



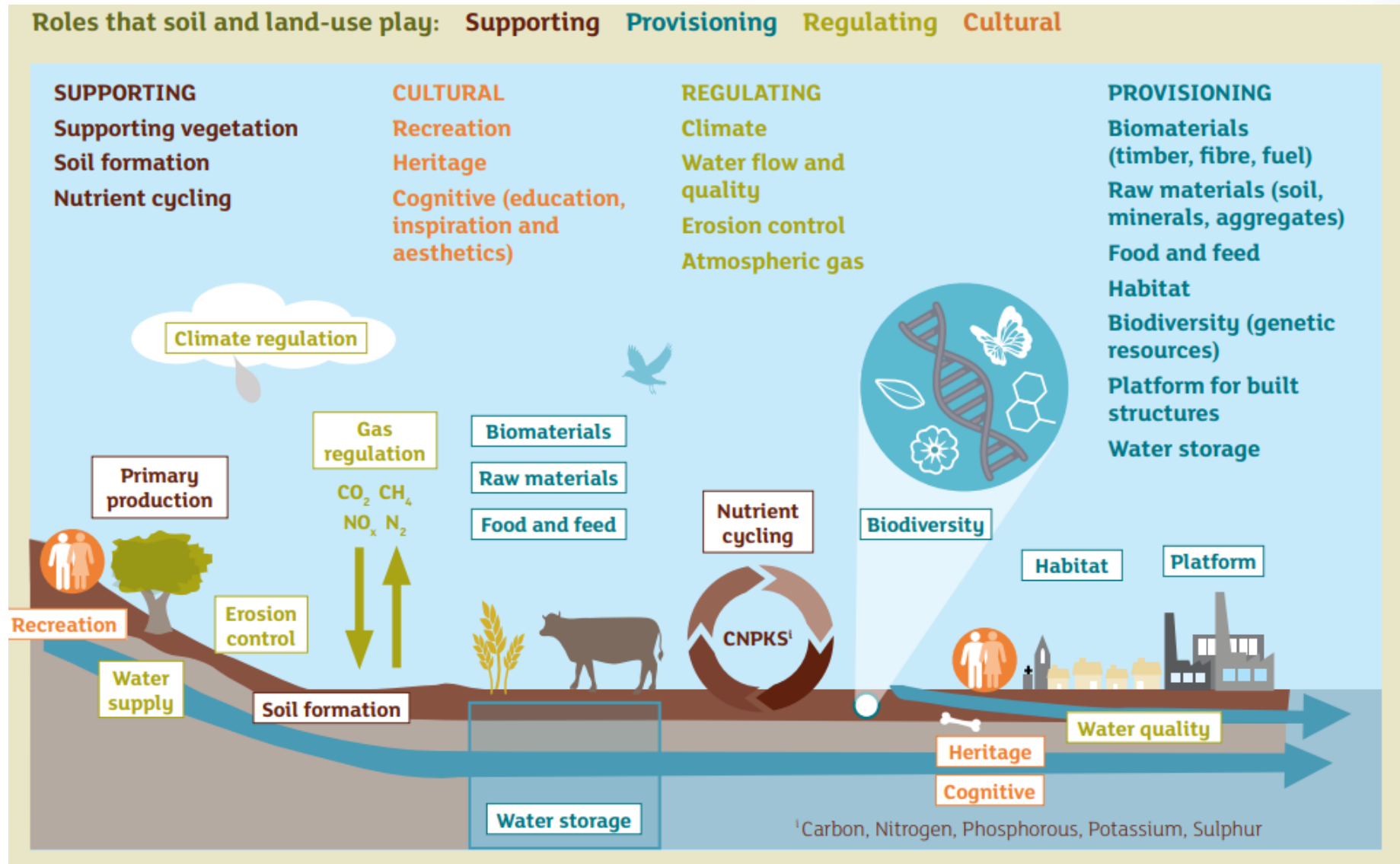
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All about Soils: Ground beneath our feet

Dr Alissa Flatley
ACNA4007 – Physical Landscape and the Geosphere



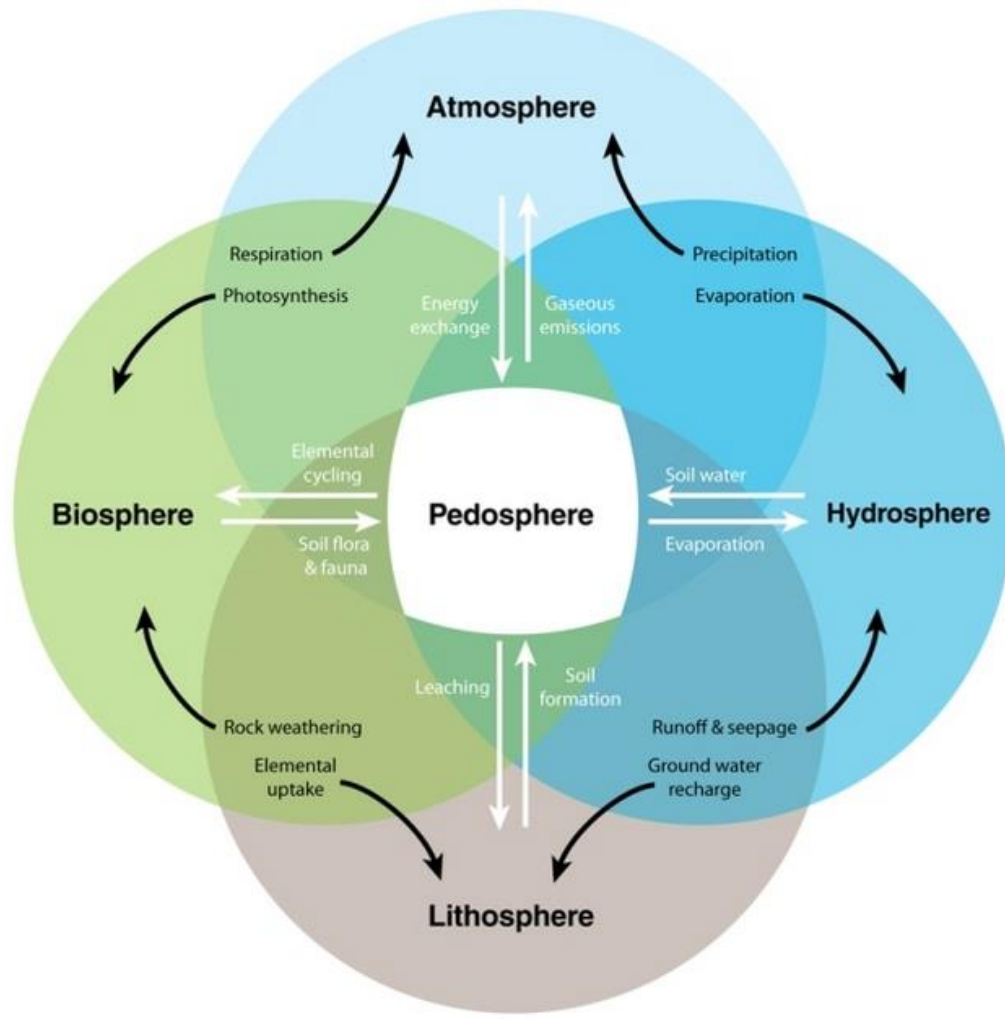
Soil Functions



Nature and categories of ecosystem services and functions provided by soil systems and land use

[CPRE_FF3_Soil_26Nov_web.pdf](#)

The pedosphere



Interactive processes linking the pedosphere with the atmosphere, biosphere, hydrosphere, and lithosphere.

[The Soil Biota | Learn Science at Scitable \(nature.com\)](http://www.nature.com/scitable/learn/soilbiota)

The term **pedosphere** is often used interchangeably with soil and captures the concept that the soil is a habitat where the integration of spheres occurs. These spheres include the lithosphere, atmosphere, hydrosphere, and the biosphere (Brady & Weil 2002)

Soils... and life

- Decomposition of detritus or dead organic material
- litter** is dead plant material (such as leaves, bark, needles, twigs...)

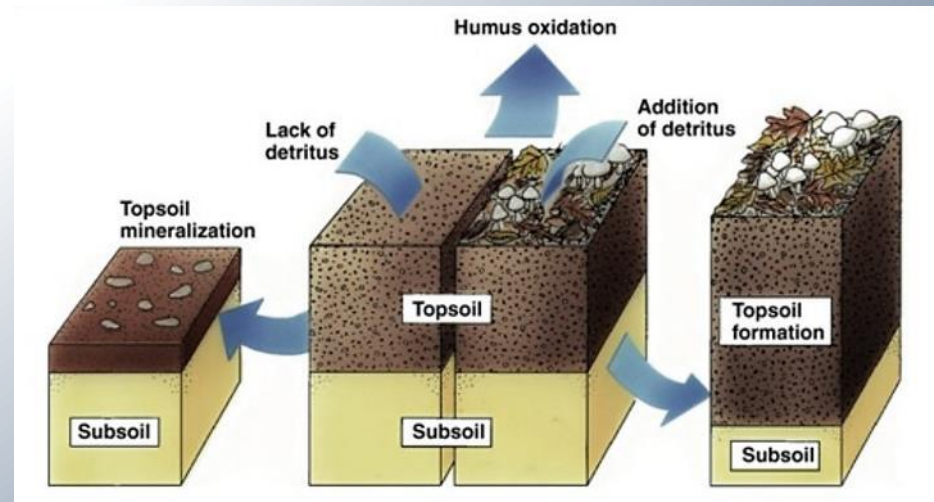


- Humification** – un-mineralized organic matter is transformed by fungi, bacteria, microbes and animals to chains of organic polymers (resistant to micro-organisms)



Element	Mineral end products
Carbon	CO_2 , CO_3^{2-} , HCO_3^- , CH_4 , C
Nitrogen	NH_4^+ , NO_2^- , NO_3^- , N_2 (gas), N_2O (gas)
Sulfur	S, H_2S , SO_3^{2-} , SO_4^{2-} , CS_2
Phosphorus	H_2PO_4^- , HPO_4^{2-}
Others	H_2O , O_2 , H_2 , H^+ , OH^- , K^+ , Ca^{2+} , Mg^{2+} , etc.

