Find out more about your soil!
Soil plug-in for Google earth
California Soil Resource Laboratory
SoilWeb Earth

And this too!
https://casoilresource.lawr.ucdavis.edu/see/

Support Soil Science and Student Farming
100% of profits go to funding student internships!
(and get a t-shirt that MEANS something…!)

Go to: soilforward.org

1

soilforward.org

2

3

soilforward.org

4

5

6

2 of the 12 Soil Orders

Aridisol

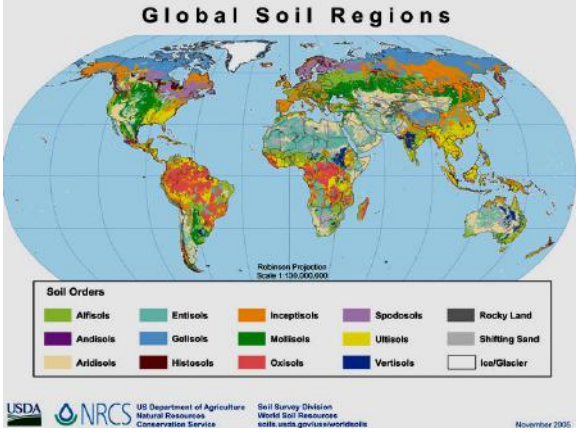
Mollisol

8

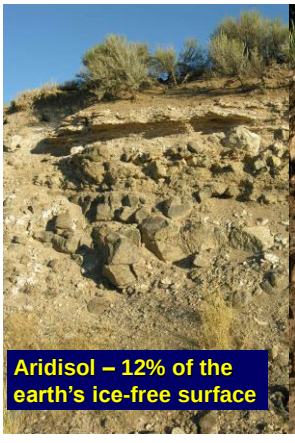
Soil!

7

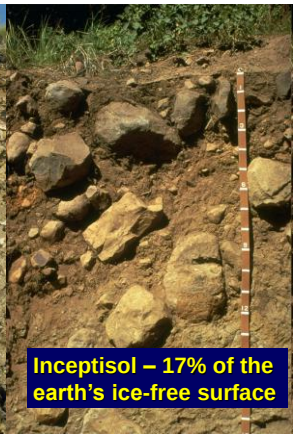
Global Soil Regions



10

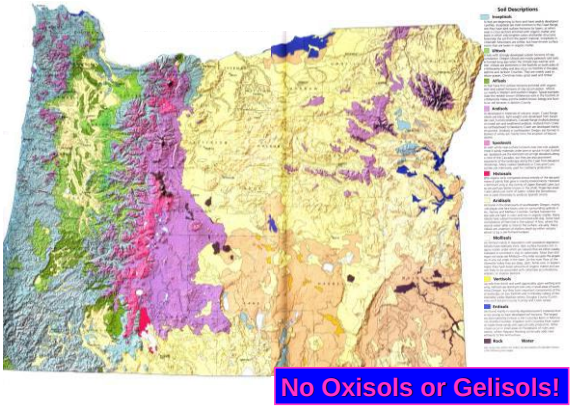


Aridisol – 12% of the earth's ice-free surface



Inceptisol – 17% of the earth's ice-free surface

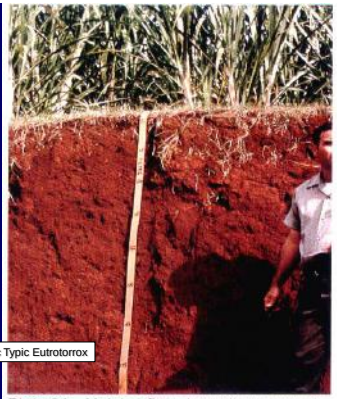
9



No Oxisols or Gelisols!

12

Oxisols



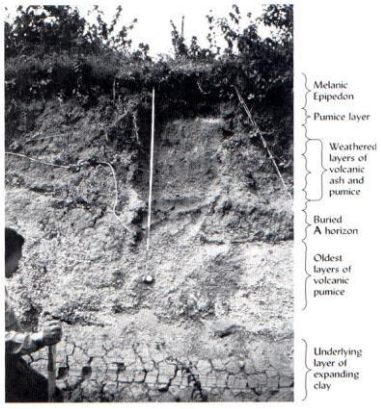
Very-fine, kaolinitic, isohyperthermic Typic Eutrotorrox

Plate 34 Molokai Oxisol growing sugarcane on Oahu, Hawaii. (A. R. Southard)

11

Andisols

Central Africa



14

13

Inceptisols

A 0 –5 cm
AB 5- 18
Bw1 18 - 33
Bw2 33 - 55
BC 55 - 76
C 76 – 100+

GEORGIA COARSE-LOAMY, MIXED, SEMIACTIVE, MESIC AQUIC DYSTRIC EUTRUDEPTS

16

Entisols

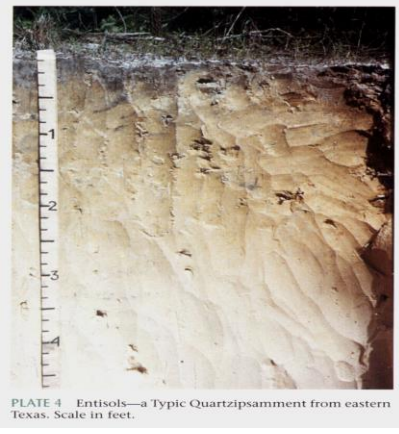


PLATE 4 Entisols—a Typic Quartzipsamment from eastern Texas. Scale in feet.

15

18

17

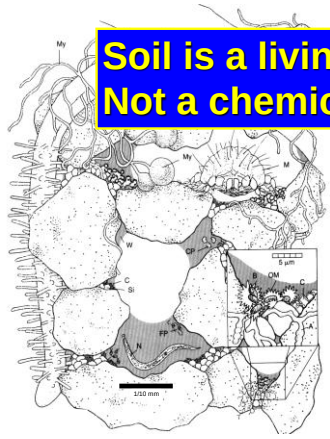
What is Soil?

Soil is:

- "Rotted" Rock
- Decomposed Organic Matter

21

Soil is a living thing! Not a chemical sponge!

