UNIVERSITY OF CALIFORNIA
Agriculture and Natural Resources | UC Cooperative Extension

Intro to Soil Health

California Tree School, Oakhurst

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Objectives

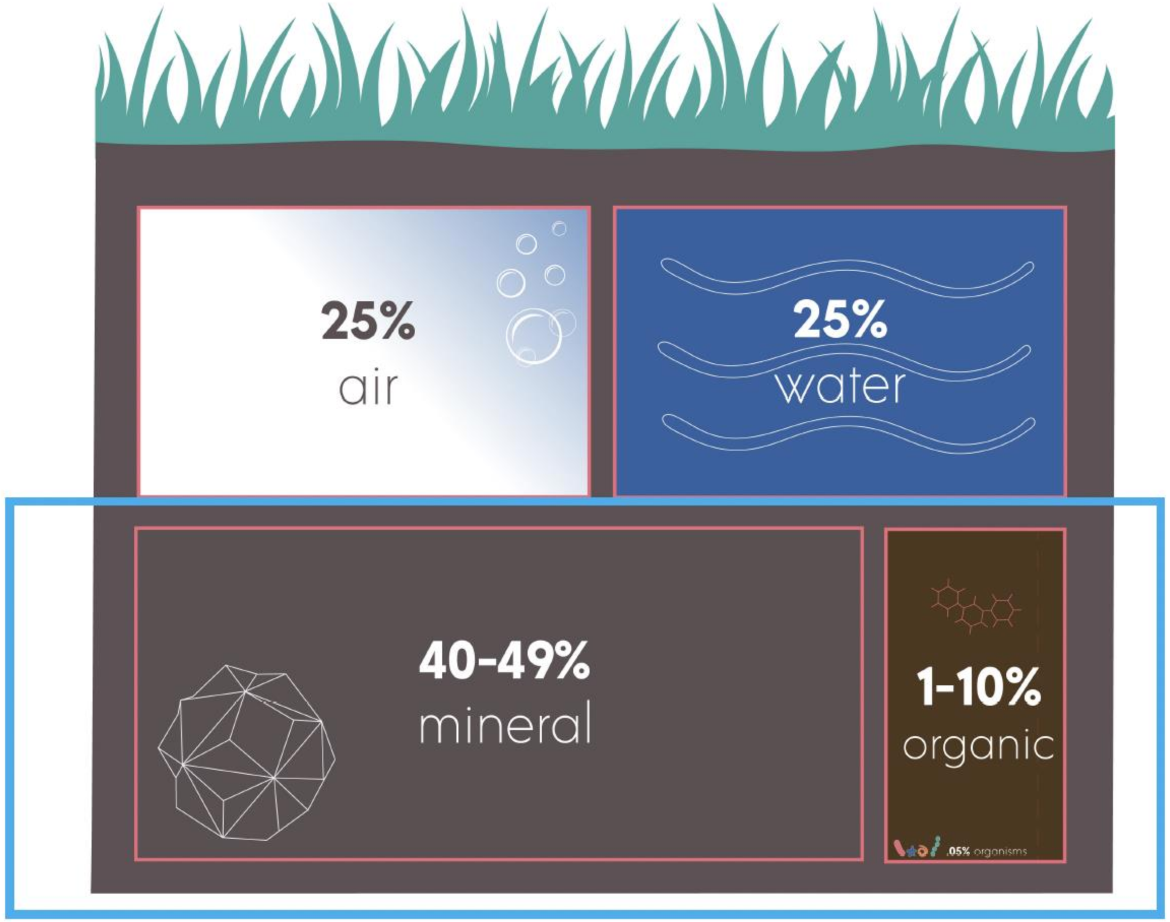
- Review soil composition as well as functional and physical differences based on texture
- Define soil health and understand how the soils physical, chemical, and biological properties drives soil's ability to function
- Discuss how different management practices effects these outcomes

Soil composition

Soil properties and functions determined by soil texture and parent material, as well as the organic fraction

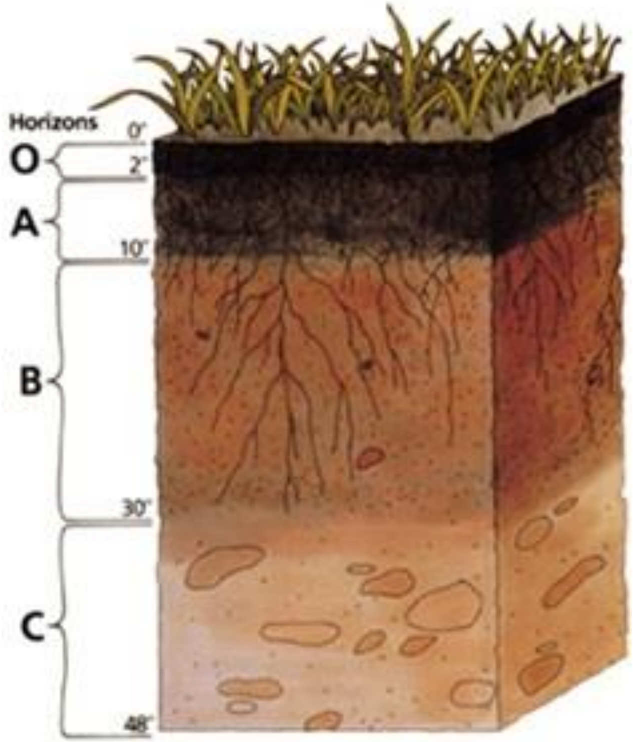
Defined by characteristics

- Color
- Particle size
- Particle arrangement
- Particle composition



Intro to Soils, SSC 100 UC Davis, 2020

Soil horizons



O (humus or organic): Mostly organic matter such as decomposing leaves

A (topsoil): Mostly minerals from parent material with organic matter incorporated.

E (eluviated): Materials like clay, iron, and organic matter are leached out, leaving behind a lighter-colored, sandier layer

B (subsoil): Rich in minerals that leached (moved down) from the A or E horizons and accumulated here.

C (parent material): The deposit at Earth's surface from which the soil developed.

R (bedrock): A mass of rock such as granite, basalt, quartzite, limestone or sandstone that forms the parent material for some soils.

https://www.soils4teachers.org/soil-horizons/

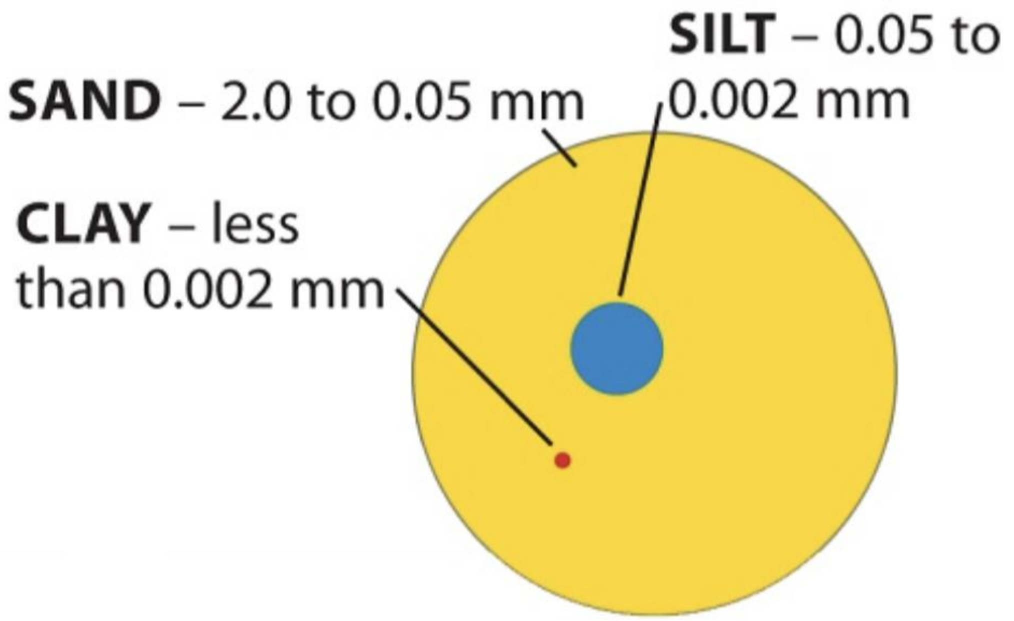
Soil texture

Particle size distribution

Fine-earth fraction < 2.0 mm: sand, silt and clay are the three soil particle sizes (or separates)

Soil texture

Describes the relative proportion of particles (sand, silt, clay) in a given soil



can not be changed by management!

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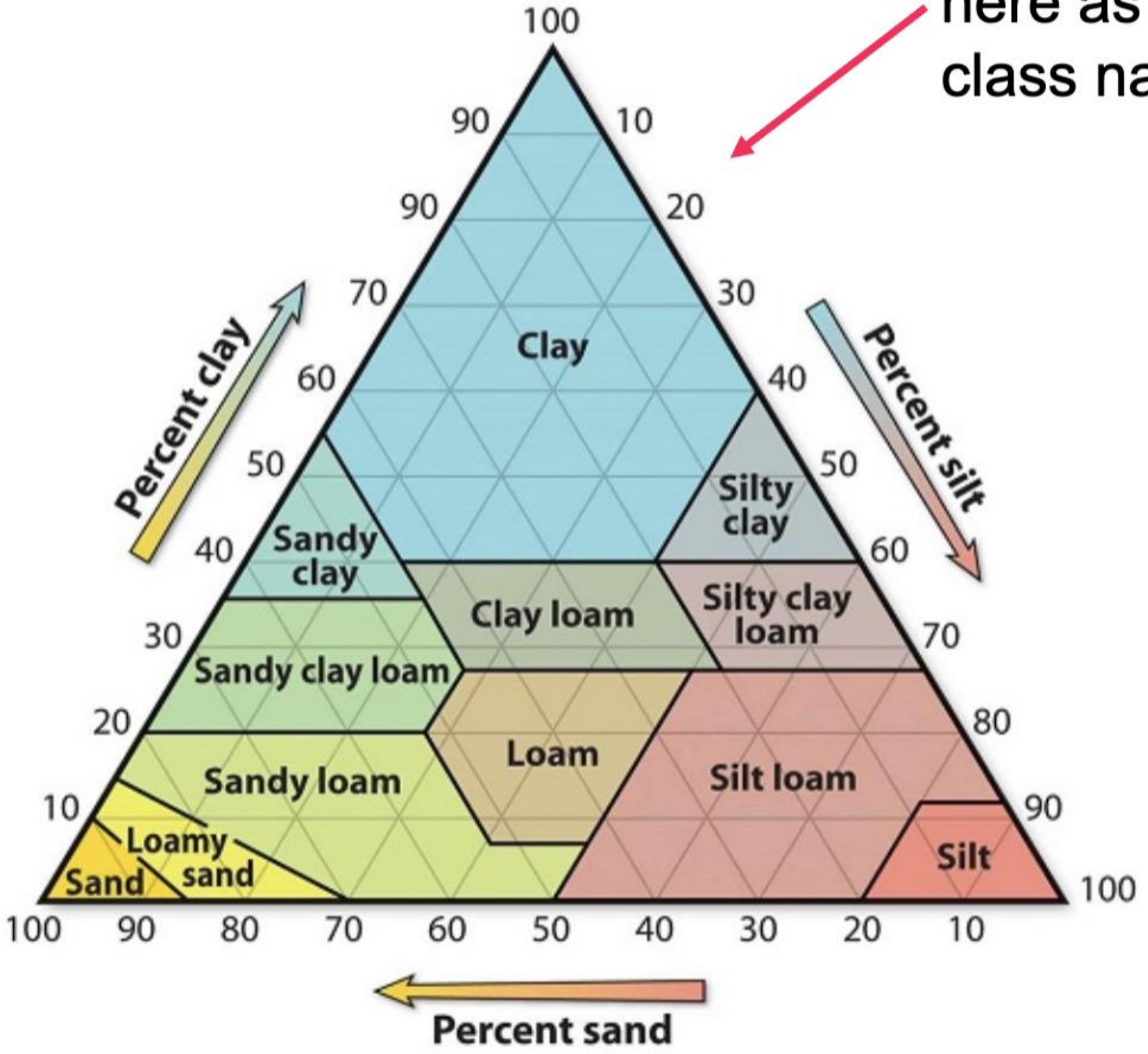
Soil textural classes

