RUSLE2

REVISED UNIVERSAL SOIL LOSS EQUATION-Version 2

Predicting Soil Erosion By Water

12/10/2015

Objects

- Review
  - Erosion
  - RUSLE2 Basics

EROSION

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

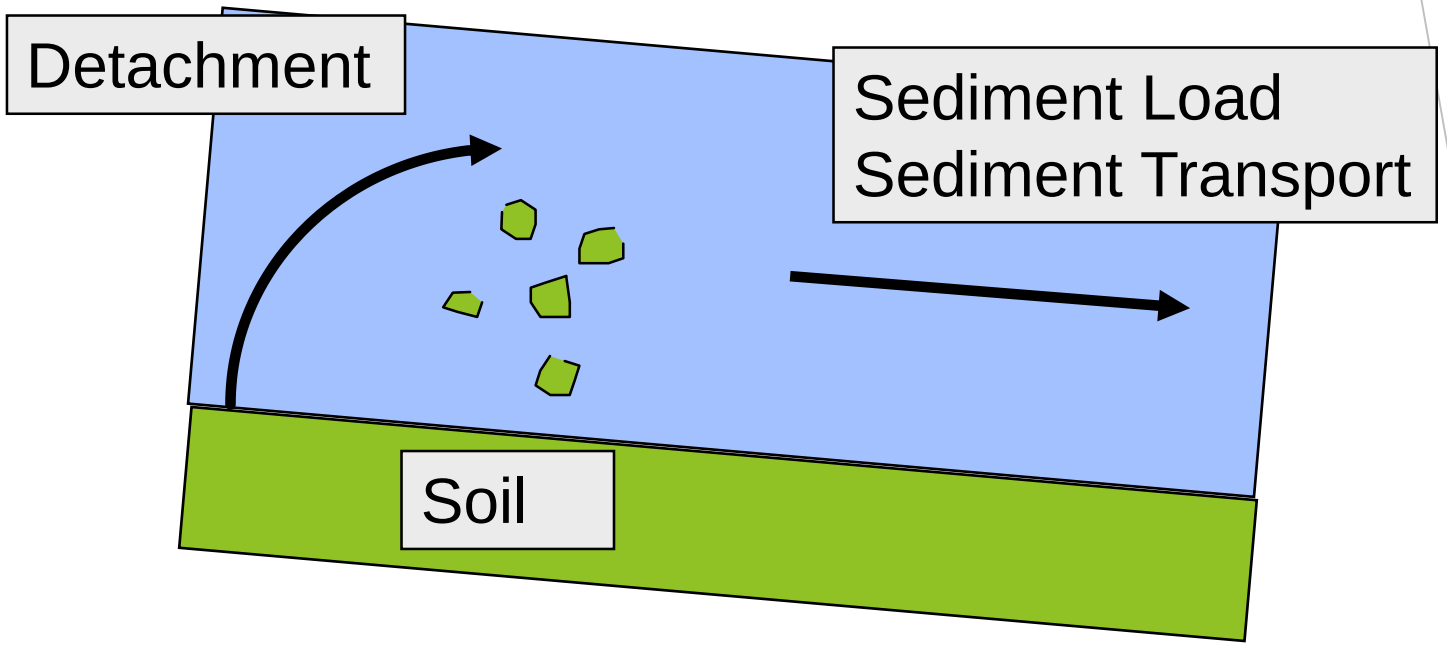
Ellison, 1944

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

DETACHMENT

