Nutrient Management for Forage Production

Herdsmanship School, Hall

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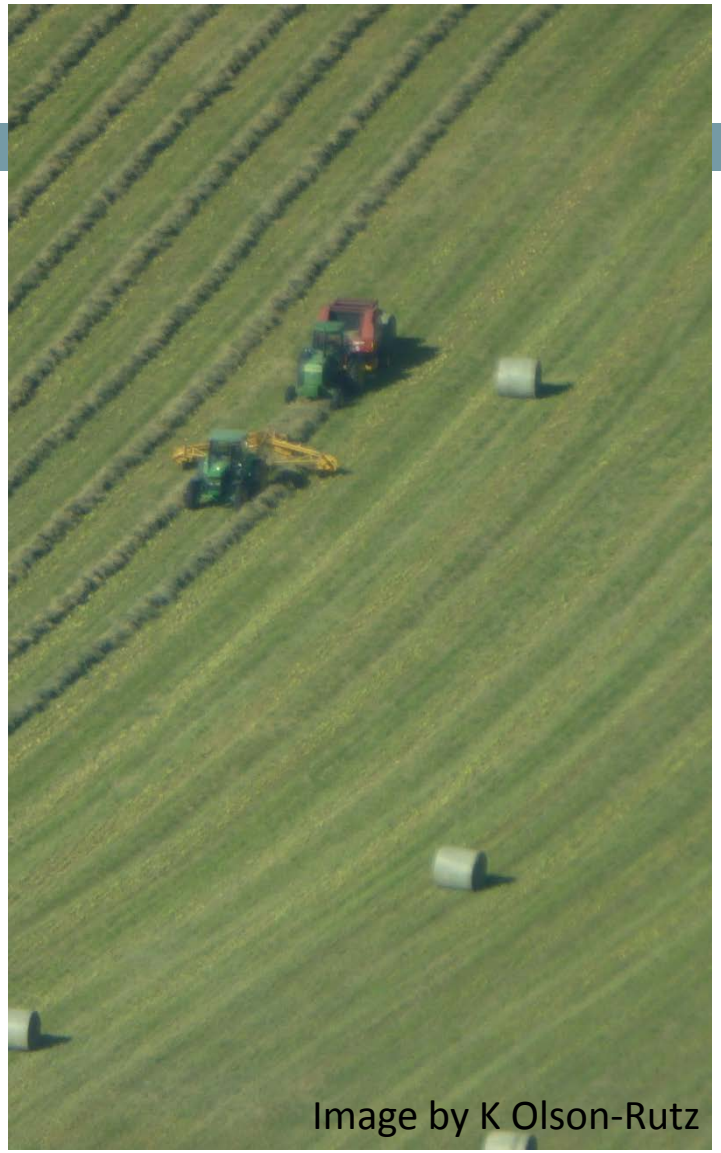
MSU Soil Fertility Extension

Why learn about soils?

- For good forage yields, and cover for livestock and wildlife
- To protect the environment
- For efficient use of resources (water, fertilizer, $)



Goals

- Cover soil fertility basics
- Show nutrient deficiency symptoms of P K S and micros on forages
- Review use of Fertilizer Guidelines to determine P and K rates on forages
- Present timing, source and placement considerations of P fertilization
- Illustrate yield and quality responses of hay to P, K, and S
- Help your bottom line

Some questions for you

Who has raised alfalfa-hay or grass hay?

Who has worked with pastures?

Who has grown annual forages (ex: Haybet barley, Willow Creek winter wheat)?

14 mineral nutrients have been found essential for growth of most plants:

Macronutrients	Micronutrients
Nitrogen (N)	***Boron (B)***
Phosphorus (P)	***Chloride (Cl)***
Potassium (K)	***Copper (Cu)***
Sulfur (S)	***Iron (Fe)***
Calcium (Ca)	***Manganese (Mn)***
Magnesium (Mg)	Molybdenum (Mo)
	Nickel (Ni)
	Zinc (Zn)

The macronutrients are simply needed in larger amounts by the plant than the micronutrients.

Nutrient deficiencies of the ***bolded red*** nutrients have been observed in Montana

Today's focus on N, P, K and S.

Nutrient inputs need to eventually balance 'losses'

- Leaching (N, S)
- As gas (ammonia, or N_2)
- Erosion (wind and water)
- Harvest

Nutrient removed in harvested crop				
Crop	N	P_2O_5	K_2O	S
Alfalfa/ton	48	11	53	5.5
Grass/ton	25	10	38	2

- Nutrient changing to unavailable form (N into microbial biomass, P tied up with minerals)

Soil test

- To identify nutrient deficiency and calculate fertilizer rates
- Can increase yield and/or save on fertilizer costs, and decrease environmental risks
- Best done in early spring, but not when soil is wet, therefore in our climate perhaps best done in late fall
- See publications listed at end for details on ‘how-to’

Soil test report for 2 fields near Hot Springs, Sanders Co.

YOUR SAMPLE NUMBER (LAB NUMBER)	INTENDED CROP	YIELD GOAL	PREVIOUS CROP
DON (31396506)	ALF/GRASS - ton	5.0	WHEAT WINTER
SCH 2C (31396507)	ALF/GRASS - ton	5.0	GRASS HAY - ton

Important info:

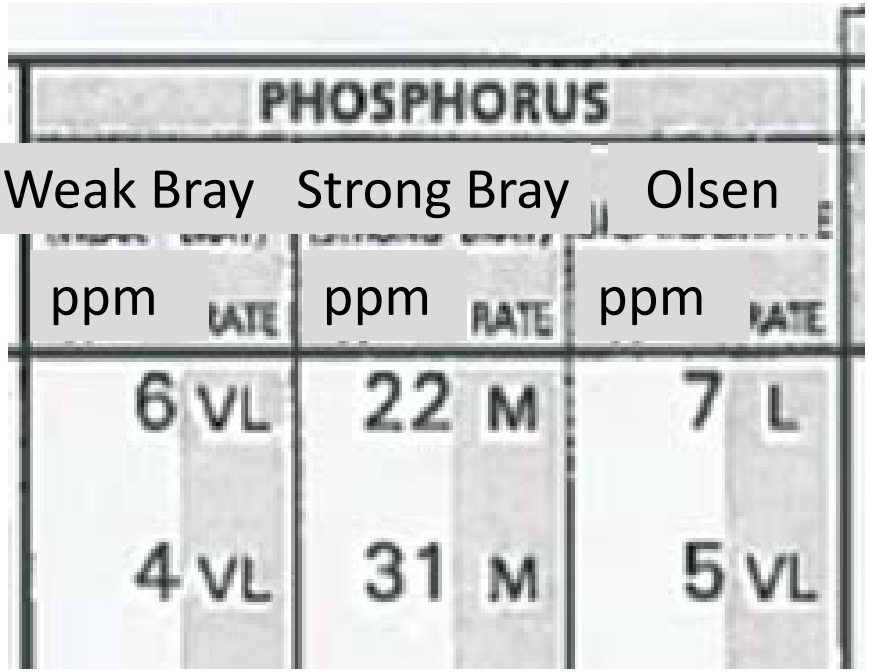
- Intended crop
- Yield goal
- Prior crop

LAB NUMBER	NITRATE-N (FIA)									
	SURFACE		depth	SUBSOIL 1			SUBSOIL 2			Total
313	ppm	lb/ac	(in)	ppm	lb/A	depth (in)	ppm	lb/A	depth (in)	lb/ac
96506	8	19	0-8							19
96507	5	12	0-8							12

To determine N rate you need:

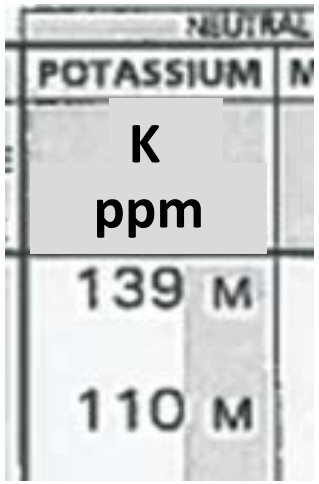
1. Yield goal
2. Soil sample depth to convert ppm to lb N/acre (ppm x 2 x actual depth in inches / 6)

Soil test report for 2 fields near Hot Springs, Sanders Co.



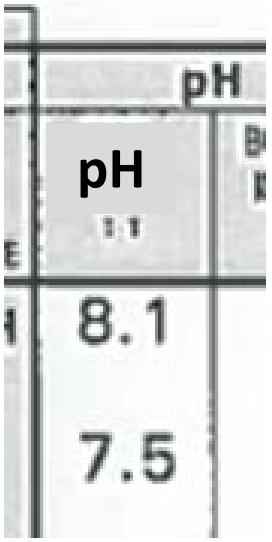
PHOSPHORUS					
Weak Bray		Strong Bray		Olsen	
ppm	RATE	ppm	RATE	ppm	RATE
6	VL	22	M	7	L
4	VL	31	M	5	VL

- P: MSU guidelines are based on Olsen P.
  - Bray works in pH < 7.3
  - Olsen works pH > 6
- Olsen P should be ~ 16 ppm



POTASSIUM	
K ppm	
139	M
110	M

- K important for alfalfa
- K should be ~ 250 ppm
- pH impacts P availability
  - P binds w/ Ca at pH > 7
  - P binds w/ Fe at pH < 6
- pH < 6 poor legume nodulation



pH
pH
8.1
7.5

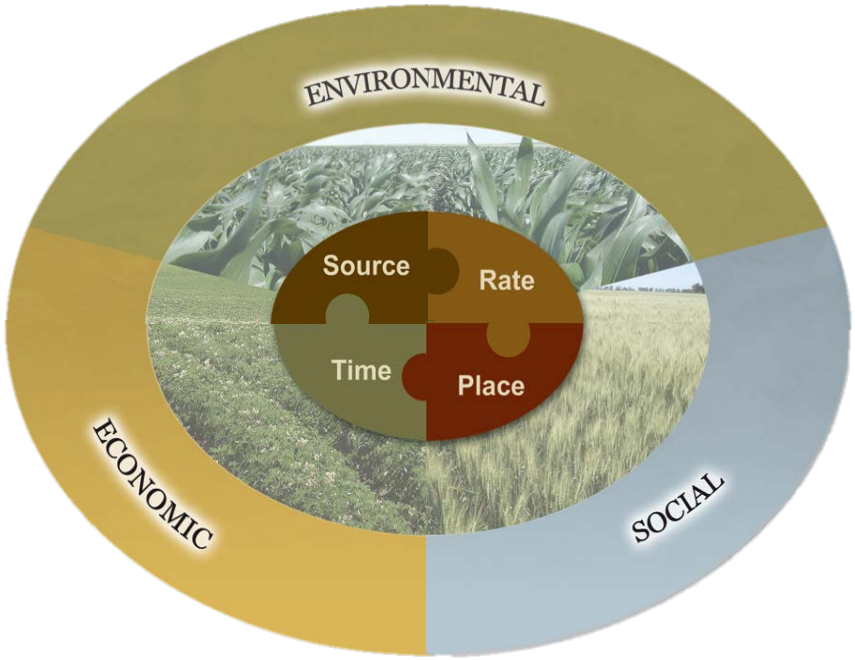
Questions?

