Fertilization of perennial legumes

Prepared for Park County,
January 29, 2014

Clain Jones,
clainj@montana.edu
994-6076

Goals

1. Cover soil fertility basics
2. Show nutrient deficiency symptoms of P K S and micros on forages
3. Review use of Fertilizer Guidelines to determine P and K rates on forages
4. Present timing, source and placement considerations of P fertilization
5. Illustrate yield and quality responses of hay to P, K, and S
6. 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)?

There are 14 mineral nutrients that have been found to be essential for growth of most plants:

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

The macronutrients are simply needed in larger amounts by the plant than the micronutrients. I'll focus on P, K, and S.

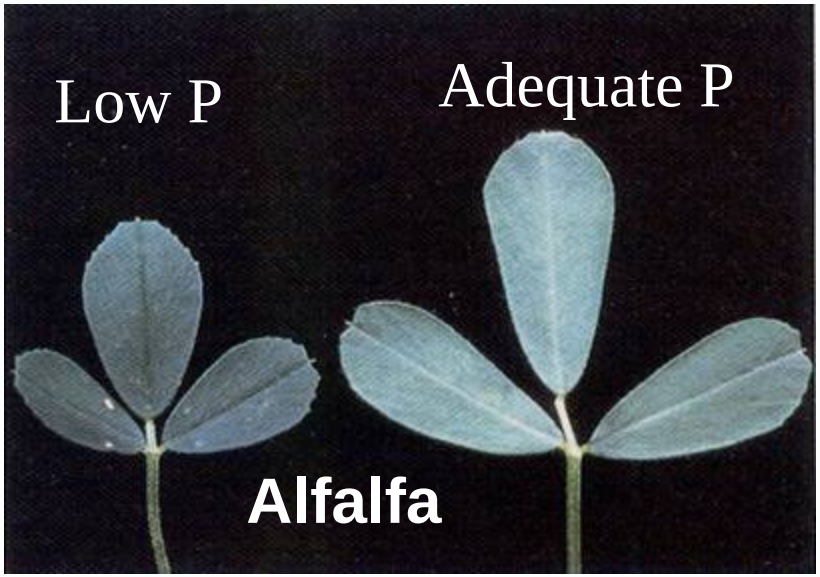
Phosphorus (P)

Why often deficient in Montana soils?

Binds with calcium to form poorly soluble calcium phosphate minerals

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

Potassium (K)

Needed in Montana?

Useful on many soils, even some having high K values (especially in spring due to cool temperatures)

