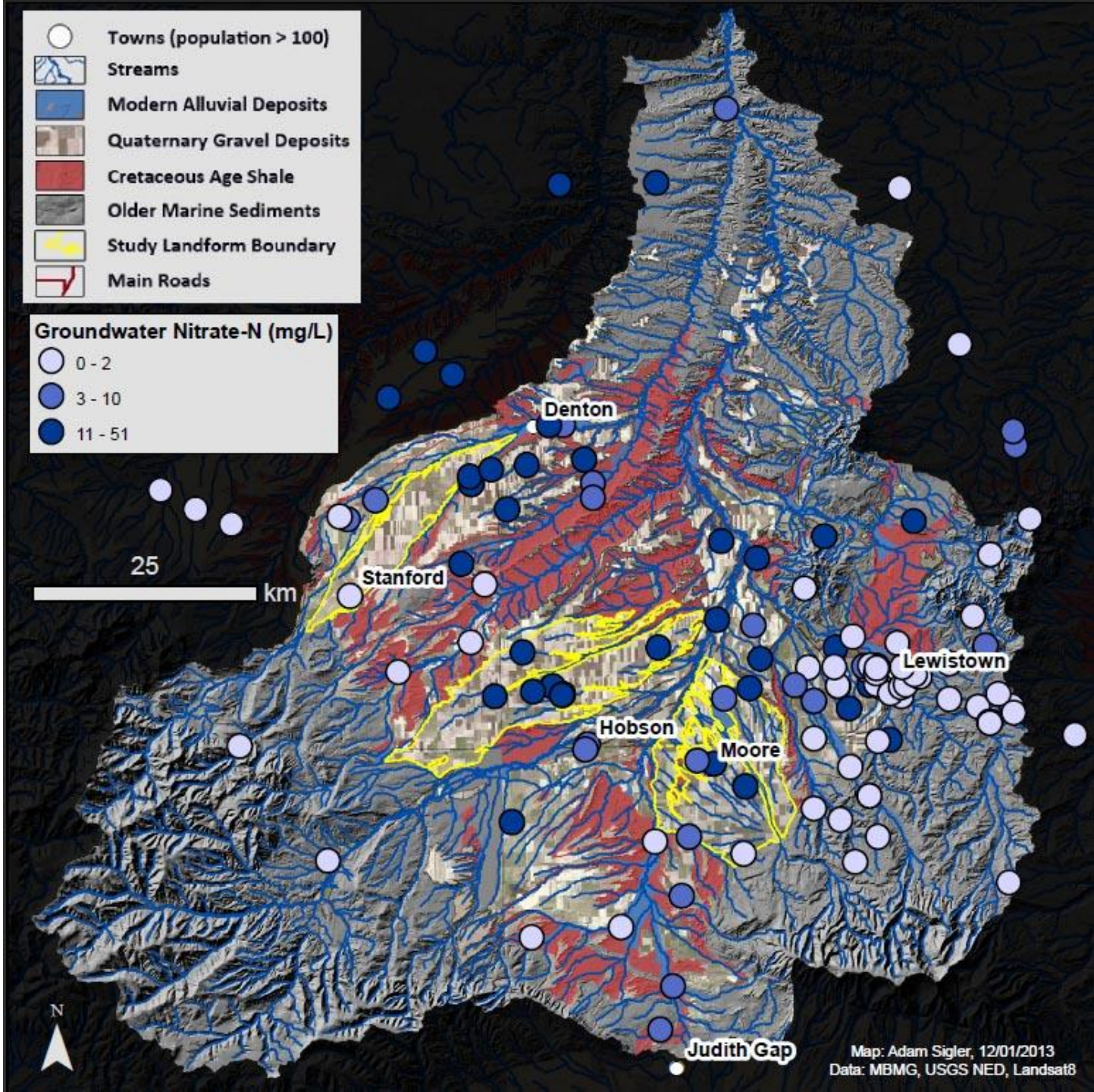
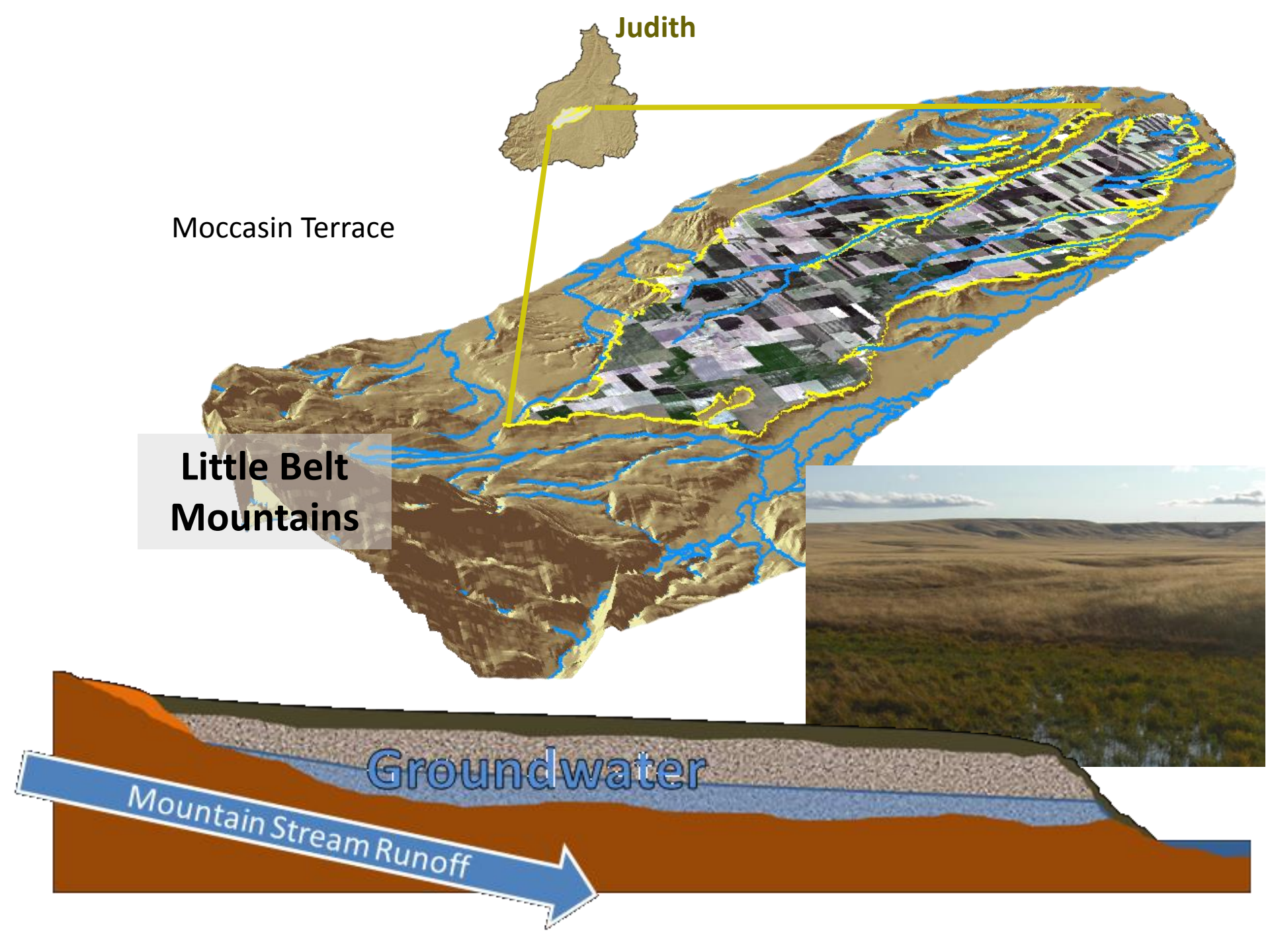
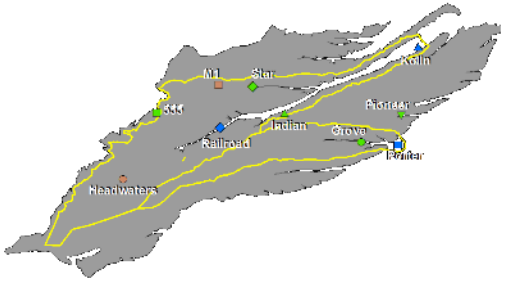
How much nitrate is in groundwater and leaving watershed in streams?




