Soils : Formation and Development
(UG HONS. 2nd Year)

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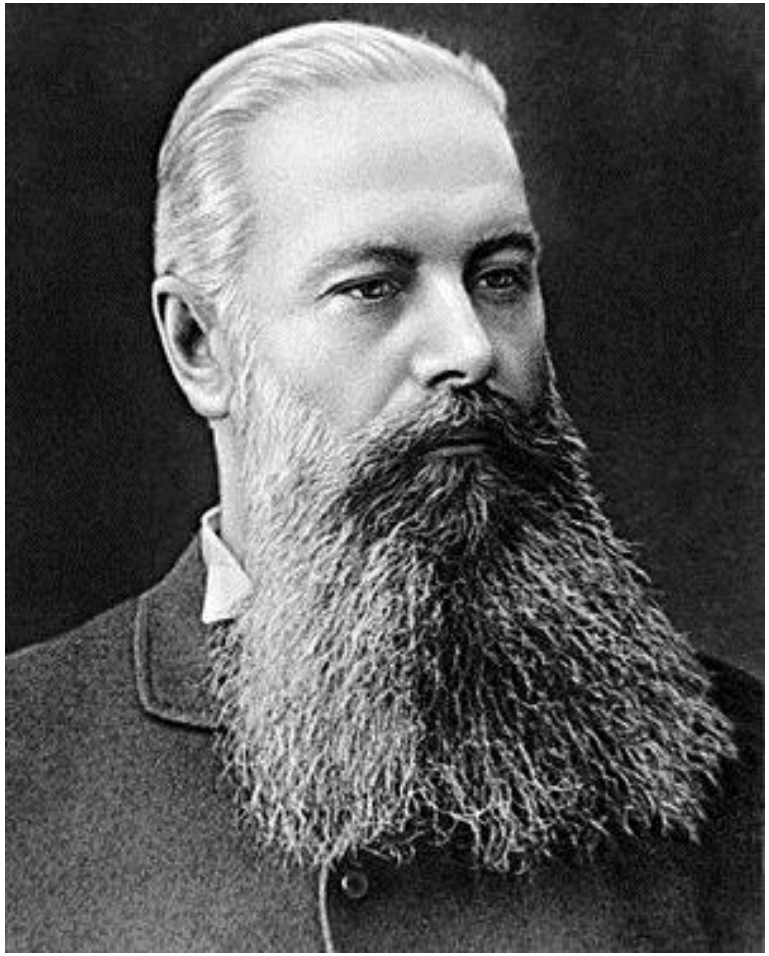
Soil: Definition

- Solid earth material that has been altered by physical, chemical and organic processes so that it can support rooted plant life.

- Engineering definition: Anything that can be removed without blasting

Major Factors of **Soil** Formation



Vasily V. Dokuchaev

Hans Jenny

Soil forming equation (Jenny, 1941)

S = f(cl, o, r, p, t, ….)
S = Soil
cl =Climate
o = Organism
r = Relief
P = Parent material
t = Time

Hans Jenny

Climate

- Temperature and precipitation
- Indirect controls (e.g., types of plants)
- Weathering rates

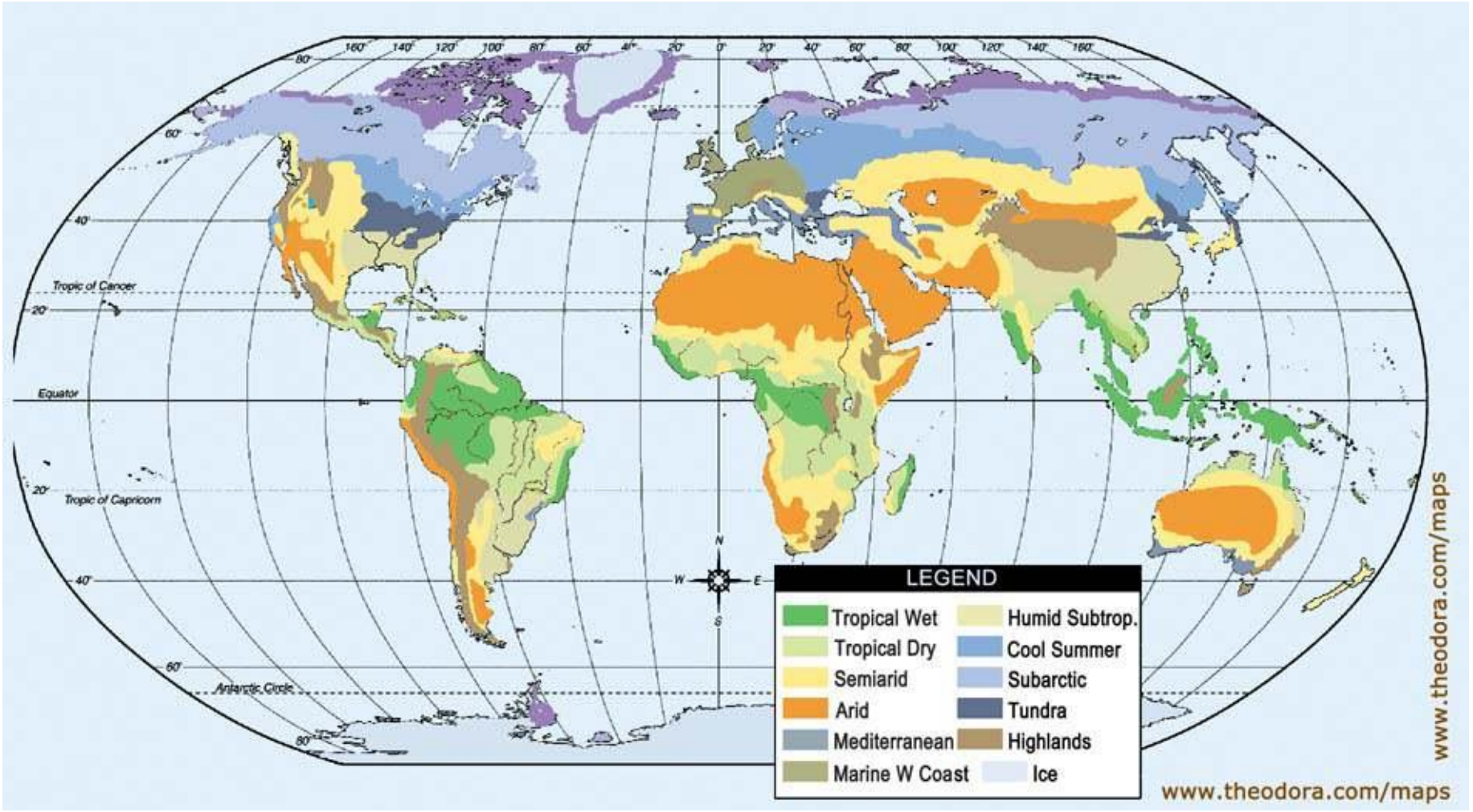
The greater the rainfall amount, the more rapid the rate of both weathering and erosion.

