INTRODUCTION TO WATER EROSION

Amir Sadeghpour, PhD

We are going to cover….

- Water erosion process
- Kinds of erosion
- Types of erosion from water
- Factors that affect soil erosion from water

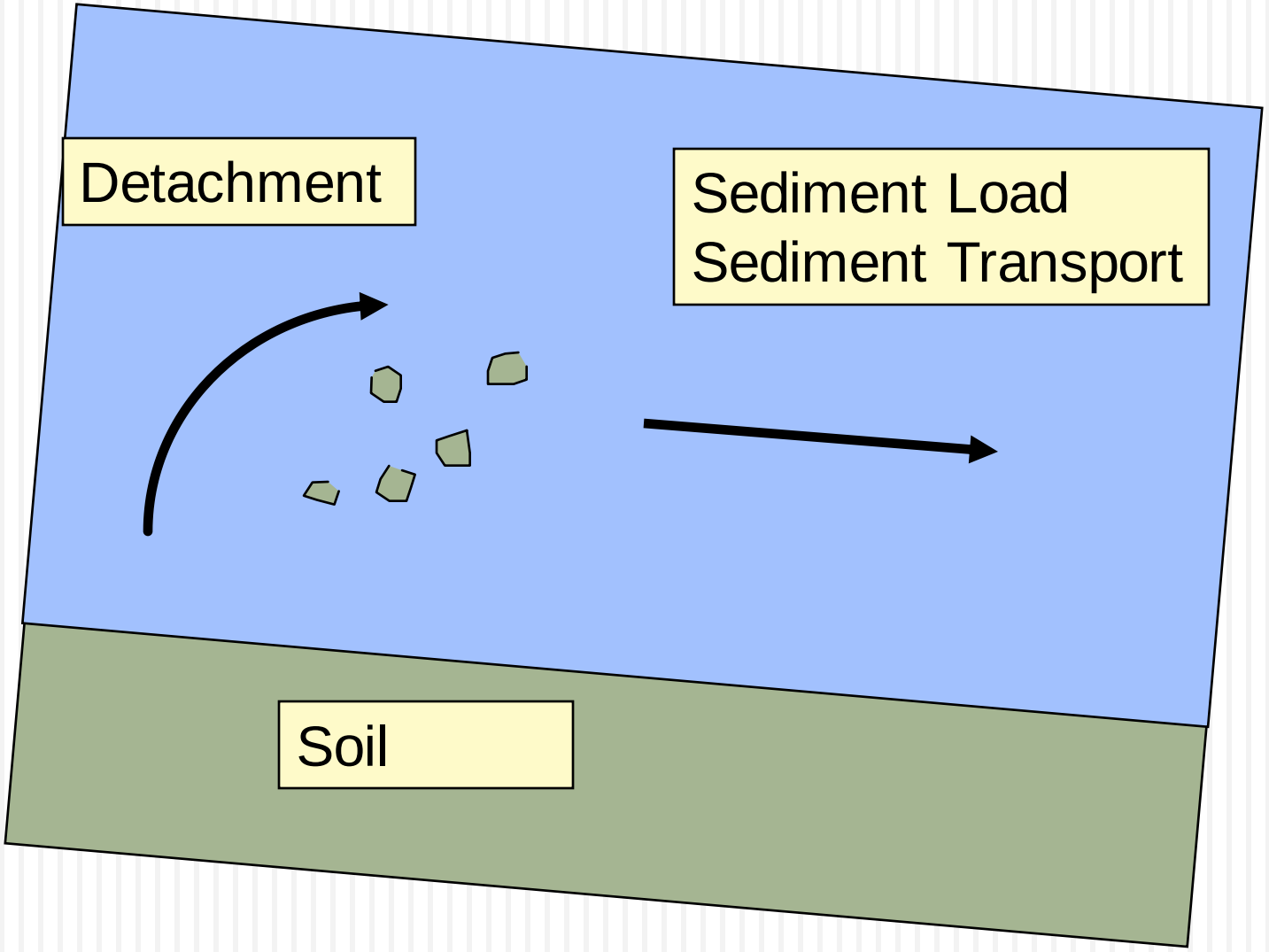
Soil erosion

- 3 things need to happen for soil to be eroding –
  - Soil detaches
    - Impact of the rain drop
    - Runoff/gravity
    - Wind
  - Soil moves
  - Soil deposits

Detachment

- Removal of soil particles from soil surface
- Adds to the sediment load
  - Sediment load is the amount of soil particles

