Role of perennial forages in prevention and remediation of nitrate impacts

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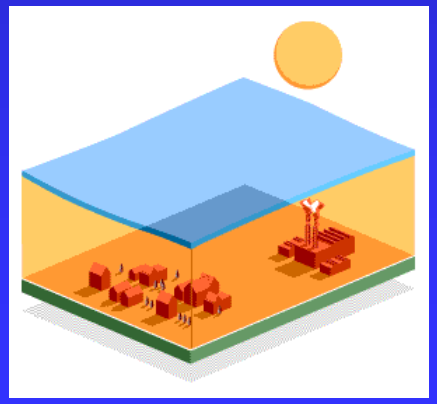
Valenti

So, what's the problem with nitrate losses?

- Drinking water quality
  - Blue baby syndrome
  - Possible chronic effects
- Hypoxia (The "Dead Zone")
- Fresh water quality
- Nitrous oxide emission
  - Greenhouse gas
  - Ozone depletion
- Economic loss

Robert Ardinger, Jr., M.D.



BBC World

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Increased expenses
Increased regulatio
Uncertain future

The public is interested

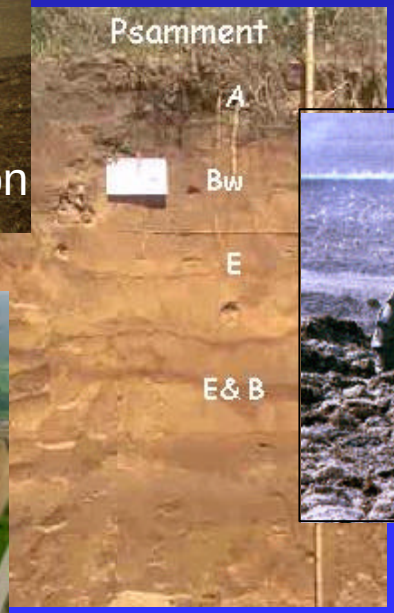
- Over 80% are concerned about water and air pollution, and loss of habitat [1]
- Over 80% agreed that stricter laws are needed to protect the environment [2]
- Nearly 90% in the Midwest favor additional incentives for farmers [3]

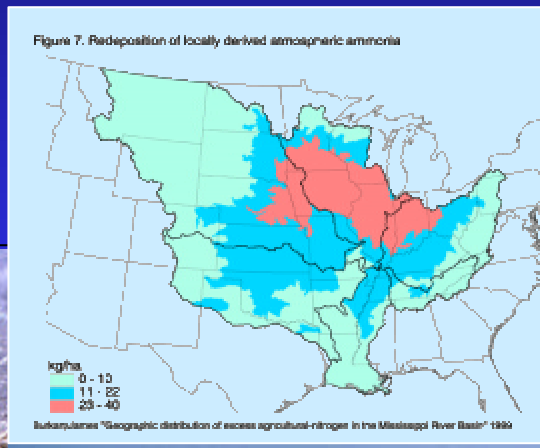
[1] nationwide Gallup Organization poll, 2001
[2] nationwide poll by Pew Research Center for the People and the Press, 1999
[3] regional poll by American Farmland Trust, 2001

Excess N loading of soils and water occurs by

- traditional agricultural practices (e.g. inappropriate timing)
- shallow or sandy soils
- tile drained soils
- excess manure or fertilizer application
- unaccounted-for sources (N deposition, mineralization)
- spills during manufacture, storage, and transport


Fall N fertilizer application





Perennial forages protect the environment

- Reduced runoff
- Less nitrate drainage
- Removal of excess N
- Reduced N fertilizer needs
- Improved air quality
- Enhanced wildlife habitat

GOAL: Reduce nitrate leaching

- Reduce the flow of water
  - Increase water use
  - Manage irrigation

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1. High yield
2. Large leaf area
3. Extended growing seaso
4. Deep roots

1. Minimum rates
2. Know your soil
3. Watch the weather

GOAL: Reduce nitrate leaching

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  - Increase water use
  - Manage irrigation
- Lower the nitrate concentration
  - High N requirement
  - Long season of uptake
  - Improved rates, timing

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- Reduce the flow of water
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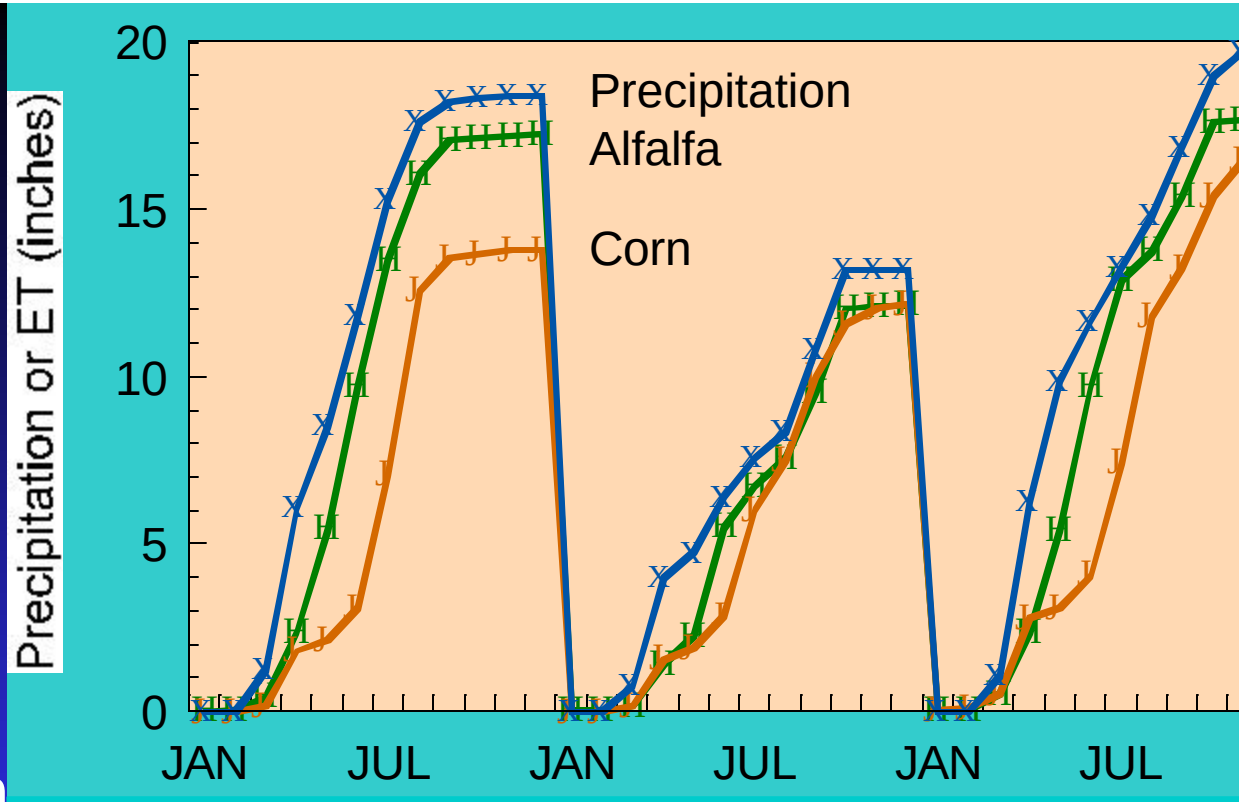
- Lower the nitrate concentration
  - High N requirement — High yield, high protein
  - Long season of uptake — Especially early and late
  - Improved rates, timing