Judith
Moccasin Terrace
Little Belt Mountains
Groundwater
Mountain Stream Runoff



Nitrate in Water

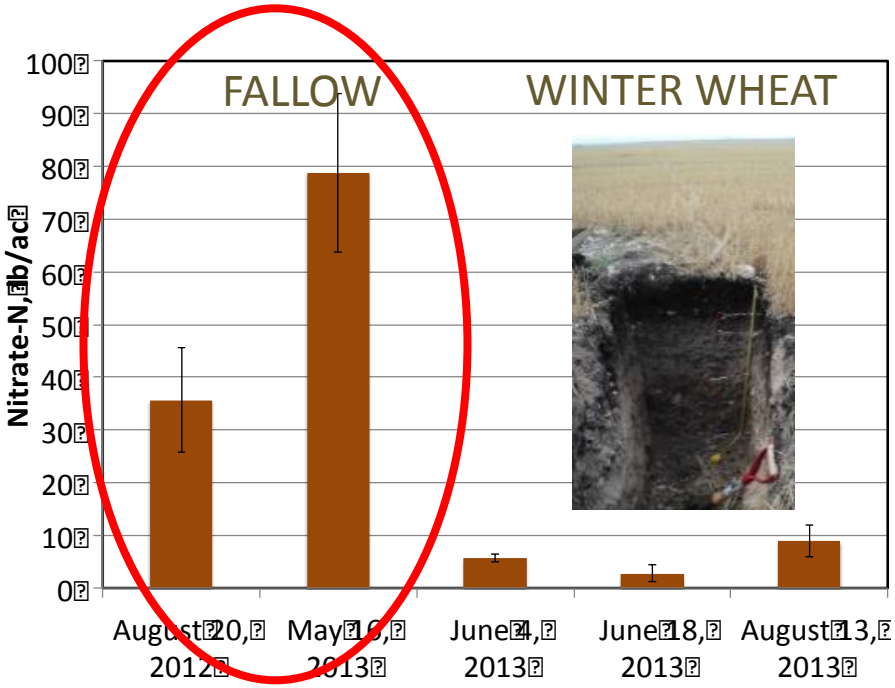
At $0.50/lb= $5 million N in Moccasin terrace aquifer

Where is the nitrate coming from?

Nitrate Sources: shale?

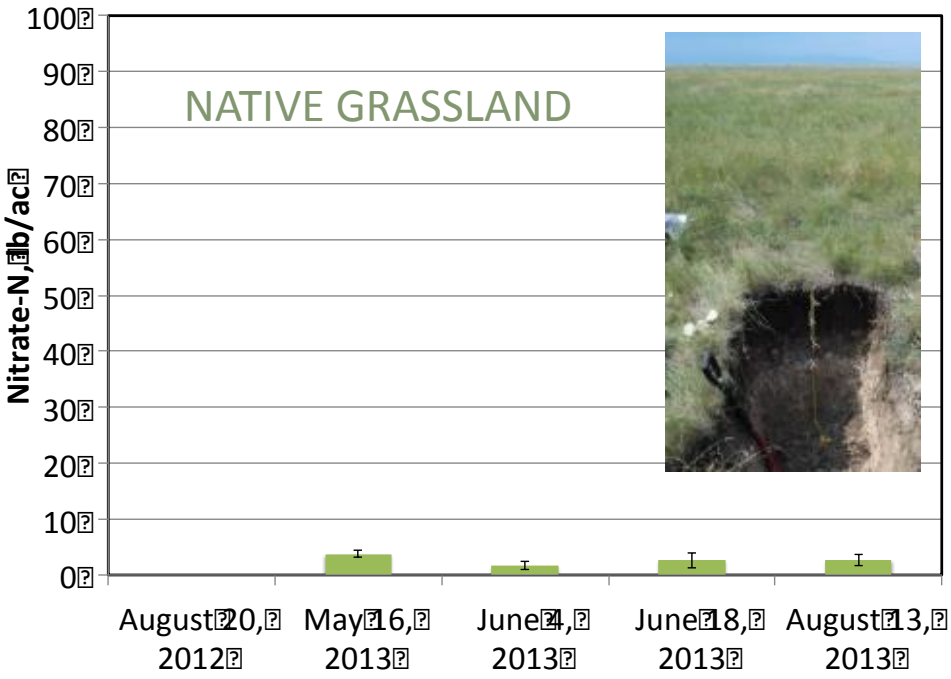
Take Home: In groundwater, no more than 7% of nitrate is from shale even using very conservative numbers; probably less than 2%.

Nitrate Sources: native range soils?

