

# **Characterizing N Fertilizer Requirements of Crops Following Alfalfa**

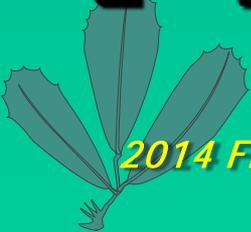
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*See: <http://alfalfa.ucdavis.edu>*

# Alfalfa – A Cash and Rotation Crop

- ❑ 19 million acres US – 1 million CA
- ❑ 4<sup>th</sup> largest economic crop in US
- ❑ \$1.3 billion in CA – largest acreage crop
- ❑ Grown in rotation with:
  - Corn/small grains (US)
  - Corn/grains/tomato/cotton/vegetables (CA)
- ❑ Life of stand typically 4-6 years
- ❑ ~150-200 K acres rotated annually (CA)



# Alfalfa - Wisconsin



# Alfalfa-Pennsylvania



# Alfalfa – New York State



# Alfalfa - Idaho



# Alfalfa South Dakota



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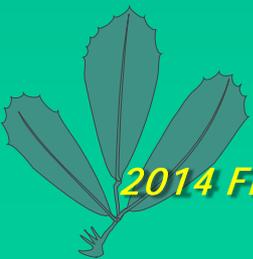
# Alfalfa-California



# Alfalfa fixes atmospheric N<sub>2</sub> and can contribute N to the soil



Source: [http://commons.wikimedia.org/wiki/File:Medicago\\_sativa\\_root\\_nodules.JPG](http://commons.wikimedia.org/wiki/File:Medicago_sativa_root_nodules.JPG)

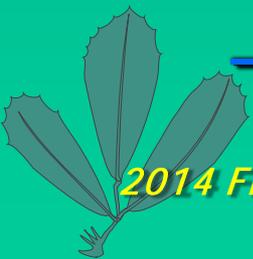


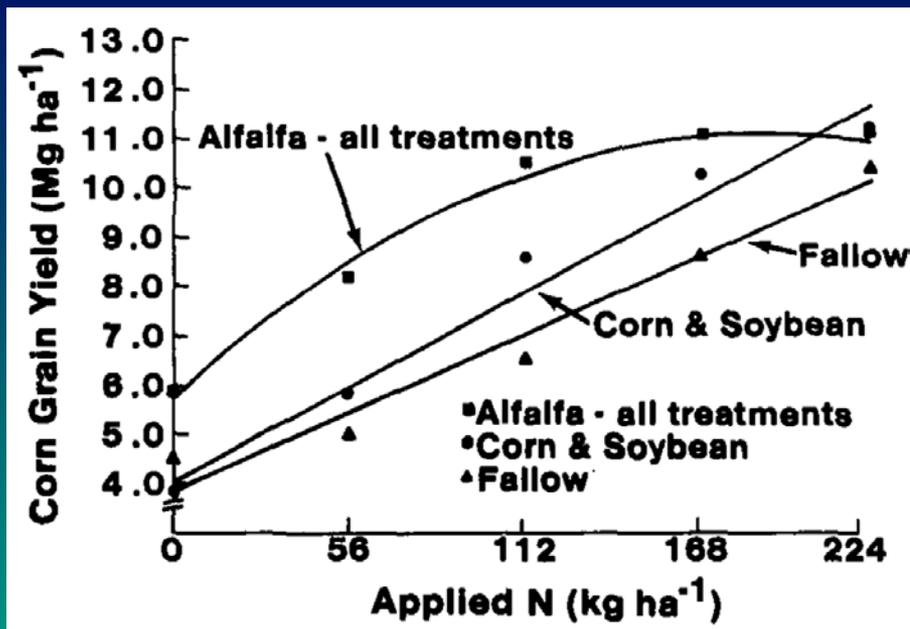
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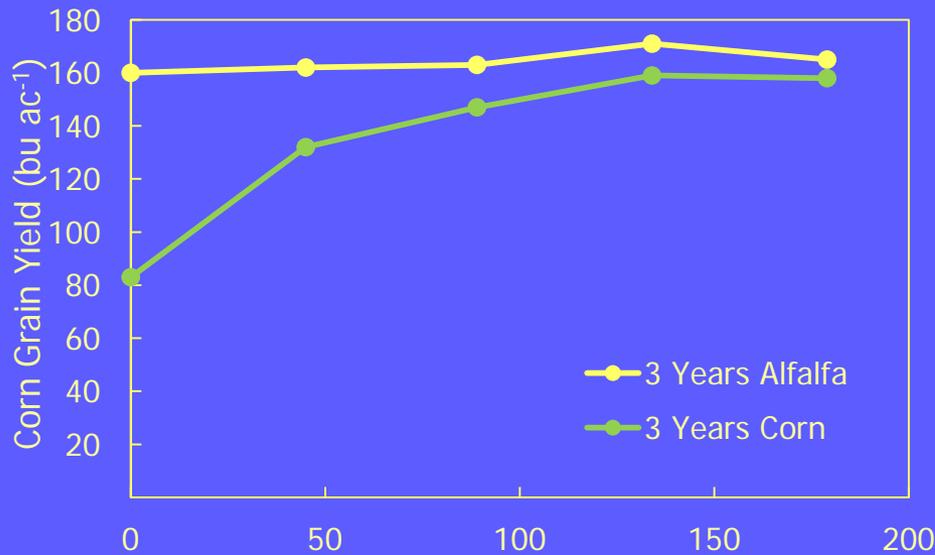
# Key Issues with N in alfalfa

- How much of the N needs of the plant are satisfied by  $N_2$  fixation?
  - 70-90% (no fertilizers recommended)
- Will the crop take up nitrate from the soil?
  - Yes, effective nitrate scrubber
- What is the contribution of alfalfa  $N_2$  fixation to subsequent crops?
  - It depends

