Tonight's hosts

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Soil Fertility and Testing

Winter Soil Fertility Series: Week 1

Jan 6, 2021

Clain Jones, Extension Soil Fertility Specialist
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Photo by K. Olson-Rutz

Today's topics

- Soil properties and how they affect plant nutrients
- How to read a soil test
- The limitations of soil properties you can influence
- 4Rs of Fertilization

Soil Quality vs Soil Health

Soil Quality = properties that change little, if at all, with land use management practices, often found on a traditional soil test

- Texture
- Cation Exchange Capacity

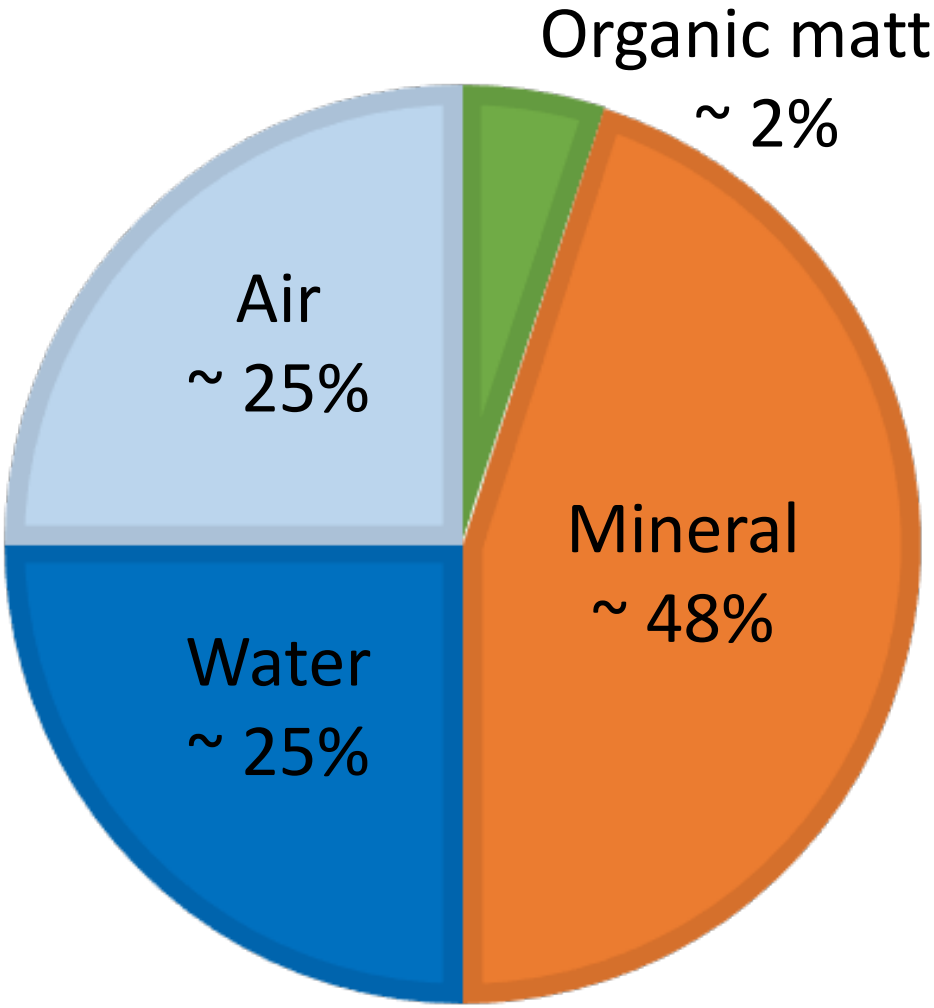
Soil Health = dynamic properties which may be subjective to measure

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

Where do SOM and soil pH belong?

On both lists

Average Soil Composition



Soil properties that affect soil nutrients and plant health

Texture

pH

Cation Exchange Capacity (CEC)

Organic matter (SOM)

- small in % volume
- controls >90% of function

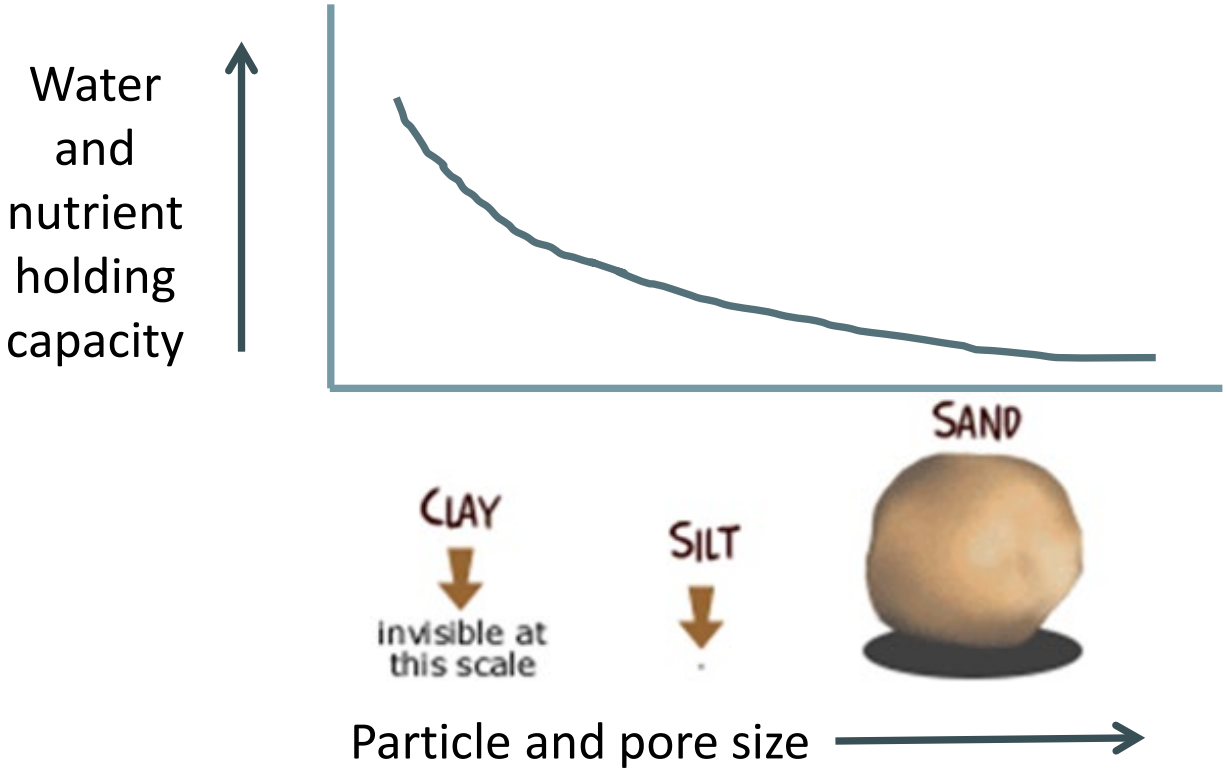
What to look for on a soil test report? Factors affecting plant health and production

Factor	Values of concern	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 (%)	N credit
Soil pH	< 5	Al toxicity
	< 6	Poor seedling establishment and legume nodulation
	> 8.3	Nutrients tied up, likely high Na
Soluble salts (EC)	> 4 (mmhos/cm)	Too saline, water stress, nutrient imbalance
Soil texture and CEC		Water and nutrient holding capacity

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

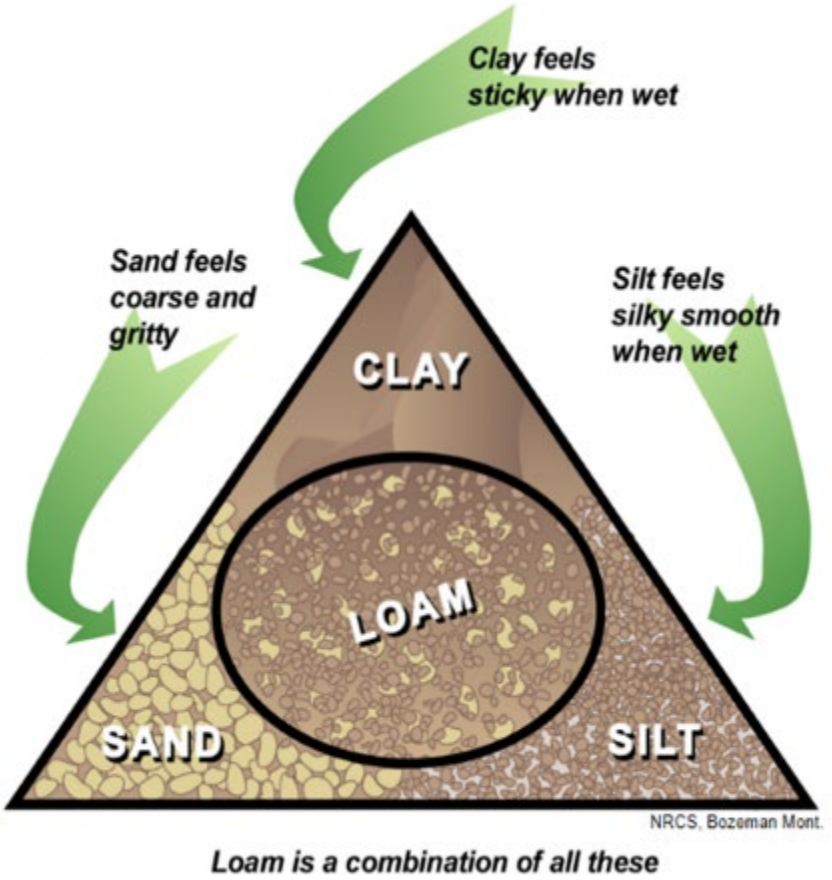
Mason jar test instructions at
http://landresources.montana.edu/soilfertility/documents/PDF/SoilTextureJarTest.pdf

