IPM Benefits of Healthy Soils:

Soil Science and Maintenance Practices for Sustainable Landscapes

Healthy Soils parts 1+2 - short for WSU ReCert class 12-4-2019.pptx, and City of Seattle IPM Seminar 9-30-2019

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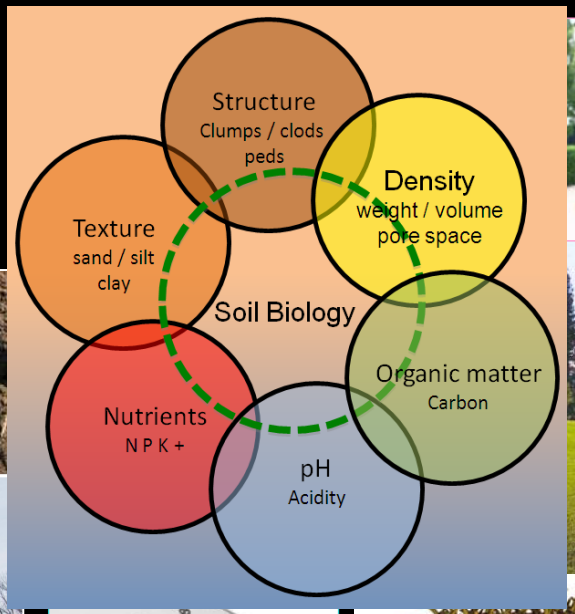
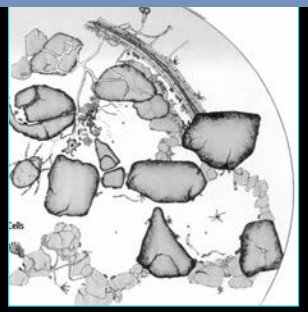
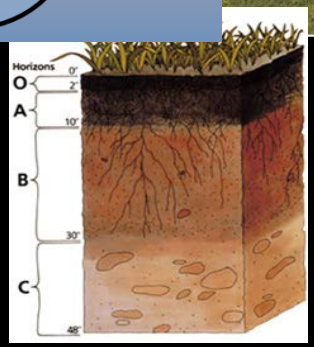
With slides from
James Urban, FASLA, ISA
Urban Tree + Soils





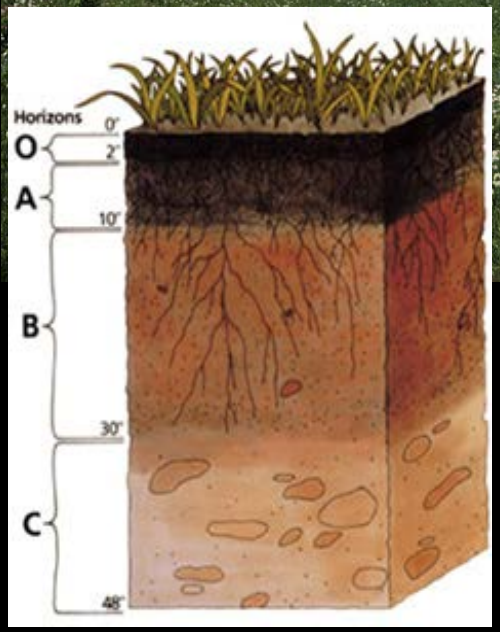


Based on Healthy Soils Part 1 and Healthy Soils Part 2 by James Urban and David McDonald from ASLA conference Phoenix 9/6/2012, and Soil Improvement for Stormwater, Erosion, & Landscape Success by David McDonald for WSU Low Impact Development. Updated 2/27/2019

www.SoilsforSalmon.org
www.BuildingSoil.org

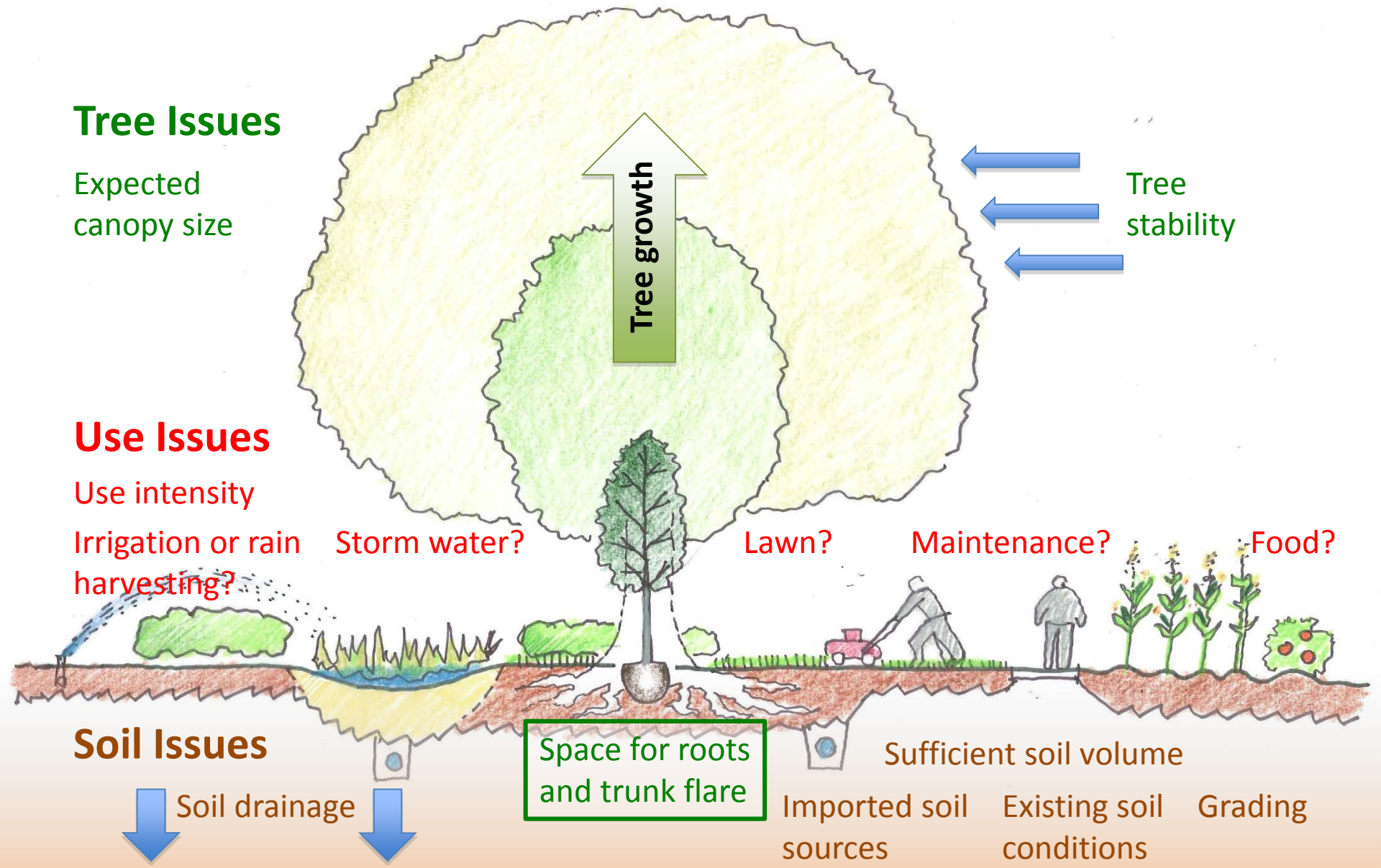
Natural soils vs. Disturbed urban soils

- Uniform across site
- Natural horizons
- Adequate OM, nutrients, structure for native plants

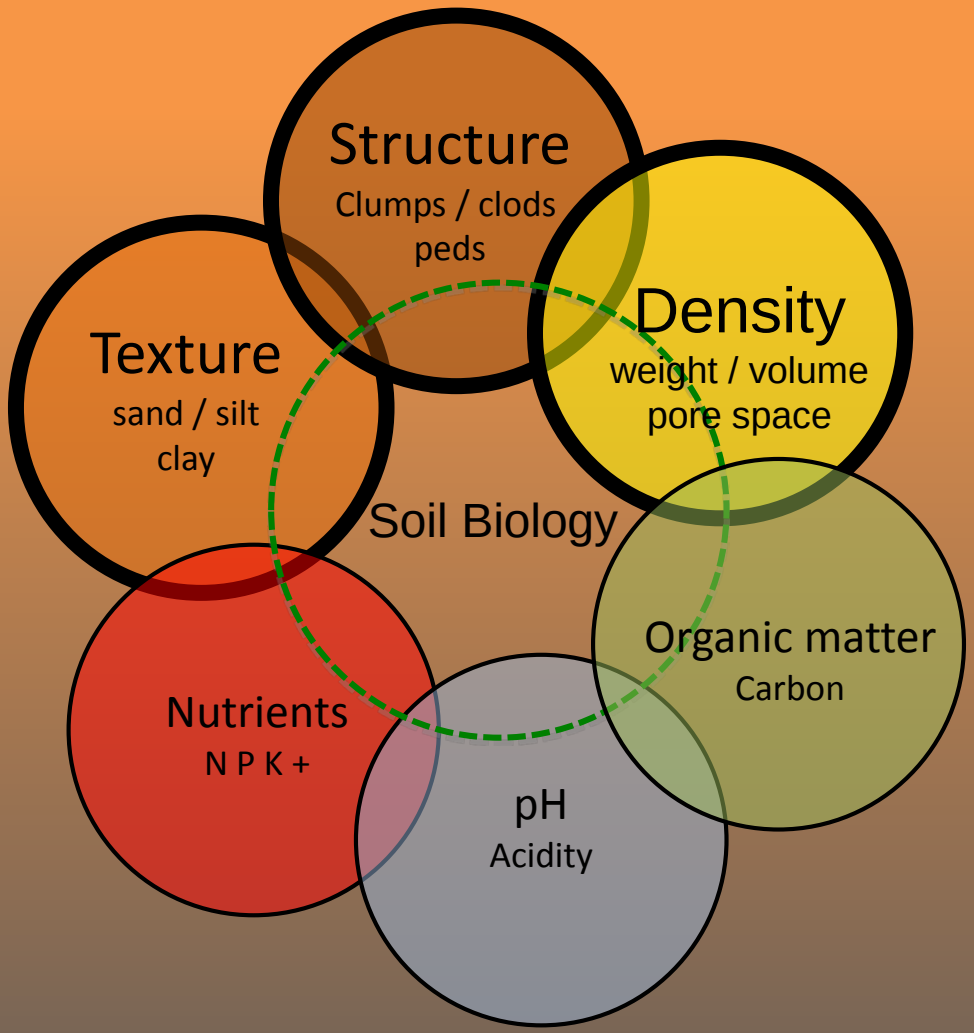


- Vary across site
- Topsoil layer removed
- Compaction, low OM
- Subsoil (or worse) fill layers
- Debris, toxins?