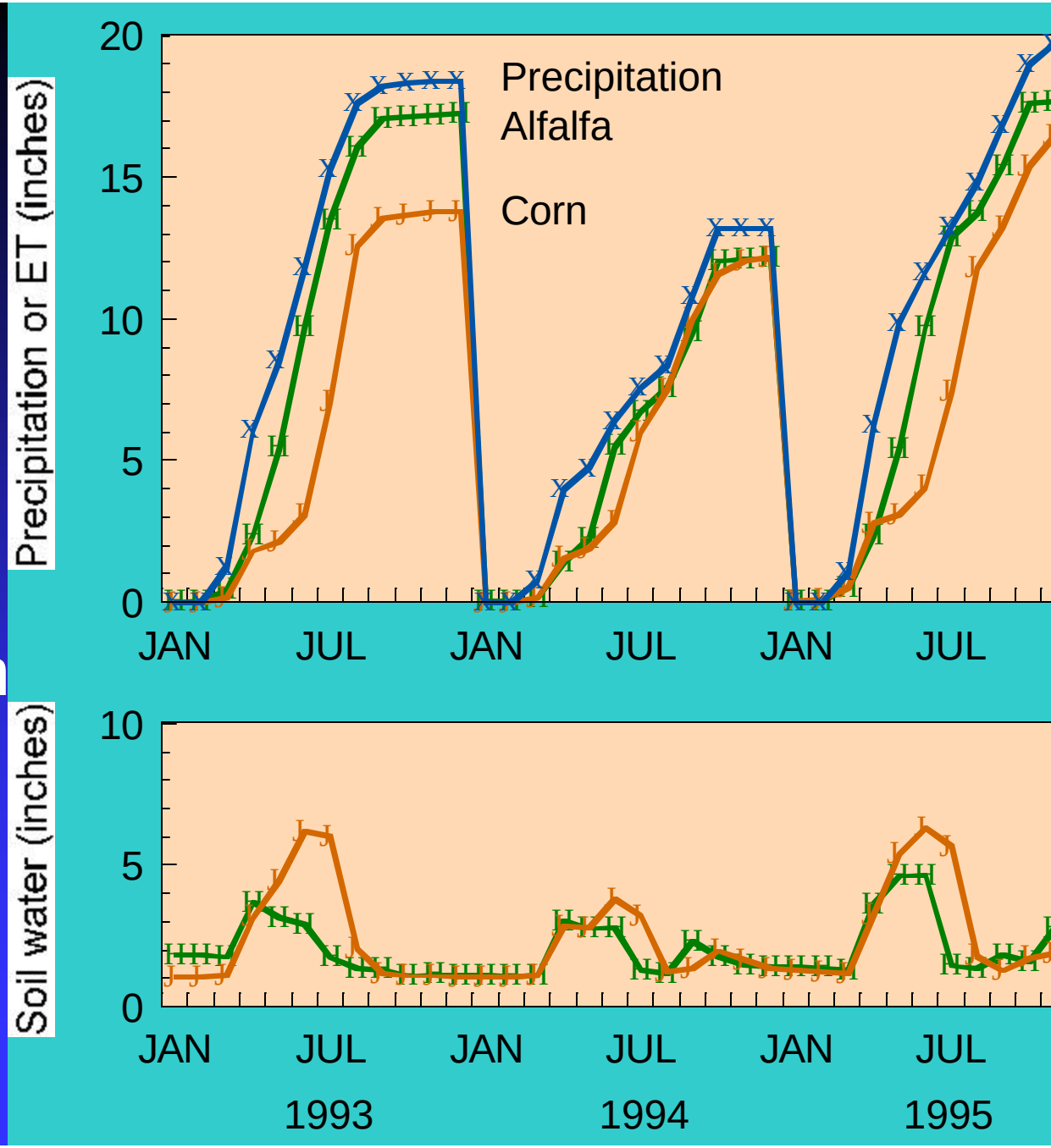
Timing of growth, water use, N demand

Cool-season vs. Warm-season

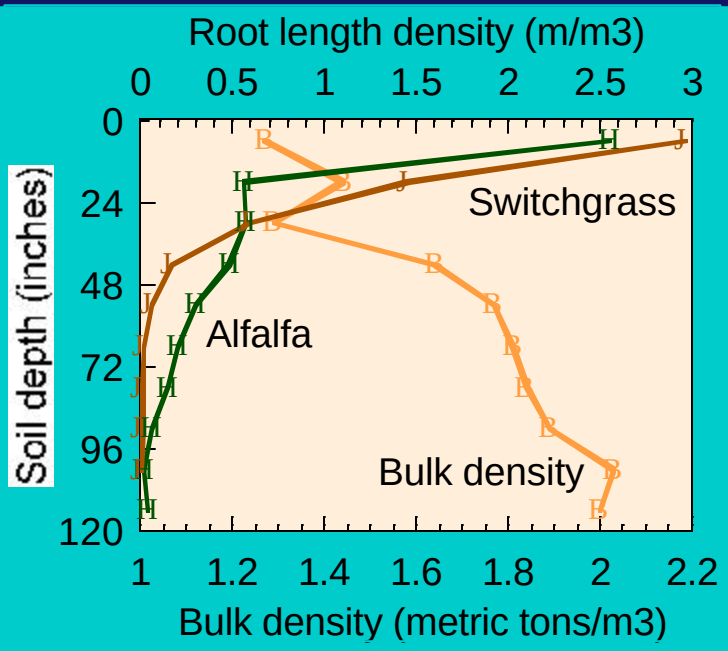


Timing of growth, water use, N demand

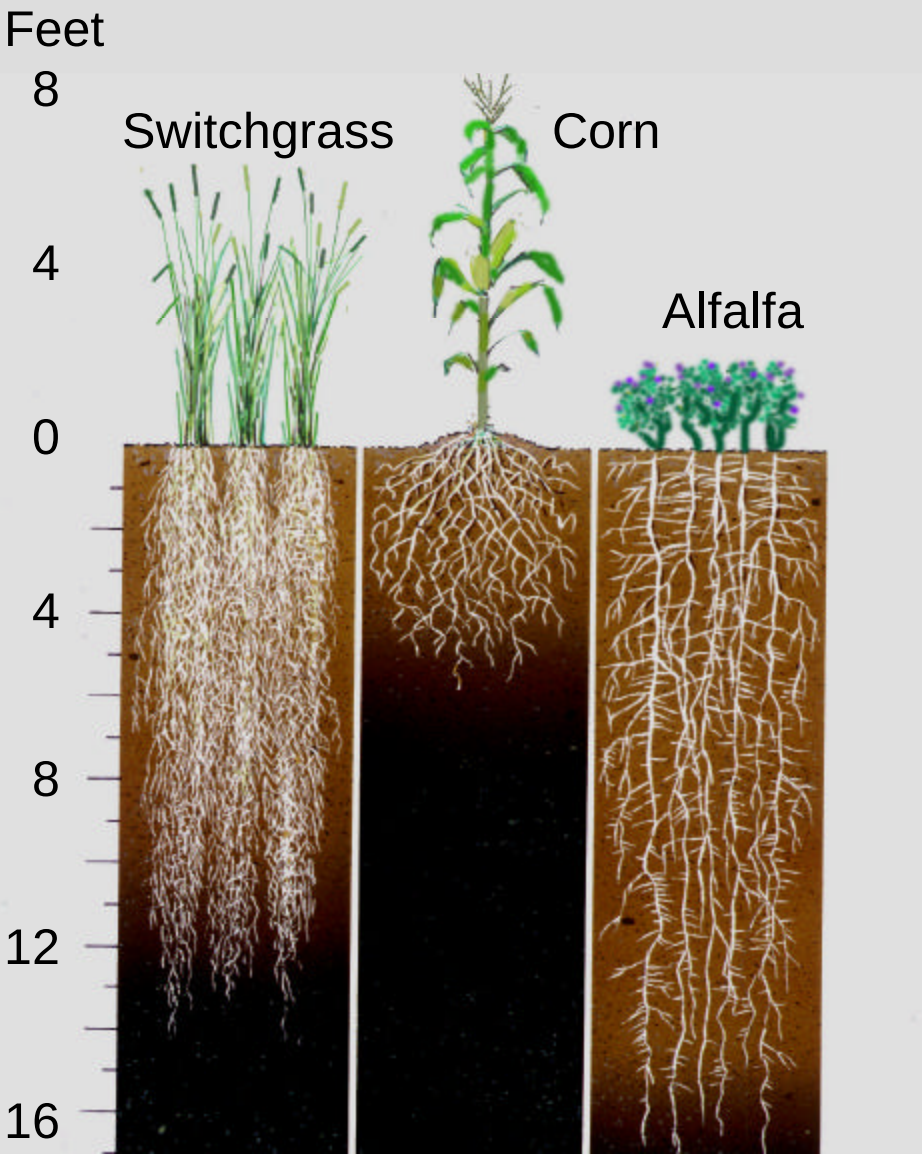
Cool-season vs. Warm-season



Rooting depth



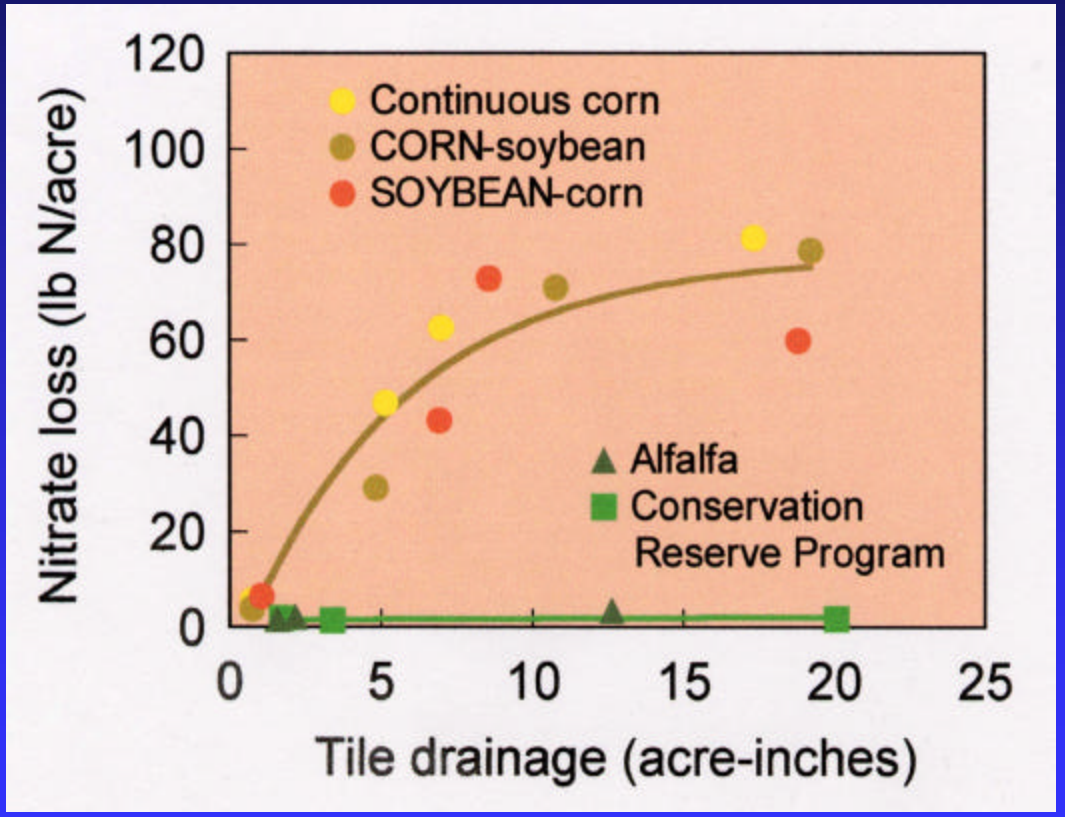
Russelle et al., 1993



