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Soil Health - 3 Ways
Physical – Chemical - Biological

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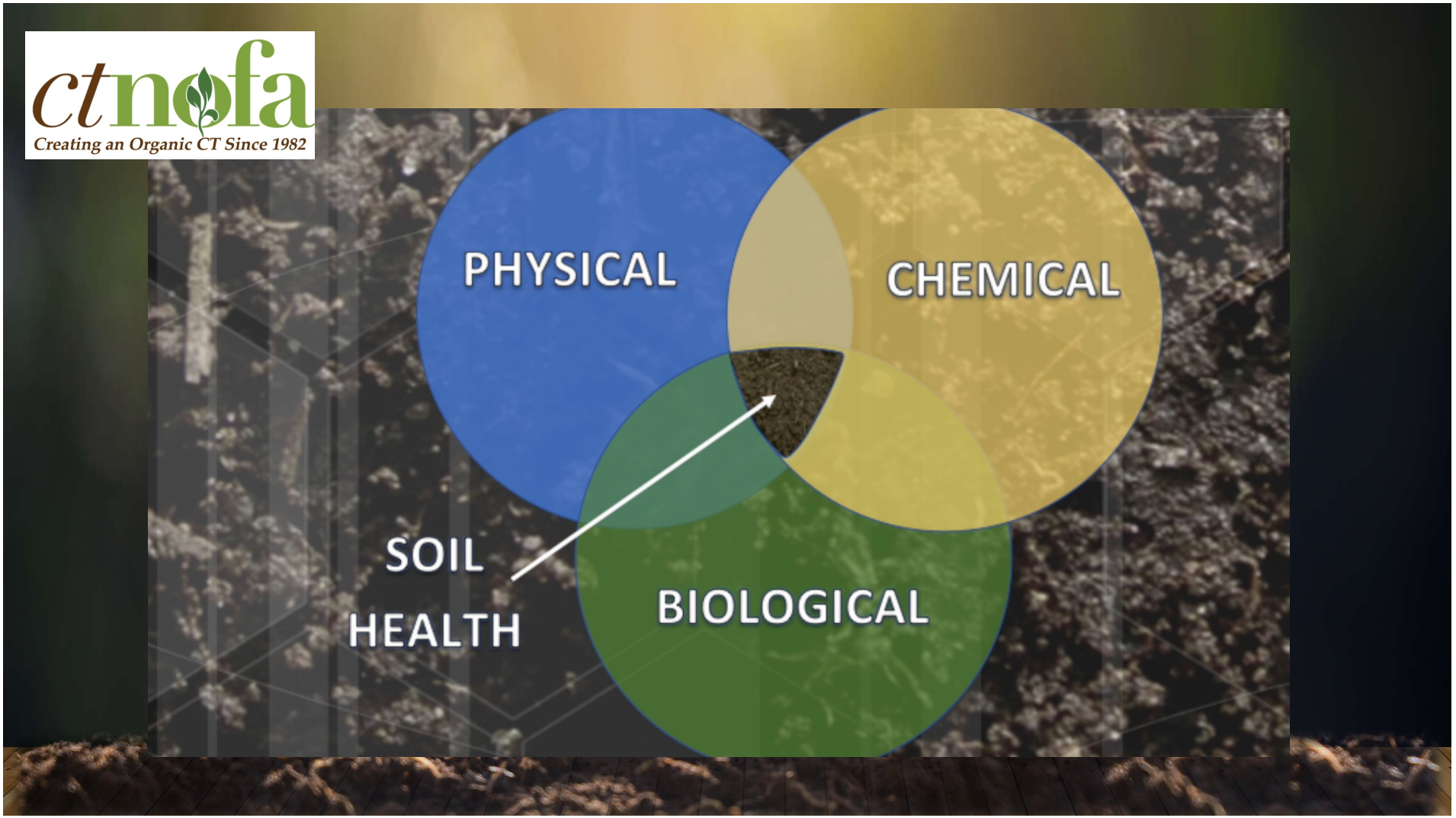

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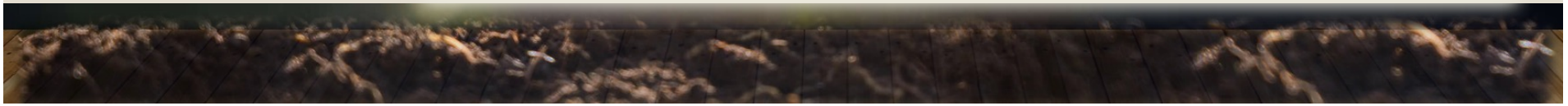
Week 1
Physical Properties of Soil

WHAT IS SOIL?

Soil is…

a mixture of **mineral** and **organic** material that is capable of supporting plant life



WHAT IS SOIL?

USDA Natural Resources Conservation Service
U.S. DEPARTMENT OF AGRICULTURE

Soil Health

https://www.nrcs.usda.gov/conservation-basics/natural-resource-concerns/soil/soil-health

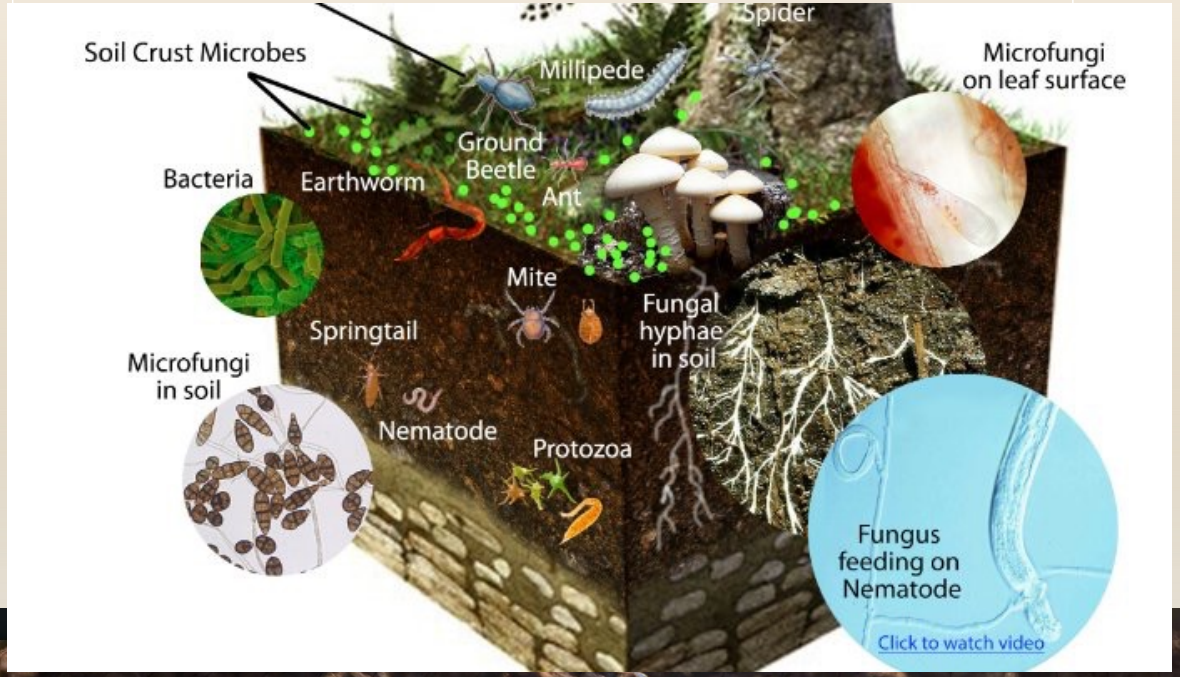
Home › Conservation Basics › Natural Resource Concerns › Soil › Soil Health

Soil is not an inert growing medium – it is a living and life-giving natural resource. It is teaming with billions of bacteria, fungi, and other microbes that are the foundation of an elegant symbiotic ecosystem.

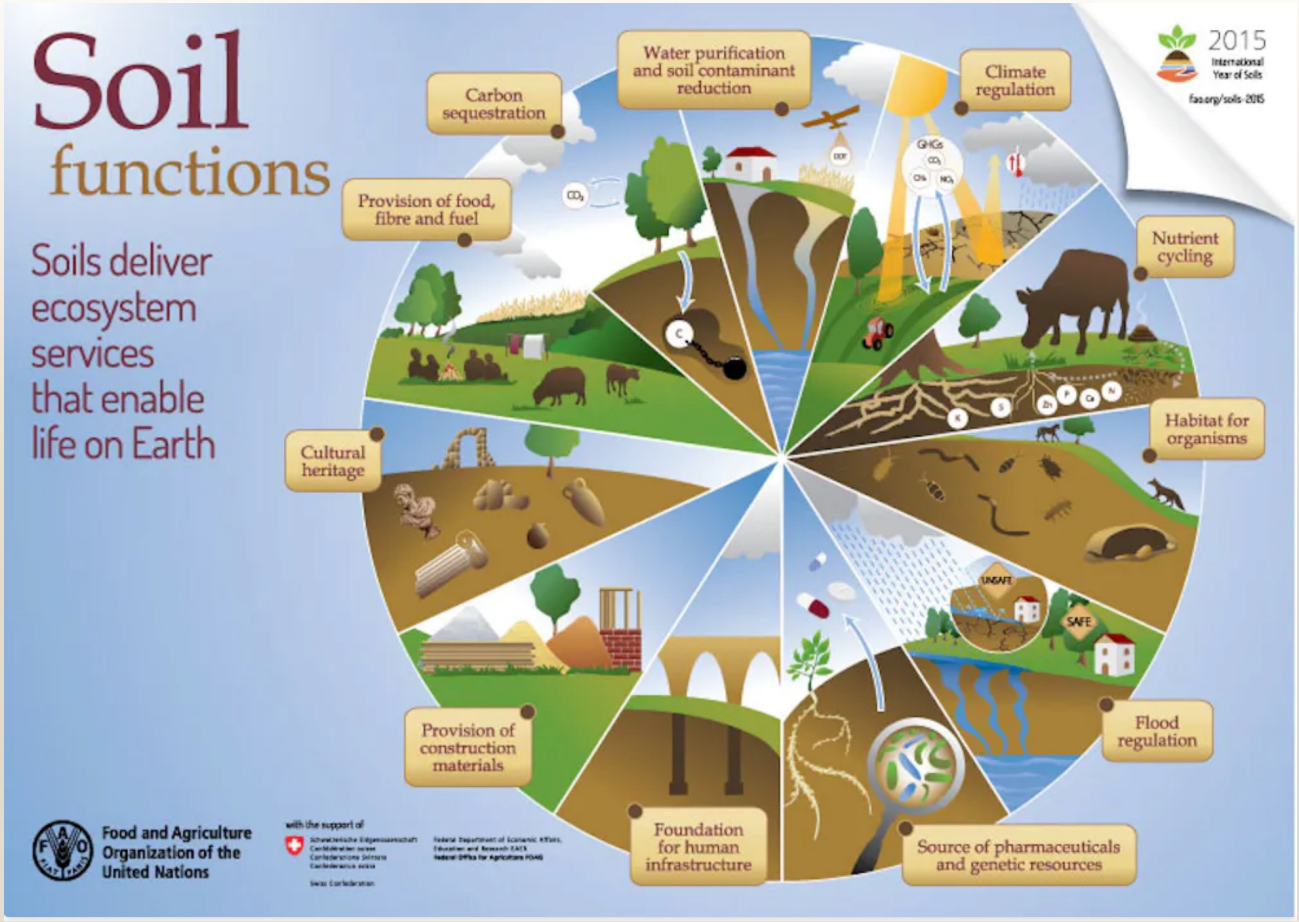
Looking at research that the BFA has performed over the past 10 years, the resulting data shows that the main determinant of nutrient dense food is the health of the soil, namely the microbial population and diversity of microbes.

What is Soil Health?

The continued capacity of the soil to function as a vital living ecosystem that sustains plants, animals, and humans



List a function of soil:


Soil functions
Soils deliver ecosystem services that enable life on Earth
2015 International Year of Soils
fao.org/soils-2015
Water purification and soil contaminant reduction
Climate regulation
Carbon sequestration
Provision of food, fibre and fuel
Nutrient cycling
Habitat for organisms
Cultural heritage
Flood regulation
Provision of construction materials
Foundation for human infrastructure
Source of pharmaceuticals and genetic resources
UNSAFE
SAFE
Food and Agriculture Organization of the United Nations
with the support of

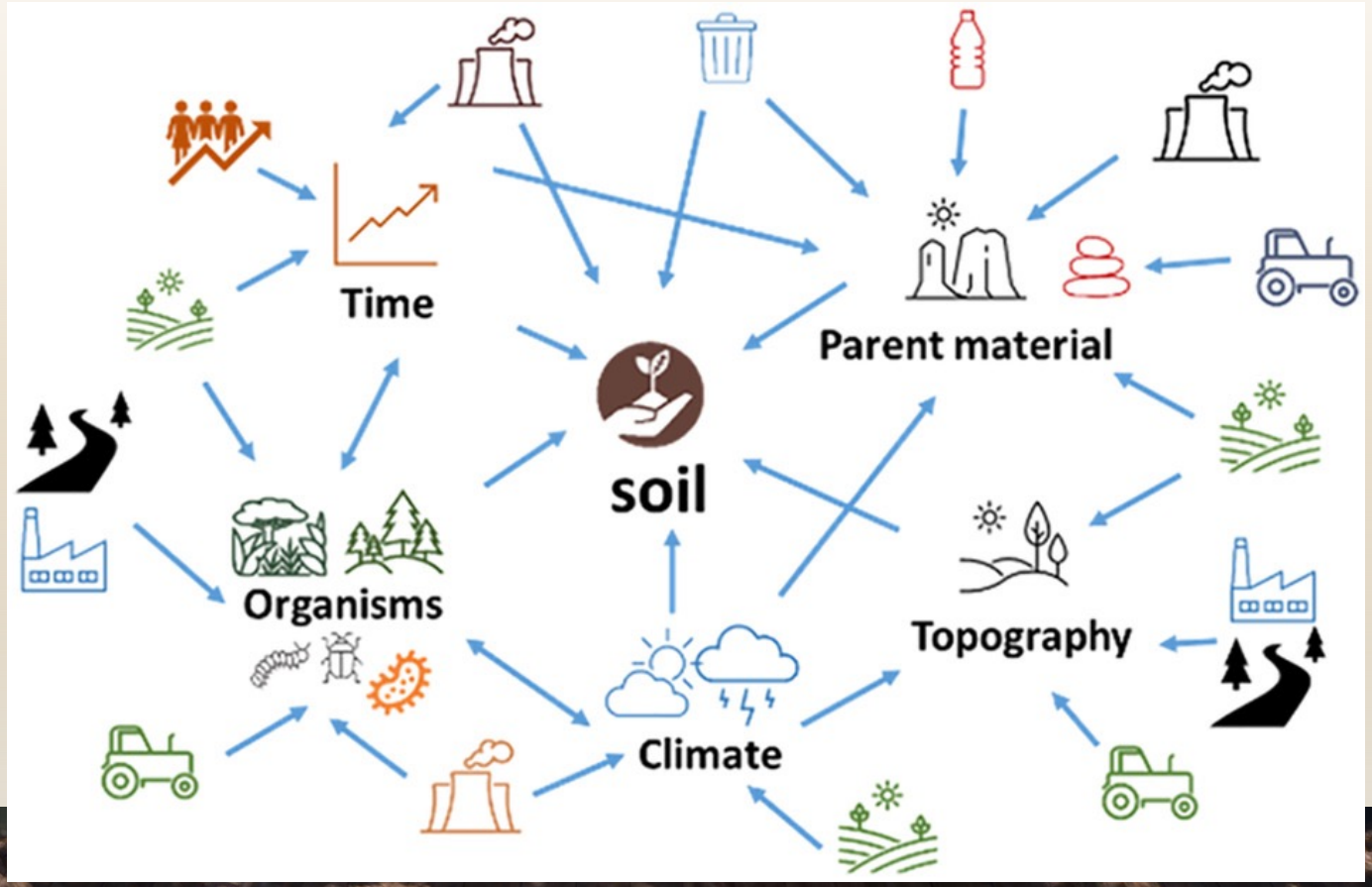
Functions of soil:

- Provides all necessary nutrients
  - Supports plant growth by providing root anchorage
  - Stores water
  - Supplies oxygen to plant roots
  - Acts as nature's recycling system, filtering out excess nutrients
  - Habitat for macro and micro organisms

Short Video: The Importance of Soil

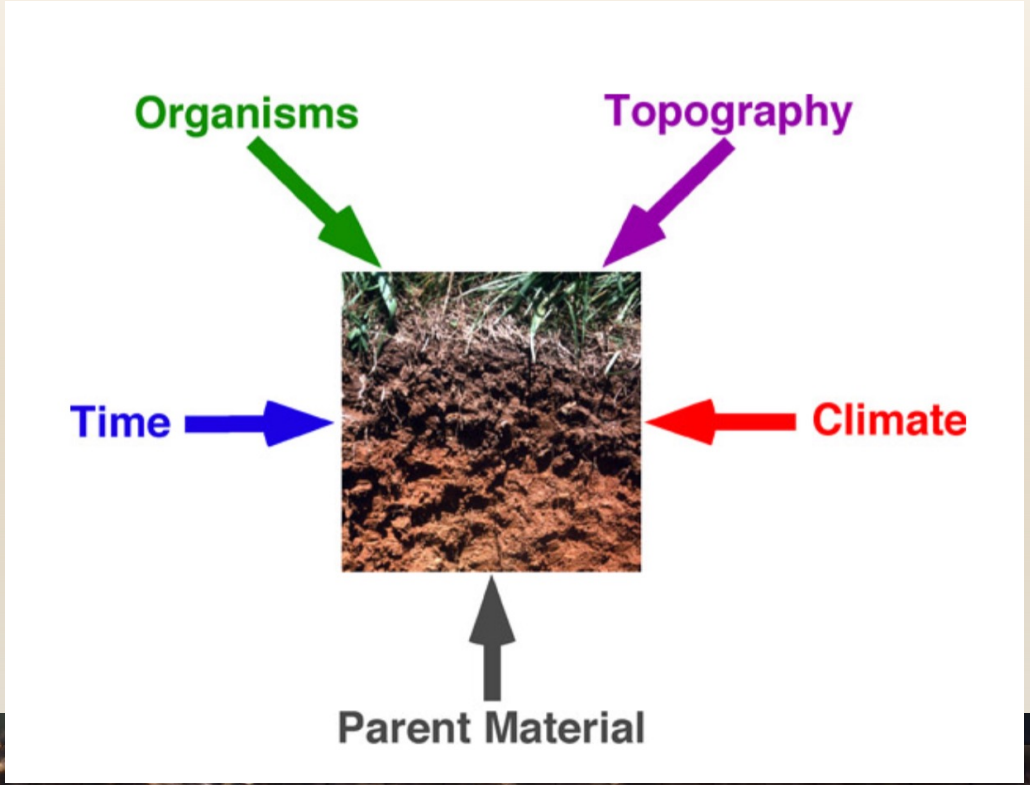
Soil Formation

HOW IS SOIL FORMED?



HOW IS SOIL FORMED?

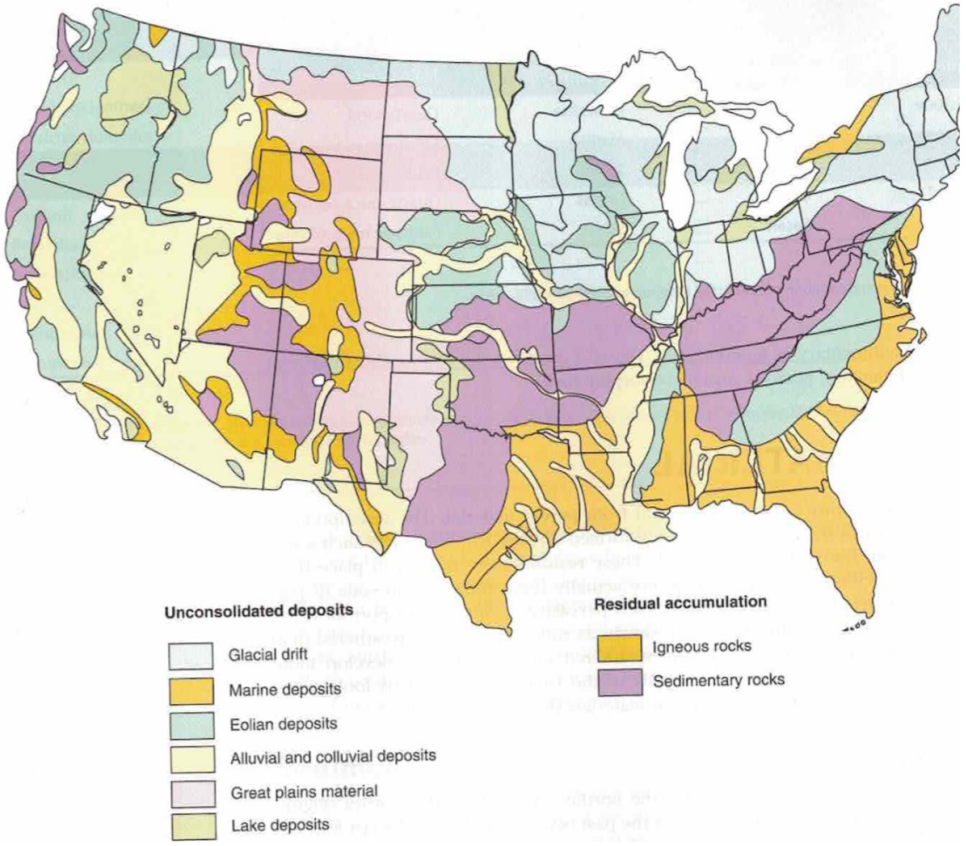
5 SOIL FORMATION FACTORS:



HOW IS SOIL FORMED?

The underlying rocks and minerals from which soil is formed

Parent Materials in the US

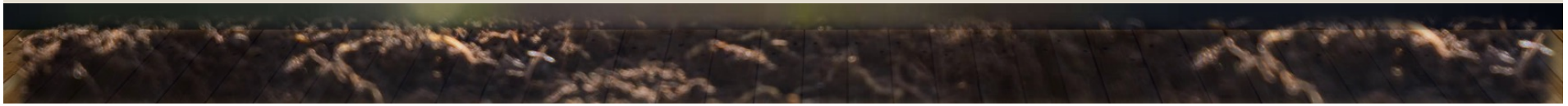


lecture 1\Science - How was soil formed from rocks (3D animation) - English.mp4

5 SOIL FORMATION FACTORS:

CLIMATE

- Affects physical and chemical weathering of rock
- Affects speed of chemical reactions
  - Generally higher temperatures lead to faster reaction times
- Affects organic matter
  - Warmth promotes greater vegetation
  - Warmth increases speed of decay and loss of organic matter
- Rainfall affects leaching
  - Higher rainfall leads to more leaching



HOW IS SOIL FORMED?

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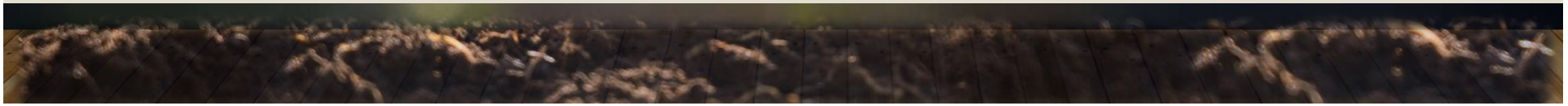
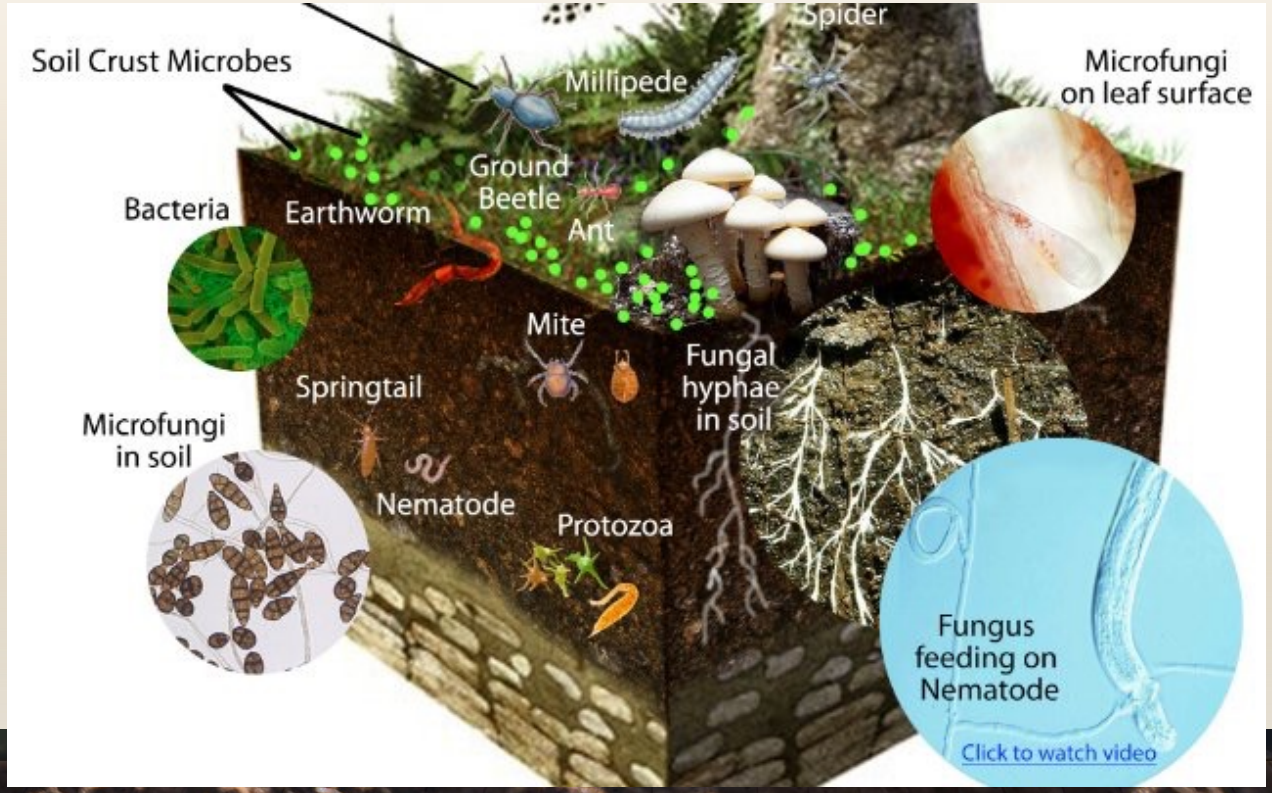
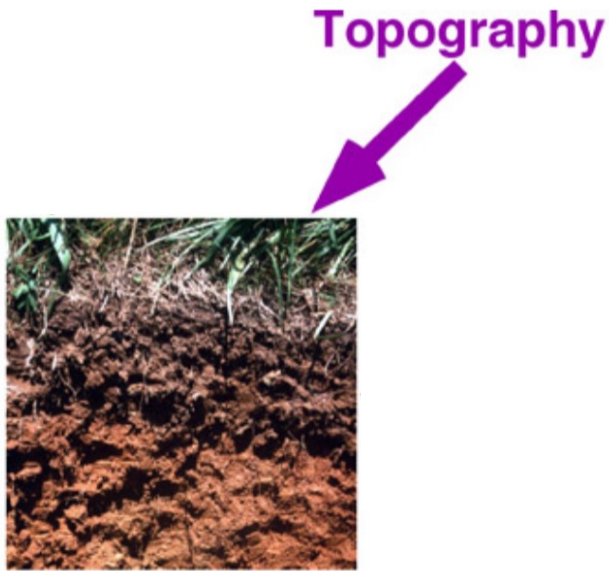


LIVING ORGANISMS



5 SOIL FORMATION FACTORS:

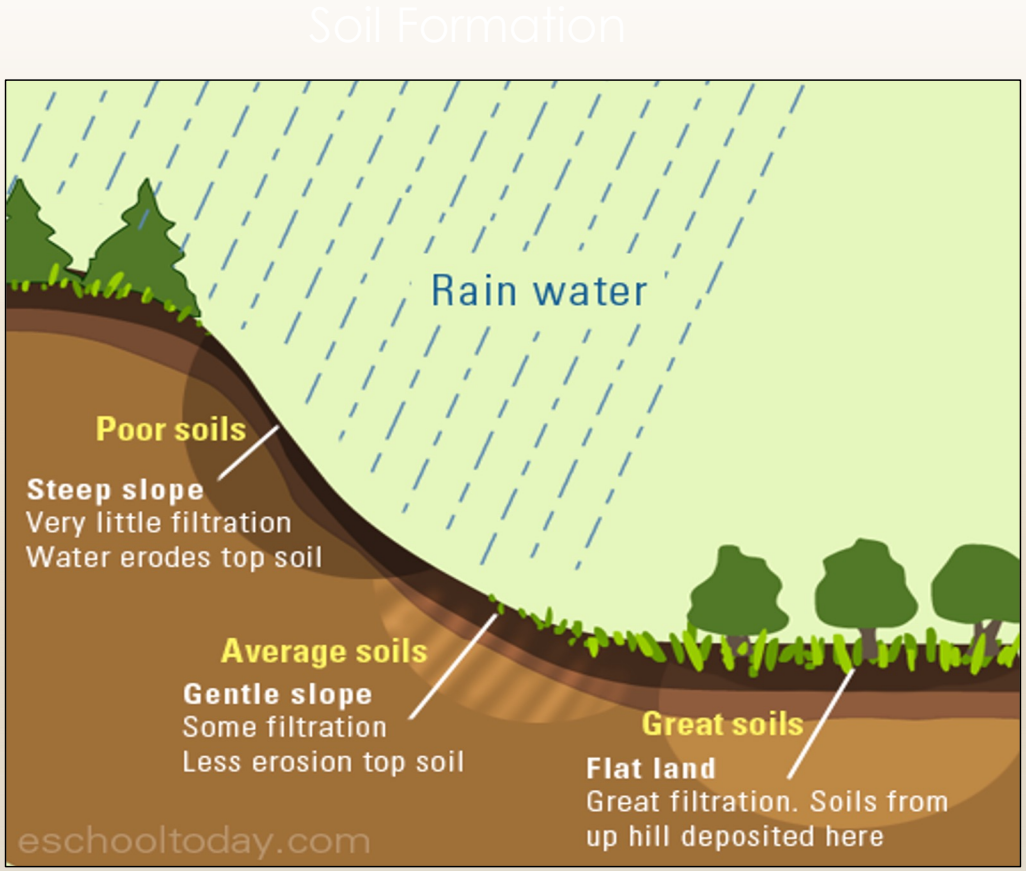


TOPOGRAPHY

Affects water movement

- Water runs off slopes, making them drier
- Water accumulates in low areas, making them moist

