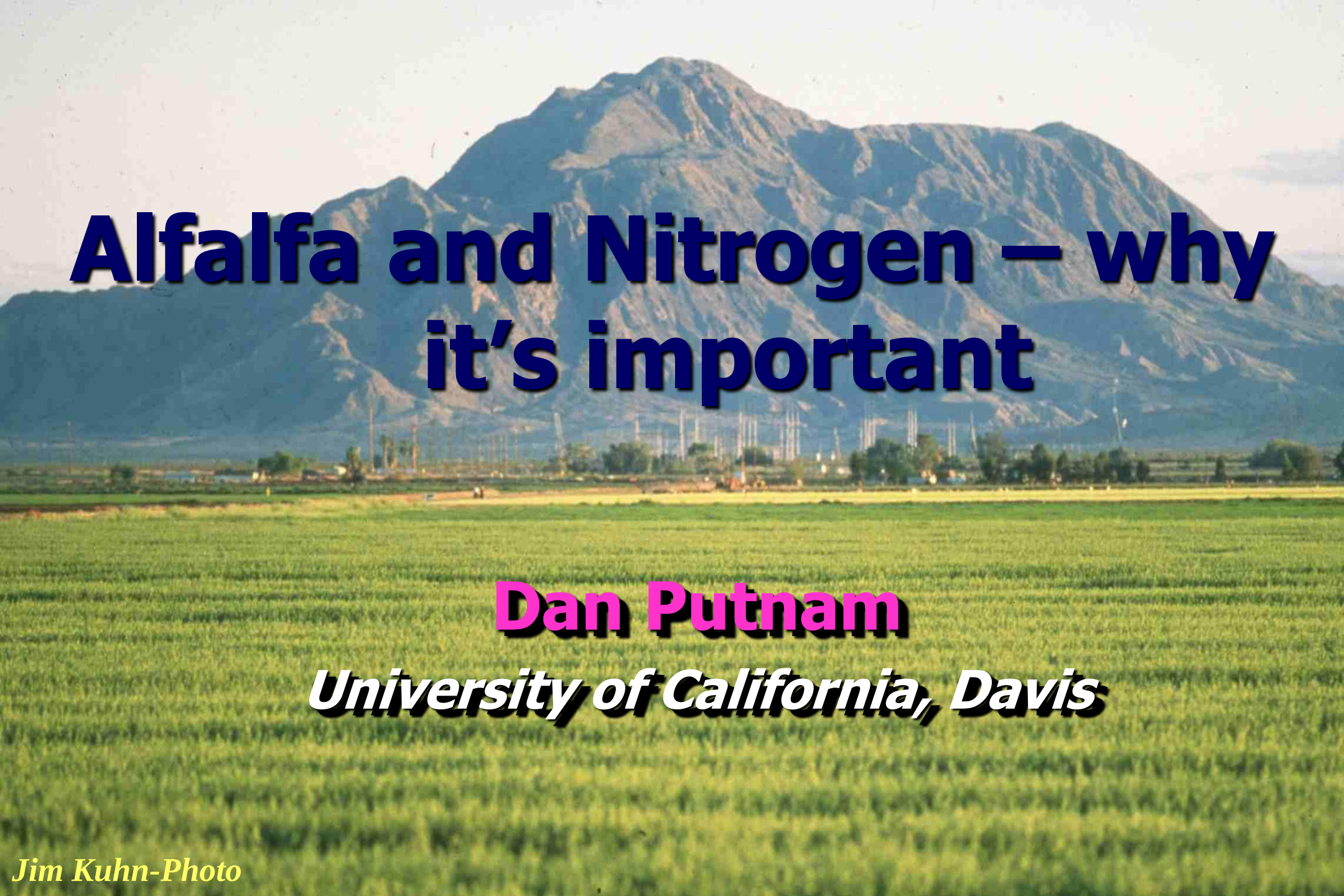


# Alfalfa and Nitrogen – why it's important

**Dan Putnam**

***University of California, Davis***

*Jim Kuhn-Photo*

# Nitrogen and Alfalfa:

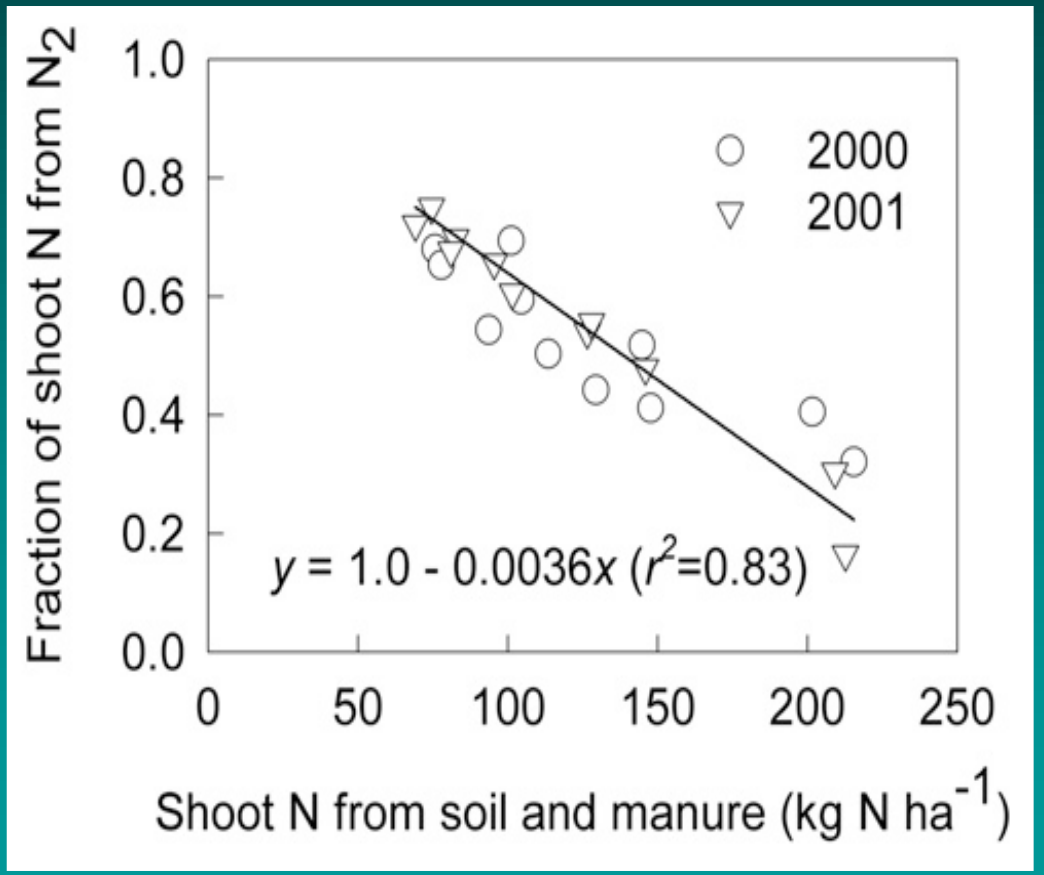
- **Three important Roles:**
  - **Produces large amounts of protein with no need for N fertilizers (environmental service)**
  - **Provides an opportunity to mitigate excess N from manures or municipal wastes through high uptake and deep roots.**
  - **Contributing N in economic amounts to subsequent crops.**

# Alfalfa Quietly Produces

- Millions of tons of protein with zero N fertilizer
- Most grain crops require some N fertilizer to maximize yield
- That fertilizer takes fossil fuels
- Each year, the protein produced by 1 million acres of alfalfa would require about 5 million acres of corn.

# Alfalfa – a 'buffer' with N

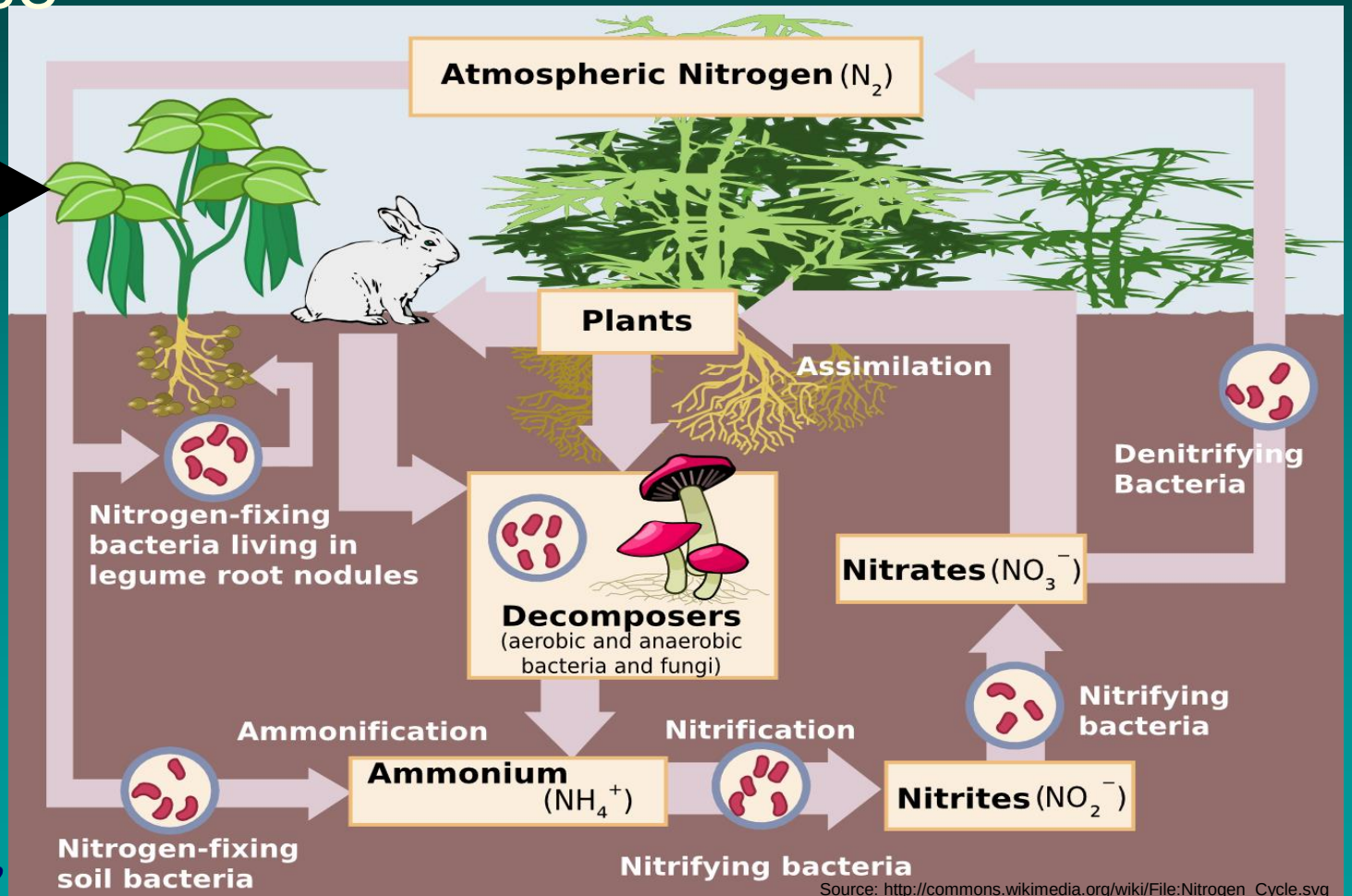
- Likely 60-80% coming from $N_2$ fixation.
- Fixes N under low N conditions
- Takes up N from soil when available



