INSTITUTE FOR
Ag Professionals

Proceedings of the 2007 CPM Short Course and MCPR Trade Show

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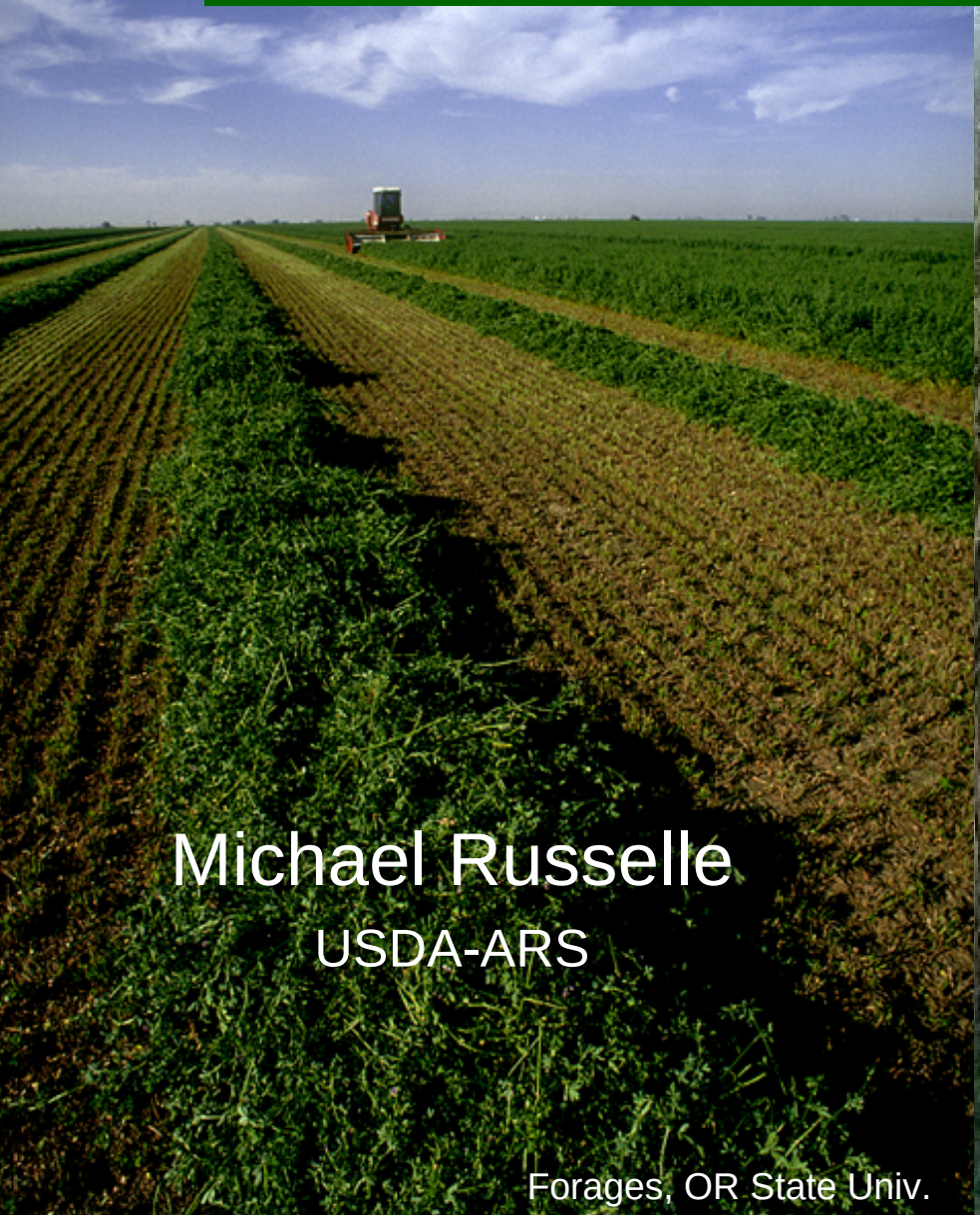
Minneapolis Convention Center

Challenges and Opportunities of Perennial Biomass Cropping Systems

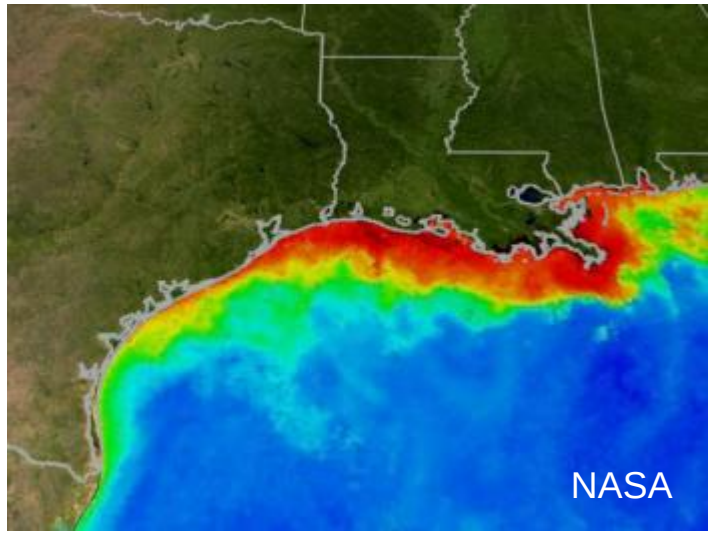


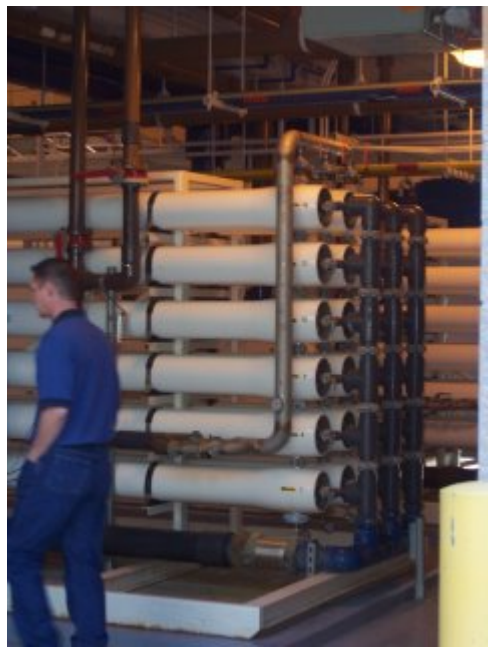
Michael Russelle
USDA-ARS

Forages, OR State Univ.