On to fertilizer rates

To get the most out of your fertilizer investment

The 4 Rs:

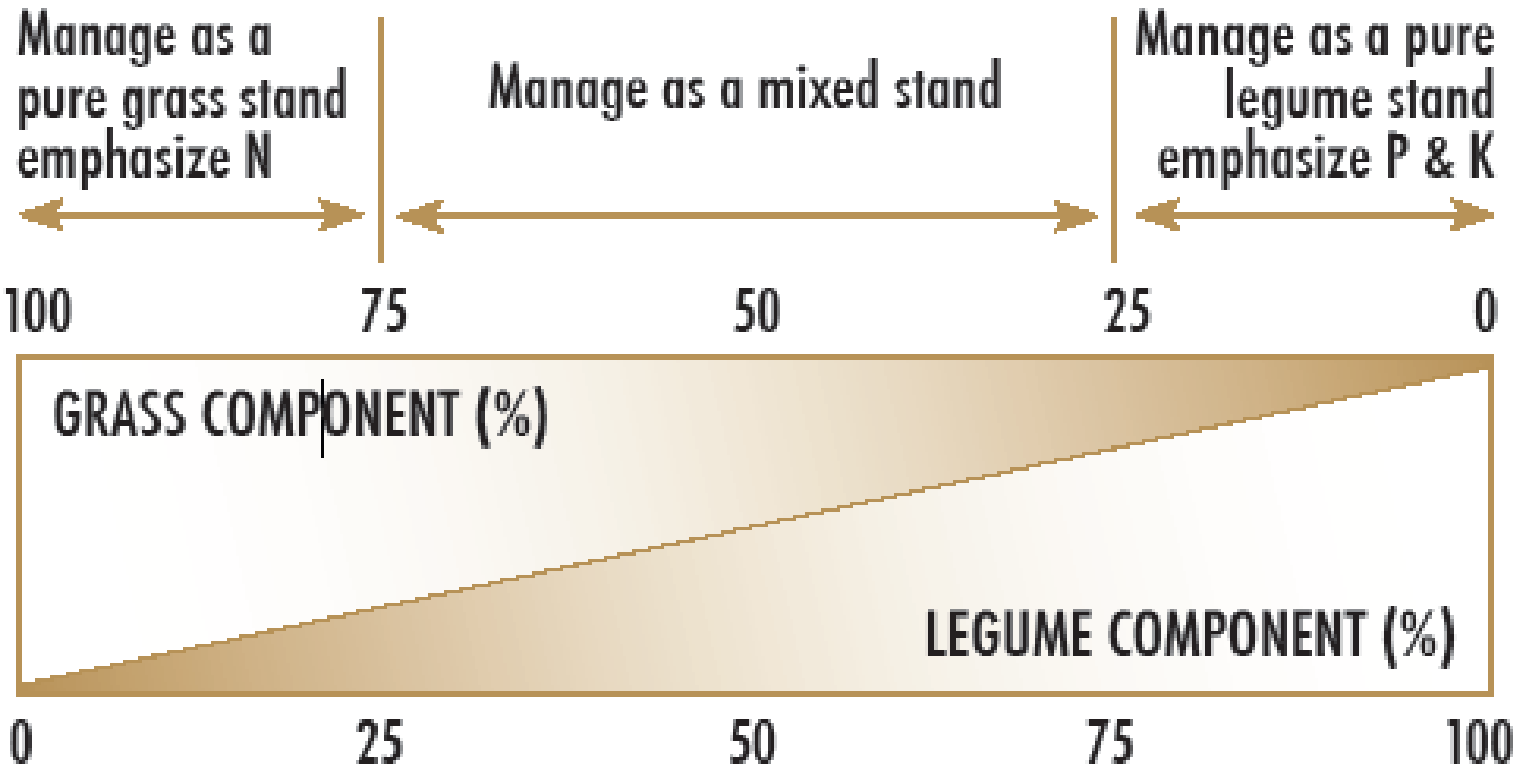
- Right rate
- Right source (including legumes)
- Right timing
- Right Placement



How much fertilizer do I need to apply?

- N based on yield goal and soil tests
- P and K based on soil tests
  - Rate recommendations are provided by testing lab
  - Or from tables given in Extension bulletins
  - Or SARC MSU Fertilizer Recommendation http://www.sarc.montana.edu/php/soiltest/
- S based on prior crop performance, tissue tests and deficiency symptoms – soil tests not reliable
- Published rates are developed for entire state and sometimes based on neighbor state's trials. They are likely not accurate for a particular field. Adjust based on which soil properties??

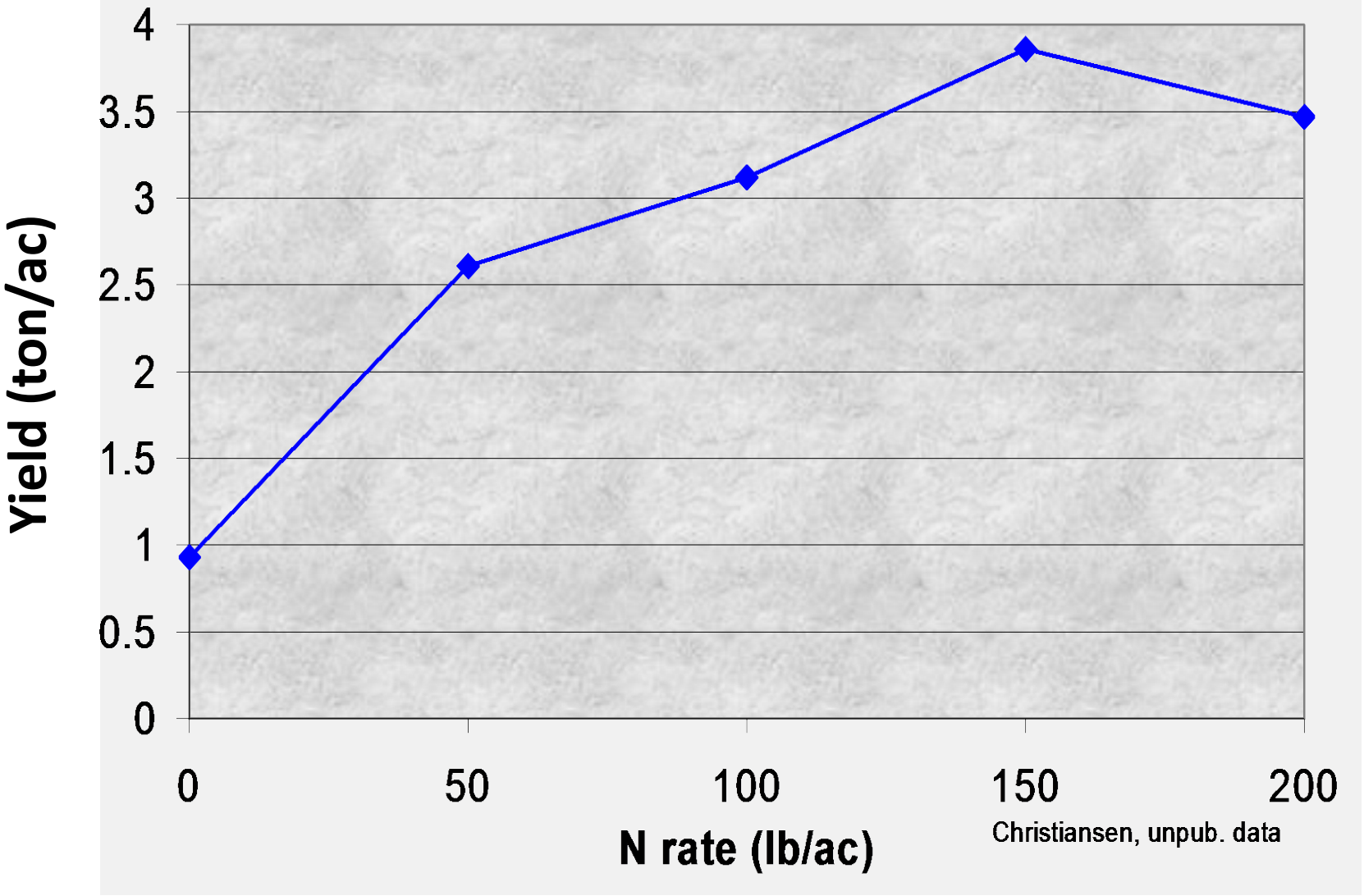
Focus of N or P and K depends on % legume in stand



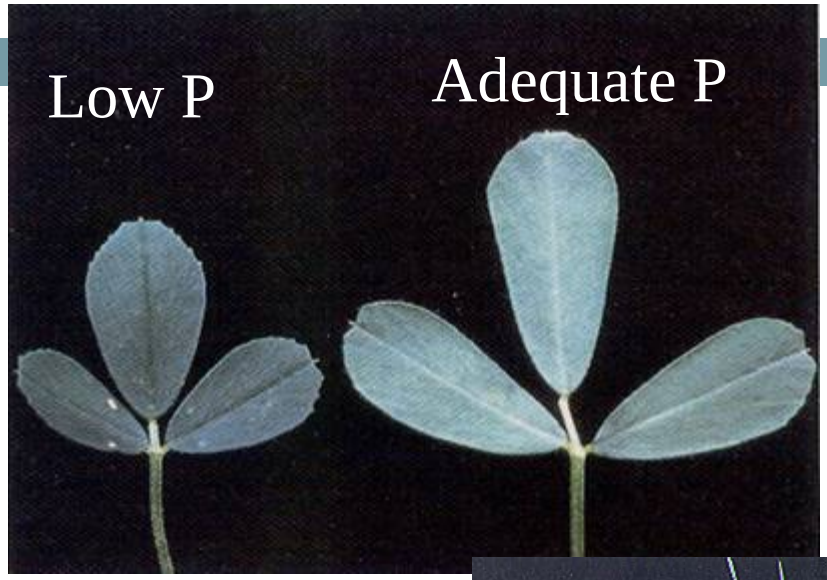
Yield increases and net returns with N greatest if < 36% alfalfa in stand and soil N < 5 lb N/acre (Malhi et al. 2004)

Diminishing return of increasing N

Applies to all crops, example on irrigated western wheatgrass, Blaine Co.