Climate

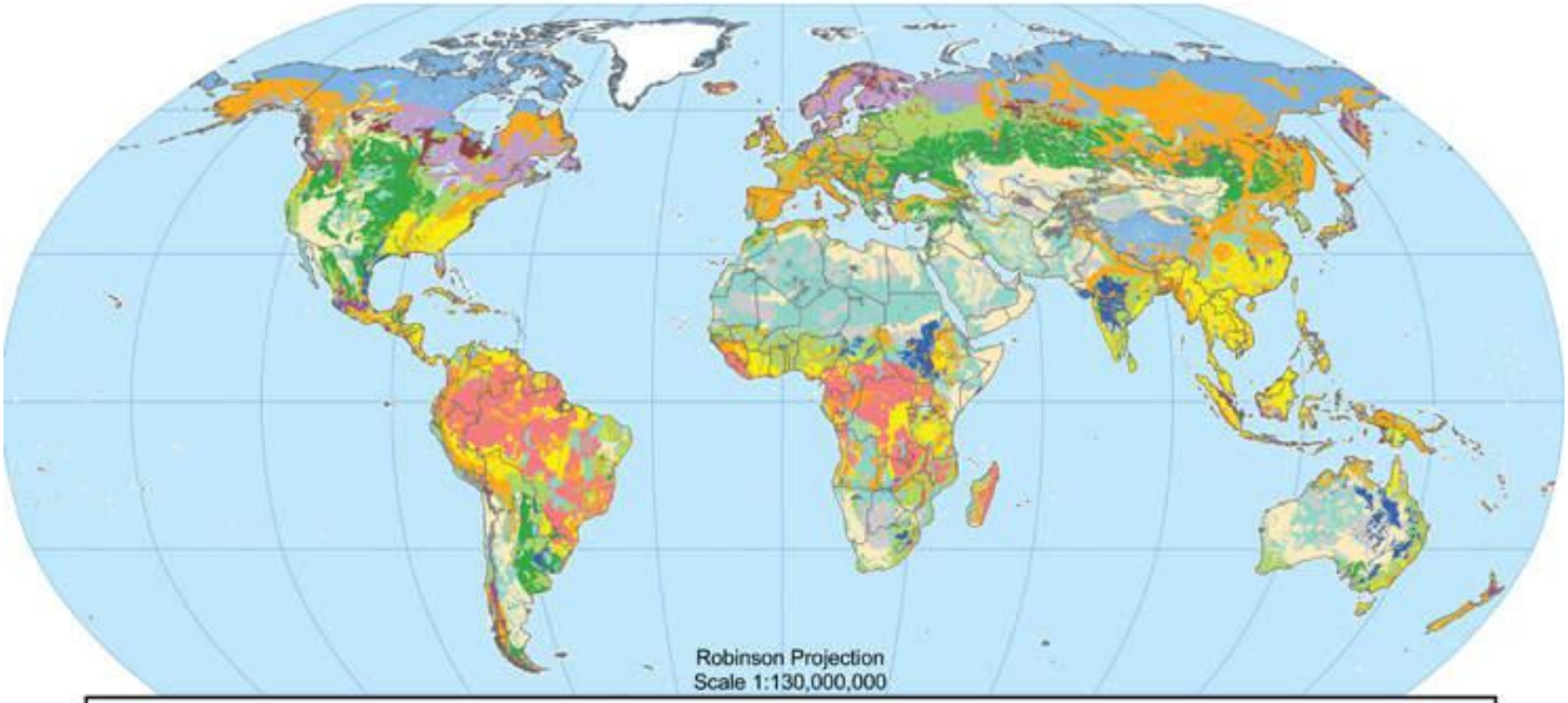
A. Overview

1. "Temperature and Precipitation"
2. Recognized by Russian soil scientists in the 19th century that similar climate zones produced similar soils.
3. Probably the single most important factor in soil development on a global scale.