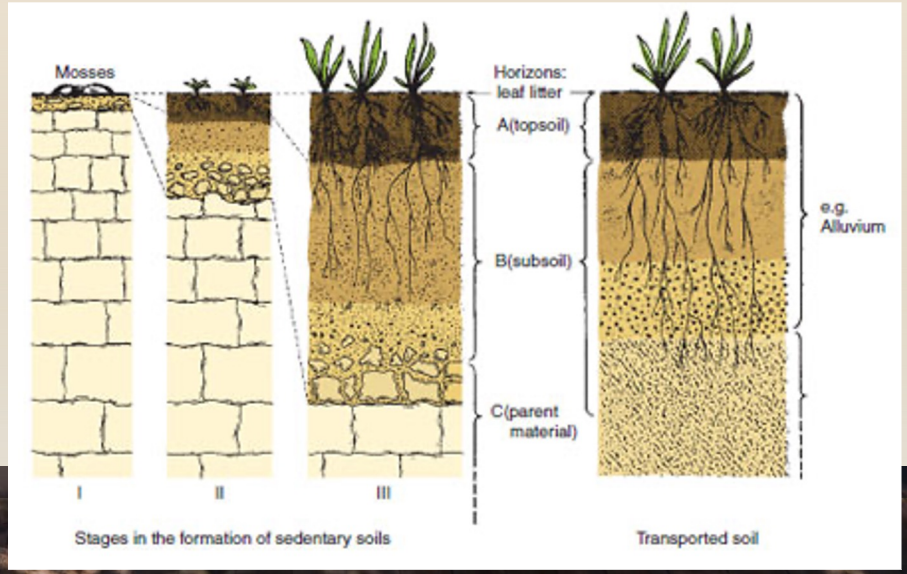
Affects leaching, chemical reactions, and types of vegetation



5 SOIL FORMATION FACTORS:

TIME

- Initially, a thin layer of soil forms on parent material
  - May take as little as a hundred years to form under warm, humid conditions
- Weathering continues, many generations of plants live and die
  - Soils become deeper and increase in organic material
  - Leaching carries materials deeper and creates soil profile
- Mature soils can be productive, but as soils continue to age, they may become highly leached and less productive



HUMANS

- Another factor influencing soils
- But our actions are: - Most rapid - Dramatic - Different from any others

HUMANS

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- But our actions are: - Most rapid - Dramatic - Different from any others
- Effects can be subtle: - Ex: air pollution

HUMANS

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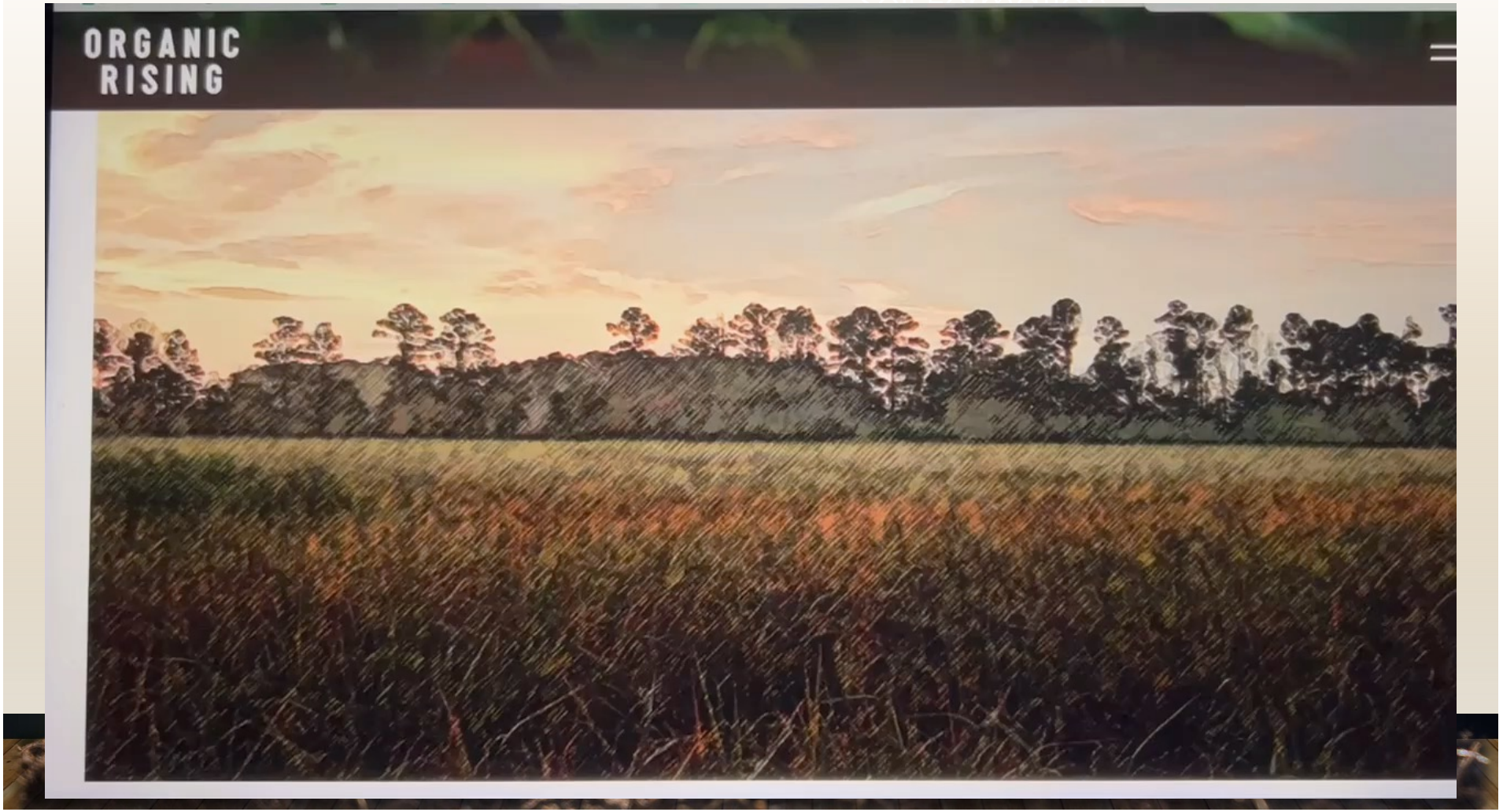
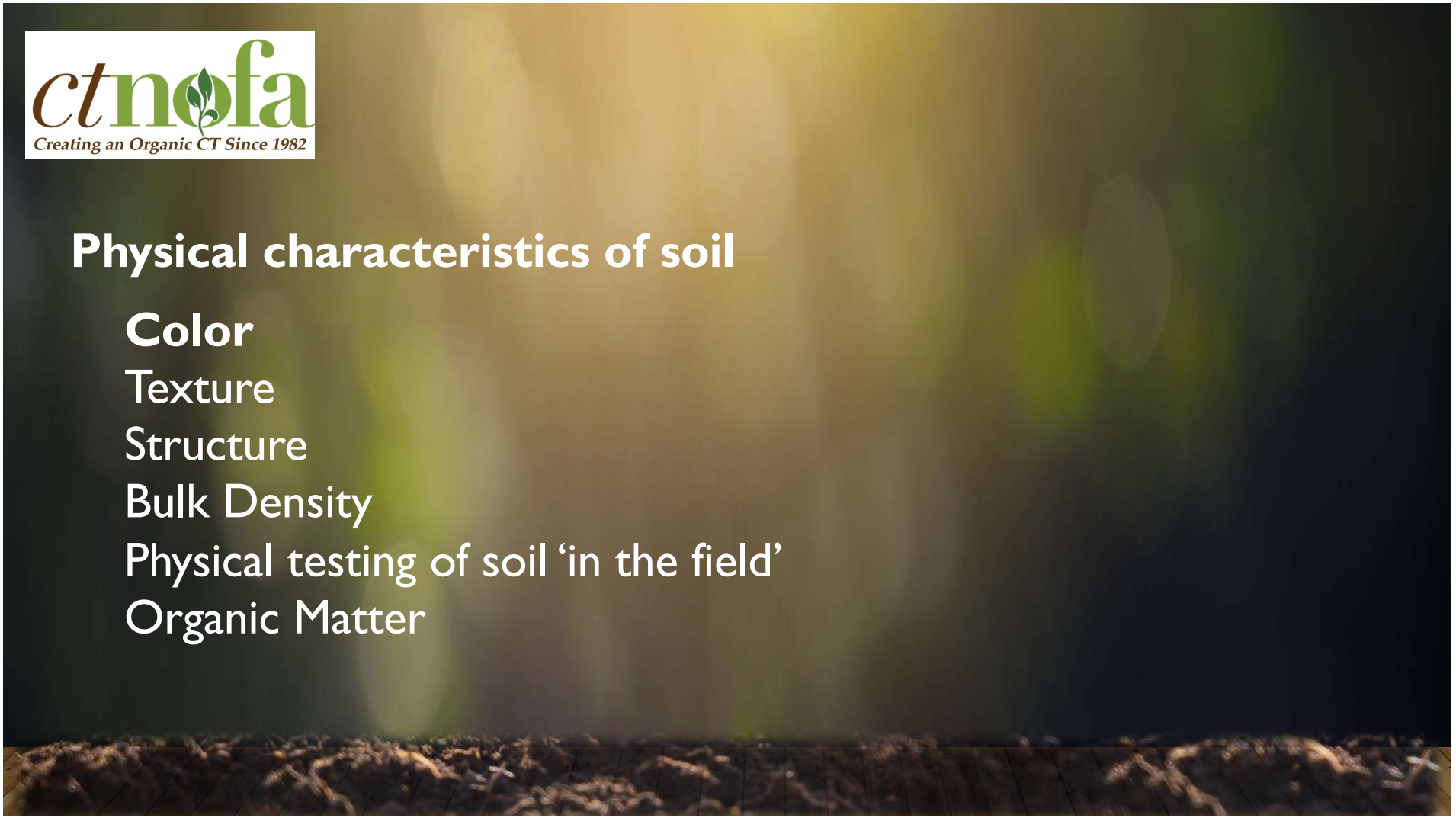
- Effects can be dramatic: - Ex: Mass movement of land

HUMANS

- Another factor influencing soils
- But our actions are: - Most rapid - Dramatic - Different from any others
- Effects can be subtle: - Ex: air pollution
- Effects can be dramatic: - Ex: Mass movement of land
- We can also have a positive effect…


ORGANIC
RISING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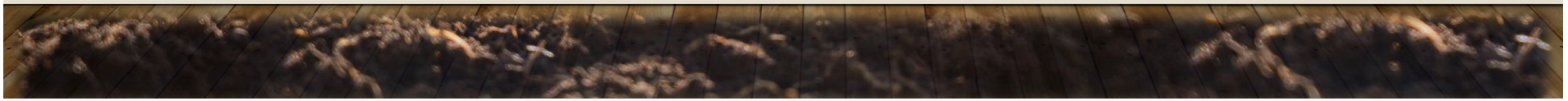
SOIL COLOR

Color is indicative of:

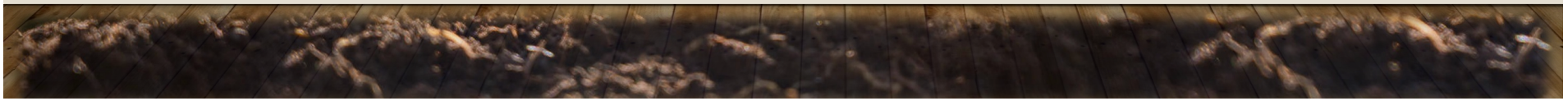
- Organic matter content
- Drainage
- Aeration

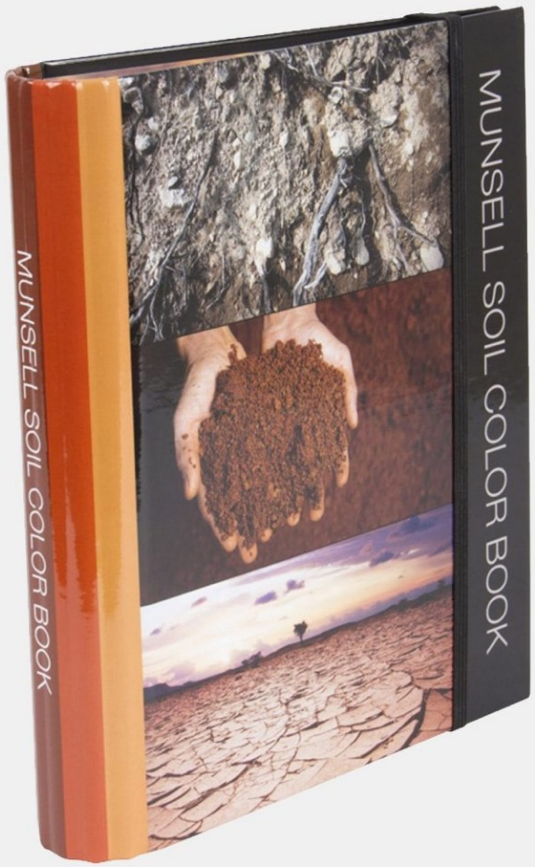
Color appears when particles become painted with some coloring agent (decaying organic material, iron oxides)



SOIL COLOR

- Influenced by its mineral composition as well as water and organic contents
- Soil needs only about 5% organic material to appear black when wet.
- Soil color is also a reflection of its age and the temperature and moisture characteristics of the climate.
- Color influences the rate of soil warming in the spring and cooling in the fall. Dark soils absorb more heat than do more reflective, light-colored soils





Color can be a clue to the mineral content of a soil. Iron minerals provide, by far, the most and the greatest variety of pigments in earth and soil.