- Mineralization** by microorganisms (bacteria, etc), i.e. oxidation of the chemical compounds in organic matter, by which nutrients in those compounds are released in soluble inorganic forms

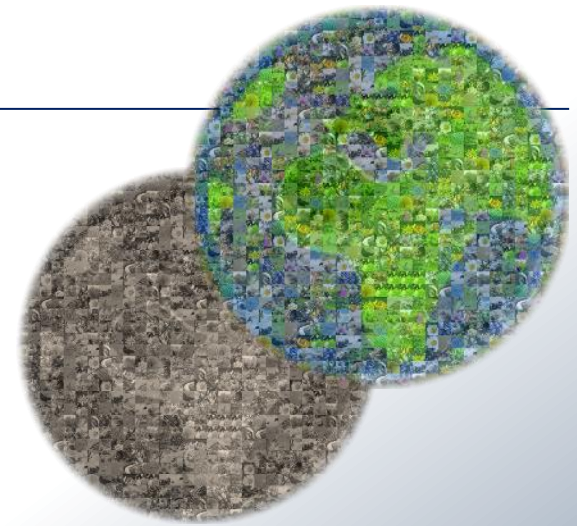


- Topsoil formation and soil properties - Water, nutrients, infiltration, aeration

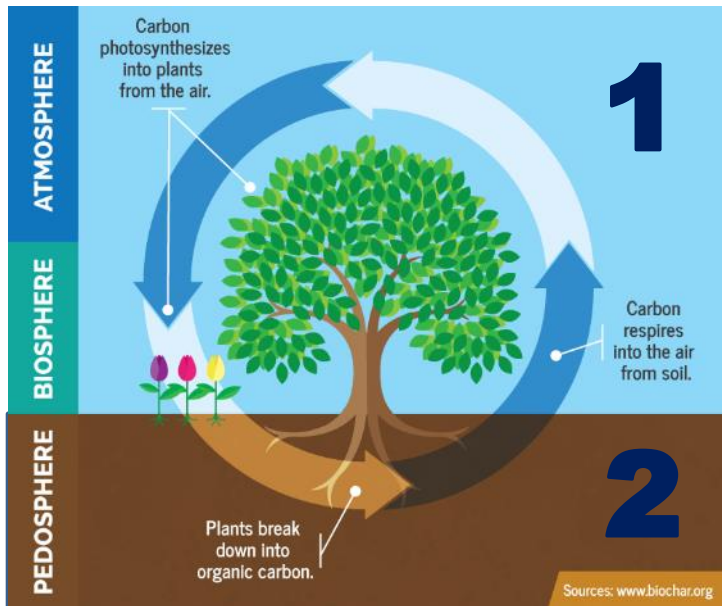
Soils... and life

1. Soils provide the **medium for life** (plant growth and new formation of organic matter via photosynthesis...)

*Despite our perception of the world as driven by **photosynthesis**, virtually all net primary production ends up as soil organic matter and, because of its relatively long residence time, soils contain twice as much carbon as vegetation - more ecology occurs below than above-ground (Bardgett 2005)*



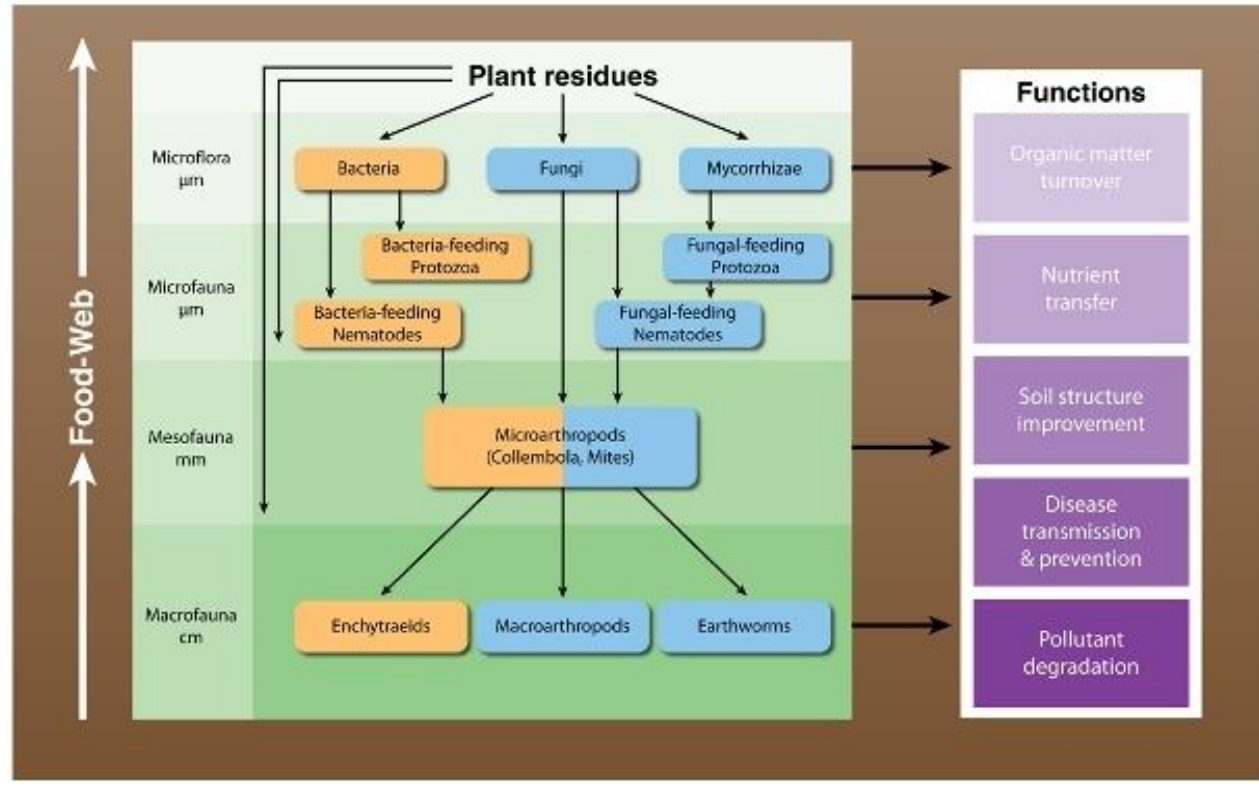
2. **Decomposition** - one of the two major life-generating processes; pairs with photosynthesis to maintain function of ecosystems and balance of atmosphere



- The soil is food web – a recycling machine... !!
- Food webs do not follow traditional rules (more omnivores and decomposers)
- Is terrestrial world brown and black, not green?
- Highly **diverse** on microscopic and micro-level but “we do not know their names or what they do”...

The soil biota

- Trophic levels in a soil food web.



The soil fauna is the collection of all the microscopic and macroscopic animals in a given soil.

Soil animals can be conventionally grouped by size classes: macrofauna (cm; enchytraeids, earthworms, macroarthropods), **mesofauna** (mm; microarthropods, mites and collembolan), and **microfauna** (µm; protozoa, nematodes)

Soil Organisms

- Soils vary in physical and chemical properties... (soil types!)