K deficiency symptoms

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

   K is mobile in plant

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

4. Wilting, stunted, shortened internodes.

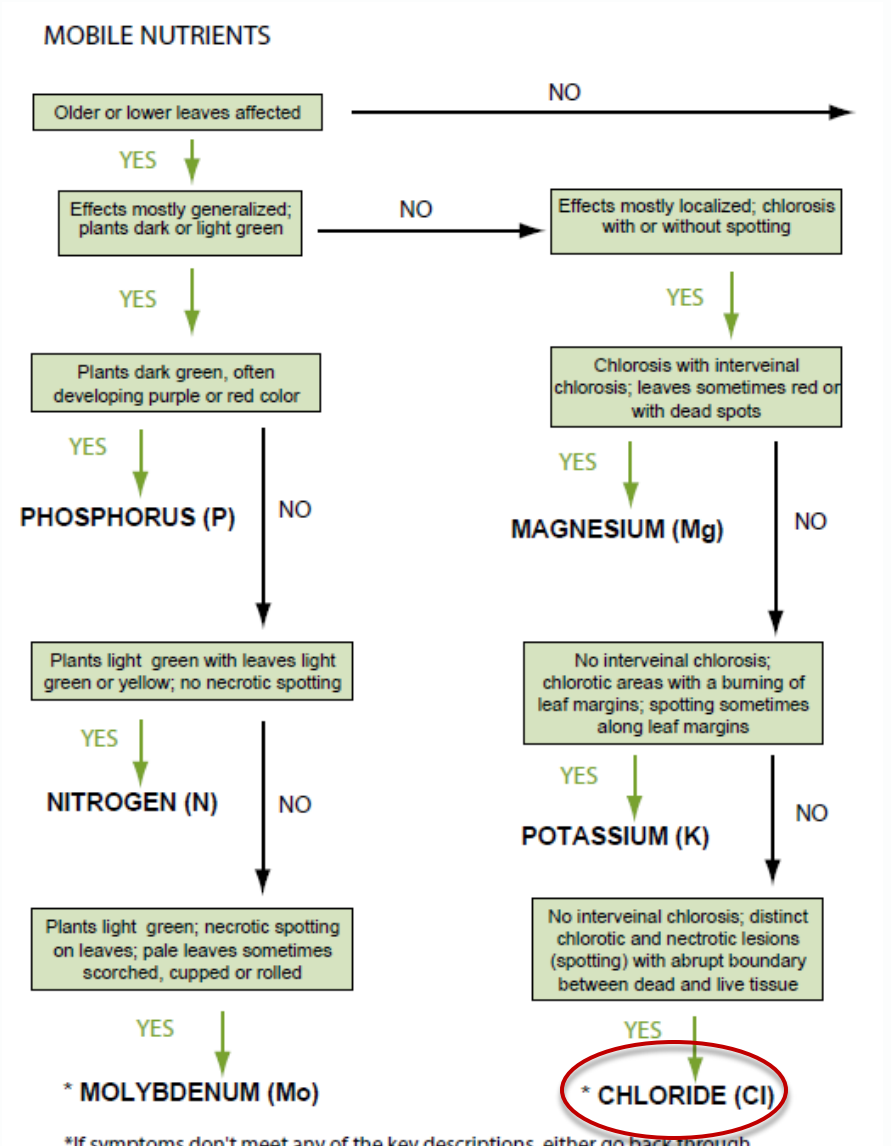
S deficiency symptoms

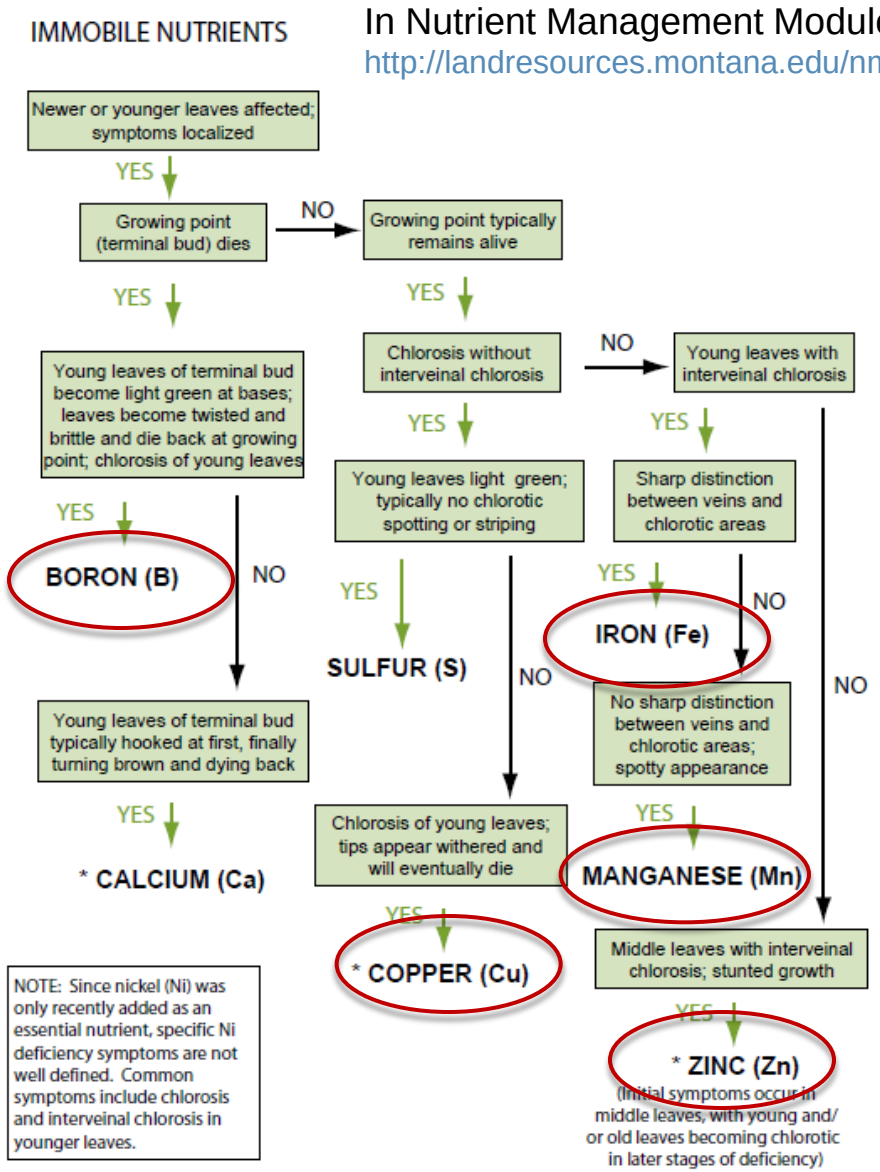
1. Upper leaves light green to yellow. WHY?

   S is immobile in plant

2. Small, thin stems
3. Low protein
4. Delayed maturity
5. No characteristic spots or stripes

Visual tissue assessment





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

Questions?

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

- < 25 % legume treat as grass stand
- > 75 % legume treat as legume stand
- Yield increases and net returns greatest if < 36% alfalfa in stand and soil N < 5 lb N/acre (Malhi et al. 2004)

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
  - MAP is safer than DAP
- Too much K can lead to luxury consumption by crop and risk of milk fever