Common Pigmenting Agents in the Soil

10YR 2/1 humus	10YR 2/1 todorokite	10YR 2/1 pyrite	10YR 2/1 iron sulfide	10YR 2/1 ferrihydrite
2.5YR 4/6 lepidocrocite-fine	10R 4/8 hematite-fine	2.5YR 3/4 maghemite	5R 3/6 hematite-coarse	10YR 8/3 gypsum
10YR 8/2 dolomite	10YR 8/2 calcite	5Y 6/4 jarosite	10YR 6/1 quartz	5Y 5/1 glauconite
5YR 6/8 lepidocrocite-coarse	7.5YR 6/6 akaganeite	7.5YR 5/6 goethite-fine	10YR 7/8 schwertmannite	10YR 8/6 goethite-coarse

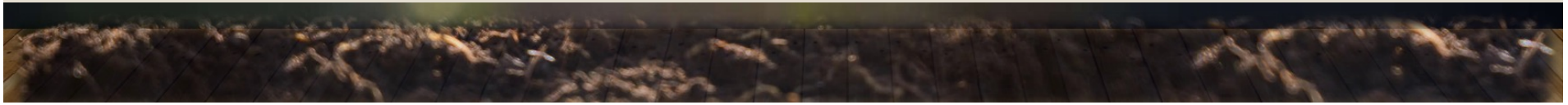
high quartz, gypsum, or calcium carbonate content.

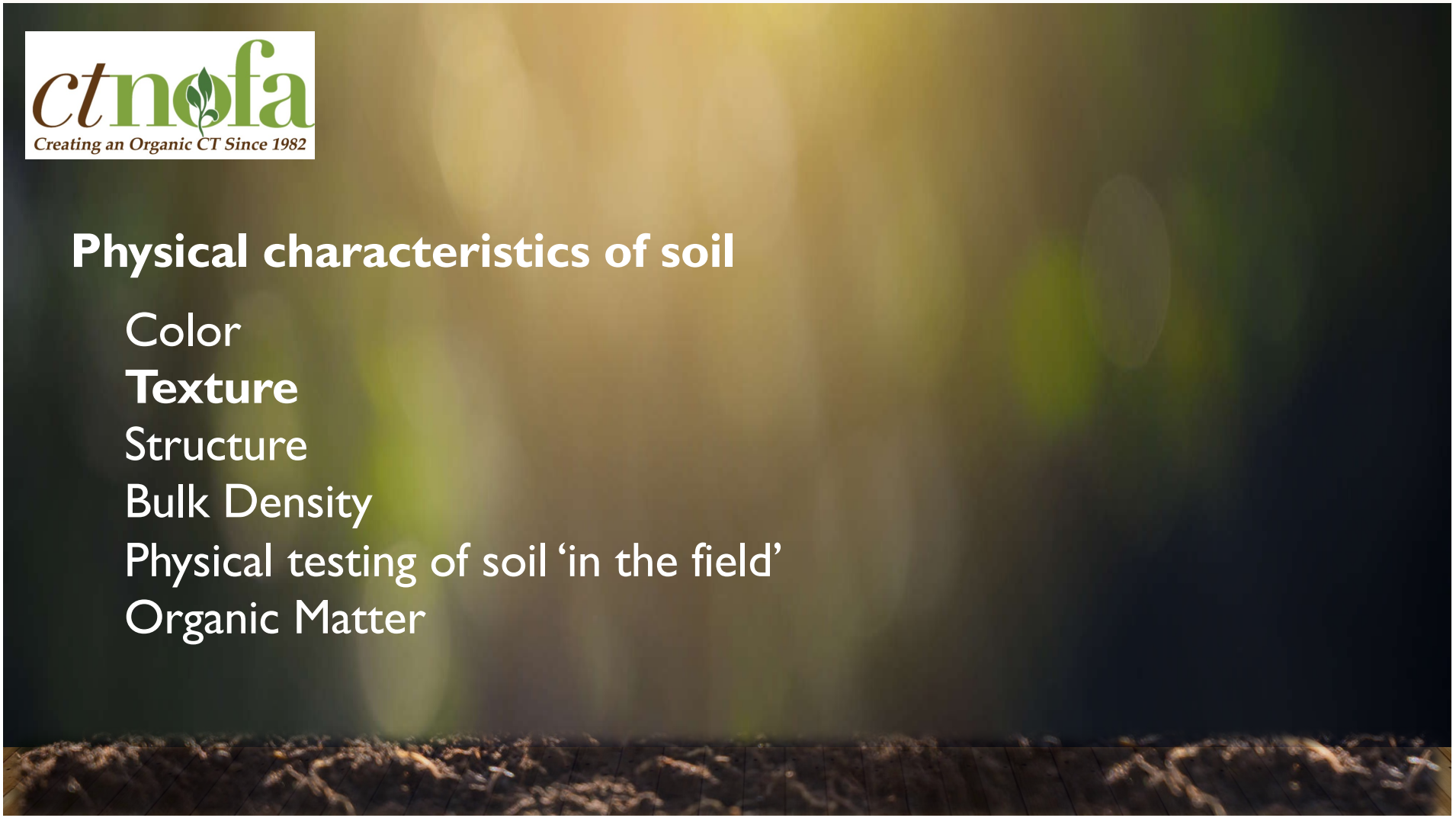
Black: high organic matter (humic acid)

Red/Yellow: oxidized iron, good drainage

Grey: poorly drained, waterlogged

White: high gypsum or calcium carbonate

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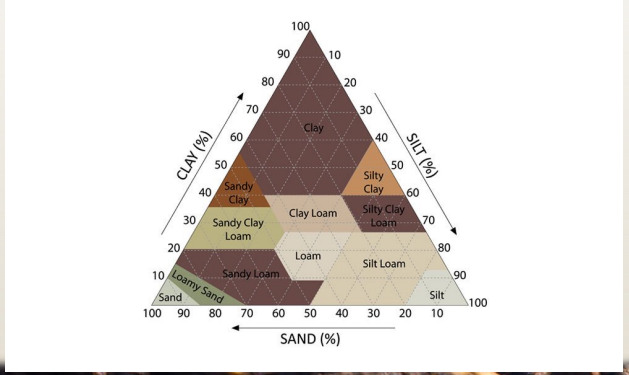
PHYSICAL PROPERTIES OF SOIL
SOIL TEXTURE

Soil texture refers to the proportion of sand, silt and clay sized particles that make up the mineral fraction of the soil.



SOIL TEXTURE

The most fundamental property of soils

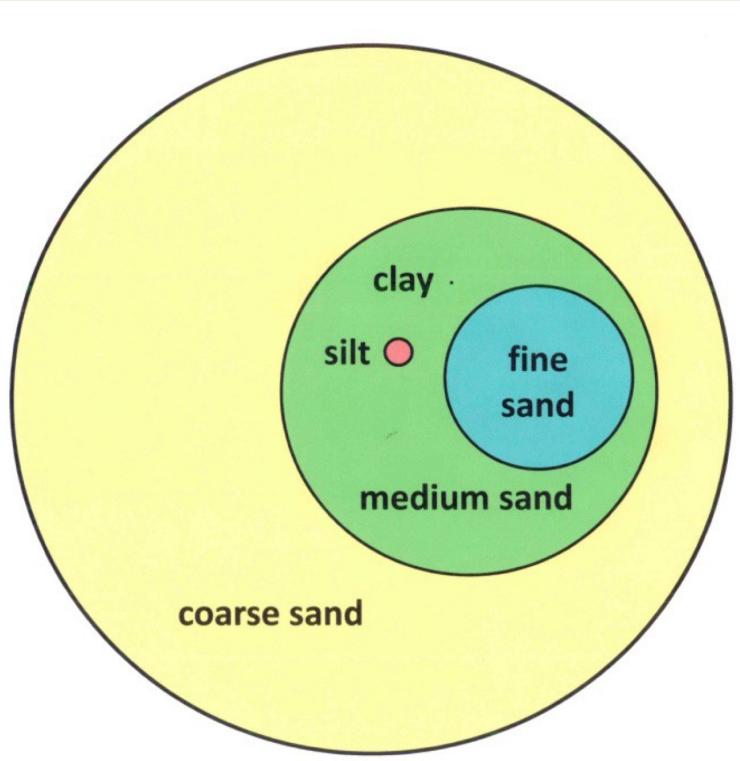
Influences other soil traits: water holding capacity, aeration, nutrient retention

The proportion of the three sizes of soil particles –

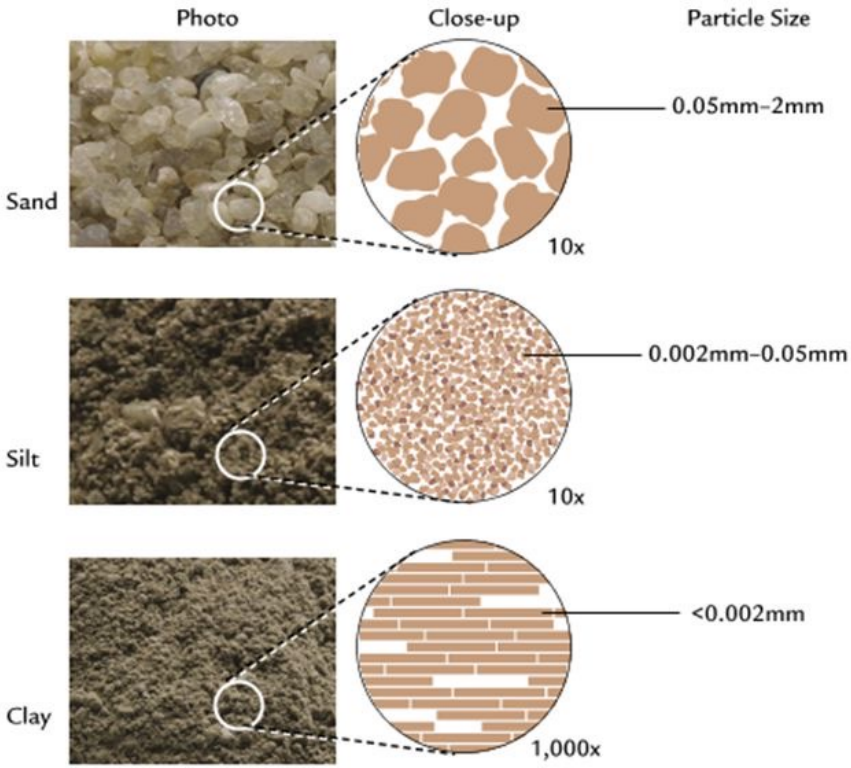
<u>sand</u> (large)

<u>silt</u> (medium)

<u>clay</u> (small)

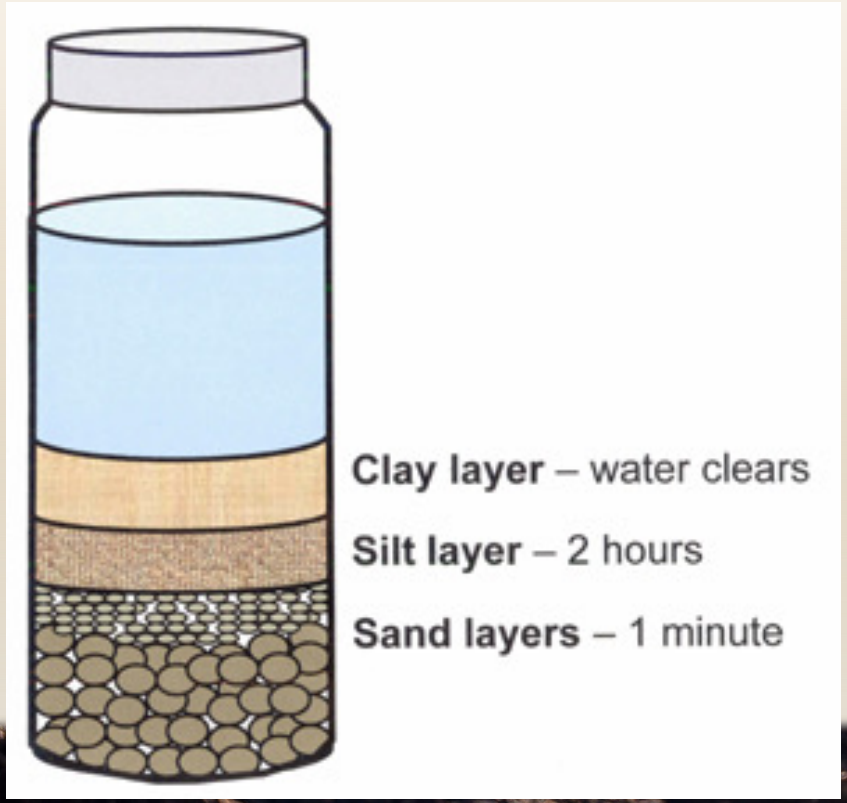


Sand, Silt, and Clay



SOIL TEXTURE TEST – THE JAR METHOD

INSTRUCTIONS:



- Fill mason jar with 2/3rds soil, fill rest of jar with water.
- Add a teaspoon of dish soap; the detergent acts as a surfactant that helps separate out the different soil particles.
- Shake the jar well and let sit for a day. The separation of the soil into layers of different thicknesses will tell you the dominant characteristics of your soil.