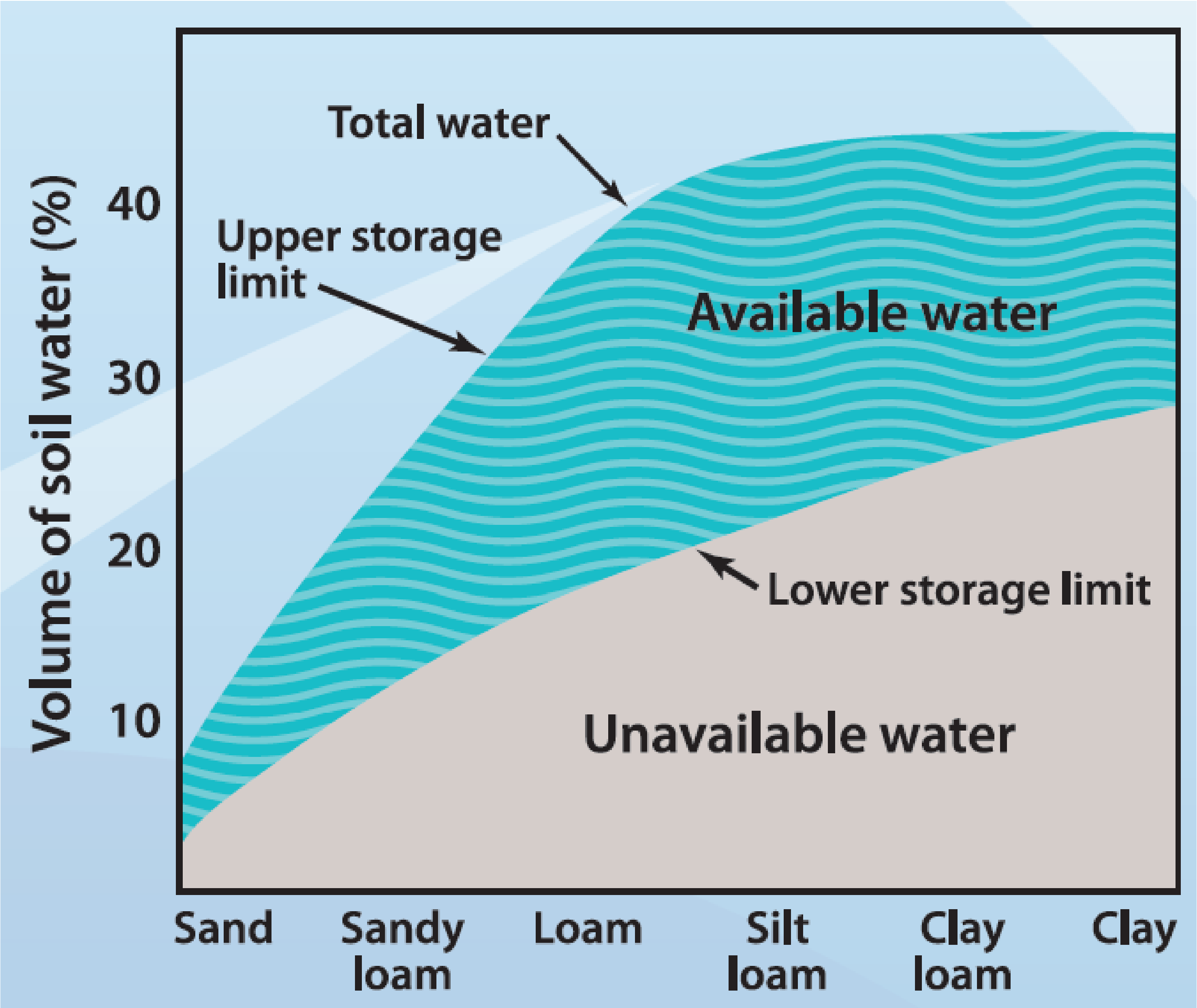
NOTE: Clay is used here as a texture class name.



Influence of soil texture

- Soils with smaller particle (silt and clay)
  - Greater capacity to hold water and nutrients
  - Increased interaction and ability to hold on to organic matter
  - Increased area for microbial colonization

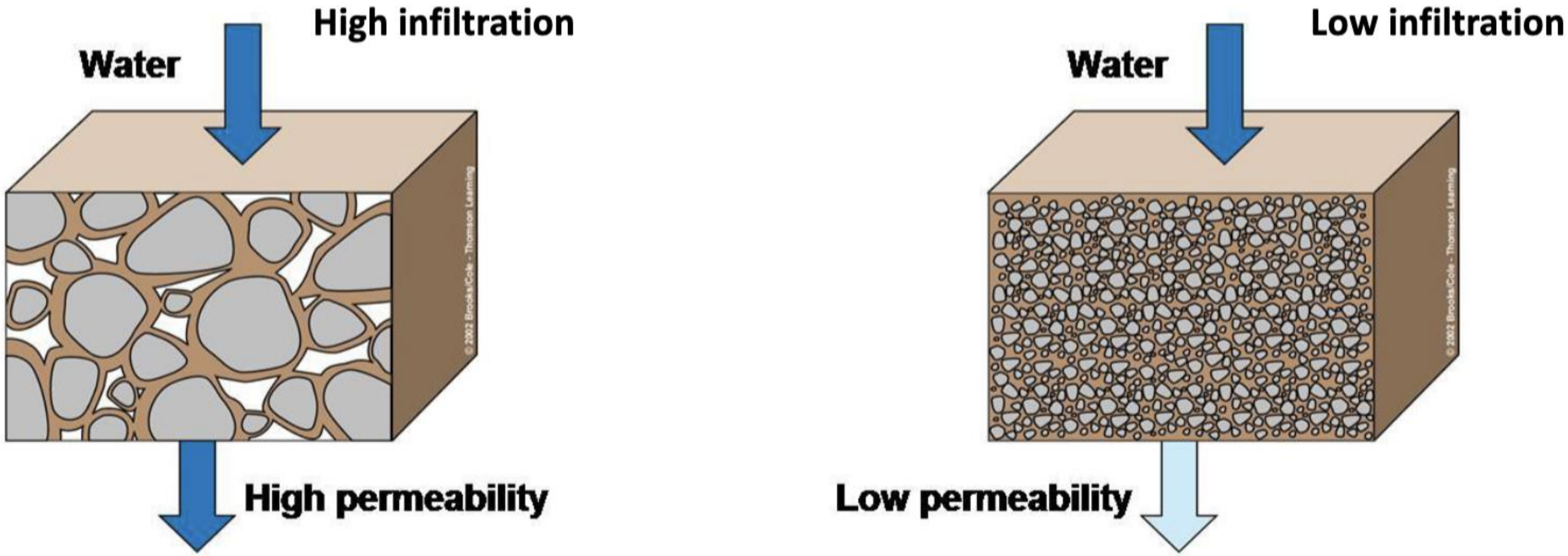
Water availability based on soil texture



Kramer 1983

Infiltration – movement of water through soil
Permeability- ease which air water roots move through soil

Depends on size and continuity of pores- influenced by soil particle size, arrangement and composition



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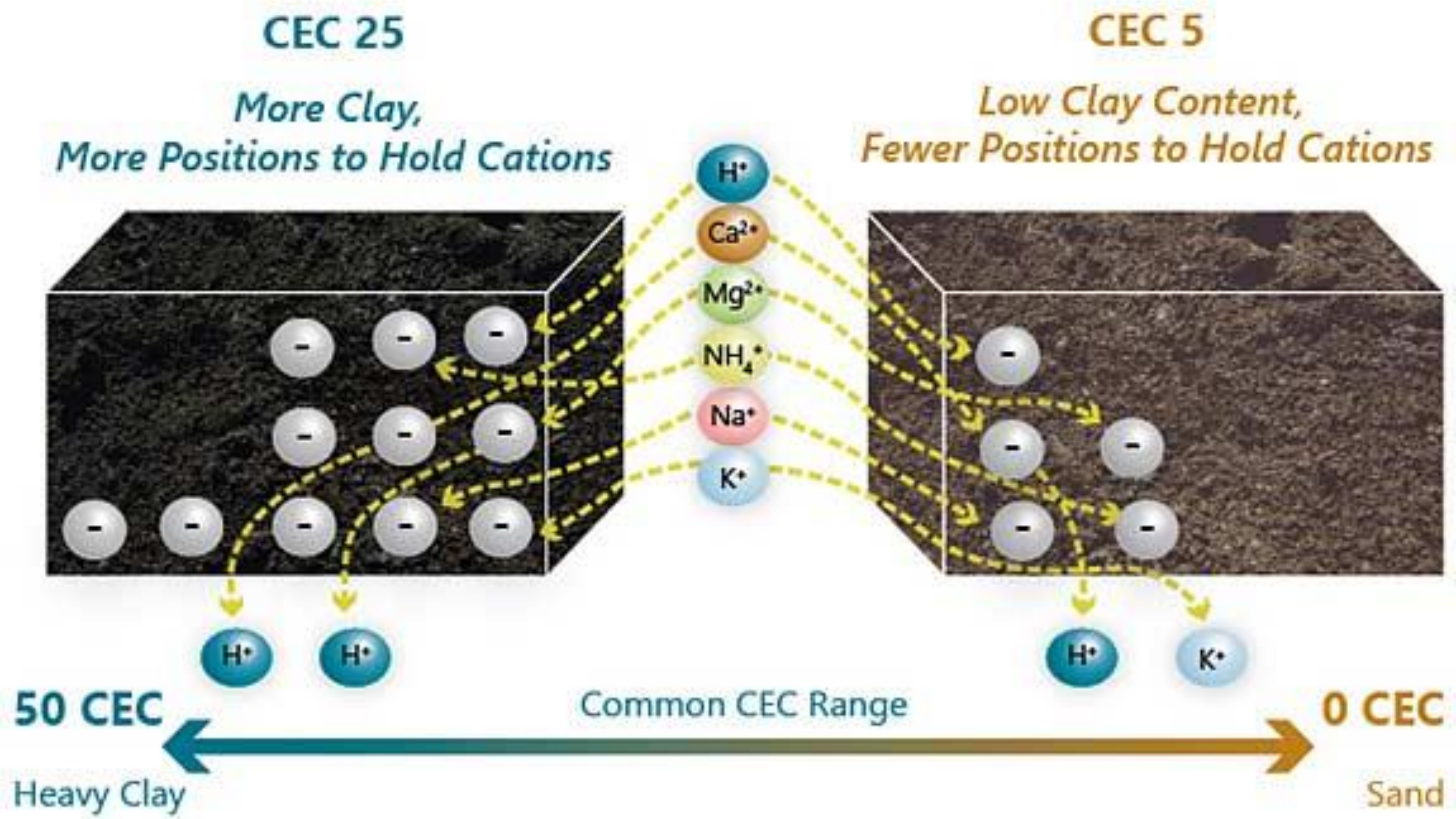
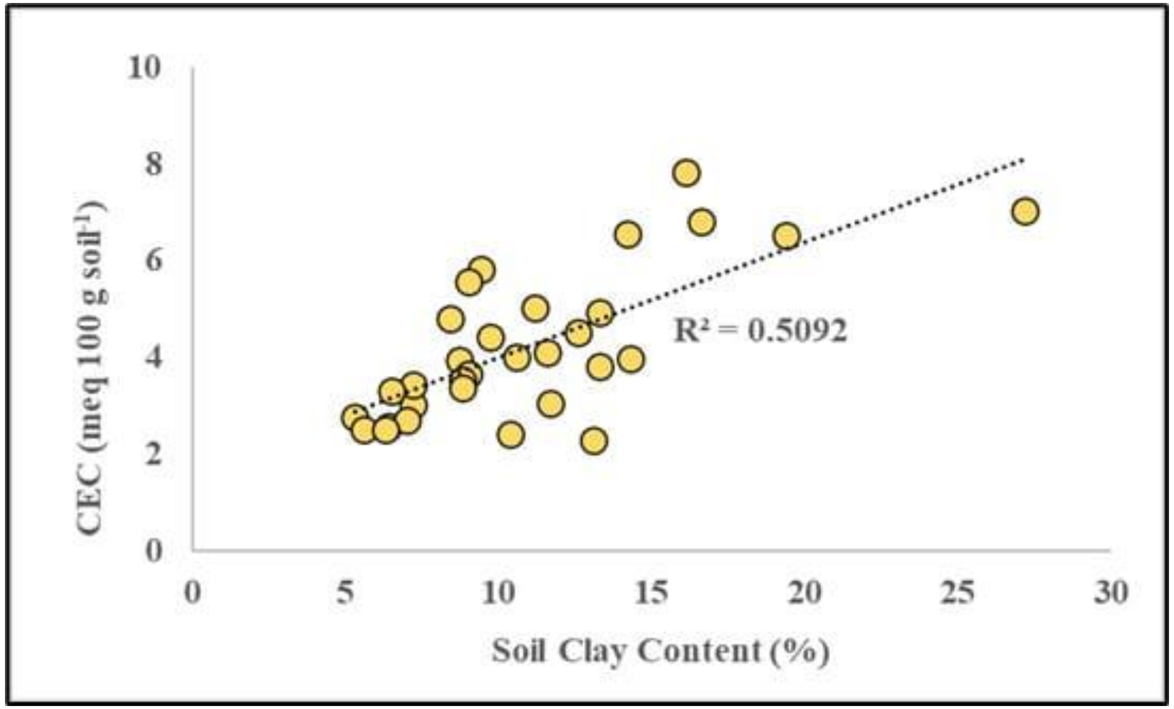
Relationship between soil texture and soil fertility

