University of Idaho
Extension

SOILS & FERTILIZERS

IDAHO MASTER GARDENER TRAINING

“We will try this winter to cover our garden with a heavy coating of manure. When earth is rich it bids defiance to droughts, yields in abundance, and of the best quality. I suspect that the insects which have harassed you have been encouraged by the feebleness of your plants; and that has been produced by the lean state of the soil.”

Thomas Jefferson – Letter to Martha Jefferson

SOILS & FERTILIZERS

Soil Forming Factors

Soil Texture

Soil Structure

Carbon : Nitrogen Ratio

Soil/Water Relationships

pH

Plant Nutrients

Mulches

Fertilizer 101

Green Manure and Cover Crops

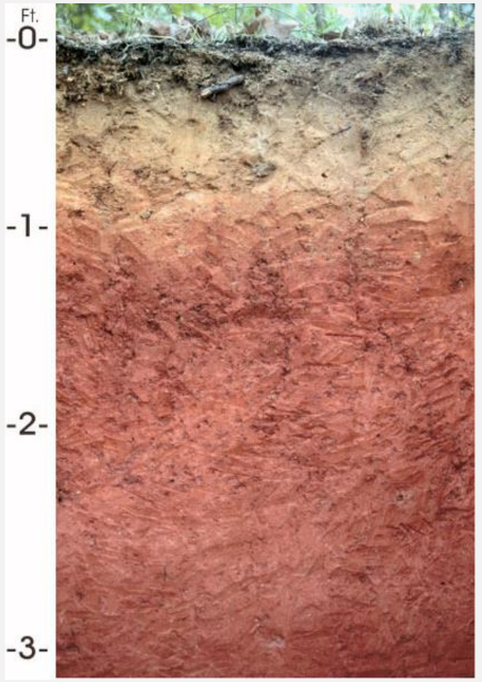
Organic Fertilizers

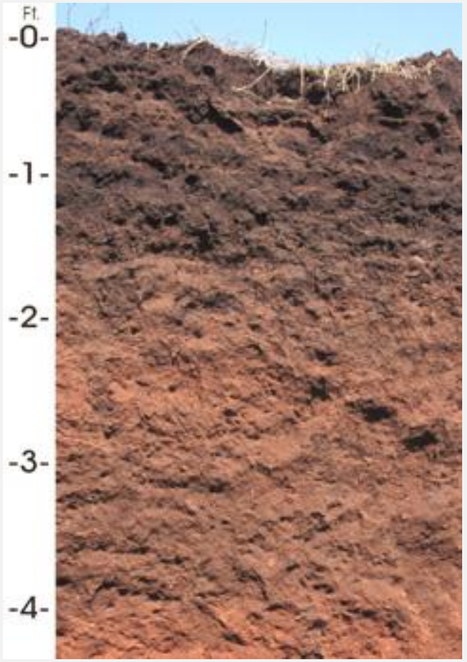
Additional Resources

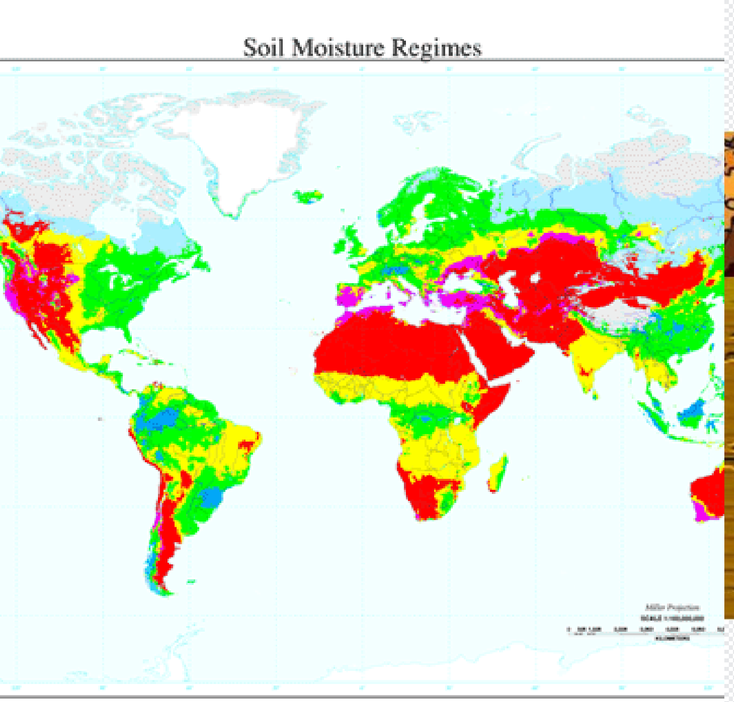
SOIL FORMING FACTORS

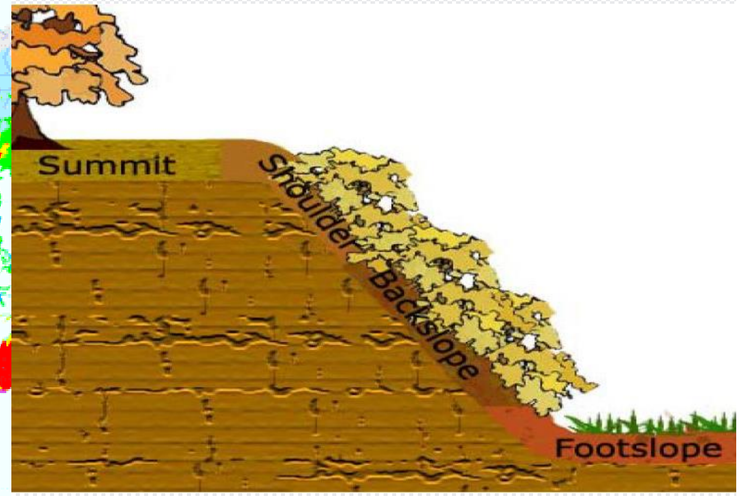
CL.O.R.P.T.

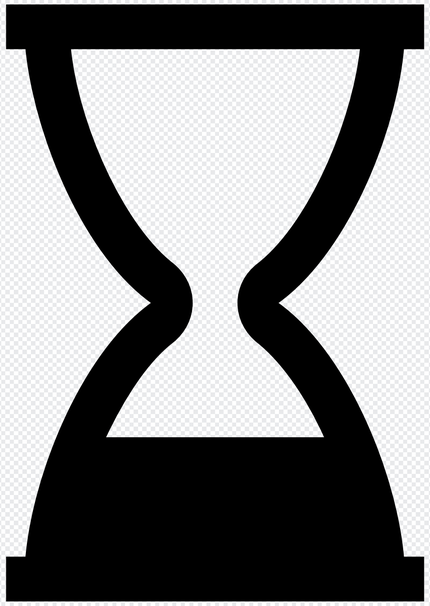
*Cl*imate, Living *O*rganisms, *R*elief (topography), *P*arent Material, *T*ime





