RUSLE2

REVISED UNIVERSAL SOIL LOSS EQUATION-Version 2

Predicting Soil Erosion By Water:
A Guide to Conservation Planning

OBJECTIVES

- Understand erosion processes
- Learn RUSLE2 and its software
- Learn field office applications of RUSLE2

EROSION

"Erosion is a process of detachment and transport of soil particles by erosive agents."

Ellison, 1944

- Erosive Agents
  - Raindrop impact
  - Overland flow surface runoff from rainfall

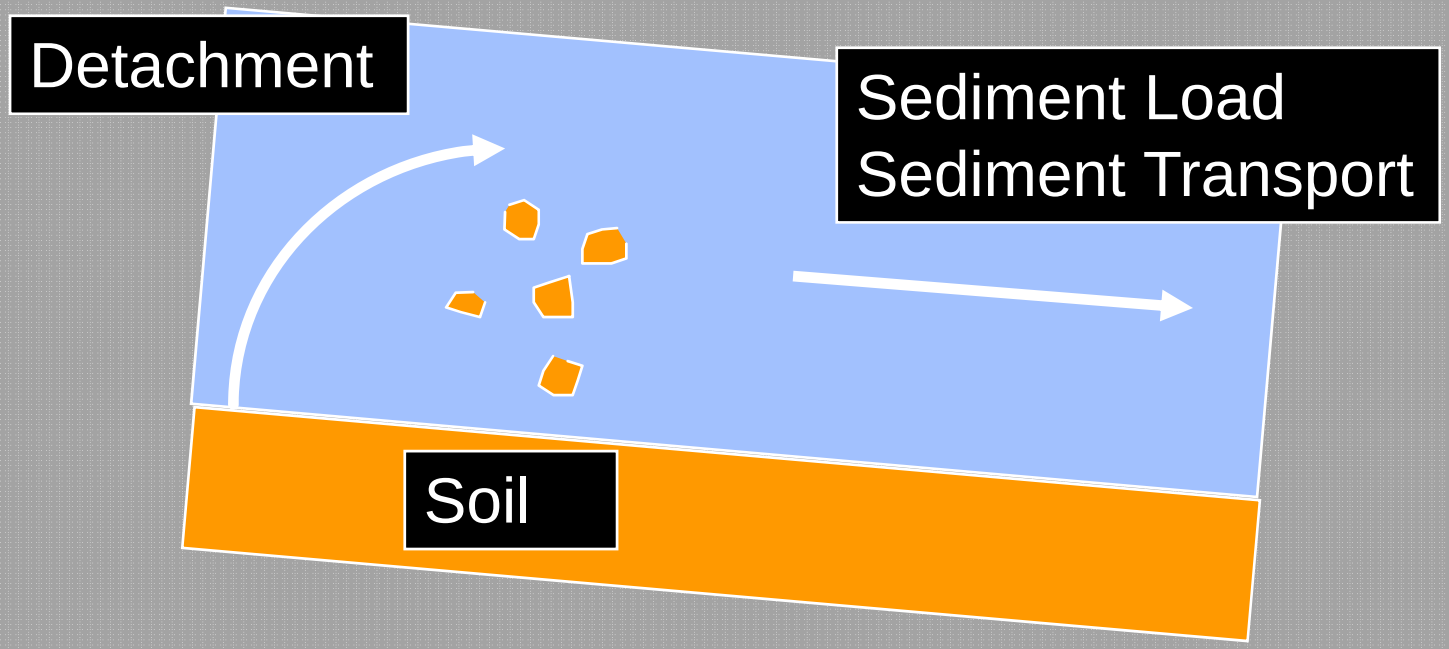
TYPES OF EROSION

- Interrill and rill (sheet-rill)
- Ephemeral gully
- Permanent, incised (classical) gully
- Stream channel
- Mass movement
- Geologic

DETACHMENT

- Removal of soil particles from soil surface
- Adds to the sediment load
  - Sediment load: Rate sediment is transported downslope by runoff

