SOILS 101: A practical approach

Kevin Marini
UCCE Placer/Nevada Counties

SOILS 101:
AGENDA

Soil Basics

Soil Fertility
(how plants and soil interact)

Soil Food Web

Fertilizers/Amendments

SOILS 101:

A QUOTE BY CHARLES E. KELLOGG, USDA 1938

"Essentially, all life on this planet depends on the soil…There can be no life without soil and no soil without life…they have evolved together."

STEP 1:

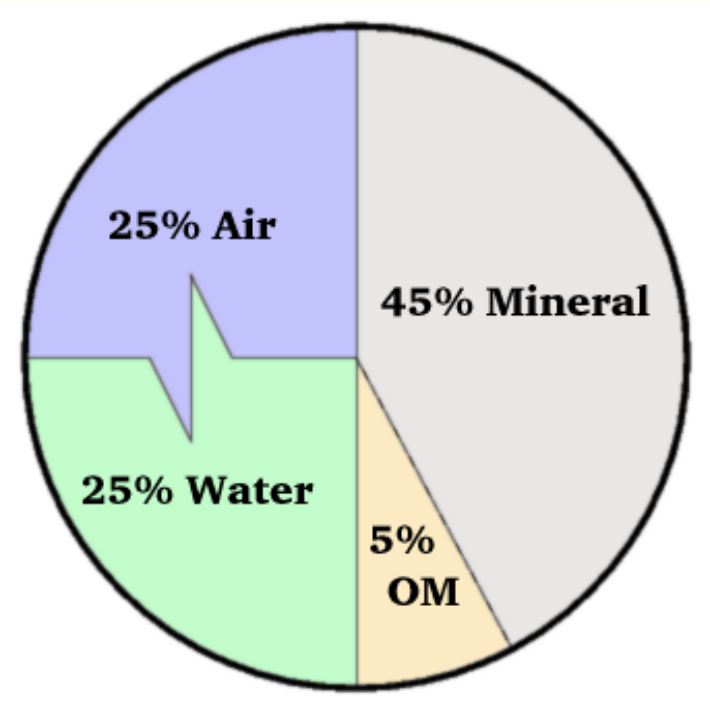
START WITH SOIL BASICS

Why learn about Soil?

- It's what plants grow in!
- To determine how to water/fertilize plants
- To assess problems (disease, nutrient deficiencies, etc…) related to these plants
- To understand how to support the living organisms there
- Because playing with soil makes us happy!

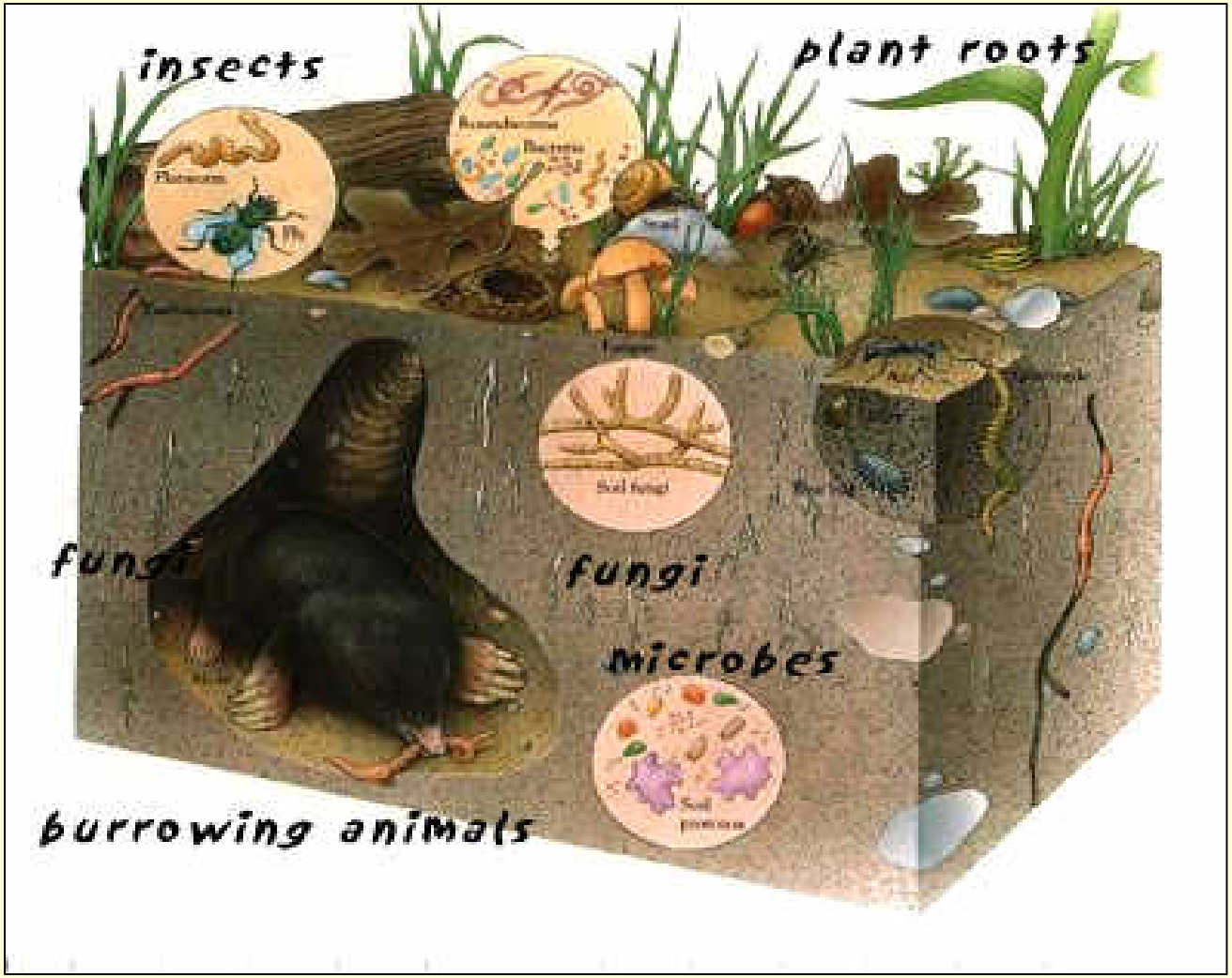
Your Soil…exposed!

Soil = Minerals, Organic Matter, Air Water, and ??????



An ideal garden soil is fertile, deep, easily crumbled, well-drained and fairly high in organic matter and…

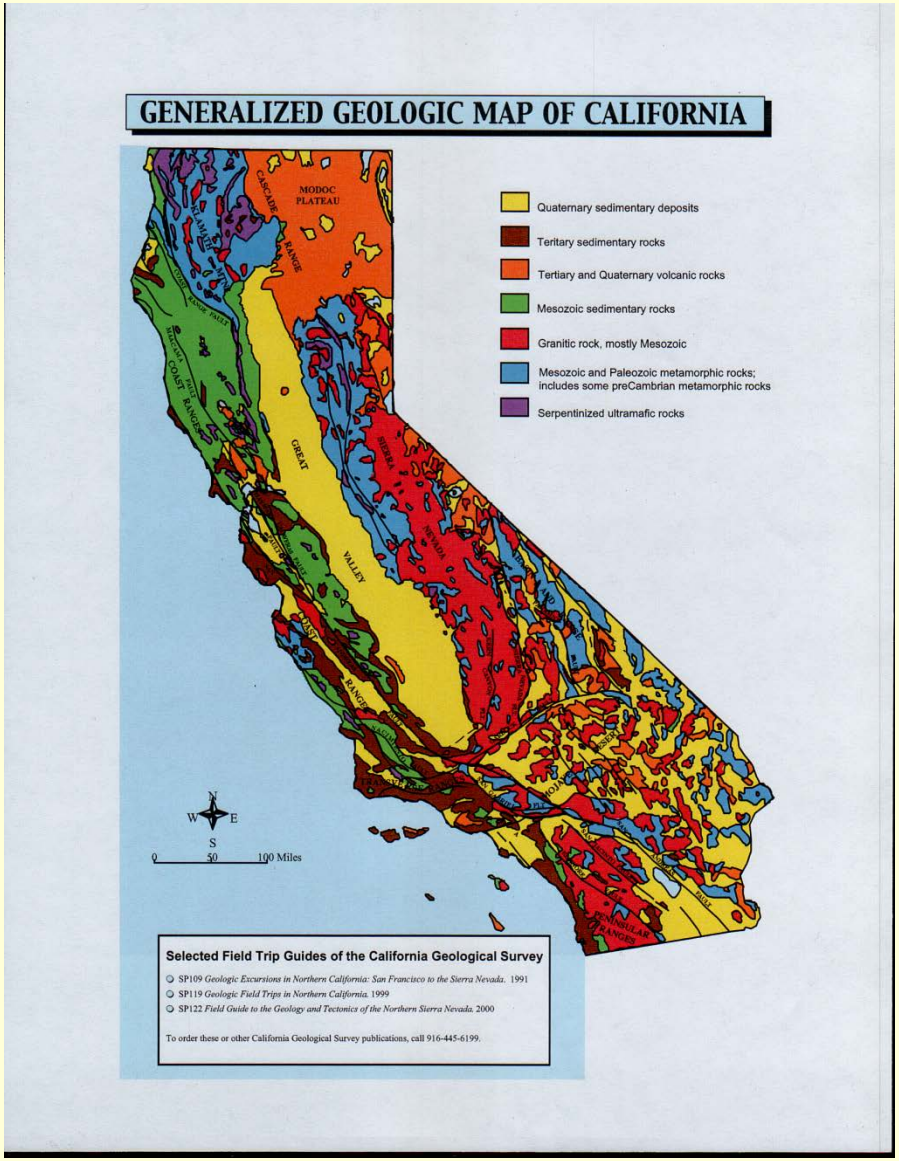
Full of Life!


insects
plant roots
fungi
fungi
microbes
burrowing animals

Where does soil come from?

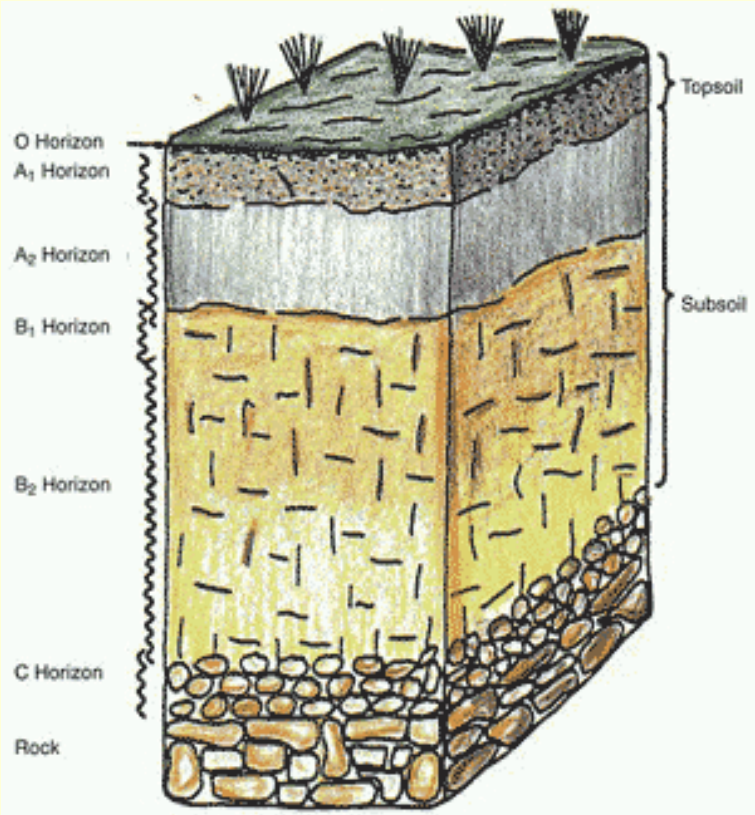
Rocks!