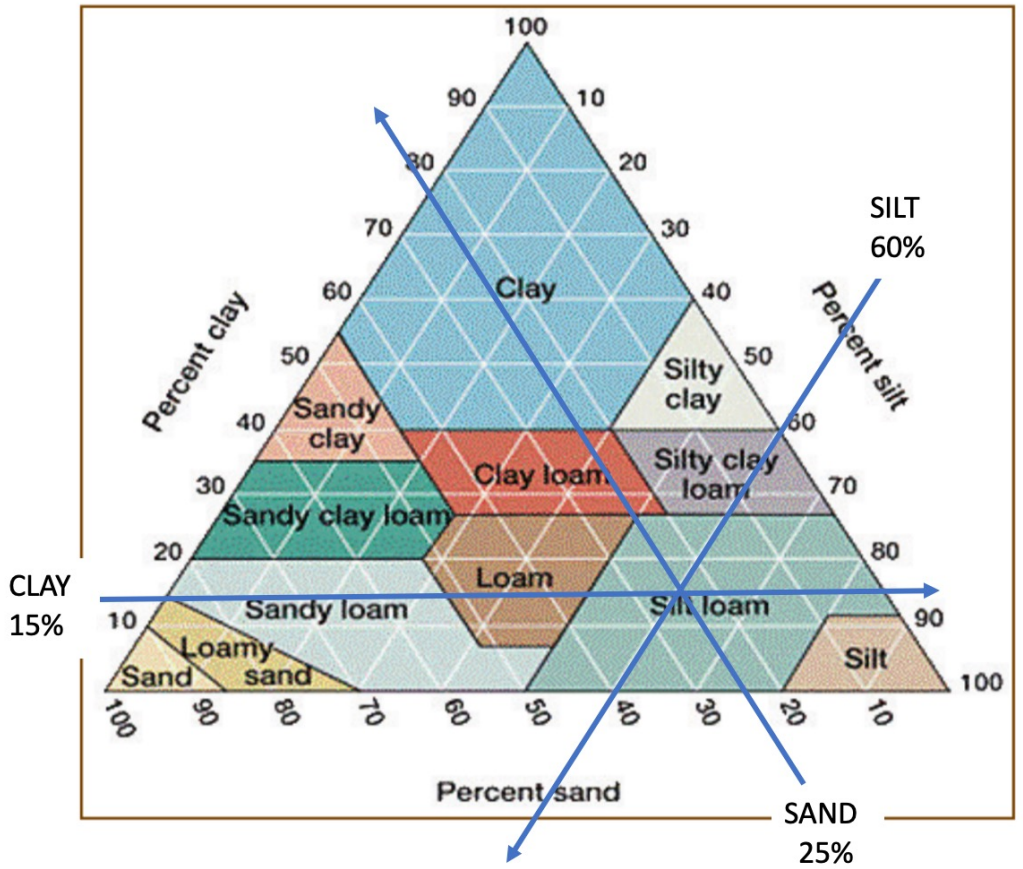
-book: *The Market Gardener, p. 22*

The USDA Soil Textural Triangle

- Draw a horizontal line to the right of the percent **clay**
- Draw a line downward and to the left from the percent **silt**
- Draw a line up and to the left from the percent **sand**

15% clay, 60% silt, 25% sand

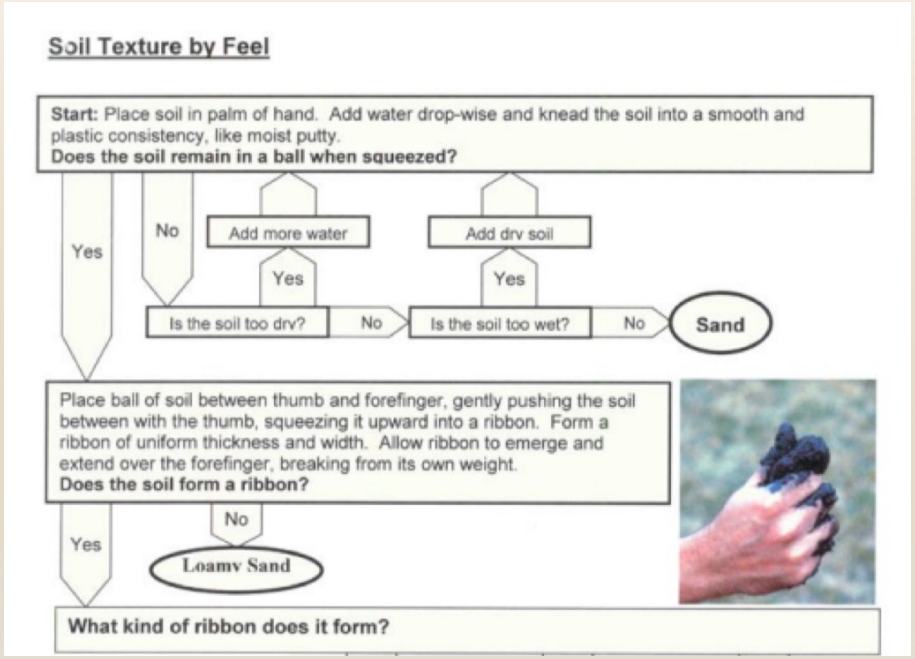
These threes lines will intersect at a point inside the triangle, indicating soil texture type

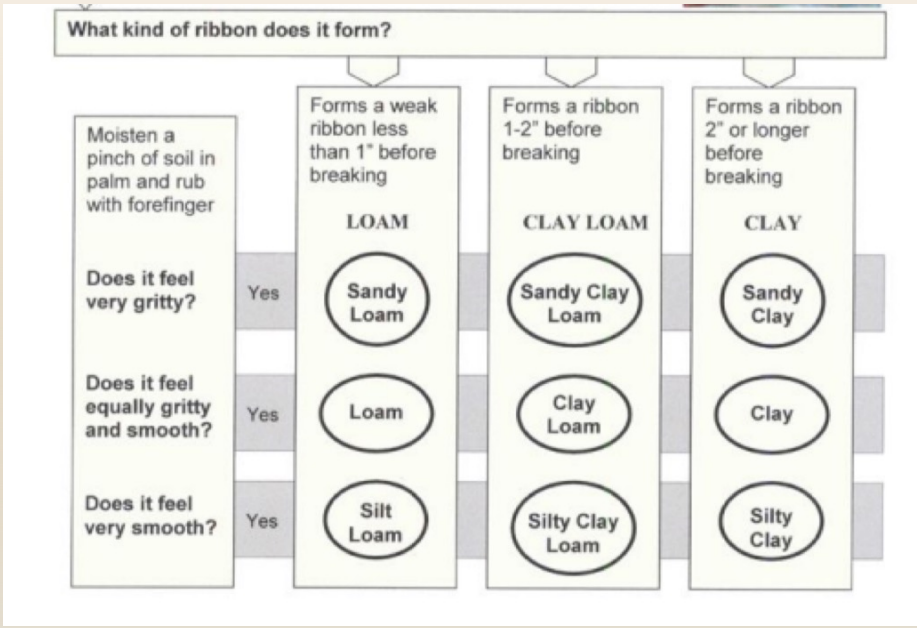


Ribbon Test to determine Soil Texture

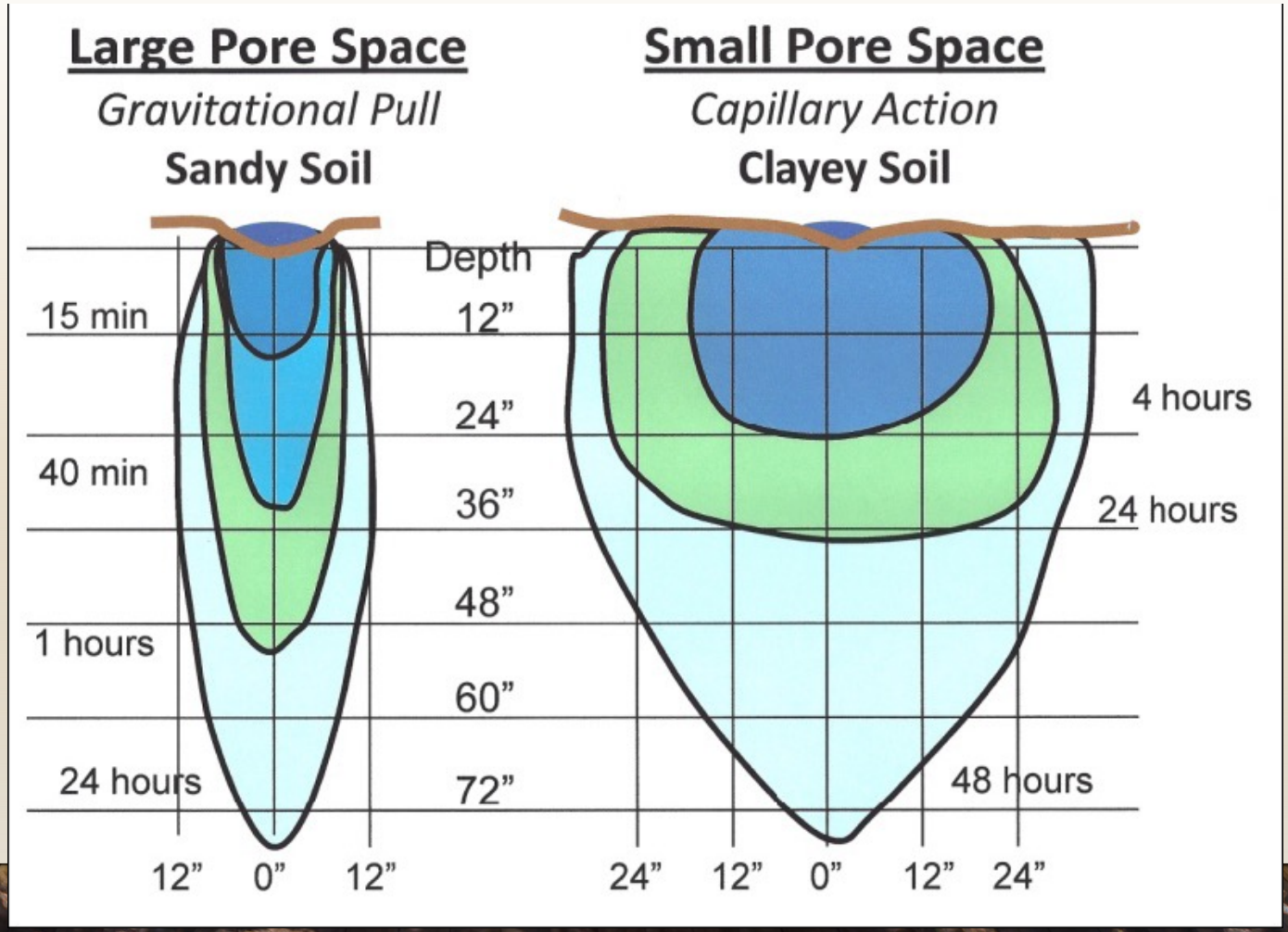
Determining soil texture using the “hand feel” method.

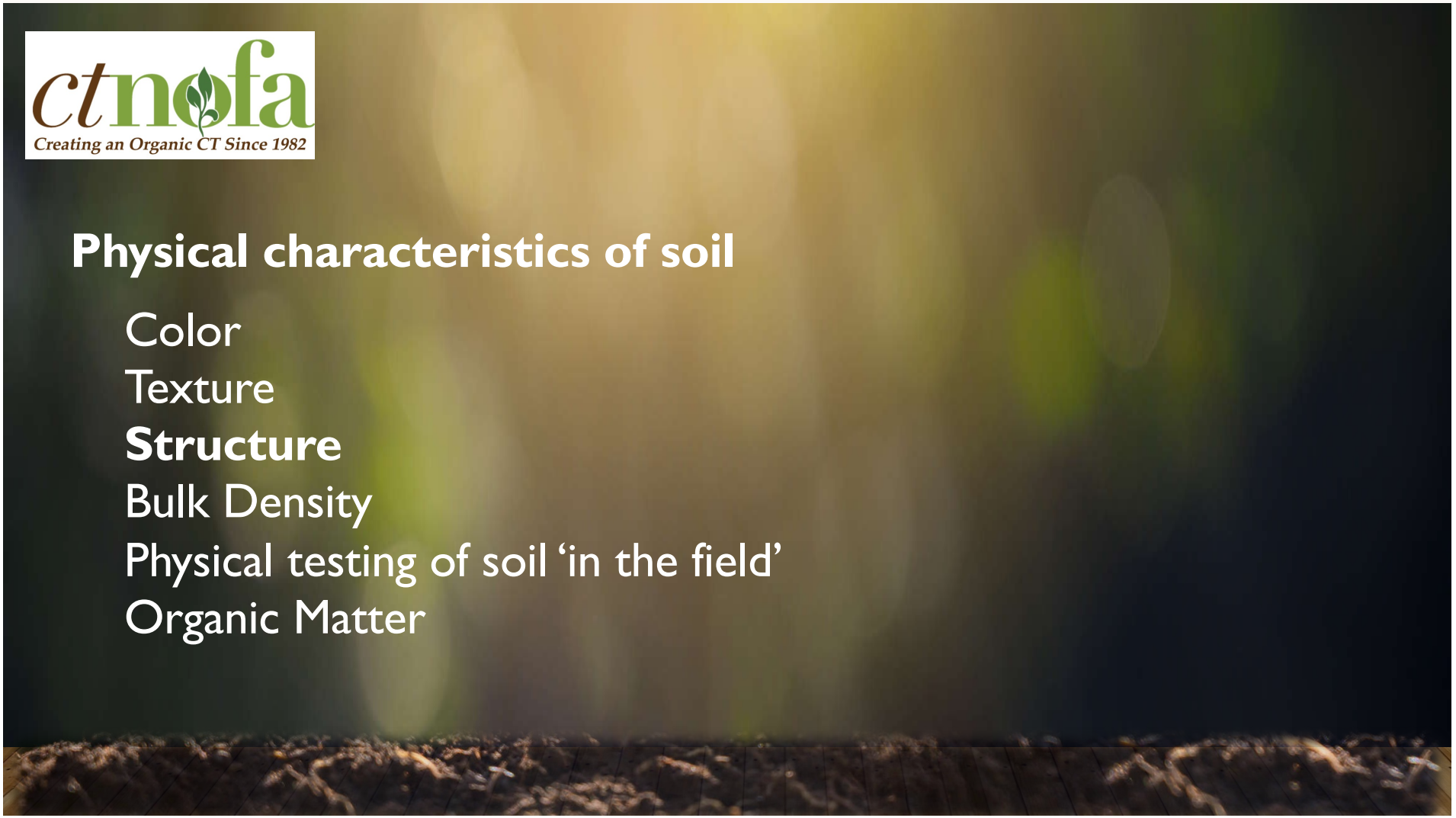
Follow instruction from the Flowchart for Estimating Soil Texture by Hand Feel Method.