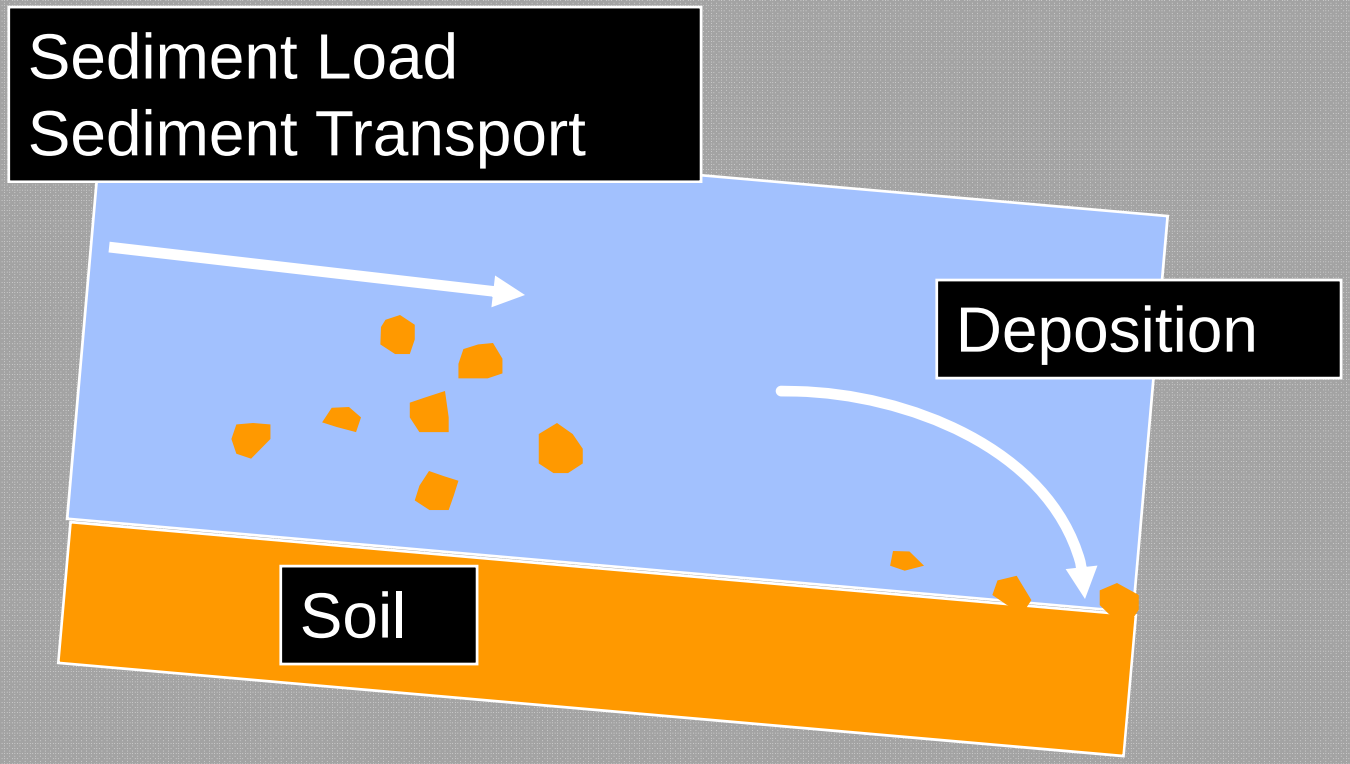
DETACHMENT



DEPOSITION

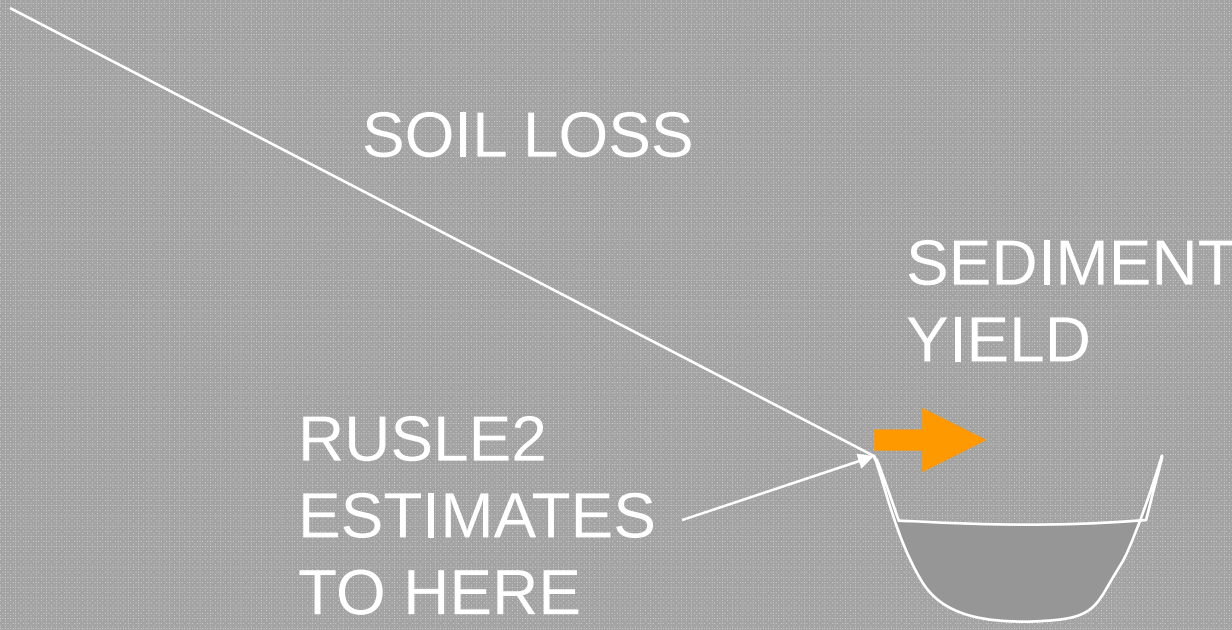
- Reduces the sediment load
- Adds to the soil mass
- Local deposition
  - Surface roughness depressions
  - Row middles
- Remote deposition
  - Concave slope
  - Strips
  - Terraces