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

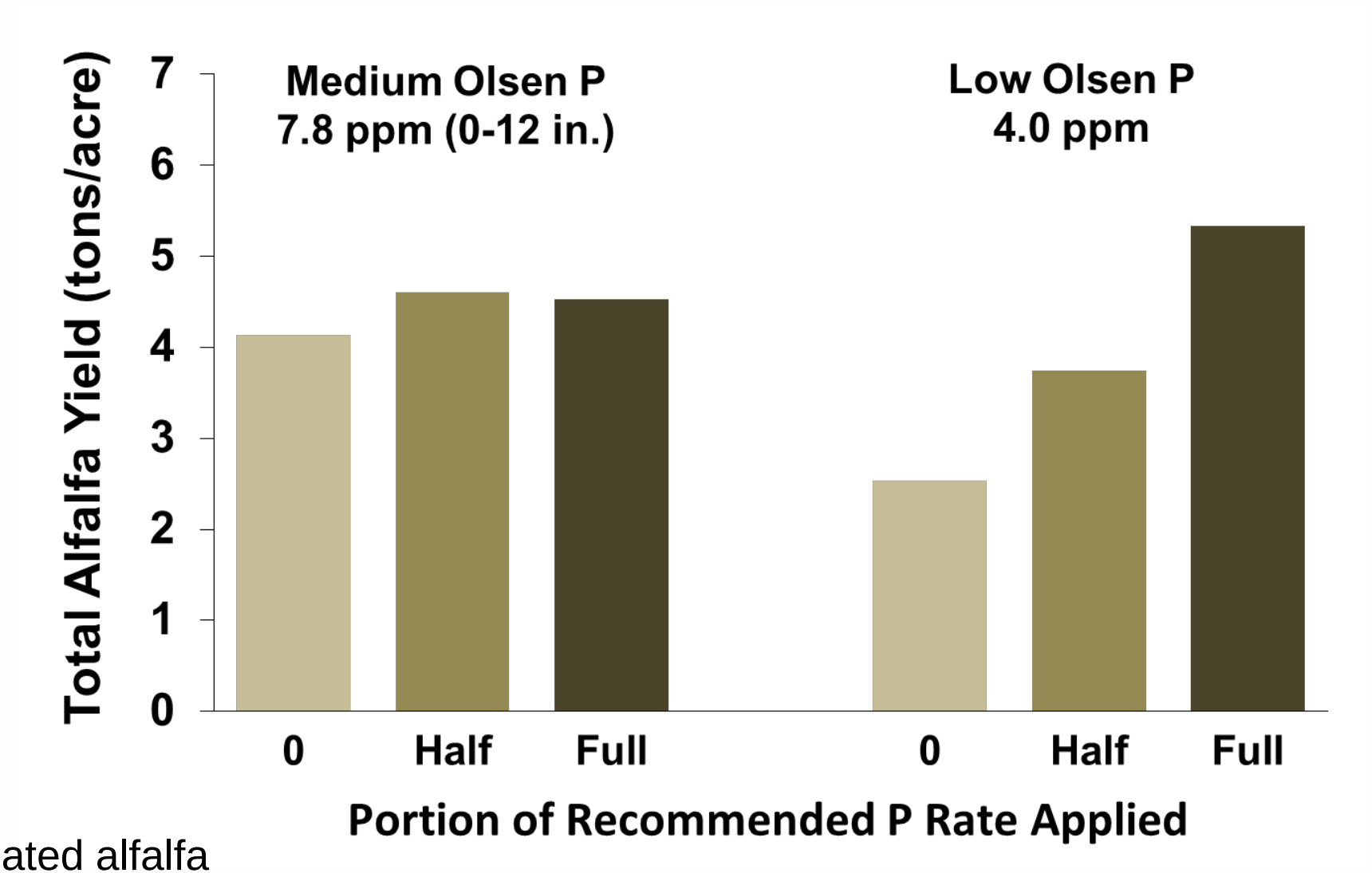
Alfalfa response to P

- Alfalfa more likely to respond if soil levels low.
  - Irrigated alfalfa in Utah (Koenig et al 2009):

    Olsen P = 7.8 ppm (top 12”), minimal P response

    Olsen P = 4.0 ppm (top 12”), large P response
- 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).

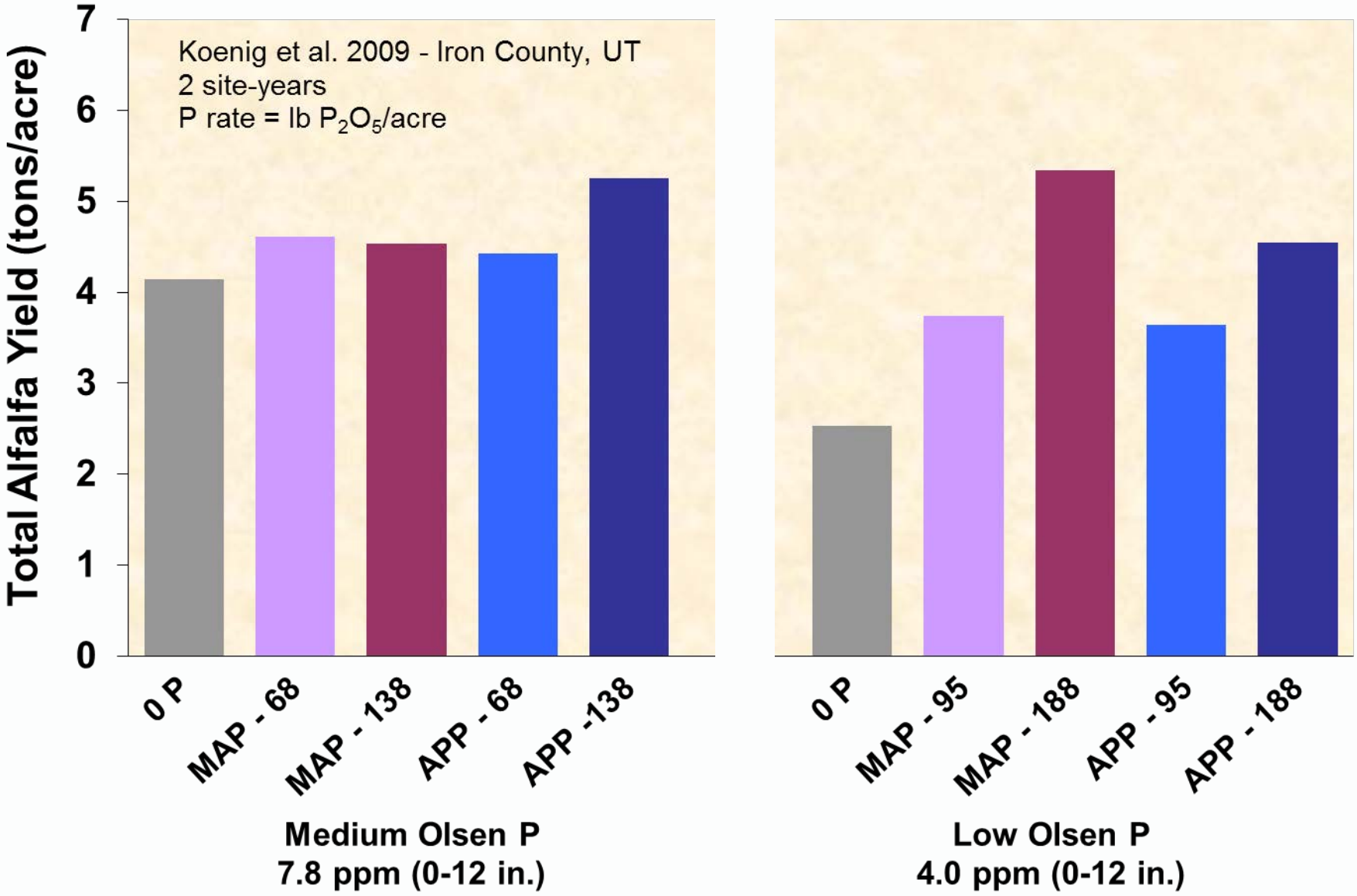
Response to broadcast MAP depends on soil P level