To begin with…



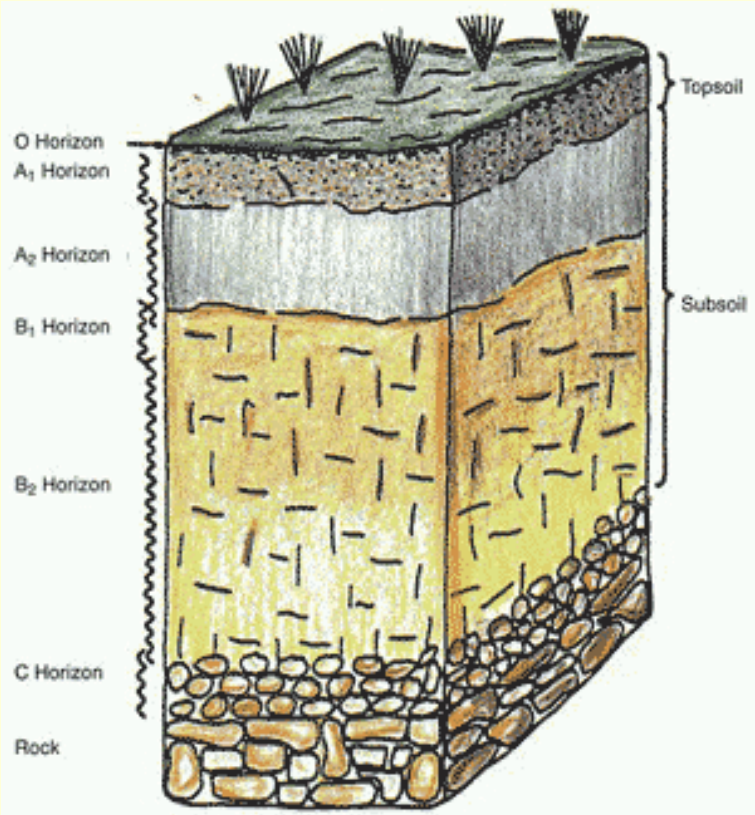
Your Soil…exposed!

Mineral content is a result of dynamic processes involving parent material (rock), biotic activity, topography, time, climate, and more!



Your Soil…exposed!

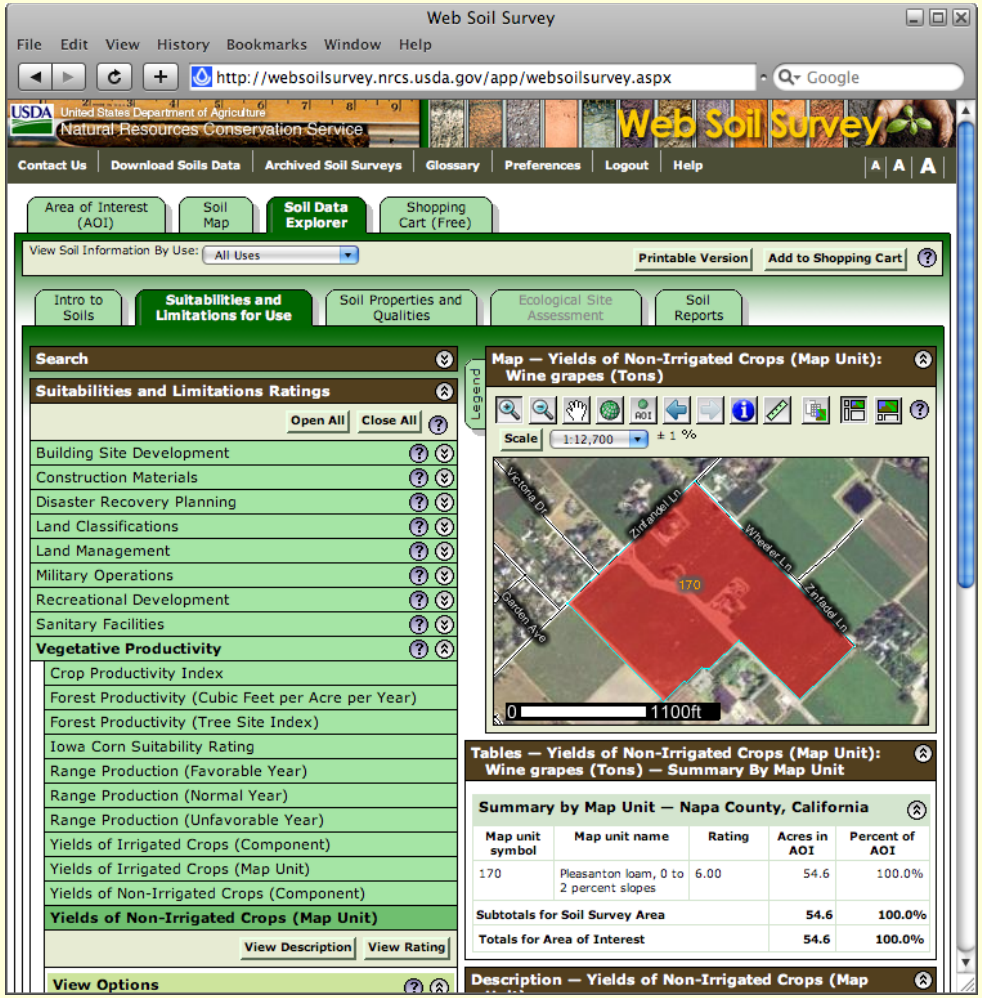
So where do I find out about my soil's parent material???



NRCS Web Soil Survey:
http://websoilsurvey.nrcs.usda.gov

Web soil survey factoids

- Drainage
- Slope
- Topography
- Water features
- Crop Worthiness
- Buildability
- More!!

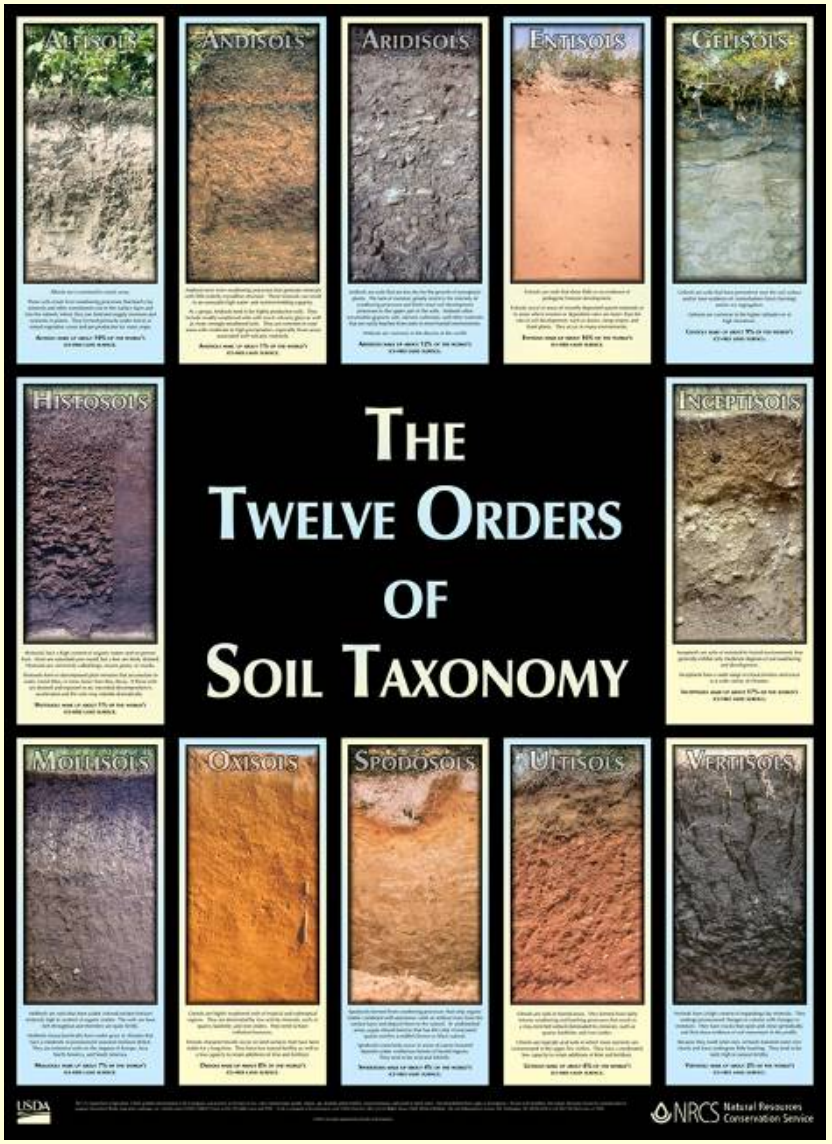


Your Soil…exposed!

Soil Types

Officially Classified by:

1. Depth
2. Color
3. Soil Texture
4. Soil Structure



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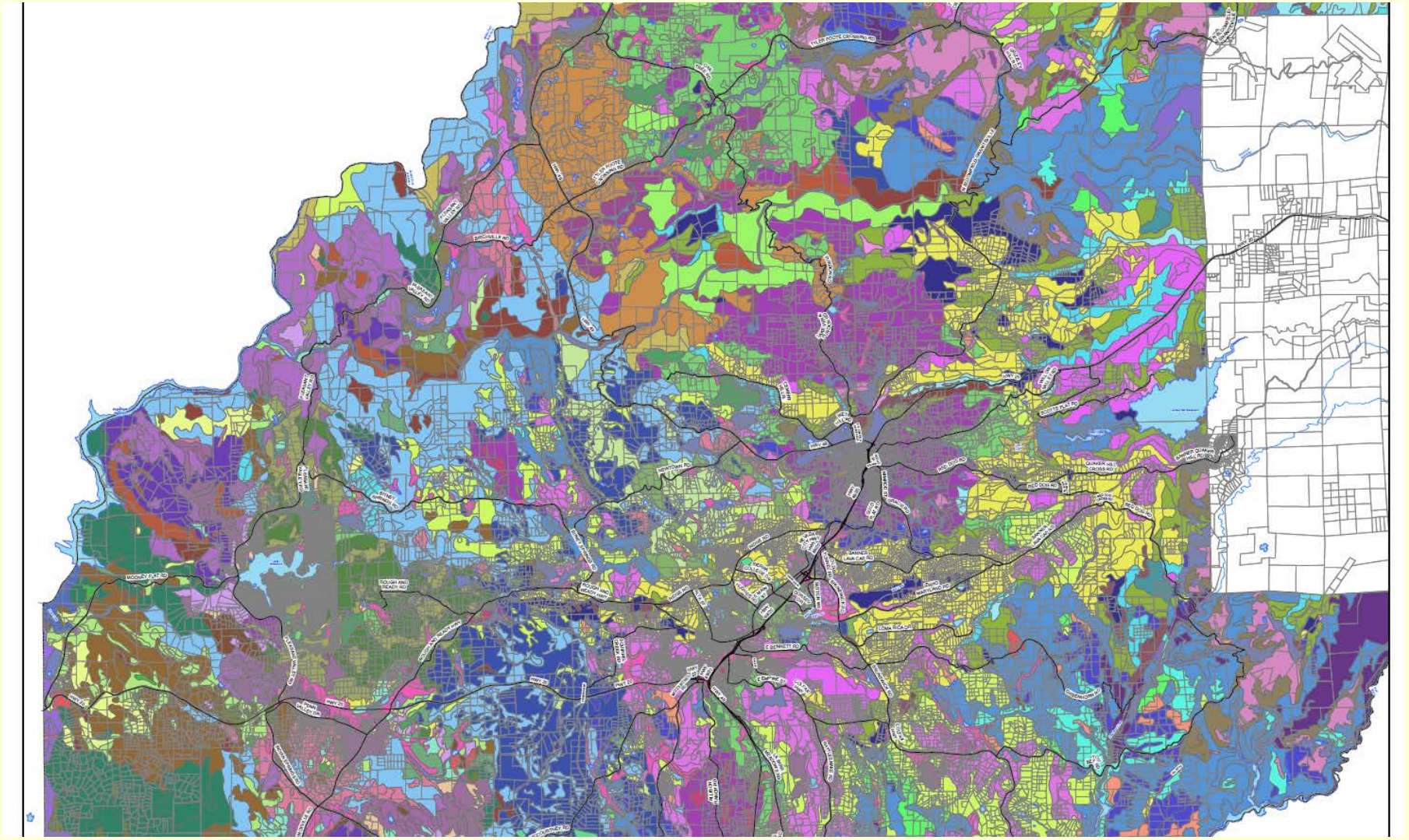
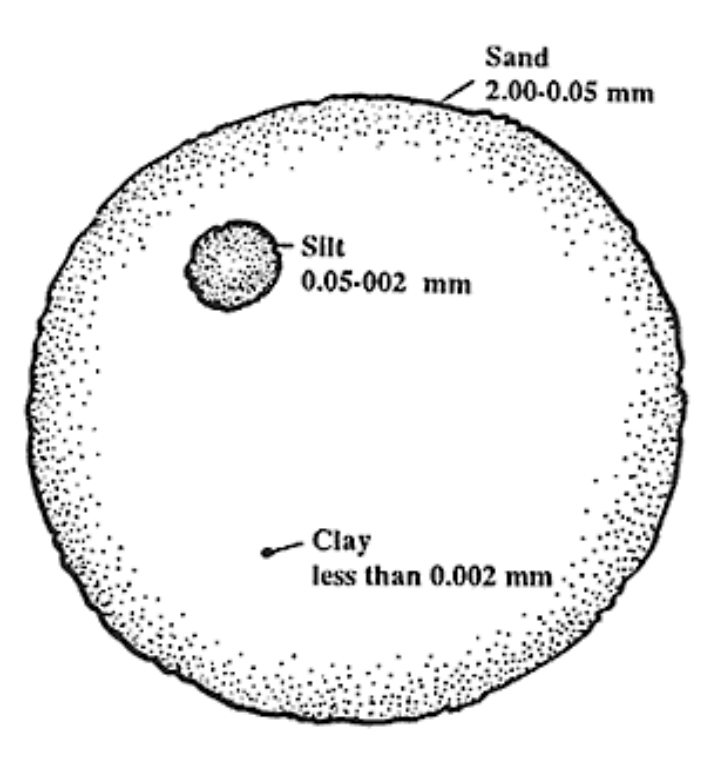


Your Soil…exposed!