Global Climate Regions



Global Soil Regions



USDA NRCS US Department of Agriculture
Natural Resources
Conservation Service

Soil Survey Division
World Soil Resources
soils.usda.gov/use/worldsoils

November 2005

Climate

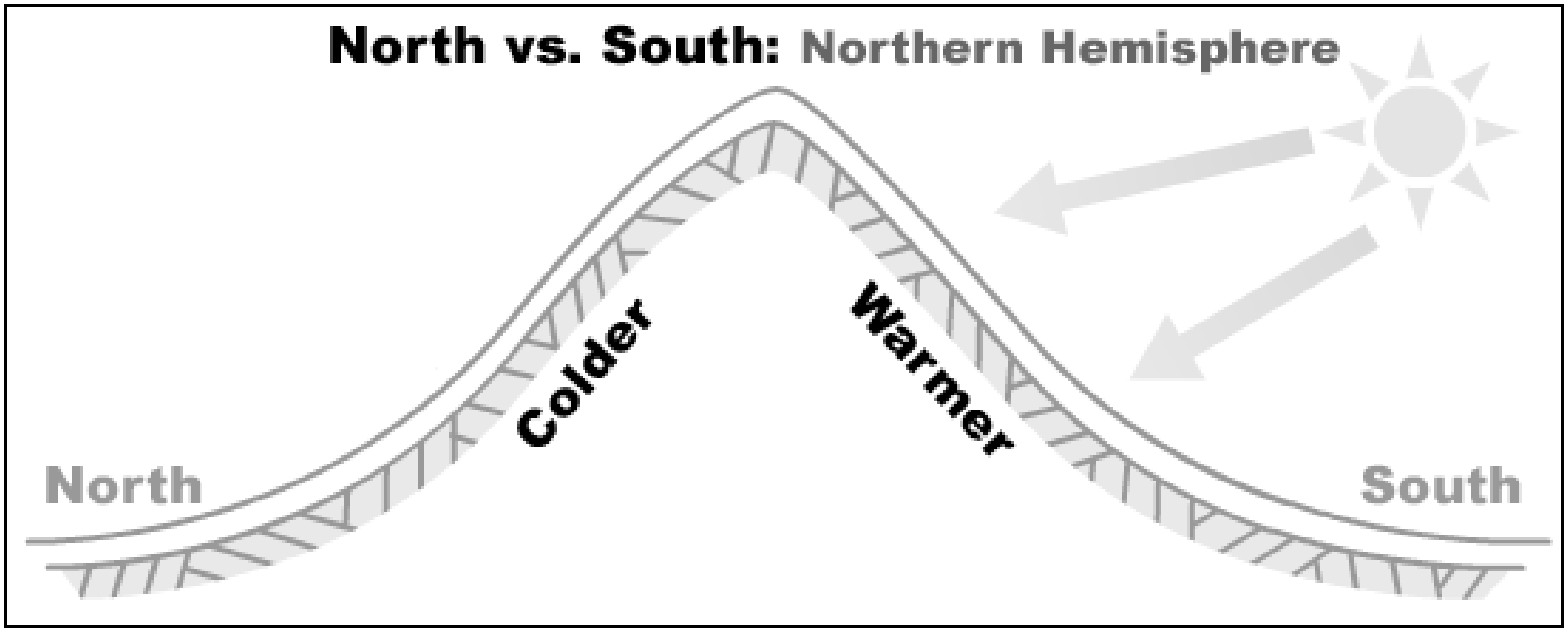
B. Microclimate

1. Exposure

a. Boulder

b. Hillside

Role of climate on development of mountain soils



Organisms

- Types of native vegetation
- Weathering is dependent of plant growth

- Plant and animal activity produces humic acids that are powerful weathering agents.

- Plants can physically as well as chemically break down rocks.

- Plants stabilize soil profiles, Animals (including humans) tend to increase erosion.

Organisms

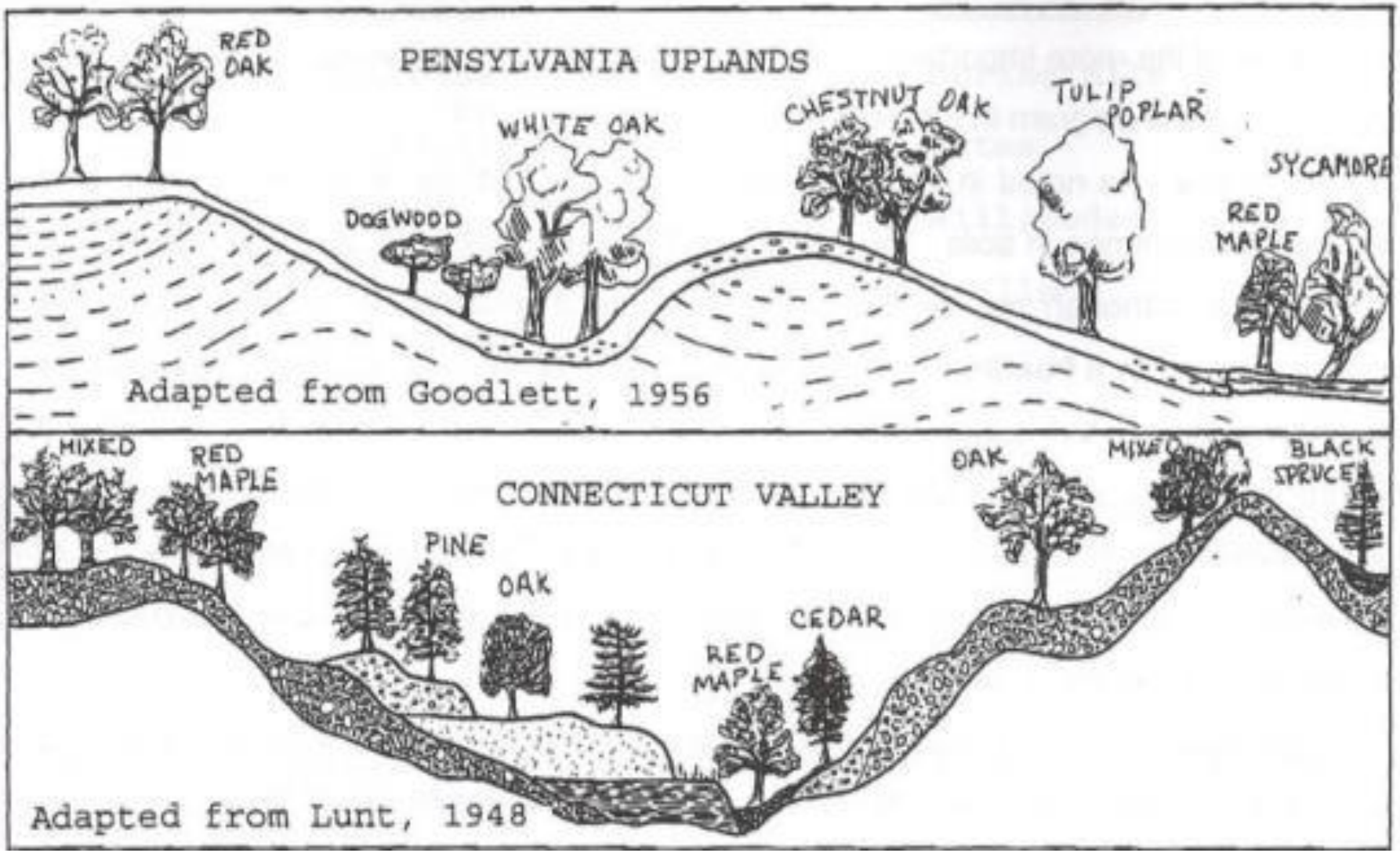
A. Microflora
Bacteria
Actinomycetes
Fungi
Algae
(do best in warm, wet conditions)

B. Macroflora
Grasses
Shrubs
Trees
(tend to react to conditions rather than create them)
Produce large amounts of organics
Protect soil from erosion

Organisms

C. Microfauna
Protozoa
Nematodes

D. Macrofauna
Earthworms,
Ants
Reptiles
mammals


PENSYLVANIA UPLANDS
RED OAK
WHITE OAK
CHESTNUT OAK
TULIP POPLAR
SYCAMORE
DOGWOOD
RED MAPLE
Adapted from Goodlett, 1956
CONNECTICUT VALLEY
MIXED
RED MAPLE
PINE
OAK
CEDAR
RED MAPLE
OAK
MIXED
BLACK SPRUCE
Adapted from Lunt, 1948