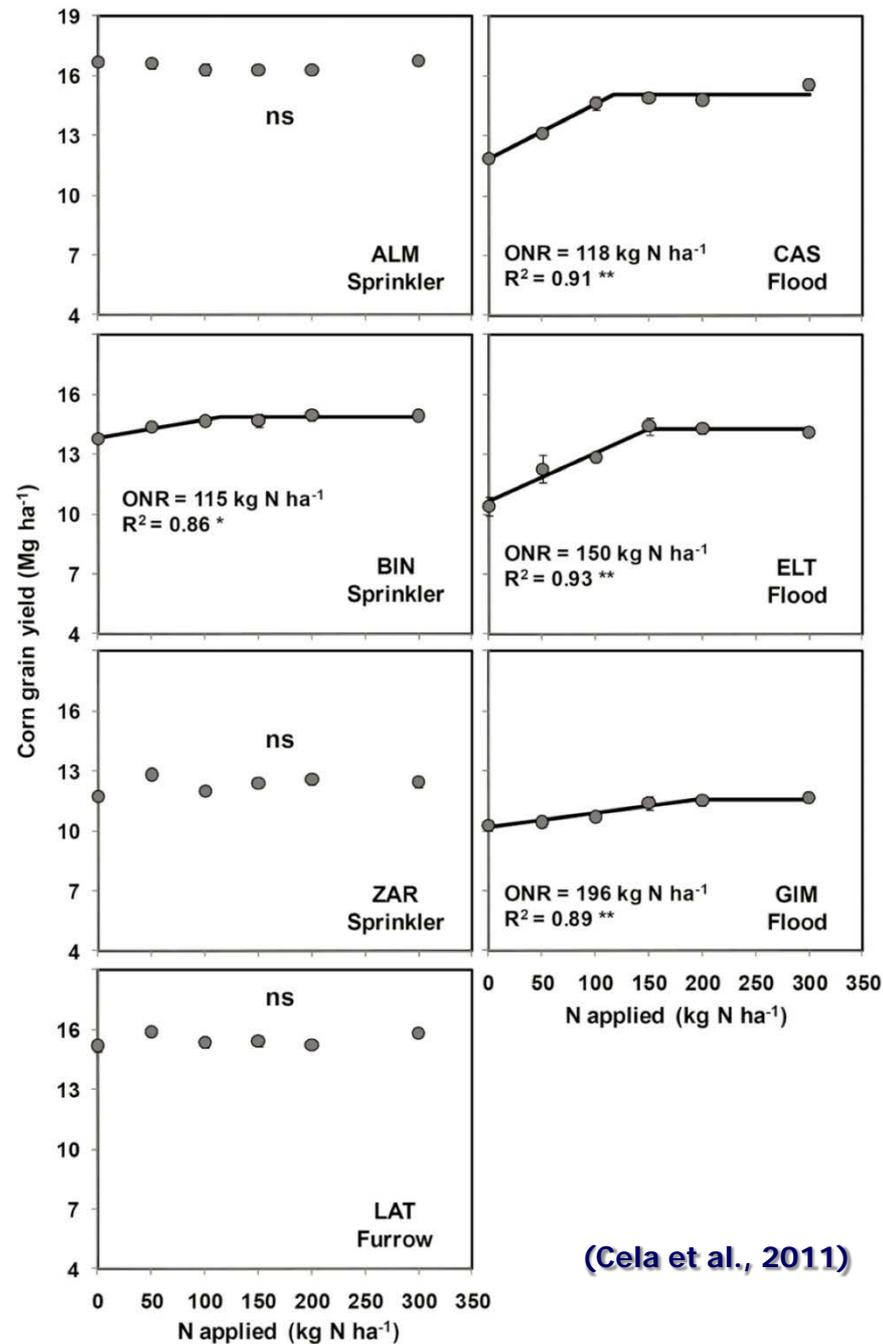




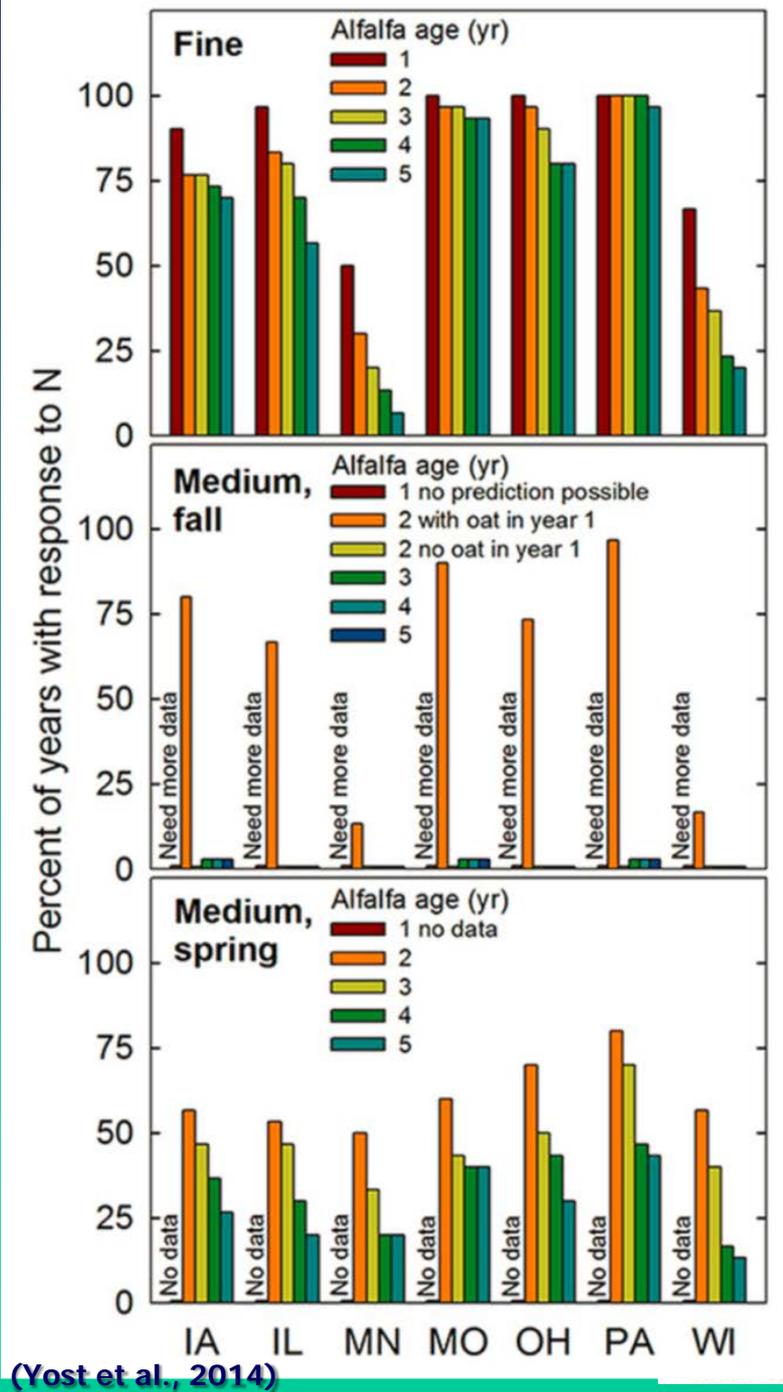
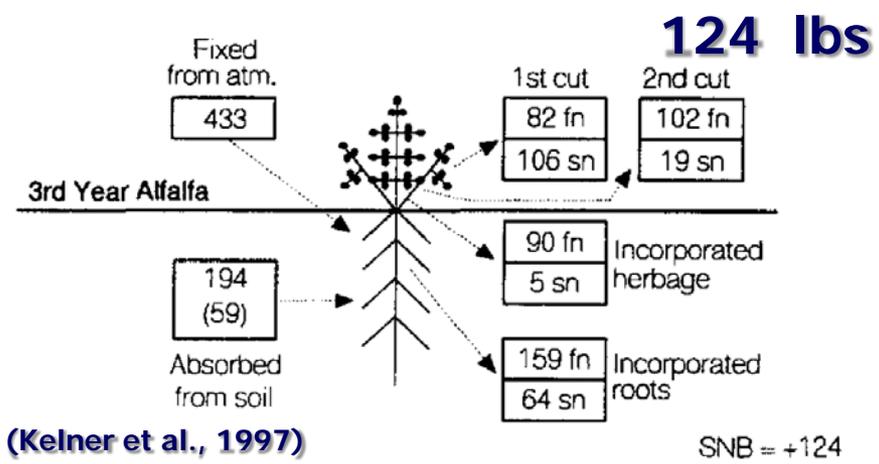
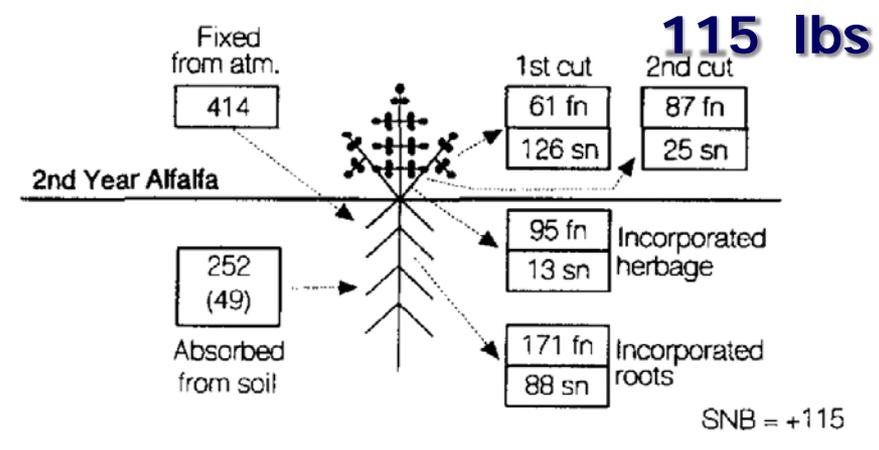
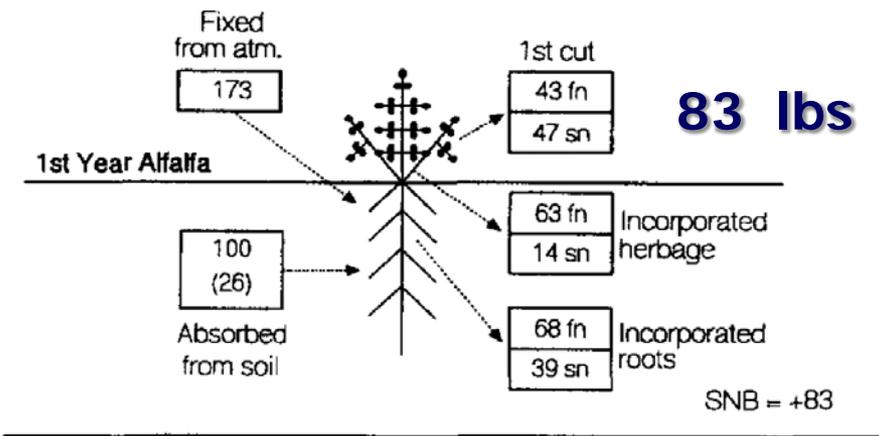
(Hesterman et al., 1986)



