GEOL 408/508

SOIL EROSION AND ITS CONTROL

Chapter 17

Brady and Weil, Rev. 14th Ed.

SIGNIFICANCE OF SOIL EROSION AND LAND DEGRADATION - 1

Land degradation:

- no soil phenomenon is more destructive worldwide than wind & water caused erosion
- human activities have degraded 5 billion ha (43%) of Earth's vegetated land in past 50 yrs
- desertification has occurred on 3.6 billion ha

Soil-vegetation interdependency:

- degradation of vegetation will cause degradation of soil and vice versa
- overgrazing, deforestation, inappropriate methods of crop production provides less protection to soil & encourages erosion
- degraded soil provides less crop support

SIGNIFICANCE OF SOIL EROSION AND LAND DEGRADATION - 2

Geological versus accelerated erosion:

- **Geological erosion:**
  - **erosion that takes place naturally, without human influences**
  - **generally the rate is slow enough for net soil formation and accumulation**
  - **rate varies greatly with rainfall & type of regolith**
  - **water erosion generally greatest in semiarid reg'ns**
- **Sediment loads:**
  - **Mississippi & Yangtze were muddy prior to human influence**
  - **all rivers now carry significantly incr'sd sed loads**
  - **sediment is pollutant in greatest conc in streams**

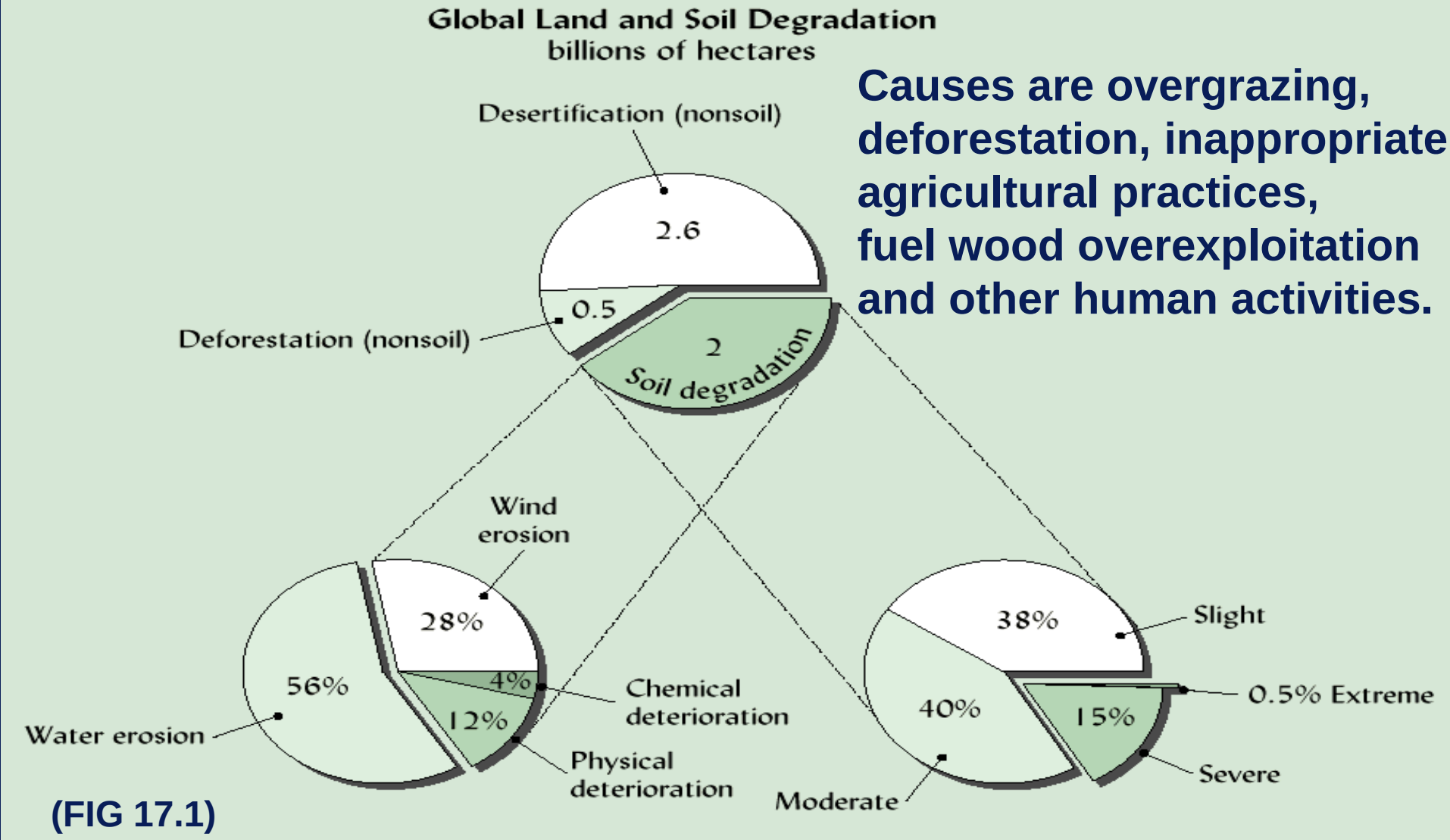
SIGNIFICANCE OF SOIL EROSION AND LAND DEGRADATION