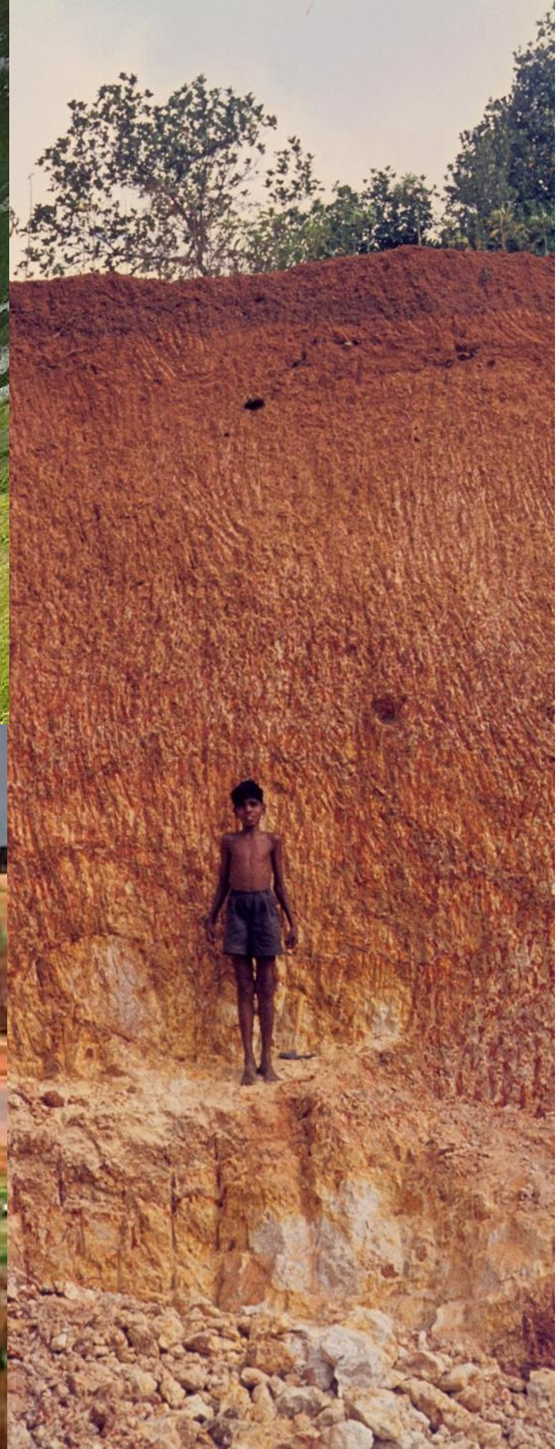


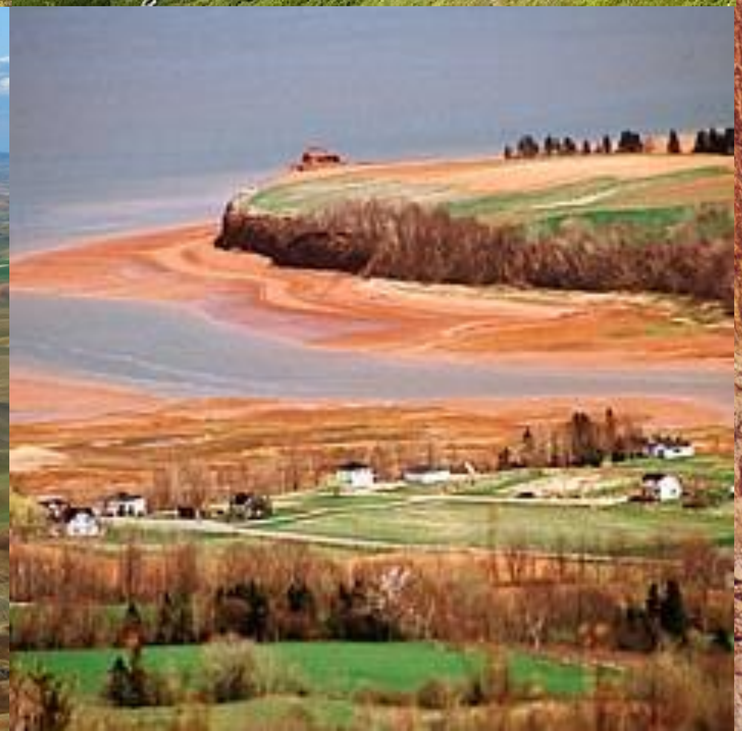




SOIL FORMING FACTORS

- Climate
- Relief/Topography
- Living Organisms (Biota)
- Time

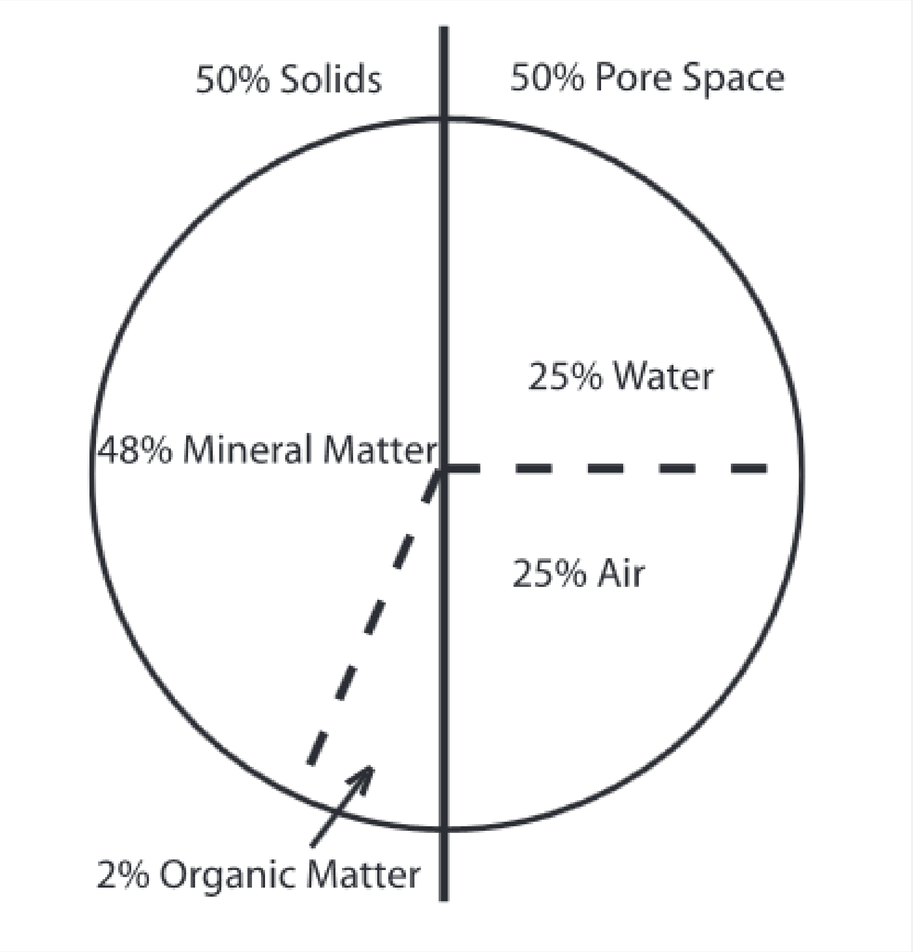




PARENT MATERIAL

- Alluvium
- Colluvium
- Eolain & Loess
- Lacustrine & Marine deposits
- Residual / residuum

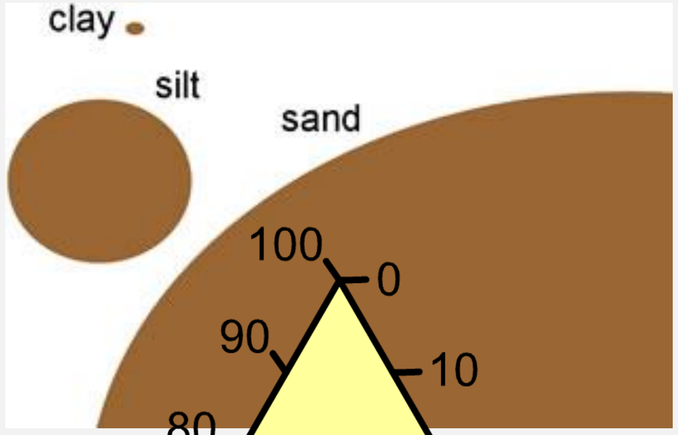
MAJOR COMPONENTS OF MINERAL SOIL

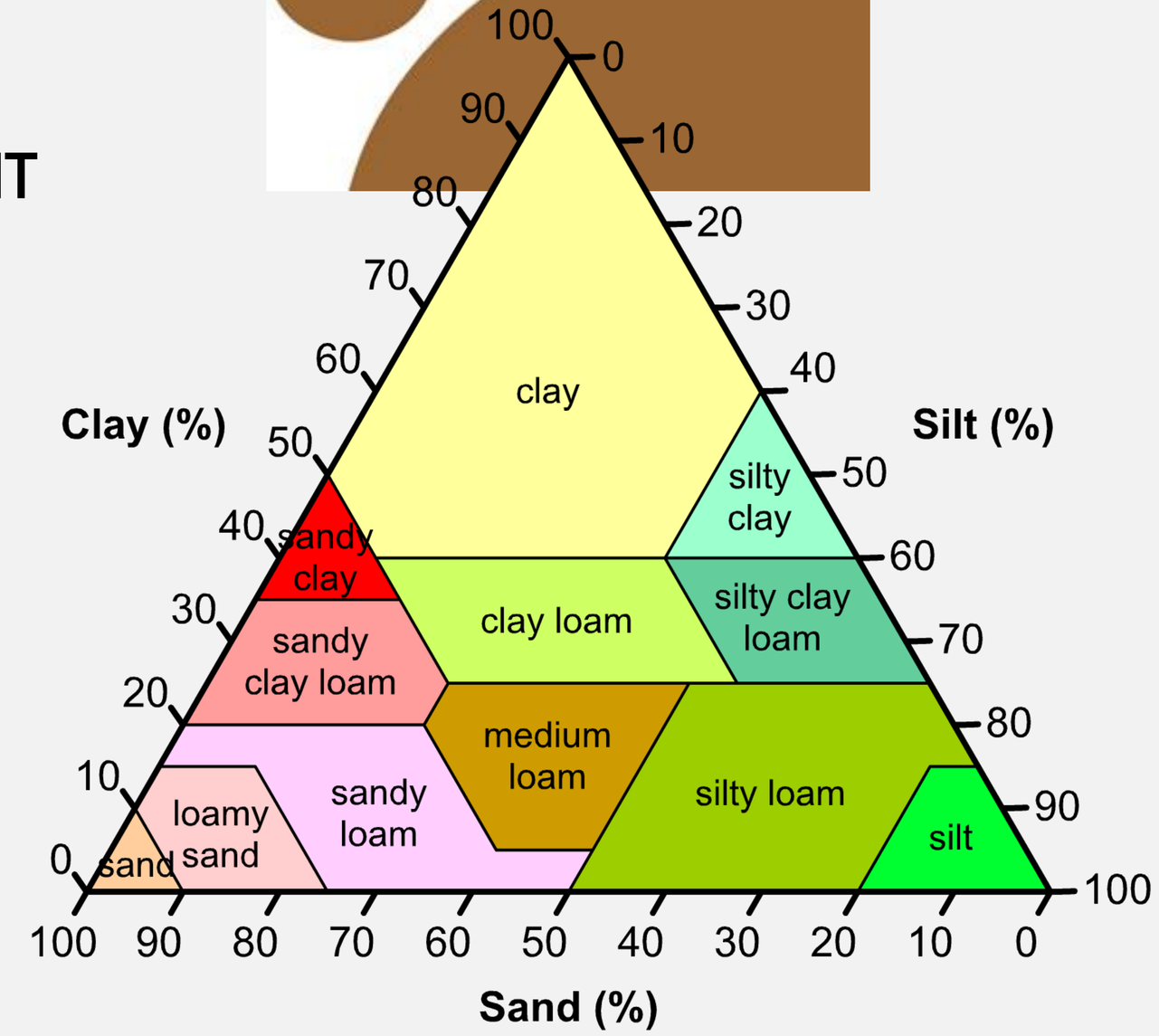


SOIL TEXTURE

TEXTURE AND SOIL MANAGEMENT

- Sandy soils need more frequent water
- Clay soils prone to waterlogging
- Loams tend to have optimal conditions for water & nutrient retention