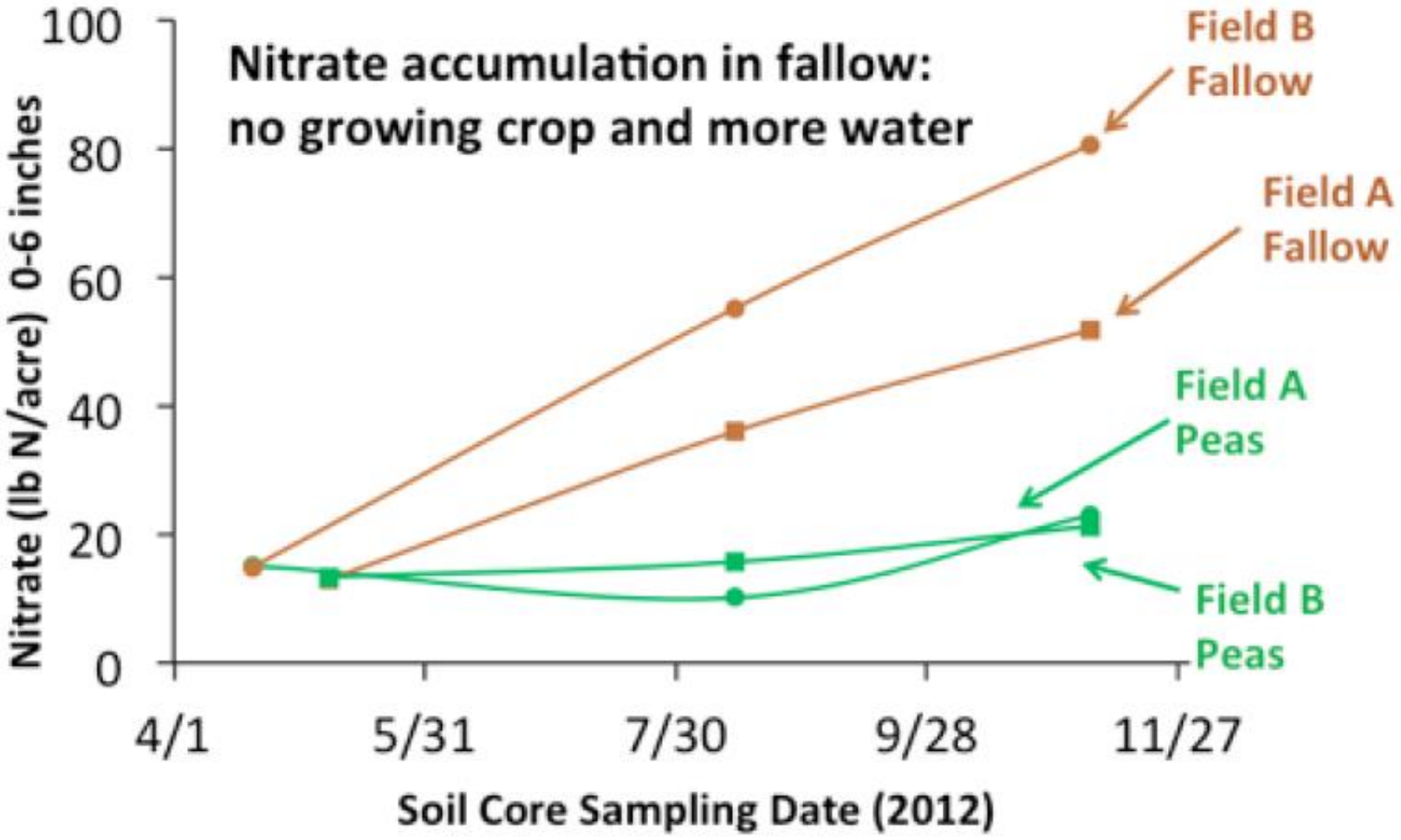


Nitrate-N, 0-12 inches

Take Home: Nitrate production from organic matter in fallow and over winter, combined with fertilization in spring, create a leaching-susceptible pool.



Nitrate Source:
Organic matter mineralization mainly during fallow



Take Home: Mineralization of organic matter is 30-60 lb/acre in the top 6 inches; this is on par with annual fertilizer rates.

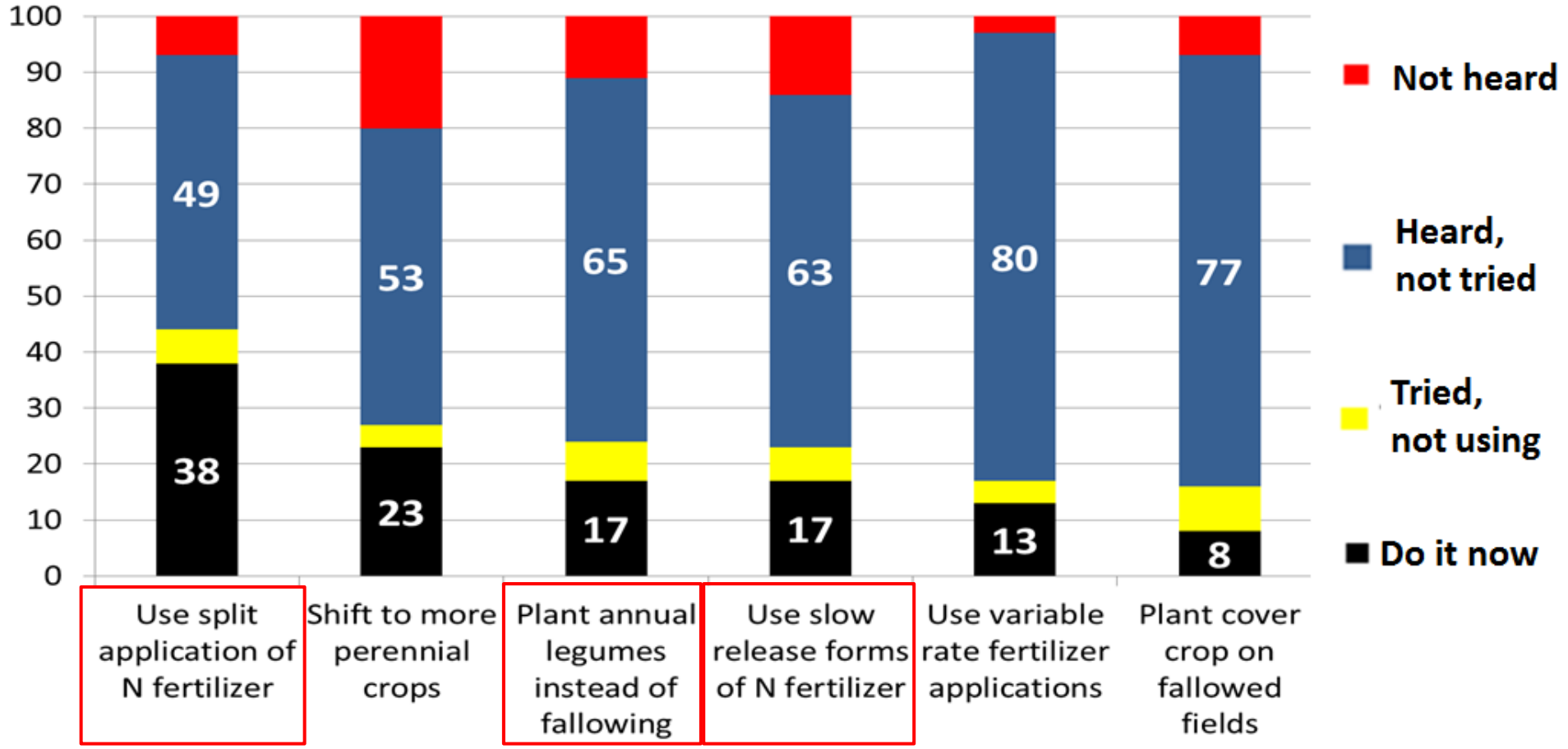
Nitrate source summary

- Least important
  - Shale is not as important as cultivated soil
  - Native range (and likely perennial forages) not an important source
- Most important
  - Organic matter (via mineralization)
  - Fertilizer
  - Mineralization is on par with fertilizer

How decide management practices to study?