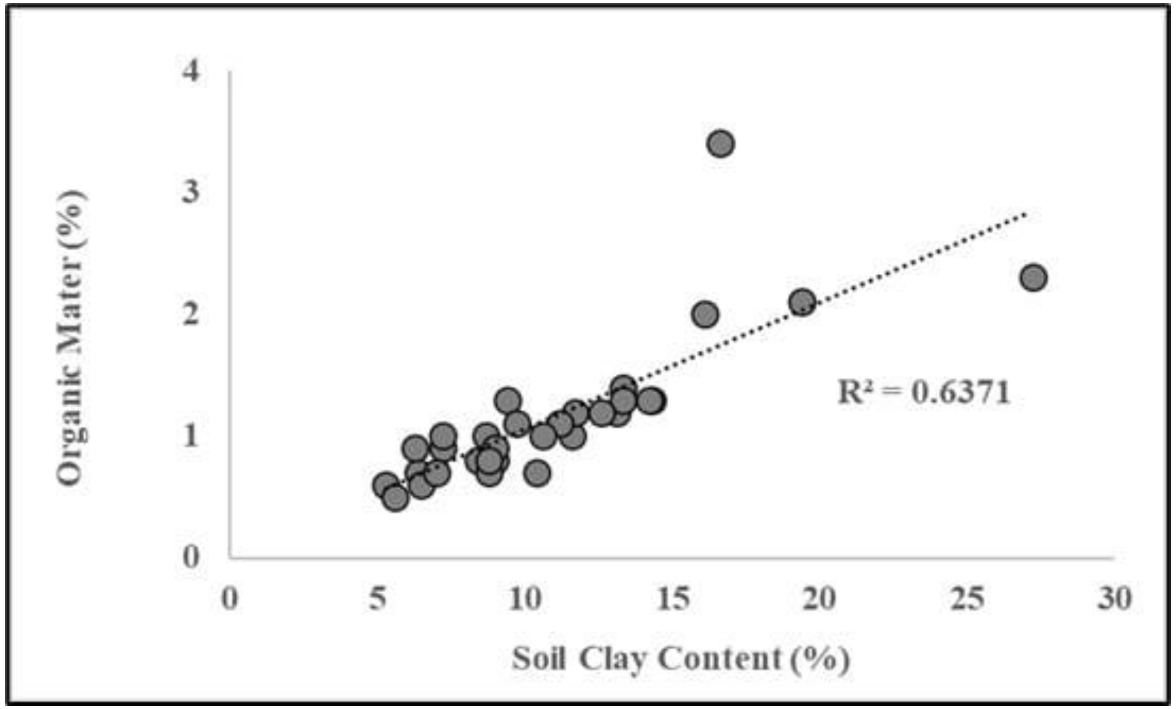
Cation Exchange Capacity - CEC is a soil's ability to hold and exchange positively charged ions



Depiction of the soil CEC. *Adapted from Spectrum Analytics Inc., 2019 https://www.pioneer.com/us/agronomy/Base-Saturation-Cation-Exchange-Capacity.html*

Relationship between soil texture and soil fertility





What is the correlation between OM and CEC?

Why is it important to know your soils texture?

Miller 2023, Extension Agronomist University Delaware https://sites.udel.edu/weeklycropupdate/?p=23750

Soil Shake Test

2. Grab a handful of soil (fill the jar between 1/3 and ½ full)
3. Put the soil in a jar with a lid
4. Fill the jar with water 2/3rd full
5. Add 1-2 drops dish soap- dispersion agent
5. Close the lid and shake the jar for 5 minutes
6. Let the jar sit
7. Observe the layers that form in the jar- wait 24-48+ hours
8. Mark the tops of the layers
9. Measure the height of each layer and divide by total height of the soil to find percentage.

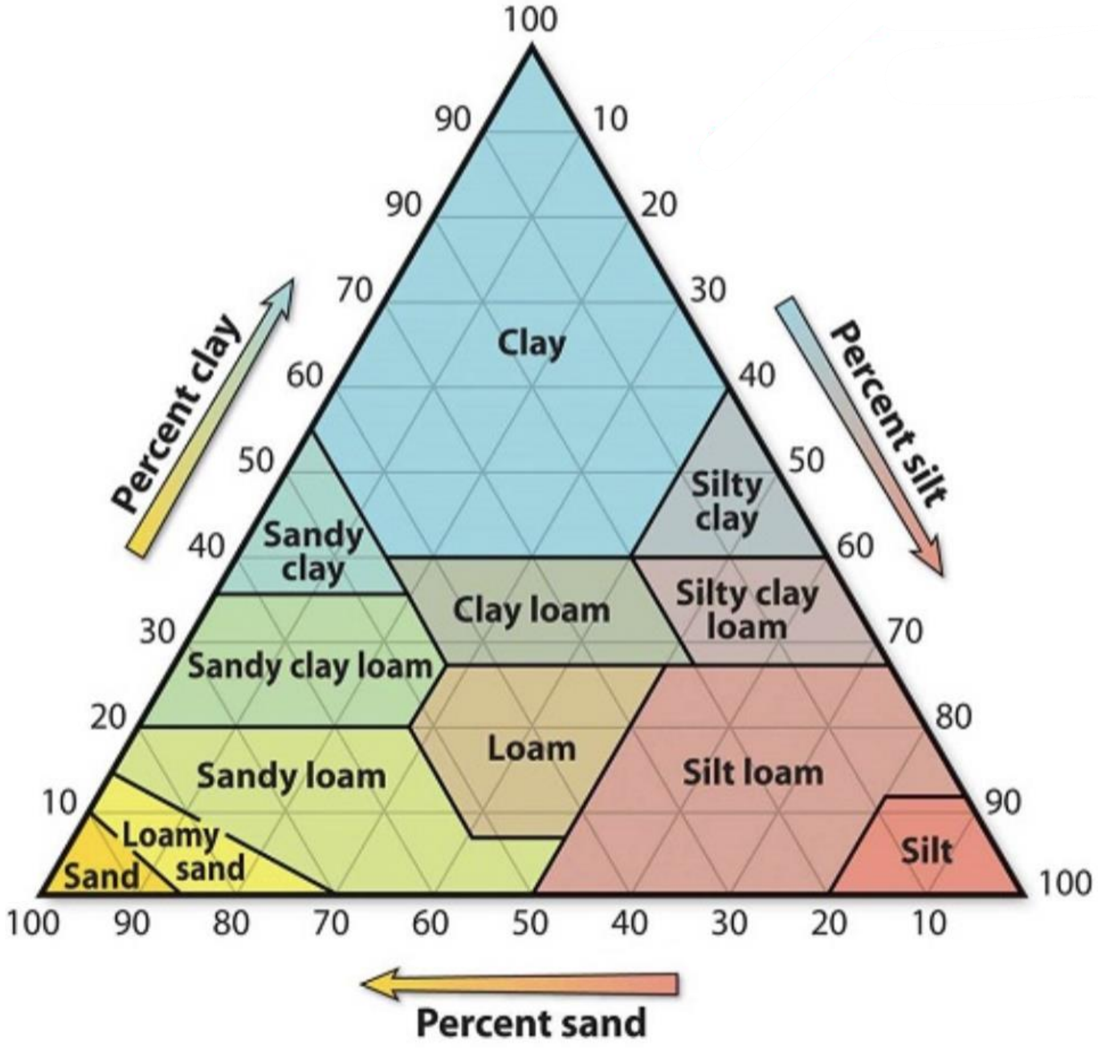
[Organ state extention]

