

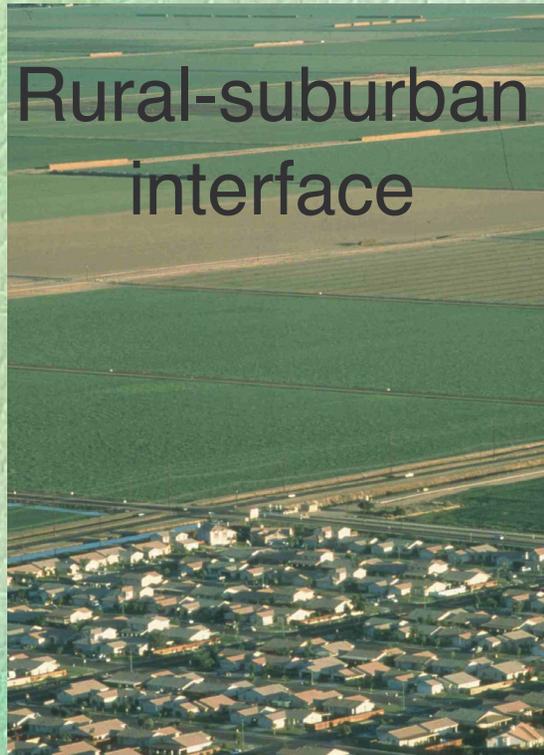
Balancing Cows and Crops to Recycle Nutrients

Michael Russelle

US Dairy Forage Research Center
(Minnesota Cluster)

Plant Science Research Unit, St. Paul, MN

So, what's the problem?



Concentration



For cattle, production of **milk** is 2 to 3 times more efficient than **meat** in use of N and P



The average dairy cow produces 18,000 lb of milk



and excretes
more than **200 lb N** and **45 lb P** per year
in **42,000 lb** of manure



Feed N & P
utilization

Manure N & P
utilization



Nitrogen -

The second most difficult problem dairy farmers face

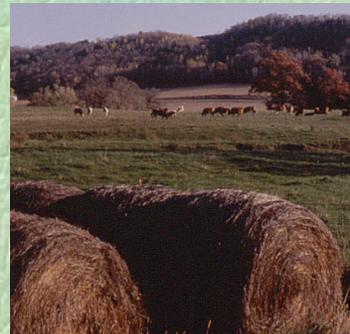
- Limits productivity
- Enters the farm in many ways
- Exists in several forms
- Is changed by living organisms
- Moves by many pathways



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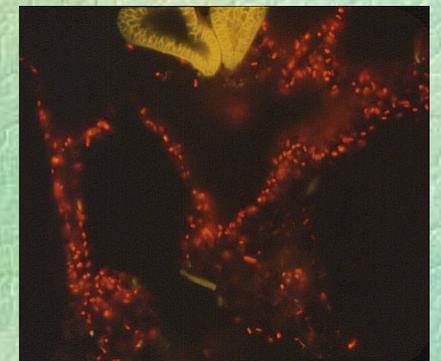
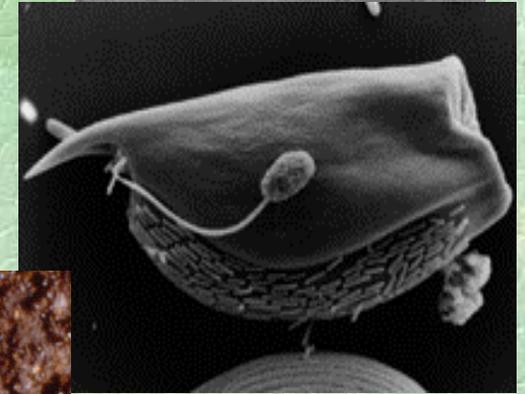
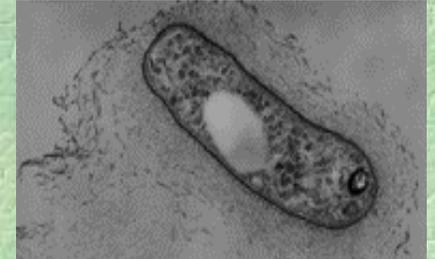
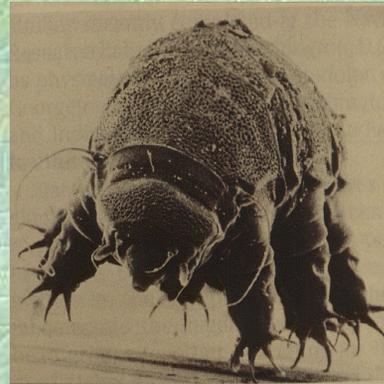
The second most difficult problem dairy farmers face