- Surveyed ~300 producers in Judith Basin and Fergus Counties to determine present practices (59% response rate)
- Met with two research advisory groups from Judith River Watershed
- Selected practices that advisory group members felt were practical/economical.

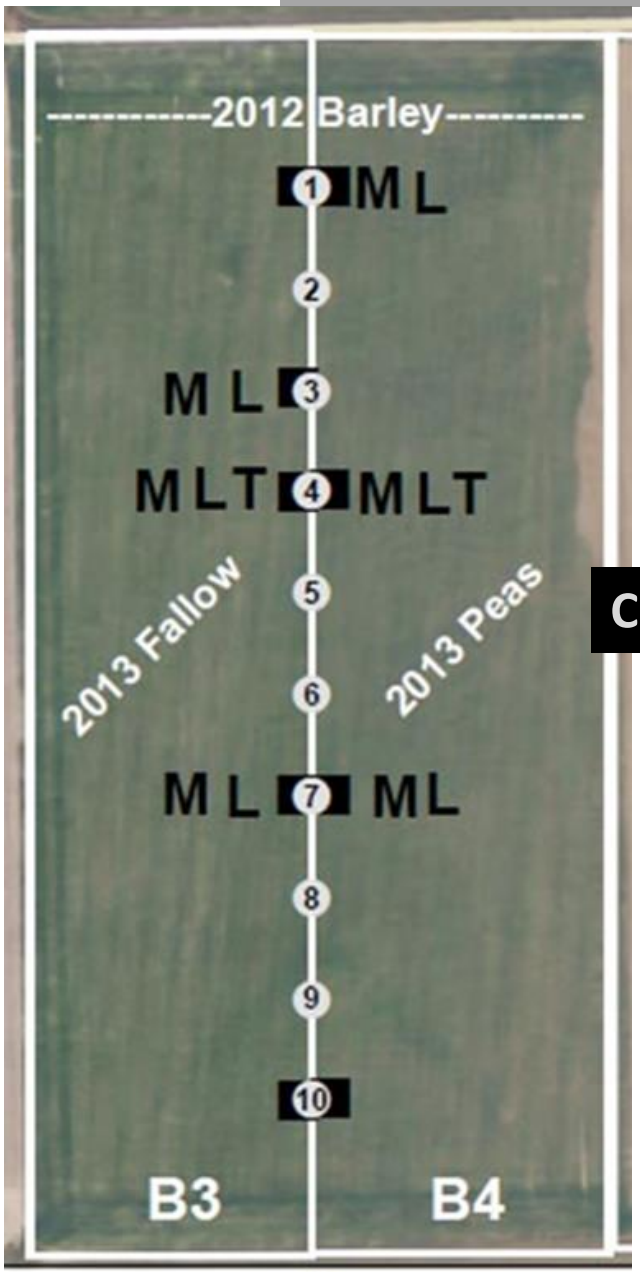
Nitrogen management practices (subset)



Didn't want to choose:

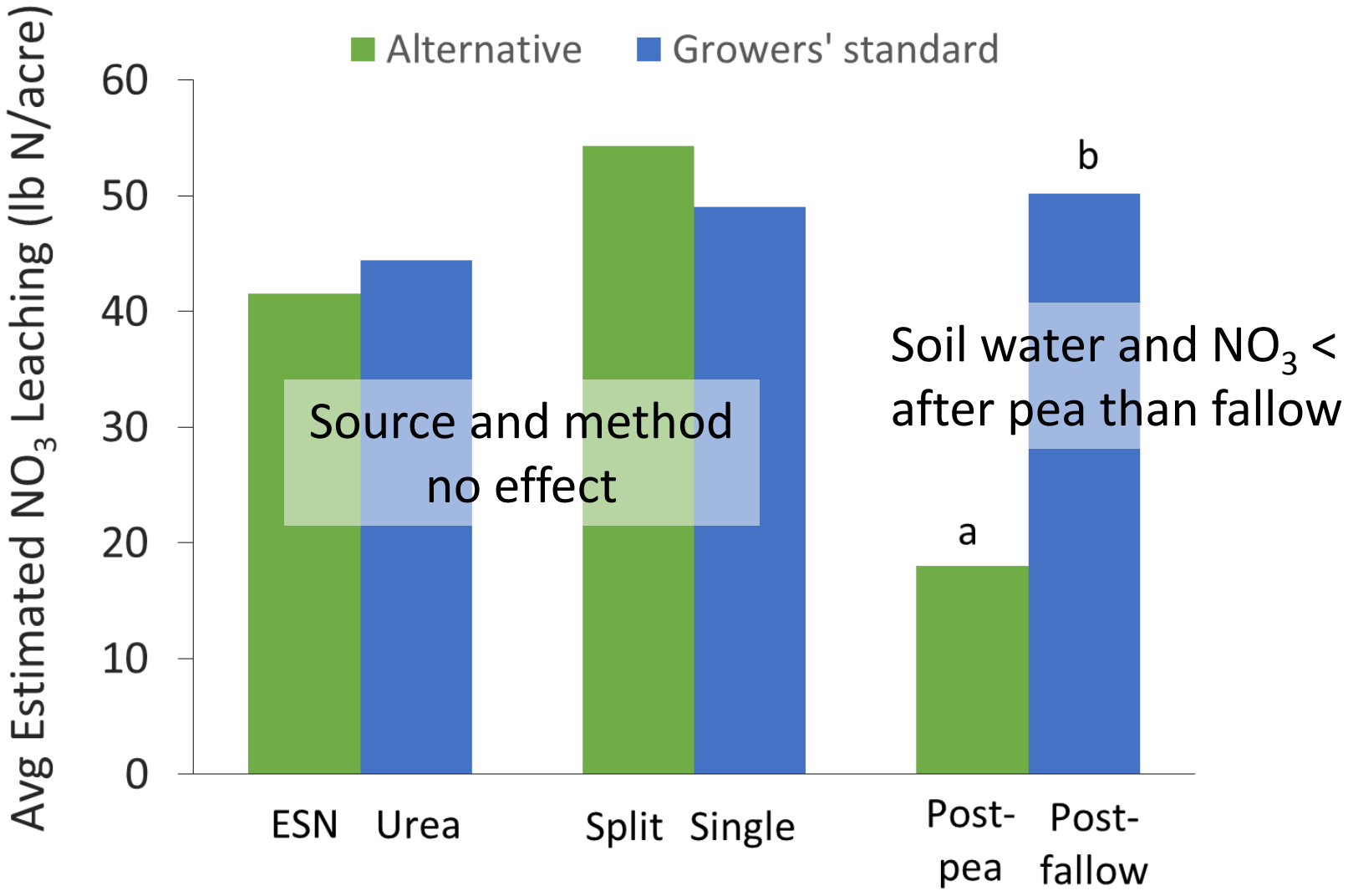
1. things no one has heard of
2. things that people have tried and abandoned