Table 2. Typical Numbers of Soil Organisms in Healthy Ecosystems

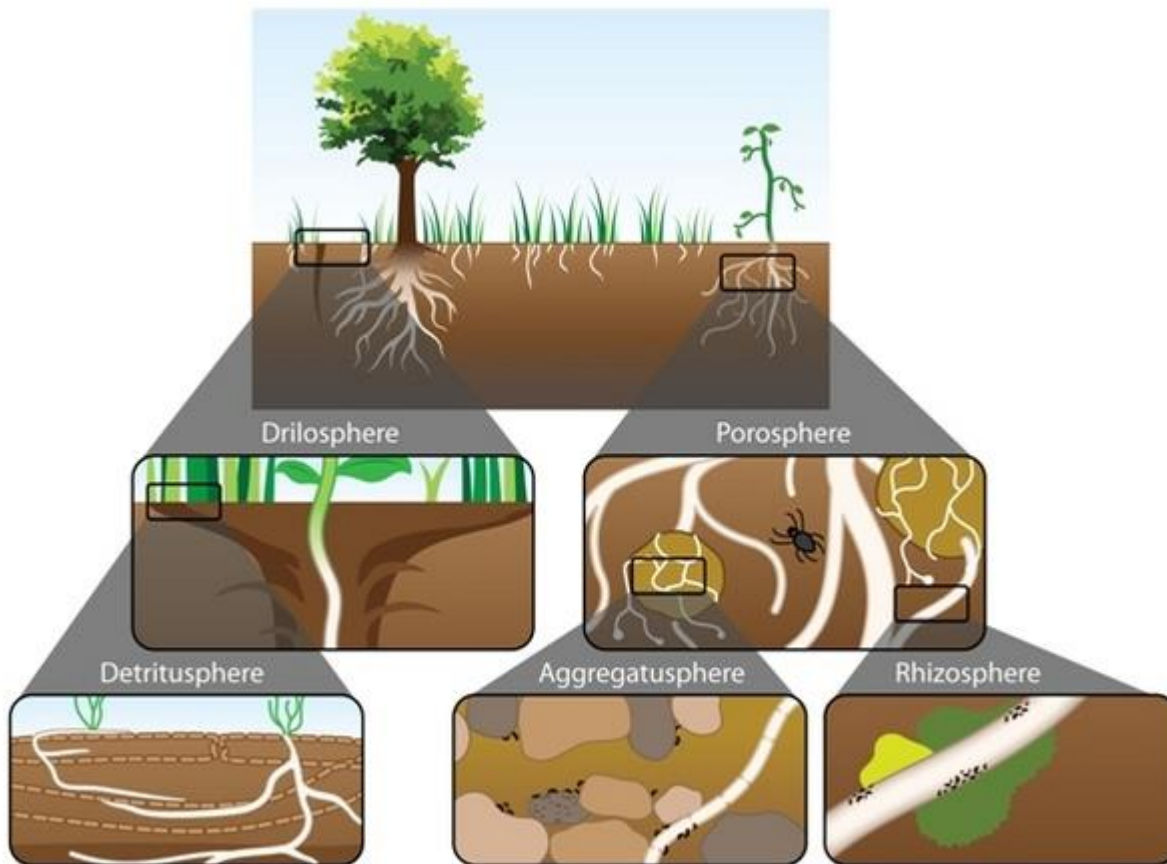
	Ag Land	Prairie	Forest
Organisms per gram (teaspoon) of soil			
Bacteria	100 million - 1 billion	100 million - 1 billion	100 million - 1 billion
Fungi	Several meters	10's - 100's of meters	1-50 kilometers (in conifers)
Protozoa	1000's	1000's	100,000's
Nematodes	10-20	10's - 100's	100's
Organisms per square meter			
Arthropods	< 10	45-200	900-2,300
Earthworms	4-25	8-42	8-42 (0 in conifers)

All soil organisms help decompose nutrient rich organic material (decaying plants, animals, and animal waste), which increases soil organic matter (SOM) that feeds plants. **Larger soil organisms, such as earthworms and arthropods, add nutrients to the soil through their waste as they shred and feed on SOM**



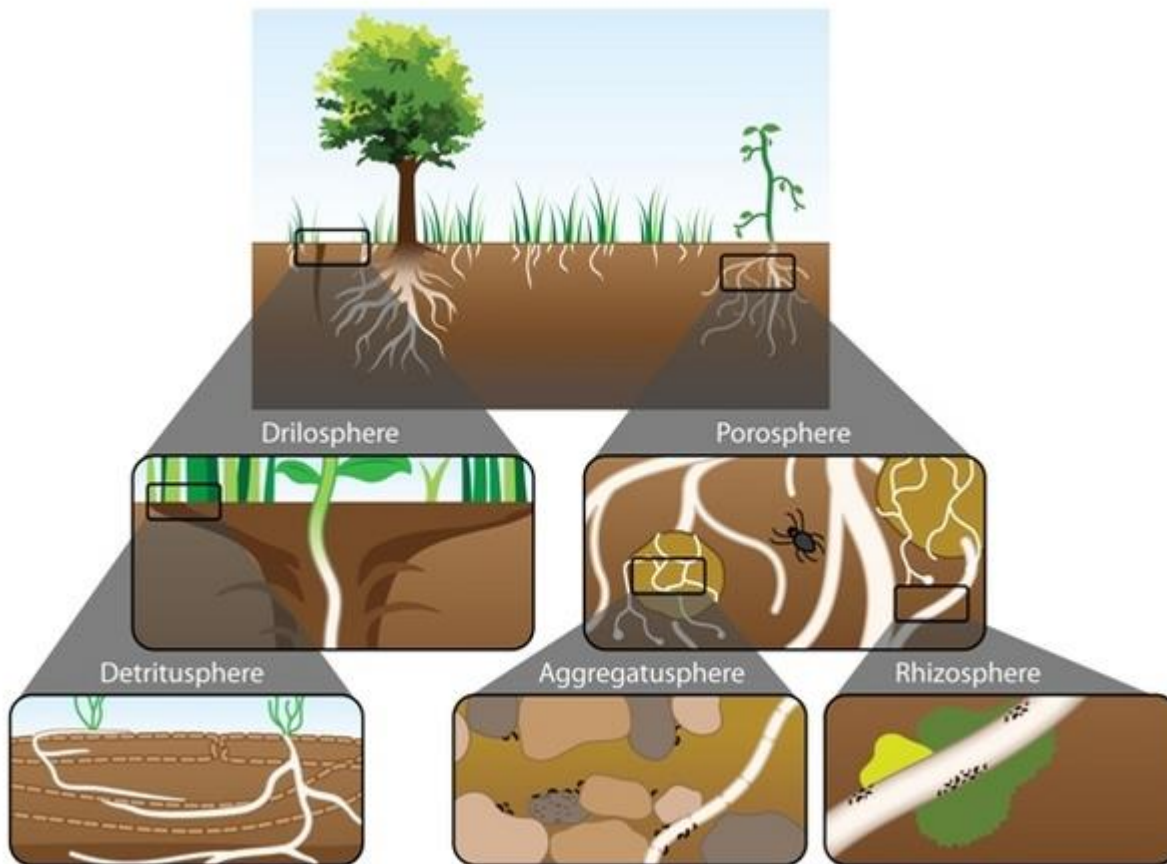
Soil Hotspots

- Zones or ecosystems containing areas of activity include the “**drilosphere**” (the portion of the soil volume influenced by secretions of earthworms), the **porosphere** (the total pore space), **detritusphere** (dead plant and soil biota), **aggregatusphere** (the sum of aggregates) and the **rhizosphere**.



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the zone of chemical, biological, and physical influence generated by root growth and activity.

Soil Texture

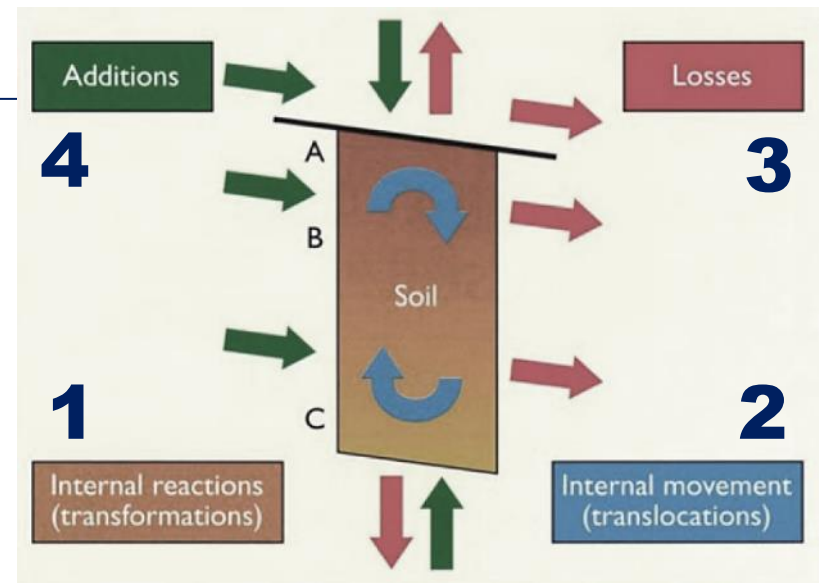
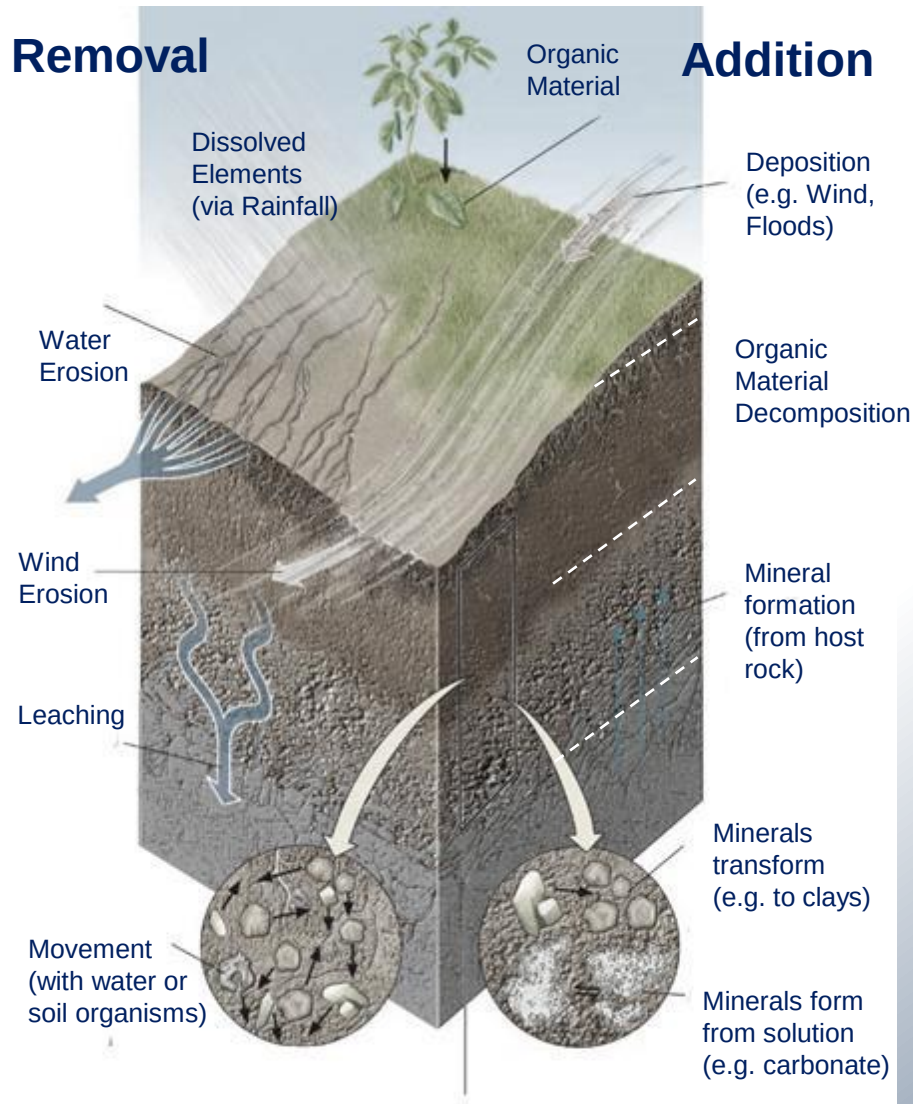
- Soils vary in physical and chemical properties... (**soil types!**)