Bioethanol.ru

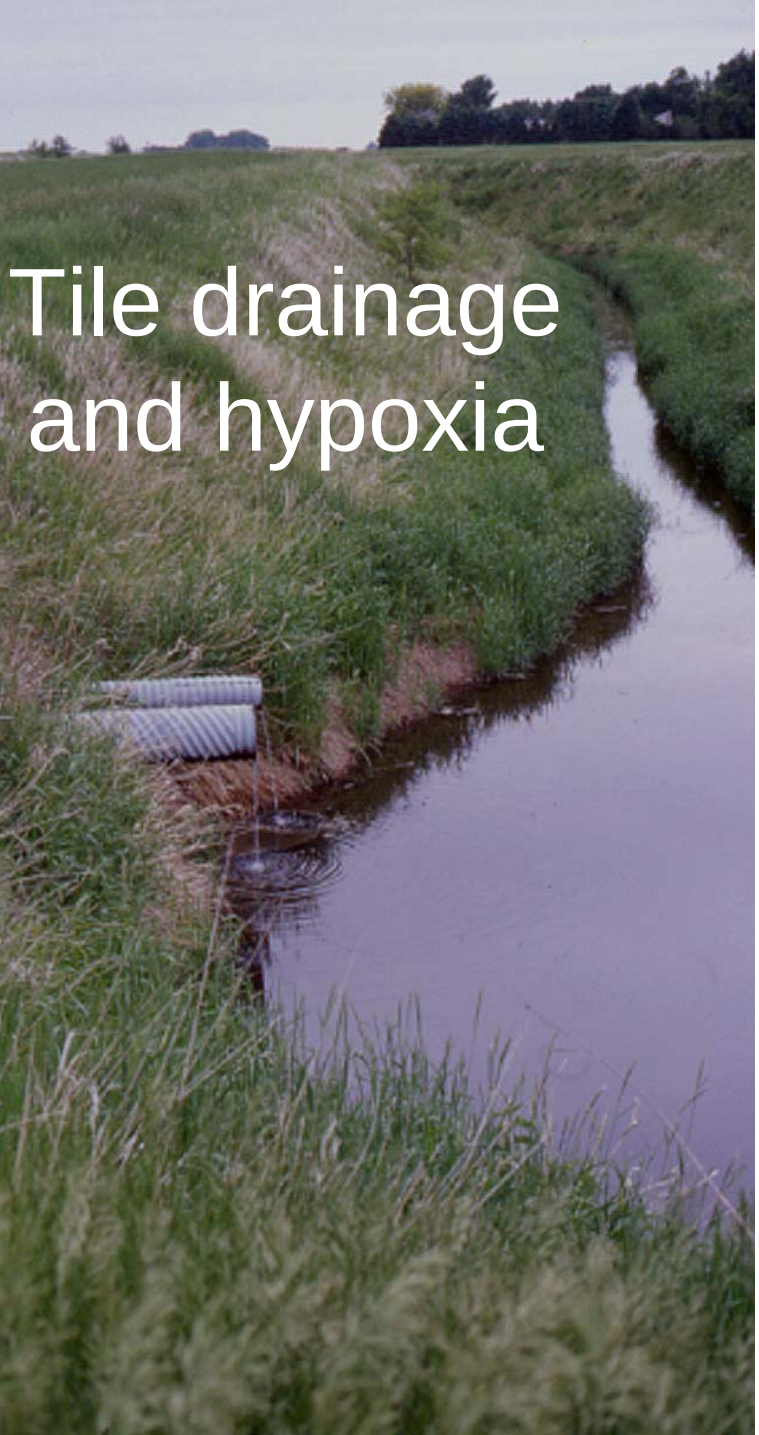
Water quality

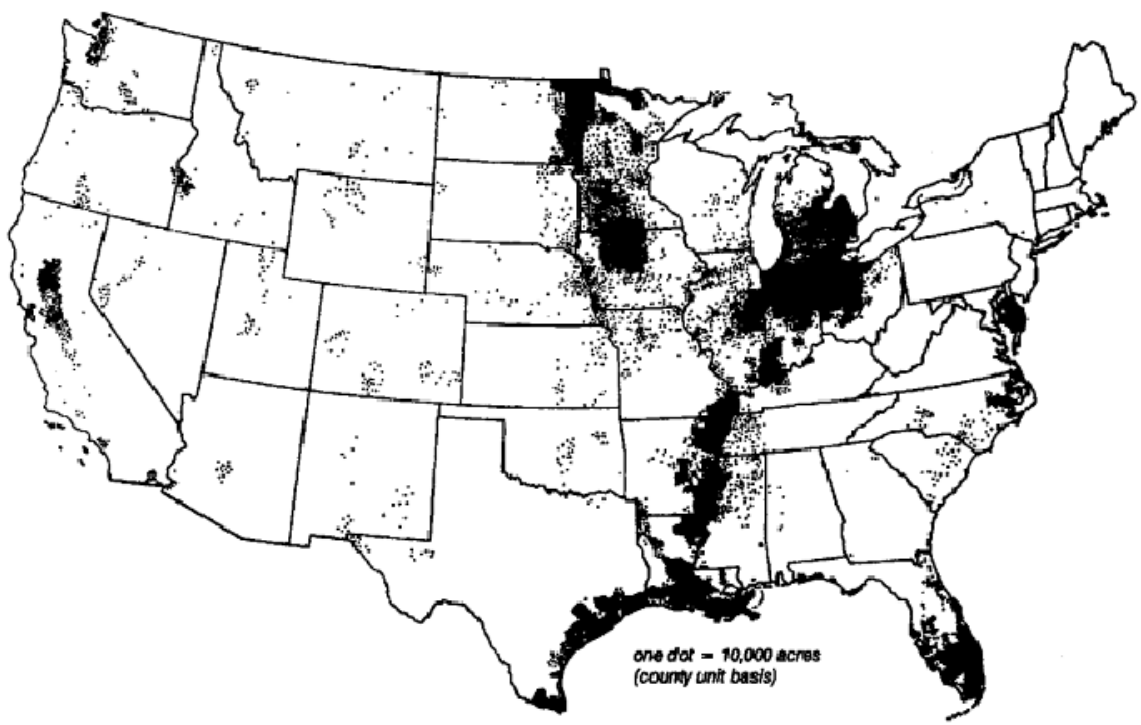


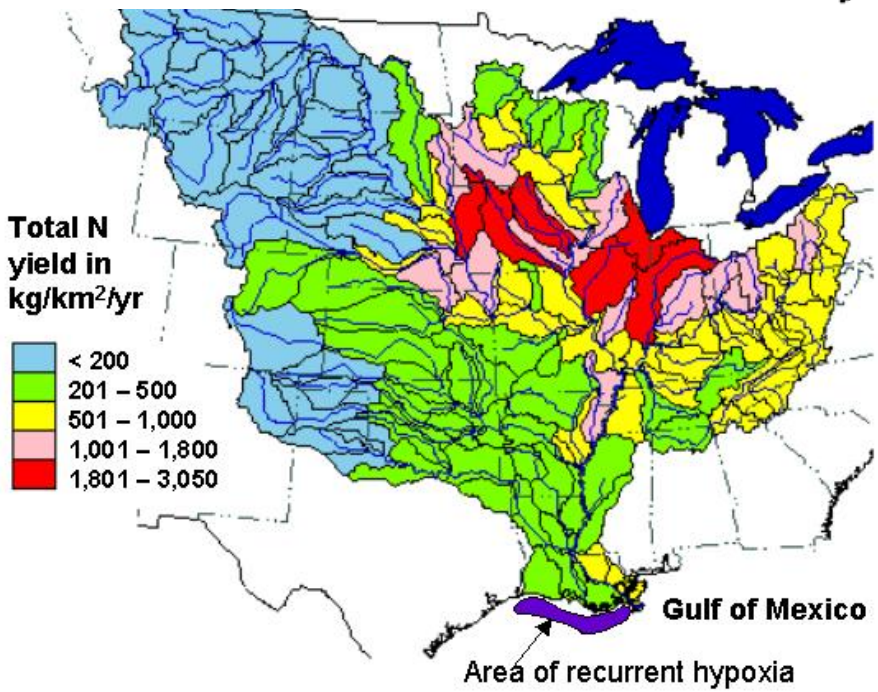


City of Davis, CA

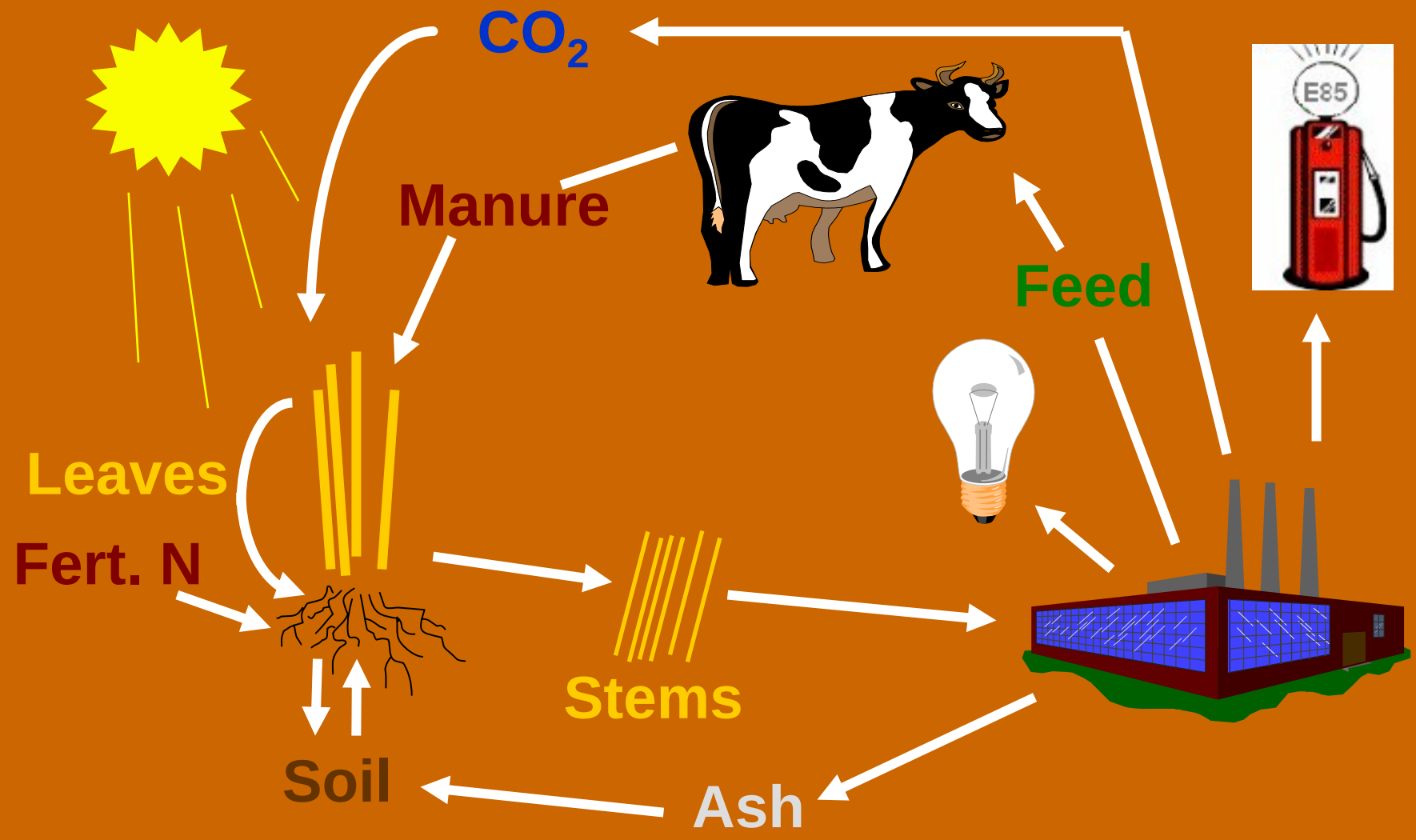
Tile drainage and hypoxia







A Perennial C4 Grass Biomass System



What about Miscanthus?

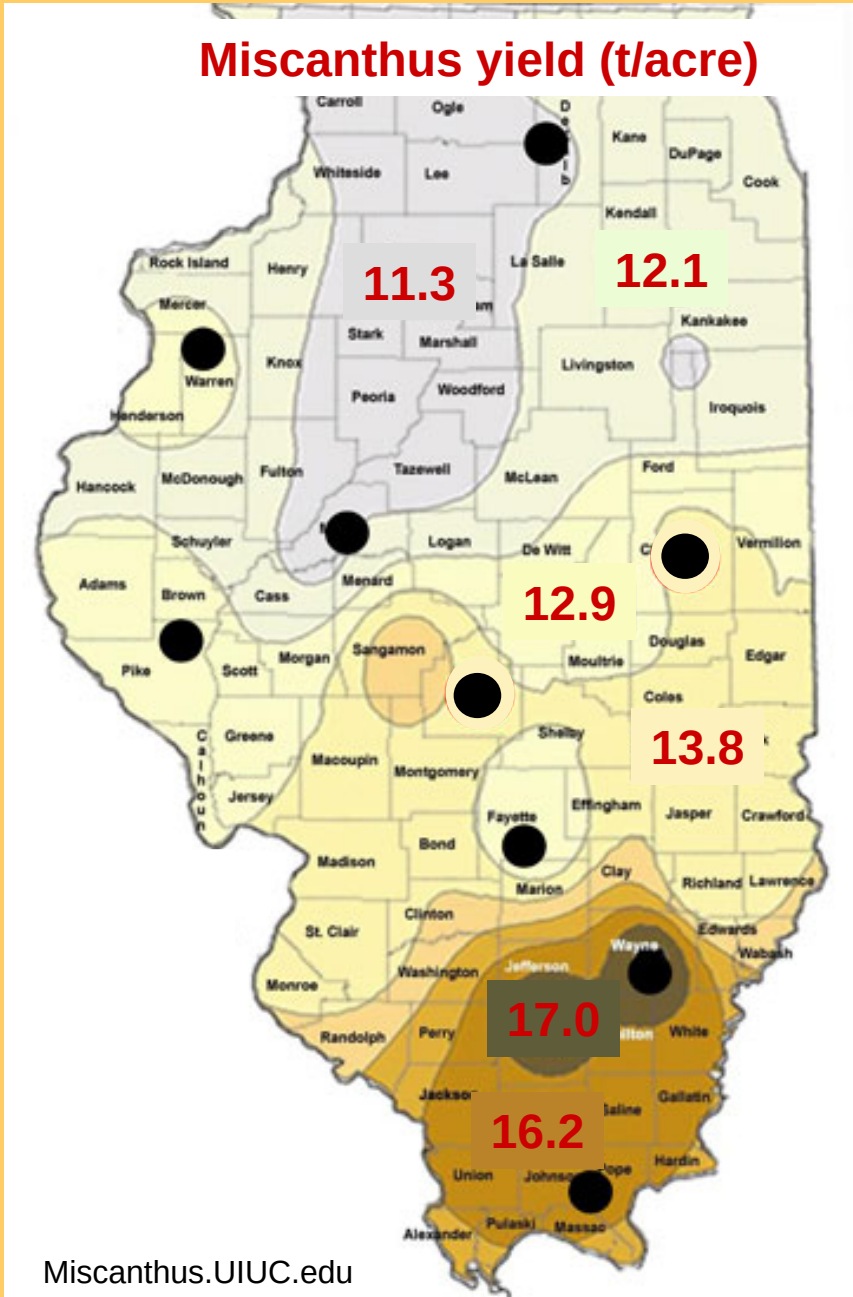
2 to 5 years to reach maturity, ***but***
12 to 25 years before replanting