Soil Goals and Requirements



Physical properties of soil



Air and water movement / **Soil Profile**

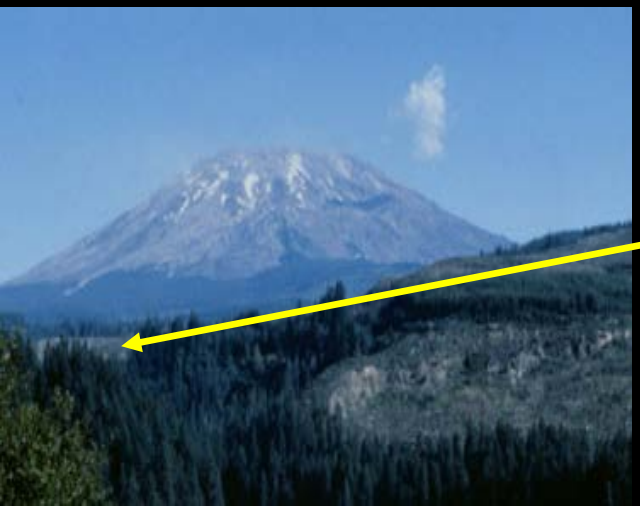
Sub-Soils in the Puget Sound Basin: Leftovers from glaciers & volcanoes

glacial till: unsorted, unstratified mixtures of clay, silt, sand, gravel, and boulders; deposited under ice, or in moraines

hardpan: till compacted under glacier

outwash soils: layers sorted by particle size by water - sand / gravel / rocks

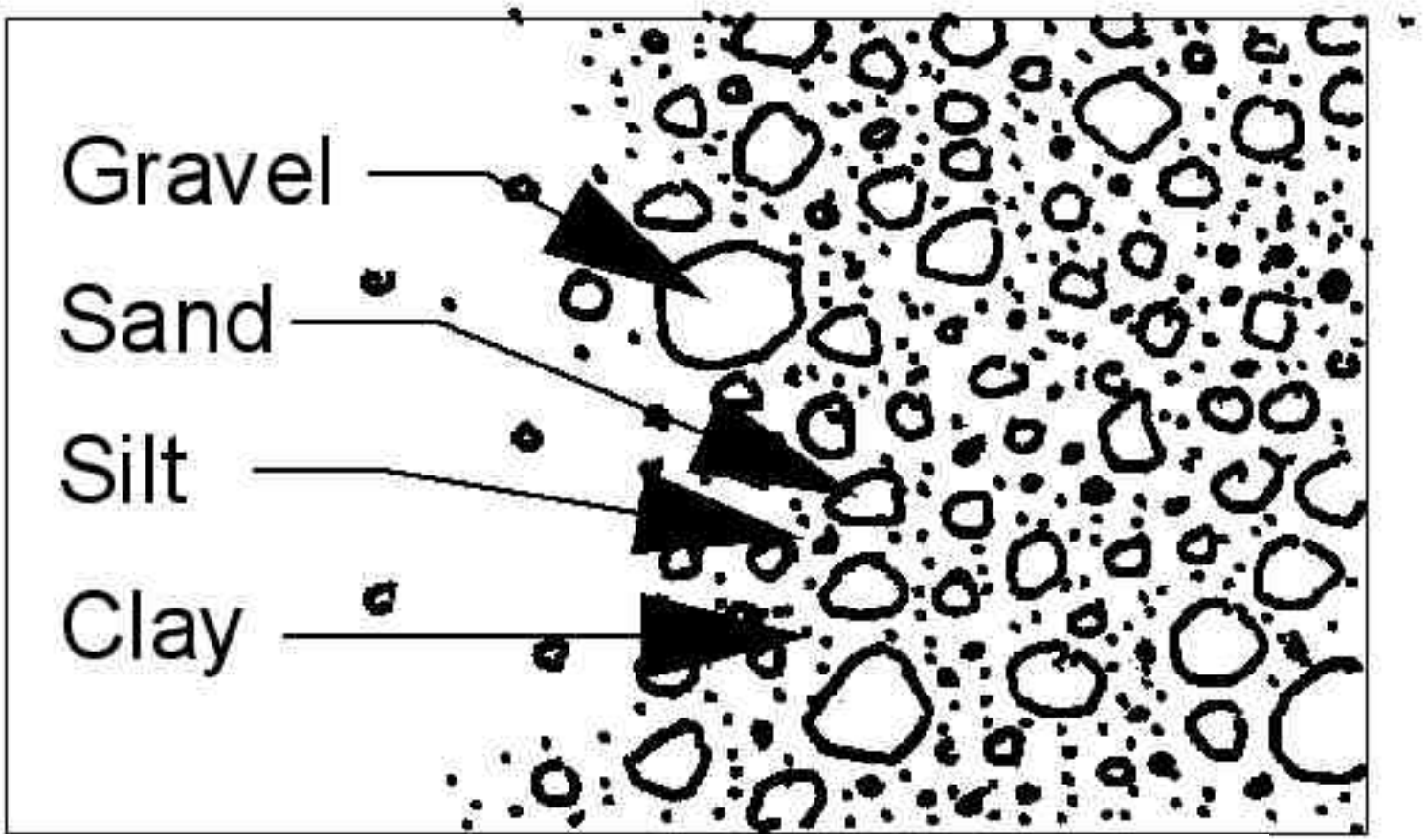
lake/marine bed soils: clay or silt that settled out in lakes & estuaries



volcanic ash: light, fertile, holds moisture - mostly blown east of Cascades

mudflows: mixed size, compact - like till

Learn about Puget Sound soils at:
www.puyallup.wsu.edu/soilmgmt/Soils.html



Soil Texture (= particle size)

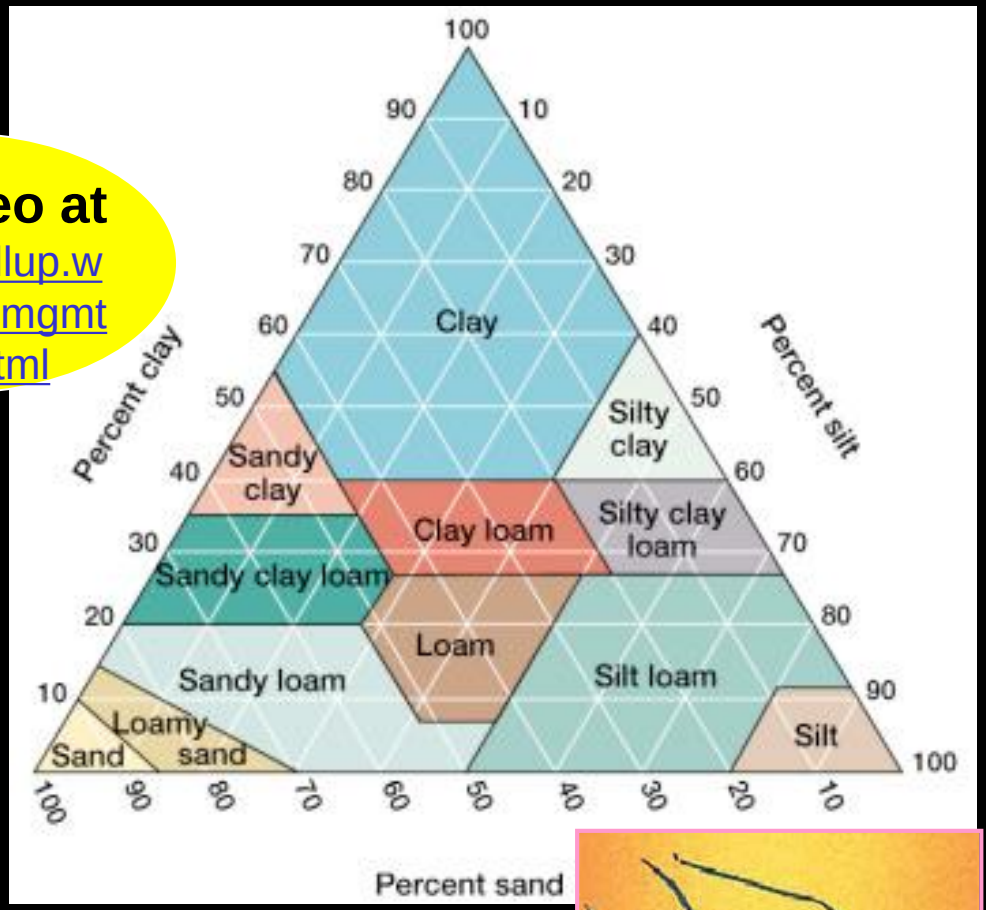
Soil Texture Test

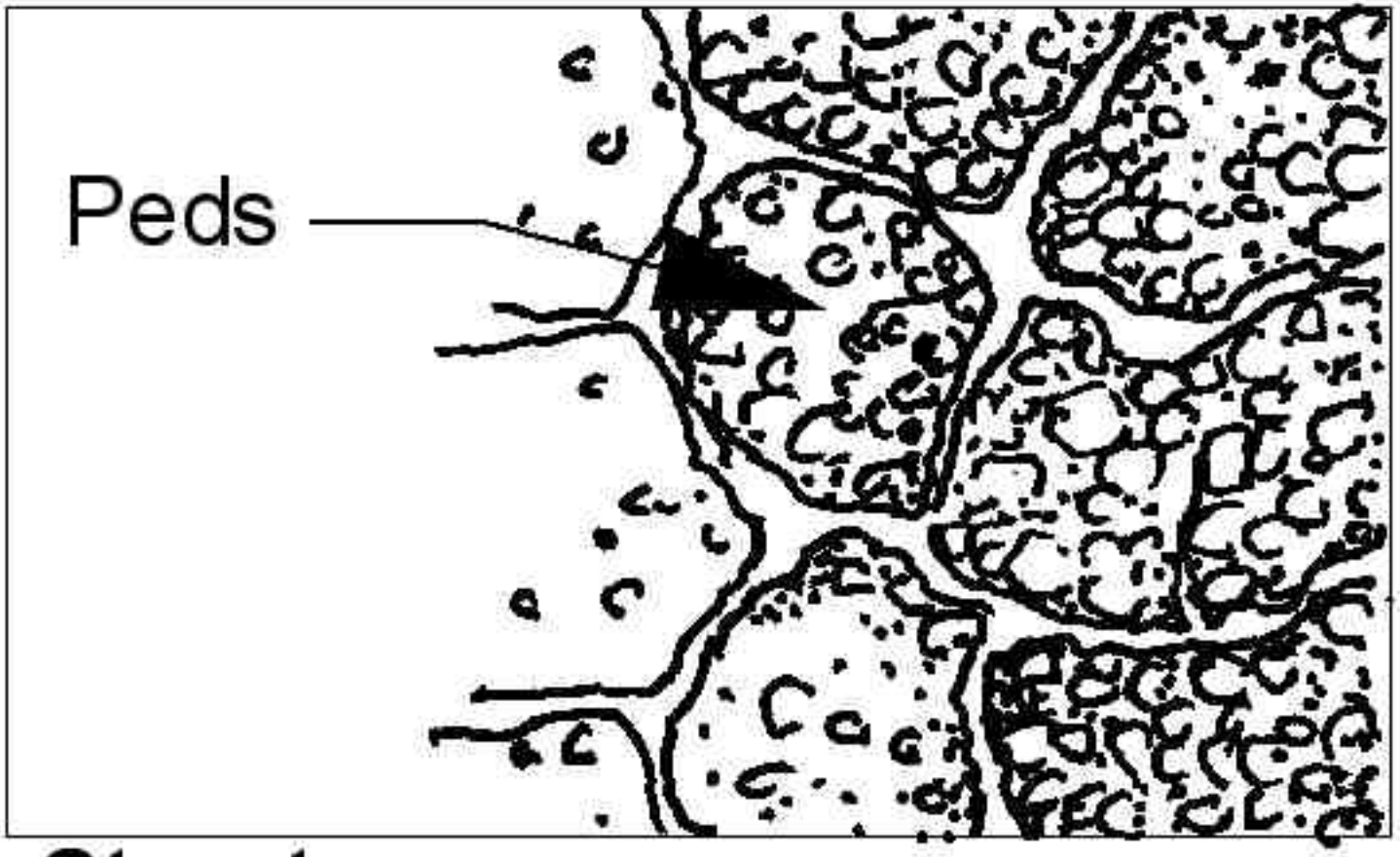
See video at www.puyallup.wsu.edu/soilmgmt/Soils.html

Ribbon+feel test:

Moisten soil, roll between hands, then squeeze out with thumb:

- Sand: no ribbon, grainy
- Sandy loam: ½ inch ribbon
- Loam: thick 1 inch ribbon
- Silt: makes flakes rather than ribbon
- Silty clay loam: thin, breaks easily, has floury feel
- Sandy clay loam: stronger, has grainy feel
- Clay: long (3 inch) ribbon, has smooth feel