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- Nitrogen gas (N_2)
- Ammonia (NH_3)
- Nitrous oxides (NO_x)
- Organic N ($R-NH_2$)
- Ammonium (NH_4^+)
- Nitrate (NO_3^-)

Nitrogen -

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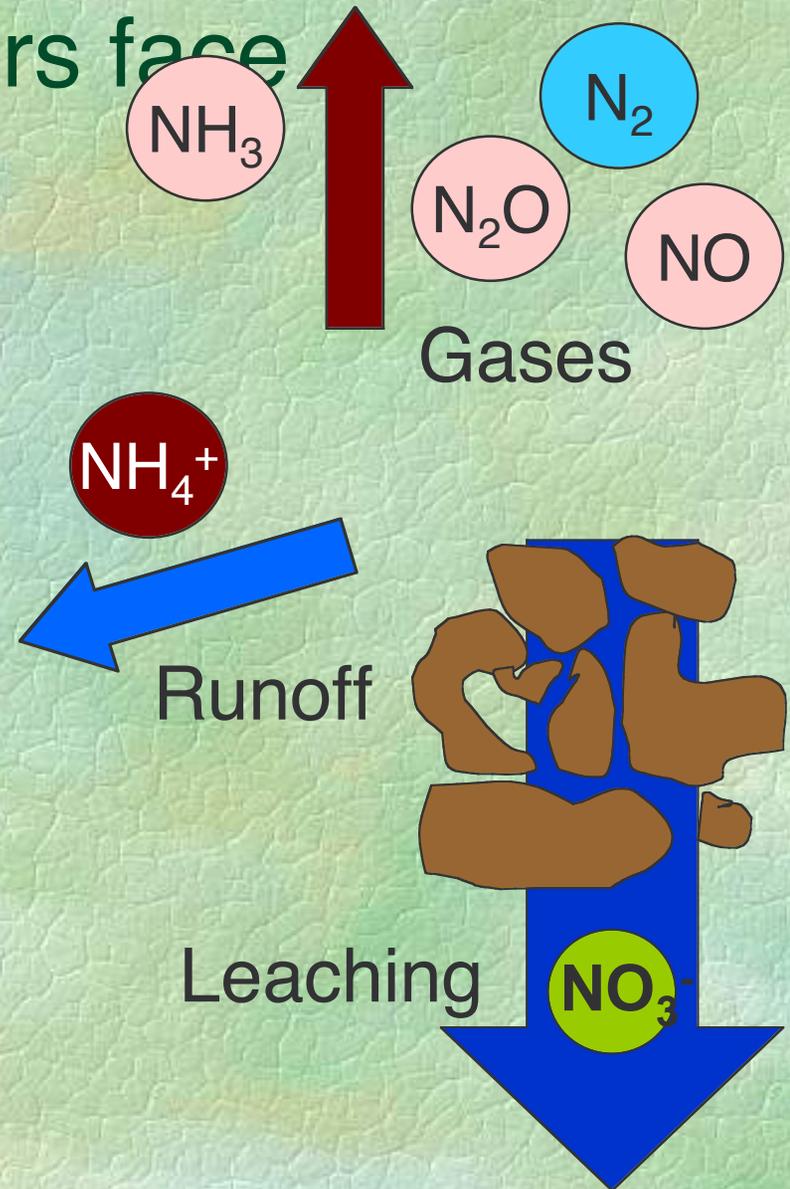


and COWS, of course!

Nitrogen -

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Phosphorus - The emerging key to sustainability

- Is often overfed
- Accumulates in the soil
- Is lost on sediment and dissolved in runoff water



