Soil Health and Soil Fertility:
&
A Few Comments on Exports

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A few announcements:

- Western Alfalfa & Forage Symposium
  - Reno, Nevada – Nov. 19-20-21, 2019
  - Watch http://alfalfa.ucdavis.edu
- Sign Up for the 'Alfalfa Blog'
  - Recent articles on Exports, Grazing, weed management, Lorsban insecticide
  - Just Google 'Alfalfa Blog' and it usually comes up.
  - 1x or 2x per month
  - Sign up for notices

What about Exports?

Arizona hay grown for Export, Nov. '17

Exports

- In the past 10 years, exports have gone from a minor to a major component of production in some regions (Western US, Spain).

Global Exports Alfalfa & Grass (2001-2017 – ITC)

Increase of +266,000 MT/year

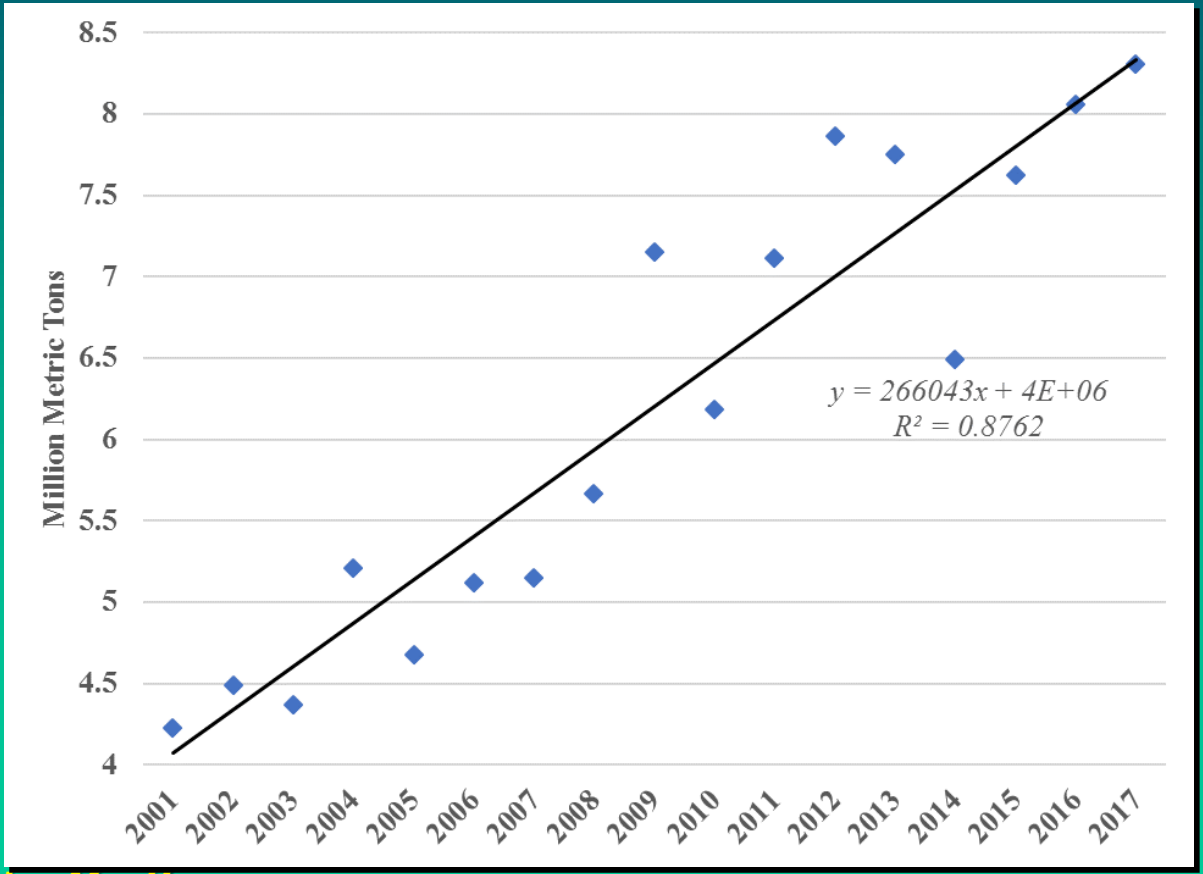
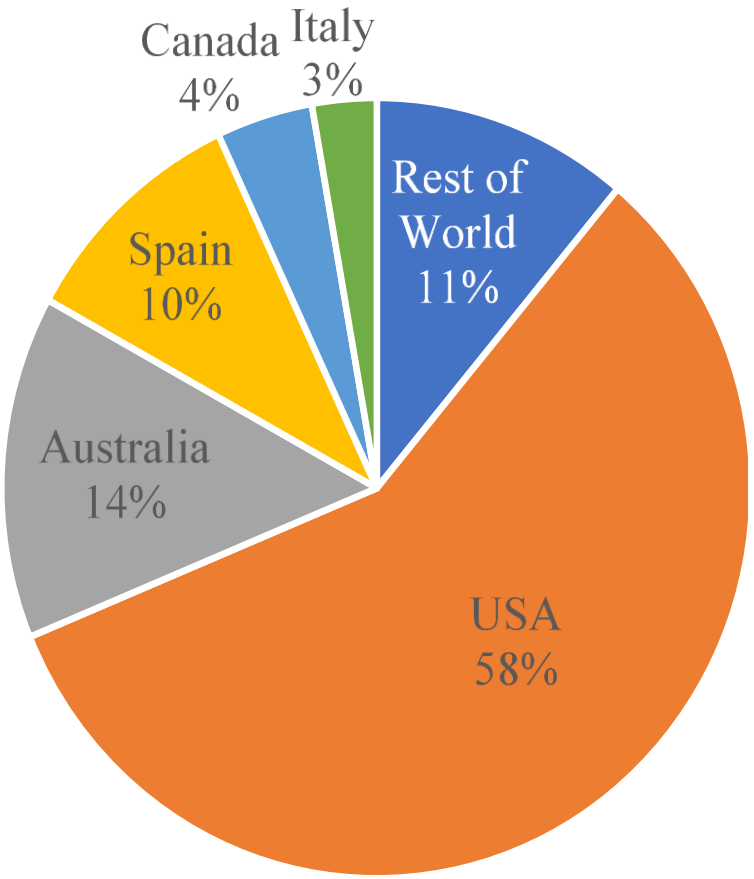
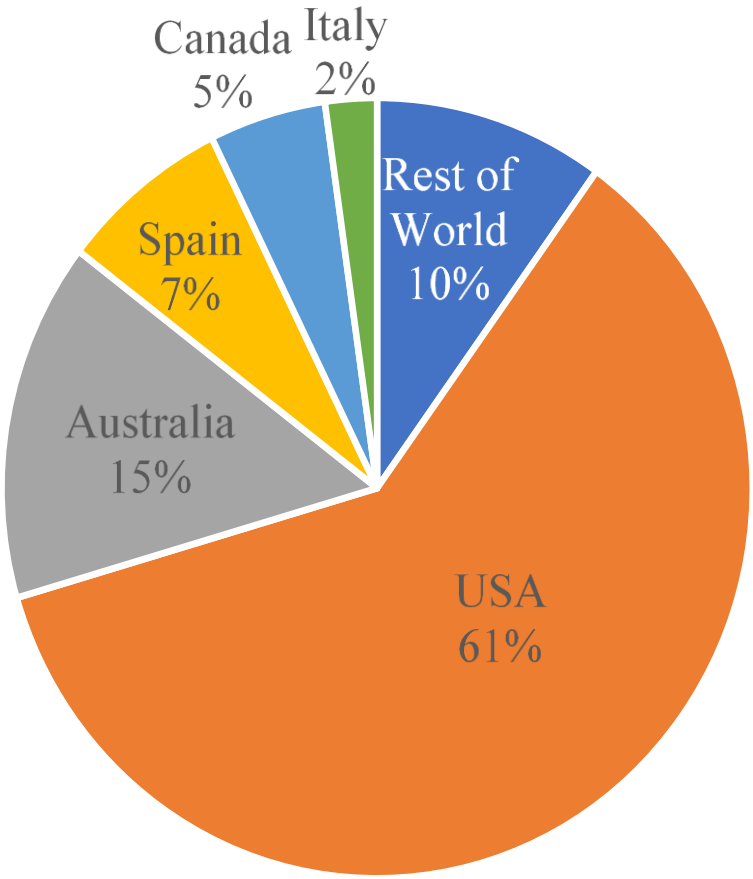


Figure 2. Global Exports of Alfalfa and Grass Hays by Country Share of Quantity and Value, 2017 (Source: ITC Trade Map)

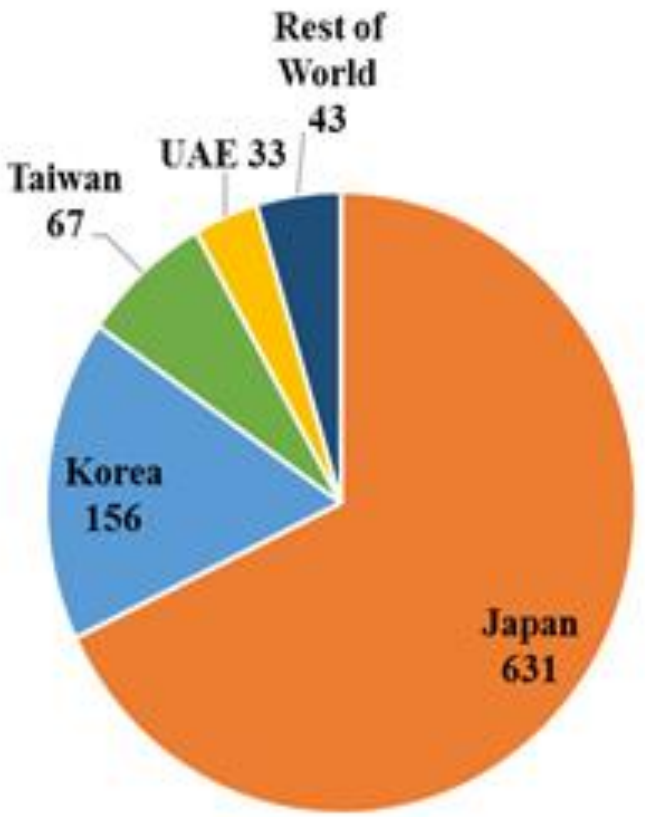


Quantity

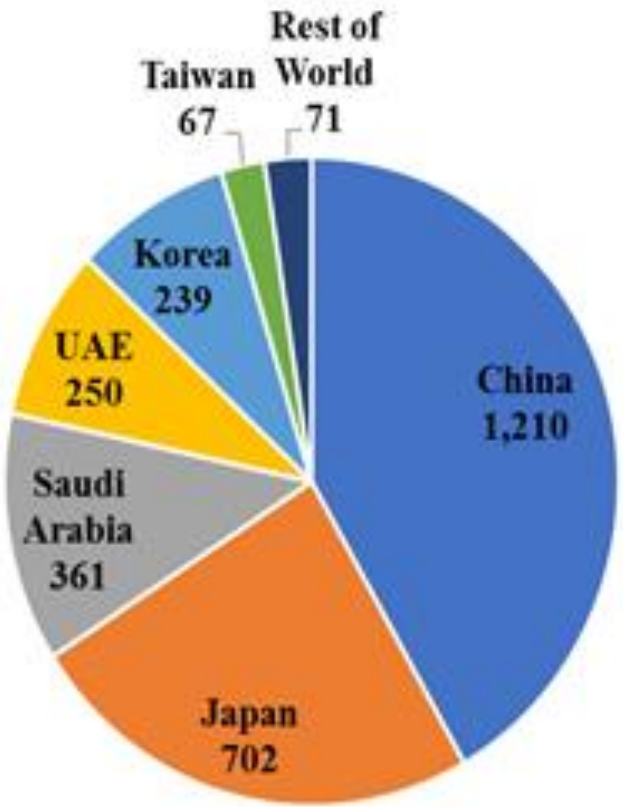


Value

US Alfalfa Exports:



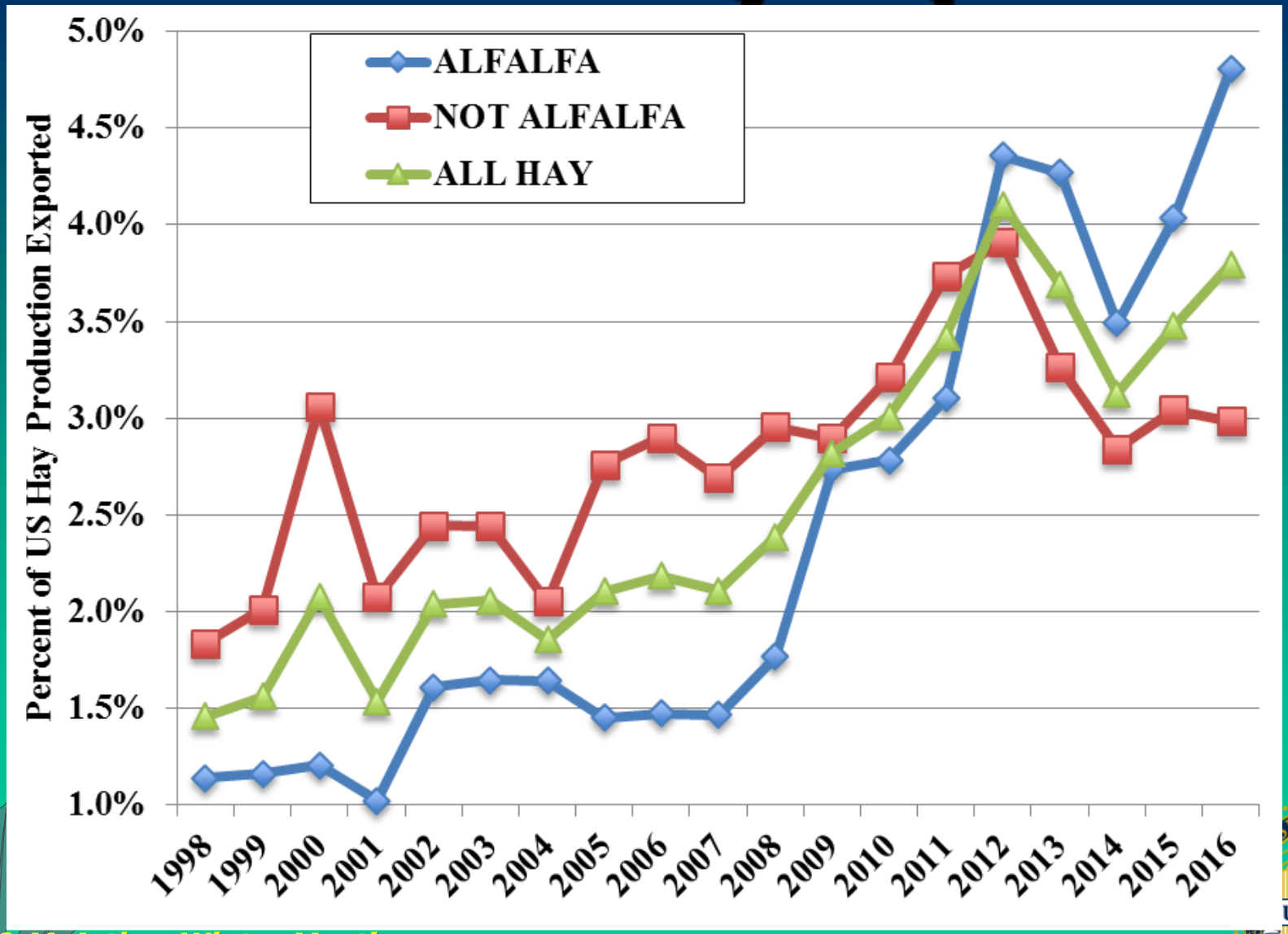
Total 2007 Exports = 930,000 MTs



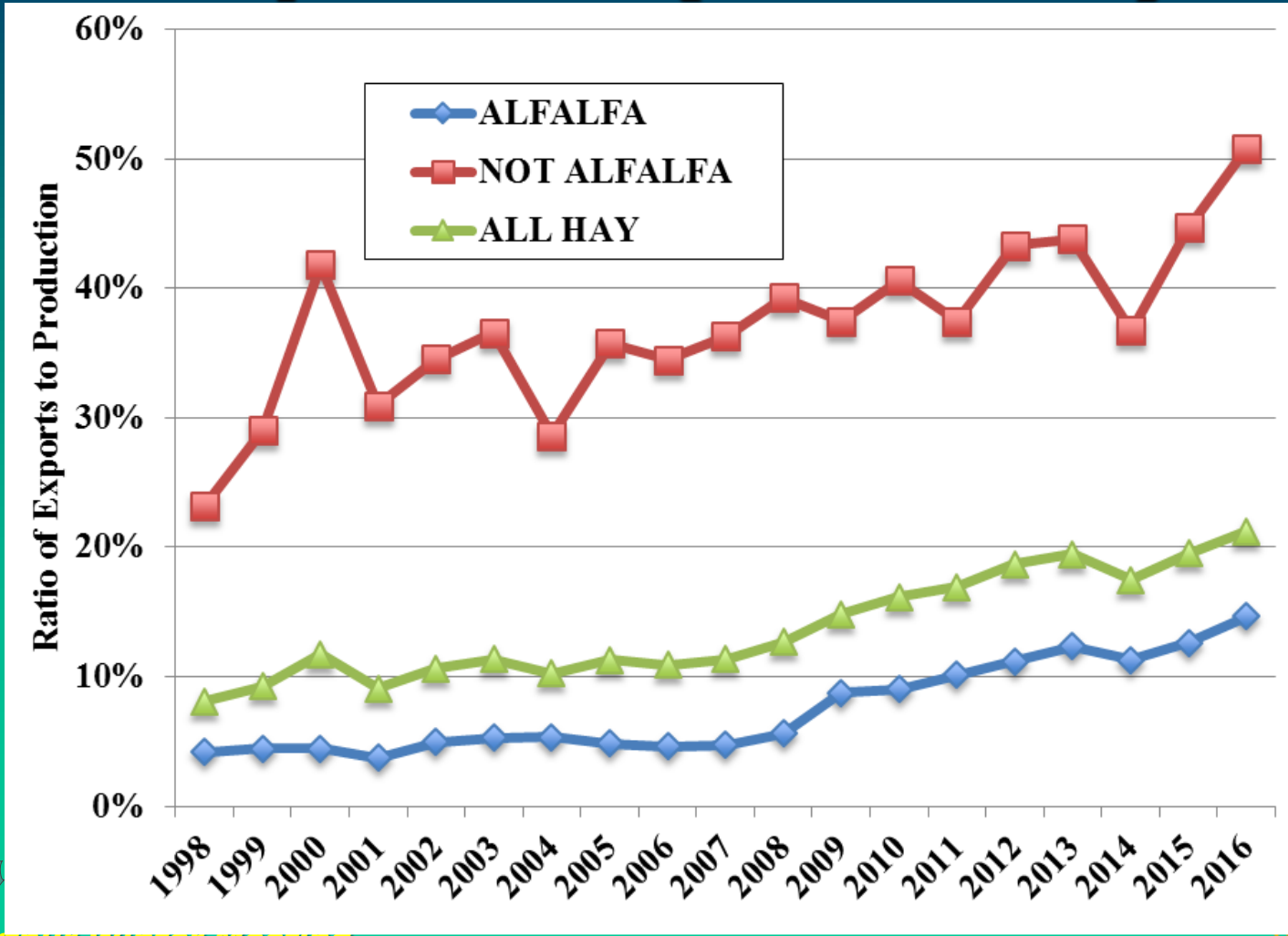
Total 2017 Exports = 2.9 million MTs

Figure 5: Volume of US alfalfa Exports by Destination 2007 and 2017. Total grass and alfalfa exports exceeded 5 MMTs (2017).

% of US Hay Exported



% of Western state's Hay Exported (7 states)



Export Product Mix

50%	Alfalfa			Timothy	11%
7%	Perennial Ryegrass			Annual Ryegrass	2%
11%	Fescue			Orchardgrass	1%
1%	Bentgrass			Klein	4%
9%	Sudangrass			Bermuda	4%

(Source: USFEC, Bill Plourd)

A few problems can occur

Key Problem Issues

- Importers have world perspective
  - Can reject from one area, favor another (play games)
- Cost/price squeeze
- Distance from farm to port
- Dock Strike, slowdown (2014)
- Maintaining, defining quality
- GMO sensitivity
  - Rejection of loads with low level detection (China)
- Trade Wars

Potential Impact of Trade War with China (D. Sumner, Ag Issues Center)

- 25% tariff + 7% tax = 32% tax (2018)
- Total US Production – 16,900,000 MT
- Western States price ($297/MT)
- Quantity to China (1,181,000 MT)
- Value $351 million
- Estimated Price decline 7.5%
- Estimated Revenue loss: $377 million/ year
- (conservative estimate)

Late 2018- Early 2019

- October, 2018 volume of exports to China was about 50% of those earlier in year. 30% of those of 2017 max.
- Increase in Saudi demand makes up for some of this.
- Low acreage (<700,000 in CA) helps.
- USDA-FAS (Foreign Ag. Service) indicates alfalfa hay GMO acceptance in China is high priority.

Soil Health and Soil Fertility in Alfalfa

Are soils:

A. An inert mineral matrix mostly useful to support roots?
B. A place to put fertilizers
C. A complex living, breathing 'organism' that provides plant nutrients and supports all life on earth?
D. Something that gets your clothes dirty?

What is Soil Health?

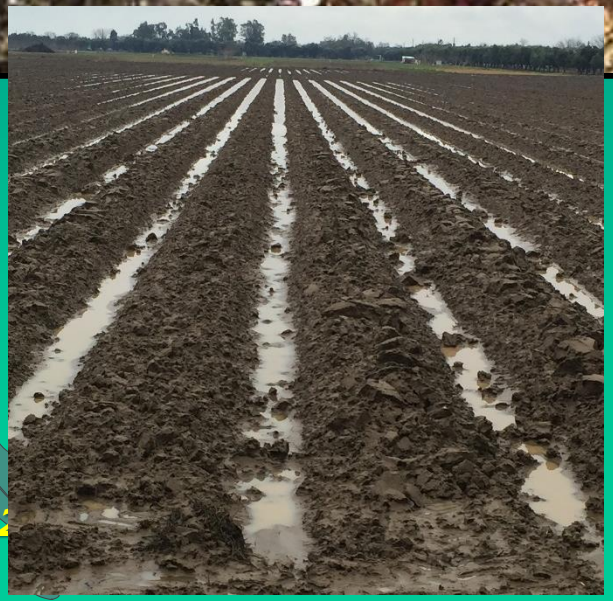
Kate Scow, UC Davis

What is soil health?

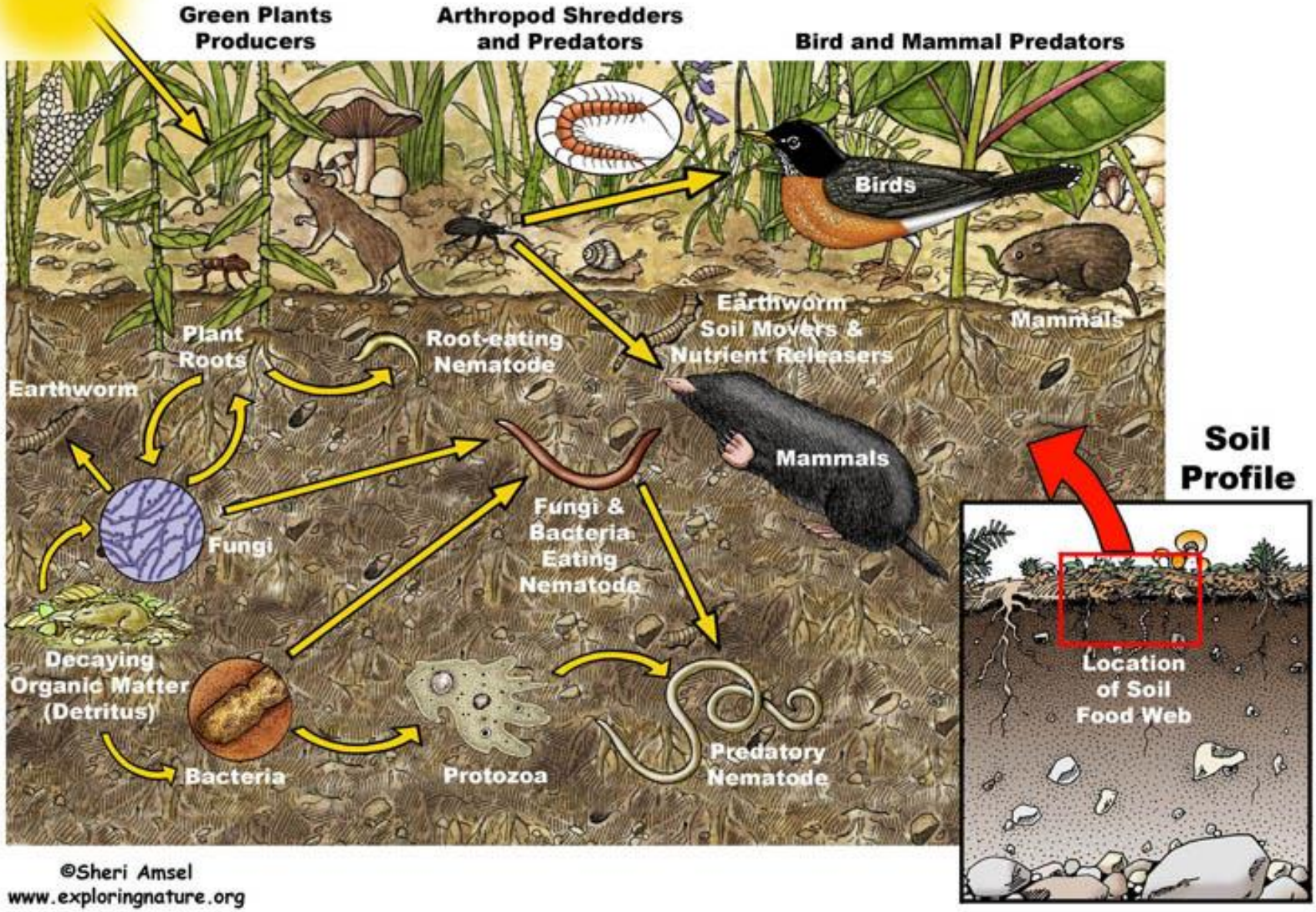
- Soil health, also referred to as soil quality, is defined as the continued capacity of soil to function as a <u>vital living ecosystem</u> that sustains plants, animals, and humans.
- This definition speaks to the importance of managing soils so they are <u>sustainable for future generations</u>.