# The N Cycle

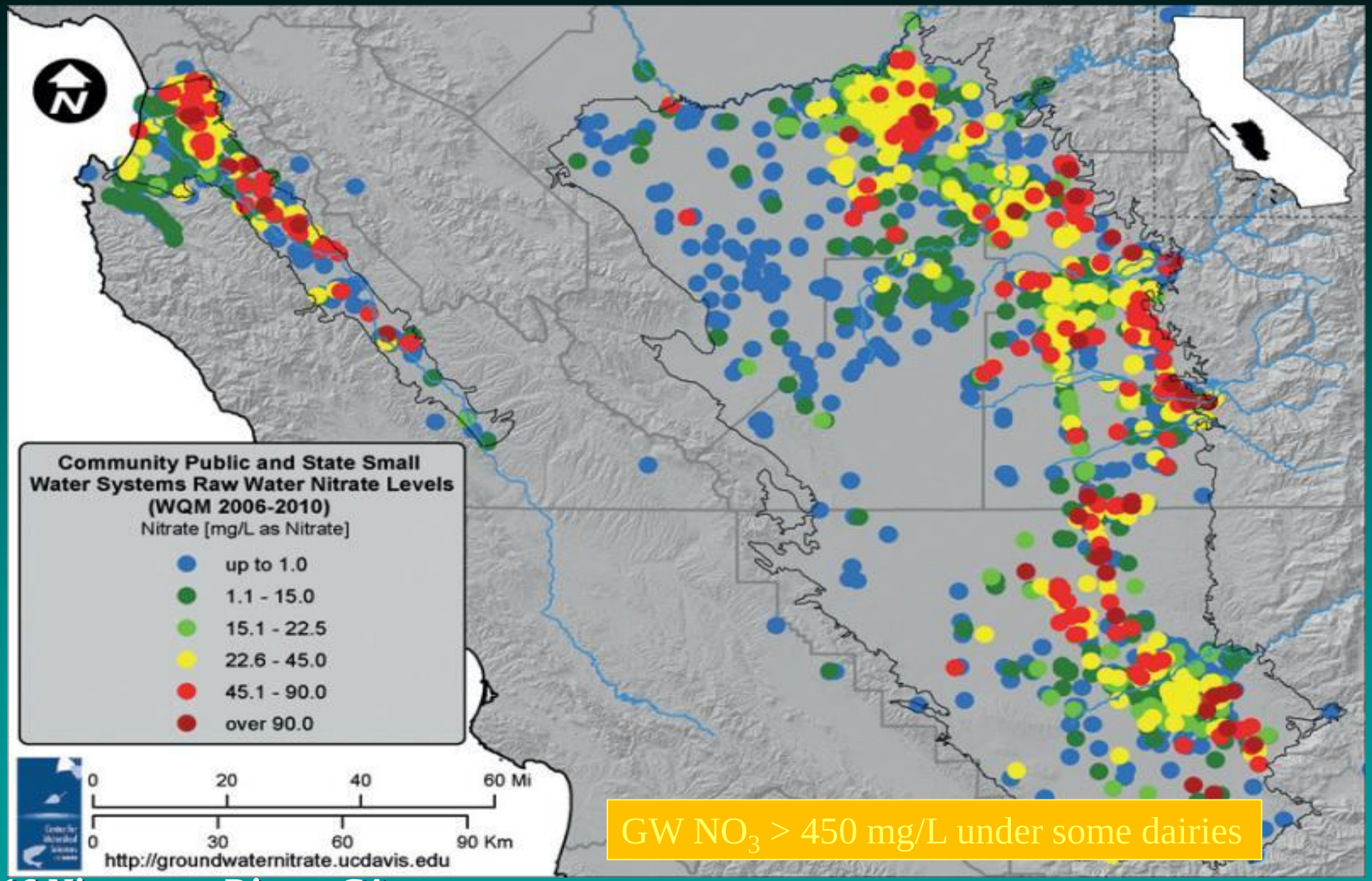
Alfalfa can help increase soil N, which subsequent crops can use


Source: http://commons.wikimedia.org/wiki/File:Alfalfa--Luzerne.jpg




*2016 Nitrogen – Dixon,*

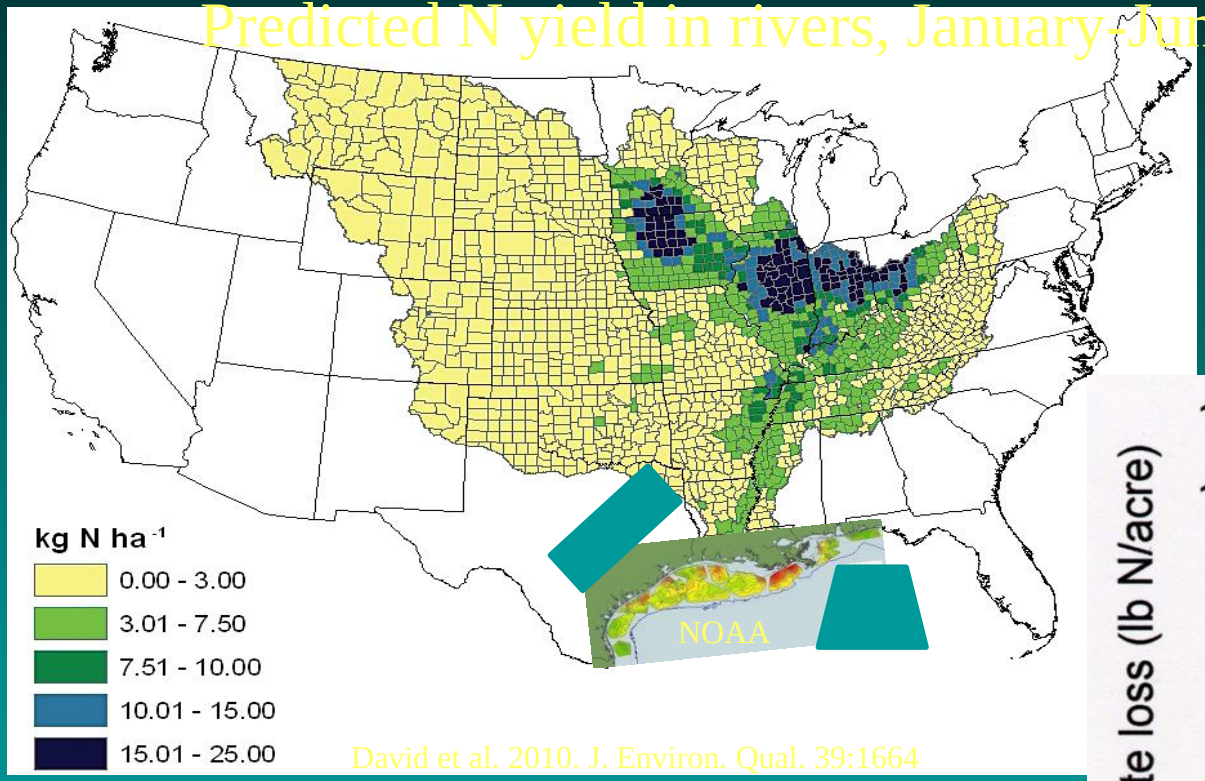
# Degradation of groundwater aquifers by nitrate



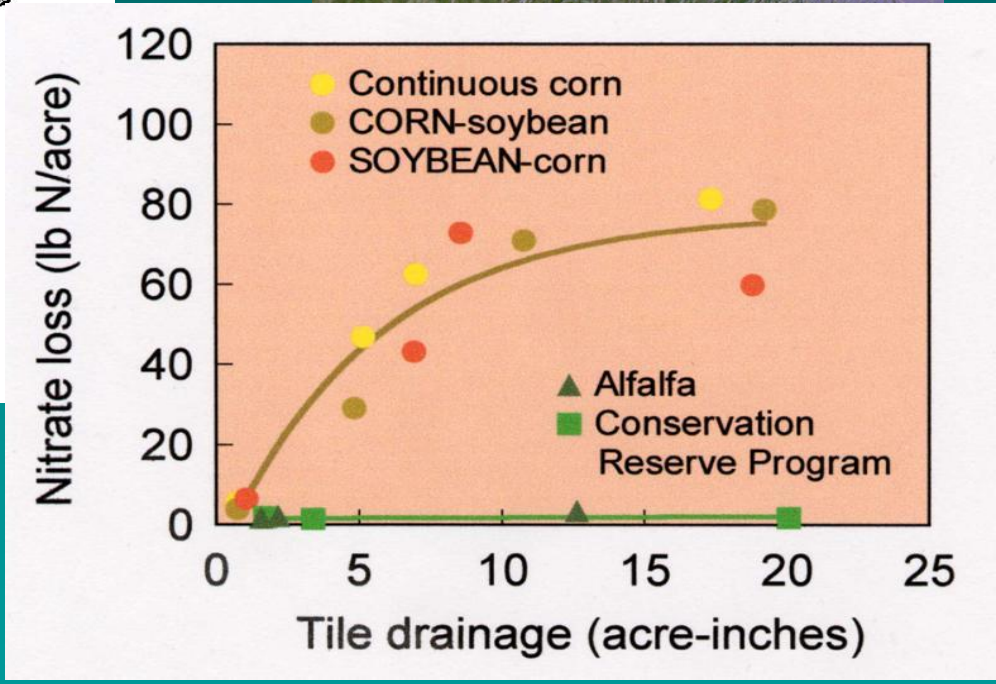

*2016 Nitrogen – Dixon, CA*

Harter et al. 2012. Addressing $NO_3$ in CA drinking water

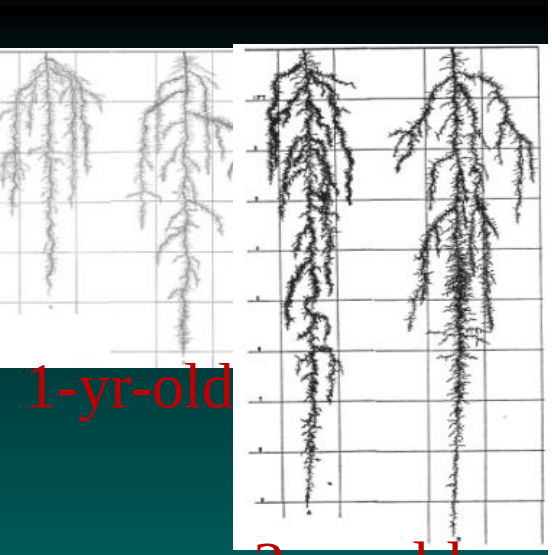
# Subsurface drainage is required for agriculture in much of the USA *but is related to hypoxia in the Gulf*