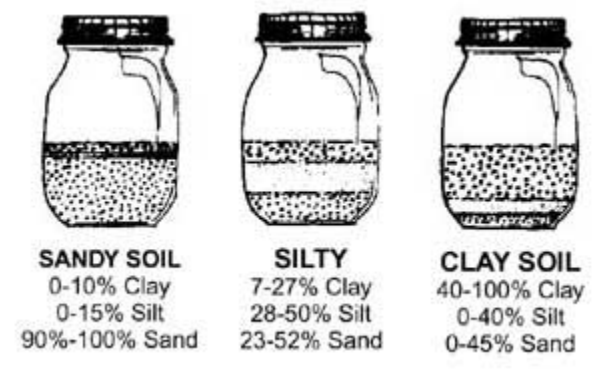
Soil Texture:

Relative proportions of
Sand, Silt and Clay

In general, you are not going to change or alter your SOIL TEXTURE…



What's your soil texture?
1) jar test, 2) soil texture by feel

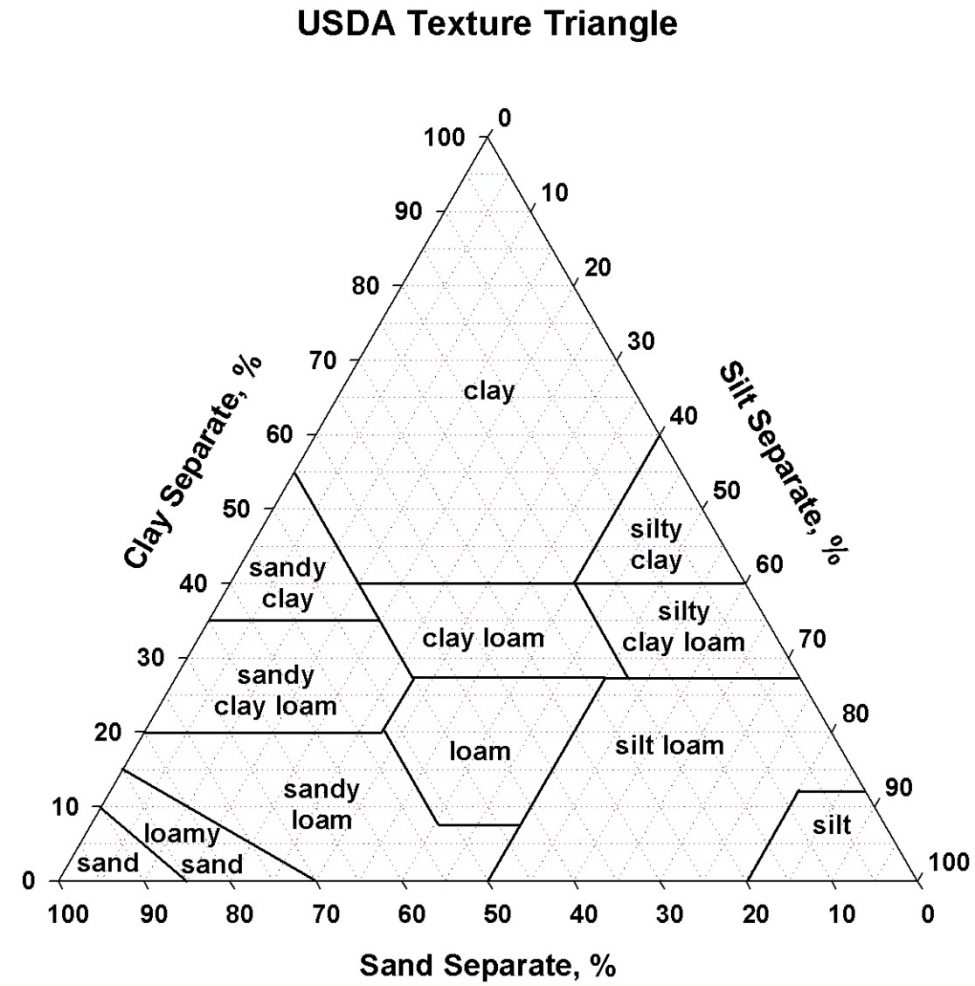


Your Soil…exposed!

Your Soil…exposed!

Soil Texture:

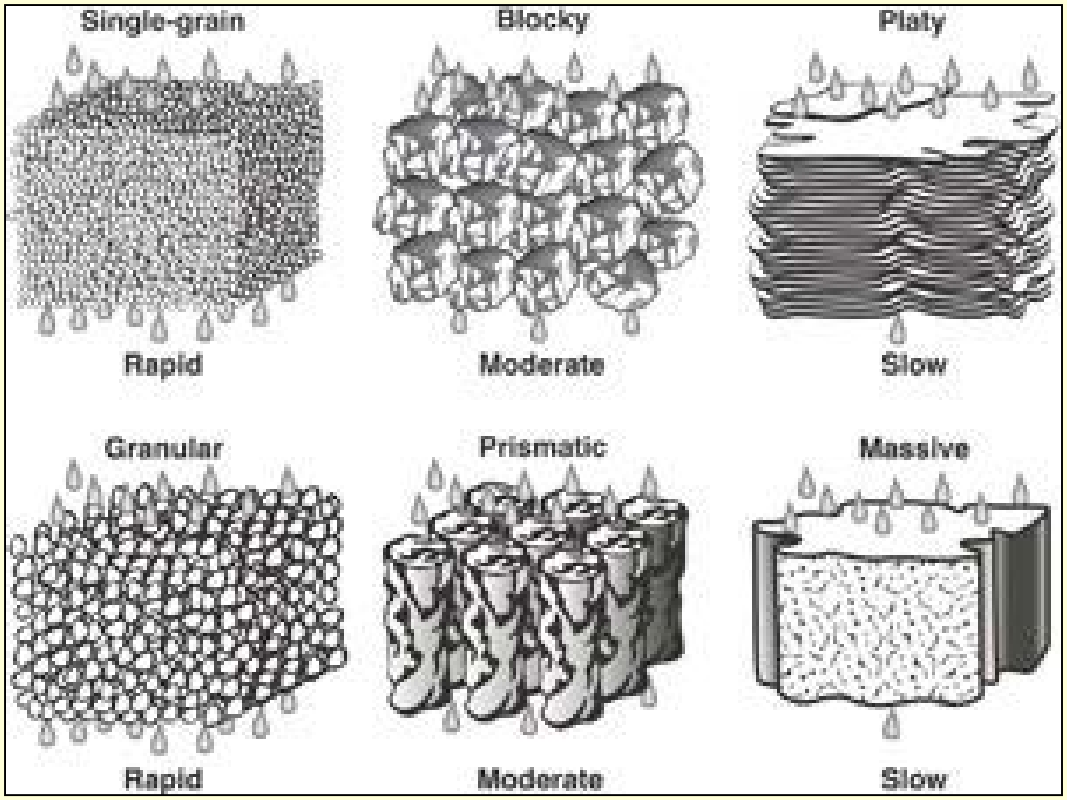
Why is it important to know?



Your Soil…exposed!

Soil Structure:

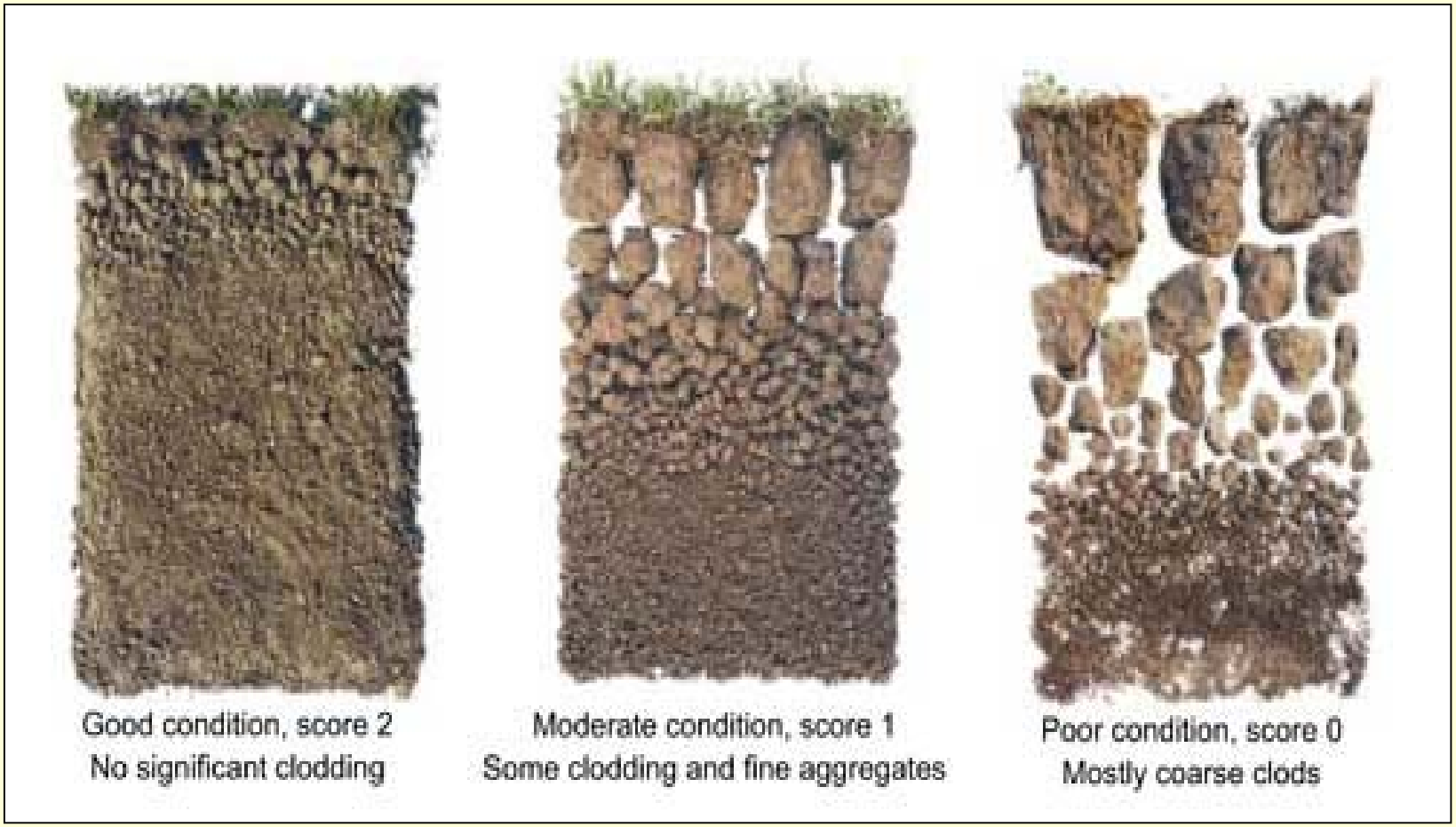
How soil particles are grouped together in **aggregates**



The structure influences air and water movement through soil or "PORE SPACE"…YOU CAN IMPROVE Your Soil Structure!!