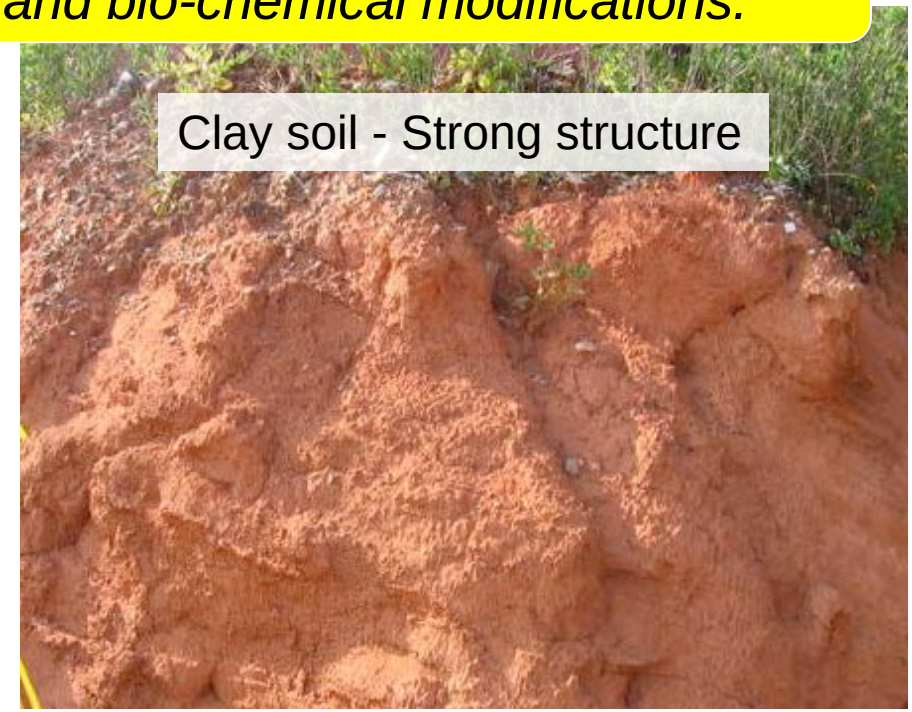


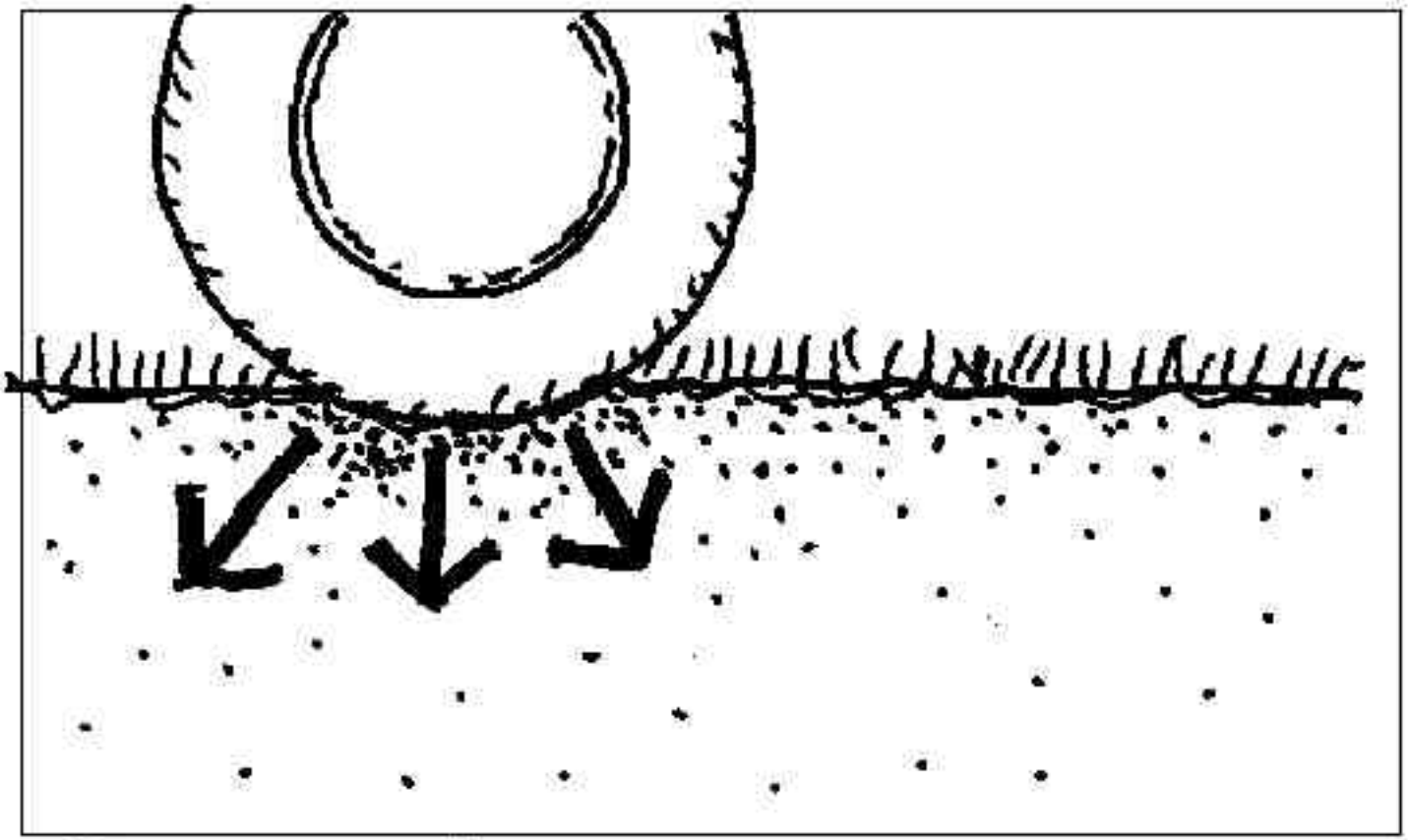


Structure

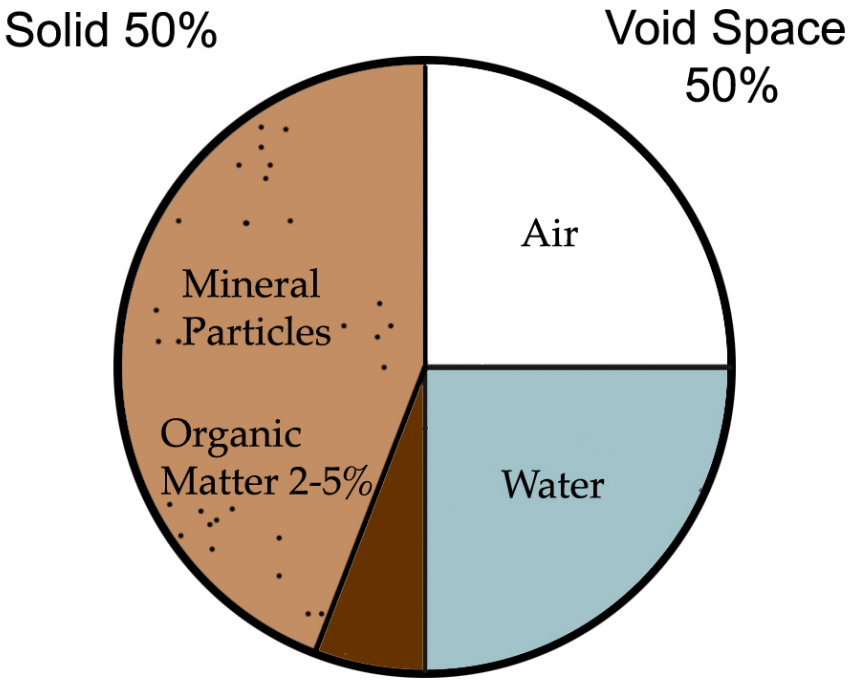
Don’t grind up your soil! Mix loosely to preserve the peds.

Organic amendments (compost) improve structure in all soil types, through biological activity and bio-chemical modifications.