Example calculation

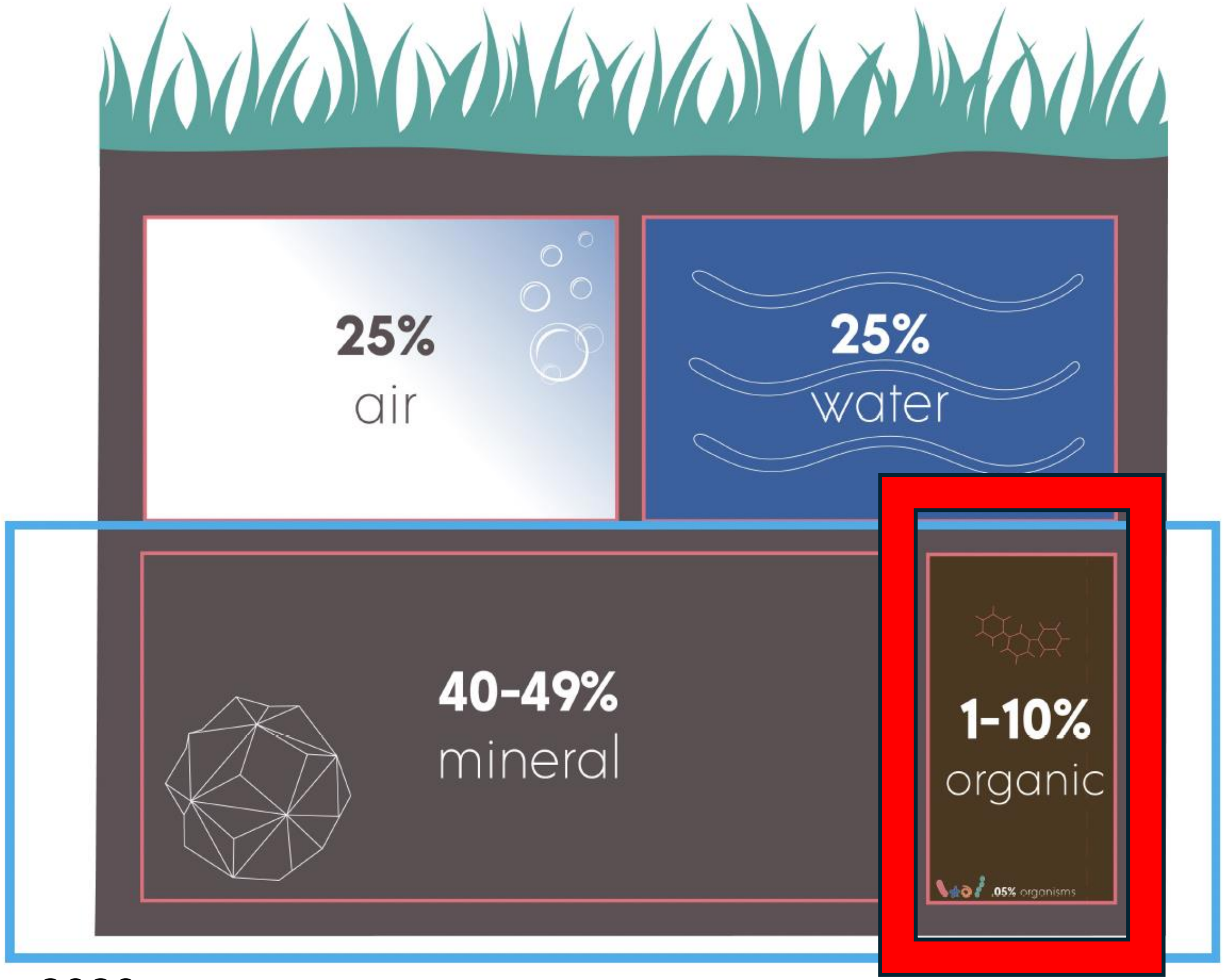
Sand - 1.5in = 3.81 cm
Silt - .48in =1.22 cm
Clay - .02 in = .05 cm

Total 5.08 cm

Sand – 3.81/5.08 = 75%
Silt – 1.22/5.08 = 24%
Clay = .05/5.08 = 1%



Biological Faction



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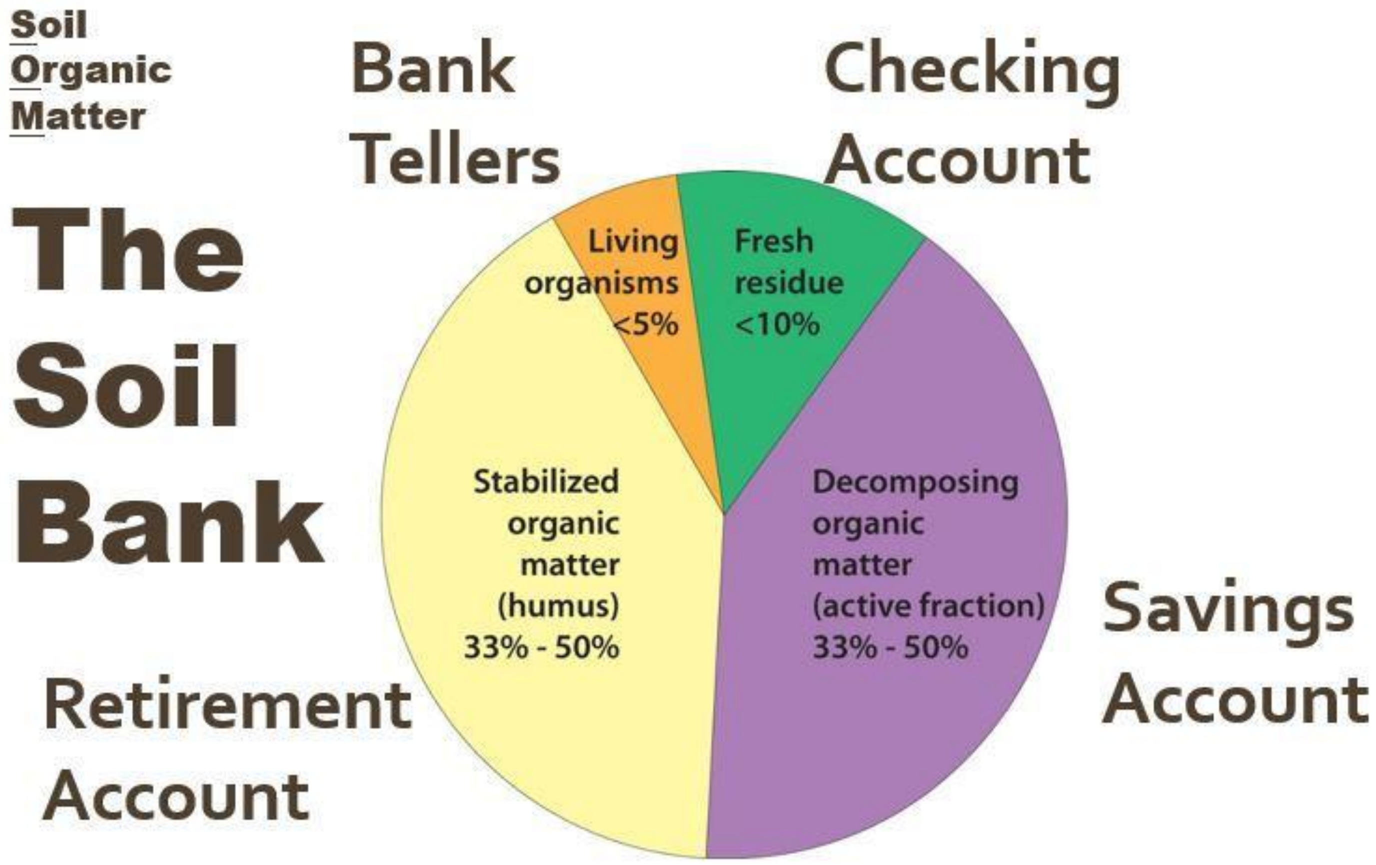
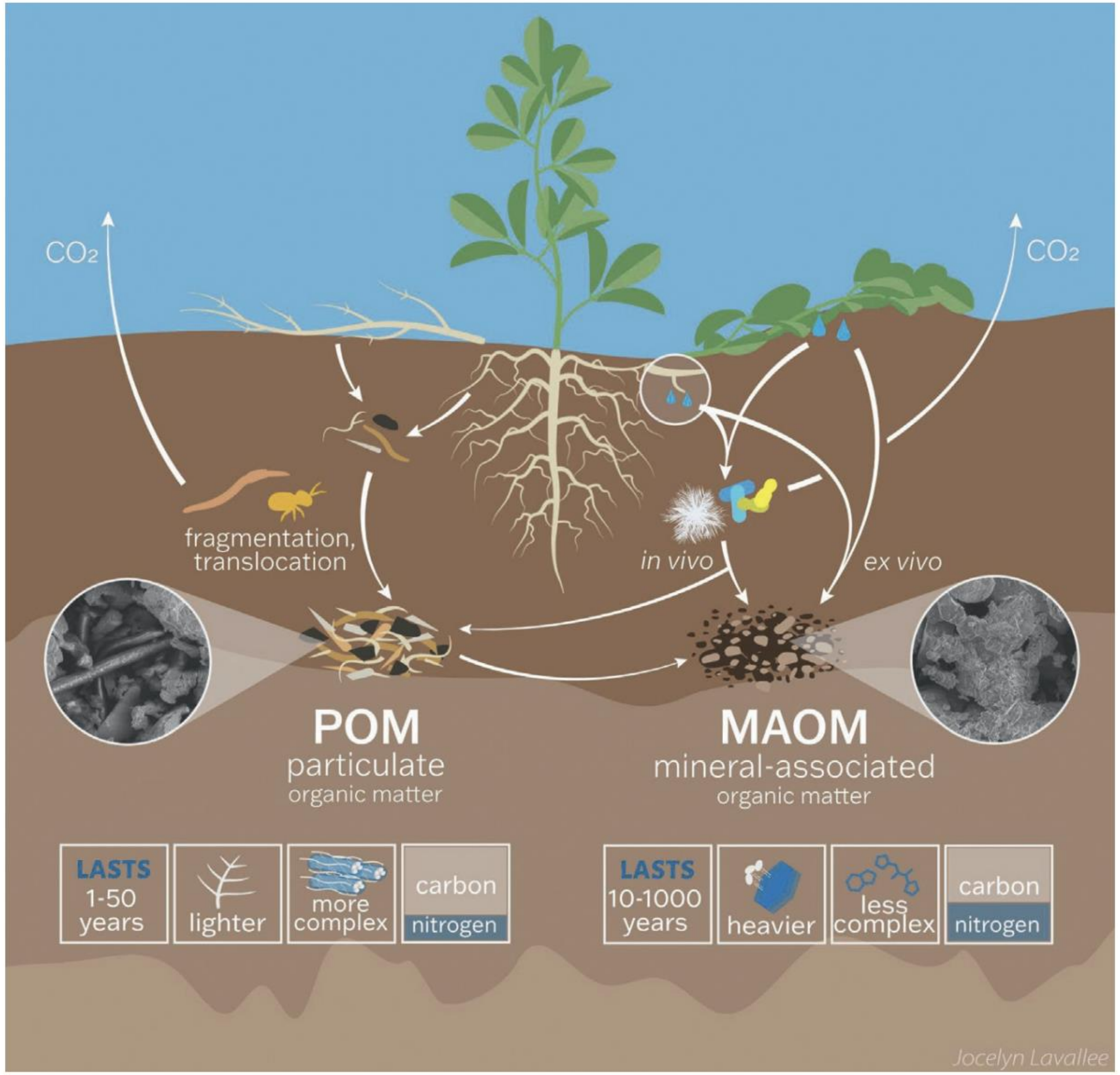
Organic Matter Complex

- Refers to material composed of carbon-based compounds that originate from living organisms
- 60% Carbon
- Smaller amounts of N and P and S