Mason jar texture test

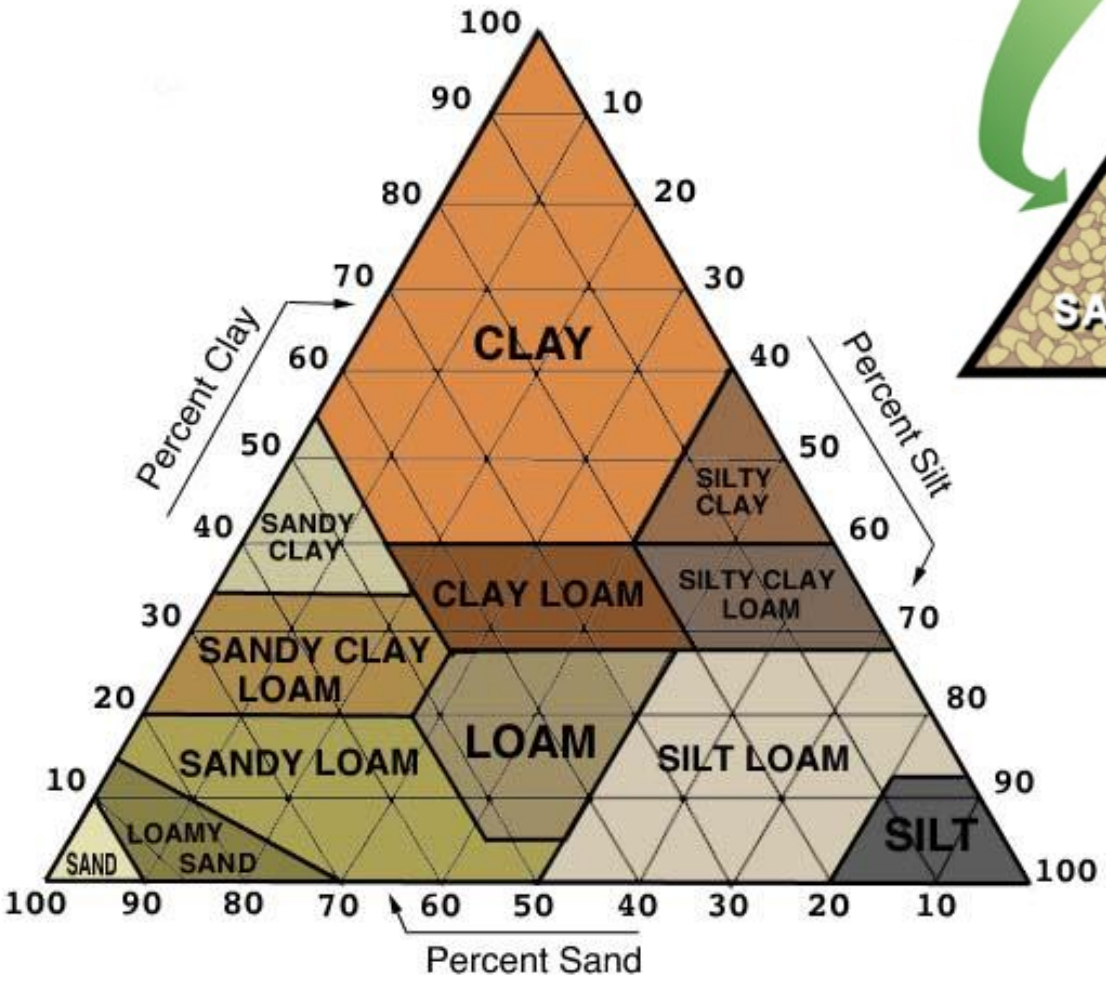
- Fill a straight sided jar 1/3 with soil
- Add water until almost full
- Add 1 tsp **dishwasher** soap or water softener (why?)
- Shake and let settle
- Mark sand depth at 1 min.
- Mark silt depth after 2-6 hours (or by color/texture change with clay at 24 hr)
- Calculate clay by difference (or measure at 24 hours)

http://landresources.montana.edu/soilfertility/documents/PDF/SoilTextureJarTest.pdf

Using the soil texture triangle



Loam is a combination of all these



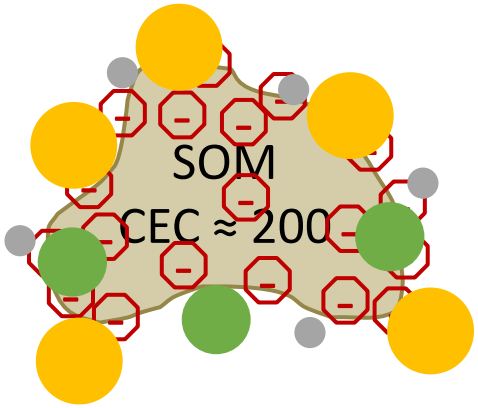
Texture Effects on Soil Properties

	Drainage Infiltration	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.

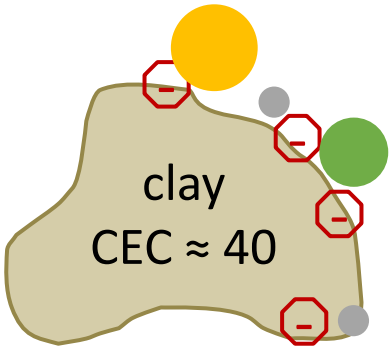
Cation Exchange Capacity CEC

the parking spaces for nutrients in the soil

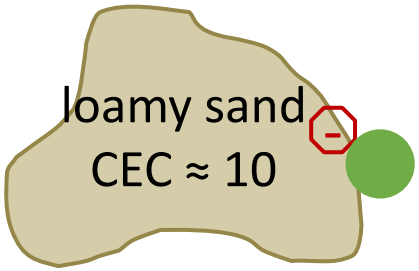


- CEC is the total neg. charge on a soil (meq/100g)
- A high CEC soil (> 15) has the capacity to attract and hold nutrients with positive charges, e.g. K^{+}, Zn^{+2}, NH_4^{+}
- Large surface area (clay, SOM) ≈ larger CEC ≈ generally more fertile.
- What else might high CEC soils hold onto?

  Herbicides
- CEC of mineral soil is hard to change but can slowly change SOM



1 Tbsp has surface area of a football field

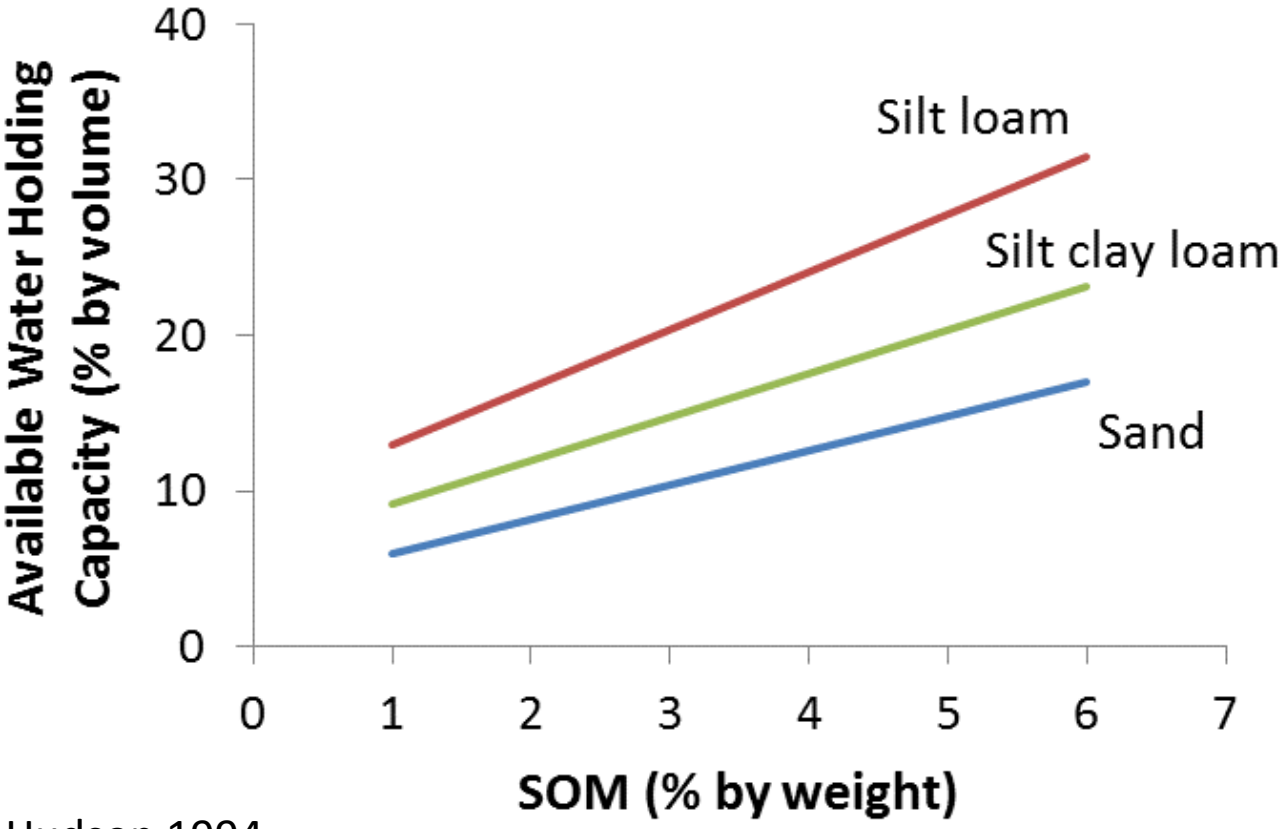


1 Tbsp sand has surface area of a kitchen table

SOM = Soil organic matter

What does SOM do for soil?