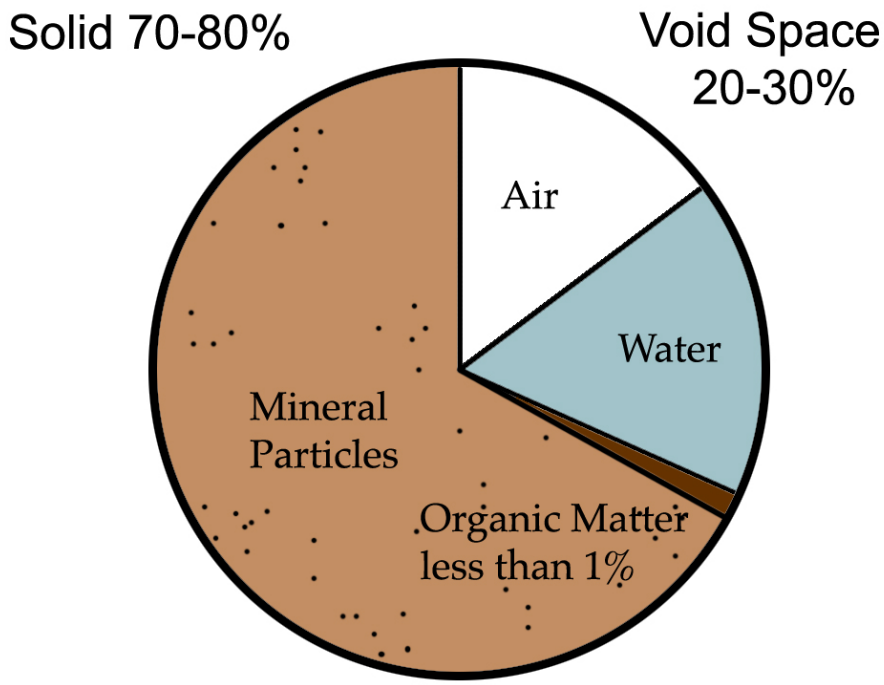




Density or Compaction



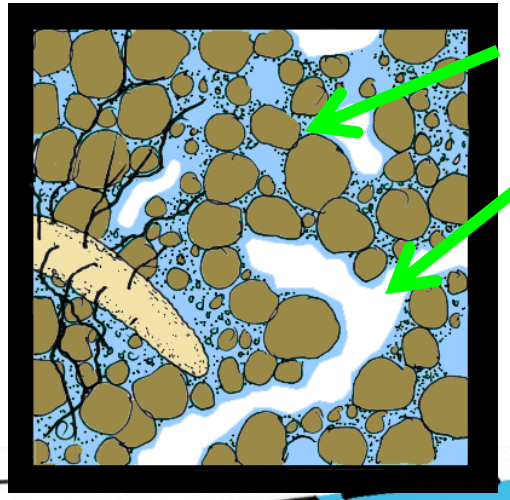
IDEAL FOREST SOILS

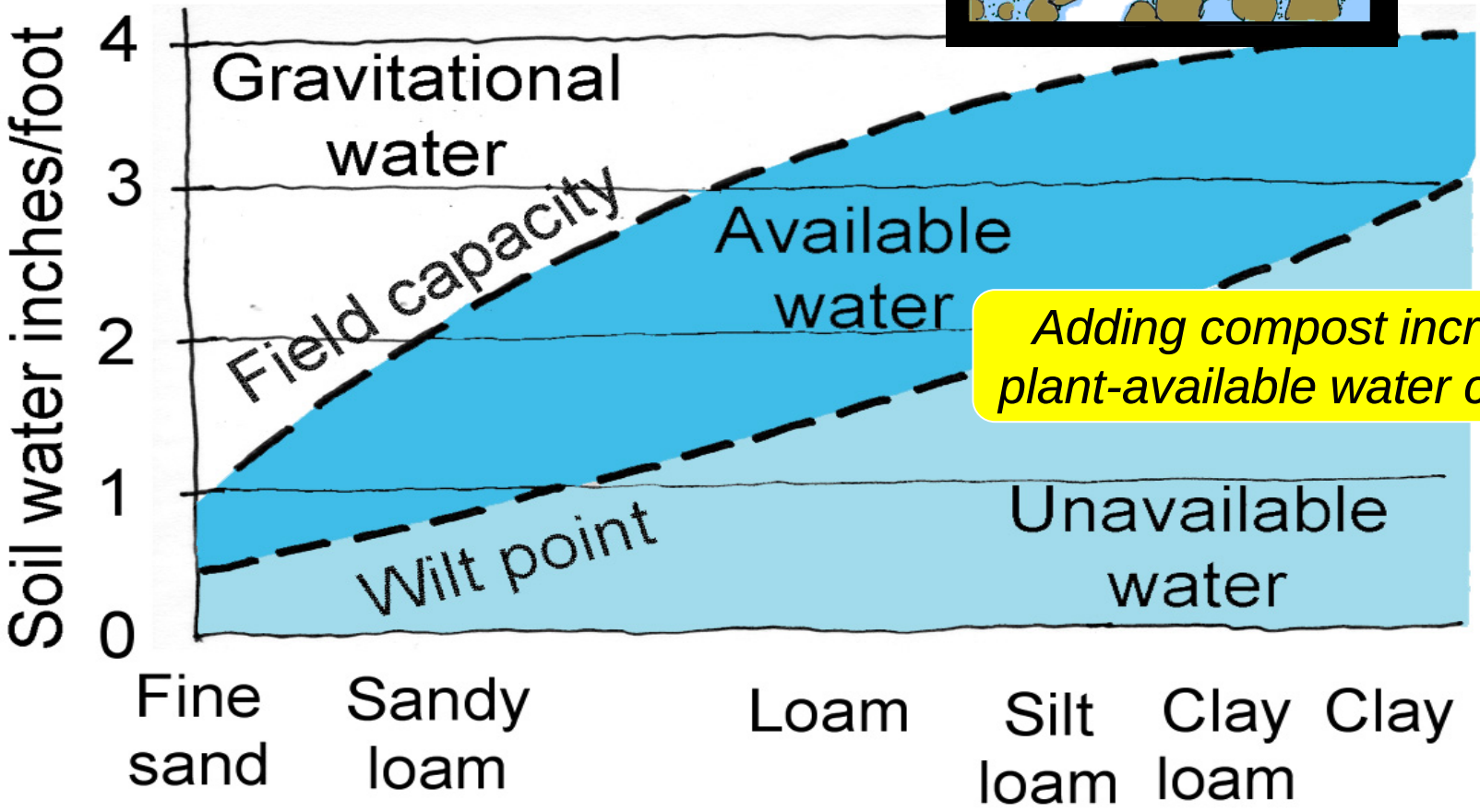


URBAN SOILS

As compaction increases, pore space for water and air decreases

Plant-available water depends on pore spaces and organic matter





Adding compost increases plant-available water capacity

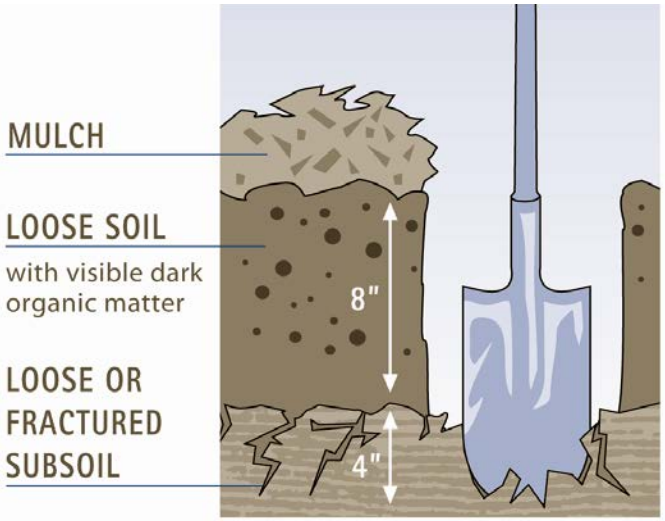
Examining a soil profile with a soil probe / core sampler

Only works 6 -12” deep, so better for lawns than trees.

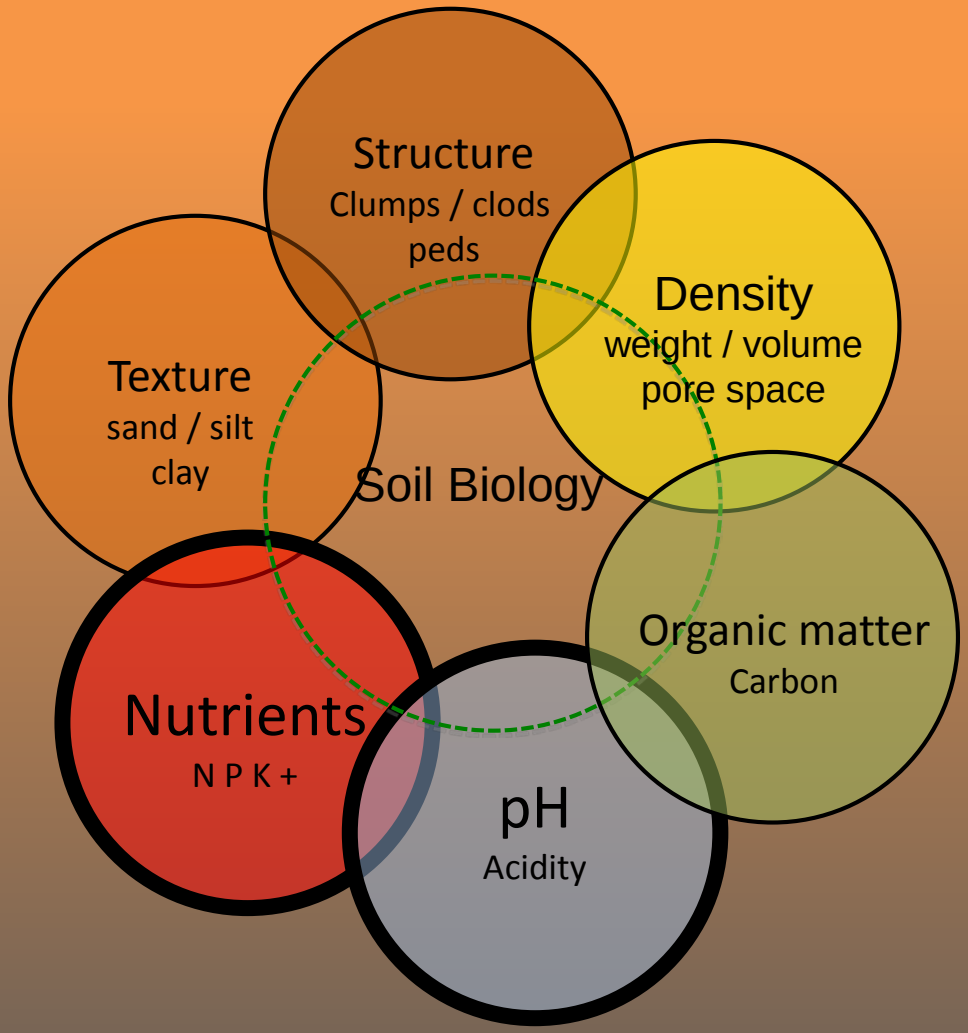
Compacted vs. Amended

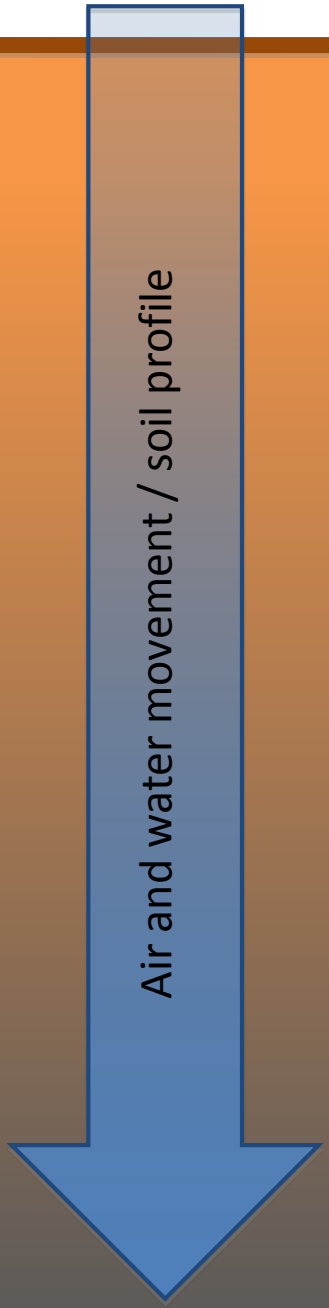
Examining soil profile with shovel

To verify scarification of subsoil and amendment of upper 8” with compost.



Chemical properties of soil





Elements Required by Plants

Base elements	Macronutrients	Micronutrients
Oxygen (O)	Nitrogen (N)	Boron (B)
Hydrogen (H)	Phosphorus (P)	Chlorine (Cl)
Carbon (C)	Potassium (K)	Cobalt (Co)
	Calcium (Ca)	Copper (Cu)
	Magnesium (Mg)	Iron (Fe)
	Sulfur (S)	Manganese (Mn)
		Molybdenum (Mo)
		Zinc (Zn)

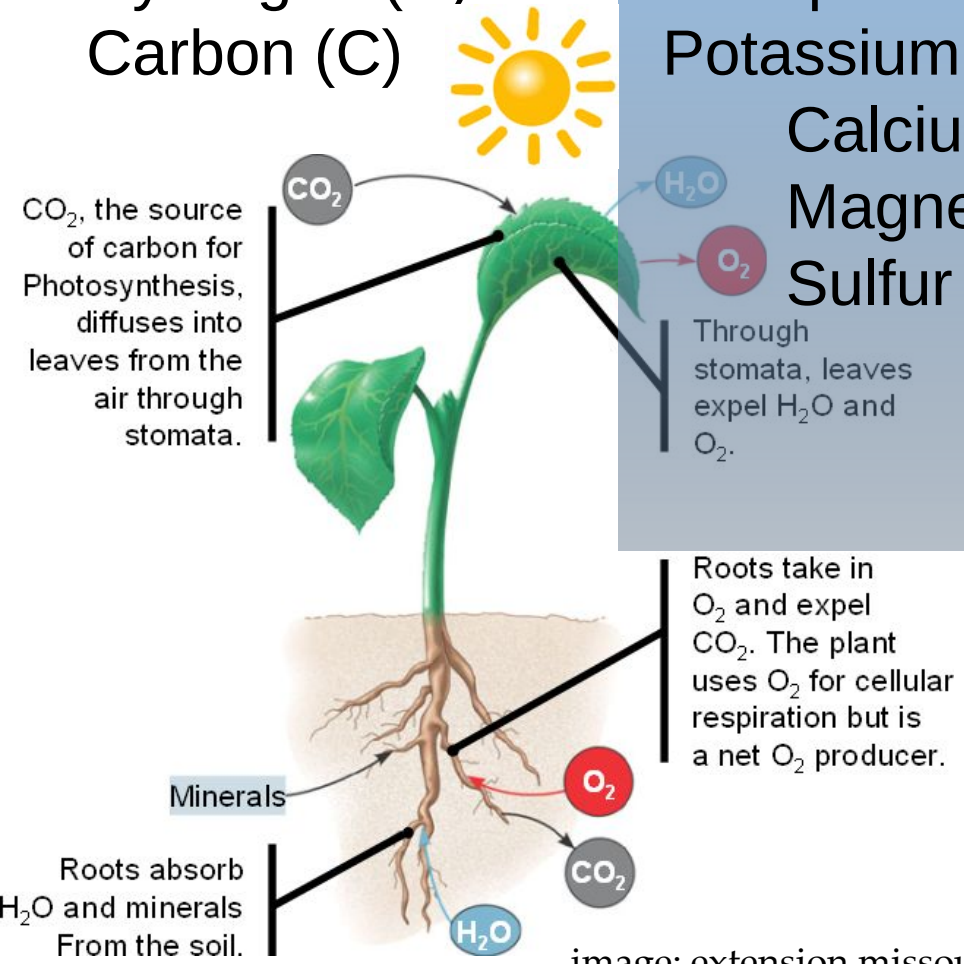
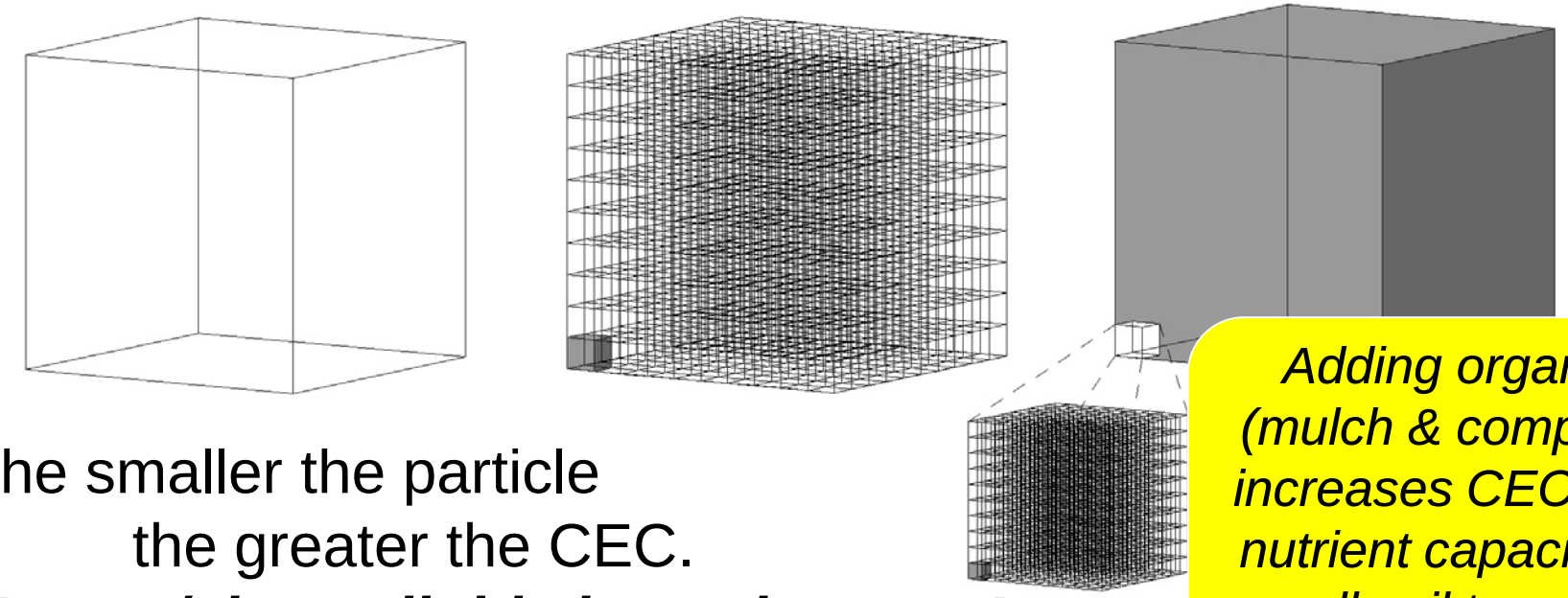


image: extension.missouri.edu

Adding compost increases nutrient availability to plants!