DEPOSITION



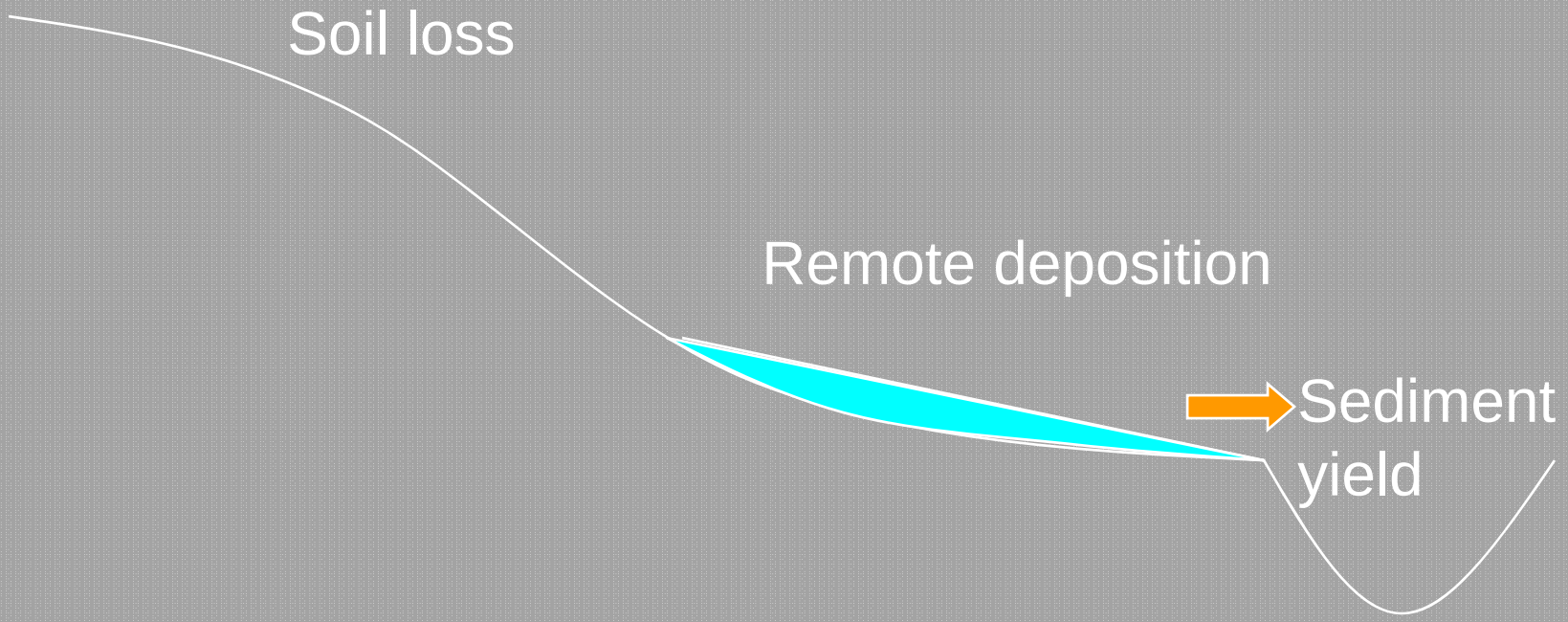
DEFINITIONS

Simple Uniform Slope

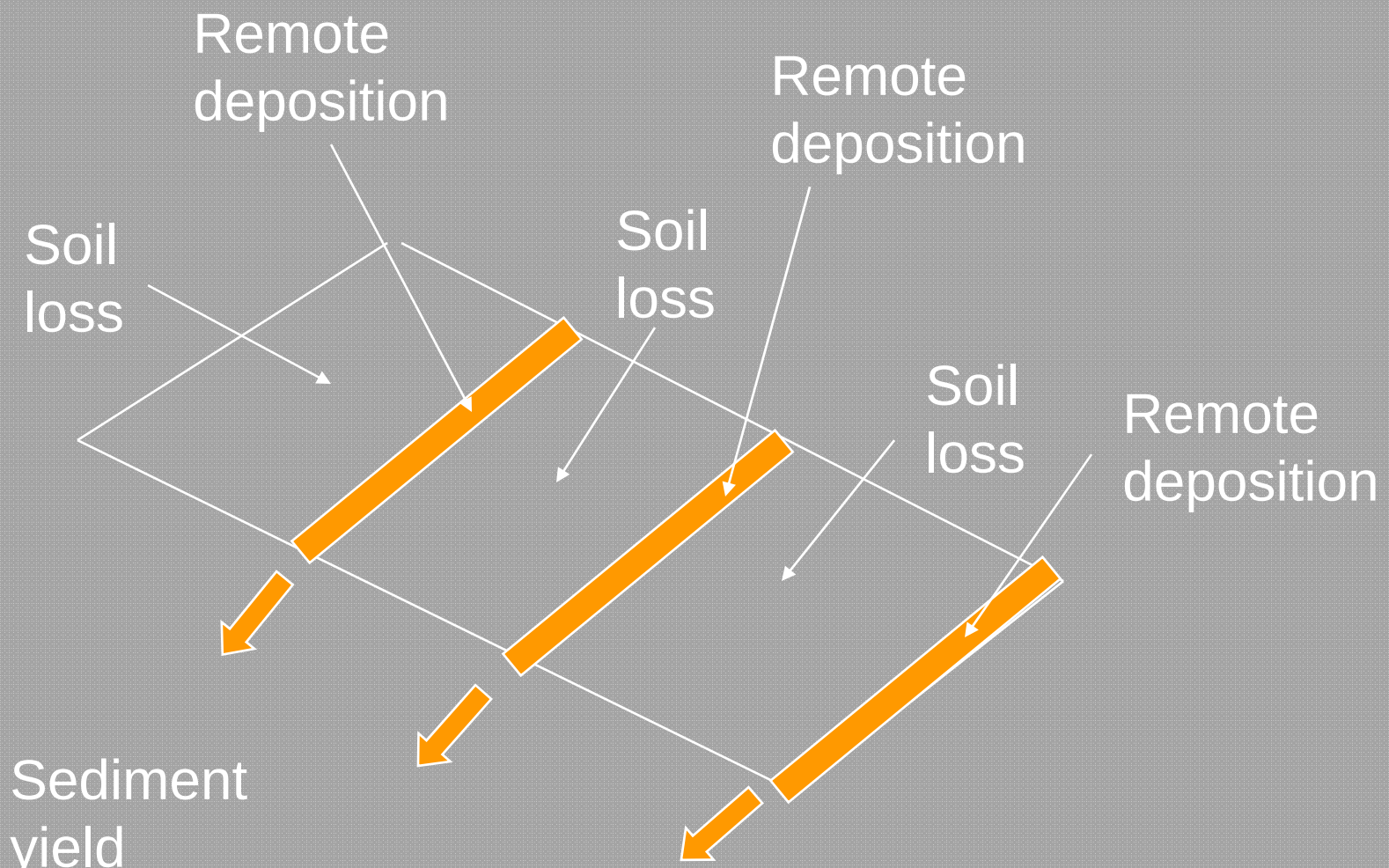


DEFINITIONS

Complex Slope



Deposition with Terraces



Credit for Deposition

Local Deposition

- Full credit

Remote Deposition

- Partial credit
- Amount
- Location
- Spacing of terraces

EROSION IS A CONCERN

- Degrades soil health
  - Reduces soil productivity
  - Reduces soil organic matter
  - Removes plant nutrients
- Causes downstream sedimentation
- Produces sediment which is a pollutant
- Produces sediment that carries pollutants

WHERE EROSION CAN BE A PROBLEM

- Low residue crops
- Crops produced with tillage operations
- Rows up/down steep slopes
- Low maintenance pasture
- Disturbed land with little cover

PLANNING VARIABLES

- Soil loss on eroding portions of hillslope
- Detachment (sediment production) on hillslope
- Conservation planning soil loss for hillslope
- Ratio of segment soil loss to soil tolerance adjusted for segment position
- Sediment yield from hillslope/terraces

RUSLE2 Area

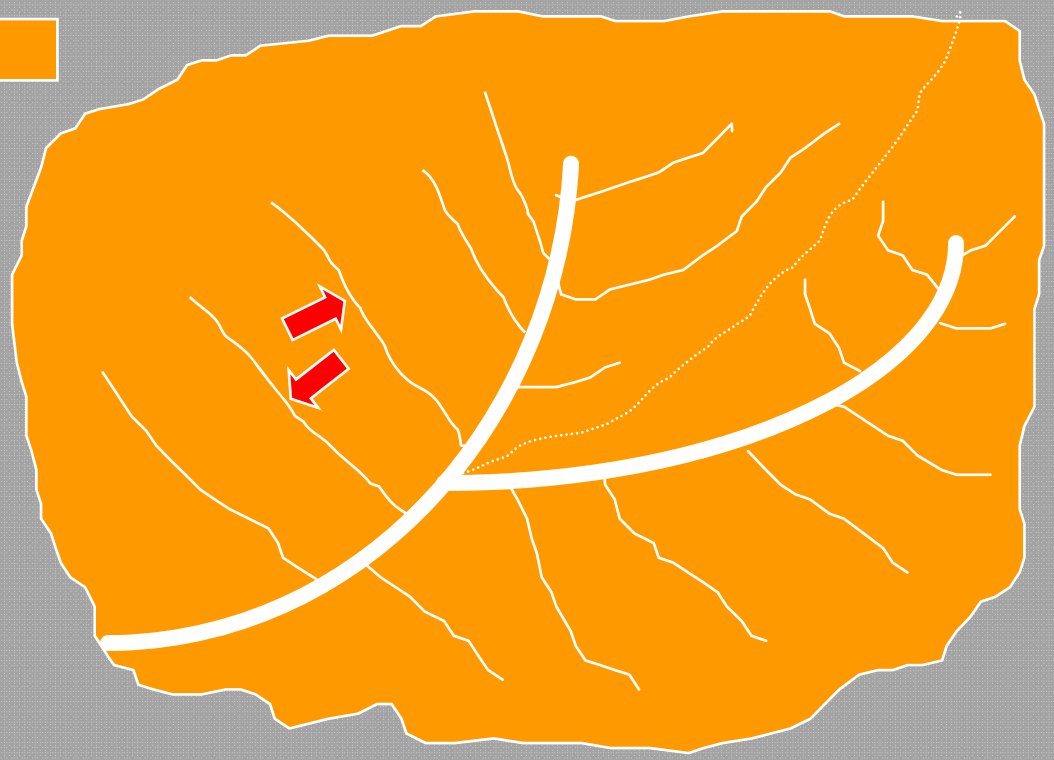
Landscape

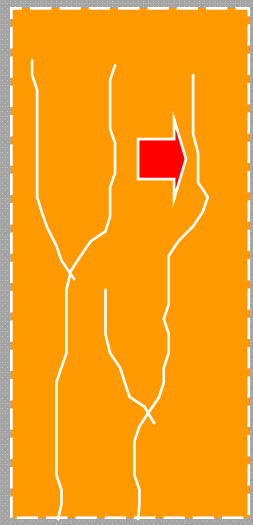
Overland flow

Interrill

Rill

Ephemeral Gully (Concentrated flow)





Erosion Types

FACTORS AFFECTING INTERILL-RILL EROSION

- Climate
- Soil
- Topography
- Land use
  - Cultural practices (crops and tillage)
  - Supporting practices (contours, terraces, filter strips, etc.)