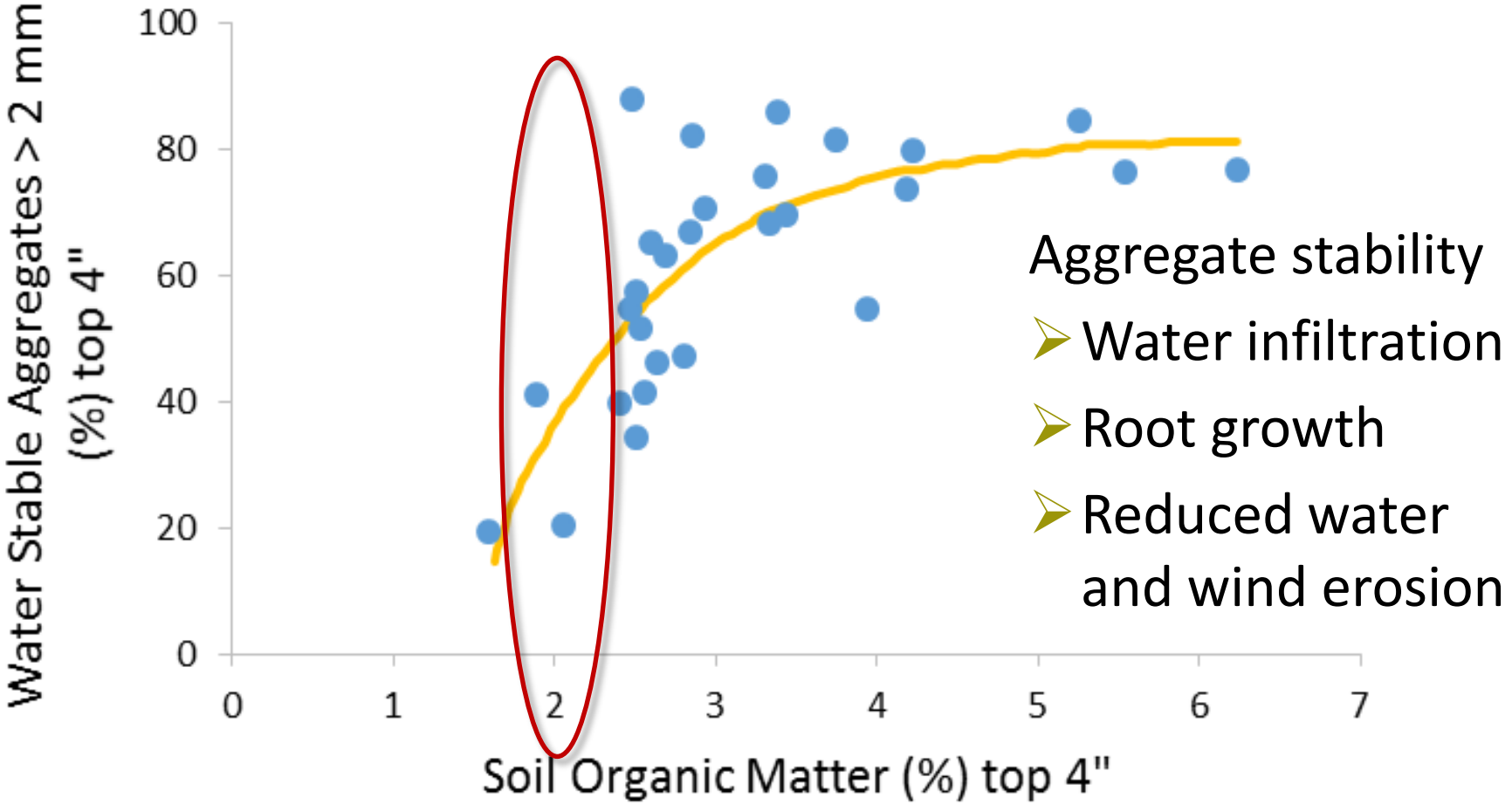
- As decomposes it releases nutrients bound in OM structure



Hudson 1994

- Increases water holding capacity which helps nutrients move from soil to plant roots and should increase yield

Small increases in SOM lead to potentially large improvement in soil structure



Aggregate stability

- Water infiltration
- Root growth
- Reduced water and wind erosion

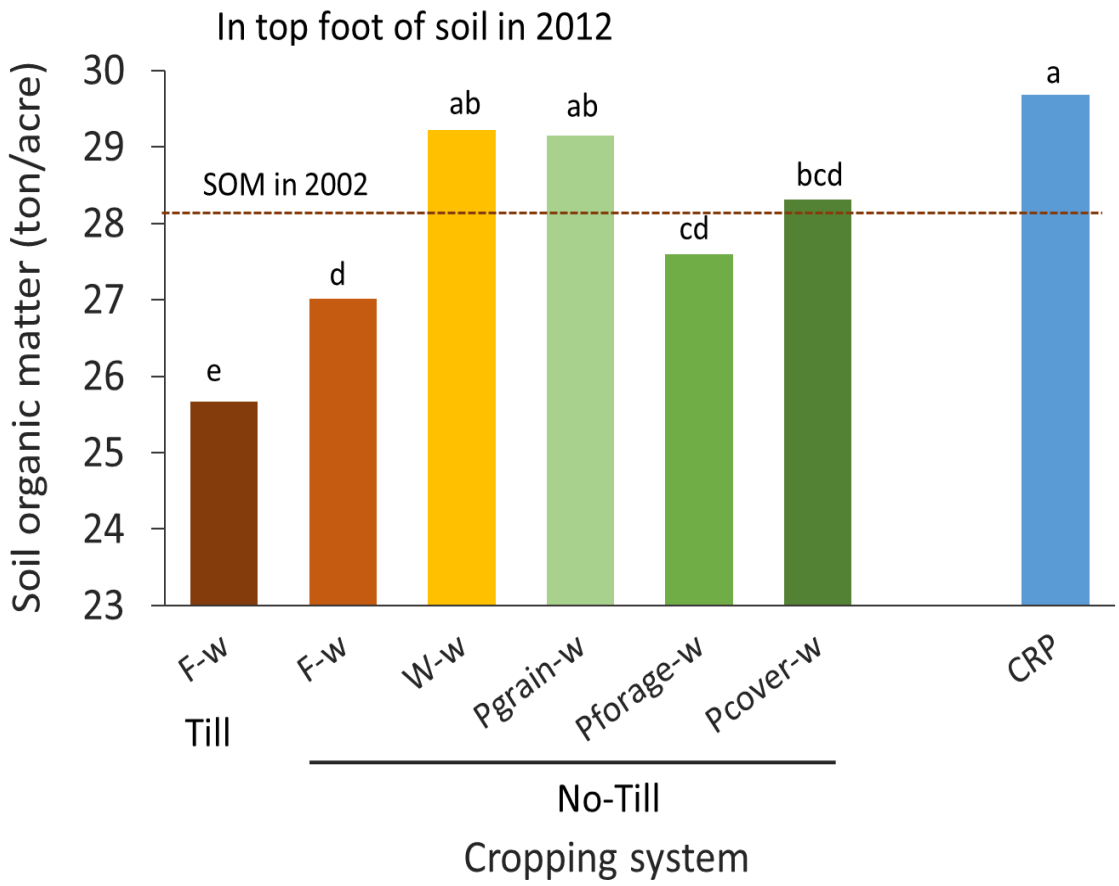
Fisher et al., 2007
Australia, irrigated, variety of soil types

Changing SOM?

- Guesses on how long to increase soil organic matter (SOM) from 1.4 to 1.5%?

1. 2 years
2. 10 years
3. 20 years
4. 50 years

- A long time. MSU study, CRP increased SOM from 1.4% to 1.5% in 10 years in top foot.
- Fallow, especially tilled – loses SOM!
- Hay, or heavily grazed pasture maybe maintaining, likely losing SOM



Engel et al. 2017

Questions?