Farming over Instruments

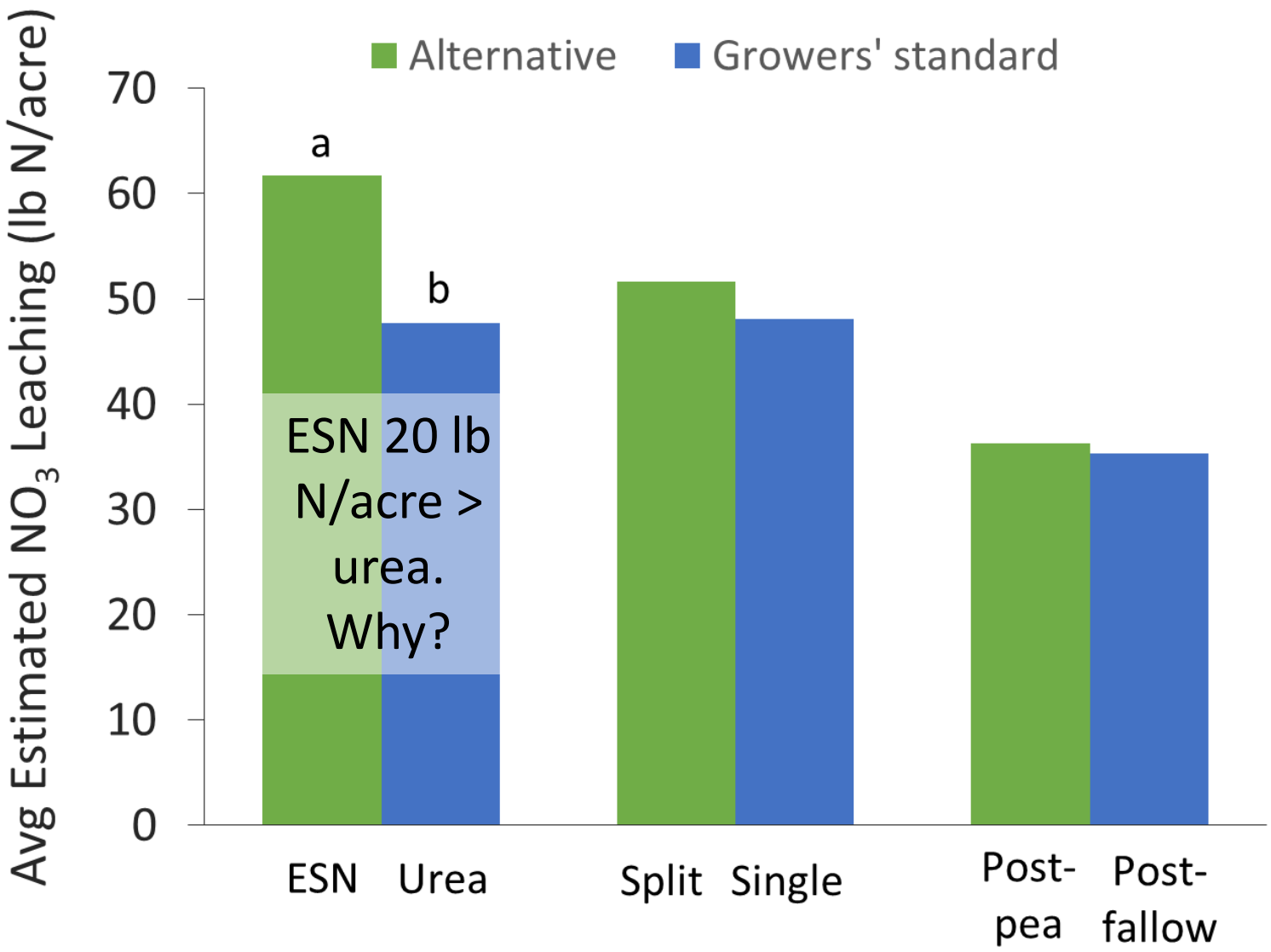


Constant interaction on logistics = relationship building

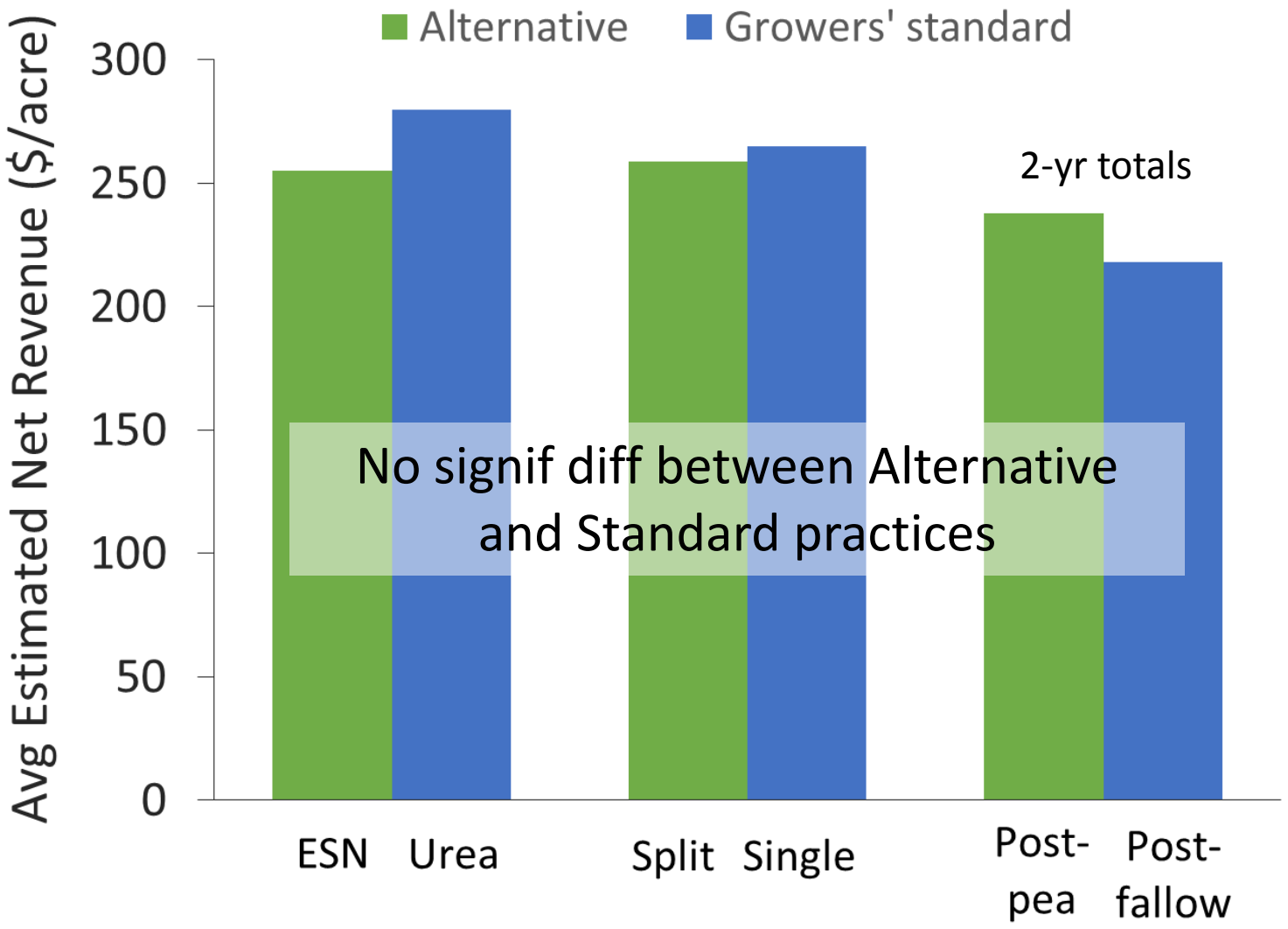
Estimated nitrate leaching Aug 2012 to Aug 2013 under winter wheat



