Soil Building Practices and Forage Nutrient Management

Stone Child College, Box Elder

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Image by Matt Lavin

Clain Jones clainj@montana.edu 994-6076

MONTANA STATE UNIVERSITY

MSU Soil Fertility Extension

Why should land owners know something about soils?

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

Today's topics

- Explain soil health vs quality
- Present what can be learned from a soil test
  - Soil properties
  - Soil nutrients
- Discuss which properties you can influence
- Present management for soil health
- Provide fertilizer rate and application guidelines for optimal benefit
- Consider options other than soil tests to guide soil nutrient management

Clickers are better than cell phones because:

25% A. You don't listen to Siri giving you wrong directions

25% B. They don't need to be turned off during a presentation

25% C. They screen calls from telemarketers

25% D. They make your dog obey

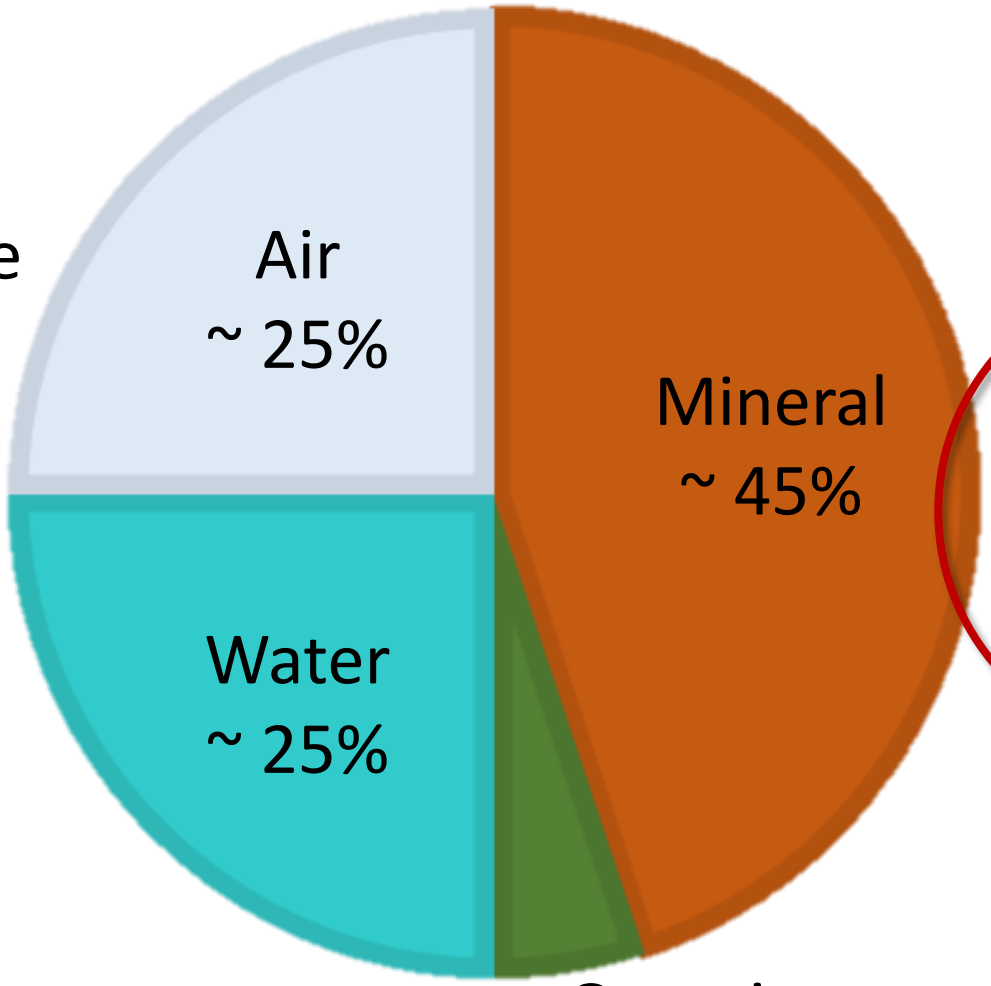
Response Counter

What describes a good soil?

- Good aeration, drainage and tilth
- Organic matter and organisms!
- Doesn’t crust, has few clods, and no hardpan
- Soaks up heavy rains with little runoff
- Stores moisture for drought periods
- Resists erosion and nutrient loss
- Produces healthy, high quality forage and vegetables

Practices to benefit soil

- Minimize disturbance
- Keep soil surface covered



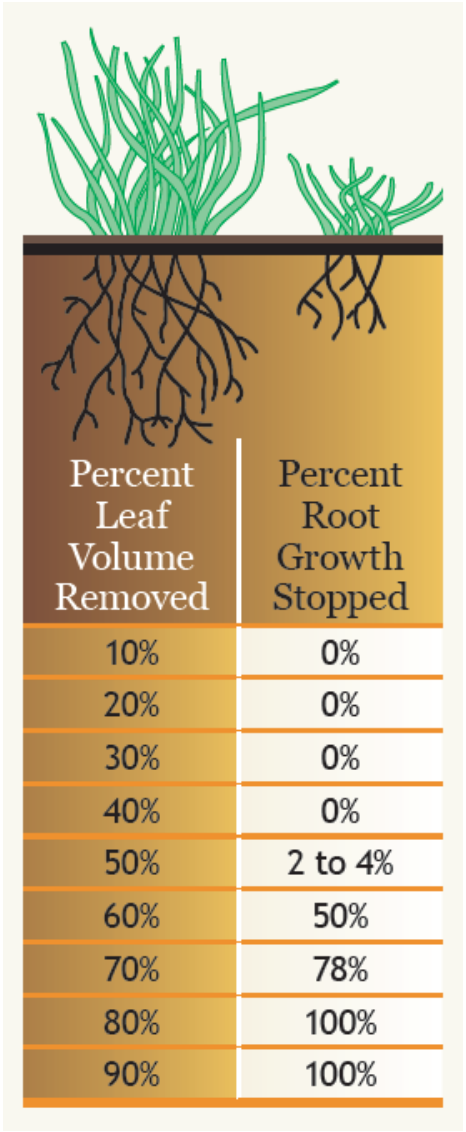
- Nutrient mgt (soil test; 4Rs)
- Increase diversity
- Keep living root in soil

The plant cover you don't harvest…..

Affects

- Re-growth rate
- Root growth
- Organic matter
- Nutrient cycling, amount, storage
- Water infiltration and storage
- Soil temperature

Take ½, leave ½ for plant and soil health



Percent Leaf Volume Removed	Percent Root Growth Stopped
10%	0%
20%	0%
30%	0%
40%	0%
50%	2 to 4%
60%	50%
70%	78%
80%	100%
90%	100%

NRCS Grazing Management and Soil Health

Aboveground residue (lb/acre)	Water infiltration (in/hr)
0	0.5
750	1.0
2150	8.5
5800	9.4
High elevation Utah rangeland, Allred 1950	

Grazing intensity	Water runoff (lb/acre)	Soil loss (tons/ac)
No grazing	23	6.7
Moderate	121	6.7
Heavy	202	14
Texas rangeland, Blackburn et al., 1982		

Questions?

On to *evaluating soil health*

Soil Quality vs Soil Health

Soil Quality = properties that change little, if at all, with land use management practices

- Texture
- pH
- Cation Exchange Capacity

Which are measured with conventional soil tests?

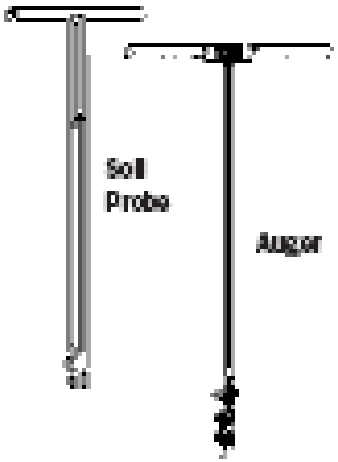
Soil Health = dynamic properties which may be more subjective to measure, but can be changed

- Aggregation
- Microbial activity
- Tilth
- Nutrient availability
- Water holding capacity
- Compaction

SOM often is included in both lists

Soil test

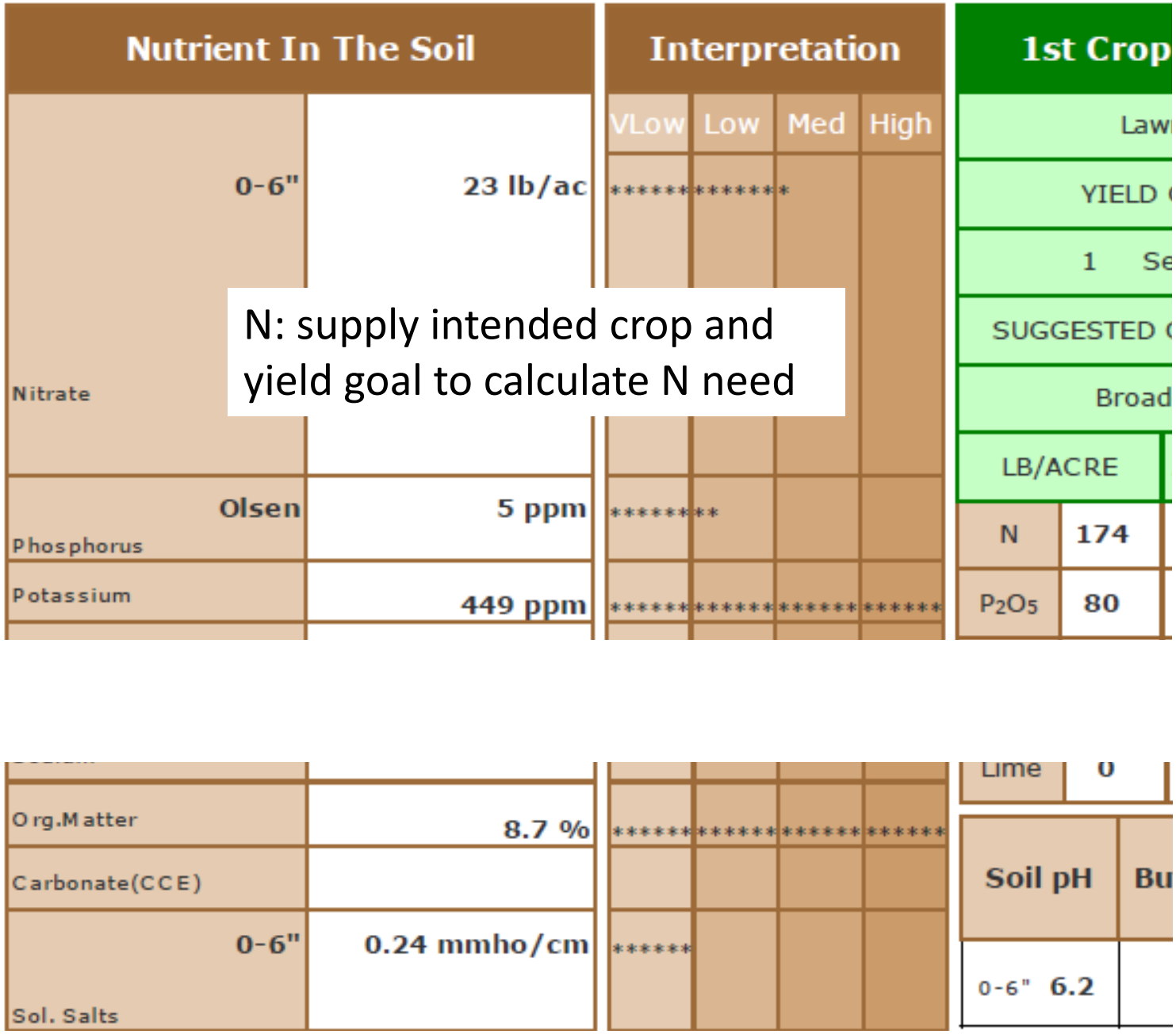
- To identify nutrient deficiency or imbalance
- To help calculate fertilizer rates
- Can increase yield and/or save on fertilizer costs, and decrease environmental risks
- Best done in early spring, but not when soil is wet, therefore in our climate perhaps best done in late fall
- See publications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