Parent Material

- Chemistry
- Mineralogy
- Grain size

Parent Materials

A. Residual Soils

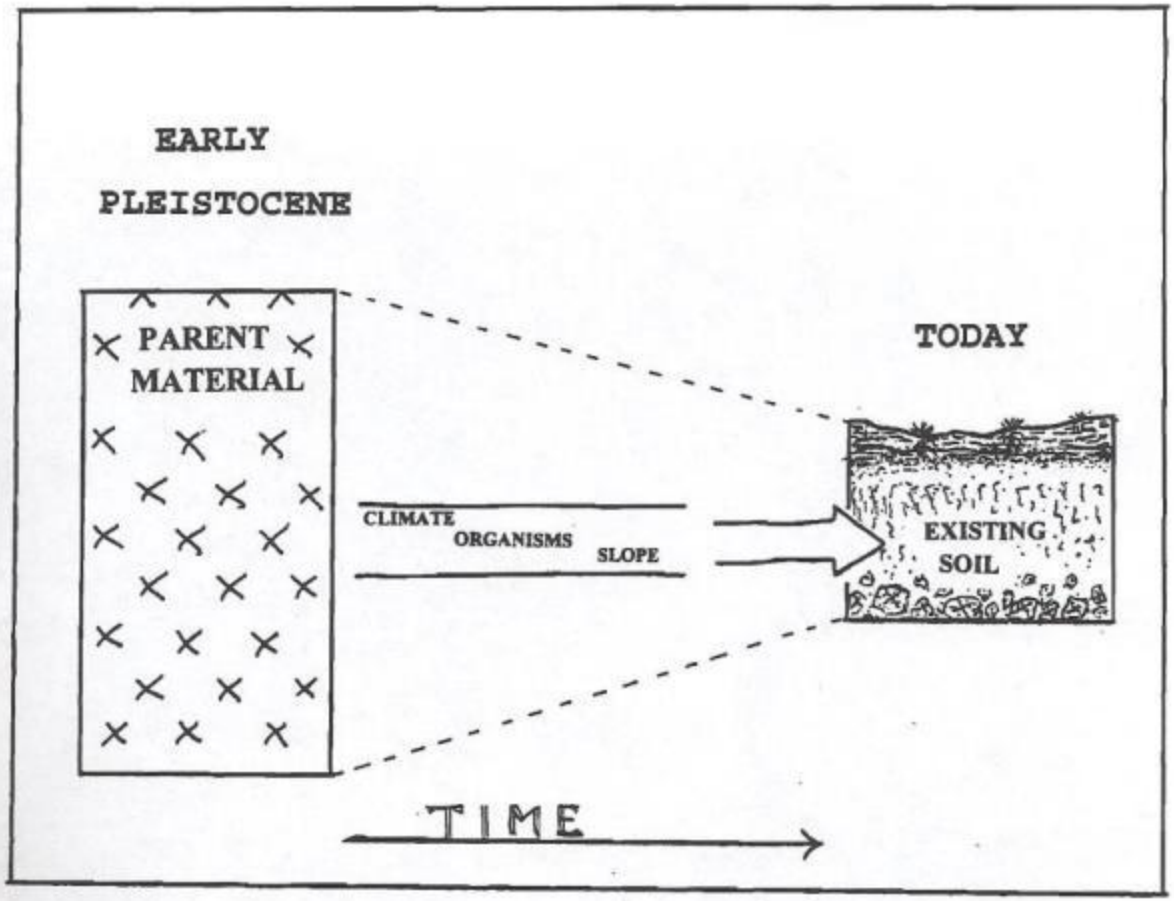
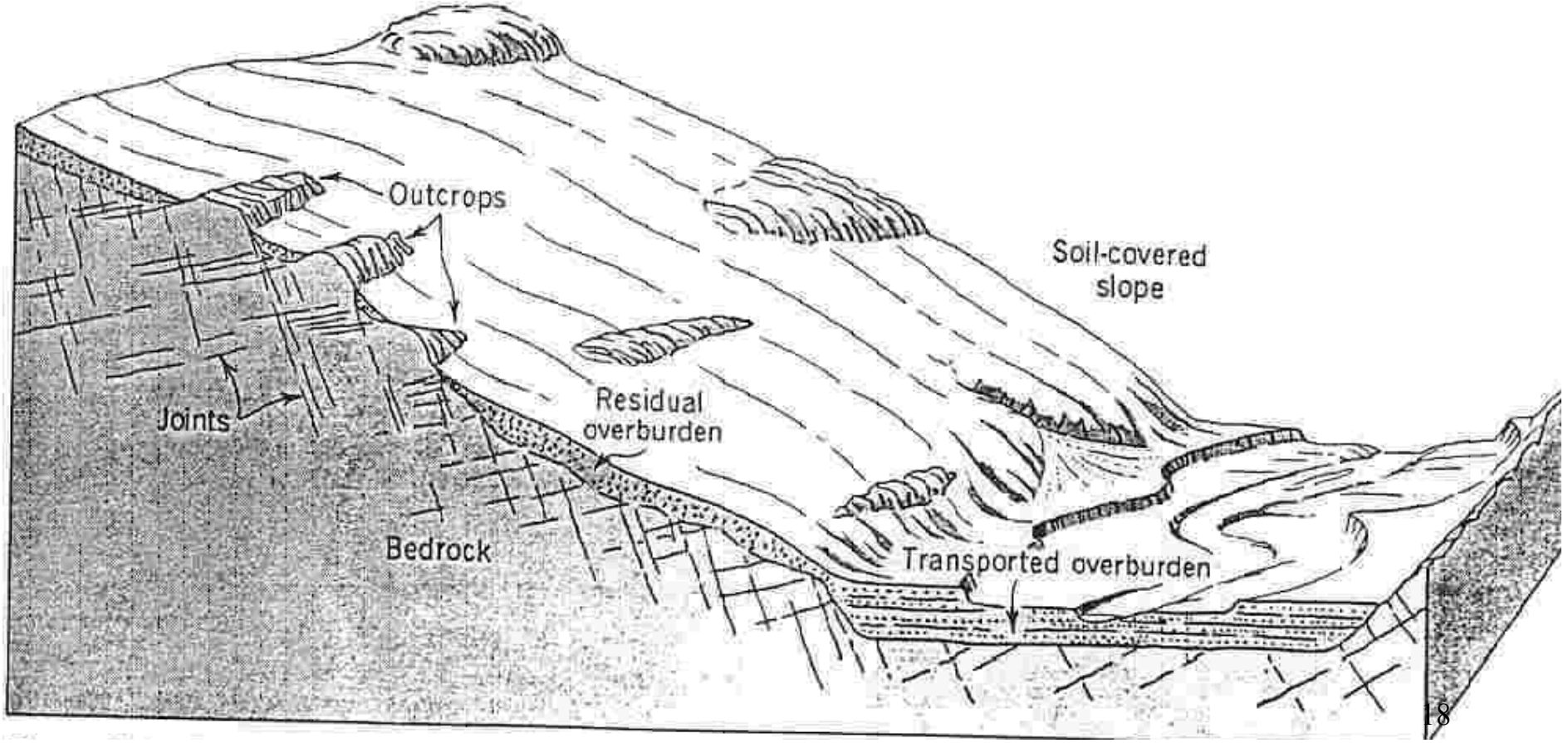