Perennial forages reduce nitrate loss from tile drains –

a partial solution for hypoxia?

40 million acres are tile drained in the Upper Midwest



Randall, Huggins, Russelle et al., 19

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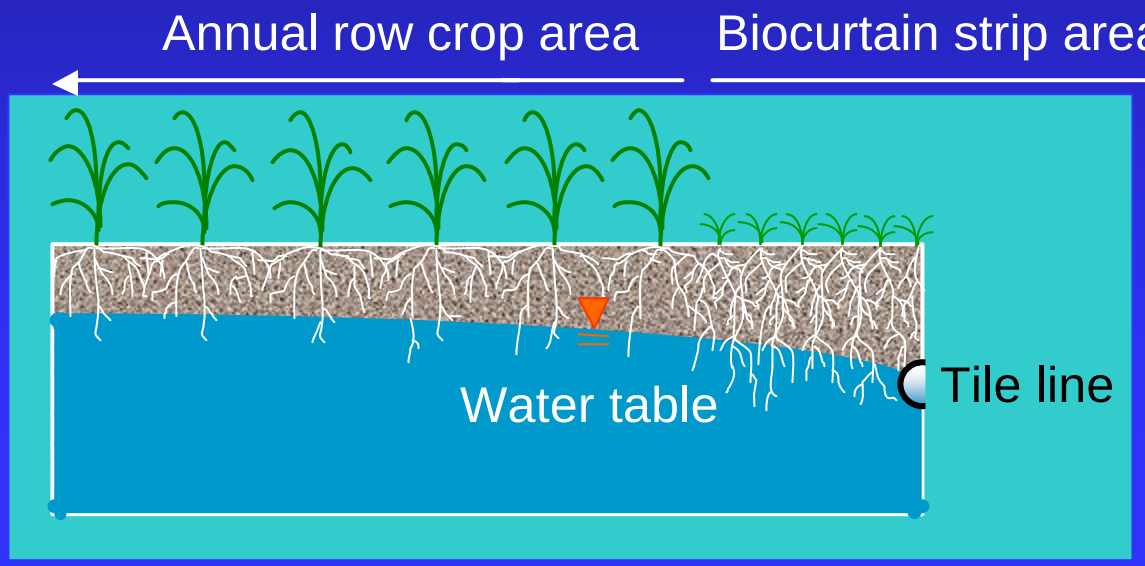
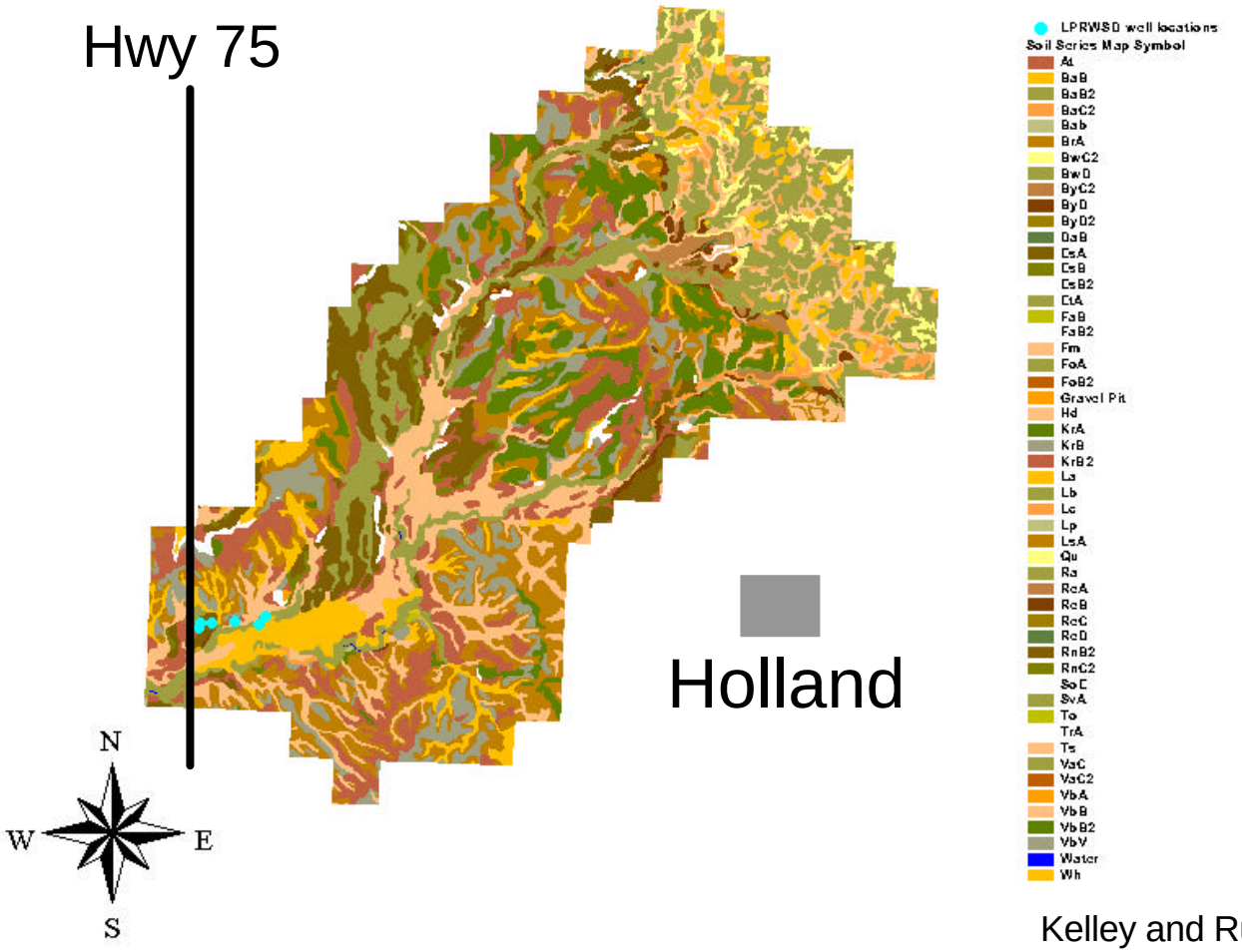