What to look for on a soil test report? Factors affecting plant health and production

Factor	Value	Impact/consider
Nutrient content	Nutrient dependent	Too little = hungry plants, too much = contaminate water, burn plants
Soil organic matter	≤ 1 (%)	Minimize bare soil, increase N, add legumes
	> 3 (%)	Little need for extra N on pasture
Soil pH	< 5	Poor seedling establishment
	< 6	Poor legume nodulation
	> 8.3	Nutrients tied up
Soluble salts (EC)	> 4 (mmhos/cm)	Too saline, water stress, nutrient imbalance
Soil texture and CEC		Water and nutrient holding capacity

Example soil test report, submitted by Aaron for Stone Child College (2018)



Nutrient In The Soil		Interpretation				1st Crop
		VLow	Low	Med	High	Law
0-6" Nitrate	23 lb/ac	**********				YIELD (
						1 Se
						SUGGESTED (
						Broad
						LB/ACRE
Olsen Phosphorus	5 ppm	********				N 174
Potassium	449 ppm	**********	**********	**********	**********	P_2O_5 80
Org.Matter	8.7 %	**********	**********	**********	**********	Lime 0
Carbonate(CCE)						Soil pH Bu
0-6" Sol. Salts	0.24 mmho/cm	******				0-6" 6.2

N: supply intended crop and yield goal to calculate N need

Ideally:

Olsen-P>16 ppm

K>250 ppm

OM > 3%

Salts < 4

6 < pH < 80

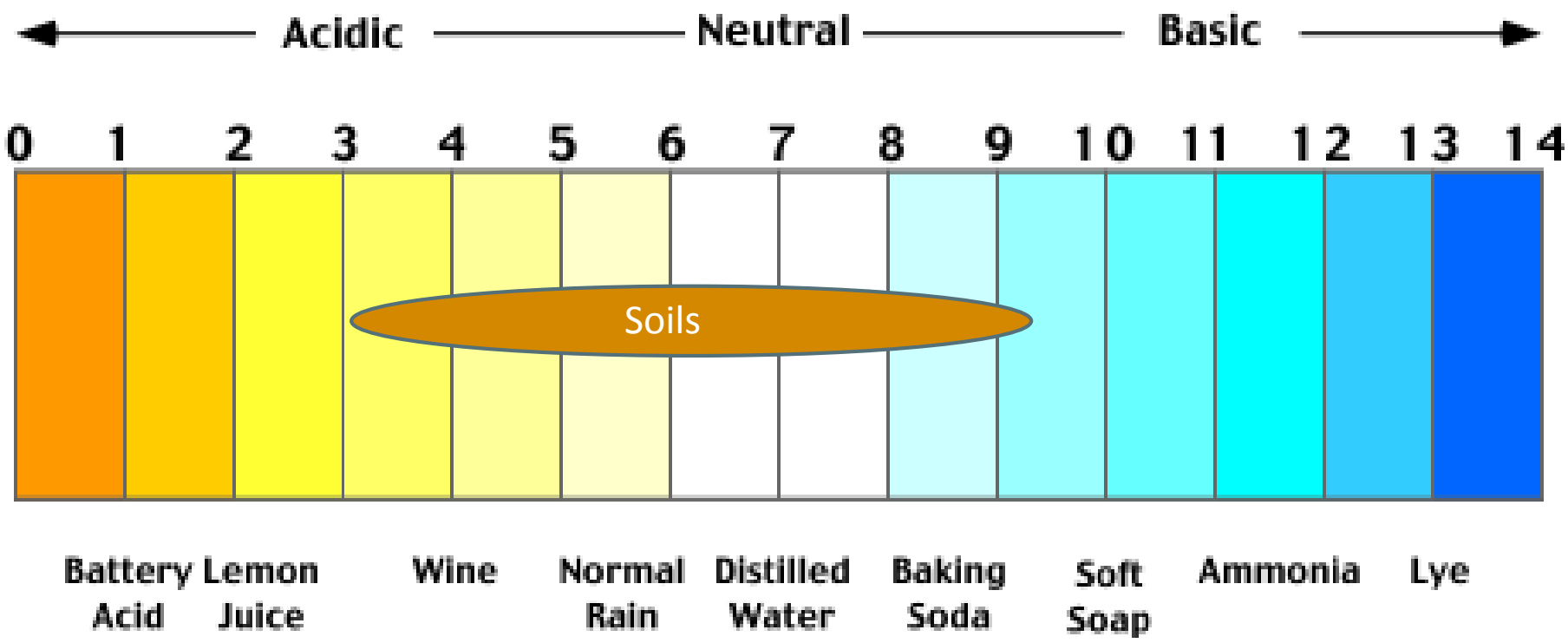
Comparison of soil test results (top 6") submitted by Aaron Aquino with adequate soil levels. 4 garden soils and 9 hay field soils.

Measurement	Garden Range	Hay Field Range	Adequate levels
Nitrogen (lb/ac)	13-37	7 - 23	Crop dependent
Phosphorus (ppm)	**3-11**	**2 - 5**	>16
Potassium (ppm)	304-457	263 - 449	>250
Chloride (lb/ac)	-	**3** - 11	> 10
Sulfur (lb/ac)	**8**-18	10 - 16	> 10
Zinc (ppm)	0.9-1.02	**0.43** - 1.48	> 0.5
Organic Matter (%)	3.8-6.3	**2.2** - 8.7	> 3
Salts (mmhos/cm)	0.22-0.46	0.14 – 0.29	< 4.0
pH	6.6 – **8.1**	6.2 – **8.1**	6.0 – 8.0

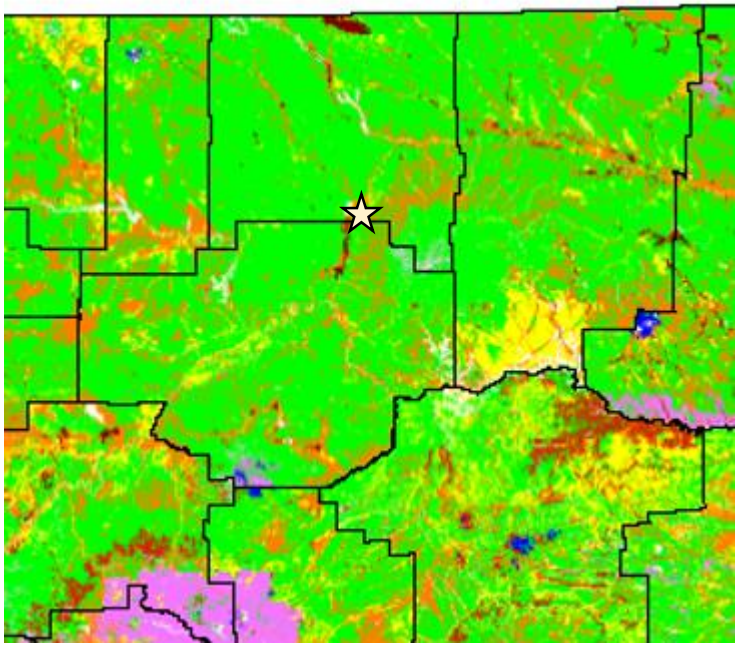
Soil pH – which is true?

Response Counter

1. Has no influence on nutrient availability — 25%
2. Is difficult to alter — 25%
3. Most vegetables prefer pH > 7.5 — 25%
4. Legumes prefer pH < 6 to fix N — 25%



What were surface pH values in this region historically?

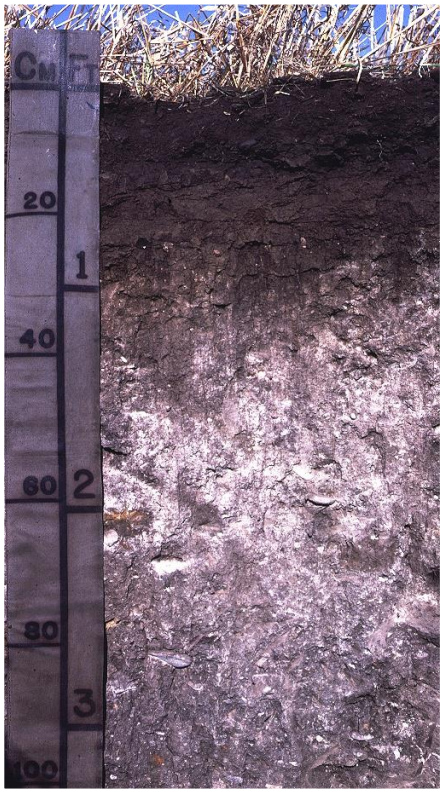


pH

- 4.5 – 5.0
- 5.0 – 5.5
- 5.5 – 6.0
- 6.0 – 6.5
- 6.5 – 7.3
- 7.3 – 7.8
- 7.8 – 8.4
- 8.4 – 10.2