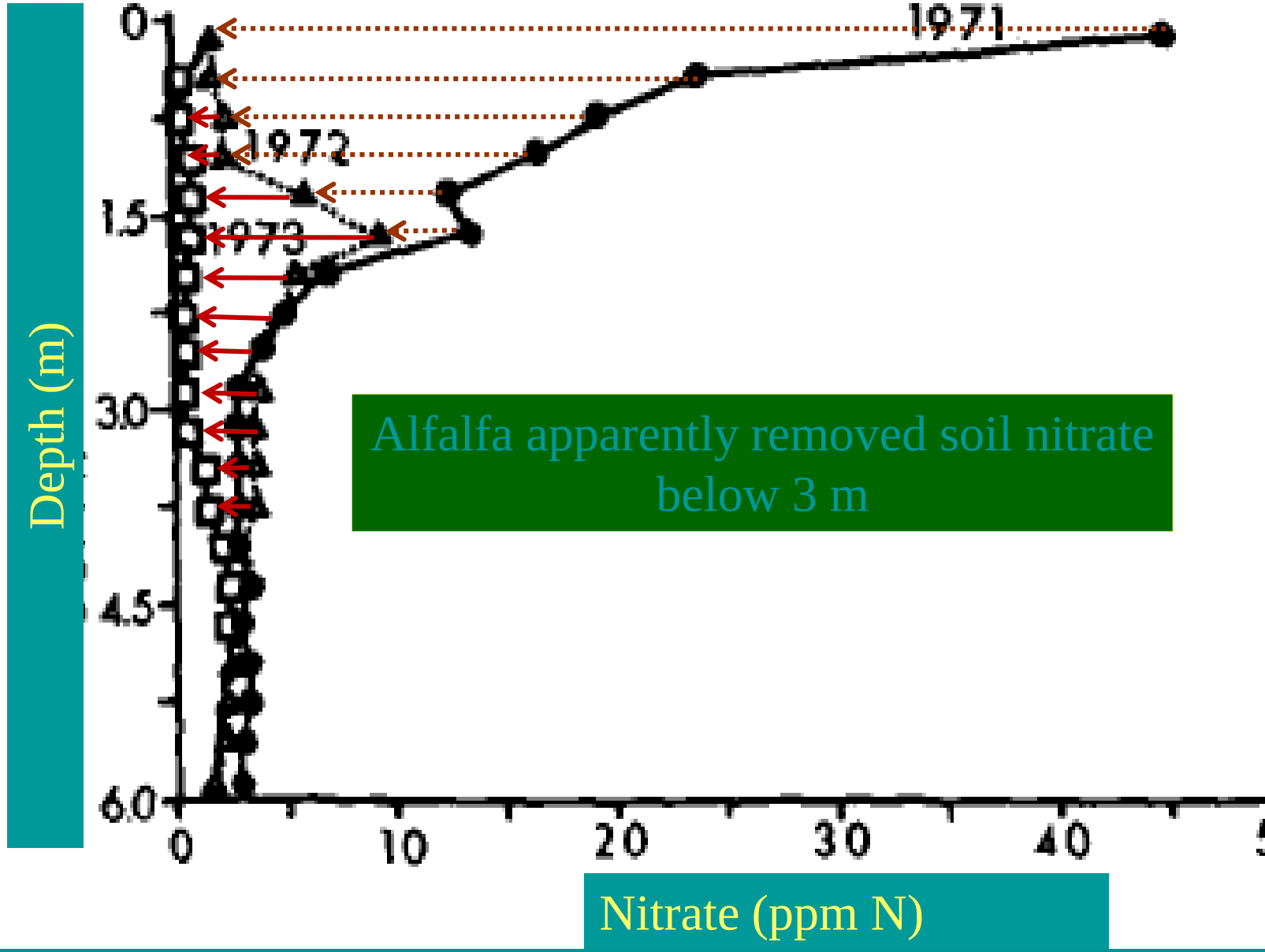

David et al. 2010. J. Environ. Qual. 39:1664




Randall et al. 1997. J Environ. Qual. 26:1240




Jean and Weaver, 1924




Alfalfa apparently removed soil nitrate below 3 m

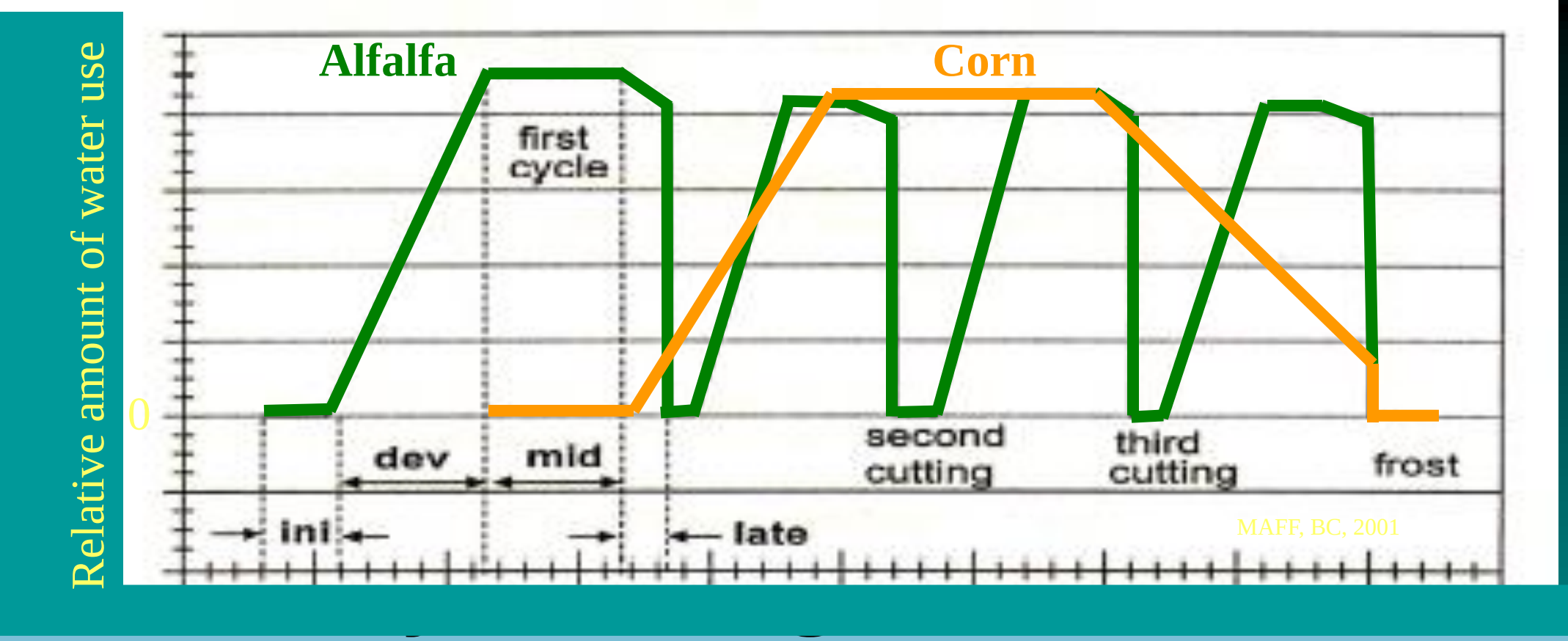


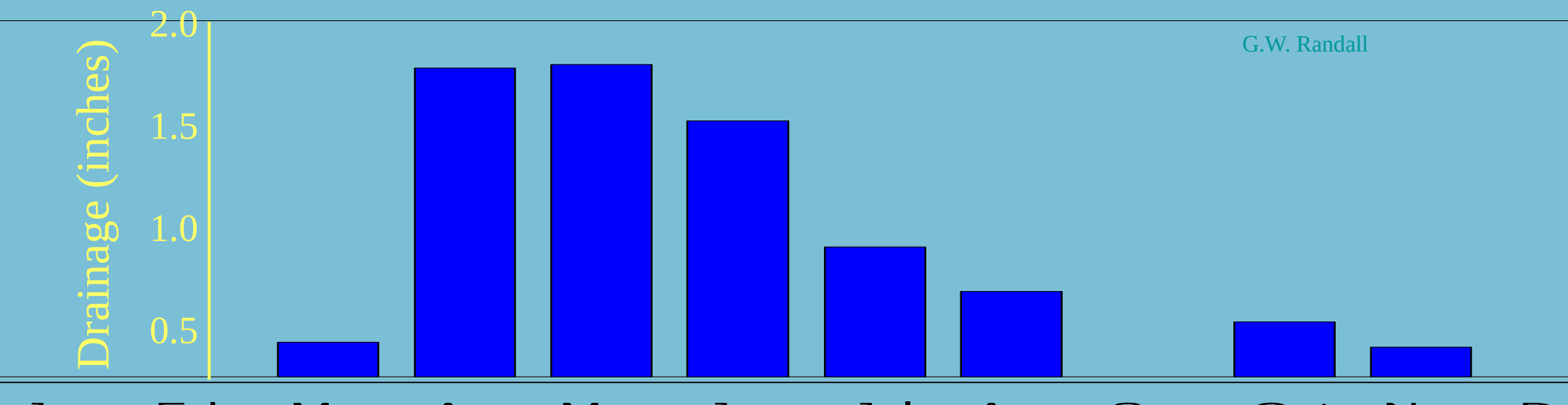
Mathers et al. 1975. J. Environ. Qual. 4:403

# Alfalfa forage in CA can remove 250-1000 lbs. N/acre per year …

Table 1. Crop removal of Nitrogen at different alfalfa yield and protein levels. Shaded area indicates most likely range for California Central Valley locations.

| | Crude Protein of Alfalfa Forage | | | | | |
|---|---|---|---|---|---|---|
| | 16 | 18 | 20 | 22 | 24 | 26 |
| | %Nitrogen in Forage | | | | | |
| Tonnage | 2.56% | 2.88% | 3.20% | 3.52% | 3.84% | 4.16% |
| (t/a) | Crop Removal of N | | | | | |
| | lbs N/acre | | | | | |
| 5 | 256 | 288 | 320 | 352 | 384 | 416 |
| 6 | 307 | 346 | 384 | 422 | 461 | 499 |
| 7 | 358 | 403 | 448 | 493 | 538 | 582 |
| 8 | 410 | 461 | 512 | 563 | 614 | 666 |
| 9 | 461 | 518 | 576 | 634 | 691 | 749 |
| 10 | 512 | 576 | 640 | 704 | 768 | 832 |
| 11 | 563 | 634 | 704 | 774 | 845 | 915 |
| 12 | 614 | 691 | 768 | 845 | 922 | 998 |
| Shaded area representas most likely outcome | | | | | | |


Relative amount of water use
Alfalfa
Corn
first cycle
0
dev
mid
ini
late
second cutting
third cutting
frost
MAFF, BC, 2001


Drainage (inches)
2.0
1.5
1.0
0.5
G.W. Randall

# Per cutting N uptake:

Table 2. Estimated per-cut crop removal of Nitrogen at different alfalfa yield and protein levels. Shaded area indicates most likely range for California Central Valley locations.

| | Crude Protein of Alfalfa Forage | | | | | |
|---|---|---|---|---|---|---|
| | 16 | 18 | 20 | 22 | 24 | 26 |
| | %Nitrogen in Forage | | | | | |
| Tonnage (t/a) | 2.56% | 2.88% | 3.20% | 3.52% | 3.84% | 4.16% |
| | Crop Removal of N | | | | | |
| | lbs N/acre | | | | | |
| 0.5 | 26 | 29 | 32 | 35 | 38 | 42 |
| 0.75 | 38 | 43 | 48 | 53 | 58 | 62 |
| 1 | 51 | 58 | 64 | 70 | 77 | 83 |
| 1.25 | 64 | 72 | 80 | 88 | 96 | 104 |
| 1.5 | 77 | 86 | 96 | 106 | 115 | 125 |
| 1.75 | 90 | 101 | 112 | 123 | 134 | 146 |
| 2 | 102 | 115 | 128 | 141 | 154 | 166 |
| 2.25 | 115 | 130 | 144 | 158 | 173 | 187 |
| 2.5 | 128 | 144 | 160 | 176 | 192 | 208 |
| 2.75 | 141 | 158 | 176 | 194 | 211 | 229 |

# How much nitrogen is taken up/produced?

- Depends on:
  - Yield
  - Location
  - Soil texture
  - Alfalfa stand age
  - Alfalfa stand density
  - Mineralization rate

Fertilizer N replacement value
(N credit)