Soil texture (fineness or coarseness) affects plant rooting, **soil structure** and **organic matter** content.

Soil texture and structure determine the pore-size distribution, **soil water holding capacity** and the amount of water to air-filled pore space in **soil aggregates** that provide habitat for soil organisms.

Soil Formation



... open system

- Wide range of biological, chemical and physical processes... (Pedogenesis)
1. Neoformation- and **transformation processes** (e.g. weathering)
 2. **Translocation processes**
 - Soil horizons and soil types (taxonomy varies by country or system)...

Soils... and life

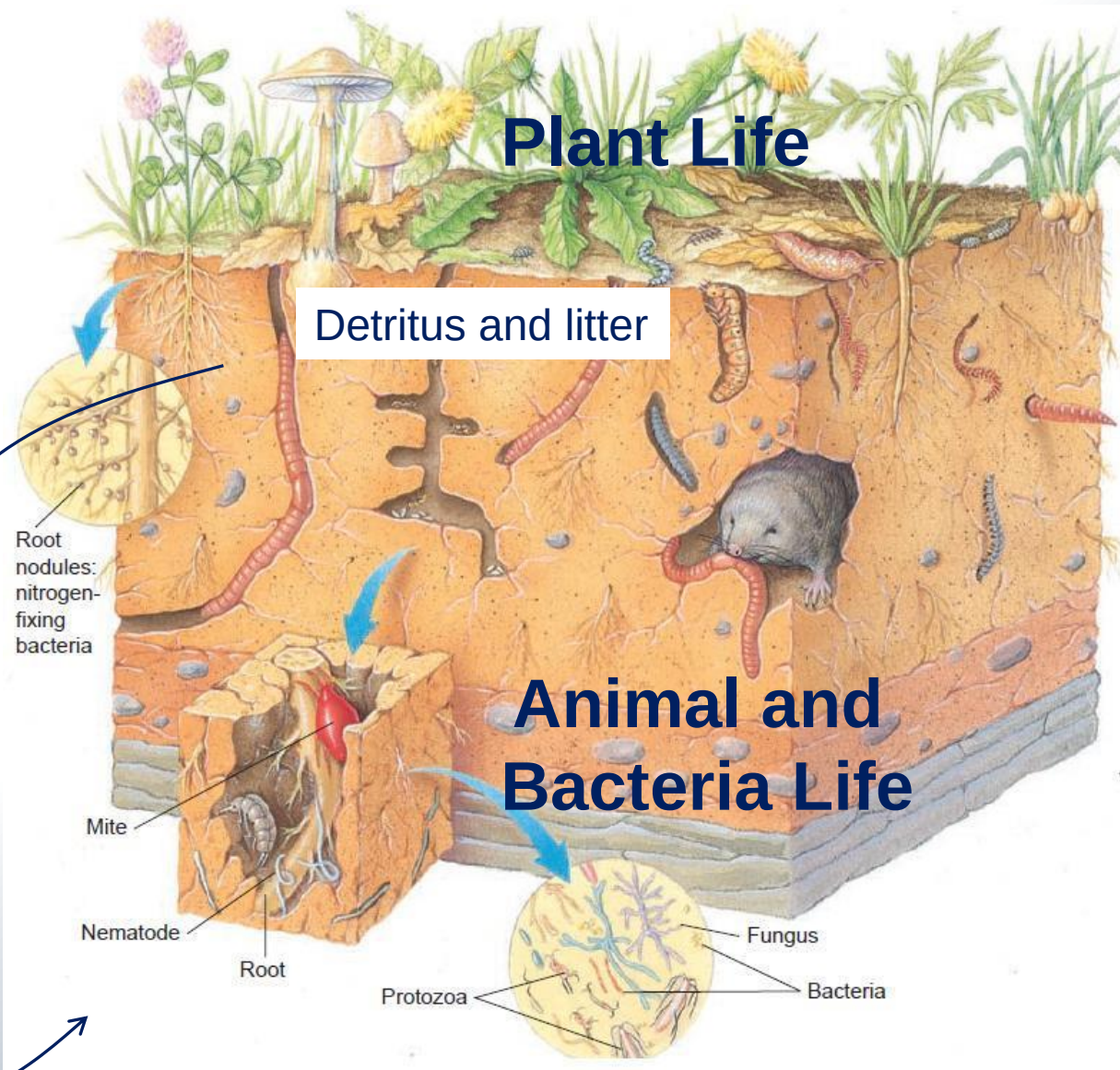
- Vary in physical and chemical properties... (soil types!)
- Habitat on various scales for flora *and* fauna
- Provide nutrients for primary production (life)

Decomposition =

Mineralization (oxidation of organic matter to release nutrients)

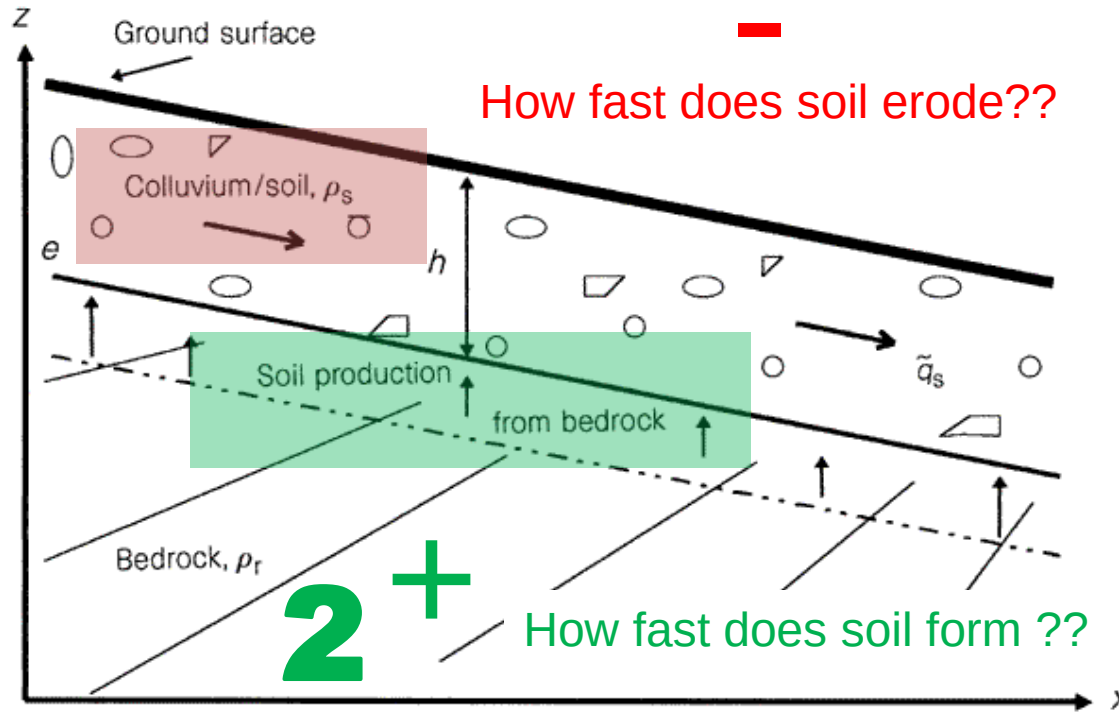
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Humification (transformation of organic matter into stable forms to improve soil properties)