Find CEC, Salts (EC), SOM and texture on soil test

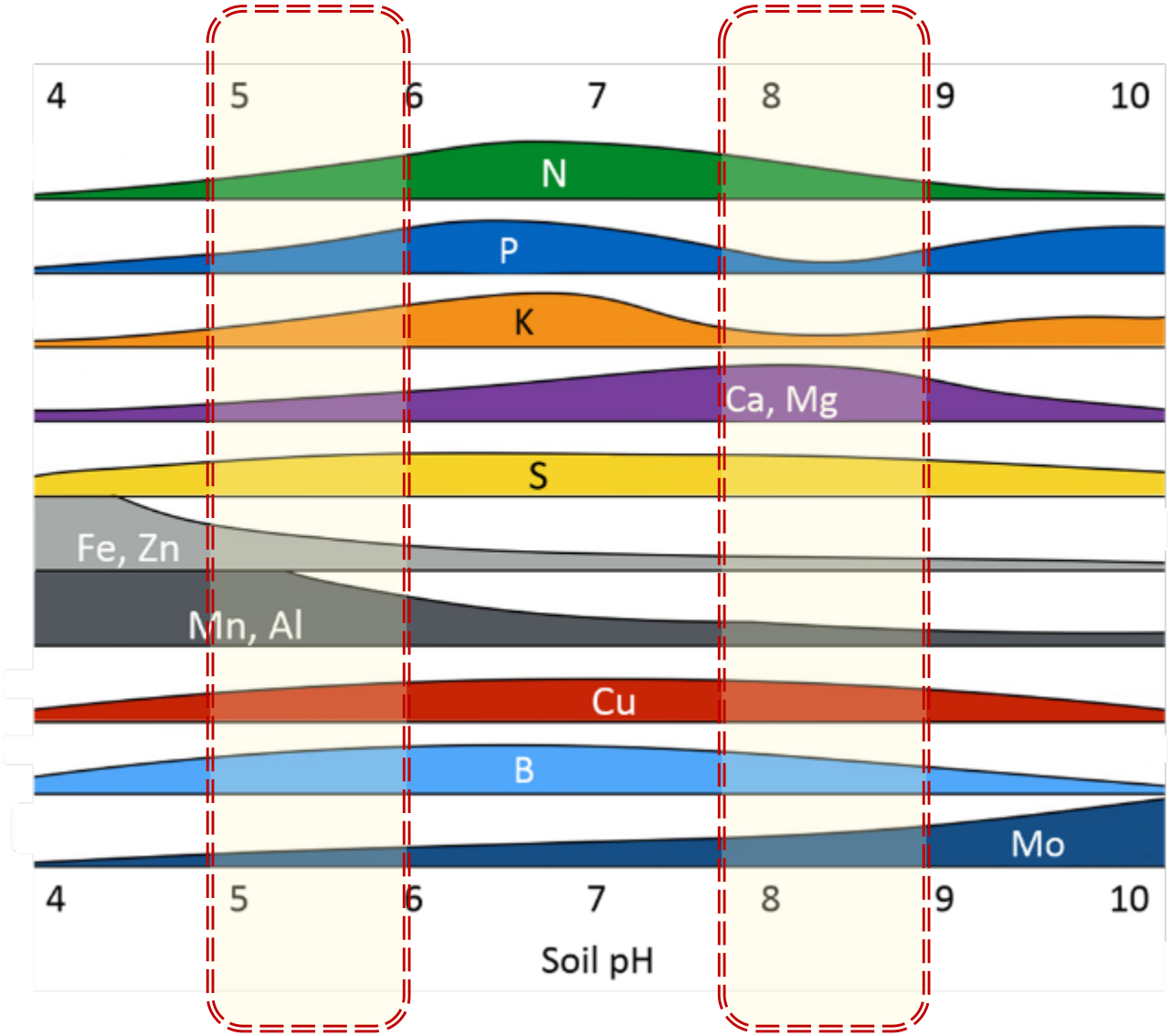
Factor	Values of concern	Impact/consider
Soil organic matter	≤ 1 (%)	Minimize bare soil, increase N, add legumes
	> 3 (%)	N credit
Soluble salts (EC)	> 4 (mmhos/cm)	Too saline, water stress, nutrient imbalance
Soil texture and CEC		Water and nutrient holding capacity

On to pH

pH affects soil nutrient availability

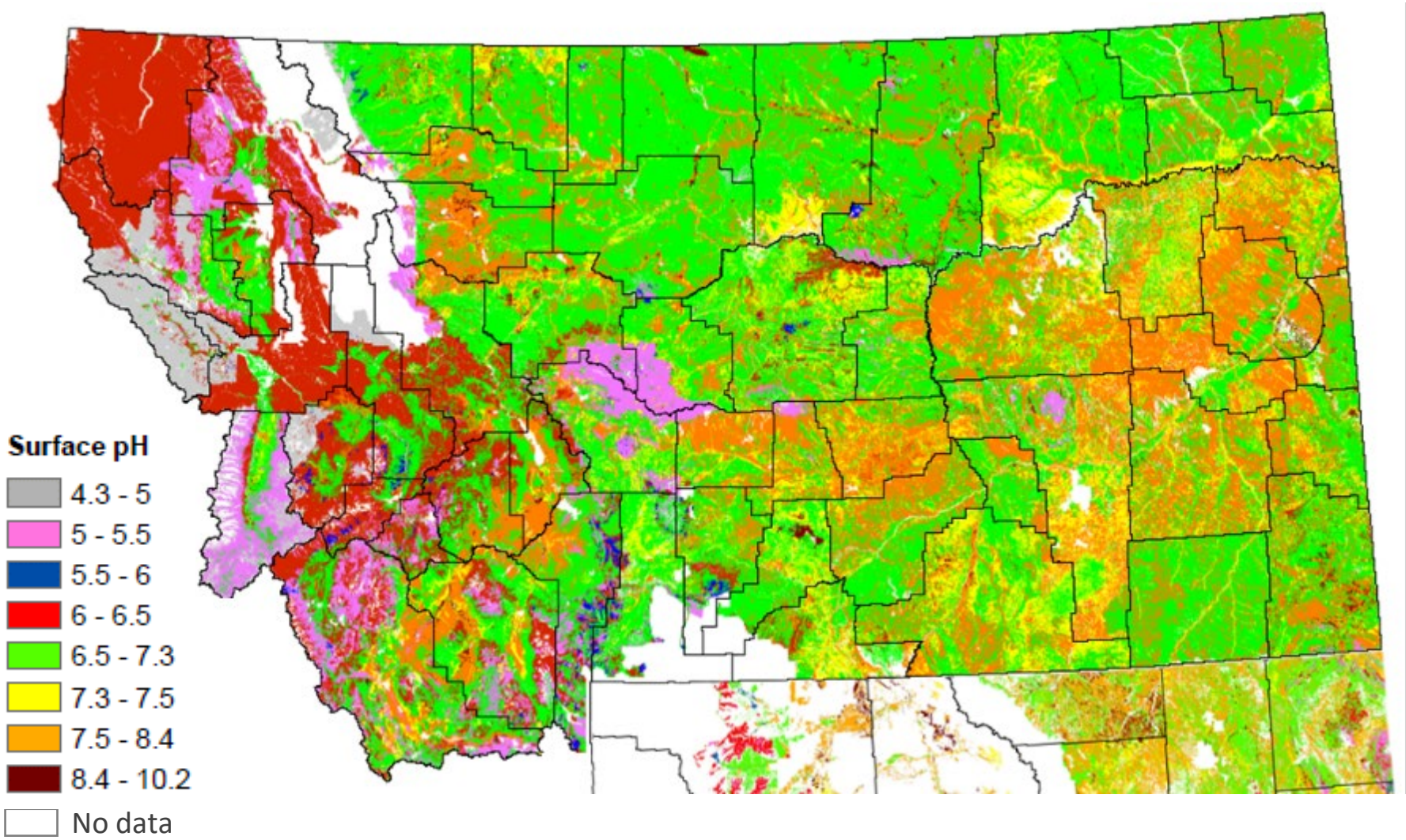
Low pH, acidic soils – may limit N, and eventually Ca, Mg, K, Mo because they don't stick tight and can leach away (Fe) or form minerals (P), Al toxicity

High pH, alkaline calcareous soils – may limit P, Fe, Mn, B, Cu, Zn, plant can't get them