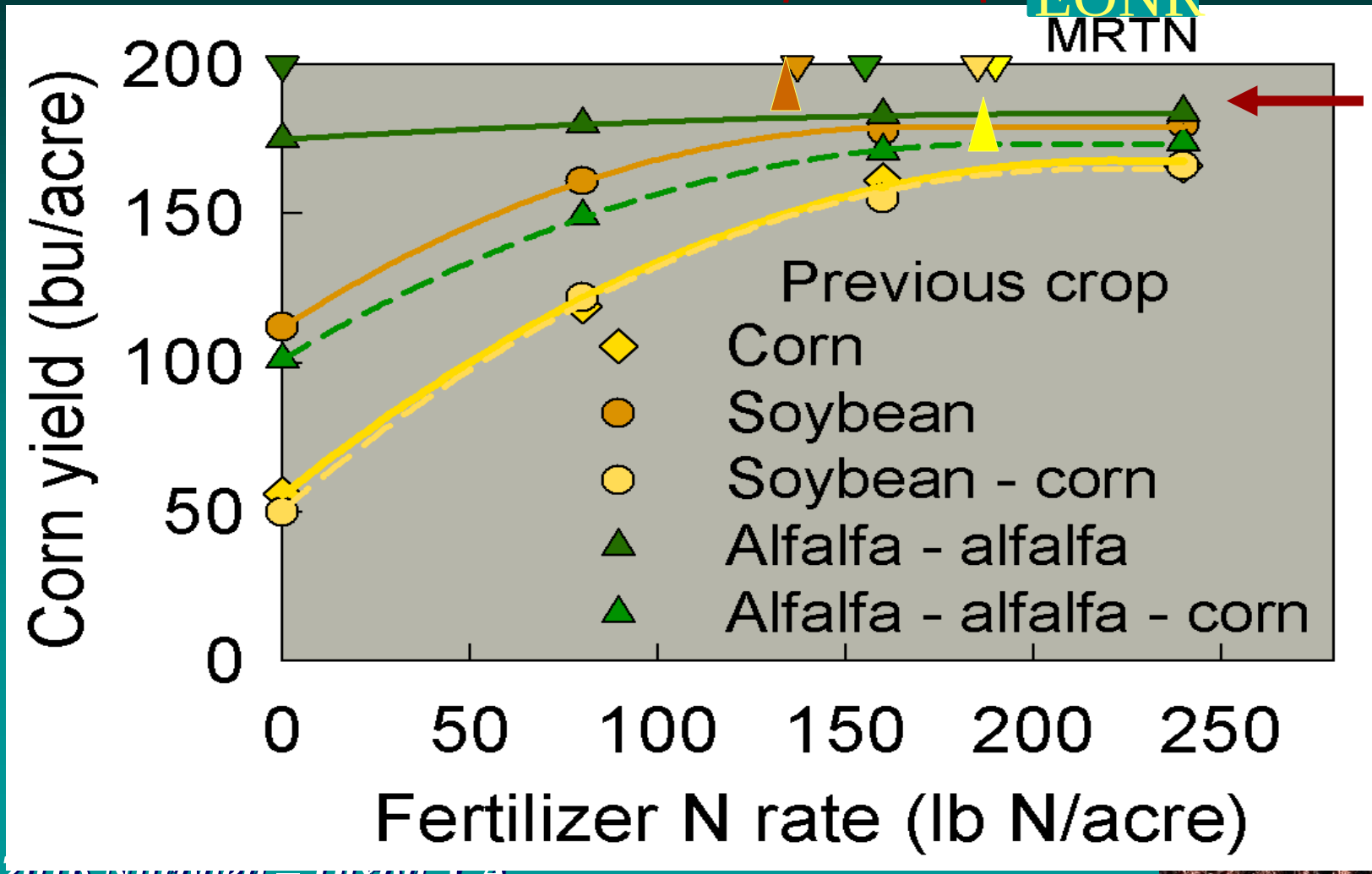
Alfalfa

Soybean

(12.5 t/ha)

EONR

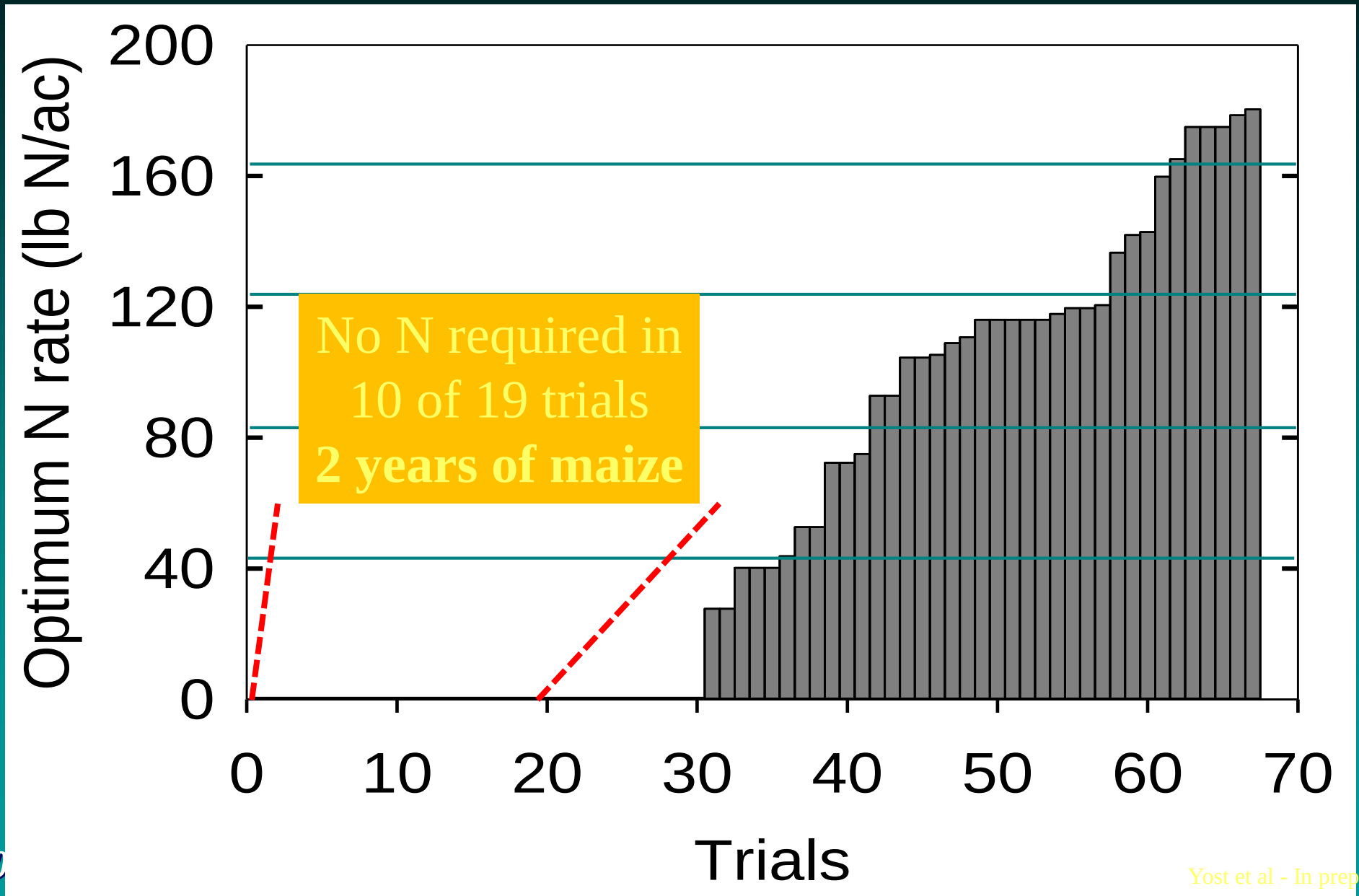
MRTN




**Other rotation effects**

Mallarino and Pecinovsky, 2006, ISRF08-15

# Half the time: no response to N in **both** years of maize




Yost et al - In preparation

# Nitrogen credits

## Nitrogen credits are an easy way for growers to determine how much N fertilizer they can save

### Nitrogen Credits for Alfalfa and Soybean in Wisconsin

| First year credit: | medium & fine textured soils > 8 inches of regrowth | medium & fine textured soils < 8 inches of regrowth | sandy soils > 8 inches of regrowth | sandy soils < 8 inches of regrowth |
|---|---|---|---|---|
| | Nitrogen Credit (lb N/acre) | | | |
| **Alfalfa** (stand denisty) | | | | |
| Good .... (70-100 % alfalfa, > 4 plants/ft$^2$) | 190 | 150 | 140 | 100 |
| Fair ..... (30-70 % alfalfa, 1.5 - 4 plants/ft$^2$) | 160 | 120 | 110 | 70 |
| Poor..... (0-30 % alfalfa, < 1.5 plants/ft$^2$) | 130 | 90 | 80 | 40 |

**Second year credit:** In the second cropping year following fair and good stands on medium and fine textured soil, you can take a 50 lb N/acre credit.

**Soybean**

40 lb N /acre is available to crops following soybean in a rotation. No credit on sandy soils.