Geological versus accelerated erosion:

Accelerated erosion:

- occurs when humans disturb the soil by a variety of activities (grazing livestock, plowing hillsides,etc.)
- rate may be 10-1000X as destructive as geol eros'n
- 4 billion Mg of soil moved annually in US; 2/3 by water and 1/3 by wind; >50% from croplands
- soil is commonly removed at a rate faster than formation
- may make soils more heterogenous
- evidence is different colors due to exposed B or C horizons

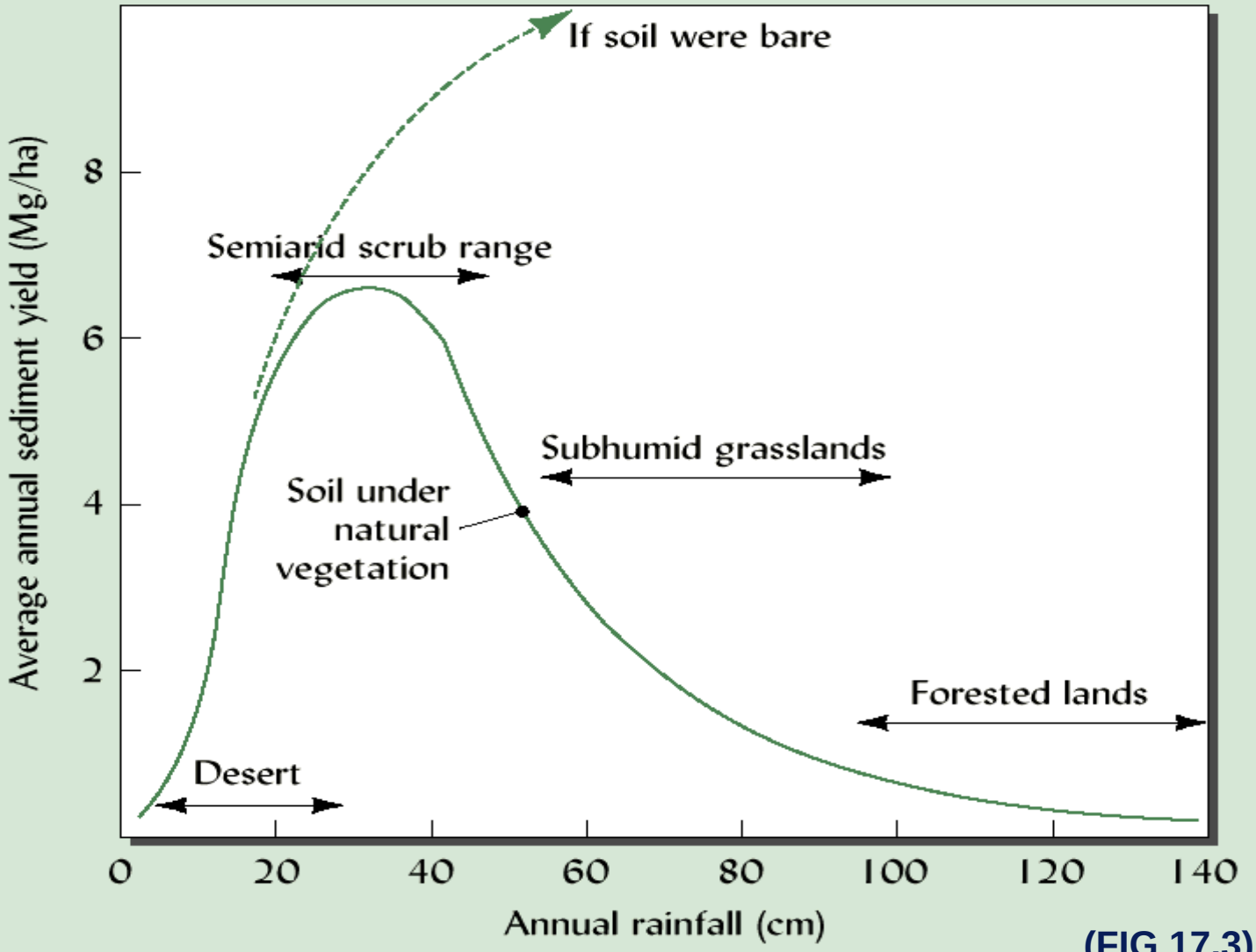
SOIL DEGRADATION AS A PART OF GLOBAL LAND DEGRADATION