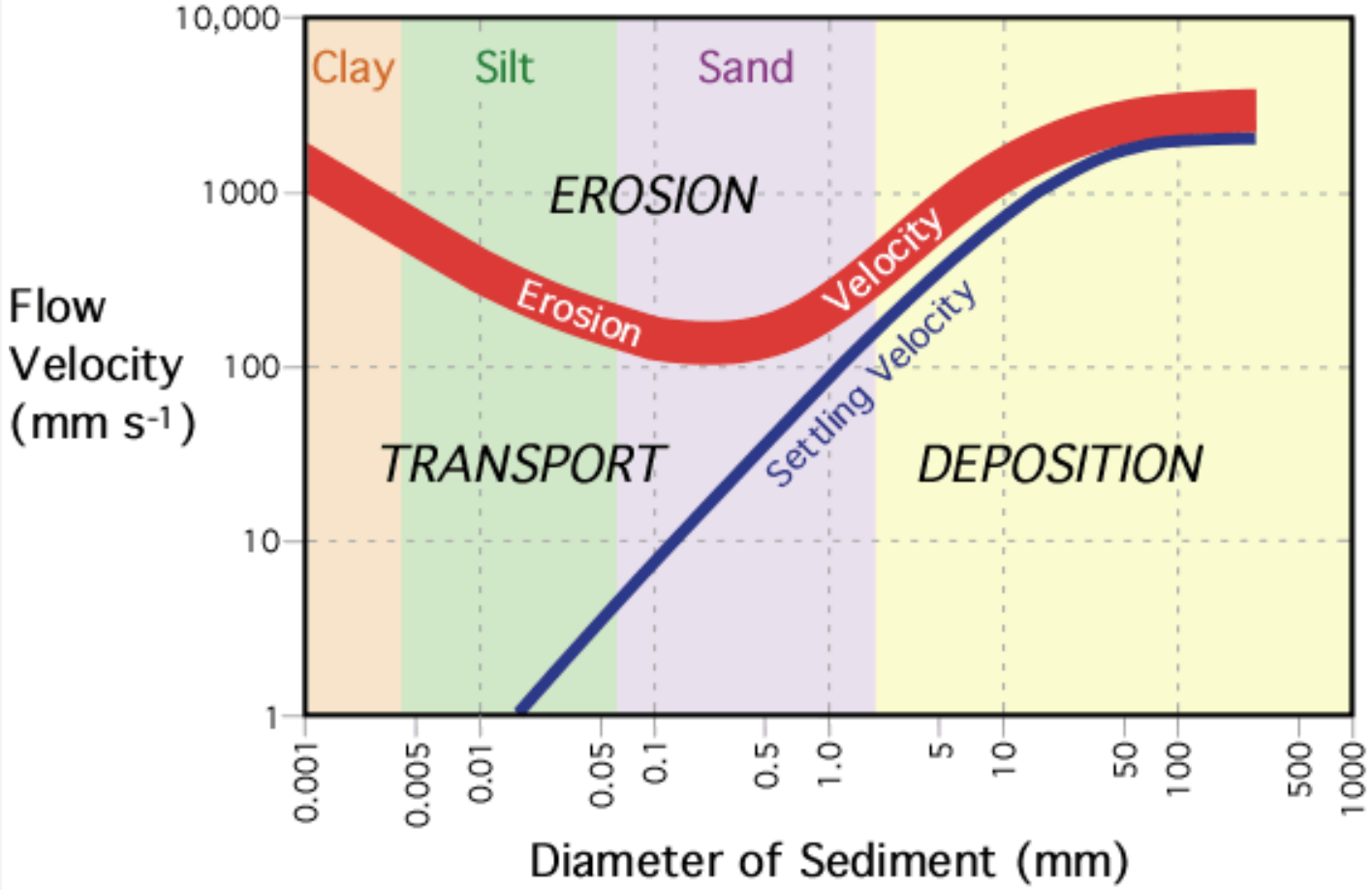
Detachment



Soil moves

- Flow velocity
- Size of particle
- Strength of bonds
  - Clays, silts smaller, but stronger bonds than sand
  - Needs higher velocity