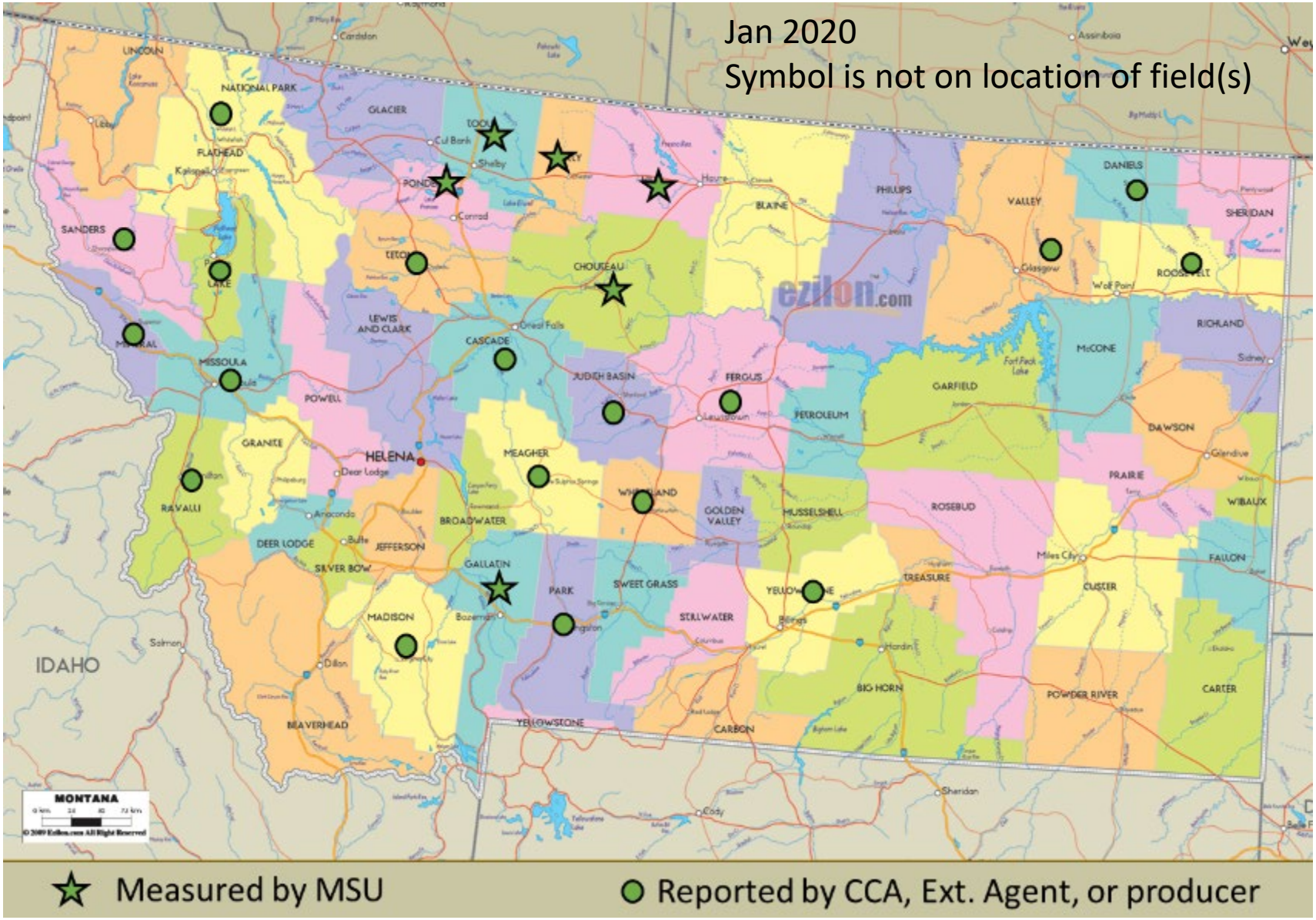
Troeh and Wegner, 2013

What were historical surface horizon pH values in Montana?



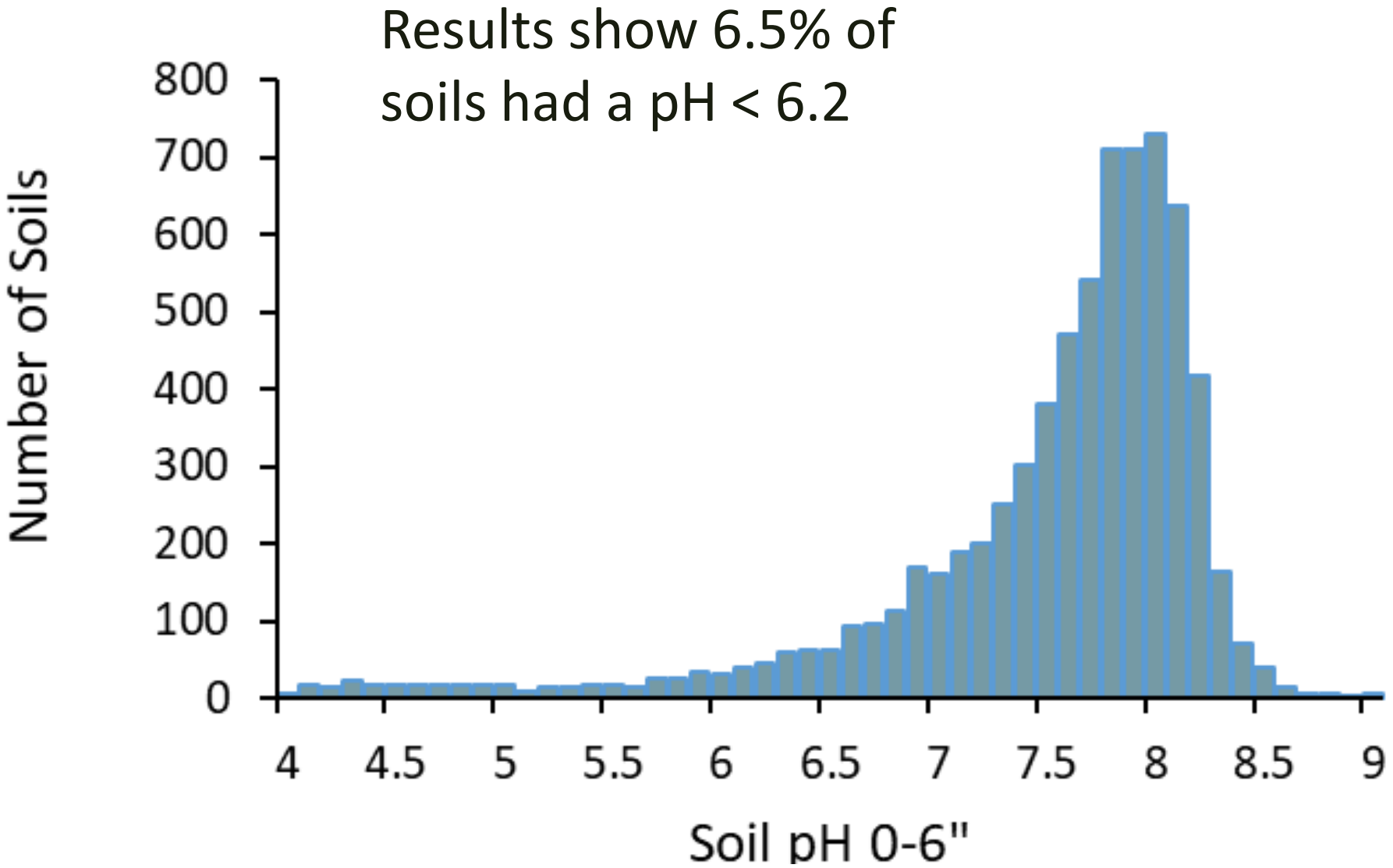
Map courtesy of Bill Drummond, MT NRCS

Soil acidification: MT counties with at least one field with pH < 5.5



40% of 20 random locations in Chouteau County have pH < 5.5 in top 2”

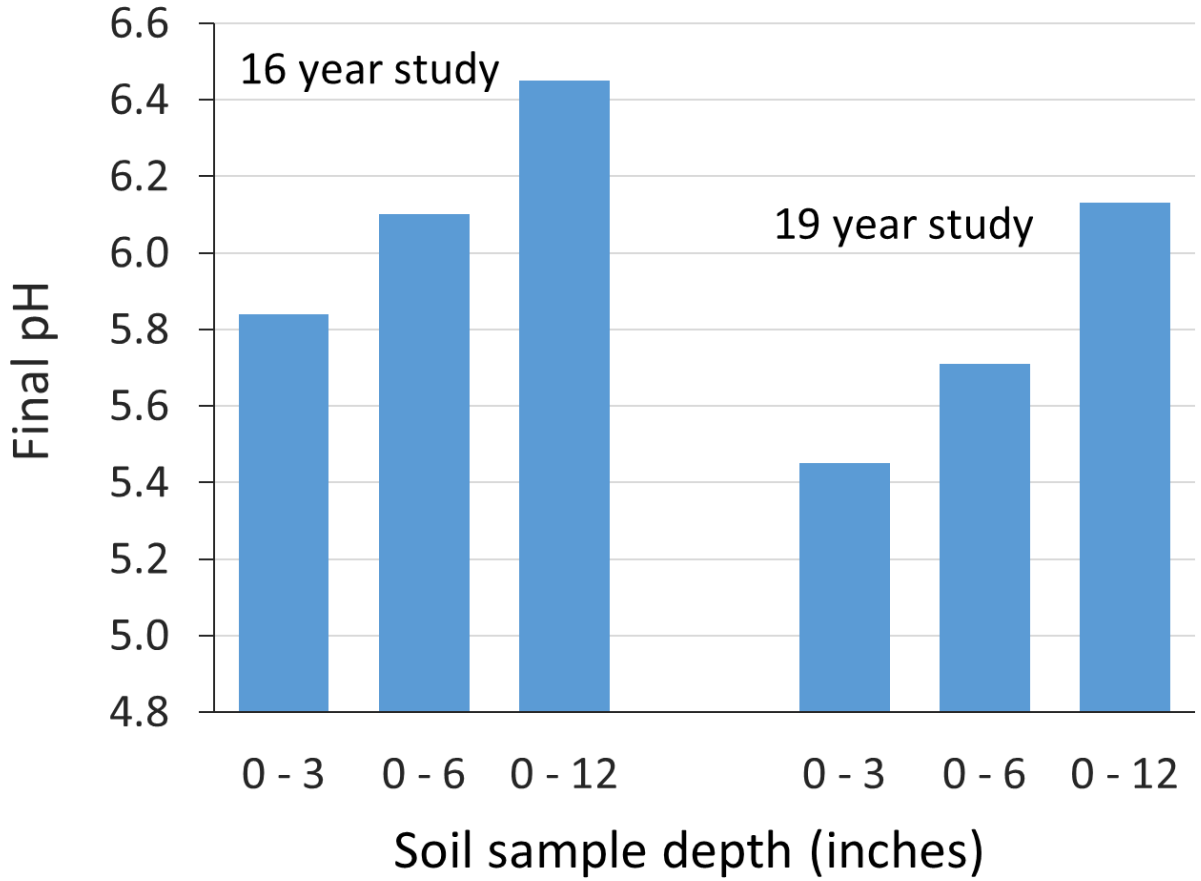
Soil pH distribution north central MT, 2018



AgVise Lab, ND, 7130 samples; Reeves and Liebig 2016, Mandan, ND

Soil sampling for pH

1. Field pH test on soil/water slurry of top 3” or send to lab.
   Why not the standard 6”?



2. Test 3-6” if might till.
3. Avoid compositing samples from different slope areas.

Reeves and Liebig 2016, Mandan, ND

Is this a real issue or us looking for more work?