RUSLE2 FACTORS

Daily Soil Loss

a = r k l s c p

Daily Factors

r - Rainfall/Runoff

k - Soil erodibility

l - Slope length

s - Slope steepness

c - Cover-management

p - Supporting practices

Average annual soil loss = sum of daily soil loss values

Different formulation from USLE and RUSLE1

RUSLE2 APPLICATIONS

- Cropland
- Pastureland
- Disturbed forest land
- Construction sites
- Surface mine reclamation
- Military training lands
- Parks
- Waste disposal/landfills

RUSLE2 Factors

(Keep in mind that factors are on a daily basis)

- r- rainfall/runoff (erosivity)
- k- erodibility factor
- l- slope length factor
- s- slope steepness factor
- c- cover-management factor
- p- supporting practices factor

R - EROSIVITY

- Annual sum of daily values
- Average annual (average of annual values)
- Daily value=average annual x fraction that occurs on a given day

R - EROSIVITY

Measure of erosivity of climate at a location

Las Vegas, NV	8
Phoenix, AZ	22
Denver, CO	40
Syracuse, NY	80
Minneapolis, MN	110
Chicago, IL	140
Richmond, VA	200
St. Louis, MO	210
Dallas, TX	275
Birmingham, AL	350
Charleston, SC	400
New Orleans, LA	700

Reduction by Ponding

- Significant water depth reduces R (erosivity) of raindrop impact
- Function of:
  - 10 yr EI (storm intensity)
  - Landslope

SOIL ERODIBILITY - K

- Measure of soil erodibility under standard unit plot condition
  - 72.6 ft long, 9% steep, tilled continuous fallow, up and down hill tillage
- ***Independent of management***
- Major factors
  - Texture, organic matter, structure, permeability

SOIL ERODIBILITY - K

- Effect of texture
  - clay (0.10 - 0.20) resistant to detachment
  - sand (0.05 - 0.15) easily detached, low runoff, large, dense particles not easily transported
  - silt loam (0.25 - 0.37) moderately detachable, moderate to high runoff
  - silt (0.43 - 0.65) easily detached, high runoff, small, easily transported sediment

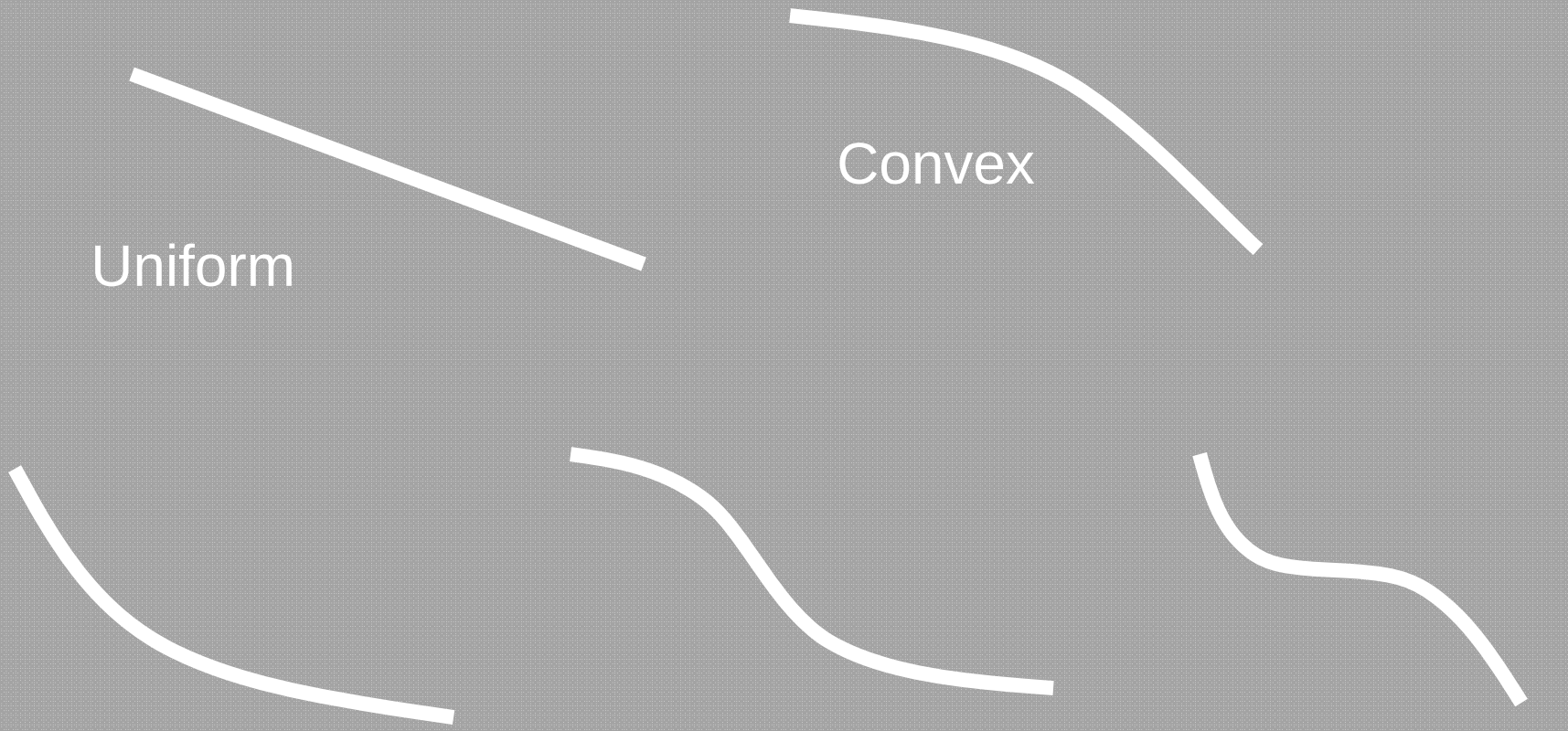
Time Variable K

- Varies during year
- High when rainfall is high
- Low when temperature is high
- Very low below about 25^0 F

LS - TOPOGRAPHY

- Overland flow slope length
- Slope lengths for eroding portions of hillslopes
- Steepness
- Hillslope shape