Hjulström-Sundborg diagram

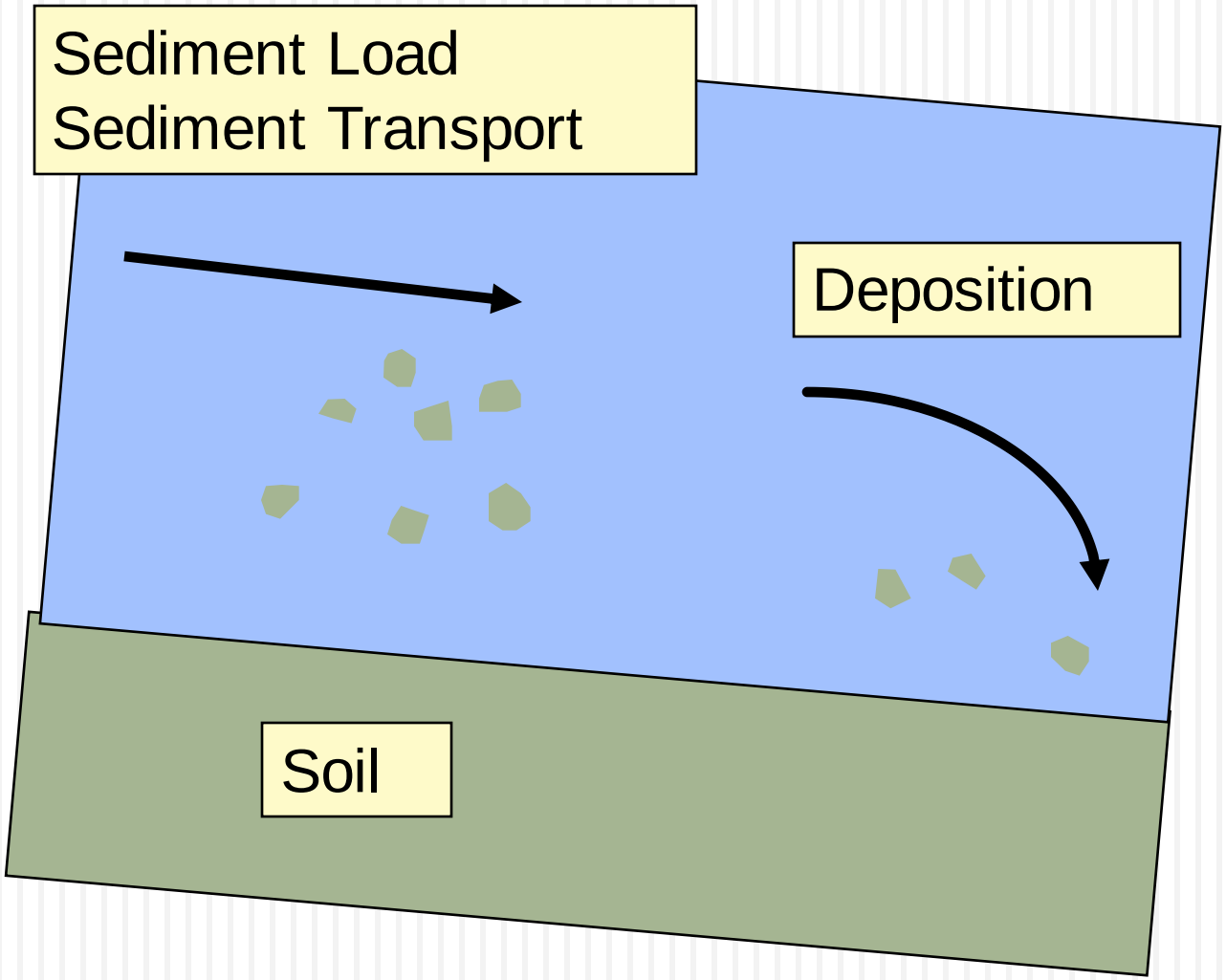


https://www.youtube.com/watch?v=HW6FBj17vlk

Deposition

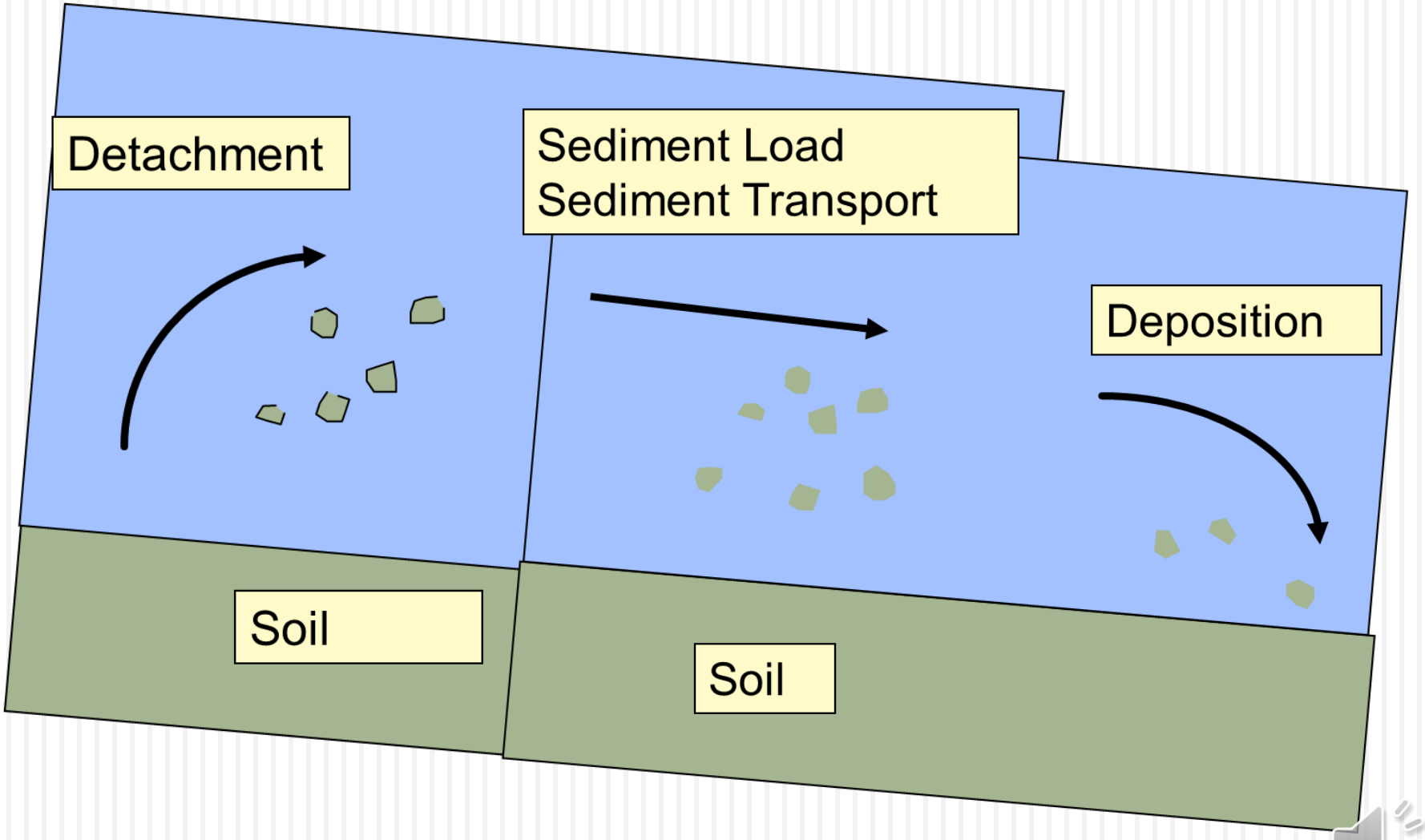
- Reduces the sediment load
- Adds to the soil mass
- Local deposition
  - Surface roughness depressions
  - Row middles/between ridges
- Remote deposition
  - Concave slope
  - Upper edge of grass strips
  - Terrace channels
  - Impoundments