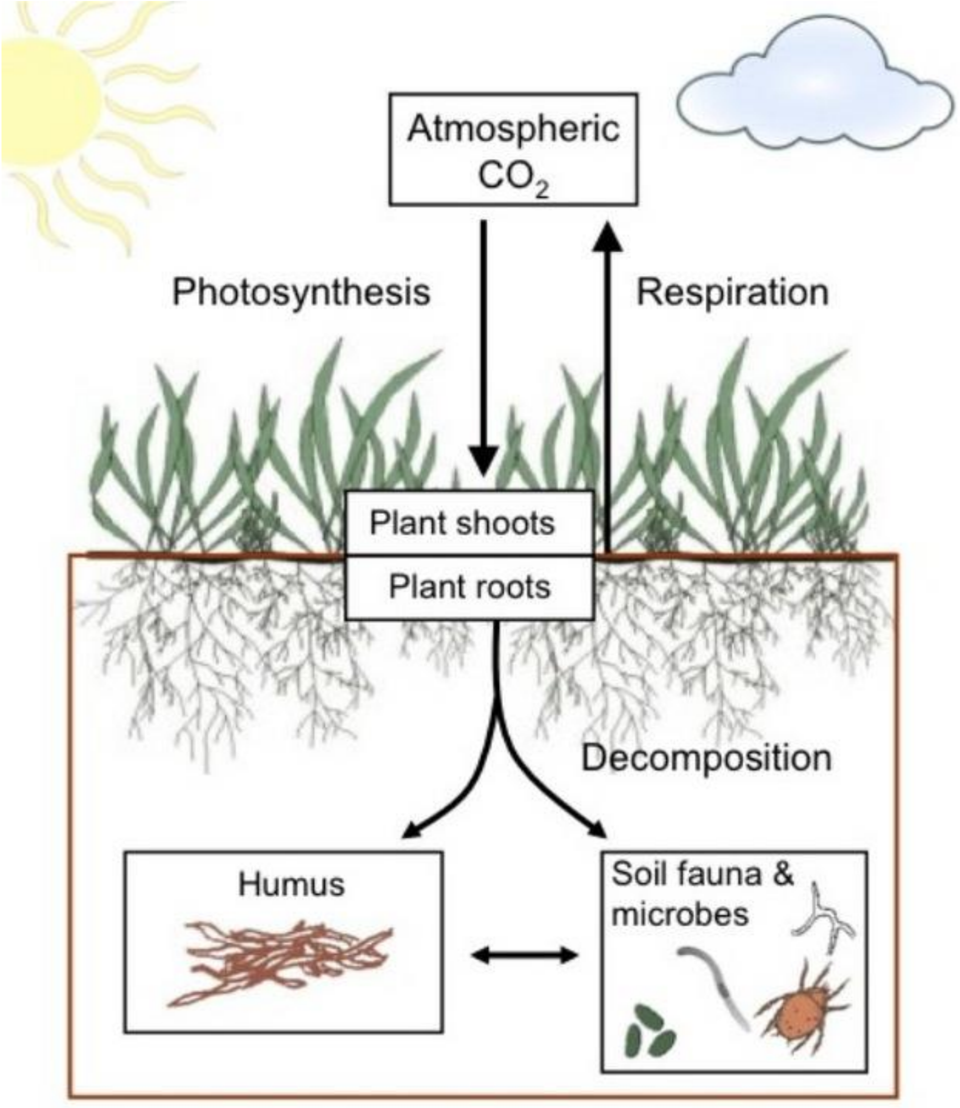


Understanding organic matter fractions



Cotrufo et al., 2022. Advances in Agronomy, Volume 172

The relationship between above ground and bellow ground life!

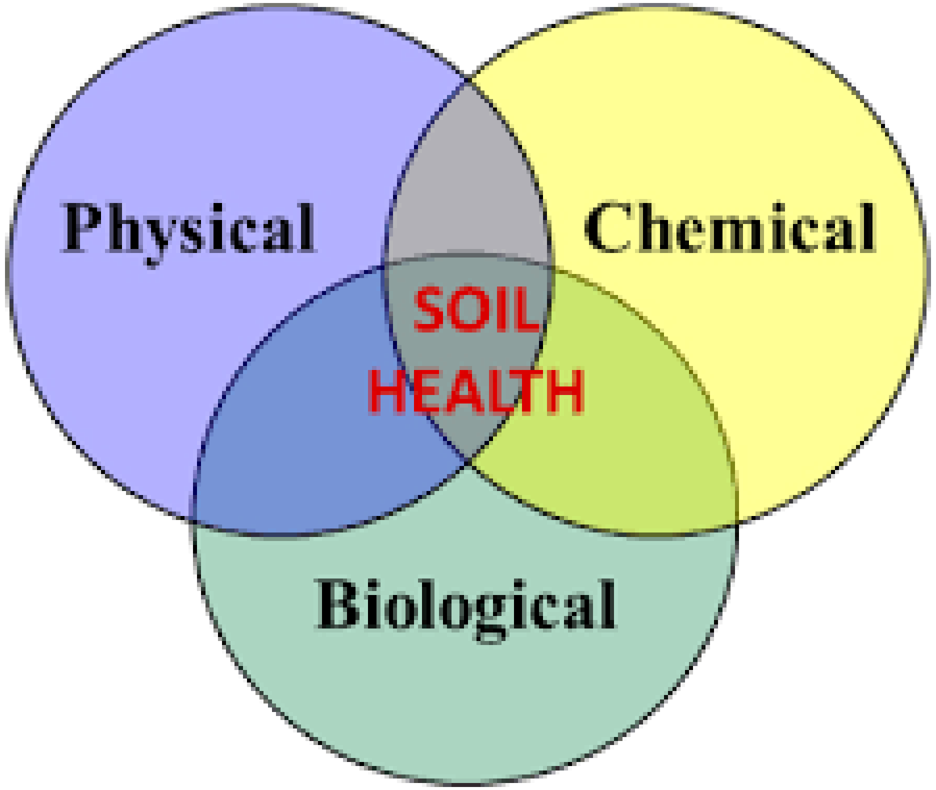


Root exudates- fluids released by plant roots into the soil. Complex mixture of organic compounds - sugars, amino acids, and organic acids.

Ontl, T. A. & Schulte, L. A. (2012) Soil Carbon Storage. *Nature Education Knowledge* 3(10):35

Three factors contributing to soil health

NRCS definition: The continued capacity of the soil to function as a living ecosystem that sustains plants animals and humans



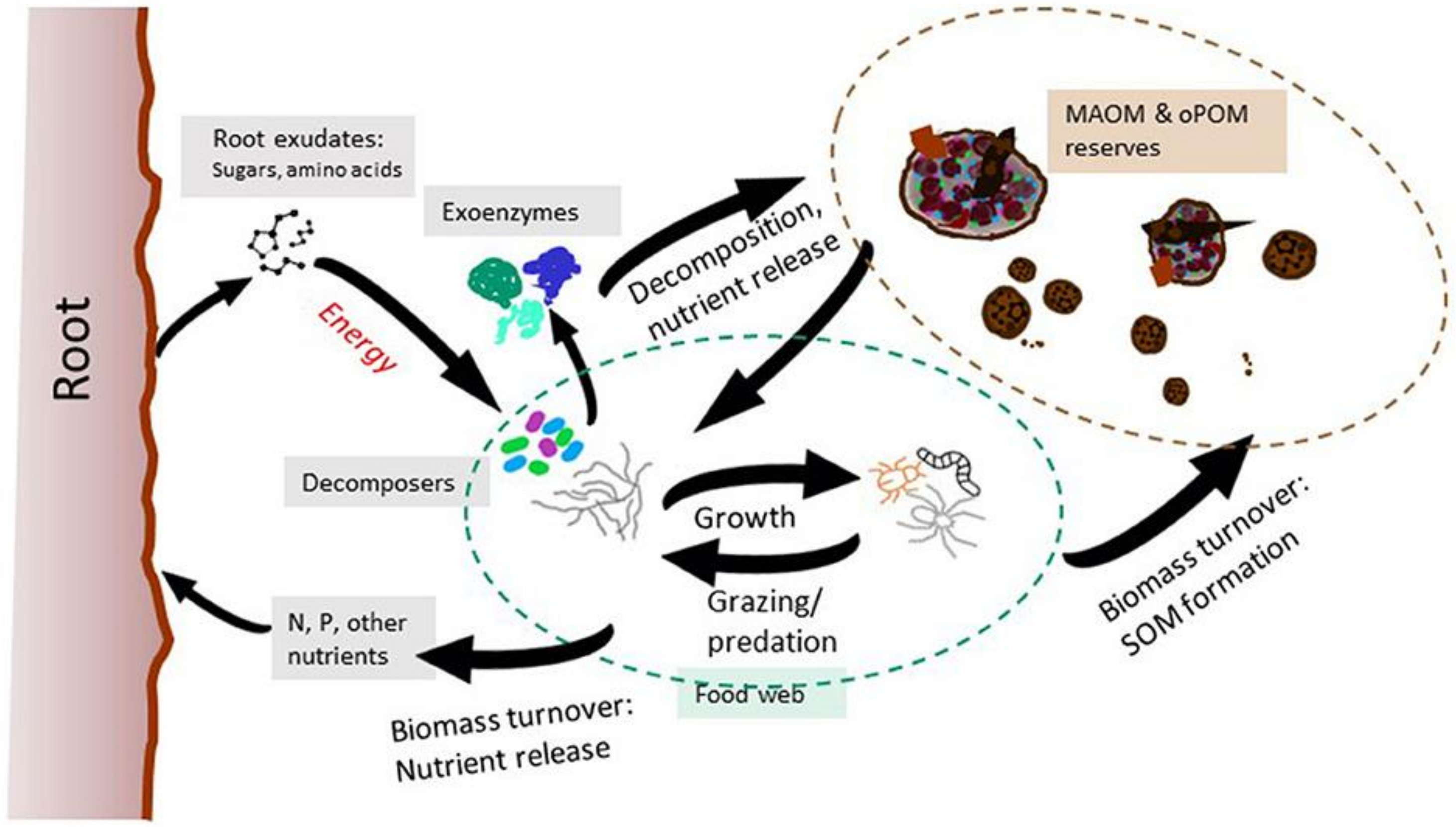
USDA United States Department of Agriculture

Photo credit: The Institute for Local Self Reliance

Connecting chemical and biological properties

Nutrient Cycle

The movement and transformation of chemical elements and compounds between living organisms, the atmosphere, and the soil



Drinkwater and Snapp 2022

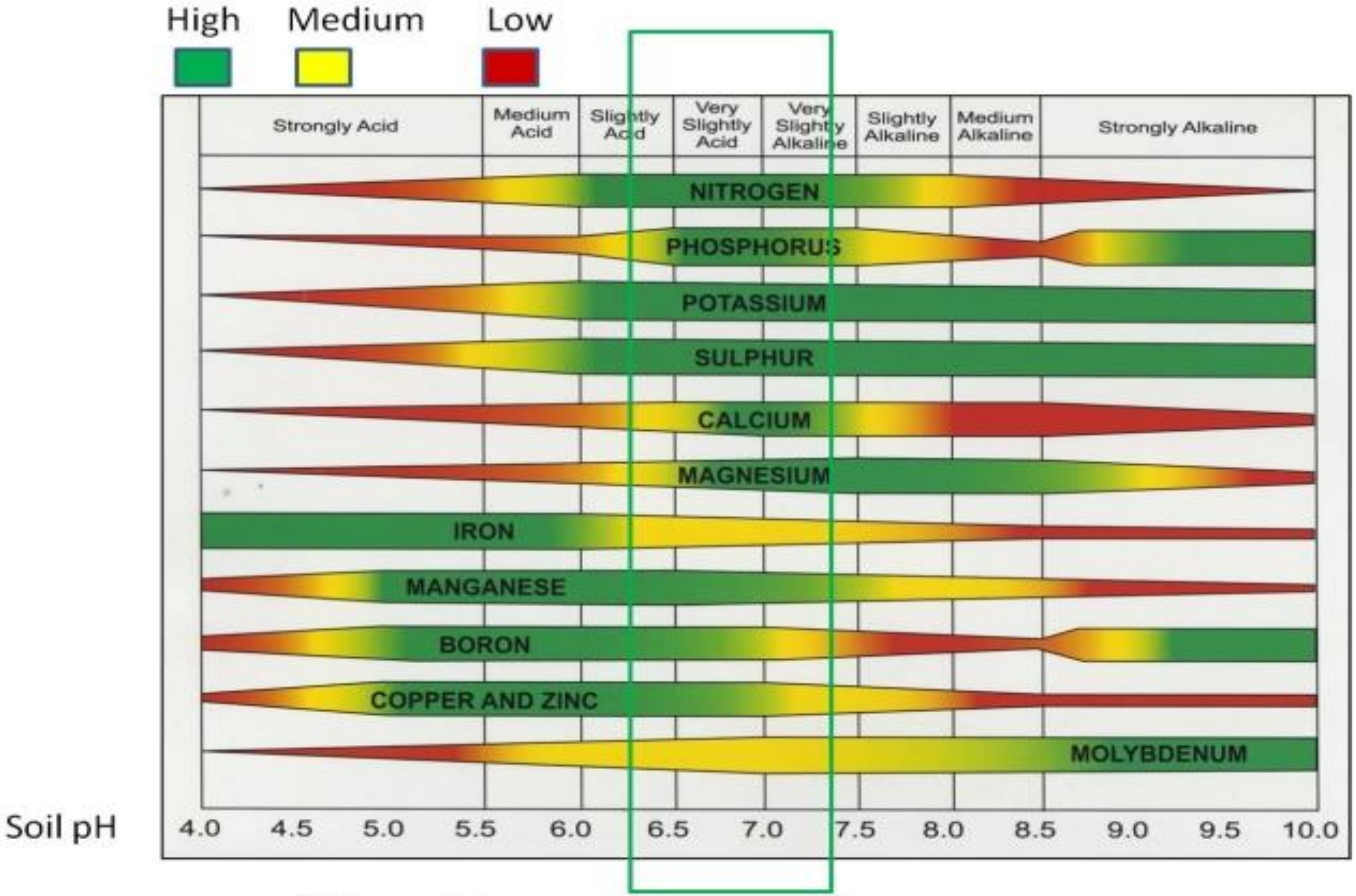
Soil pH

- Measures how acidic or alkaline soil is and is a key indicator of how well plants will grow in that soil.