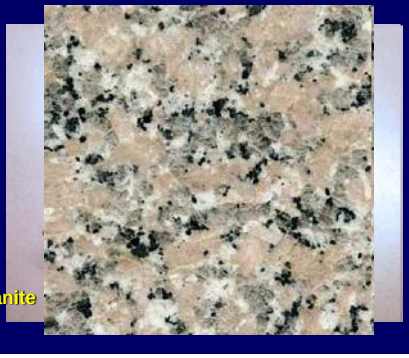


B – Bacteria
A – Actinomycetes
My – Mycorrhizae
H – Saprophitic fungus
N – Nematode
CP – Ciliate protozoa
FP – Flagellate protozoa
M – Mite

< 1mm

19

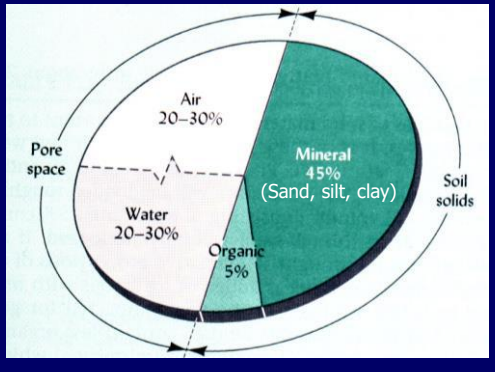
Rock – primary mineral



Granite

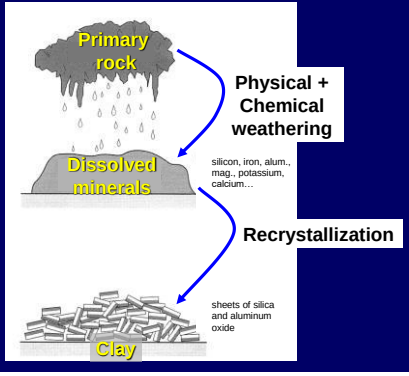
23

The four components of soil:



22

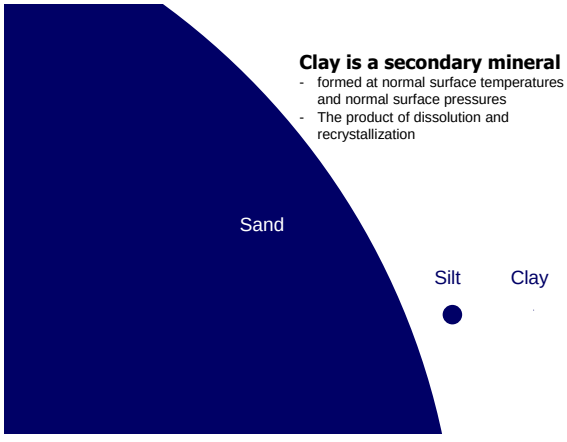
Rocks dissolve and recrystallize



25

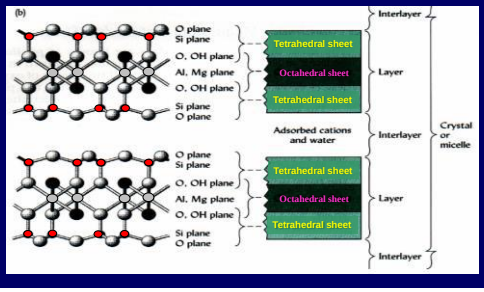
Clay is a secondary mineral

- formed at normal surface temperatures and normal surface pressures
- The product of dissolution and recrystallization



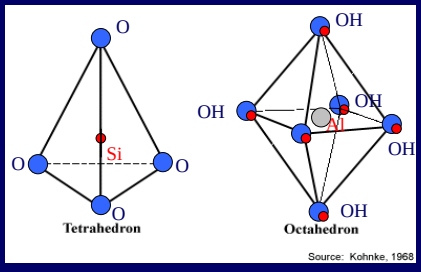
24

…and recrystallize.
Clay – secondary mineral



27

When rocks dissolve…

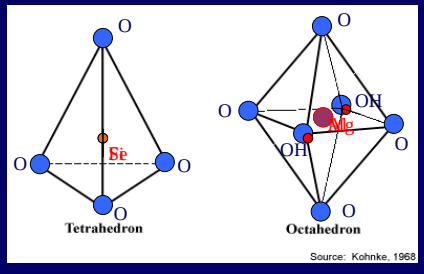


Tetrahedron - a 3D geometric form contained by four plane faces; a triangular pyramid.
Octahedron - a 3D geometric form contained by eight plane faces.

26

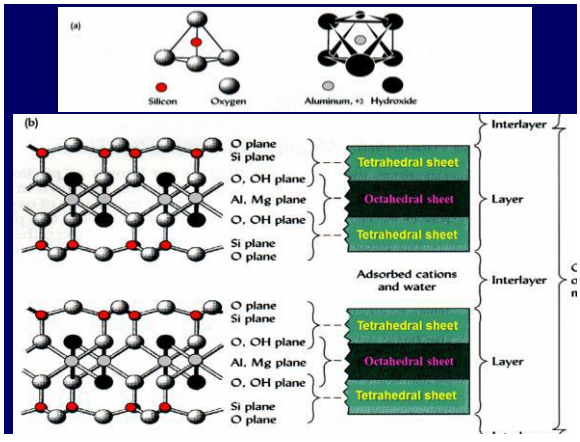
Isomorphous substitution

Within the silica tetrahedron and aluminum octahedron

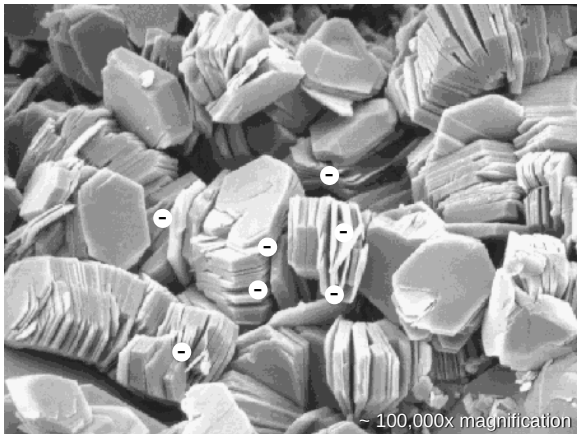


What ions are present in the soil water solution is determined by the PM and the weathering environment.

30

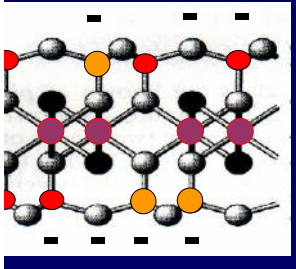


29



33

Isomorphic Substitution…
a source of negative charge in soils!

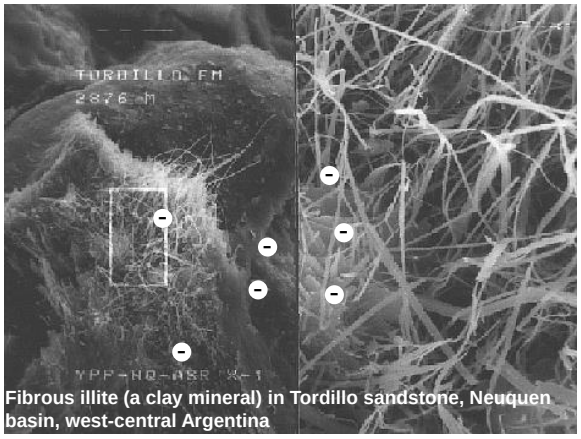


Silica Tetrahedral sheet

Aluminum Octahedral sheet

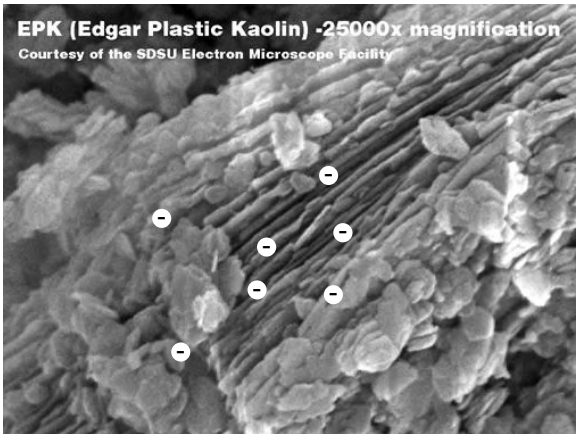
Silica Tetrahedral sheet

32



Fibrous illite (a clay mineral) in Tordillo sandstone, Neuquen basin, west-central Argentina