Causes are overgrazing, deforestation, inappropriate agricultural practices, fuel wood overexploitation and other human activities.

(FIG 17.1)

Generalized relationship between annual rainfall and soil loss from geologic erosion by water



(FIG 17.3)

ON-SITE AND OFF-SITE EFFECTS OF ACCELERATED SOIL EROSION

Types of on-site damages:

- loss of fertile topsoil, esp. organic & fine fractions
- amount & quality of lost nutrients is high
- transported soil may spread plant diseases
- remaining soil has poorer phys & chem properties

Types of off-site damages:

- **Damages from sediment:**
  - sediment may deposited onto low-growing veg'n
  - high turbidity in streams blocks sunlight to SAV, fouls gills of fish
  - sediment covers bottom & spawning habitats
  - sediment fills reservoirs, reducing capacity
  - sediment fills shipping channels; need dredging

ON-SITE AND OFF-SITE EFFECTS OF ACCELERATED SOIL EROSION - 2

Types of off-site damages:

- **Windblown dust:**
  - **blowing sands may bury roads & fill ditches**
  - **sandblasting may damage fruits, foliage, paint and other surface finishes**

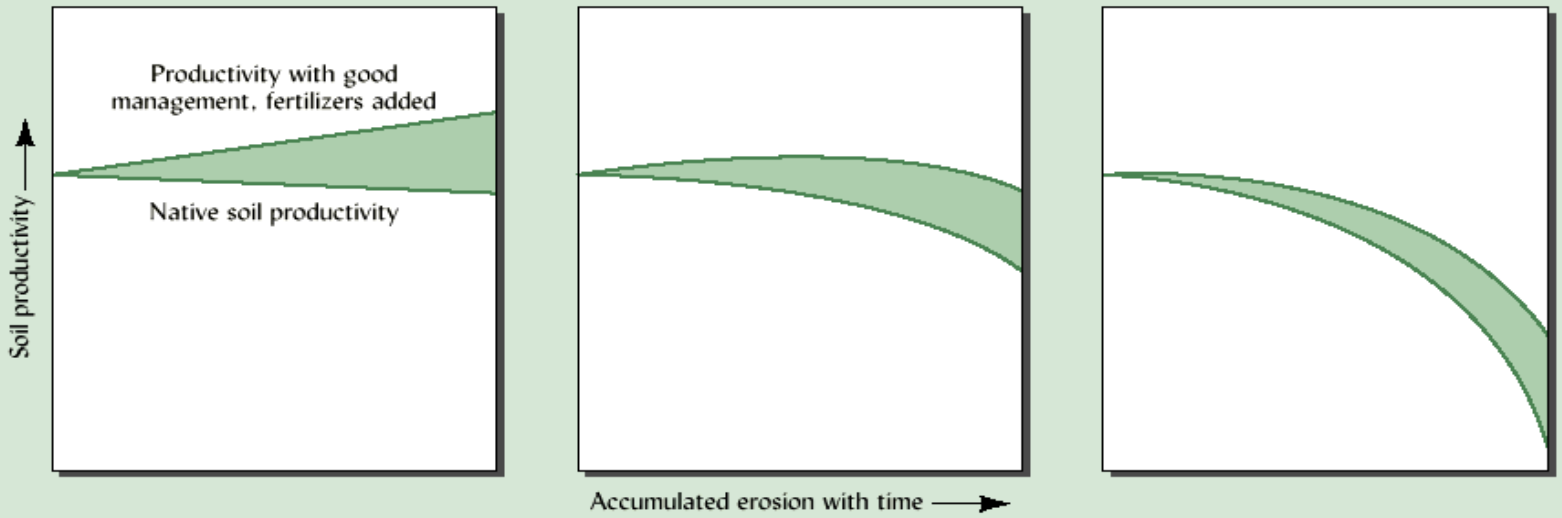
- **Health hazard:**
  - **fine particles are carried long distances & are known as fugitive dust**
  - **the finest particles, respirable dust, may reach deep into lungs**
  - **particles themselves will cause inflammation & may also carry toxic substances**
  - **EPA foresees need to reduce emissions of fine dust**