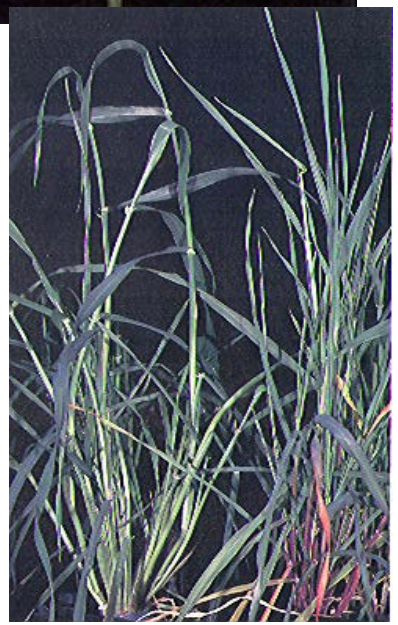


P Deficiency Symptoms



1. Dark green, often purple
2. Lower leaves sometimes yellow
3. Upward tilting of leaves may occur in alfalfa
4. Often seen on ridges of fields

Corn



Barley, image by IPNI

P rates

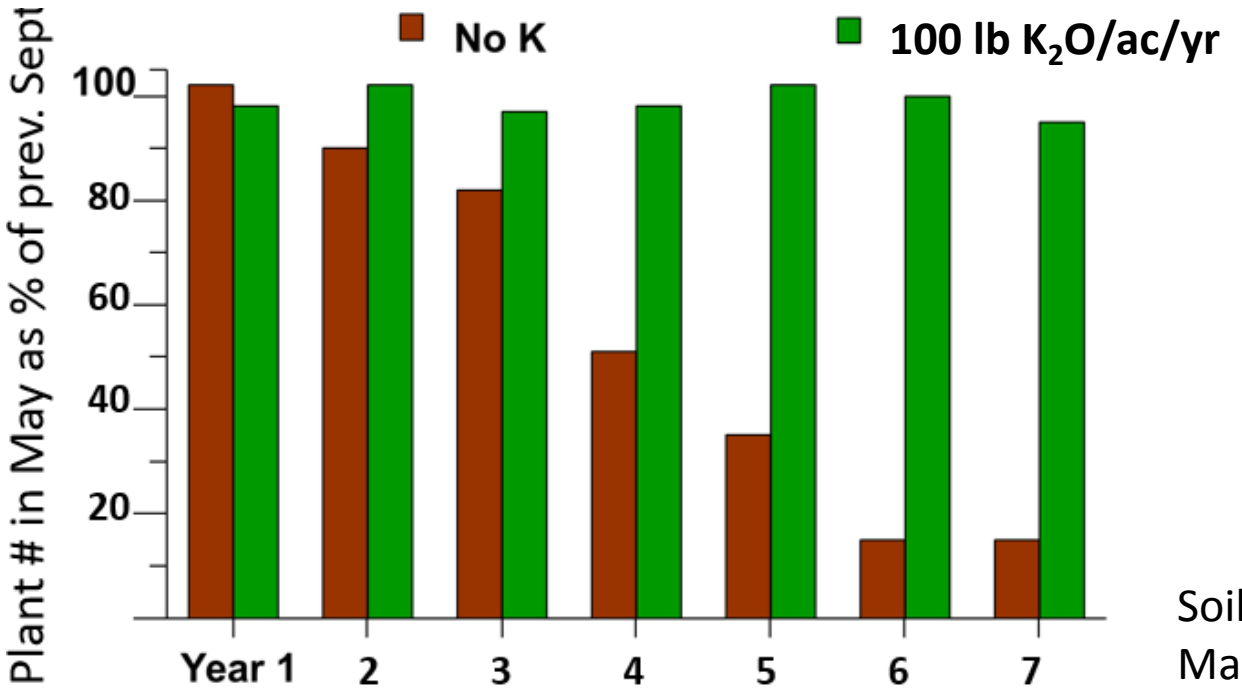
P guidelines for alfalfa and grass in MT based on soil analysis (Table 18 in EB0161 w/ alfalfa/grass revised).					
Crop	Olsen P Soil Test Level (ppm)				
	0	4	8	12	16
	P Fertilizer Rate (lb P_2O_5/acre)				
Alfalfa	140	110	75	40	20
Alfalfa/grass (50/50)	93	73	53	30	13
Grass	45	35	30	20	5
If soil test is above 16 ppm then use removal rate					

Potassium (K)

Needed in Montana?

- Useful on many soils, even some having high K values (especially in spring)
- Improved alfalfa stand persistence, shoots per plant and rhizobia activity
- Reduces leaf drop of alfalfa
- Improved resistance to plant diseases

How might lack of K affect an alfalfa-hay field?



K helps reduce winterkill

Soil K 116 ppm (0-6”)
Manitoba, IPNI

K deficiency symptoms

1. Alfalfa – white spots on leaf edges
2. Grasses and corn – chlorosis and necrosis on *lower* leaves first. WHY?

   K is mobile in plant

3. Weakening of straw-lodging in small grains, breakage in corn.

Wheat image by IPNI

4. Wilting, stunted, shortened internodes.

K rates

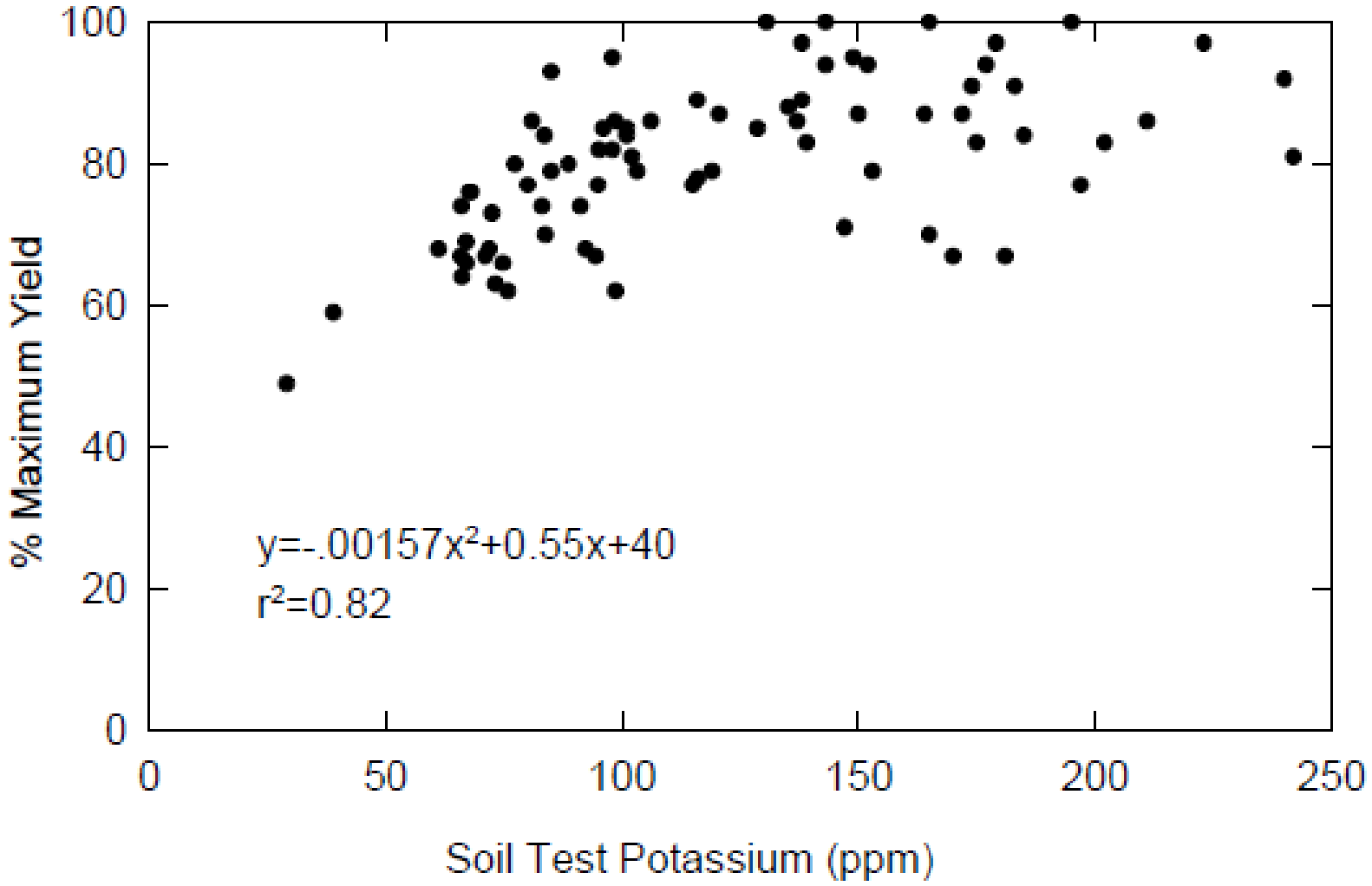
K guidelines for alfalfa and grass in MT based on soil analysis (Table 19 in EB0161, alfalfa/grass rates revised).

Crop	K Soil Test Level (ppm)					
	0	50	100	150	200	250
	K Fertilizer Rate (lb K_2O/acre)					
Alfalfa	240	205	170	140	95	30
Alfalfa/grass (50/50)	192	165	137	112	76	26
Grass	80	70	60	45	30	15

If soil test is above 250 ppm then use removal rate.