Strategic planting of perennials to prevent nitrate loading of ground water

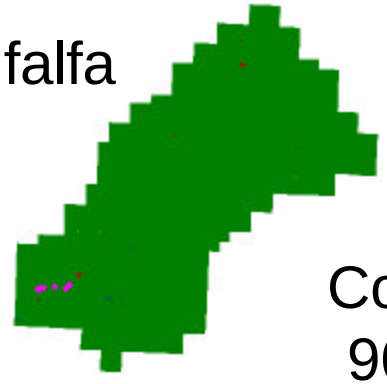
Holland wellfield soils map



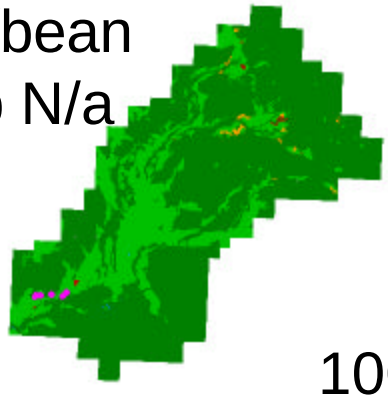
Kelley and Russelle, 2001

Predicted nitrate loss
no irrigation
GLEAMS

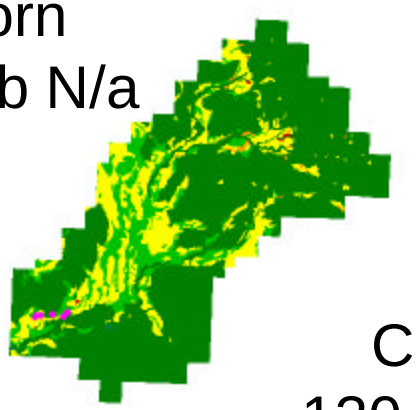
Alfalfa



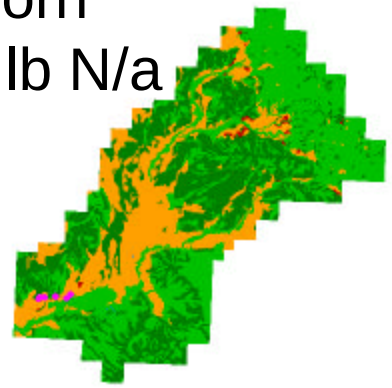
Corn/bean
90 lb N/a



Corn
100 lb N/a



Corn
130 lb N/a



< 2 lb N/a Dark green
2-4 lb N/a Light green
4-8 lb N/a Yellow
8-16 lb N/a Orange
> 16 lb N/a Red

Kelley and Russelle, 2002

Predicted nitrate loss
irrigation
GLEAMS

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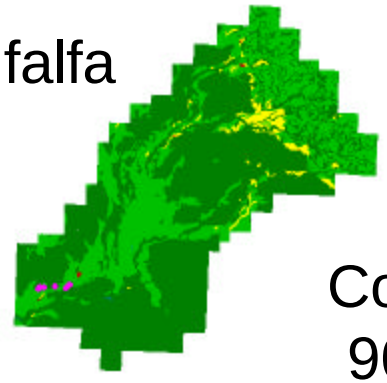

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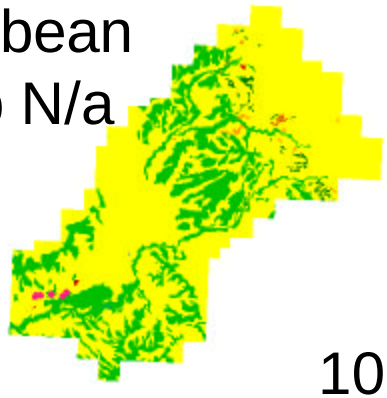

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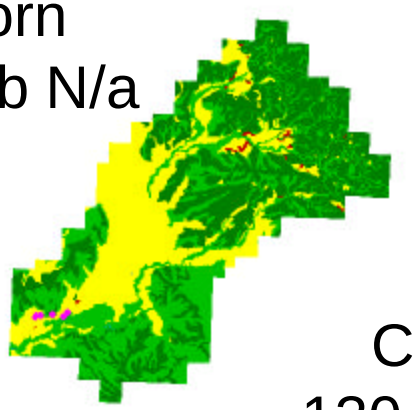

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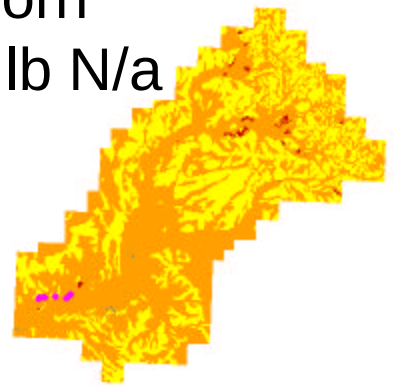

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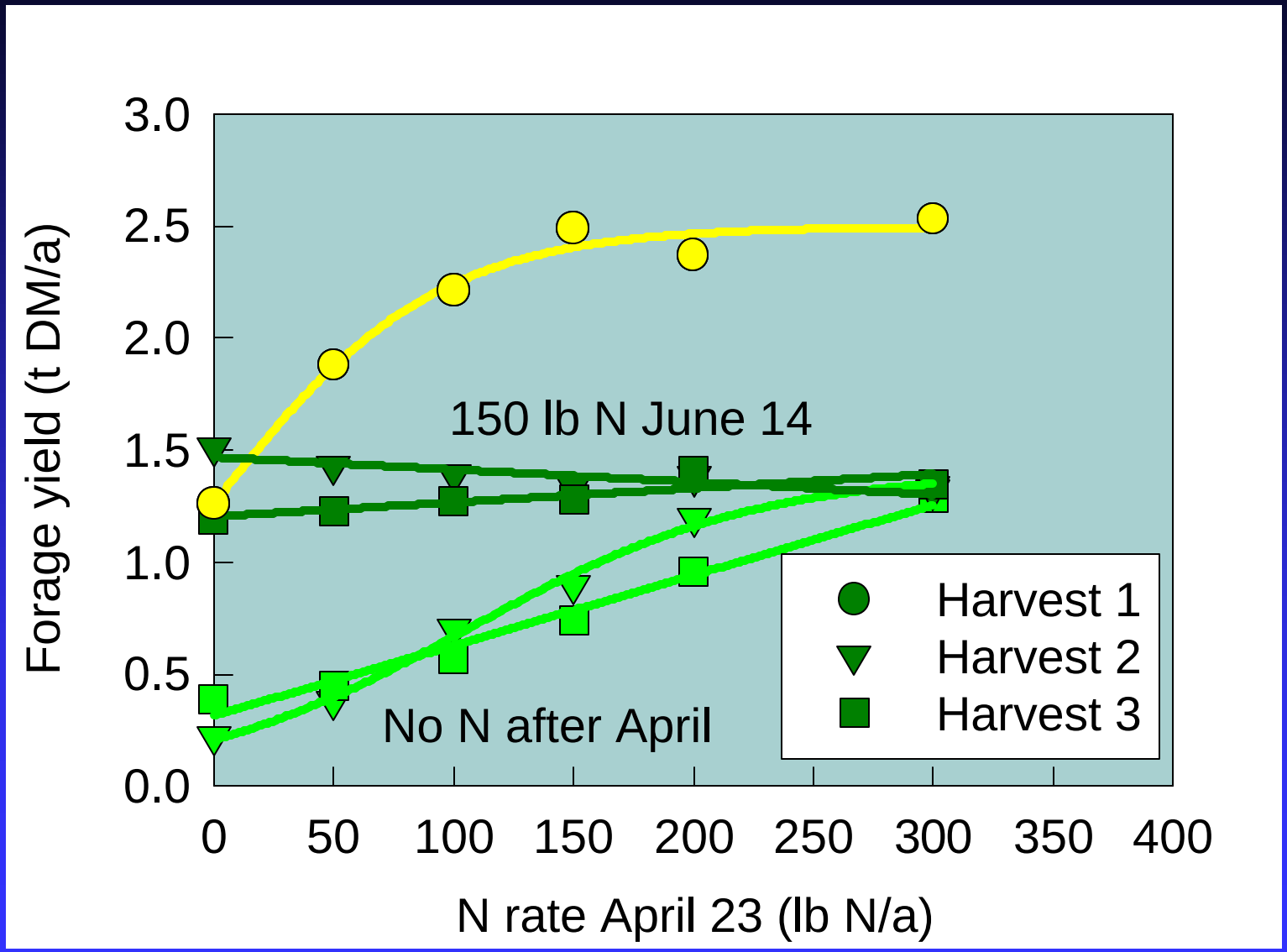
Kelley and Russelle, 2002