Sand	Silt	Clay
1 Particle Fine **Sand** .2mm	1,000 Particles **Silt** .02mm	1,000,000 Particles **Clay** .002 mm
0.24mm^2 Surface Area	2.4 mm^2 Surface Area	24 mm^2 Surface Area

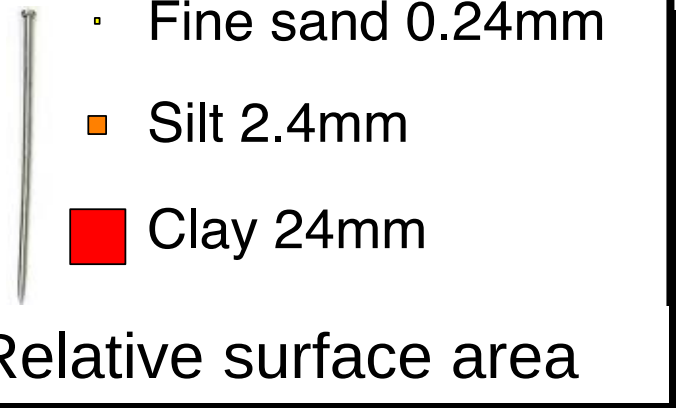


The smaller the particle
the greater the CEC.
Humus/clay colloids have the most!

Adding organic (mulch & compost) increases CEC and nutrient capacity of all soil types.

Cation Exchange Capacity *(CEC) for planting soil mixes*

Low fertility soil	Less than 5
Medium fertility	5-10
High fertility	10-30
Compost/humus	**up to 200!**



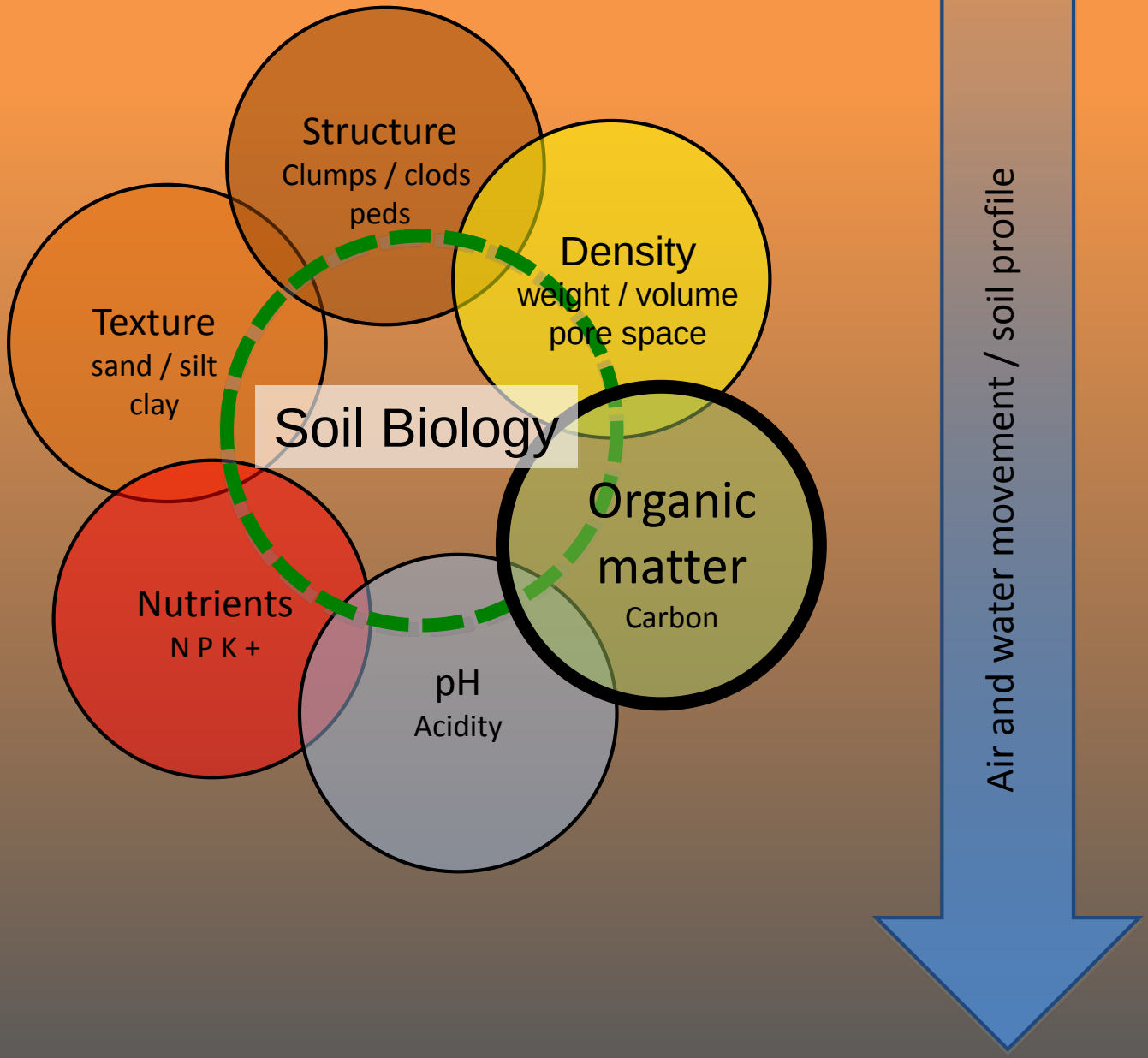
USDA pH Classification

	pH range	
Ultra acid	1.8 - 3.4	Toxic to most plants
Extremely acid	3.5 - 4.4	Restrictive to most plants
Very strong acid	4.5 - 5.0	
Strongly acid	5.1 - 5.5	Acid-tolerant plants
Moderately acid	5.6 - 6.0	
Slightly acid	6.1 - 6.5	Best nutrient availability for most plants
Neutral	6.6 - 7.3	
Slightly alkaline	7.4 - 7.8	Alkaline-tolerant plants
Moderately alkaline	7.9 - 8.4	
Strongly alkaline	8.5 - 9.0	Restrictive to most plants
Very strongly alkaline	9.1 - 11.0	Toxic to most plants

Lower or higher pH decreases availability of different nutrients

Adding humus (compost) buffers soil pH towards 6.3 to 6.8, best for nutrient availability to plants

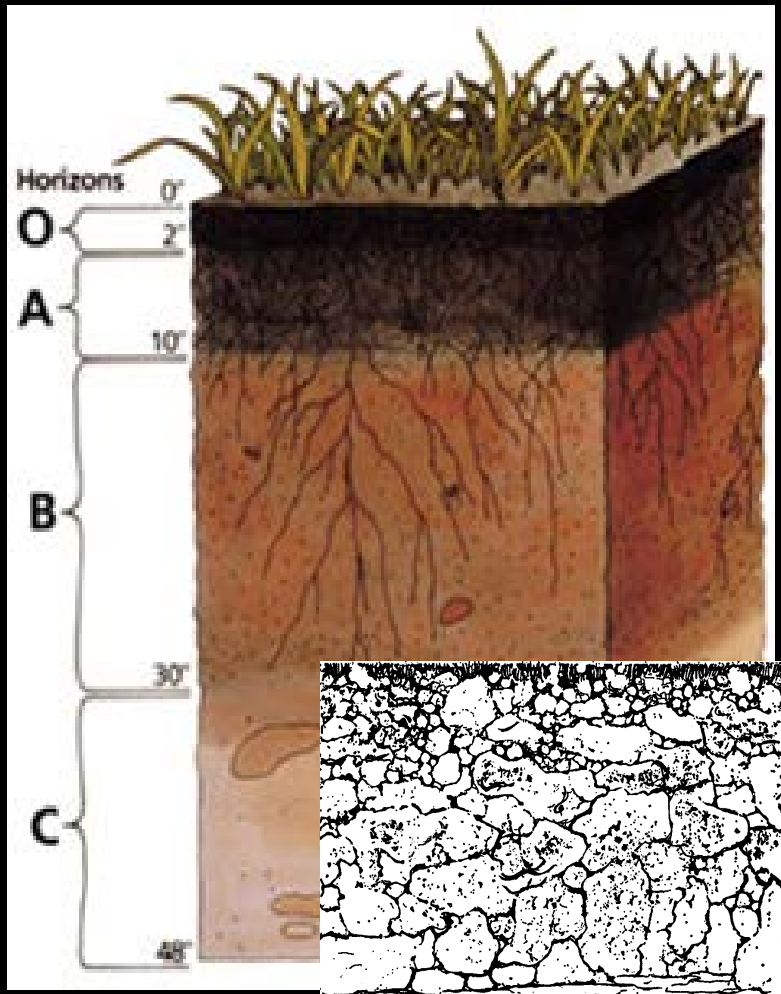
Organic & Biological properties of soil

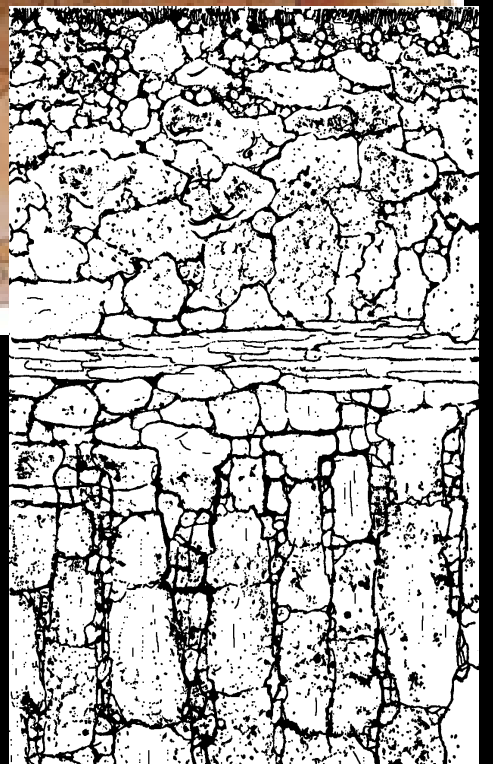


Soil development from parent “dirt” & rock – *biology in action!*

<u>Soil horizons & their evolution</u>

- Substratum (C) or bedrock (R) weathers physically & chemically to subsoil (B)
- Primarily <u>biological</u> processes create topsoil (A) and organic (O) horizons