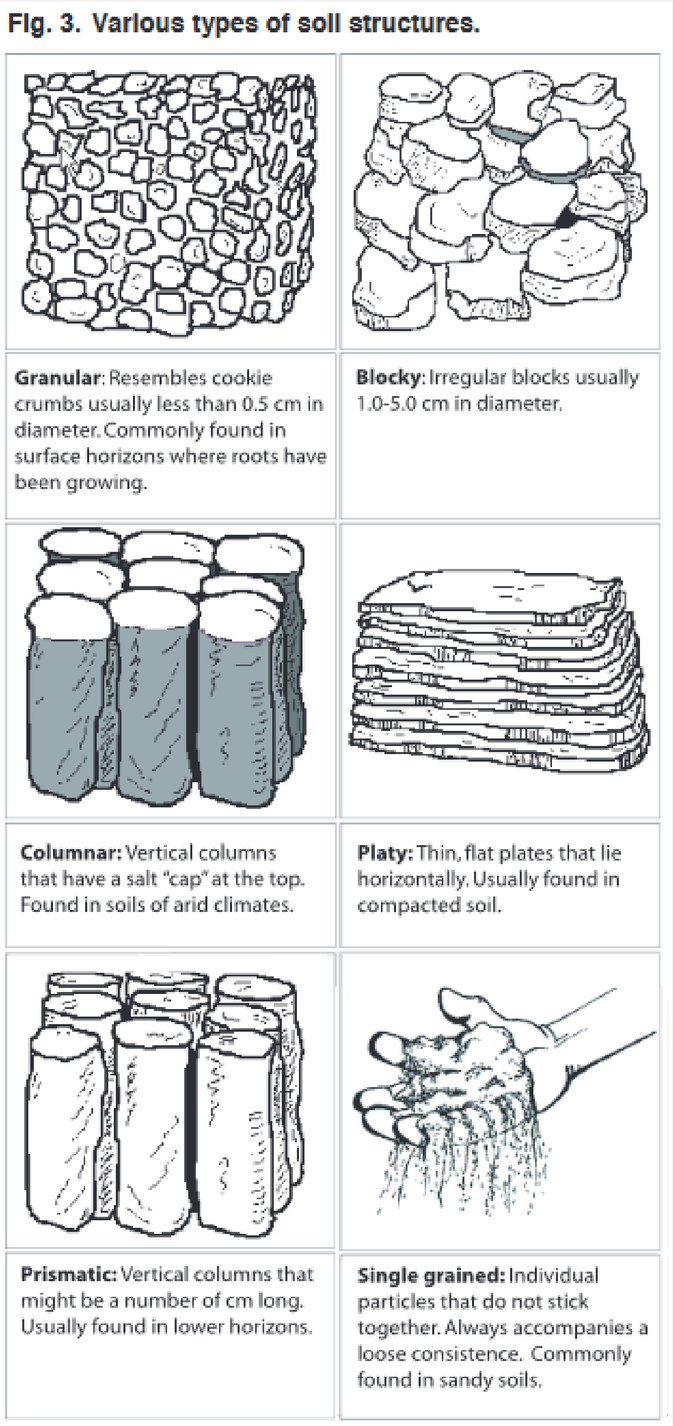


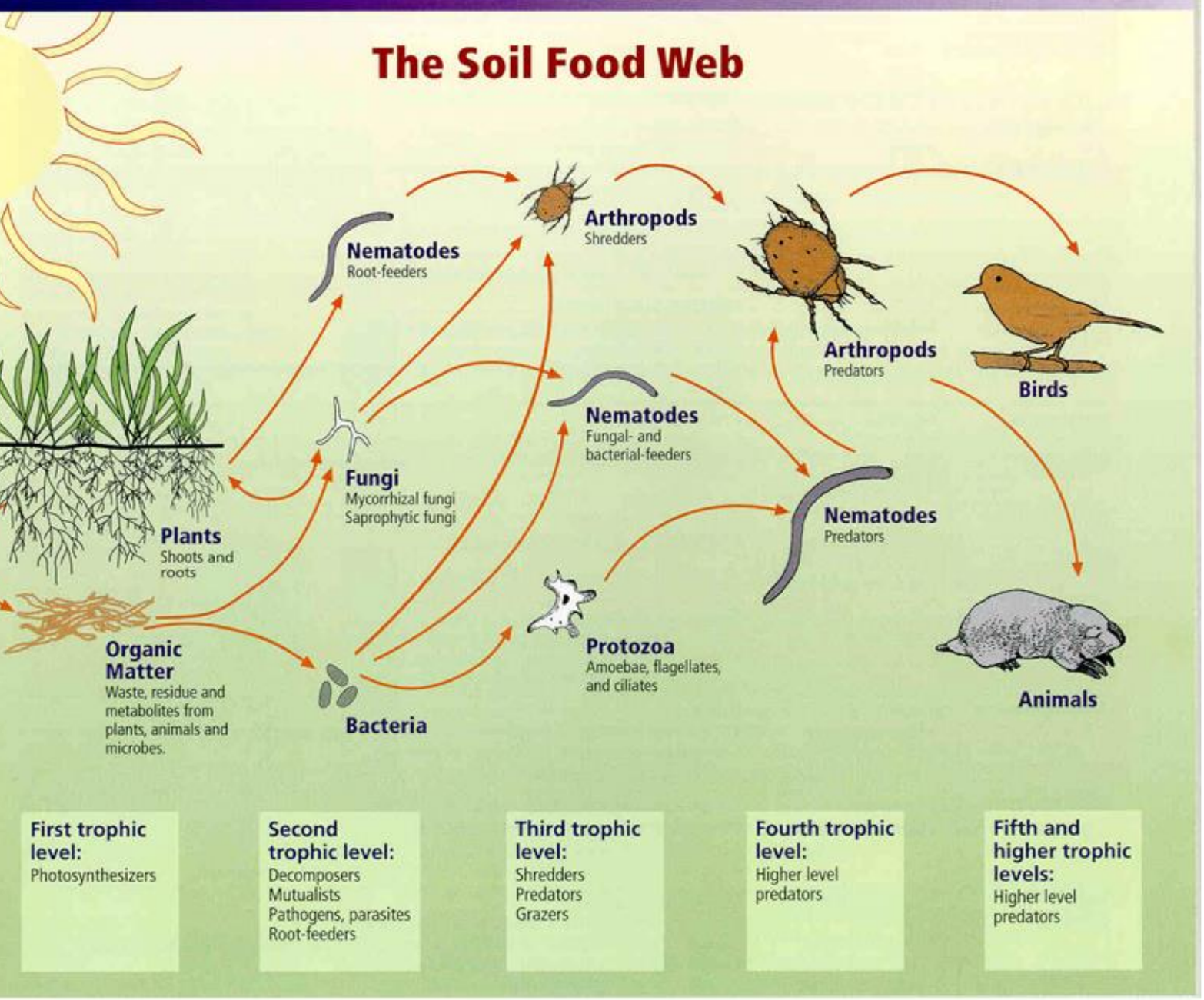


https://www.youtube.com/watch?v=GWZwbVJCNec

SOIL STRUCTURE

- Structure provides space for water, air, roots and nutrients
- Over-working soils or working wet soils destroys structure and leads to compaction
- Plants and added organic materials help build soil structure





Relationships between soil food web, plants, organic matter, and birds and mammals
Image courtesy of USDA Natural Resources Conservation Service
http://soils.usda.gov/sqi/soil_quality/soil_biology/soil_food_web.html.