Figure 4-1 Major factors in soil formation. With time, parent material undergoes alteration, and a significant fraction is lost through the processes of chemical weathering and erosion.

Parent Material

B. Transported Soils

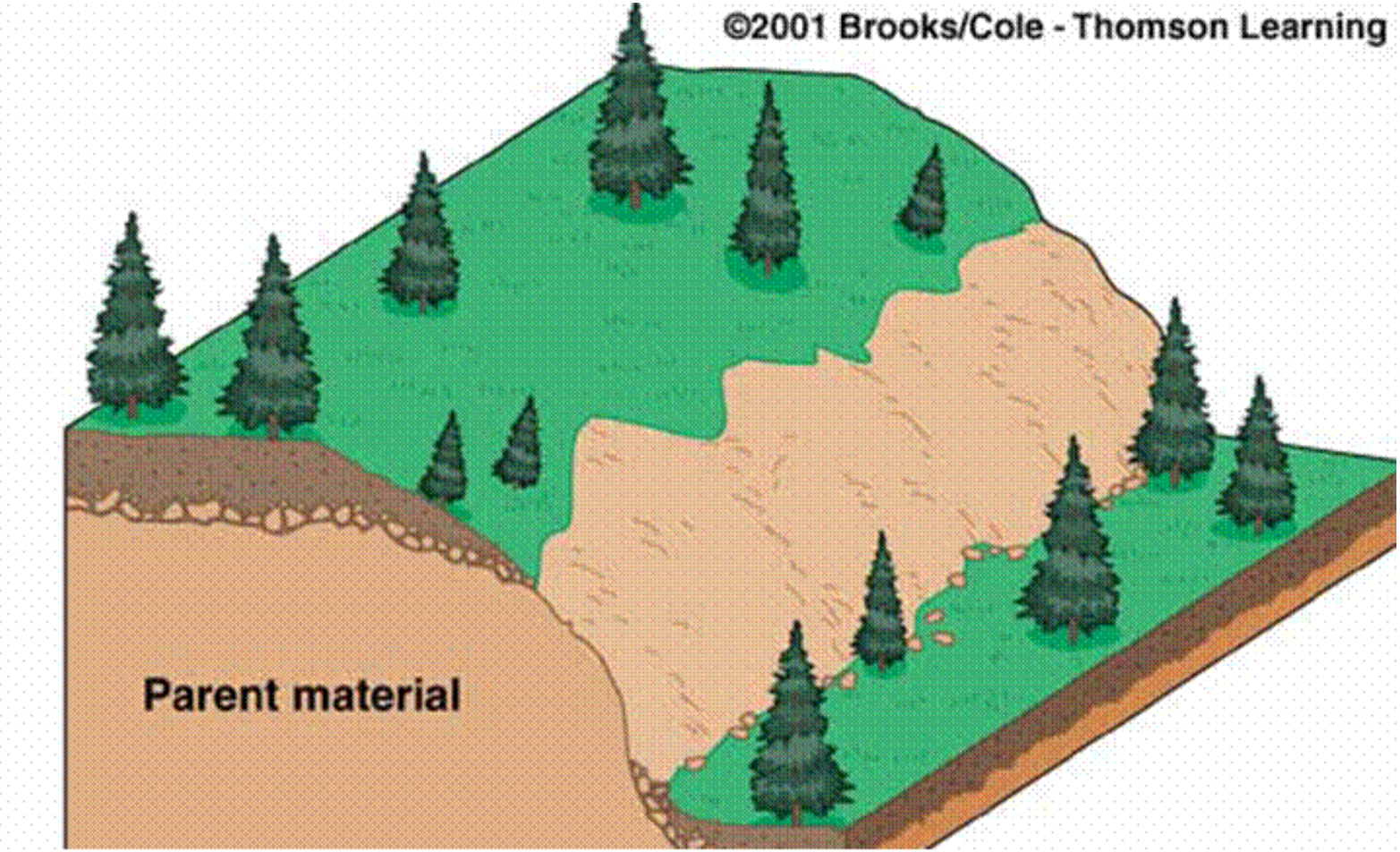


Topography

- Ground slope
- Elevation
- Aspect (e.g., north facing vs. south facing slopes)