--NRCS

Soil Degradation



Soil food web: creators and beneficiaries of soil health



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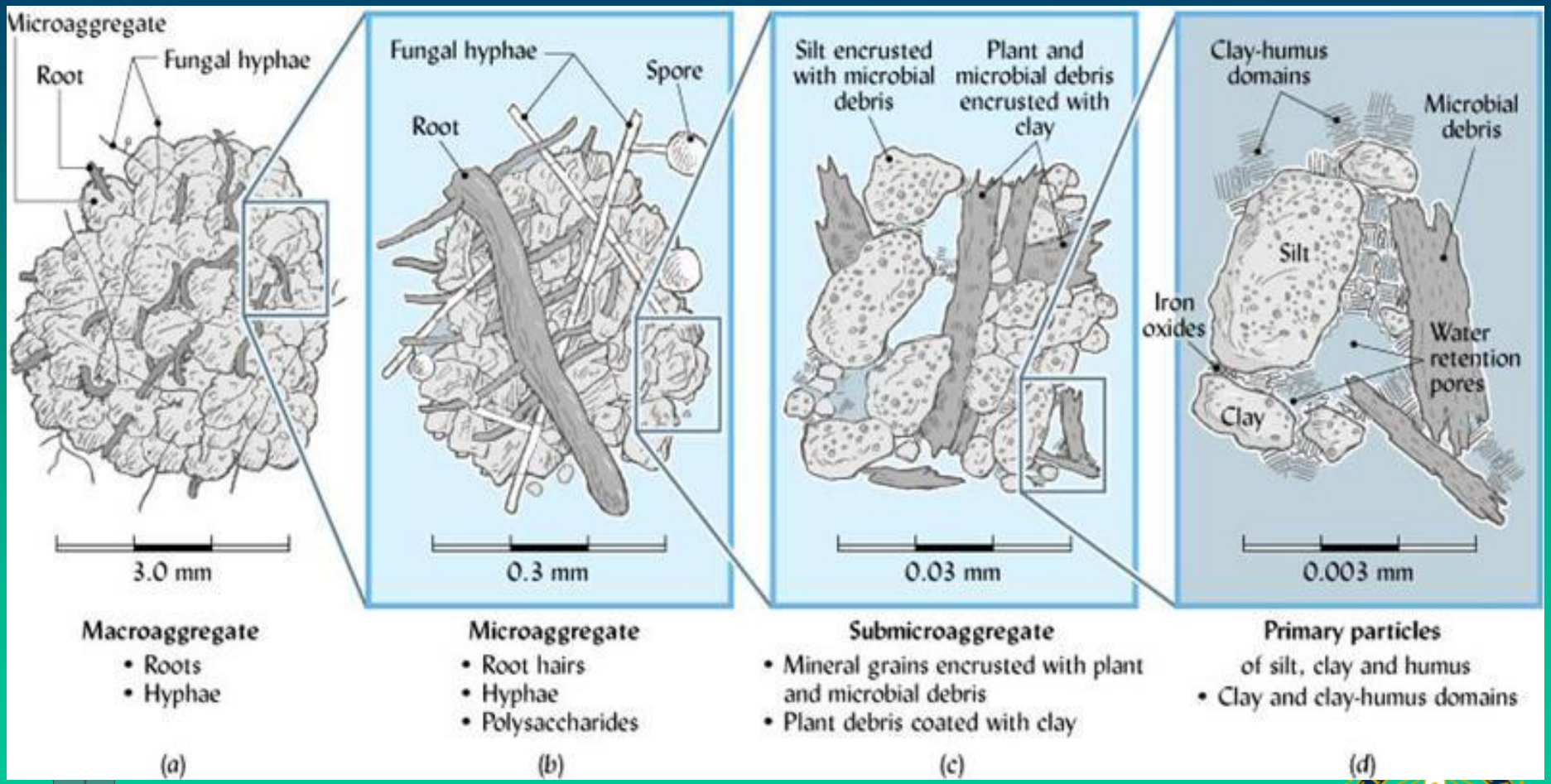
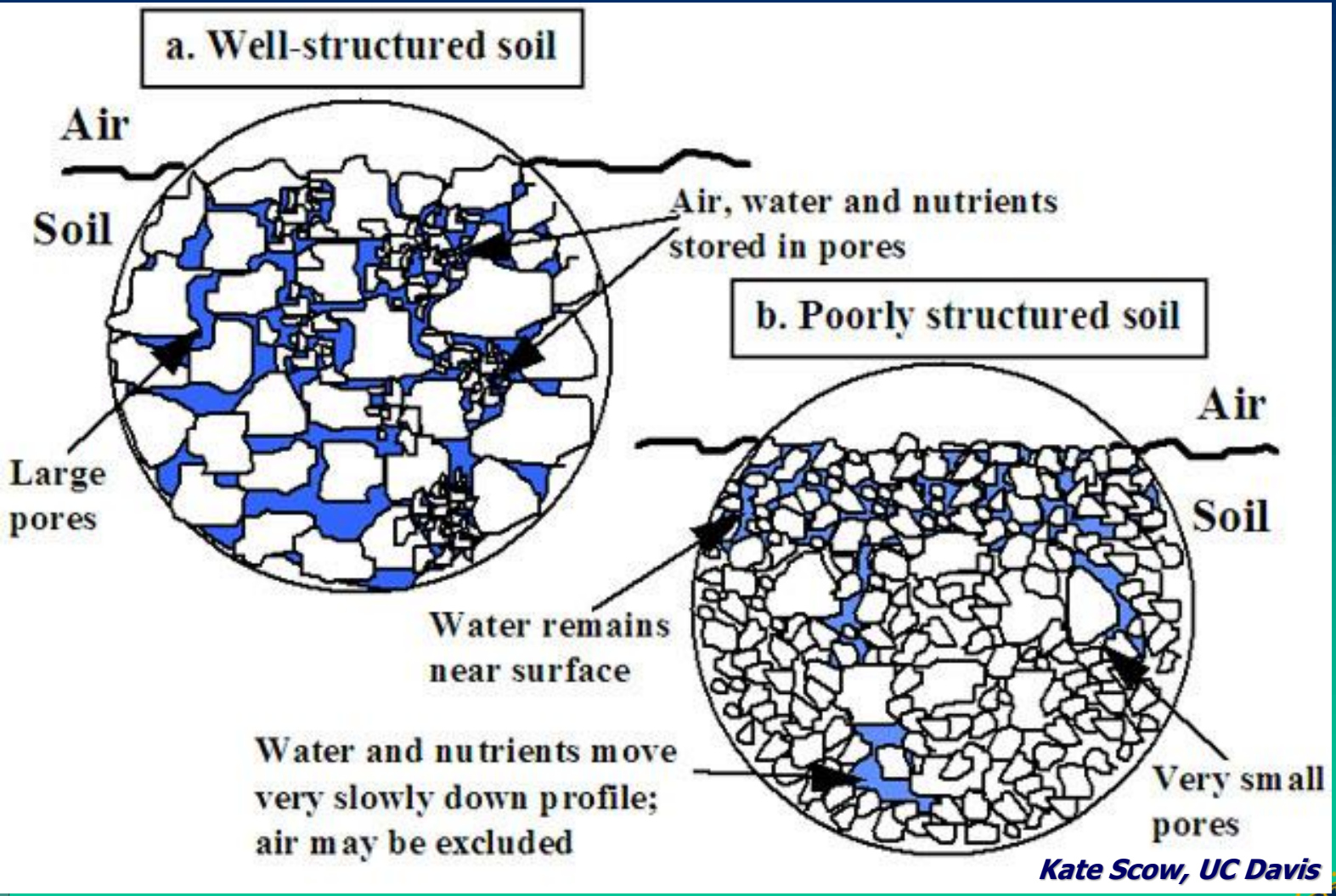
Organic matter and microbes in create aggregate structure: fueled by carbon inputs



Kate Scow, UC Davis

Brady and Weil, 2010 from Tisdall and Oades

Soil structure for water movement and gas exchange



Kate Scow, UC Davis

Soil Structure

Kate Scow, UC Davis

Don't Treat Your Soil
LIKE DIRT

How is this relevant to forages?

- Soil Fertility: Satisfying the needs of crop production
  - Alfalfa, Other forage crops
- Long-term building of 'soil health'
  - Soil Fertility (over time)
  - Optimizing soil condition (drainage, salinity, structure), organic matter
  - Sustain soils for other crops, future
- Forages have a lot of positives
  - But we can 'mine' soils as well!

Rotation Study Treatments

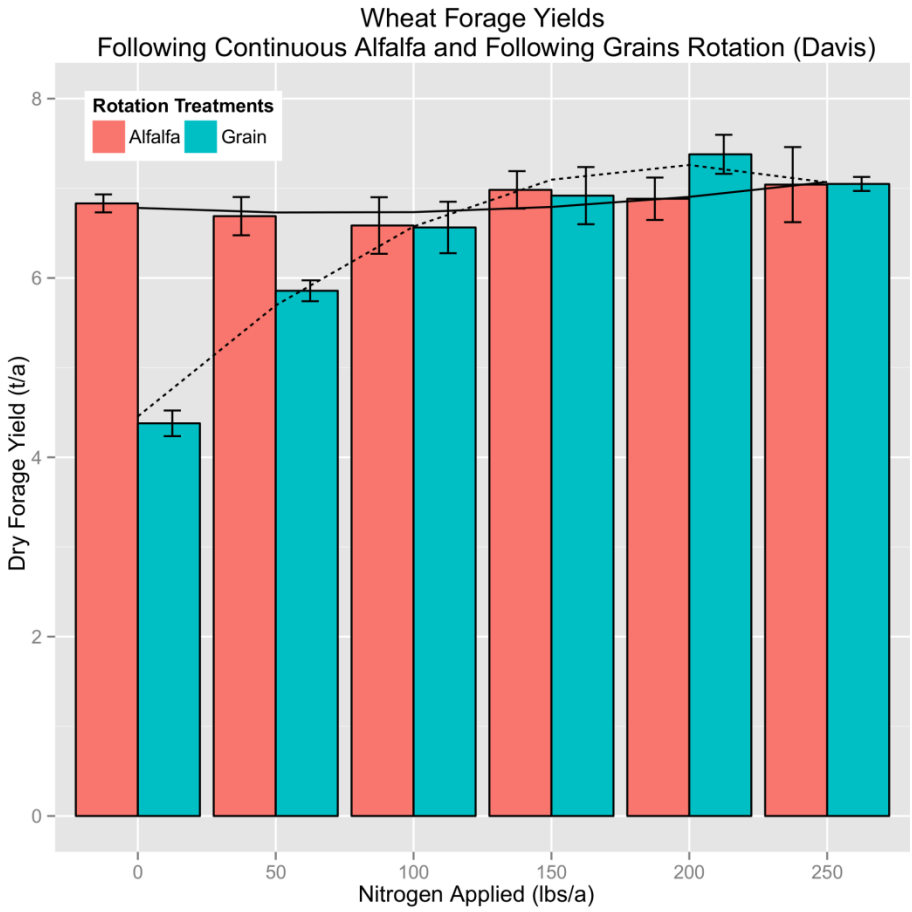
5 Years – N Treatments in Wheat following Alfalfa vs. Grains

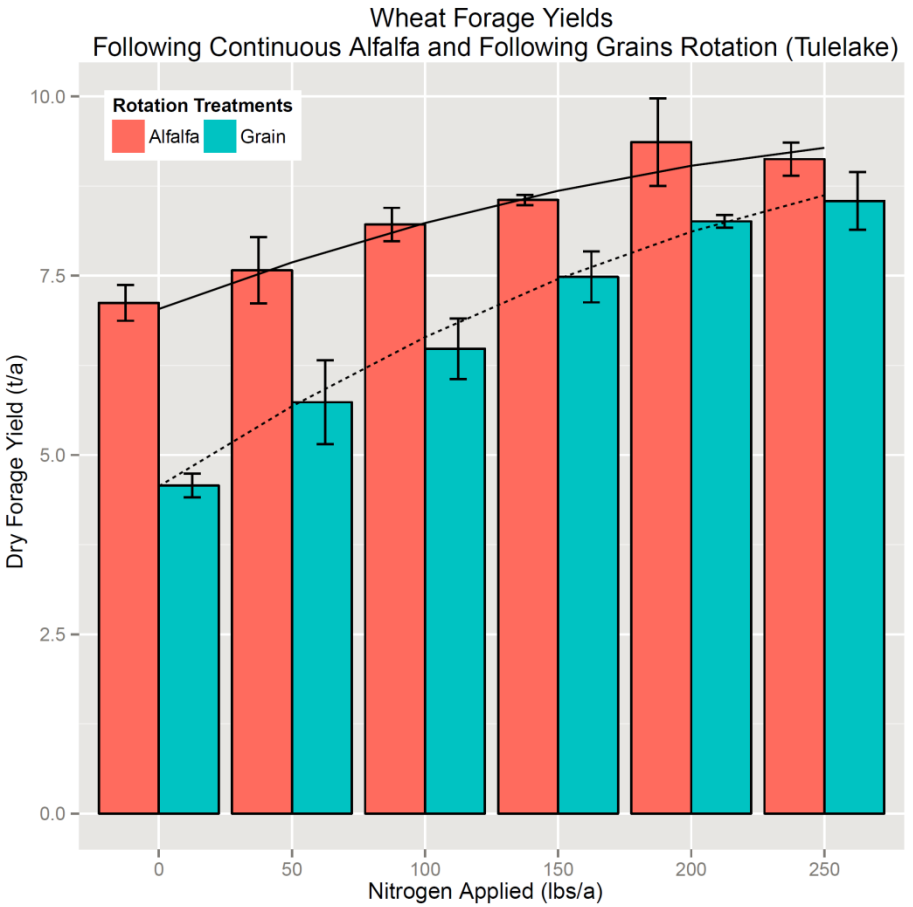
Tulelake

Kearney

(Davis site not pictured)

Wheat Yields – Effect of Crop Rotation



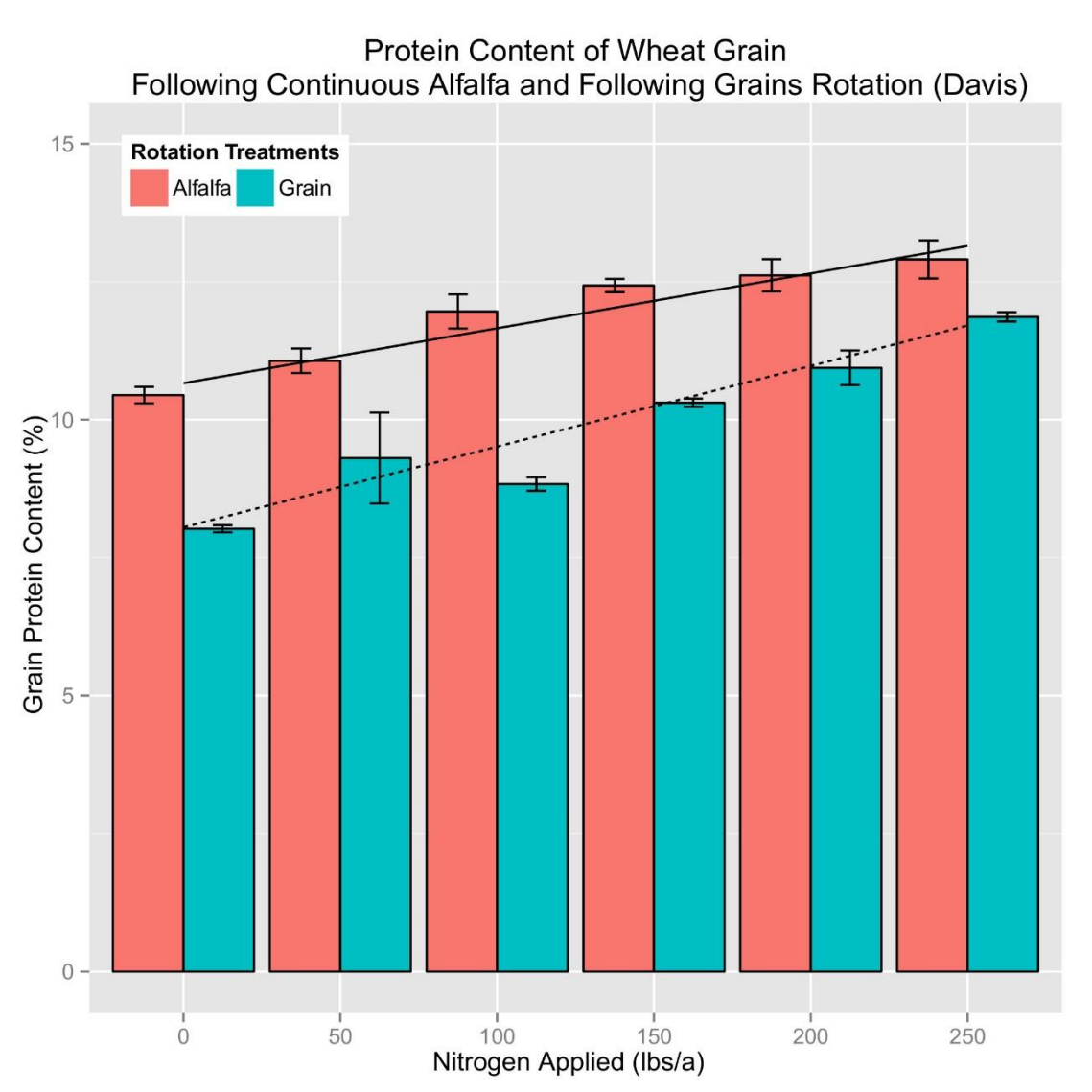


Davis

Tulelake

Alfalfa rotation benefits wheat grain protein content

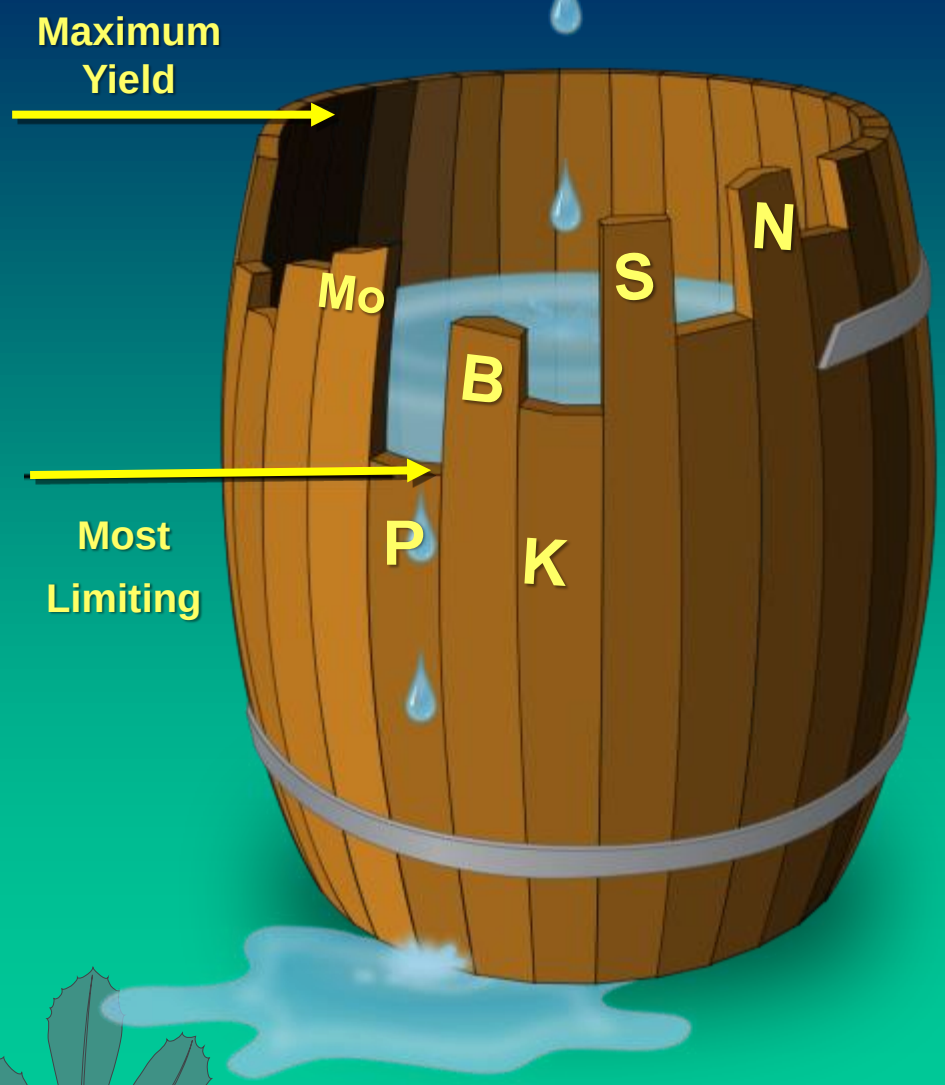
Fertilization helped increase protein content, even at high N fertilization rates.