Very low N requirement, excellent retention
- only 25 lb N/acre harvested in IL trials

Yields in Europe	
County	dry tons/acre/yr
Denmark	2 – 7
Britain	4 – 7
Switzerland	6 – 8
Germany	2 – 13
Spain	6 – 15
Italy	13 – 14
Greece	12 – 20

Lewandowski et al., Biomass & Bioenergy 19:209

150-bushel corn crop = 3.5 t/acre stover
(not all harvestable)



Miscanthus.UIUC.edu

Potential benefits

Excellent reductions in soil erosion

Excellent soil carbon improvement

Fair to excellent wildlife habitat

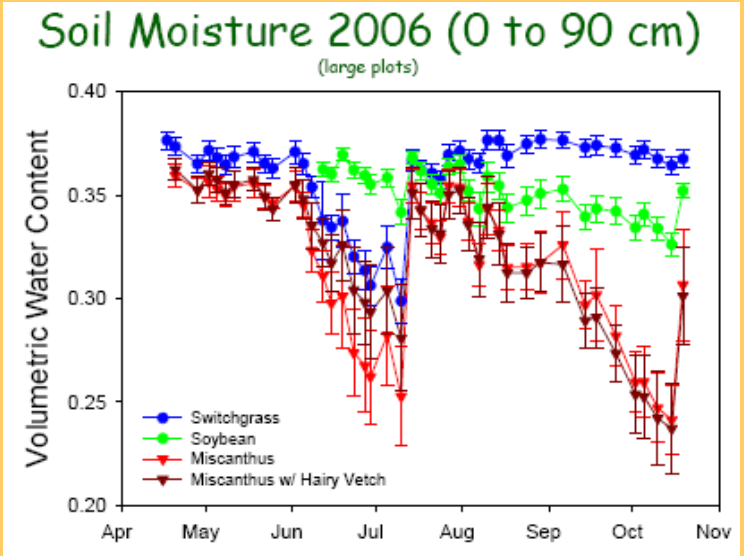
Low inputs required after fully established

OR DFW

Implications for water quality and flow

Compared to corn:

- Perennials will reduce nitrate losses through tile drainage
- Switchgrass may reduce total flow, but may not
- Miscanthus likely to cause large decreases in flow
  - Low stream flow in late summer and fall
  - Less dilution of riverine nitrate

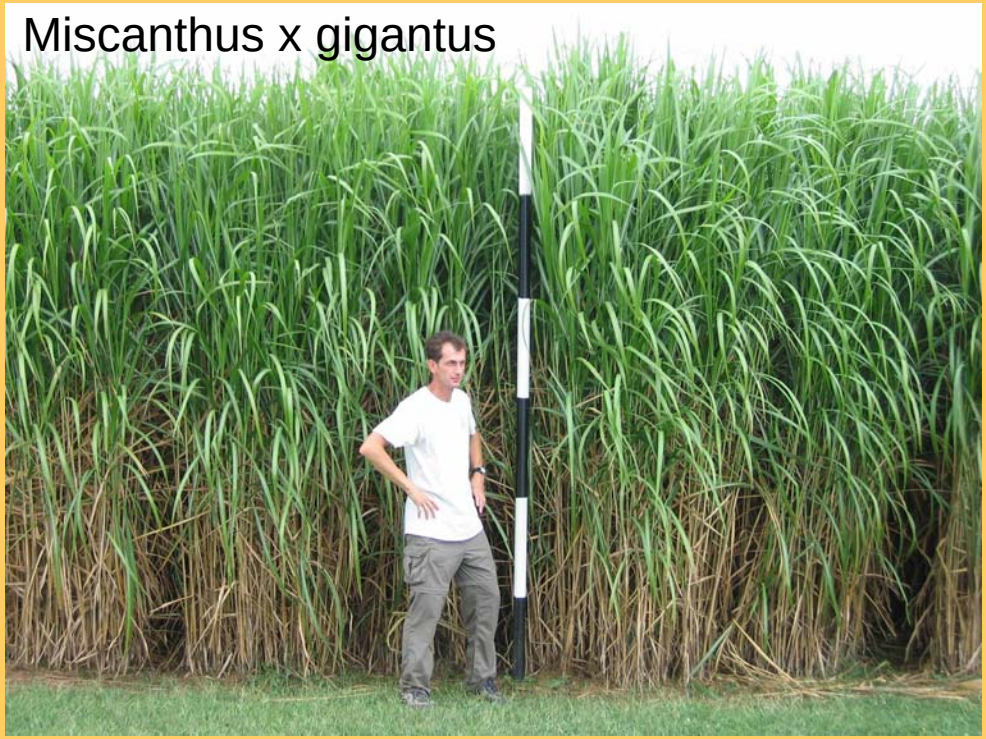


McIsaac et al., UIUC

Potential problems

- Long rotation – reduced flexibility
- Yield loss (>30%) if harvest delayed until spring (Adler et al., Agron. J. 98:1518)
- Weed control during establishment of mixtures
- Low yields in first few years
  Multi-site SG study: 0.4, 2.5, 3.2, 4.2 t/a in years 1 to 4 (Perrin et al., 2006)
- Lower winterhardiness with harvest stress?
- Increasing disease incidence?