To avoid toxic luxury consumption by first cutting, apply ½ the rate after first cutting and rest after last cutting for following year

Relative alfalfa yield vs soil test K



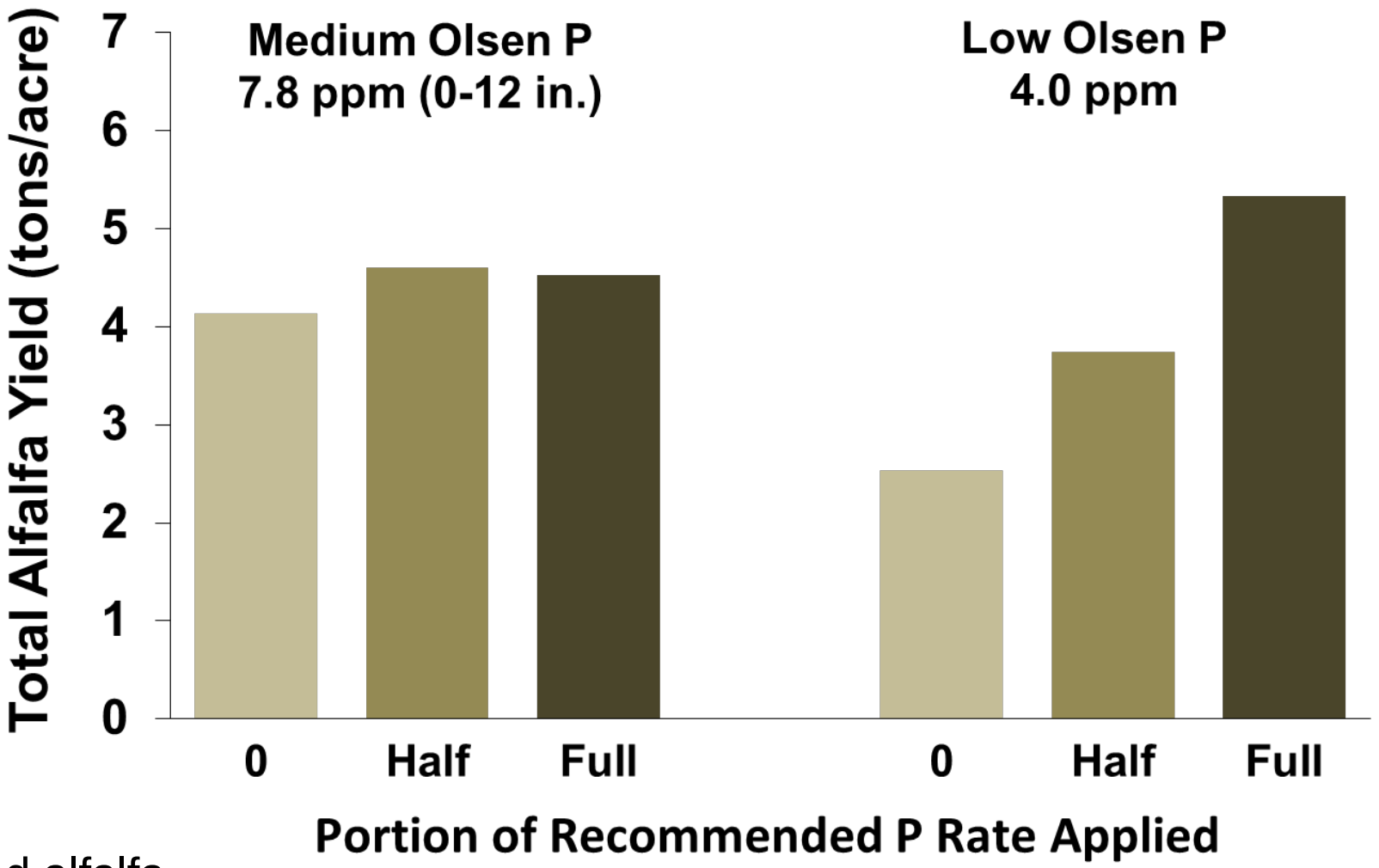
Koenig 2001 WNMC

Questions?

Alfalfa response to P

- P can be ‘banked’ for several years.
  - A single 100-400 lb P_2O_5/ac on alfalfa produced similar yield, protein and profit as same amount divided over 5 annual applications (Malhi et al. 2001).
- Alfalfa more likely to respond if soil levels low.

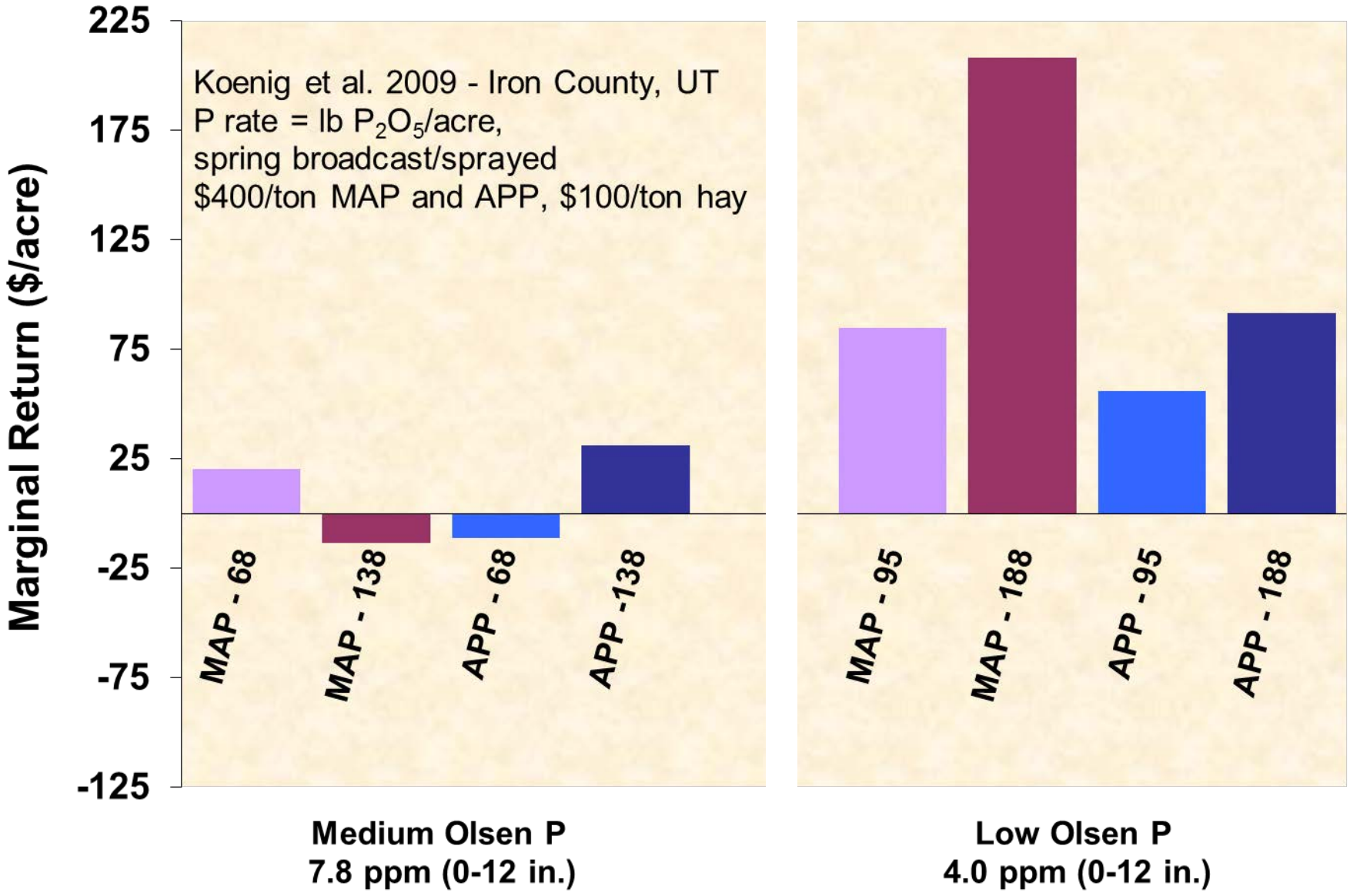
Response to broadcast MAP depends on soil P level



Irrigated alfalfa

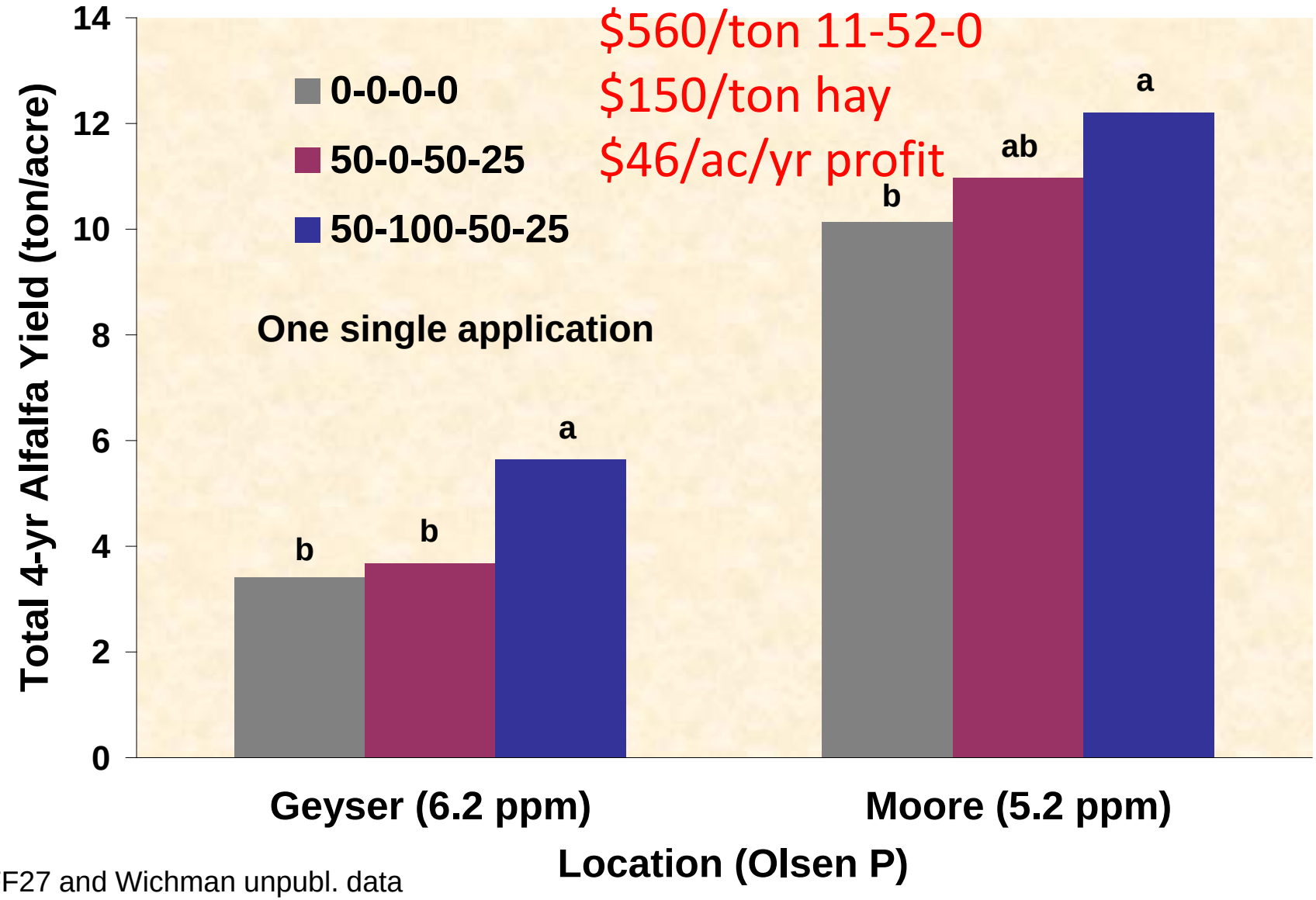
Iron County, UT, Koenig et al. 2009

Marginal return on P by rate and source



APP = fluid ammonium polyphosphate (10-34-0)