ORGANIC MATTER

IT'S NOT ROCKET SCIENCE…
IT'S NOT THAT SIMPLE

- Builds structure
- Source of nutrients
- Increases water holding capacity
- Increases aeration
- Provides energy for microorganisms

CARBON : NITROGEN RATIO (C:N)

CONTROLS NITROGEN AVAILABILITY FROM ORGANIC MATTER

- Plant residue made up of sugars, starches, proteins, hemicelluloses, celluloses, lignin, fats, waxes etc..
- Decomposition regulated by soil biota
- C:N > 25:1, net loss of N for plants
- C:N < 20:1, excess N for plants

Material	C:N Ratio
Straw	80:1
Leaves	40-80:1
Horse Manure	25:1
Fresh Grass Clippings	19:1
Poultry Manure	15:1
Urine	0.6:1

SOIL/WATER RELATIONSHIPS

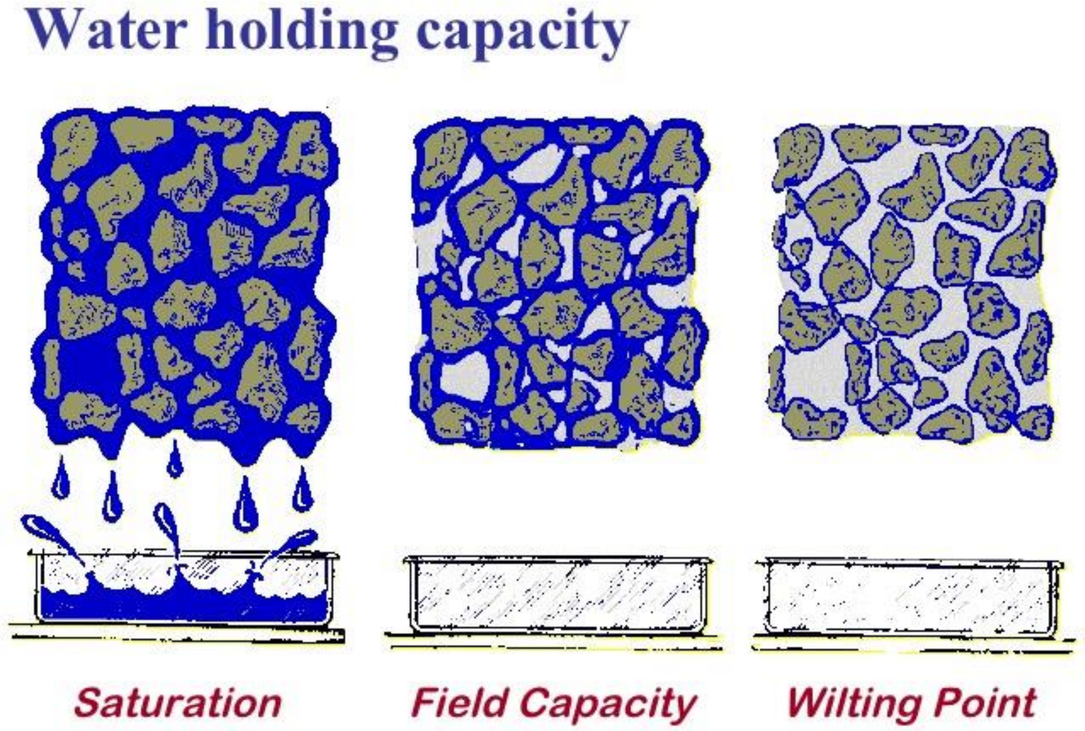


Table 2. Water-holding capacity of main soil texture groups (inches per foot).

Texture	Field capacity	Wilting point	Available water
Sand	1.3	0.6	0.7
Sandy Loam	2.5	1.3	1.2
Loam	3.6	1.8	1.8
Silt Loam	4.4	2.3	2.1
Clay Loam	4.6	2.6	2.0
Clay	4.7	2.8	1.9

Note: Figures are averages and vary with structure and organic matter.

SOIL/WATER RELATIONSHIPS

WATER INFILTRATION RATE

Table 1. Steady infiltration rates for general soil texture groups in

Runoff Potential	Infiltration Rate (inches/hour)
Low	<5.67
Moderately Low	1.42-5.67
Moderately High	0.14-1.42
High	>0.14

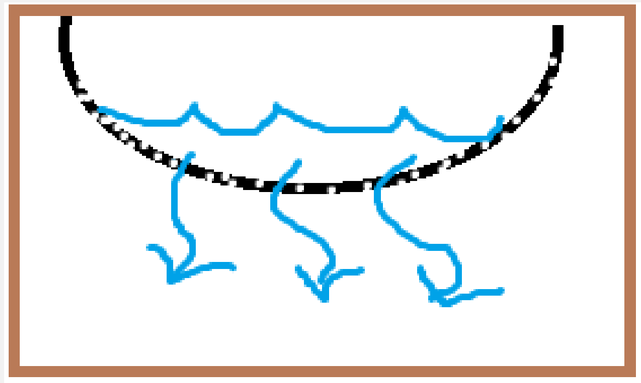
SOIL/WATER RELATIONSHIPS

PERMEABILITY RATE

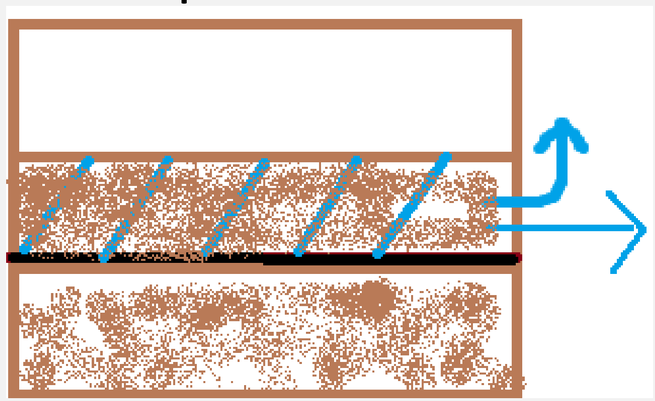
"Rate water moves through soil"

- Affected by
  - Soil compaction
  - Plow layers
  - Hard pans
  - Clay layers
  - Rock or changes in soil texture

Permeable



Impermeable



https://www.youtube.com/watch?v=vmo0FRAVgkM

SOIL/WATER RELATIONSHIPS

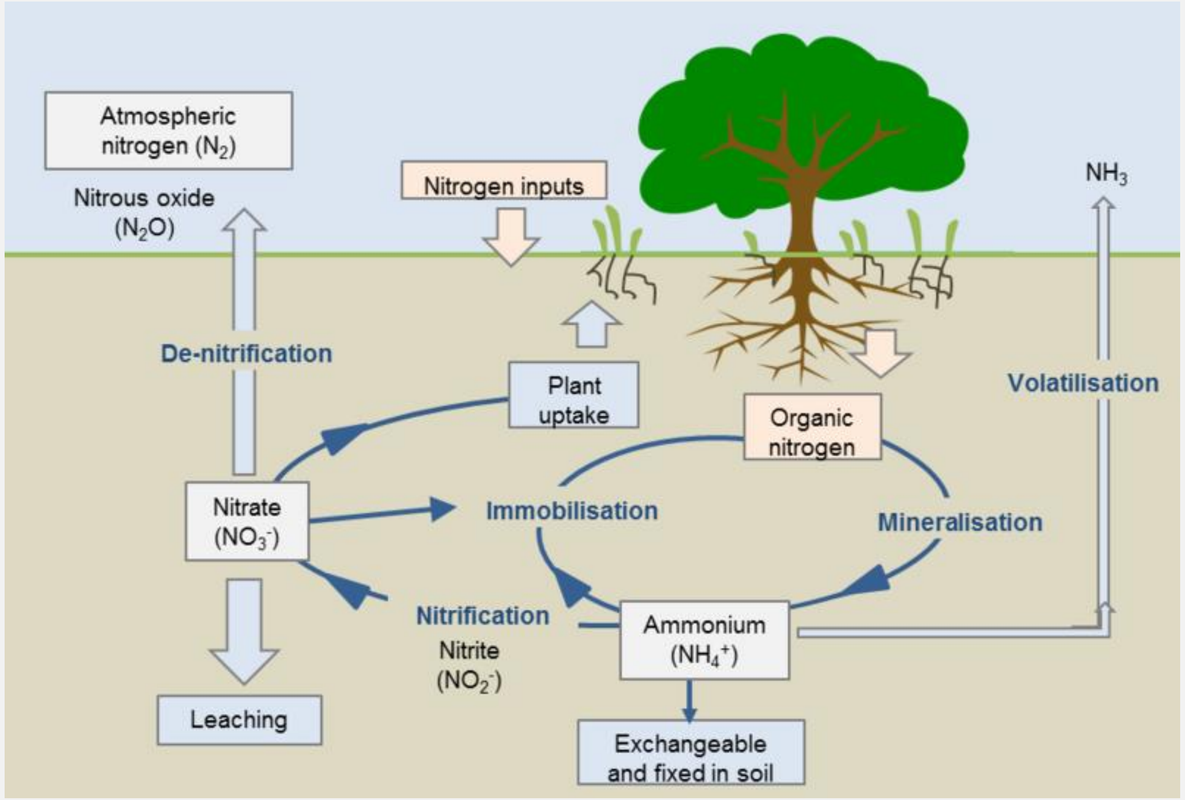
SOIL COMPACTION

- Low infiltration & permeability rates
- Poor root penetration
- Overcome compaction mechanically or biologically

SOIL/WATER RELATIONSHIPS

WATER, AIR, LEACHING AND SALTS

- Plants need air for their roots too
  - Saturated soils cause problems
    - Cool longer
    - Promote fungal and bacterial plant diseases
    - Excessive water leaches soluble nutrients
  - Salts accumulate from fertilizer, manure, wood ash, and areas with high evaporation