Safflower field near Big Sandy, 2018
pH 4.3 – 4.5 in bare areas

Image courtesy Scott Powell

Crop losses from low pH are due to:

- pH < 5.2 Al toxicity
- pH < 6.0 limited N-fixing nodules on legumes
- pH < 6.0 increase in Ceph. stripe disease
- Change in herbicide efficacy and persistence

- Crops' tolerance varies with species and variety

More about this in February 10 session

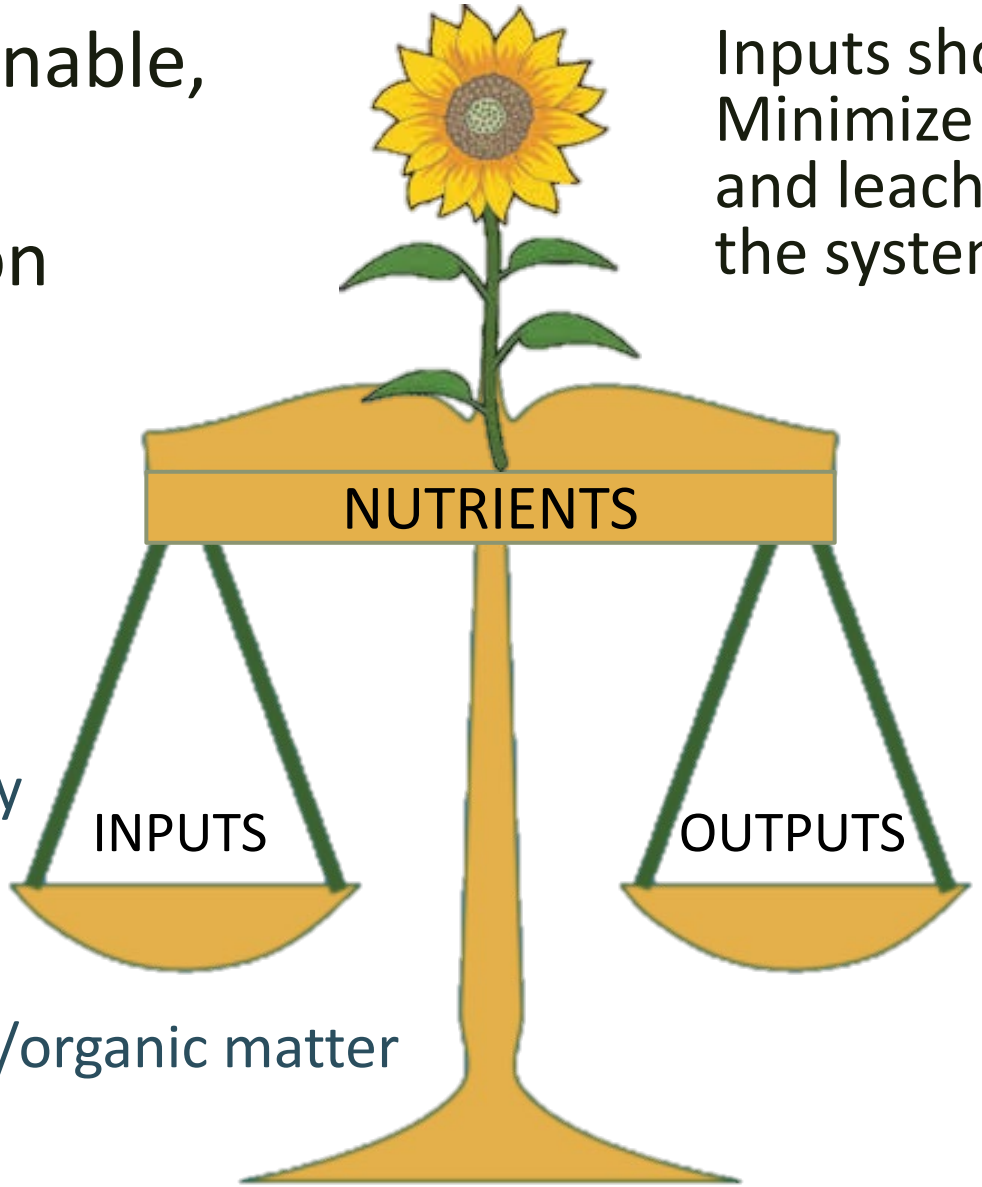
Crop	Min pH
Alfalfa	5.7
Barley	5.3
Pea	5.5
Wheat	5.1-5.4

Questions?

On to soil nutrients

For sustainable, healthy production

Inputs should = Outputs
Minimize erosion, runoff and leaching losses from the system



Fertilizer
Manure

N-fixation by legumes

Mineral soil/organic matter

Harvest

Erosion

Runoff

Leaching

Escape to atmosphere

In many ag systems, outputs > inputs = mining the soil for nutrients
Loss of soil productivity leads to financial loss

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

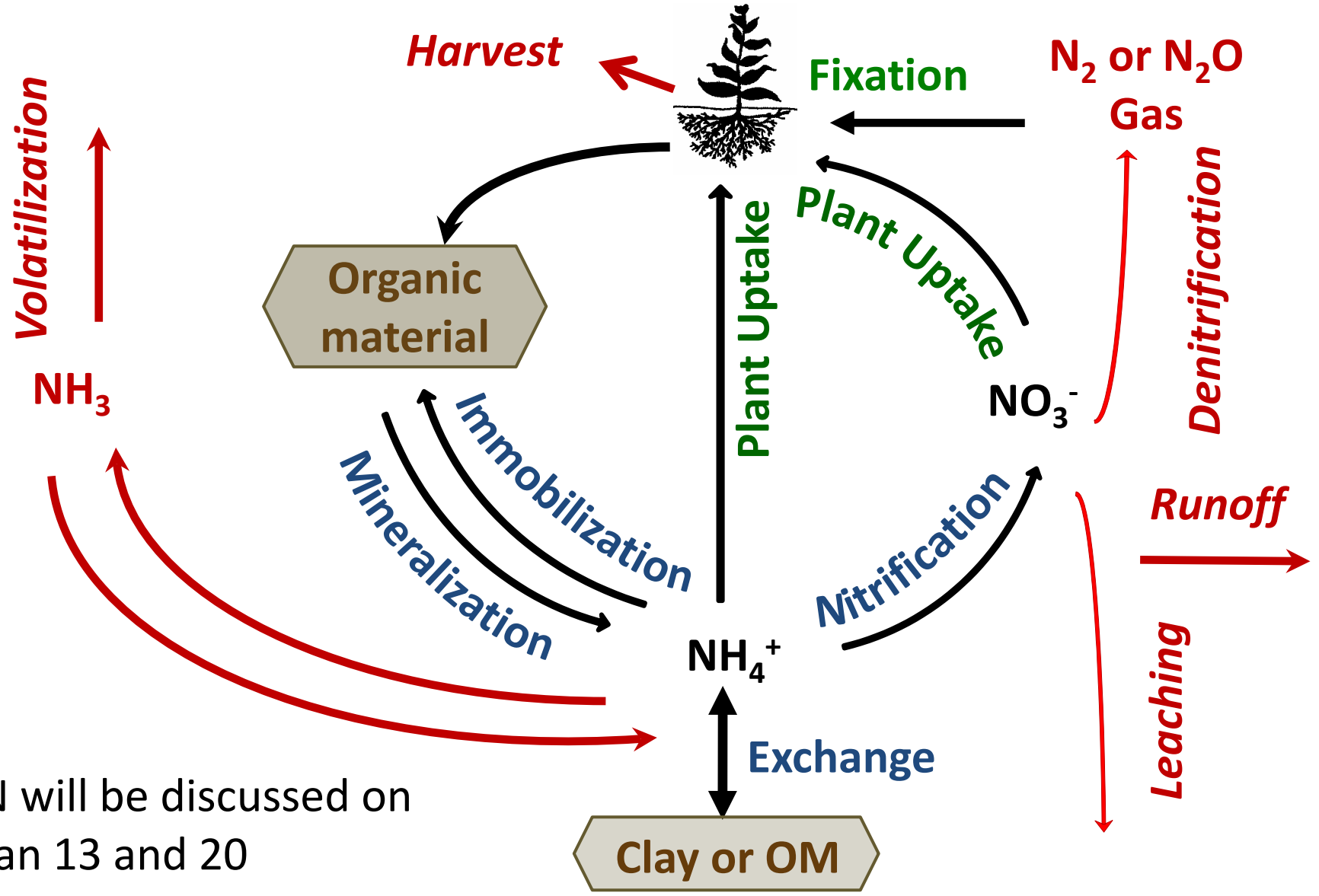
Macronutrients	Micronutrients
Nitrogen (N)	**Boron (B)**
Phosphorus (P)	**Chloride (Cl)**
Potassium (K)	**Copper (Cu)**
Sulfur (S)	**Iron (Fe)**
Calcium (Ca)	**Manganese (Mn)**
Magnesium (Mg)	Molybdenum (Mo)
	Nickel (Ni)
	Zinc (Zn)

