Managing for Cropping Success

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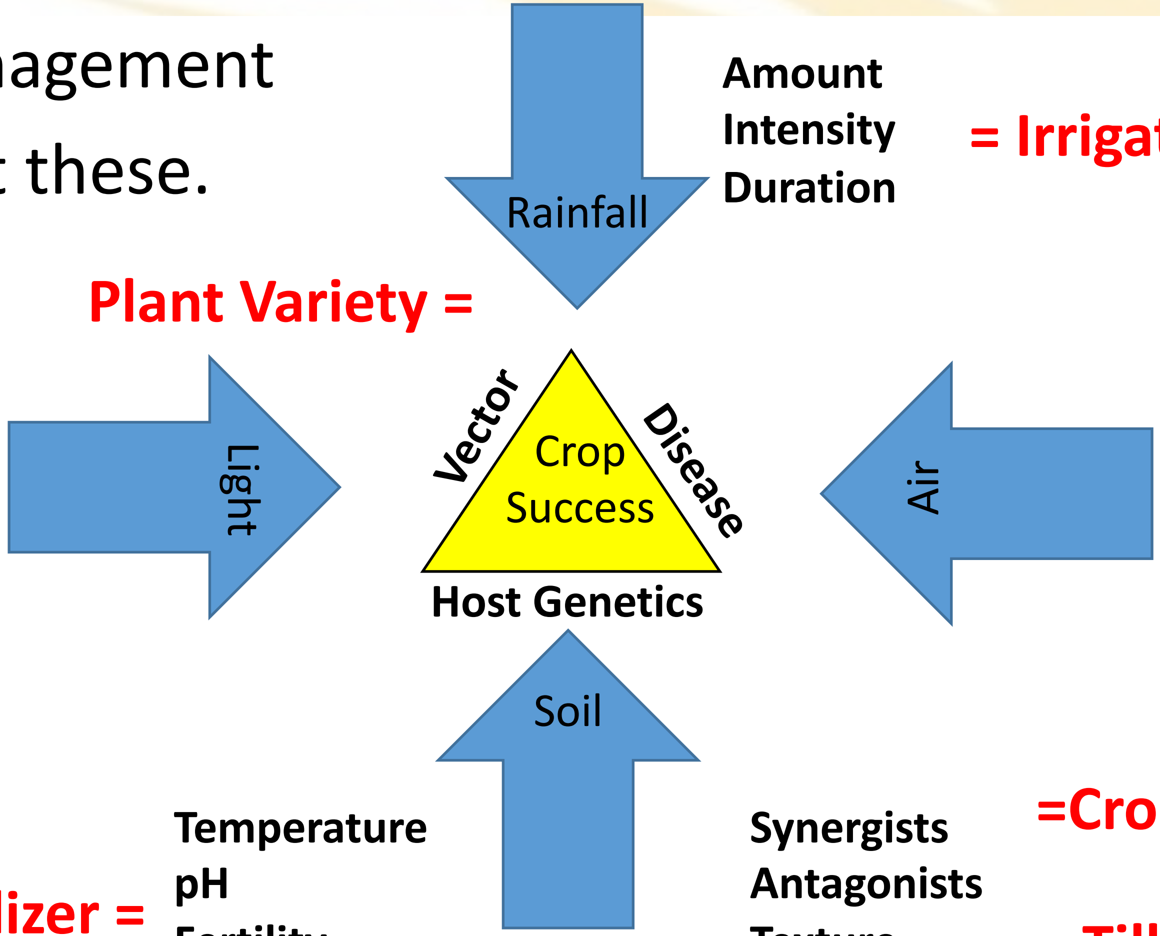
Ag Resources Consulting, Inc
Albany, MN

Organic Farming - More Than One Way to do Things

Organic Farming still about what a farmer can control.

- Different management decisions affect these.



Amount
Intensity
Duration

= Irrigation

Plant Variety =

Planting Date =

Intensity
Day Length
Heat Units
Quality
Other Factors

Pollutants
Temperature
Humidity
Direction
Velocity

Fertilizer =

Tile =

Temperature
pH
Fertility
Structure
Aeration

Synergists
Antagonists
Texture
Type
Crop Debris

=Crop Rotation/Cover Crops

= Tillage and Residue Management

The Main Challenges of Transitional/Organic Farms

Fertilizer

Weed Control

Weed Control

Lack of Fertility and Weeds

- Don’t want corn fields looking like this.
- Excess Fertility promotes weeds
- Low Fertility allows the weeds to compete and get ahead of the crop

Soil Fertility and Nutrient management

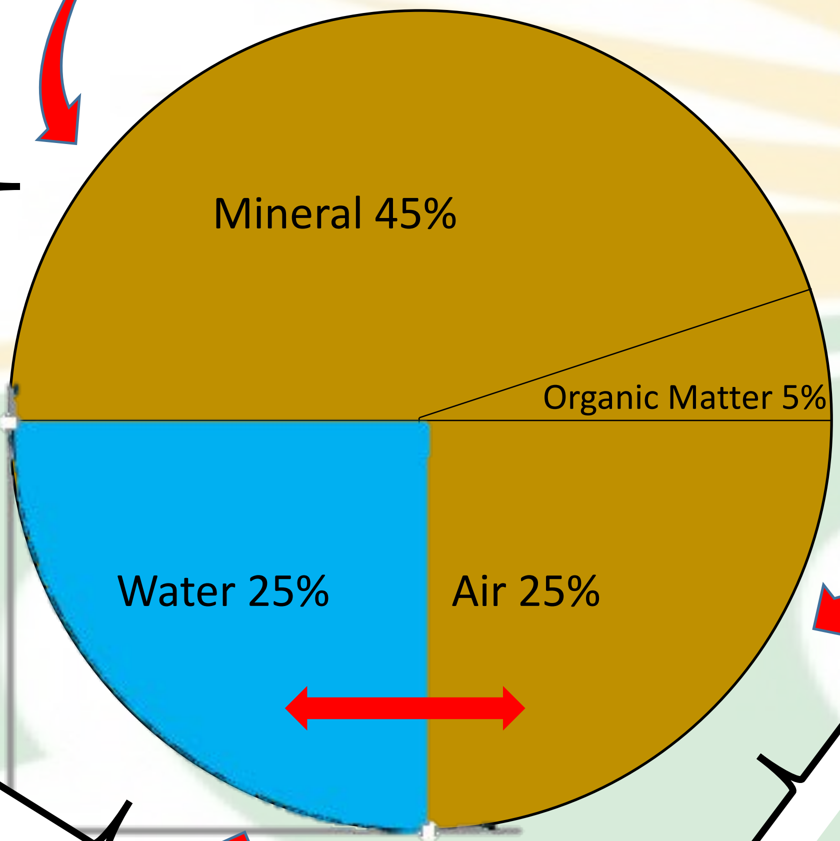
The One Solution for Everything

- There are no silver bullets.
- Conventional Farming is often easier to pigeon hole – reactionary practices
- Organic Farming needs to be a systems approach – proactive practices
- Organic is very limited in reactionary practices

Soil: Components We Can Manage

Soil Fertility

- Clay
- Silt
- Sand
- Rocks



- **Organic matter**
  - **a. Raw Material**
  - **b. Decomposing Material**
  - **c. Humus**
  - **d. Biology**
  - **e. Minerals**

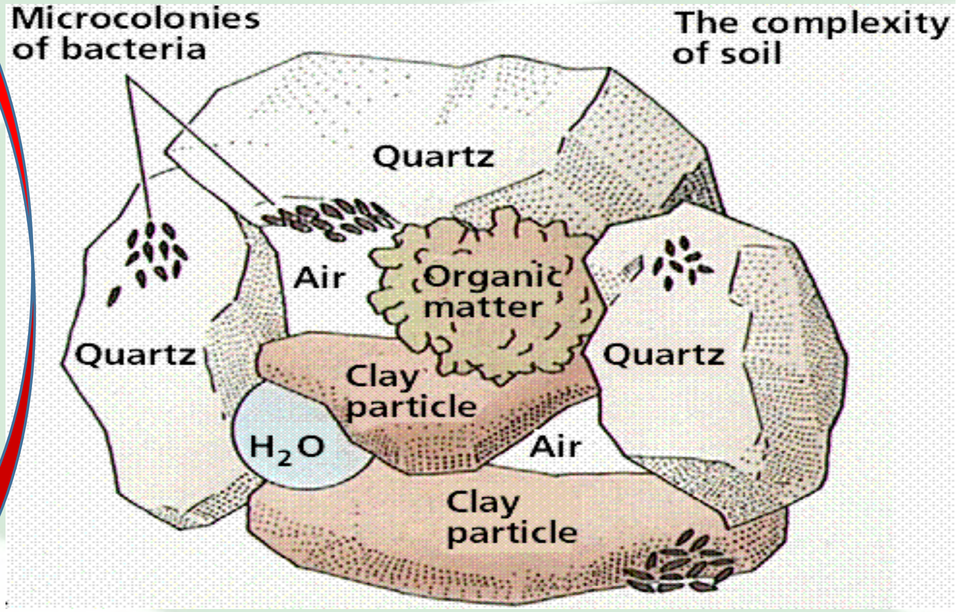


Image from http://www.emc.maricopa.edu/faculty/farabee/biobk/biobookplanthorm.html

Air

Water

a. Plant Available Water

b. Plant Unavailable Water

Soil Health

Variation Across Individual States

- Using Specific Recommendations
- University Recommendations verses site specific recommendations
- Minnesota, Wisconsin, North Dakota
  - Potassium availability and fertilizer applications
    - Vary by location
    - Difference in Parent Material

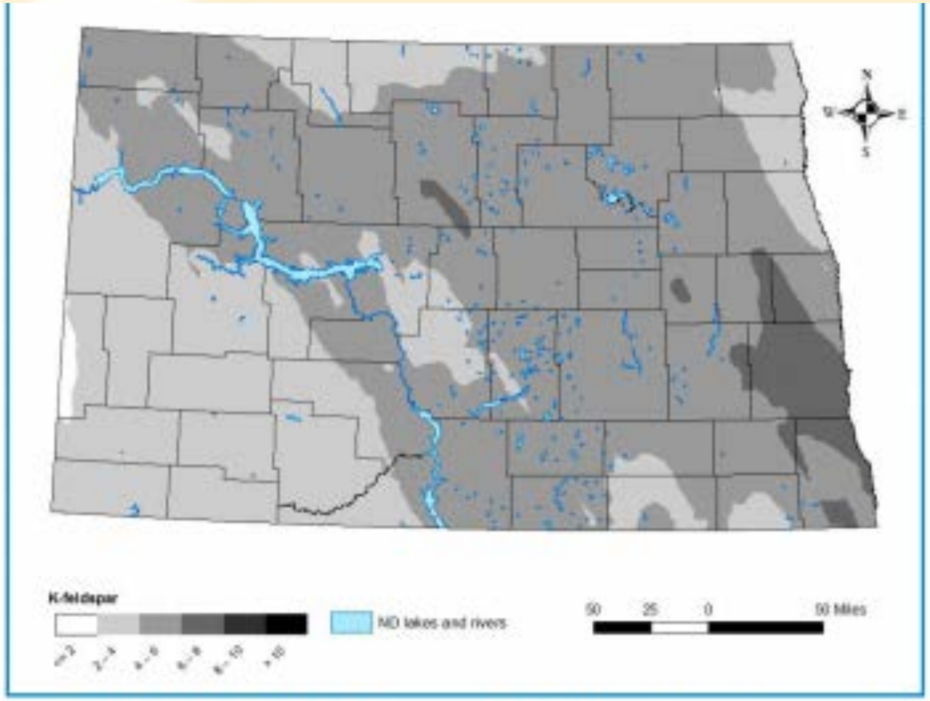
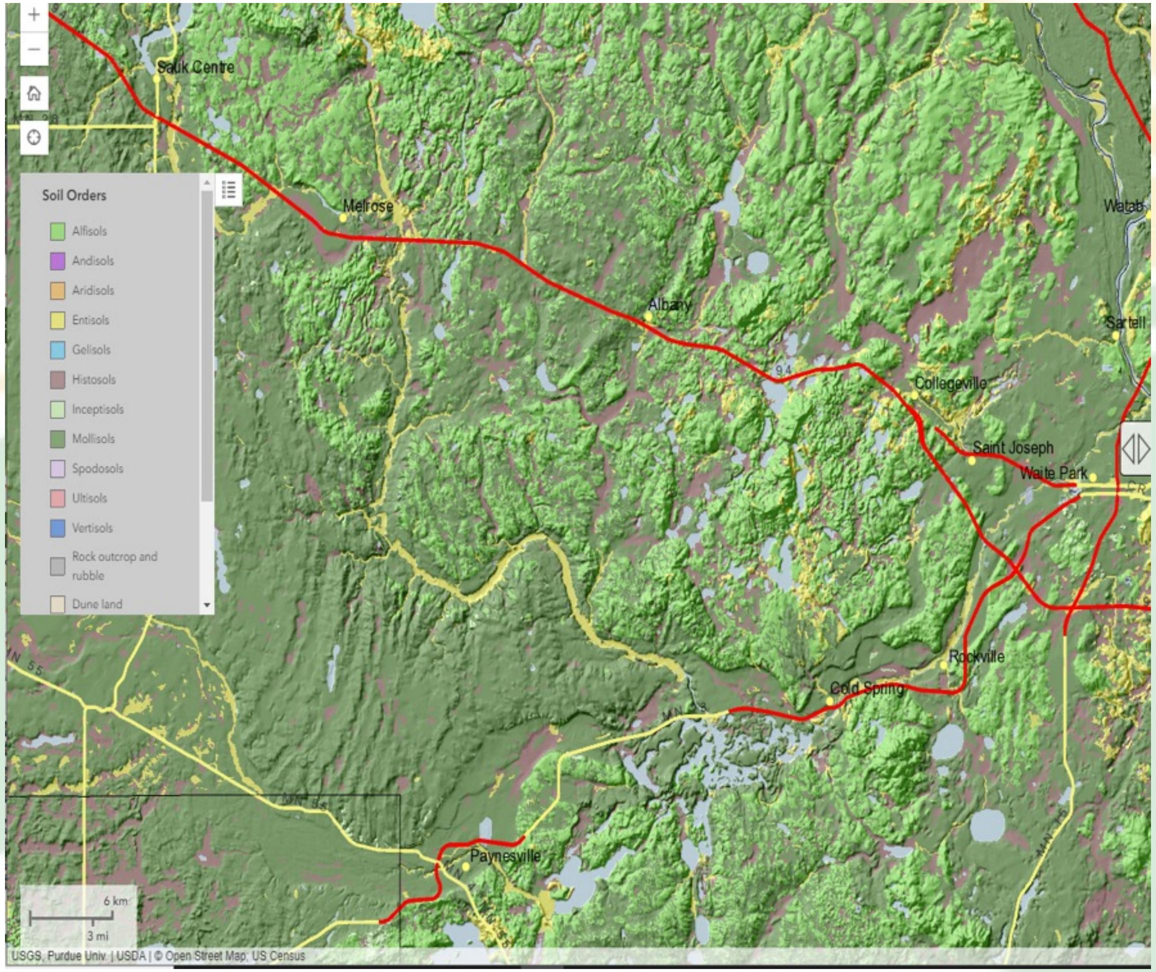
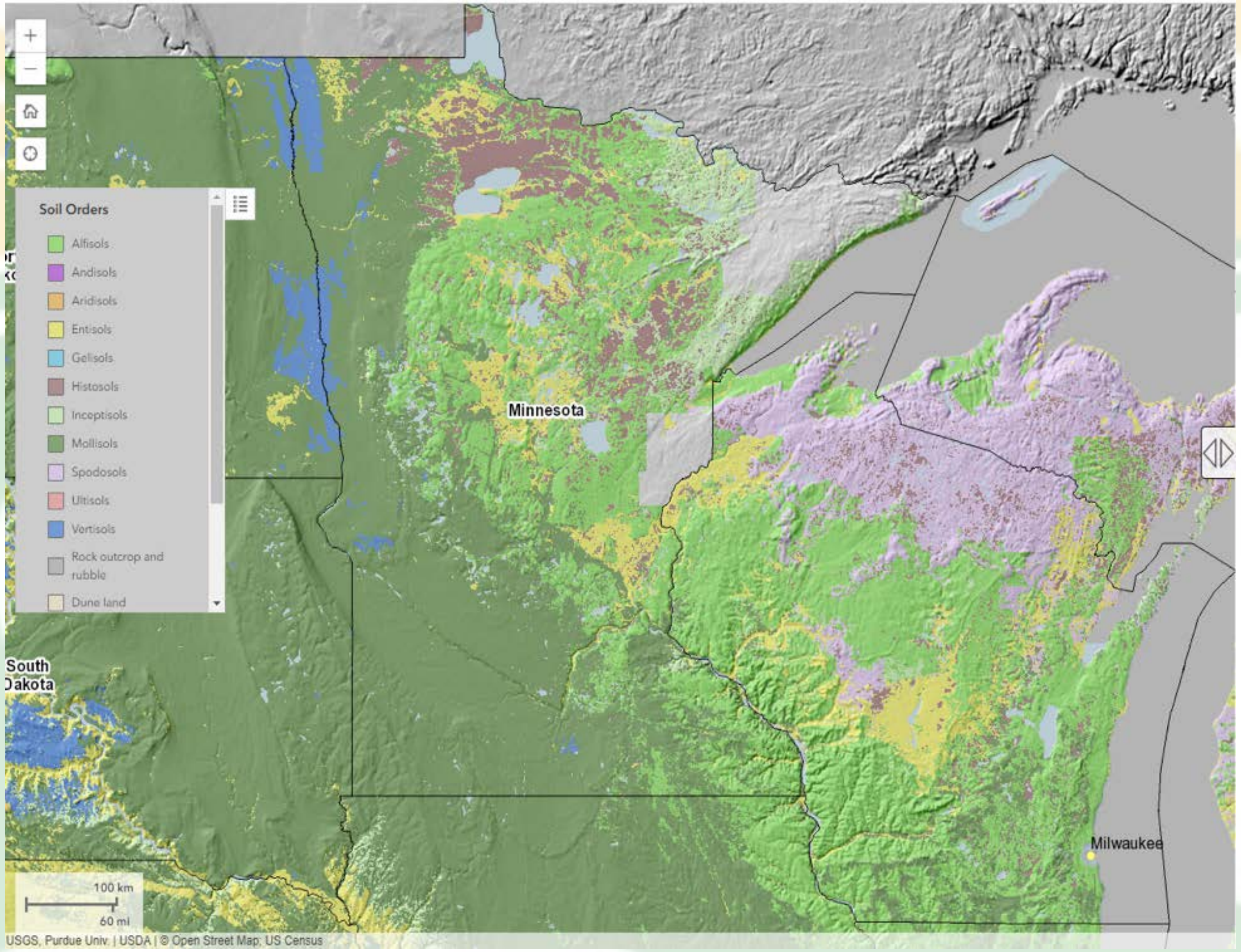


Figure 9. North Dakota K-feldspar content (%) in surface soil minerals.