(Fox and Piekielek, 1988)



(Cela et al., 2011)



(Yost et al., 2014)

# 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
Tonnage (t/a)	%Nitrogen in Forage					
	2.56%	2.88%	3.20%	3.52%	3.84%	4.16%
	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 represents most likely outcome

**...and most of the nitrogen comes right out of thin air!**

# Estimating Nitrogen Credits



## Nitrogen Credits for Alfalfa and Soybean in Wisconsin

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

**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

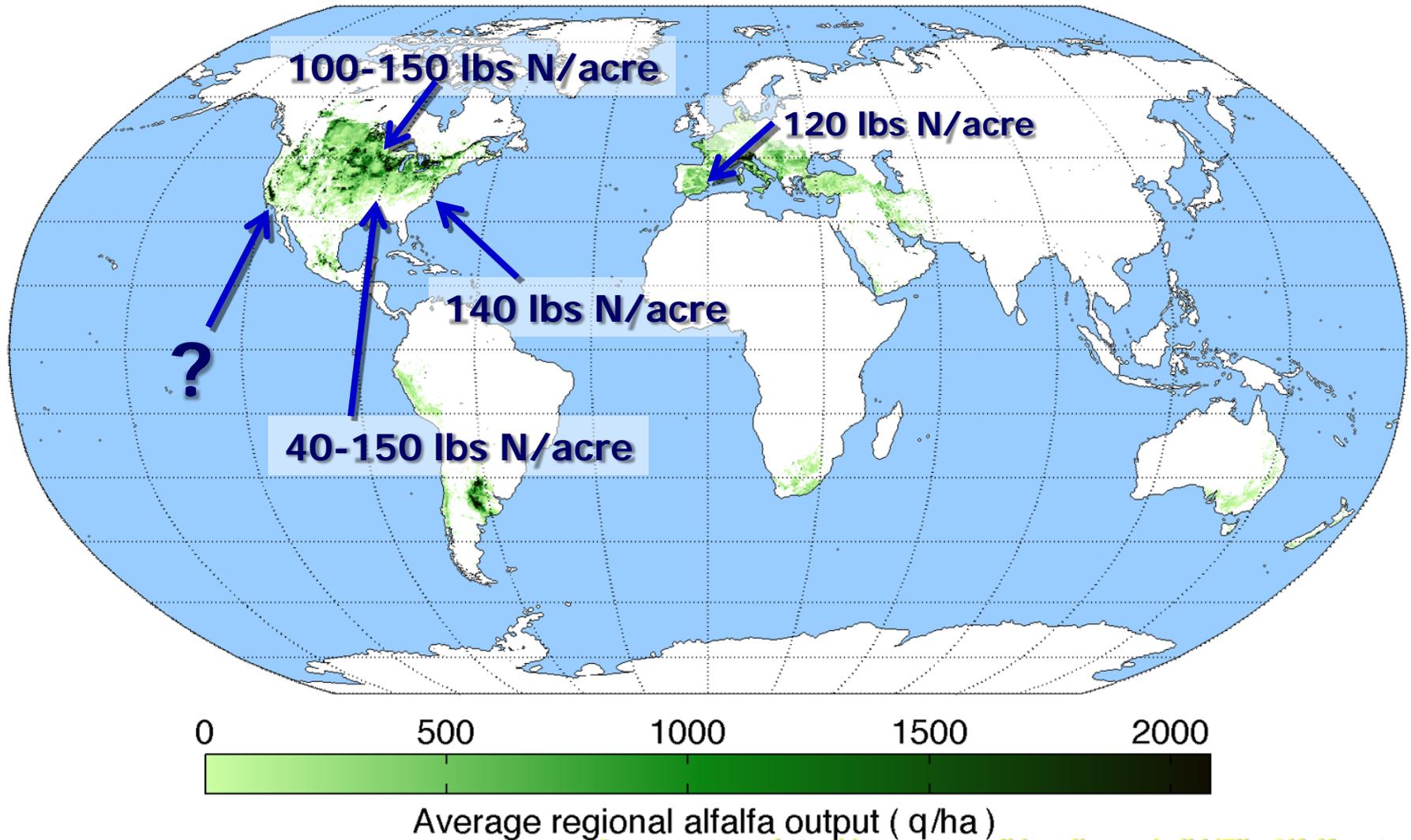


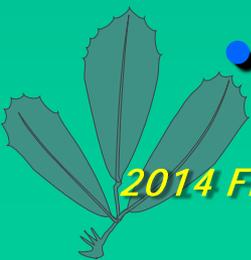
Image source: <http://commons.wikimedia.org/wiki/File:Alfalfaoutput.png>

# How much N is contributed to subsequent crops?

- **Depends on:**
  - Location
  - Temperature
  - Soil moisture (irrigation)
  - Soil texture
  - Alfalfa growth, stand age, stand density
  - Mineralization rate

# Developing Nitrogen Credits for California:

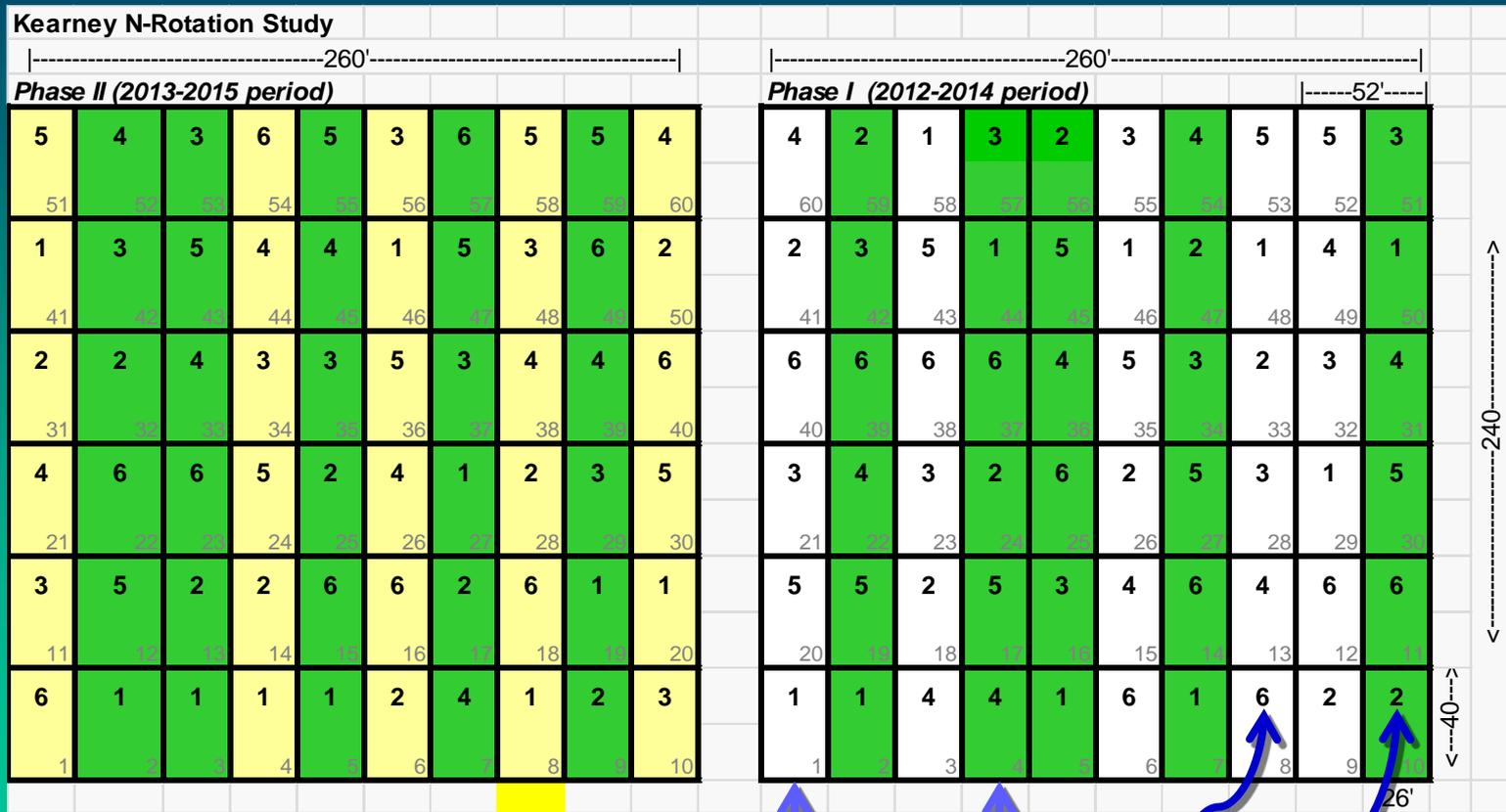
- **Two Rotation Treatments:**
  - Continuous Alfalfa (3+ years)
  - Grain Rotation (Sudangrass/Wheat) for at least 1.5 yrs
- **Three Locations:**
  - Davis (Solano County)
  - Kearney (Fresno County)
  - Tulelake (Siskiyou County)
- **Six Nitrogen Rate Treatments in Wheat:**
  - 0, 50, 100, 150, 200, 250 lbs N/acre