Deposition



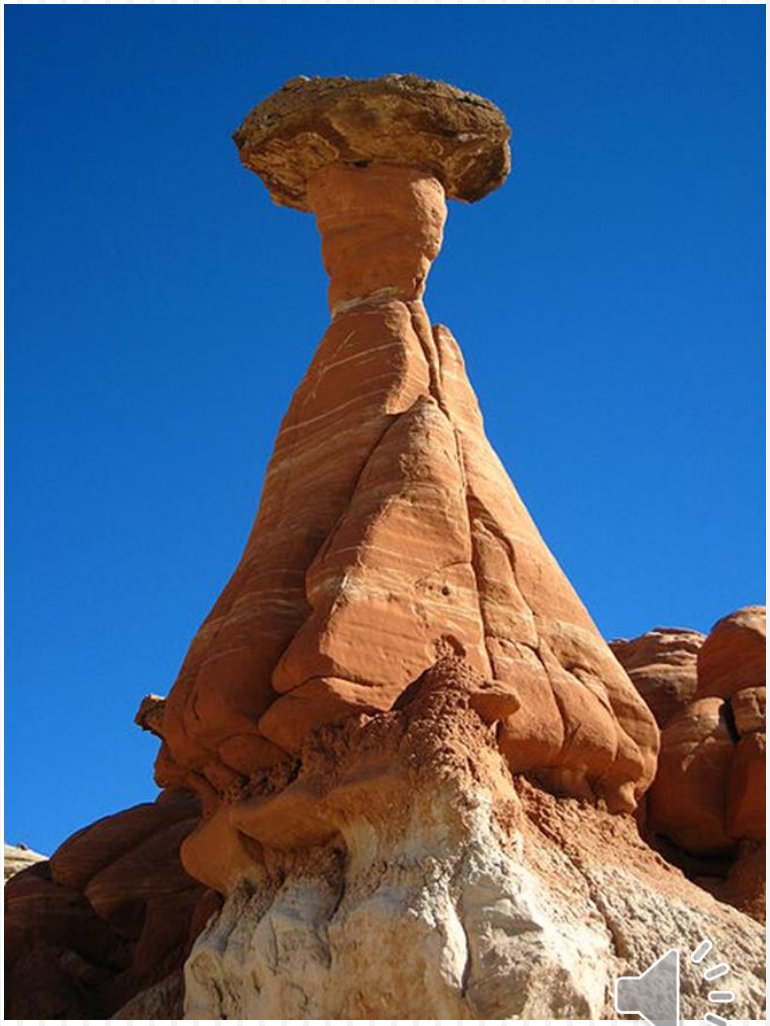
Detachment

Deposition



Kinds of soil erosion

- Geologic
  - Happens over long periods of time (centuries, millennia)
  - Needed for soil formation
- Accelerated erosion
  - Primarily human induced