Retrieved from https://www.ag.ndsu.edu/publications/crops/north-dakota-clay-mineralogy-impacts-crop-potassium-nutrition-and-tillage-systems/sf1881.pdf

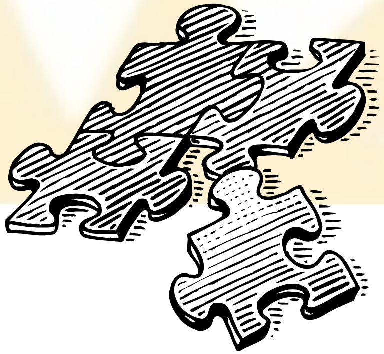
Temperature Zone and Soil Types of the Region





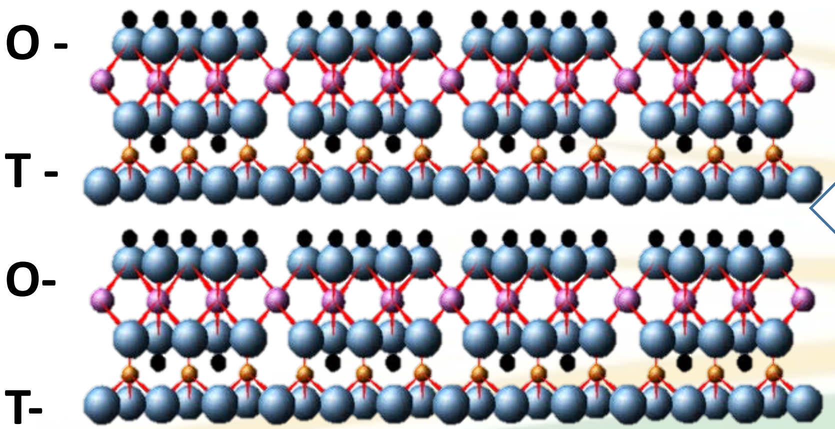
Retrieved from https://soilexplorer.net/

Clay Makeup Differs According to Region

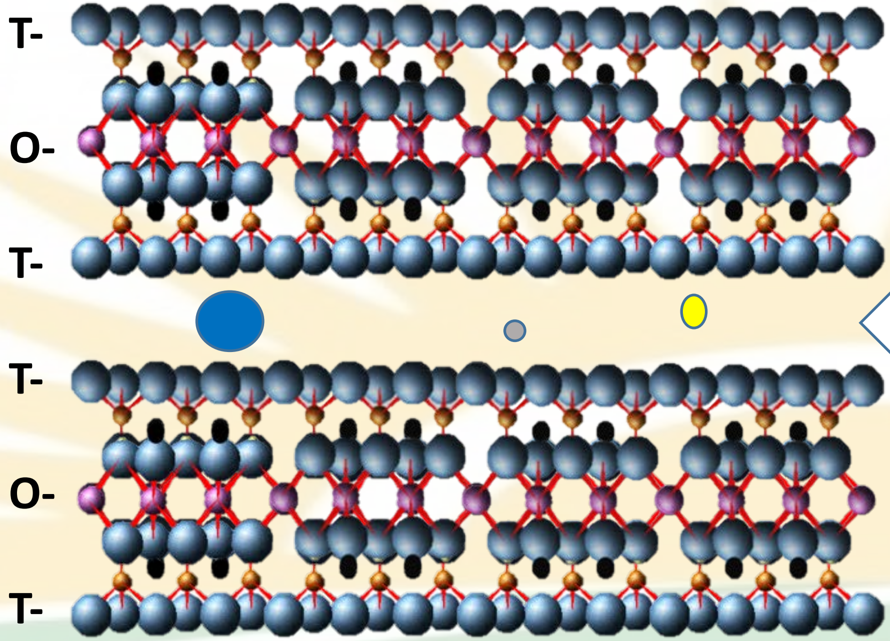


- Different clays are comprised of different elements.
  - Trioctahedral vermiculites
    - $K_{.8}(Mg_{2.5}Fe_{.5})(Si_{2.7}Al_{1.3})O_{10}(OH)_2$ - Release K, Mg, Fe, Si, Al, O, H
  - Kaolinite Orthochysolite
    - $Mg_3Si_2O_5(OH)_4$ - Release Mg, Si, O, H (No K release because not present)
- What Minerals are released from your soil depends on type of CLAY. Different regions need to address certain minerals because of this difference.
- Depends on location in an area because of different parent material.

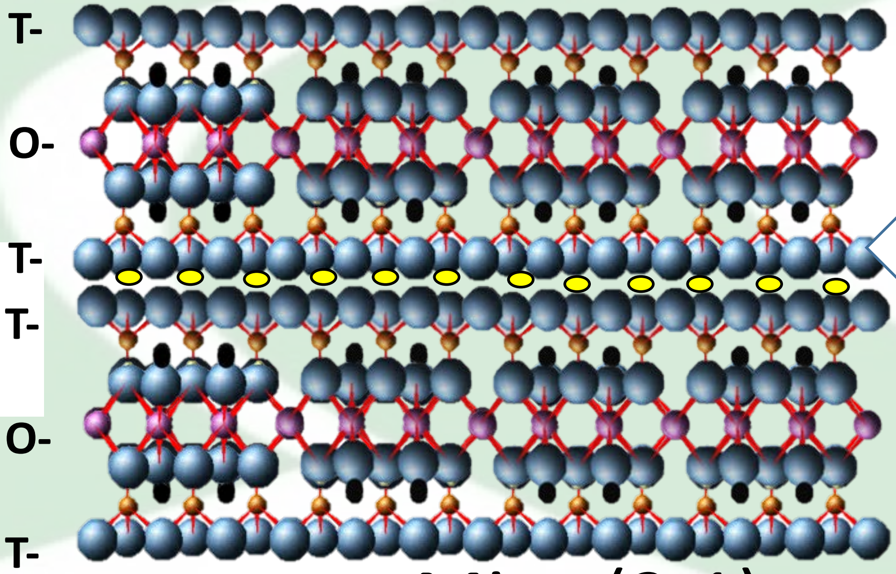
Composition of Clay



Kaolinite (1:1)



Smectite (2:1)

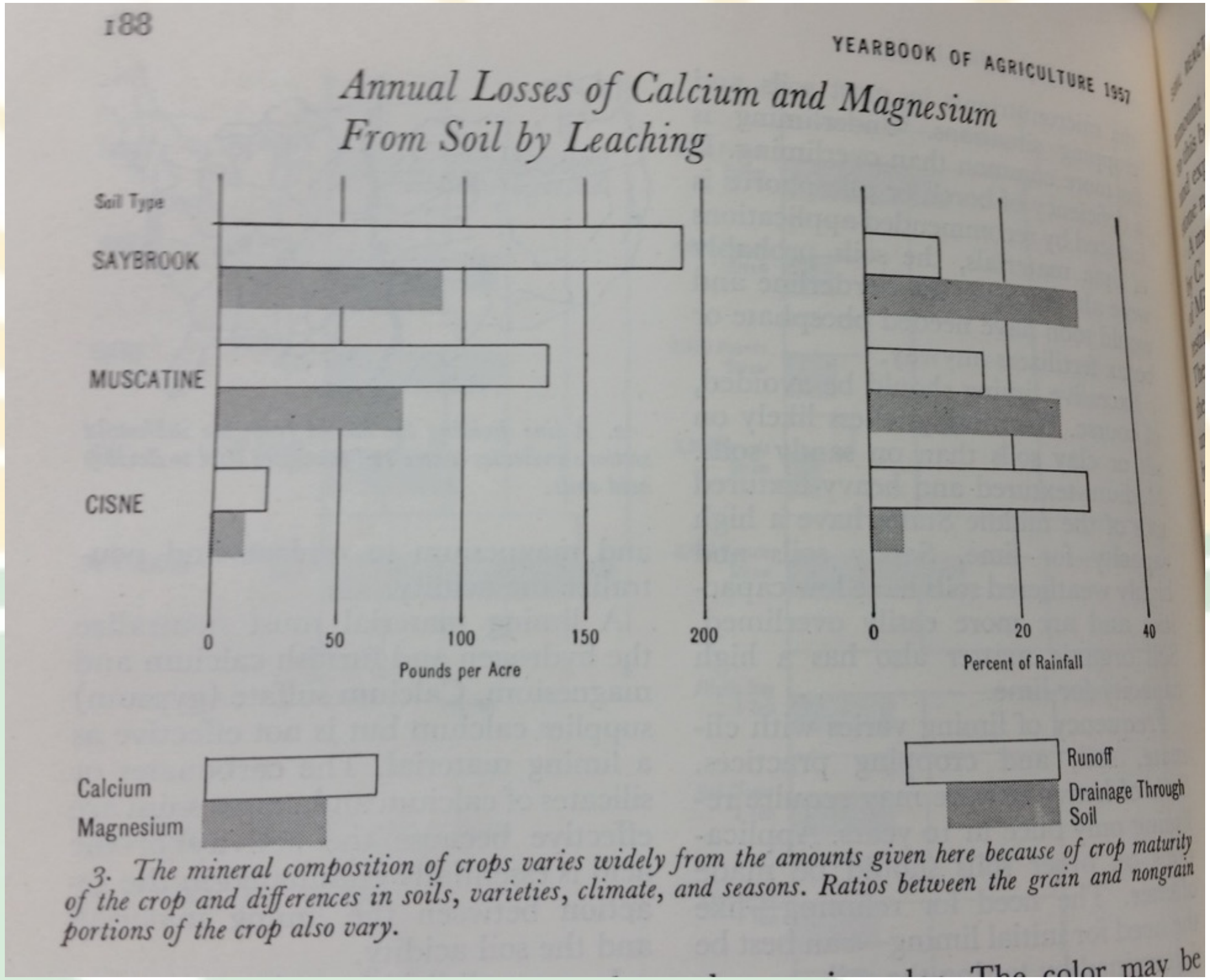


Mica (2:1)

- Clays are comprised of octahedral and tetrahedral sheet arranged in layers

What Happened to My Nutrients?

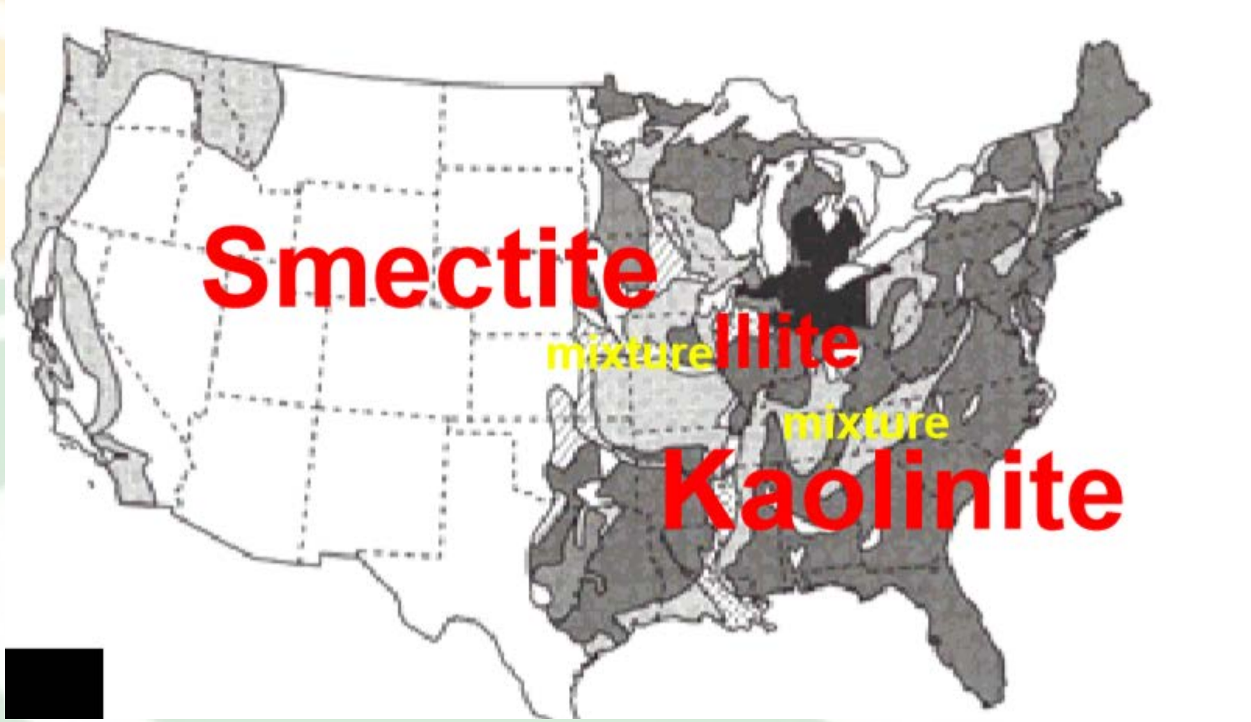
- These are soils from Central WI
- Anions (N,S,B) and even Cations (Ca, Mg, Na) leach over time from soils
- Leaching rate increases with rainfall
- If native parent material does not weather fast enough to release new cations into solution, soil nutrient levels will drop
- Can be mitigated with deep rooted crops which draw up leached nutrients



Soil, the 1957 yearbook of agriculture

Soil: Managing a Resource

- Crops planted
- Tillage
  - Type
  - Frequency
- Manure and Fertilizer Management
- Cover Crops – Food determines Biology
- Most of what the farmer can manage is related to the existing soil. Cannot change the soil which is there.



Images from Howard Woodard, Fundamentals of Nutrient Management

How Much and What?

1. What is a high enough level of nutrients?
2. If nutrient levels are low, how much is economical to apply?

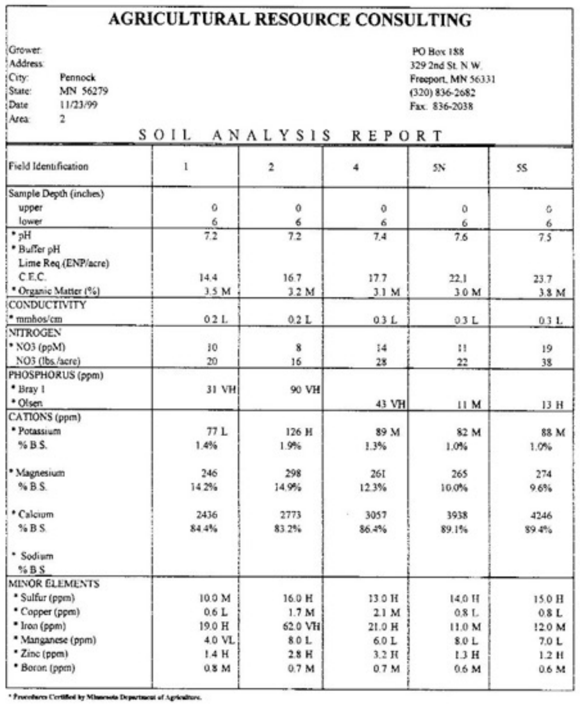
Qualitative is Useful But Limited

- While:
  - Nutrient deficiencies can be observed through visual signs
  - Soil attributes can be seen, smelt, or felt
- It is difficult by qualitative metrics alone to apply the proper material at the correct amount

How do I Know I need them?

- Qualitative data
  - Gathered by using senses i.e. sight, smell, feel, taste
    - Soil
    - Plants

- Quantitative data
  - Collected with scientific equipment from
    - Soil test
    - Plant tissue test
    - NDVI Readings
    - Biological test



AGRICULTURAL RESOURCE CONSULTING

Grower:
Address:
City: Pennock
State: MN 56279
Date 11/23/99
Area: 2

PO Box 188
329 2nd St. N.W.
Freeport, MN 56331
(320) 836-2682
Fax: 836-2038

SOIL ANALYSIS REPORT

Field Identification	1	2	4	5N	5S
Sample Depth (inches)					
upper	0	0	0	0	0
lower	6	6	6	6	6
* pH	7.2	7.2	7.4	7.6	7.5
* Buffer pH					
Lime Req.(ENP/acre)					
C.E.C.	14.4	16.7	17.7	22.1	23.7
* Organic Matter (%)	3.5 M	3.2 M	3.1 M	3.0 M	3.8 M
CONDUCTIVITY					
* mmhos/cm	0.2 L	0.2 L	0.3 L	0.3 L	0.3 L
NITROGEN					
* NO3 (ppM)	10	8	14	11	19
NO3 (lbs./acre)	20	16	28	22	38
PHOSPHORUS (ppm)					
* Bray 1	31 VH	90 VH			
* Olsen			43 VH	11 M	13 H
CATIONS (ppm)					
* Potassium	77 L	126 H	89 M	82 M	88 M
% B.S.	1.4%	1.9%	1.3%	1.0%	1.0%
* Magnesium	246	298	261	265	274
% B.S.	14.2%	14.9%	12.3%	10.0%	9.6%
* Calcium	2436	2773	3057	3938	4246
% B.S.	84.4%	83.2%	86.4%	89.1%	89.4%
* Sodium					
% B.S.					
MINOR ELEMENTS					
* Sulfur (ppm)	10.0 M	16.0 H	13.0 H	14.0 H	15.0 H
* Copper (ppm)	0.6 L	1.7 M	2.1 M	0.8 L	0.8 L
* Iron (ppm)	19.0 H	62.0 VH	21.0 H	11.0 M	12.0 M
* Manganese (ppm)	4.0 VL	8.0 L	6.0 L	8.0 L	7.0 L
* Zinc (ppm)	1.4 H	2.8 H	3.2 H	1.3 H	1.2 H
* Boron (ppm)	0.8 M	0.7 M	0.7 M	0.6 M	0.6 M

* Procedures Certified by Minnesota Department of Agriculture.

Standard Soil Tests

- No single test is good or bad in itself, (some are more accurate and better predictors) it all depends on how it is interpreted.

- Soil tests can be used as a tool to sell fertilizer by determining how much fertilizers and soil amendments should be applied

Or

- Soil tests can be used as a tool to monitor nutrient cycling and nutrient availability in soil to better asses the need for added fertilizer and soil amendments to achieve optimum plant growth, quality and yield

- Monitoring change is as important as specific values.

AG RESOURCE CONSULTING INC.

131 5th Street, Albany, MN 56331-0667 (320) 845-6321

Sample Information	Client Information	Dealer Information
Date Sampled: 5/1/2002 Date Tested: 5/4/2002 Acres: 20.6 Area: 1	Grower: Joe Farmer	Dealer:

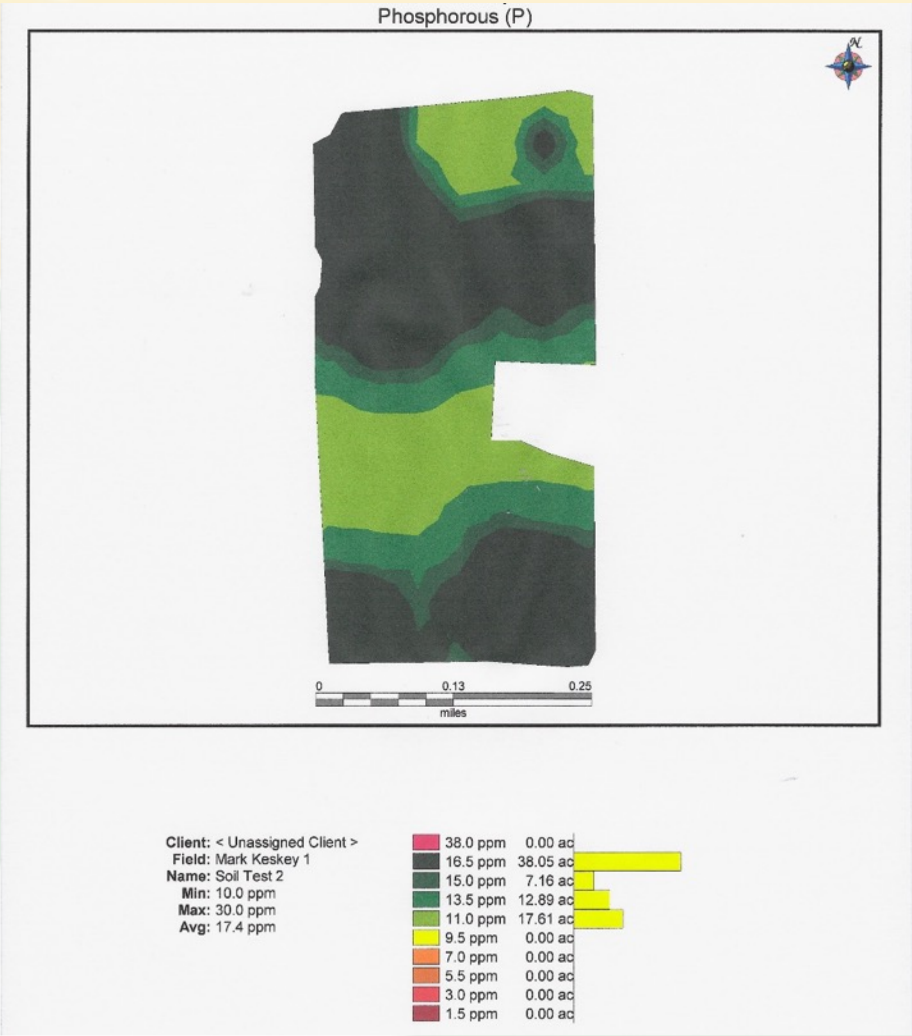
Field Identification	1	Depth in Inches		Cation Exchange Capacity and % Base Saturations					
		upper	lower	C.E.C.	K % B.S.	Mg % B.S.	Ca % B.S.	Na % B.S.	H % B.S.
		0	6	17.6	1.8%	9.6%	53.9%	0.6%	34.1%

Test	Result	Interpretation	Previous Crop	U.of M. Nutrient Requirements Crop 1	Crop 2	Crop 3
* pH	6.2	Medium Acid				
* Buffer pH						
Lime Req. (ENP)	3000	VL · L · M · H · VH	Wheat	Corn	Soybeans	Alfalfa
* Org. Mat. (%)	2.8	>>>>>>>>>>>>>>>>	Yld Goal	150	40	5
SOLUBLE SALTS						
* mmhos/cm	0.2	<<<<<<	Lime/Tons	3.0	3.0	3.0
NITROGEN						
* NO3 (ppM)	6	>>>>>>>>>>>>>>>>	N	176	0	0
NO3 (lbs./acre)	12					
PHOSPHORUS						
* Bray I (ppm)	18	>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>	P2O5	11	0	10
* Olsen (ppm)			P2O5			
CATIONS (ppm)						
* Potassium	121	>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>	K2O	42	0	49
* Magnesium	203	>>>>>>>>>>>>>>>>	Mg	0	0	0
* Calcium	1893	>>>>>>>>>>>>>>>>	Ca			
* Sodium	24					
MINOR ELEMENTS						
* Sulfur (ppm)	10.0	>>>>>>>>>>>>>>>>>>>>>>>>>>	S	25	25	25
* Copper (ppm)	0.5	>>>>>>>>>>>>>>>>	Cu	3	3	3
* Iron (ppm)	42.0	>>	Fe	0	0	2
* Manganese (ppm)	16.0	>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>	Mn	0	0	0
* Zinc (ppm)	1.8	>>	Zn	1	1	[illegible]
* Boron (ppm)	1.1	>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>	B	1	1	[illegible]