Determine Your Soil Structure:

1. Shovel test



Good condition, score 2
No significant clodding

Moderate condition, score 1
Some clodding and fine aggregates

Poor condition, score 0
Mostly coarse clods

Determine Your Soil Structure:

2. Soil Drainage or PERC test

To test drainage, dig a whole about 1 foot deep.
Fill with water and allow it to drain completely.
Immediately refill the pit and measure the depth of the water with a ruler.
15 minutes later, measure the drop in water in inches, and multiply by 4 to calculate how much water drains in an hour.

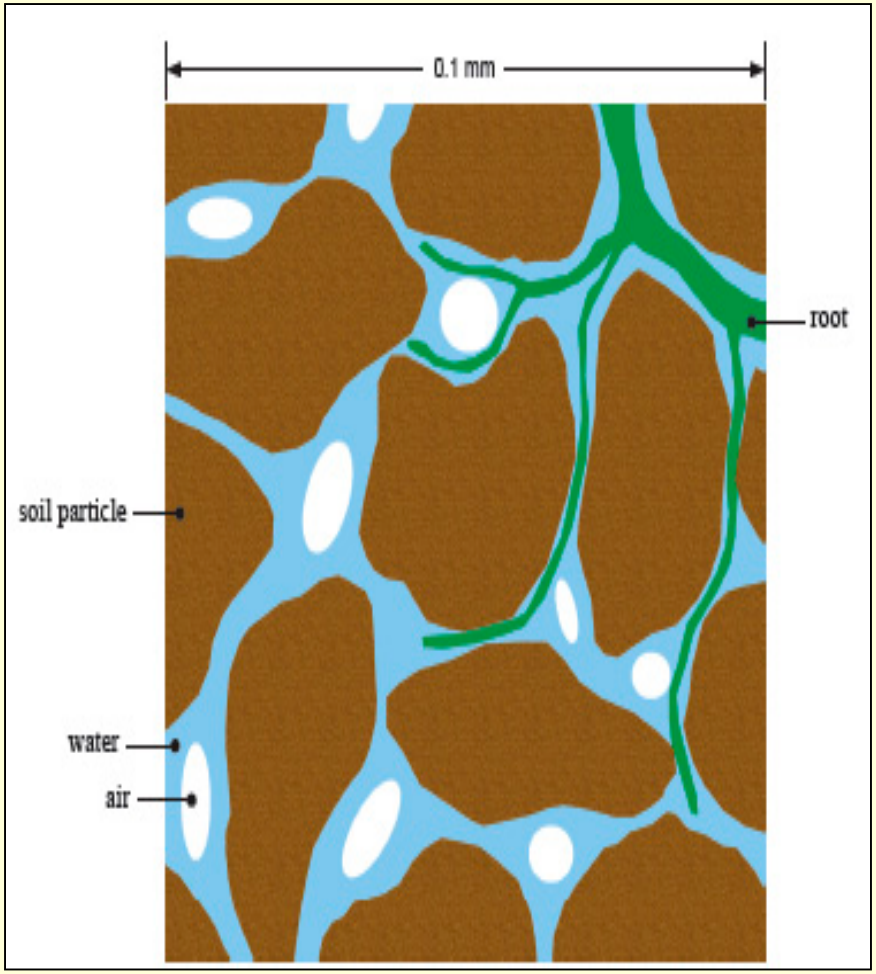
--Less than 1 inch per hour is poor drainage, indicating the site may stay wet for periods during the year. Plants that don't tolerate poor drainage will suffer.

--1 to 6 inches of drainage per hour is desirable.

--Soils that drain faster than 6 inches per hour have excessive drainage, and you should consider choosing plants that tolerate dry conditions and "drought" soils.

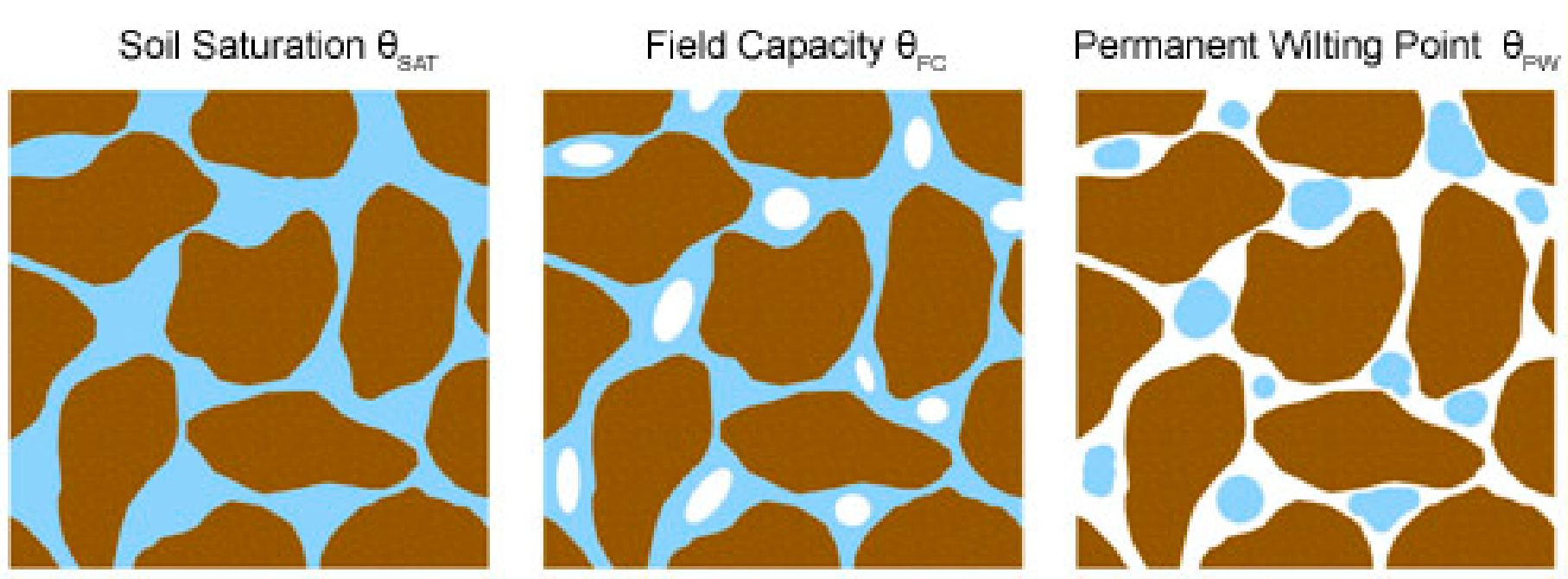
Your Soil Structure:

- Good Soil Structure = holds water and air, good pore space ☺
- Bad Soil Structure = holds less water, lacks air, poor pore space ☹



Your Soil Structure:

- The Soil Solution – nutrient availability



Your Soil Structure:

How can you improve it?

- Avoid compaction of planted areas – reduced tillage, permanent paths, mulch
- Add organic matter to the soil – compost!!
- Grow cover crops!
- Proper watering and fertilization
- Build and Nurture Soil Food Web

Soil Texture by Feel Exercise

STEP 2:

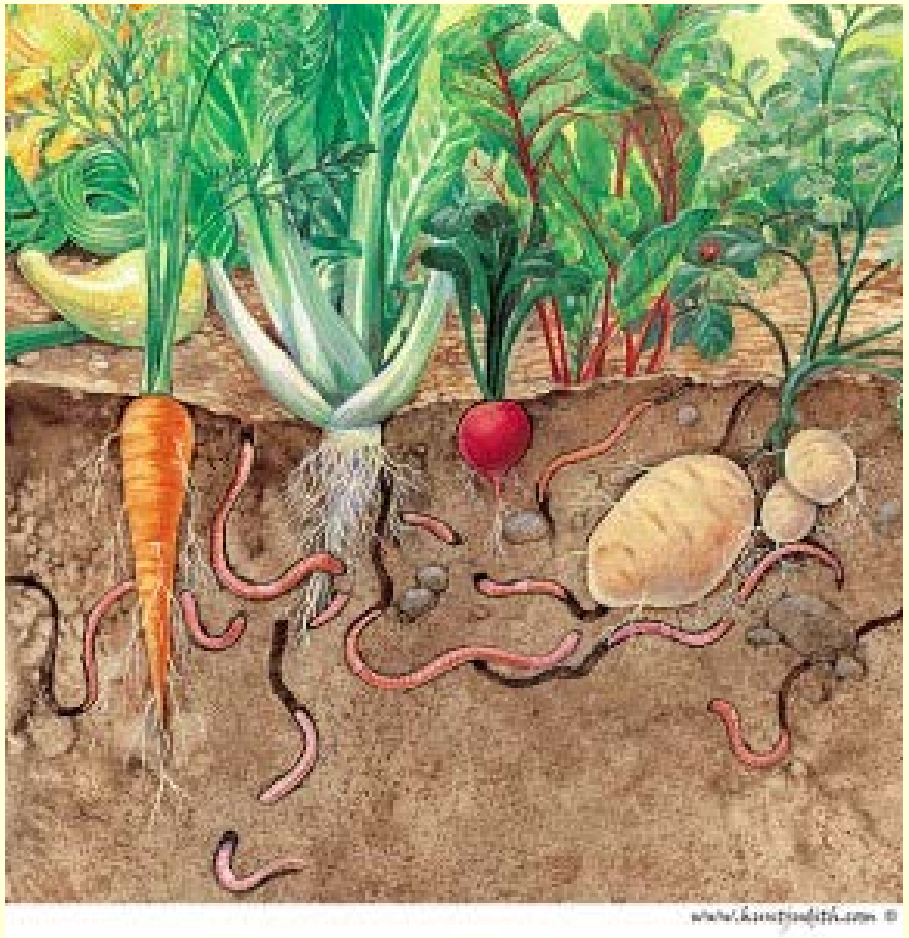
SOIL FERTILITY

Understanding Your Soil

Soil Fertility:

Clay particles AND
organic matter
hold onto
nutrients and water
in the soil.

Let's start with clay…

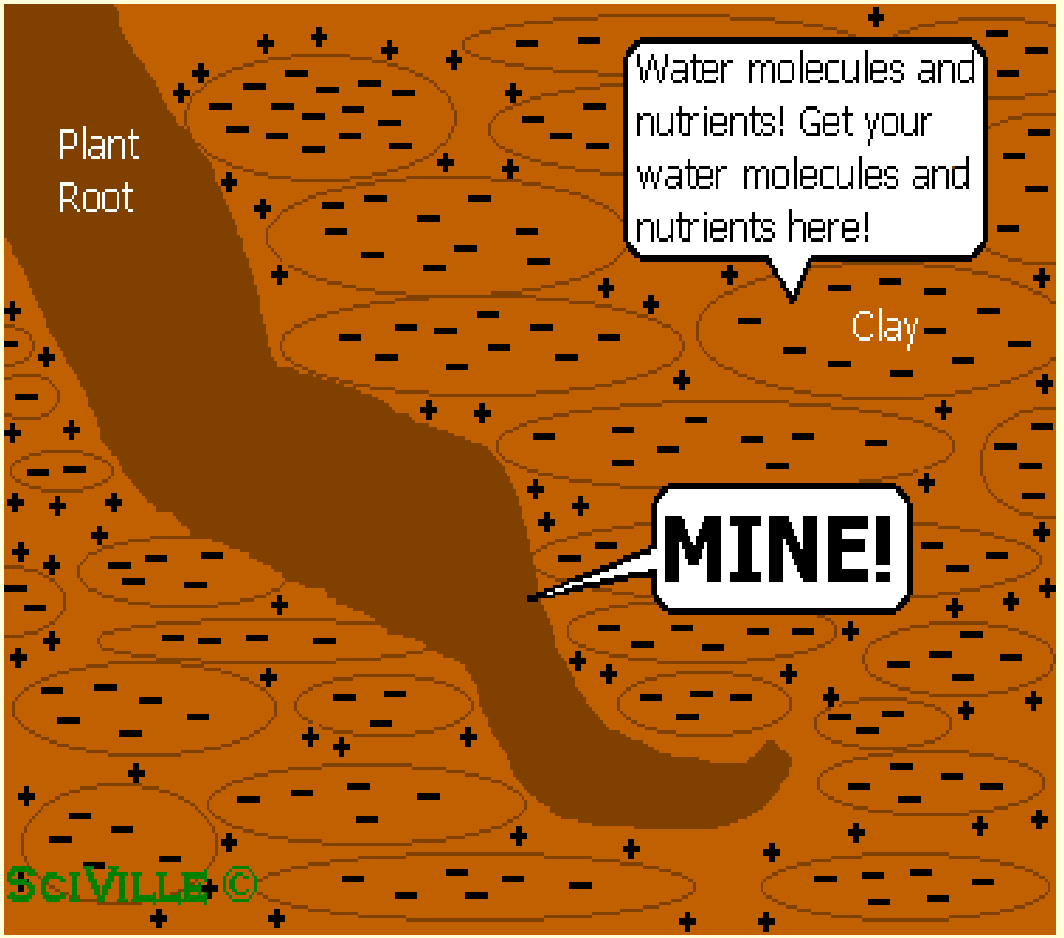


Understanding Your Soil

Soil Fertility:

Clay particles are sooo important!!