Single P application increases alfalfa yield for 4 years (N, K, and S had minimal effect)



FF27 and Wichman unpubl. data

Phosphorus and potassium for new seedings

- Base rates on soil tests
- Build up soil P and K levels prior to seeding for several years worth
- Additional P and K seed placed can increase seedling establishment
  - < 10-15 lb (N + K_2O)/acre to reduce risk to seedlings
  - < 25 lb 11-52-0/acre with seed
- Too much K can lead to luxury consumption by crop and risk of milk fever

Questions?

On to sulfur

Sulfur

- Eroded or coarse-textured soils are more susceptible to sulfur deficiency, particularly after high rainfall
- Alfalfa is S deficient at tissue concentrations <0.25% (leaves from top 1/3 of plant at budding). For other forages contact testing lab or see our Extension documents
- S > 0.30% can cause livestock health problem

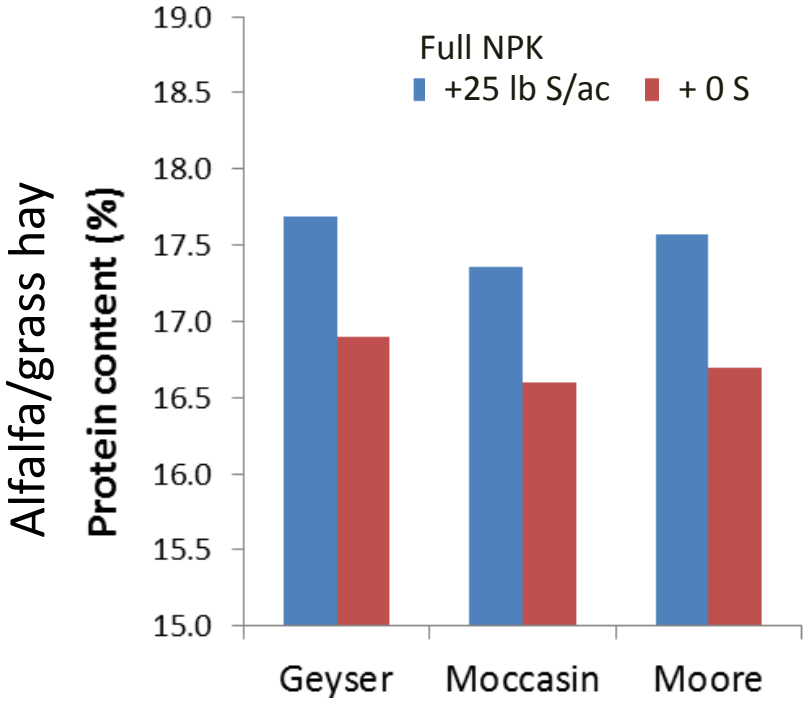
Sulfur visual deficiency symptoms

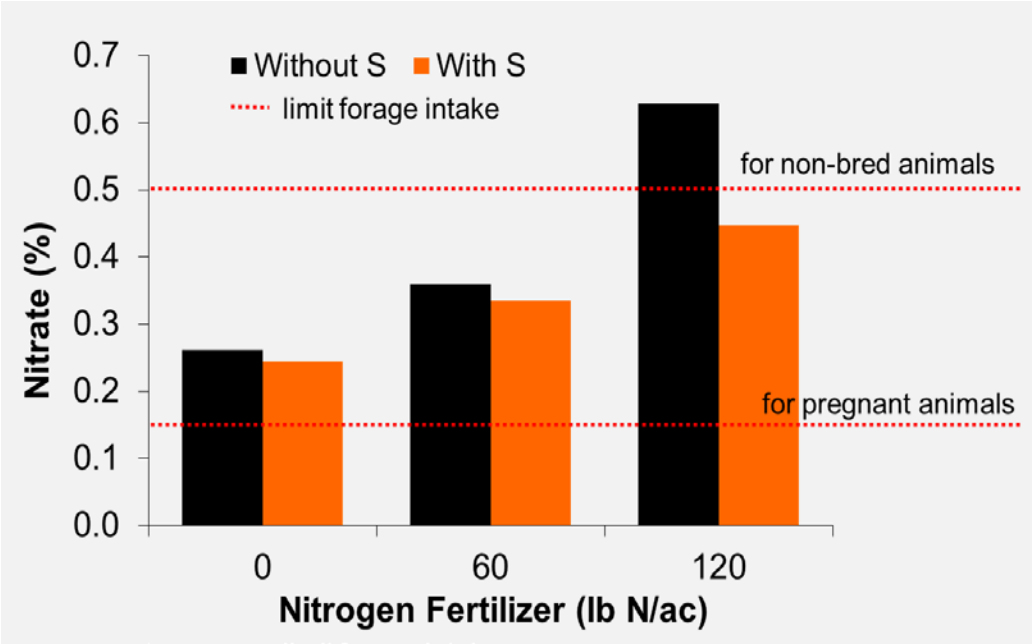
- Yellow or light green ***upper*** leaves
- Small thin stems
- Delayed maturity
- No characteristic spots or stripes

Images from IPNI

S influence on forage quality

- N conversion to protein requires S
- Increased S can lead to increased protein (FertFact #27) and digestibility, and reduced nitrate concentration (Westcott unpub data)