COMPARATIVE RATES OF WATER MOVEMENT INTO A SANDY LOAM AND A CLAY LOAM

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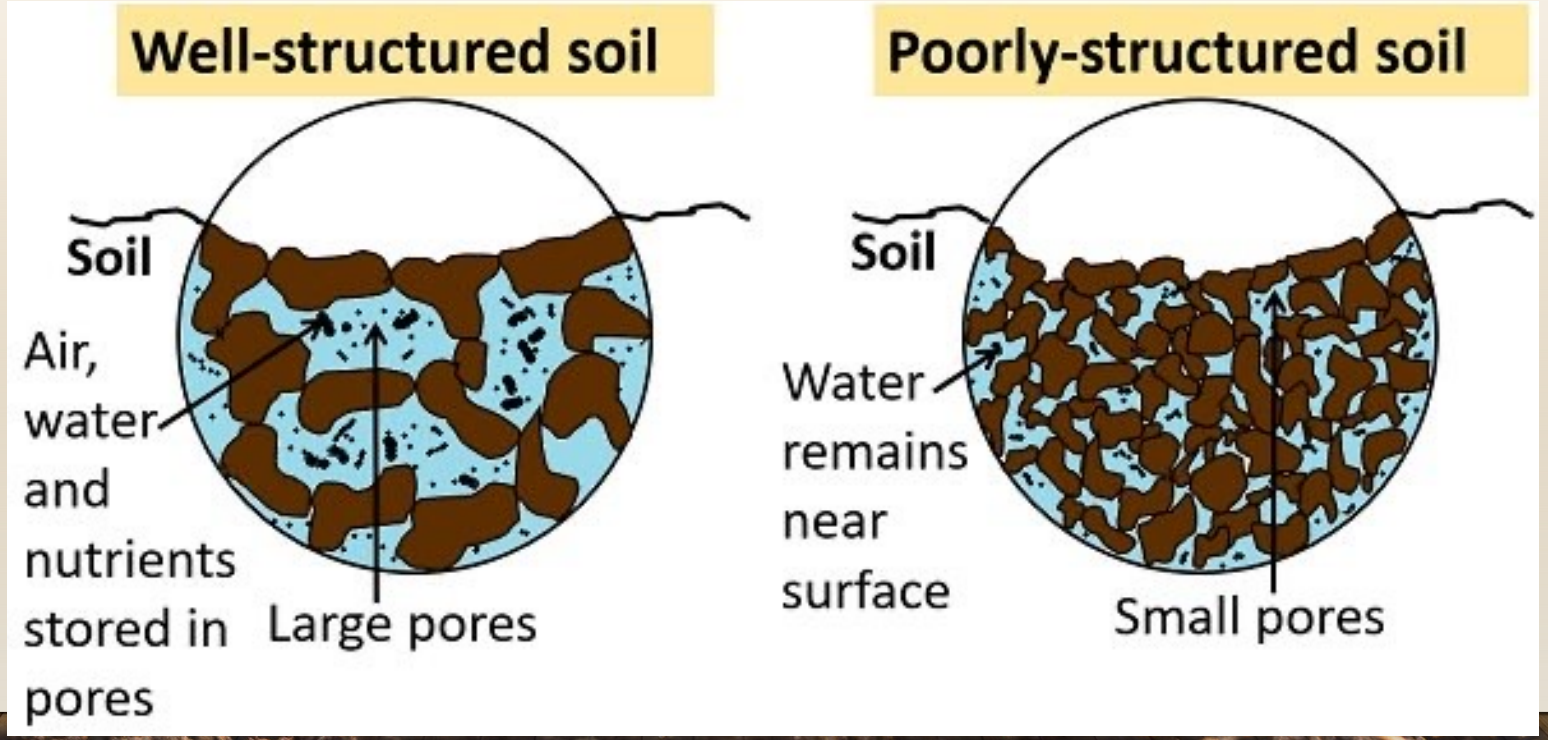
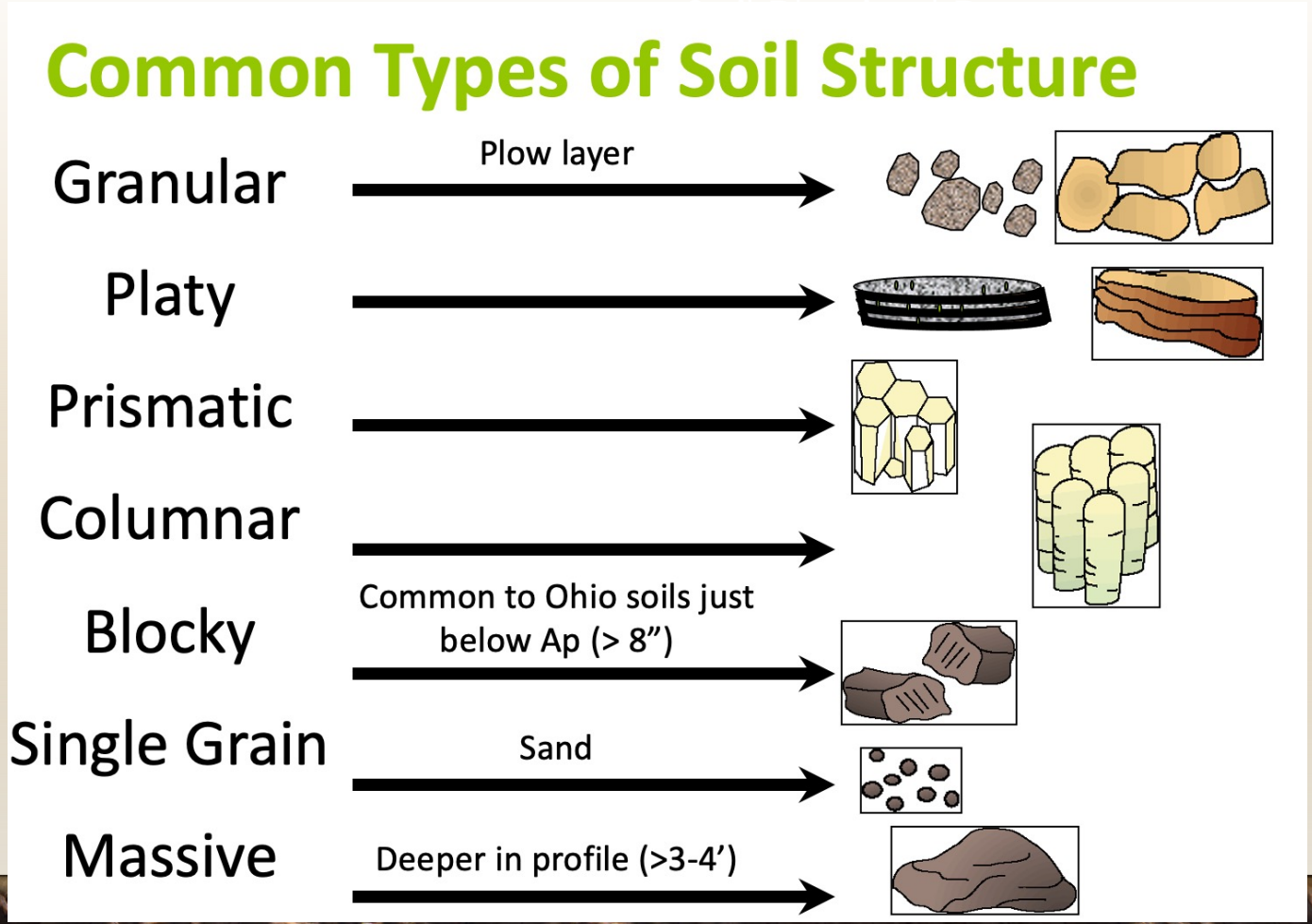
SOIL STRUCTURE

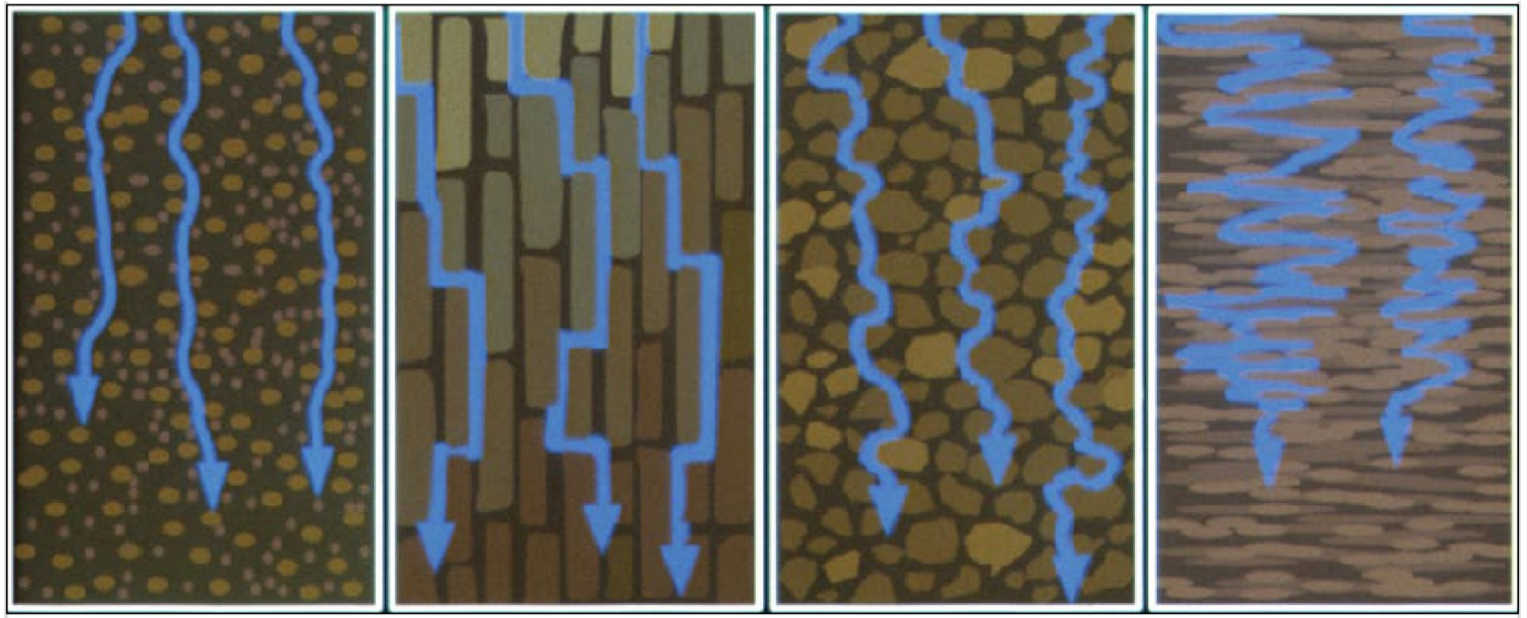
Soil structure refers to the way soil particles clump together into large units (soil aggregates)



Common Types of Soil Structure



WATER MOVEMENT IN SOIL. EFFECT OF STRUCTURE



Granular-	Prismatic –	Blocky –	Platy –
Porous; a mellow soil	Sides of the prisms like an avenue for water movement; periodically desiccated soils	Good water percolation; Humid regions	Water penetration is restricted

https://www.youtube.com/watch?v=cmdoDjKwEo4&t=1s (14:05)