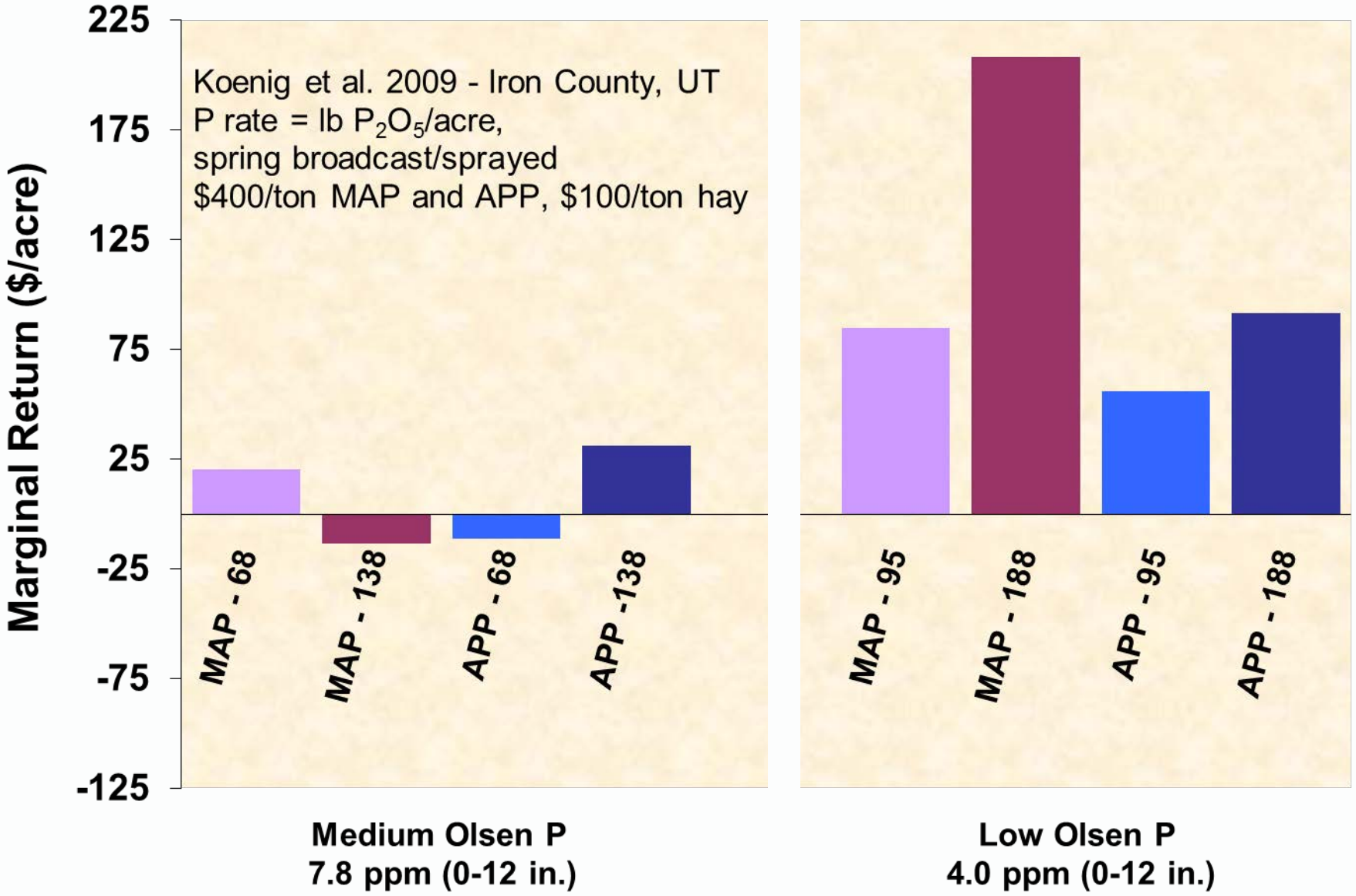
Irrigated alfalfa

Iron County, UT, Koenig et al. 2009

P rate and source on alfalfa yield



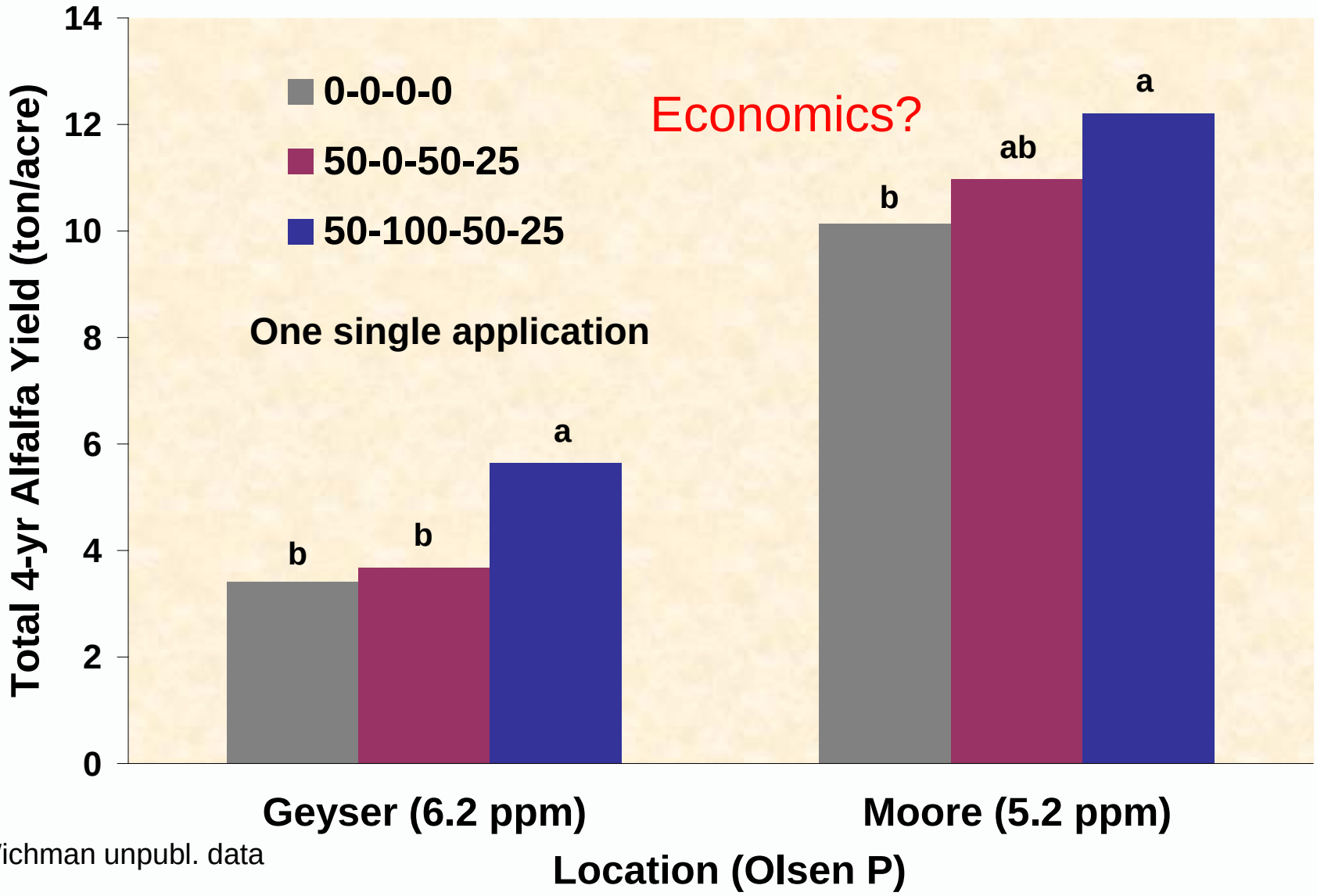
Marginal return on P by rate and source



P rate and source on yield

Medium soil P		Low soil P
yes	**P > no P**	***yes***
no	**MAP > APP**	***yes***
no	**full P > $^1/_2$P**	***yes***

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



Wichman unpubl. data

What would you do?