35

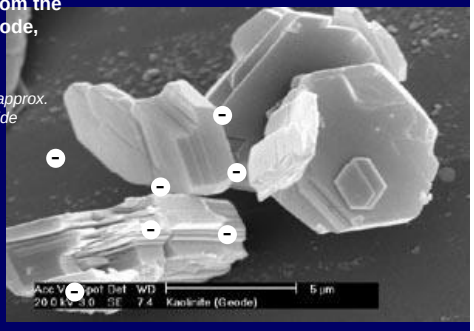


34

Kaolinite

Well crystallized kaolinite from the Keokuk geode, USA

Field of view approx. 18 microns wide

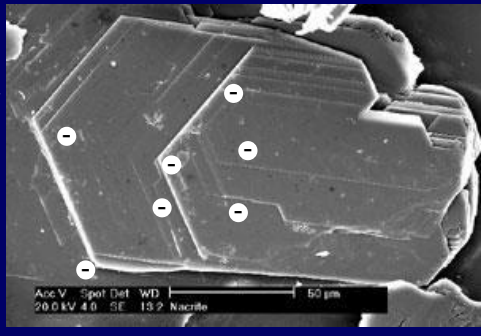


37

Nacrite

Nacrite, Lodève Basin, France

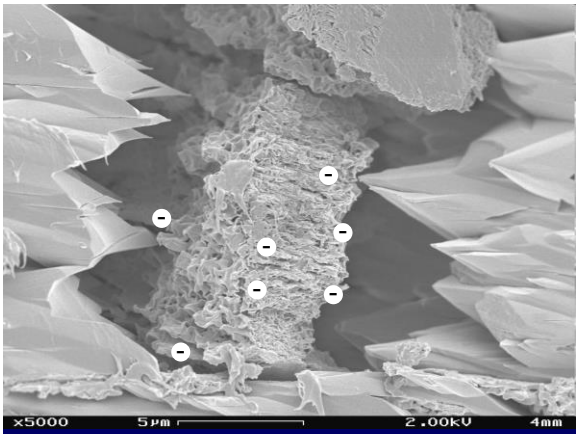
Field of view approx. 200 microns wide



36

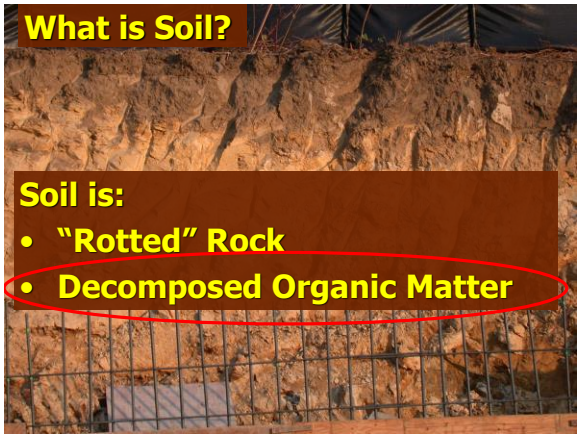
…net negative charge due to isomorphic substitution on the secondary mineral called clay!!!

39



38

What is Soil?



Soil is:

- "Rotted" Rock
- Decomposed Organic Matter

41

Clay

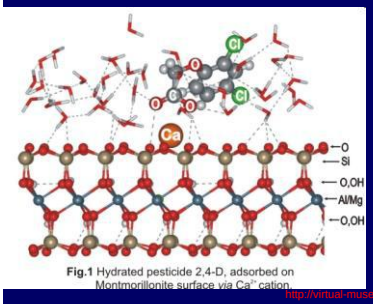
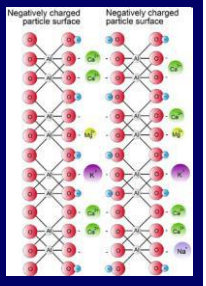
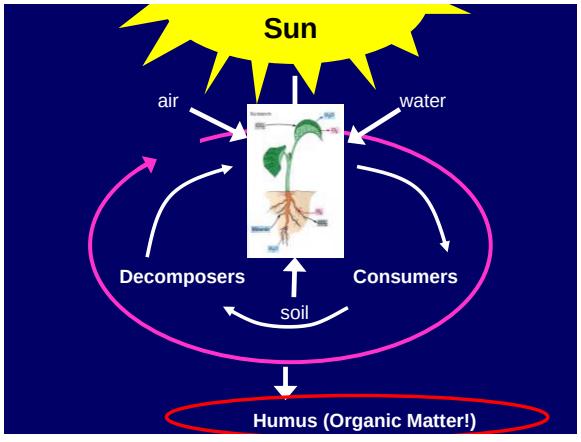


Fig.1 Hydrated pesticide 2,4-D, adsorbed on Montmorillonite surface via Ca^{2+} cation



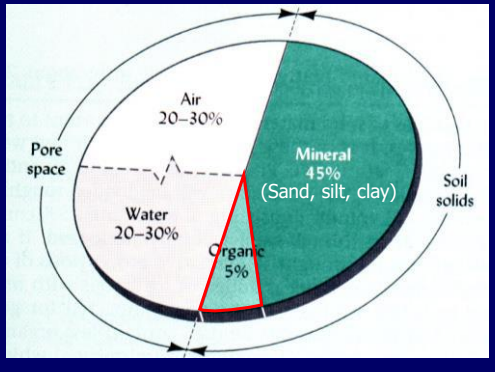
http://virtual-museum.soils.wisc.edu/soil_smectite/index.htm

40



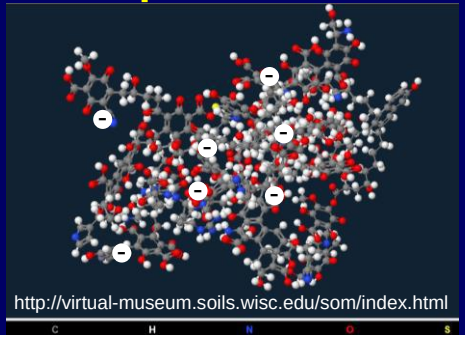
43

What is Organic Matter?



42

Organic Matter – a random complex molecule!

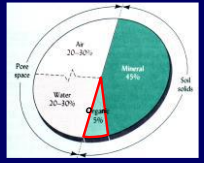


45

Functions of Organic Matter

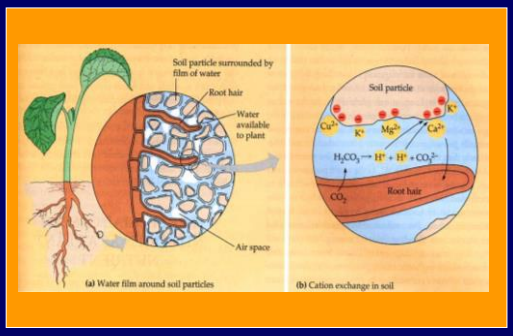
Organic Matter

…provides another source of charge in soils – twice that of clay!