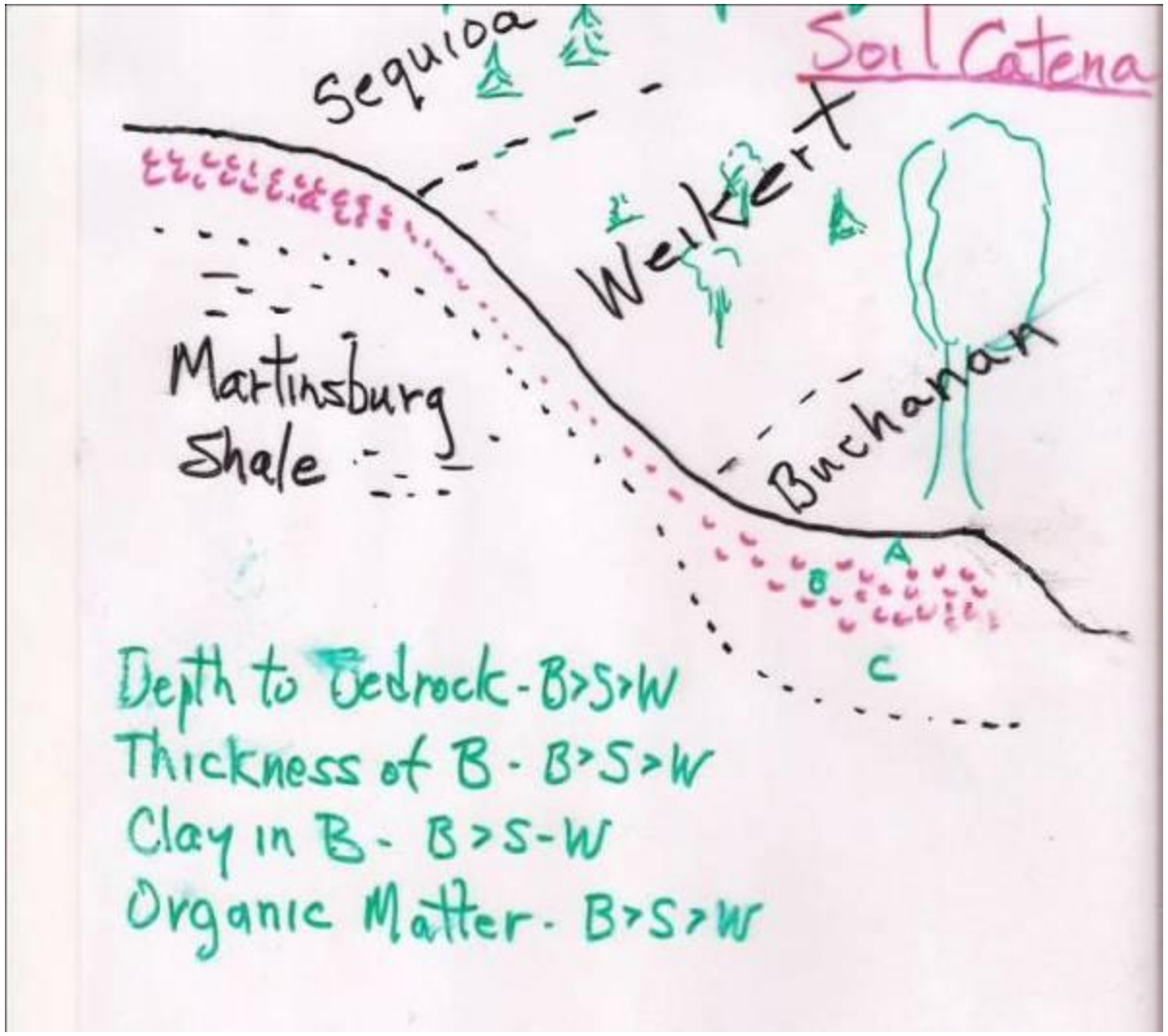
Slope

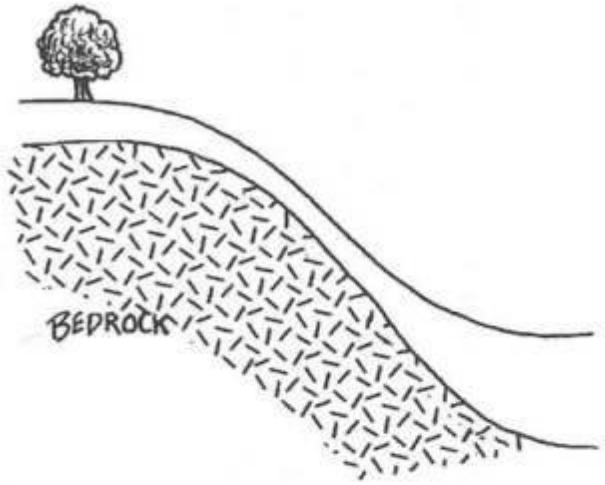
A. Very few completely flat areas



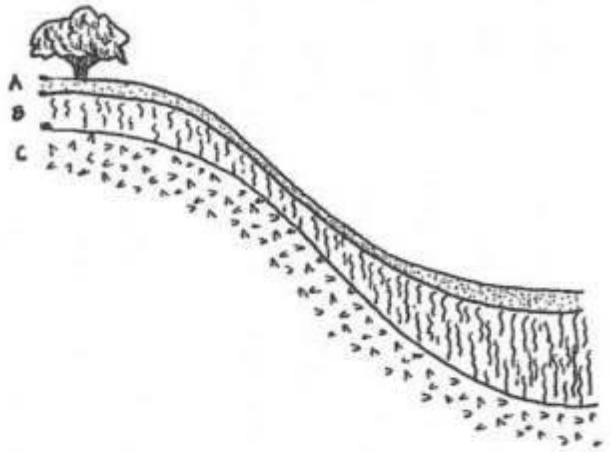
Slope

A. Very few completely flat areas

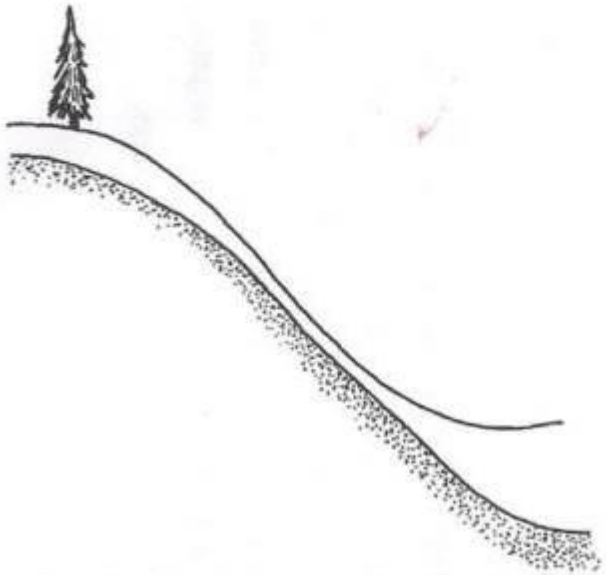




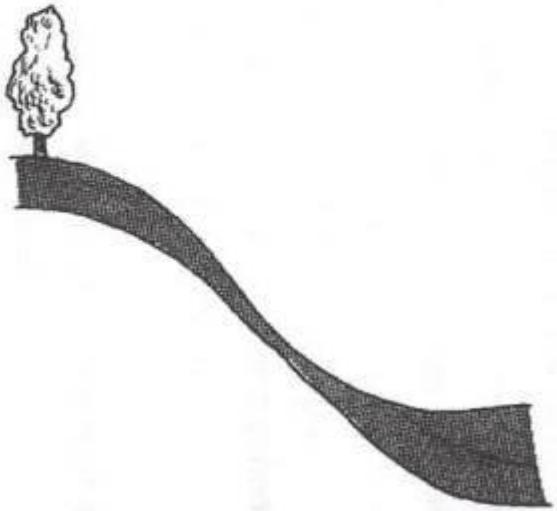
A. Depth to Bedrock



B. Thickness of B Horizon



C. Total clay increase in the B



D. Organic Matter

SCS

Figure 4-9 Effects of slope on selected soil properties.