Good Soil Fertility and Stewardship

- Is highly compatible with high yields, quality, and profitability
- Resists 'extractive' soil management practices

Justus von Liebig (1850s): *Law of the Minimum*



Yield is limited by the most deficient plant nutrient. If one of the essential plant nutrients is deficient, plant growth will be poor even when all the other nutrients are abundant

In California….

- P and K are the most frequently limiting nutrients for alfalfa
- Growers often do not monitor adequately either soil or plant
- Typically under-applied on deficient soils
- P and K uptake/removal levels are high
- Perennial plant, thus a multi-year question

Differences in Harvest Index

Alfalfa removes nutrients…

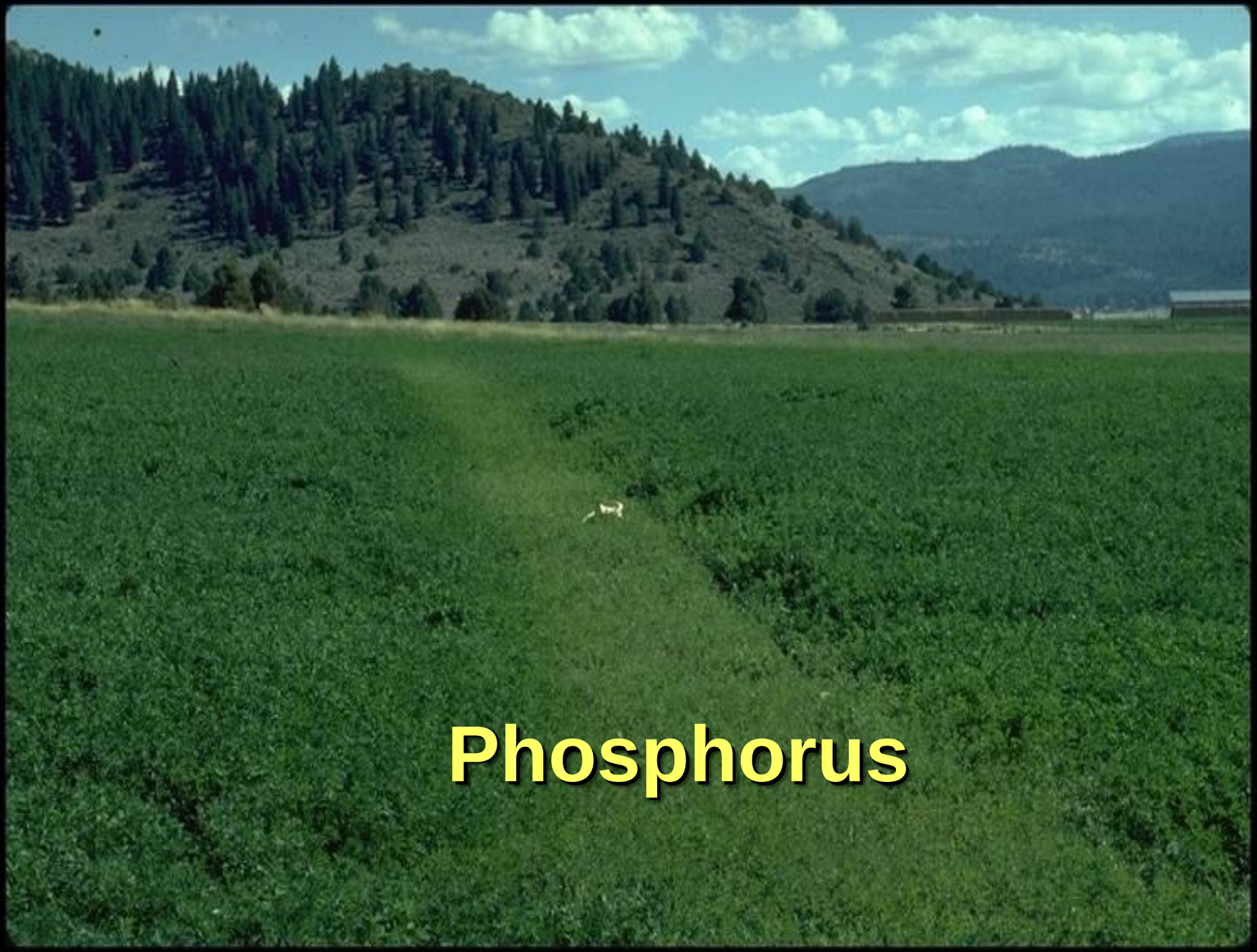
P & K Nutrients removed in a alfalfa crop at various yield levels						
	Forage Yield Level					
	4 t/a	6 t/a	8 t/a	10 t/a	12 t/a	14 t/a
	Nutrient Removal (lbs./acre/year)					
Nutrient						
P (P2O5)	21(47)	31(71)	42(95)	52(119)	62(143)	72(165
K (K2O)	160(192)	240(288)	320(384)	400(480)	480(576)	560(672)
(Adapted from Meyer et al., 2007)						

In 4 years, CA alfalfa removes an <u>average</u> of

- **168 lbs P (288 max)**
- **1280 lbs K (2240 max)**

How (and when) do you know Whether a mineral is limiting?

Potassium Deficiency



Phosphorus

Molybdenum

Nitrogen

Sulfur Deficiency

Over Irrigation

- Visual symptoms not always reliable
- Yield loss occurs before visual symptoms apparent

Nutrient Deficiencies in Alfalfa

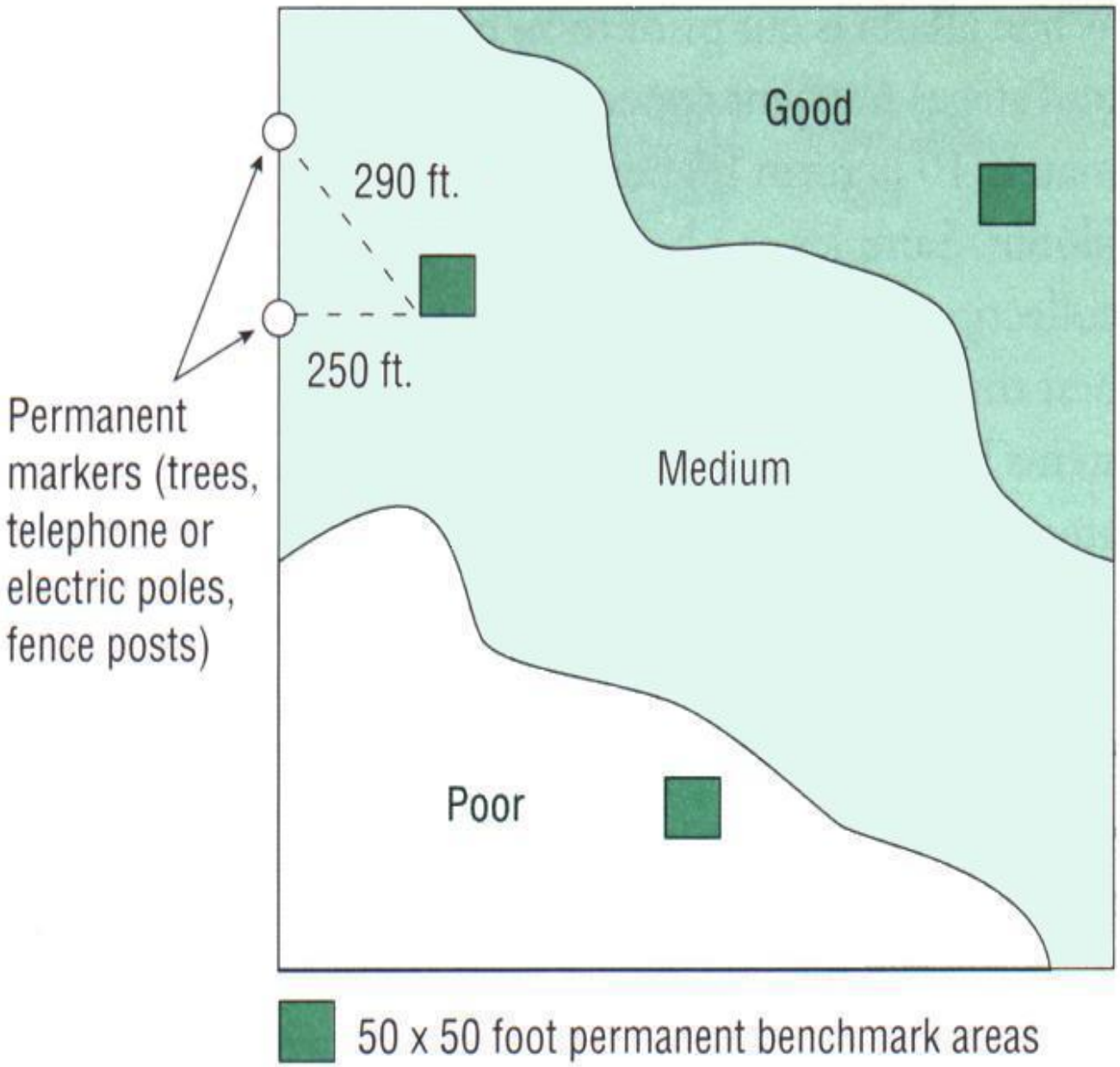
Element	Deficiency Symptom
Nitrogen	Generally yellow, stunted plants
Phosphorus	Stunted Plants with small leaves, plants are sometimes dark blue-green or reddish
Potassium	Pin-spots on leaf margins, on more mature leaves, turning yellow to brown leaf tips and edges
Sulfur	Generally yellow, stunted plants
Molybdenum	Generally yellow, stunted plants

Diagnosing Nutrient Deficiencies in Alfalfa

- **Visual Observation**
  - *Too late…?*
- **Soil Testing**
  - *Pre-Plant Diagnostics*
- **Plant Sampling**
  - *In-Season Diagnostics*
- **Fertilizer Strips in Field**
  - *Confirm Diagnosis*

Soil Sampling

- Highly recommended during establishment.


Good
290 ft.
250 ft.
Permanent markers (trees, telephone or electric poles, fence posts)
Medium
Poor
50 x 50 foot permanent benchmark areas

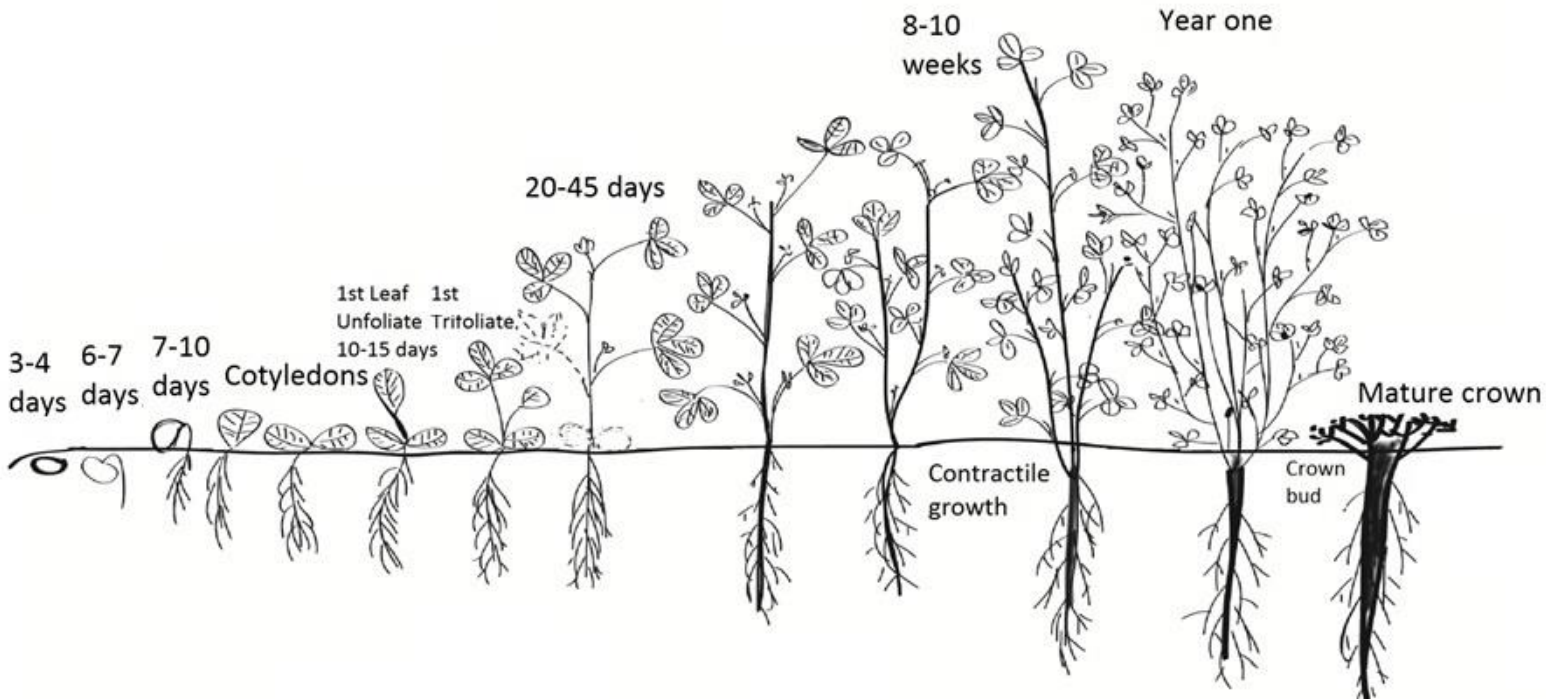
Soil Sampling

- Several areas of field
- To rooting depth (3-4’)
- Anticipate 2-3 years replacement supply

Understand your soil status

Interpretation of Soil Test Results for alfalfa production					
		Soil Value (ppm)			
Nutrient	Extract	Deficient	Marginal	Adequate	High
Phosphorus	Olsen P	<5	5-10	10-20	>20
Potassium	NH_4 acetate	<40	40-80	80-125	>125
Expect response?		Likely	Frequently	Sometimes	Rarely

Early availability of P important to nurture 'baby' to strong, deep-rooted plant



Dr. Mohammad Akmal, Illustration

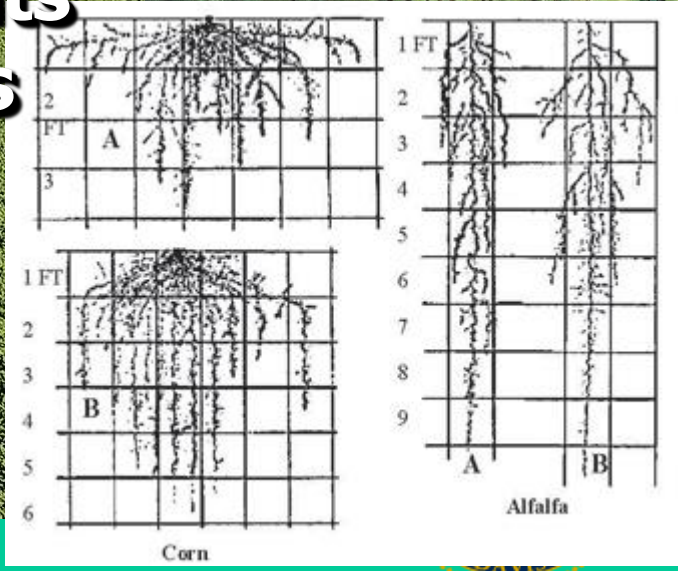
But, Where are the Roots?