Miscanthus x gigantus

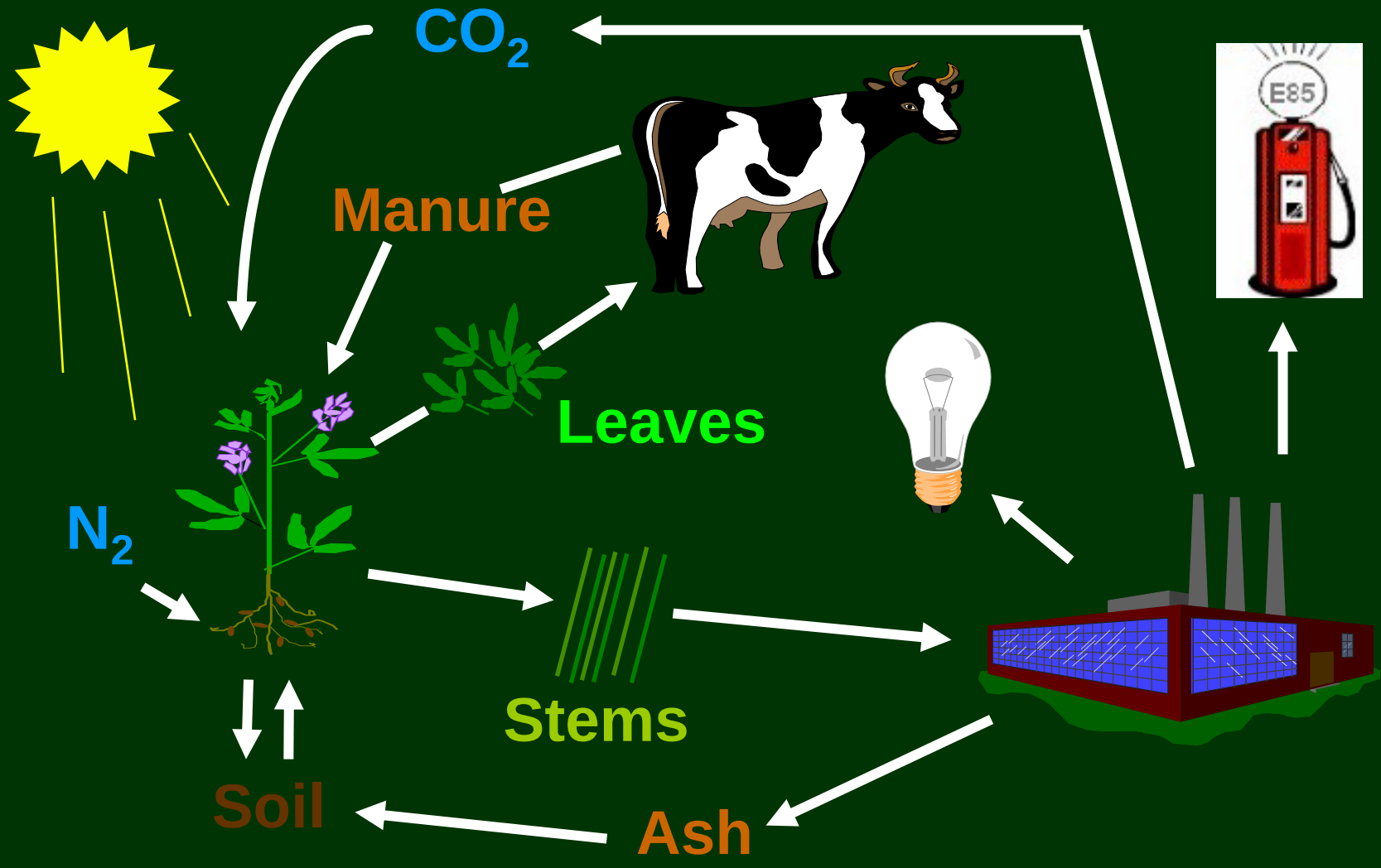


Steve Long, Univ. IL

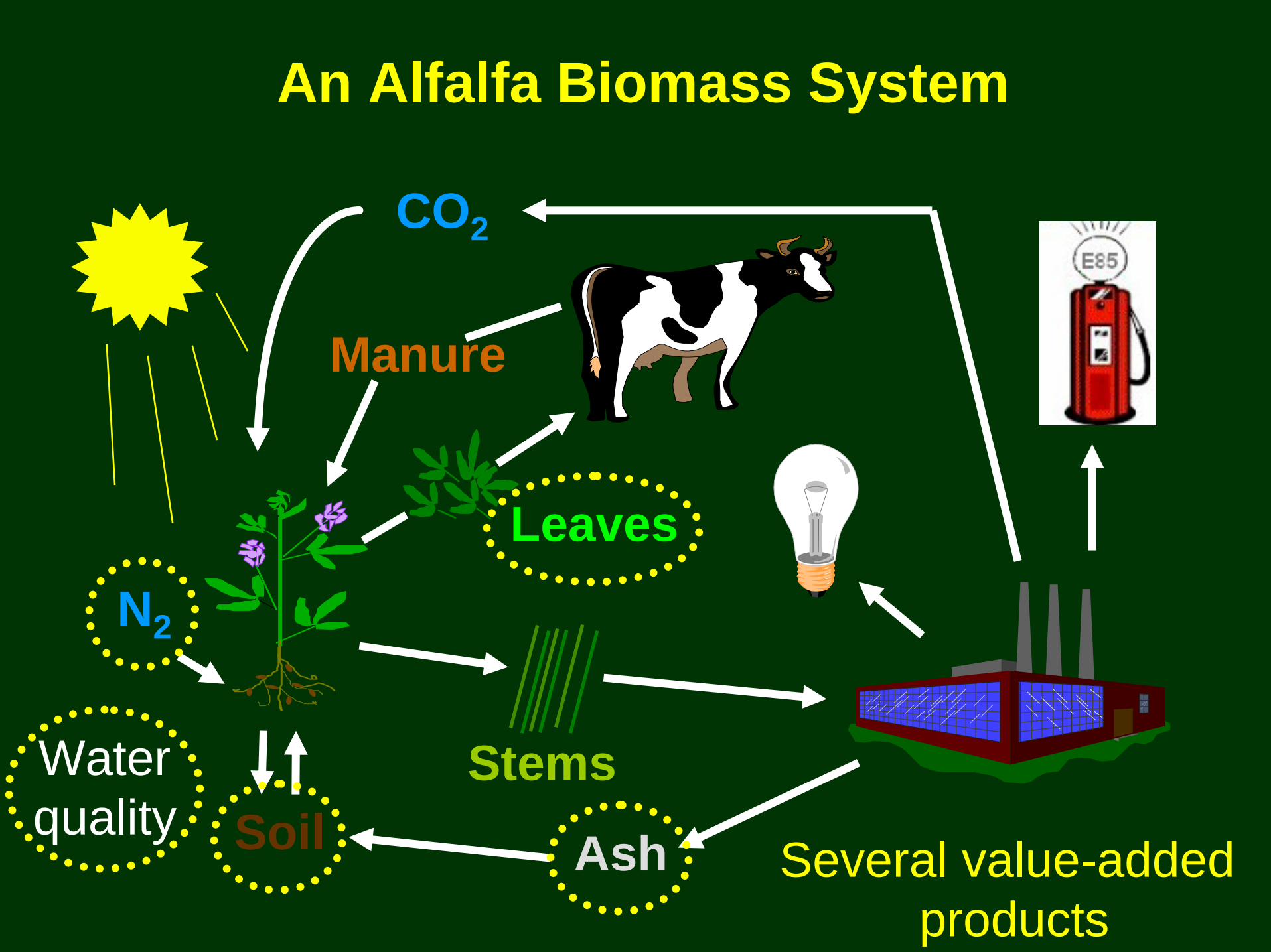
Switchgrass

DOE NREL

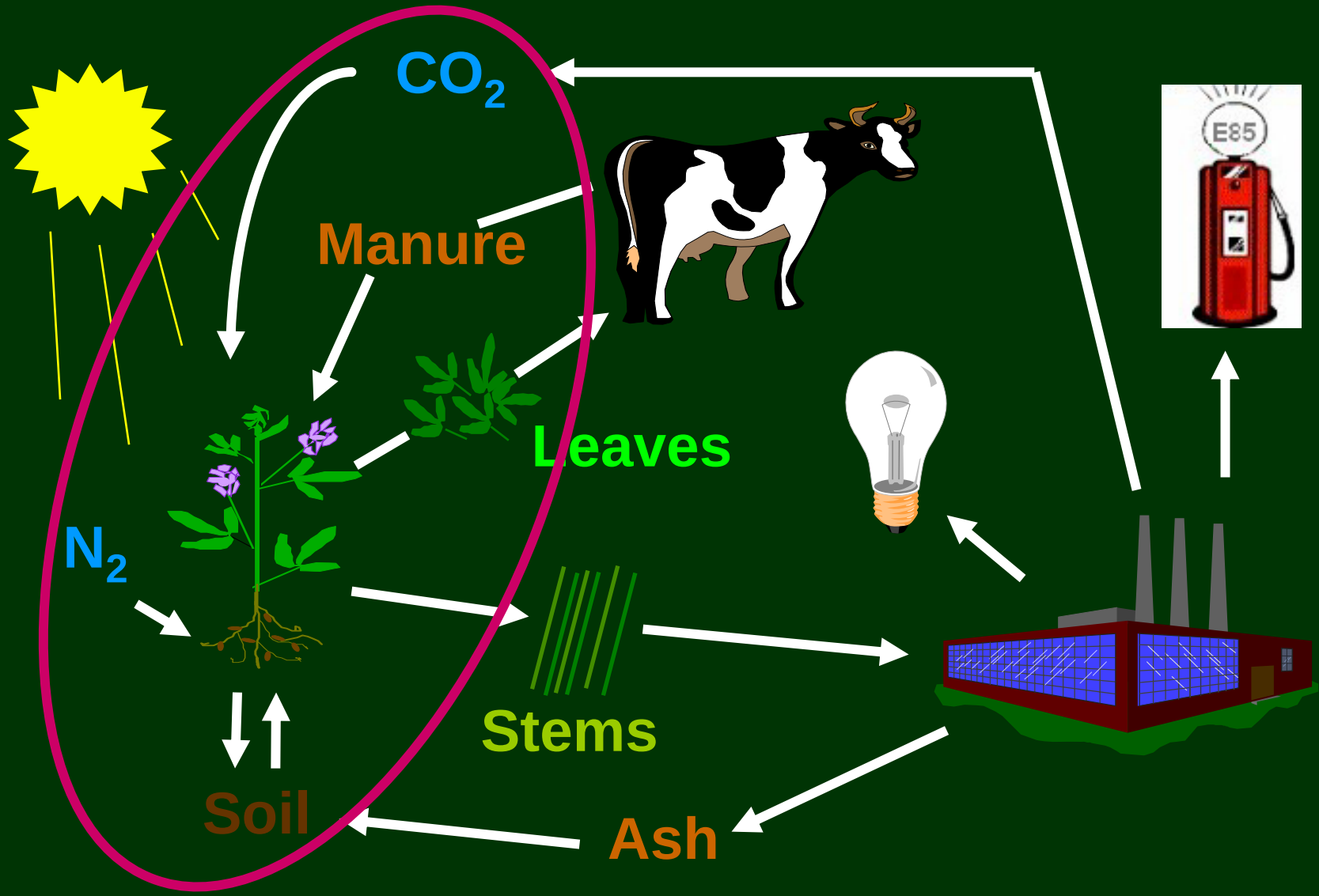
An Alfalfa Biomass System



An Alfalfa Biomass System



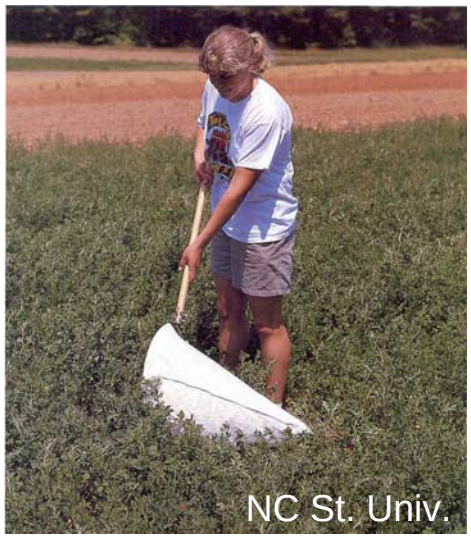
An Alfalfa Biomass System



Alfalfa is not a new crop

Established infrastructure

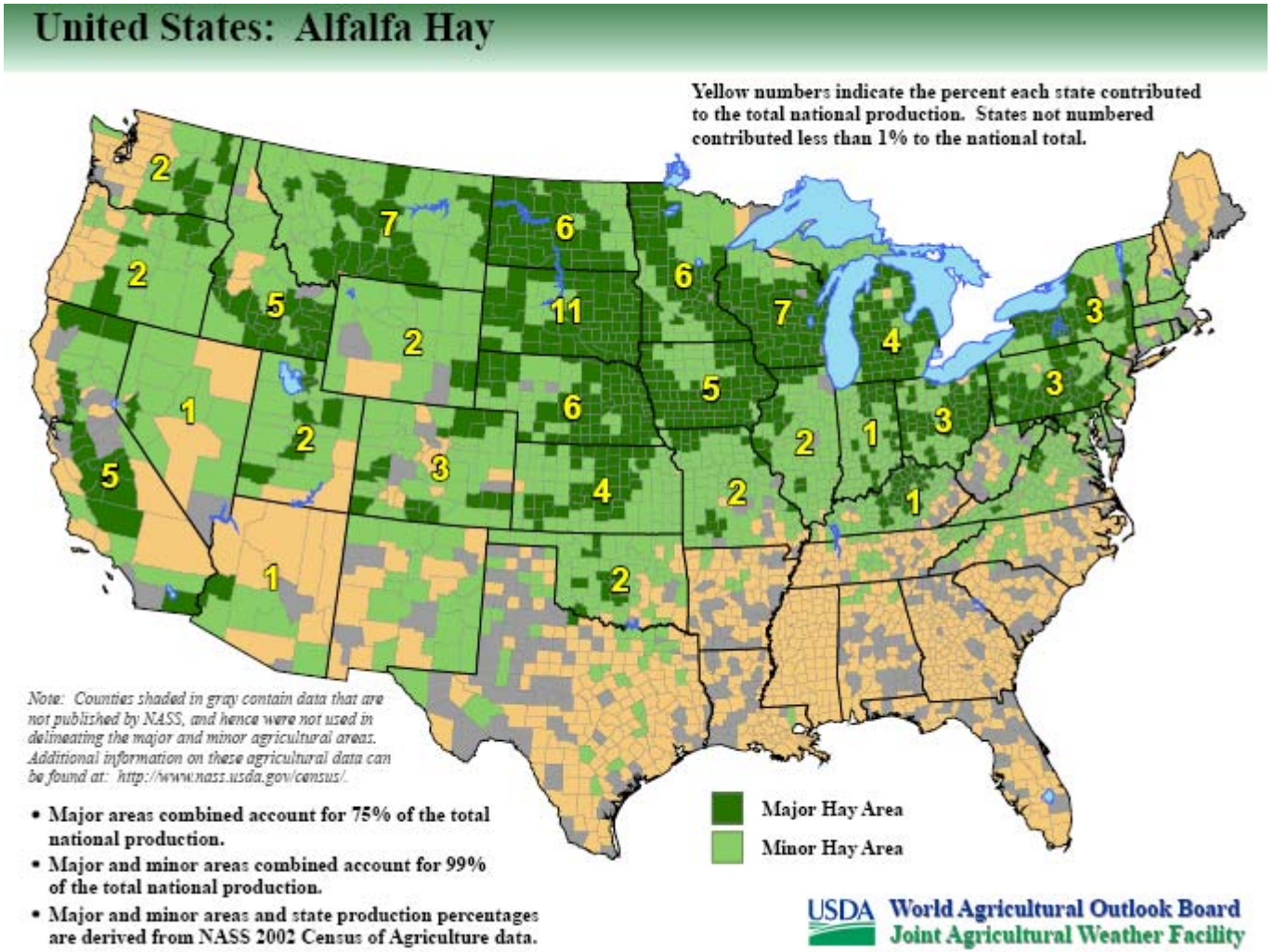
- Private and public plant improvement