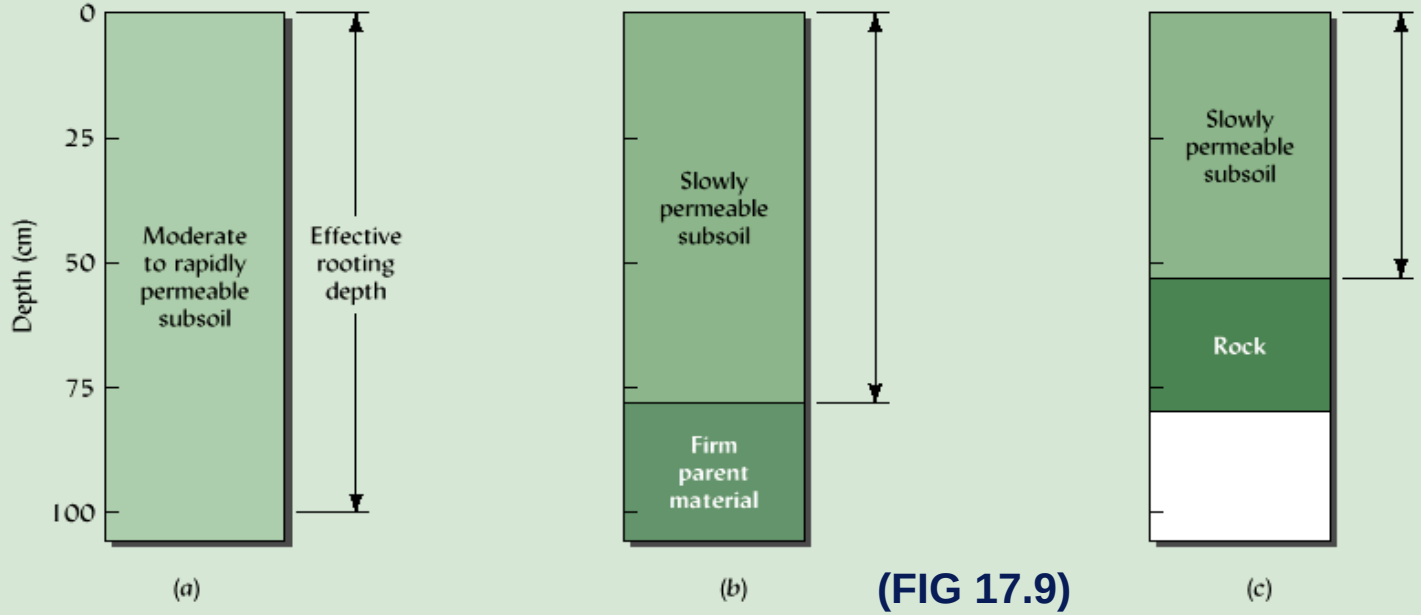
ON-SITE AND OFF-SITE EFFECTS OF ACCELERATED SOIL EROSION - 3

Types of off-site damages:

- **Estimated costs of erosion:**
  - **data are very imprecise, on-site losses: $4-27 billion**
  - **off-site losses: $5-17 billion**
  - **total losses: $9-44 billion**
  - **losses are result of poor land management**
- **Maintenance of soil productivity:**
  - **can replace nutrients lost by use of fertilizer**
  - **loss of OM & water-holding capacity much more difficult to overcome**
  - **productivity may be reduced by 20-40%**
  - **ultimate restrictions are often prop's such as depth to a rooting restr'n layer & perm. of subsoil**

Effect of erosion over time on the productivity of three soils differing in depth and permeability





(FIG 17.9)

ON-SITE AND OFF-SITE EFFECTS OF ACCELERATED SOIL EROSION - 4

Soil-loss tolerance:

A tolerable soil loss (T value) is the maximum amount of soil that can be lost annually via erosion without degrading the soil's long-term productivity.