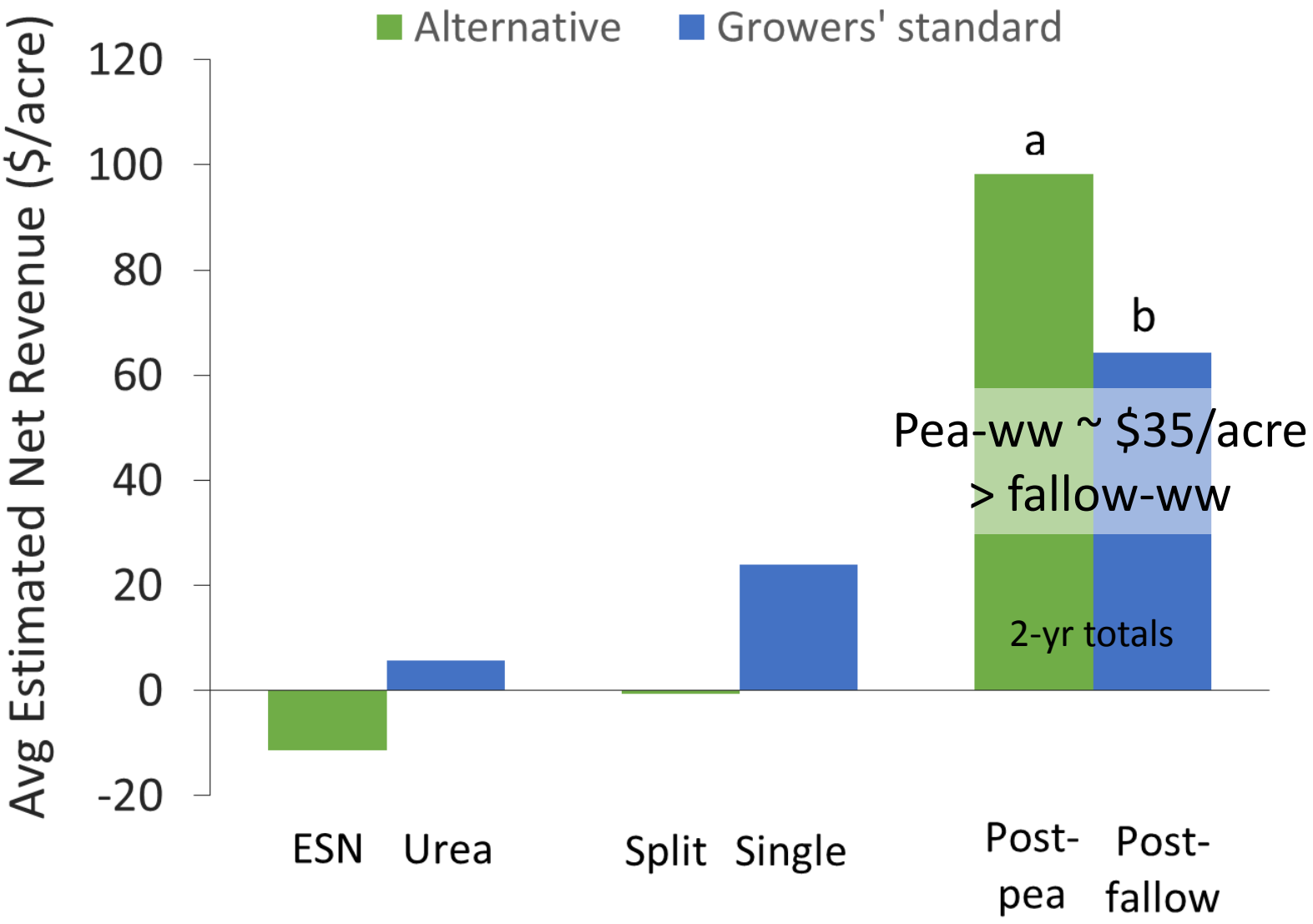
Estimated nitrate leaching in Aug 2013 -Aug 2014 crop year