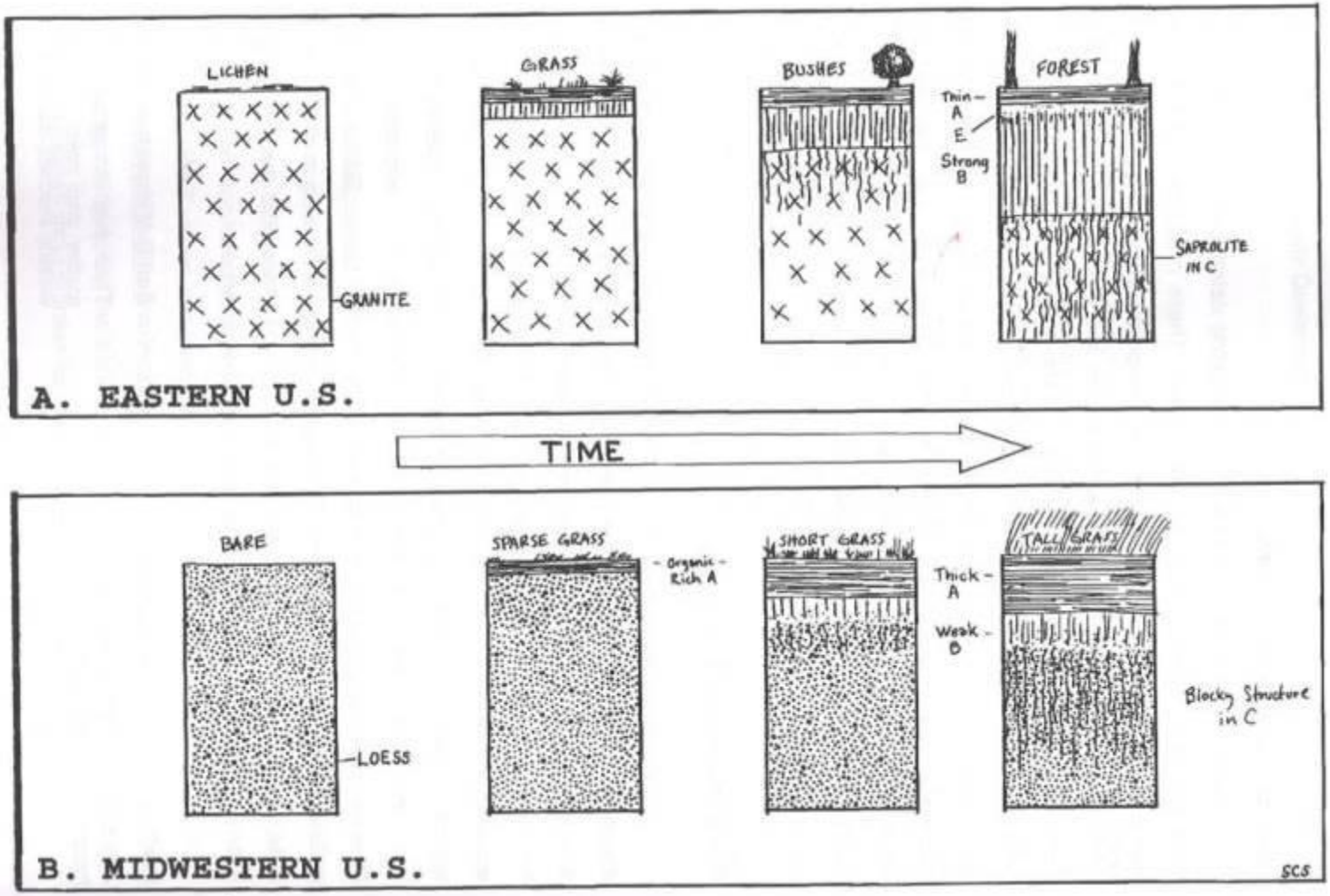
Time

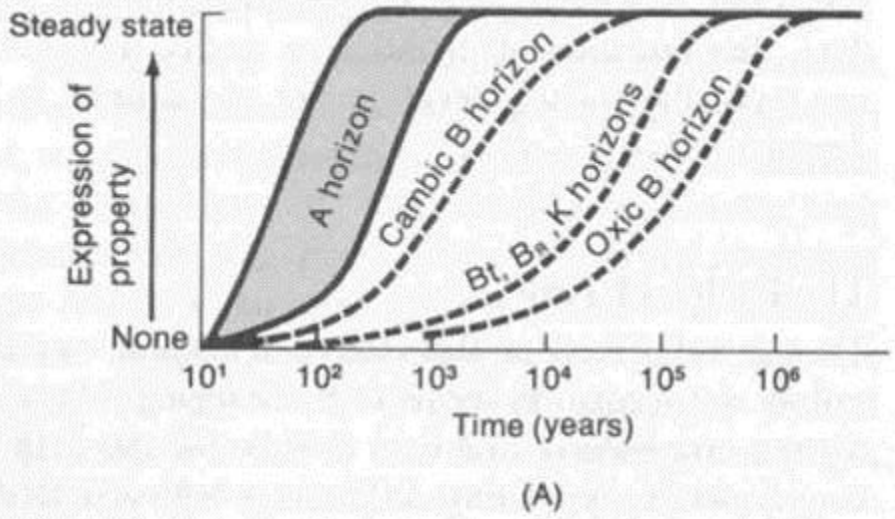
- Development and destruction of soil profiles

- Typical reaction rates are slow, the longer a rock unit has been exposed, the more likely it is to be weathered.