Water erosion

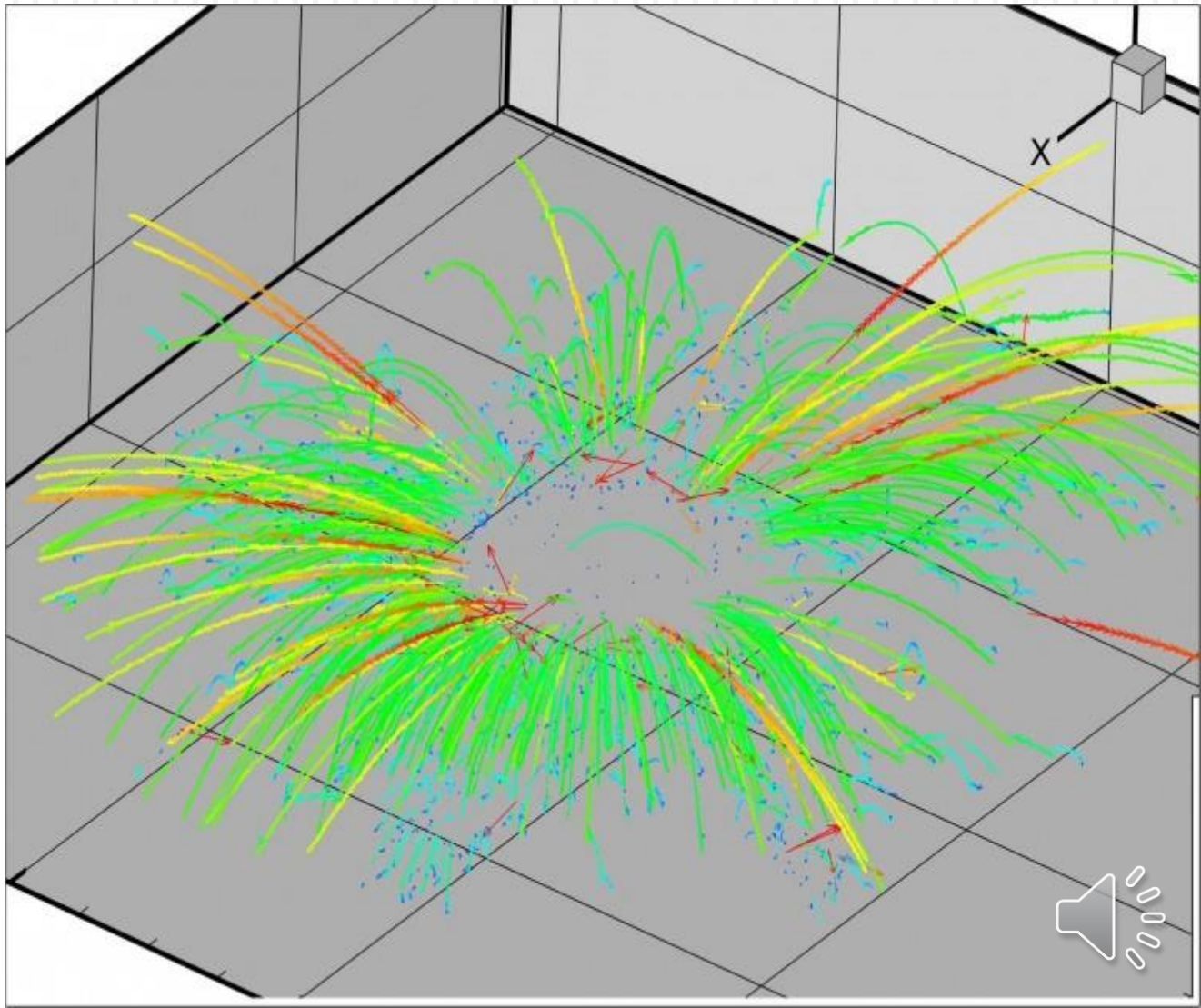
- Occurs when precipitation is higher than the soils' water holding capacity (capacity of a soil to hold water).
- Dominate form in humid and semi humid parts of the world
- Occurs in arid and semi arid when storms occur on land with little vegetative cover

Types of water erosion

- Splash
- Sheet/inter-rill
- Rill
- Gully
- Tunnel
- Streambank
- Coastal

Splash

- Precipitation fills pore space in soil – moves particles apart
- Subsequent drops move particles



Sheet/Inter-rill and rill

Inter-rill = sheet erosion between rills

Rill = first, smallest concentrated flow

Sheet = uniform removal of soil by water in thin layers, often over large areas.

Ephemeral gully

Size between rill and gully.

Can usually be “closed” with tillage but will reappear.

Usually has a tree branch pattern (dendritic)

Gully – larger, deeper than ephemeral gully.