FACTORS AFFECTING SOIL STRUCTURE

CLAY

ORGANIC MATTER

IRON AND ALUMINUM OXIDES

THE TYPE OF EXCHANGE BASES

ORGANISMS

CALCIUM CARBONATE

AGRICULTURAL PROCESSING

PRACTICES TO ENHANCE THE SOIL STRUCTURE

ORGANIC MATTER MANAGEMENT

CROP ROTATION AND DIVERSIFICATION

CONSERVATION TILLAGE

COVER CROPPING

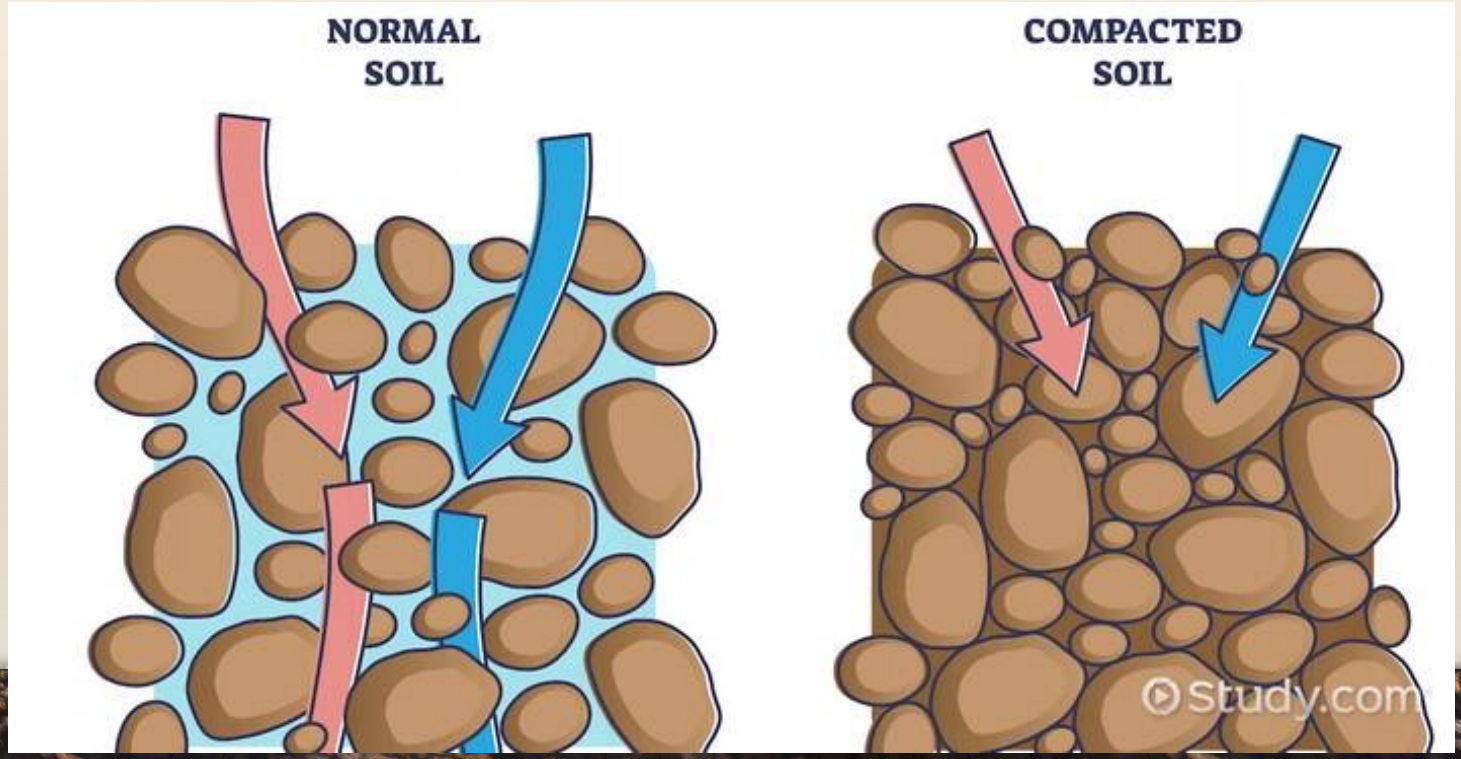
SOIL AMENDMENTS

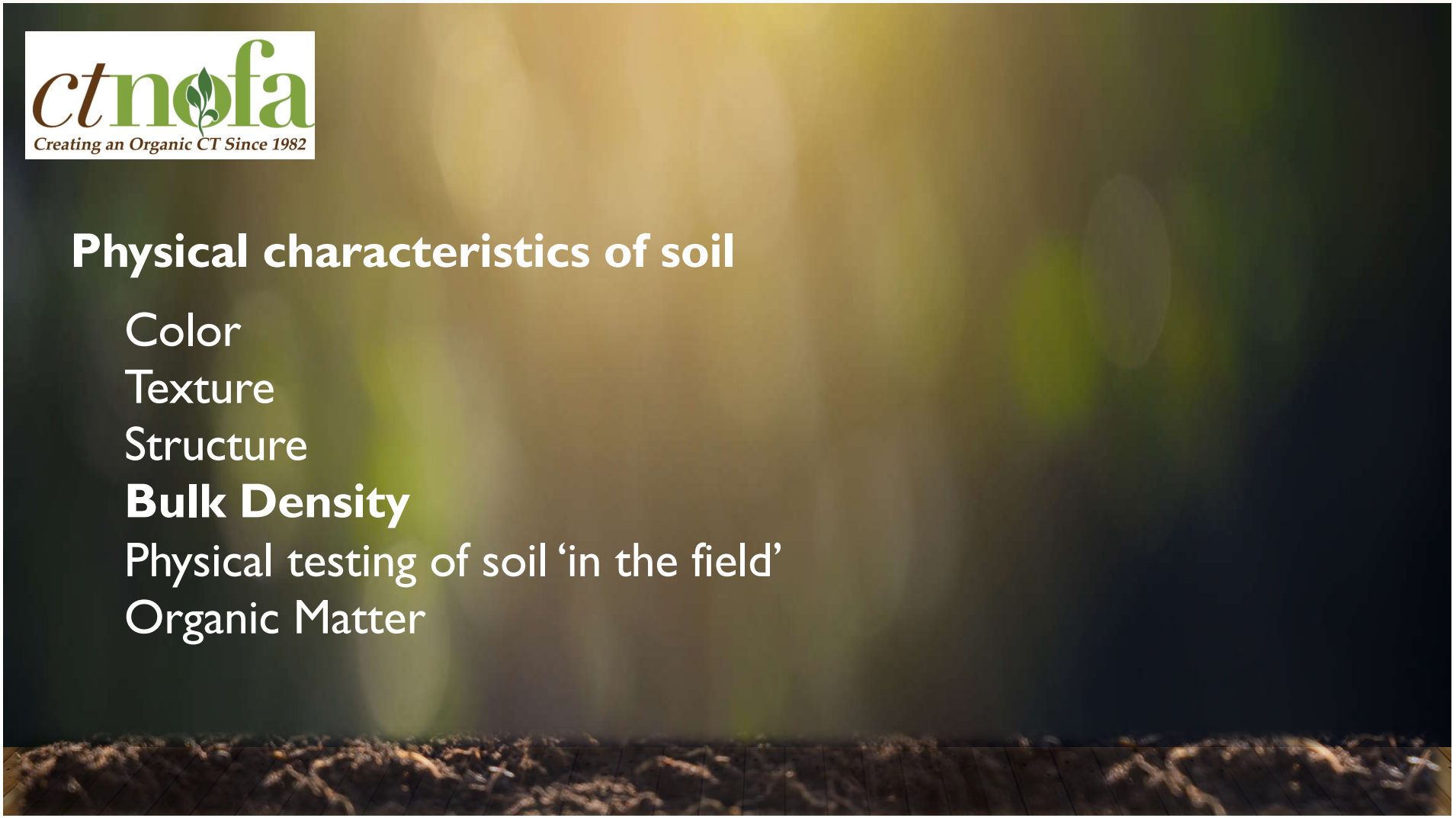
Soil Health
BENCHMARKS

This infrographic was designed with the help of Flaticon

COMPACTED SATURATED SOIL

Traffic, splashing rain or irrigation, and cultivation tend to destroy soil structure, resulting in soil compaction. A compacted soil is one in which porosity has been reduced with a corresponding increase in bulk density. Soil structure will become more 'platy/massive'

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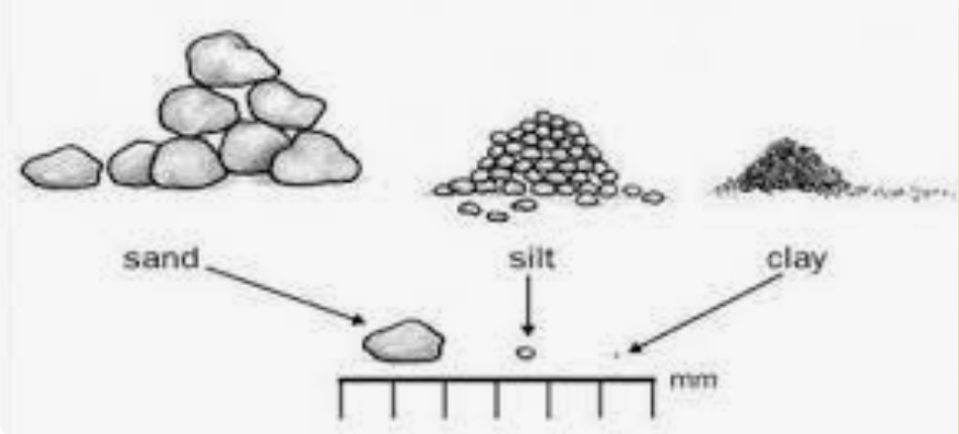
BULK DENSITY

Bulk density is an indicator of soil compaction and soil health.

Inherent factors that affect bulk density such as soil texture cannot be changed.



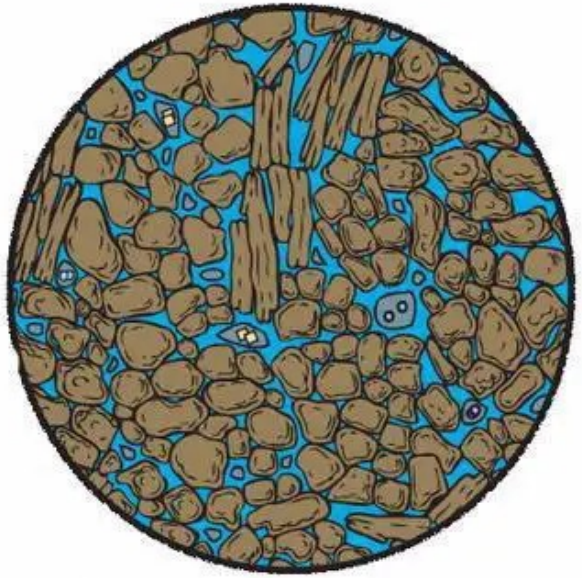
Bulk density is dependent on soil organic matter, soil texture, the density of soil mineral (sand, silt, and clay) and their packing arrangement.

BULK DENSITY

Brick = high bulk density, low pore space

Sponge = low bulk density, high pore space

BULK DENSITY

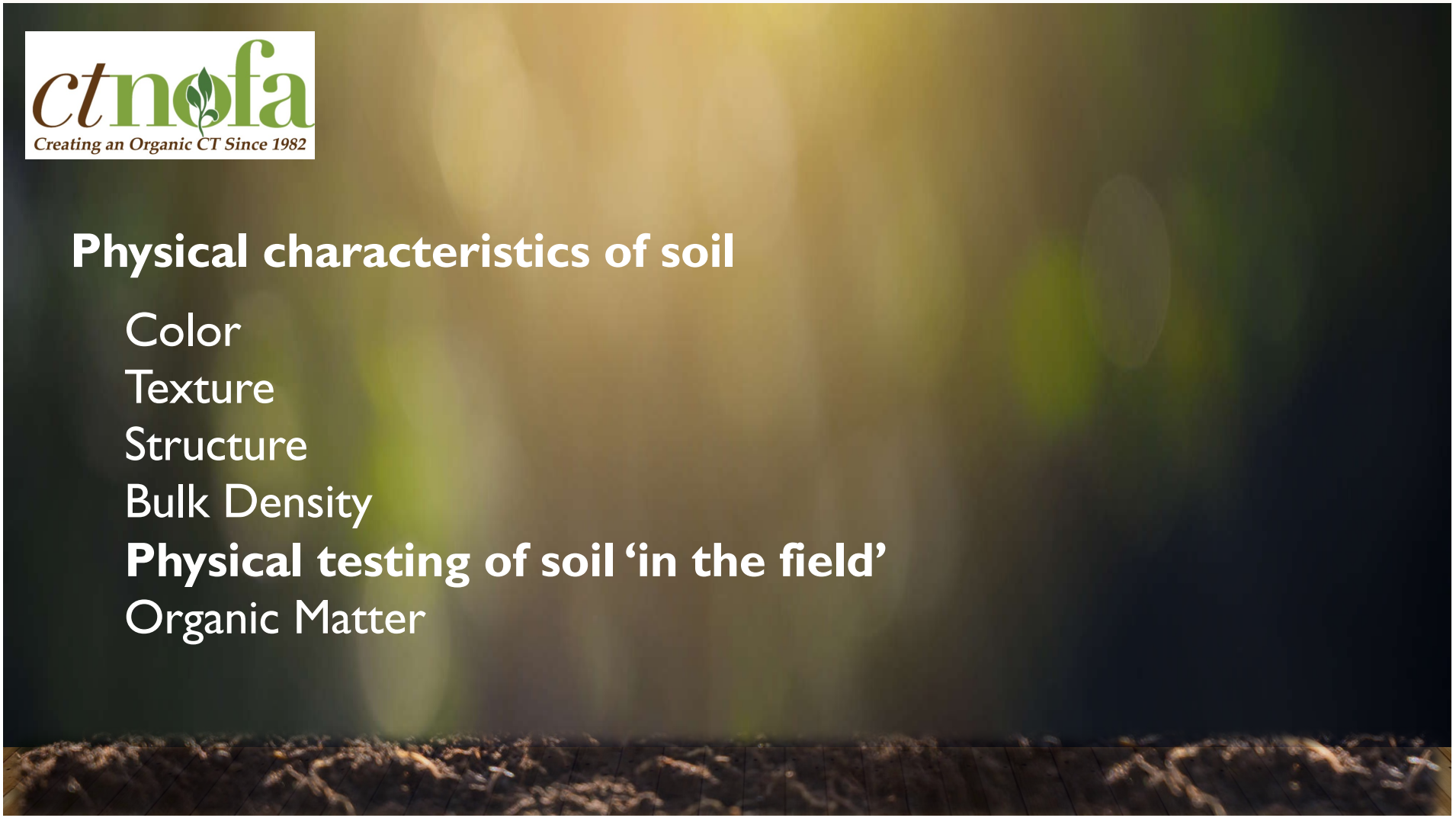


Lower bulk density
Lower weight
More pore space

Higher bulk density
Higher weight
Less pore space

BULK DENSITY

Bulk density typically increases with soil depth since subsurface layers are more compacted and have less organic matter, less aggregation,
and less root penetration compared to surface layers, therefore contain less pore space.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Visual Assessment of Soil Health: Penetration Resistance

Penetrometer

Site 1:_____

Penetrometer readings showed at 3” depth intervals

3”- _____ psi

6”- _____ psi

9”- _____ psi

12”- _____ psi

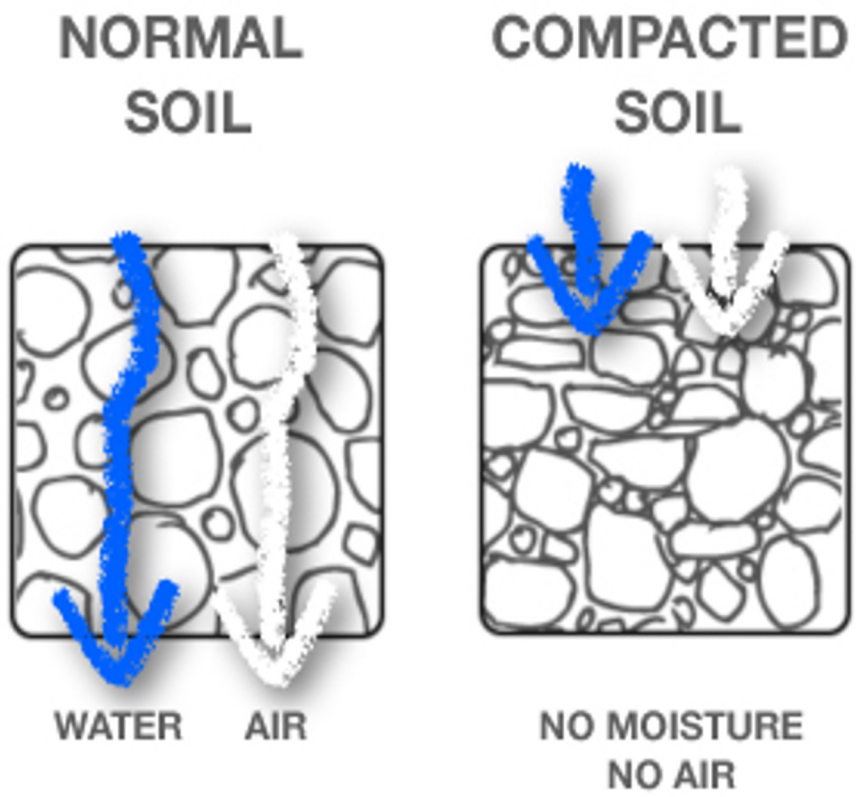
15”- _____ psi

18”- _____ psi

21”- _____ psi

How can compaction be reduced?

- Reduce the number of trips across the area.
- Till or harvest when the soils are not wet.
- Reduce the pressure of equipment.
- Maintain or increase organic matter in the soil.
- Harvest timber on frozen soil or snow




NOFA

SLAKE TEST – Undisturbed Soil vs. Tilled Soil

These samples belong to the same soil type and have been in corn-bean rotation for over 20 years, but their treatment was very different!!!.

The land on the left has not been plowed or fertilized with anhydrous ammonia for more than 20 years and has benefited from a rye cover crop.

The land on the right was plowed annually and fertilized with anhydrous ammonia in the fall.

This photo was taken about 2 minutes after the samples were immersed in water.

The plowed land practically “exploded” as soon as it hit the water. Repeated plowing of the soil has destroyed its structure, removing interstitial space and the biological “glue” that helps hold the soil together, leading to its disintegration.

In contrast, with minimal soil disturbance, the no-tilled soil had excellent porosity and high biological activity, giving it a healthy structure that could withstand water shock.

In less than five minutes, the plowed land disappeared completely, while the unplowed land remained almost intact.

We wanted to see how long it would last and continued adding water (to compensate for evaporation) for several weeks.

We stopped after 6 weeks, during which time the no-till soil sample was still 95% intact.

Credit: Daily Factfinder

Recording Data:
[Sample A] Describe the spot:

_____

[Sample B] Describe the spot:

_____

Roughly what percentage of the soil clod remains on each mesh basket after 1 minute?