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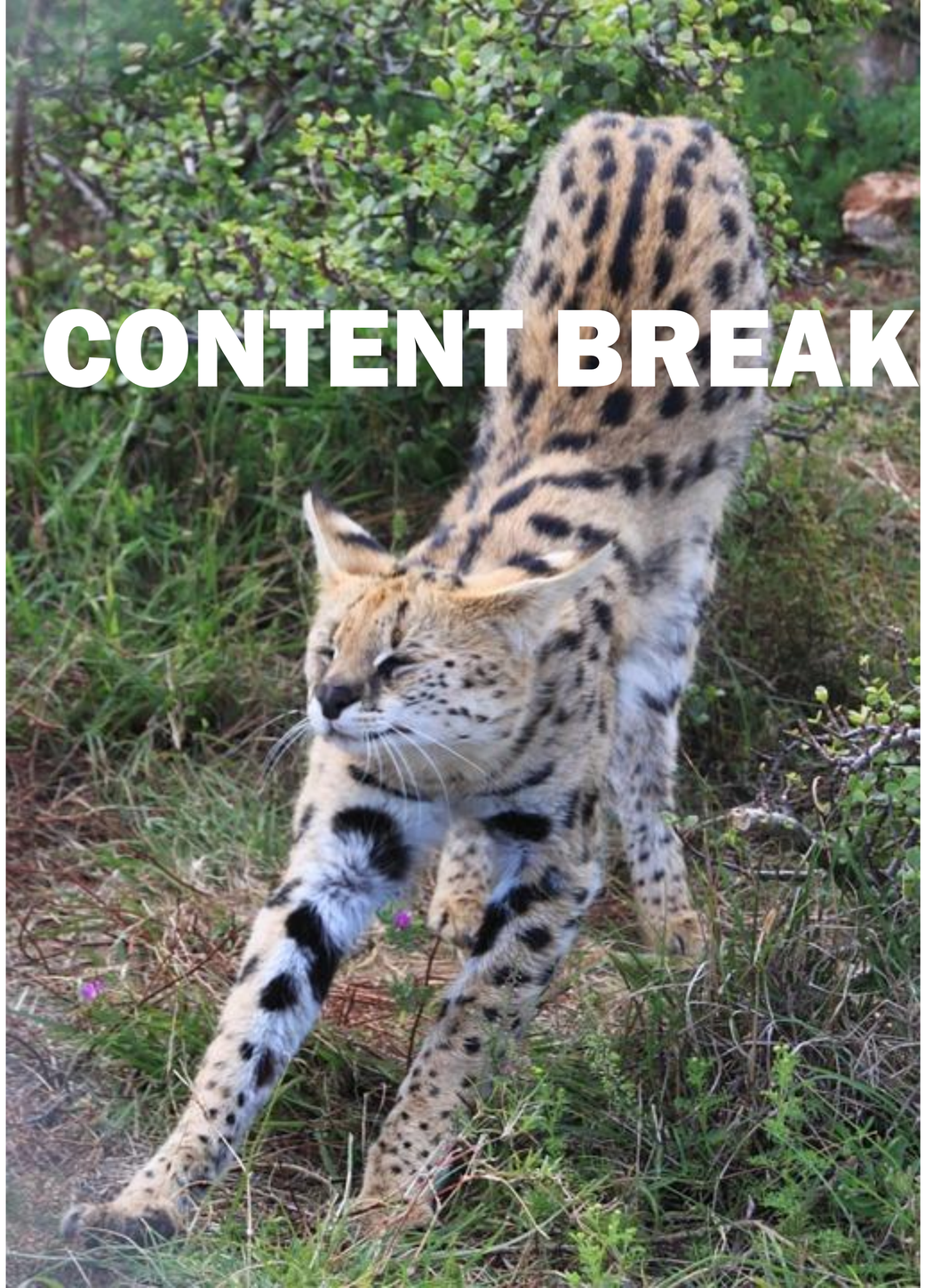
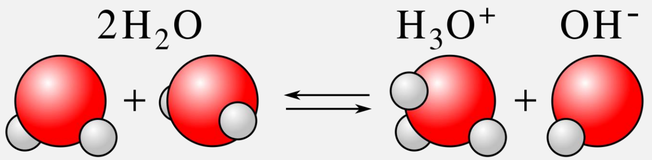
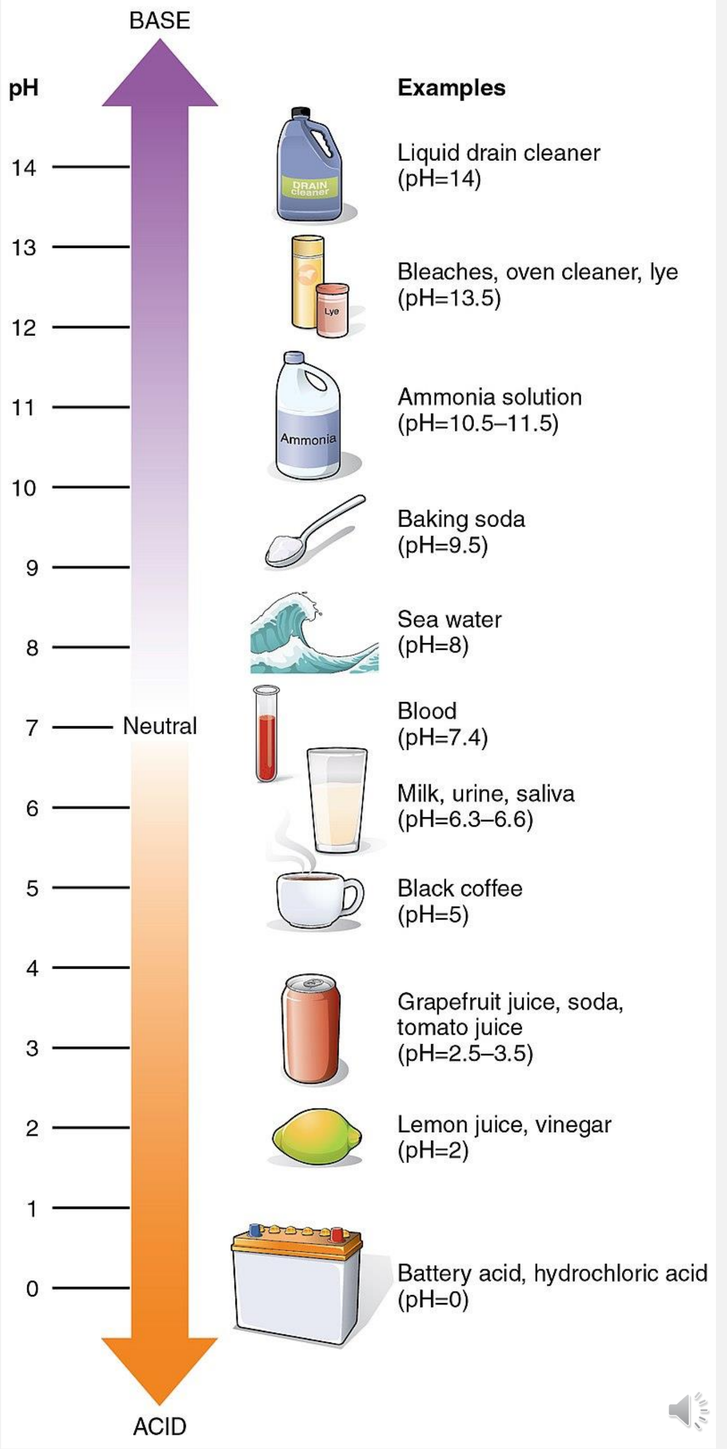


PH

THE MASTER VARIABLE

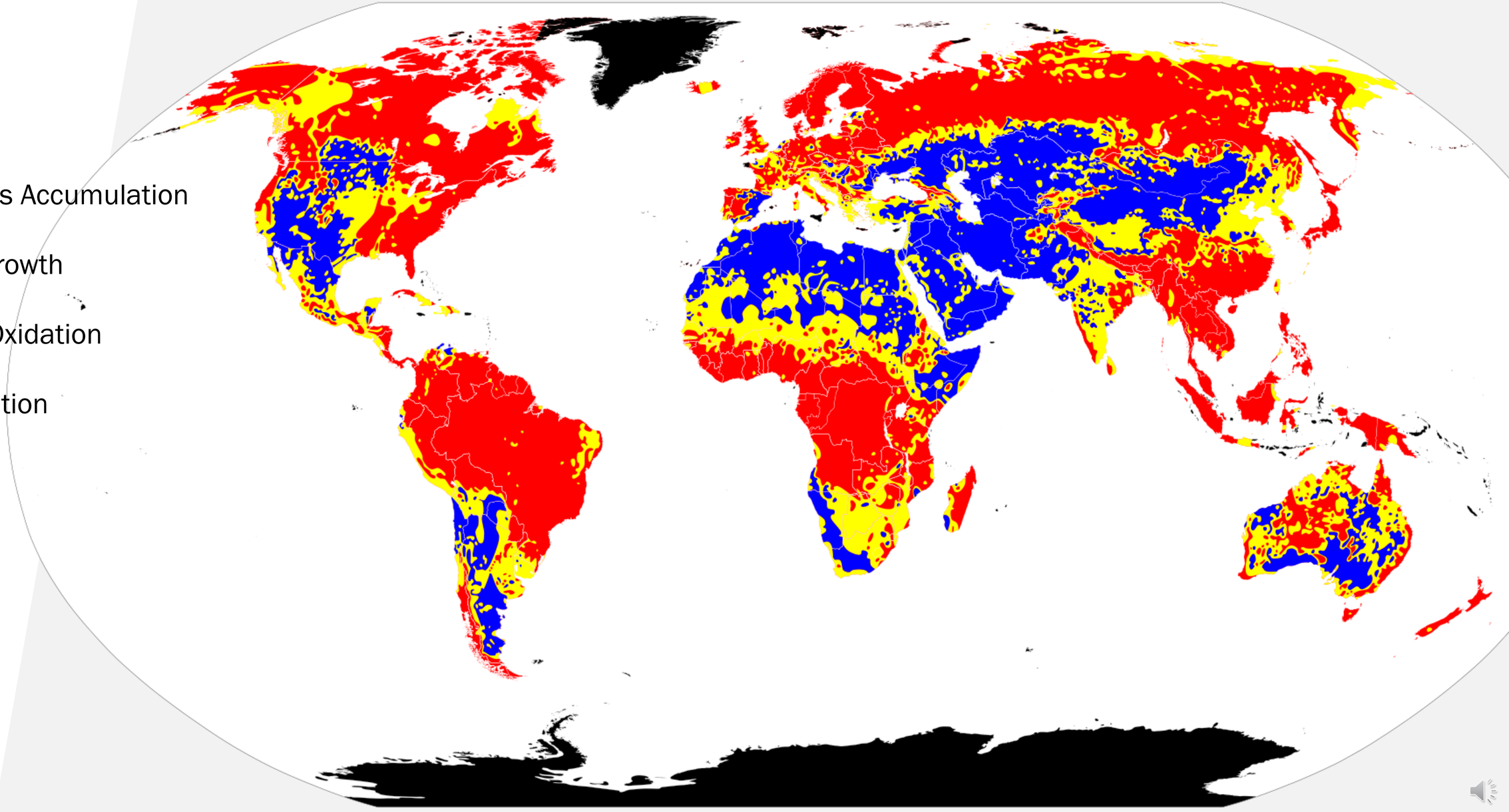
- A measure of the hydrogen ion concentration of a liquid
- Represented by pH scale
  - 1 unit of difference is 10X
    - pH 6 is 10x more acidic than 7
    - pH 5 is 100x more acidic than 7