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

Mirconutrient focus of Jan 27, 2021 session

Nitrogen is most commonly lacking nutrient and greatest fertilizer expense

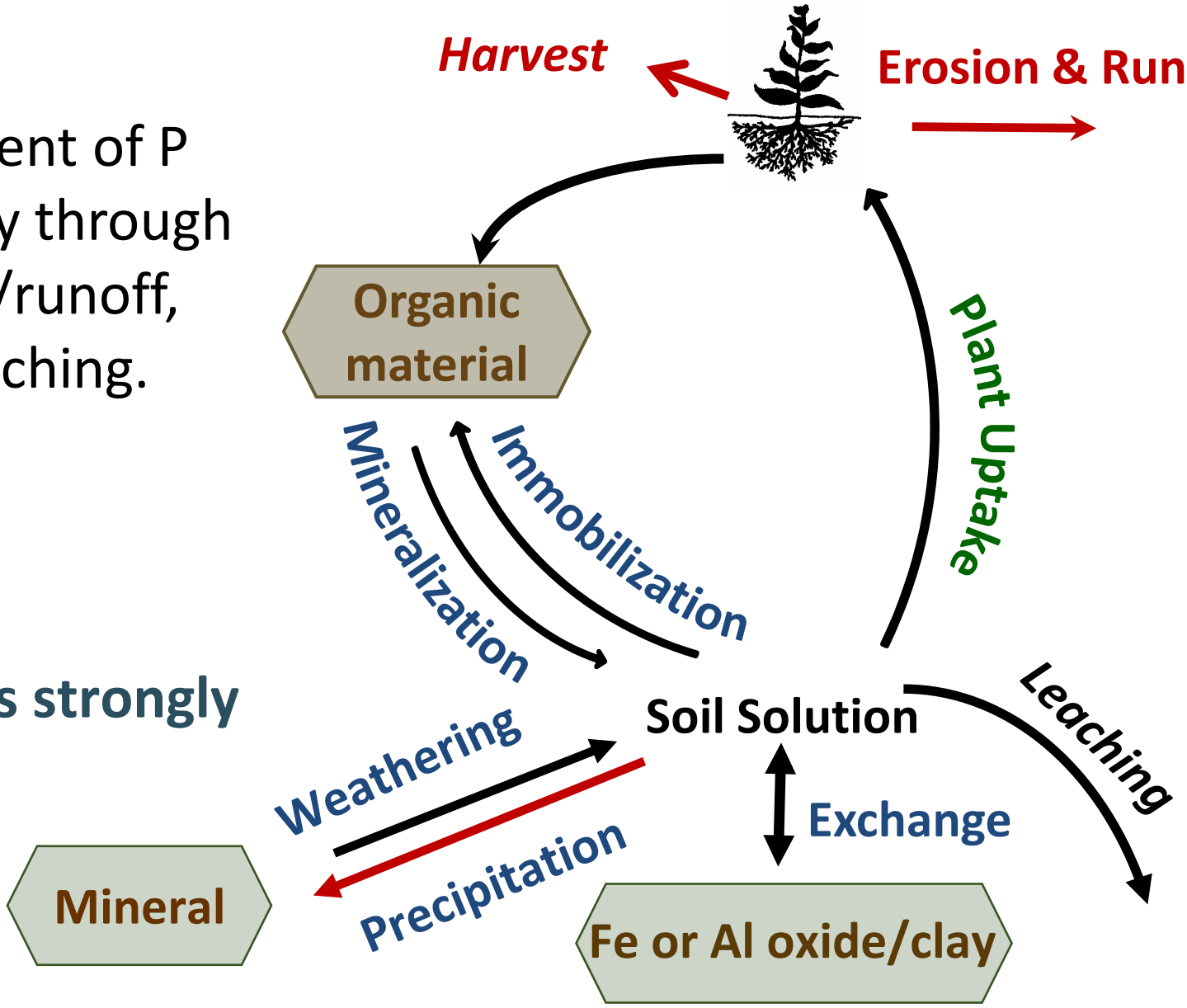


N will be discussed on Jan 13 and 20

Phosphorus is next nutrient most commonly added in MT fields

Movement of P is largely through erosion/runoff, NOT leaching.

Why?



P binds strongly to soil

Low soluble P concentrations due to:

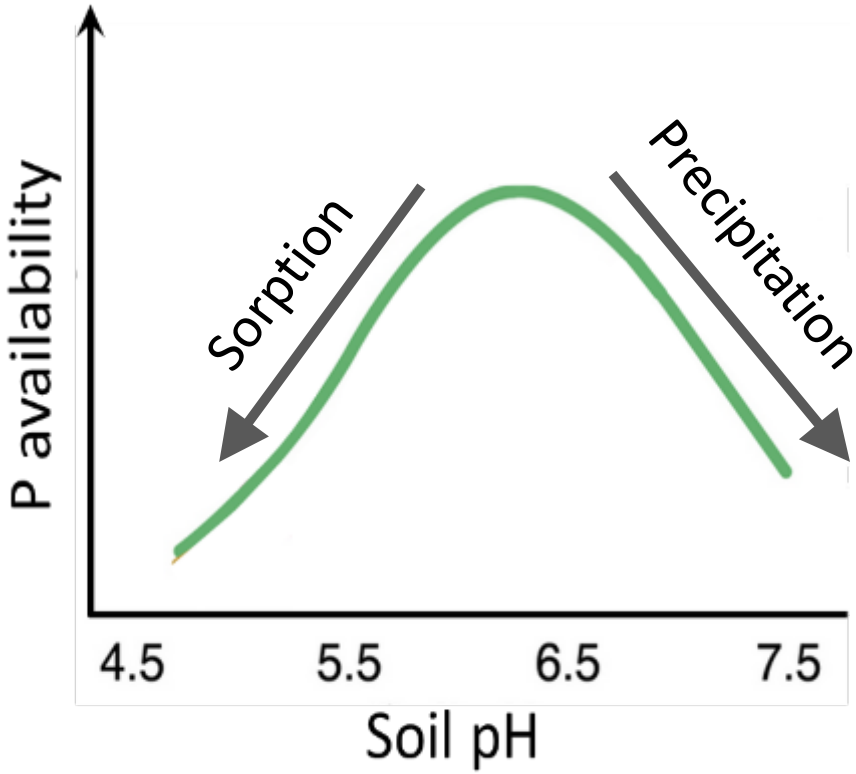
- Precipitation and low solubility of calcium phosphate minerals, in high lime soils
- Sorption (binding to soil) and precipitation with iron and aluminum increases at low pH and may becoming a concern in parts of MT

At what pH levels would you likely need to fertilize with more P?

A. Below ≈ 6

B. Above ≈ 7

C. Below ≈ 6 and above ≈ 7



Gov. W. Australia, Dept of Ag. and Food

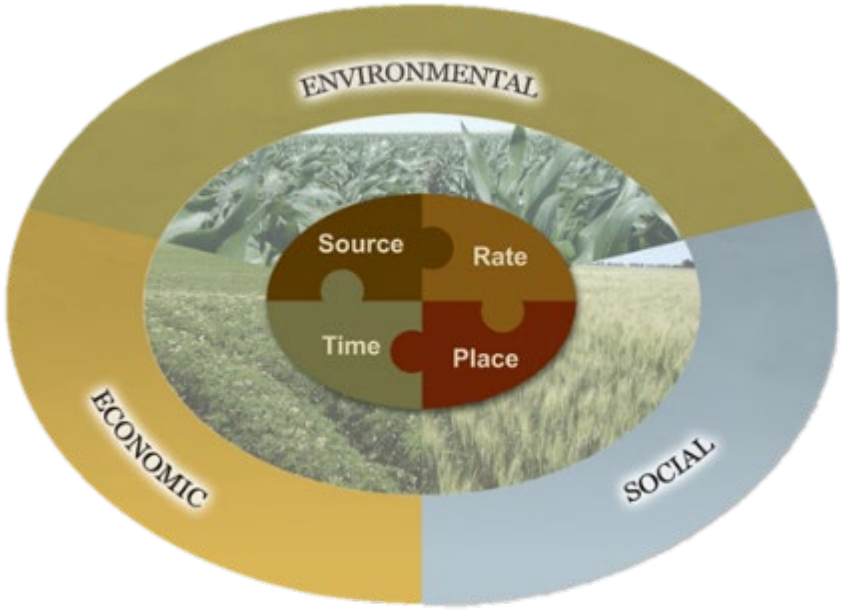
Questions?

On to soil testing and fertilizer rate calculations

How do I know what to add to my soil???