Sample A_____ Sample B_____

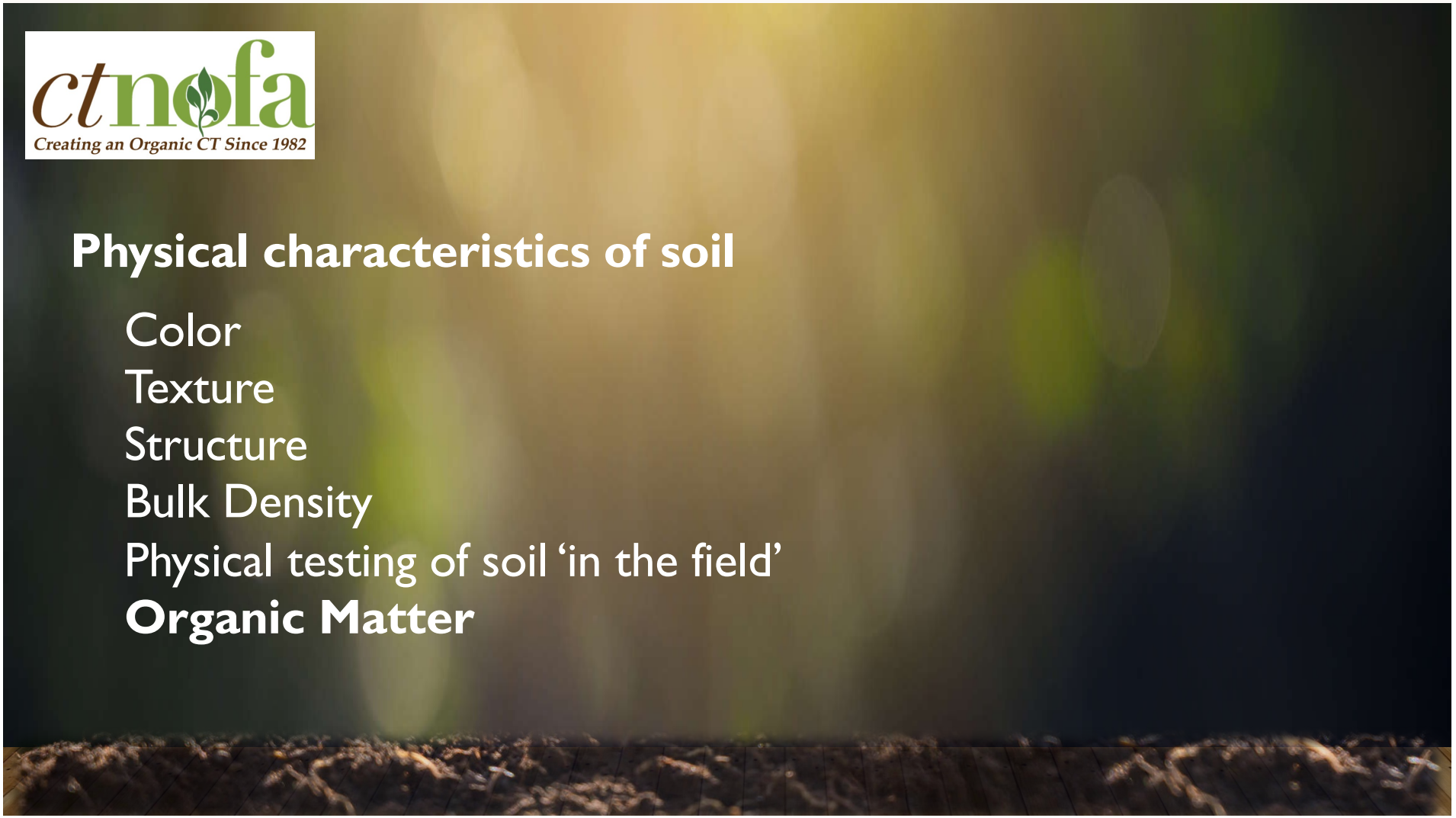
Roughly what percentage of the soil clod remains on each mesh basket after 5 minutes?

Sample A_____ Sample B_____

Protocol:

- Choose and record location(s) to observe
- Clear surface to be sampled of residue. Trim away vegetation.
- Using scrap lumber and hammer/mallet drive ring to depth of 3 inches. [Be careful to hammer ring straight down, to ensure that a gap does not form between soil and ring.
- Line soil in ring with plastic wrap, covering ring
- Pour 1 inch of water (444mL if ring is 6") into ring over wrap
- Remove wrap by gently pulling it out and note the time
- Record the time (in minutes and seconds) it takes when the water is gone and the surface is glistening
- If the surface is uneven, count the time until half the surface is exposed and just glistening
- If soil is very dry, repeat the test. The 1st inch has wet the soil and the 2nd is a better infiltration test.

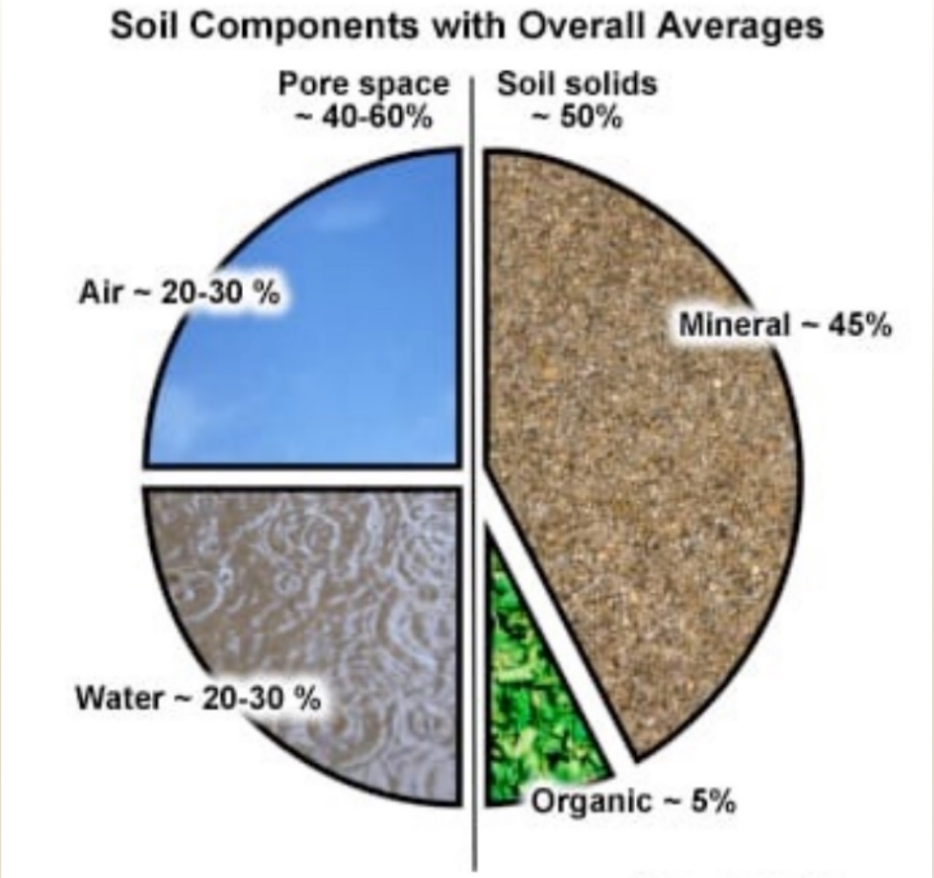
_____ Time that water is gone


ctnofa
Creating an Organic CT Since 1982
Physical characteristics of soil
Color
Texture
Structure
Bulk Density
Physical testing of soil 'in the field'
Organic Matter

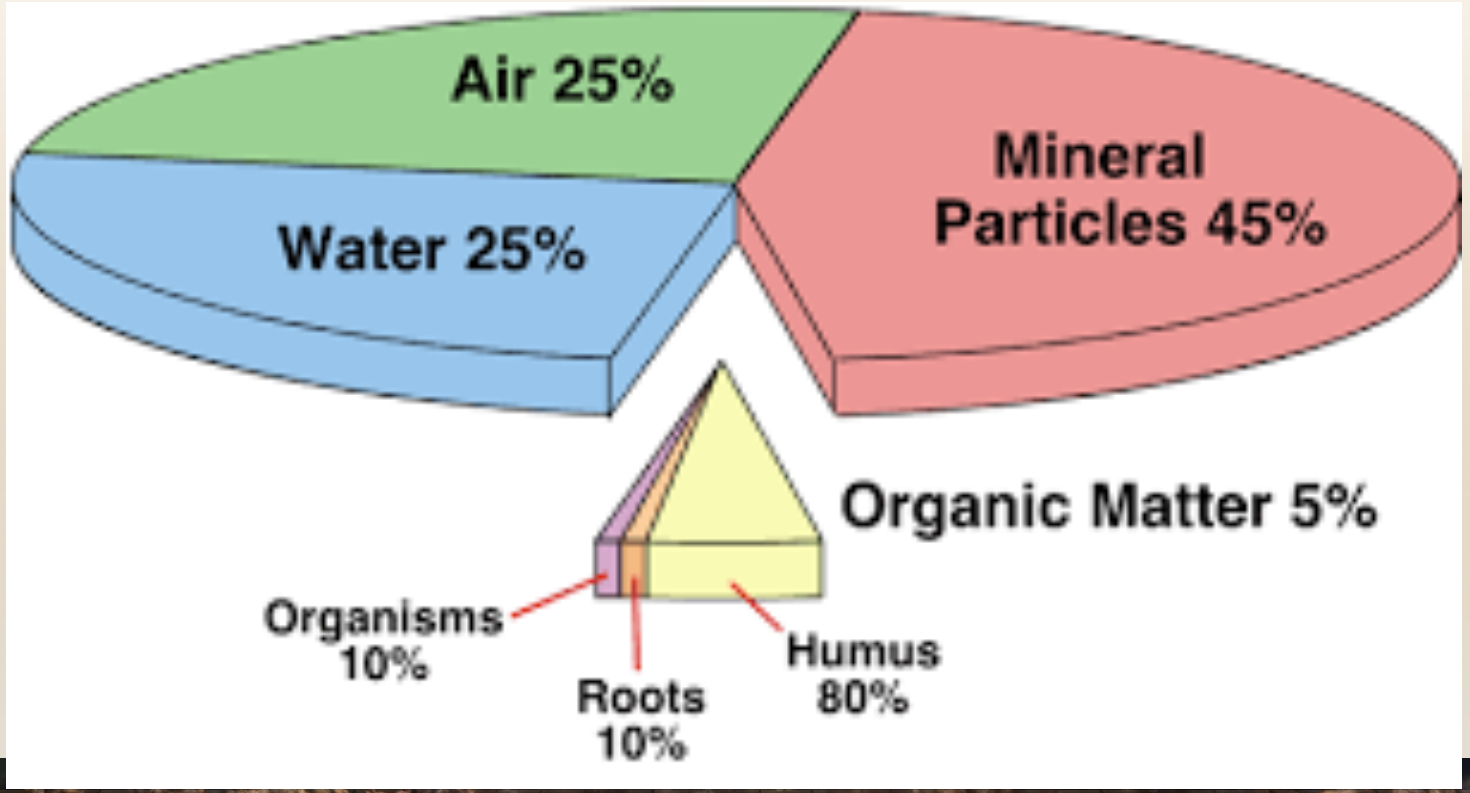
SOIL ORGANIC MATTER

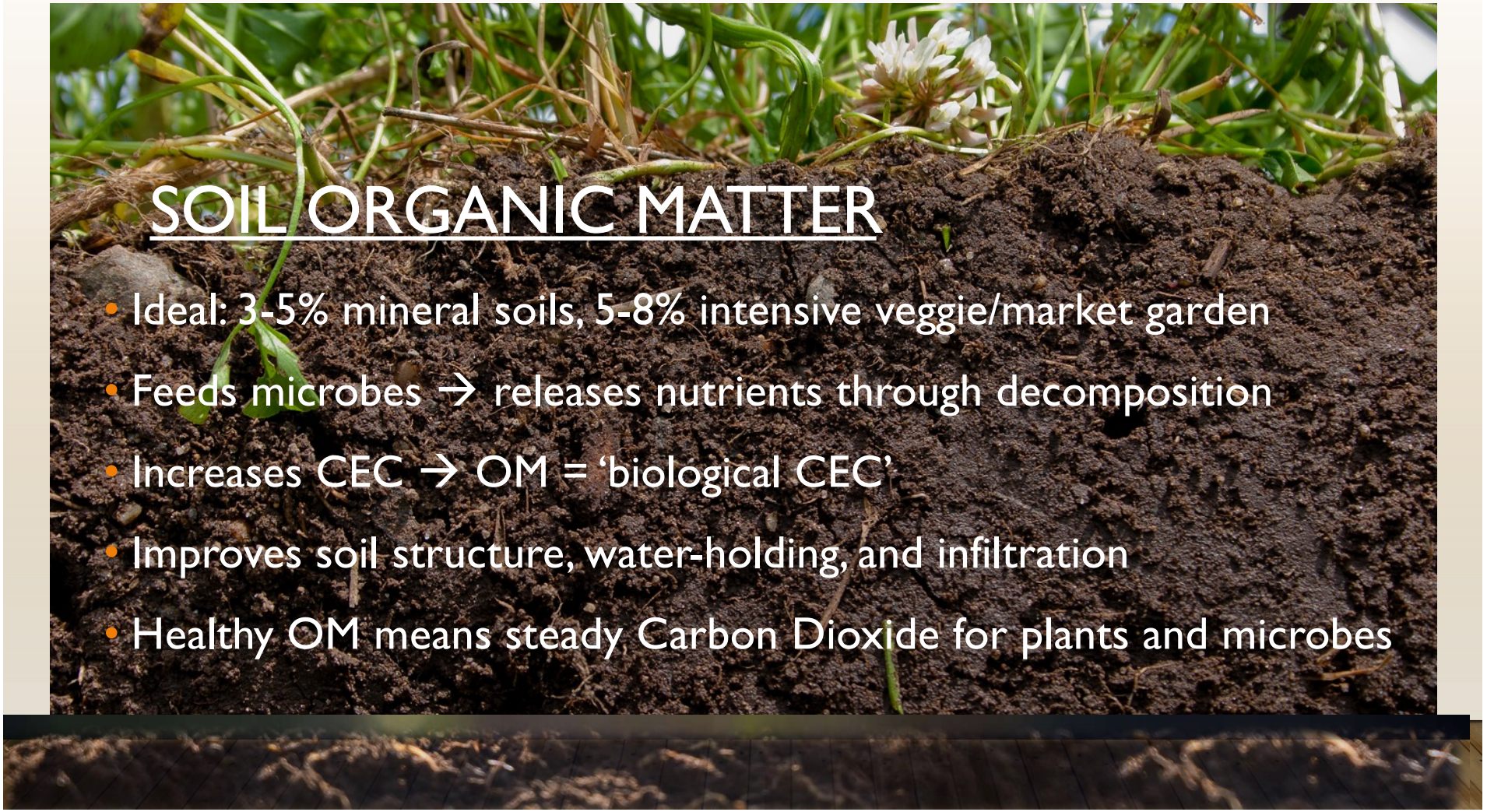
Moisture content varies considerably
with factors such as soil drainage and the amount and frequency of rain or irrigation.

For most agricultural crops, conditions are best when the pore space is filled about equally with water and air



SOIL ORGANIC MATTER





SOIL ORGANIC MATTER

- Ideal: 3-5% mineral soils, 5-8% intensive veggie/market garden
- Feeds microbes → releases nutrients through decomposition
- Increases CEC → OM = 'biological CEC'
- Improves soil structure, water-holding, and infiltration
- Healthy OM means steady Carbon Dioxide for plants and microbes

Soil Health

Just a 1% increase in soil organic matter can boost yields, reduce inputs, and improve resilience.