Usually will not “close” with tillage

V or U shaped

Also dendritic pattern

Tunnel erosion= removal of subsurface soil

Department of Primary Industries Victorian Resources Online

South Australia's Upper South East Dryland Salinity and Flood Management Program

Streambank erosion

removal of soil and other material, such as rock and vegetation, from the **streambank**

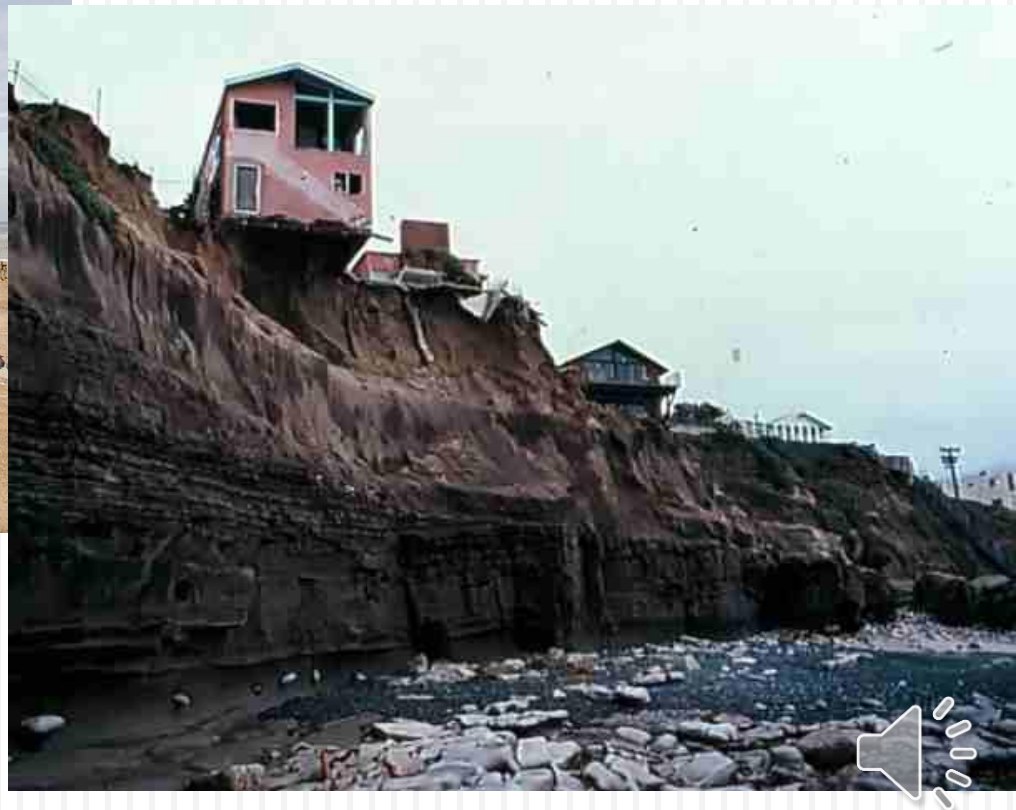
Connecticut Dept of Energy and the Environment

Center for Watershed Studies Virginia Tech

is a naturally occurring process, but the rate at which it occurs is often increased by anthropogenic activities, i.e.. urbanization and agriculture.

Coastal erosion (or shoreline retreat) is the loss of **coastal** lands due to the net removal of sediments or bedrock from the shoreline.

<-*Wikipedia*



Cal State LA Dept of Geological Sciences >

4 types of coastal erosion

- Abrasion
  - waves transport material which hit the cliff and gradually wear it away.
- Hydraulic action
  - as waves approach the coast they trap air and force it into gaps in the cliff. Eventually this weakens the rock making it easier to wash away.
- Attrition
  - waves cause the rocks to crash against each other, breaking them down into smaller and rounder pieces.
- Corrosion (also known as solution)
  - salts and acids in seawater dissolve the rock gradually over thousands of years.

Tillage erosion

- Tillage erosion is a form of erosion that is limited to movement of soil within a field.
- Tillage erosion causes topsoil to be removed from the high points of fields and exposes subsoil.
- Total amount of soil that is moved with tillage erosion may exceed that of water erosion.

Gene Alexander, USDA-NRCS

Tillage Erosion

Up and down hill tillage

Tillage (chisel, disc, etc.) along contour

Plowing on the contour, throwing furrow downhill

(SARE)