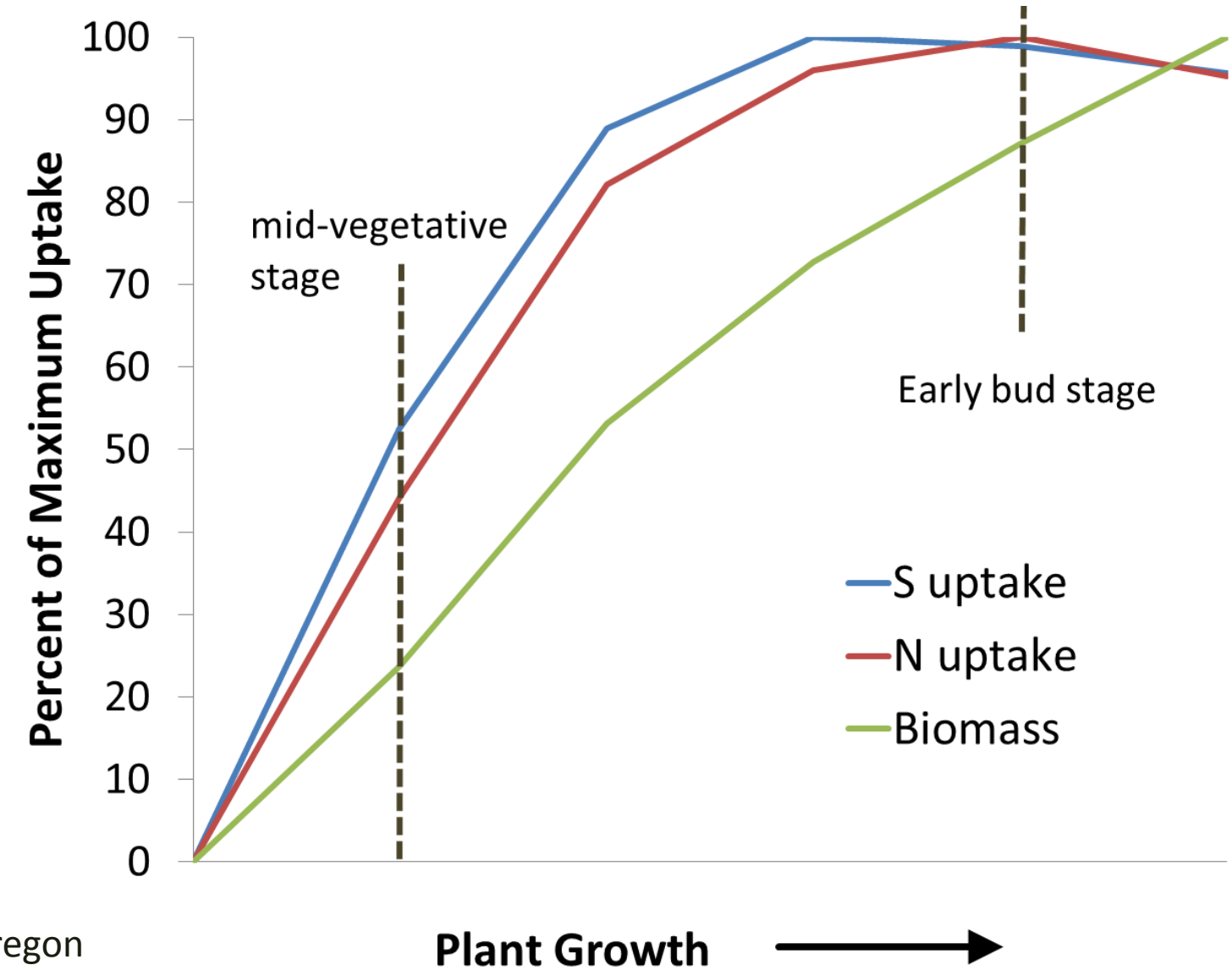




Sulfur maintenance

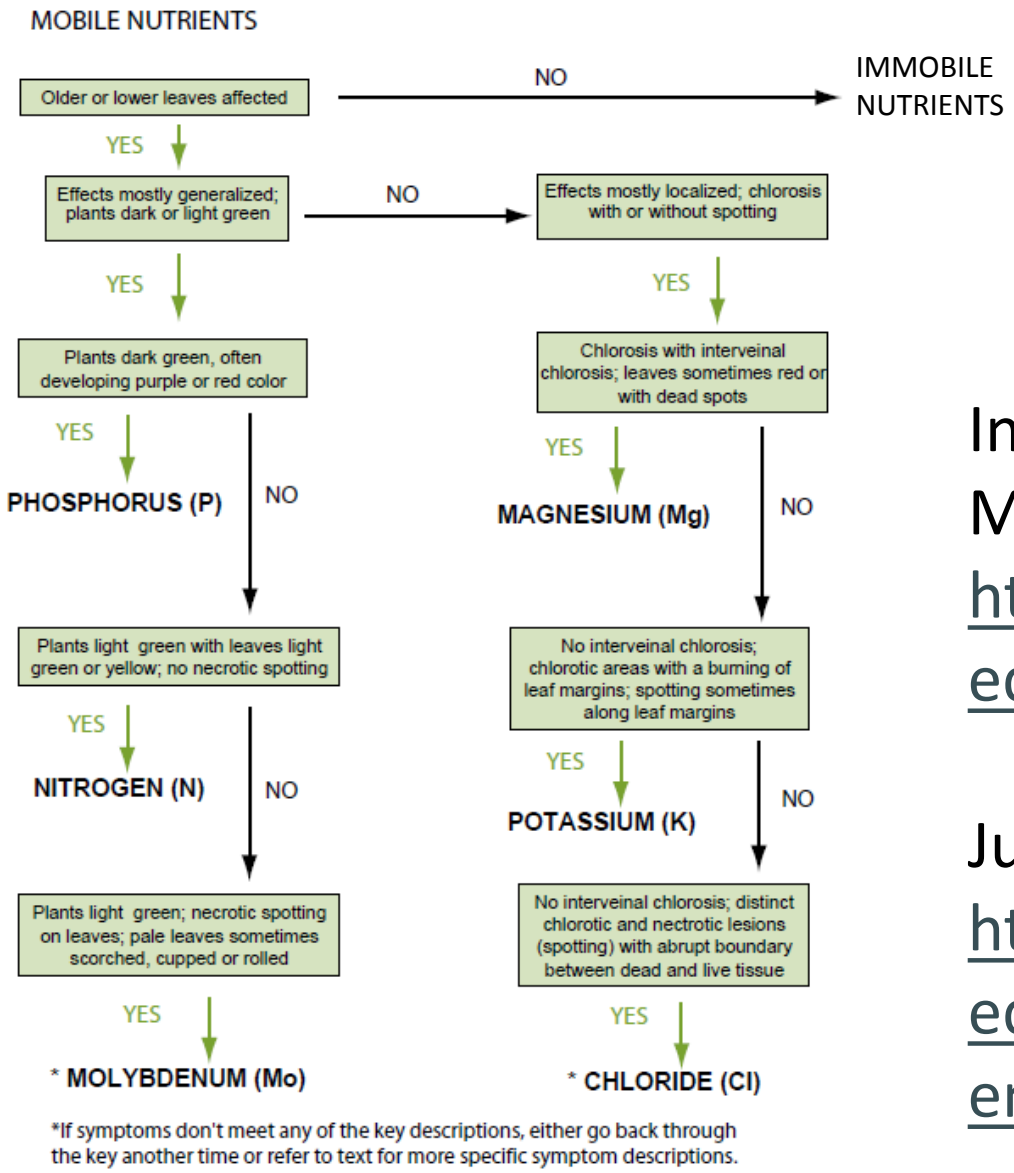
- Grazing removes less S than hay harvest
- S can be maintained by elemental S every few years
- 20 lb S/acre sulfate-S for in-season S deficiency in legume/grass mix

Provide S before mid-vegetative stage in alfalfa



Union, Oregon
Pumphrey and Moore 1965

Visual tissue assessment flow chart



Once tissues show symptoms, yields may be already hurt

In Nutrient Management Module 9 http://landresources.montana.edu/nm

Just the flow chart online at http://landresources.montana.edu/soilfertility/nutrientdeficiencies.html

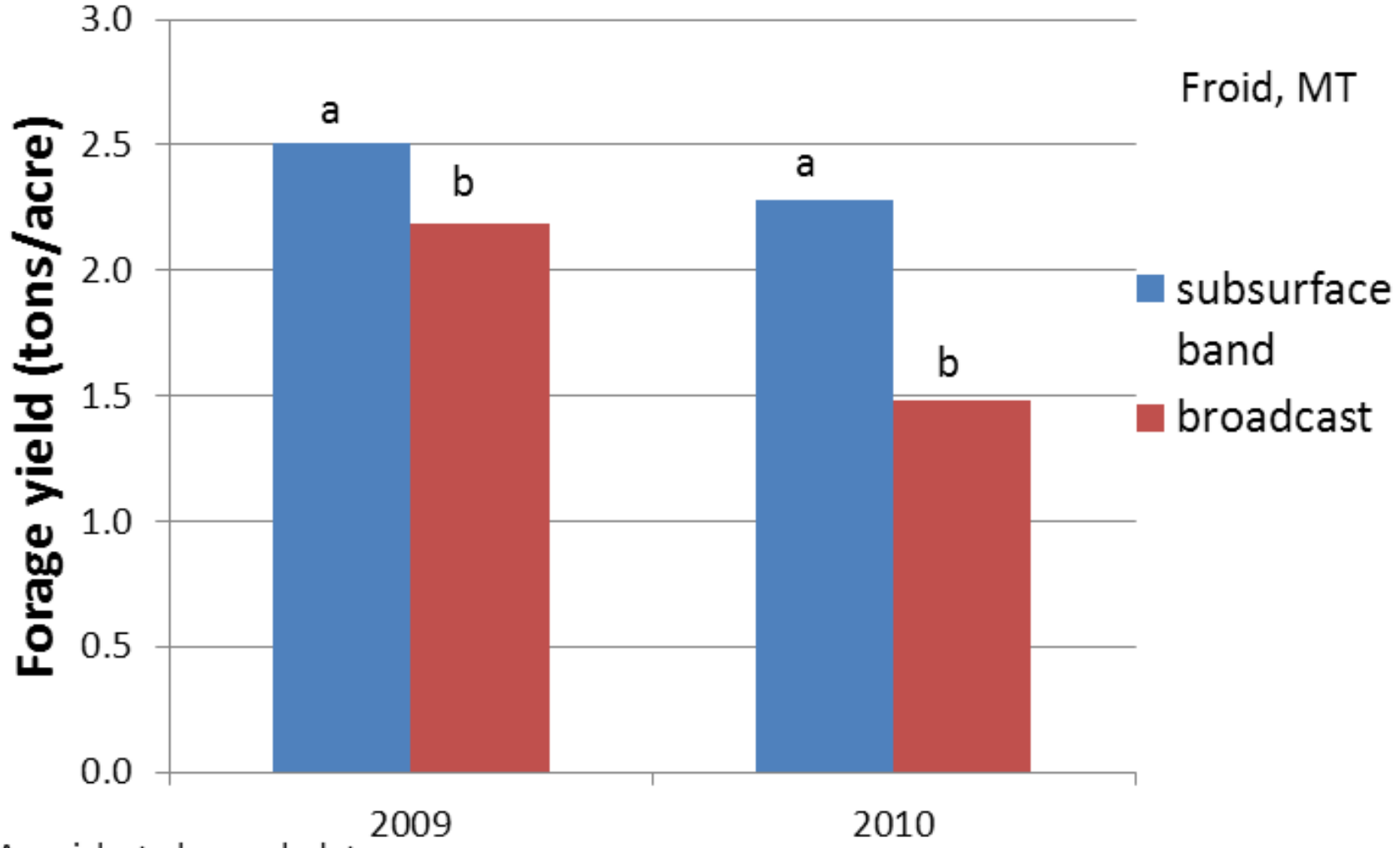
Questions?

On to N placement, timing, N-credit

Challenges to high N use efficiency in perennial systems, and N options

- Urea needs 0.5” water or tillage to incorporate N
- Plant residue
  - intercepts fertilizer
  - increases volatilization
  - can tie up N
- Surface band liquid N
- Polymer coated N works for extended forage season or late cutting

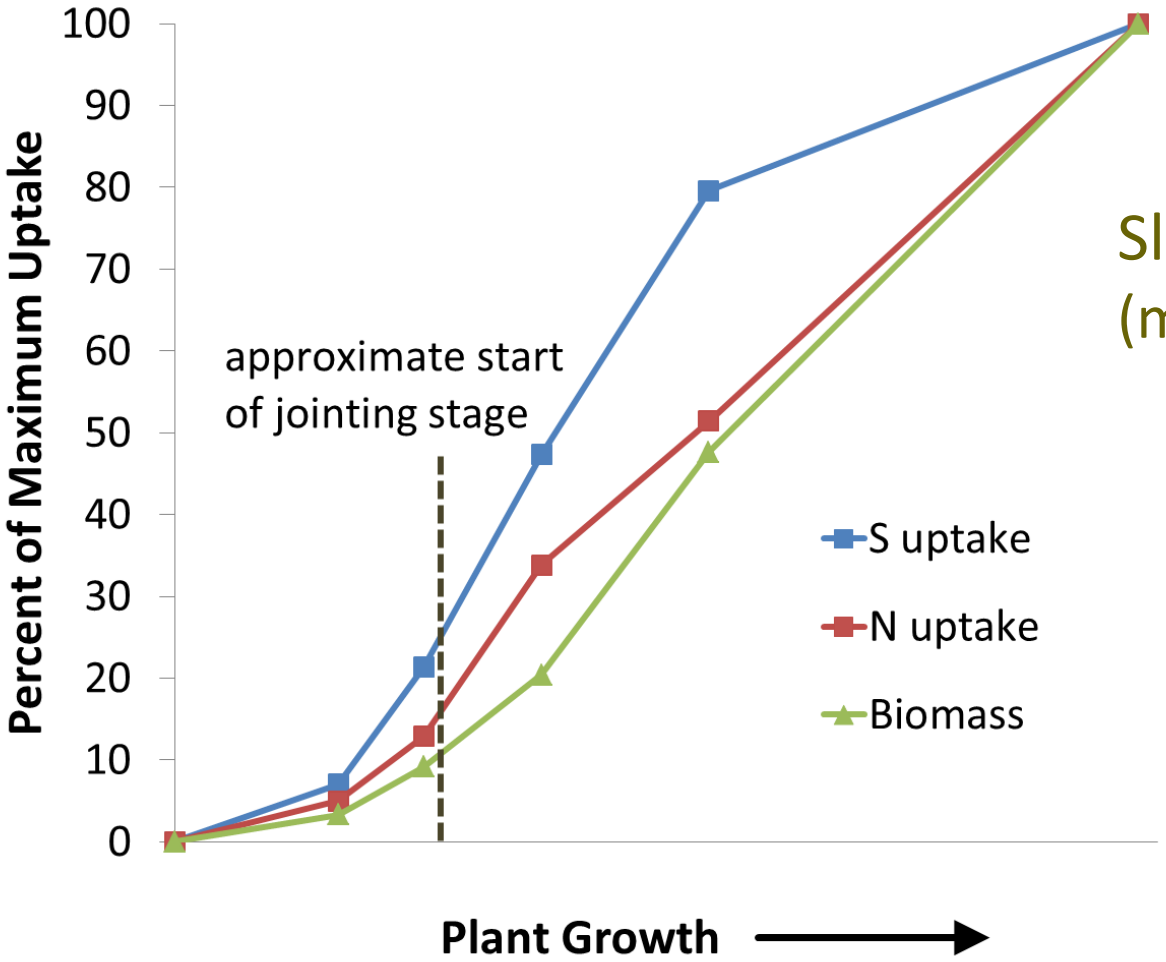
Urea placement affects Hays annual forage yield