# Field Layout (Kearney)

Phase II (2014-15)

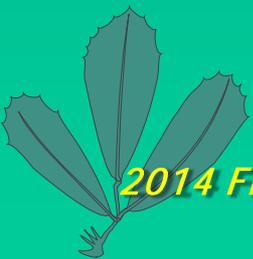
Phase I (2013-14)



Grains

Alfalfa

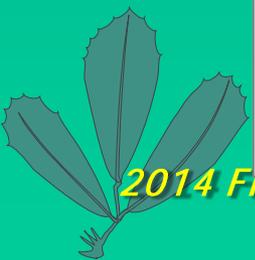
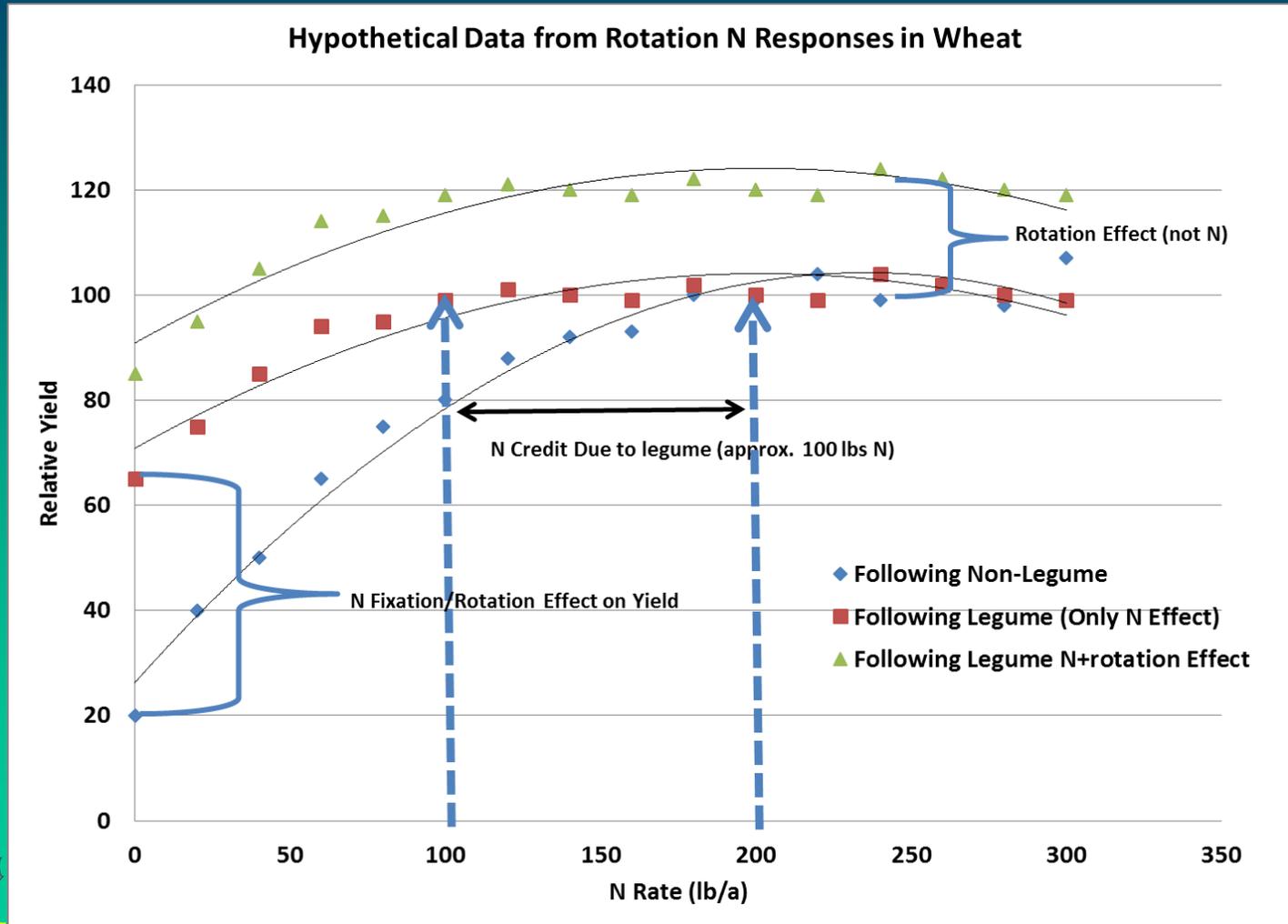
N Rates



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# Developing Nitrogen Credits for California – wheat as bioassay



# Rotation Study Treatments

## Continuous Alfalfa and Grain Rotation

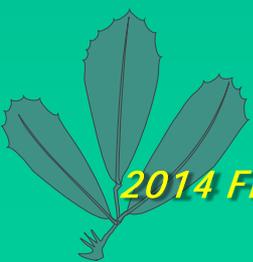


**Tulelake**



**Davis**

**(Kearney site not pictured)**



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# Rotation Study Treatments

## N Treatments in Wheat following Alfalfa and Grains

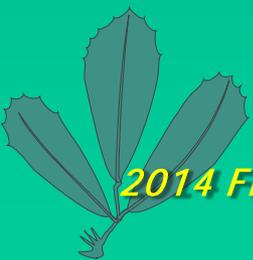


**Tulelake**



**Kearney**

(Davis site not pictured)



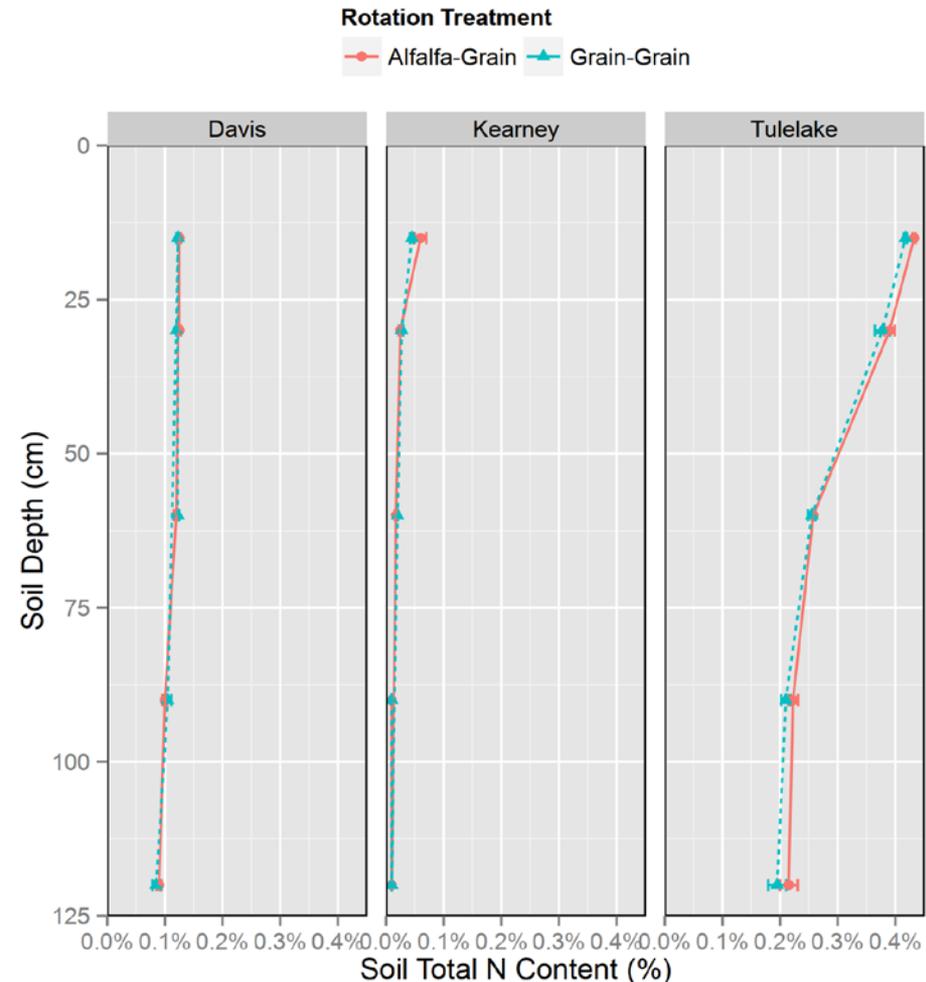
# How much do soil tests say?