- Private seed production and marketing
- Variety testing
- Extension Service / crop consultants
- Machinery manufacturers
- Transportation



Alfalfa is widely adapted in the USA

2002 Agricultural Census

21 million acres 72 million tons $7.5 billion as forage

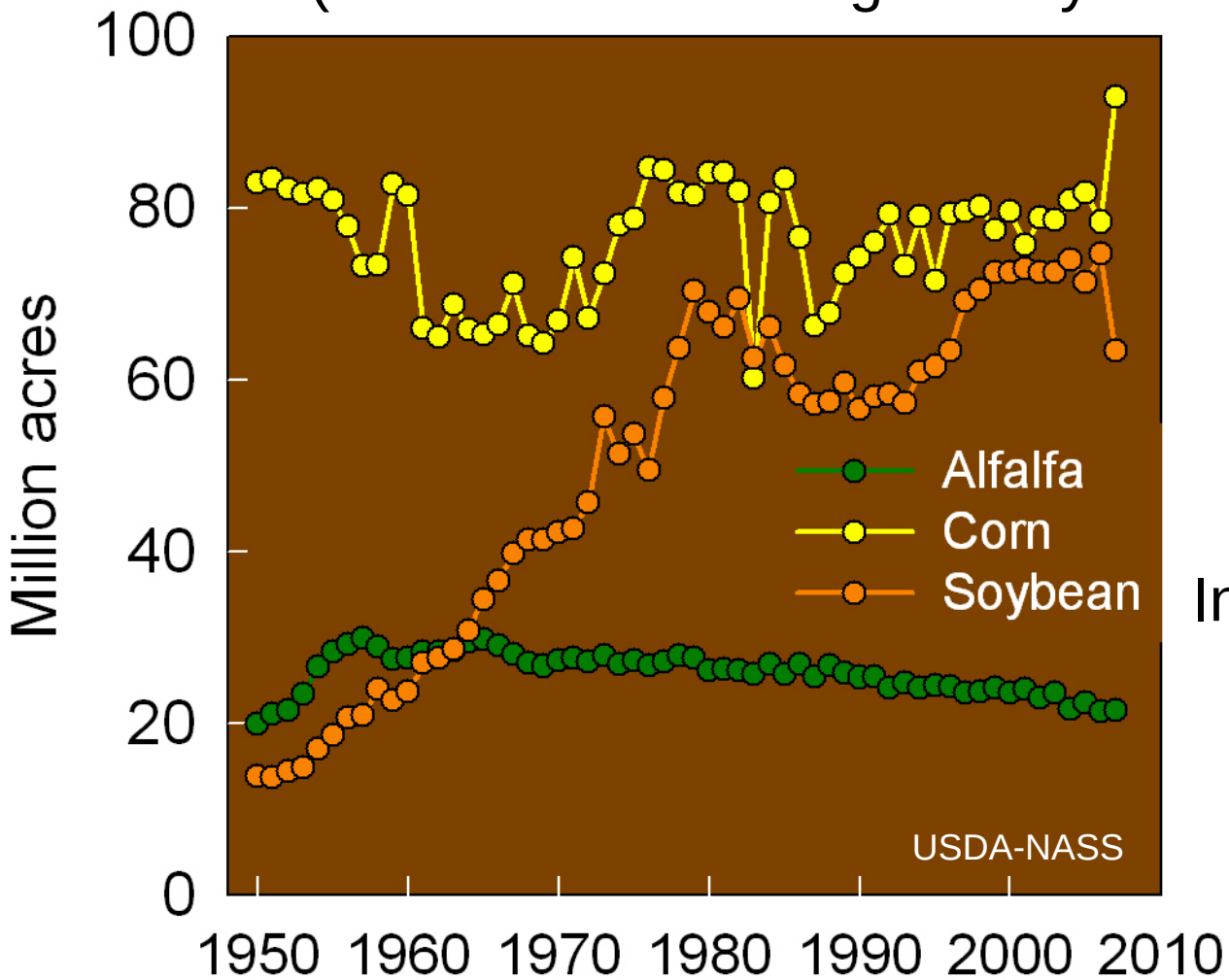


Declining alfalfa acreage

Consolidation of livestock industry

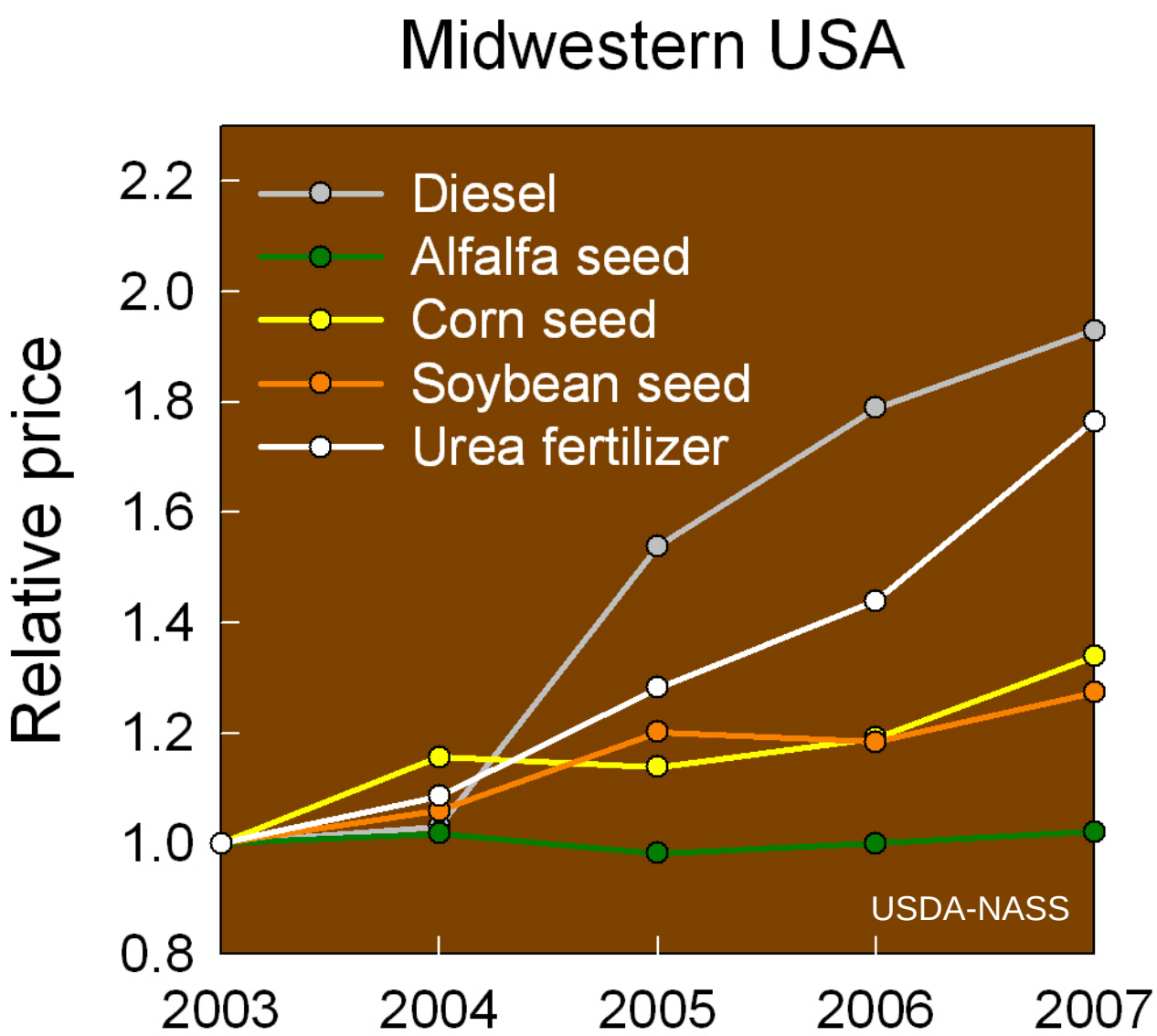
Changing feed practices

(increased corn silage & soybean meal)