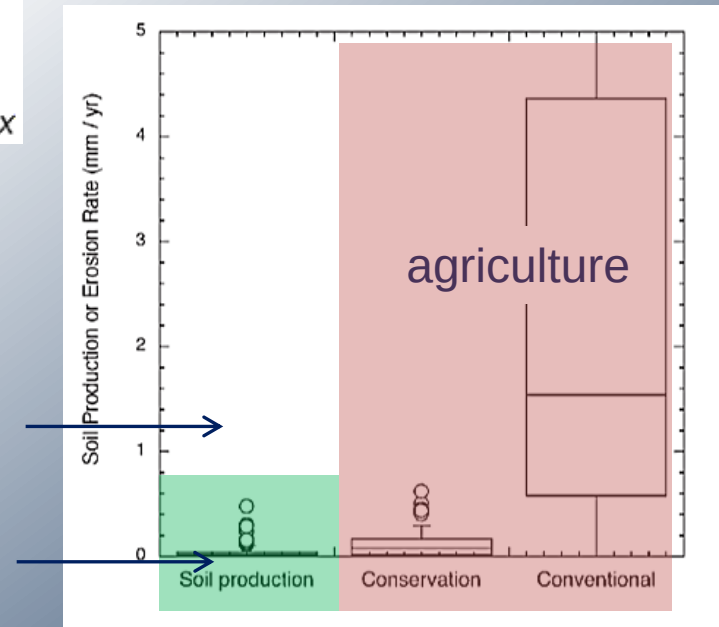
The worlds biggest recycling machine!

Soils and Landscape



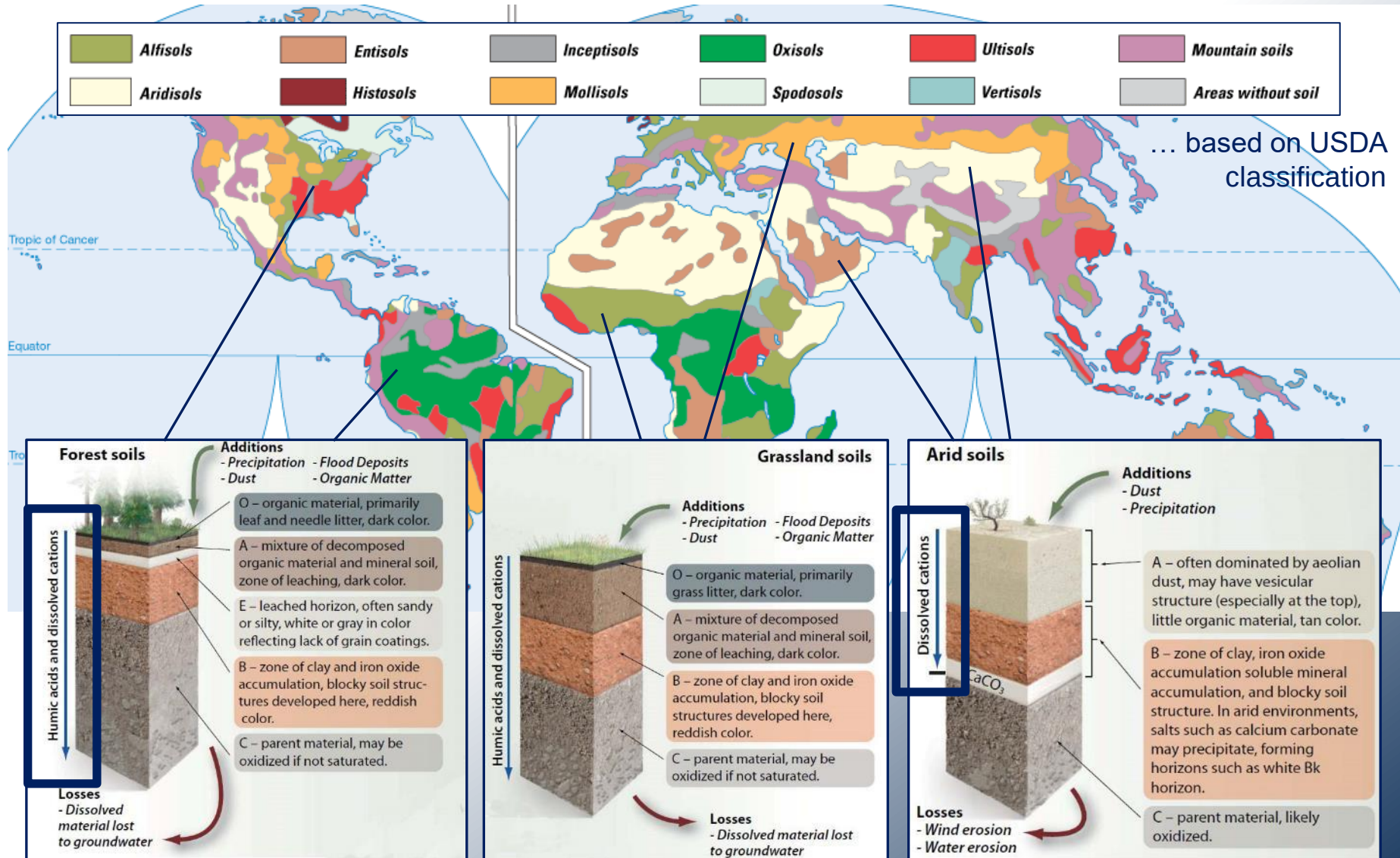
- Soil formation possible only if formation rate is faster than erosion

- Soil production rate vs removal (erosion) rate under agricultural use... is an issue!
- Global average: 114 mm per 1000 years (Stockmann et al. 2014)
- So, what drives soil formation ??



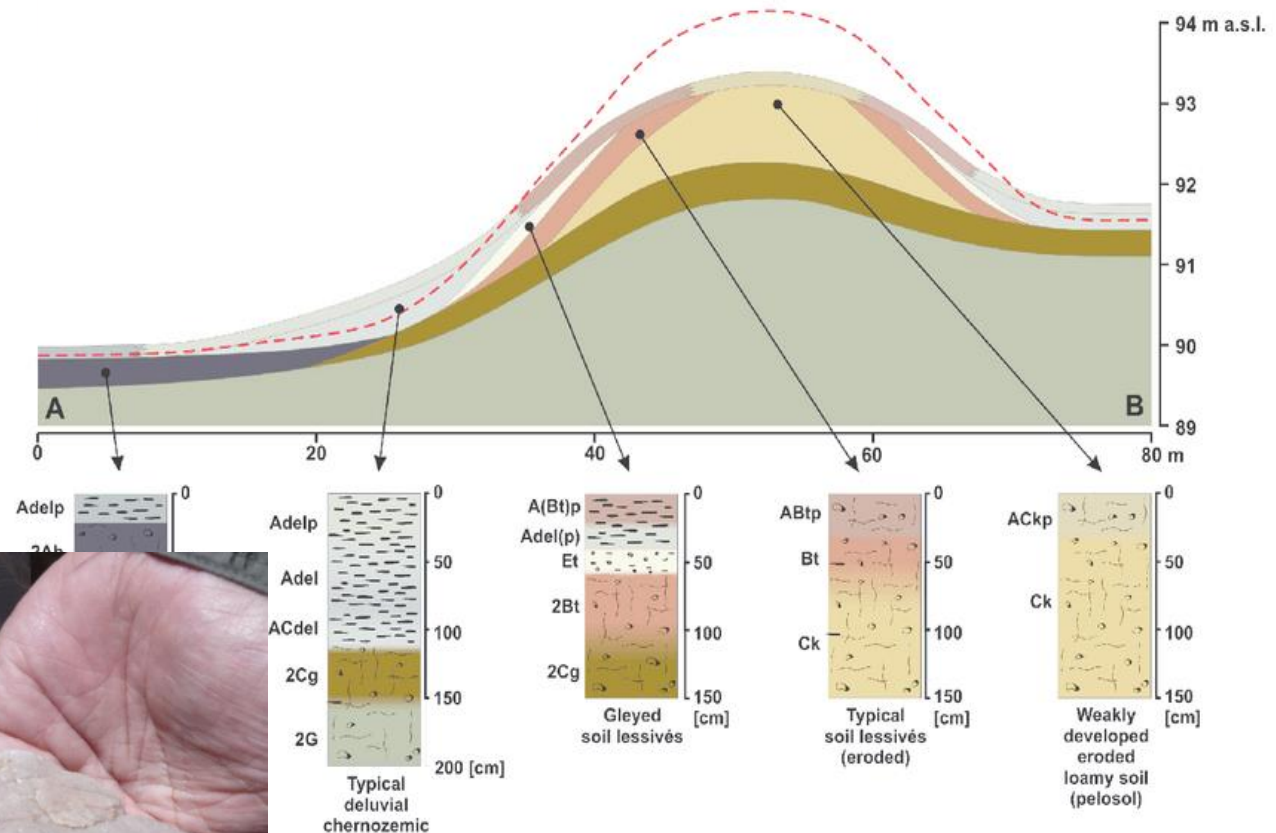
What drives soil formation?