Map courtesy of NRCS

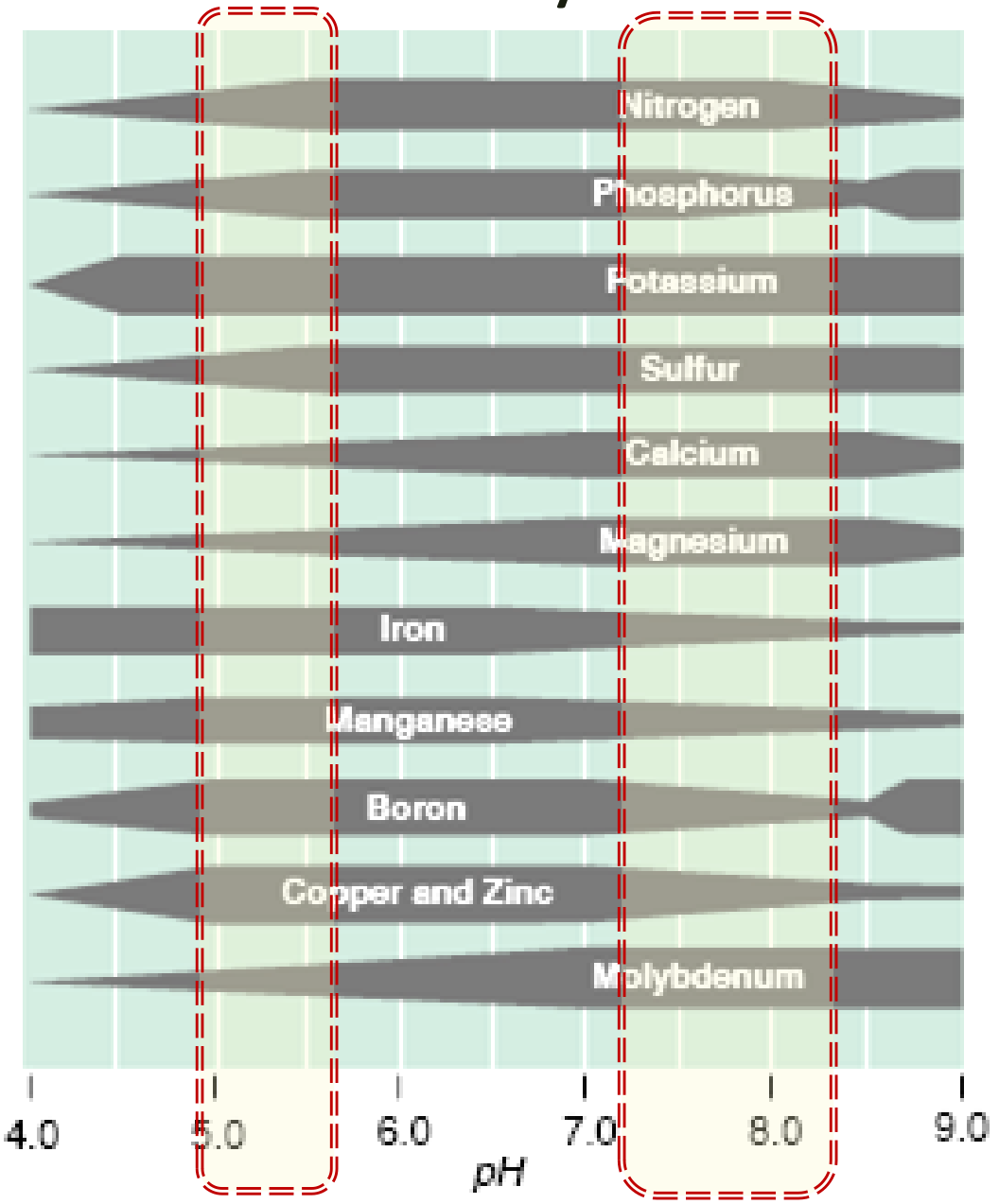
pH varies greatly across MT. North-central tends to have neutral to basic (high pH) soils, but growing pockets of acid soil especially in Chouteau County.



pH affects soil nutrient availability

Low pH, acidic soils – may limit N, Ca, Mg, Mo because they don't stick tight and can leach away (Fe) or form minerals (P)

High pH, alkaline calcareous soils – may limit P, Fe, Mn, B, Cu, Zn because they stick tight to the soil, plant can't get them



What is the best option to lower pH in highly calcareous soils?

17% A. Add elemental sulfur (S)

17% B. Add gypsum ($CaSO_4$)

17% C. Add pine needles

17% D. No reasonable option to lower significantly and QUICKLY on LARGE scale

17% E. Use ammonia based N fertilizers (e.g., urea)

17% F. Plant legumes

What might happen if you add 230 lbs S/1000 sq. ft.?

A. Soil S levels may become toxic
B. Soil salt levels may become toxic
C. You spend $366/1000 sq ft ($16K/acre)

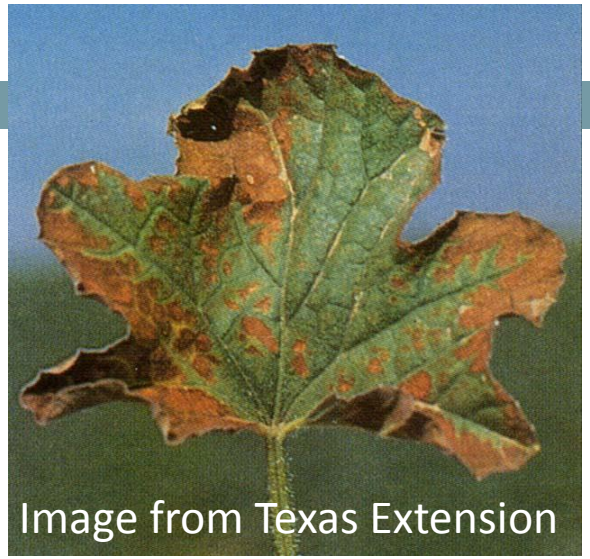


Image from Texas Extension

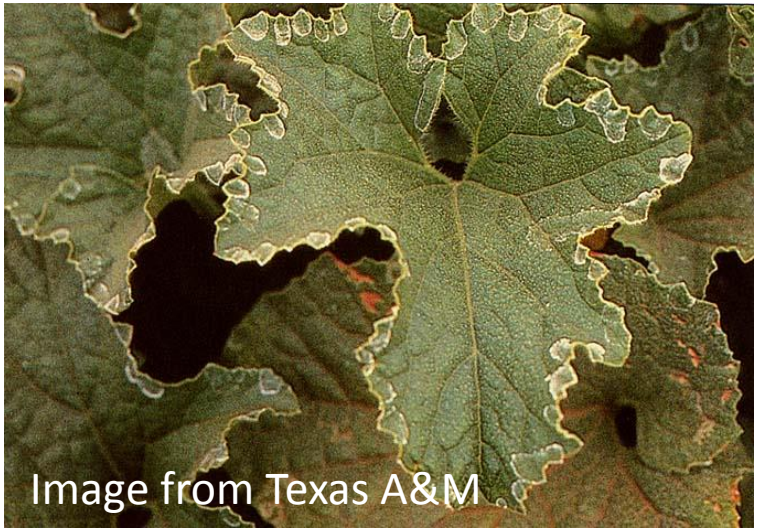
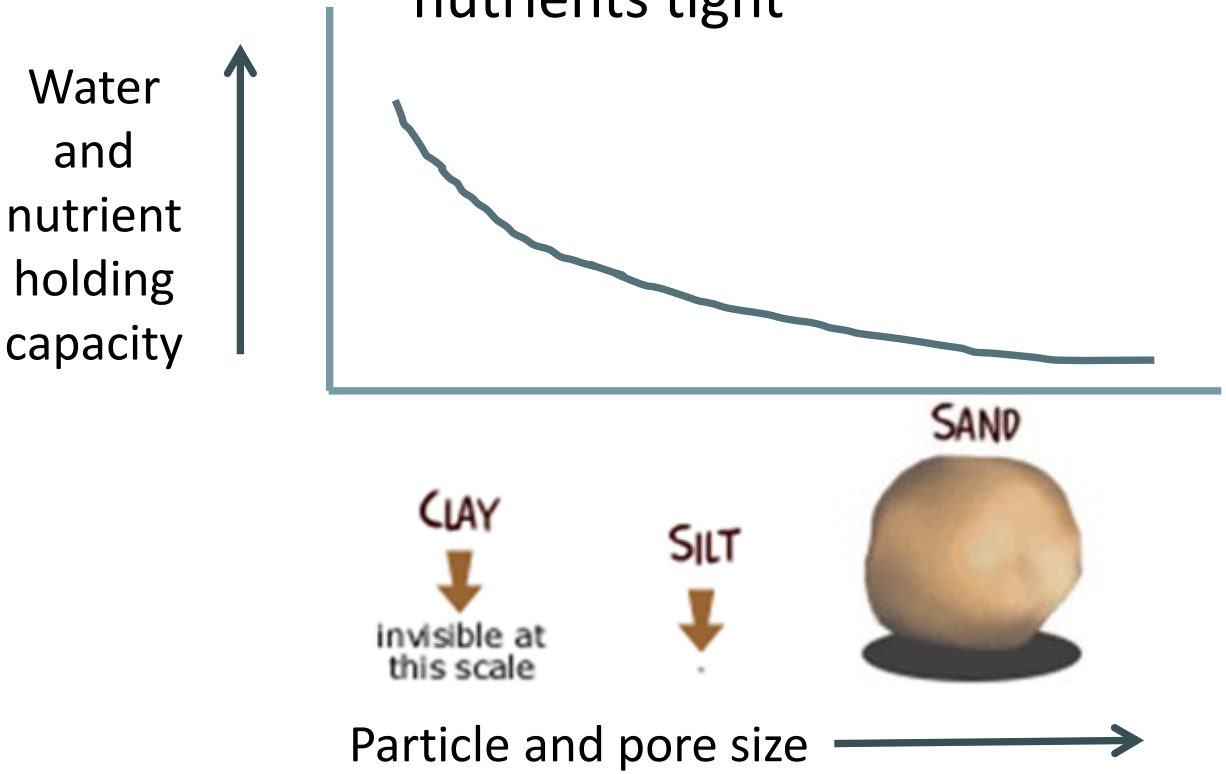


Image from Texas A&M

Soil texture

Sand: large pore space, low surface area = low water or nutrient holding capacity

Clay: small pore space, large surface area, often negative charge on surface = holds water and nutrients tight