Hillslope Shape



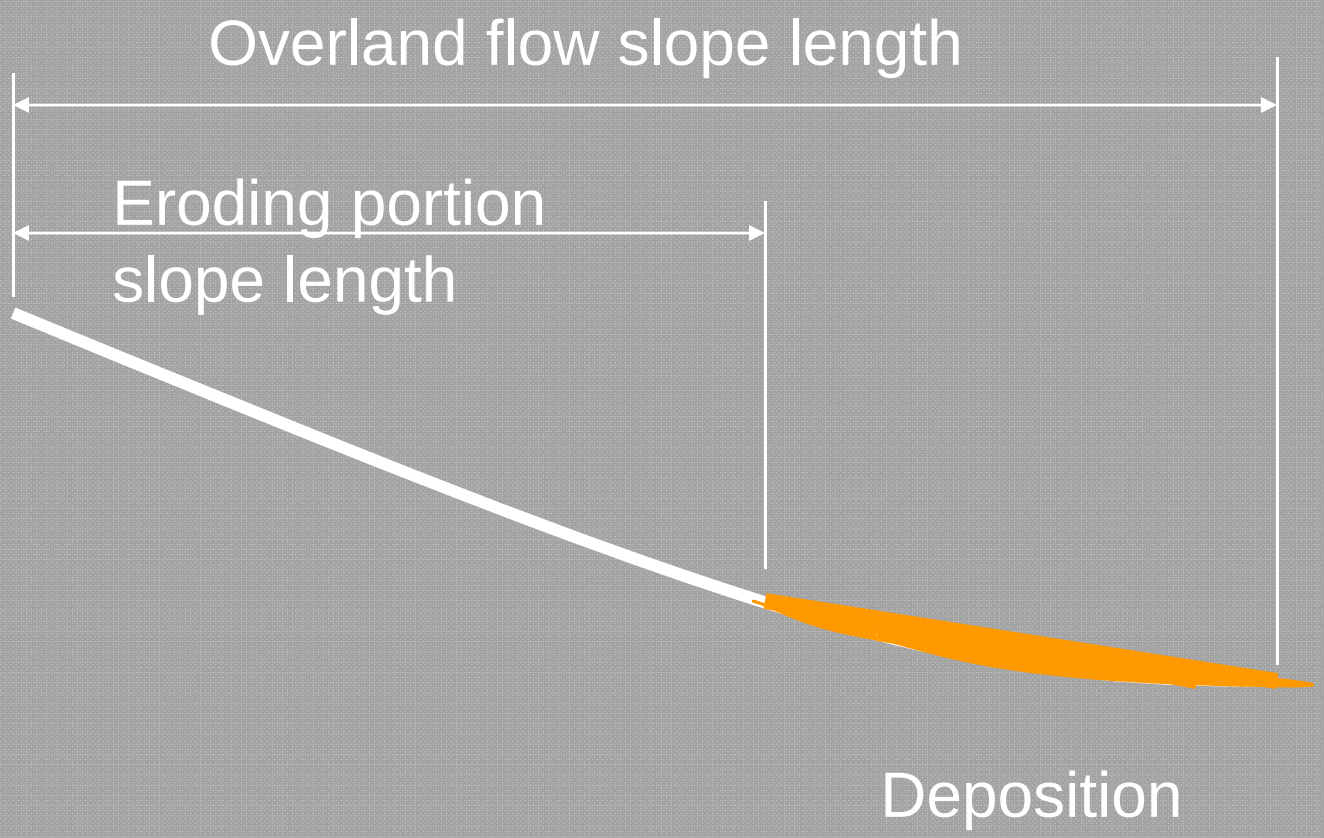
Overland Flow Slope Length

- Distance from the origin of overland flow to a concentrated flow channel or soil deposition area
- The slope length used when the analysis requires that the entire slope length be considered (filter strip planning)

Slope Length for Eroding Portion of Slope

- Traditional definition
  - Distance from origin of overland flow to concentrated flow or to where deposition begins
  - Grass strips, terraces, and concave or convex slopes require special consideration

Slope Length for Concave Slope



Rule of Thumb for Deposition Beginning on Concave Slopes

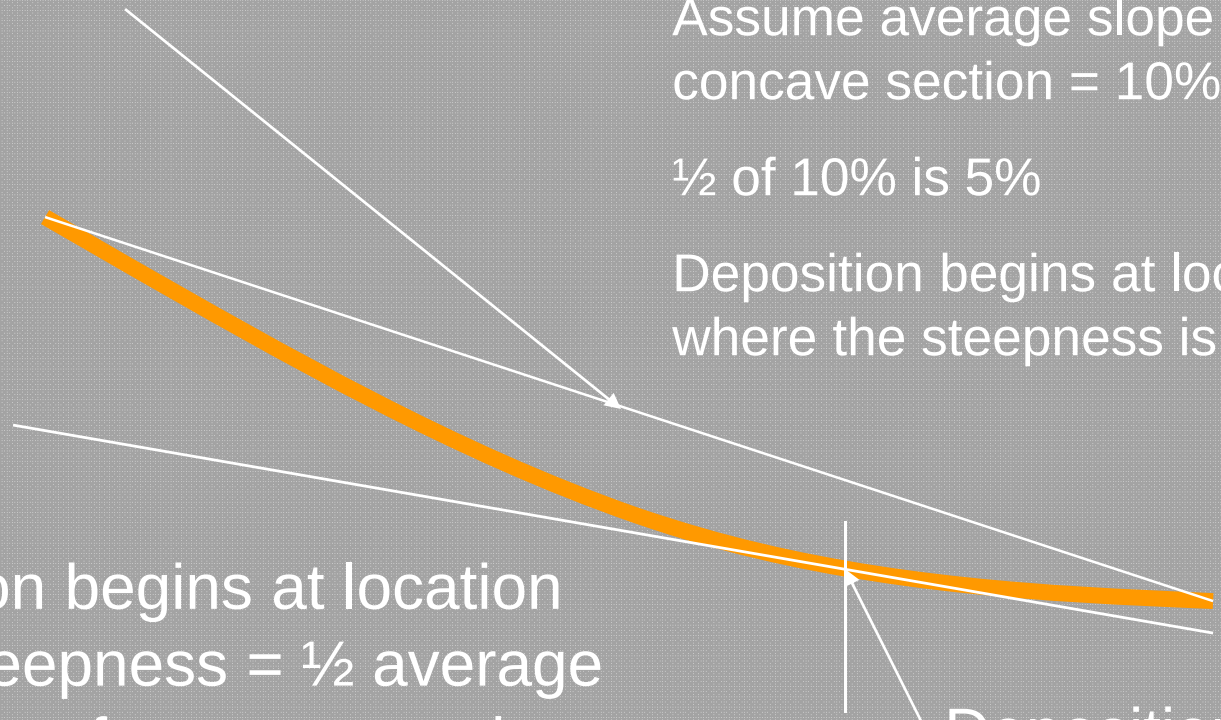
Average steepness of concave portion

Example:

Assume average slope of concave section = 10%

½ of 10% is 5%

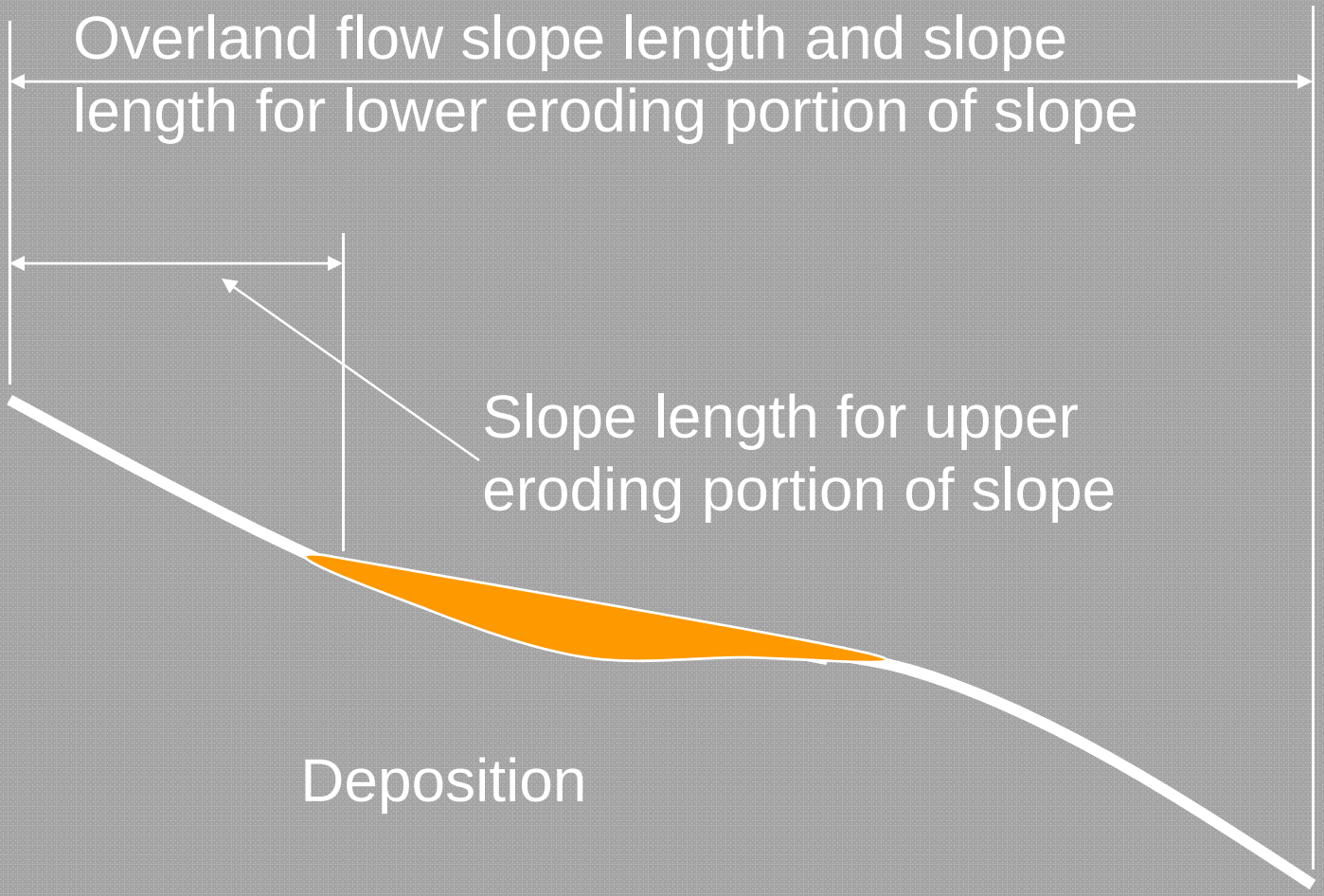
Deposition begins at location where the steepness is 5%