- Continuous alfalfa maintained relatively high soil nitrate concentrations compared to grain rotation
- Much less than 25 ppm  $\text{NO}_3^-$  optimum
- Soil total N was not significantly affected

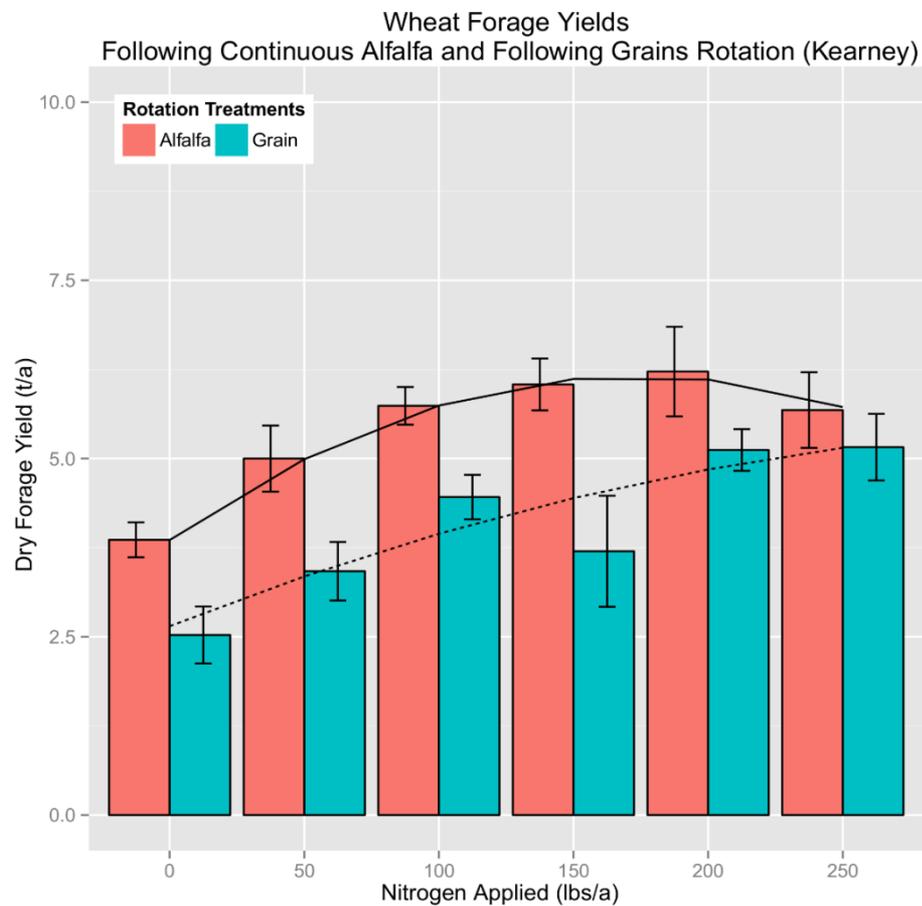
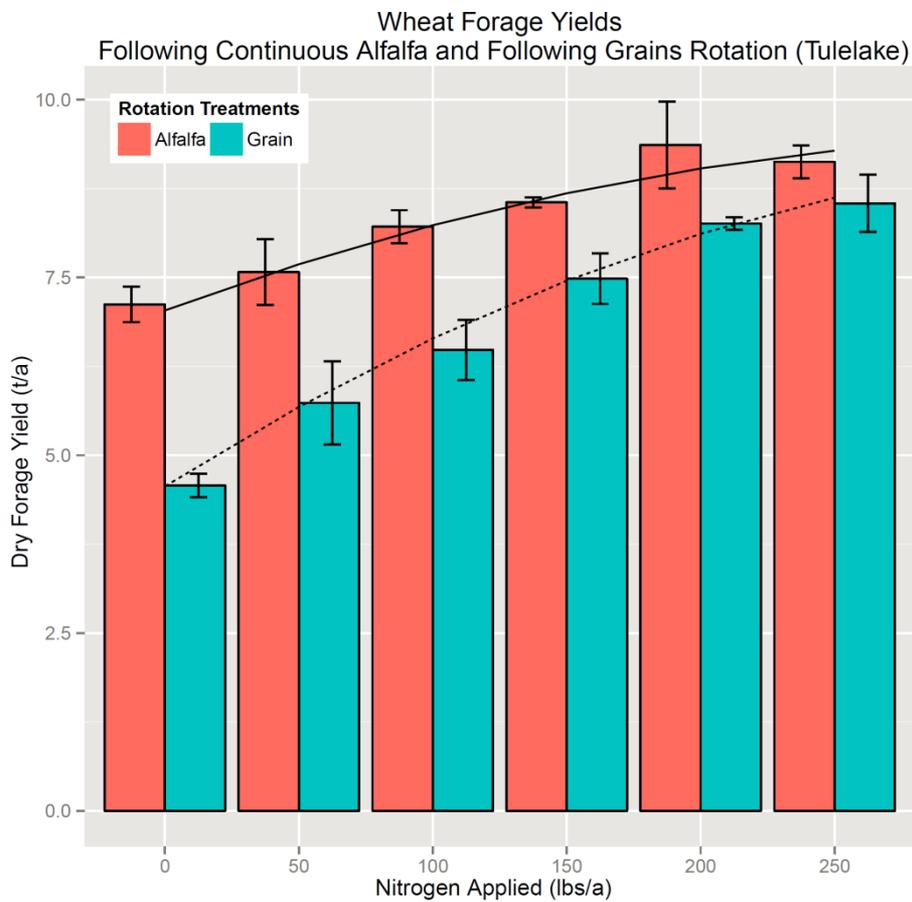
## Nitrate Concentrations in Top 30 cm of Soil

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

Soil Total N Content by Depth  
After Continuous Alfalfa and after Grains Rotation  
At Davis, Kearney, and Tulelake



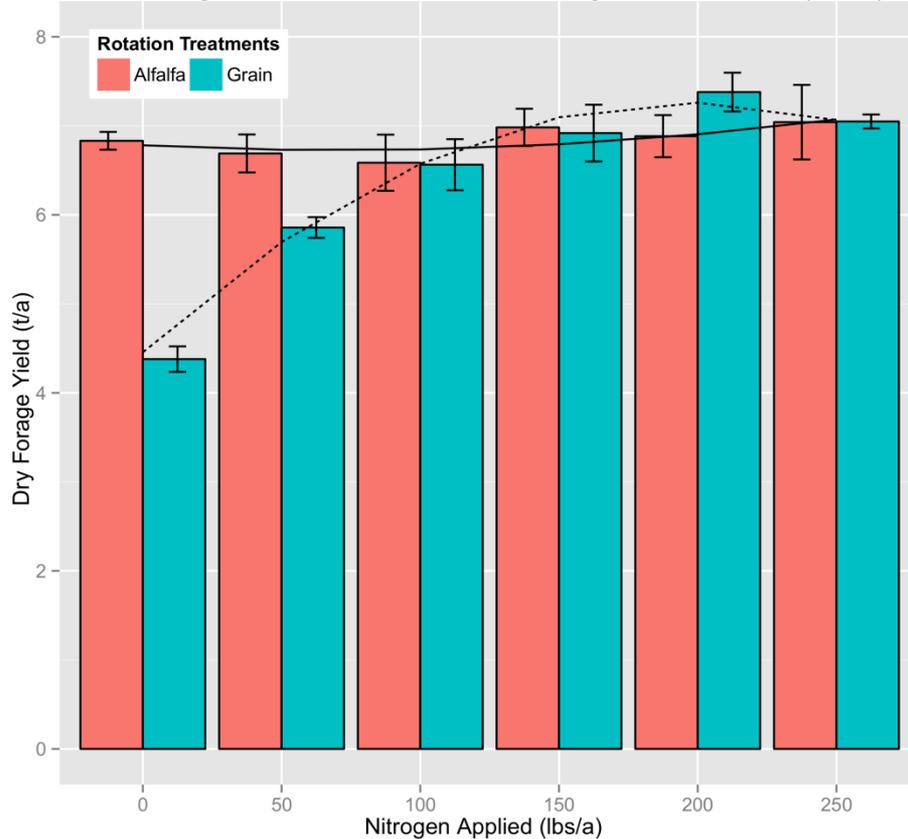
# Wheat following alfalfa benefited from fertilization at Tulelake and Kearney