Single large or smaller annual applications over 5 years?

@ $400/ton MAP and $100/ton hay

@ $1050/ton MAP and $100/ton hay

P fertilization for timothy hay

- On irrigated timothy hay in Alberta (Pfiffner et al. 2007)
- If P deficient then yield response equal with 5 annual broadcast applications of 26 lb P_2O_5/ac or single pre-seeding application of 174 lb P_2O_5/ac

QUESTIONS?

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 rates

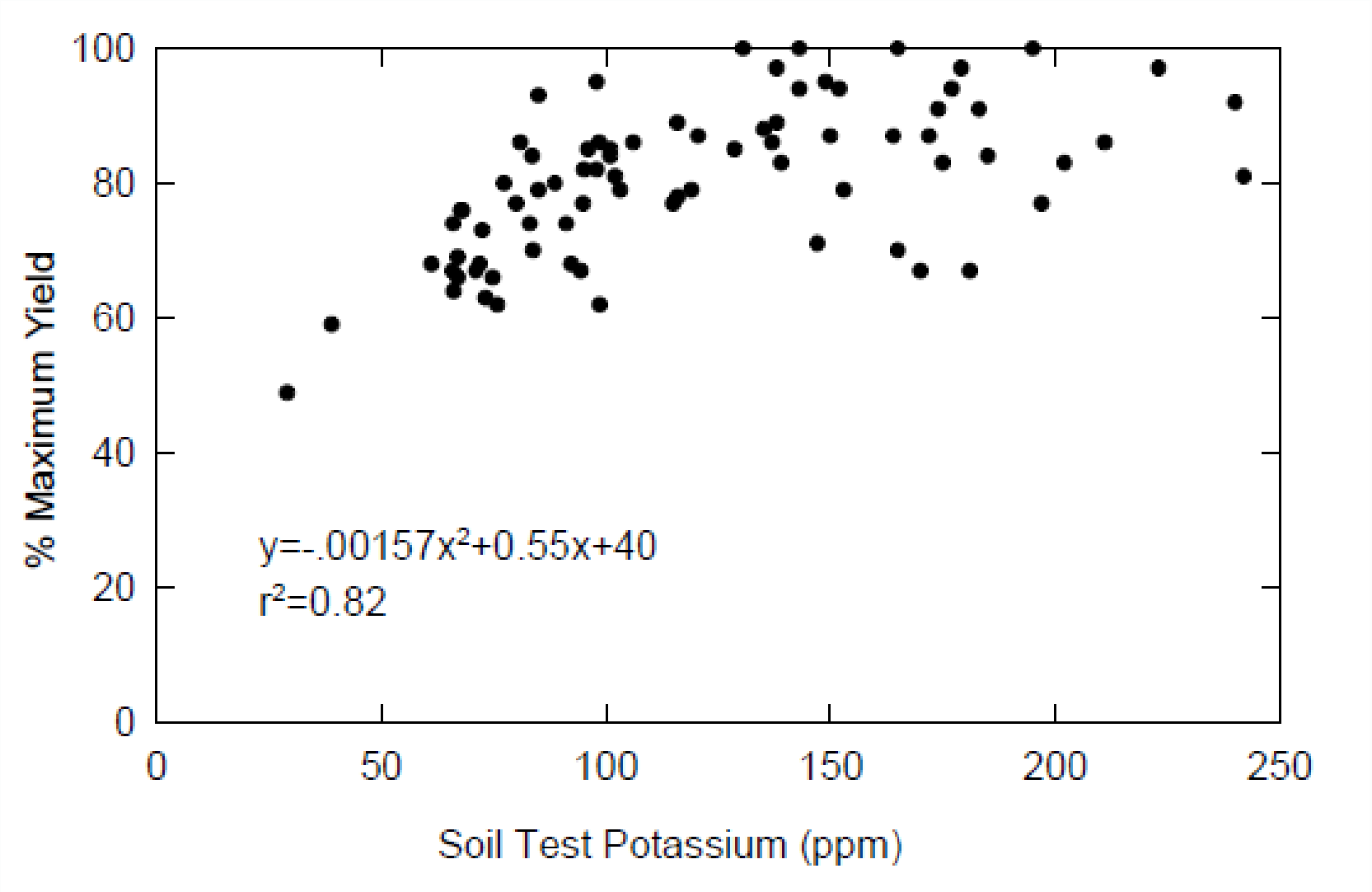
K guidelines for alfalfa and grass in MT based on soil analysis (Table 19 in EB0161, alfalfa/grass rates revised).

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.