Angvick et al. unpub data

Optimal timing depends on source

Readily available N (urea, UAN): shortly after **GRASS** green-up



Willamette Valley, Oregon, Hart et al. 1989

Slowly available N (manure, slow-release N)

- take time to become available
- apply well before needed – e.g. fall

N Application considerations

Conventional

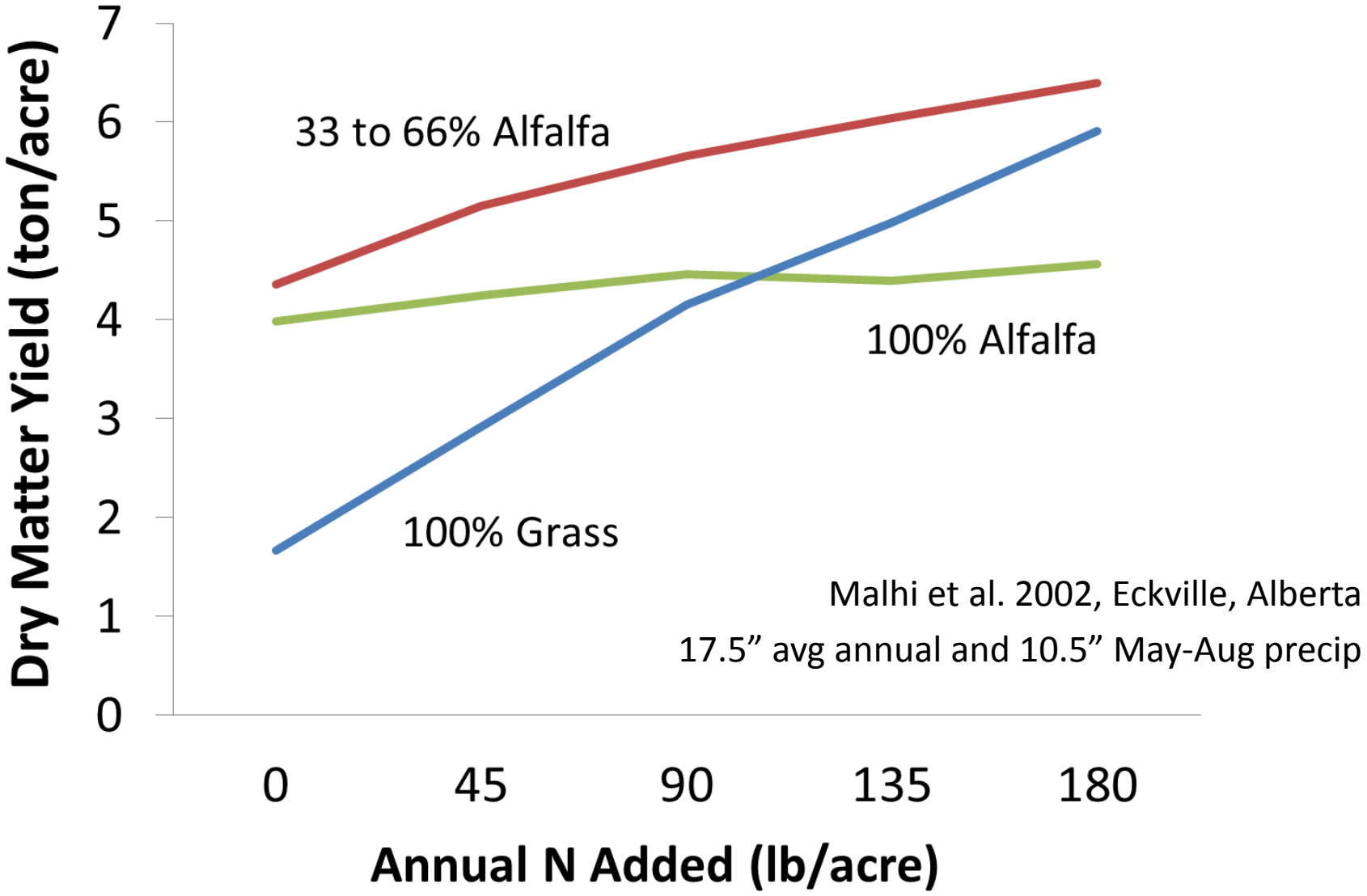
- Do not apply on snow, before heavy rains or snowmelt
- Apply and incorporate (nitrogen) shortly before plants ‘take off’ in the spring
- Broadcast N fertilizer needs to be incorporated by tillage or ½” water ‘event’
- Provide additional N mid-season if needed

Manure

- Incorporate in the fall or spread composted in the spring, once ground thaws, but before growth starts
- Do not apply on snow or frozen ground
- Consider the salt, weed seed, pathogen and potential herbicide content - know your source!

Other options?

Adding N – having alfalfa in mix may be best source of N



Malhi et al. 2002, Eckville, Alberta

17.5” avg annual and 10.5” May-Aug precip

Benefits of alfalfa depend on age of stand and years after termination

- N benefits
  - greatest in first year after alfalfa termination, then declines over next 6 years for small grain yields
  - greater and longer with alfalfa stands at least 3-4 yrs old
- Non-N benefits of greater water extraction are improved for about 5 subsequent small grain yrs
  - more important in drier subsequent crop yrs
  - greater from at least 2 year old alfalfa stands

Forster 1998 Univ. Manitoba thesis

Recommended N credits in Montana

Fertilizer N (lb/ac) to back off from a standard recommendation

Crop	N Credit (lb N/acre)
Pulse grain crop grown 1-2x	~10
Pulse grain crop grown 3+ times	~20
Pulse cover crop grown 1-2x	20-30
Pulse cover crop grown 3+ times	30-50

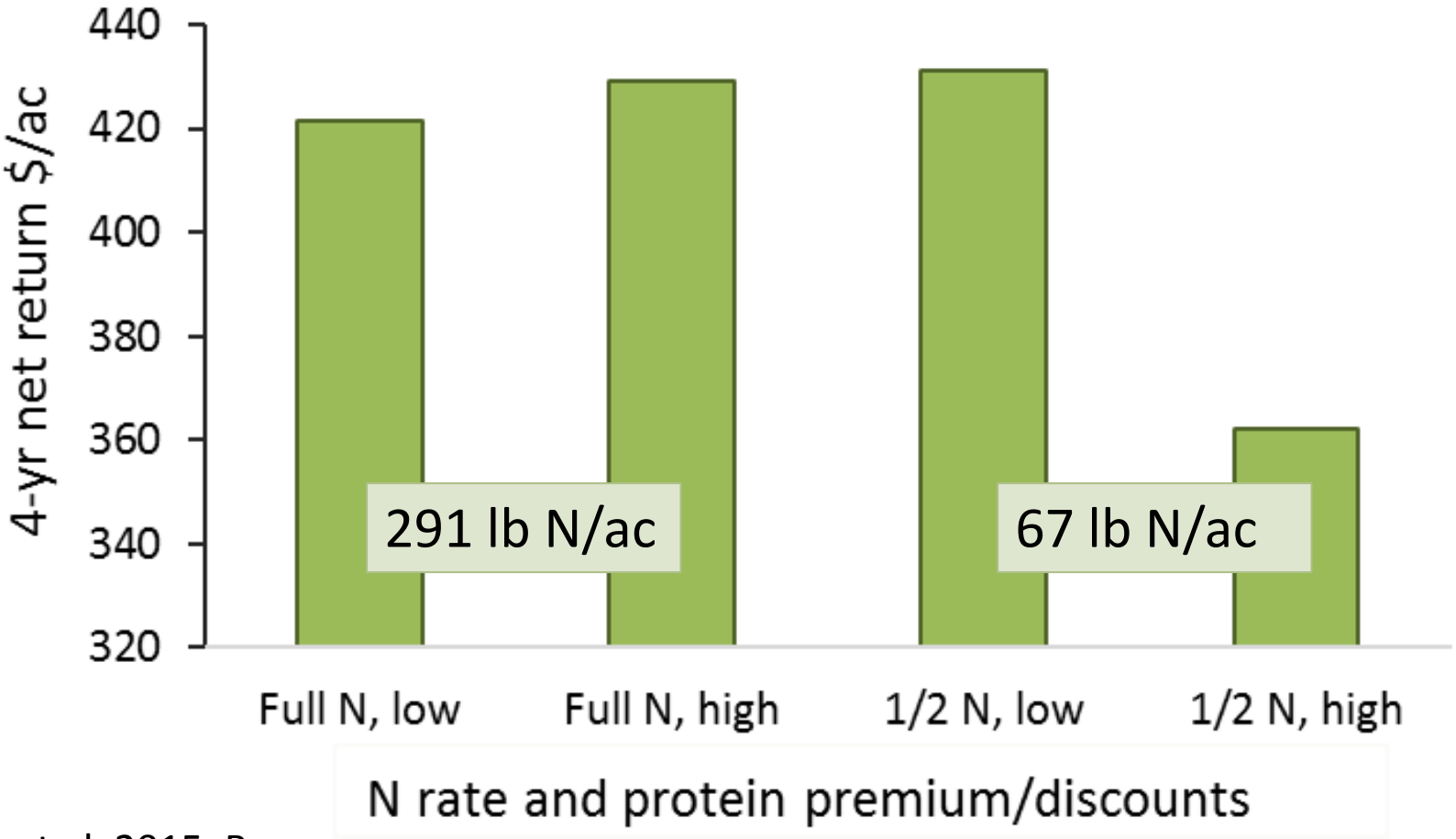
What affects amount of residue N becomes available?