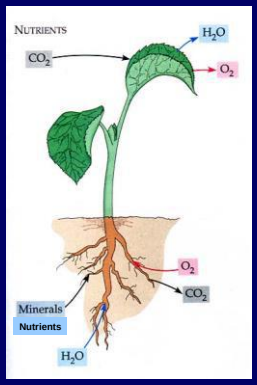
44

How a plant works

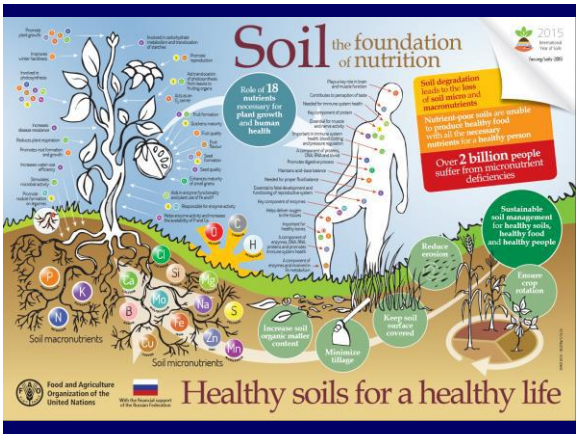


47

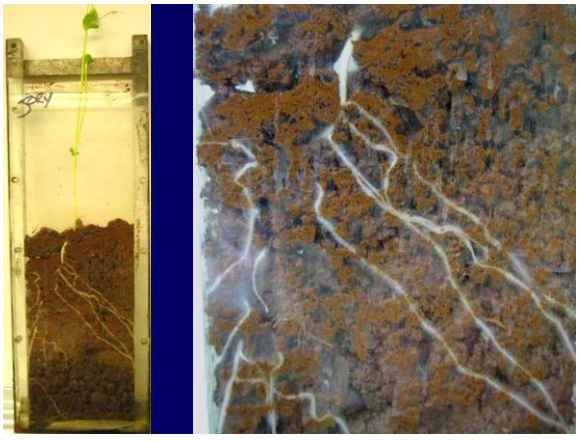
How a plant works



46



49



48

soilforward.org

51

Find out more about your soil!
Soil plug-in for Google earth
California Soil Resource Laboratory
SoilWeb Earth

Support Soil Science and Student Farming
Donate!
Buy a t-shirt that REALLY means something!
(100% of profits go to funding student internships!)

Go to: soilforward.org

50

ADD ORGANIC MATTER!!!

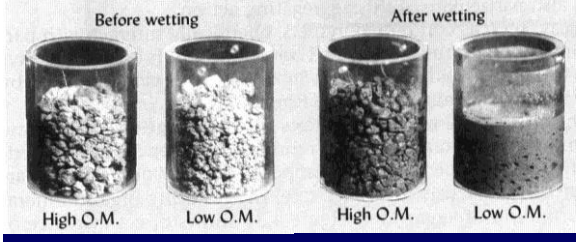
- Reservoir of plant nutrients
- Food/energy source for soil organisms
- Provides cation exchange capacity (200 cmol/kg)
- Increases water-holding capacity
- Decreases Al toxicity at low pH
- Improves soil structure (but doesn't change soil texture)
  - Positive effects on physical characteristics: infiltration, drainage, aggregation potential, pore-size distribution, available water holding capacity, erosion potential, deep water storage, diverse habitat, increased function
  - Positive effects on soil chem: buffers for neutral pH, increases nutrient availability, increased vegetation…increasing organic matter…

53

soilforward.org

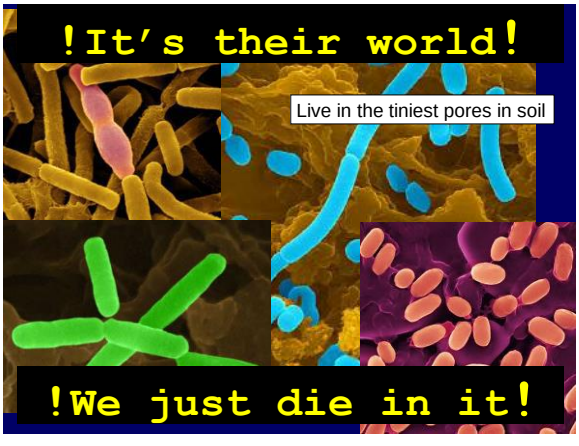
52

Effect of OM on structure stability



63

60



67

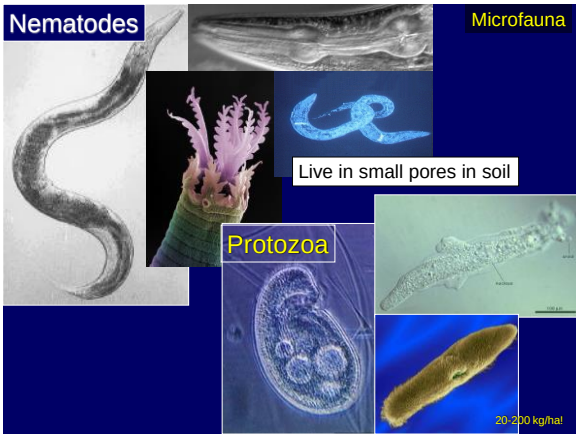
64

Microfauna

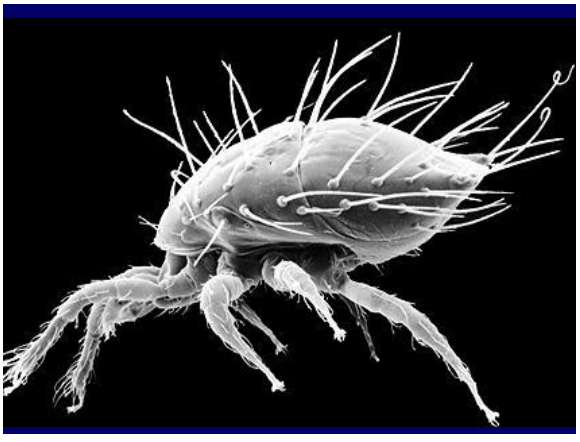
Protozoa

- Most abundant of all soil fauna
- One-celled
- Feed on bacteria (live and move in water films)
- Up to 30% of all mineralized N from protozoa