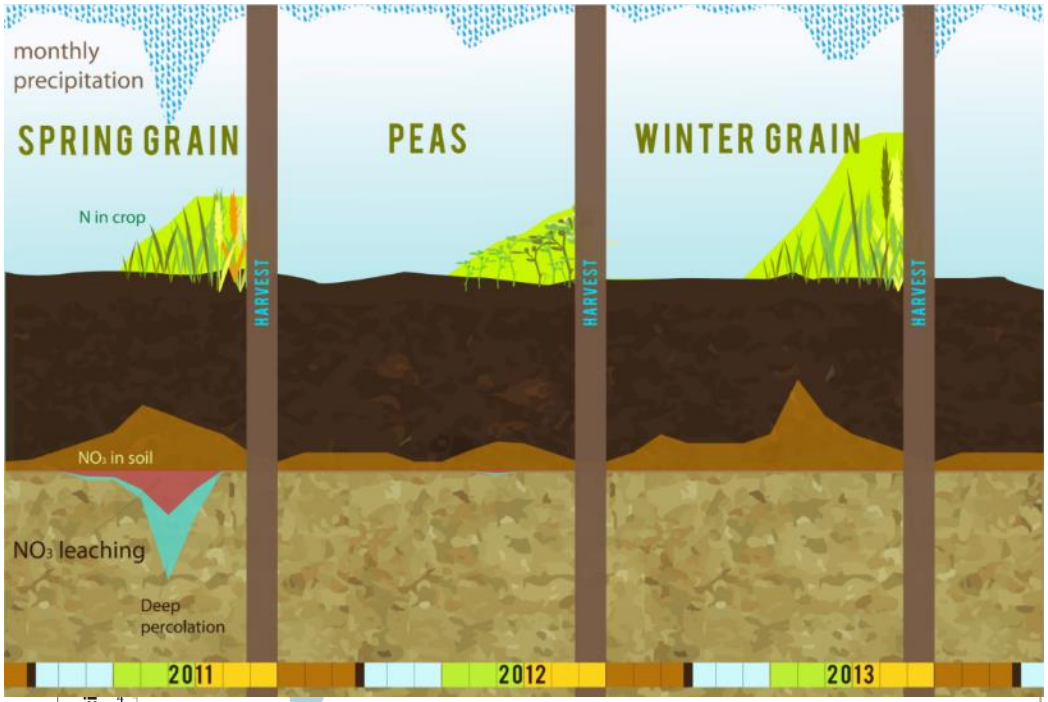


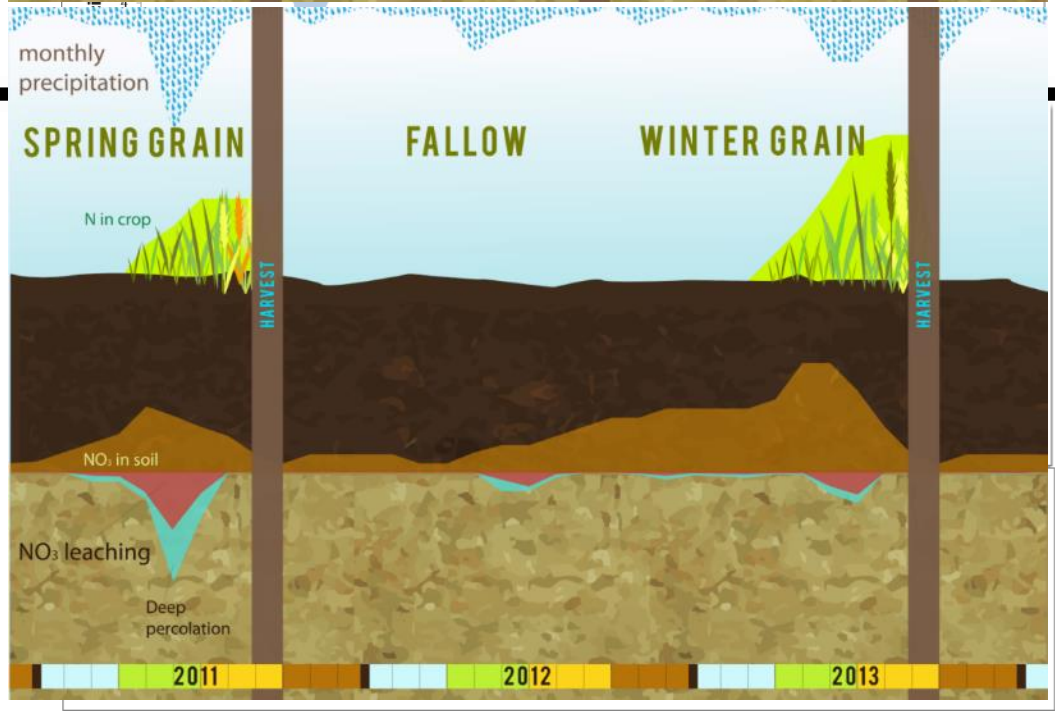
2013 Net Revenue (w/out NRCS payments)



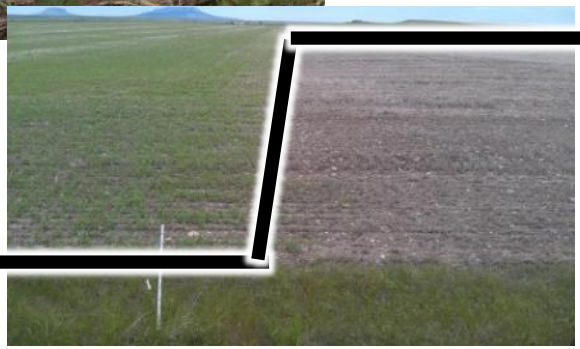
2014 Net Revenue (w/out NRCS payments)