# Wheat following alfalfa did not respond to N fertilization at Davis

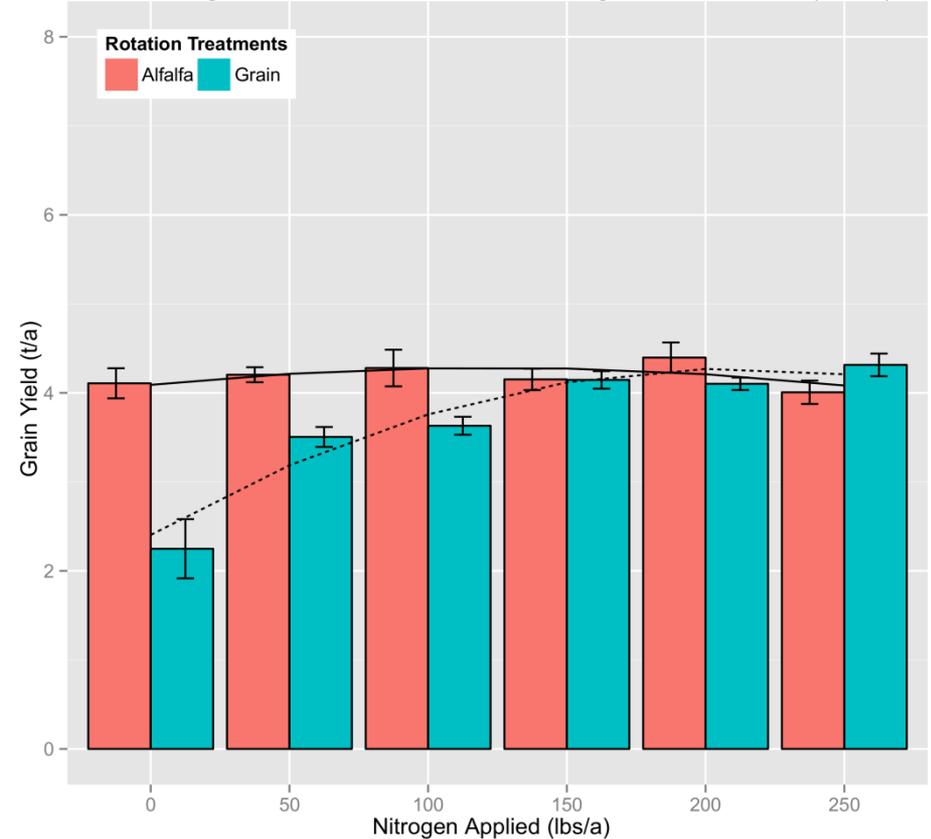
Wheat Forage Yields

Following Continuous Alfalfa and Following Grains Rotation (Davis)



Wheat Grain Yields

Following Continuous Alfalfa and Following Grains Rotation (Davis)



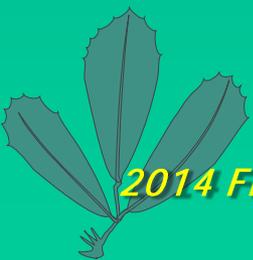
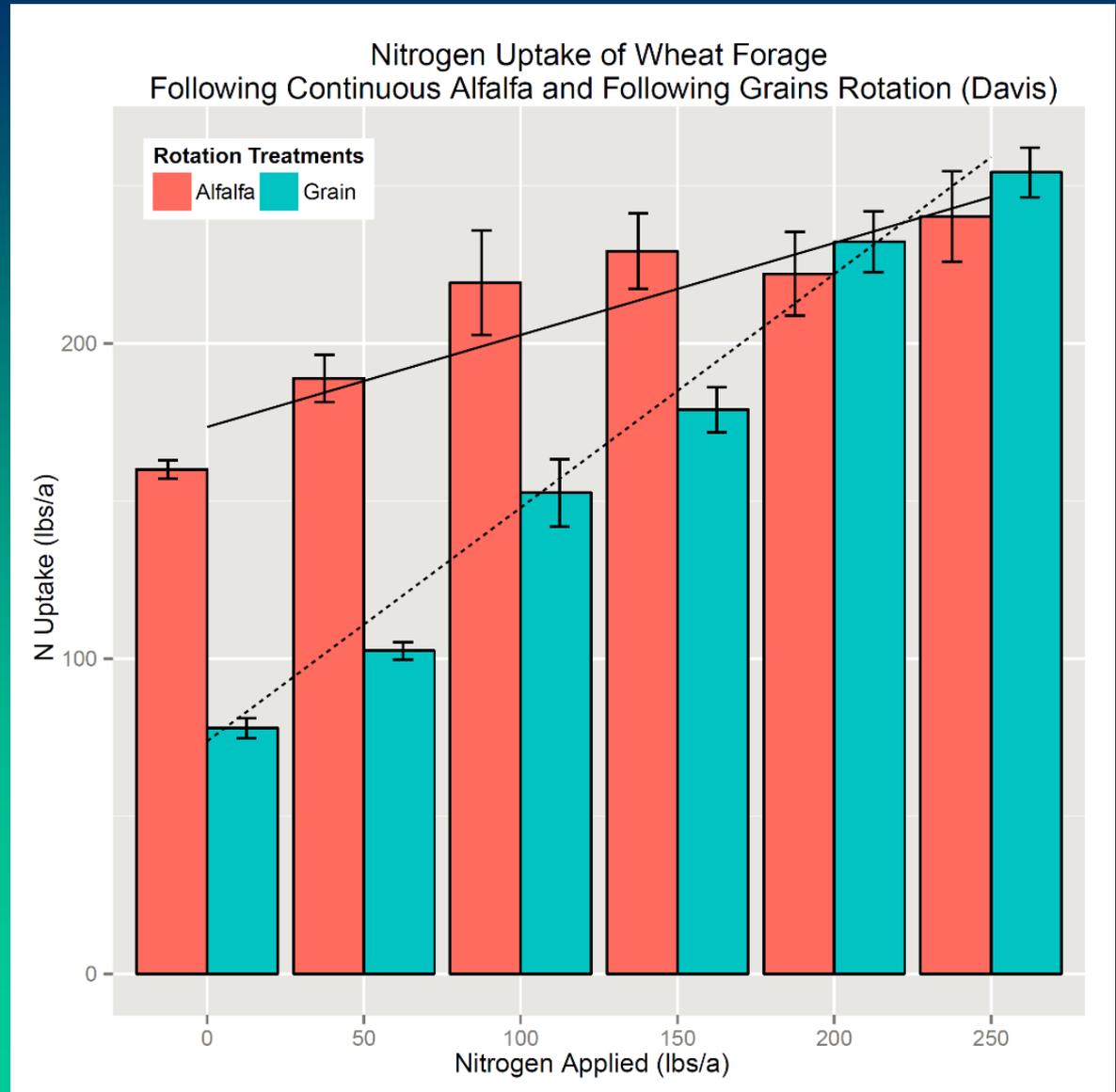
2014 FREP Conference Forage Yield