Whole-farm P management

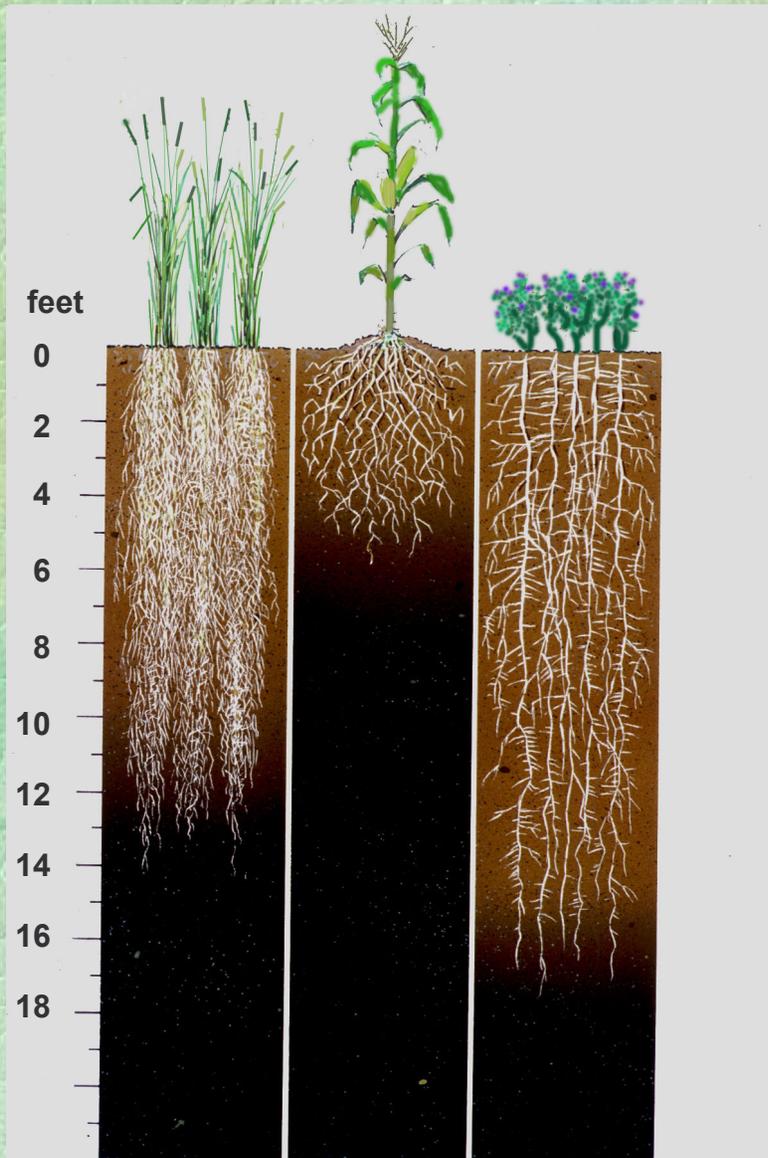
- Wisconsin dairy rations contain too much P
- Milk production and cow health can be maintained at about 0.38% of the diet
- Reducing dietary P will lower the acreage needed for manure application

| Dietary P input | Fecal P output | Years before excess soil P |
|-----------------|----------------|----------------------------|
| 0.35% | 42 | indefinite |
| 0.38 | 47 | indefinite |
| 0.48 | 65 | 11 |
| 0.55 | 78 | 6 |

(assumes 170 acres with 90 cows)

Powell, Satter, et al. 2000

Advantages of perennial crops

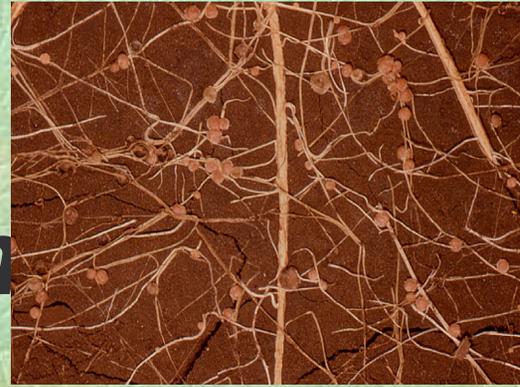


- high nutrient need
- high yield
- high quality
- high water use
- reduced runoff and soil erosion
- improved soil quality
- deep roots