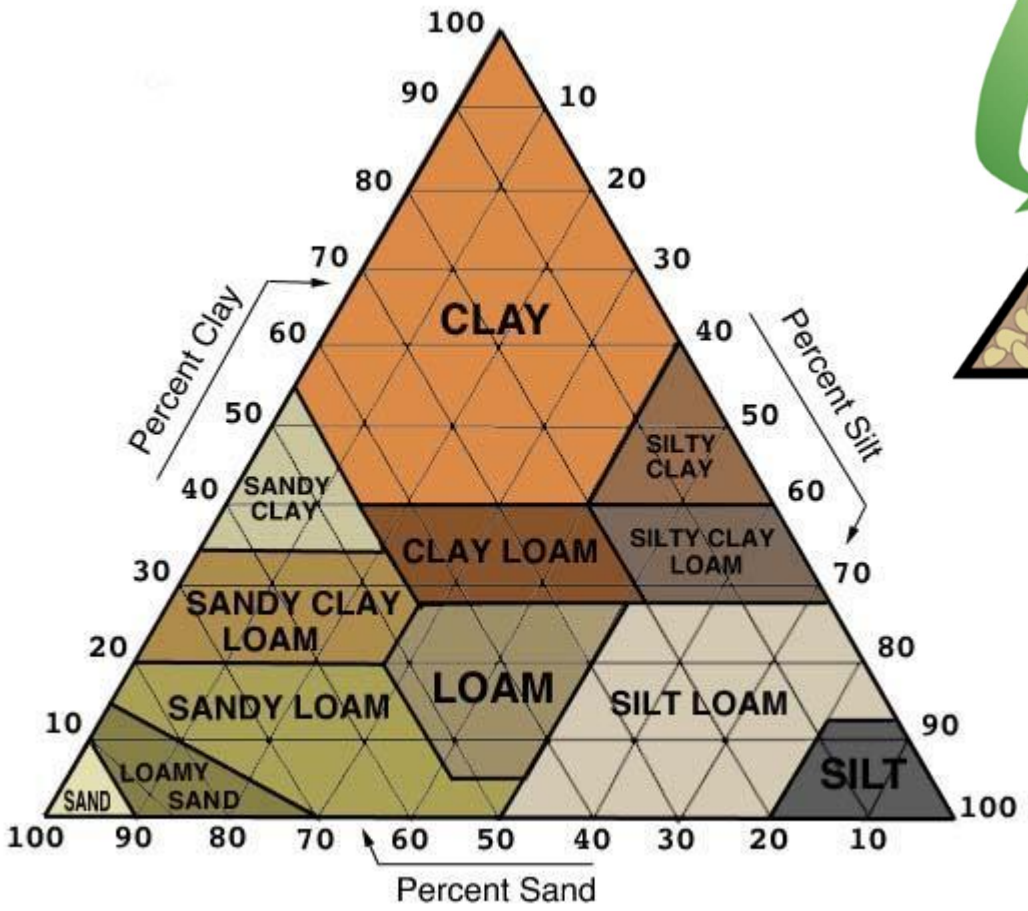


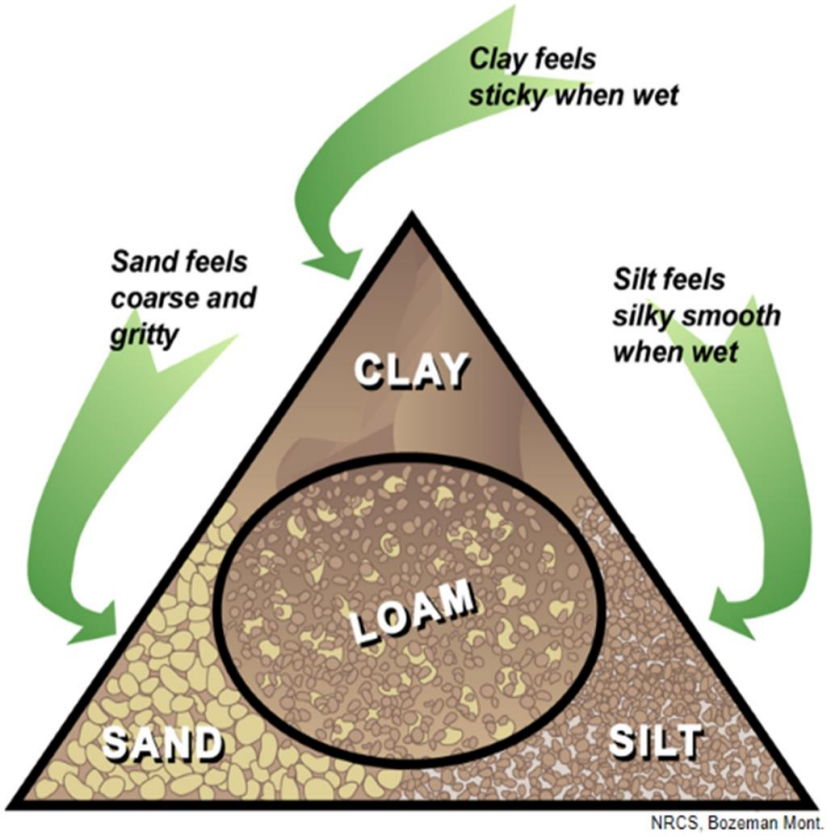
Ideal is **loam** to **clay loam** approx. equal parts of sand, silt, clay

Mason jar texture test

- Fill a straight sided jar 1/3 with soil
- Add water until almost full
- Add 1 tsp dishwasher soap or water softener
- Shake and let settle
- Mark sand depth at 1 min.
- Mark silt depth after 6 hours (or by color/texture change with clay at 24 hr)
- Calculate clay by difference (or measure at 24 hours)

Using the soil texture triangle





Loam is a combination of all these

Texture Effects on Soil Properties

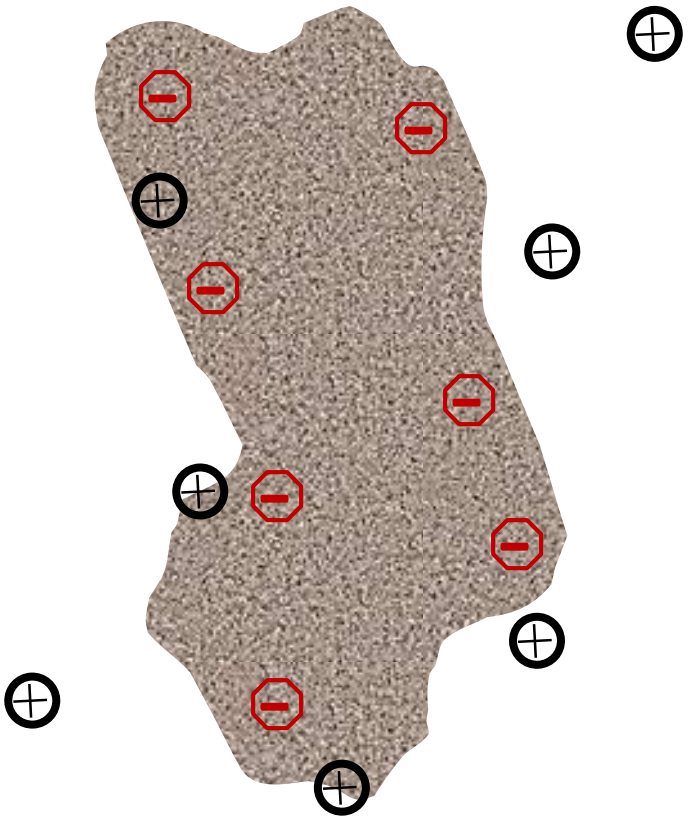
	Drainage	Water holding capacity	Aeration	CEC
Sand	excellent	poor	excellent	low
Silt	good	good	good	medium
Clay	poor	excellent	poor	high

Soils with large surface areas, such as clay and organic matter, have more cation exchange capacity and surface area and therefore are generally more fertile.

Cation Exchange Capacity CEC – the parking spaces for nutrients in the soil

- CEC is the total neg. charge on a soil
- A high CEC soil (> 15) has the capacity to attract and hold nutrients with positive charges, e.g., K^+, Zn^{+2}, NH_4^+
- Soils with large surface areas, such as clay and SOM, have more CEC and therefore are generally more fertile.
- What else might high CEC soils hold onto?

Herbicides



Management influenced by CEC and texture

- Water
  - low CEC soils – short frequent irrigation (daily) – to avoid leaching nutrients
  - high CEC soils – tend to be clay, slow irrigation less often (e.g., low flow emitters, every 3-4 days)
- Nutrients
  - low CEC soil, a little at a time to avoid leaching loss
  - High CEC, incorporate them – to avoid runoff and get to plant roots

Changing CEC?

- We can't change CEC of mineral soil or soil pH very well, but can increase SOM to influence soil CEC
- SOM can change:
  - takes a long time on cropland/pasture
  - If you harvest hay, or graze pasture you are maybe maintaining, most likely losing SOM

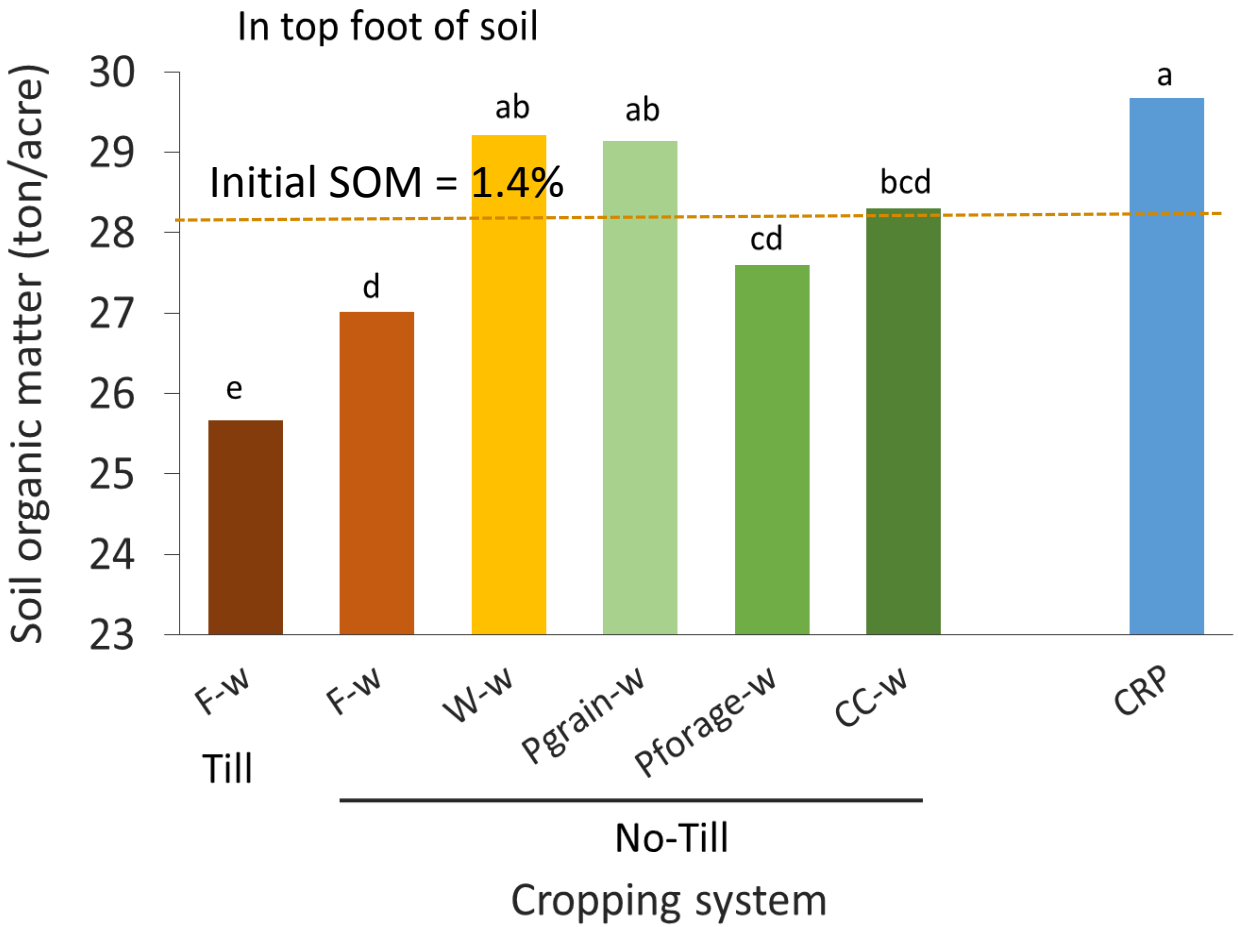
How long does it take for SOM to increase from 1.4% to 1.5% on CRP land in top foot?