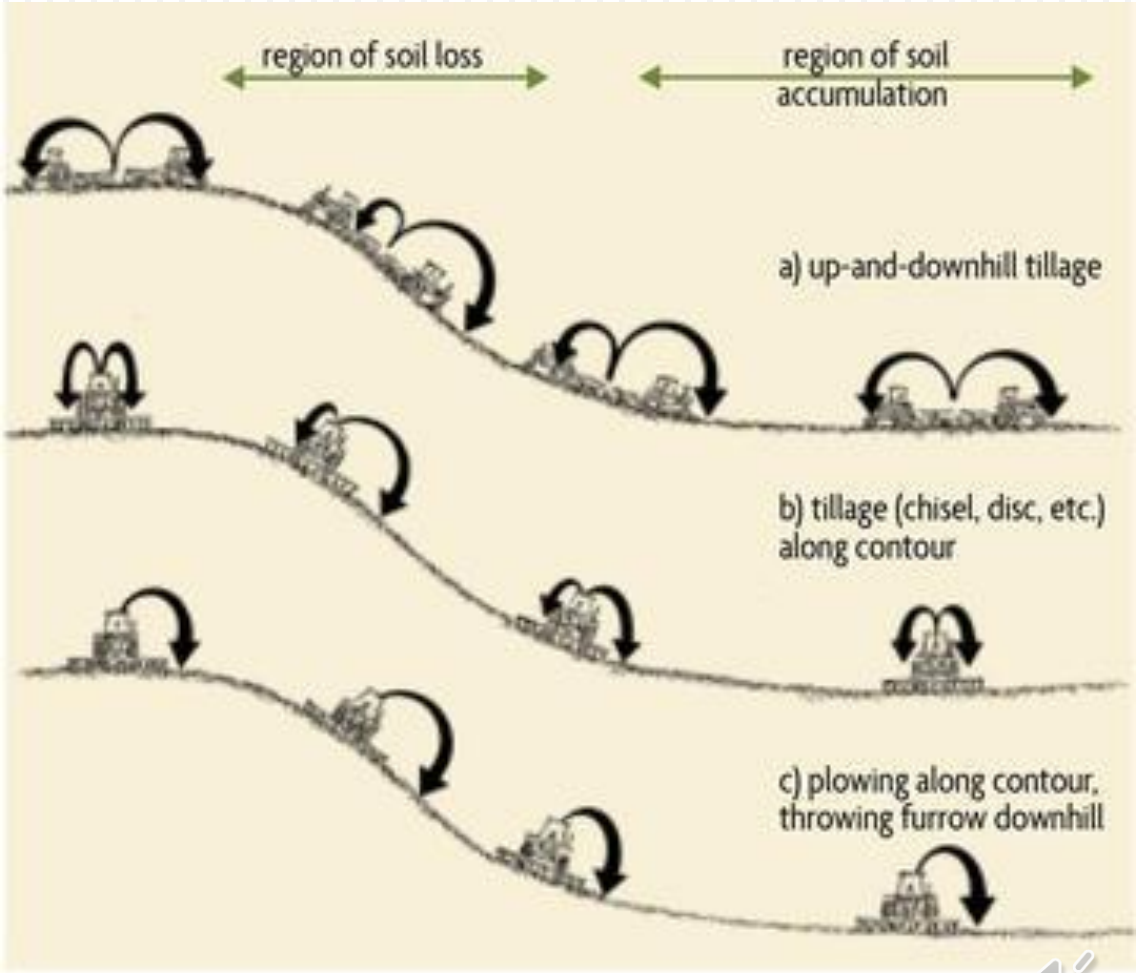


Figure 6.5. Three causes of erosion resulting from tilling soils on slopes

Differences

- Tillage erosion is soil detachment and movement through mechanical means, water does transport
- Streambank and coastal erosion are caused from movement of material by the water body.
- The other types of erosion are caused by runoff

Factors affecting soil erosion

Physical

- Climate
- Vegetative Cover
- Topography
- Soil Properties

Man-made

- Land Use
- Cultivation
- Social/economic conditions

Climate

- All climate factors can affect water erosion
  - Precipitation
  - Humidity
  - Evapotranspiration
  - Temperature
  - Solar radiation
  - Wind velocity

Climate

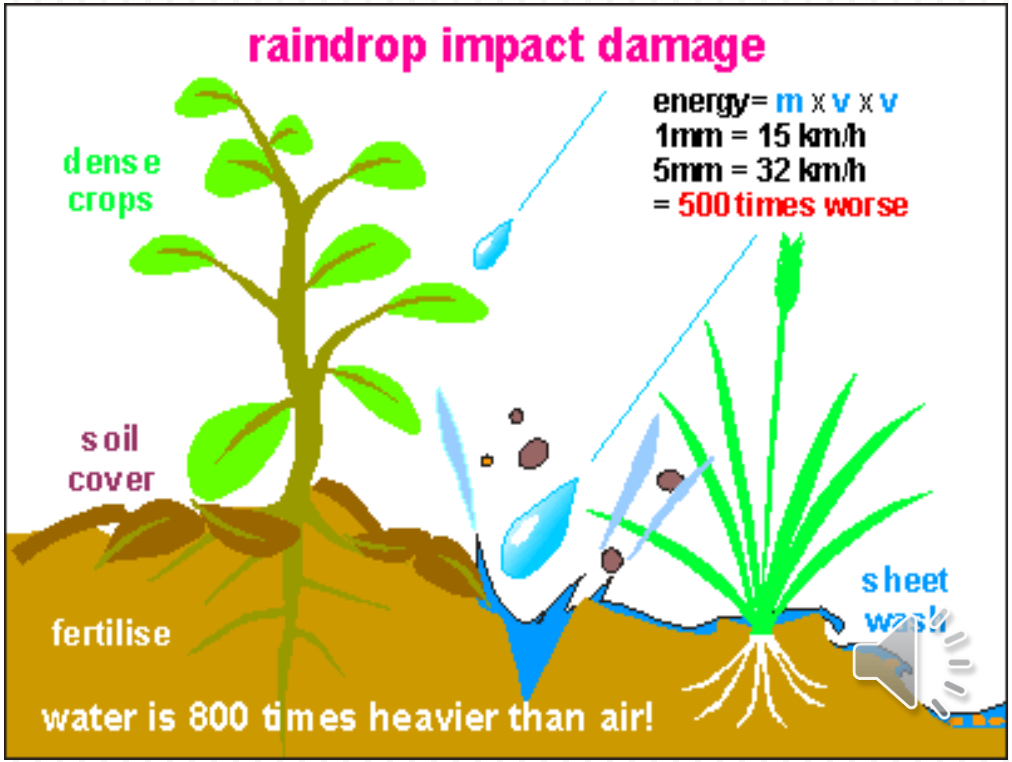
- Precipitation is the main agent of water erosion
- Amount, intensity and frequency determine magnitude of erosion
- Intensity of the rain is most critical factor
  - The more intense the rainfall, more erosion
- High temperature may reduce erosion by increasing evapotranspiration