Predicted annual nitrate leaching loss (lb N) for 23,500 acres of Holland WPZ

Water regime	Alfalfa	Continuous Corn 100	Continuous Corn 160
Dryland	610	29,300	192,400
Irrigated	32,400	61,700	335,500

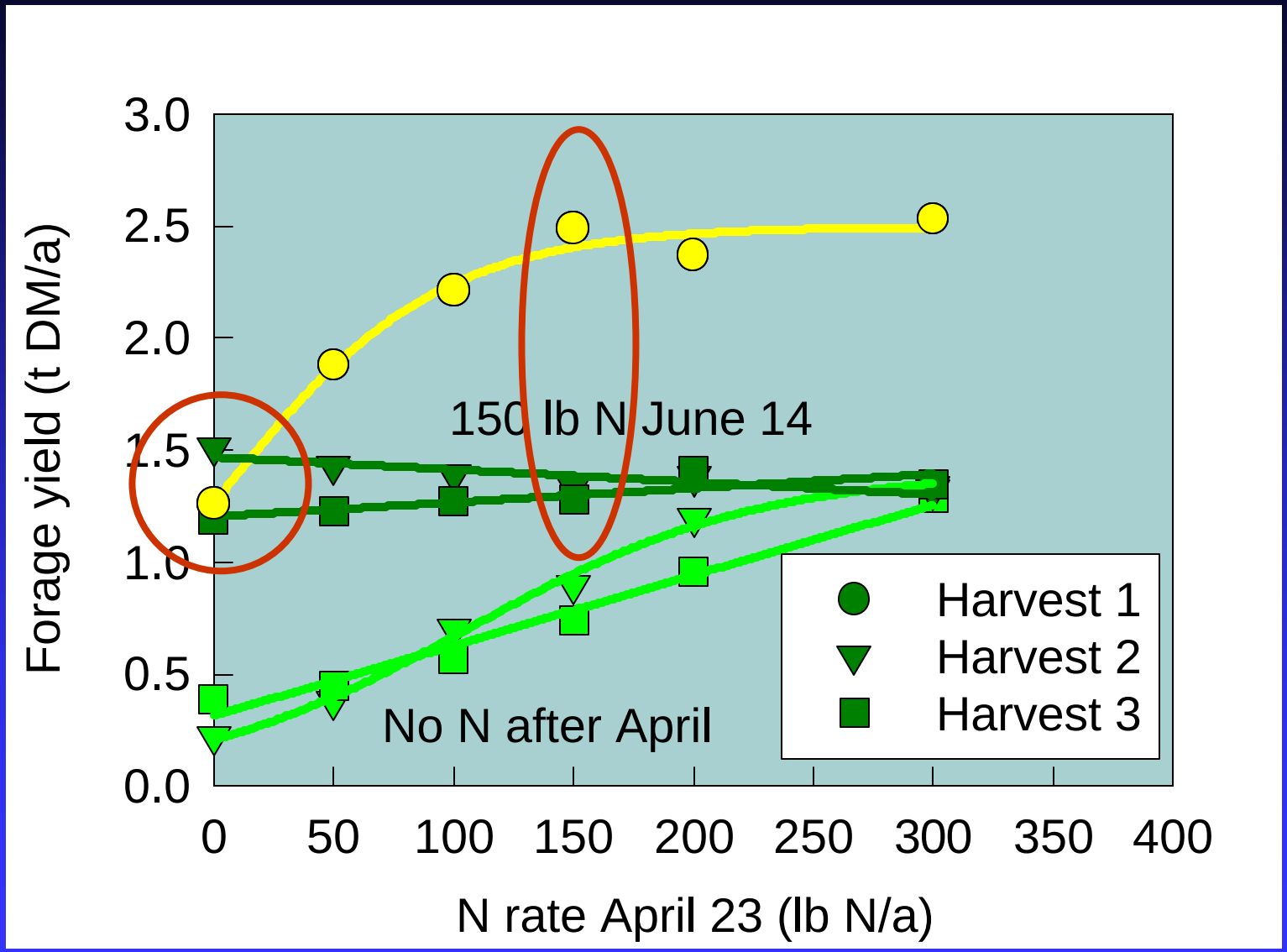
Irrigation was applied when available water supply fell to 25%.
Used 1989-1998 weather record; did not predict future weather.
Water was added to attain 90% available water holding capacity of each soil. Assumed **5 ppm** nitrate-N in irrigation water.