# Nitrogen Credits around the World

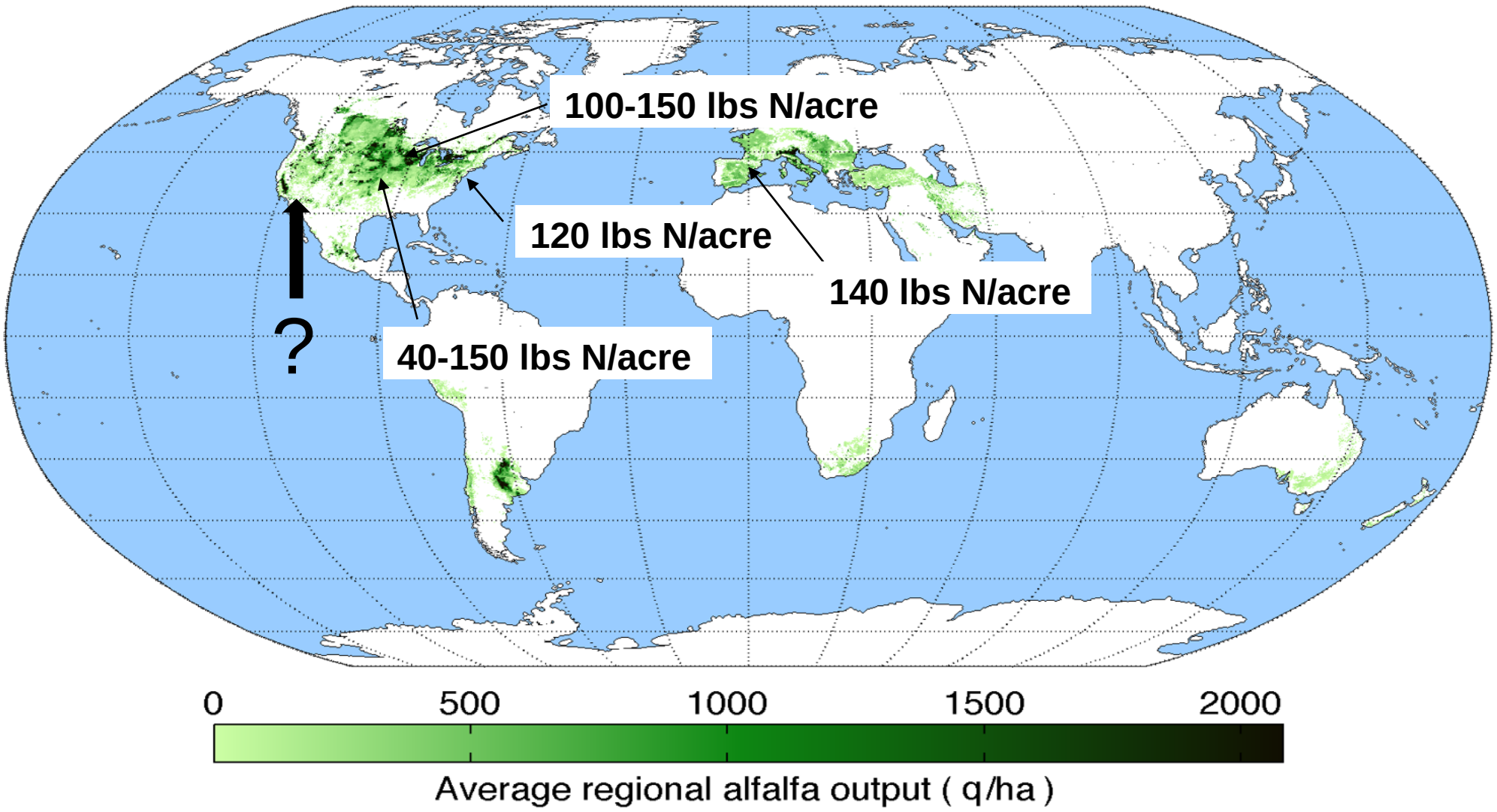
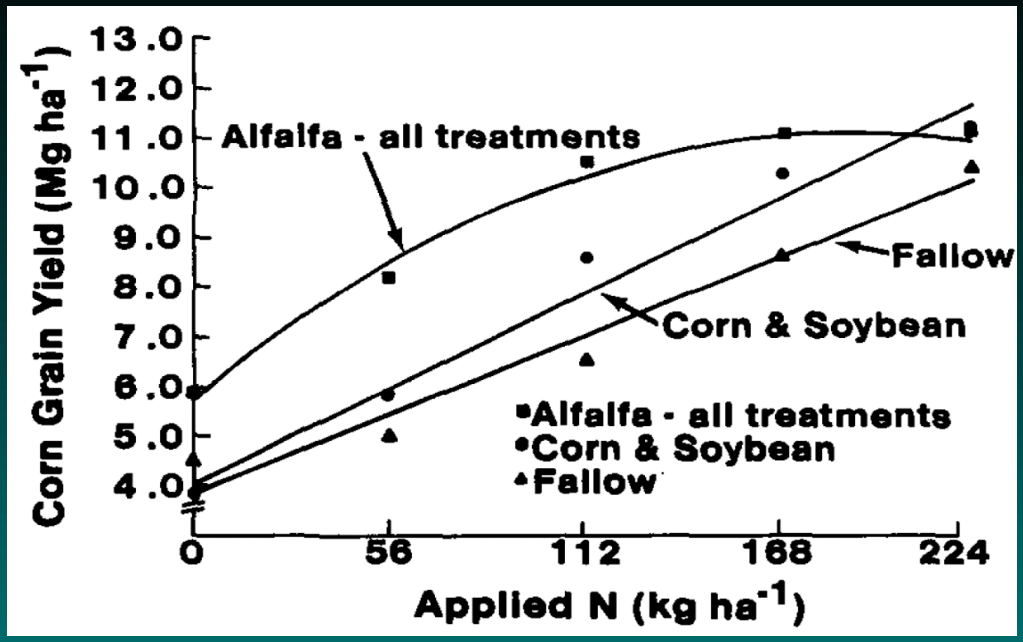
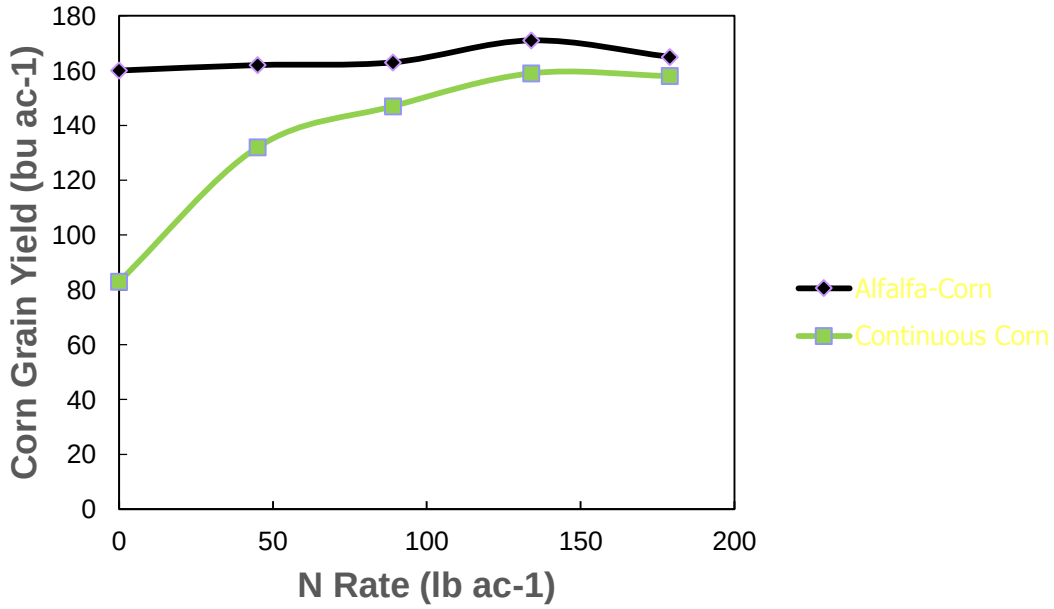


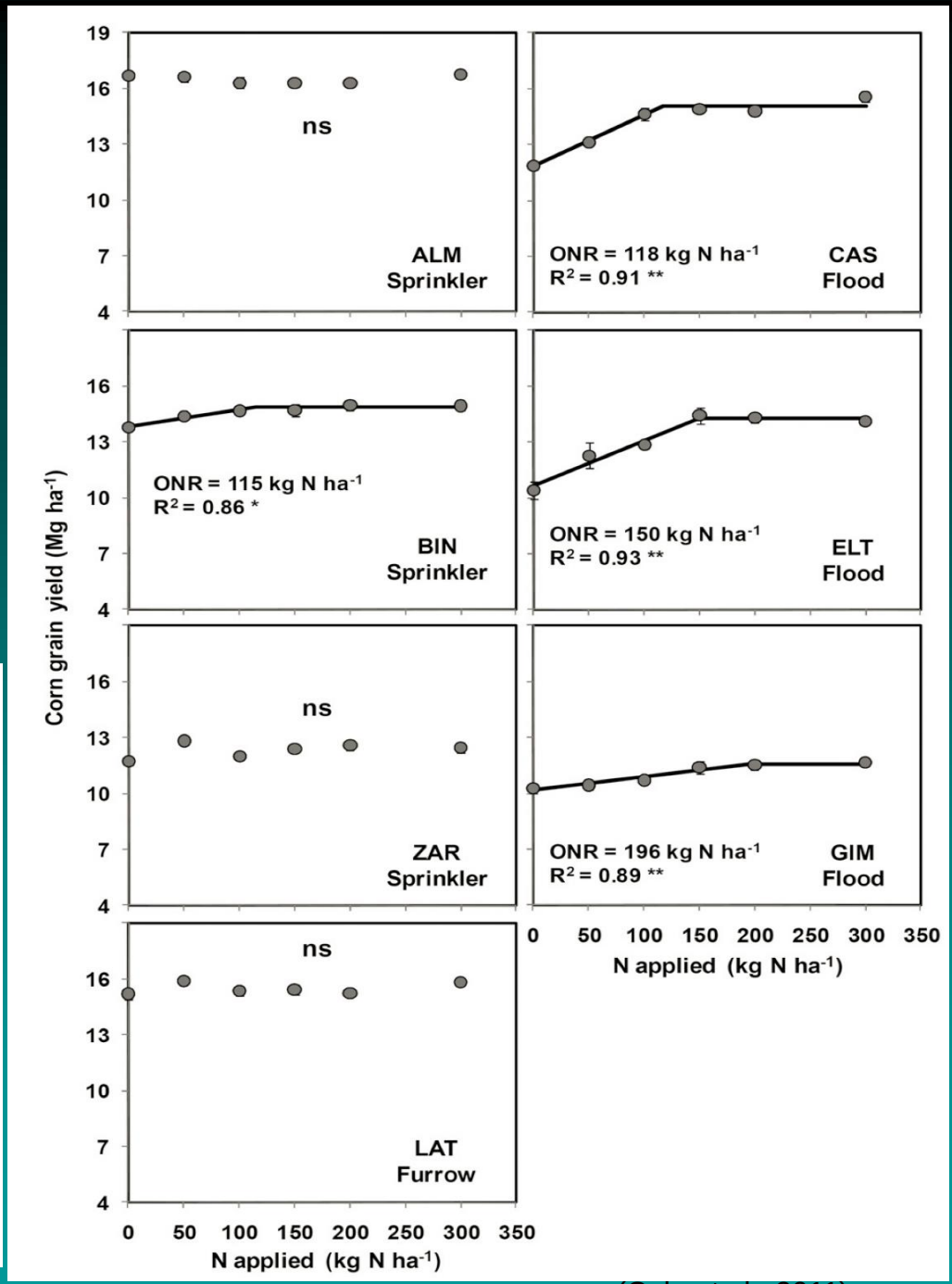



Image source: http://commons.wikimedia.org/wiki/File:Alfalfaoutput.png




(Fox and Piekielek, 1988)




(Cela et al., 2011)

# Developing Nitrogen Credits for California: Rotation Study

- Two Rotation Treatments:
  - Continuous Alfalfa (3+ years)
  - Grain Rotation (Sudangrass/Wheat)
- Three Locations:
  - Davis (Solano County)
  - Kearney (Fresno County)
  - Tulelake (Siskiyou County)
- Six Nitrogen Rate Treatments in Wheat:
  - 0, 50, 100, 150, 200, 250 lbs N/acre

# Rotation Study Treatments

## Continuous Alfalfa and Grain Rotation

Tulelake

Davis

(Kearney site not pictured)