- Chemically, it is based on the amount of hydrogen ions (H+) in the soil solution. **The pH scale ranges from 0 to 14; a pH of 7 is considered neutral.**

- If pH values are greater than 7, the solution is considered basic or alkaline; if they are below 7, the solution is acidic.

How soil pH affects availability of plant nutrients



Optimum soil pH range: 6.2 7.3

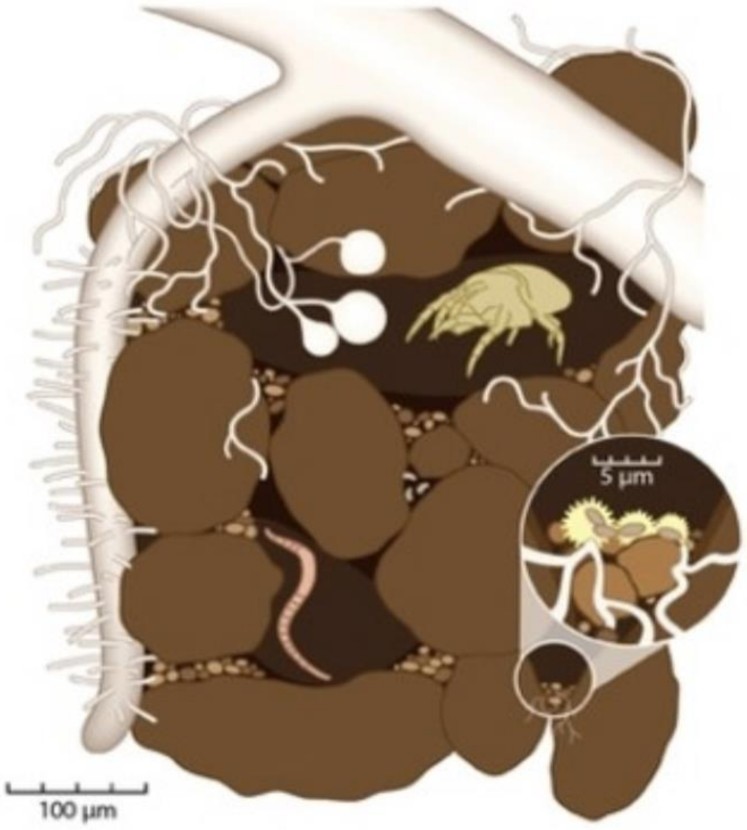
Soil Structure

Defines how soil mineral particles (sand, silt and clay) are bound together and arranged in the three dimensional space

Particles are stuck together by roots, fungal hyphae, and weak cements, including organic compounds, clays, carbonates, Fe oxides, and silica.

Soil structure- why is it important?

- Determines the capacity of soil to hold water and air
- Provides microhabitat for soil organisms
- Provides physical protection of organic matter- contributes to C sequestration




Soil aggregate stability
demonstration

Agg stability link

Ecosystem communities' effect soil

Grasslands

Deep O and A horizon

High organic matter with fertile upper layers due to the growth and decay of deep, many-branched grass roots.

Play a crucial role in carbon sequestration- in changing climate

Forested lands

More acidic

thicker POM layer

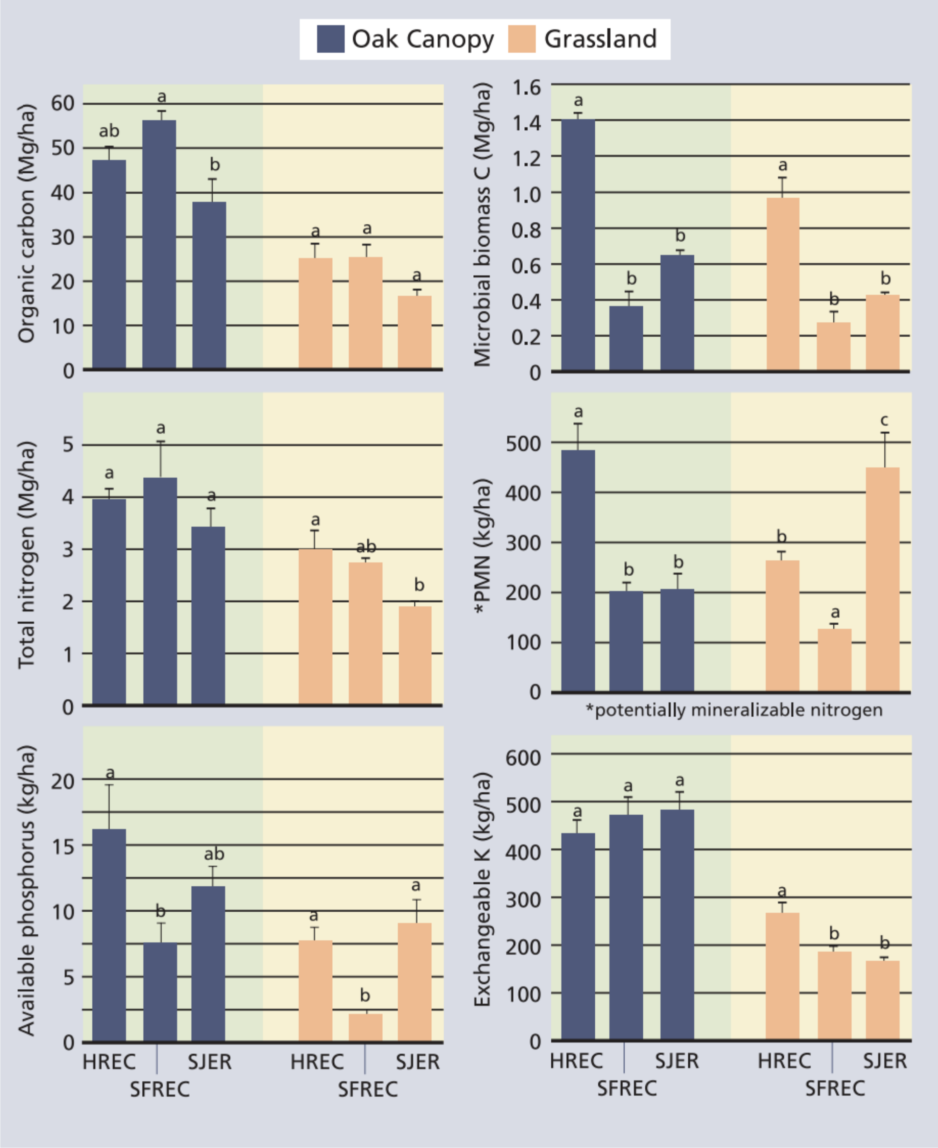
Higher carbon to nitrogen ratios in the OM complex

Lower phosphorus levels

S.A Billings, 2006. Soil organic matter dynamics and land use change at grassland/forest ectone

Evidence of oak woodlands effect on soil health

(California)Oak woodlands-Evidence indicates that oaks create islands of enhanced fertility beneath their canopy due to nutrient cycling processes.



Dahlgren et al., 2003. California Agriculture. Blue oak enhance soil quality in California oak woodlands

How does management effect soil health? For good or for bad?


SALFORD

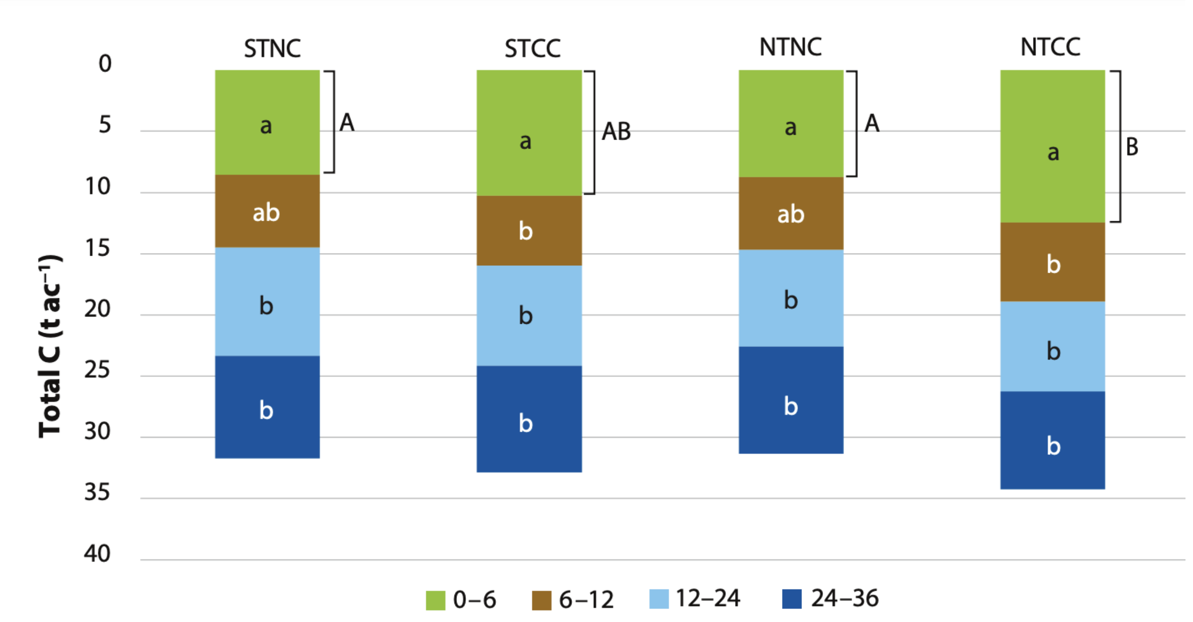
Management Guides or Principles for Regenerative Agriculture

- Reduce disturbance
- Optimize photosynthesis and living roots
- Maximize biodiversity
- Keep the soil covered
- Animal integration and wellbeing
- Know your context

No till - Mixed Results

- Shift in carbon storage
  - Powlson (2014) - out of more than 100 studies, half reported SOC sequestration rates greater or no different in tilled than no-tilled systems.
  - Mitchell (2024) -No till + cover crop increased topsoil carbon more then no till alone
    - Water infiltration, ag stability, Nutrient cycling

Why, when, how might soil tillage be used thoughtfully?