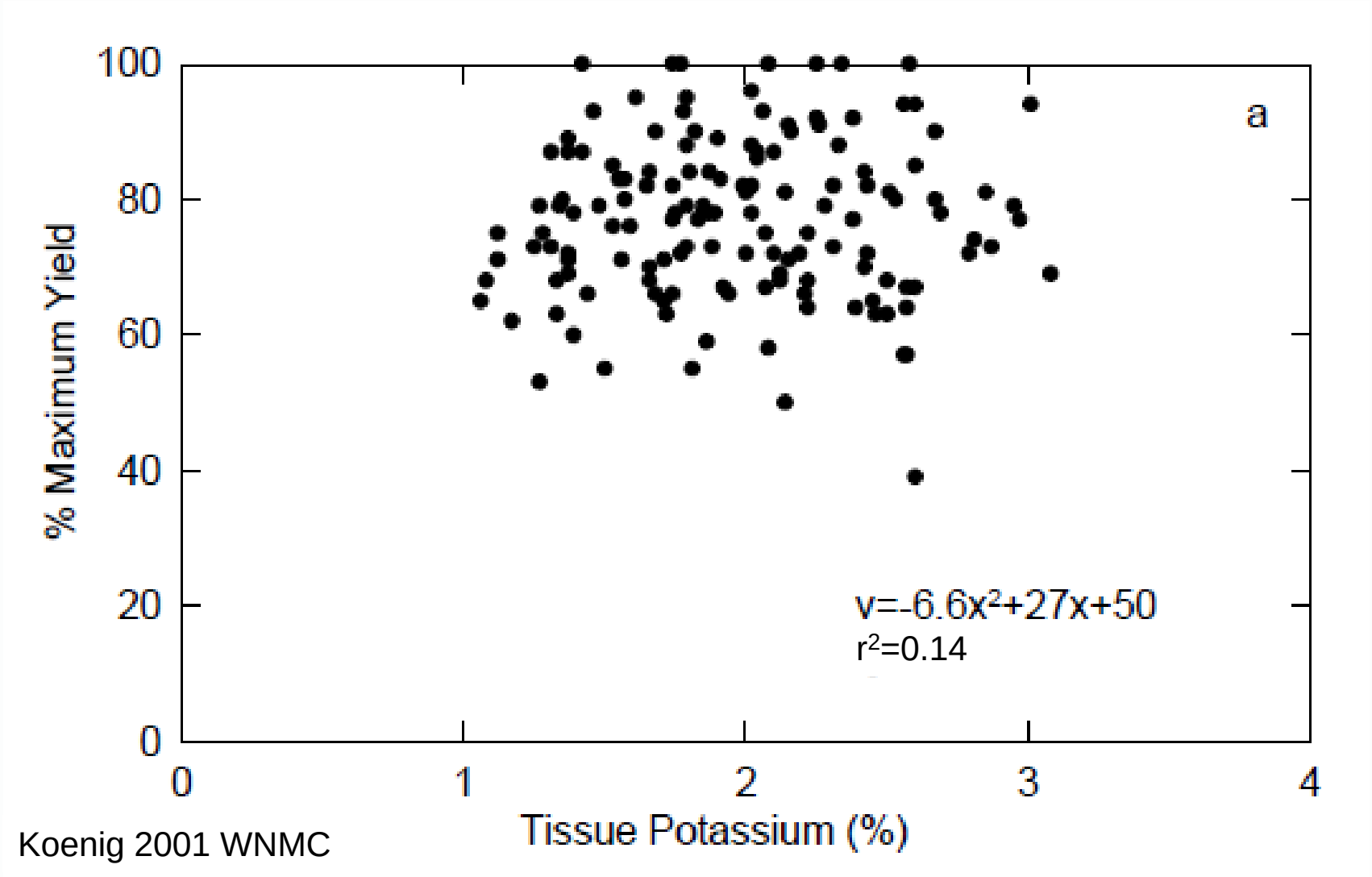
To avoid toxic luxury consumption by first cutting, apply ½ the rate after first cutting and rest after last cutting for following year

Relative alfalfa yield vs soil test K



Koenig 2001 WNMC

Relative alfalfa yield vs tissue K



Koenig 2001 WNMC

soil tests appear better indicator of availability than tissue tests

QUESTIONS?

Sulfur (S)

- Useful on sandy, acidic or low organic matter soils, especially after high rainfall (sulfate leaches)
- Tissue sampling is more reliable than soil testing. If < 0.22% S in top 6 inches of alfalfa during early bud stage then should get a yield increase with S.
- S > 0.30% can cause livestock health problem

Sulfur

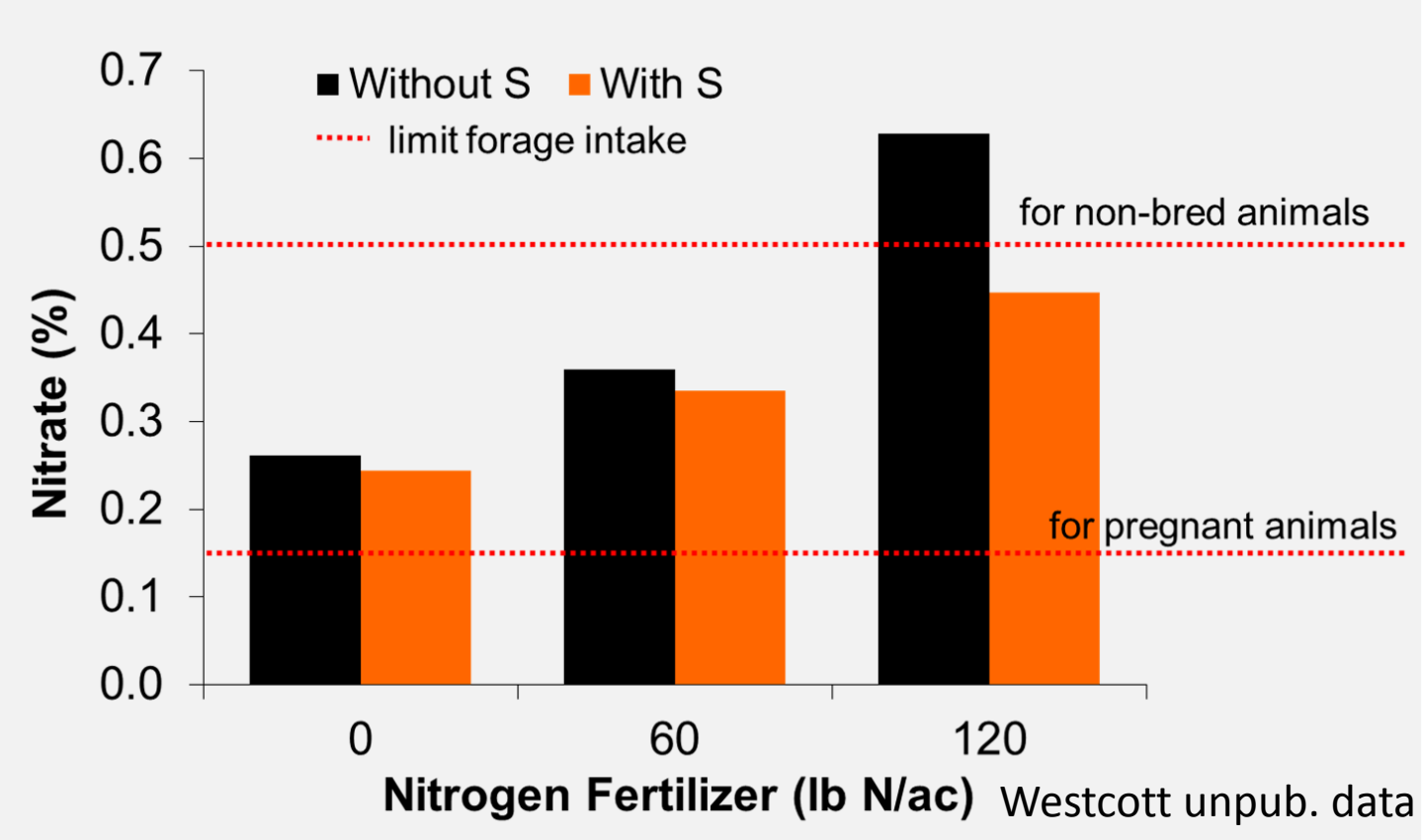
- Visual symptoms and field history, or tissue concentrations determine S deficiency – soil tests are not reliable
- Eroded or coarse-textured soils are more susceptible to sulfur deficiency, particularly after high rainfall
- Alfalfa is S deficient at tissue concentrations <0.25% (leaves from top 1/3 of plant at budding), or with N:S = 17:1.
- S > 0.30% can cause livestock health problem