*2016 Nitrogen – Dixon, CA*

# Rotation Study Treatments

## N Treatments in Wheat following Alfalfa and Grains

Tulelake

Kearney

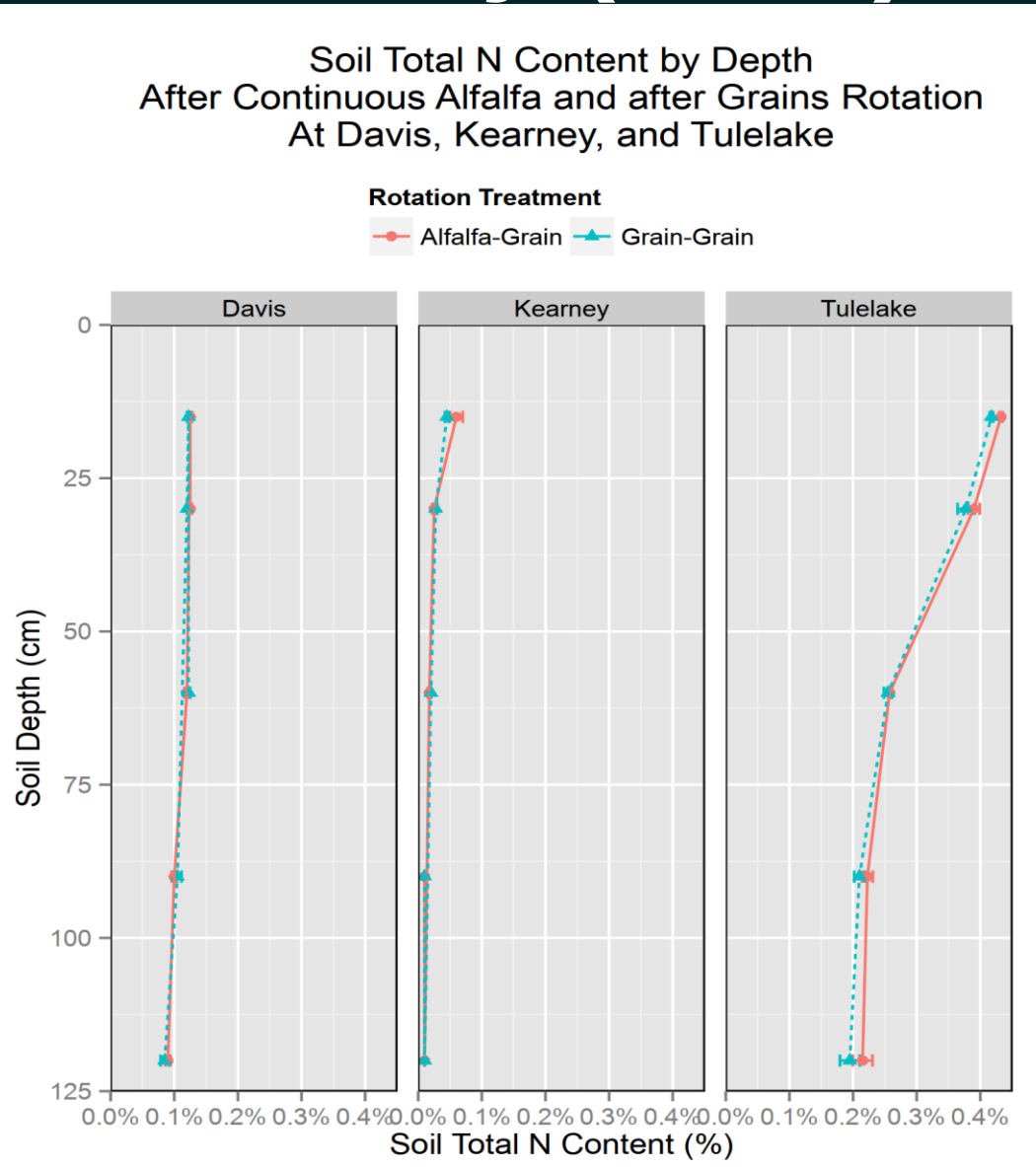
(Davis site not pictured)

# How much do soil tests say (2013)?

- **Continuous alfalfa maintained relatively high soil nitrate concentrations compared to grain rotation**
- **Much less than 25 ppm $NO_3^-$ optimum**
- **Soil total N was not significantly affected**

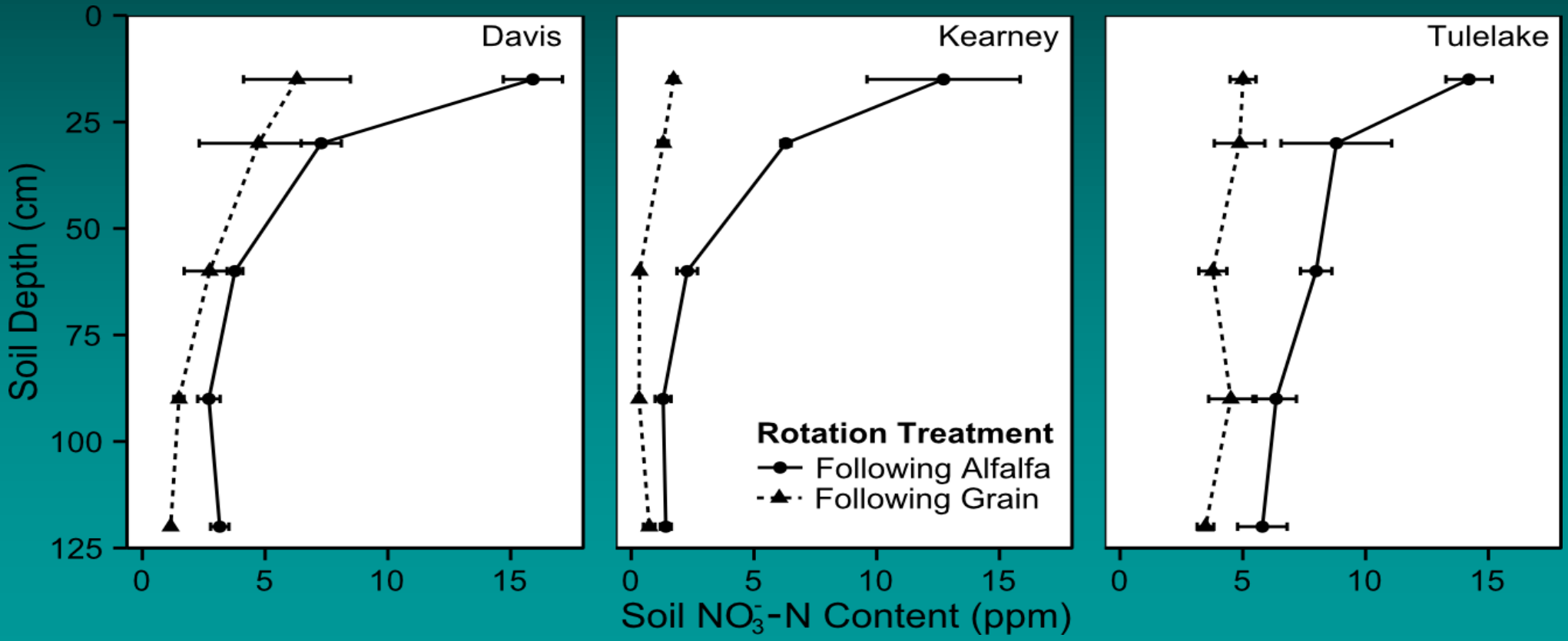
**Nitrate Concentrations in Top 30 cm of Soil**

| Rotation Treatment | Continuous Alfalfa-Grain | Grain Rotation-Grain |
|---|---|---|
| Davis | 6.79 ppm | 2.86 ppm |
| Kearney | 5.148 ppm | 0.4925 ppm |
| Tulelake | 6.95 ppm | 3.97 ppm |

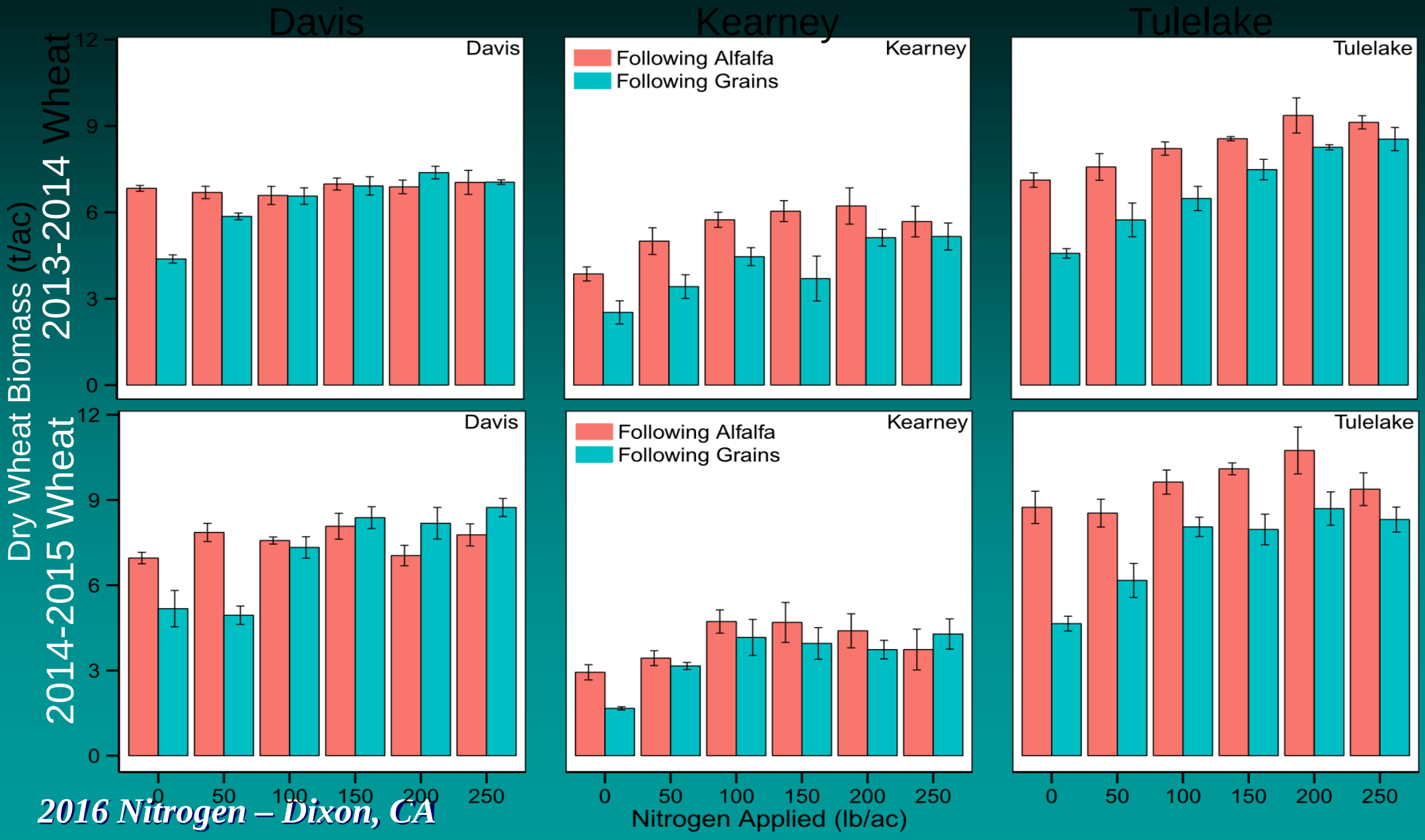


# How much do soil tests say (2014)?

- Continuous alfalfa maintained relatively high soil nitrate concentrations compared to grain rotation
- Much less than 25 ppm $NO_3^-$ optimum