Timing and rate of N



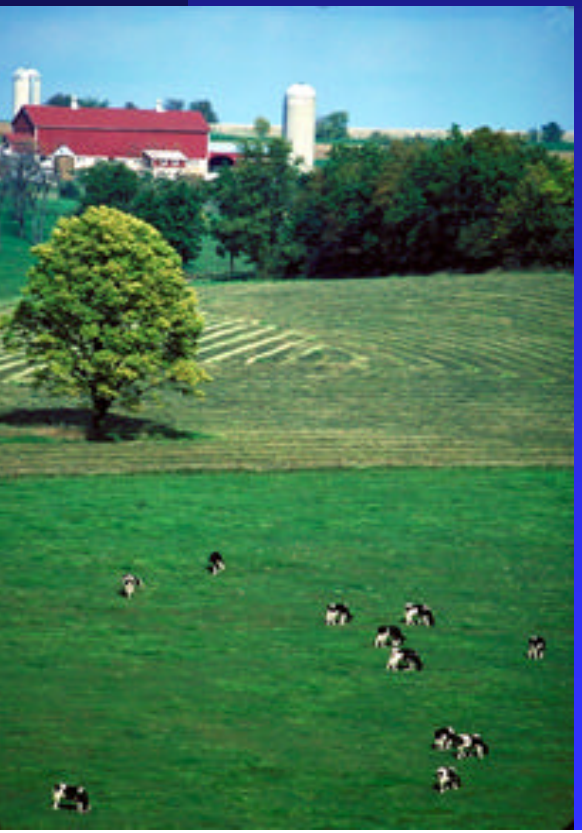
Vetsch et al., 1999

Timing and rate of N



Vetsch et al., 1999

Ground water supplies are protected under well-managed grazing in the Midwest



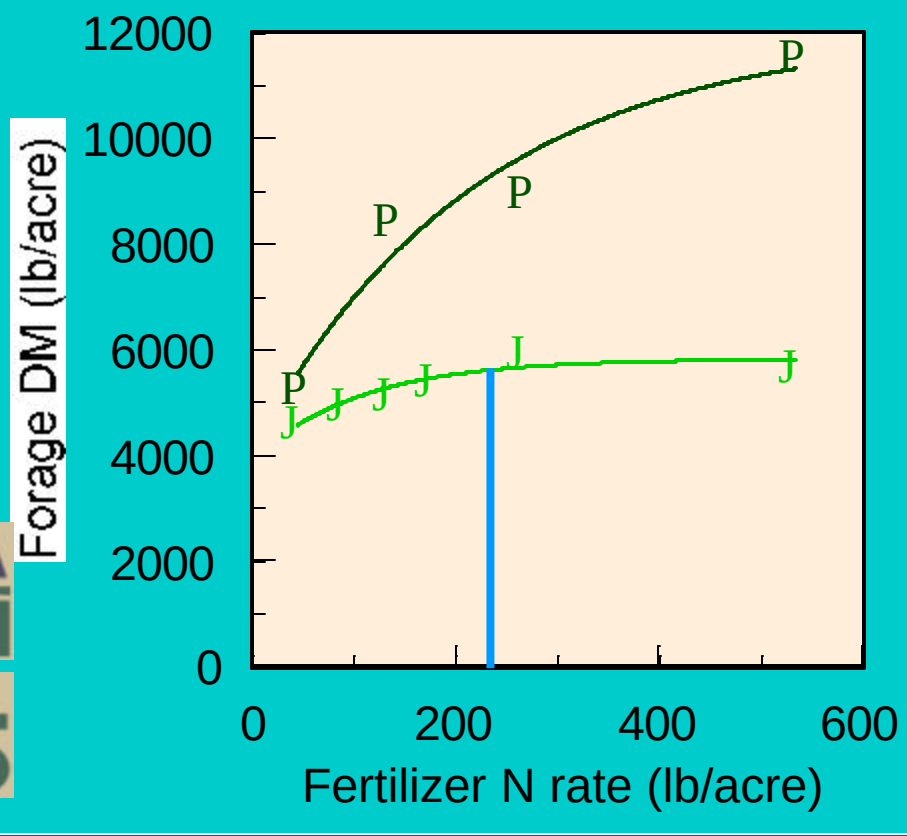
In WI and MN, *little nitrate is lost by leaching* with moderate N rates on fine-textured soils under rotational grazing with sheep, lactating dairy cows, and dairy heifers.

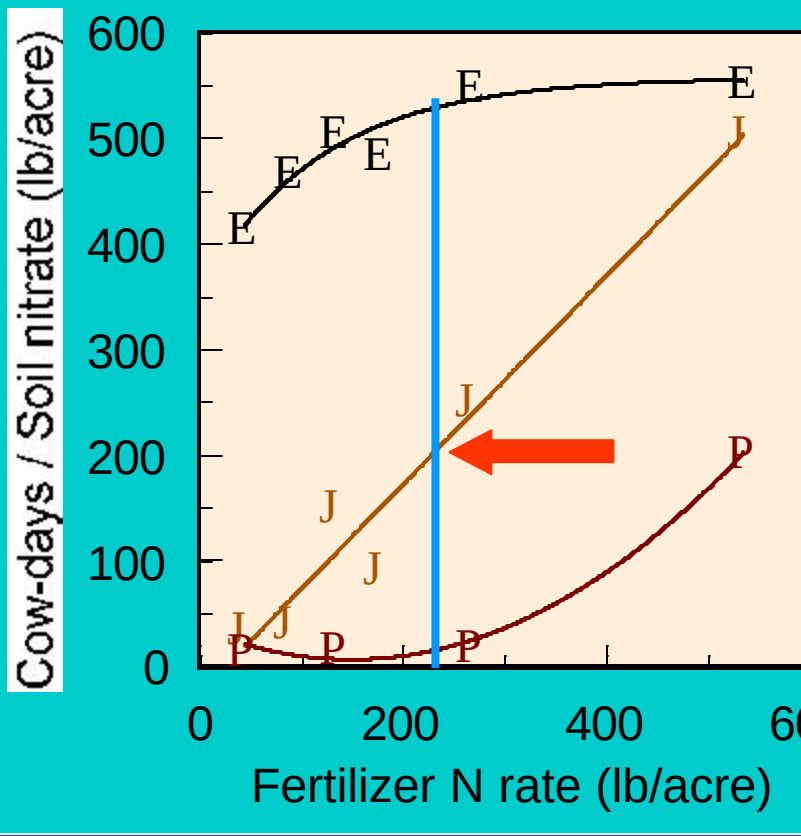
Leaching may occur in sandy soils, but groundwater impacts appear to be short-lived. *Hypothesis:* Pastures may enhance denitrification.

Serious questions remain about wintering livestock outside.

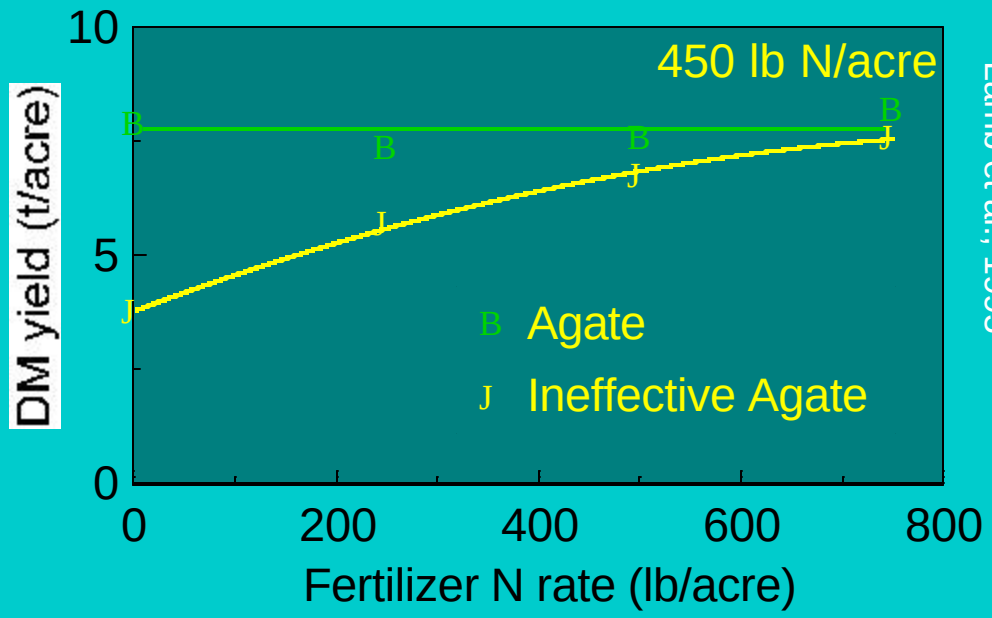
Fertilizer N improves pasture productivity, but increases the likelihood of nitrate leaching in the Midwest