Soil Sampling and Lab Methods:

- Rooting Depth?
- Phosphorus Fixation Issues with clays?
- Extraction methods?

Soil samples are very useful but….

- What are the true Rooting Patterns?
- Does Soil Sampling = Rooting Depth?
- Does the soil release nutrients to the plant the same way as the lab extract?
- Is the plant well supplied?
- Ask the Plant!



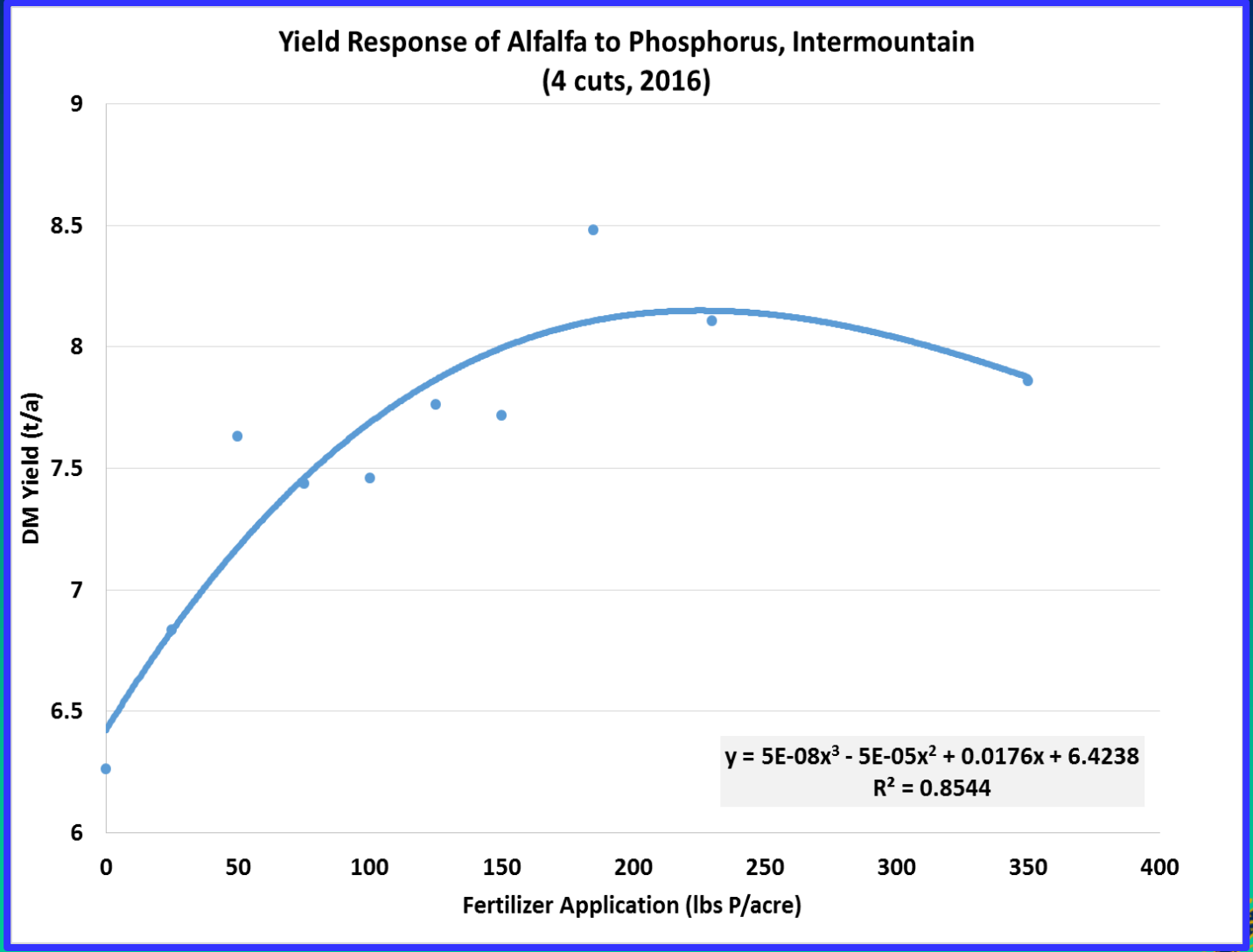
Relative Reliability of Soil and Plant Tissue Tests

Nutrient	Soil Testing	Plant Tissue
Phosphorus (P)	Good	Excellent
Potassium (K)	Good	Excellent
Sulfur (S)	Very Poor	Excellent
Boron (B)	Poor*	Excellent
Molybdenum (Mo)	Not Done	Excellent

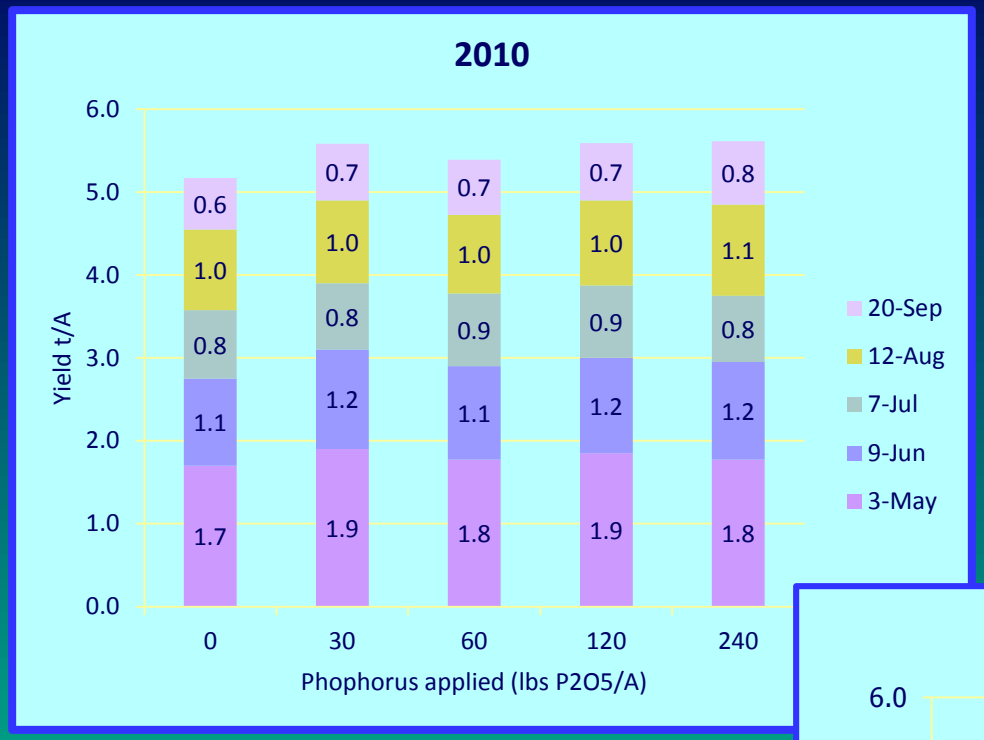
Good for evaluating toxicity of boron

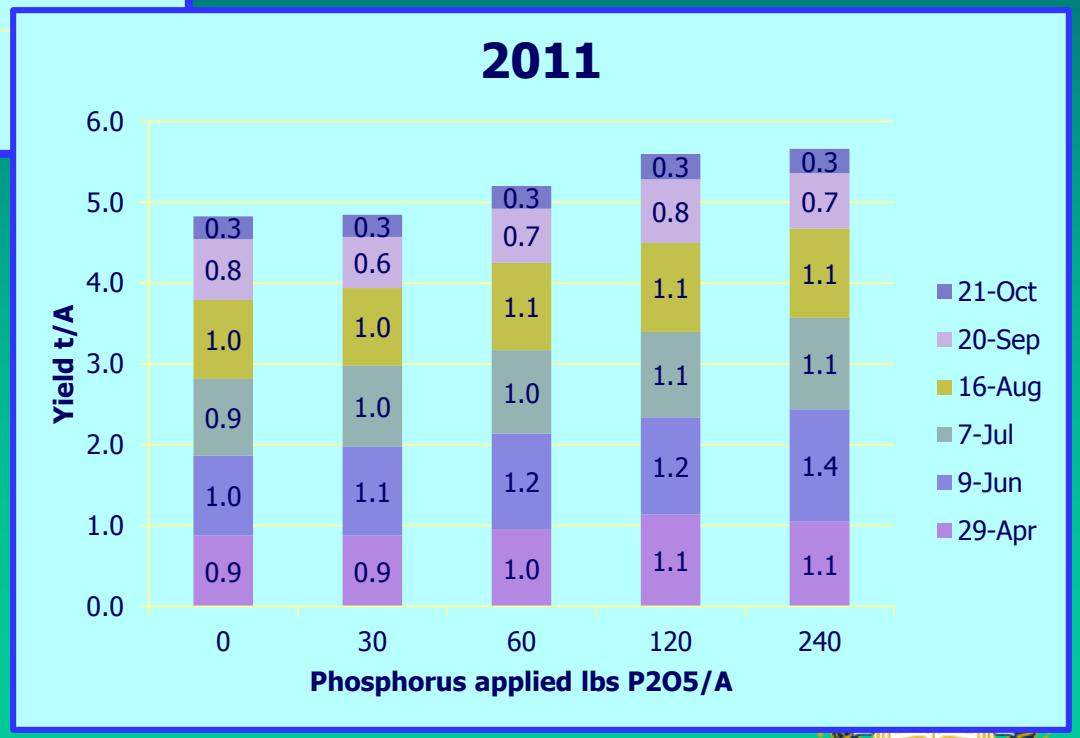
How many growers currently do soil tests?
Plant tissue tests?

P Response - Intermountain



P Response – Sac. Valley





The effect of phosphorus rate on alfalfa yield, Lancaster CA.

	Yield (tons/A)					
Lbs P_2O_5/A	Cut 1 4/30	Cut 2 6/10	Cut 3 7/14	Cut 4 8/21	Cut 5 10/2	Total
Unfertilized	1.56	1.65	1.57	1.60	1.13	7.51
100	1.90	1.84	1.71	1.74	1.19	8.38
Increase	0.34	0.19	0.14	0.14	0.06	0.87
200	1.94	1.85	1.76	1.75	1.27	8.57
Increase	0.38	0.20	0.19	0.15	0.14	1.06

The effect of phosphorus rate on alfalfa yield

Scott Valley, CA. (Olsen P 2.4 ppm)

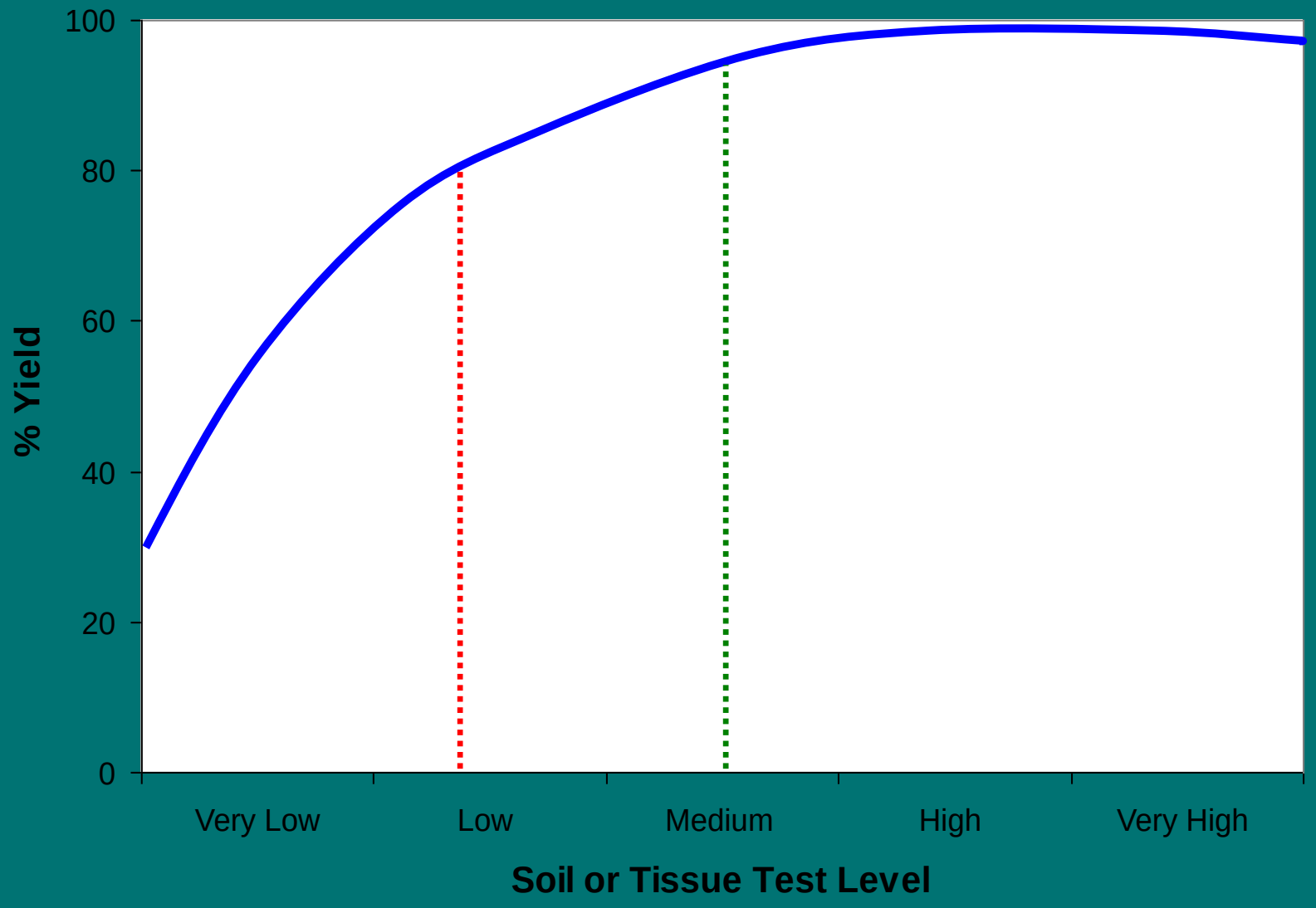
Rate (lbs P_2O_5/A)	Cut 1 6/12	Cut 2 7/21	Cut 3 8/28	Total	Increase over Unfert.
Untreated	1.94	1.44	1.25	4.63	—
40	2.25	1.79	1.49	5.53	0.90
80	2.43	1.75	1.39	5.56	0.93
120	2.68	1.79	1.46	5.93	1.30
160	2.61	1.81	1.46	5.88	1.25