Grain Yield



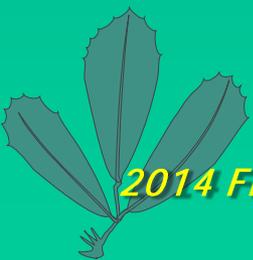
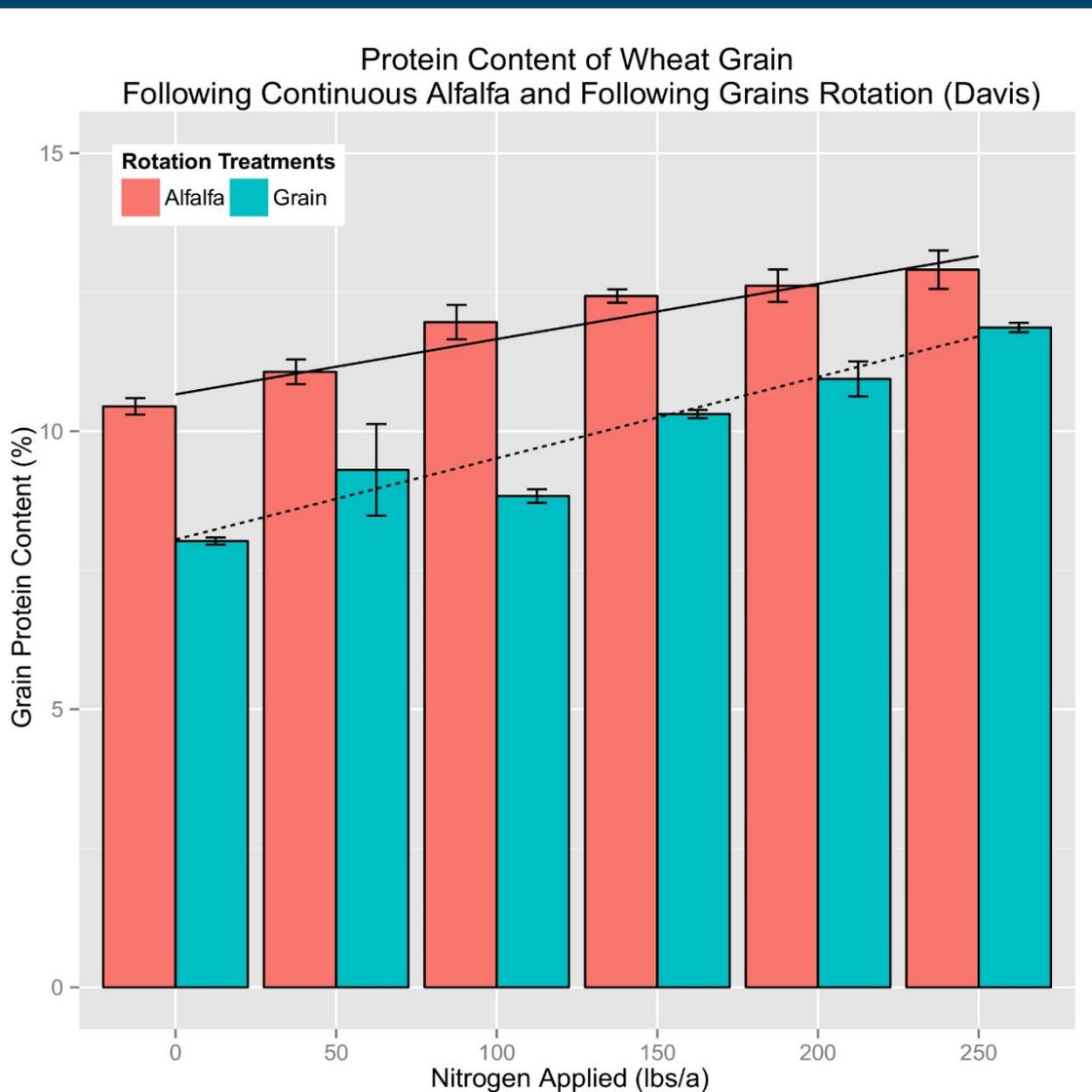
# What about N uptake at Davis?

- Same yield, but different N uptake and forage protein content
- Forage protein content was between 6% and 11%