Bacteria in
root nodules
'fix'
tremendous
amounts of N
from the air



Roots, nodules, and N₂ fixation

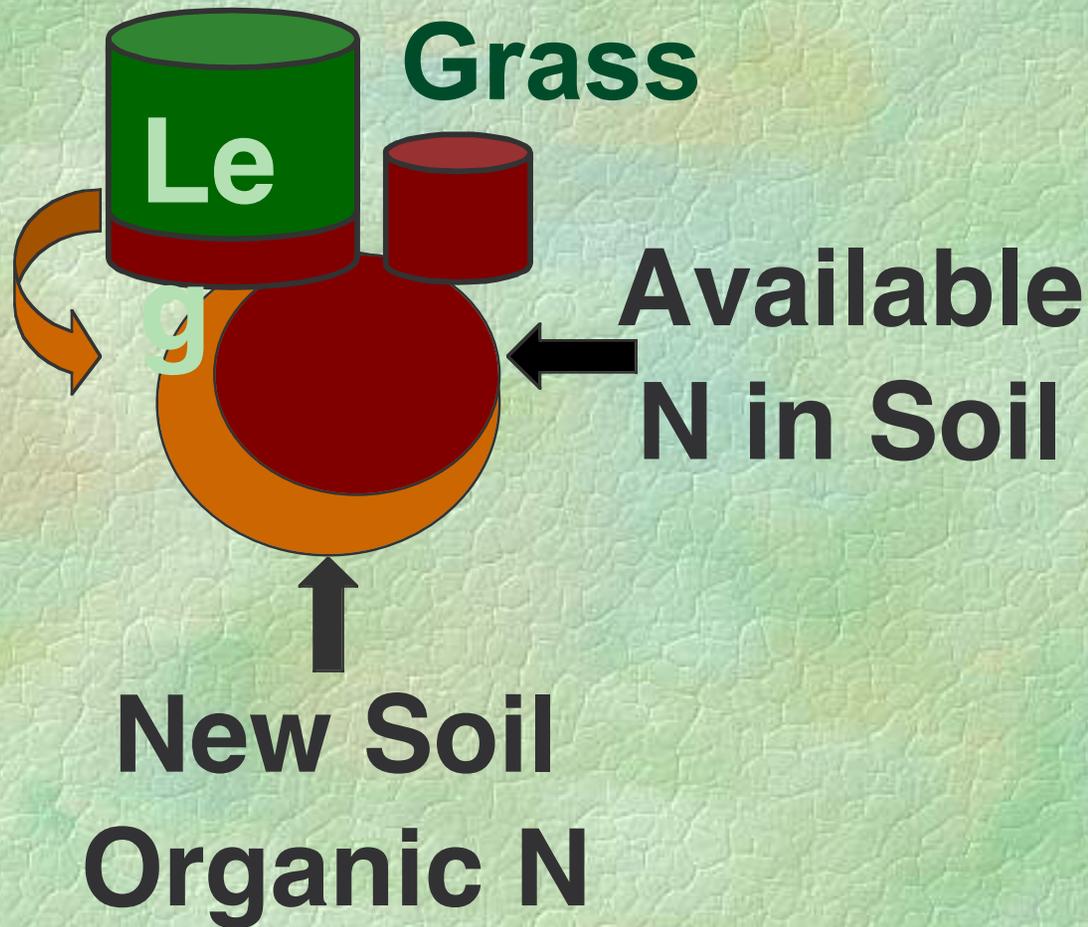


| Species | Roots | Nodules | N ₂ |
|------------------|-------------|----------|----------------|
| fixed | (mi / acre) | (# / mi) | (# / a) |
| (lb/a) | | | |
| Alfalfa 200 | 37,600 | 700 | 25 million |
| Birdsfoot 130 | 23,100 | 3000 | 70 million |

(root and nodule numbers are for the top 1 foot of soil)