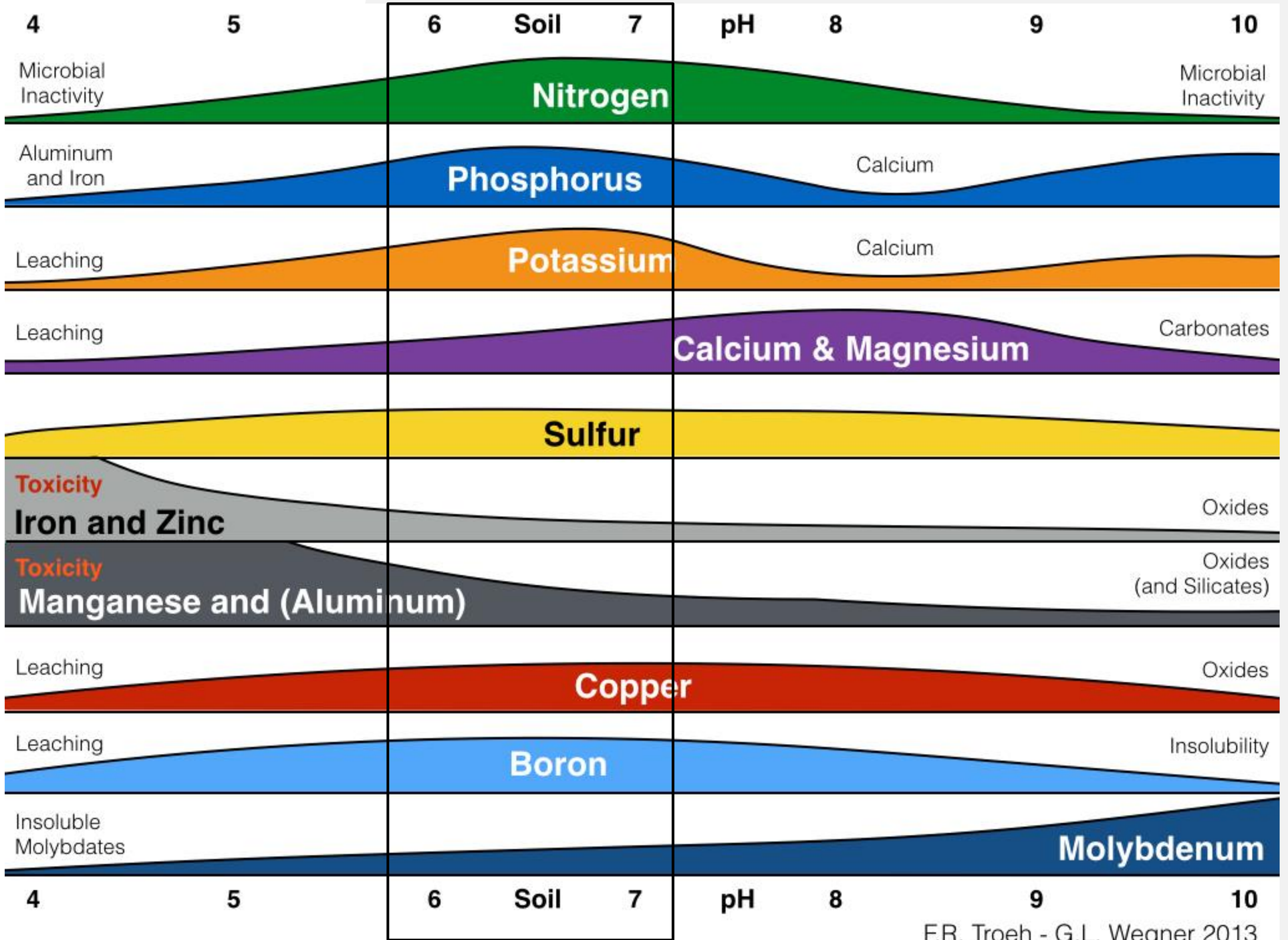




NATURALLY ACIDIFYING PROCESSES

- Rainfall
- Organics Accumulation
- Plant Growth
- Sulfur Oxidation
- Nitrification





PLANT NUTRIENTS & PH

- Increase acidity through:
  - Ammonium based nitrogen fertilizers
  - Elemental sulfur, others
- Lower acidity through:
  - Liming

PLANT NUTRIENTS

Nitrogen deficiency

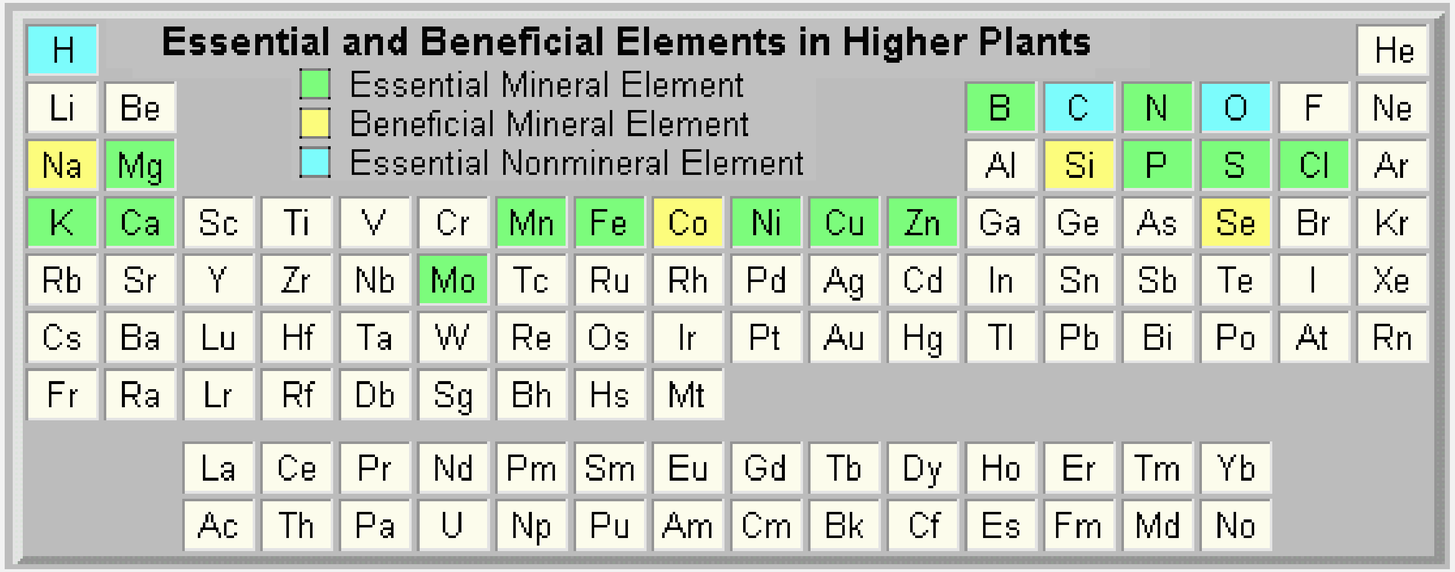
Potassium deficiency

Boron deficiency

11/15/2021

ESSENTIAL NUTRIENTS

- From air: Carbon (C), Hydrogen (H), Oxygen (O)
- From soil:
  - Macronutrients - Nitrogen (N), Phosphorous (P), Potassium (K), Calcium (Ca), Magnesium (Mg), Sulfur (S)
  - Micronutrients – Iron (Fe), Molybdenum (Mo), Boron (B), Copper (Cu), Manganese (Mn), Sodium (Na), Zinc (Zn), Nickel (Ni), Chlorine (Cl), Cobalt (Co), Aluminum (Al), Silicon (Si), Vanadium (V), Selenium (Se)



http://soils.wisc.edu/facstaff/barak/soilscience326/listofel.htm

MACRONUTRIENTS - NITROGEN

- Taken up as ammonium (NH4+) or nitrate (NO3-)
- Essential for protein synthesis and chlorophyll
- Increases yields of leaf, fruit or seed
- Tends to extend length of plant's maturity period
- Excess can cause lodging, other issues
- Mobile nutrient (translocated within plant)
- Deficiency symptoms at older leaves