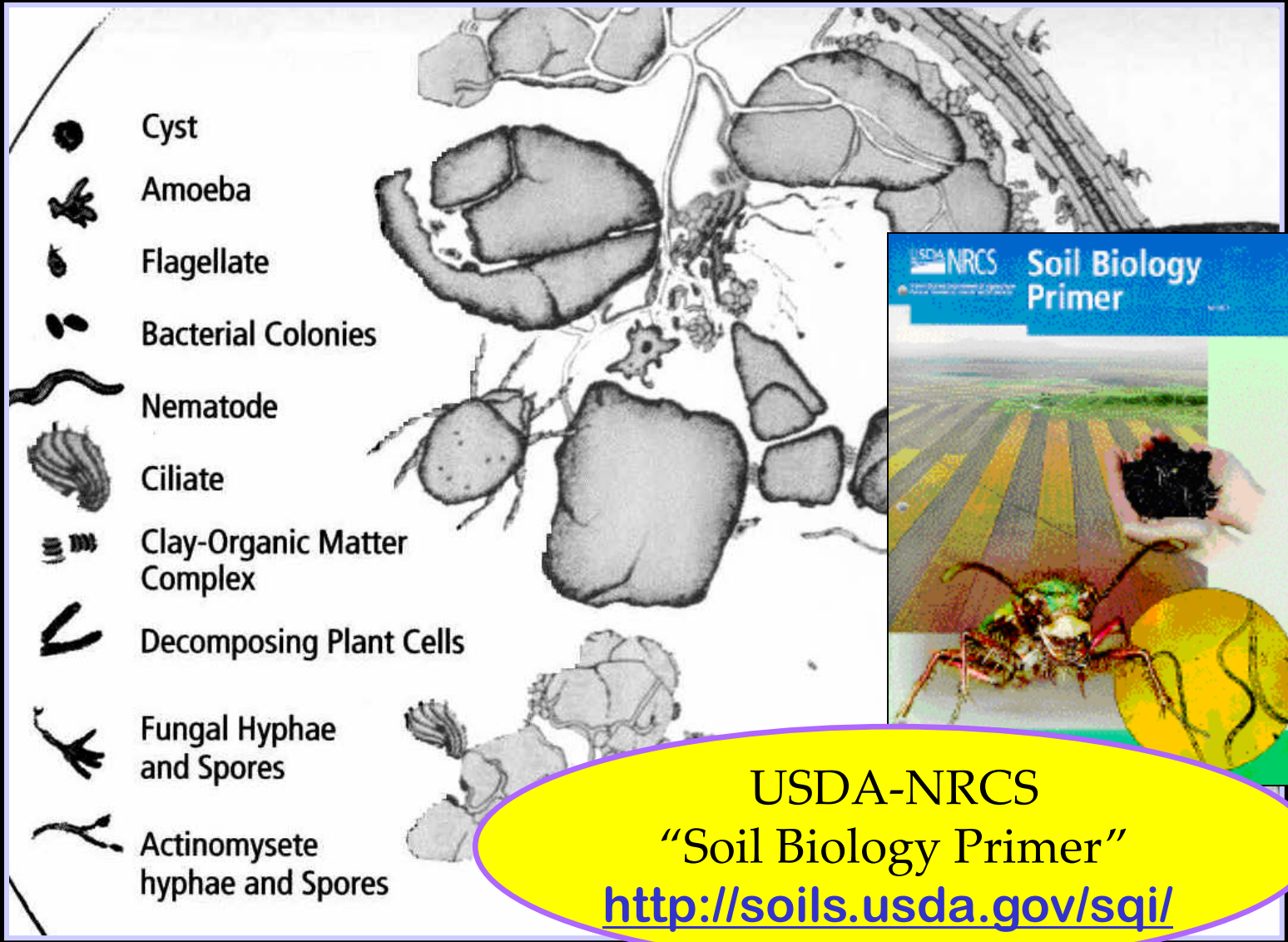


USDA - NRCS

http://soils.usda.gov

Understanding Soil Biology
Soil life provides essential functions

Soil is alive!

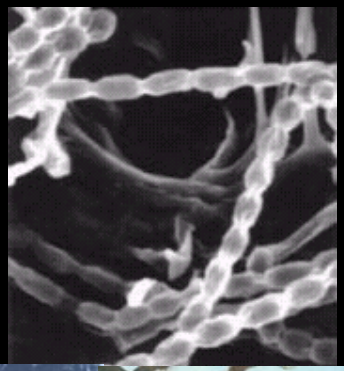


USDA-NRCS
"Soil Biology Primer"
http://soils.usda.gov/sqi/

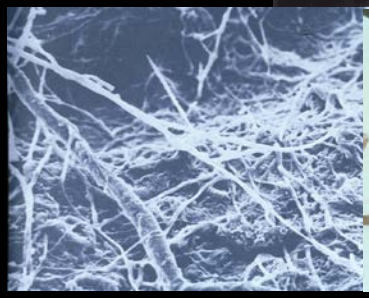
S. Rose & E.T. Elliott

Common organisms in the soil foodweb

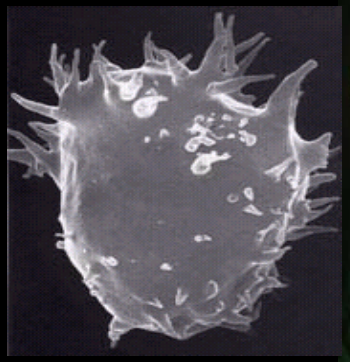
Bacteria



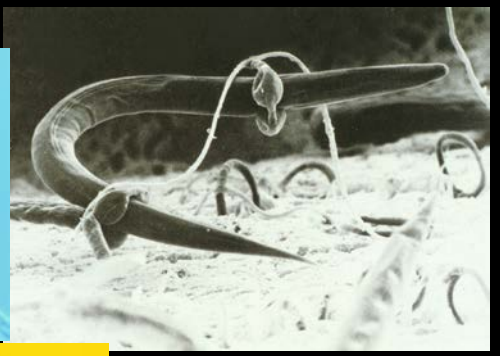
Fungi



Protozoa

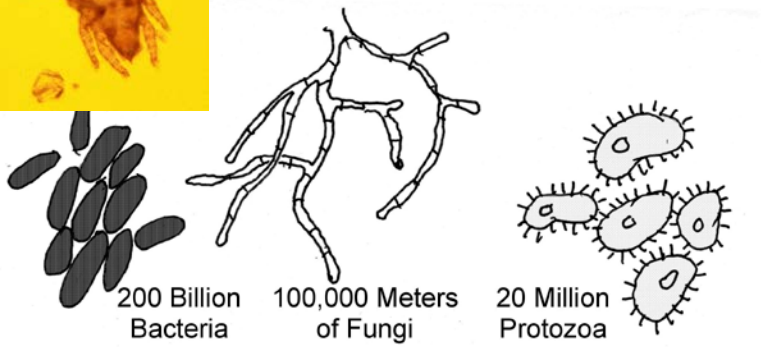


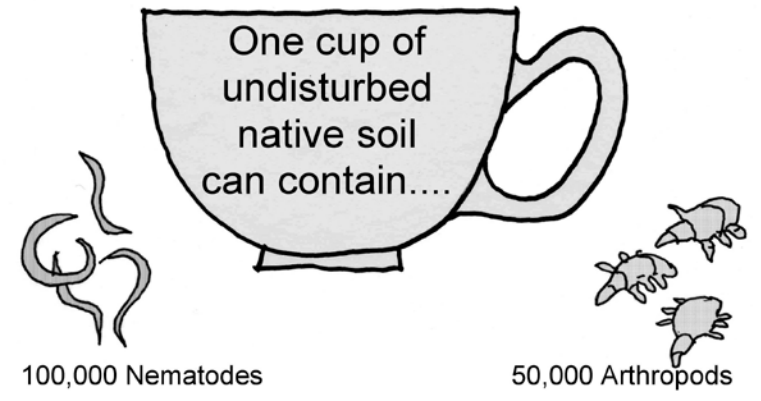
Nematodes



Arthropods

Earthworms

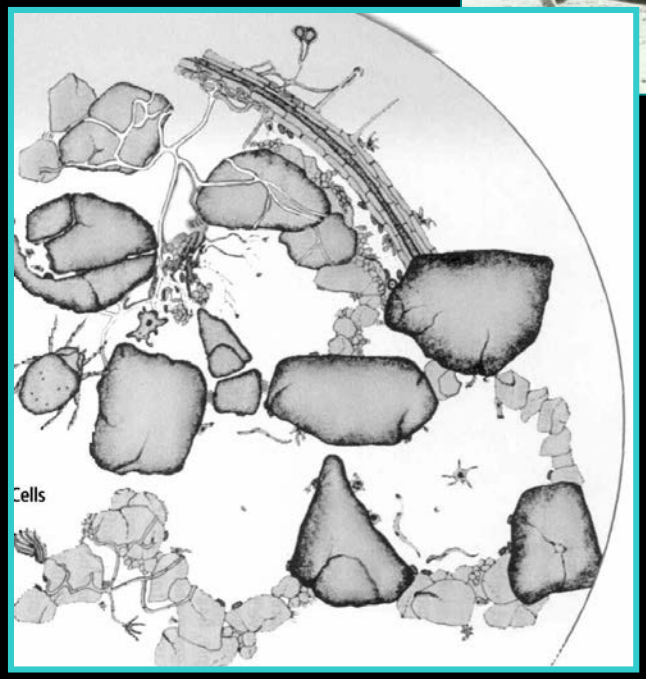


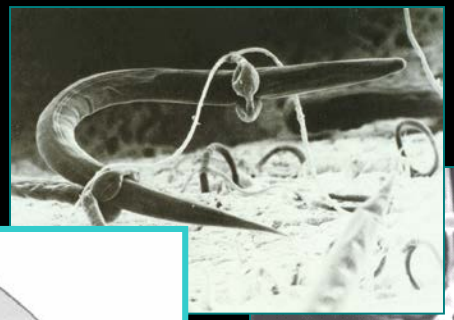


Restoring soil life, to restore soil functions

Soil organisms create:

- soil structure
- fertility = nutrient cycling
- plant disease protection
- Bio-filtration
- erosion control
- stormwater detention & moisture capacity





Compost kickstarts the soil ecosystem!
(Provides food and home for organisms)

How can we enhance & restore soil biodiversity, to improve plant growth, water quality, and reduce runoff?

- Prevent /reduce compaction (keep heavy machinery off)
- Reduce intensive use of pesticides & soluble fertilizers
- Incorporate compost into soil, and mulch regularly, to feed soil life

organic matter + soil organisms + time
creates ⇒
soil structure, biofiltration, fertility, & stormwater detention

Plants as indicators of soil differences and problems

WSDOT

I-5 Marvin Rd. Interchange

Which site is selling the next job?

Which needs more water, fertilizer, weed control?

Compost

No Compost

UW trials: up to 50% reduction in storm water runoff when glacial till soil is amended with compost.

Constantly smell the soil! Sour odor indicates poor drainage

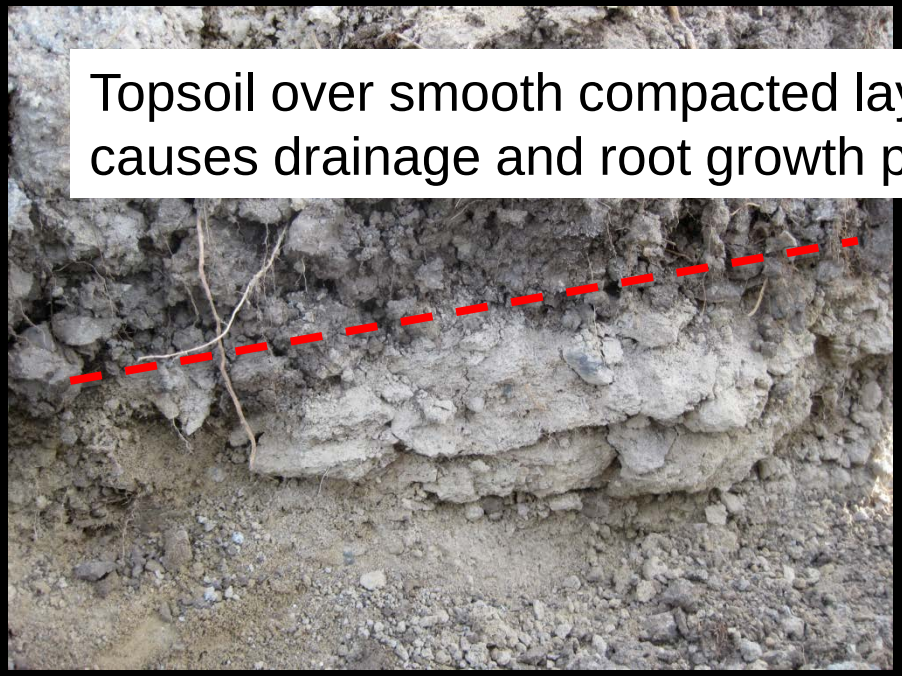
Grey color, poorly draining soil

Regulatory requirements
for new construction, in WA Dept. of Ecology's *Stormwater Mgmt. Manual for Western WA*