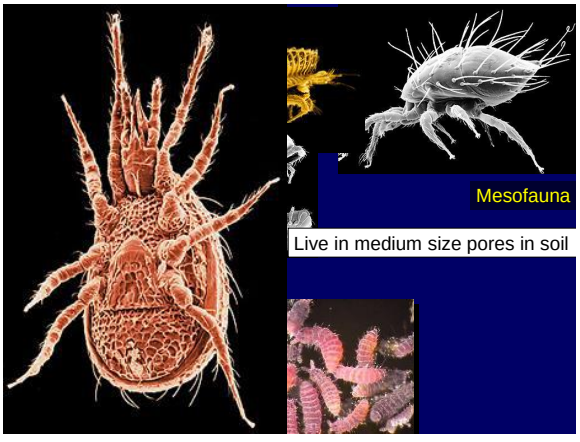
69



68



71



70

Mesofauna

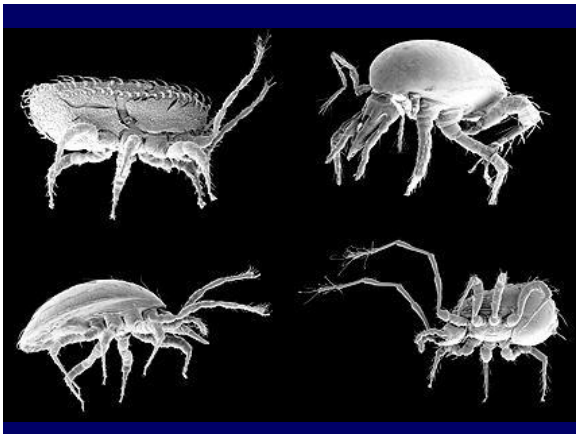
- Heterotrophs (detritivores, predators)
- Feed on fungi, protozoa, nematodes, mites
- Important in regulating populations of everything smaller

Collembola (springtails)

Fungus feeding mite

Nematode feeding mite

73



72

Worms

Voles!

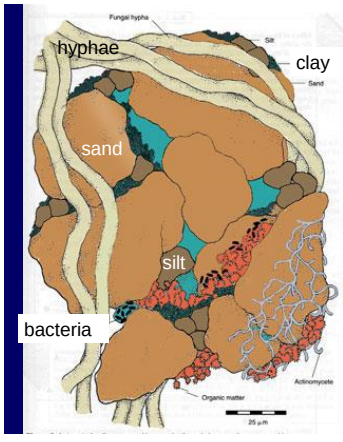
Live in large pores in soil

Macrofauna

75

Mesofauna

74



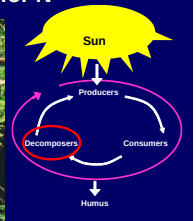
Aggregates held together by:

1. Fungal hyphae
2. Bacterial "glues"
3. Organic matter

81

Fungi – tens of thousands of spp.

- The major agent of decay in acid environs
- Network of hyphae: improves soil structure
- Decomposition of cellulose!!!
- Can compete with higher plants for N



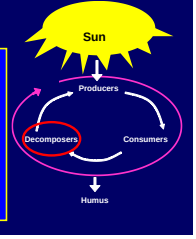
80

83

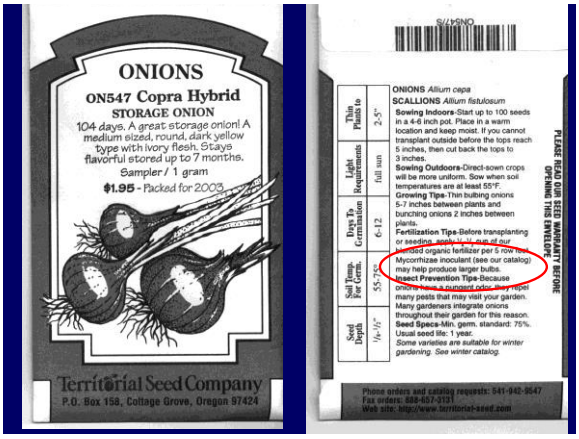
Fungi – tens of thousands of spp.

- The major agent of decay in acid environs
- Network of hyphae: improves soil structure
- Decomposition of cellulose!!!
- Can compete with higher plants for N

- Chemo Heterotrophs – energy and carbon from dead or living biomolecules (trap nematodes!)



82



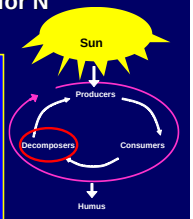
85

Fungi – tens of thousands of spp.

Got beer?

- The major agent of decay in acid environs
- Network of hyphae: improves soil structure
- Decomposition of cellulose!!!
- Can compete with higher plants for N

- Chemo Heterotrophs – energy and carbon from living (trap nematodes!) or dead biomolecules
- 3 groups, yeast, mold, mushrooms
- Mycorrhizae - symbiotic relationships with most plants
- Produce chemicals that are toxic (or otherwise…)



84

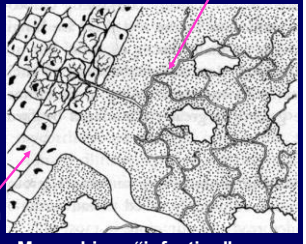
87

N capture (mycorrhizal fungi)

(Fungus Root)

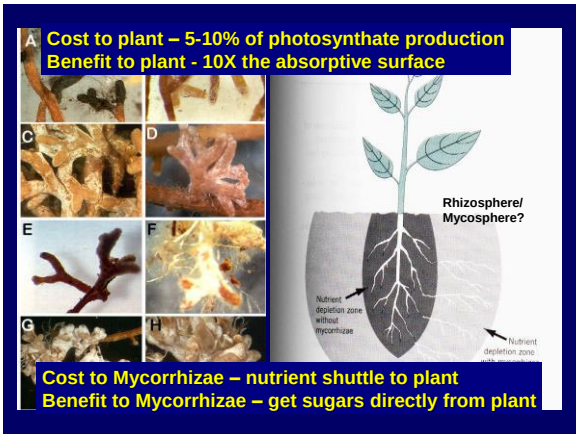
- Soil fungi that form symbiotic relationship with plant roots
- Extend root surface area for uptake of nutrients
  - Fungus transfers nutrients (N,P,K) to plant
  - Especially important for phosphorous uptake because it is immobile in the soil
- Plant provides fungus with carbon (root exudates)

Ecto & endo types



Mycorrhizae "infecting" a plant root and extracting nutrients from rock particles.

86



Cost to plant – 5-10% of photosynthate production
Benefit to plant - 10X the absorptive surface

Cost to Mycorrhizae – nutrient shuttle to plant
Benefit to Mycorrhizae – get sugars directly from plant

89

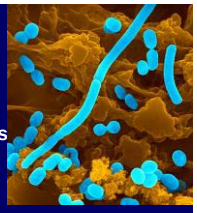
Crops with mycorrhizal associations

- onions
- corn
- cotton
- wheat
- soybeans
- potatoes
- alfalfa
- sugarcane
- cassava
- rice
- most vegetables
- beets
- apples
- grapes
- citrus fruit
- trees (lumber and fiber)
- cacao
- coffee
- rubber

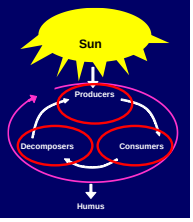
Oregon industries:
Wine!
Christmas trees!

88

Bacteria – 1 billion -1 trillion/g soil (up to 20,000 spp.)