In the past 50 years alfalfa declined by 136,000 acres annually

Input cost trends



Compatibility with corn

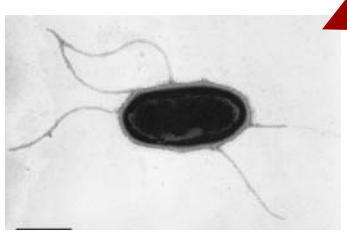

Tim McCabe, NRCS


Don Reicosky, USDA-ARS

- Nitrogen credit
- Residue cover
- Erosion control
- Aesthetics
- Wildlife habitat

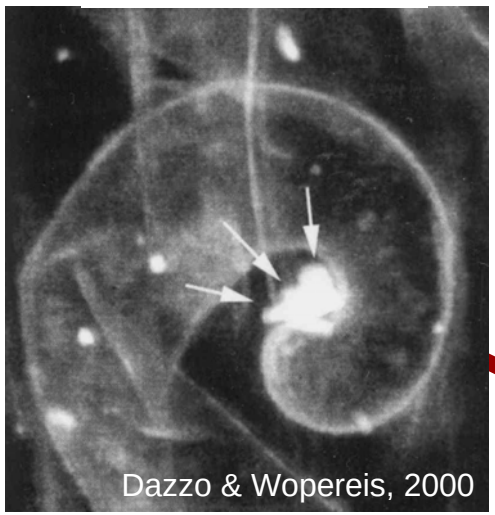
Symbiotic N_2 fixation

Sinorhizobium



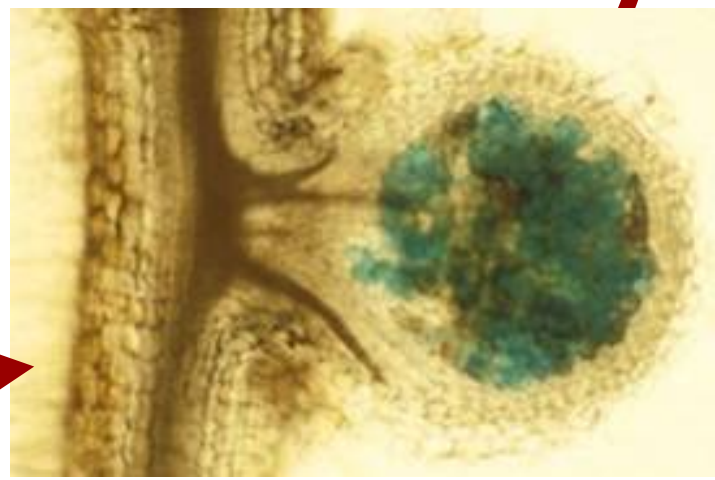
Dazzo & Wopereis, 2000

Root hair curling around rhizobia



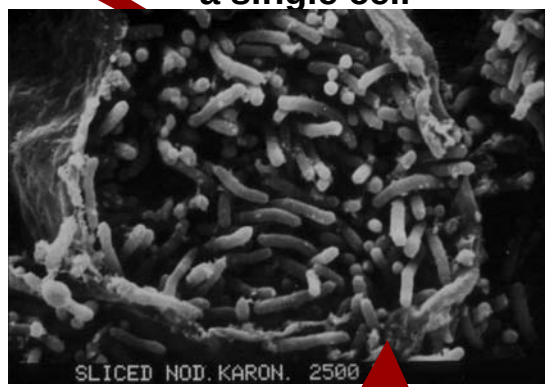
Bacteria reproduce in infection threads

Alfalfa root nodule

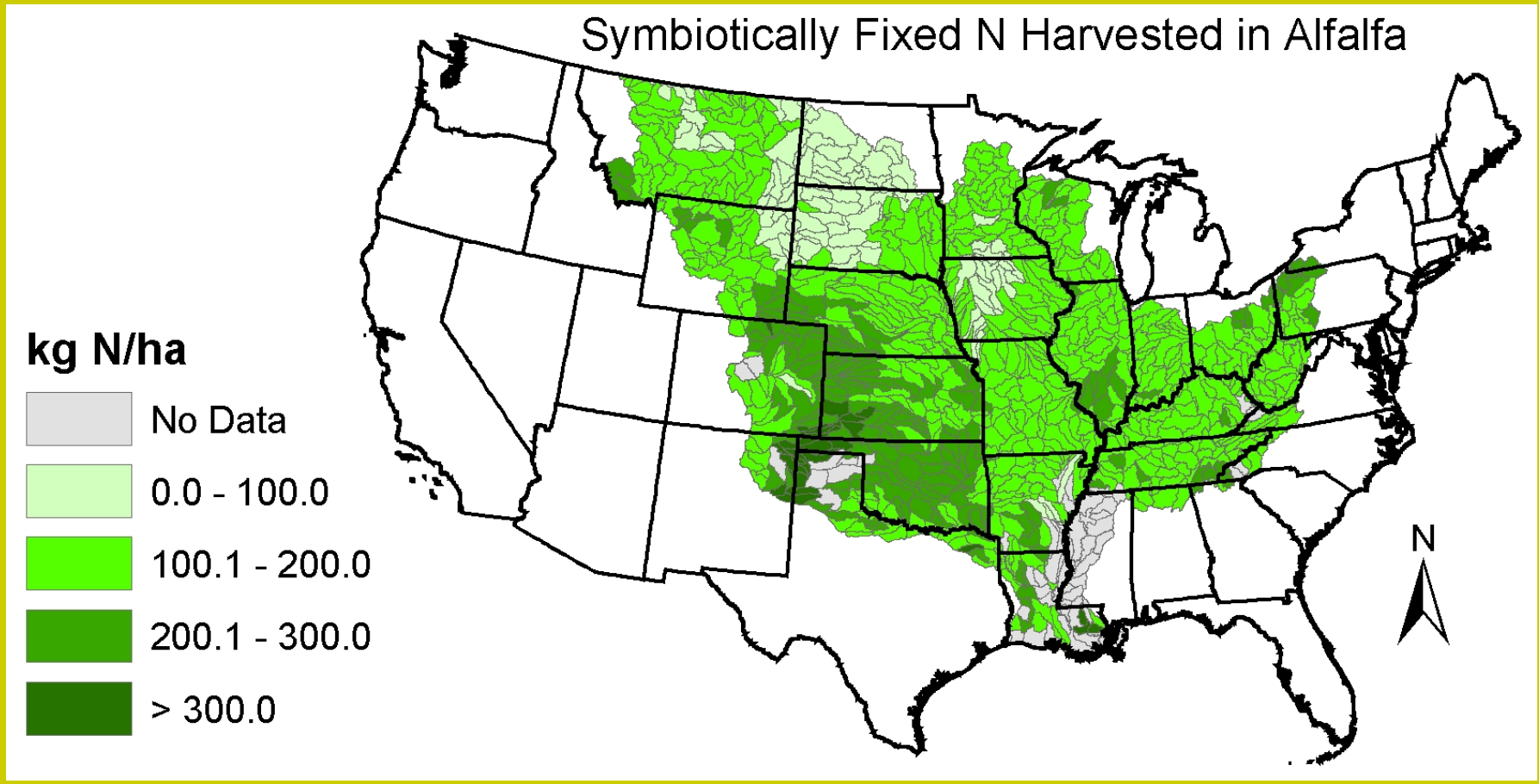


M. Barnett

Bacteroids filling a single cell



Vance et al., 1980



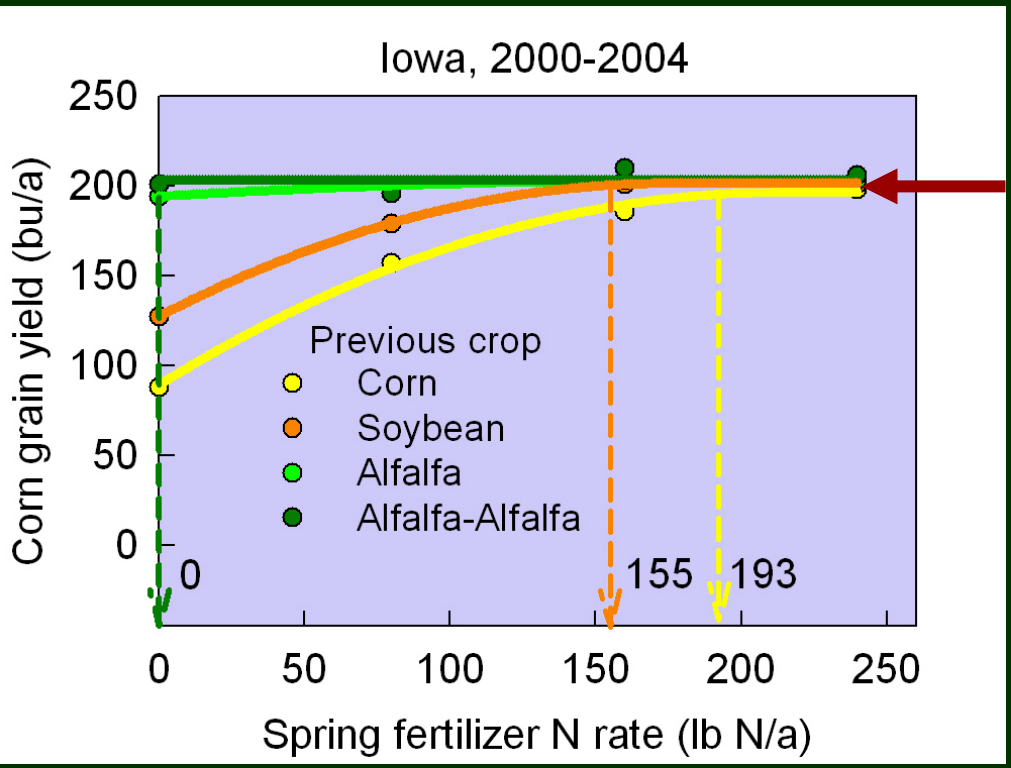
Russelle and Birr, 2004

Fixation rates:

Alfalfa 40 to 400 lb N/acre mean=**135** lb N/acre

Soybean 0 to 165 lb N/acre mean=**75** lb N/acre

Fertilizer N replacement value and other rotation effects



Other rotation effects

Fertilizer N replacement value

Mallarino et al., 2005

Yield benefit
$30 to 60/acre

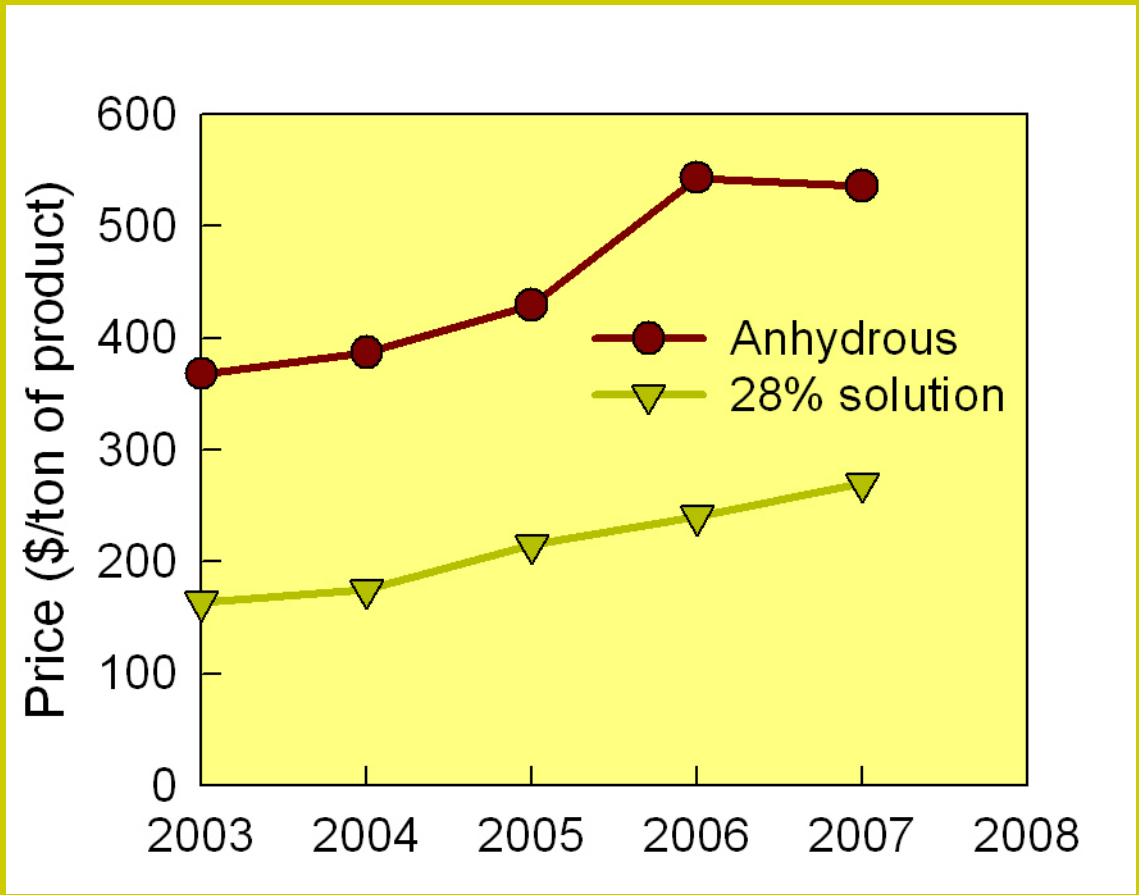
Lower fertilizer N required (2 yr)
$75 to 150/acre

No insecticide required (1 yr)
$15/acre

Total
$120 to 225/acre

Fertilizer N cost was **22%** of total cost of corn production in 2005

Average farm price for fertilizer N
North Central Region



Alfalfa and livestock manure

- Large nutrient removal
- Limits nitrate leaching
- Limits runoff
- Opportunity for summer applications


Univ. Missouri Ext. Serv.


Les Everett

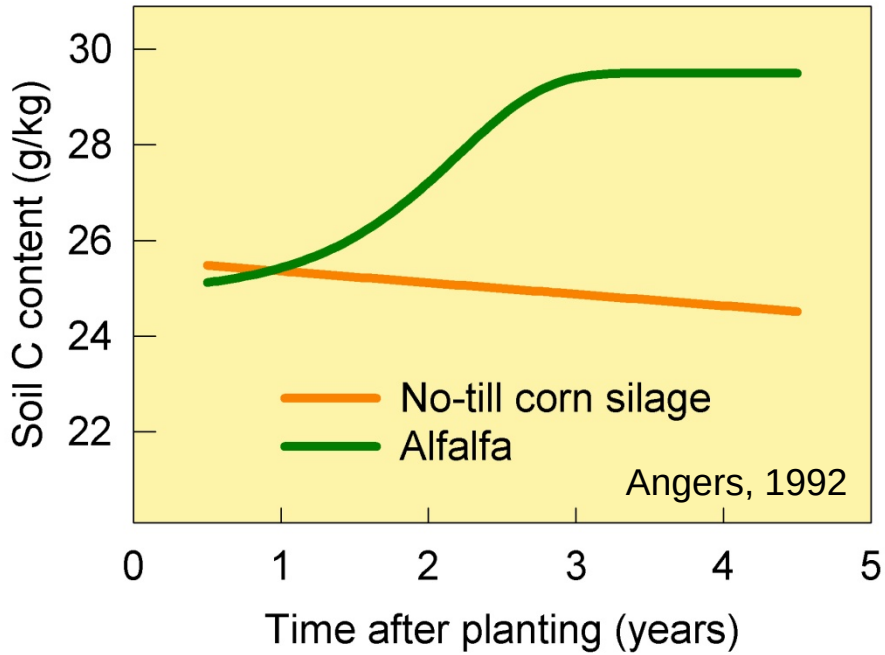
Alfalfa builds soil C and N

Annual cropping

3 yr perennial
- 3 yr annual

Alejandro La Manna, INIA, Uruguay

Quebec, Canada

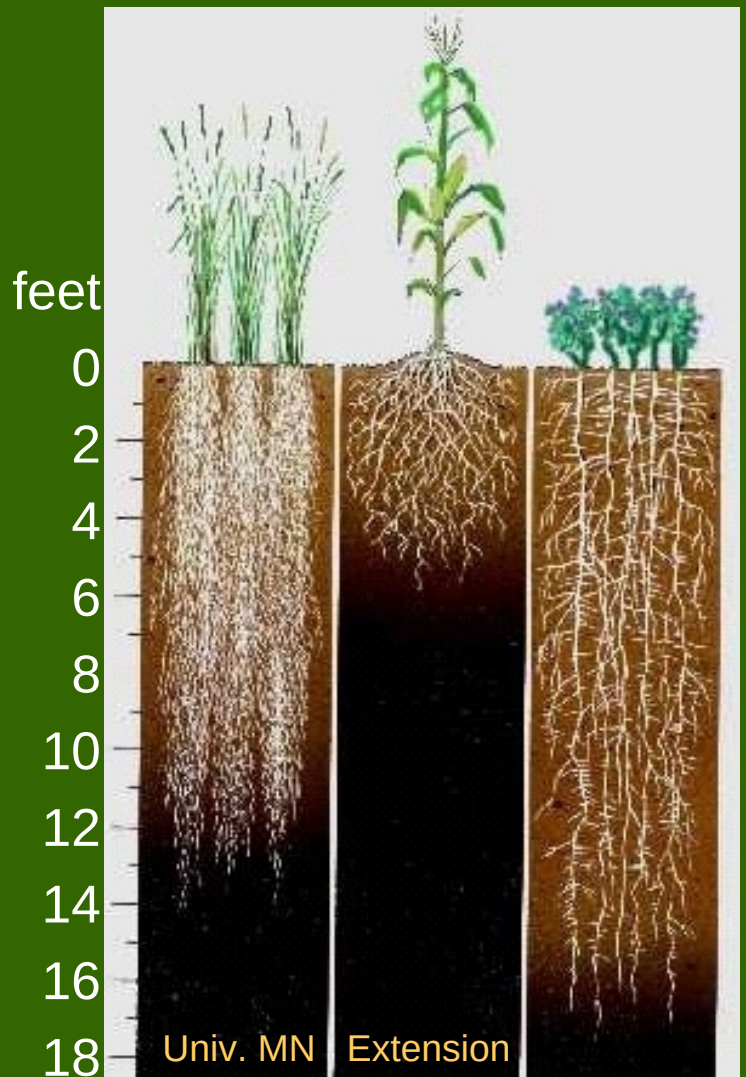


Maximum N benefit after 1 to 3 yrs of alfalfa

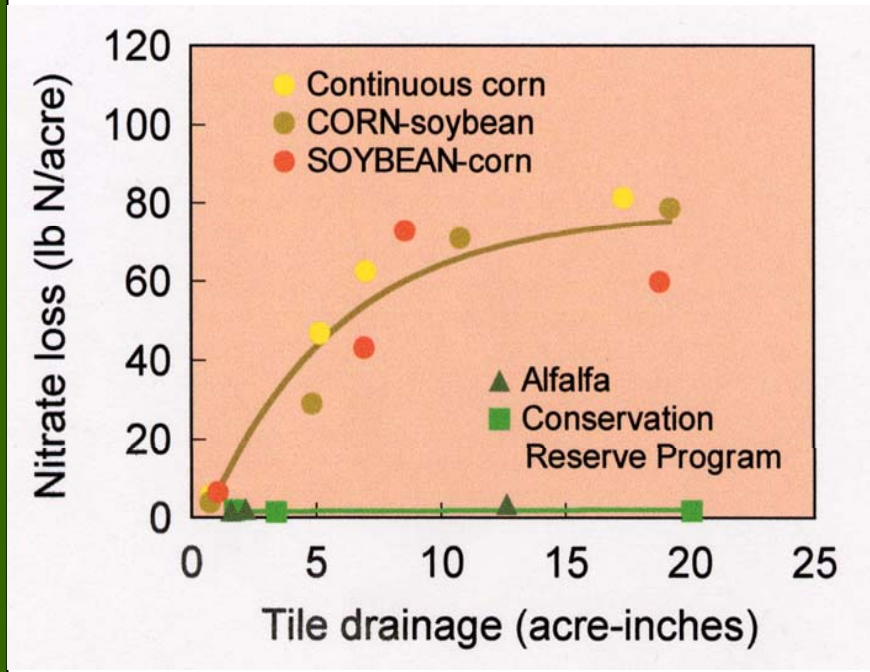
100 to 190 lb N/ acre fertilizer N replacement value

Improved water quality from tile drained soils

Alfalfa:
- Deeply rooted
- High yield potential
- High nitrate uptake
- Long growing season