Understand your soil status

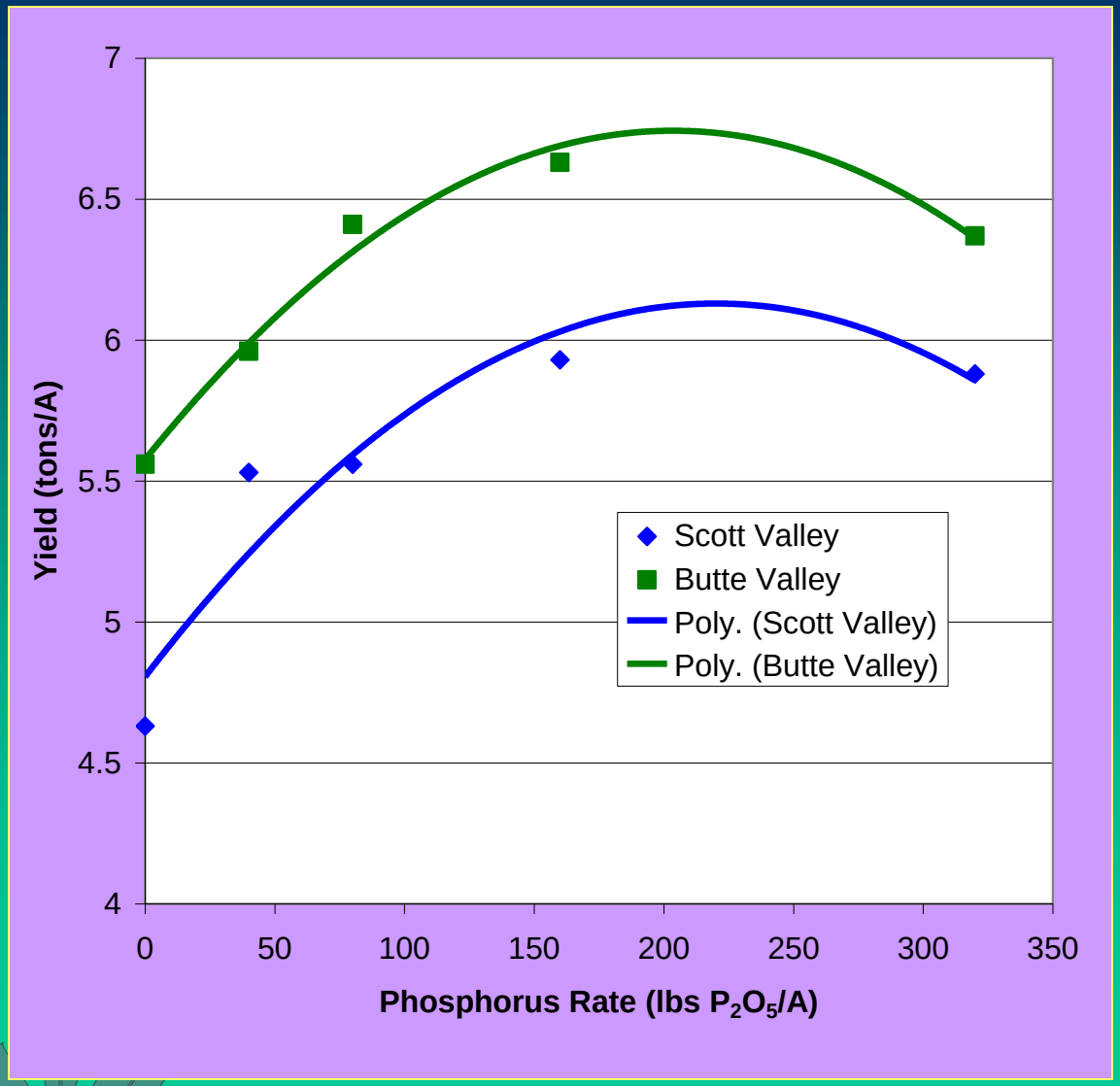
Recommended ranges of P & K applications for alfalfa at different soil test values

		Soil Value		
Nutrient	Yield Level (t/a)	Deficient	Marginal	Adequate
Phosphorus (P_2O_5)	8	120-180	60-90	0-45
	12	180-270	90-130	0-60
Potassium (K_2O)	8	300-400	150-200	0-100
	12	400-600	200-300	0-150

Potential Yield Increase from Fertilizer Application



Reduced Rate?



- Greatest response from initial increments of fertilizer
- Long – term build up?

What about in-season?

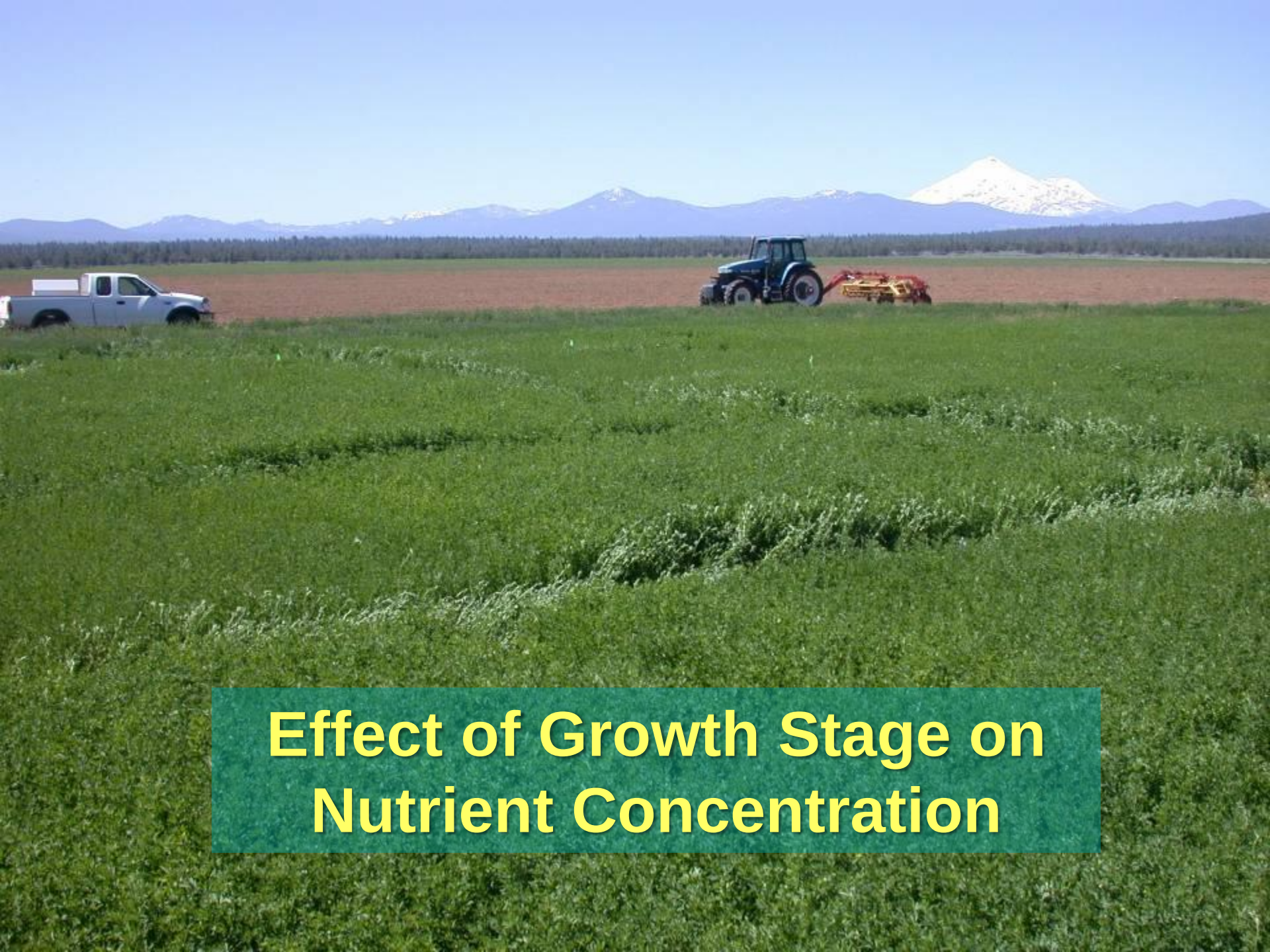
- Opportunity for incorporation past
- Was soil application adequate?
- Ongoing deficiency?
- Ask the plant!

2019-M

Tissue Sampling

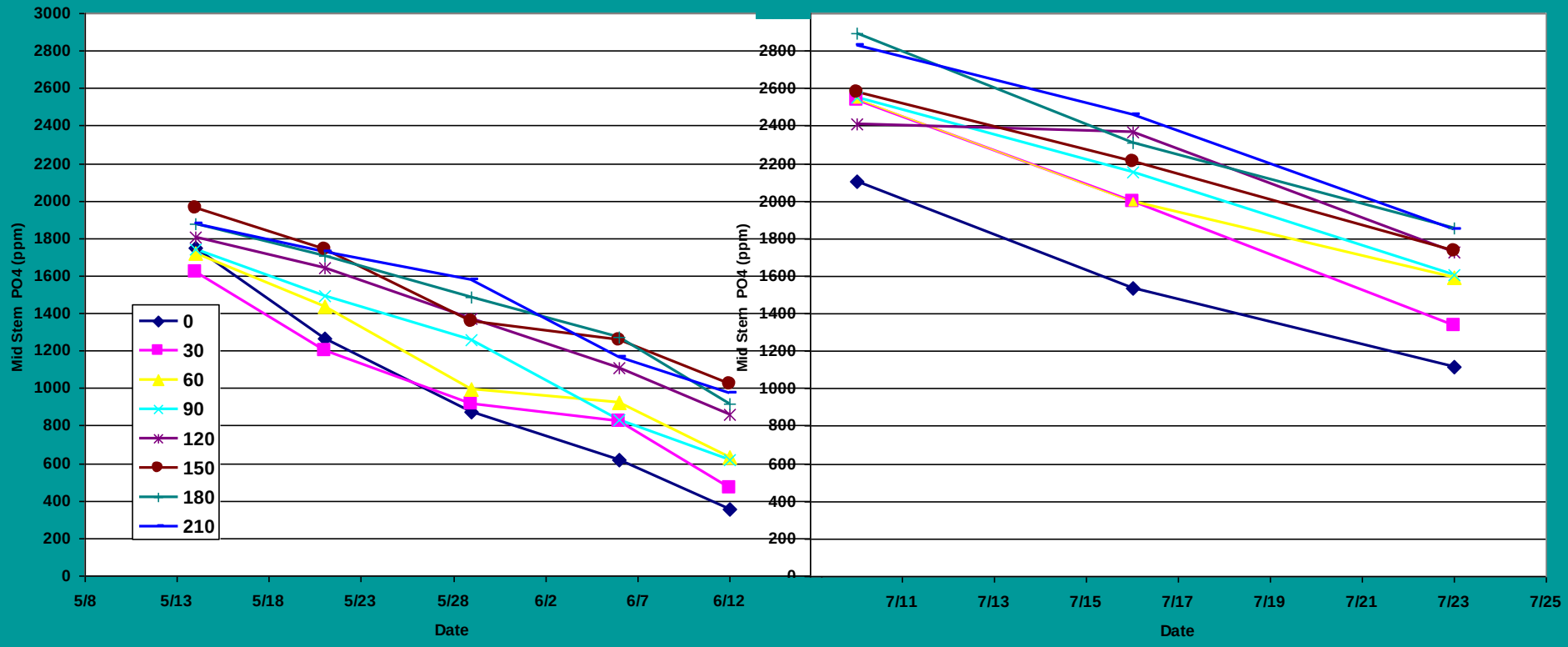
Interpretation of Plant Tissue Tests results – 10% bloom stage					
	Plant Tissue Value				
		Deficient	Marginal	Adequate	High
			ppm		
Nutrient					
Phosphorus	Mid 3rd Stem	300-500	500-800	800-1500	>1500
Potassium	Mid 3rd Stem	-.40-0.65	0.65-0.80	0.80-1.50	>1.4%

(Adapted from Meyer et al., 2007)



Effect of Growth Stage on Nutrient Concentration

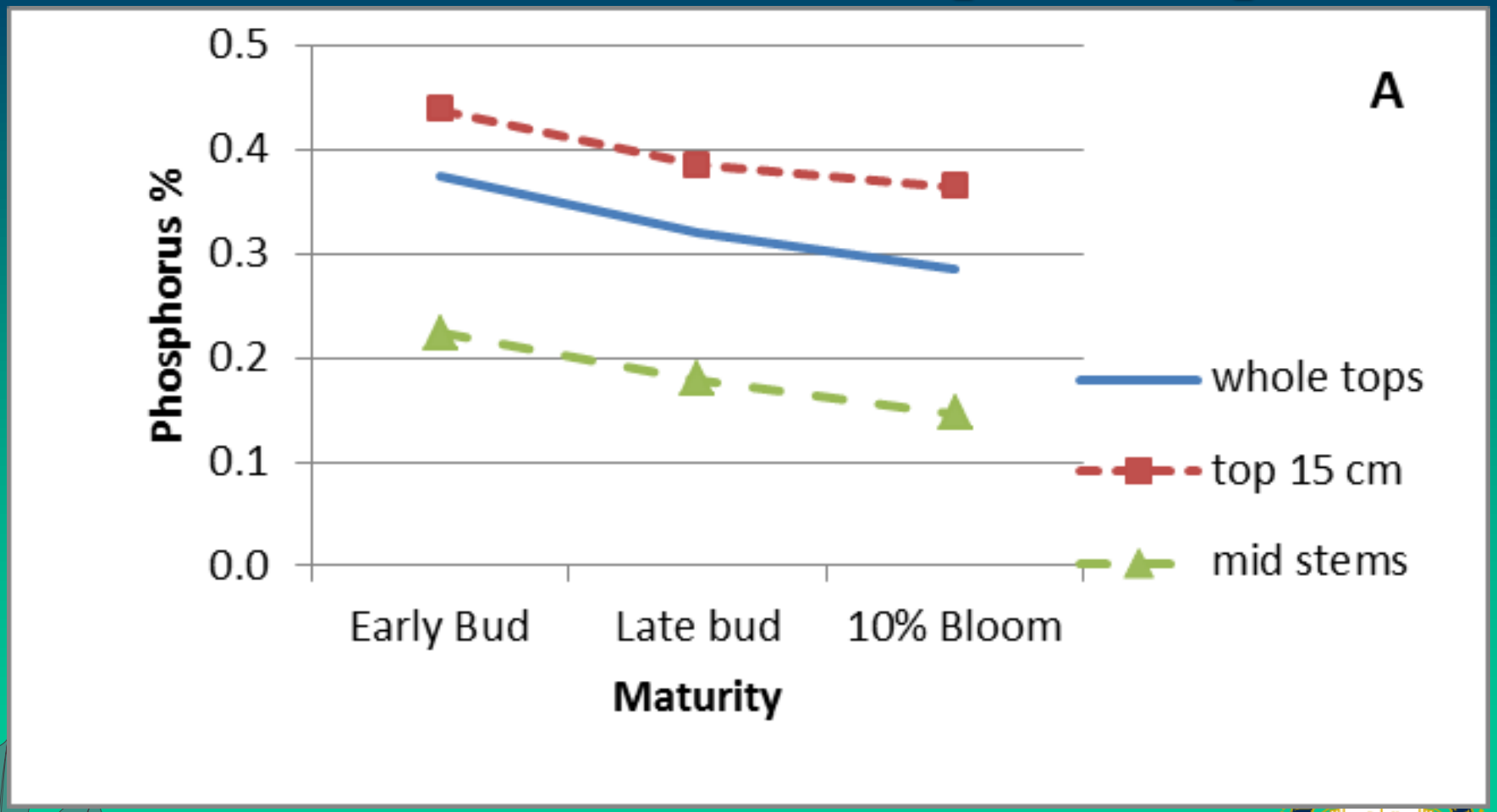
Effect of Maturity and Cutting on Mid-Stem PO_4-P