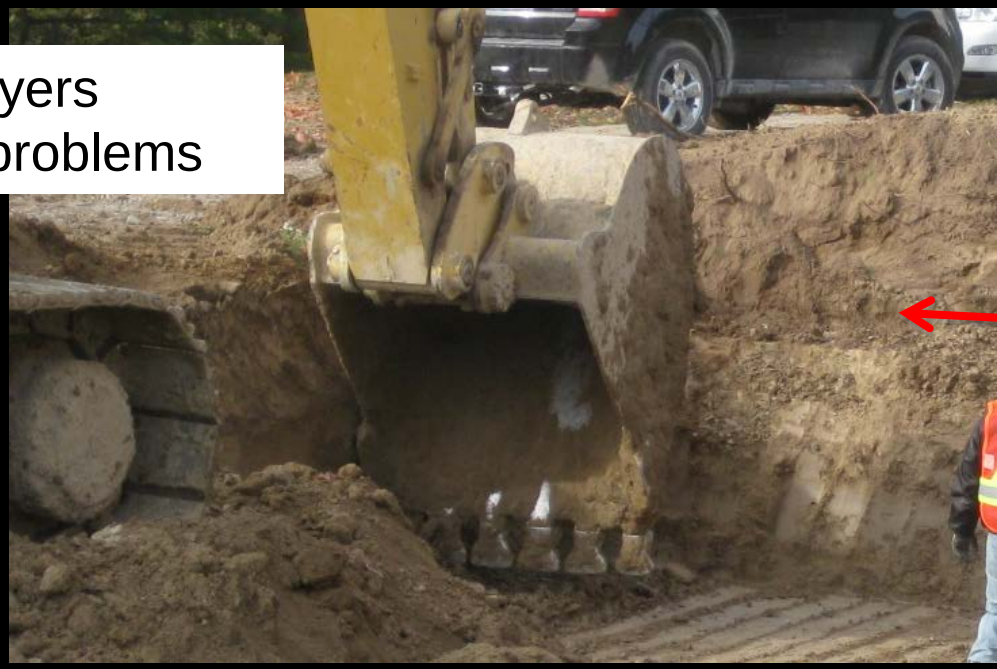
BMP T5.13 "Post-Construction Soil Quality and Depth"

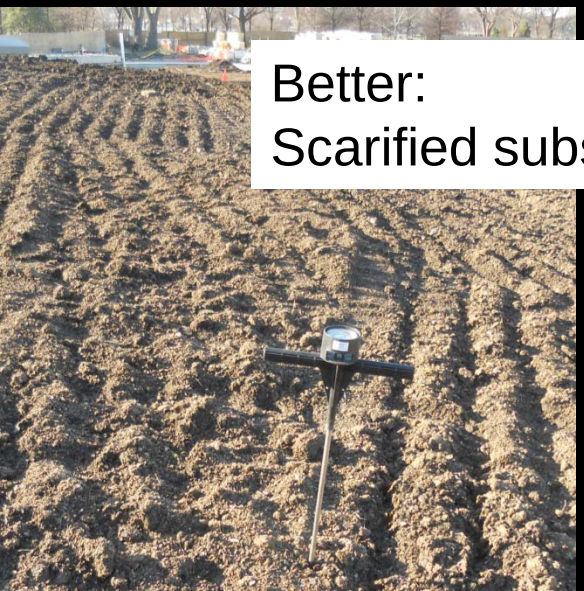
- Retain native soil and duff wherever possible
- All areas cleared and graded require 8 inch soil depth:
  - Organic matter content ≥ 10% dry weight (5% for turf)
  - Use native topsoil, amend existing soil with compost, or import topsoil blend
  - Subsoil scarified 4 inches below 8-inch topsoil layer
  - Protect amended soil from compaction
  - Mulch after planting
  - Maintenance practices to replenish organic content

Soil Interfaces



Topsoil over smooth compacted layers causes drainage and root growth problems





Better:
Scarified subsoils

Loss of organic matter

- Plan to preserve existing soil & vegetation where possible
- Minimize grading, cut and fill
- Minimize traffic off road bases
- Even a low-organic subsoil can be substantially restored by amending 10-25% (by volume) with mature, stable compost.

Chemical changes

- pH (sometimes due to compacted, anaerobic conditions)
- Nutrient deficiencies (loss of topsoil)
- Toxins: oil, metals, chemicals

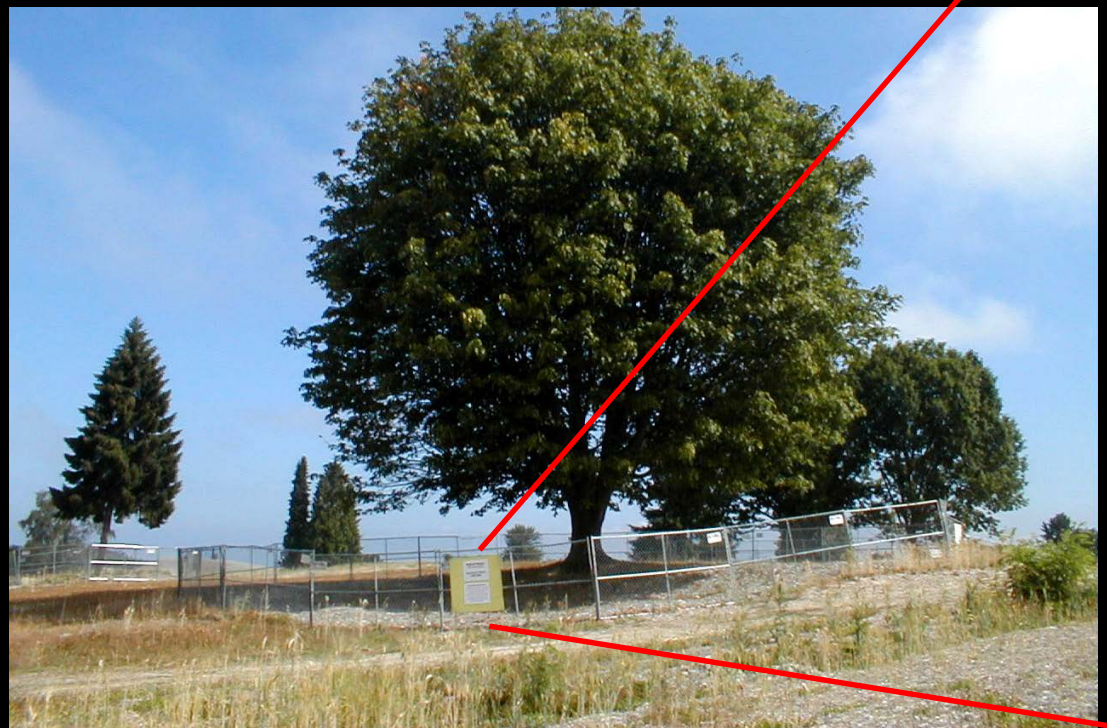
Compost amendment tends to correct all of these

Visually examine and smell, then test for suspected deficiencies, toxins, & pH

Chose well-adapted plants, tolerant of your soil conditions (pH etc.)

Protect soil & vegetation during construction

- Fence ***vegetation & soil protection zones***
- Inform all contractors & subs: no stockpiles etc.
- If temporary vehicle access required, place steel plates over 6” coarse wood chip.



Restoring soil in place

- Place sub-drainage if req'd
- Range of equipment for different-sized sites
- If compacted, rip (scarify) to 12-18" depth before or while amending
- 2-4" compost mixed into upper 8-12" of soil

Soil harvesting, storage, & re-installation

- Harvest at start of grading
- Store covered with breathable fabric, coarse wood chips, or sterile annual grass to prevent erosion and weeds
- Amend with compost just before re-spreading
- Rip in first lift to avoid sharp soil interfaces (which can limit air and water movement)
- Don’t work soil when saturated

Soil Installation
Working with soils with retained peds

Teeth on loader bucket

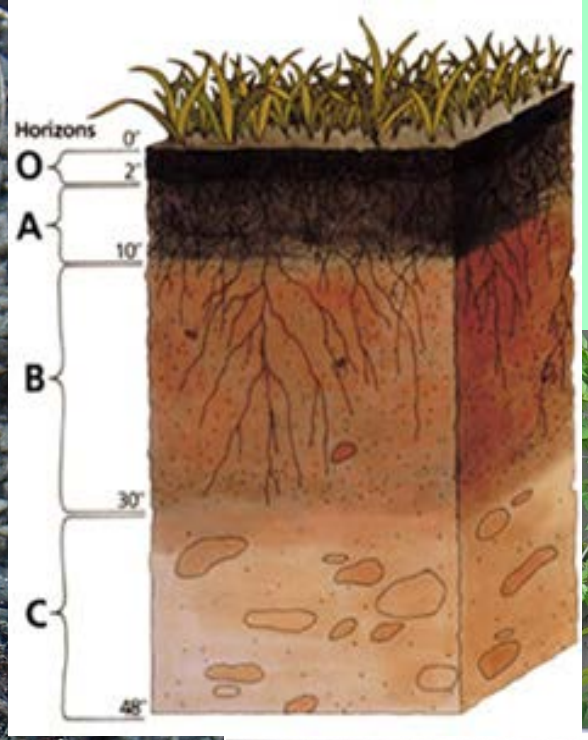
Constantly loosen soil while installing to avoid buildup of deep compaction. Back drag over loader tracks each time.

Require all equipment to have teeth on bucket to scarify soil

Require low ground pressure equipment (4 psi preferred - 5 psi max)

Amending soils on site

- Place sub-drainage if req'd
- Range of equipment for different-sized sites
- If compacted, rip (scarify) to 12-18" depth before or while amending
- 2-3" compost mixed into upper 8-12" of soil



Add Compost: Most of it in the top layer of the soil profile – *mimic natural profile!*

How to Select Compost

Know your supplier!

Field tests:

- earthy smell - not sour, stinky, or ammonia
- brown to black color
- uniform particle range
- stable temperature (does not get very hot if re-wetted)
- not powdery or soaking wet

Soil/compost lab test info:

- Nutrients
- Salinity
- pH
- % organic content (OM)

Mfr.-supplied info:

- State permitted composting facility
- Meets US Compost Council (STA) "Seal of Testing Assurance" TMECC lab test methods, specs:
  - C:N ratio
  - Weed-seed trials
  - Nutrients, salinity, contaminants
  - Size: "screen", % fines

Stability /Maturity:

- use Solvita test on-site (> 6)

or

- rely on mfr's TMECC tests: CO^2 evolution and seedling growth

Compost Based Erosion Control BMPs

- EPA-approved BMPs: **blankets**, **berms**, and **socks** see www.buildingsoil.org
- "2 for 1" value – use compost for erosion control, then till in at end to restore soil:
  - No disposal costs
  - Faster planting, better growth
- Costs: blankets similar to rolled products, but savings on disposal, plus 2 for 1 benefits

More info at **www.BuildingSoil.org**

Soil biological additive products

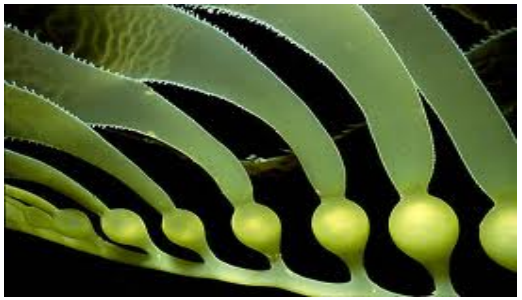
Compost teas – useful in remediation, but just use good compost for soil preparation

Mycorrhizal inoculants – species specific, also in soil from healthy trees

Kelp & other organic additives – match plant nutrient needs – good for micronutrients

Fertilizers – stick with organic sources, match plant needs – compost often supplies most needs for establishment.