- Soil = f (humans, lithology, **climate, vegetation...**)



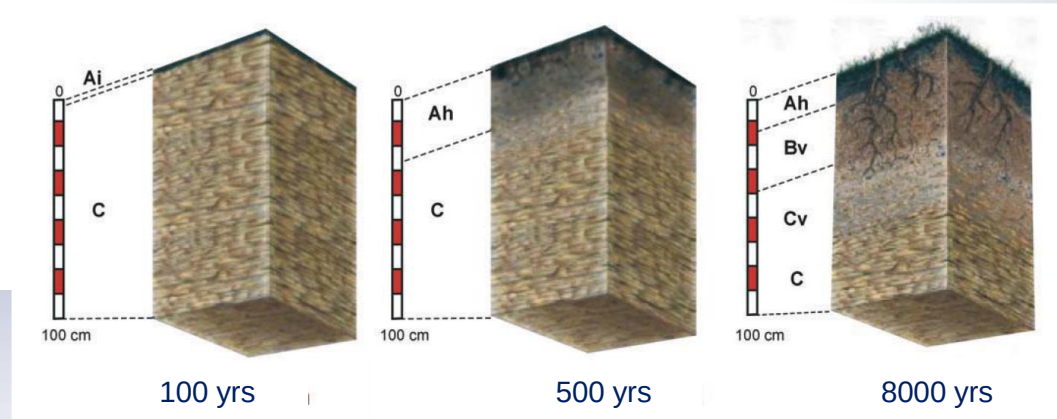
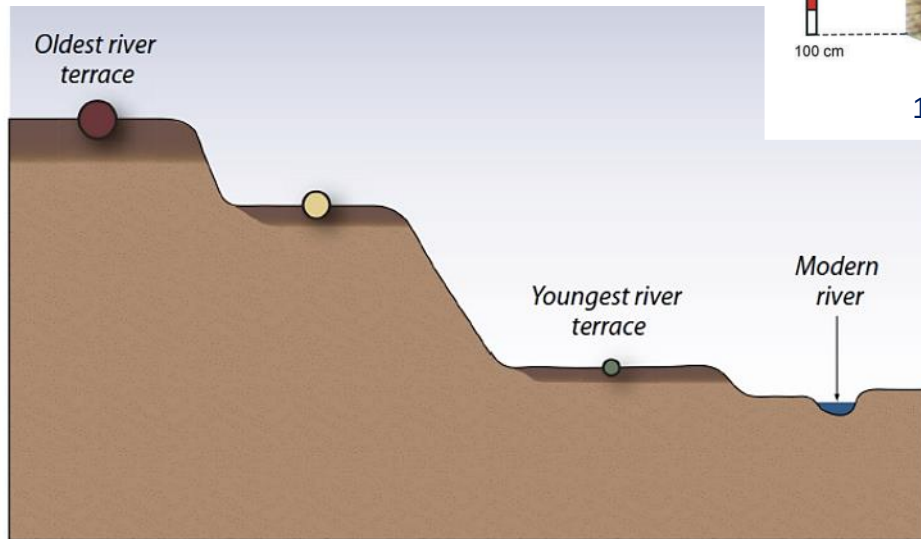
What drives soil formation?

- Soil = f (humans, lithology, climate, vegetation, relief/topography)
- Topo-sequence (catena):
sequence of varying profiles along changing relief/ topography (comparable parent material !?)



What drives soil formation?

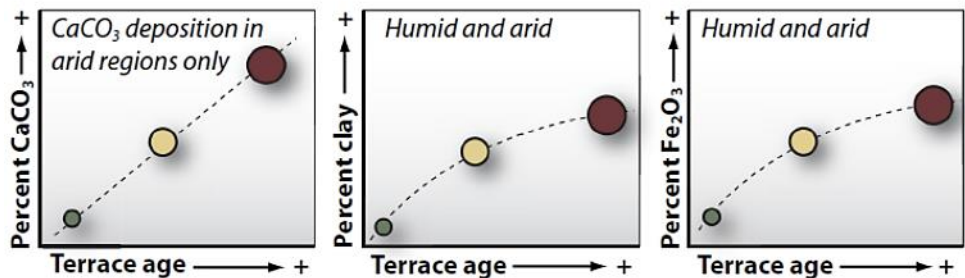
- Soil = f (humans, lithology, climate, vegetation, relief/topography, time)
- Chrono-sequence:
sequence in substrates of
varying age (comparable
parent material !?)



- Change over time in
physical and chemical
properties...

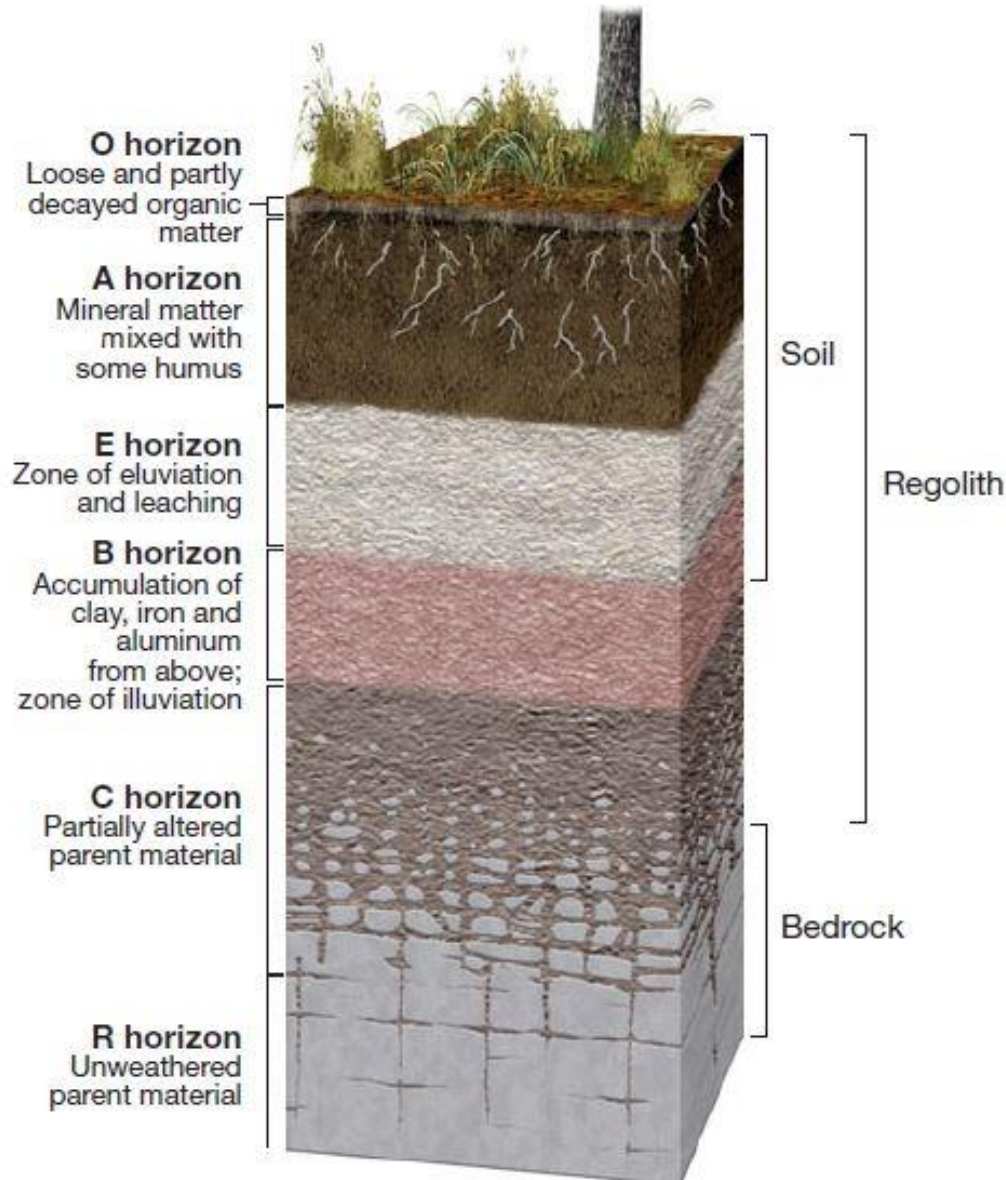
- Thickness
- Horizons
- Colour
- Chemistry
- Biology

- Relation between time and
properties = relative age!!



What drives soil formation?