- Small particles with a lot of surface area
- Clay particles are negatively charged
- Attracts/holds water molecules
- Repels negative charges

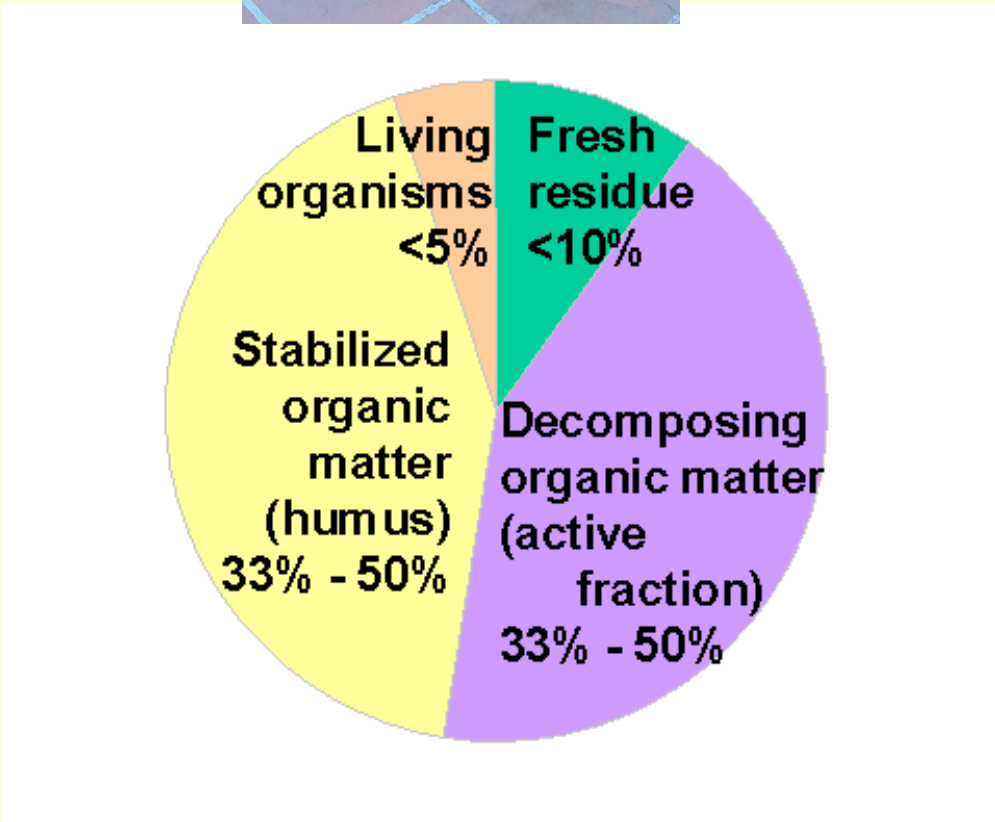


Understanding Your Soil

Soil Fertility:

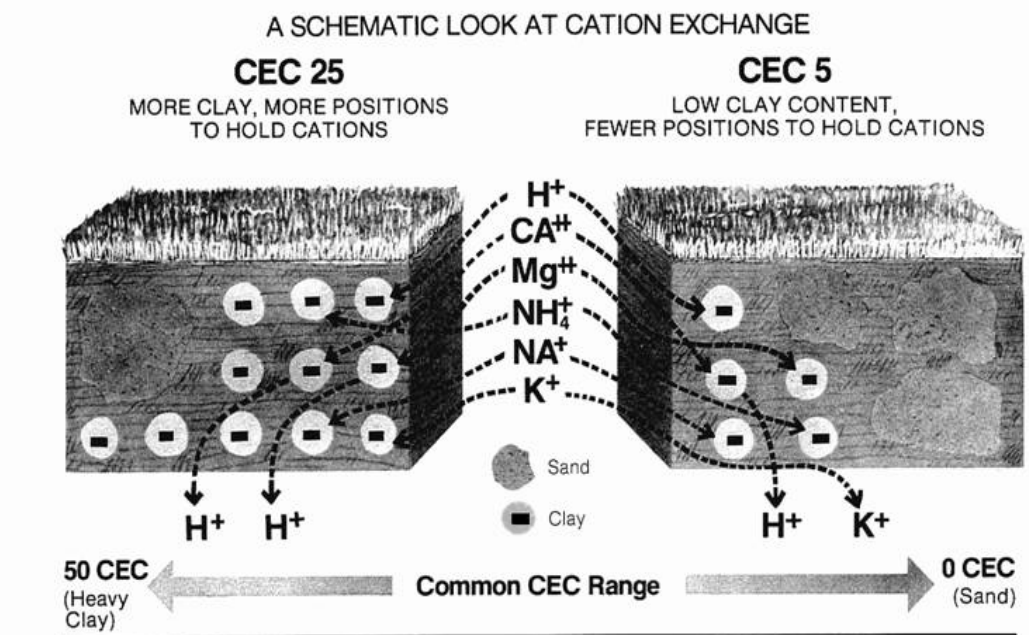
Organic Matter breaks down into **stable humus**, which holds water and nutrients just like clay particles.

It also acts as “glue” and helps particles aggregate and is food for soil organisms (humic and fulvic acids).



Understanding Your Soil

The amount of CATIONS that can be held by soil (*clay and humus*) is the **CATION EXCHANGE CAPACITY (CEC).**

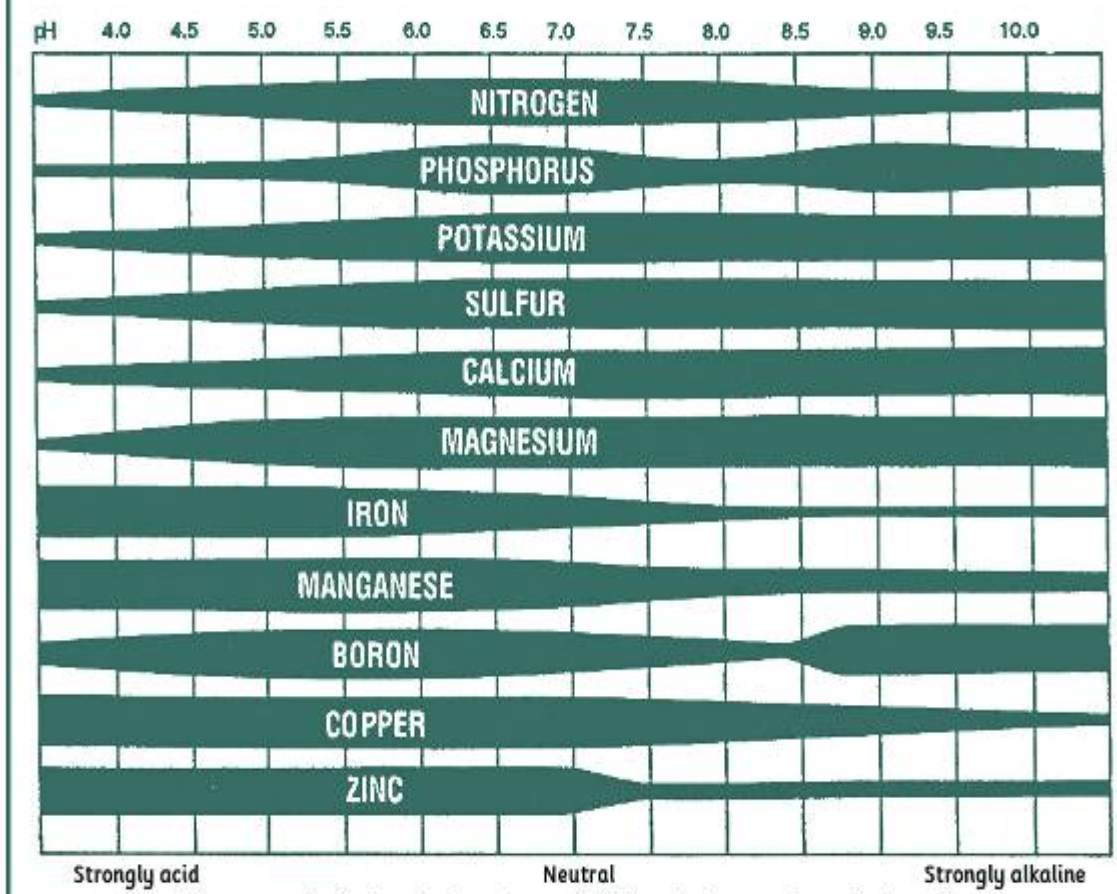


SOME PRACTICAL APPLICATIONS	
Soils with CEC 11-50 Range	Soils with CEC 1-10 Range
• High clay content • More lime required to correct a given pH • Greater capacity to hold nutrients in a given soil depth • Physical ramifications of a soil with a high clay content • High water-holding capacity	• High sand content • Nitrogen and potassium leaching more likely • Less lime required to correct a given pH • Physical ramifications of a soil with a high sand content • Low water-holding capacity

Understanding Your Soil

And what about pH?