Recommendations

Organic Grid / Zone Sampling

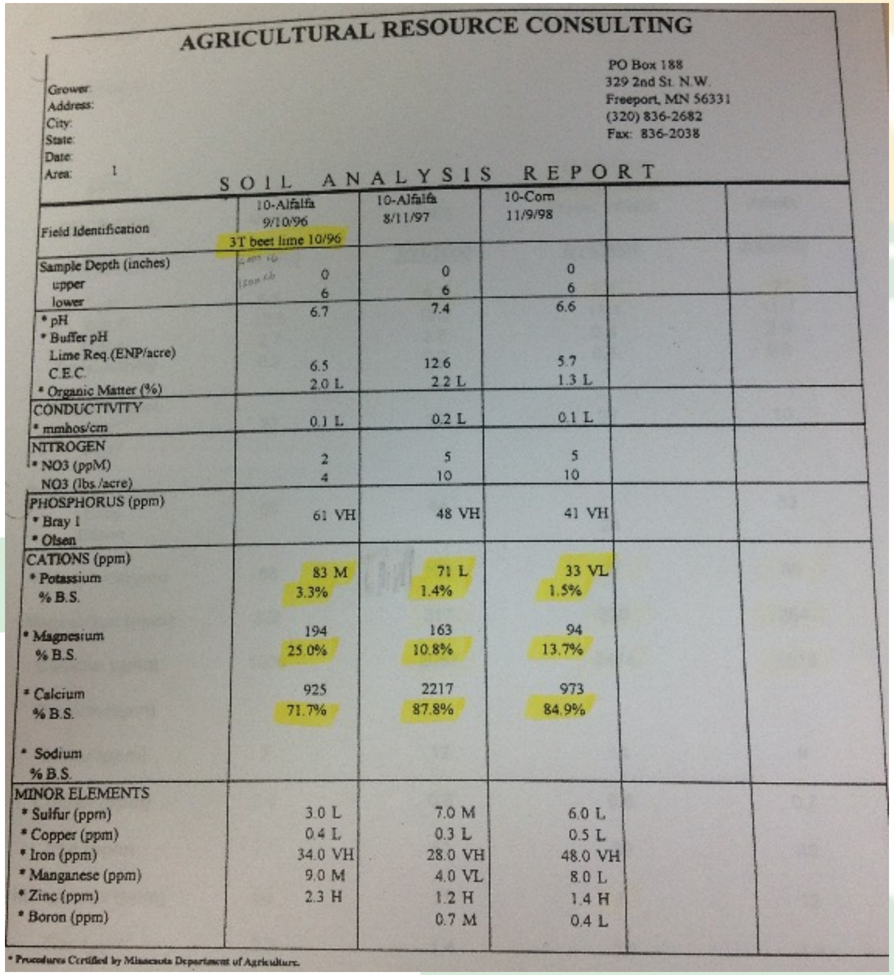
- While Manure is often used for N sources, VRA other dry fertilizers
  - Legume
    - Soybeans
    - Alfalfa
  - Crops not requiring N that year from manure
- Put nutrients where you need them
  - Over application = Wasted Resources
    - Ties up or leaches other nutrients
    - Ca and K, P and Zn
  - Under application = Lost Potential Revenue
- Helps to identify limiting factors to yield



Still Boils Down To Good Nutrient Management

- Starts with a soil test
  - Where are my nutrient levels now???
- Take an inventory of nutrients on your farm
- Use the soil test to monitor your trends

- **Exporting**
  - Milk
  - Animal
  - Manure
  - Hay/Grain
- **Importing**
  - Bedding
  - Feed
  - Manure



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329 2nd St. N.W.
Freeport, MN 56331
(320) 836-2682
Fax: 836-2038

Grower:
Address:
City:
State:
Date:
Area: 1

SOIL ANALYSIS REPORT

Field Identification	10-Alfalfa 9/10/96 3T beet lime 10/96	10-Alfalfa 8/11/97	10-Corn 11/9/98		
Sample Depth (inches)					
upper	0	0	0		
lower	6	6	6		
* pH	6.7	7.4	6.6		
* Buffer pH					
Lime Req.(ENP/acre)					
C.E.C.	6.5	12.6	5.7		
* Organic Matter (%)	2.0 L	2.2 L	1.3 L		
CONDUCTIVITY * mmhos/cm	0.1 L	0.2 L	0.1 L		
NITROGEN					
* NO3 (ppM)	2	5	5		
NO3 (lbs./acre)	4	10	10		
PHOSPHORUS (ppm)					
* Bray I	61 VH	48 VH	41 VH		
* Olsen					
CATIONS (ppm)					
* Potassium	83 M	71 L	33 VL		
% B.S.	3.3%	1.4%	1.5%		
* Magnesium	194	163	94		
% B.S.	25.0%	10.8%	13.7%		
* Calcium	925	2217	973		
% B.S.	71.7%	87.8%	84.9%		
* Sodium					
% B.S.					
MINOR ELEMENTS					
* Sulfur (ppm)	3.0 L	7.0 M	6.0 L		
* Copper (ppm)	0.4 L	0.3 L	0.5 L		
* Iron (ppm)	34.0 VH	28.0 VH	48.0 VH		
* Manganese (ppm)	9.0 M	4.0 VL	8.0 L		
* Zinc (ppm)	2.3 H	1.2 H	1.4 H		
* Boron (ppm)		0.7 M	0.4 L		

* Procedures Certified by Minnesota Department of Agriculture.

Soil Fertility

- **More fertilizer does not necessarily equal more yield or higher Quality!**

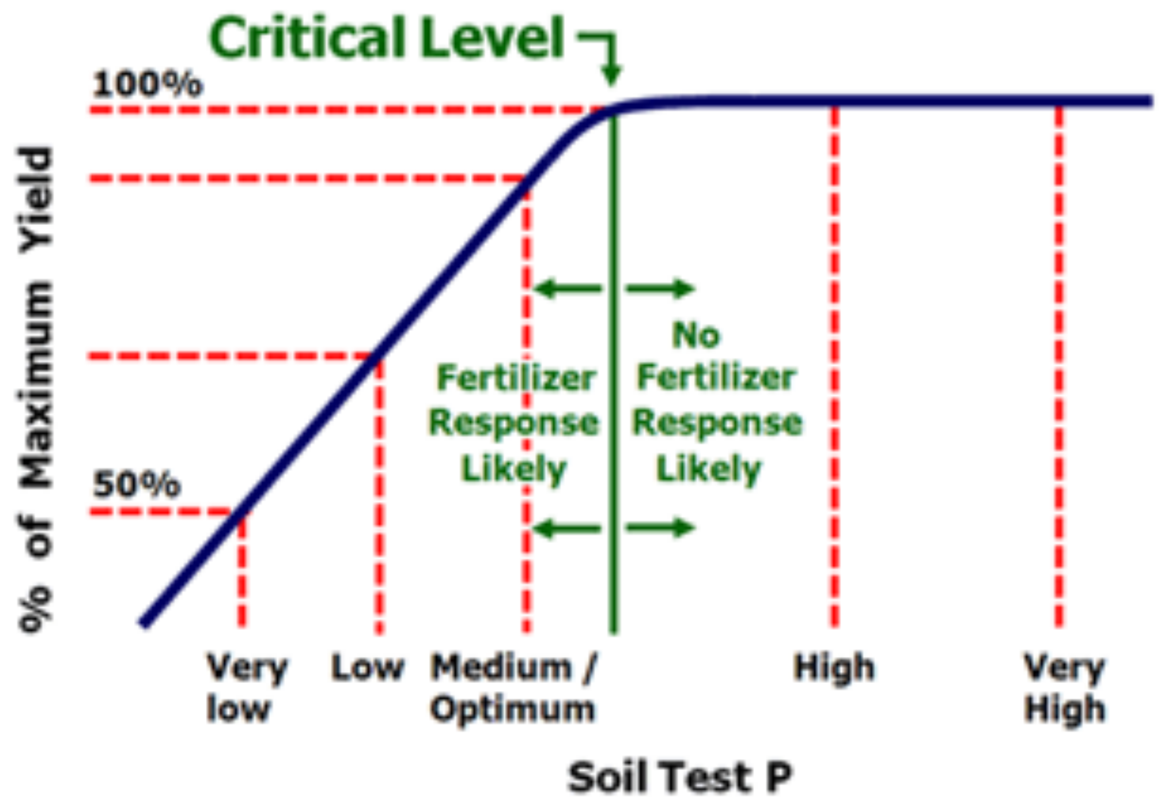


Image from https://www.pioneer.com/CMRoot/pioneer/us/images/agronomy/crop_insight/soil_testing/critical_nutrient_levels.gif

Soil Test Level verse Fertilizer Need

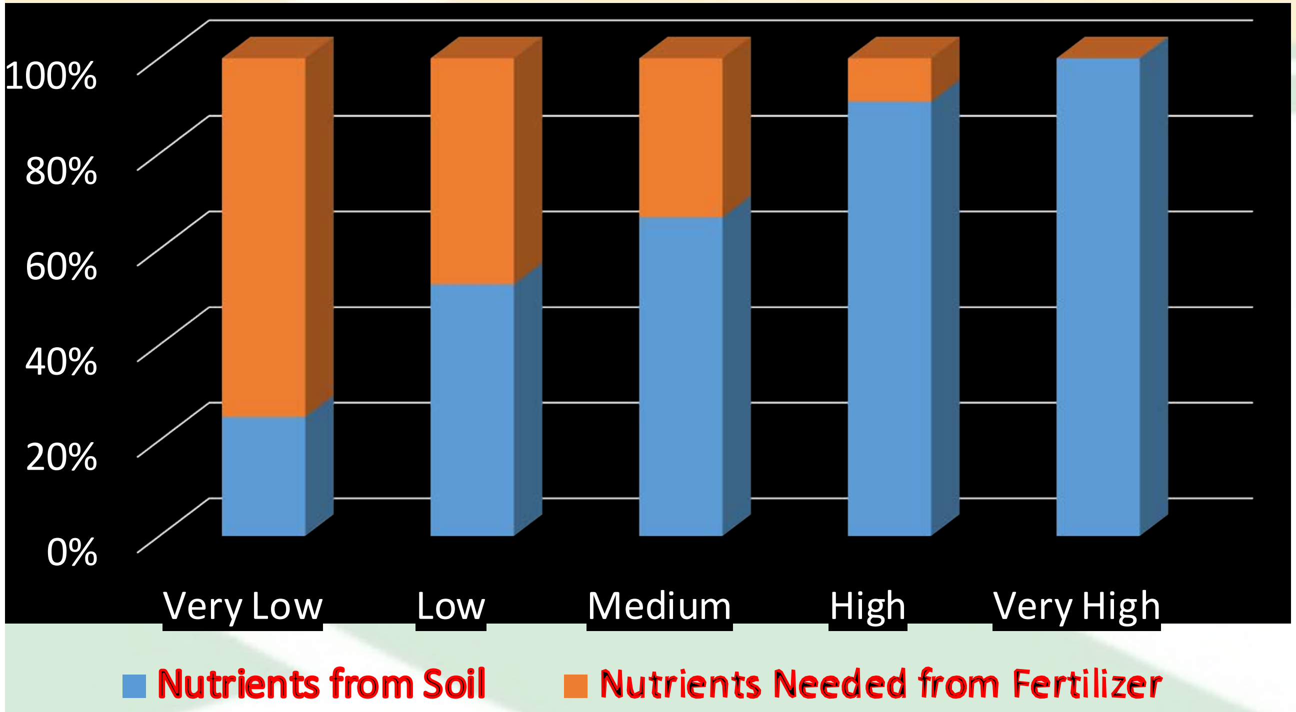


Image from Fertilizer Guideline for Agronomic Crops in MN

Soil Amendment and Fertilizer

- Soil Amendment: Is a substance added directly to the soil to positively influence a chemical, physical, or biological property of the soil.

- Fertilizer: Is a substance applied to the soil to provide a necessary nutrient for desired plant growth.

Fertilizers

- Manure
- Mined Dry Fertilizer
- Mined Lime (Not Beet Lime or Water Treatment Lime)
- Gypsum

- Nitrogen Fertilizers: Anhydrous Ammonium, Urea, Ammonium Sulfate, UAN
- Phosphorous Fertilizers: DAP, MAP

- Nitrogen Fertilizers: Plow down, Manure, Chilean Nitrate, Feather Meal, Blood Meal, Bird or Bat Guano, Fish, Soybean Protein, Plant Protein
- Phosphorous Fertilizers: Manure, Rock Phosphate, Bone Meal, Fish
- Potassium Fertilizers: Potassium Sulfate,
- Most Trace Minerals: Are allowed in a limited fashion in the Sulfate form based upon soil test levels

https://www.frenchgardening.com/tech.html?pid=3099955709430326

http://china-lotus.en.alibaba.com/product/501410575-213077909/potassium_magnesium_sulphate_fertilizer_potassium_sulfate.html

http://jerpchem11.blogspot.com/2009/10/today-in-chemistry-class-mr.html

Sources of Nutrients

- Natural release from the mineral portion of the soil and the organic matter
- Mined Material
  - Mined material that has nothing added to it is certifiable (or if what is added is certifiable)
    - Potassium Sulfate
    - Rock Phosphate (Bio Phos)
    - Gypsum
    - (Trace Minerals are accepted but they are restricted products)
  - Manure that has no additives is acceptable for organic production
    - Raw Poultry Litter
    - Poultry Pellets (CPM)
    - Hog Manure
    - Cattle Manure
  - Compost
- Alfalfa Crop
  - Grown in the rotation for either on farm use or sale
- Cover Crop
  - Generally before or after a primary crop

Nitrogen

- Organic Matter
  - Soil Mineralizable Nitrogen
- Manure
  - Either from farm or imported
- Alfalfa - Legume/Grass Hay
  - Grown in the rotation for either on farm use or sale
- Cover Crop – Legume Cover Crop or Capture Crop
  - Generally before or after a primary crop
- Other Nitrogen sources become cost prohibited on a large scale

Components of Soil Organic Matter

- Organic Matter
  - ❖Comes from biological component

  - Raw Materials
  - Decomposing Materials
    - ❖ Responsible for releasing nutrients and feeding biological life
  - Humus
    - ❖ Very stable; Important for holding nutrients like clay particles

Image from http://smallfarms.oregonstate.edu/Fall2010WinterCoverCrops

Image from http://boalogistics.com/wp-content/uploads/2012/11/manure.jpg

Image from http://faculty.yc.edu/ycfaculty/ags105/week08/soil_colloids/soil_colloids_print.html

Active and Passive Organic Matter

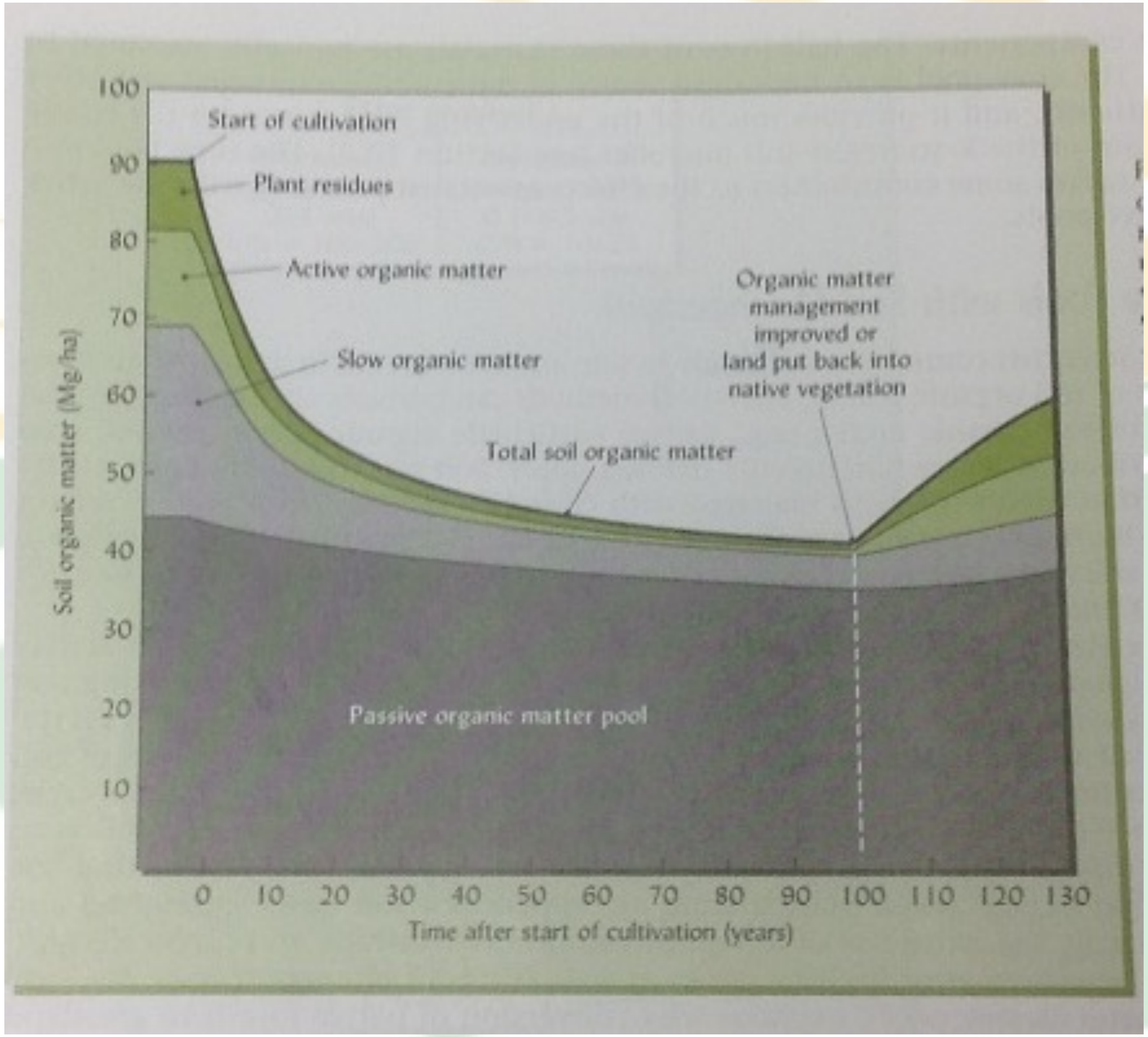


Image retrieved from pg 512, The Nature and Properties of Soils, Brady and Weil

Active Organic Matter

e from http://smallfarms.oregonstate.edu/Fall2010WinterCoverCrops

Feeds different microbial populations

Image from http://boalogistics.com/wp-content/uploads/2012/11/manure.jpg

Non-Labile Organic Matter

- Very stable and slow to break down
- Mainly holds water and nutrients

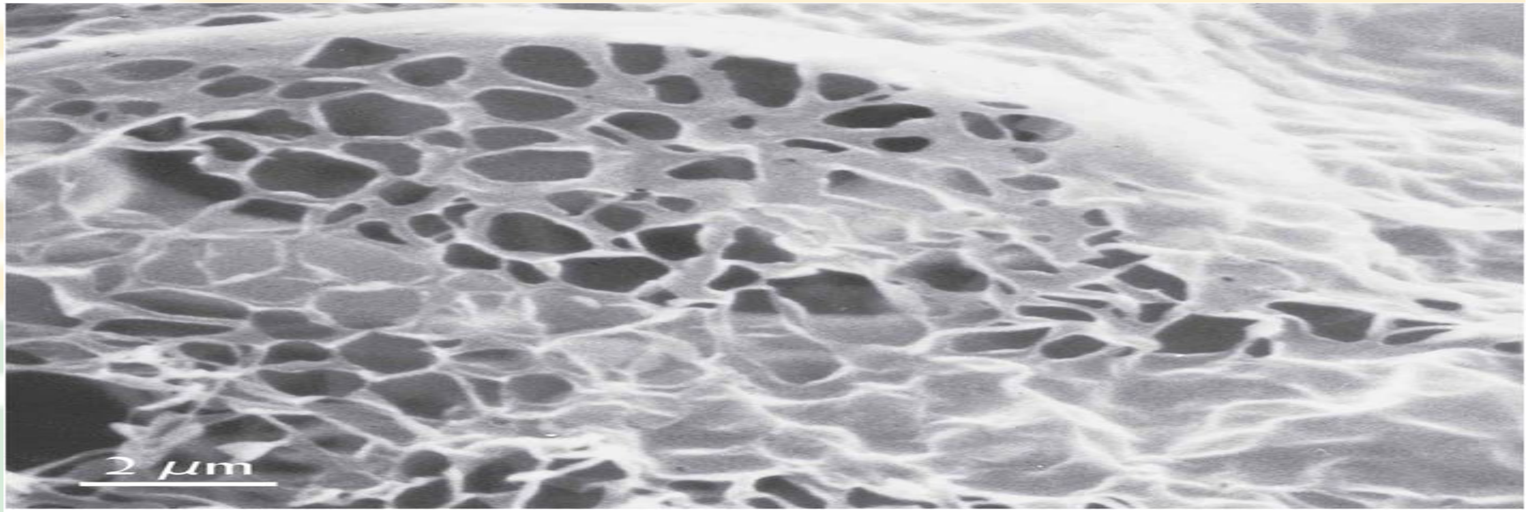
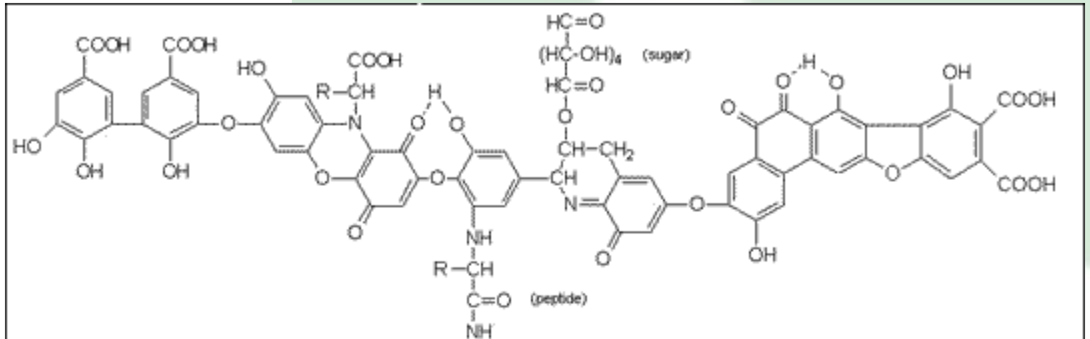