Dubach and Russelle, 1994

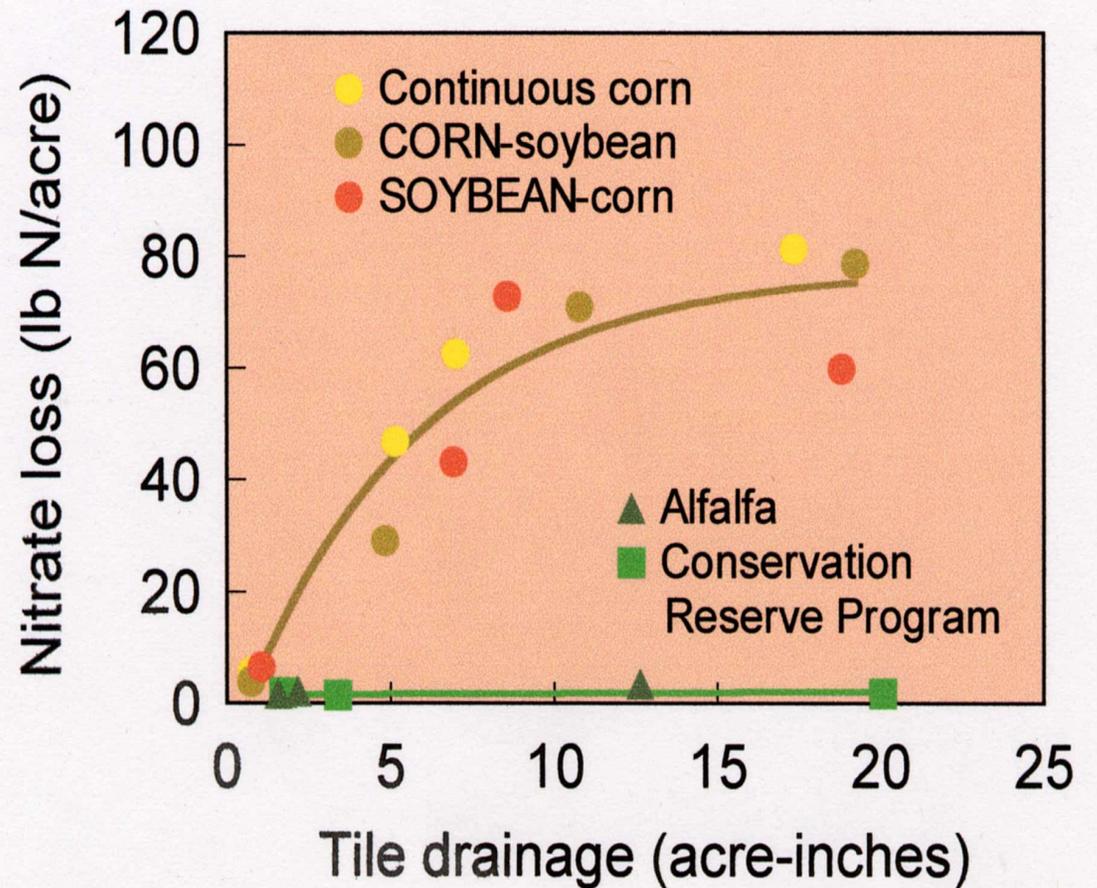
Legumes serve as N buffers



Alfalfa and grass CRP effectively filter tile drain water



>40 million acres are tile drained
in the Upper Midwest



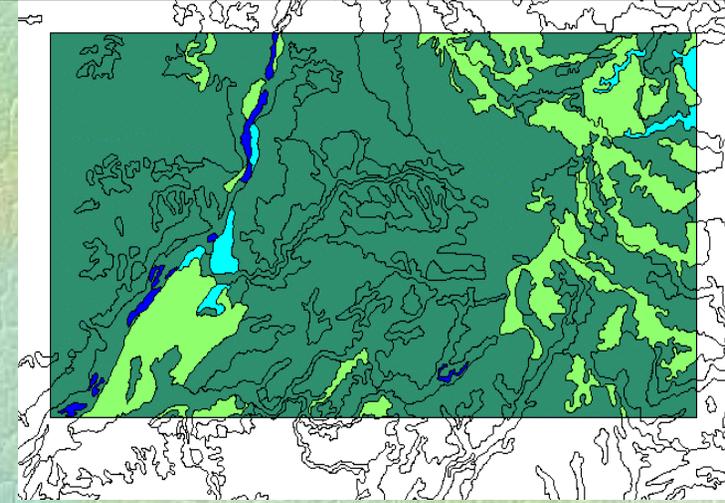
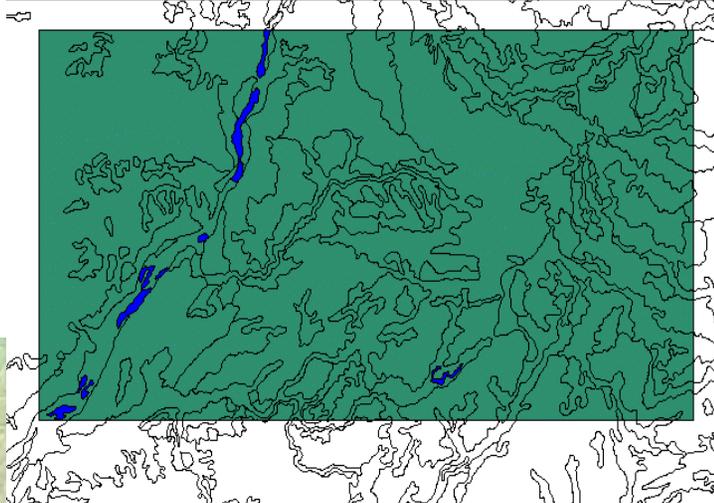
Randall, Huggins, Russelle et al., 1997

KEY: Nitrate leached (kg/ha)

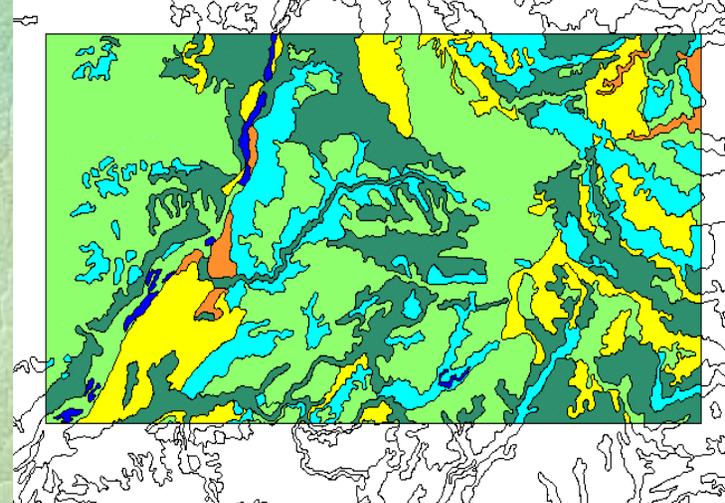
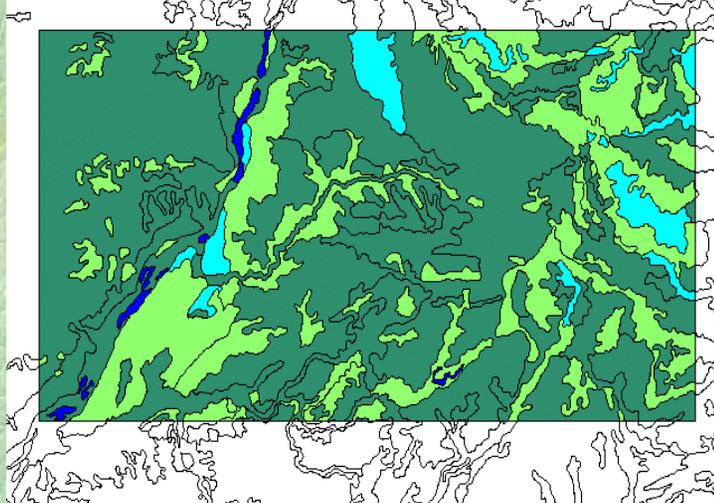