Deposition begins at location where steepness = ½ average steepness of concave portion

Deposition begins

Slope Length for Concave:Convex Slope



Basic Principles

- Sediment load accumulates along the slope because of detachment and transport
- Transport capacity function of distance along slope (runoff), steepness at slope location, cover-management, storm severity (10 yr EI)
- Deposition occurs where sediment load becomes greater than transport capacity

Slope Length Effects

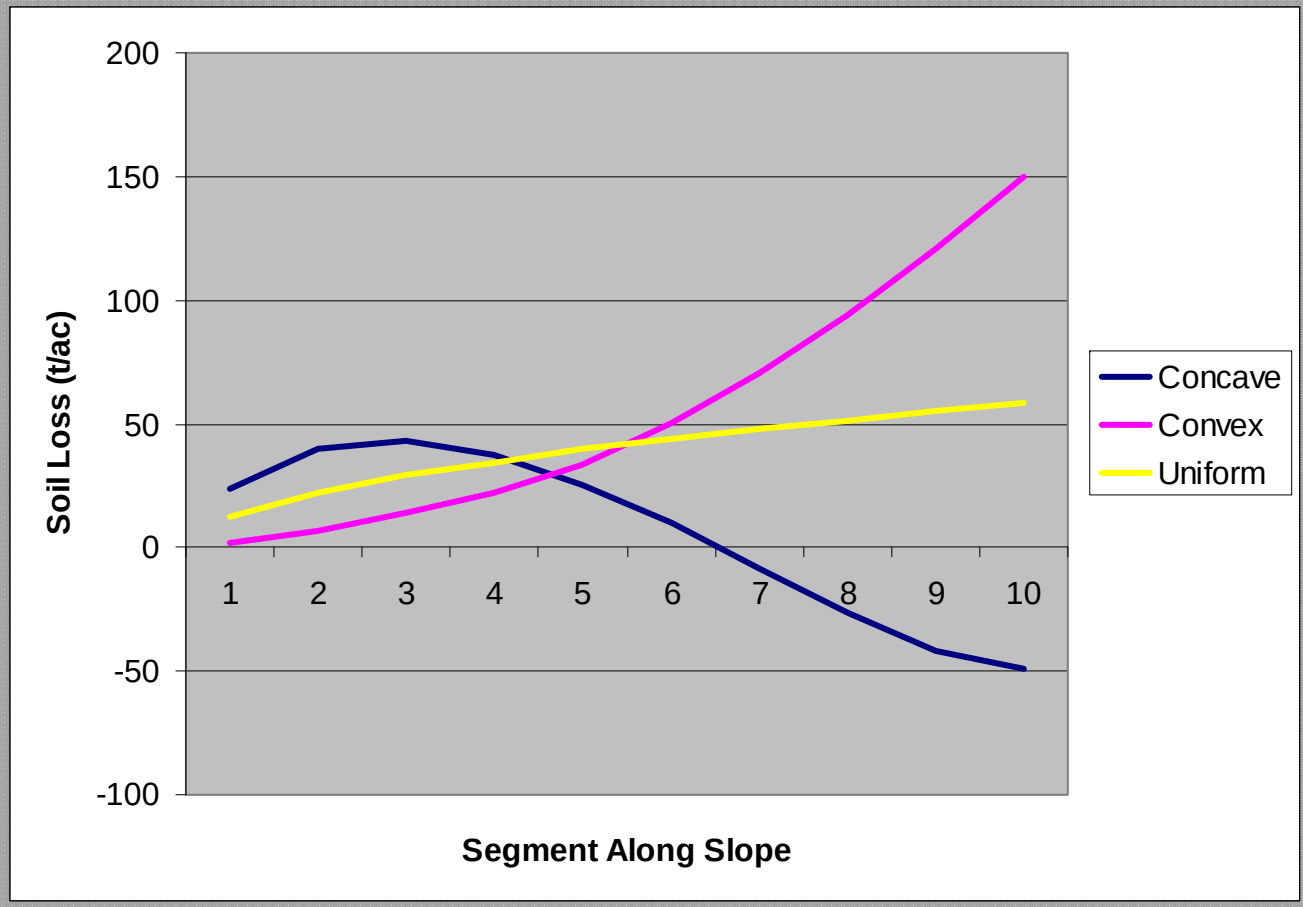
- Slope length effect is greater on slopes where rill erosion is greater relative to interrill erosion
- Examples:
  - Steep slopes
  - Soils susceptible to rill erosion
  - Soils recently tilled
  - Low soil biomass

Percent Slope

- More effect on erosion than slope length
- Above 10 percent – erosion is maximized based on slope gradient
- Up and down hill farming is worst case for erosion