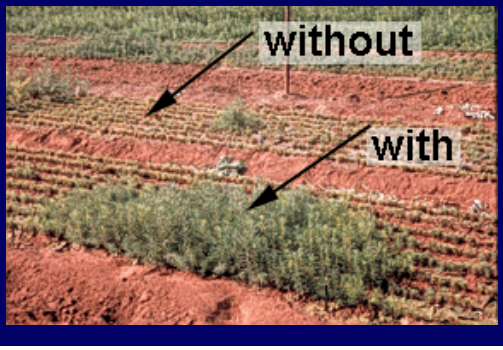


- Exist in both forest and grassland soils
- Aerobic, anaerobic, and facultative forms
- Autotrophic and heterotrophic forms
- Most do best under high Ca^{2+}, high pH
- Do best when soil temp 20-40C (68-100F) but seldom killed by temp extremes



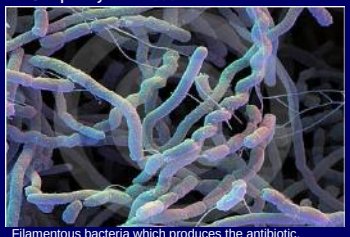
91

Douglas Fir Trees with and without mycorrhizae inoculation



90

Streptomyces - 199901-008



Filamentous bacteria which produces the antibiotic, Streptomycin.

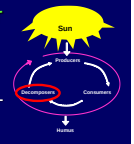
Thanks bacteria!!!

From - http://www.scharfphoto.com/fine_art_prints/archives/000611.php

93

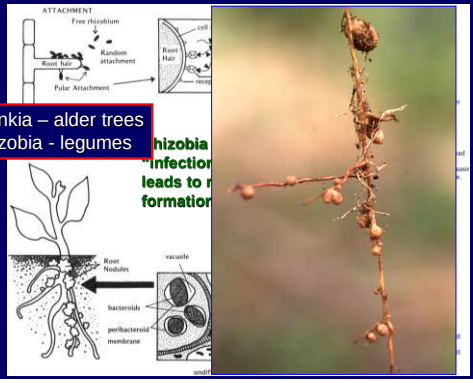
Actinomycetes - fungus-like, filamentous bacteria, huge numbers in soil; second only to "regular" bacteria

- Historically classified as fungi - misnomer
- Specialized group of soil bacteria - (unicellular, no nuclear membrane)
- Aerobic heterotrophs – decompose OM – humus-forming, also parasitic/symbiotic relationships with some plants
- Produce antibiotic compounds t competition etc. (side benefit – drugs e.g. streptomycin)
- Super resistant to hostile enviro
- Sporulate – smell "good" after ra



92

Nodulation in Legumes



Frankia – alder trees
Rhizobia - legumes

hizobia
infectio
leads to
formatio

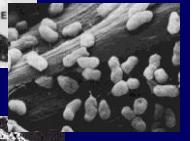
95

Bacteria and N fixation

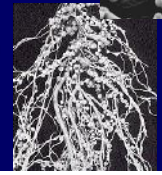
Types of Biological Nitrogen Fixation (N^2 from atmosphere)

Free-living (asymbiotic)
- Cyanobacteria
- *Azotobacter*

Associative
- Rhizosphere–*Azospirillum*
- Lichens–cyanobacteria (with fungi)
- Leaf nodules



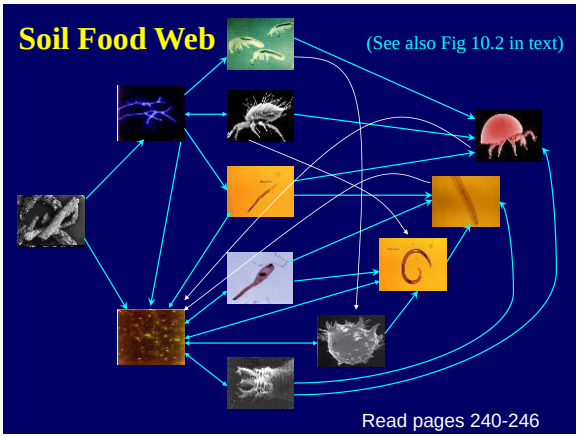
Symbiotic – nodule forming
- Legume-rhizobia
- Actinorhizal-*Frankia*



94

Soil Food Web

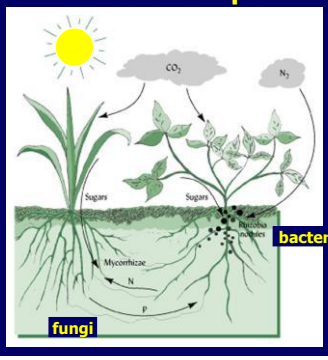
(See also Fig 10.2 in text)



Read pages 240-246

97

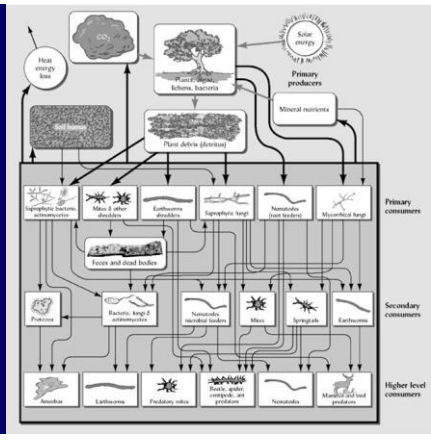
Complex, mutually beneficial relationships



96

Soil!

104



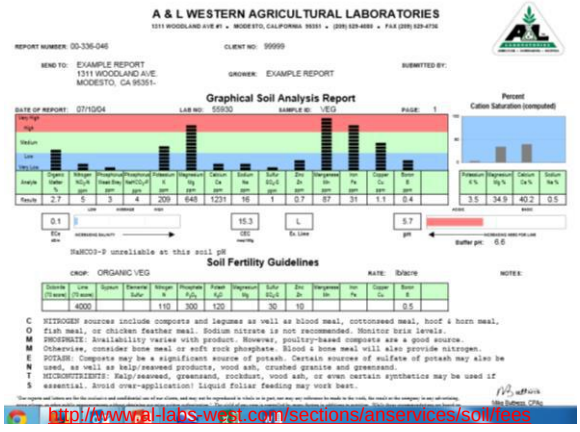
98

Why study soil?

- World population is increasing rapidly
- Only 10% of the world's land area is suitable for growing crops
- Most of the most arable land is already in production
- Soil quality is degrading world-wide

http://www.tranquileye.com/clock/

115



http://www.al-labs-west.com/sections/anservices/soil.htm

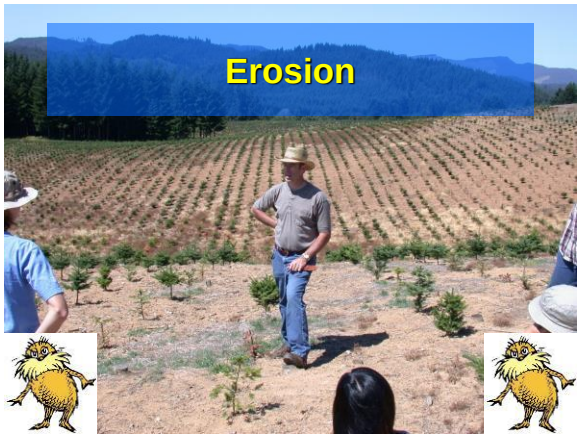
105

Erosion:

The DEFINITION –
A process that transforms *soil* into *sediment*

- Natural - geologic erosion (soils *form* over time in most settings) usually, soil formation > soil loss

117



116

119

118

Erosion:

DEFINITION –
A process that transforms *soil* into *sediment*

- Natural - geologic erosion (soils *form* over time in most settings) usually, soil formation > soil loss
- Human-induced
  - Over-grazing – 1/3 of all land degradation,
  - Forest harvest – in rain forests, bad practices responsible for 0.5 b ha of land degradation…so far

- Tied with damage to plant communities (increasing susceptibility to erosion)
- 85% of degradation of soils is due to the destructive action of Wind & Water (2/3 of that is by the action of water)

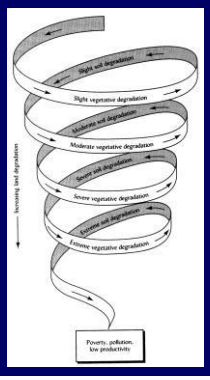
121

120

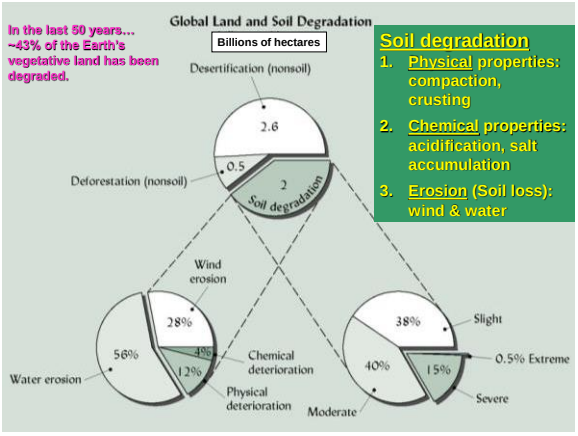
Downward spiral of land degradation

Plant-soil interaction

Overgrazing, deforestation, inappropriate crop production methods

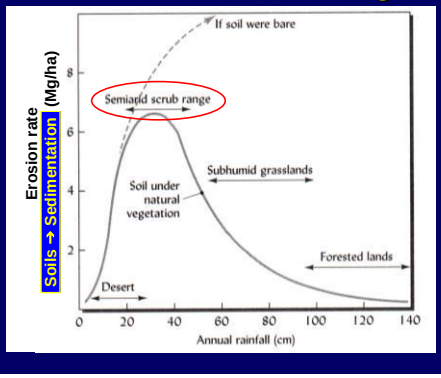


123



122

Erosion vs. rainfall and veg cover



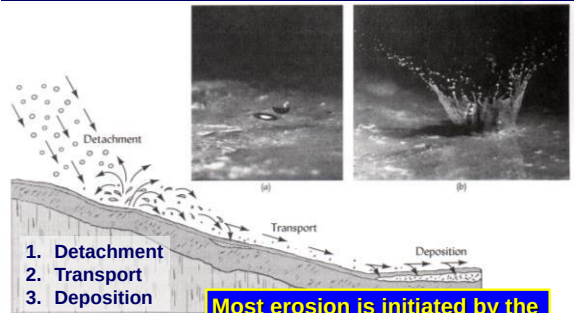
125

Factors affecting rates of erosion

- Topography
- Land use practices
- Vegetation type
- Rainfall amount, frequency, and intensity
- Soil chemical properties (high CEC = more plant cover = less erosion)

124

Erosion mechanics



1. Detachment
2. Transport
3. Deposition

Most erosion is initiated by the impact of raindrops, NOT by the flow of running water

127

Geologic erosion - greatest in semi-arid environments

Geologic erosion - greatest in semi-arid envi

Geologic erosion - greatest in sem onments

Geologic gre -arid environments

erosion - g atest in semi-arid environments

Semi-Arid environments!!!

126

129

3 Types of water erosion

1) Sheet erosion (largest volume of soil moved)

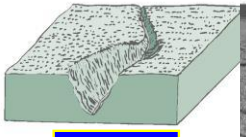
Uniform removal, raindrop splashed soil carried away by flowing water (laminar flow)

128

3 Types of water erosion

3) Gully erosion

Largest volumes of soil lost due to erosion occur in sheet erosion



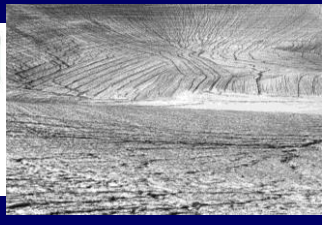
Gully erosion

Very concentrated flow, large channels with high water velocities (turbulent flow)

131

3 Types of water erosion

2) Rill erosion



Rill erosion

Concentrated flow due to non-uniform surface, small channels develop (turbulent flow)

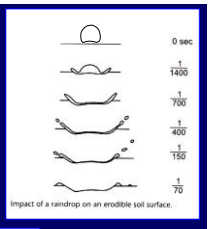
130

R: rainfall erosivity

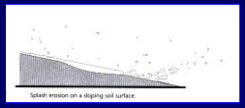
(Driving force in sheet and rill erosion)

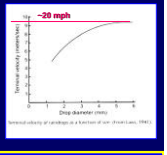
A = RKLSCP

- rainfall intensity/duration
- size & distribution of drops
- terminal velocity of drops
- angle of impact



A heavy rainstorm may splash (detach) as much as 200 tons soil/ha clogging surface pores, ↓ infiltration capacity and ↑ erodibility





In temperate regions only 5% of rainfall is of intensities great enough to be erosive. In the tropics, 40% of rainfall is of sufficient intensity to erode soils

133

RUSLE – Revised Universal Soil Loss Equation

http://www.iwr.msu.edu/rusle/factors.htm

A = R*K*L*S*C*P Know this…

- R= **r**ainfall erosivity
- K= soil erodibility
- L = slope **l**ength
- S = **s**lope steepness

} Soil-related factors

- C = **c**over and management
- P = erosion-control **p**ractices

} Land management factors

T-factor? Amount of soil (in tons/hectare) that a landscape can lose due to erosion and not effect productivity

132

A = RKLSCP

L = slope length

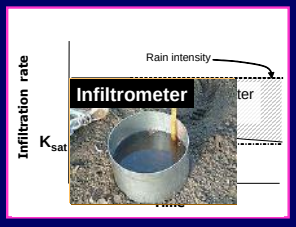
S = slope steepness

135

K: soil erodibility factor

A = RKLSCP

- Infiltration capacity
- Aggregate stability
  - **particle cohesion**
    - **frictional resistance between particles**
    - **cementation by OM, living & otherwise**
  - **particle size/density**