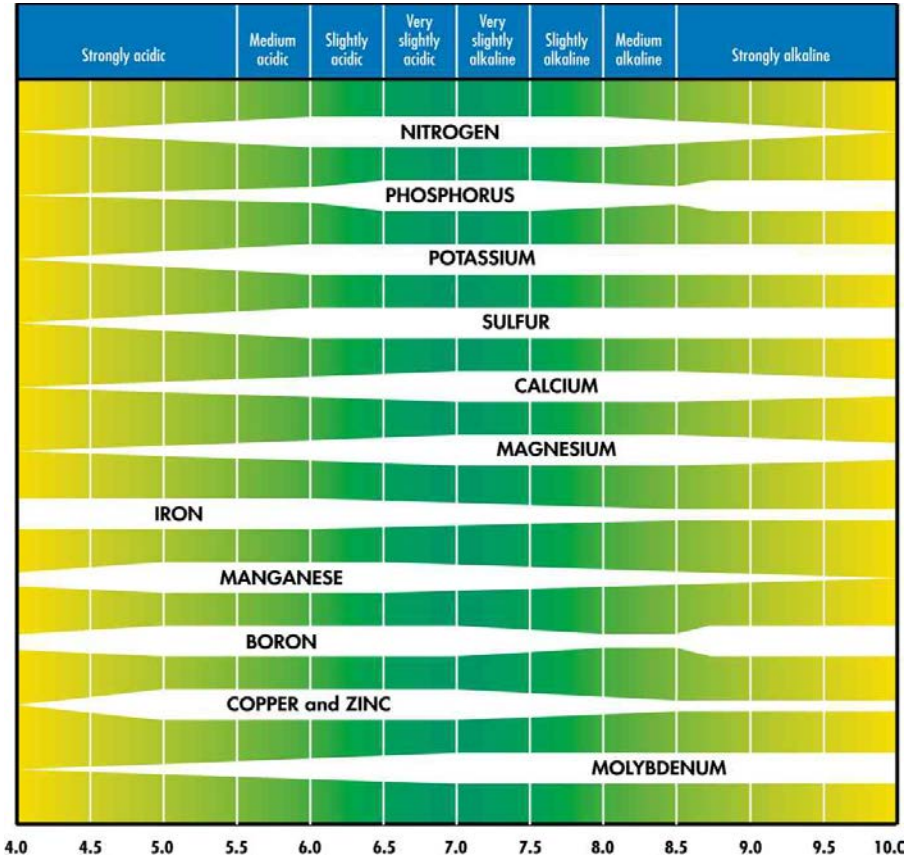
Base fertilization on soil test results!



Soil chemistry & pH modifications

- **Match plant selection to site soils**, rather than trying to modify chemistry
- Compost buffers pH, acid or alkaline towards optimal 6.3-6.8
- Compost increases cation exchange capacity (CEC) = nutrient storage & avail
- Lime as needed for Ca & Mg plant needs
- Sulfur applications only lower pH temporarily

Plant problems?
Get a soil test.



Rationale for less fertilizer for urban trees and landscapes

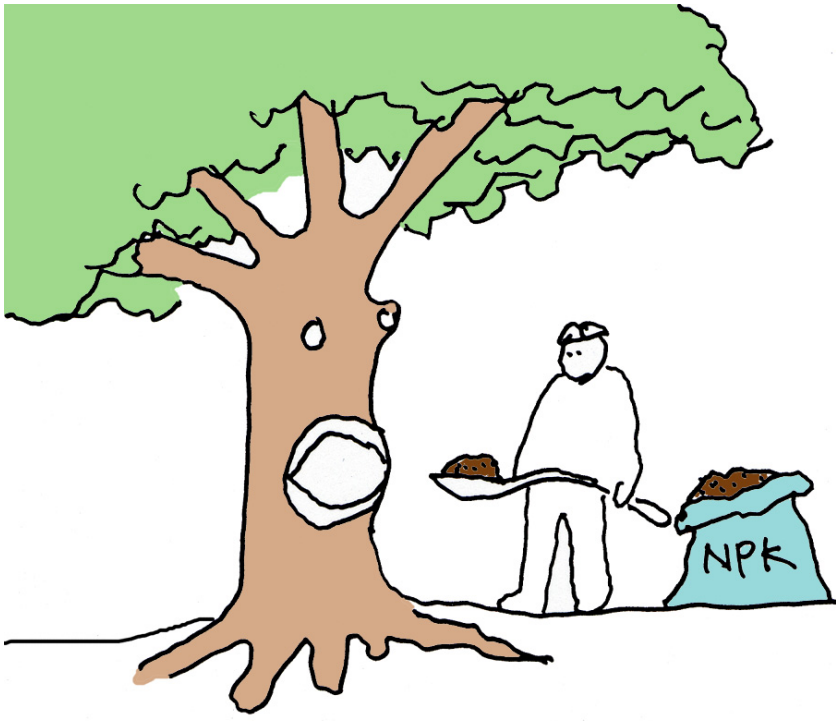
Not crops – Fruit production or crop yields not required

Sufficient required nutrients available to support plant goals

No yearly harvest/removal of biomass

Slower growth may be a desirable trait

Too much N increases sucking insects and foliar diseases, and annual weeds



Feed the soil, not the plant by mulching and leaving fallen leaves.
Plant problems? Get a soil test.

Soil Maintenance

Using mulches after planting and for annual maintenance

BENEFITS:

Mulches limit weed growth, and make weeds that sprout easier to pull or cultivate.

Mulches conserve water, moderate soil temperature, and reduce erosion.

Mulches replenish soil organic matter, enhancing soil biodiversity, structure, and nutrient cycling
= increased plant vigor.

Mulching

WHEN After planting, and once every year or two:
- Spring or fall on trees and shrubs to prevent weeds.
- Early summer on gardens. (Let soil warm up.)
- Fall on beds to prevent erosion and compaction.

WHERE Whole beds, paths, 3 ft. or larger ring around trees & shrubs in lawns.

HOW Remove weeds & grass before spreading mulch. Keep mulch away from plant stems. Use cardboard weed barrier (not fabric) to control aggressive weeds.

Mulching

WHAT

Woody mulches (arborist wood chips, bark) for woody plants (trees & shrubs).

Non woody mulches (compost, leaves, grass clippings, composted manure or biosolids) for non-woody plants (annuals, perennials, berries, roses).

HOW MUCH

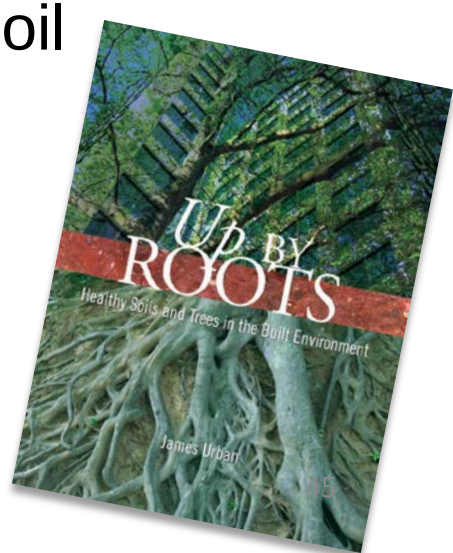
Compost, leaves, sawdust, fine bark, grass clippings: 1-2” deep.

Wood chips or coarse bark: 2-4” deep.

Other Soil Maintenance Practices

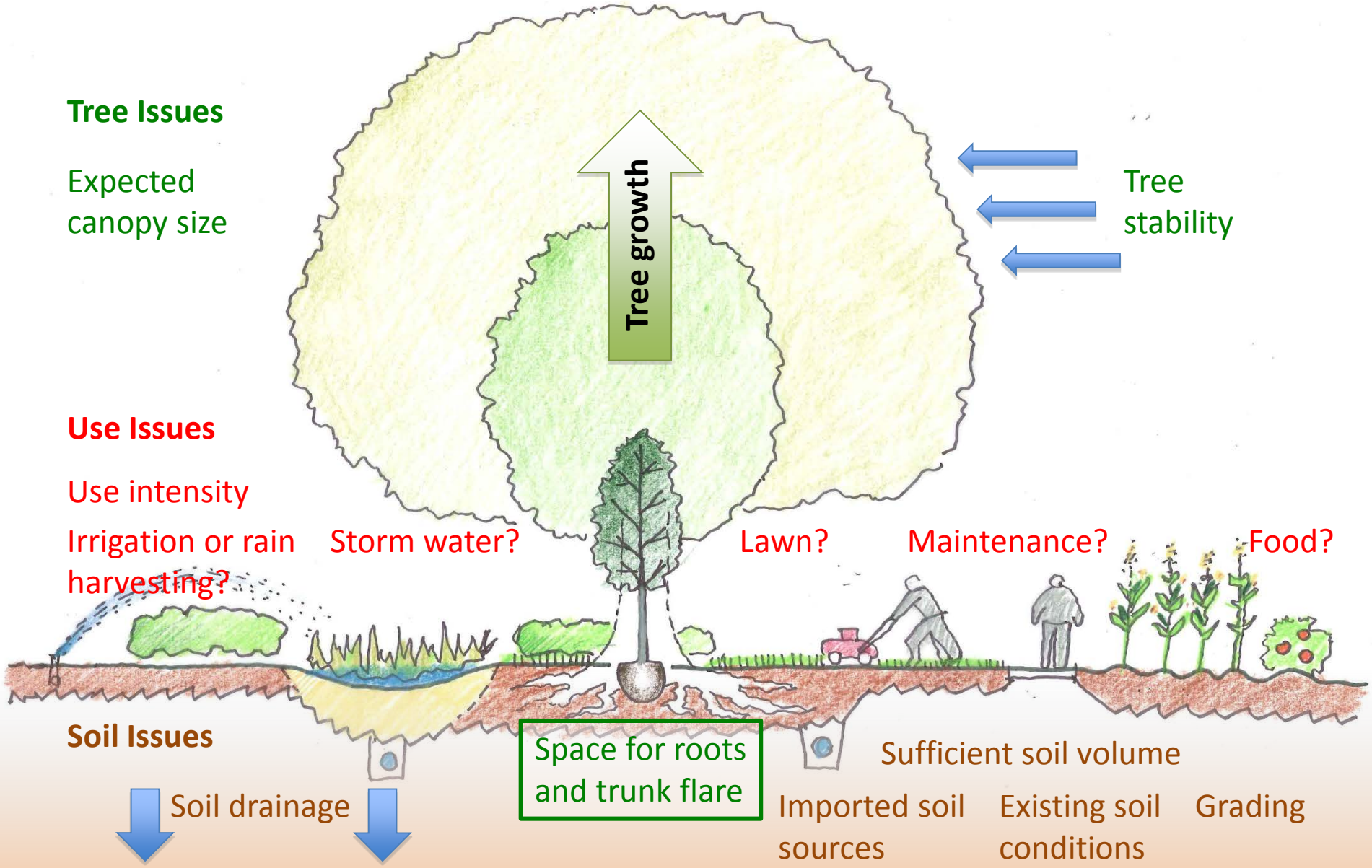
- Leave plant litter, recycle fall leaves and chipped prunings into mulch on site.
- Mulch-mow lawns (leave the clippings)

- Base all fertilizer applications on soil tests (every 1-3 years on most sites).
  Learn about soil testing at
  www.puyallup.wsu.edu/soilmgmt/Soils.html
  See videos and factsheets on "Collecting a soil sample", " "Determining soil texture by hand", and "Understanding soil test results".



- More urban soil remediation & maintenance strategies in *Up by Roots* by James Urban.

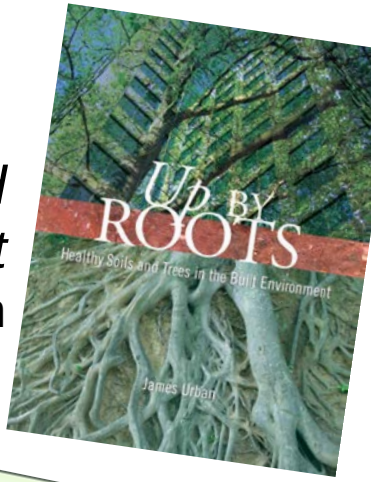
Soil Goals and Requirements – ***Right plant, right place, <u>right</u> <u>soil</u>!***



Resources to learn more:

WSU Soil Management – testing & more
www.puyallup.wsu.edu/soilmgmt/Soils.html

www.sustainablesites.org



Up By Roots: *Healthy Soils and Trees in the Built Environment*
By James Urban, available at Amazon

Building Soil Manual www.buildingsoil.org

Natural Landscaping: Design, Build, Maintain
and other resources in English and Spanish at
www.seattle.gov/util/landscapeprofessionals