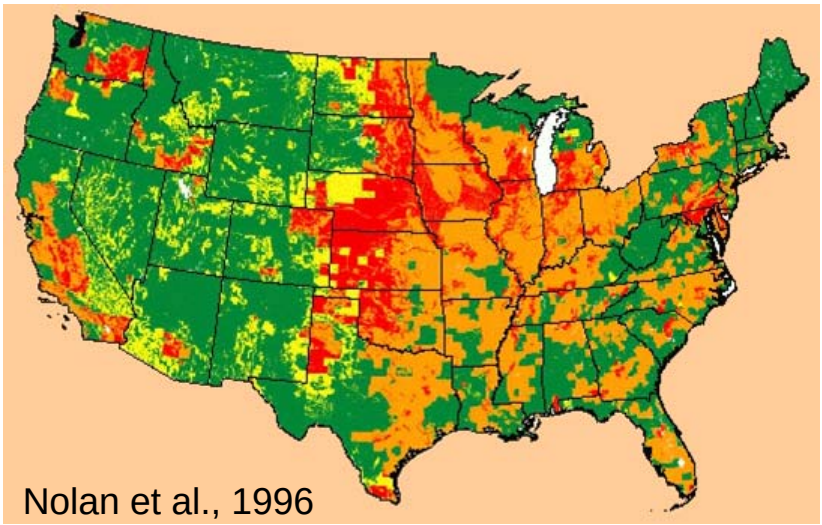


Nitrate loss from tile drains



Randall et al., 1997

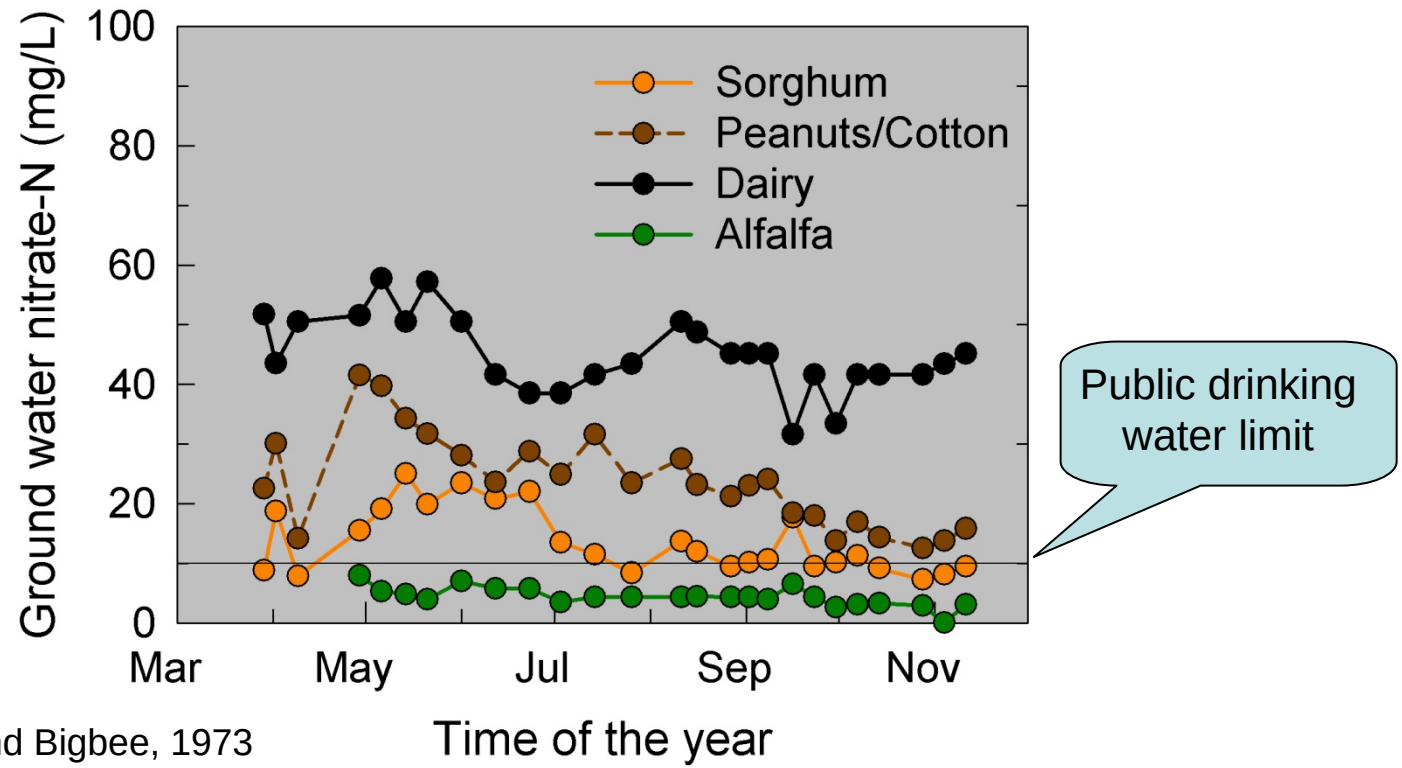
Ground water vulnerability



Nolan et al., 1996

Protected ground water quality

Nitrate in the Ogallala aquifer



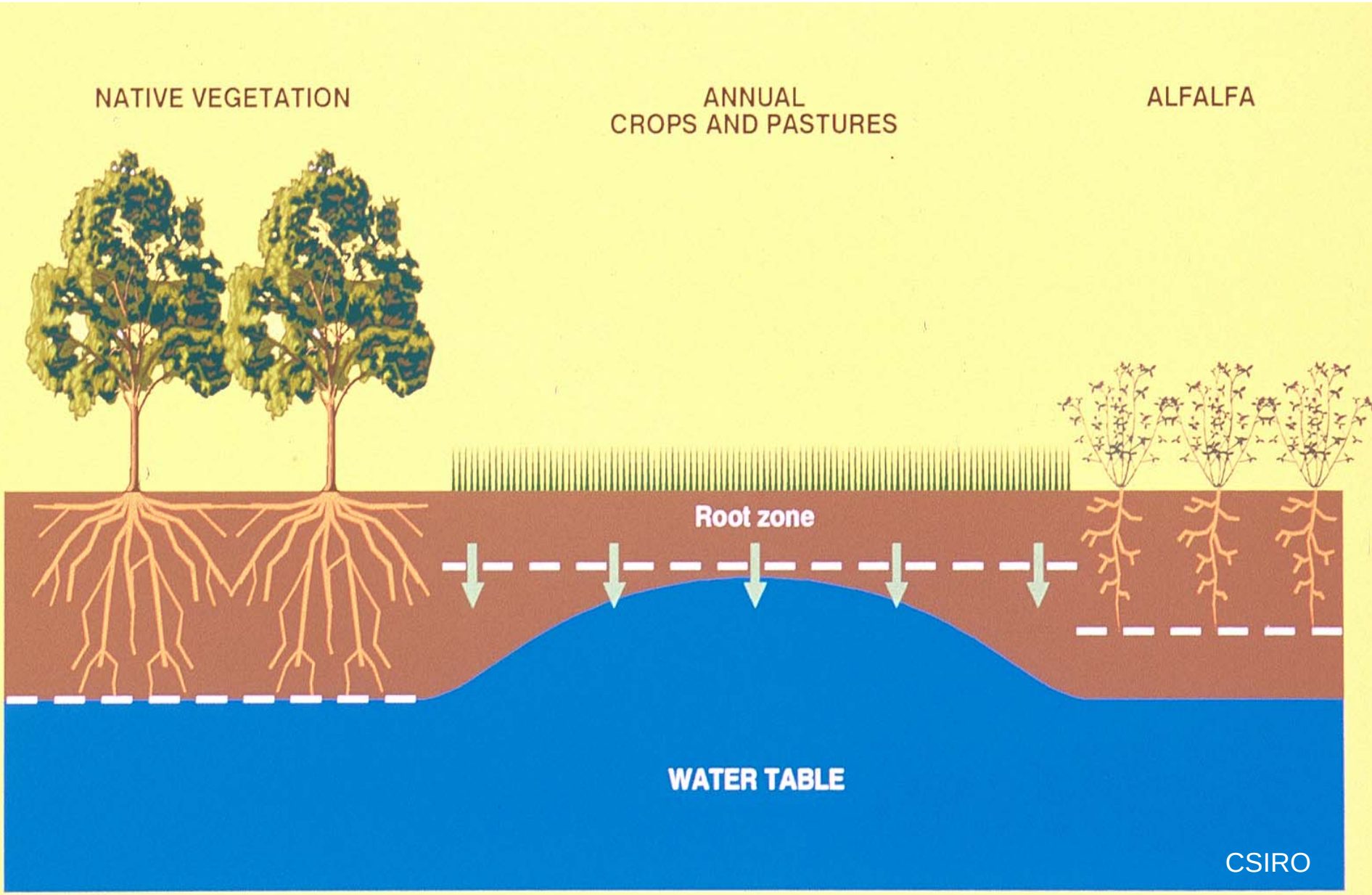
Taylor and Bigbee, 1973

Removal of excess nitrate


CP Rail


Bruce Fritz

Salinity control in arid regions



Alfalfa enhances wildlife habitat

Example: Alfalfa in California

> 27% (182 species) of all resident and migratory terrestrial wildlife (mammals, birds, amphibians, and reptiles) use alfalfa for **cover, feed, or reproduction**

> ~1000 species of insects, mites, spiders, and their relatives live in alfalfa fields

D.H. Putnam et al., 2001

Open, green space

One-pass separation of leaves and stems is feasible

90% leaves
27% protein
20% fiber

90% stems
13% protein
50% fiber

K. Shinners, U WI

Alfalfa for biomass – ARS & U of MN research

- Early 1990s
  - Integrated gasification combined cycle process
  - Stems for energy, leaves for feed
- Early 2000s
  - Reduced harvest frequency
  - Thick stems
    (plant breeding, management)
  - Disease and insect resistance

  - ➢ *Doubled stem yield, equal leaf yield*
- Currently
  - from genes to plants to fields

Alfalfa – a crucial crop for the biomass feedstock portfolio

- Multiple benefits
- Multiple products
- Knowledge base
- Infrastructure

Needs

- Variety development
  - Yield of stems and leaves
  - Carbohydrate components
- New management systems
  - Shorter rotations
  - More rapid establishment
- Measurement of impacts
  - Economics
  - C and greenhouse gas balance
  - Water quality
  - Fertilizer N credit