- **Common range of T values:**
  - **for soils in US: 5-11 Mg/ha**
  - **majority of US soils have value of 11 Mg/ha**
  - **will take 225 yr to lose equiv of entire Ap horizon**
  - **with good mgmt may be able to replace Ap as it is lost**
- **Significance of T values:**
  - **T values are used to detr regulatory compliance**
  - **obvious controversy as to appropriate limits**

MECHANICS OF WATER EROSION

Soil erosion by water is a three-step process:

1. detachment of soil particles
2. transportation via floating, rolling, dragging, splashing
3. deposition at a lower elevation (Figure 17.9)

Influence of raindrops:

- detaches soil; destroys granulation; transports soil
- impact is most influential factor in soil erosion

Transportation of soil:

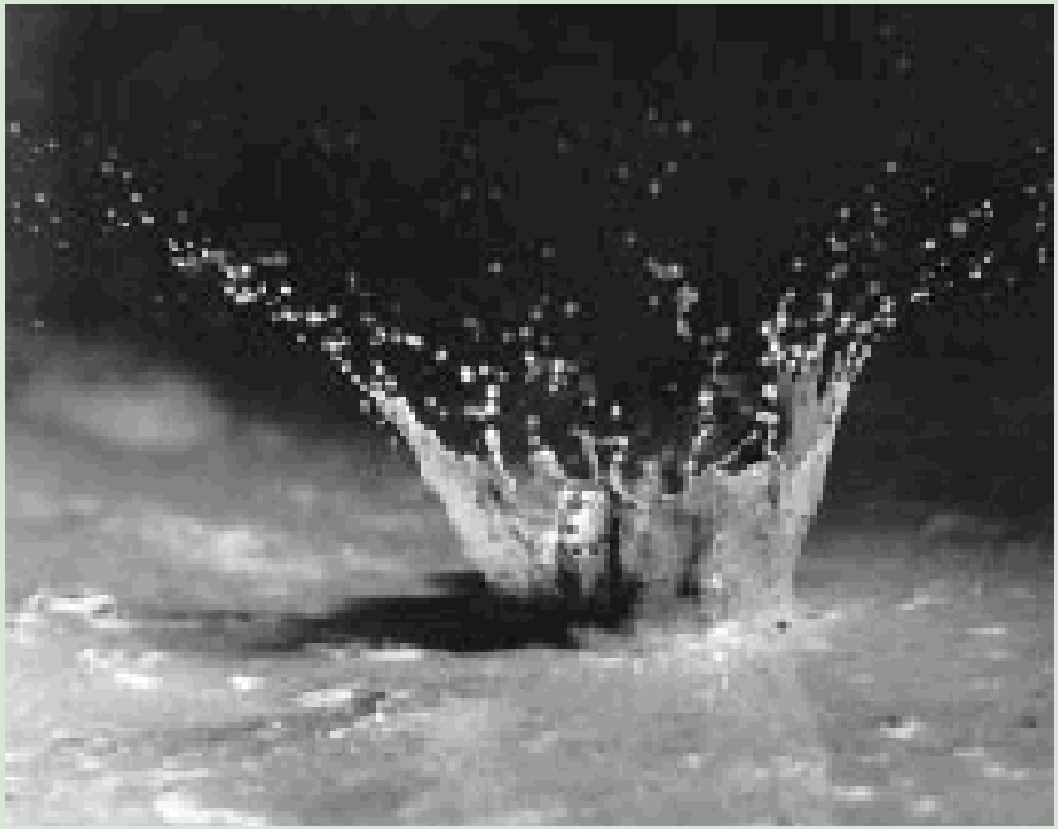
- raindrop splash effect: up to 0.7 m vert. & 2 m horiz
- running water: major role in soil transport
- sheet flow will detach little soil

Types of water erosion:

- **sheet**: more or less uniform removal
- **rill**: formation of tiny channels
- **gully**: large channels that present obstacles to equip

The three-step process of soil erosion by water begins with the impact of raindrops on wet soil.