Table 2. Effects of soil acidity/alkalinity on plant nutrient availability



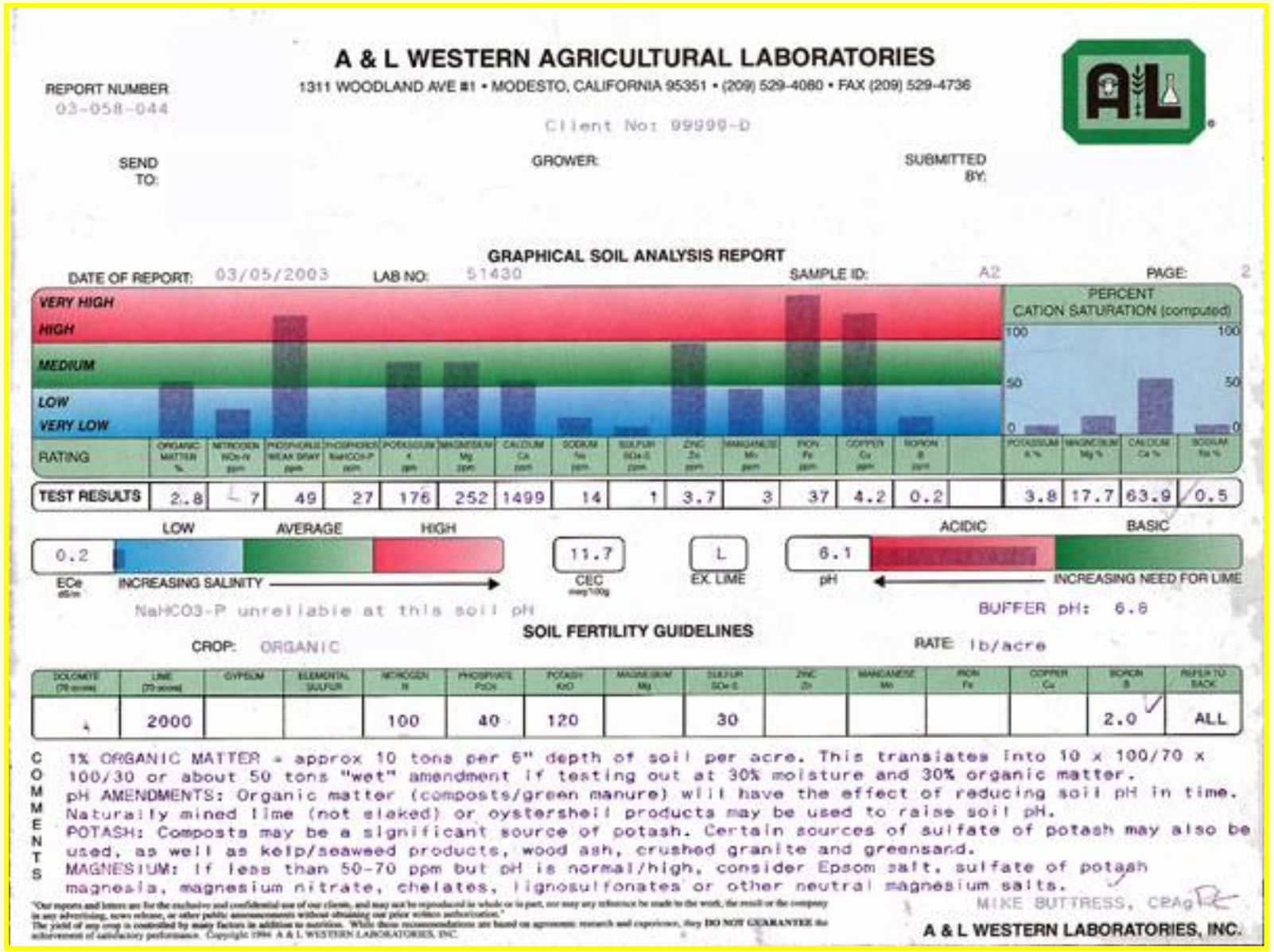
The general relation of pH to the availability of plant nutrients in the soil: the thicker the bar, the more available the nutrient.

Understanding Your Soil

- So, how do you figure out your CEC?

- How do you know what nutrients are in the soil to begin with?

Soil Analysis



A & L WESTERN AGRICULTURAL LABORATORIES

1311 WOODLAND AVE #1 • MODESTO, CALIFORNIA 95351 • (209) 529-4080 • FAX (209) 529-4736

REPORT NUMBER 03-058-044

Client No: 99999-D

SEND TO:

GROWER:

SUBMITTED BY:

GRAPHICAL SOIL ANALYSIS REPORT

DATE OF REPORT: 03/05/2003 LAB NO: 51430 SAMPLE ID: A2 PAGE: 2

VERY HIGH
HIGH
MEDIUM
LOW
VERY LOW

PERCENT CATION SATURATION (computed)

100 50 0

RATING	ORGANIC MATTER %	NITROGEN NO3-N ppm	PHOSPHORUS (BRAY) ppm	PHOSPHORUS NaHCO3-P ppm	POTASSIUM K ppm	MAGNESIUM Mg ppm	CALCIUM Ca ppm	SODIUM Na ppm	SULFUR SO4-S ppm	ZINC Zn ppm	MANGANESE Mn ppm	IRON Fe ppm	COPPER Cu ppm	BORON B ppm		POTASSIUM K %	MAGNESIUM Mg %	CALCIUM Ca %	SODIUM Na %
TEST RESULTS	2.8	L 7	49	27	176	252	1499	14	1	3.7	3	37	4.2	0.2		3.8	17.7	63.9	0.5

LOW AVERAGE HIGH

0.2 ECe dS/m — INCREASING SALINITY

11.7 CEC meq/100g

L EX. LIME

6.1 pH — ACIDIC / BASIC — INCREASING NEED FOR LIME

NaHCO3-P unreliable at this soil pH

BUFFER pH: 6.6

SOIL FERTILITY GUIDELINES

CROP: ORGANIC

RATE: lb/acre

DOLOMITE (70 score)	LIME (70 score)	GYPSUM	ELEMENTAL SULFUR	NITROGEN N	PHOSPHATE P2O5	POTASH K2O	MAGNESIUM Mg	SULFUR SO4-S	ZINC Zn	MANGANESE Mn	IRON Fe	COPPER Cu	BORON B	REFER TO BACK
4	2000			100	40	120		30					2.0	ALL

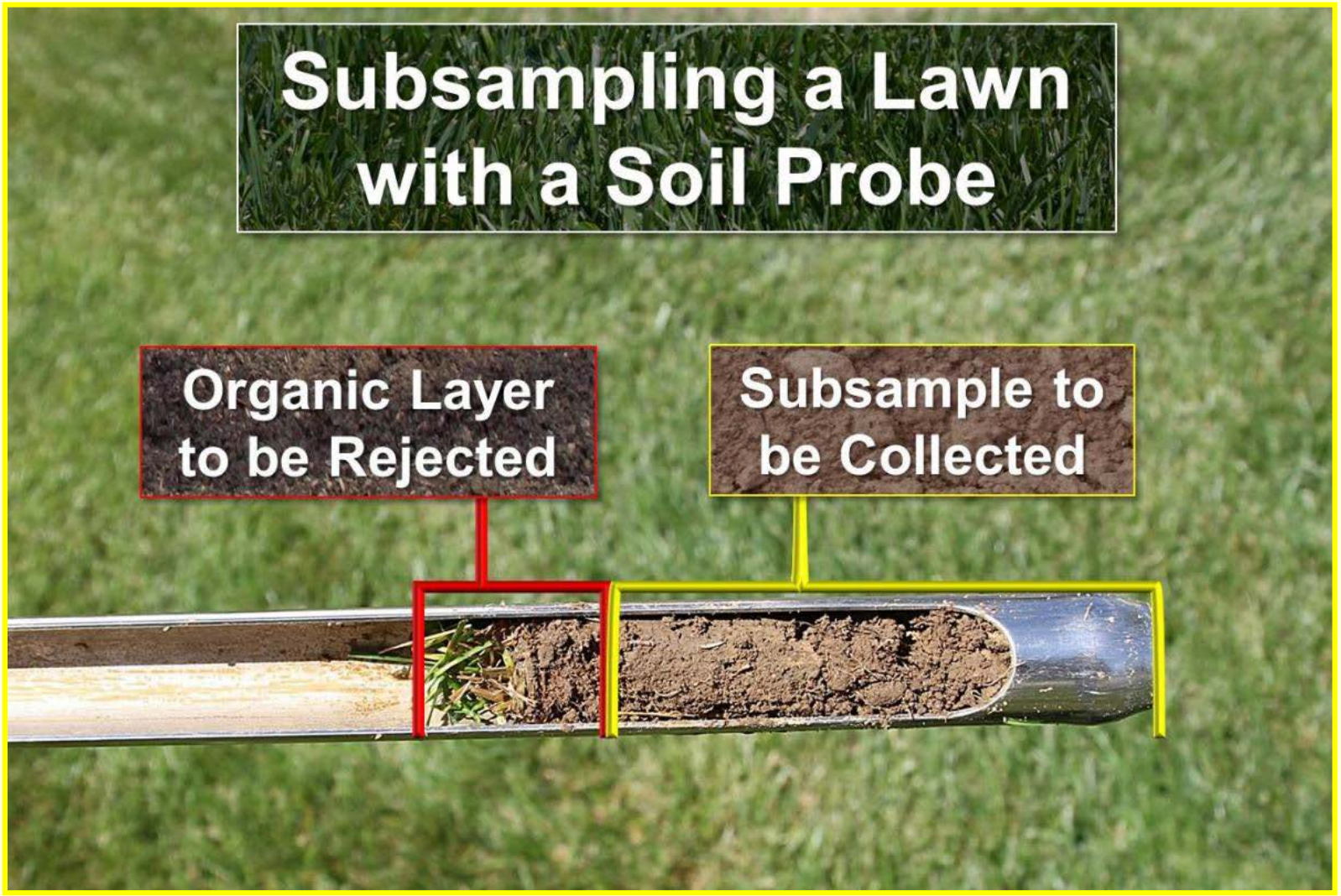
COMMENTS

1% ORGANIC MATTER = approx 10 tons per 6" depth of soil per acre. This transiates into 10 x 100/70 x 100/30 or about 50 tons "wet" amendment if testing out at 30% moisture and 30% organic matter.
pH AMENDMENTS: Organic matter (composts/green manure) will have the effect of reducing soil pH in time. Naturally mined lime (not slaked) or oystershell products may be used to raise soil pH.
POTASH: Composts may be a significant source of potash. Certain sources of sulfate of potash may also be used, as well as kelp/seaweed products, wood ash, crushed granite and greensand.
MAGNESIUM: If less than 50-70 ppm but pH is normal/high, consider Epsom salt, sulfate of potash magnesia, magnesium nitrate, chelates, lignosulfonates or other neutral magnesium salts.

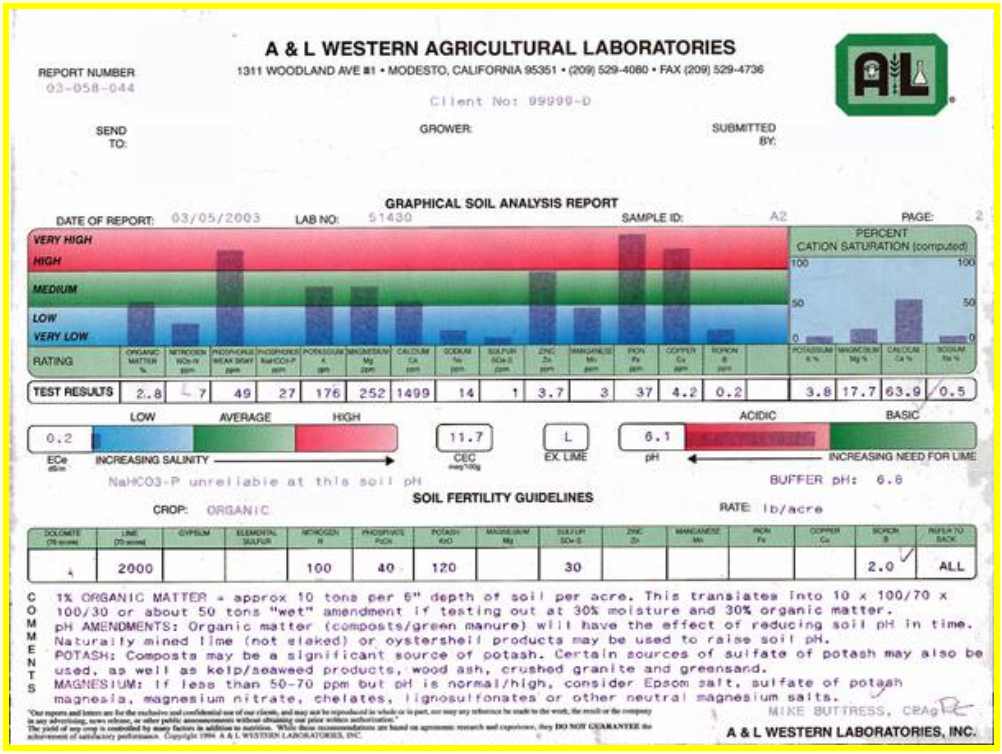
MIKE BUTTRESS, CEAg

A & L WESTERN LABORATORIES, INC.