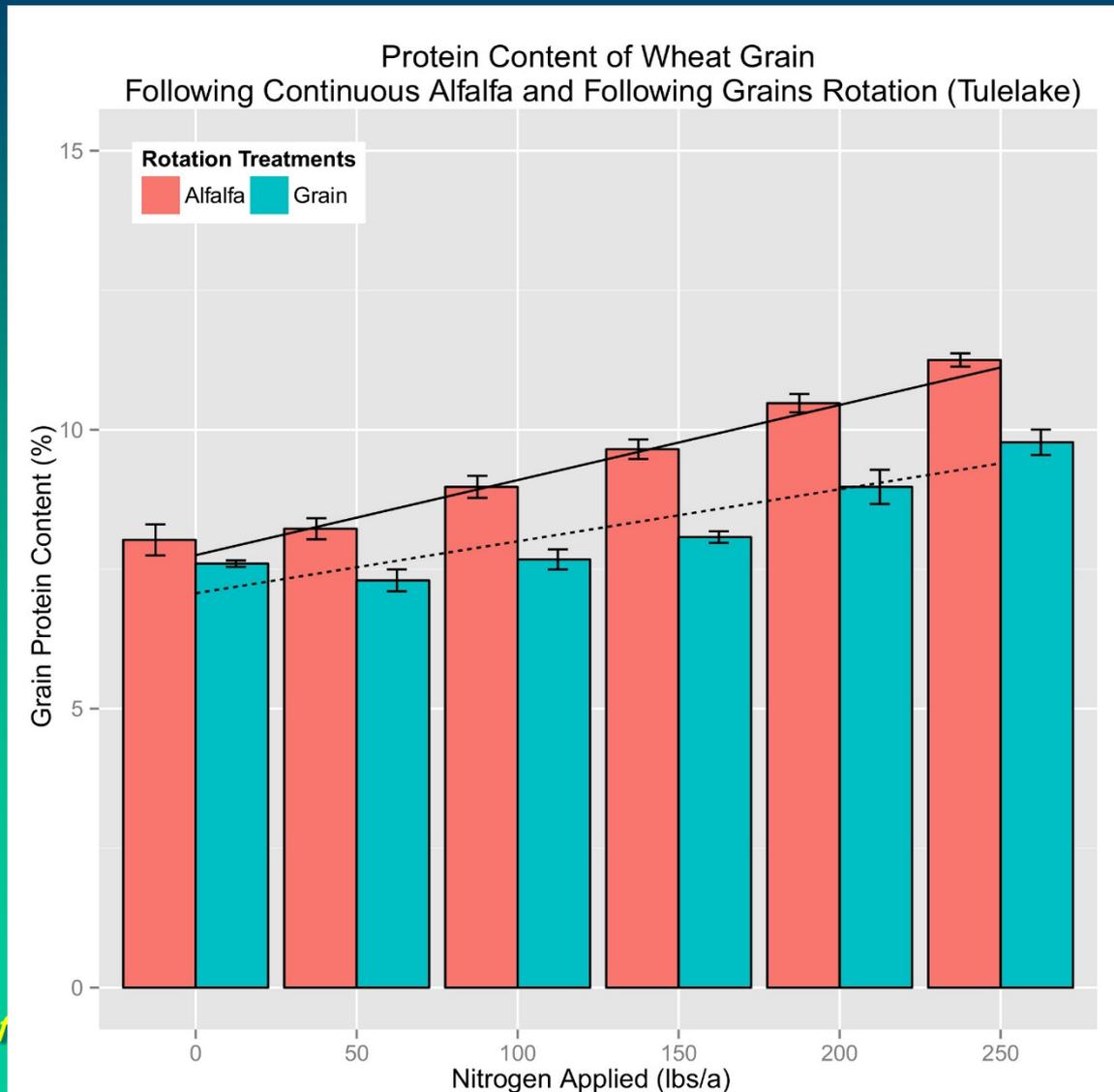


# Continuous alfalfa treatment benefited grain protein content at Davis

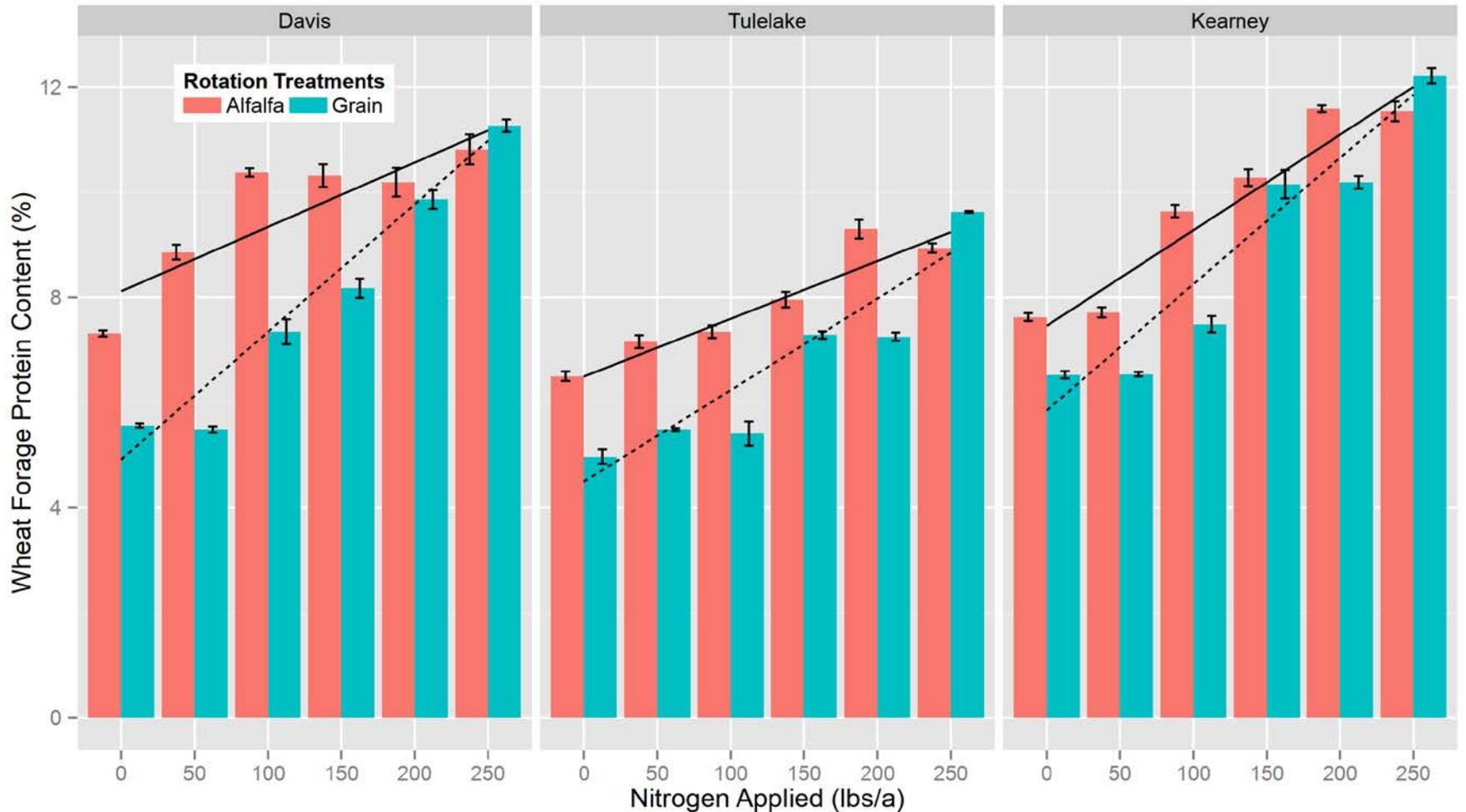
Fertilization helped increase protein content, so N from alfalfa satisfied N needs for high yields.



# Continuous alfalfa also benefited grain protein content at Tulelake

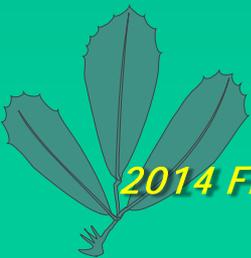
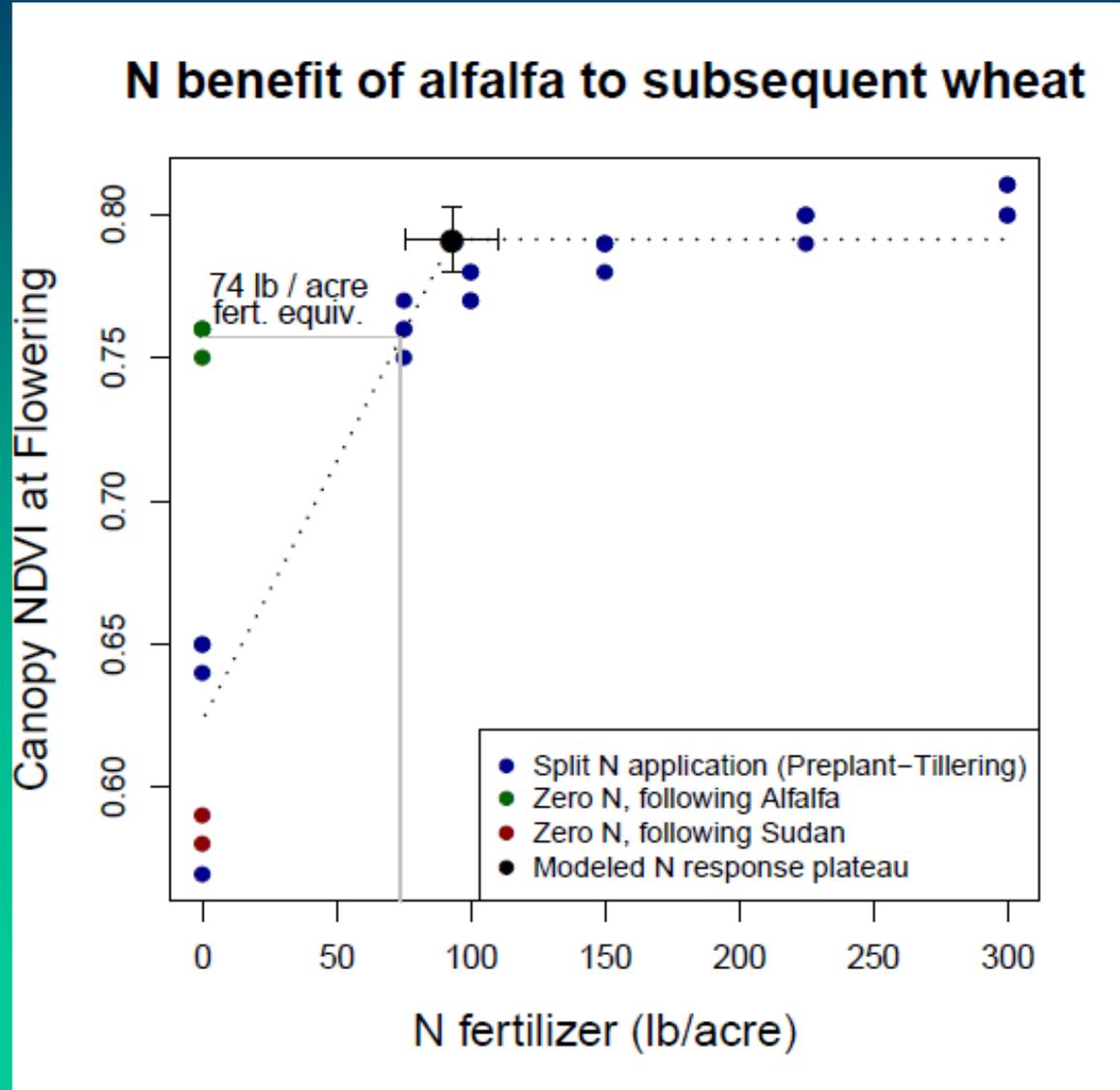


# Wheat forage protein content was likely only affected by alfalfa's N contribution



# Utilizing Plant Samples to estimate rotation value:

## □ NDVI prediction





# Conclusions

- **Based on forage yields, without considering economic N rates, alfalfa's N contribution was:**
  - 80-100 lbs N/acre at Kearney (Coarse Soil)
  - 100-150 lbs N/acre at Tulelake (Medium-Textured Soil)
  - 100-150 lbs N/acre at Davis (Medium-Textured Soil)
- **Alfalfa provided enough N to satisfy wheat crop at Davis.**
- **Benefits to grain protein - More N increased grain protein content.**
- **Non-N rotation effects may have been at play at Tulelake and Kearney**

# Further Work

- ❑ **Phase II: Replications – Year effects.**
- ❑ **Predictability of Soil Residual N?**
- ❑ **Predictability of early plant measurements?**
- ❑ **Generalized (integrated) recommendation for California's rotations which consider stand, other factors**



# Many thanks!



# References

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- ❑ Yost, M.A., Russelle, M.P., Coulter, J.A., 2014. Field-specific fertilizer nitrogen requirements for first-year corn following alfalfa. *Agronomy Journal* 106, 645. doi:10.2134/agronj2013.0416