MACRONUTRIENTS - PHOSPHOROUS

- Phosphorus (P in fertilizers, designated as phosphate, P_2O_5)
- Critical for metabolic processes
- Associated with root & fruit production
- Mobile (translocated) within plant
- Deficiency symptoms are small plants with dark green and purple coloration

MACRONUTRIENTS - POTASSIUM

- Potassium (K or in fertilizers, designated as potash, K_2O)
- Vital to water movement and nutrient regulation
- Improves cold hardiness, disease resistance, general durability
- Mobile (translocated) within plant
- Deficiency symptoms are yellow or brown discoloration along outer margins of older leaves

Potassium deficiency for Xanthosoma sp.
Photograph by Marc Ouye

MACRONUTRIENTS - SULFUR

- Essential for protein synthesis
- Required for legume nodulation
- Not mobile within plant
- Deficiency symptoms: whole leaf turns pale green/yellow starting with ***younger leaves***

MACRONUTRIENTS - CALCIUM

- Aids in development of leaves and roots
- Essential for cell walls and new plant cell formation
- Not mobile within plant
- Deficiency symptoms: primary leaf emergence delayed, terminal bud death

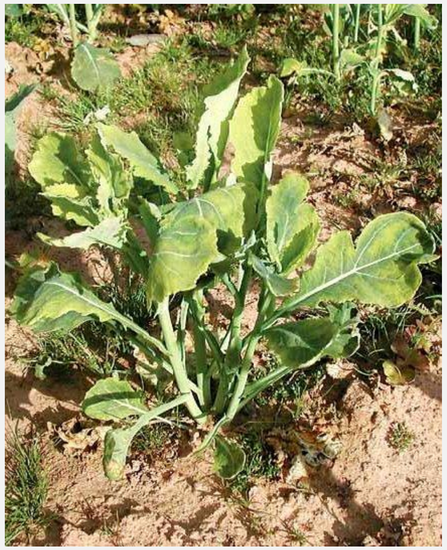
MACRONUTRIENTS - MAGNESIUM

- Essential for photosynthesis
- Involved in phosphate metabolism & plant respiration
- Activates many plant enzymes for growth processes
- Mobile within plant
- Deficiency symptoms: yellow discoloration between leaf veins. Reddish purple discoloration extends from outer edge of leaf inward.

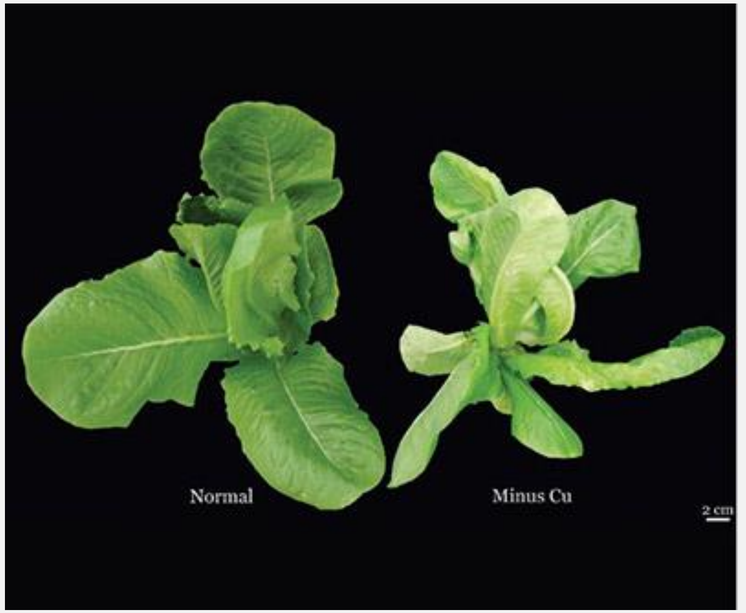
http://www.omafra.gov.on.ca/IPM/english/grapes/plant-nutrition/magnesium.html

MICRONUTRIENTS

- Boron (B) – Essential to pollen and seed formation
  - Deficiency: yellow leaves near growing point, buds die
- Chlorine (Cl) – active in energy reactions, water retention and fungal root-disease resistance
  - Deficiency: upper leaves wilt then yellow
- Copper (Cu) – necessary for chlorophyll, other functions
  - Deficiency: young leaves pale, wilt; seedheads may not form



https://www.agric.wa.gov.au/mycrop/diagnosing-boron-deficiency-canola



https://www.extension.umn.edu/agriculture/nutrient-management/micronutrients/copper-for-crop-production/index.html

MICRONUTRIENTS

- Iron (Fe) – catalyst of chlorophyll formation, oxygen carrier
  - Deficiency: leaves pale yellow, white between leaf veins
- Manganese (Mn) – helps enzyme systems, metabolic reactions & chlorophyll synthesis
  - Deficiency: leaves yellow/gray, reddish/gray with green veins
- Molybdenum (Mo) – need for nitrogen use and fixation
  - Deficiency: young leaves wilt and die along margins; older leaves yellow

Photo by Scott Nelson

MICRONUTRIENTS

- Nickel (Ni) – important for nitrogen metabolism
  - Deficiency – unobserved in field conditions, yellowing young leaves and death of meristem tissue in lab
- Zinc (Zn) – necessary for chlorophyll, carbohydrates and growth hormones
  - Deficiency – yellowing between leaf veins; stunted plant with short internodes
- Cobalt (Co) – aids root-nodule forming bacteria in legumes fix nitrogen
  - Deficiency – poor nitrogen fixation

Zinc deficient corn

MULCHES

ANY MATERIAL SPREAD ON SOIL TO PROTECT IT

- Organic Mulches
- Inorganic Mulches

ORGANIC MULCHES

KEEP IT COURSE AND THE SOIL OPEN

- Grass clippings
- Hay
- Straw
- Bark
- Sawdust
- Wood shavings
- Leaves
- newspapers

INORGANIC MULCHES

- Plastic films, weed barriers, Aluminum foil, old carpet
- Same benefits as organic mulches but no incorporation possible
- Perforated plastic, landscape cloth allows water and air to reach soil

SEASONAL MULCHES & PROBLEMS

- **Summer Mulches** – control weeds, reduce evaporation, stabilize soil temp
- **Winter Mulches** - reduce evaporation, stabilize soil temp, *applied too early can cause plant injury by delaying hardening off
- **Problems with Mulches**
  - Introduce weeds
  - Provide habitat
  - Prolong cool soil temps in spring
  - Add carbon (C) to C:N ratio

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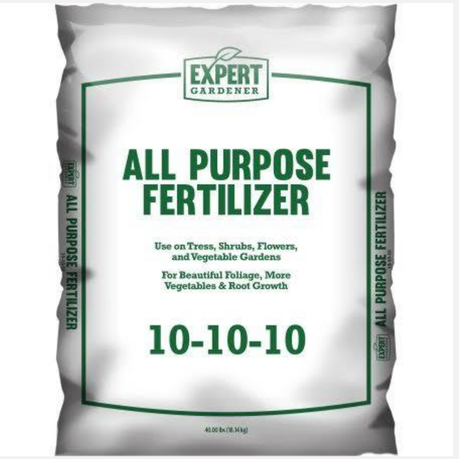
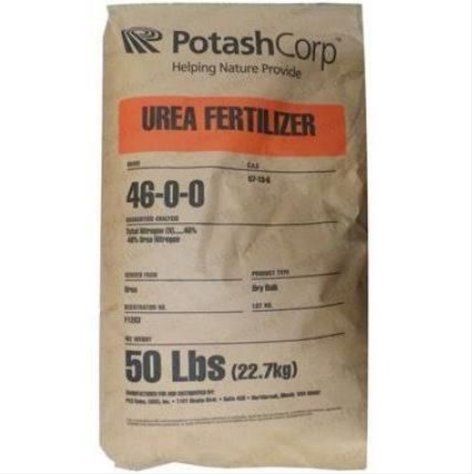
FERTILIZER TERMINOLOGY

- Mixed fertilizer—A fertilizer that contains two or more of the macronutrients (N, P, K).
- Complete fertilizer—A fertilizer that contains all three macronutrients (N, P, K).
- Incomplete fertilizer—A fertilizer that is missing one, or more, of the major components found in a complete fertilizer.
- Grade—The guaranteed minimum analysis, in percent, of plant nutrients in a fertilizer, expressed as total N, available P_2O_5, and soluble K_2O.