Effect of Slope Shape on Erosion

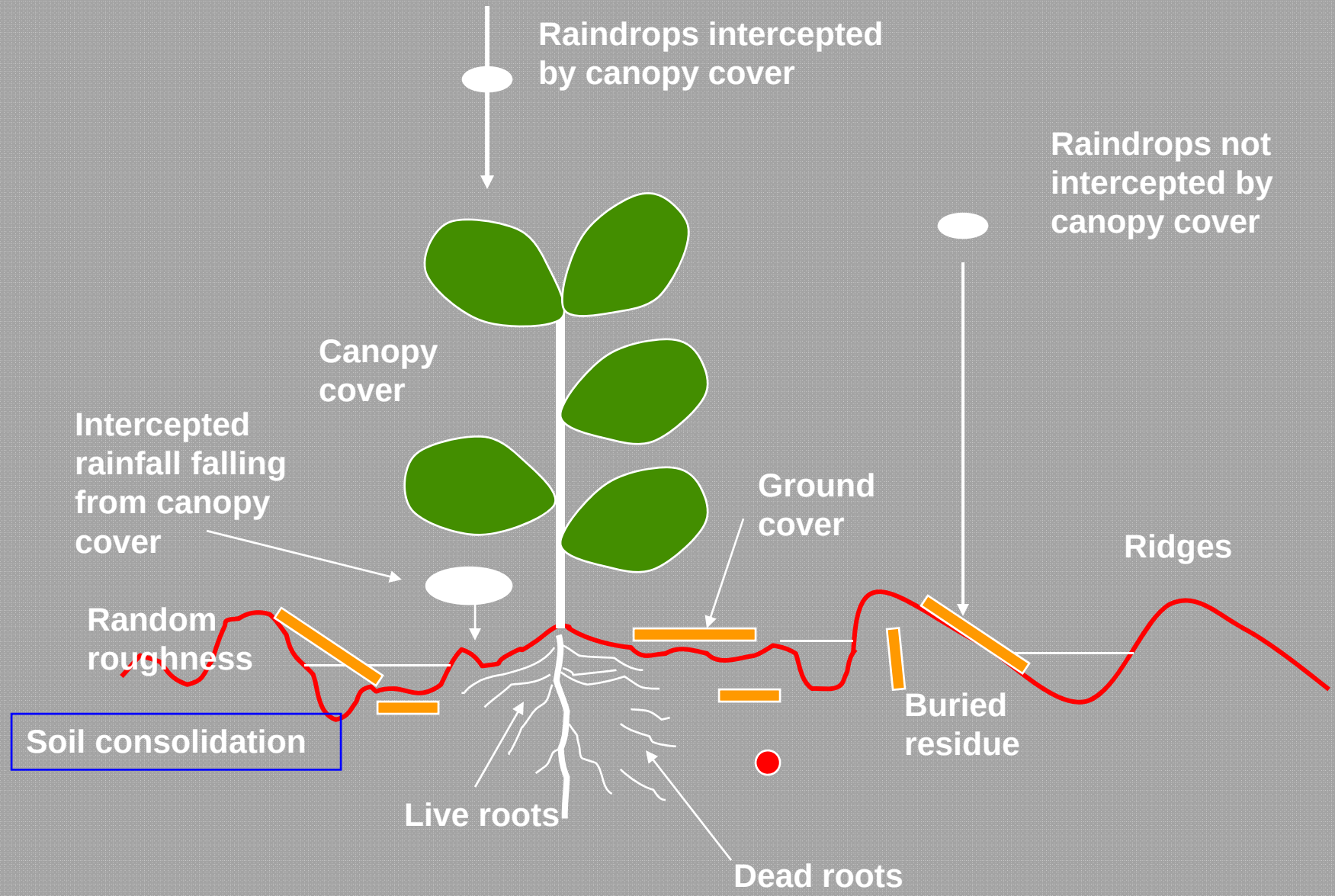
100 ft long, 1% to 19% steepness range



Cover-Management

- Vegetative community
- Crops and cover crops
- Crop rotation sequence
- Tillage vs No Till
- Application of surface and buried materials (mulch, manure)
- Increasing random roughness

Cover-Management Effects



Canopy

- Cover above soil surface that intercepts rainfall but does not touch soil surface to affect surface flow
- Main variables
  - Percent of surface covered by canopy
  - Effective fall height

Ground Cover

- Cover directly in contact with soil surface that intercepts raindrops, slows runoff, increases infiltration
- Examples
  - Live plant material
  - Plant residue and litter
  - Applied mulch
  - Stones (permanent mulch)

Ground Cover

- Live cover depends on type of vegetation, growth stage, and biomass produced
- Residue
  - Amount added by senescence, flattening, and falling by decomposition at base
  - Decomposition
    - Rainfall amount, C:N ratio, and Temperature

Random Roughness

- Creates depressions
- Usually creates erosion resistant clods
- Increases infiltration
- Increases hydraulic roughness that slows runoff, reducing detachment and transport capacity
- Decreases with rainfall event

Ridges

- Ridges up and downhill increase soil loss by increasing interrill erosion
- Function of:
  - Effect increases with ridge height
  - Effect decreases with slope steepness above 6%
- Ridge height decays with rainfall amount and interrill erosion
- Effect shifts from increasing soil loss when up and downhill to decreasing soil loss when on the contour

Crop Residue and Tillage

- Killing vegetation converts live standing to dead standing and live roots to dead roots
- Tillage Operations
  - Flatten standing residue to flat residue (ground cover)
  - Bury flat residue
  - Resurface buried residue
  - Redistribute dead roots in soil
  - Material spread on surface
  - Material incorporated (lower one half of depth of disturbance)
- Decomposition at plant base causes standing residue to fall

Soil Consolidation

- Overall, freshly tilled soil is about twice as erodible as a fully consolidated soil
- Erodibility decreases with time
  - Seven years in the Eastern US
  - Depends on rainfall in Western US, up to 25 years

Supporting Practices

- Contouring/Cross-slope farming
- Strips/barriers
  - Rotational strip cropping, buffer strips, filter strips, grass hedges, filter fence, straw bales
- Terraces/diversions
- Impoundments
- Tile Drainage

Contouring/Cross Slope Farming

- Redirects runoff
- Fail at long slope lengths
- Effectiveness depends on ridge height
  - (no ridge height—no contouring effect)
  - Minimal effect with No Till Farming

Contouring/Cross Slope Farming (continued)

- Function of:
  - Ridge height
  - Row grade
  - Cover-management
  - Hydrologic soil group
  - Storm severity (10 yr EI)
- Varies with time
  - Tillage forms ridges
  - Rainfall events decay ridges

Buffer/Filter Strips

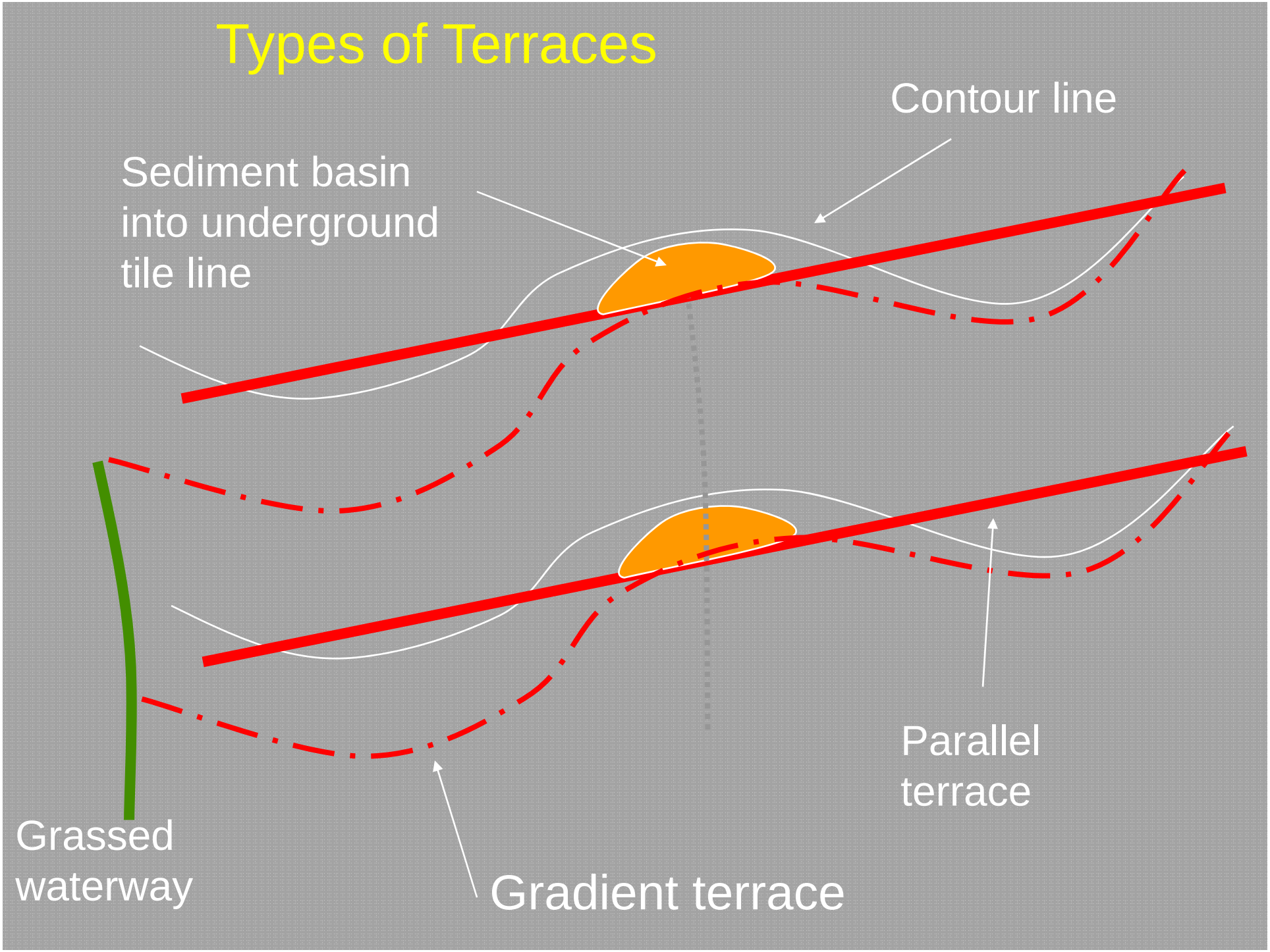
- Narrow strips of dense vegetation (usually permanent grass) on contour
  - Effective by inducing deposition (partial credit) and spreading runoff
  - Most of deposition is in backwater above strip
- Buffer strips
  - Multiple strips
  - Either at bottom or not a strip at bottom
  - Water quality-must have strip at bottom and this strip twice as wide as others
- Filter strip-single strip at bottom