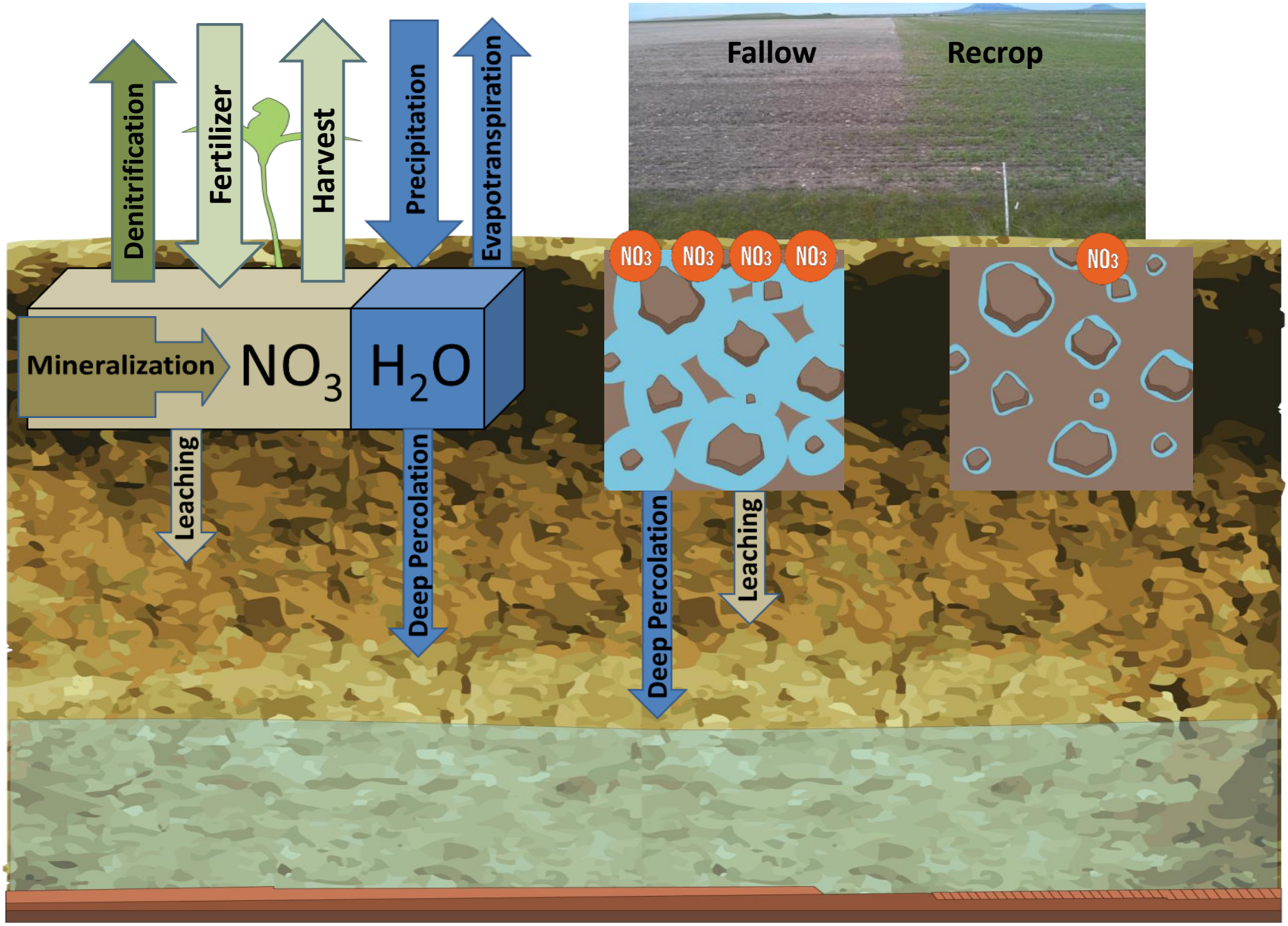

monthly precipitation
SPRING GRAIN
PEAS
WINTER GRAIN
N in crop
HARVEST
HARVEST
HARVEST
NO₃ in soil
NO₃ leaching
Deep percolation
2011
2012
2013


monthly precipitation
SPRING GRAIN
FALLOW
WINTER GRAIN
N in crop
HARVEST
HARVEST
HARVEST
NO₃ in soil
NO₃ leaching
Deep percolation
2011
2012
2013

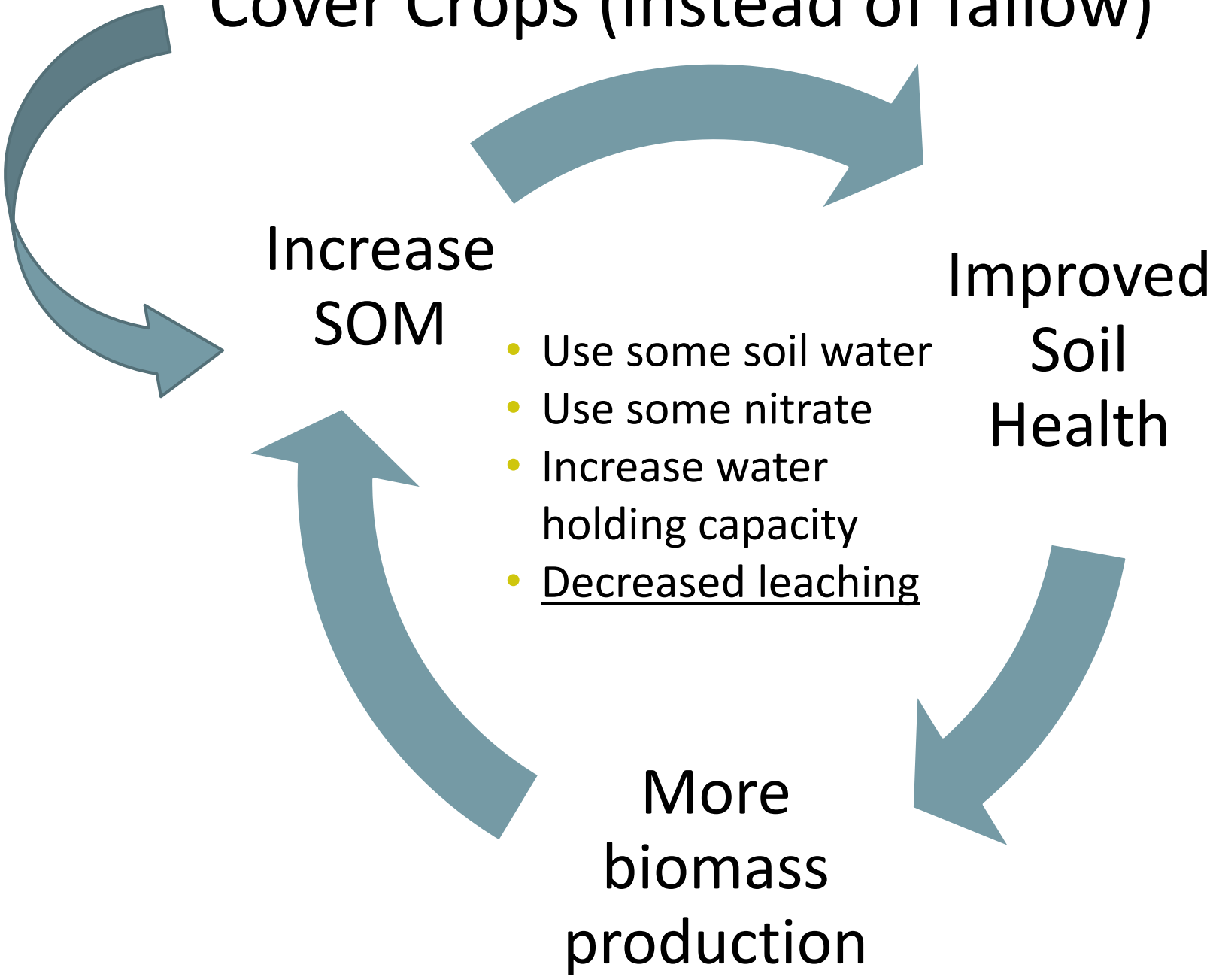

Peas




Fallow


Denitrification
Fertilizer
Harvest
Precipitation
Evapotranspiration
Fallow
Recrop
Mineralization
NO_3
H_2O
NO3
NO3
NO3
NO3
NO3
Leaching
Deep Percolation
Deep Percolation
Leaching

Cover Crops (instead of fallow)



Summary

- Nitrate in groundwater is a growing economic and environmental issue
- Nitrate leaching requires both deep percolation and soil nitrate
- In Montana, most nitrate is likely from fertilizer and organic matter decomposition
- Practices that decrease deep percolation and soil nitrate levels (e.g. fallow replacement, perennials) will likely be more effective than practices that only affect soil nitrate

Questions?

For more information see MSU Extension's

Nutrient Management Modules:
http://landresources.montana.edu/nm/

Soil & Water Management Modules:
http://landresources.montana.edu/SWM

Crop & Fertilizer Management Practices to Minimize Nitrate Leaching
http://landresources.montana.edu/soilfertility/publications.html

Cover Crop Research
http://landresources.montana.edu/soilfertility/covercrops.html

Judith River Watershed Project
http://waterquality.montana.edu/judith/index.html