Time

A. A dynamic system





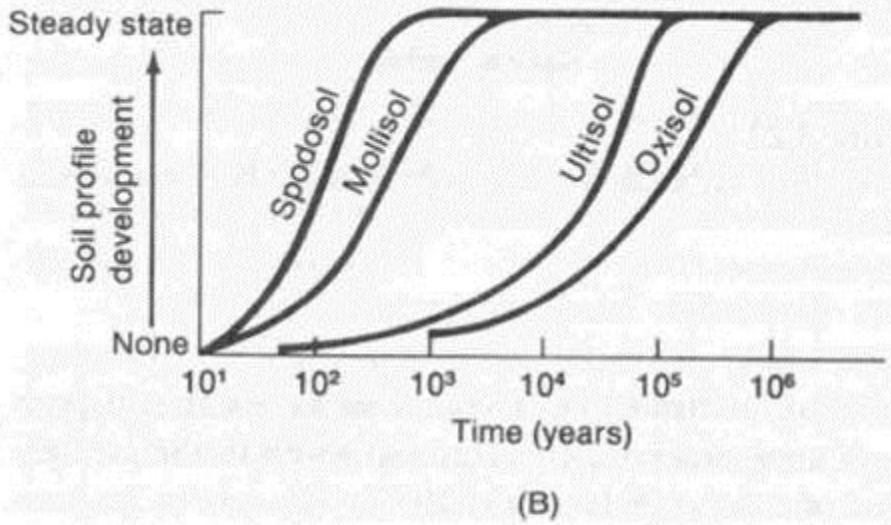
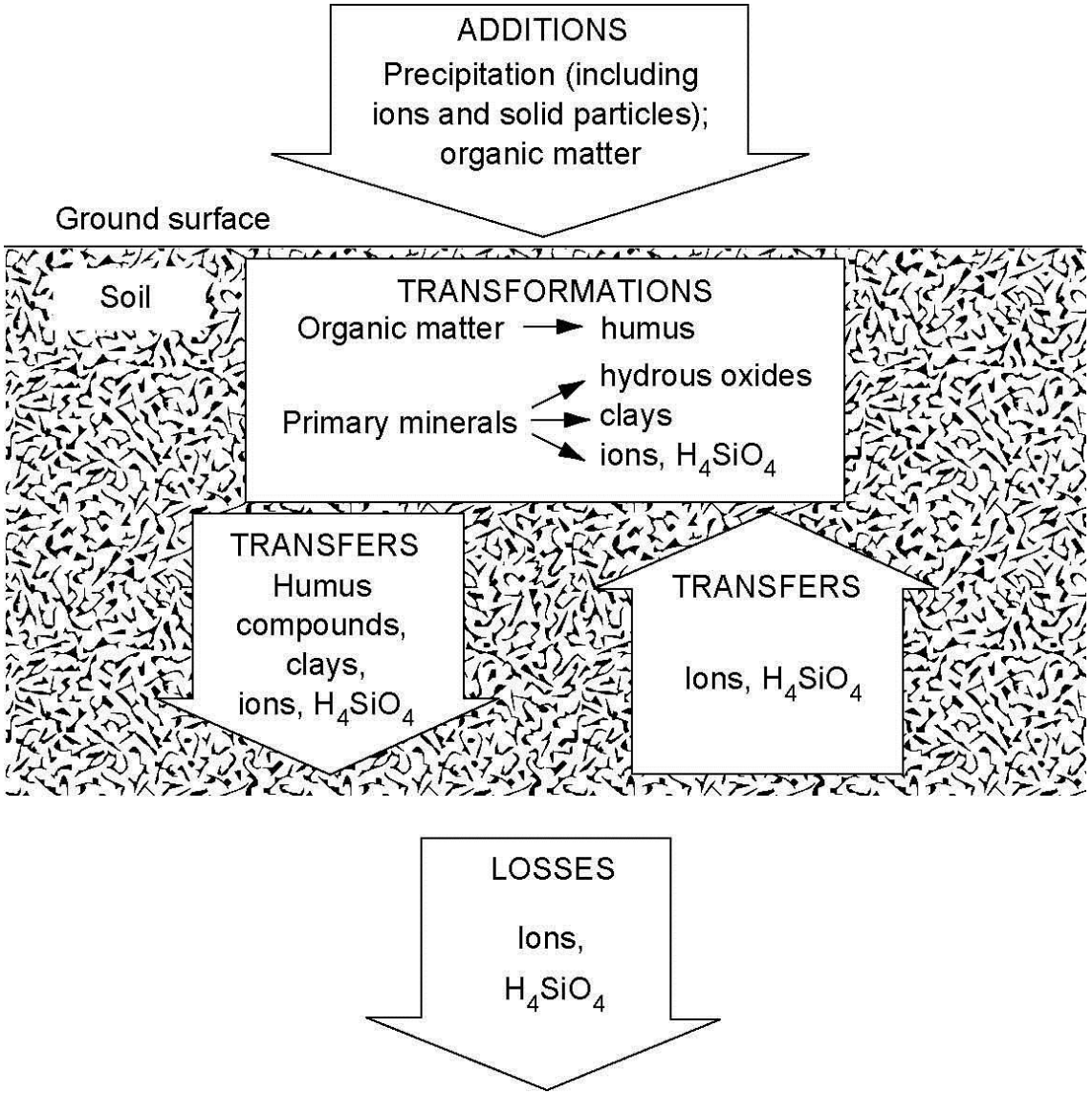


Figure 3.24
Diagram showing the variations in time to attain the steady state for (A) various soil properties and (B) various soil orders.
(After Birkeland 1984)

Soil Development



Additions to Soils

- Inputs from outside ecosystem
  - Atmospheric inputs
    - Precipitation, dust, deposition
  - Horizontal inputs
    - Floods, tidal exchange, erosion, land-water movement
- Inputs from within ecosystem
  - Litterfall and root turnover

Transformations

- Decomposition of organic matter
- Humification to form complex organic matter
- Weathering of rocks
  - Physical weathering
    - Fragmentation of rock
      - Freeze-thaw; drying-wetting; fire
    - Physical abrasion
      - Abrasion by glaciers
  - Chemical weathering
    - Dissolves primary minerals
    - Forms secondary minerals

Decomposition

- Breakdown of soil organic matter to form soluble compounds that can be absorbed or leached

- Depends on
  - Quantity of input
  - Location of input (roots vs. leaves)
  - Environment
    - Temperature
    - Moisture

Limits of Soil Development

Balance Between:

- Downward Lowering of Ground Surface
- Downward Migration of Soil Horizons

If erosion rapid or soil evolution slow, soils may never mature beyond a certain point.

Extremely ancient soils may have lost everything movable

References

1. The nature and properties of Soils by N. C. Brady
2. Text book of soil Science by J.A. Daji
3. Text book of soil science by Biswas and Mukherjee
4. Fundamentals of Soil Science H.D. Foth

Inviting Questions and seeking clarification

Thank you