Alfalfa **Corn**

Normal

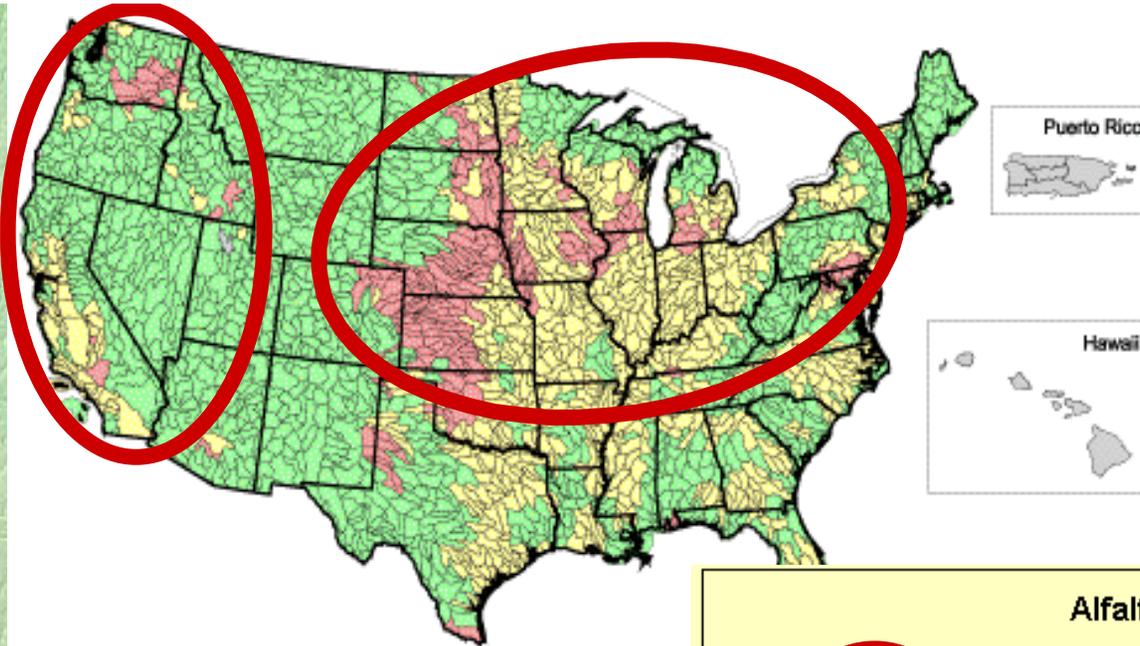


Wet



Kelley and
Russelle, 2000

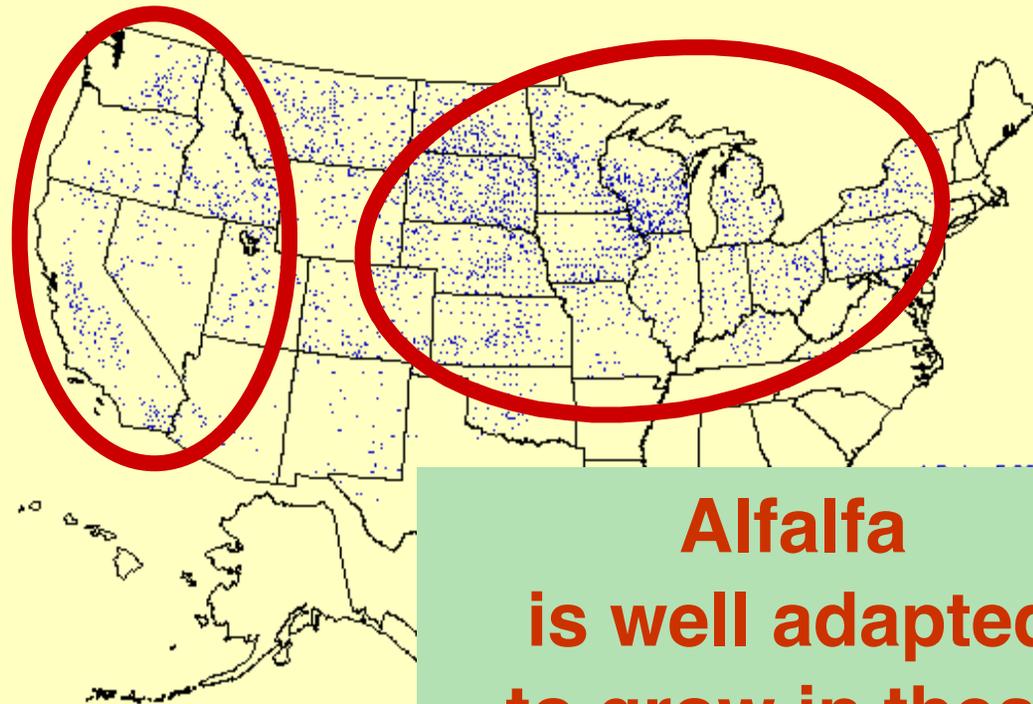
Risk of ground water nitrate contamination