Russelle et al., 19





Legumes help balance N



Lamb et al., 1995

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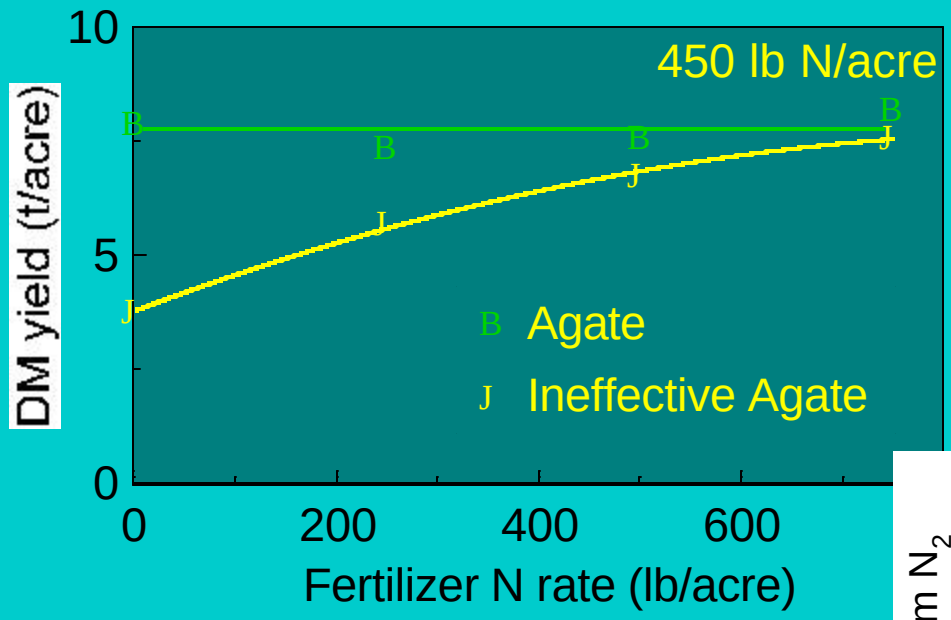
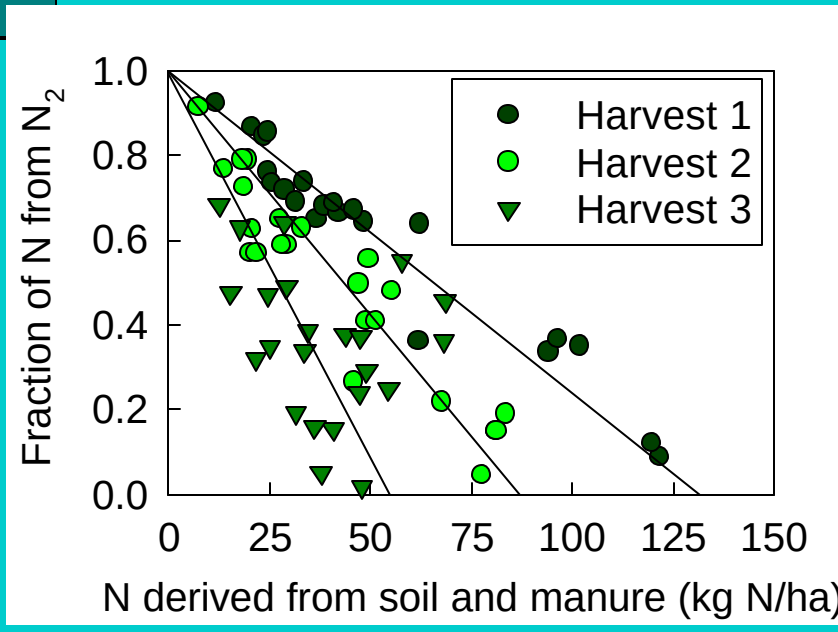
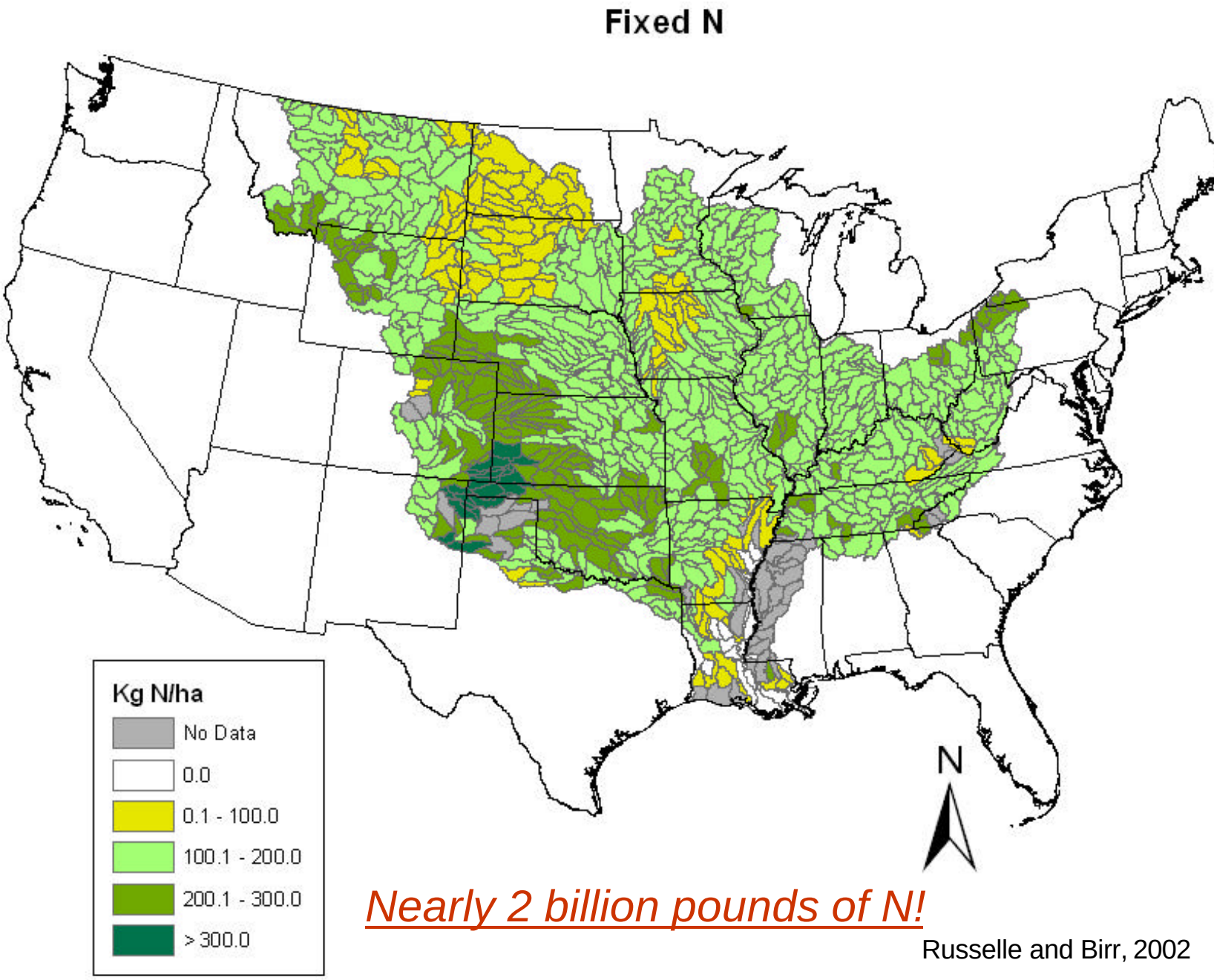




Russelle et al., 2003

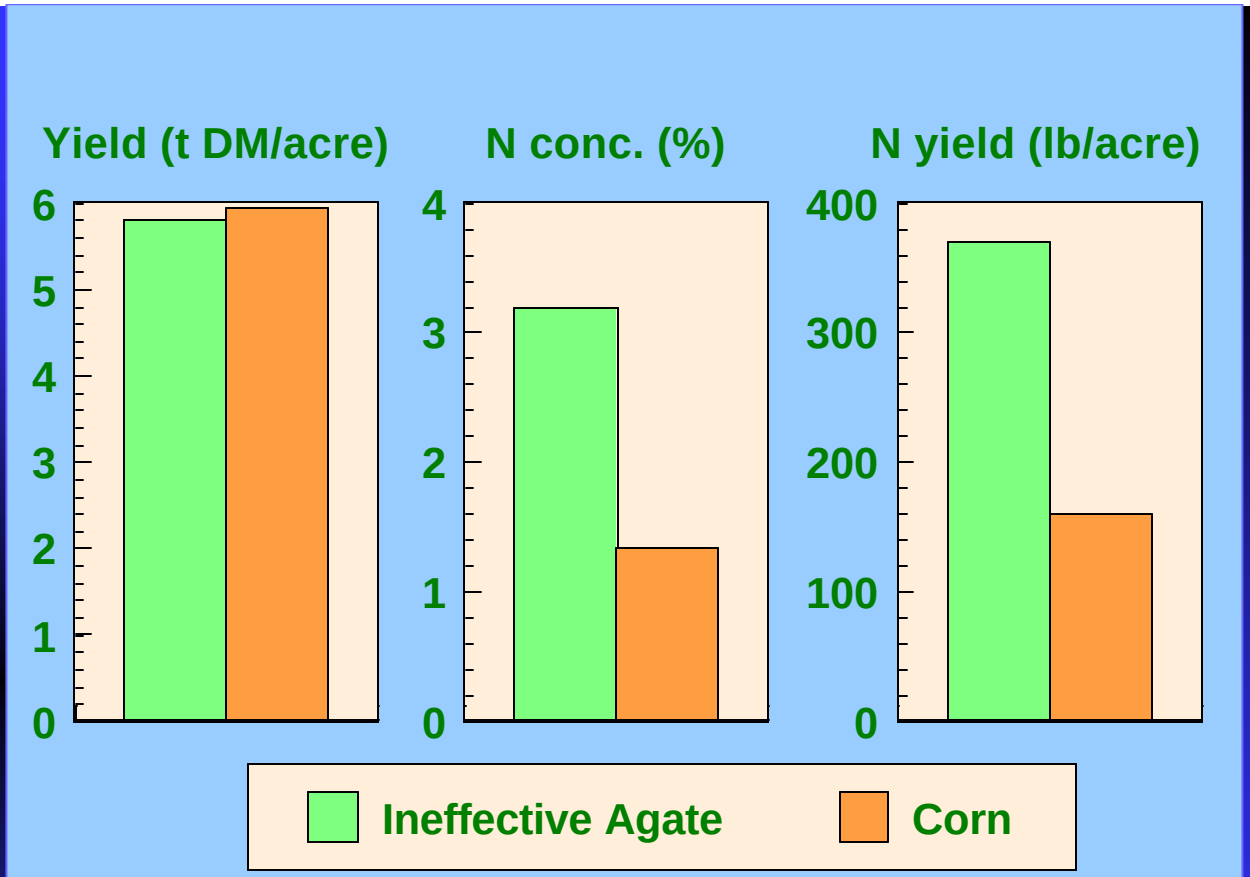


Nearly 2 billion pounds of N!