Image from http://faculty.yc.edu/ycfaculty/ags105/week08/soil_colloids/soil_colloids_print.html



Model structure of humic acid (Stevenson 1982)

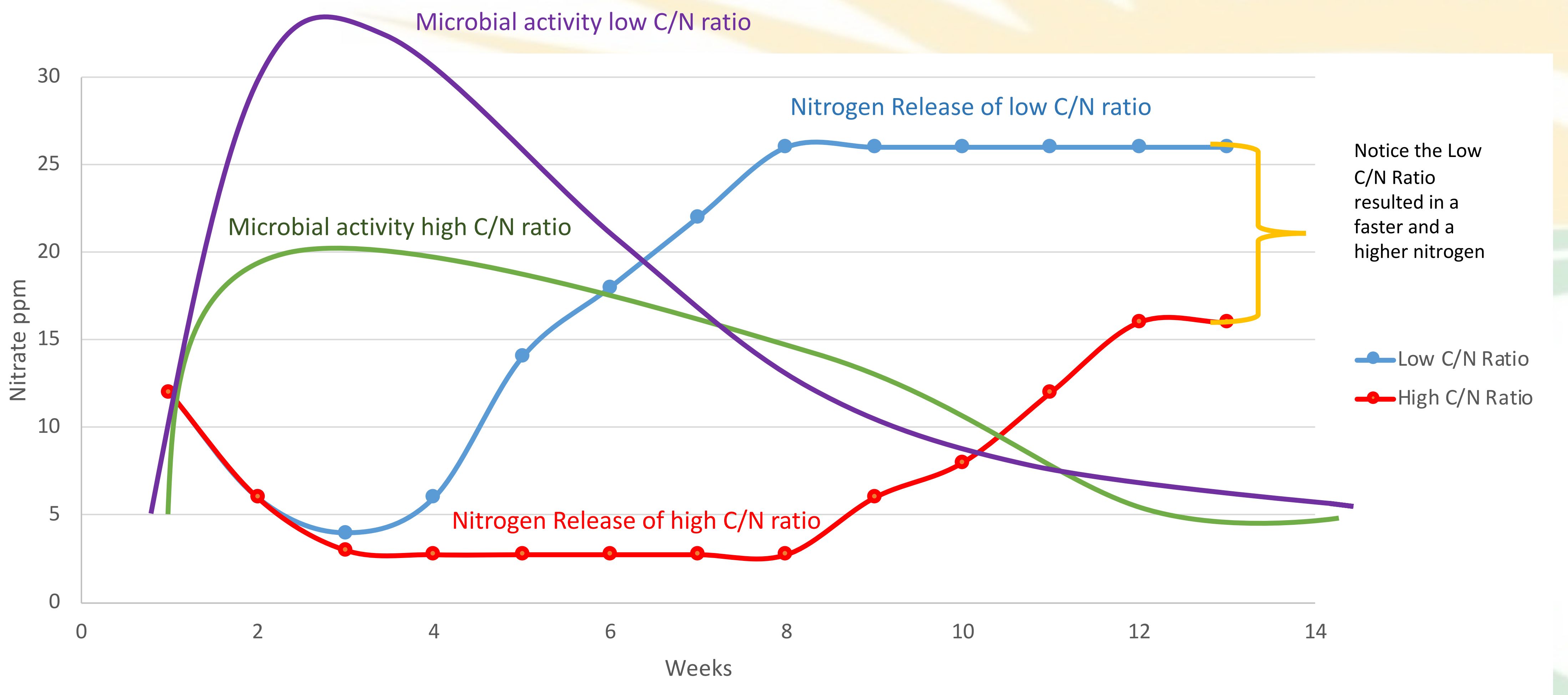
http://www.humintech.com/001/articles/article_definition_of_soil_organic_matter4.html

Nitrogen/Nutrient Needs

- Properly identifying nutrient needs on the farm requires:
  - Current nutrient levels (Soil test)
  - Crop desired to be grown
    - University **GUIDELINES** adapted to area, soils, climate, and farm economics
  - Previous crops
    - Any legume credit from previous 2 years
    - Previous crop residue breakdown
    - Cover crop
      - Break down of cover crop residue (+ or – N)
      - Estimated N credit either from legumes in mix (clovers) or N capture from scavengers (radishes)

- Manure history
  - 2nd Year N credit
  - Any Fall or Spring manure applications
    - Rate
    - Timing
      - Time of year
      - Incorporation time
    - Type

Predicting the Microbial Breakdown (Comparison)

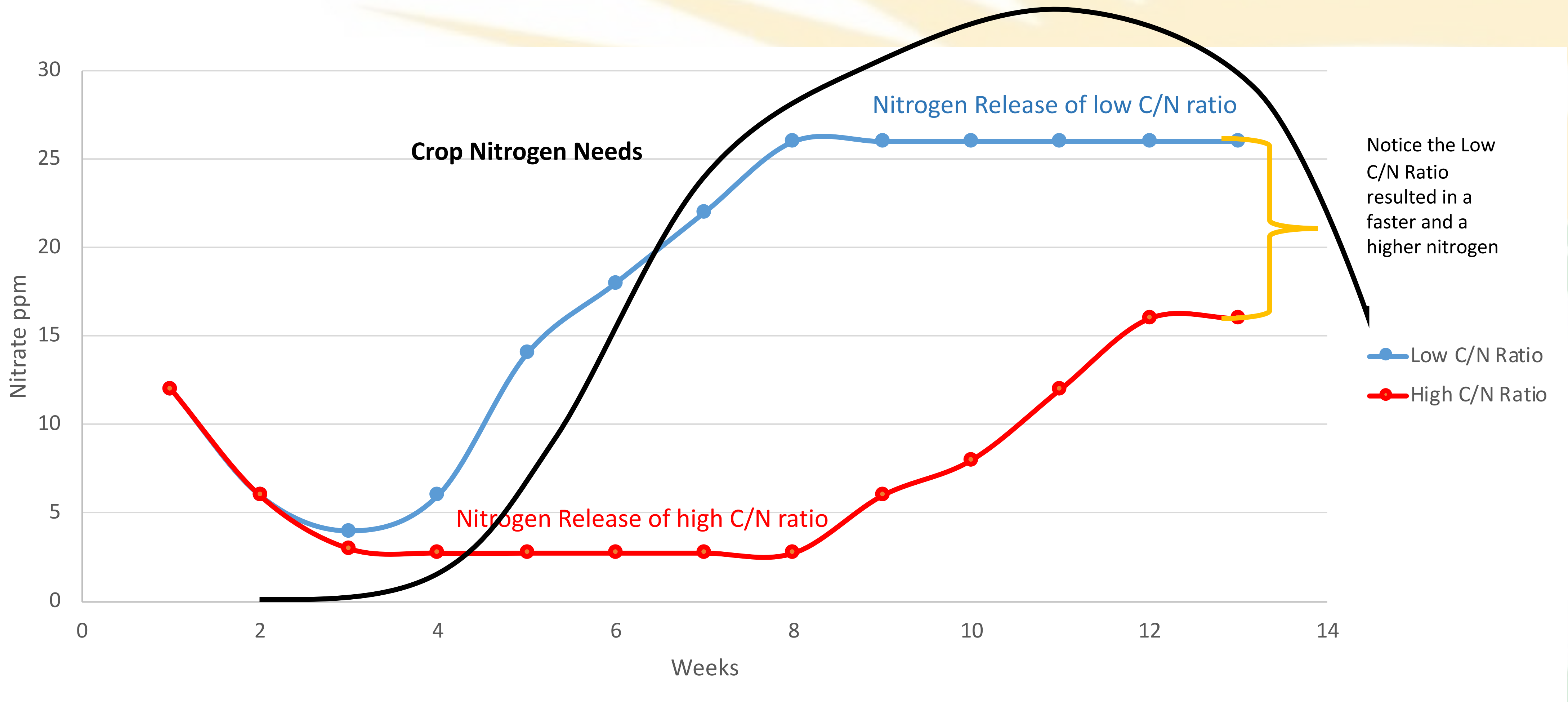


Carbon to Nitrogen Ratios

Material	Carbon to Nitrogen Ratio
Bacteria	5 - 1
Fungi	10 - 1
Poultry Litter	10 - 1
Dairy Free Stall	13 – 1
Alfalfa plow-down	13 – 1
Sheep Manure	16 – 1
Grass clippings	17 – 1
Soybean Stubble	20 – 1
Oat Straw	60 – 1
Corn Stover	80 – 1
Wheat Straw	127 – 1
Wood	641 – 1

Values retrieved from Brady and Weil, The Nature and Properties of Soils, pg 505 and http://compost.css.cornell.edu/OnFarmHandbook/apa.taba1.html

Microbial Breakdown (Comparison)



Nitrate & Solvita Test

AG RESOURCE CONSULTING INC.

Grower: Solivita Test Fields
Address:
City:
State:
Date: 2/14/12
Area: 1

131 5th St.
PO Box 667
Albany, MN 56307-0667
(320) 845-6321
Fax: 845-6320

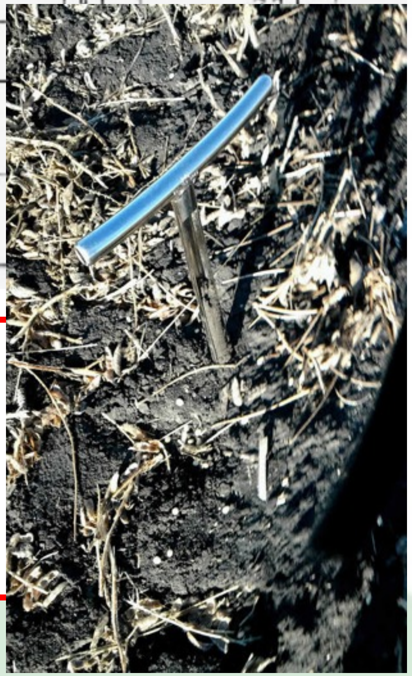
SOIL ANALYSIS REPORT

Field Identification Solvita CO2	14A 40.15	14C 30.05	34A 41.59	PK11 28.4	R7 8.22
Sample Depth (inch) upper lower	0 6	0 6	0 6	0 6	0 6
	6.7	6.9	6.8	6.8	6.4
Buffer pH					
Lime Req.(ENP/acre)					2000
C.E.C.	7.1	5.7	7.8	6.7	11.1

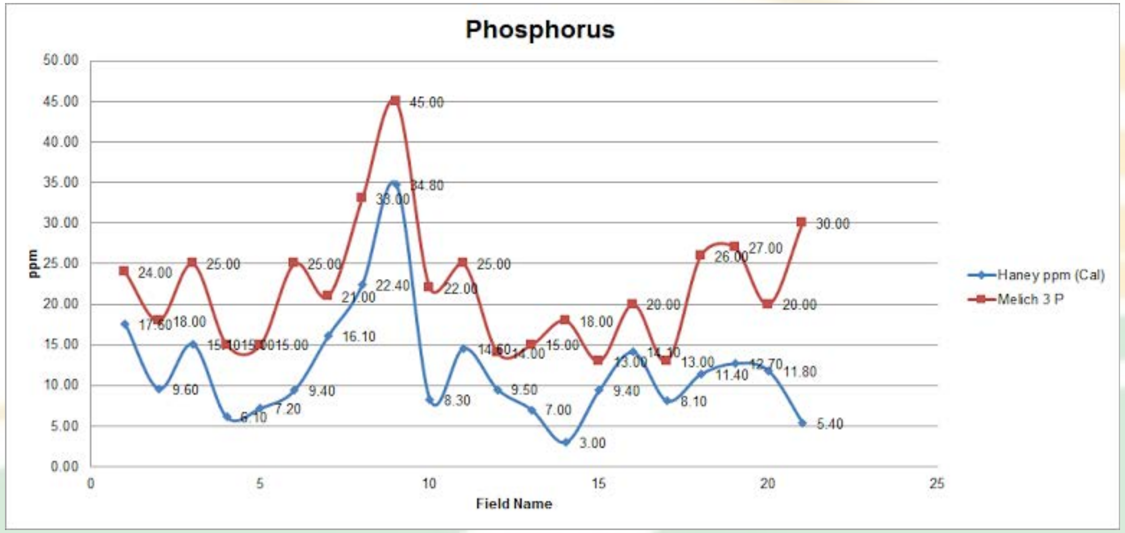
CATIONS (ppm)

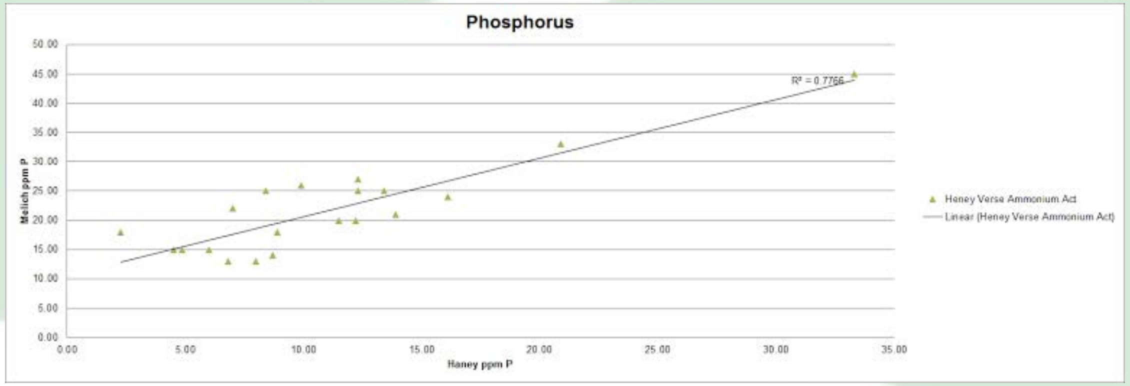
	Diverse Crop Rotation with cover crops and manure				Corn/Soybean
Solvita CO2 ppm	40.15 ppm	30.05 ppm	41.59 ppm	28.4 ppm	8.22 ppm

- Solvita can help indicate speed of mineralization of cover crops and manure
- Is also an indication of speed of mineralization of active organic matter
  - Crop production can be maintained at lower soil levels with higher biological activity



Haney Test – Solvita Test





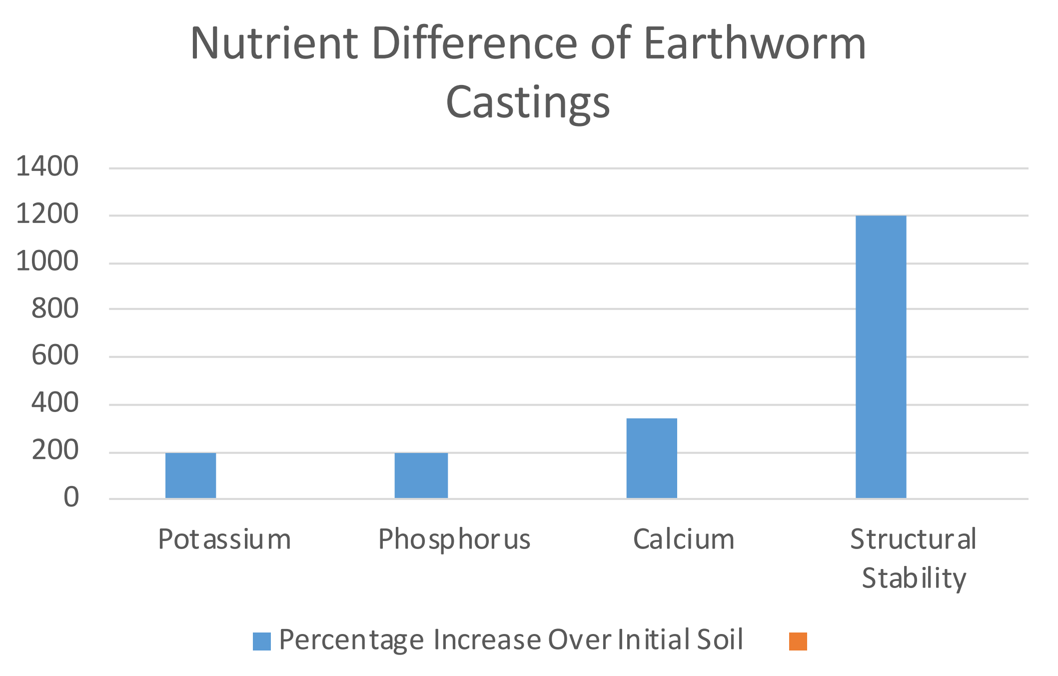
Haney - Soil Health Analysis

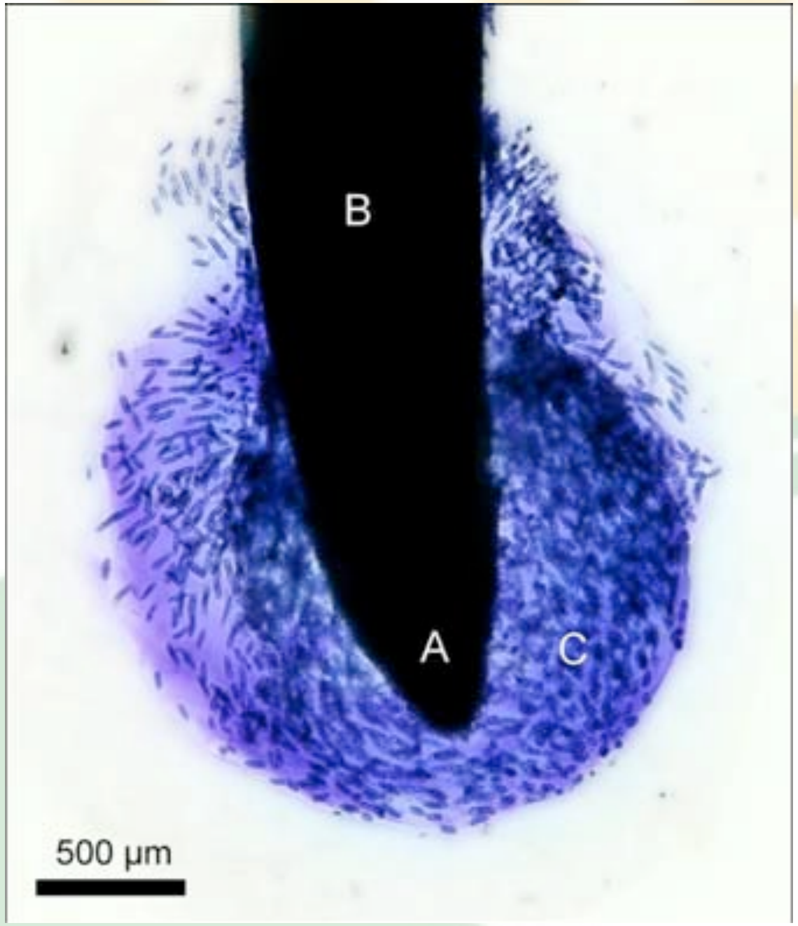
1:1 Soil pH	7.3
1:1 Soluble Salts, mmho/cm	0.40
Excess Lime Rating	1
Organic Matter, %LOI	3.6
WDRF Buffer pH	7.2
Solvita CO2 Burst	
CO2-C, ppm C	34.7
Water Extract	
Total Nitrogen, ppm N	51.9
Organic Nitrogen, ppm N	22.9
Total Organic Carbon, ppm C	191
H3A Extract	
Nitrate, ppm NO3-N	26.6
Ammonium, ppm NH4-N	2.3
Inorganic Nitrogen, ppm N	28.9
Inorganic (FIA) Phosphorus, ppm P	13.8
Total (ICAP) Phosphorus, ppm P	22.8
Organic Phosphorus, ppm P	9.0
ICAP Potassium, ppm K	29
ICAP Calcium, ppm Ca	773