Risk of Groundwater Nitrate Contamination (1970 - 1995)

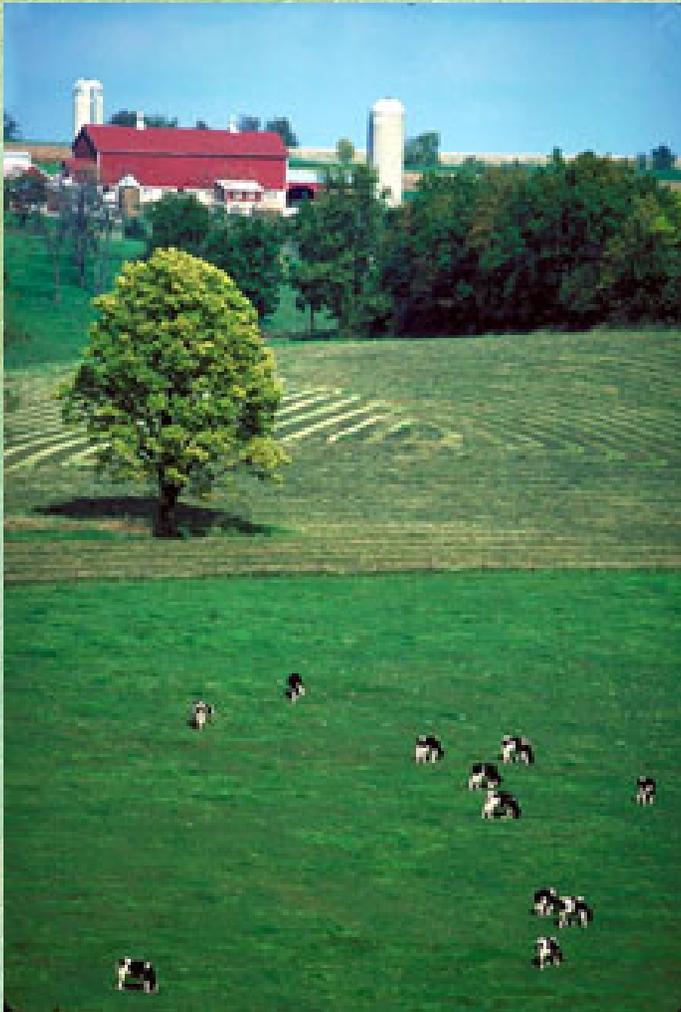
- Low Risk
- Moderate Risk
- High Risk
- Insufficient Data

Alfalfa Hay Harvested: 1997



Alfalfa
is well adapted
to grow in these
areas

Grazed pastures help prevent ground water contamination



- Nitrate leaching under pastures contaminates ground water in humid regions
- We found very little nitrate leaching loss under well managed pastures in the Upper Midwest
- Research is continuing on sandy soils