Rotational Strip Cropping

- Equal width strips on contour
- Strips are rotated through a crop rotation cycle
- Offset starting dates among strips so that strips of close growing vegetation separate erodible strips
- Benefit:
  - Deposition (full credit)
  - Spreading runoff
  - Reduced ephemeral gully erosion not credited in RUSLE2

Terraces

- Ridges and channels periodically placed along hillslope that divides hillslope into shorter slope lengths except for widely spaced parallel terraces that may have no effect on slope length
- Benefit:
  - Shorten slope length and change slope gradient
  - Trap sediment
  - Runoff management system
- Evenly spaced to fit equipment
- Maintenance required to deal with deposition


Types of Terraces
Contour line
Sediment basin into underground tile line
Parallel terrace
Grassed waterway
Gradient terrace

Deposition in Terraces

- Deposition occurs when sediment load is greater than transport capacity
- Sediment load from sediment entering from overland area
- Transport capacity function of grade and storm erosivity
- Deposition depends on sediment characteristics
- Deposition enriches sediment in fines

Diversions

- Ridges and channels placed at strategic locations on hillslope to shorten slope length
  - Reduce runoff rate and rill erosion
- Generally designed with a steepness sufficiently steep that no deposition occurs but not so steep that erosion occurs

Impoundments (Small sediment control basins)

- Deposition by settling process
- Function of:
  - Sediment characteristic of sediment load reaching impoundment

Subsurface Drainage Systems

- Reflects effects of deep drainage systems
  - Tile drainage systems
  - Lateral, deep drainage ditches
- Describe by:
  - Assigning hydrologic soil group for undrained and drained soil
  - Fraction of area drained

RUSLE2 Databases

- Plans / Worksheets / Profiles
- Climate
- EI distribution
- Soil
- Management
- Operations
- Vegetation
- Residue
- Contouring
- Strips
- Diversion/terrace, sediment basin systems

Profiles

- Central part of a RUSLE2 soil loss estimate
  - Profile is reference to a hillslope profile
- Five things describe a profile
  - Location
  - Soil
  - Topography
  - Cover management
  - Supporting practice
- Save common rotations to make RUSLE2 use easier

Worksheets (like LU&T-3)

- Three parts: Alternative managements, practices; Alternative profiles; Profiles for a field or watershed
- Alternative management, practices
  - Compare alternatives for a single hillslope profile
- Alternative profiles
  - Compare specific hillslope profiles
- Field/Watershed
  - Compute average soil loss/sediment yield for a field or watershed
- Can save worksheets

Concept of Core Database

- Climate based on county data
- Soils data includes erodibility value, soil texture, hydrologic soil group of undrained soil, efficient subsurface drainage, time to full soil consolidation, and rock cover – updated annually
- Core databases were set up for vegetation, residue, and operations
  - NRCS data manager maintains these databases
- Working databases developed from the core databases by State Agronomists

Operations Database

- Operations describe events that change soil, vegetation, and residue conditions
- Mechanical soil disturbance, tillage, planting, seeding, frost, burning, harvest
- Describe using effects and the sequence of effects
- Speed and depth of tillage

Vegetation Database

- Live plant material
- Residue size and toughness
  - 5 types: small, fragile (soybeans); moderate size, moderately fragile (wheat); large size, nonfragile (corn); large size, tough (woody debris); gravel, small stones
- Static variables include:
  - Residue name, yield, retardance, senescence
- Time varying variables
  - Root biomass in upper 4 inches
  - Canopy cover percent
  - Fall height
  - Live ground (surface) cover percent

Contouring/Cross Slope Farming

- To have contouring, must have ridge heights
  - To have ridge height, must have operation that creates ridges
  - Ridge height assigned in operation
- Row grade
  - Relative row grade or absolute

RUSLE2 APPLICABLE PROCESSES

- Interrill and rill erosion - YES
- Sediment yield from overland flow slope length - YES
- Sediment yield from terrace channels and simple sediment control basins - YES
- Ephemeral or permanent incised gully erosion – NO
- Stream channel erosion – NO
- Mass wasting – NO

Applicable Land Uses

- All land uses where overland flow and interrill-rill erosion occurs
- Best: Cropland
- Moderate: Disturbed lands like military lands, construction sites, landfills, reclaimed lands
- Acceptable: pasturelands, disturbed forestlands, parks and recreational areas

Cropland Applications

- Best: Clean tilled corn, soybean, wheat crops
- Moderate: Conservation tillage, rotations involving hay
- Acceptable: Hay, pasture
- Most variable: Support practices, especially contouring

MOST APPLICABLE GEOGRAPHIC REGIONS

- Rainfall occurs regularly
- Rainfall predominant precipitation
- Rainfall exceeds 20 inches
- West problem area because of infrequent storms
- Original research – Columbia, MO

APPLICABLE SOILS

- Best: Medium Texture
- Moderate: Fine Texture
- Acceptable: Coarse Texture
- Organic Soils - NO

APPLICABLE TOPOGRAPHY

- Slope Length
  - Best: 50 - 300 feet
  - Moderate: 0 - 50 ft , 300 - 600 ft.
  - Acceptable: 600 - 1000 feet
  - >1000 feet - NO

APPLICABLE TOPOGRAPHY

- Slope Steepness
  - Best: 3 - 20%
  - Moderate: 0 - 3%, 20 - 35%
  - Acceptable: 35 - 100%
  - >100% (> 45 degrees) - NO

SUMMARY

- RUSLE2 varies in its applicability
- Results from RUSLE2 must be evaluated for logical sequence of operations and realistic results
- Confidence in results varies – best on Missouri cropland
- Garbage in – garbage out!

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