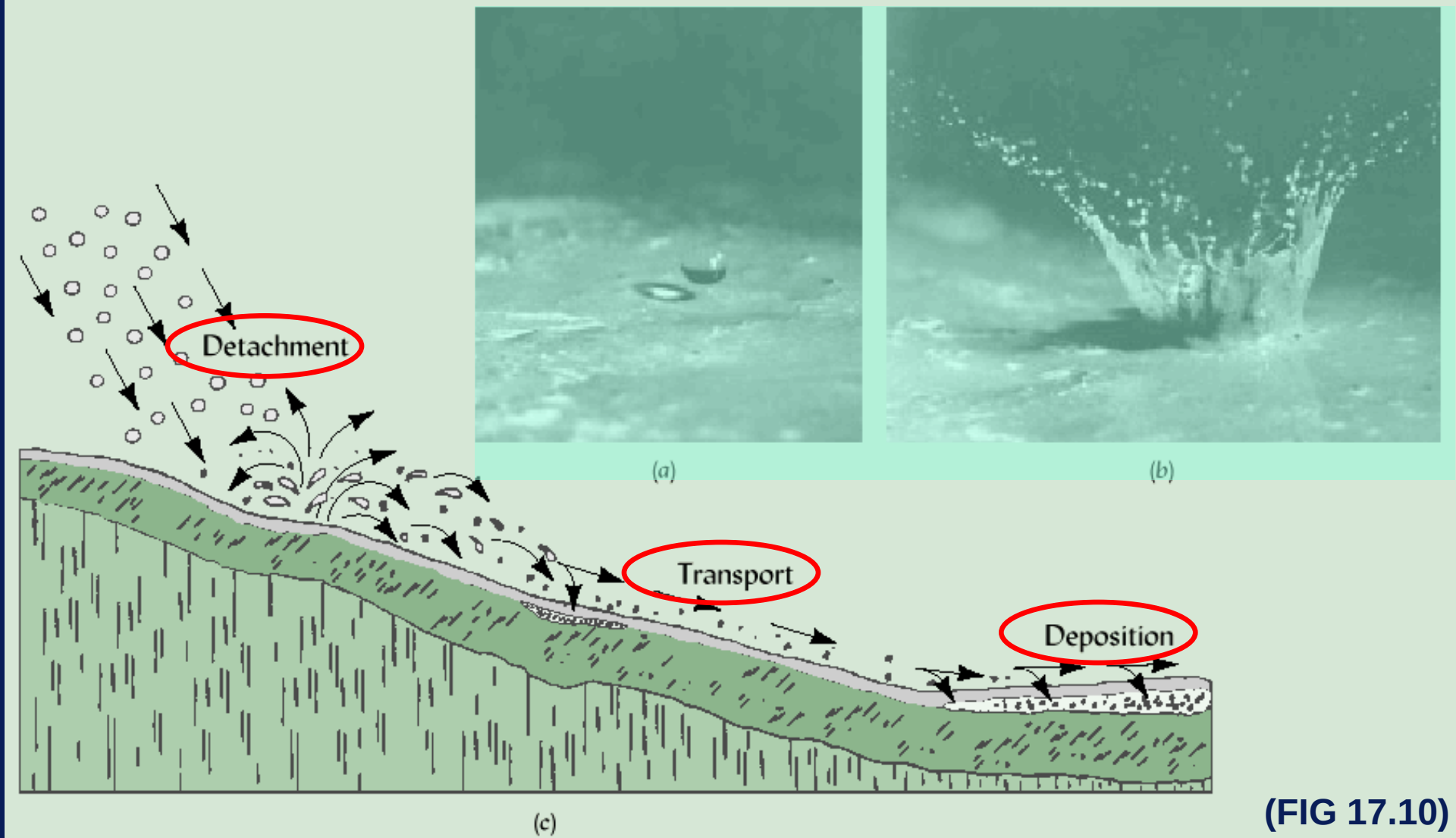
(a)



(b)

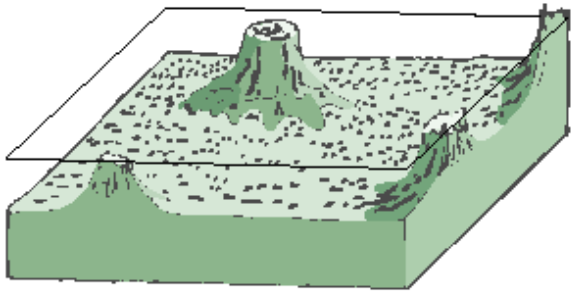
(Figure 17.9)