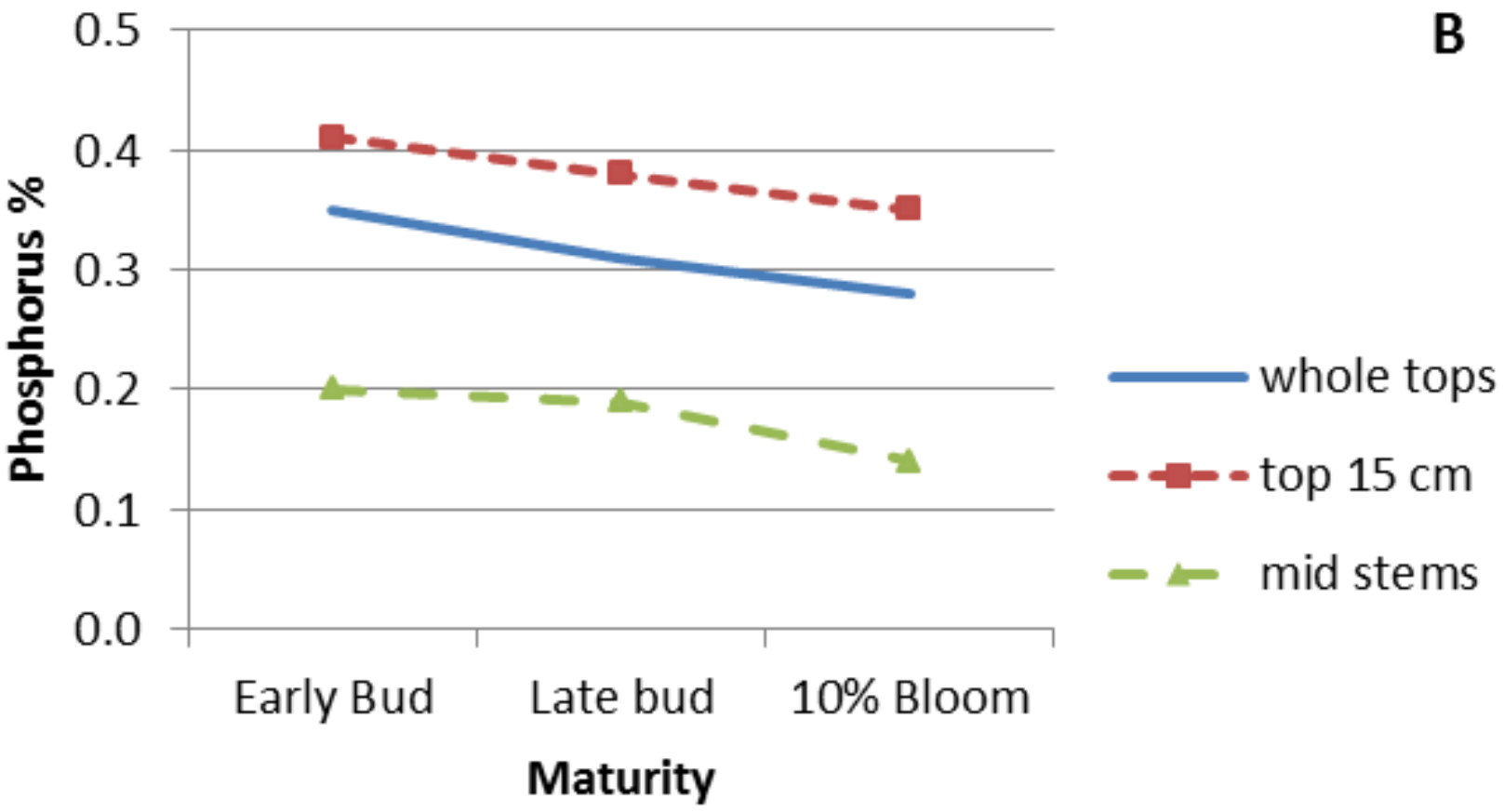
1st Cut

2nd Cut

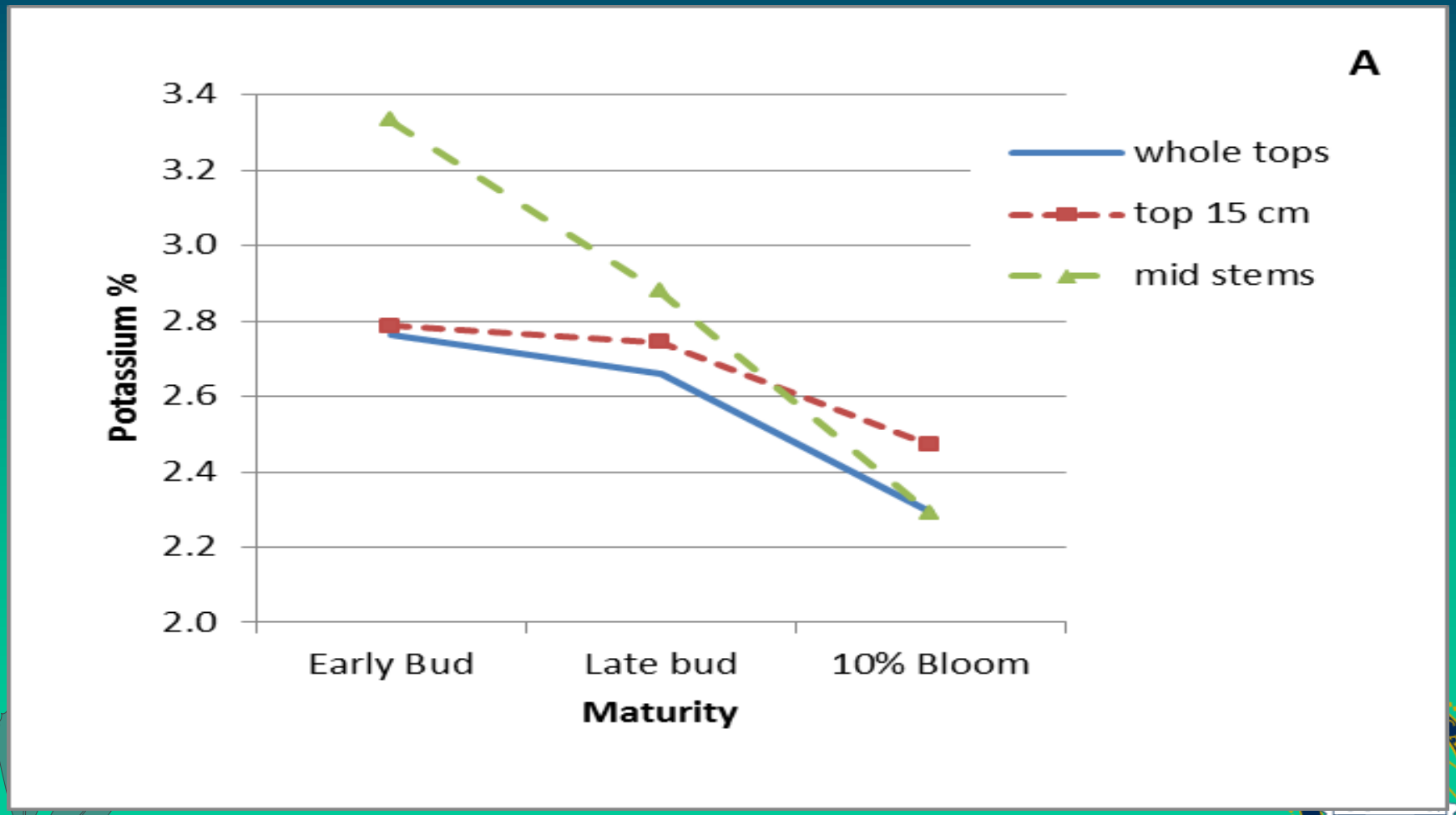
Maturity Effects on P Concentration (2010)



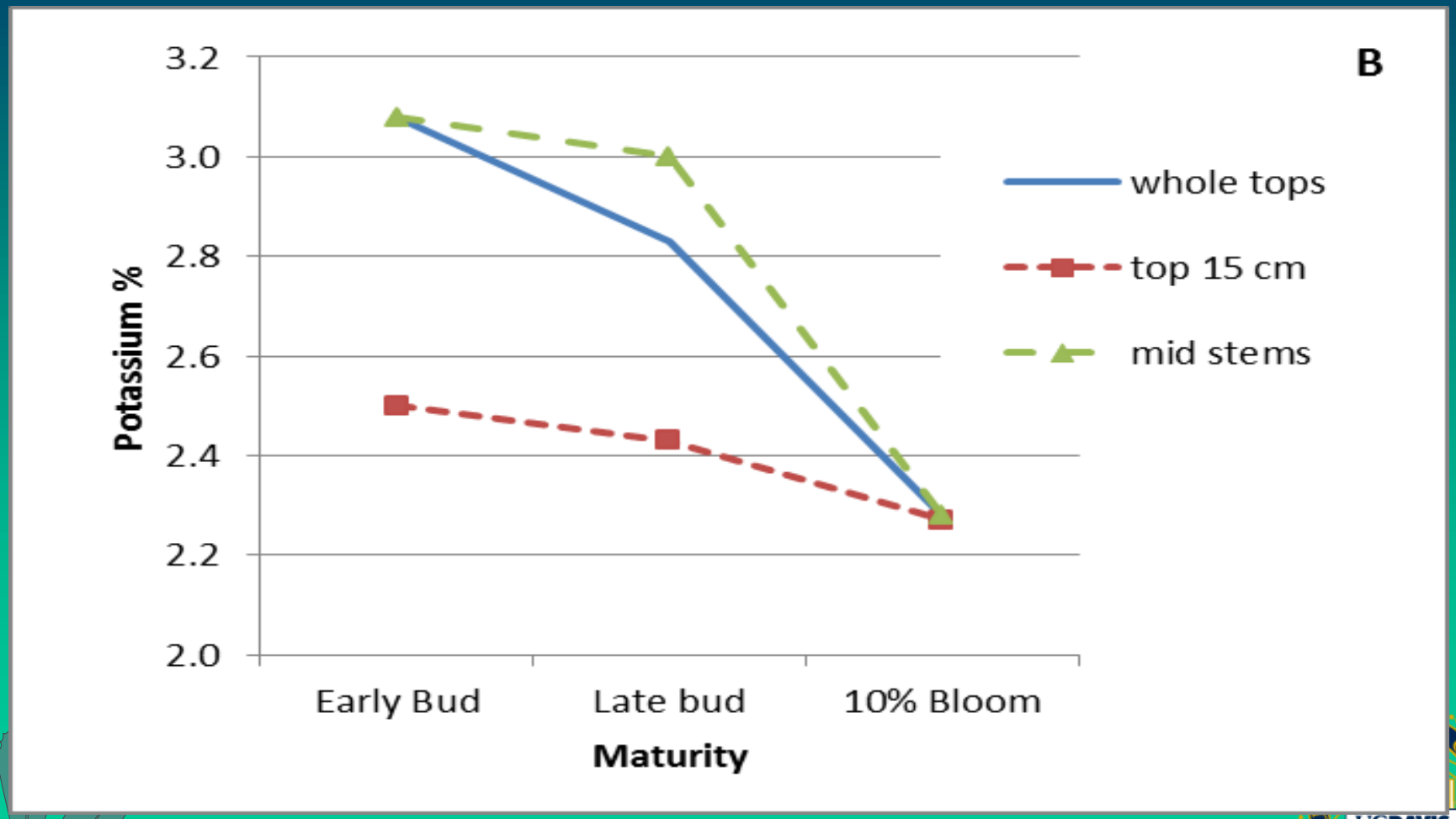
Maturity Effects on P Concentration (2011)



Maturity Effects on K Concentration (2010)



Maturity Effects on K Concentration (2011)