Diverse cropping systems - Michael Fields Agricultural Institute



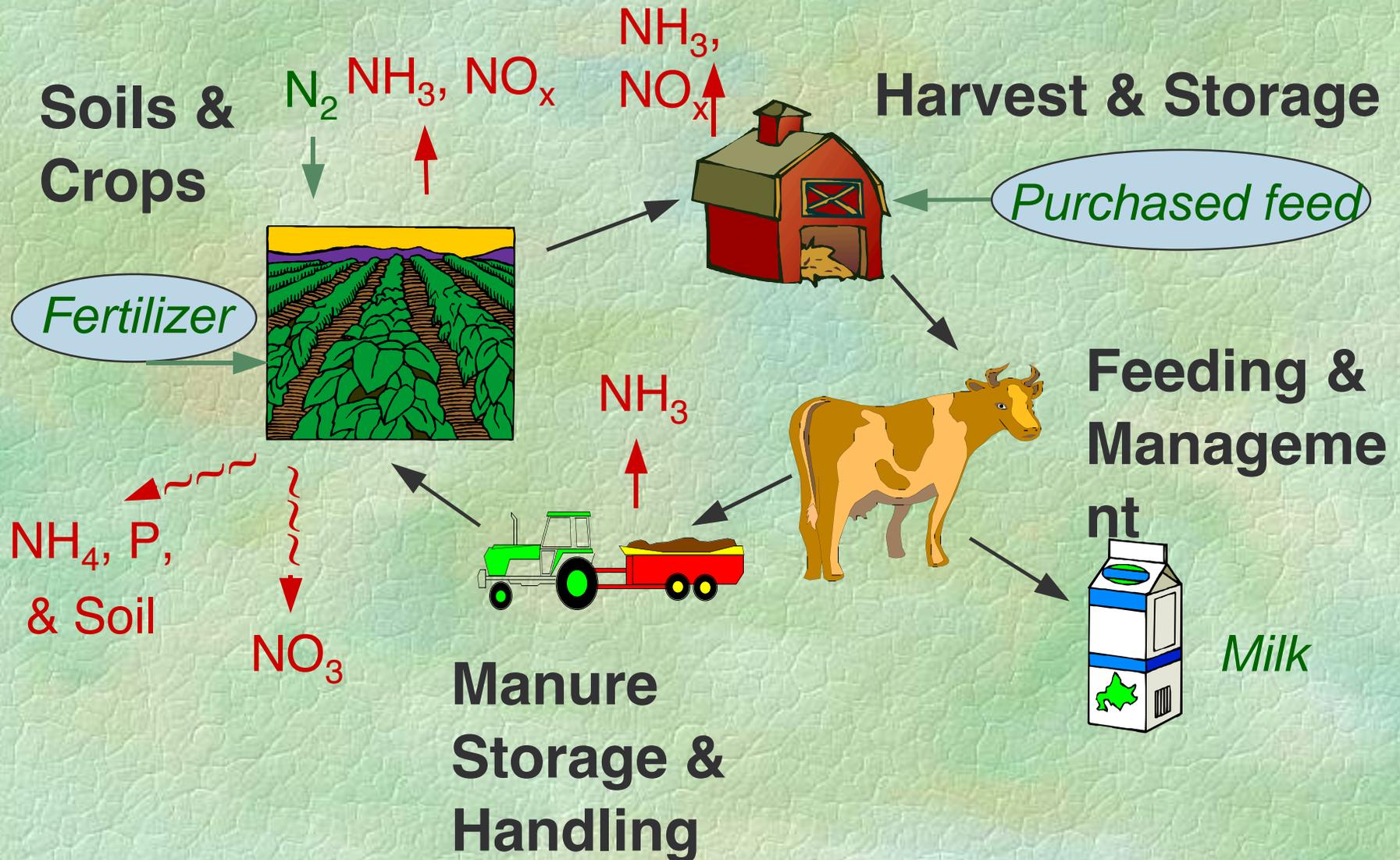
- Continuous corn **WICST**
- Corn-soybean **Arlington and Lakeland**
- Corn-soybean-wheat-red clover
- Corn-3 years of alfalfa
- Corn-oats-alfalfa



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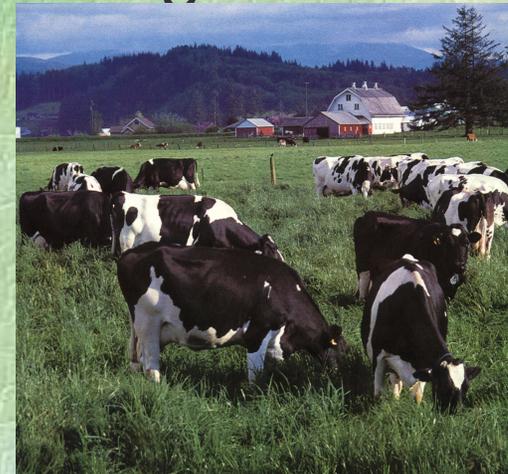
DAFOSYM -- Dairy Forage System Model



What problems remain?

Application of knowledge

- Avoiding and reducing N and P build-up
- Reducing excessive animal/land ratios
- Improve manure handling
- Controlling runoff



What problems remain?

Creation of new knowledge

- Ammonia losses
- Manure N availability - ^{15}N
- Site-specific cropping systems
- Novel crop traits (tannins, 'fast' roots, etc.)
- Novel manure management



Our goal -

Finding a balance of cows and crops
to recycle nutrients effectively