ICAP Aluminum, ppm Al	164
ICAP Iron, ppm Fe	67
Calculations	
Organic C:Organic N	8.3
Nitrogen mineralization, ppm N	8.1
Organic Nitrogen Release, ppm N	15.6
Organic Nitrogen Reserve, ppm N	7.3
Phosphorus mineralization, ppm P	6.4
Organic Phosphorus Reserve, ppm P	2.6
Phosphorus Saturation Al/ Fe, %	9.9
Phosphorus Saturation Ca, %	3.0
Soil Health	
Soil Health Calculation	8.36
Cover Crop Suggestion	60% Legume 40% Grass

Soil Health and Biological Activity

- Soil fertility is only part of providing nutrients for a growing plant.
  - Soil is not a dead medium
  - It is a living ecosystem
  - Important to understand that the better this ecosystem is functioning, the better the crop growth.
  - The greater the biological activity, the lower soil test levels are necessary to maintain crop production





Jones, Nguyen, and Finlay, Carbon flow in the thizosphere: carbon trading at the soil-root interface, Plant Soil (2009) 321:5-22, Image retrieved from: http://www.planta.cn/forum/files_planta/jones_et_al_2009_ps_286.pdf

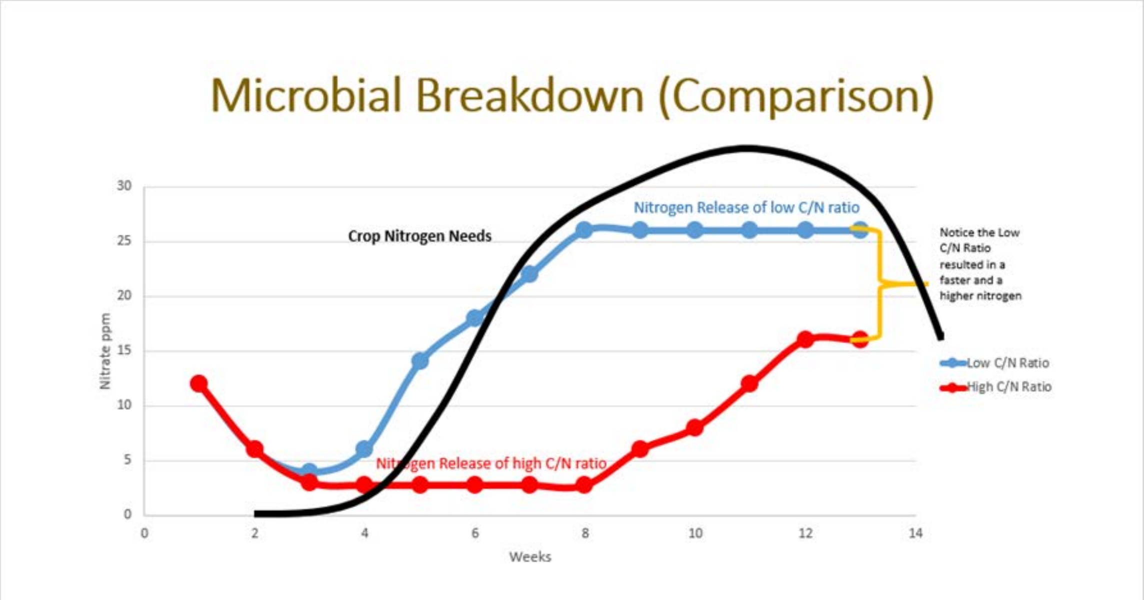
Estimating N credits Forage/Cover Crops

Nitrogen fixation or capture varies depending upon:

- Type of Species
- Amount of growth before termination
  - Longer established legumes provide more predictable N release for subsequent crop
- Residual N amount in profile (can only capture what is remains 0=0)

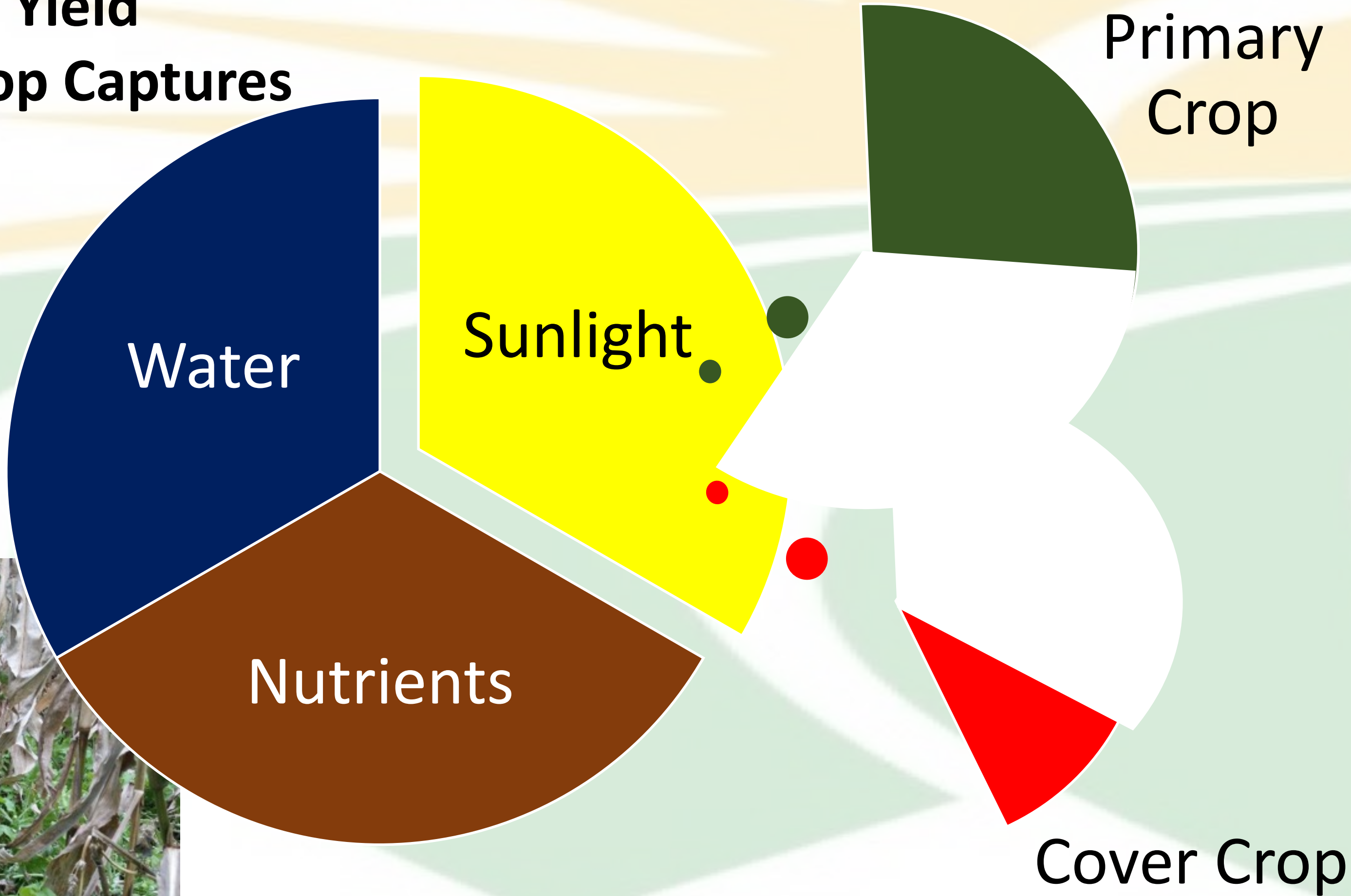
Factors which effect N Credit

- Well Established Legume Stands are most predictable
- Factors that effect N availability
  - C/N ratio of biomass
  - Seasonal variation in weather and soil temperature
  - When and how the Cover Crop is terminated
  - The more Cover Crop is allowed to lignify, the more it will slow the N release

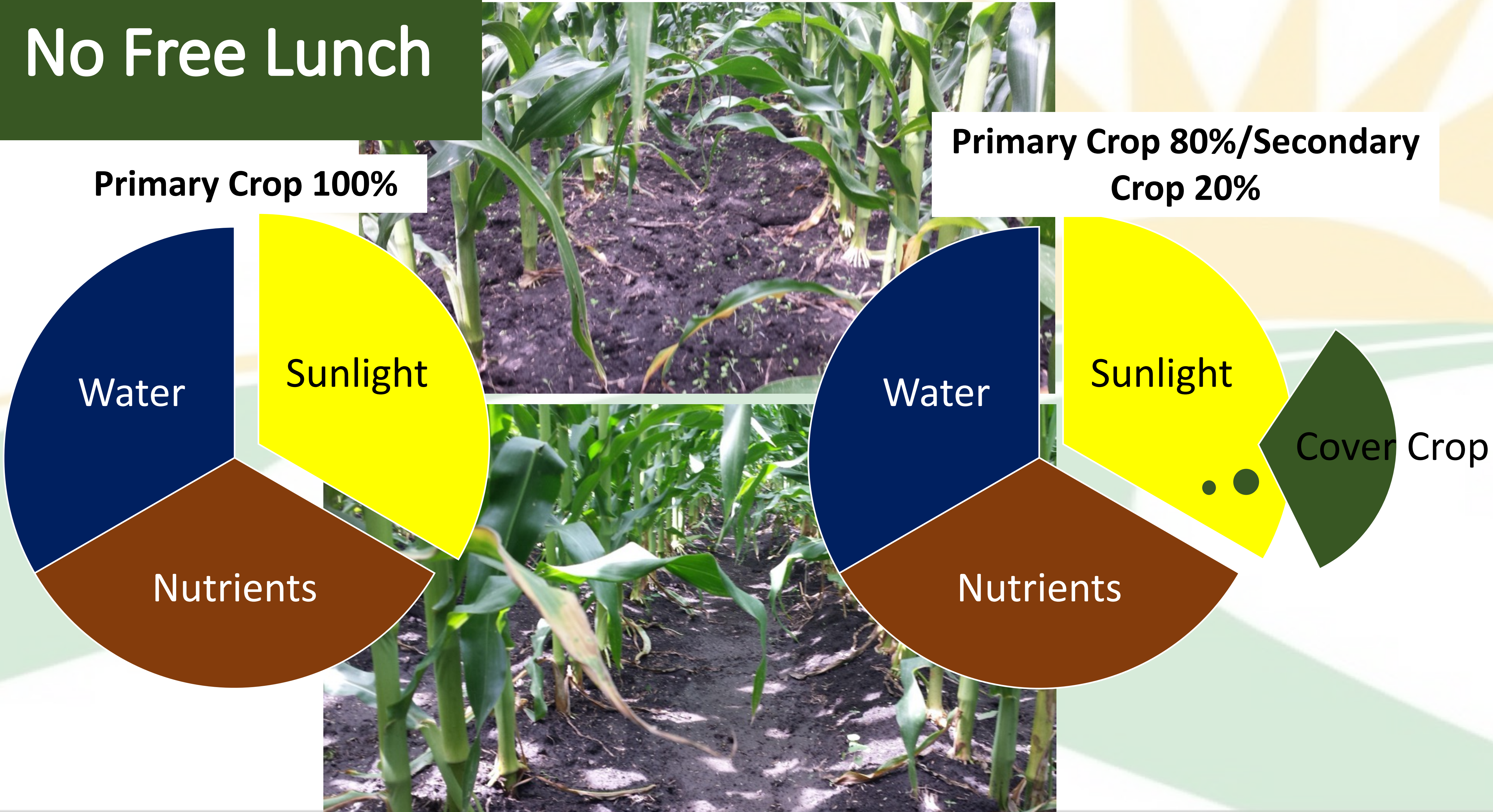


Ideal is Capture Excess

Primary Crop 80% Sunlight=100% Yield /Secondary Crop Captures excess 20%



No Free Lunch



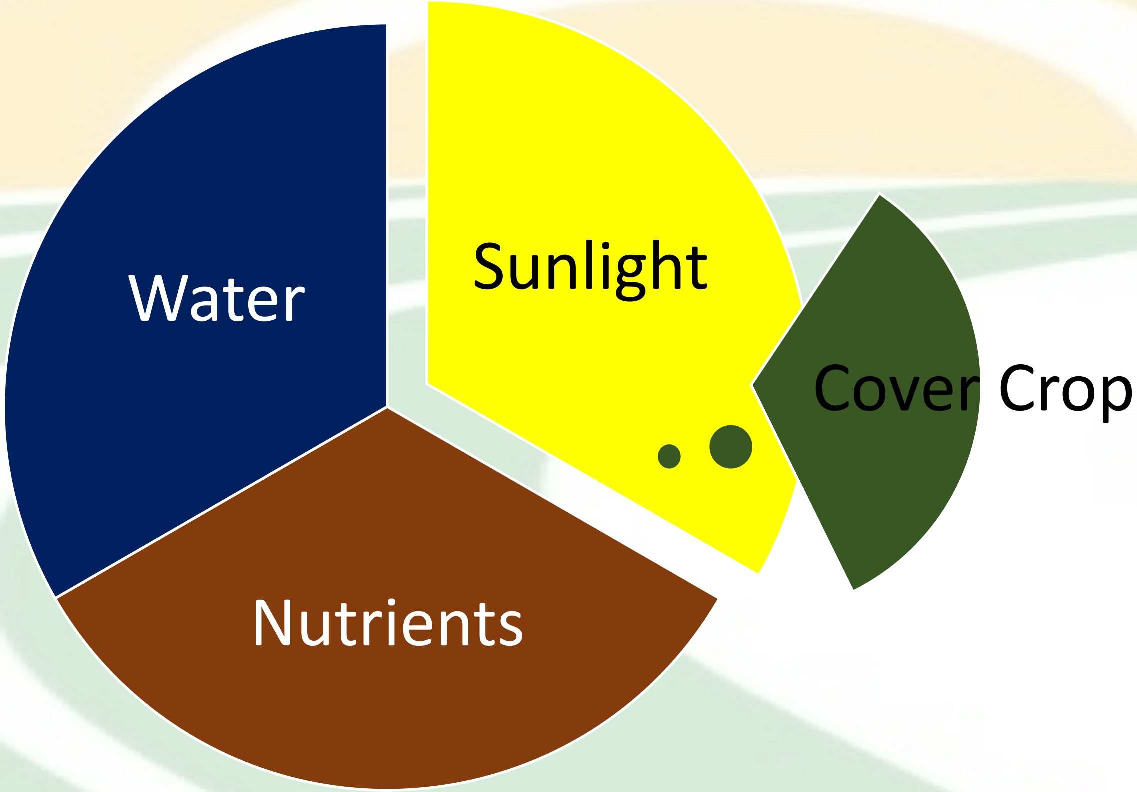
Timing: Water/Sunlight

Timing of inter-seeding the Cover Crop

- **Irrigation allows the farmer to control the water**

No Free Lunch

Primary Crop 80%/Secondary Crop 20%



It is easier to account for the cost of a cover crop verse a benefit!

Increase Insect Pressure

https://extension.entm.purdue.edu/fieldcropsipm/images/insects/fallarmyworm01.jpg

http://www.extension.umn.edu/garden/insects/find/cutworms-in-home-gardens/img/M1225-3-lg.jpg

Instead of Cover Crop – Think Crop Diversity

https://www.ag.ndsu.edu/archive/dickinso/research/2006/agron06f.htm

Instead of Cover Crop – Think Crop Diversity

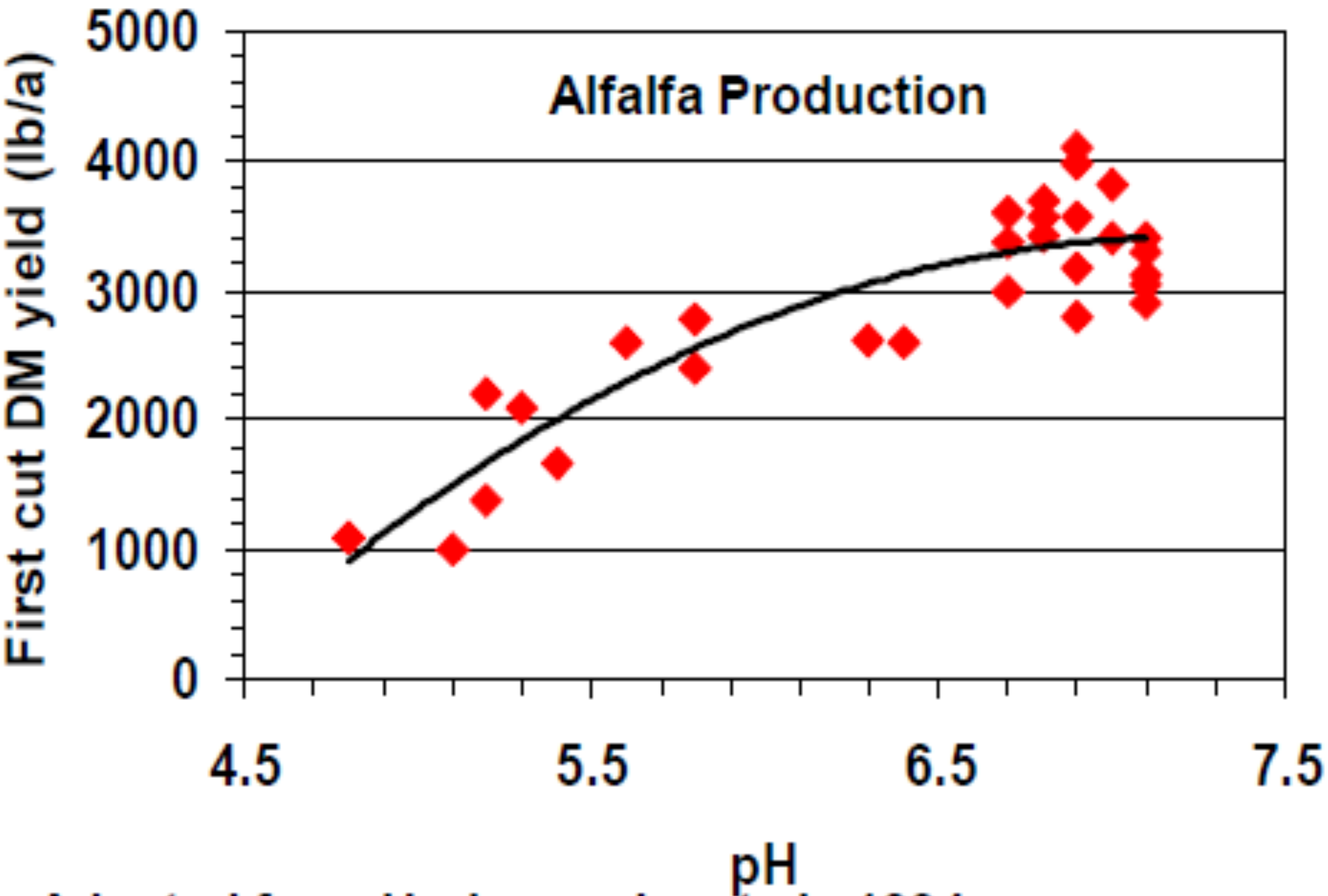
Crop diversity accomplishes many factors besides fertility while also providing benefits like a cover crop.