25% A. 2 yrs

25% B. 5 yrs

25% C. 10 yrs

25% D. >20 yrs



Response Counter

Engel, unpub data, MSU Post Farm, 2012

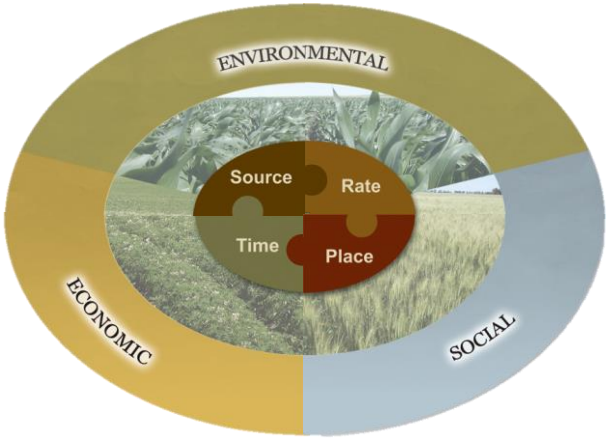
Questions?

On to *fertilization*

To get the most out of your fertilizer investment

The 4 Rs:

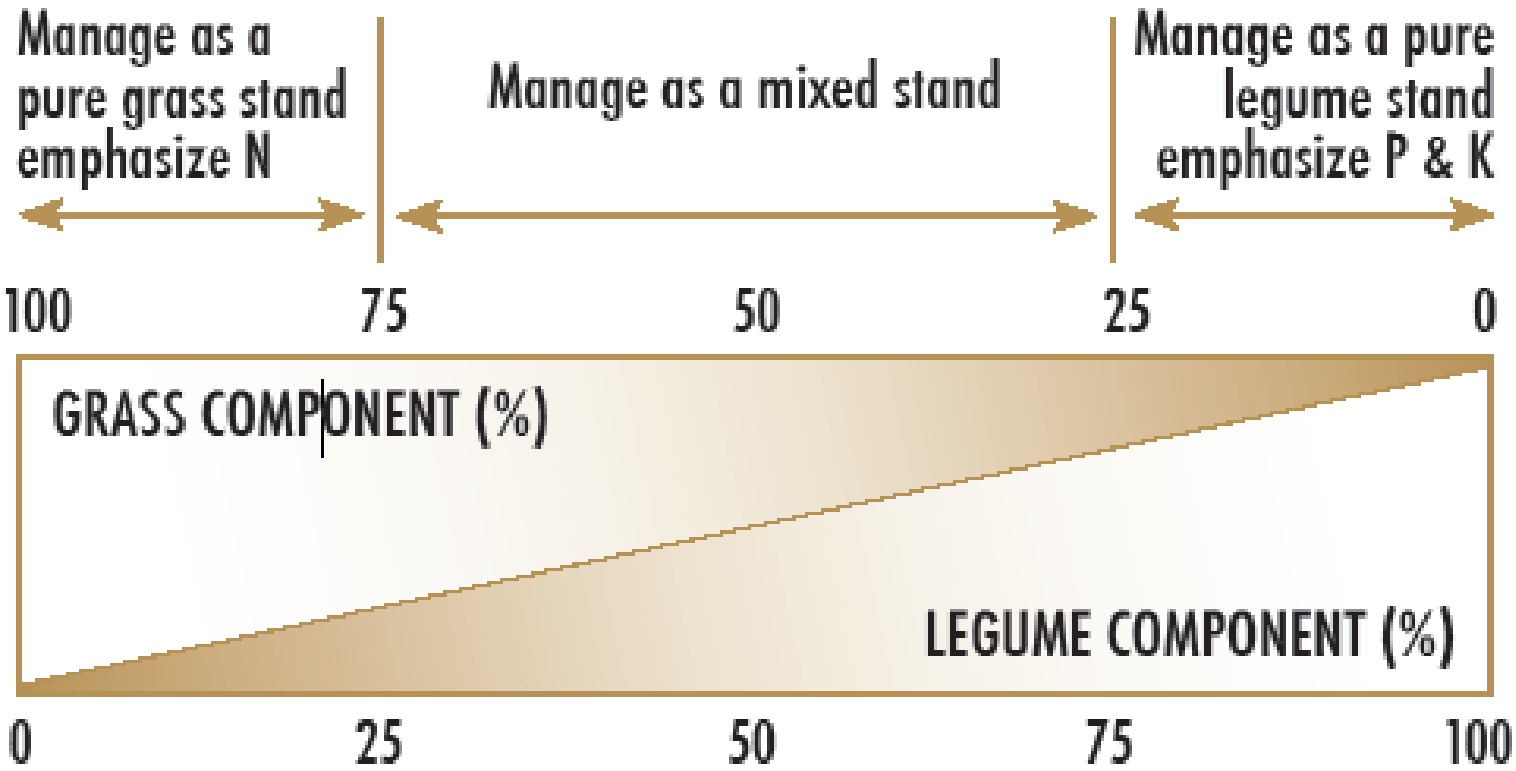
- Right rate
- Right source (including legumes)
- Right timing
- Right Placement



How much fertilizer do I need to apply?

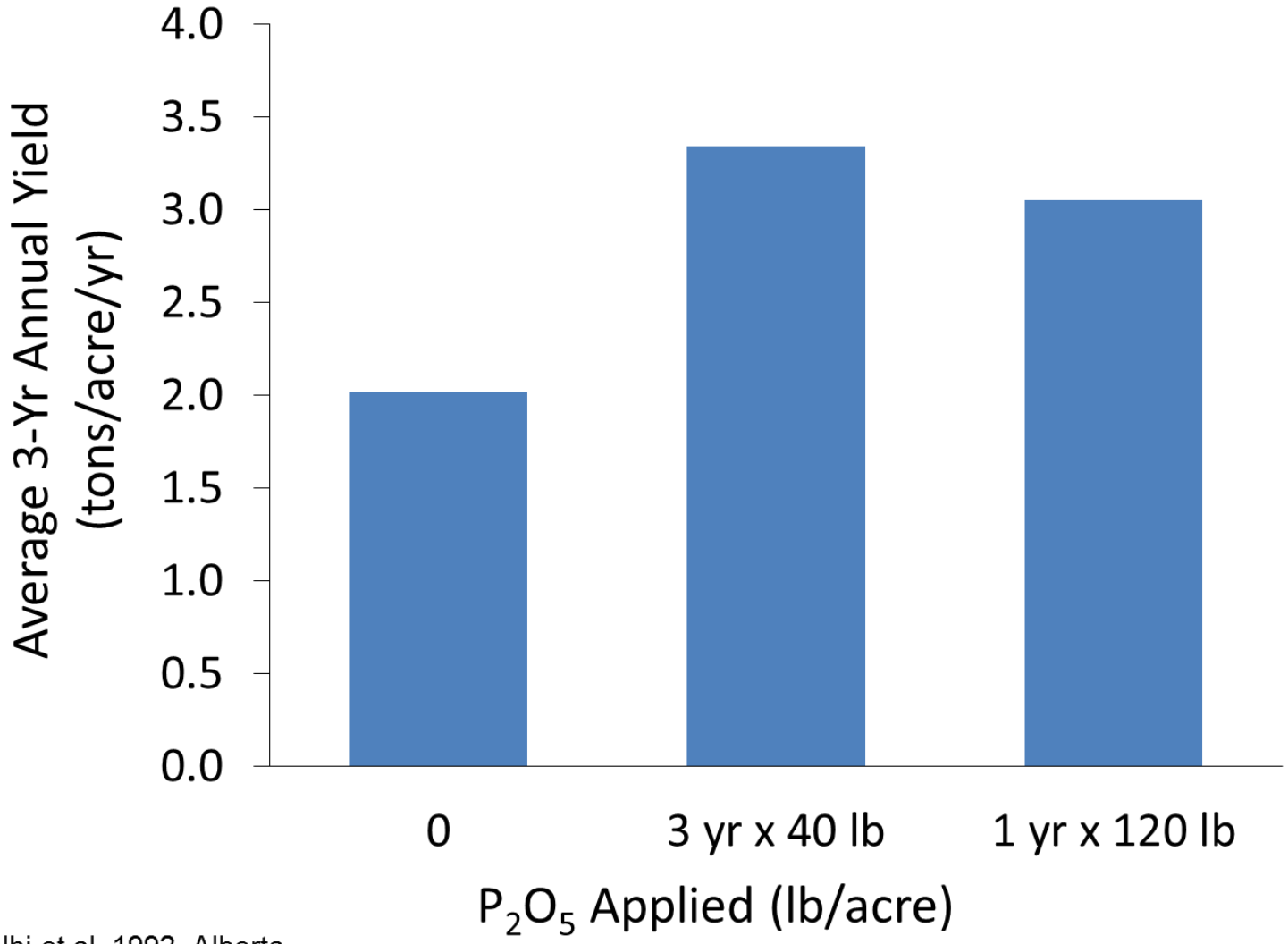
- N based on yield goal and soil tests
- P and K based on soil tests
  - Rate recommendations are provided by testing lab
  - Or from tables given in *Soil Nutrient Management for Forages: Nitrogen* and *Soil Nutrient Management for Forages: PKS & micros*
- S based on field history and deficiency symptoms
- 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 greatest if < 36% alfalfa in stand and soil N < 5 lb N/acre (Malhi et al. 2004)