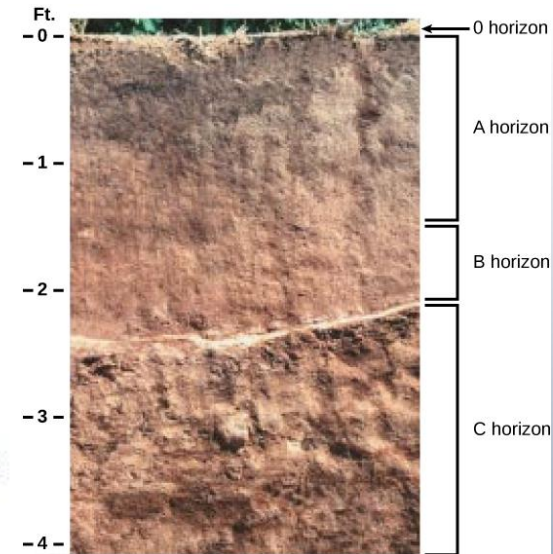
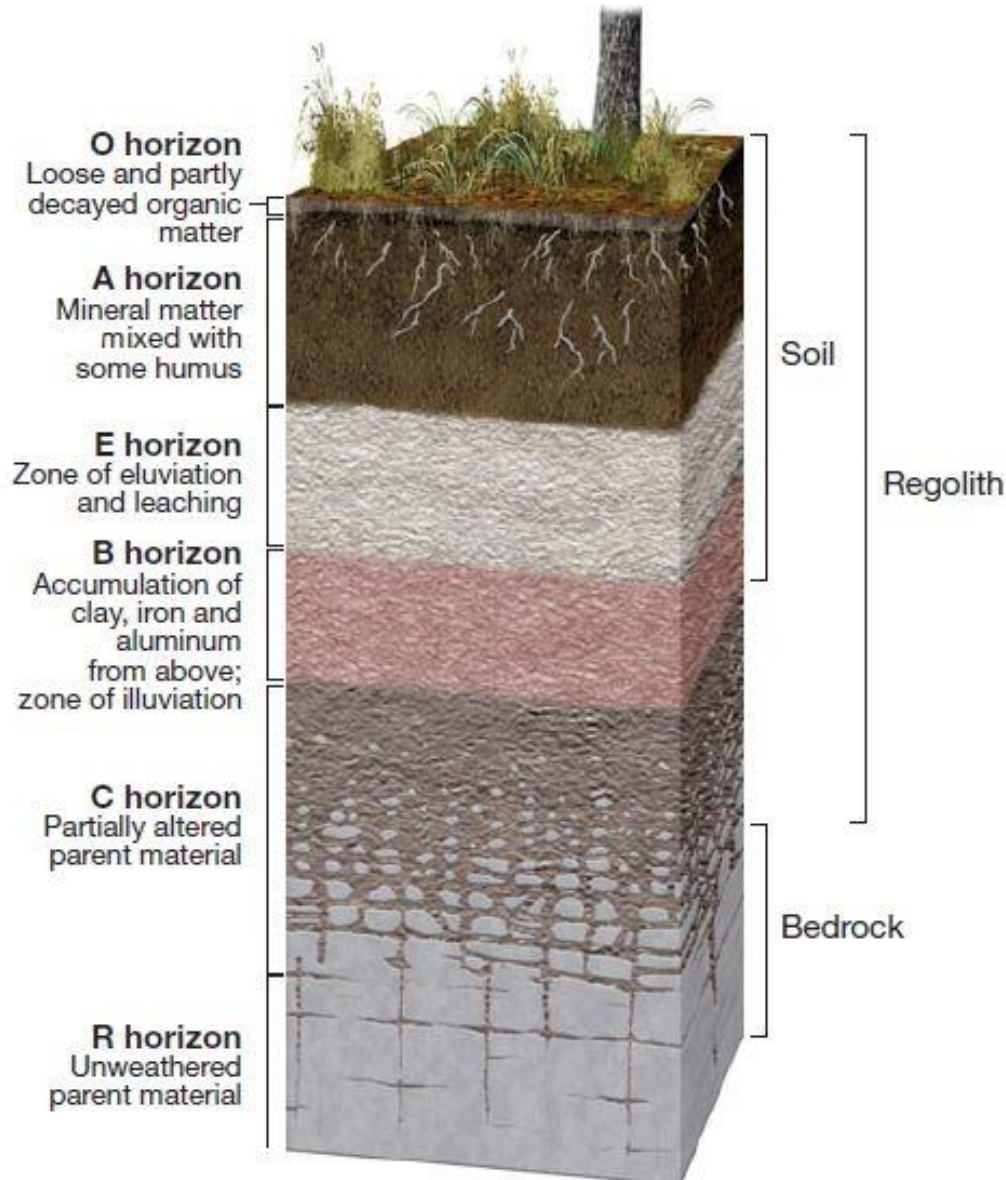
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- Change over time in physical and chemical properties...
 - Thickness
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What drives soil formation?

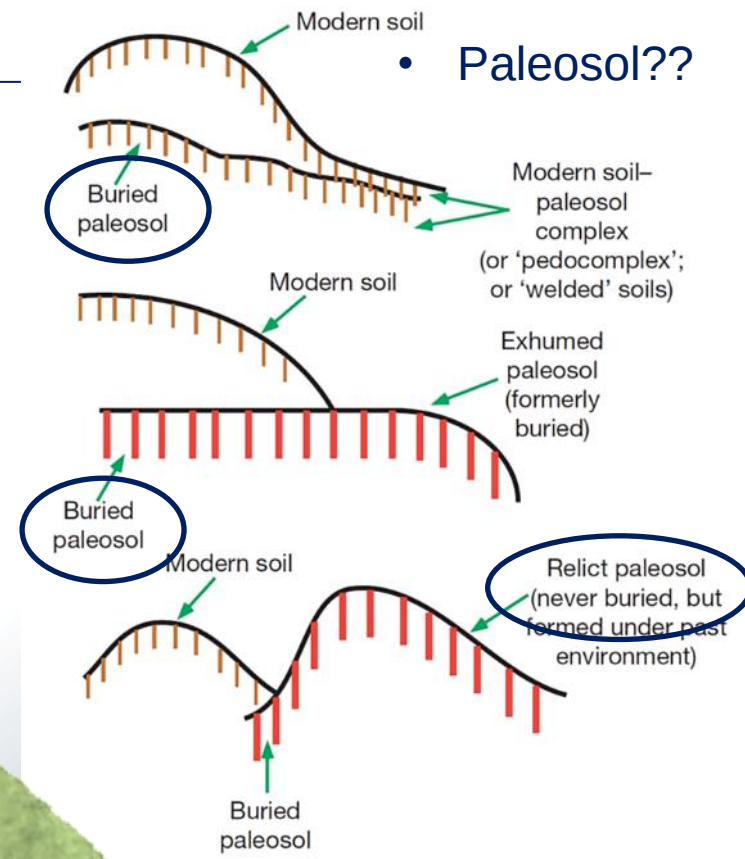
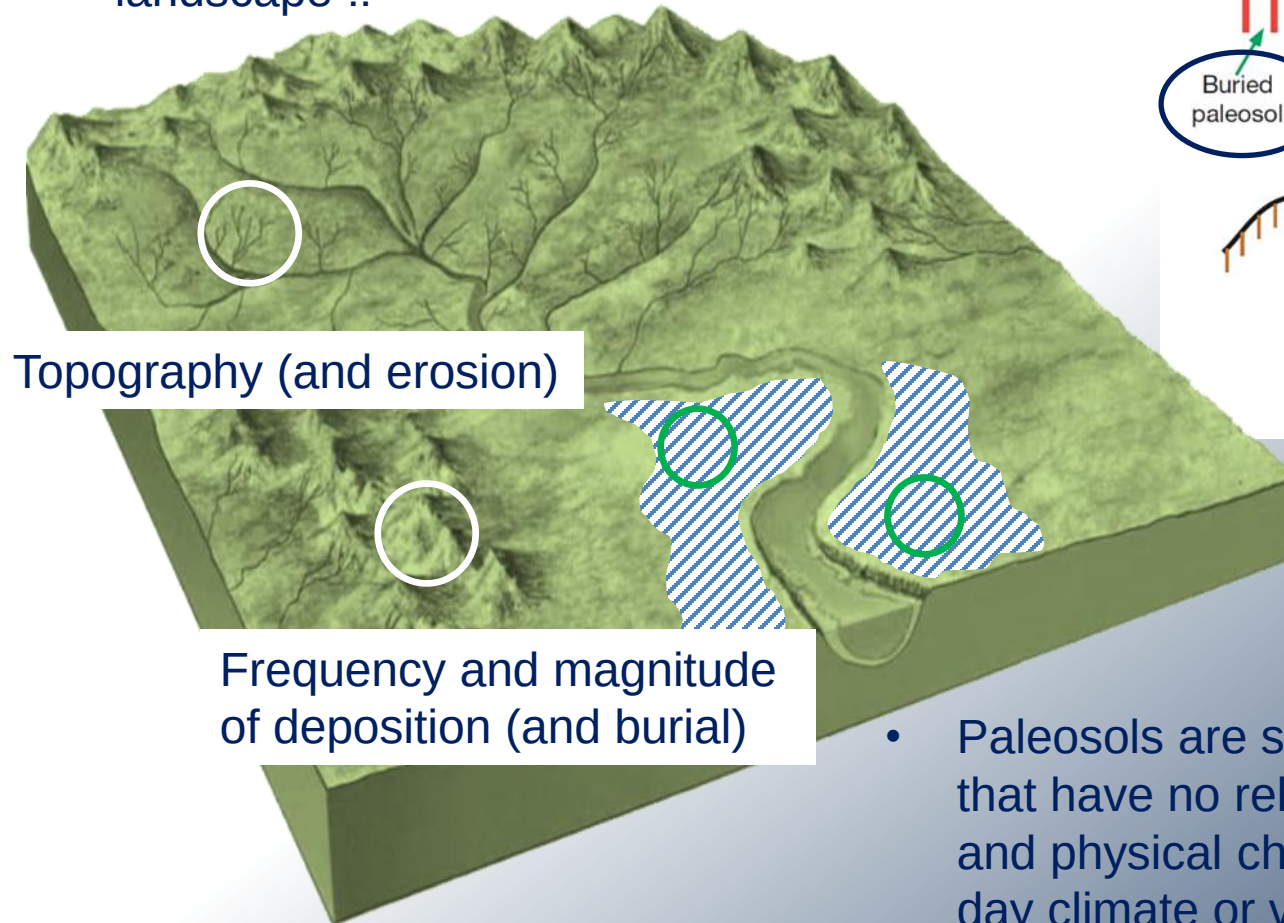
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- Change over time in physical and chemical properties...
- Thickness
- Horizons
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Soils and the landscape