THE THREE-STEP PROCESS OF SOIL EROSION BY WATER

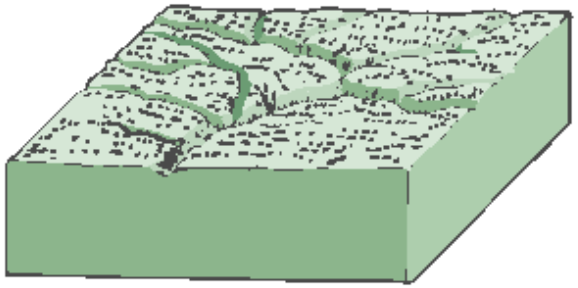


(FIG 17.10)

THREE MAJOR TYPES OF SOIL EROSION



(*a*) Sheet erosion



(*b*) Rill erosion

(*c*) Gully erosion

(*a*) Sheet erosion

(*b*) Rill erosion

(*c*) Gully erosion

(FIG 17.11)

MODELS TO PREDICT THE EXTENT OF WATER-INDUCED EROSION

The water erosion prediction project (WEPP):

- WEPP is a simulation model that calculates, on a daily basis, rates of hydrologic, plant-growth & litter-decay processes
- predicts on-site & off-site effects of raindrops impact, splash erosion, interrill flow, rill formation, channelization, gully formation & sediment deposition

The universal soil loss equation (USLE):

- an empirical model that predicts average yearly loss by rill & sheet erosion
- a simple, long-used model (since 1970s)

MODELS TO PREDICT THE EXTENT OF WATER-INDUCED EROSION

The universal soil loss equation (USLE):

A = RKLSCP

A, the predicted soil loss, is a product of

R = rainfall erosivity	**Rain-related factor**
K = soil erodibility	**Soil-related factor**
L = slope length	**Soil-related factor**
S = slope gradient (steepness)	**Soil-related factor**
C = cover & management	**Land-mgmt factor**
P = erosion-control practices	**Land-mgmt factor**

The revised universal soil loss equation (RUSLE):

- **same basic factors as USLE**
- **improved definitions & interrelationships in a computer software package**

OMIT THESE SECTIONS:

Not responsible for the following sections:

17.5
17.6
17.7
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17.15

EROSION AND SEDIMENT CONTROL ON CONSTRUCTION SITES

Principles of erosion control on construction sites:

Five basic steps in planning to minimize erosion:

1. **Where possible, schedule main excavation activities for low-rainfall periods of the year**
2. **Divide the project into as many phases as possible, so that only a few small areas must be cleared of vegetation at any one time**
3. **Cover disturbed soils as completely as possible, using vegetation or other materials**
4. **Control the flow of runoff to move the water safely off the site without destructive gully formation**
5. **Trap sediment before releasing runoff water off-site**

EROSION AND SEDIMENT CONTROL ON CONSTRUCTION SITES - 2

Keeping the disturbed soil covered:

- soils freshly disturbed by grading have very high erodibility
- after grading, areas not active should be seeded of covered ASAP
- cover seeded reas with mulch or erosion blankets
- use hydroseeder on difficult to access areas
- should stockpile topsoil & cover with grass

Controlling the runoff:

- cover all ditches or banks with “armor”
- hard armor: riprap, gabions, interlocking blocks
- soft armor: grass sod, erosion blankets
- bioengineering with brush mattresses, live stakes (willow is good), combinations

EROSION AND SEDIMENT CONTROL ON CONSTRUCTION SITES - 3

Trapping the sediment:

- for small areas, filter runoff prior to release using straw bales of woven silt fences
- on large sites, use protected slopes & channels with retention/sedimentation ponds
- may also add/use constructed wetlands
- construction sites must now use permanent retention/sedimentation ponds
- too little attention/enforcement paid to containment during construction activities

LAND CAPABILITY CLASSIFICATION AS A GUIDE TO CONSERVATION

- Land capability classes indicate the degree of limitation imposed on land uses

- Each class may have four subclasses that indicate the type of limitation:
  - risks of erosion (e)
  - wetness, drainage, flooding (w)
  - root-zone limitations; acidity, density, shallowness (s)
  - climactic limitations, e.g., short growing season (c)
  - see Figures 17.43 & 17.44

Intensity with which each land capability class can be used with safety.