Soil Analysis



Adding Amendments



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NaHCO3-P unreliable at this soil pH

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6.1 pH ACIDIC BASIC INCREASING NEED FOR LIME

BUFFER pH: 6.6

SOIL FERTILITY GUIDELINES

CROP: ORGANIC RATE: lb/acre

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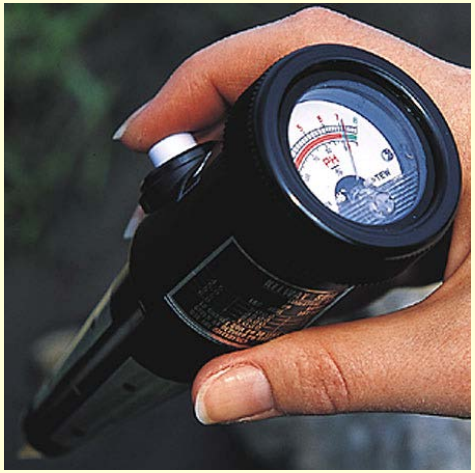
MIKE BUTTRESS, CRAg

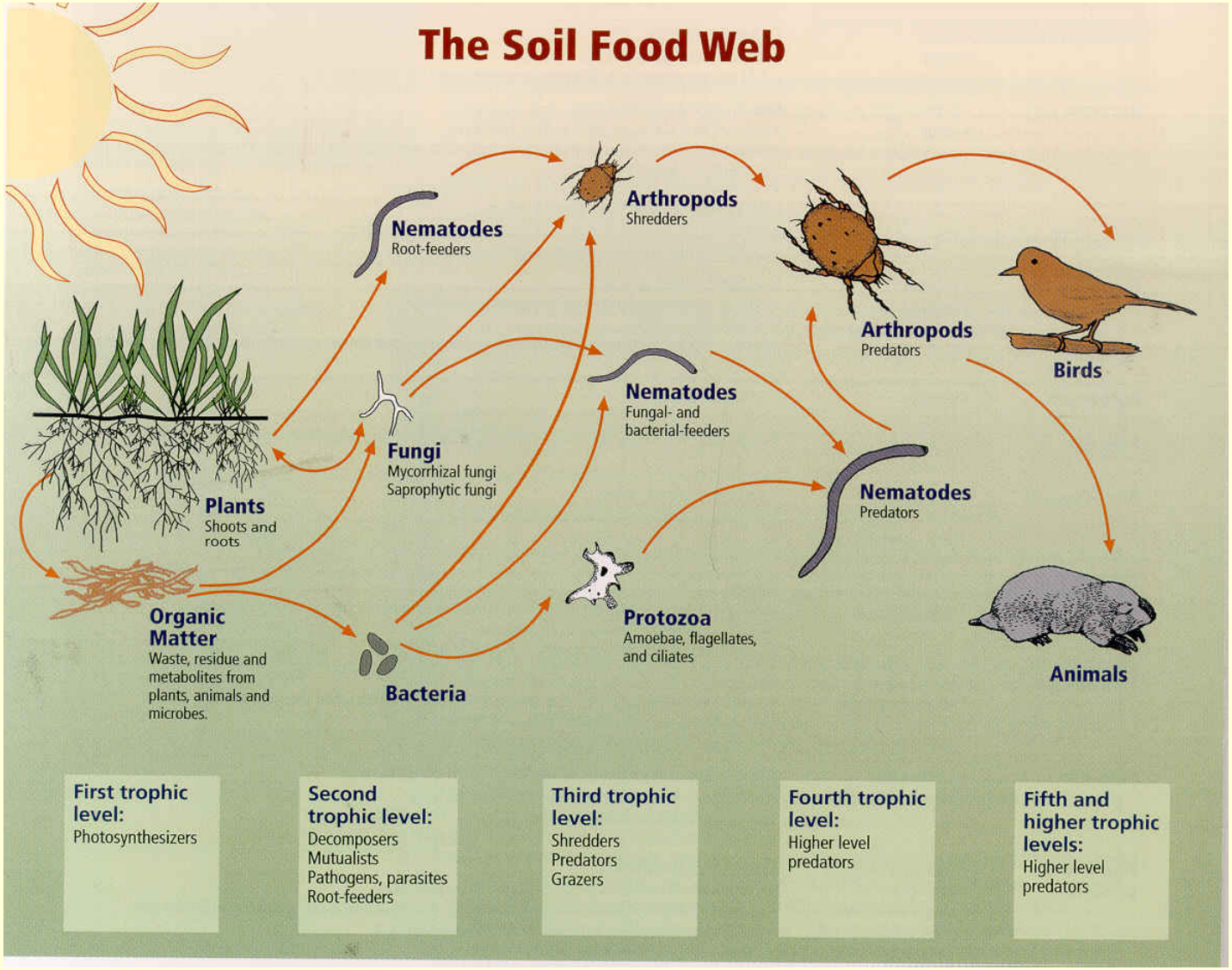
A & L WESTERN LABORATORIES, INC.

Soil analysis results will help determine what amendments you add.

Good guideline but not 100% accurate as far as PLANT AVAILABLE nutrients.

Ongoing soil monitoring





Soil is the most species-rich microbial ecosystem in the world!!!

Beneficial microbial functions in soil

Importance of below-ground biology

plant-soil-microbe interactions

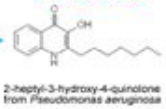
N_2 nitrogen fixation

NO_3^- ← NH_4 nutrient cycling (N & P) & carbon dynamics

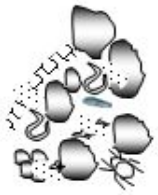
PO_4^{2-} ← organic matter

plant-growth promoting rhizobacteria phytostimulation

root exudates



2-heptyl-3-hydroxy-4-quinolone from *Pseudomonas aeruginosa*



suppression of root pathogens

aggregation and structure

symbionts & endophytes

nutrient (P) mobilization

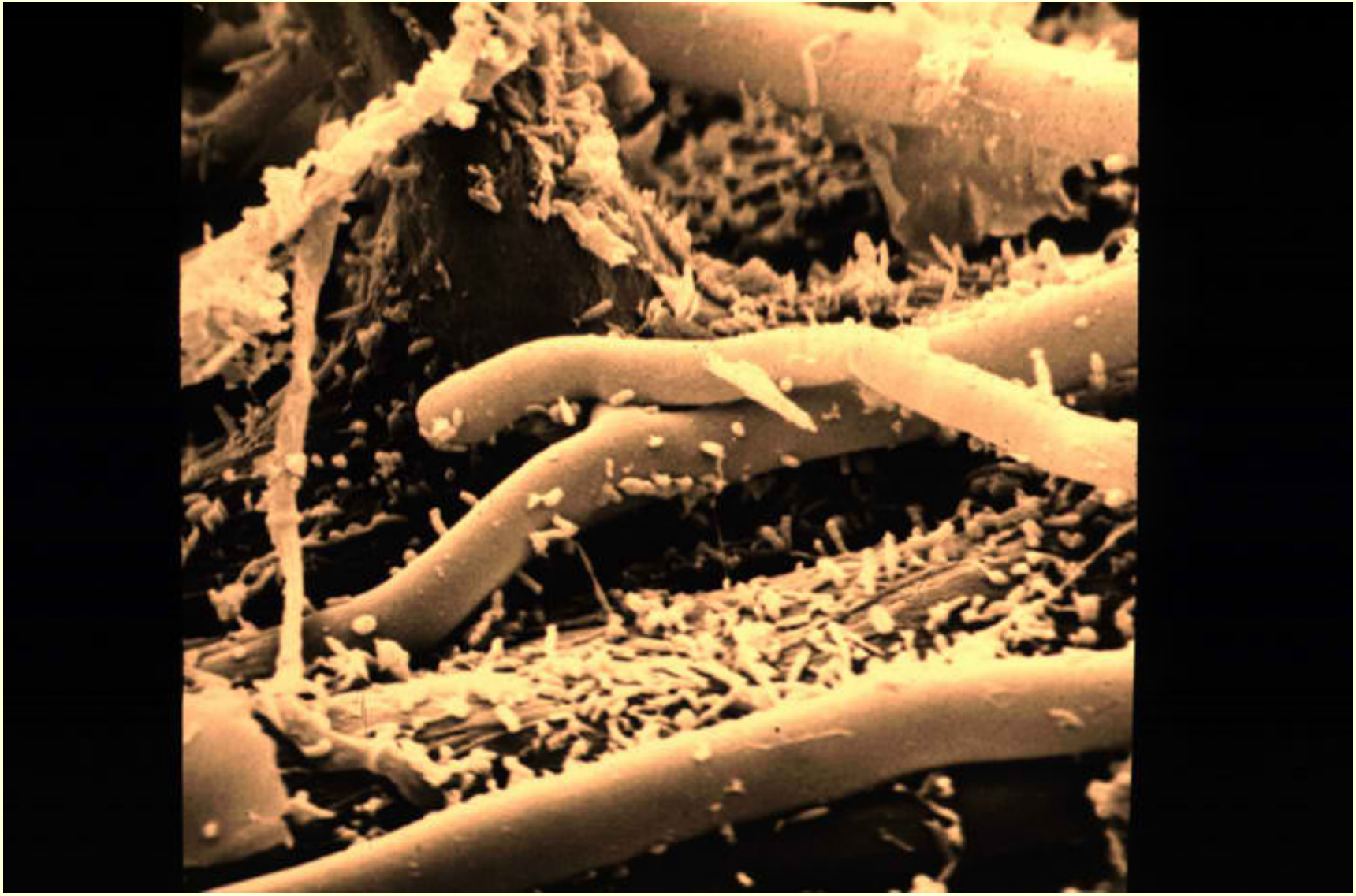
mycorrhizal root-soil interaction

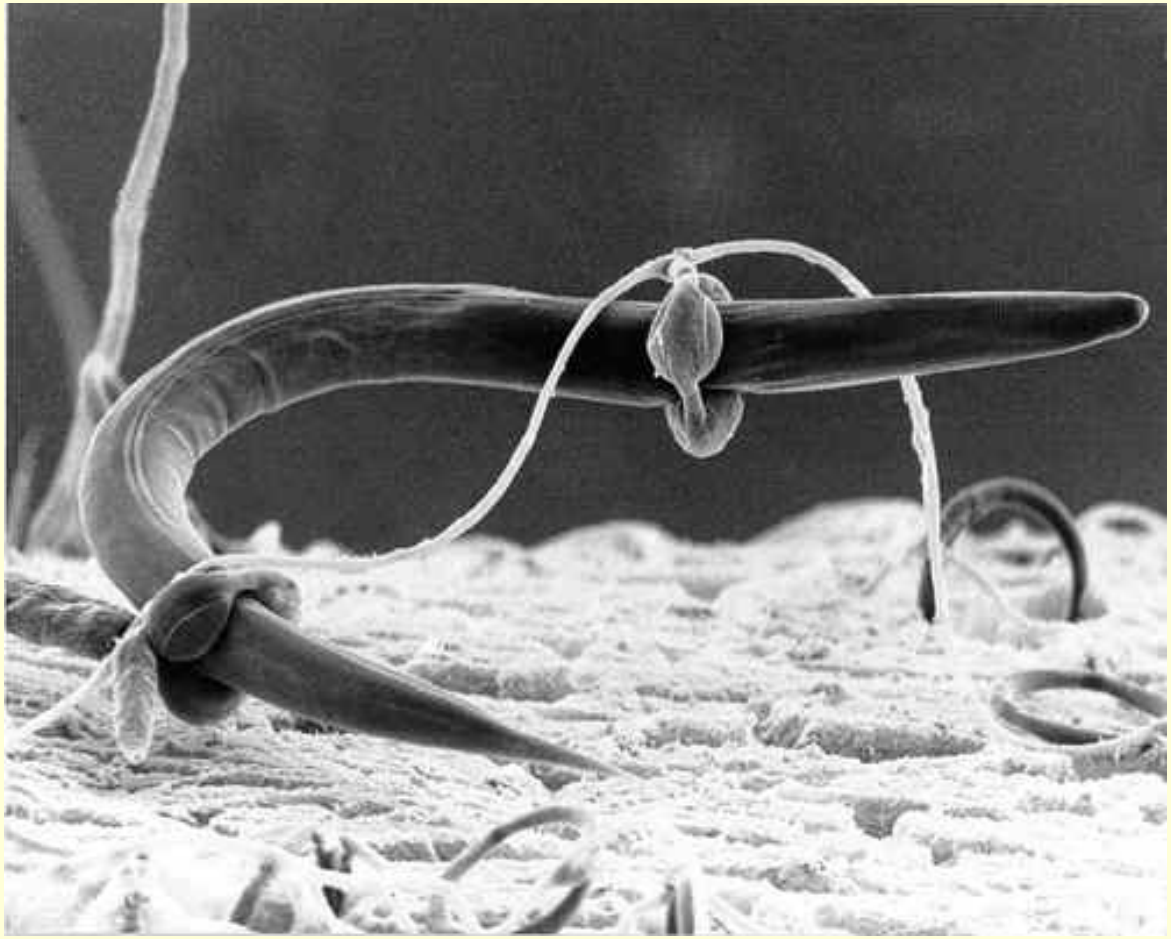
CSIRO Agriculture – Richardson / Vadakattu