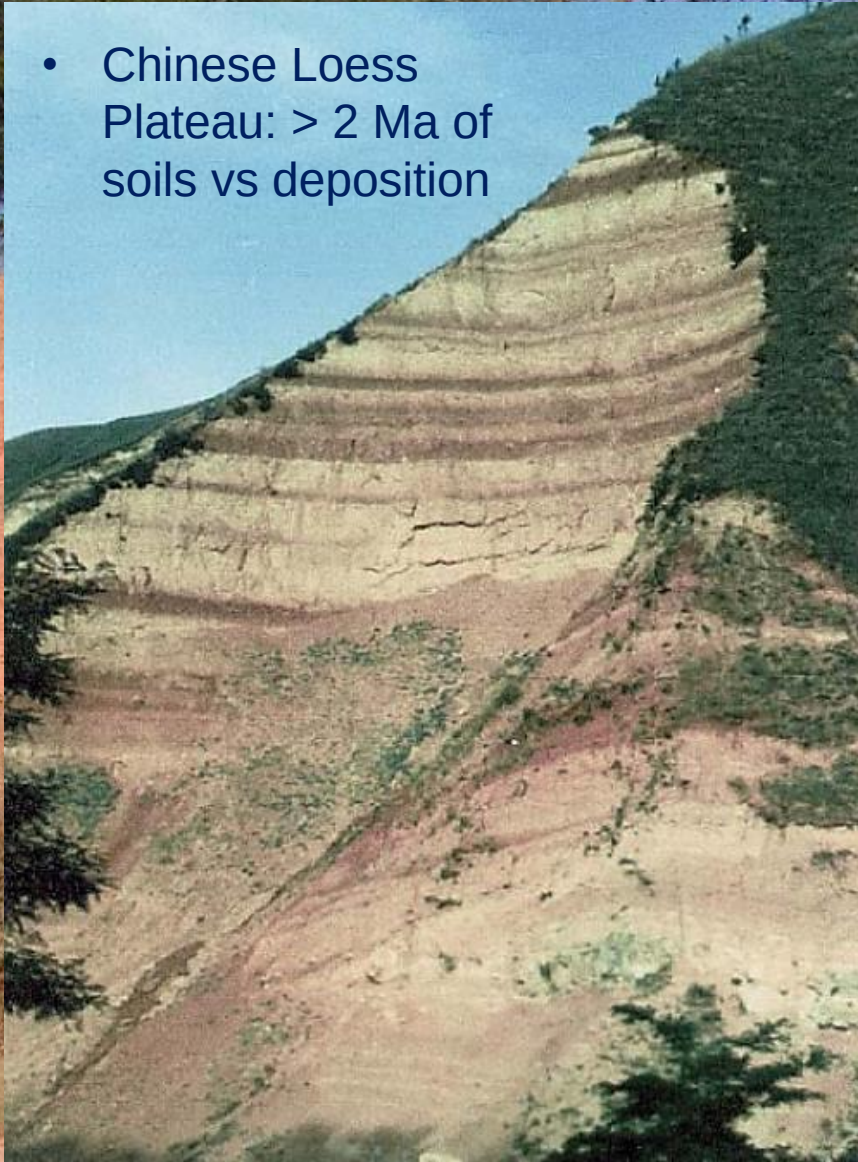
- Where can soils form *and* **preserve**?
What are limiting factors?
- Well-developed soil reflects formation in a morpho-dynamically (relatively) **stable** landscape !!



- Former soil preserved by burial (geology)
- Paleosols are soils formed long periods ago that have no relationship in their chemical and physical characteristics to the present-day climate or vegetation (soil science)

Paleosols and Paleoenvironment

- Chinese Loess Plateau: > 2 Ma of soils vs deposition



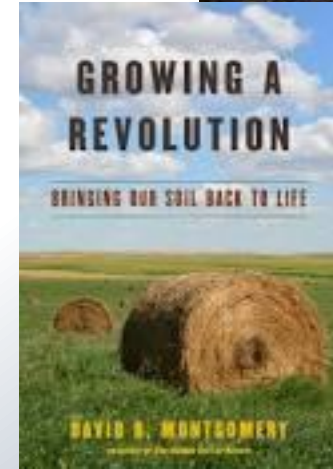
1. Buried, past landsurface (“window in time”)
2. Environmental- and landscape reconstruction (“archive”)

Recommended videos

Soil – Growing a Revolution

(1:11 h length):

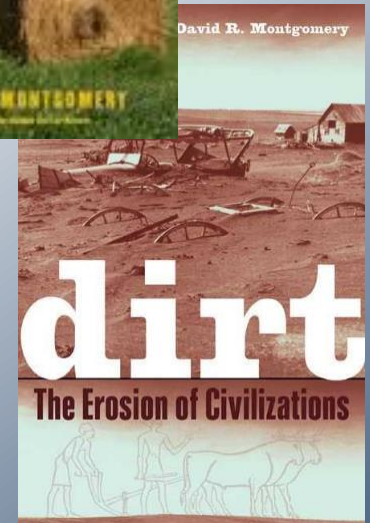
<https://www.youtube.com/watch?v=c4p-kQ6D8aA>



Soil Erosion – Historical Perspective

(1:02 h length):

<https://www.youtube.com/watch?v=KcY4Kwa9fsk>



Talks by David R. Montgomery Ph.D., Professor,
Quaternary Research Center and Department of Earth and
Space Sciences, University of Washington, Seattle, WA

Lab Activity...

Today – Soils Lab: Observations & Soil Tests

[ACNA4007: Soils Lab \(uwtsd.ac.uk\)](http://uwtsd.ac.uk)

Soil Characterization Protocol Field Guide

Task

Identify, measure and record the horizons in a soil profile at a study site. Measure and record the physical and chemical properties that characterize each horizon. Photograph the soil profile. Collect soil samples from each horizon.

What You Need

- ☐ Spray mist bottle full of water
- ☐ Golf tees, nails or other marking device that can be pushed into a soil horizon
- ☐ Trowel, shovel, or other digging device
- ☐ Soil color book
- ☐ Marking pen
- ☐ Camera
- ☐ Pencil or pen
- ☐ Acid bottle filled with distilled vinegar
- ☐ Soil Horizon Definitions page from [Site Definition Sheet](#)
- ☐ Paper towels
- ☐ Meter stick or tape measure
- ☐ Rolling pin, hammer, or other utensil for crushing peds and separating particles

In the Field

Identifying and Measuring Horizons

1. Make sure the sun shines on the profile if possible.
2. Use a trowel to scrape a few centimeters of soil off of the profile to expose a fresh soil face.
3. Determine whether the soil profile is moist, wet, or dry. If the soil profile is dry, moisten it with the spray mist bottle.
4. Start at the top of the profile and observe the characteristics of the soil moving towards the bottom of the profile.
5. Look carefully at the soil profile for distinguishing characteristics such as color, texture, shapes, roots, rocks, small dark nodules (called concretions), worms, small animals, insects, and worm channels. These observations will help to define the horizons.
6. Working in a straight vertical line, place a marker (such as a golf tee or nail) at the top and bottom of each horizon to clearly identify it. Be sure there is a consensus from all of the students regarding the depths of the soil horizons.
7. Measure the top and bottom depth of each horizon beginning at the top (surface) of the profile. Start with the meter stick or tape measure at 0 cm at the top of the profile. Note the depths at which each horizon starts and ends.
8. Record the top and bottom depth of each horizon on the [Soil Horizon Definitions page](#).



Back to the land:
rethinking our approach to soil



FOOD & FARMING FORESIGHT – Paper 3



GL08P 2014 Soil Characterization Protocol – 3 Soil (Photograph)

https://moodle.uwtsd.ac.uk/pluginfile.php/888724/mod_folder/content/0/Soil%20Characterization%20Protocol.pdf?forcedownload=1

This lab should take approximately 1hr, 15mins.