Climate

- High humidity associated with higher soil water – more erosion
- Solar radiation can affect rate of evaporation
- Wind velocity
  - Increases evaporation
  - Changes soil water

Vegetative cover

- Intercepts, absorbs, reduces raindrops energy
- Plant height, canopy structure determine benefit
- Surface residue cover
  - soaks up raindrop,
  - reduces bounce
  - increases soil roughness
  - slows runoff velocity
  - filters soil particles



Vegetative cover

- Soil detachment decreases with increased cover
- Dense, short growing plants better than sparse, tall vegetation
- The denser the canopy and thicker the litter, the lower total soil erosion

Topography

- Soil erosion increases with increase in field slope
- Topography determines water velocity
- Runoff transport capacity increase with slope steepness
- Soil on convex fields are more readily eroded than concave fields due to interaction of soil creep.

Topography

- Degree (or %) slope, length and size of slope determine the rate of surface runoff
- Rill, gully and stream channel erosion are typical of sloping watersheds.

Soil properties

- Soil erosion is influenced by:
  - Soil texture
  - Organic matter content
  - Macroporisity
  - Water infiltration

Soil properties

- Antecedent water content affects soil pore space available for rainwater absorption
- Soil aggregations affects rate of detachment and mobility
- Clay particles move easier than sand, but clay forms stronger, more stable aggregates.
- Organic material stabilize soil structure and coagulate soil colloids.

Soil properties

- Compaction:
  - reduces soil macroporosity
  - reduces water infiltration
  - increases runoff
- Large and unstable aggregates are more detachable
- Interactive processes among soil properties define soil erodibility.

Social/Economic factors affecting soil erosion

- From land use
- From cultivation
- From social and economic conditions

- *Principles of Soil Conservation and Management by Humberto Blanco and Rattan Lal, Springer Science+Business Media, 2008*

Land Use - Deforestation

- Removes protective vegetative cover
- Removal process can increase compaction
  - Harvest
  - Clearing
- Erosion rates on sloping deforested land can increase 5-20 times

Land Use – Overgrazing

- Too many animal units – too small an acreage- too long
  - Thins and/damages vegetation
  - Reduces organic matter
  - Degrade soil structure
  - Adds to much P
  - Foot traffic increases compaction
    - Decreases water infiltration
    - Affects drainage

Land Use - Overgrazing

- In wet, clayey soils
  - Compaction and surface runoff increase erosion
  - Increase erosion on pasture causes
    - Siltation
    - Sediment related pollution
  - In dry regions
    - Animal traffic degrades aggregates of surface soil
    - Increase risk of wind erosion
  - Can increase sand content as detached fine particles are removed by wind and water

Land Uses - Other

- Urbanization
- Mineral extraction
- Industrial activities
- Road construction
- Forest fires

- Decrease/degrade vegetation
- Increase compaction
- Decrease infiltration
- Increase runoff
  - Siltation
  - Sedimentation
  - Etc.

Mismanagement of cultivated land

- Expansion of farming to marginal land is a common cause of soil erosion
  - Intensive plowing
  - Wheel traffic
  - Shifting cultivation
  - Indiscriminate chemical input
  - Irrigation with low quality water
  - Removal/absence of vegetative cover

Mismanagement of cultivated land

- Removal of crop residues
  - For fodder
  - For fuel
- Intensive cultivation/tillage
  - Accelerates water runoff and soil erosion
  - Declining soil and water quality

Mismanagement of cultivated land

- Shifting cultivation
  - Land with depleted soils are abandoned to “recover”
    - Often slash and burn
    - Not left long enough to really “heal”
    - Left bare and subject to erosion in the meantime

Mismanagement of cultivated land

- High chemical inputs
- Irrigation
- Salinization
- Monocropping

Social and Economic Conditions

- Ineffective conservation policies
- Poorly define land tenure
- Lack of incentives + weak institutional support
- High population density
- Low income/limited resources
- Non-availability of inputs