Soil Organism populations in healthy soils

	Ag Land	Prairie	Forest
	Organisms per gram (teaspoon) of soil		
Bacteria	**100 mil. -1 bil.**	**100 mil. -1 bil.**	**100 mil. -1 bil.**
Fungi	**Several yards**	**10s – 100's of yds**	**1-40 miles (in conifers)**
Protozoa	**1000's**	**1000's**	**100,000's**
Nematodes	**10-20**	**10's – 100's**	**100's**
	Organisms per square foot		
Arthropods	**< 100**	**500-2000**	**10,000-25,000**
Earthworms	**5-30**	**10-50**	**10-50 (0 in conifers)**

Bacteria and fungal hyphae (USDA)





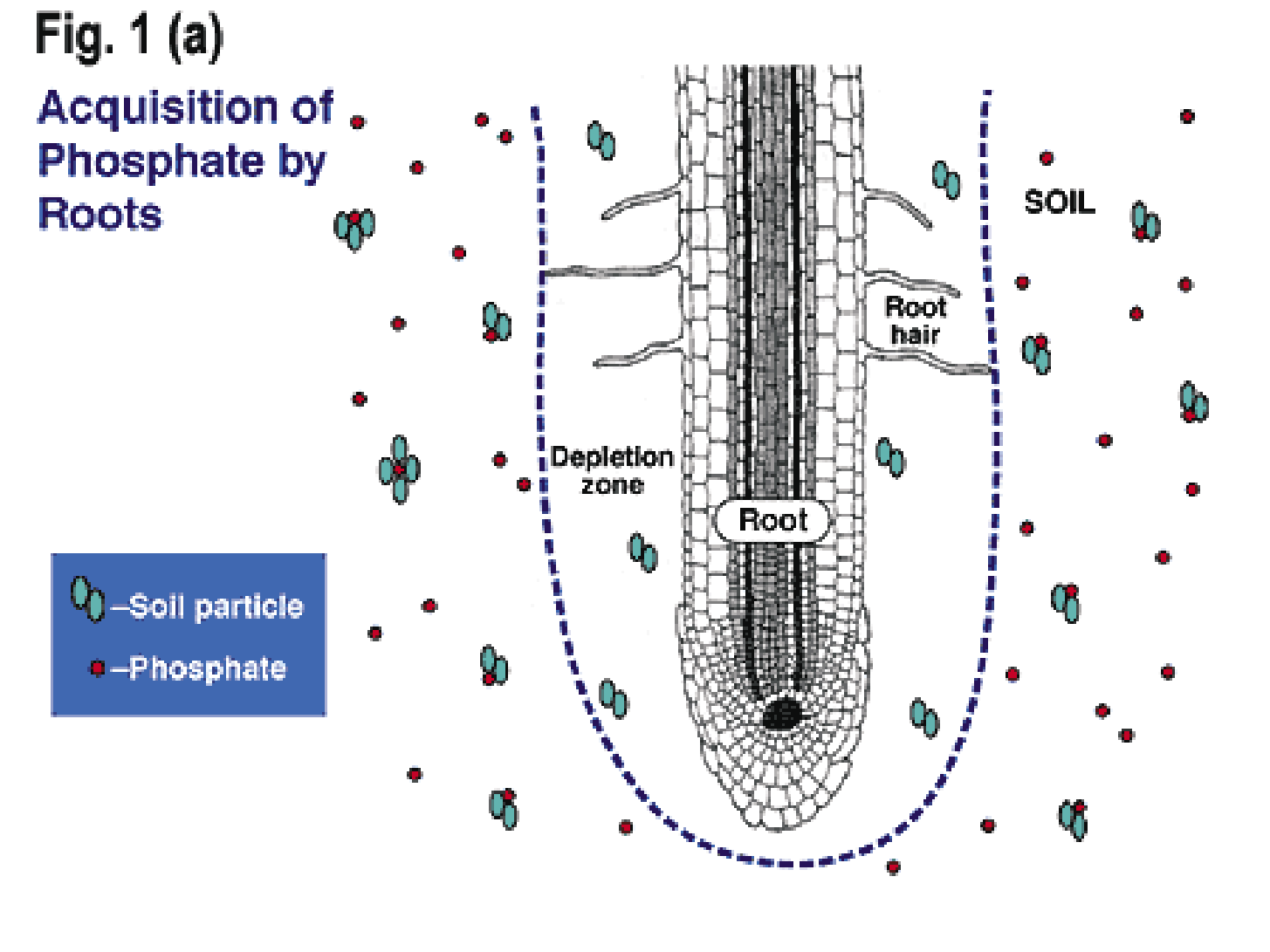
Nematode captured by the constricting rings of the predatory fungus *Arthrobotrys anchonia*.

Ciliates – a type of Protozoa in soil – sometimes called “soil salmon” – have an BIG appetite for soil bacteria

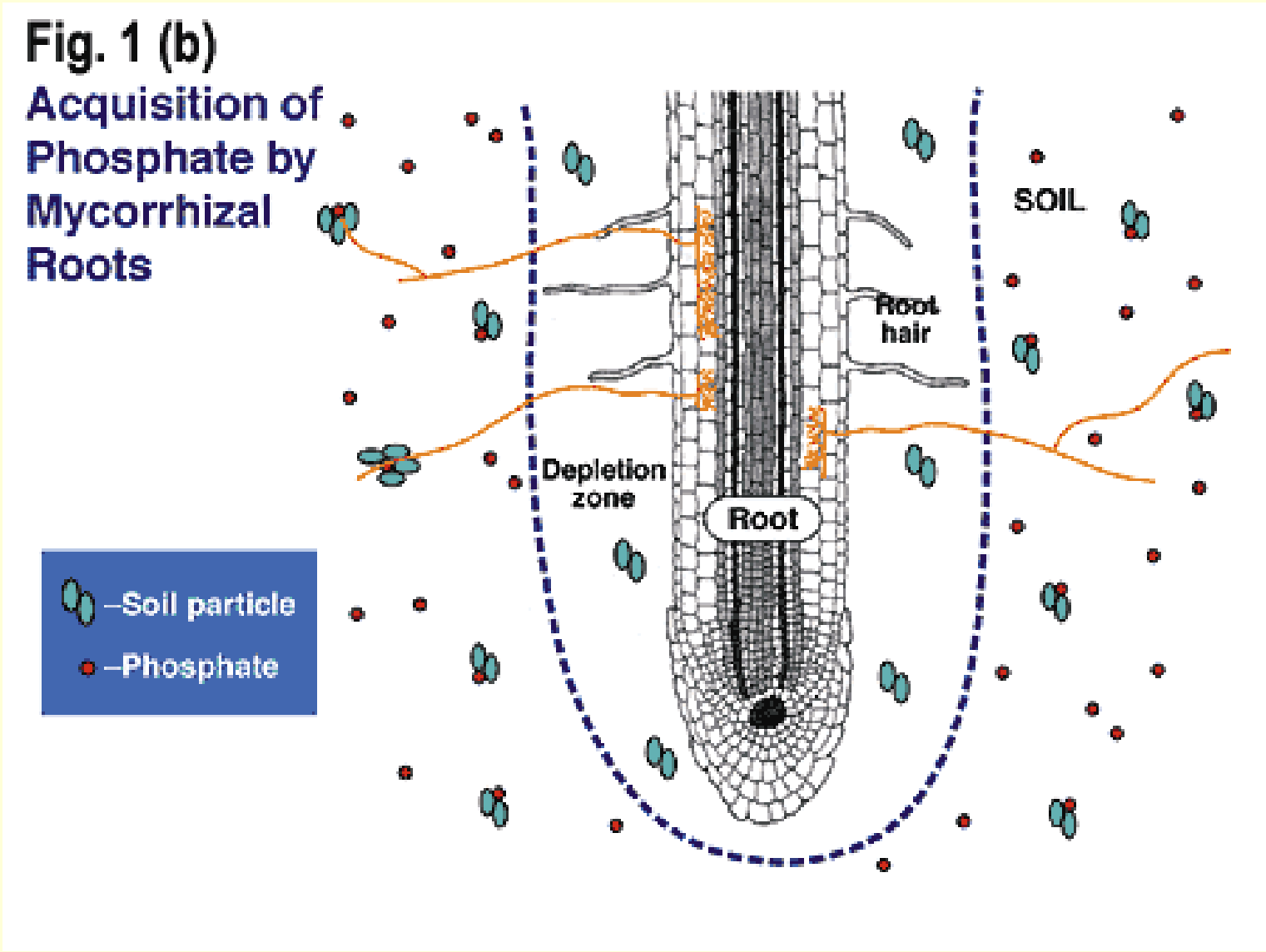
Soil Organisms – What do they do??

- Decomposition of organic matter
- Cycling of minerals and nutrients
- **Reservoirs of nutrients – “fertilizer bags”**
- Redistribution of minerals and nutrients
- Sequestration of carbon
- Degradation of pollutants, pesticides
- Modification of soil structure
- Biological regulation of pest species

Soil Organisms – Mycorrhizal Fungi



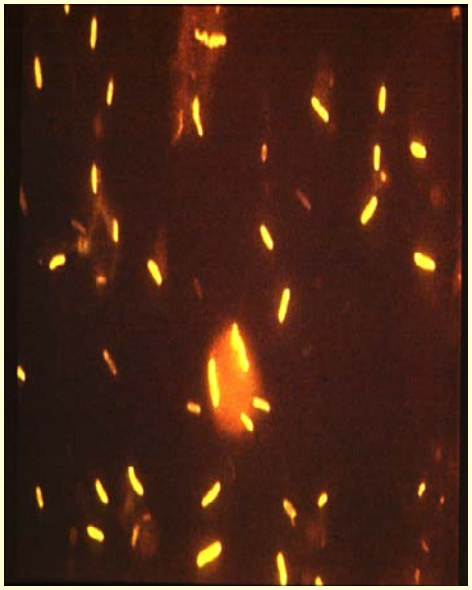
Soil Organisms – Mycorrhizal Fungi



Soil Organisms – Nitrogen-Fixing Bacteria

Bacteria are the only organisms capable of taking gaseous nitrogen and combining it with hydrogen to make ammonia.

Soil Microbes – lab analyses



Counting

- Direct counts of individuals
- Plate counts of colonies

Activity levels

- Respiration (CO_2 production)
- Nitrification rates
- Decomposition rates

Cellular constituents

- Biomass C, N, or P
- Enzymes
- Phospholipids
- DNA and RNA

Threats to HEALTHY SOIL

- Soil Erosion
- Excessive Tillage
- Synthetic Fertilizer
- Overwatering
- Soil Compaction
- BARE SOIL

Simple Way to Improve Soil: Compost and Mulch!!!

Mulch vs. Compost

- Mulch = Organic or inorganic material spread on the soil surface

- Compost = Rotted organic matter made from plant material and/or manure
  - Usually incorporated into the soil

Mulching with Wood Chips

Potential Benefits of Mulch

- Reduces weeds & erosion
- Insulates roots from temp. extremes
- Conserves soil moisture → ↑ root growth
- Increases microbial activity
- Increases water penetration
- Improves plant establishment
- Improves Soil Structure over time

Potential Problems with Mulch

- May prolong saturation in heavy soils
  - Favors root and crown rot
- May host plant diseases, insects, and nuisance fungi
- Some wood chips poor quality
- Can’t see soil moisture
- Time consuming to spread

Mulch Basics
(Wood Chips)

- Softwood mulches (pine, cypress, etc.) last longest – less microbial feeding
- Keep mulch 6-12 in. away from the base of trees & shrubs when soil wet, poorly drained
- Application rate: Generally 2-4 in. deep
  - Fine = <2 in. Coarse = 4-6 in.
- Keep mulch on top of soil to prevent N tie-up

Mulch Basics

Other Types of Mulches

- Straw
- Pine needles
- Oak leaves
- Plastic
- Gravel

Working with Foothill Soils

What did you learn about our local soils??????