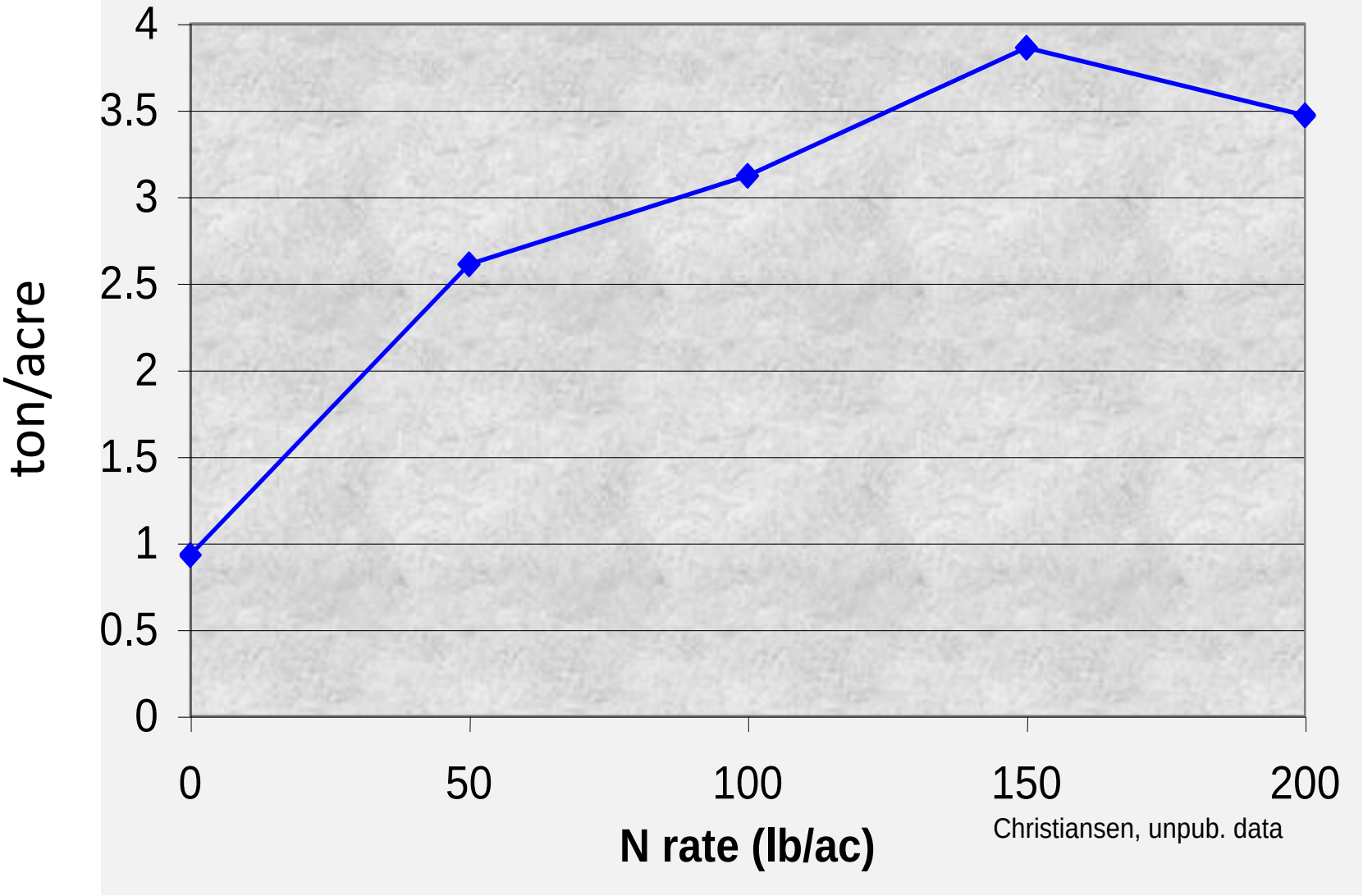
P on established alfalfa



Malhi et al. 1992, Alberta

Diminishing return of increasing N

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



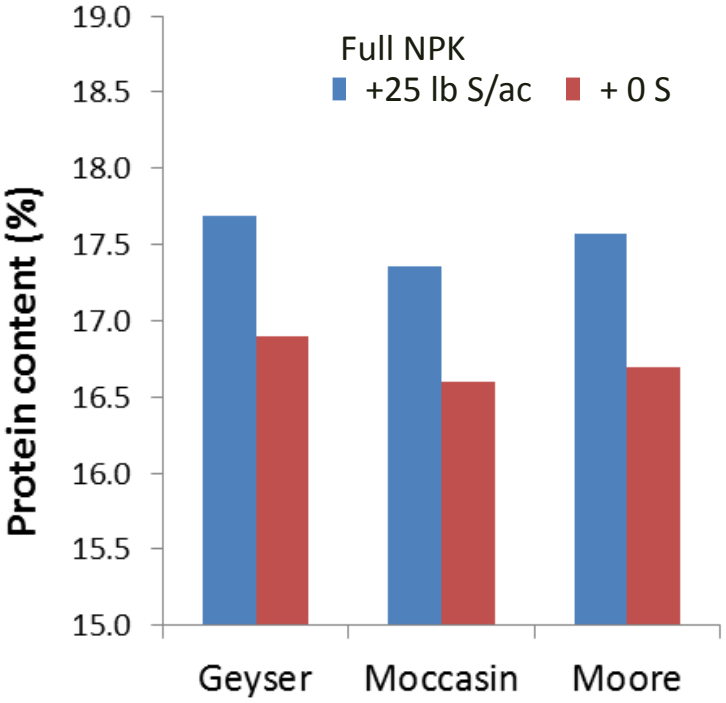
Sulfur tissue tests and visual symptoms are better than soil tests

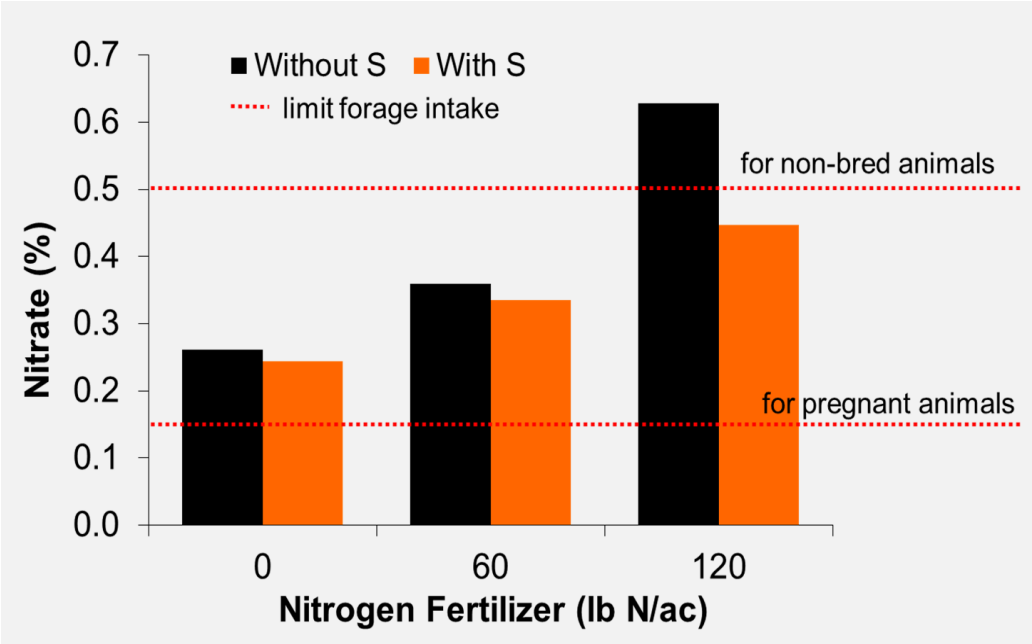
- Standard sulfate soil test too unreliable
- Better to use
  - visual symptoms (yellow or light green upper leaves)
  - tissue tests critical values provided by lab or our documents
  - Last year production performance

Wheat, image 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)





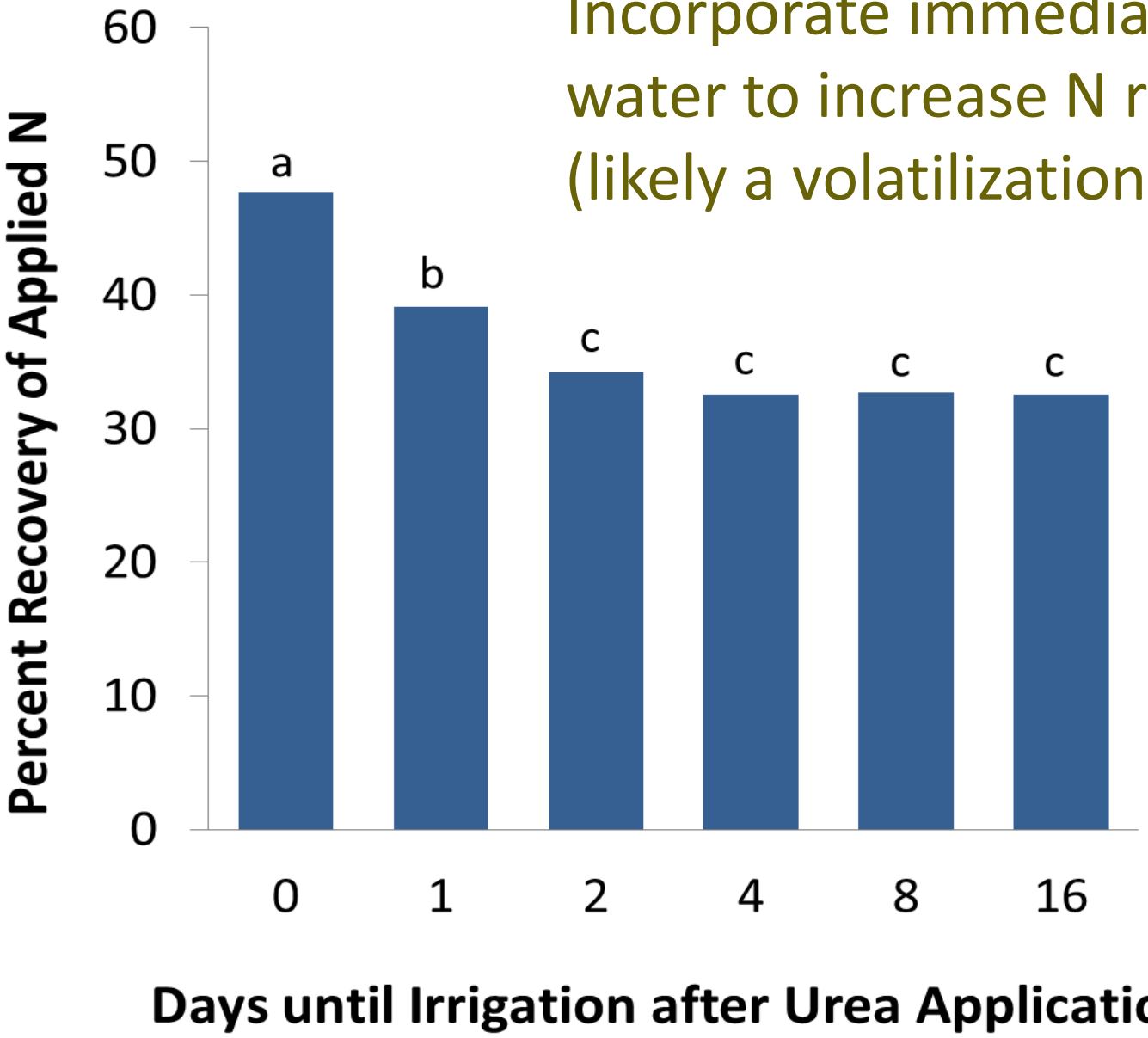
Questions?