# What did aboveground biomass tell us?

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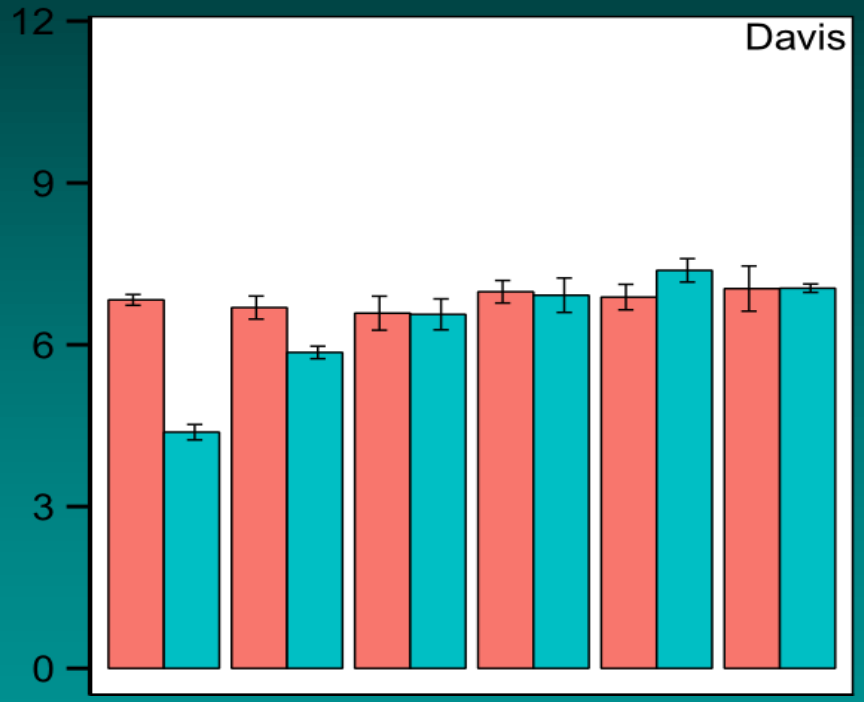
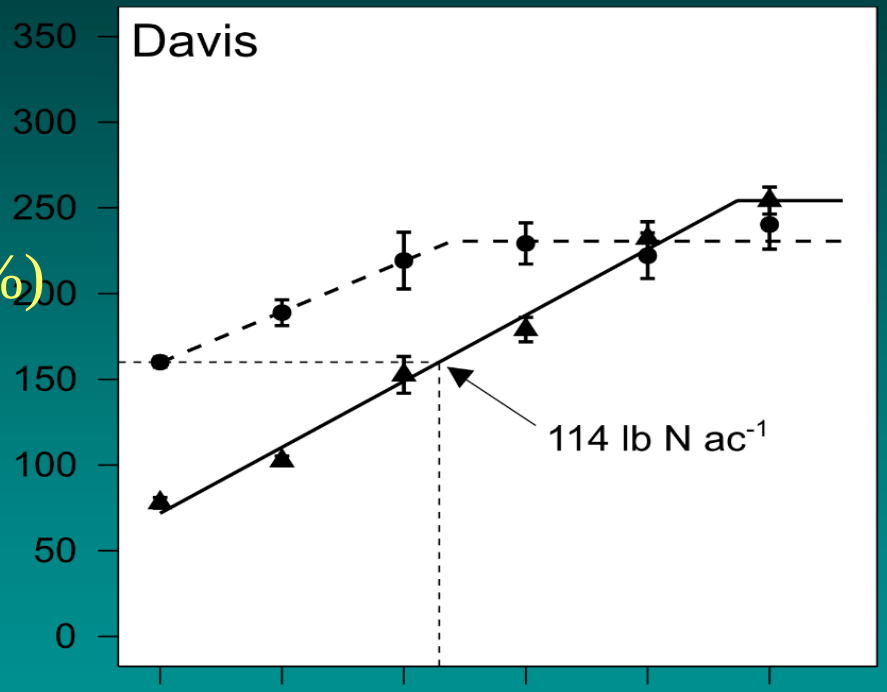
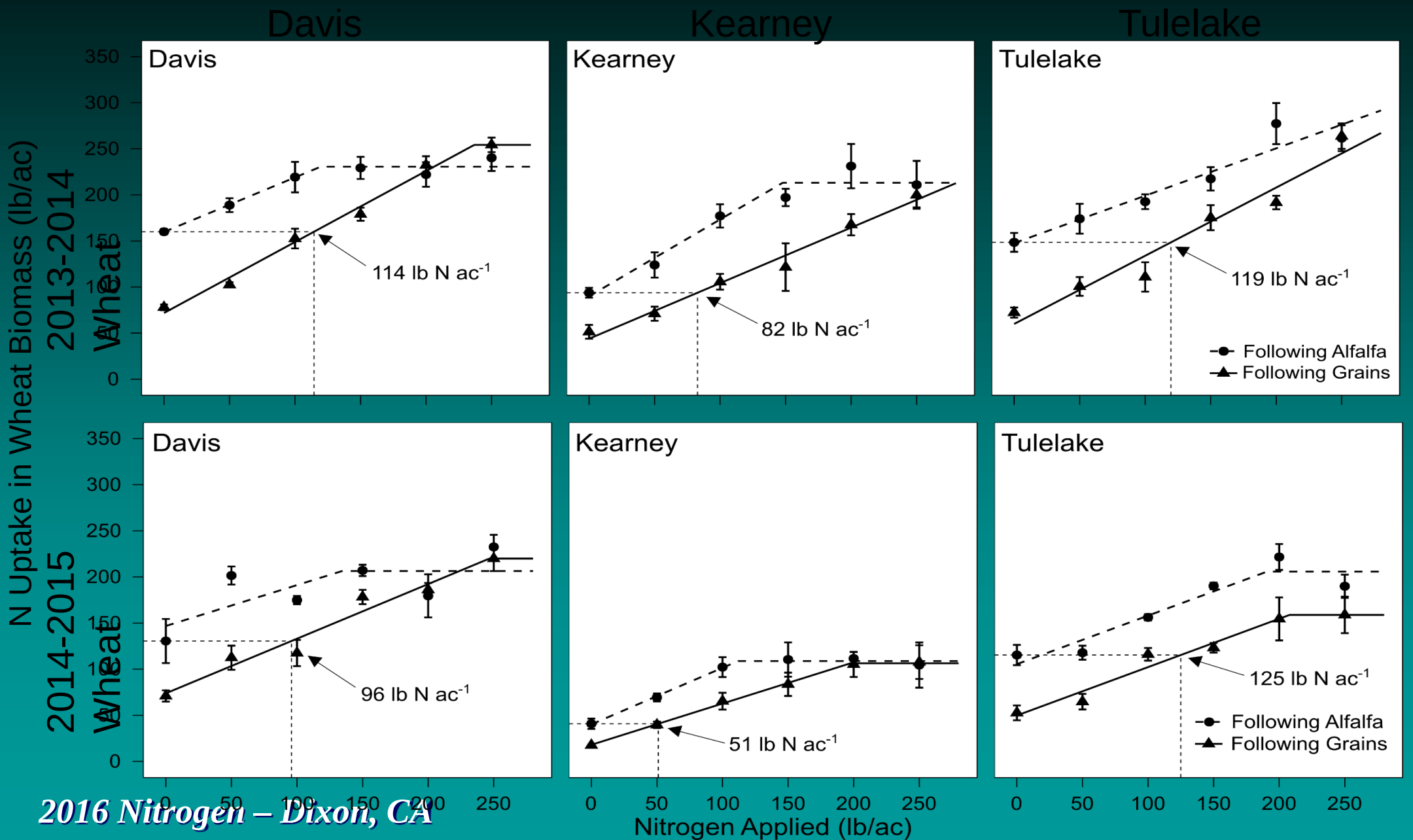
# Calculating nitrogen uptake



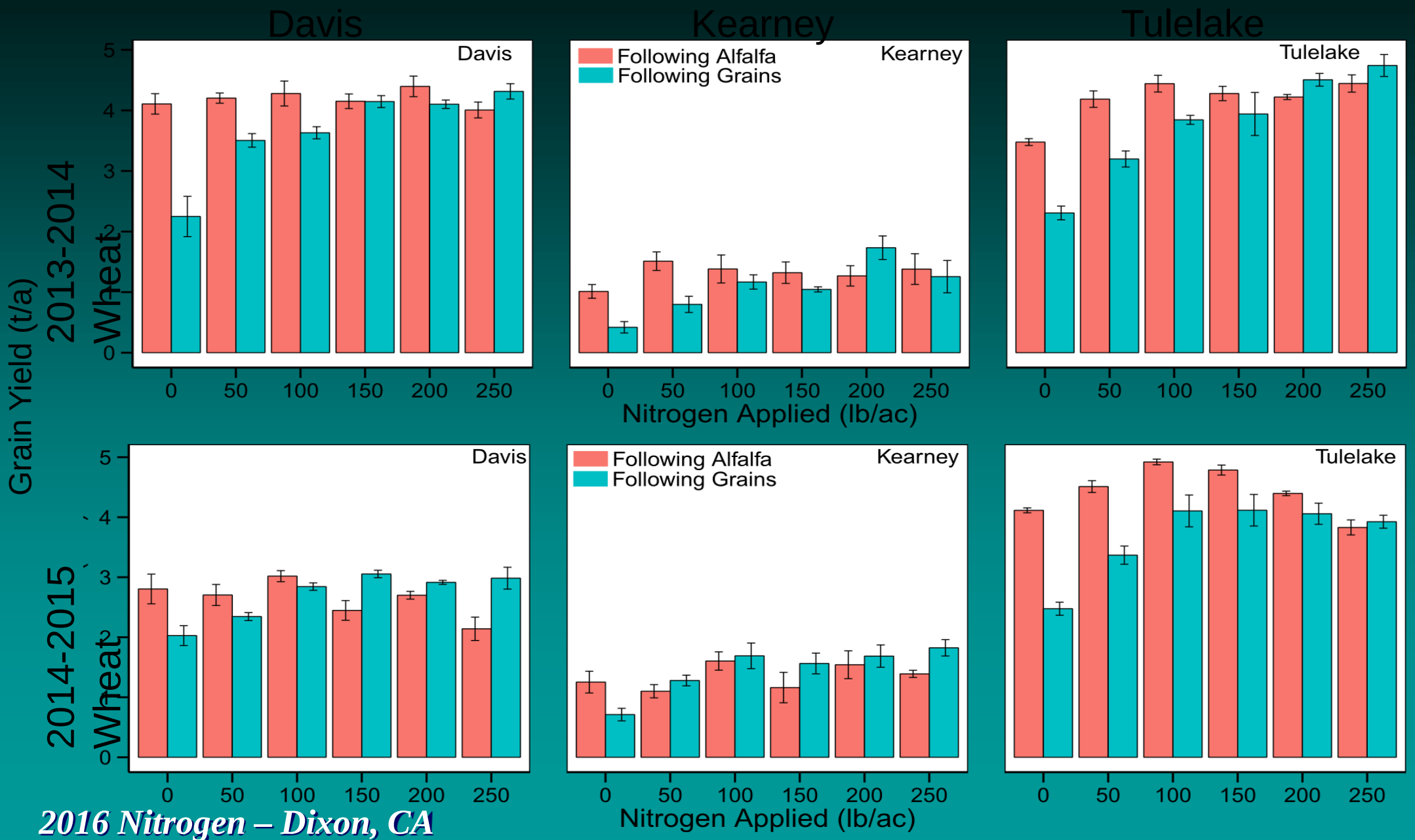

N Content (%)