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
- 45 lb S/acre annually sustains high alfalfa yield and protein (Manitoba, Malhi et al. 2004)

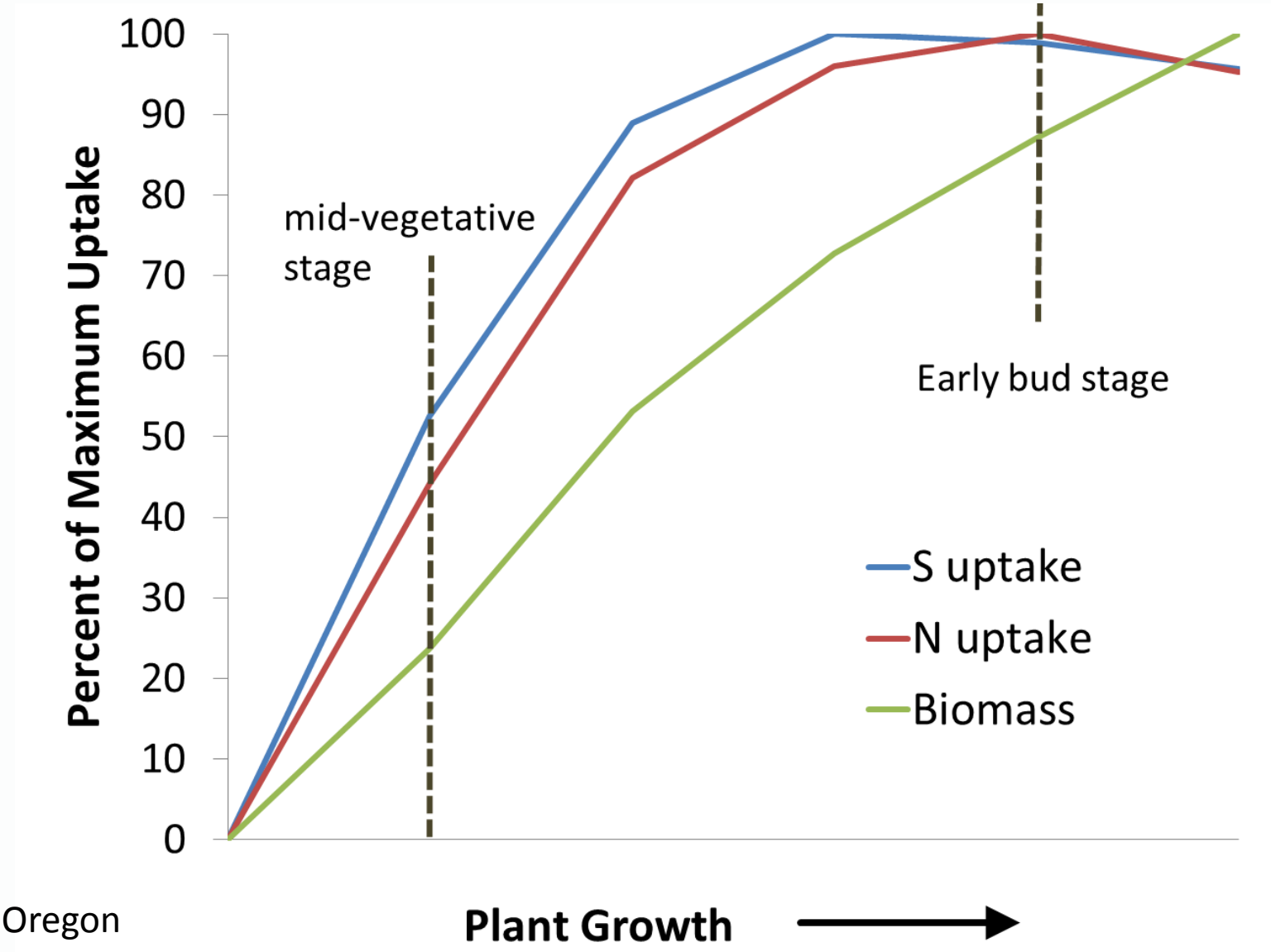
S influence on annual forage quality

N conversion to protein requires S



25 lb S/ac on dryland alfalfa and alfalfa/grass mix increased forage protein 0.8 points