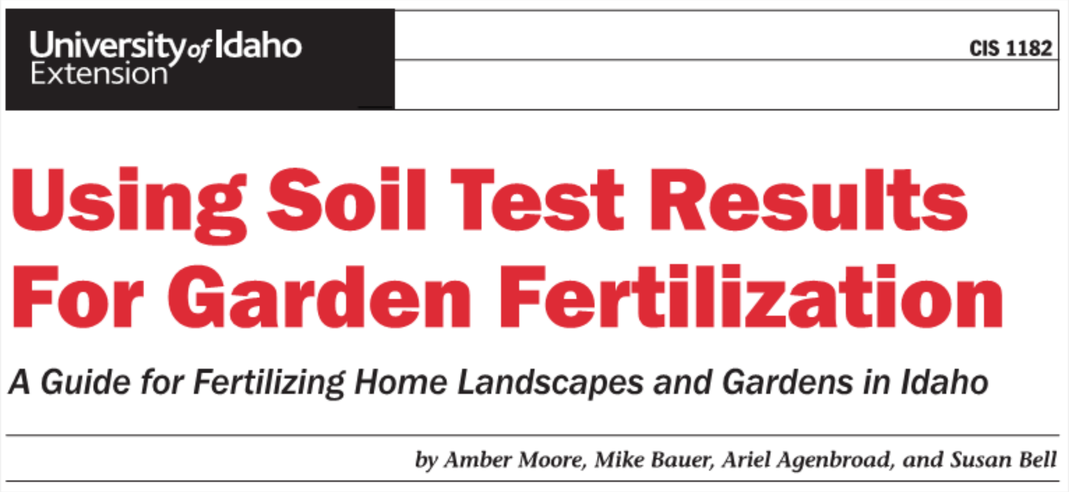
FERTILIZER TERMINOLOGY

- **Chelates** – organic substances that keep metal ions plant available (Cu, Fe, Mn, Zn)
- **Soil amendments** – substance added to soil to change pH or physical properties

NUTRIENT SOURCES & FERTILIZER TYPES

FERTILIZER TIMING

- Depends on fertilizer type and plants
  - More frequent in course soil textures
- Generally apply when plant is actively growing
- Apply foliars when cool (not cold) and plants well watered
- P, K, & lime in fall, incorporated
- N in spring, not more than 50-75 lbs/A at once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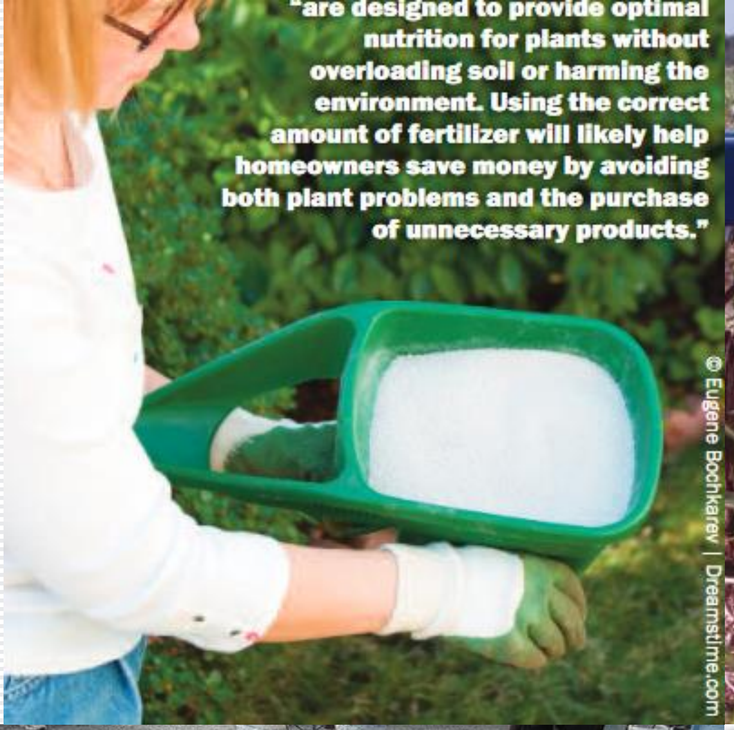
CIS 1182

Using Soil Test Results For Garden Fertilization

A Guide for Fertilizing Home Landscapes and Gardens in Idaho

by Amber Moore, Mike Bauer, Ariel Agenbroad, and Susan Bell

http://www.extension.uidaho.edu/homegard.aspx



FERTILIZER APPLICATION

- BROADCAST
- BANDING
- FERTIGATION
- FOLIAR

SALT ACCUMULATION AND LEACHING

- Salts in fertilizer can harm plants if soil is dry
  - Can prevent plants from taking up adequate water
- Leach potted plants every 4-6 months and garden soils once per year
  - Use twice the pot volume of water
  - Don’t let plant sit in leached water
  - Leach before you fertilize

GREEN MANURE

GROWN AND INCORPORATED TO IMPROVE SOIL

- Increase fertility and soil humus
- Improve aggregation, porosity, bulk density & permeability
  - Better results in clay vs sandy soils
- Incorporate 2 weeks before planting
- Don’t let green manure go to seed

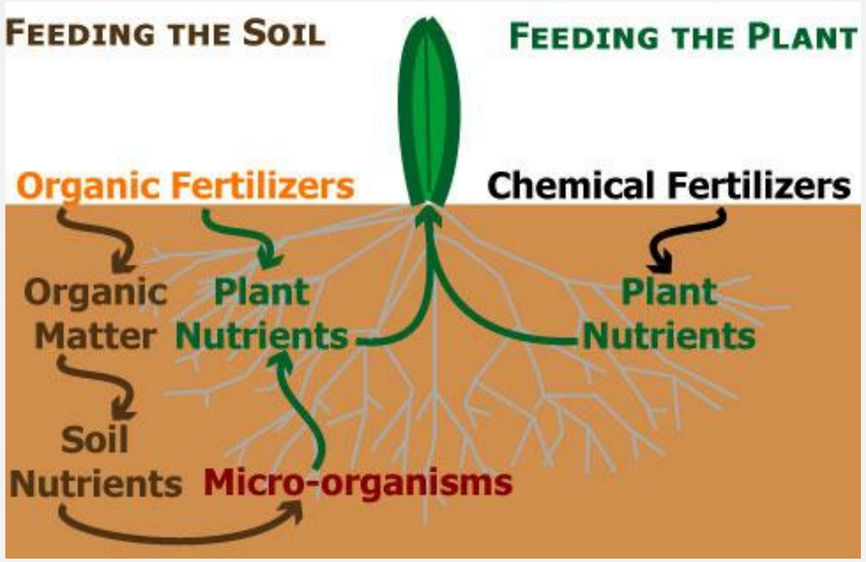
COVER CROPS

GROWN PERENNIALLY* TO REDUCE EROSION, NUTRIENT LEACHING & SUPPRESS WEEDS

- Commonly used in orchards, vineyards & garden paths/unused areas
- Provides organic matter, stores/adds nutrients, feeds pollinators, reduces erosion
- Can compete with main crop
- Can be home for pests & host for diseases

ORGANIC FERTILIZERS

- Generally depend on microbes to break down
- Most effective when soil moisture and temperature favor microbes
- Not shown to be more effective or “safer”*



ORGANIC FERTILIZERS

Top Sources of Nitrogen, Phosphorus, and Potassium

Nitrogen (N)	*Phosphorus (P)*	*Potassium (K)*
bat guano	*bat guano*	*crab waste*
blood/blood meal	*bone meal*	*cucumber skins (burned)*
crab waste	*crab waste*	*granite (dust)*
feather meal	*cucumber skins (burned)*	*greensand*
fish meal (dry)	*hair*	*kaolinite (clay)*
hair	*mushroom compost*	*kelp*
hoof/horn meal	*phosphate*	*sulfate of potash magnesia*
shrimp waste	*shrimp waste*	*wood ashes*

Material	%Nitrogen	%Phosphate	%Potash	Availability*	Notes**
Alfalfa hay	2-3	0.5-1	1-2	slow/mod.	
Bone meal	1-6	11-30	0	moderate	alkaline
Blood meal	12	1-2	0-1	rapid	acidic
Cottonseed meal	6	3	1	slow	acidic
Composts	1-3	1-2	1-2	moderate	alkaline
Feather meal	12	0	0	moderate	
Fish meal	6-12	3-7	2-5	rapid	acidic
Grass clippings	1-2	0-0.5	1-2	moderate	
Hoof/horn meal	12-14	1.5-2	0	moderate	alkaline
Kelp	1-1.5	0.5-1	5-10	moderate	zinc, iron
Leaves	1	0-0.5	0-0.5	slow	
Legumes	2-4	0-0.5	2-3	moderate	

Material	%Nitrogen	%Phosphate	%Potash	Availability*	Notes**
Manures: *Cattle*	2-3	0.5-1	1-2	moderate	weed seed
Horse	1-2	0.5-1	1-2	slow	weed seed
Swine	2-3	0.5-1	1-2	rapid	
Poultry	3-4	1-2	1-2	rapid	
Sheep	3-4	0.5-1	2-3	moderate	weed seed
Pine needles	0.5	0	1	slow	acidic
Sawdust	0-1	0-0.5	0-1	very slow	
Sewage sludge	2-6	1-4	0-1	moderate	zinc, iron
Seaweed extract	1	2	5	rapid	zinc, iron
Straw/corn stalks	0-0.5	0-0.5	1	very slow	
Wood ashes	0	1-2	3-7	rapid	

https://www.youtube.com/watch?v=uzphhbmz4ZM

SOILS & FERTILIZERS

Questions?

Soil Forming Factors

Soil Texture

Soil Structure

Carbon : Nitrogen Ratio

Soil/Water Relationships

pH

Plant Nutrients

Mulches

Fertilizer 101

Green Manure and Cover Crops

Organic Fertilizers

Additional Resources