On to *increasing fertilizer effectiveness*

Challenges to high N use efficiency in perennial systems

- Difficult to incorporate N
- Plant residue
  - intercepts fertilizer
  - increases volatilization
  - can tie up N

Incorporate immediately with water to increase N recovery (likely a volatilization effect)

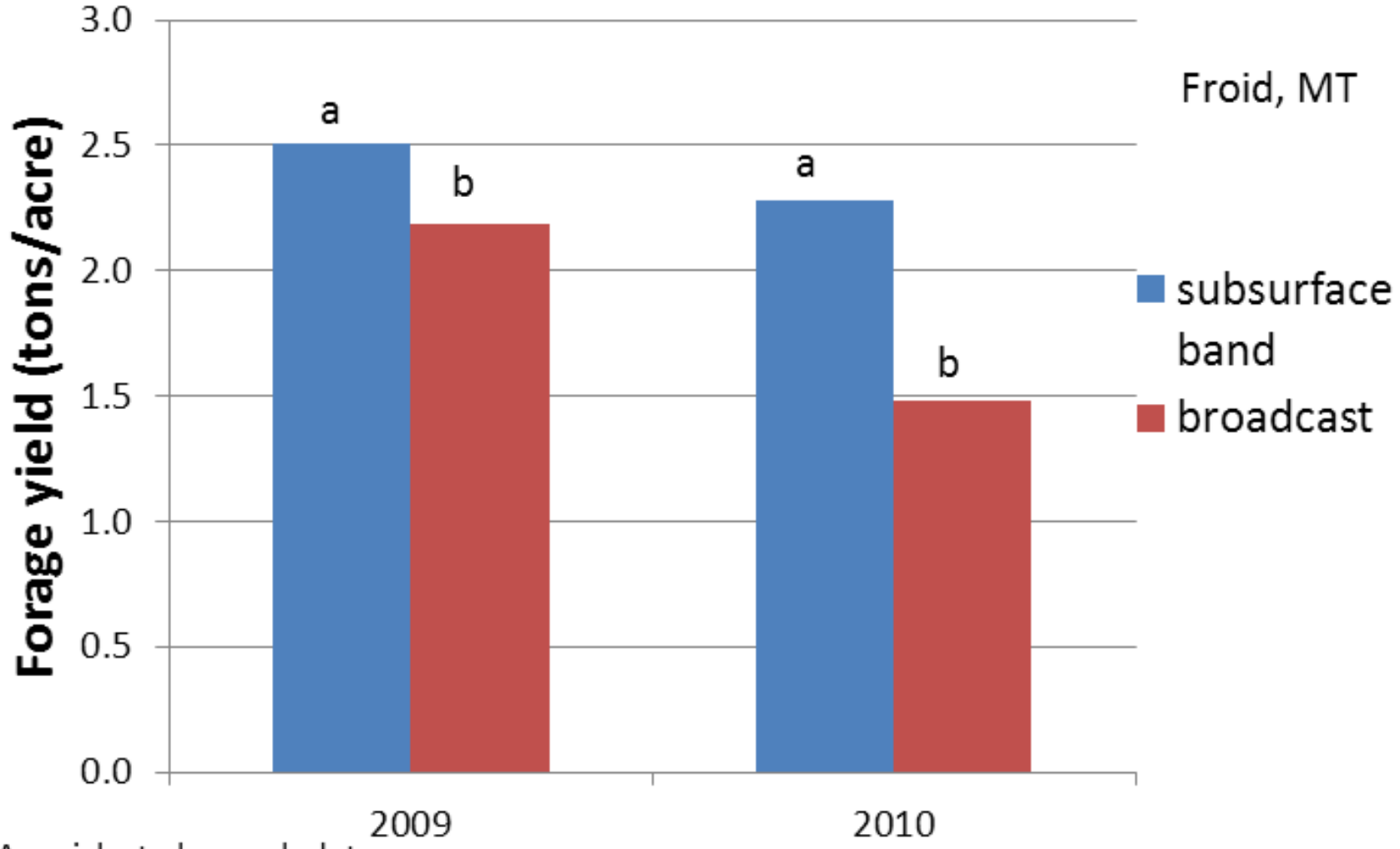


0.8” irrigation

Eckville, Alberta

Bromegrass, Malhi et al. 1995

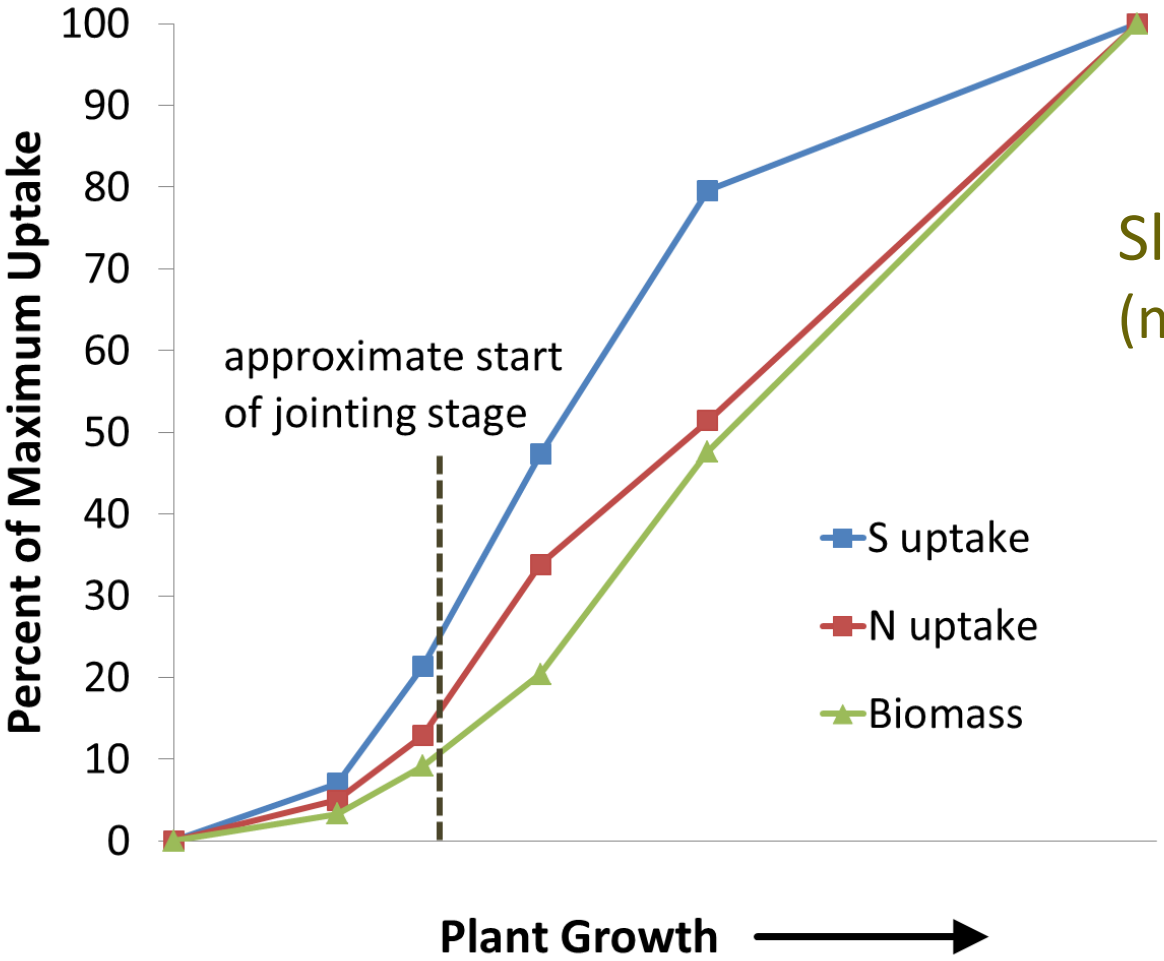
Urea placement affects Hays annual forage yield



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

Application considerations

Conventional

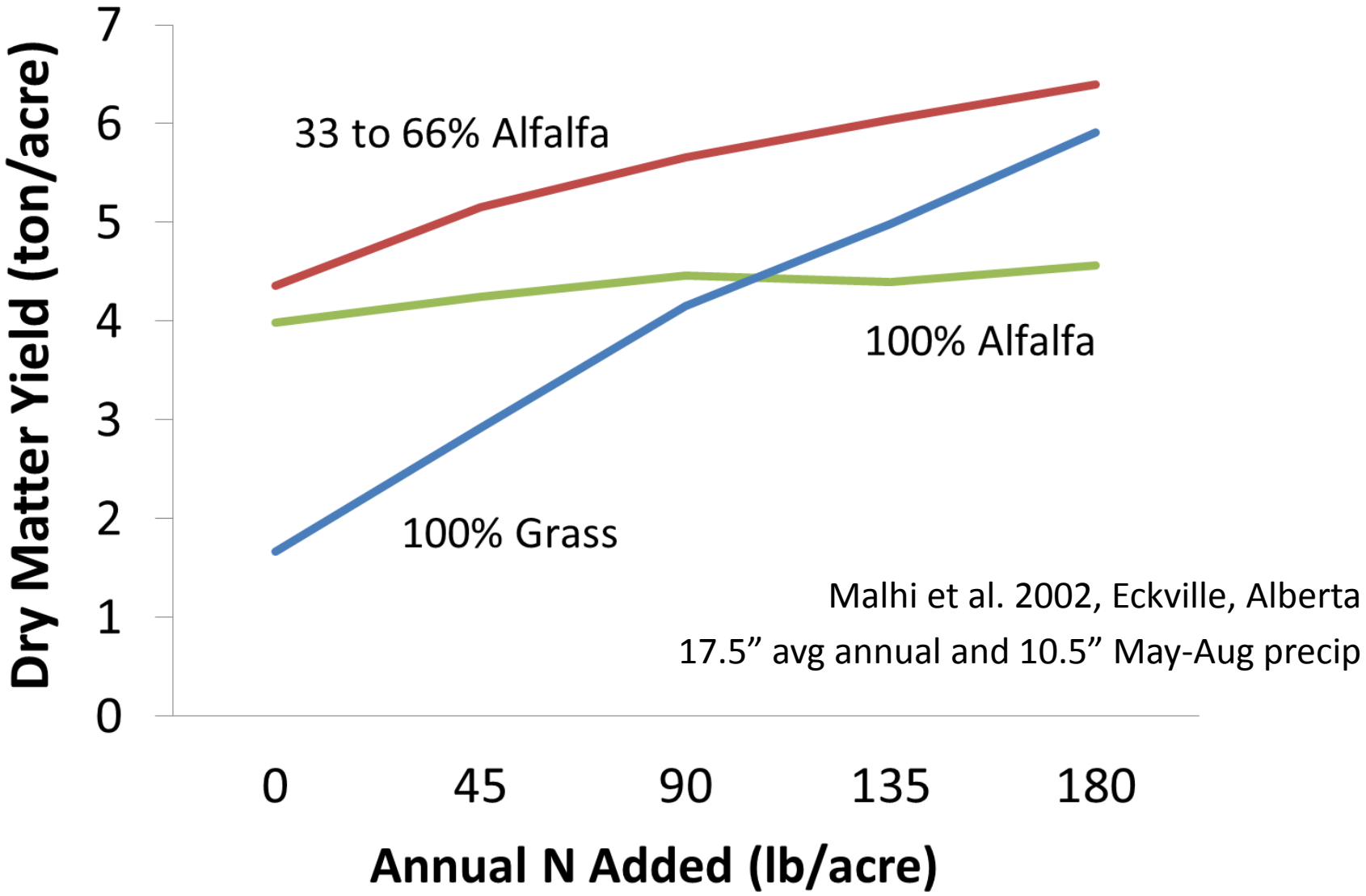
- Do not apply on snow, before heavy rains or snowmelt
- Apply and incorporate (nitrogen) shortly before plants ‘take off’ in the spring
- Broadcast N fertilizer needs to be incorporated by tillage or ½” water ‘event’
- Provide additional N mid-season if needed