- Slower in no-till than till, e.g., pea residue decomposition was 43% (NT) vs. 55% (till) in 1 yr
- Faster with higher residue N and phosphorus (P) concentrations
- Pulse cover crop decomposes faster than pulse residue (Lupwayi et al. 2004, north-central Alberta)

BUT: rapid nutrient release is not necessarily desirable because potential loss from system before uptake by next crop

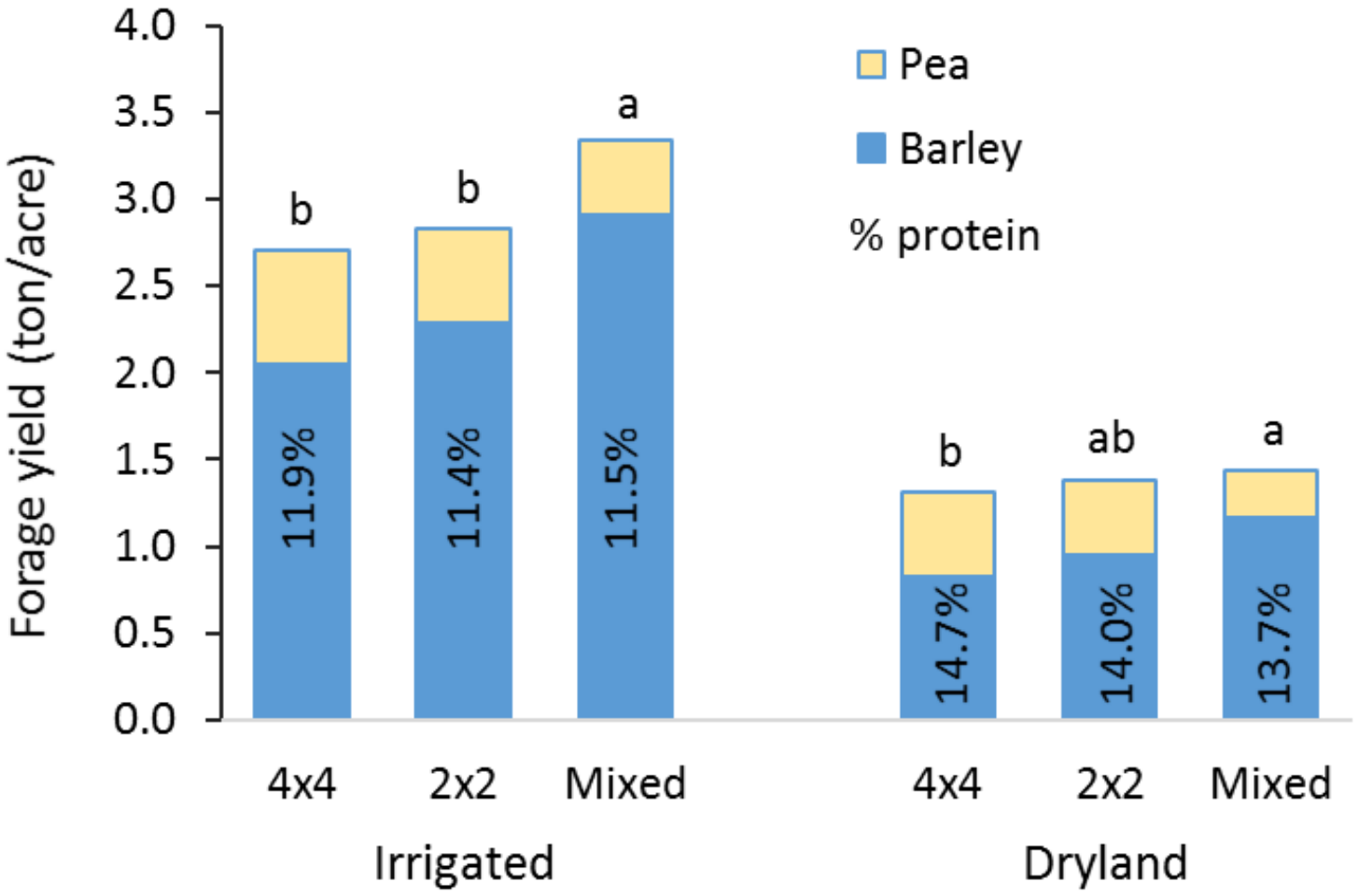
Alternating pea-hay with wheat can save on N fertilizer costs especially when protein discounts are low

Net return on 2 cycles of pea-hay with wheat on dryland (4-yr total lb N applied/acre)



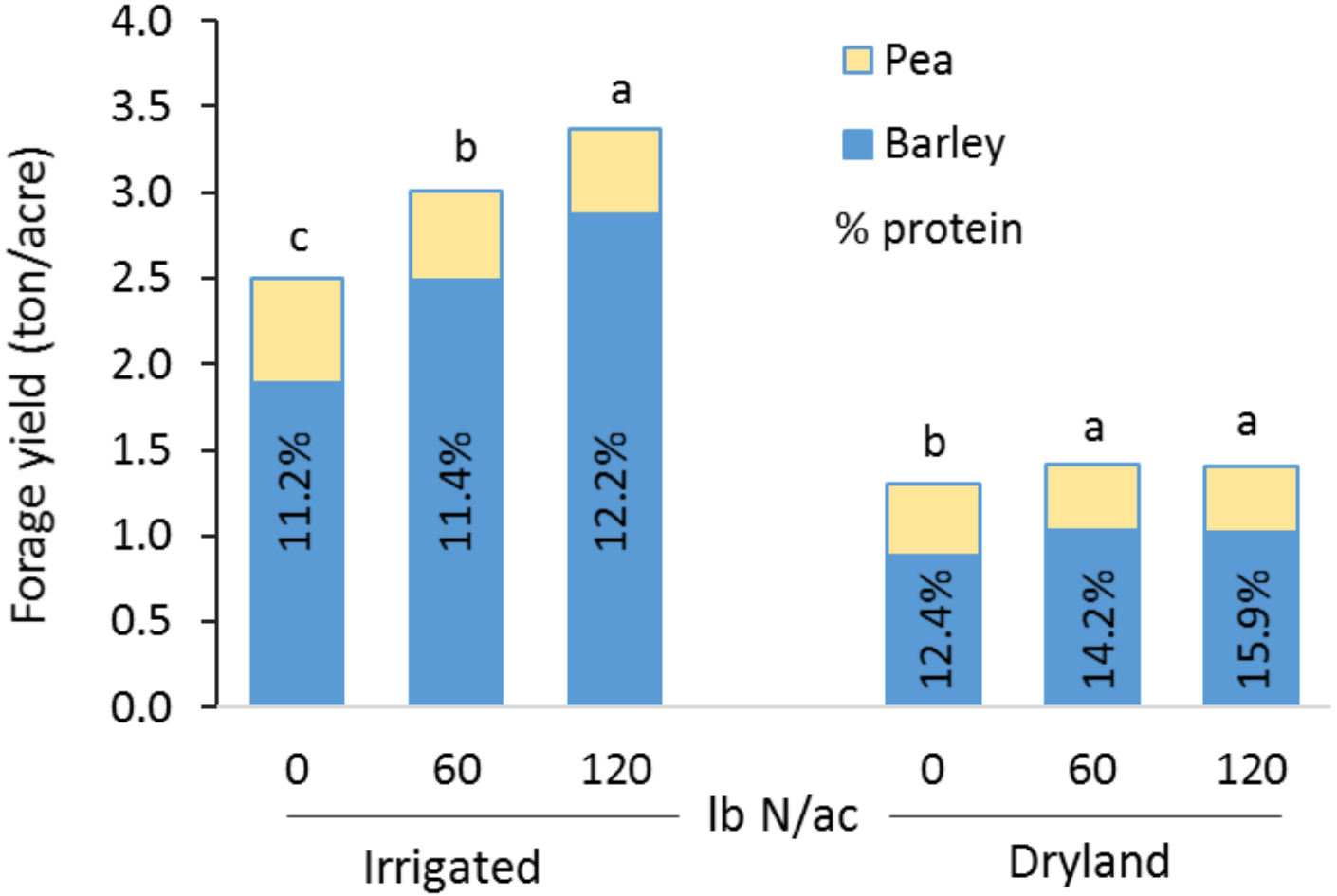
Miller et al. 2015, Bozeman

Interseeding pea and barley w/in row produces higher total forage than species in separate rows



Ffact 35, 3 years at each location, N broadcast at barley 2-3 leaf stage

N fertilizing pea/barley increases yield and protein, above 60 lb N/ac beware of high forage nitrate



Ffact 35, 3 years at each location, N broadcast at barley 2-3 leaf stage

Decision to fertilize

- Immobile nutrients can be banked – know soil test levels and if low, build up P and K when prices low
- If goal is low input, long-term sustainable production rather than prime quality hay, adequate P and K are key and cheaper than re- or interseeding
- If a field containing legumes will be rotated into a different crop soon, consider N for immediate yield gain
- If you need to buy hay or rent pasture, you should consider fertilizing

Conclusions

- Nitrogen, phosphorus, potassium, and sulfur can all produce growth responses in forage
- Economic benefits often aren't realized in the first year (so don't base decisions on 1 yr studies!)
- Soil testing is essential for determining fertilizer needs

Pick up a copy or download these Extension Bulletins

http://landresources.montana.edu/soilfertility/publications.html

http://landresources.montana.edu/soilfertility/soilscoop.html

Photo by Ann Ronning

Additional info at:
http://landresources.montana.edu/soilfertility