Questions to ask before you add fertilizer

1. Which elements do I need? (e.g. N, P, K, S, Zn)
2. 4R Stewardship, the right:
   - Rate
   - Source
   - Time
   - Placement
   - (Rotation)



3. Will I get a return ($ or environmental) on my investment?

Soil test: a first step to wise use of fertilizer $

- To help calculate fertilizer rates
- To identify nutrient deficiency or imbalance
- 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 MT200702AG and MT200803AG for instructions
- Home kits are not ideal. See our Soil Scoop on testing kits vs lab results

How to soil test and what to do before you send the sample to the lab

Use our Soil Scoops on soil testing

- *Getting a good sample*
- *Once you have the sample* check list

Soil sample checklist	
Date	
Location	
Garden/farm/forage	
Depth increment	
Tests	
* Nitrate-N, exch. K, pH, OM, EC	
* Olsen P (rather than Bray)	
Zn and/or Cl	
CEC and exchange-able Na	
Texture	
Prior crop	
Past management	
Intended crop	
Yield goal (if farm)	
* Required by NRCS	

https://landresources.montana.edu/soilfertility/soilscoop/index.html

Example soil test report

Location: Sample date:

Desired crop	Prior crop	Nitrate-N			P ppm		K ppm
		ppm	lb/ac	Depth (in)	Bray	Olsen	
Forage		2	4	0-6	13	5	161
Wheat	Fallow Cereal Legume ?		12	0-6	14	9	353
			15	6-24			
			9	24-36			
Ideal		Crop dependent			20-40	16 - 30	250 - 500

- Ideally an actual number, rather than a rating (low, medium, high, very high or deficient, sufficient) is provided.
- Drawback of soil test kits is usually rating only, no numbers
- Sometimes a recommendation is provided. Is yours based on DESIRED CROP yield goal? and MT GUIDELINES?

Online MSU soil fertility guideline calculator

http://www.sarc.montana.edu/php/soiltest/

Submit Clear form

1. Topsoil sample results:			*2. Soil Nitrate Results:*				
Olsen P	6	ppm	Sample #	top	bottom	Soil test value	
Extractable K	50	ppm	1	0	6	60	ppm
Soil Organic Matter	1.5	%	2	6	12	65	
			3	0	0	0	
			4	0	0	0	

3. Crop Management:		
Last year's crop: sugarbeet	New Crop barley-malt	Yield goal of 80 bu/acre

Submit

P calculations

MSU guidelines are based on *OLSEN P*. Type of P soil test to use is based on soil pH.

Crop	P (ppm)			pH
	M3	Bray1	Olsen	
Wheat	37	14	4	6.5
Ideal	61-90	20-40	16-30	6-7.5

- Bray works in pH < 7.3
- Olsen works pH > 6
- Mehlich-3 over broad range

In calcareous soils

[(Mehlich P/2.05) – 14] = Olsen P

How much fertilizer P (in lb P_2O_5/ac) for above wheat crop?

Table 18 (subset). P fertilizer guidelines based on soil analysis (EB0161)

Crop	Olsen P soil test level (ppm)				
	0	4	8	12	16*
	P fertilizer rate (lb P_2O_5 /acre)				
W Winter	55	50	45	40	35

* With P>16 ppm consider using crop removal rates (EB0161 Table 21) as P fertilization guideline.

Look at your soil test:

Soil pH?

P test type?

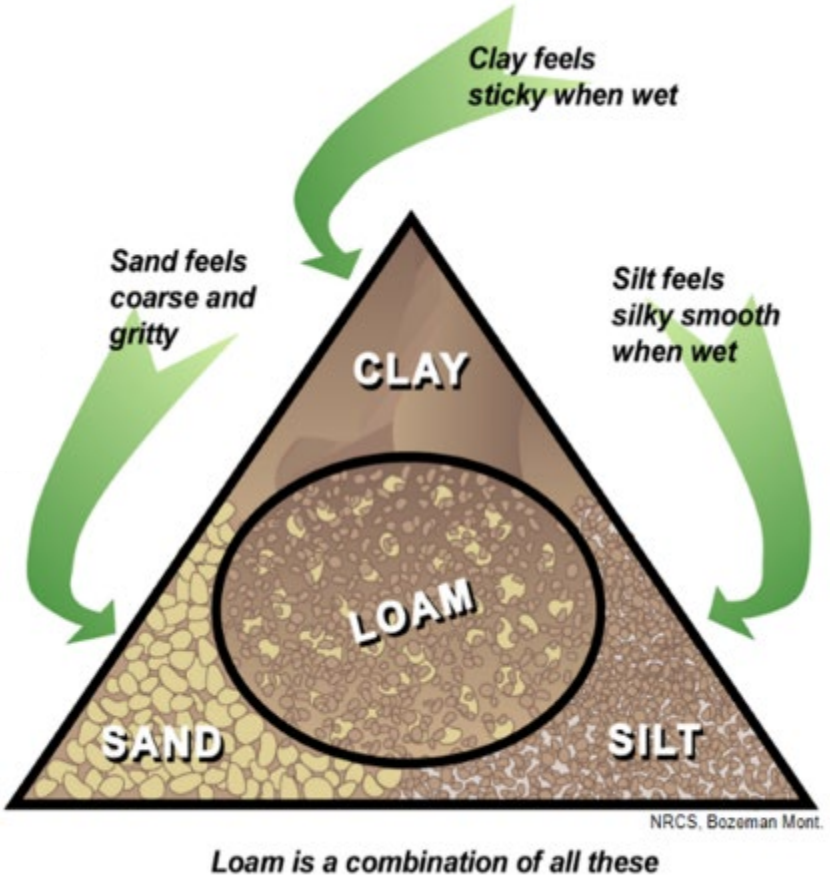
P soil test level?

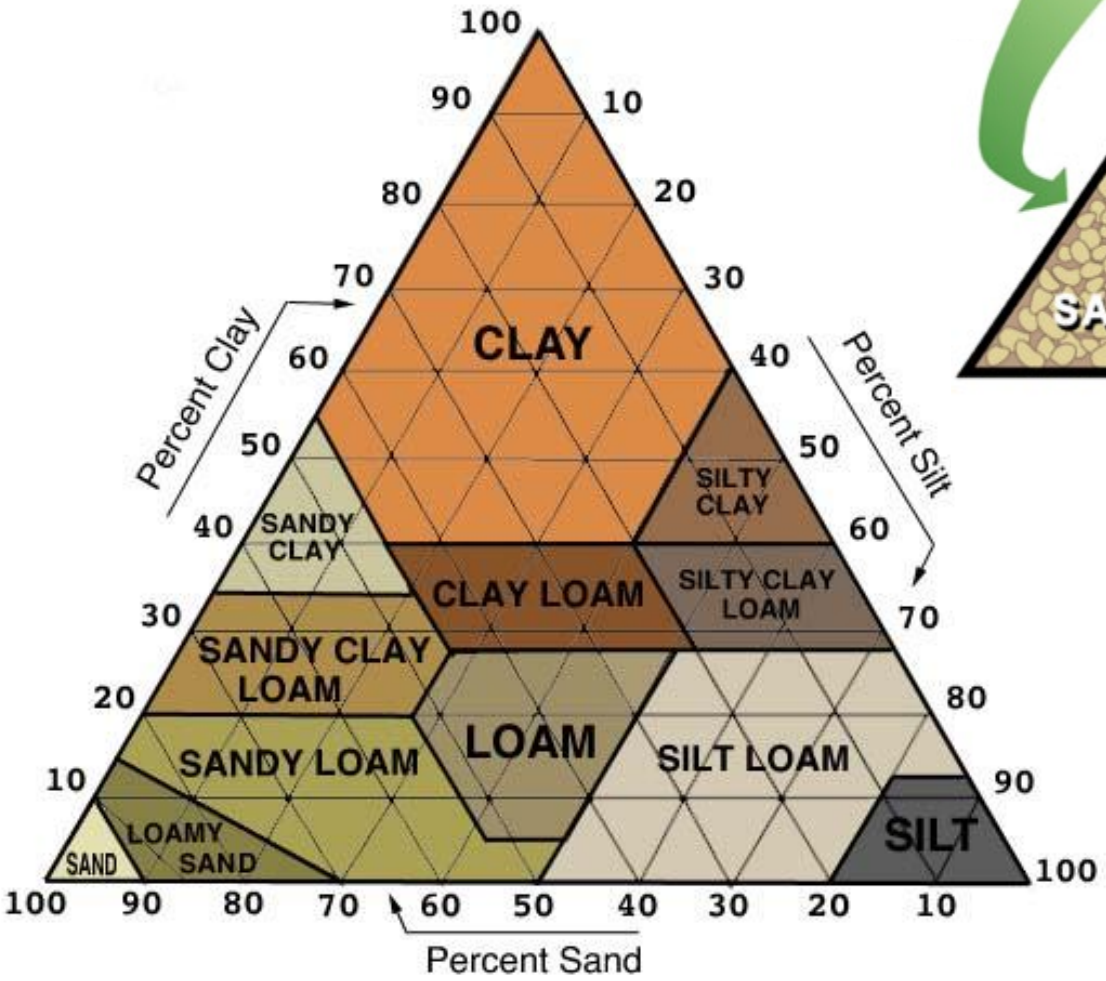
Recommendation?

Summary

- Understanding soil properties guides proper fertilization
- Soil tests, the online calculator and MSU Extension publications are important tools to calculate fertilizer rates, maximize plant heath, protect environment
- The right rate, source, placement and timing leads to optimal fertilizer use and plant health
- Observe and adjust to your specific conditions

Check your jar's silt level. Use the soil texture triangle





Note: silt should be measured at 6 hours, but who is going to be awake at that hour??

Resources

On soil fertility website under *Extension Publications*

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

- *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

Photo by Ann Ronning

Thank you! Questions?

Please help us improve this seminar series by completing the short evaluation; link provided in chat box soon.

Future sessions
Jan 13: N fundamentals
Jan 20: N specifics by crop type
Jan 27: Micronutrients
Feb 3: Forage Nutrient Mgt
Feb 10: Sustainable Nutrient Mgt
Feb 13: Cover crops

This presentation and more information on soil fertility is available at http://landresources.montana.edu/soilfertility