- 1.) It allows for good cover crop establishment
- 2.) Breaks weed cycles
- 3.) Three years hay is 3 years No-Till
- 4.) Rotational Crops avoid excessive nutrient buildup from heavy manure applications

https://www.ag.ndsu.edu/archive/dickinso/research/2006/agron06f.htm

N fixation, pH, and Alfalfa/Cover Crop Production

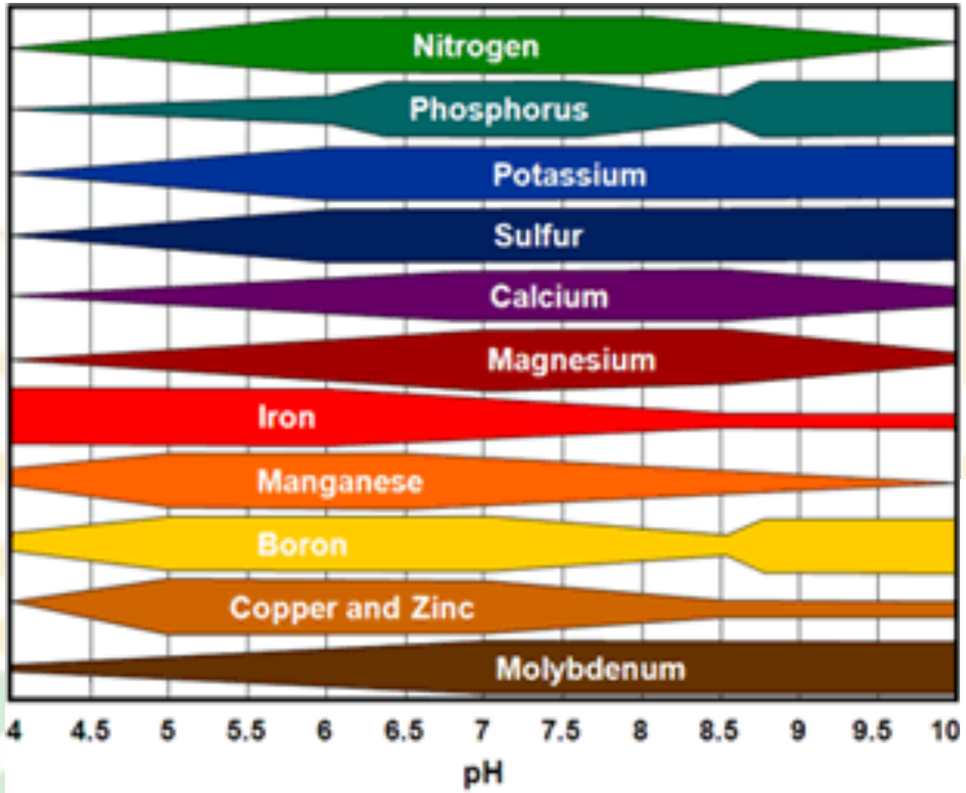
- Rhizobium Bacteria function under pH range
- Molybdenum



Adapted from Undersander et al., 1994

pH

- The pH of the soil effects the availability of nutrients.
- The pH of the soil effects what microbes flourish and who dies.
  - Rhizobium Meliloti



https://www.pioneer.com/CMRoot/pioneer/us/images/agronomy/crop_insight/soil_testing/nutrient_availability_chart.gif

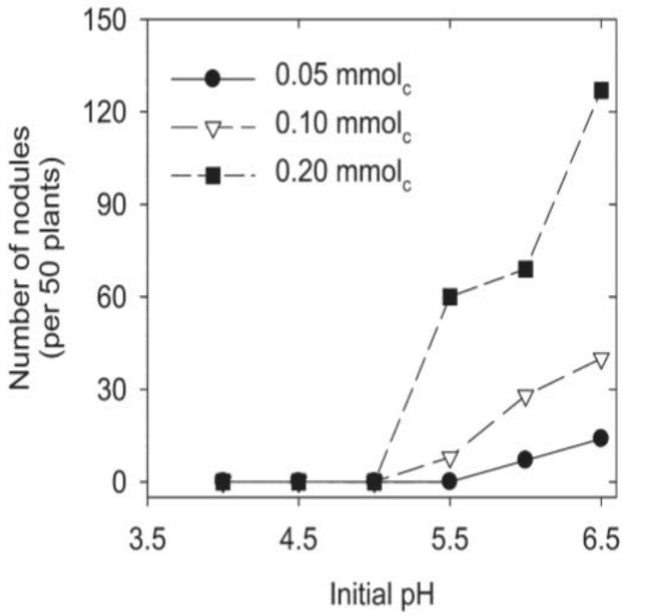


Fig. 1. Effect of initial soil pH on the nodulation of soybean. Calcium was supplied at three levels: 0.05, 0.10, or 0.20 mmol$_c$ Ca per plant. Data taken from Albrecht (1937).

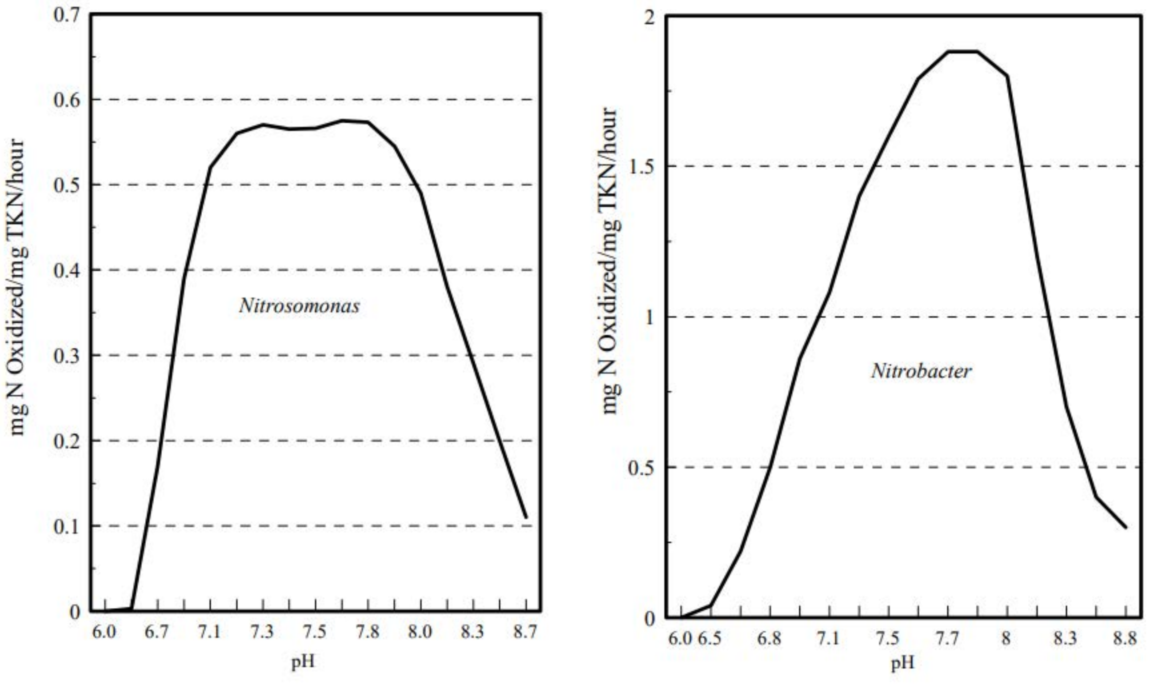
SSSAJ: Volume 71: Number 2• March–April 2007

Graph retrived from A Review of the Use of the Basic Cation Saturation Ratio and the “Ideal” Soil, P. Kopittke and N. Menzies

pH is Still Important for Other Crops

- While Ca mitigates the effect of low pH on Rhizobia bacterium, pH still effect other microbial species.
  - Nitrosomonas
  - Nitrobacter

- Most of the bacteria associated with N operate best in a 6.5-8 pH soil.



Source: Grady and Lim 1980

Figure 3
Effects of pH on *Nitrosomonas* and *Nitrobacter* enrichment cultures

Nitrification, 2002, EPA

Cost of Nutrients

- There are many factors which effect cost of Nutrients
- Dry Fertilizer
  - Distance from supplier
  - Blending facilities and options
  - Spreading
    - Custom
    - Owned Spreader
    - Rented
- Manure
  - Distance from livestock facilities
  - Cost of Hauling
    - Nutrient concentration per ton
    - Application cost
- Cover Crops
  - Seed cost
  - Seeding cost
  - Loss of Primary crop potential
- Alfalfa
  - Seed cost
  - Seeding cost
  - Nutrients exported

Why Not Alfalfa?

- Projected Corn/Oats

- Corn Cost - $741/Acre
- Corn Gross Profit (175 bu x $8.5) - $1487.5

- Estimated profit of $746/Acre

- Oats Cost - $454.50
- Oats Gross Profit (85 bu x $5.25) - $506.25

- Estimated profit of $51.75

- Estimated profit $398.88/yr over the rotation

- Projected Alfalfa (3 Yr)/Corn/Oats/Corn

- Alfalfa Profit/3yr average - $133.80/yr

- Corn Profit of $800/Yr

- Oats Profit of $51.75

- Estimated Profit over the rotation of $342.2/yr over the rotation

Why Not Alfalfa?

- Additional Expensive Equipment Required
- Storage space
- Highly variable crop depending on
  - Weather
  - Current markets
  - Quality of harvested crop
- Additional Labor requirement
- Timing
  - First cutting is generally when row crops need weed control
- Added stress and work load all Summer long
  - Limiting vacations or family time

Why More of a Rotation?

- Projected Corn/Oats Nutrient Flow

Nutrients	N	P	K
Corn Removal	117	61	43
Oats/Stover Removal	91	36	95
Nutrients Applied	251	187	172
Net Result of Rotation	43	90	34
Net Result of Rotation over 6 yrs	**129**	**270**	**102**

- Projected Alfalfa (3 Yr)/Corn/Oats/Corn Nutrient Flow

Nutrients	N	P	K
Alfalfa Removal	678	159	651
Corn Removal	234	122	86
Oats/Stover Removal	91	36	95
Nutrients Applied	303	226	208
Net Result of Rotation	700	91	624
Net Result of Rotation over 6 yrs	**700**	**91**	**624**

Why Alfalfa?

Questions?

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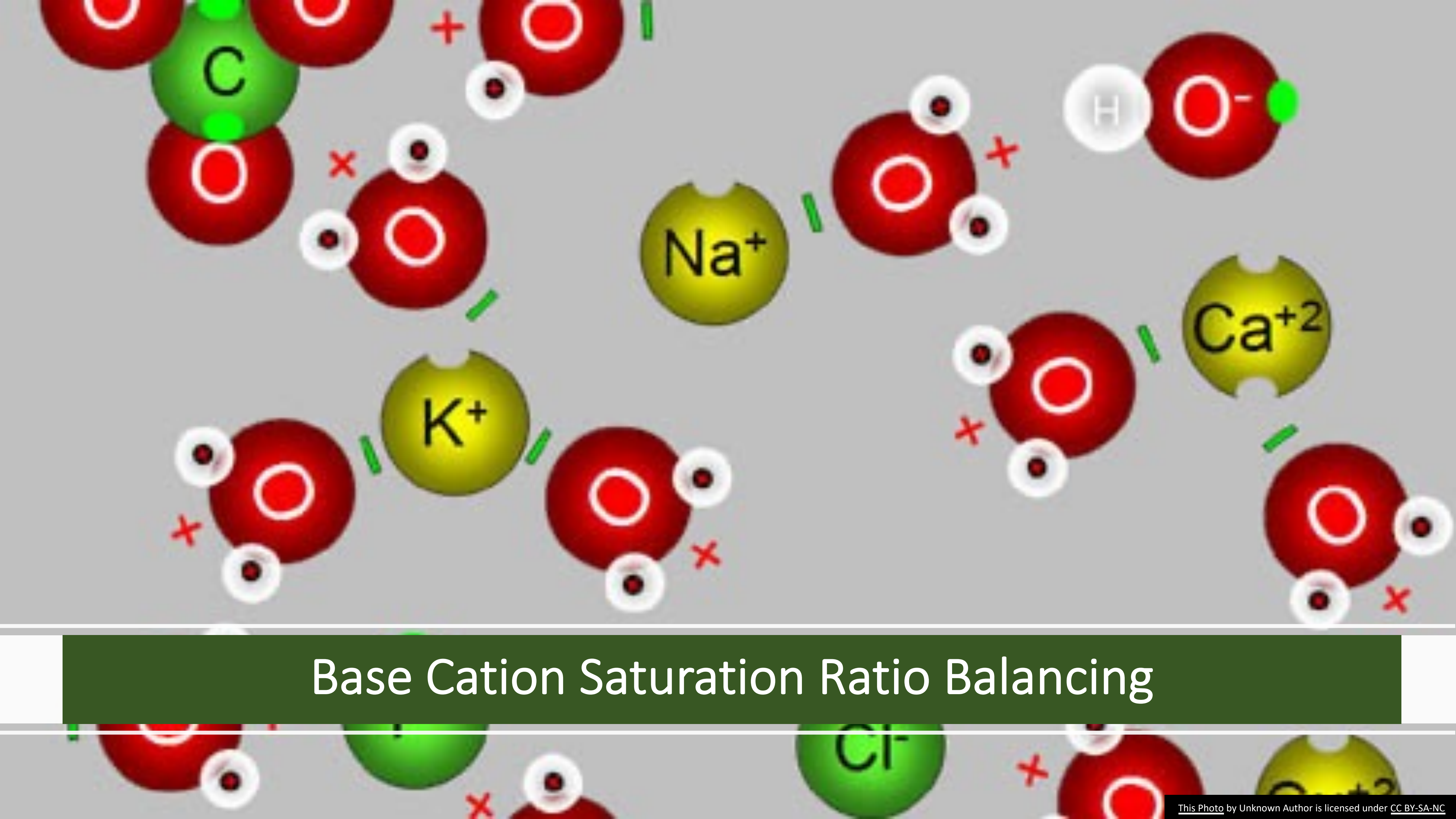
A Few Misconceptions?



Base Cation Saturation Ratio Balancing

Base Cation Saturation Ratios (BCSR)

- The cation balance approach assumes that there is an ideal balance between cations in the soil and that once this balance is reached, soil and plant health will be improved, soil structure and biological activity will be enhanced and weed, insect and disease pressures will be reduced or eliminated.

5% Base Saturation Potassium (K)
12% Base Saturation Magnesium (Mg)
68% Base Saturation Calcium (Ca)

Common Misconceptions

- Magnesium
  - Often heard today by many people that it makes soil tight
  - Attributed to Albrecht but not found in his writings, he wanted Mg

"A liberal virgin store of magnesium in the more active form or a large stock in the mineral reserve may have been saving us with respect to shortages of this nutrient." (Albrecht on Soil Balancing, pg. 91)

- Sole observation from his literature on excess Mg

"Then again, the rotation and the fallowing – all without soil treatment – which give a decrease in the organic matter, in the nitrogen, and in the calcium saturation, serve to give an increase in magnesium saturation." (Albrecht on Soil Balancing, pg. 91)

Today, Mg Represented as making Soil Tight

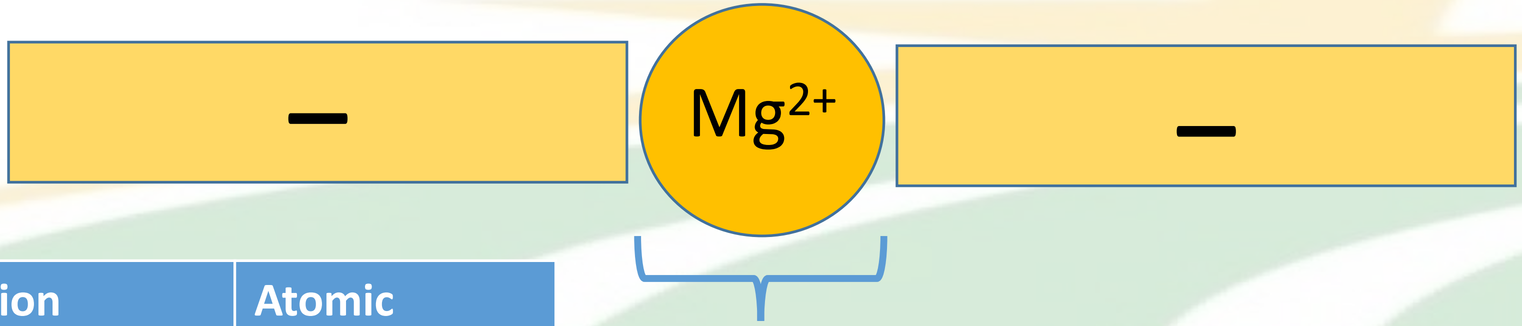
- However,

Poor Flocculators		Good Flocculators		Excellent Flocculators	
Na	+1	Ca	+2	Al	+3
K	+1	Mg	+2	Fe	+3

Increasing Positive Charge

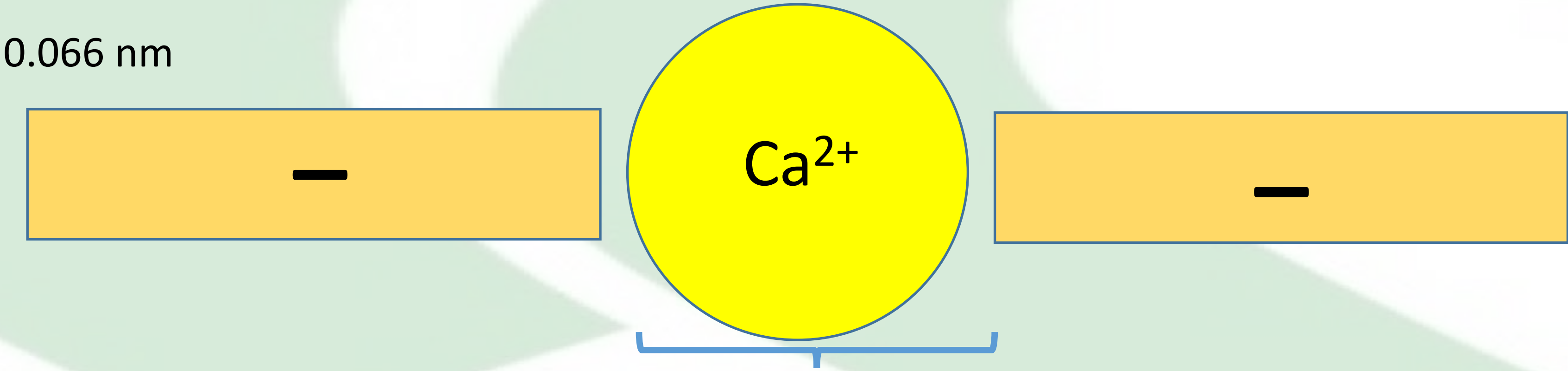
Flocculation Chemistry (Common misconceptions)

- Magnesium has a smaller ionic radius ergo there is less pore space between two colloids with Magnesium in between verses Calcium causing the soil to be compacted.



Ion radius 0.066 nm

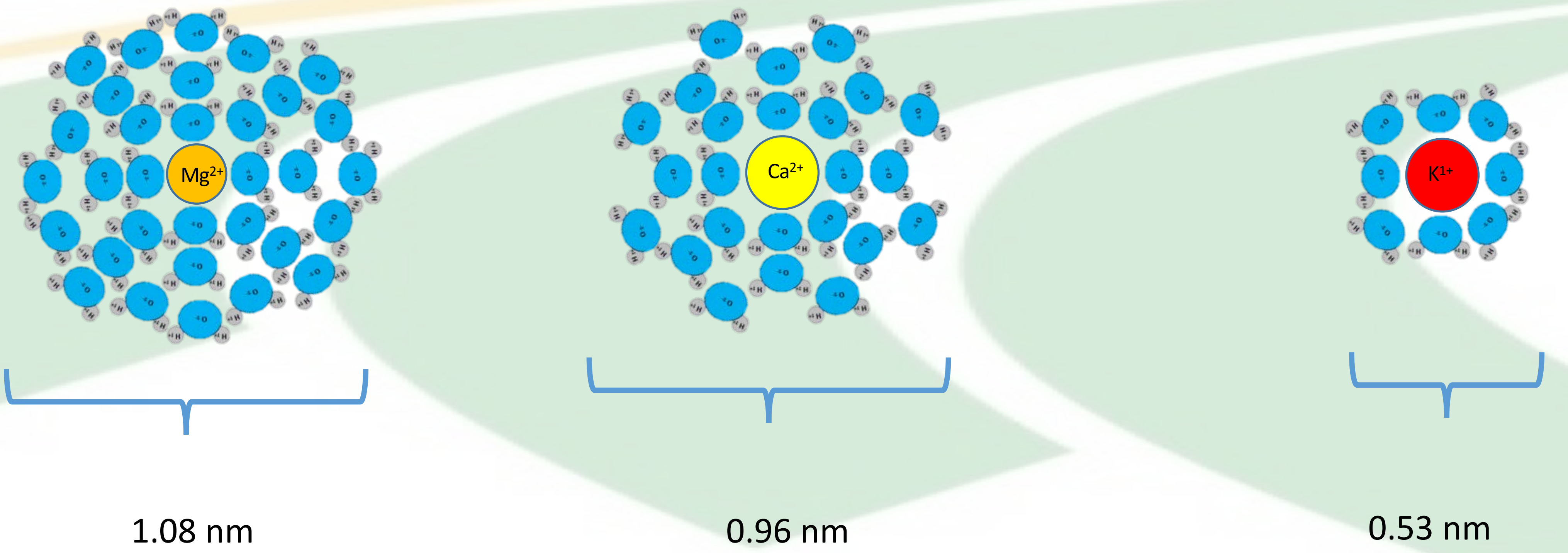
Cation	Atomic Radius
Na	1.86
K	2.31
Mg	1.6
Ca	1.97



Ion radius 0.099 nm

Cation Chemistry { Hydration layer/radius

- Different for different cations based on their size and charge



Flocculation Chemistry (Common misconceptions)