Provide S before mid-vegetative stage in alfalfa



Union, Oregon
Pumphrey and Moore 1965

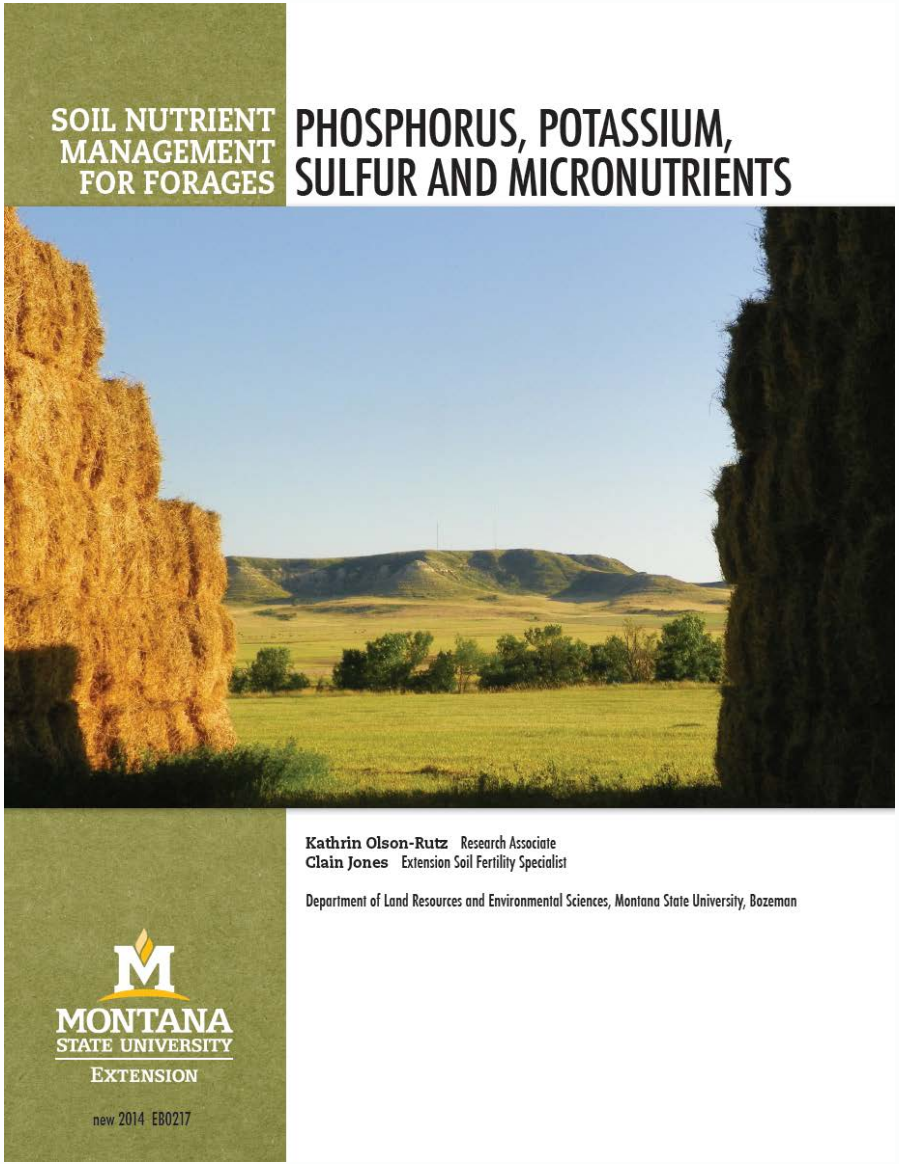
Decision to fertilize

- 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 advice on 1 yr studies!)
- Soil testing is essential for determining fertilizer needs

Keep eyes out for soon to be printed Extension Bulletins



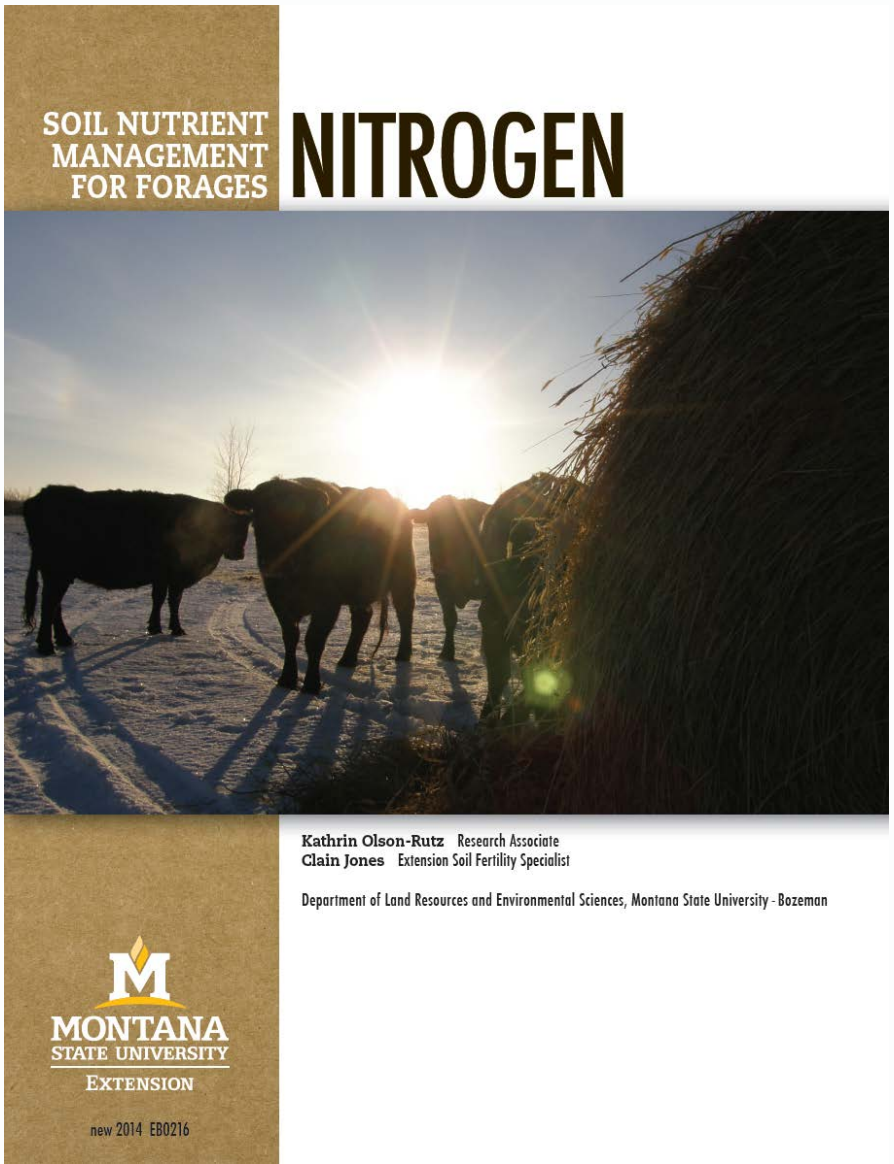


Photo by Ann Ronning

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