P Mitchell, et al., 2024 Cal ag

Erosion Demonstration

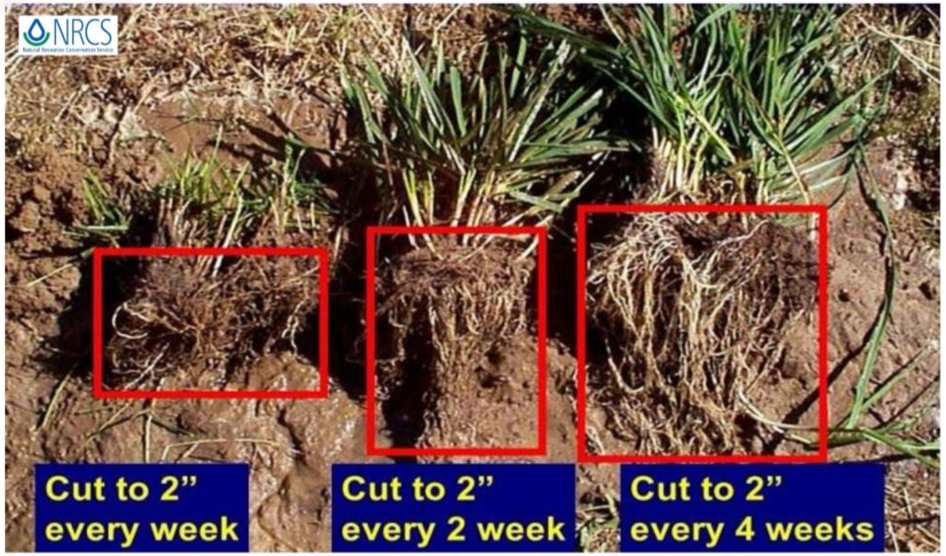
What are specific considerations in our area we want to manage for?

Critical thinking excursive

Group A : Discuss how grazing can provide benefits for soil health, in what situations may it hurt?
Group B: Discuss how fire may benefit or harm soil health?
Group C: Describe how the combination of practices – grazing plus fire may benefit or harm soil health?

Management Effects of Grazing

Grasslands Evolved with Grazing Regimes to Cycle Carbon and Nutrients

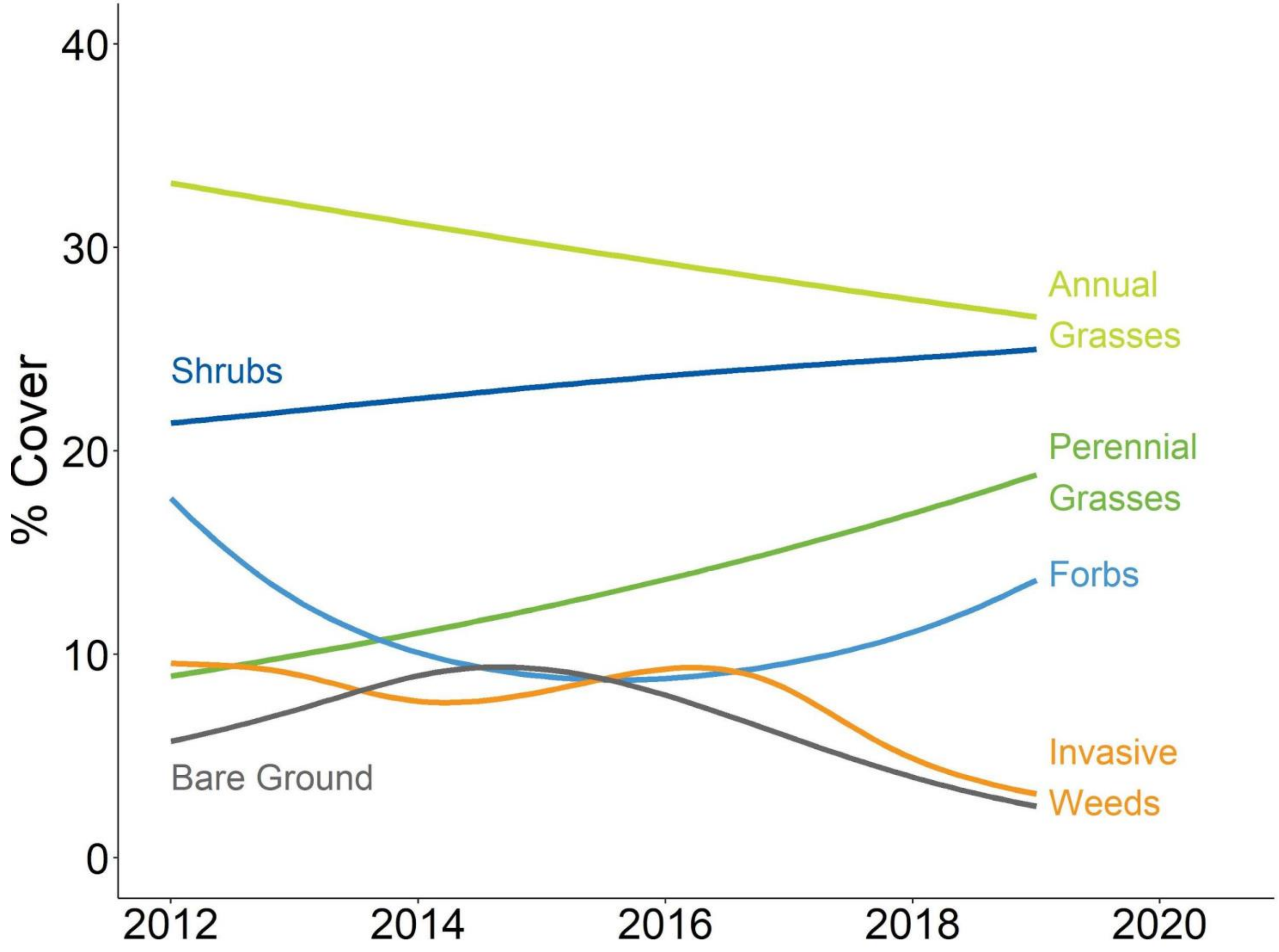


Livestock Cycling Minerals from plants

Dung Beetles moving minerals underground feeding microbes

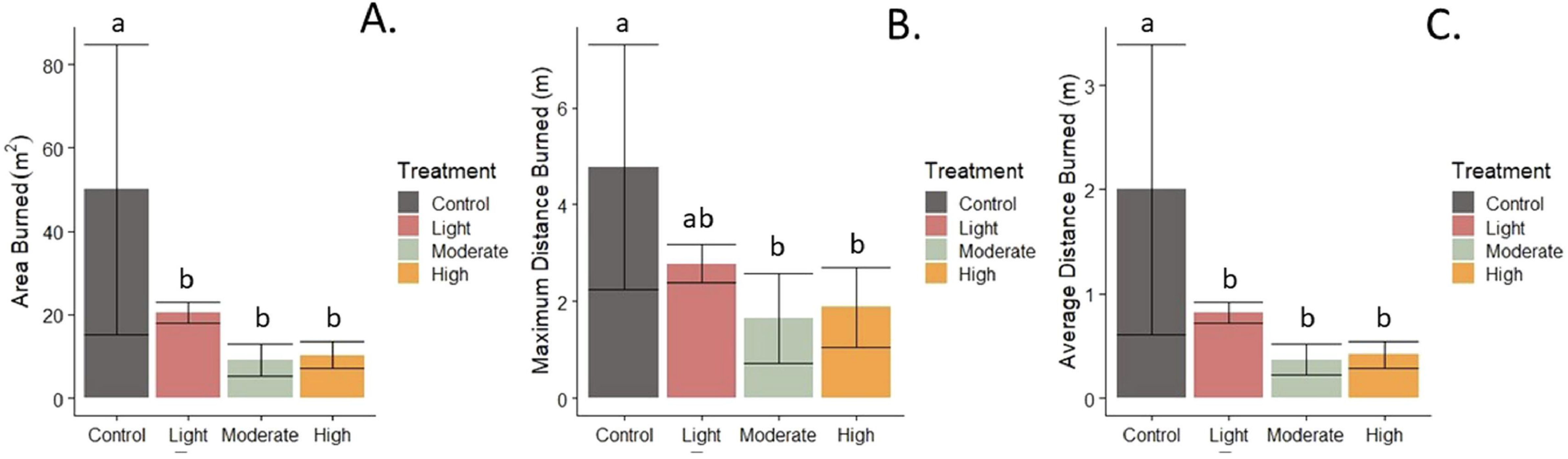
Slides by TomKat Ranch

Grazing Management Can Encourage Proper Grassland Function or Limit it



Slides by TomKat Ranch

Grazing Effect on Burn Potential



Rangeland Ecology& Management. Orr et al., 2023

PRESCRIBED FIRE:

Natural tool for Fuel reduction, Mineral cycling and disturbance

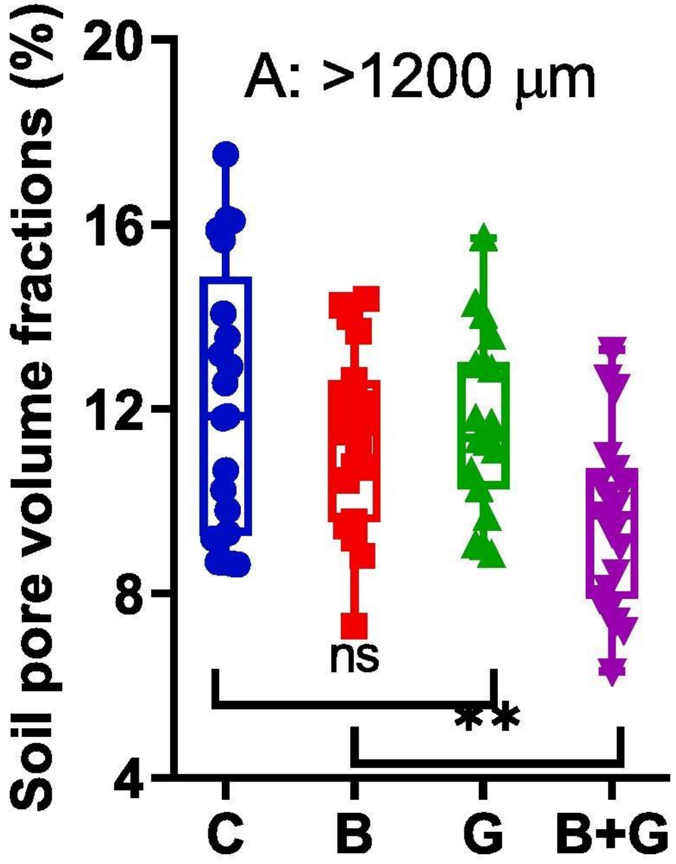
Left: October 1, 2021 Burned

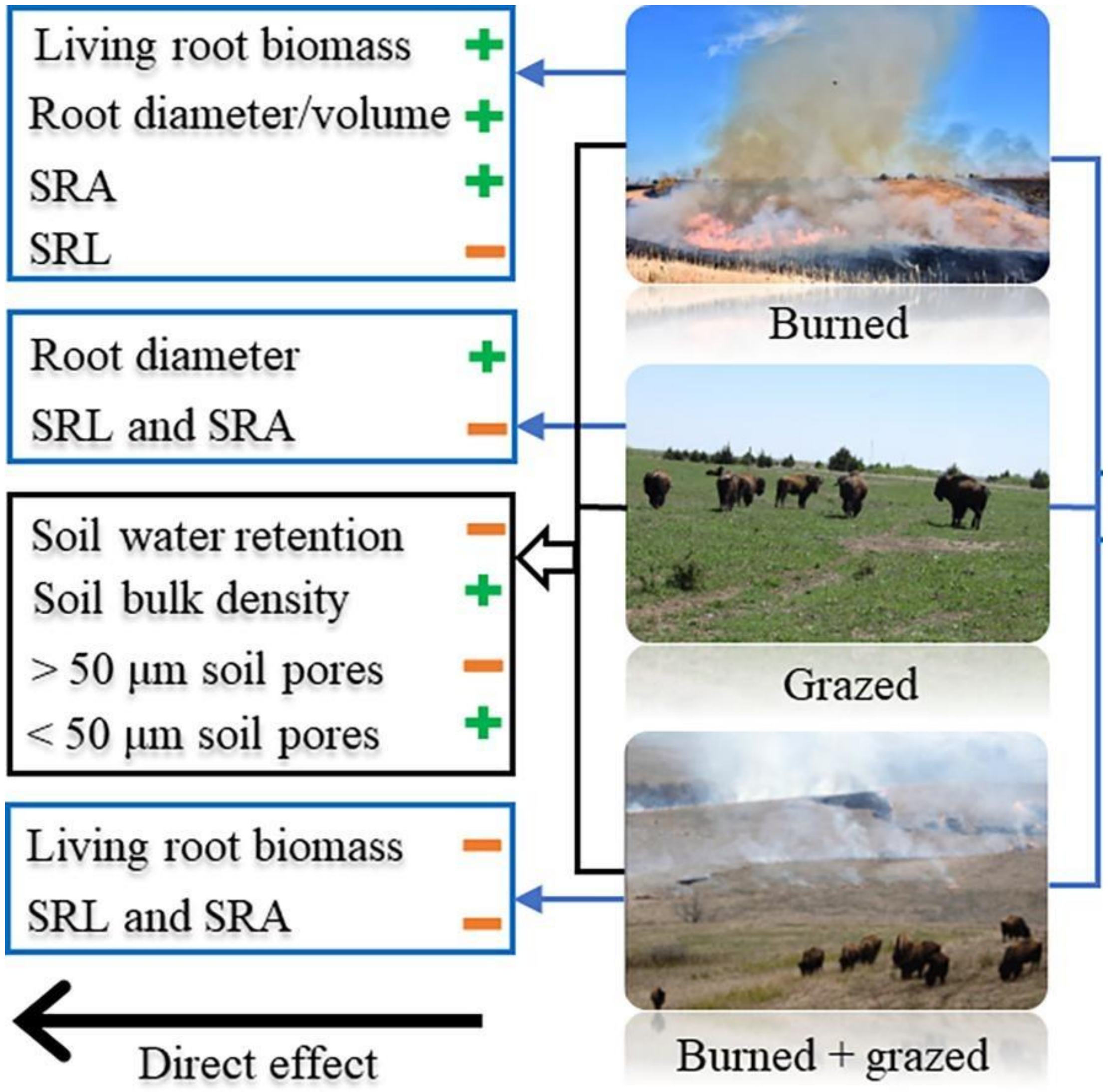
Below: May 10, 2022 Regrowth and Second Graze

Slides by TomKat Ranch

Long-term fire and grazing regimes modify soil physical properties and root traits in North American tallgrass prairie

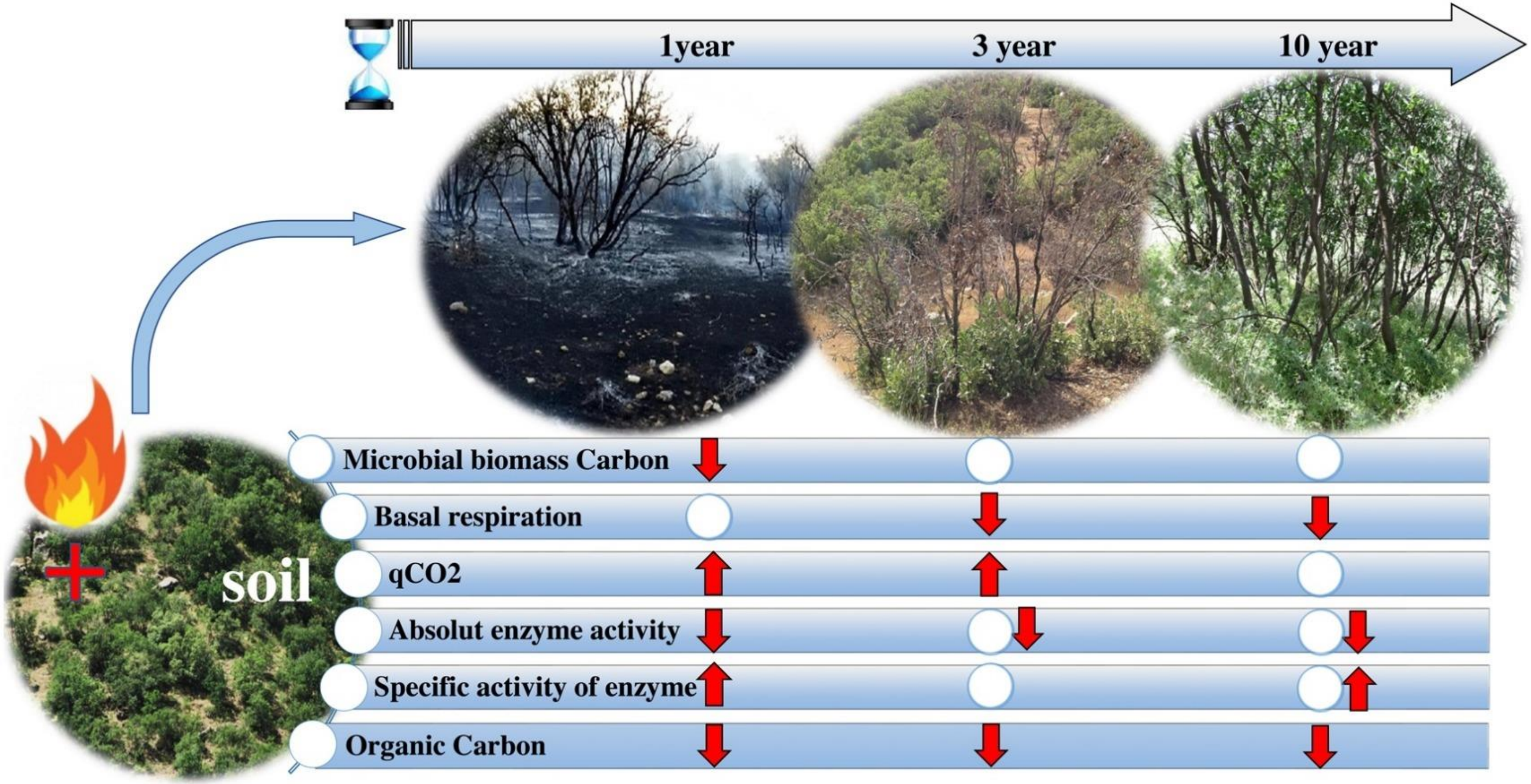
C- unburned & ungrazed
B - annually burned
G - annually grazed,
B + G - annually burned and grazed





Jia et al (2024)

Comparing soil microbial eco-physiological and enzymatic response to fire in the semi-arid Zagros woodlands



Sadeghifar et al., 2020

Missing information on fire + grazing regemes

Meta-data analysis of soil sample data and wildfire and prescribed fire data was conducted to find any differences in soil quality before and after both wildfires or prescribed fires occurred.

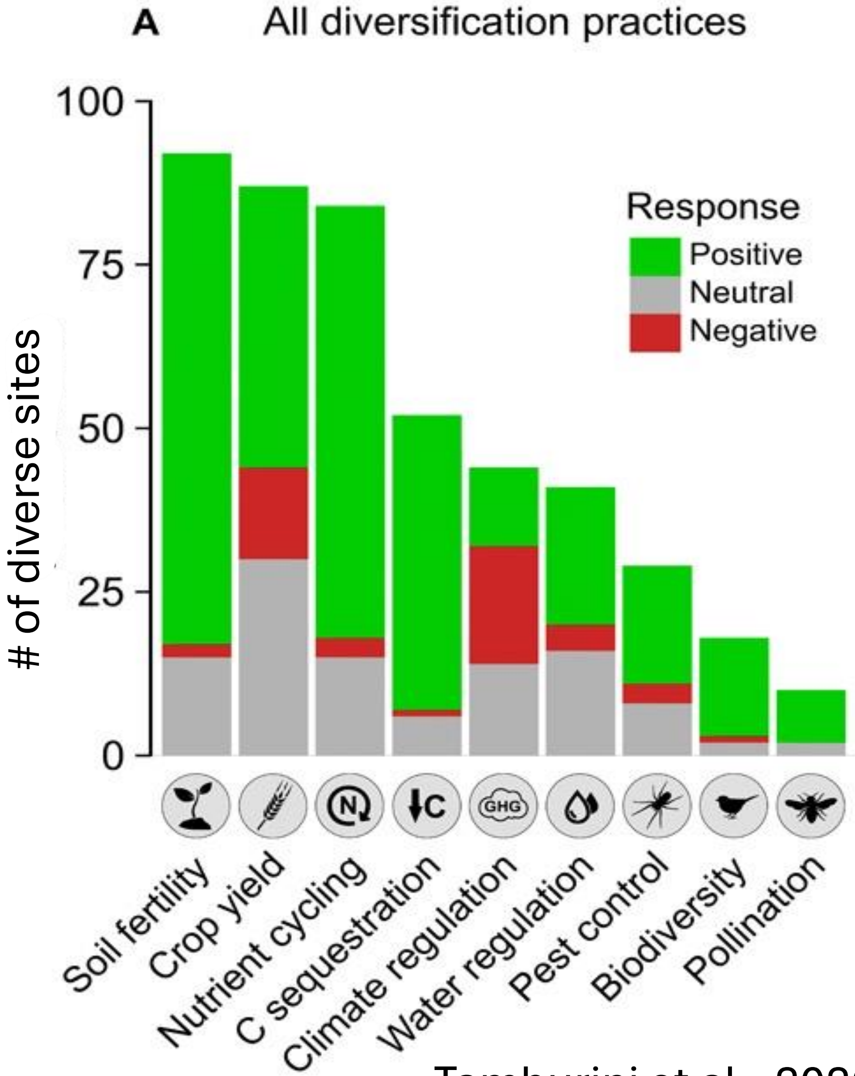
Next, the soil sample data was analyzed to determine if any significant changes in soil quality differed due to the type of fire.

The results of this study were deemed inconclusive because of a lack of data and other confounding variables.

Nelson, Kate. University of Nebraska-Lincoln, (2022). Wildfires & Prescribed Fires: Do They Impact Soil Quality?

Impacts of bio- diversity on soil, water, climate and more

Phot Credit : ATTRA



Tamburini et al., 2020

Grazing

- **Positive Impacts:**
- Moderate grazing reduces litter buildup, increases water and root penetration, and incorporates soil organic matter into the soil, rather than on the surface.
- Grazing can reduce rangeland fuels by removing fine fuels, which can affect fire behavior by reducing rates of spread, flame lengths, and fire intensities.
- Targeted grazing can create fuel breaks in areas with invasive annual grasses, helping to prevent wildfires from turning into megafires.

- **Negative Impacts:**

- Overgrazing can lead to soil erosion, loss of species, and changes in vegetation structure.
- In the Central Valley and Foothills region, burn probability can increase with grazing pressure, although the mechanism behind this relationship is unclear.
- The impacts of grazing on soil health depend on factors such as grazing intensity, type of vegetation, and soil type.

Prescribed fire impact on soil health

Short-Term Impacts:

•temporary decrease increase Ph and N pools.

•It can also increase fertility temporarily (potassium, calcium, magnesium) and increase pH.

•**Long-Term Impacts:**

•Prescribed fire can improve soil health by encouraging the growth of native plants and increasing species diversity in the understory.

•Prescribed fire can reduce fuel loads, making it harder for wildfires to spread rapidly and grow in intensity.

•Regular burning attracted game and created open grasslands and woodlands where indigenous foods – We know the benefits these ecosystems have on soil health

https://www.frontiersin.org/journals/sustainable-food-systems/articles/10.3389/fsufs.2021.715366/full