Russelle and Birr, 2002

Derailment near Bordulac, ND

Russelle et al., 2001



It all depends on yield and N content:

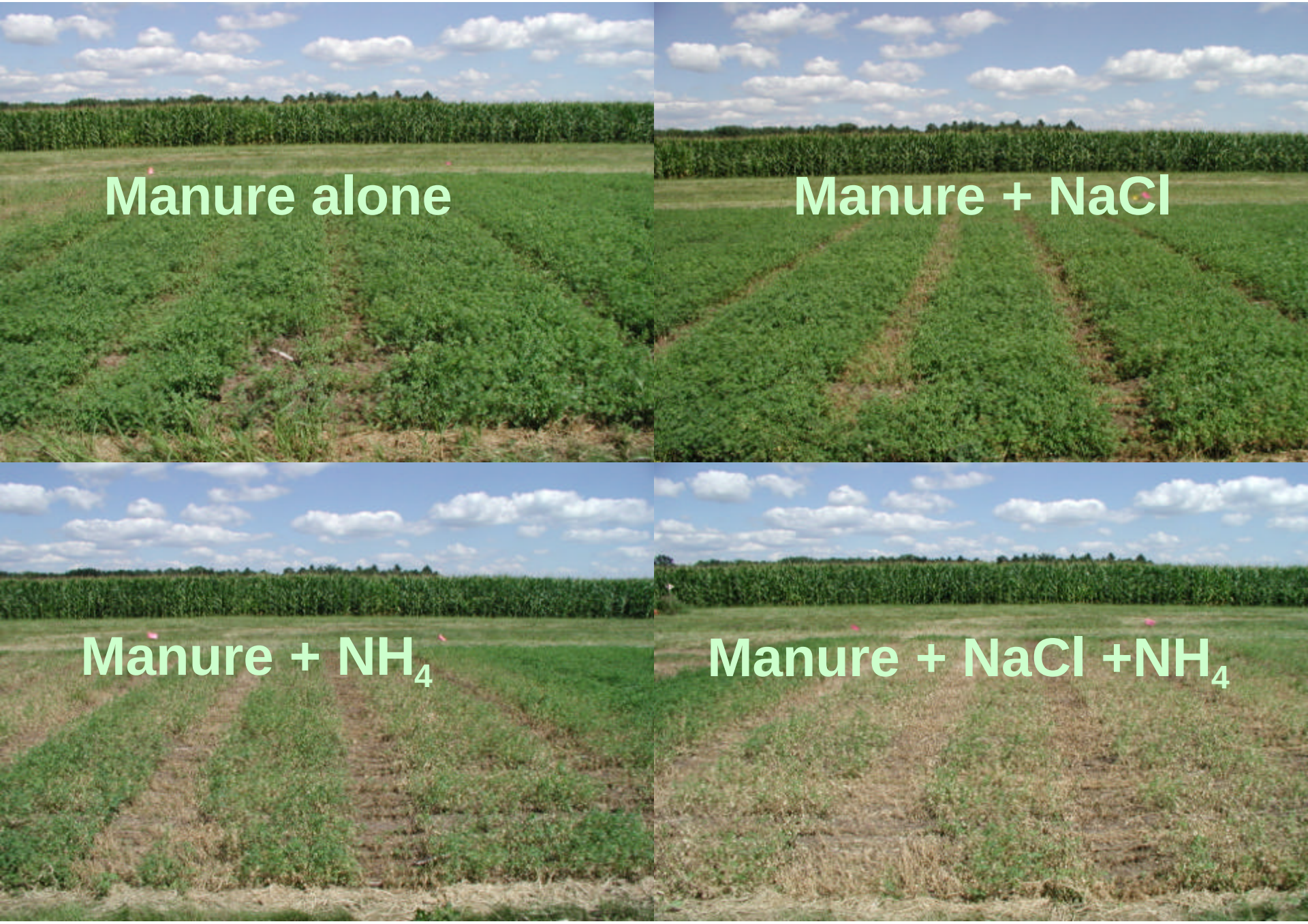
160 bu/acre corn grain	120 lb N/acre
20 tons corn silage/acre	220 lb N/acre
4 tons/acre alfalfa hay	220 lb N/acre

Can we improve alfalfa tolerance to wastewater and manure applications?

Lamb, Russelle, and Schmitt

Salt or NH_4 added to swine manure slurry

Applied broadcast
10 days after harvest

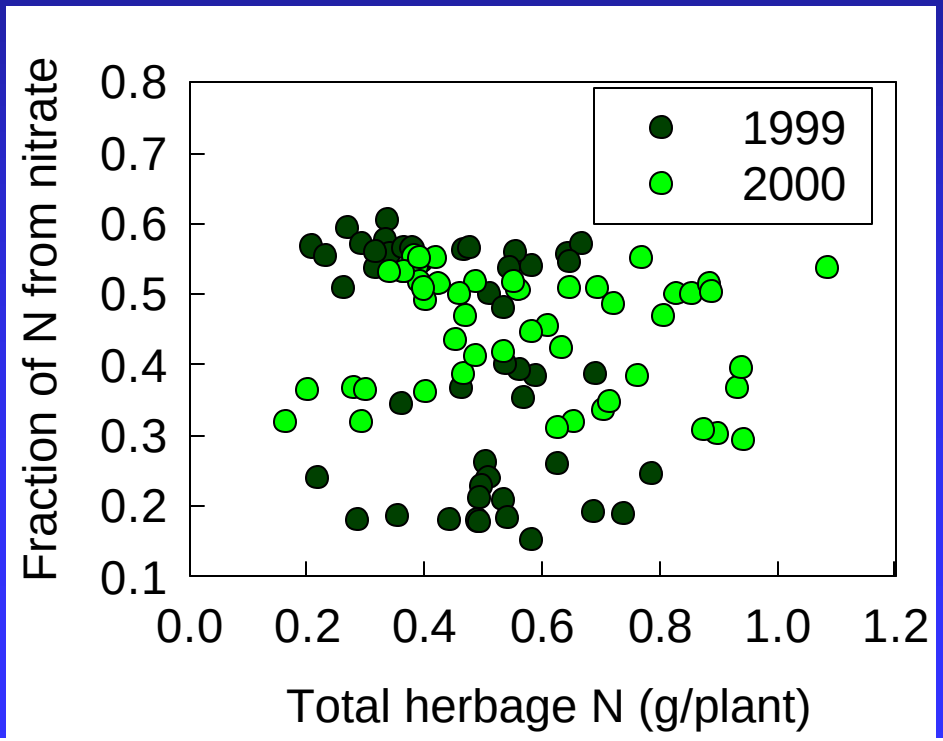

Manure alone
Manure + NaCl
Manure + NH_4
Manure + NaCl +NH_4

Can we select for NO_3 uptake in legumes?

Lamb and Russelle

Higher NO_3 uptake: ground water protection
improved N recycling on farm

Lower NO_3 uptake: mixtures with nonlegumes



Why perennial forages?

- N removal:
  perennial crops > annual crops (may not be sufficien
  harvested > grazed > non-harvested
- Economic return:
  alfalfa > grass forages (but adaptation differs)
- Additional benefits to soil protection and quality, air quality, wildlife, and aesthetics