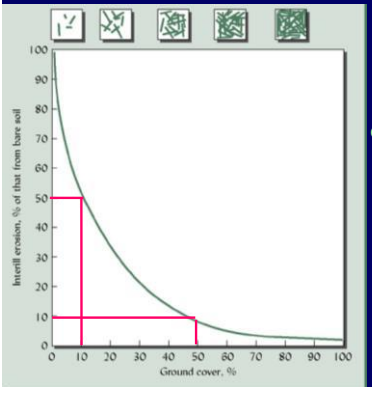


134

2. Contour cultivation – C, L & S

137

1. Mulch as a means to reduce erosion



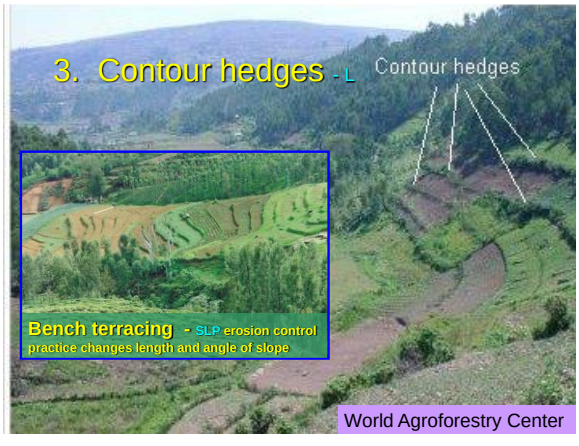
A = RKLSCP

C =cover and management

136

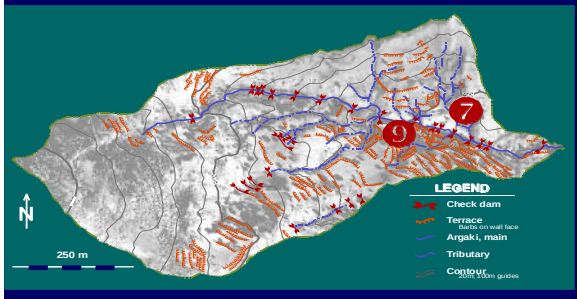
139

3. Contour hedges - L



138

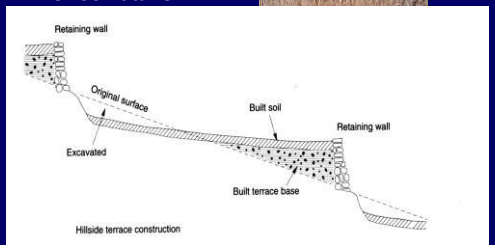
Cyprus



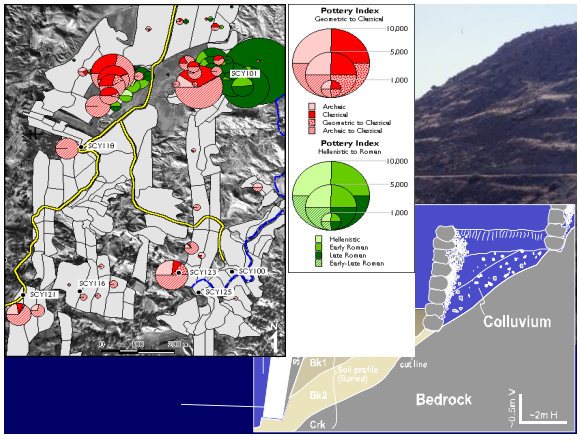
141

Ancient Conservationists

- Cyprus
  - Check dams



140



143

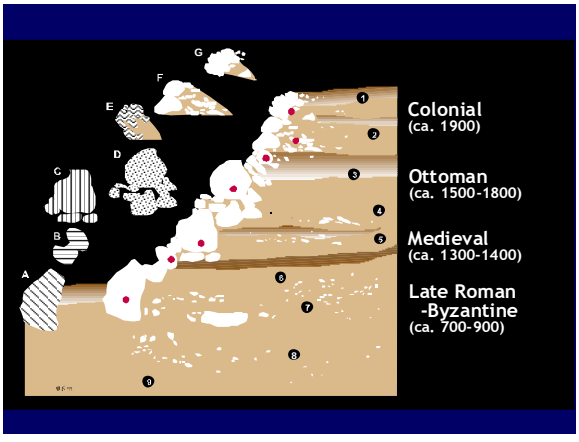
142

Conservation Tillage
Stubble mulch

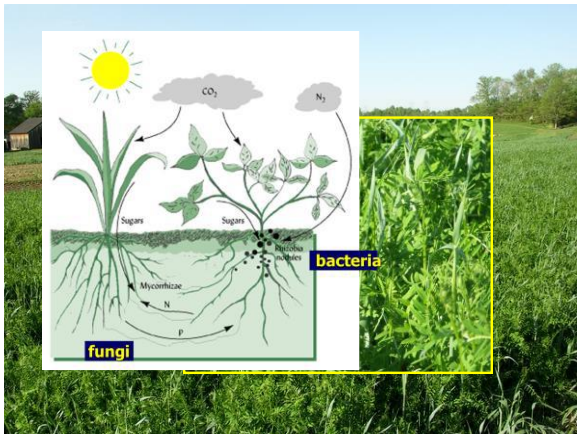
The same things that lead to good aggregate stability also lead to good soil structure, and these things lead to reduced susceptibility to soil erosion.

1. Low disturbance
2. High root abundance
3. High fungal biomass
4. High OM
5. High clay content

145



144



147

Practices that minimize erosion

A = RKLSCP

L = slope length
S = slope steepness
C = cover and management
P = erosion control practaces

1. Mulching – C, P
2. Contour cultivation – C, L & S, P
3. Grass contour hedges - L, P
4. Cover crop – C, P

146

Oregon State University
Central Analytical Laboratory
Crop and Soil Science Department 3079 Ag-Life Sciences Bldg Corvallis, OR 97331 541-737-2187

Soil Nutrient Analysis Results

Name:	James Cassidy
Organization:	OSU CSS
Contact for results:	james.cassidy@oregonstate.edu
Date submitted:	9/27/2016
Date delivered:	10/14/2016
Group number:	Gp217087

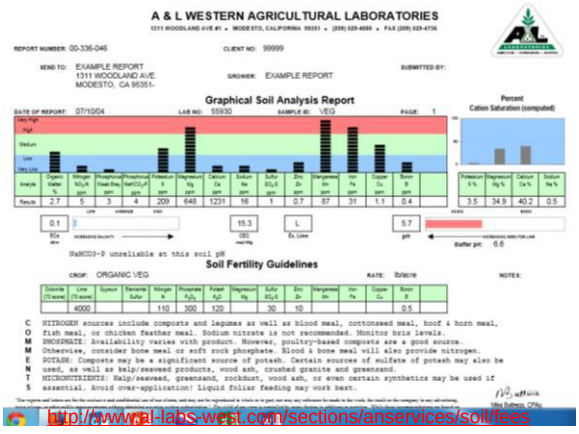
Nitrate and ammonia were extracted using 2M KCl.
Other nutrients were extracted using the Mehlich-3 procedure.
pH and EC were measured in a 2:1 water:soil slurry.
Units are given as reported in recommendations in OSU extension publications.

	ppm							meq/100g			%		
Sample ID	P	K	Mn	Cu	Zn	Fe	NO3-N	Ca	Mg	CEC	C	N	C/N ratio
1	64	152	13.2	1.4	3.7	268	BDL	5.0	1.8	7.2	5.3	0.3	16.7

BDL = Below detection limit

	pH units		µS/cm
Sample ID	pH	BpH	EC
1	5.5	6.0	76.6

149



http://www.al-labs-west.com/sections/anservices/soil.fees

148