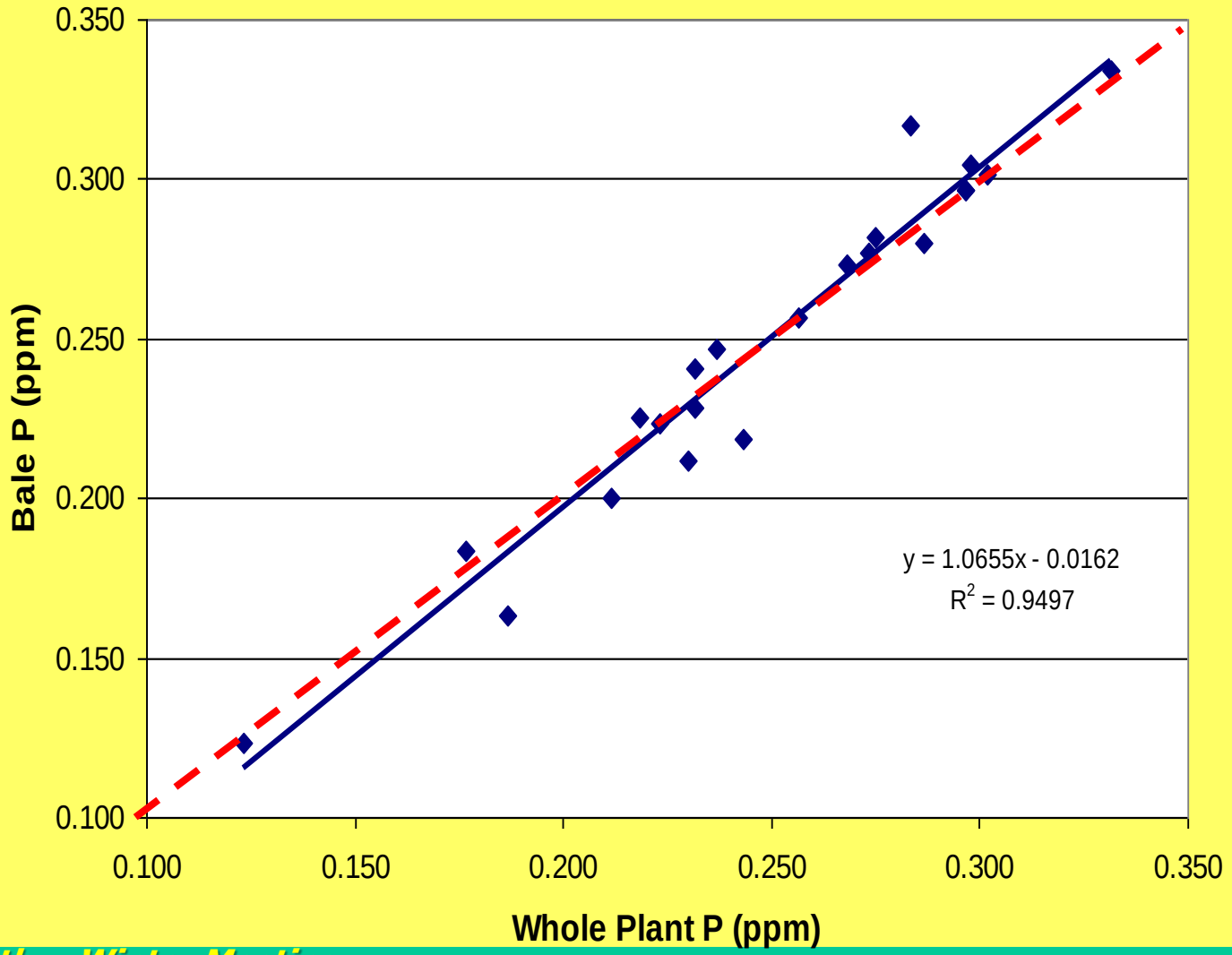
Values to Interpret Cored Bale Samples

NUTRIENT	UNIT	WHOLE PLANT TISSUE VALUE			
		DEFICIENT	MARGINAL	ADEQUATE	HIGH
Phosphorus					
Early bud	%	<0.26	0.27–0.29	0.30–0.39	>0.39
Late bud	%	<0.23	0.24–0.25	0.26–0.34	>0.34
10% bloom	%	<0.20	0.21–0.22	0.23–0.30	>0.30
Potassium					
Early bud	%	<0.91	0.92–1.24	1.25–1.60	1.60–3.42
Late bud	%	<0.87	0.88–1.19	1.20–1.53	1.53–3.27
10% bloom	%	<0.80	0.81–1.09	1.10–1.40	1.40–3.00

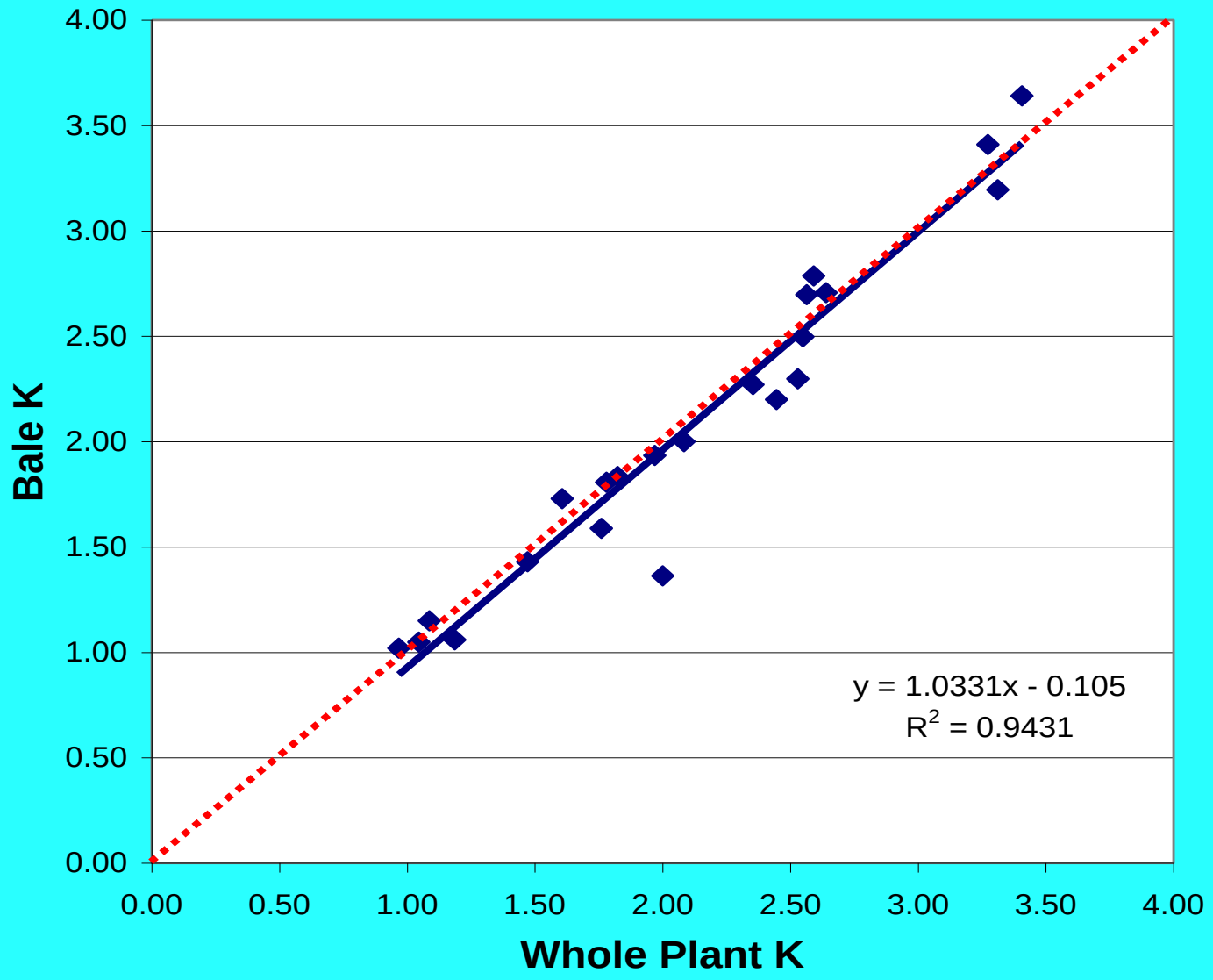
Soil samples taken along each windrow (15 to 20 cores)

- Compare results from fractionated tops, whole tops, cored bales, soil samples

Whole Plant vs. Bale P

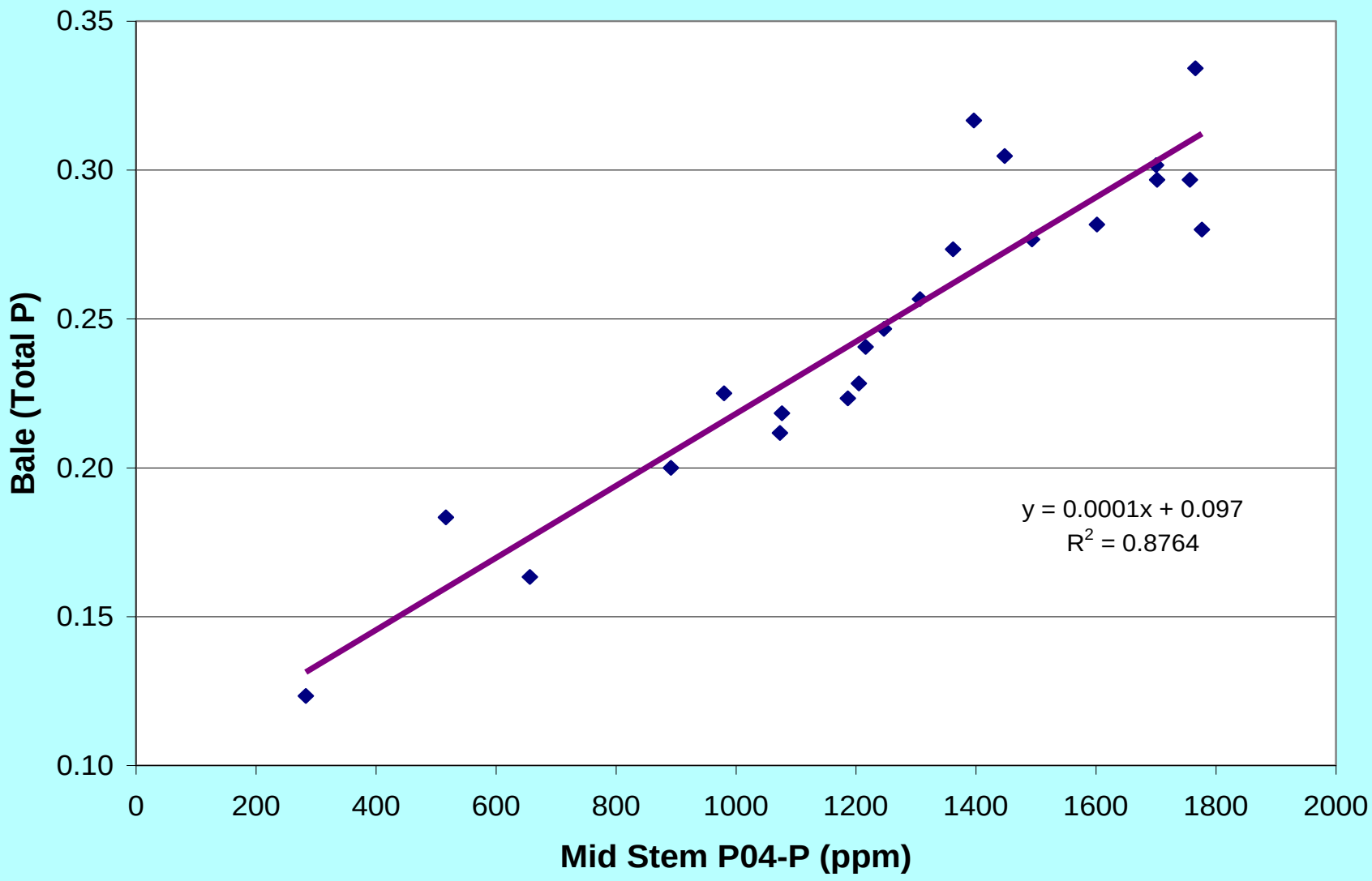


Whole Plant vs. Bale K

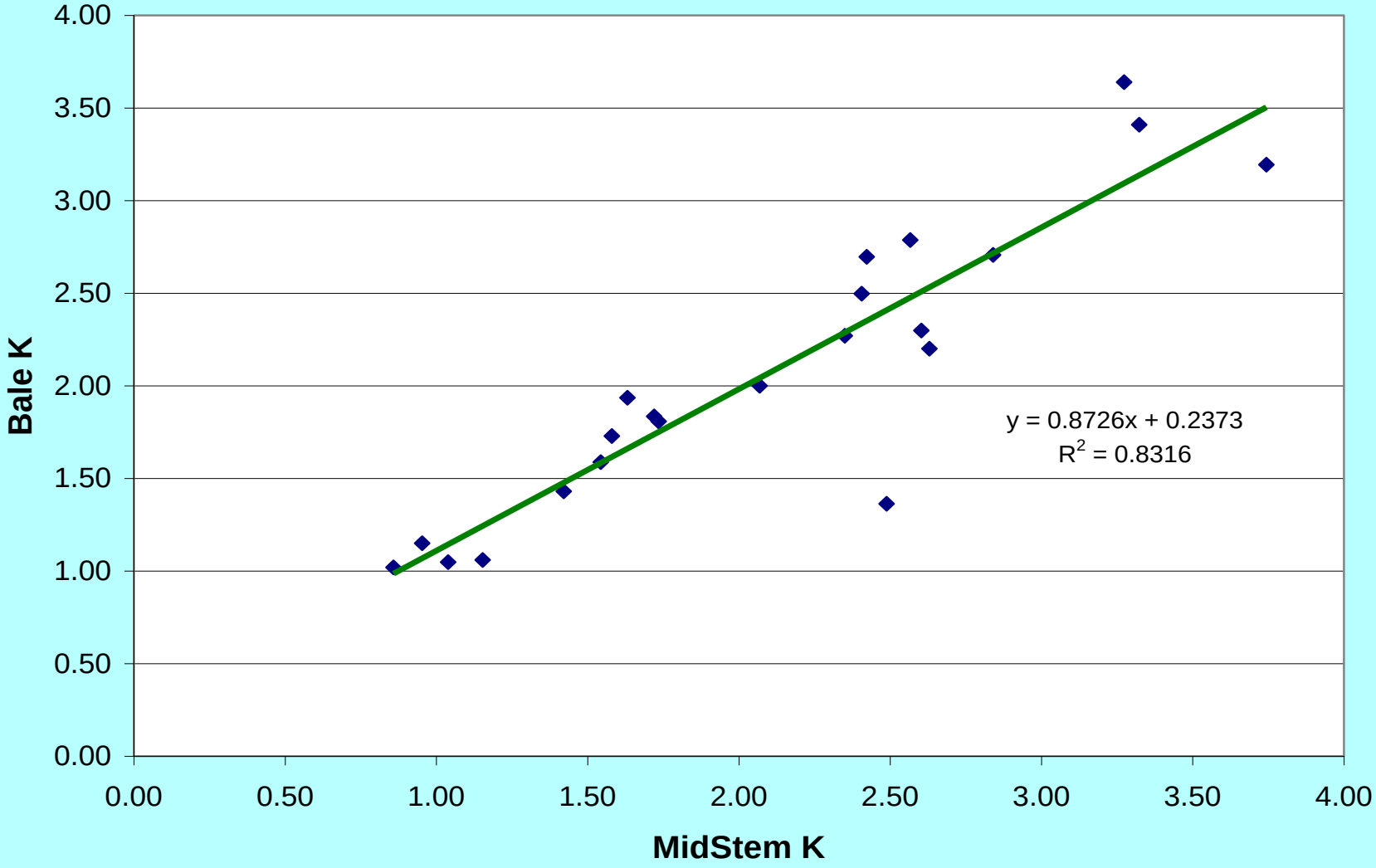


2019

Mid-Stem PO_4-P vs. Bale Total P



Bale vs. Mid Stem K



Interpreting soil or tissue test values

Recommended ranges of P & K applications for alfalfa at different soil or tissue test values

		Soil or tissue Test Value		
Nutrient	Yield Level (t/a)	Deficient	Marginal	Adequate
Phosphorus (P_2O_5)	8	120-180	60-90	0-45
	12	180-270	90-130	0-60
Potassium (K_2O)	8	300-400	150-200	0-100
	12	400-600	200-300	0-150

Approaches to Soil Fertility:

- "Recipe" Approach: (NO)
  - Applying a Fixed Amount 'cookbook'
  - Eventually results in over- or under-fertilization
- "Prescription" Approach (YES)
  - Diagnosis – visual & lab
  - Soil or plant tissue analysis
  - Tailored to needs of the field
- "Soil Health" Approach: (YES)
  - Envision limitations to soils improving over time.
  - Not just N-P-K, but organic matter, soil biology, Soil Structure
  - Soil and cropping systems management to improve soils

Cannot overstate importance of soil testing or plant tissue testing to determine fertility status

Summary

- Soil Health is multi-dimensional!
- Long term 'health' is the goal
- Soil analysis good for pre-plant assessment
  - pH, salinity, P and K
- Use Plant tissue analysis in season
  - Evaluate most limiting nutrient then fertilize and resample
  - Leave untreated strips to assess effectiveness
- Bale sampling for tissue testing practical