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

Forage fertilization strategy

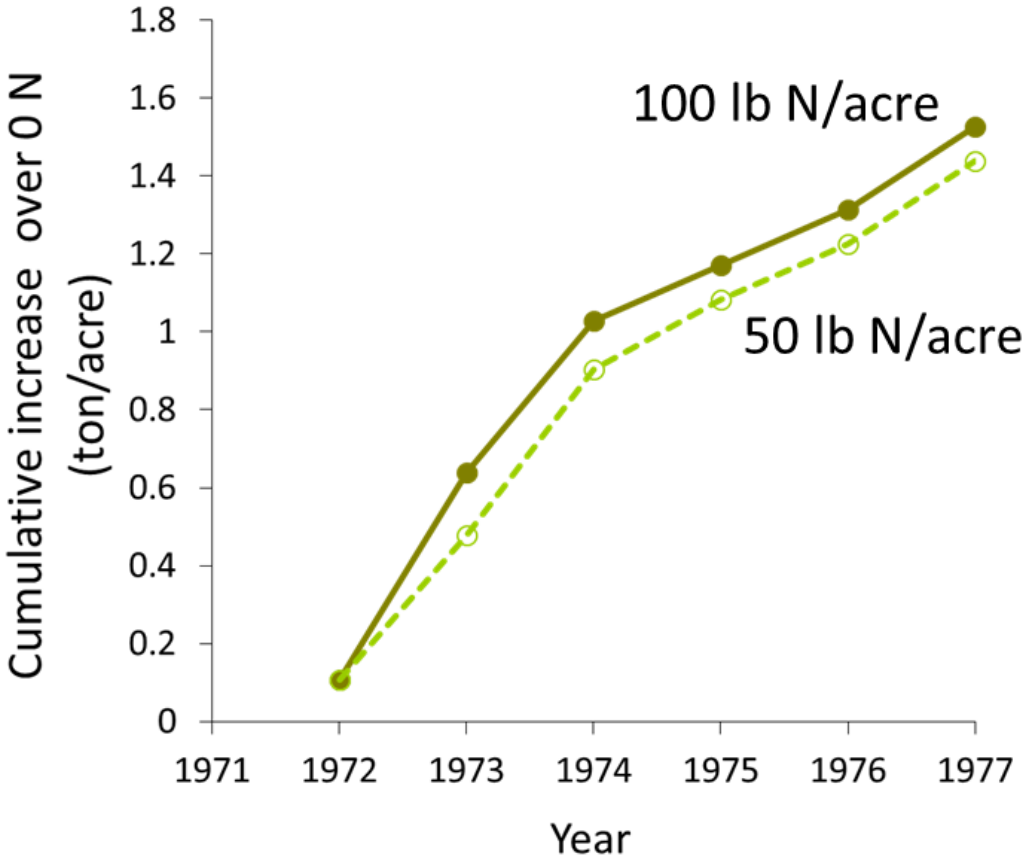
- If a field containing < 75% legumes will be rotated to a different crop soon, consider N for immediate gain
- If goal is low input, long-term sustainable production rather than prime quality hay, adequate P and K are key and cheaper than re- or interseeding
- If you need to buy hay or rent pasture, consider fertilizing for long term benefit

Which likely provides the best net return on dryland forage in Hill County?

33% A. 50 lb N/acre once in 5 years

33% B. 100 lb N/acre once in 5 years

33% C. 0 lb N/acre



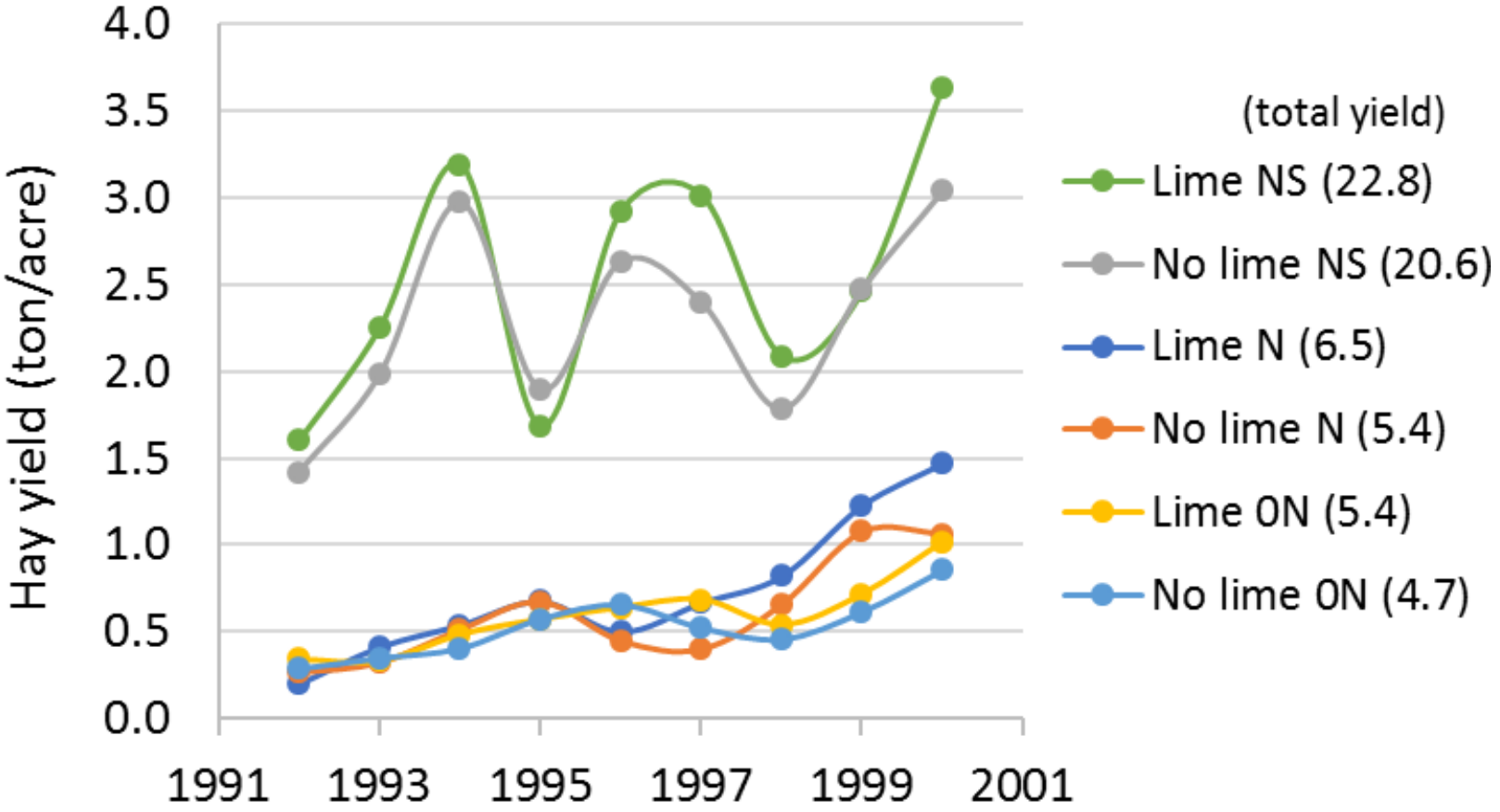
A single 50 lb N/acre on dryland grass was more economical over 5-yrs than a single 100 lb N/acre

Lorbeer et al. 1994, Jacobsen et al.1996, Havre

Response Counter

Balanced fertilization increases yield in mixed dryland brome hay

Started in 1980, annual spring surface broadcast 100 lb N/ac as AN and 9.8 lb S/ac as sulfate. Surface granular lime in 1992 to soil pH 7.



Malhi et al., 2011, SK

N alone reduced brome, NS increased brome in stand, bluegrass/fescue grasses did the reverse

Questions?

On to *evaluate and adjust management*

Evaluate plant nutrient status in addition to soil test

- Visual assessment of tissue: may identify what has been lacking to this point, once symptoms appear, yield may already be compromised. Examples posted at http://landresources.montana.edu/soilfertility/nutrientdeficiencies.html
- Tissue concentrations, not an exact science either

What is/was deficient here?

33% A. Live grass

33% B. Time to read the bag label

33% C. The wisdom to quit texting while running the spreader

ID of ‘problem’ is not always clear cut

Response Counter

Evaluate and adjust

- Indicators of soil nutrients: yield, quality (taste, appearance, forage nitrate, grain protein), nutrient deficiencies or toxicities
- Use this year's observations to fine tune rates next year
- What else might be unique to your operation to consider that isn't on a soil test? Depth to water table, other?
- What other tools?

How can I manage for healthy soils?

- Know your soil's properties and only add amendments as needed
- The right source, rate and timing leads to optimal fertilizer use and plant health
- Observe and adjust to your specific conditions
- Avoid compaction by:
  - Reducing traffic and tillage when wet
- Increase the organic matter content by:
  - Moderate grazing
  - Adding manure
- Maintain soil cover with vegetation

Resources

On soil fertility website under *Extension Publications*

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

- *Soil Nutrient Management for Forages: N* (EB0217)
- *Soil Nutrient Management for Forages: PKSMicros* (EB0216)
- *Soil Sampling Strategies* (MT200803AG)
- *Interpretation of Soil Test Reports for Agriculture* (MT200702AG)
- *Developing Fertilizer Recommendations for Agriculture* (MT200703AG)
- *Soil Sampling and Laboratory Selection* (4449-1)
  http://landresources.montana.edu/NM/
- *The Soil Scoop*
  http://landresources.montana.edu/soilfertility/soilscoop.html

Pick up a copy or download these Extension Bulletins

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

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


Questions?
Photo by Ann Ronning
Additional info at:
http://landresources.montana.edu/soilfertility/