# Using N uptake in biomass to help predict N credits



# Grain Yield

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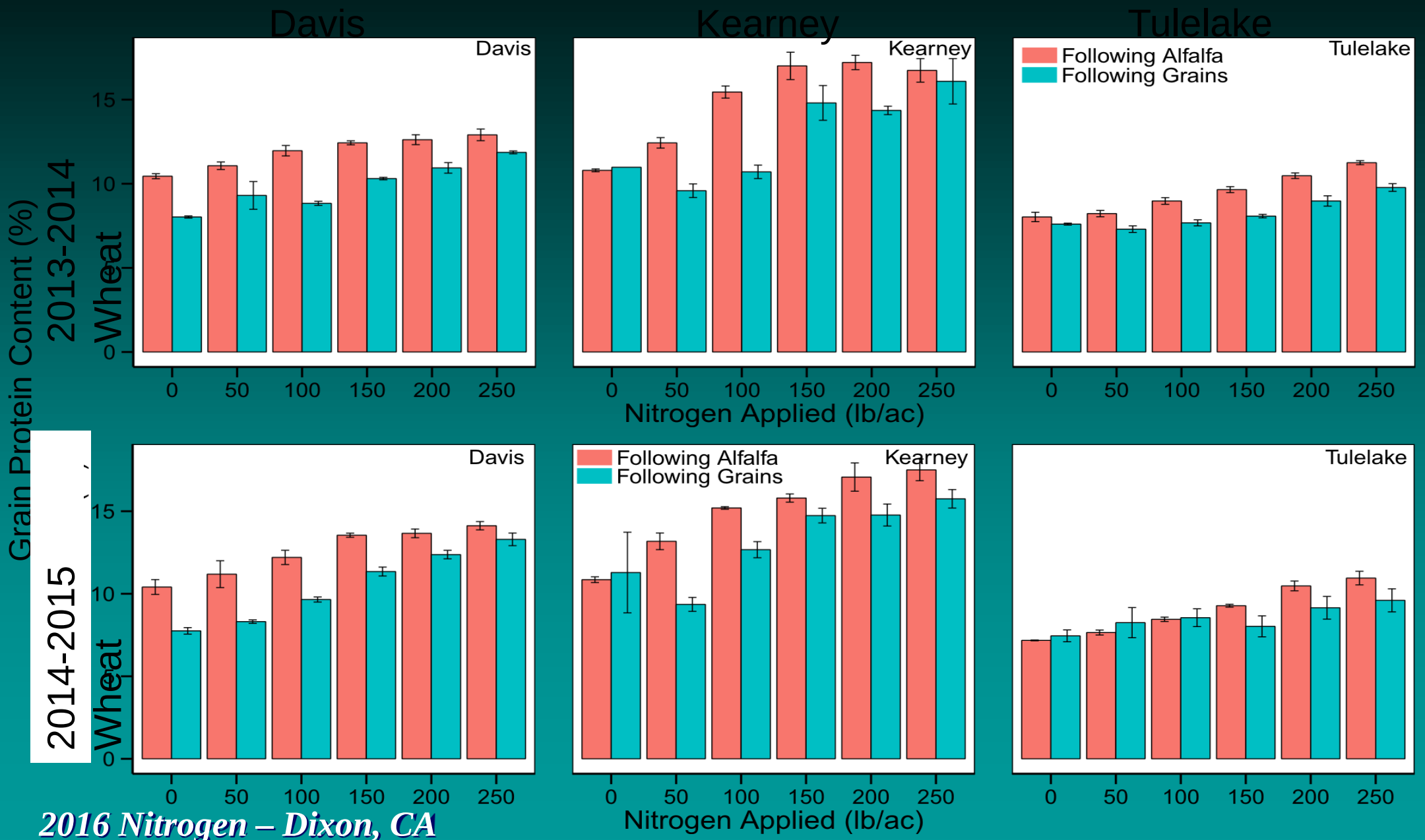
# Grain Protein Content

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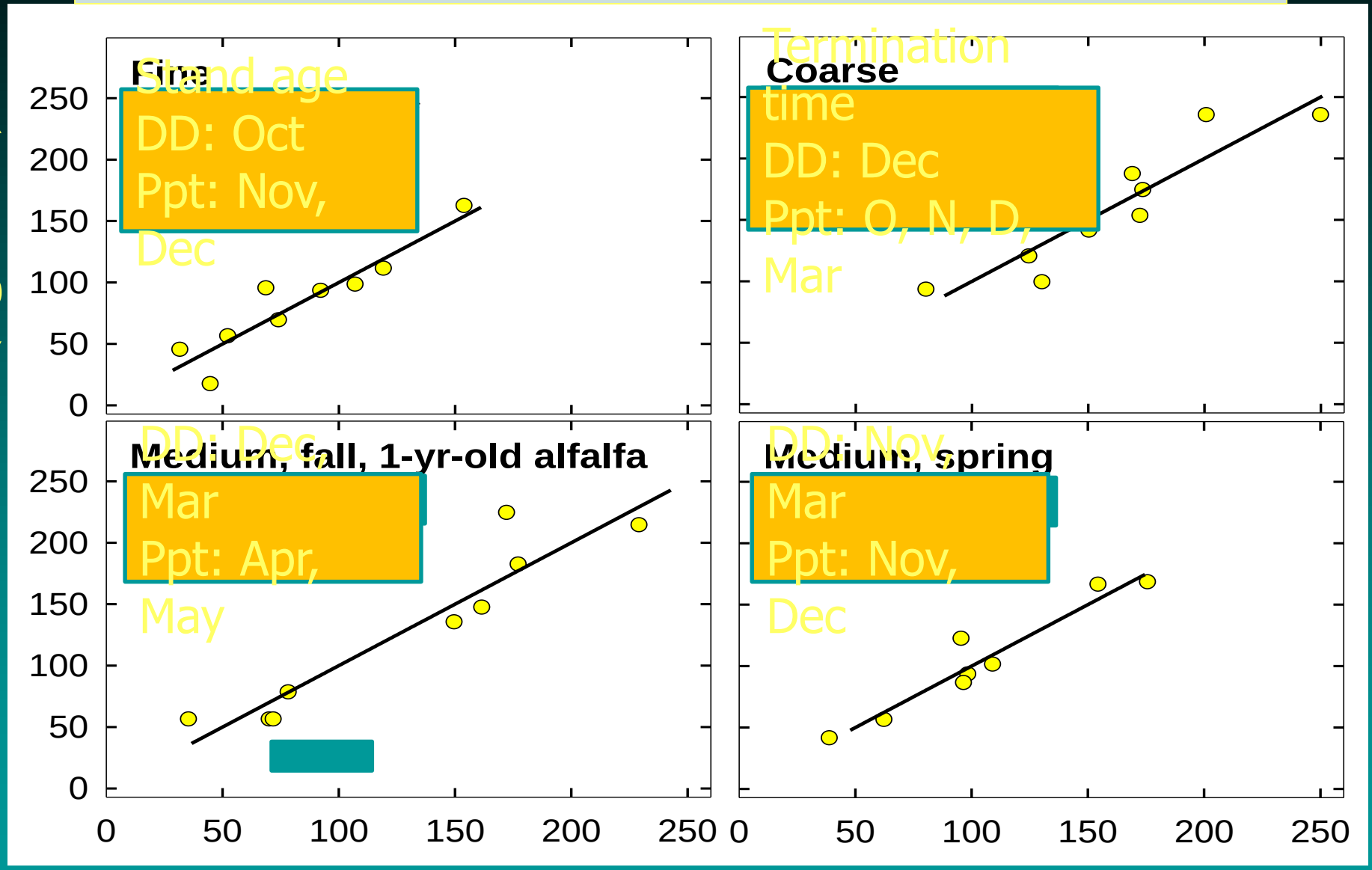
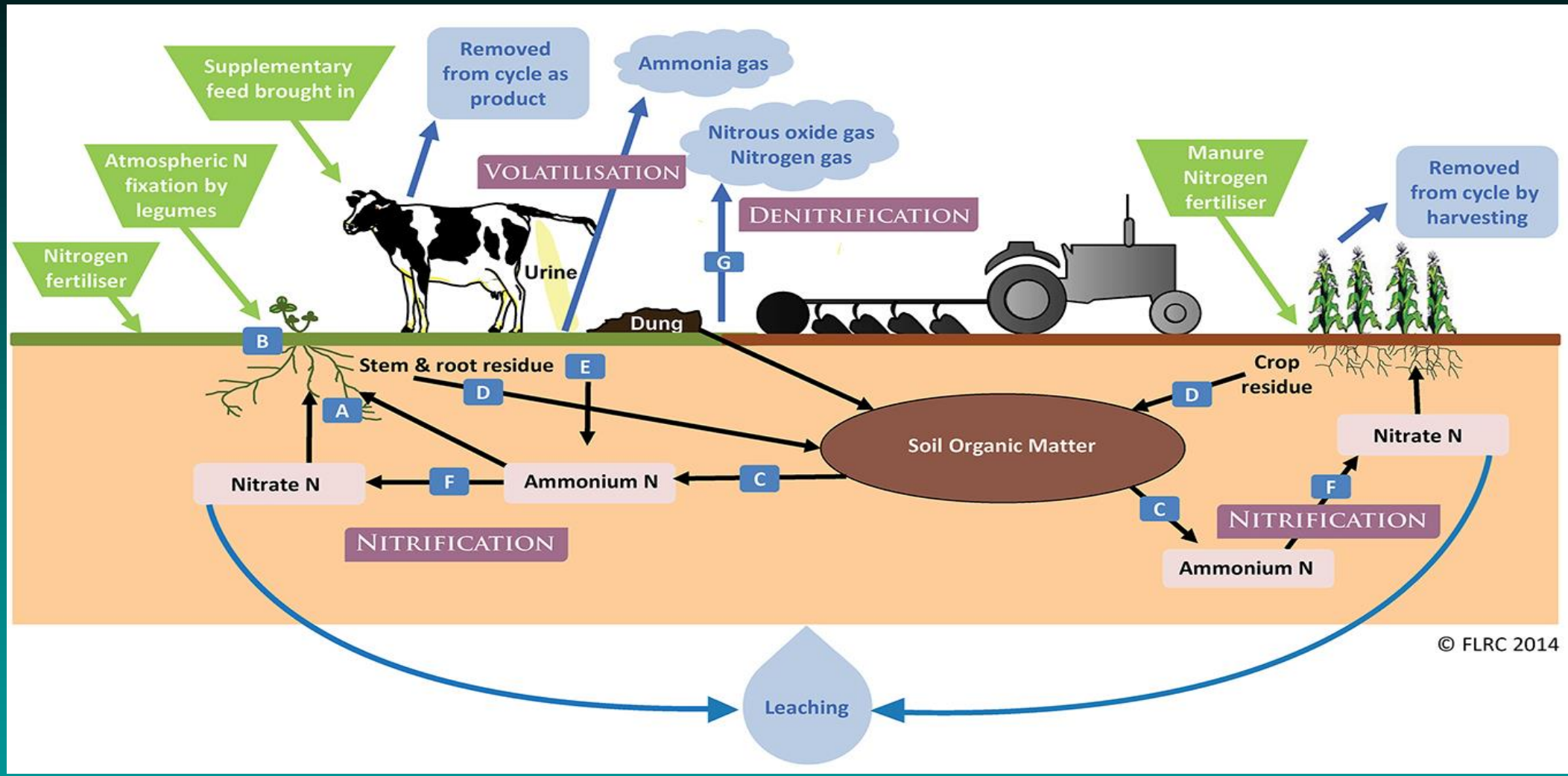
# May be able to estimate EONR within groups






Yost et al. 2014. Agron J. 106:645




Source: http://www.massey.ac.nz/~flrc/shortcourses/SNM_information.html

Alfalfa can help increase soil N, which subsequent crops can use

# Summary:

- High uptake of N by alfalfa
- Excellent crop for recycling of high N water
- Deep Rooting patterns, long season
- Does not require N fertilizers
  - Preference to recycle through grain crops
- Lack of winter vigorous growth
- Combination of crops – corn, sorghum, small grains, alfalfa

# Conclusions

- **Based on biomass alone, without considering economic N rates, alfalfa's N contribution was:**
  - **50-100 lbs N/acre at Kearney (Coarse Soil)**
  - **100-150 lbs N/acre at Tulelake (Medium-Textured Soil)**
  - **100-120 lbs N/acre at Davis (Medium-Textured Soil)**
- **Alfalfa provided enough N to satisfy wheat crop at Davis. Rotation increased grain protein content.**
- **Non-N rotation effects may have been at play at Tulelake and Kearney**

# Thanks!


FERTILIZER RESEARCH
FREP
AND EDUCATION PROGRAM


California
WHEAT
COMMISSION

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# Thanks for listening….

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