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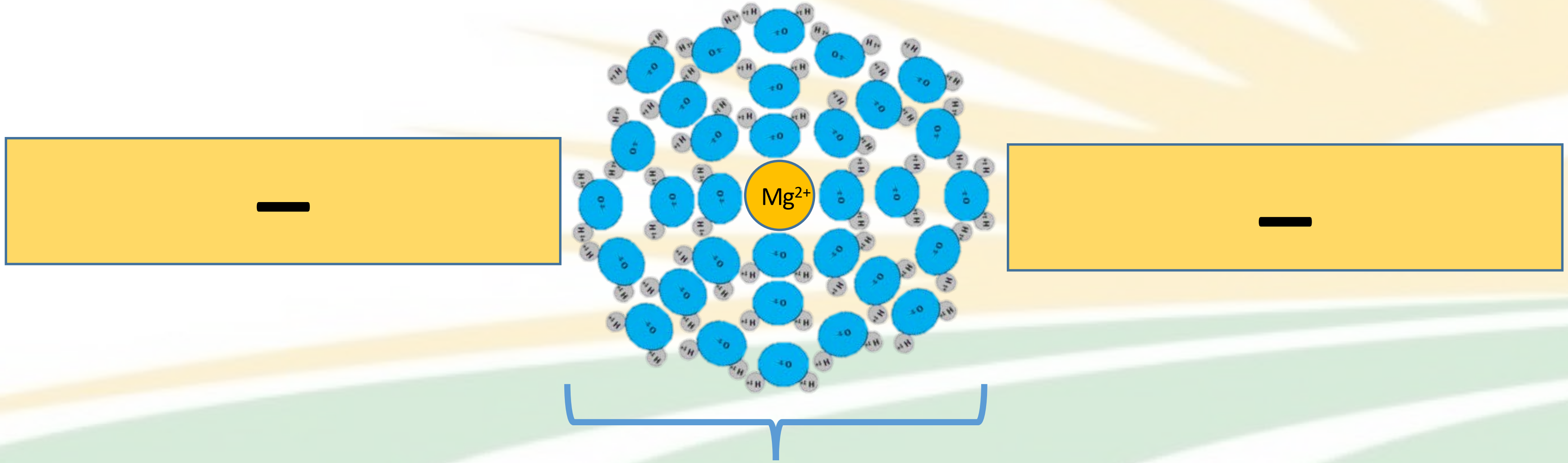
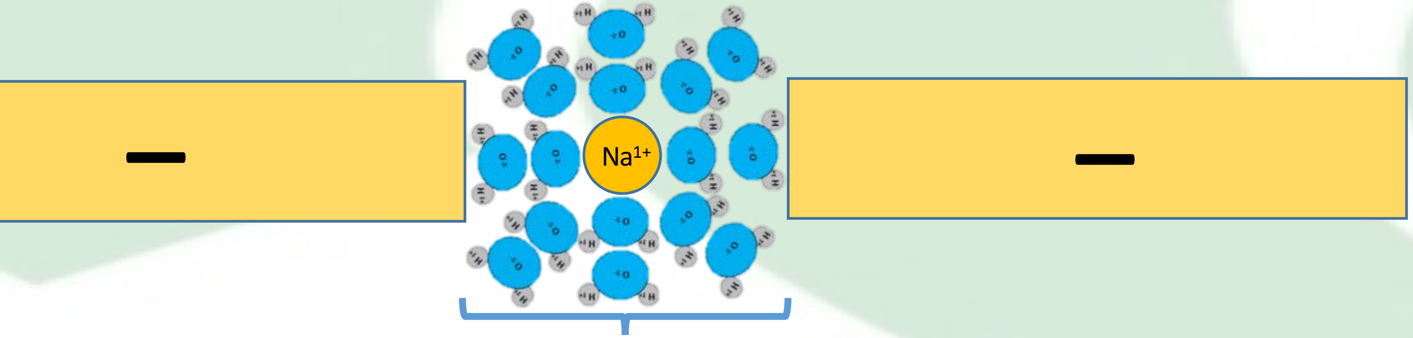
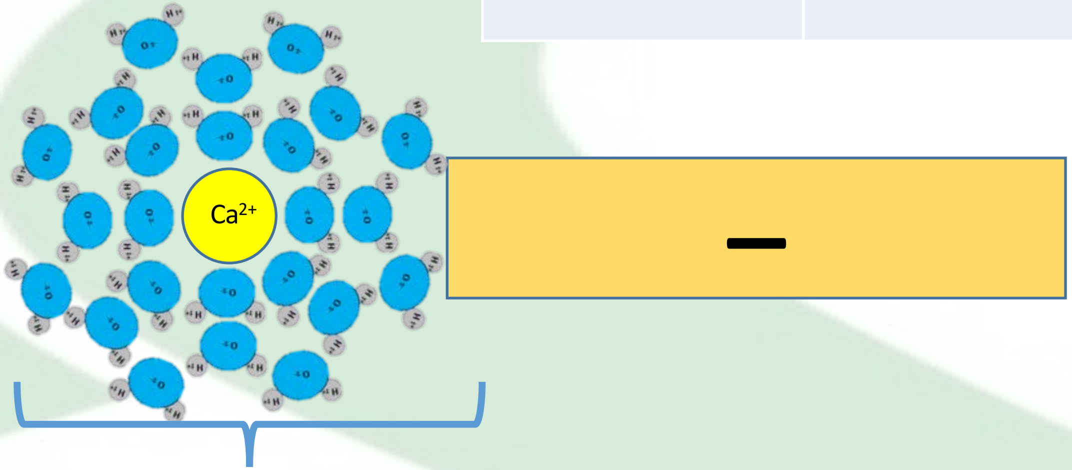


Hydration radius 1.08 nm



Hydration radius 0.79 nm



Hydration radius 0.96 nm

Flocculation Chemistry

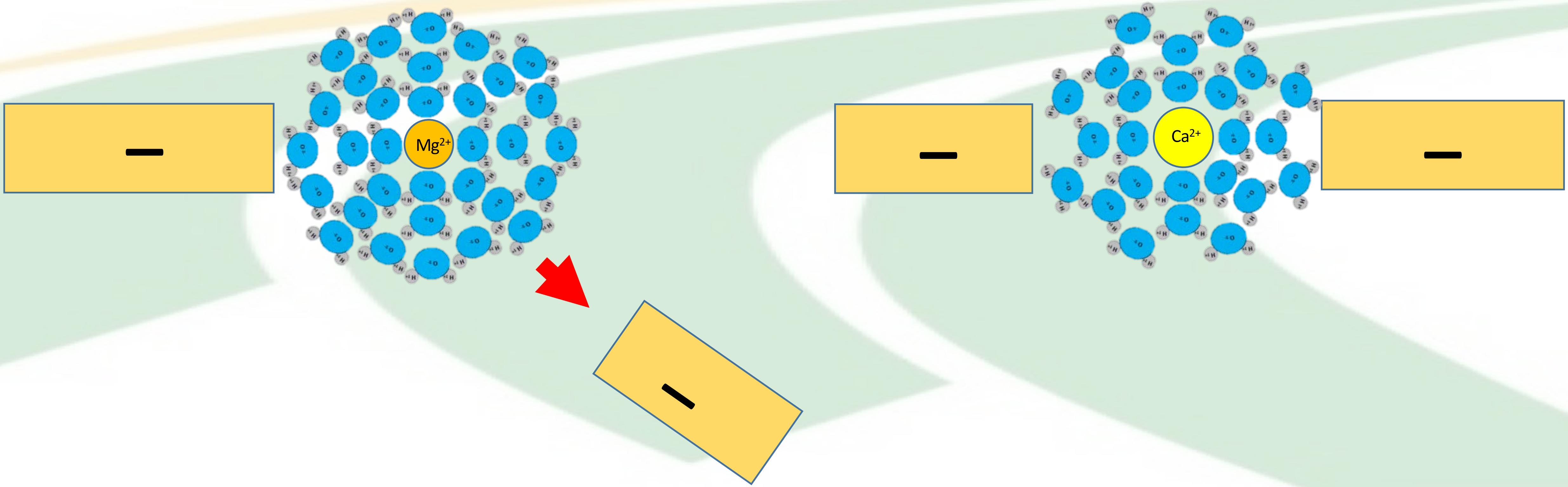
Ion		Relative Flocculating Power	**Hydration Radius**
Sodium	Na^{+}	1.0	.79
Potassium	K^{+}	1.7	.53
Magnesium	Mg^{2+}	27.0	1.08
Calcium	Ca^{2+}	43.0	0.96

Sumner and Naidu, 1998

University of Arizona Extension

Flocculation Chemistry

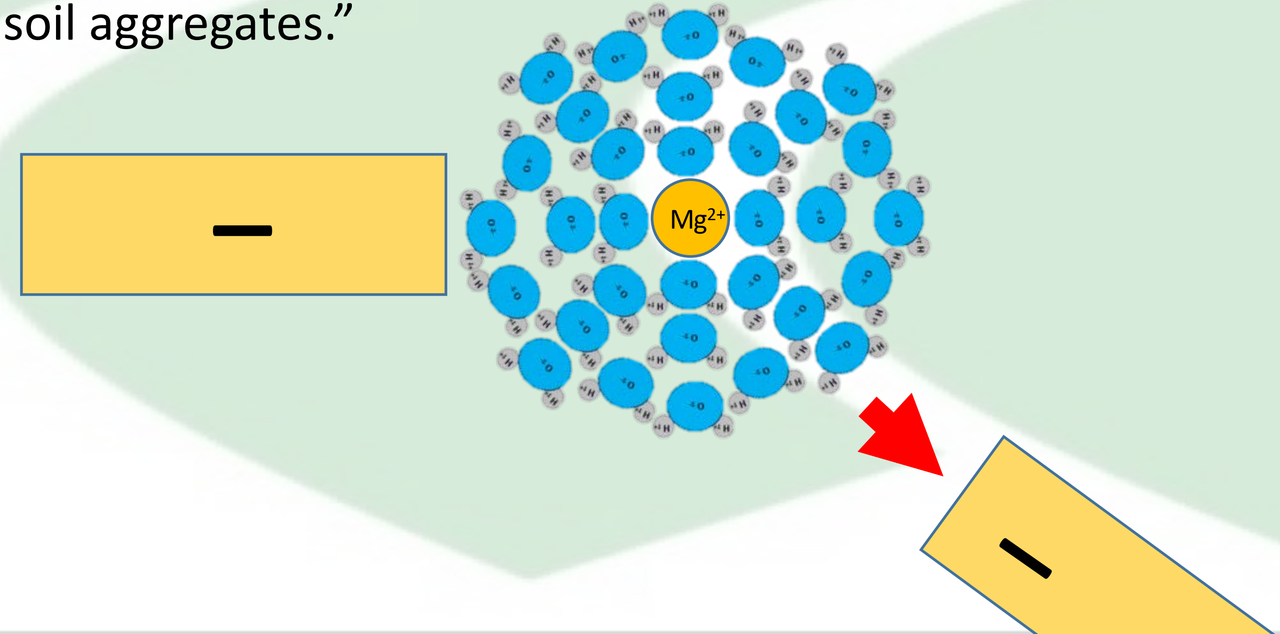
- Magnesium does not hold on to the colloids as well as Calcium which results in deflocculation **sooner** under high energy situations such as a heavy rainfall event.   (Ca will also release only takes more energy)



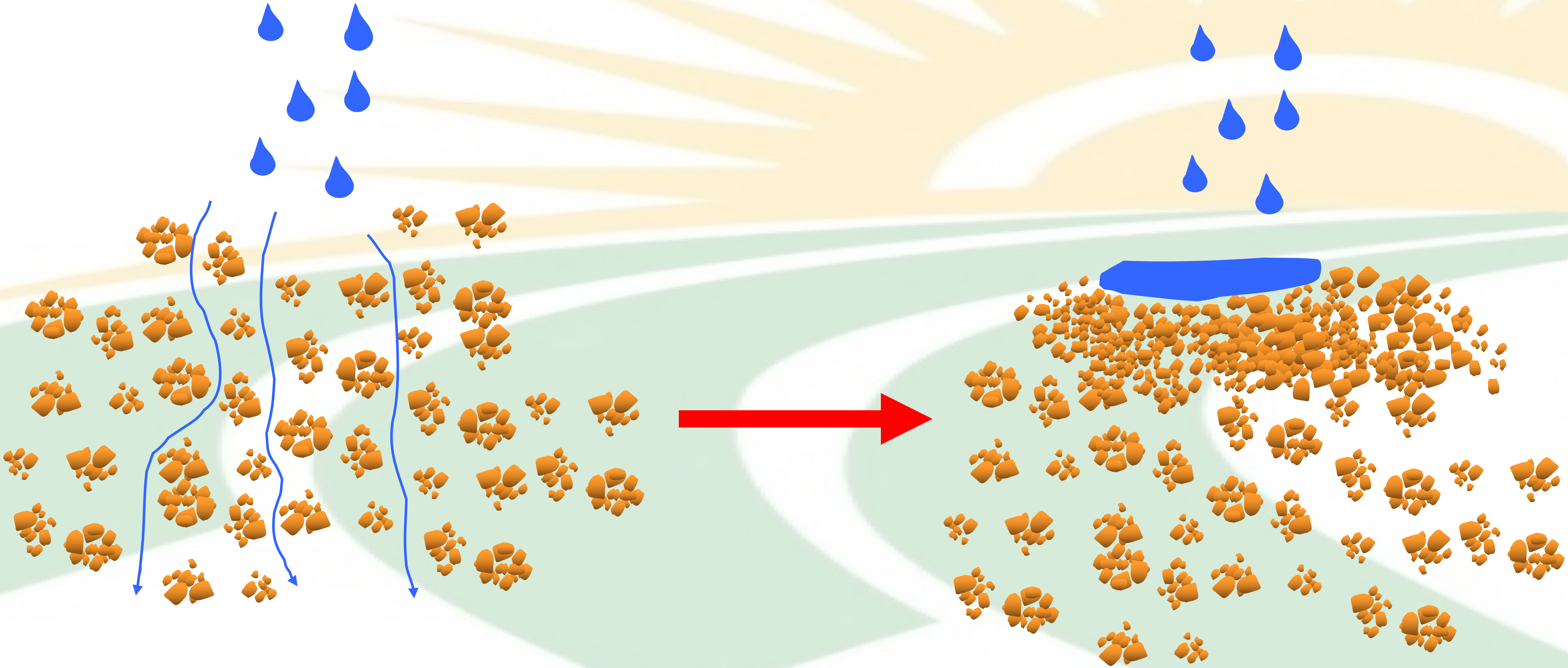
Flocculation Chemistry

- Sumner, M. and Naidu, R.. Sodic Soils. 1998. Oxford University Press. pg 128.

  - "This specific effect of Mg is due to the difference in size between hydrated Mg and Ca ions, with **resulting differences in the strength of attraction** to cation exchange sites (Chapter 3). Hydrated Mg, which is larger than hydrated Ca, decreases the linkages between external surfaces within a soil aggregate, decreasing in turn the amount of raindrop energy needed to break down soil aggregates."



Flocculation Chemistry



Images from University of Arizona Extension

Flocculation Chemistry (depends on soil type and organic matter)

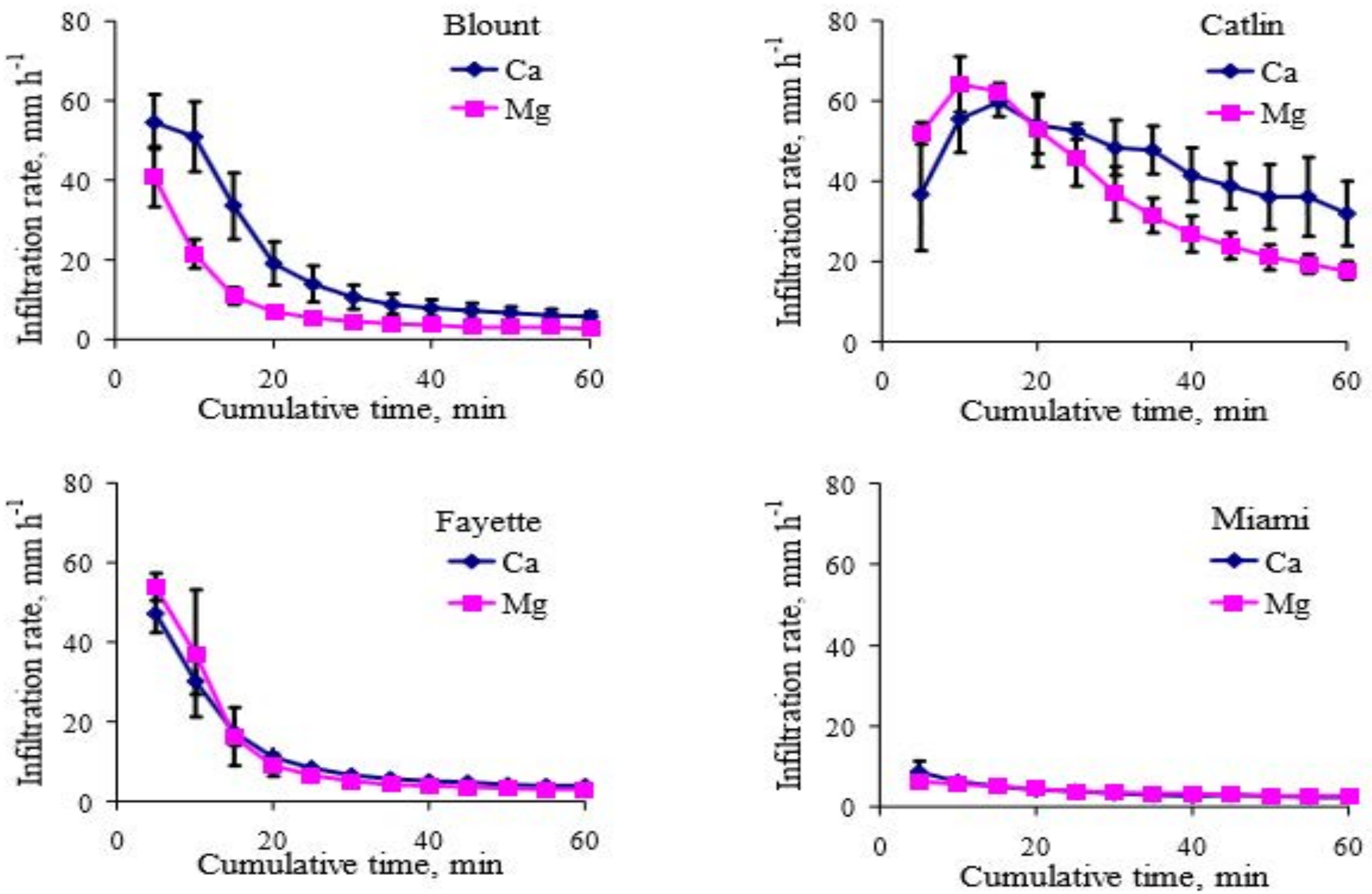


Figure 3. Infiltration rate (average of four replications) as a function of cumulative time for Ca- and Mg-saturated soils. Error bars equal one standard deviation.

Images from Effects of Exchangeable Ca:Mg Ration on Soil Clay Flocculation, Infiltration and Erosion, K. Dontsova and L.D. Norton

Flocculation Chemistry (depends on soil type and organic matter)

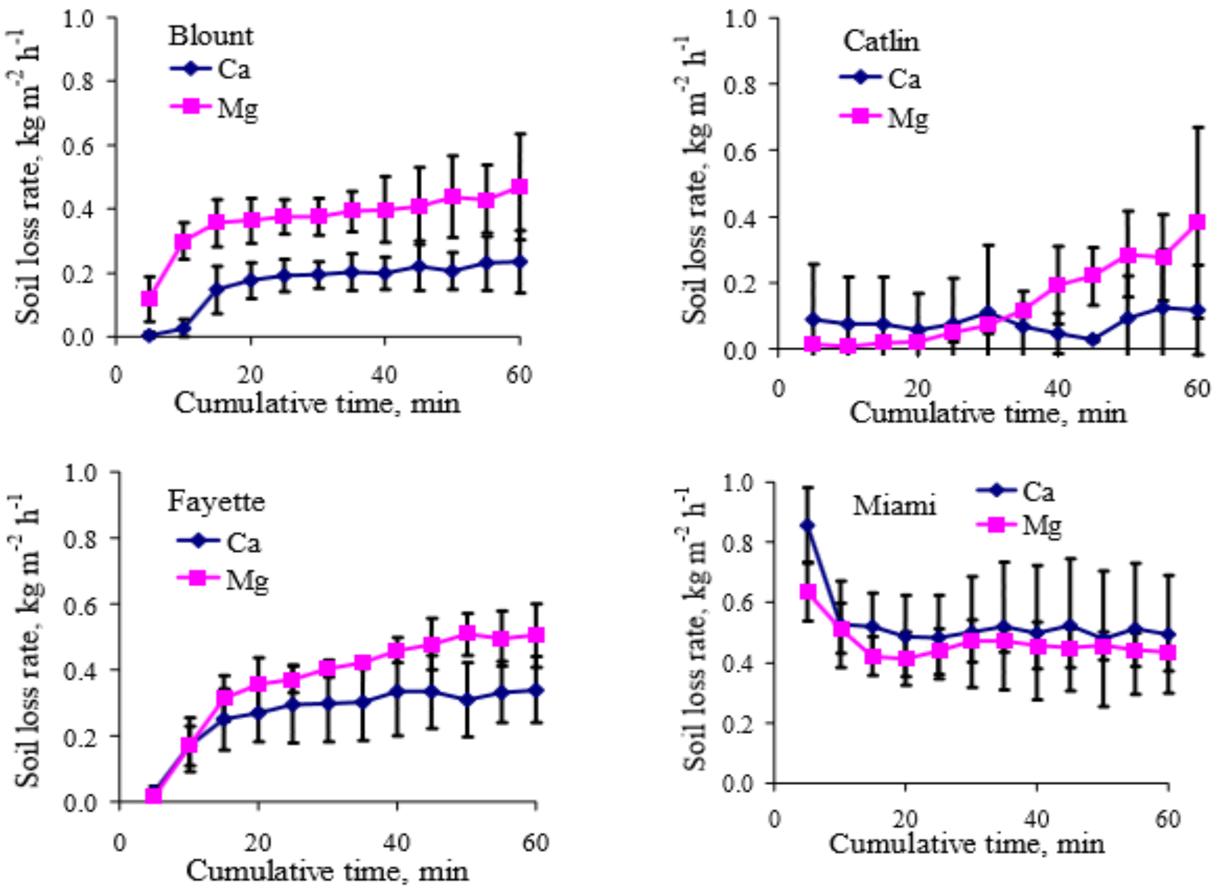


Figure 4. Soil loss rate (average of four replications) as a function of cumulative time for Ca- and Mg-saturated soils. Error bars equal one standard deviation.

Images from Effects of Exchangeable Ca:Mg Ration on Soil Clay Flocculation, Infiltration and Erosion, K. Dontsova and L.D. Norton

Flocculation Chemistry (SARE Study)

- Bulk Density = Weight of dry soil/(Volume of solids and pore space)
- Is a measure of compaction by determining the amount of pore space in soil.

Tons of Lime Applied	Bulk Density	Ca:Mg
0	1.39	3.88
2	1.38	4.34
4	1.40	5.31
8	1.41	6.29
Tons of Gypsum Applied		
0	1.35	3.43
1.05	1.35	3.43
1.4	1.36	3.81 (almost no change!!!)

Calcium Inputs for Soil Quality Improvement, Bernard Knezek

- There was no change in Bulk Density (pore space) despite the application of the soil amendments and the change in Ca:Mg ratios

Study on Corn, Alfalfa, Wheat, and Soybeans by McLean (a student of Albrecht), Hartwig, Eckert, and Triplett.

Conclusions

- "Indeed, McLean, who worked with Albrecht in Missouri during the 1940s, stated that, on the whole, "there is no 'ideal' basic cation saturation ratio or range" (Eckert and McLean, 1981),

and that

- "emphasis should be placed on providing sufficient, but not excessive levels of each cation rather than attempting to attain a favorable basic cation saturation ratio which evidently does not exist" (McLean et al., 1983)." (Kopittke and Menzies. A Review of the Use of the Basic Cation Saturation Ratio and the "Ideal" Soil. Soil Sci. Soc. Am. J. 71:259-265)

Corn Test Plot 2013

Corn (Weeds) $11/bu	SLAN (L)	SLAN (H)	SLAN (L) +	BSCR	BSCR +	Biology	Control
Yield	123	132	122	89	95	79	72
Gross Profit	$1353	$1452	$1342	$979	$1045	$869	$792
Gross after Fertilizer	$1001	**$1056**	$807	**$319**	$321	$839	$792

Difference between SLAN and BSCR:

$737

100 Acres of Corn

$73,700

Difficult to Change - Chico Case Study

- **The soil still was not balanced at the end of the study!!!!!!!!**

Units	O.M.	N ppm	P ppm	K ppm	Ca ppm	Mg ppm	S ppm	Zn ppm	B ppm	pH	CEC	% Ca	% Mg	% K
Original													33.8	3.2
Amended													30.9	5.14
Non-Amended													33	3.7

- Amended Soils: Cost

- 6000# Gypsum (slit over spring and fall) $53/ton
- 1200# Hi-Cal lime $196/ton
- 20# of Granubor $1.2/lb
- 15# of Zinc Sulfate $1.10/lb
- 6# of Manganese Sulfate $0.90/lb
- 15 ton Compost (10:5:10 N:P:K) $35/ton
- Application cost: $13.8/acre

- Total over the three years to "balance" soil

$847.50/acre

% Ca	% Mg	% K
55.4	**33.8**	**3.2**
62	**30.9**	**5.14**
59.3	**33**	**3.7**

Base Cation Saturation Ratios (BCSR)

- The cation balance approach assumes that there is an ideal balance between cations in the soil and that once this balance is reached, soil and plant health will be improved, soil structure and biological activity will be enhanced and weed, insect and disease pressures will be reduced
- Down side:
  - Some soils are next to impossible to change (high pH, high CEC, economics) or when balance is achieved, not all problems go away.
  - Makes assumption the soil will not be influenced by parent material and revert to previous form.
  - Can easily over apply some nutrients over what is needed for plant response particularly on high CEC soils (K, Ca).
  - Makes the assumption that the soil is static and not weathering similar to crop removal system.

Missed Principles

- Both Bear and Albrecht promoted good management technics as a primary method of good crop production.

- Albrecht [1942]
  - "Fertilizer use should not serve to divert attention from manure conservation, its maximum production, and its wisest use. All possible practices in better soil management should be exercised **<u>first</u>** and then fertilizers purchased and added to make up the deficiencies in soil fertility that need to be balanced for most effective crop production. **<u>Manure use</u>** represents putting back much off what came from the soil. Fertilizer use represents putting on some fertility purchased and brought from outside the farm, to add to the soil's supply."

- Bear
  - "… a well-planned crop rotation was worth 75% of everything else the farmer did."

Questions?

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Calcium, Its importance

- Necessary for cell division and growth

Table 7-6 Effect of Ca Concentration and pH on Root Elongation in Nutrient Solution

	Experiment 2				Experiment 3		
	Ca Concentration Added	Taproot Elongation Rate*	Taproot Harvest Length	Oven Dry Wt.		Ca Concentration Added	Taproot Elongation Rate
pH	ppm	mm/hr	mm	mg	pH	ppm	mm/hr
5.6	0.05	2.66	461	0.20	4.75	0.05	0.11
	0.50	2.87	453	0.23		0.50	0.91
	2.50	2.70	455	0.32			
4.5	0.05	0.04	024	0.54	4.00	2.50	0.44
	0.50	1.36	270	0.26		5.00	1.26
	2.50	2.38	422	0.31			

*Elongation rate during first 4 hr in solution. Harvested 7½ days after entering the solution.

SOURCE: Lund, 1970, *Soil Sci. Soc. Am. J.*, 34:457.

Soil Fertility and Fertilizers, Havlin et al., pg. 238

William Albrecht (Ca and pH effect of Nodulation)

Plant characters	Calcium per plant me/plant		pH at outset (first crop)					
			4	4.5	5	5.5	6	6.5
Nodules/ 50 plants		0.05	0	0	0	0	7	14
		0.1	0	0	0	8	28	40
		0.2	0	0	0	60	69	127
Height, cm		0.05	11	26	28	31	36	36
		0.1	9.5	27	34	42	44	45
		0.2	8	25	40	45	48	52
Weight of 50 plants in grams	Tops	0.05	4.8	6.3	6.8	7	7.9	7.6
		0.1	4.2	6.3	7.3	8.9	9.5	8.7
		0.2	4.6	6	8.7	9.2	9.4	9.9
	Roots	0.05	1.5	2.5	2	2	4	3.6
		0.1	1.7	2.2	2.1	4.3	4.3	4.2
Data retrieved from Albrecht 1937		0.2	1	1.7	2.5			

Table retrived from Albrecht on Soil Balancing, 1937

William Albrecht (Ca and pH effect of Nodulation)

- His experiment in 1937:
  - pH does have an effect on nodulation despite his claim later on that nodulation occurs based on Ca levels regardless of pH.
- It did prove Ca can mitigate the effects of a low pH.
  - This was verified by Lund [1970] and Silva et al [2001].

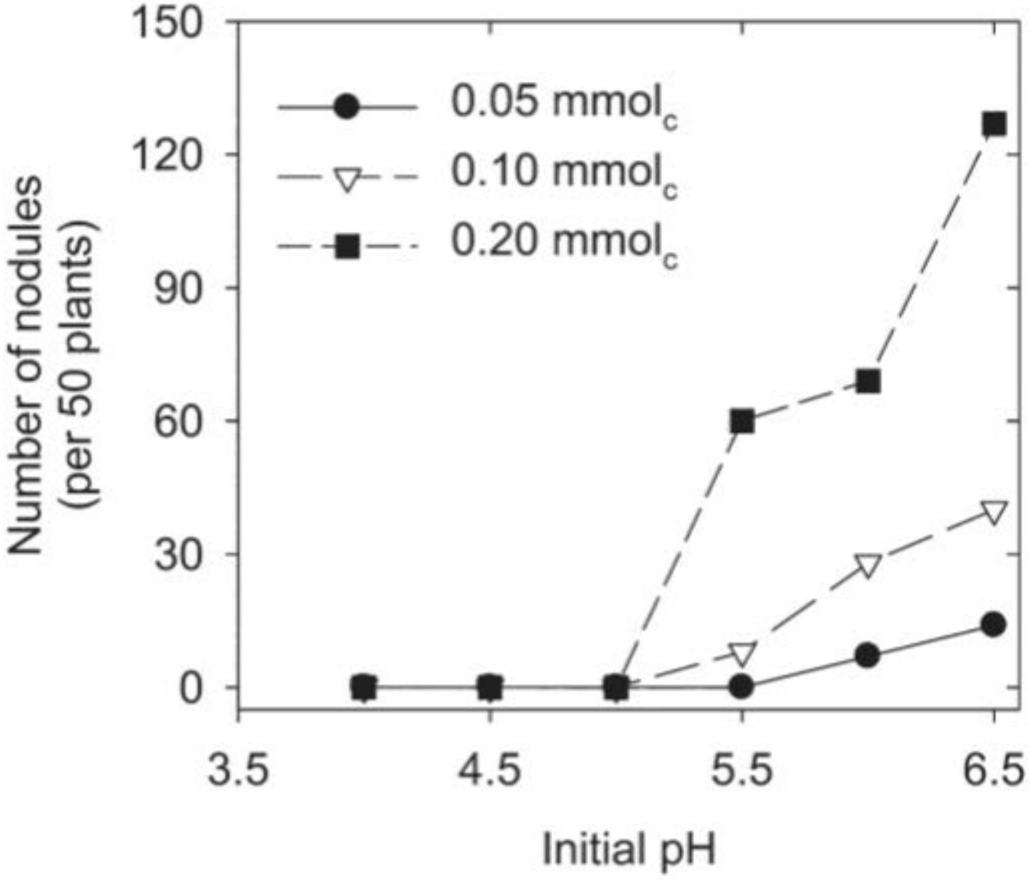


Fig. 1. Effect of initial soil pH on the nodulation of soybean. Calcium was supplied at three levels: 0.05, 0.10, or 0.20 mmol$_c$ Ca per plant. Data taken from Albrecht (1937).

SSSAJ: Volume 71: Number 2• March–April 2007

Graph retrived from A Review of the Use of the Basic Cation Saturation Ratio and the "Ideal" Soil, P. Kopittke and N. Menzies

Cost Examples

Example #1

- Dairy Farm
  - Has 750,000 Gal of Liquid Manure
    - 17.7-8.6-19.5
  - Fields all within 1-1.5 mile of farm
    - Estimated application cost $0.0075/gal
    - Need 18,000 gal for 175# N
      - Corn after Wheat
    - **$135/Acre**

- Dairy Farm
  - Has 750,000 Gal of Liquid Manure
    - 17.7-8.6-19.5
  - Field +/- 3 miles of farm
    - Estimated application cost $0.0175/gal
    - Need 18,000 gal for 175# N
      - Corn after Wheat
    - **$315/Acre**

Note the difference in cost associated with distance from source.

Example #2

- Dairy Farm
  - Has 750,000 Gal of Liquid Manure
    - 17.7-8.6-19.5
  - Fields all within 1-1.5 mile of farm
    - Estimated application cost $0.0075/gal
    - Need 13,800 gal for 135# N
      - Corn after Soybeans
      - Or after Wheat with 35# 2nd Year N Credit
      - Or after Wheat with Red Clover (~$35 cost to seed)
    - **$103.50/Acre**

- Dairy Farm
  - Has 750,000 Gal of Liquid Manure
    - 17.7-8.6-19.5
  - Field +/- 3 miles of farm
    - Estimated application cost $0.0175/gal
    - Need 13,800 gal for 135# N
      - Corn after Soybeans
      - Or after Wheat with 35# 2nd Year N Credit
      - Or after Wheat with Red Clover (~$35 cost to seed)
    - **$241.50/Acre**

Note the difference in cost associated with accounting for all N credits.
Savings $30-$70 per acre.

Example #3

- Organic Cash Crop Farm
  - Alfalfa Plowdown/CPM Pellets
    - 90-60-60
  - All manure imported
    - Estimated application cost $10/Acre
    - Need 600#/Acre for 27# N
  - **$55.50/Acre**

- Organic Cash Crop Farm
  - Alfalfa Plowdown/Chicken Litter ~$45/ton
    - 52.3-39.1-36
  - All manure imported
    - Estimated application cost $6/Acre
    - Need 1 Ton/Acre for 30# N
  - **$45/Acre**

Note the savings Hay N credit can provide. Saving here verses following Soybeans is $110-$220 in just first year savings.

Why Not Alfalfa?

- Projected Corn/Oats

- Corn Cost - $741/Acre
- Corn Gross Profit (175 bu x $8.5) - $1487.5

- Estimated profit of $746/Acre

- Oats Cost - $454.50
- Oats Gross Profit (85 bu x $5.25) - $506.25

- Estimated profit of $51.75

- Estimated profit $398.88/yr over the rotation

- Projected Alfalfa (3 Yr)/Corn/Oats/Corn

- Alfalfa Profit/3yr average - $133.80/yr

- Corn Profit of $800/Yr

- Oats Profit of $51.75

- Estimated Profit over the rotation of $342.2/yr over the rotation

Why Not Alfalfa?

- Additional Expensive Equipment Required
- Storage space
- Highly variable crop depending on
  - Weather
  - Current markets
  - Quality of harvested crop
- Additional Labor requirement
- Timing
  - First cutting is generally when row crops need weed control
- Added stress and work load all Summer long
  - No Vacations or family time

Correcting Soil Deficiencies For More and Better Forage From Permanent Pastures

ARNOLD W. KLEMME AND WM. A. ALBRECHT

At left, no soil treatment, the herbage was not eaten. At right, well-fertilized pasture was grazed short.

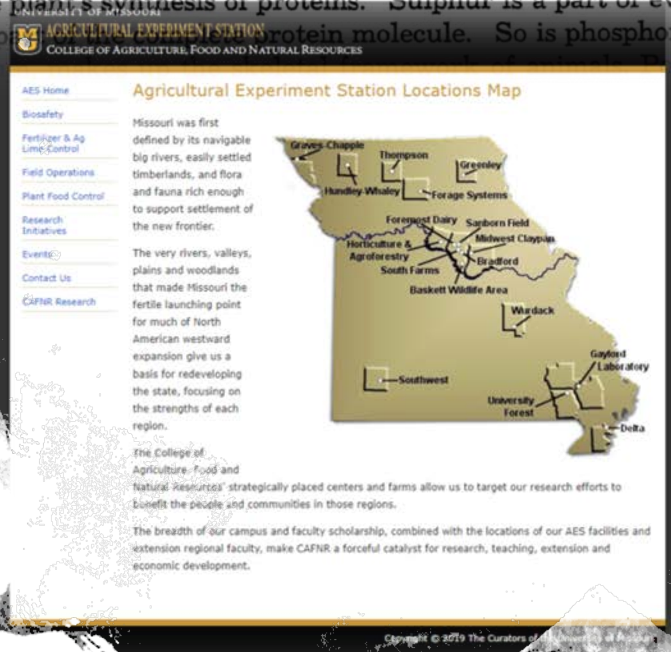
Pastures differ with the herbages they grow and with the different levels of nutrition offered by the soils.

UNIVERSITY OF MISSOURI COLLEGE OF AGRICULTURE
AGRICULTURAL EXPERIMENT STATION
J. H. LONGWELL, *Director*
BULLETIN 582 JUNE, 1952

BALANCED SUPPLY OF PLANT NUTRIENTS IS REQUIRED

The soil must provide an adequate supply of plant nutrients through the entire growing season to grow an abundant supply of nutritious forage for grazing. The soil must be fertile and that fertility must be active. Deficient fertility for the roots, going deeper as the surface soil dries, is commonly mistaken for "summer drought". The plant nutrients usually deficient in Missouri pasture soils are the same as those deficient in soils under corn or under any other crop. They are nitrogen, calcium, phosphorus, and frequently potassium and magnesium, to say nothing of others not so commonly catalogued.

Nitrogen is the chief constituent of plant proteins, which are reassembled from that source by animals into the more complete and more highly prized animal proteins. Without an ample fertility supply in the soil, a forage of high concentration of complete protein cannot be produced. Calcium, phosphorus, and sulphur are essentials coming from the soil for the plant's synthesis of proteins. Sulphur is a part of every living cell and a p... protein molecule. So is phosphorus, which



Inbox (887) - james.schroepfer@ | Soil Explorer

soilexplorer.net

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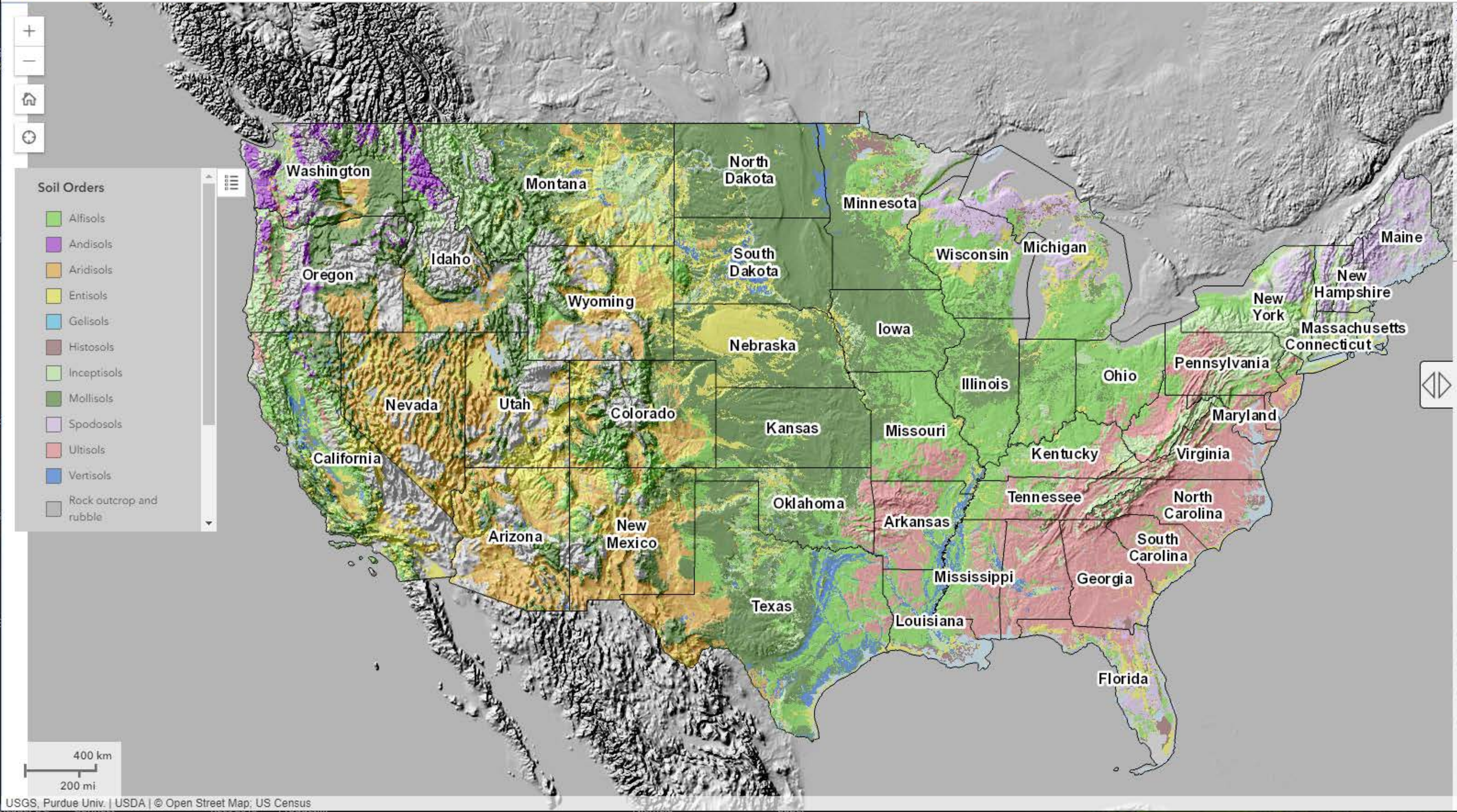

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SOIL EXPLORER

Wisconsin

Boundaries Roads and Places

Dominant Soil Parent Materials

Natural Soil Drainage Classes

Soil Orders

Surface Soil Colors

Acid Subsoils

Fragipans

Hillshade

Aerial Imagery (USGS)

Topography (USGS Topo)

Hillshade Basemap. Data sources: Global Multi-resolution Terrain Elevation Data 2010 (GMTED2010) (https://lta.cr.usgs.gov/GMTED2010), downloaded 25 November 2016. US National Elevation Dataset, 1/3 and 1/9 arc second datasets (https://viewer.nationalmap.gov/launch/), downloaded June 11-13, 2017. IndianaMAP 2013 Elevation data (http://indianamap.org), downloaded April, 2014.

Soil Orders map data source: Soil Survey Staff (2017). Gridded Soil Survey Geographic (gSSURGO) Database for the Conterminous United States. United States Department of Agriculture, Natural Resources Conservation

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