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

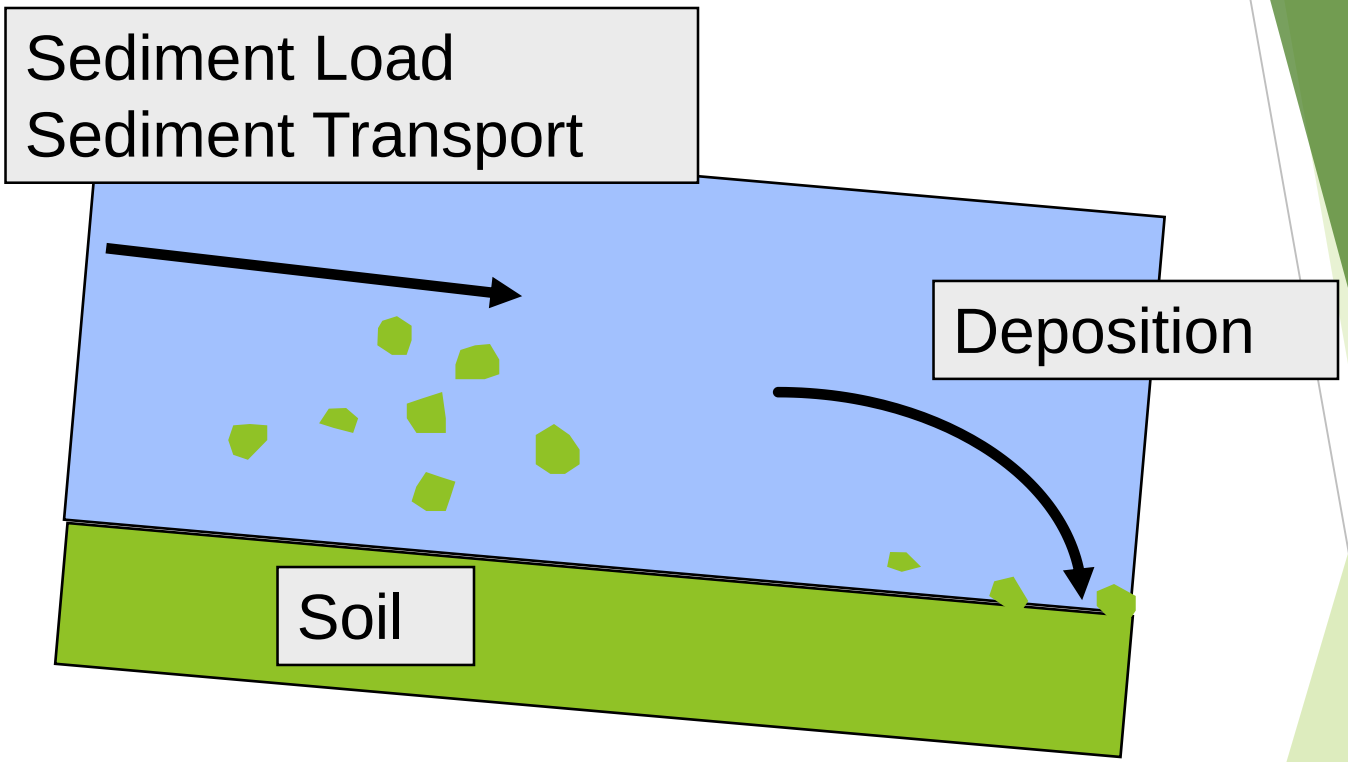
DETACHMENT



DEPOSITION

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

DEPOSITION

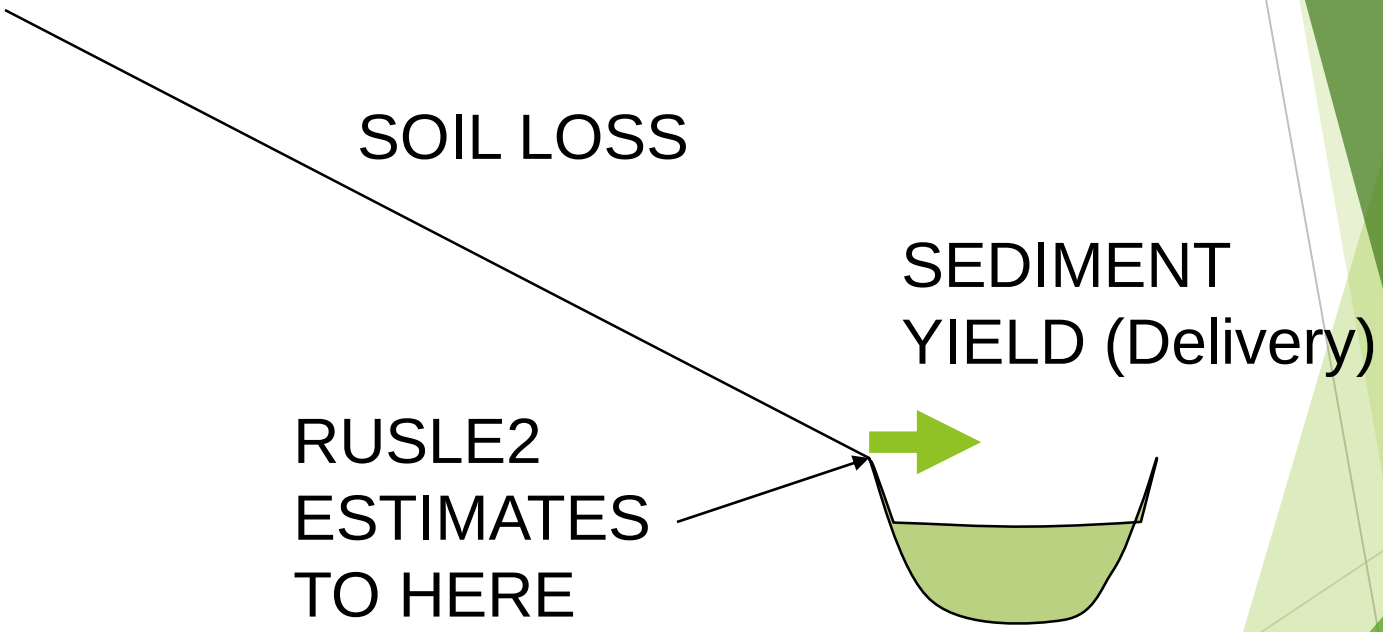


TYPES OF EROSION

- Interrill and rill (sheet-rill)-RUSLE2
- Ephemeral gully
- Permanent, incised (classical) gully
- Stream channel
- Mass movement
- Geologic

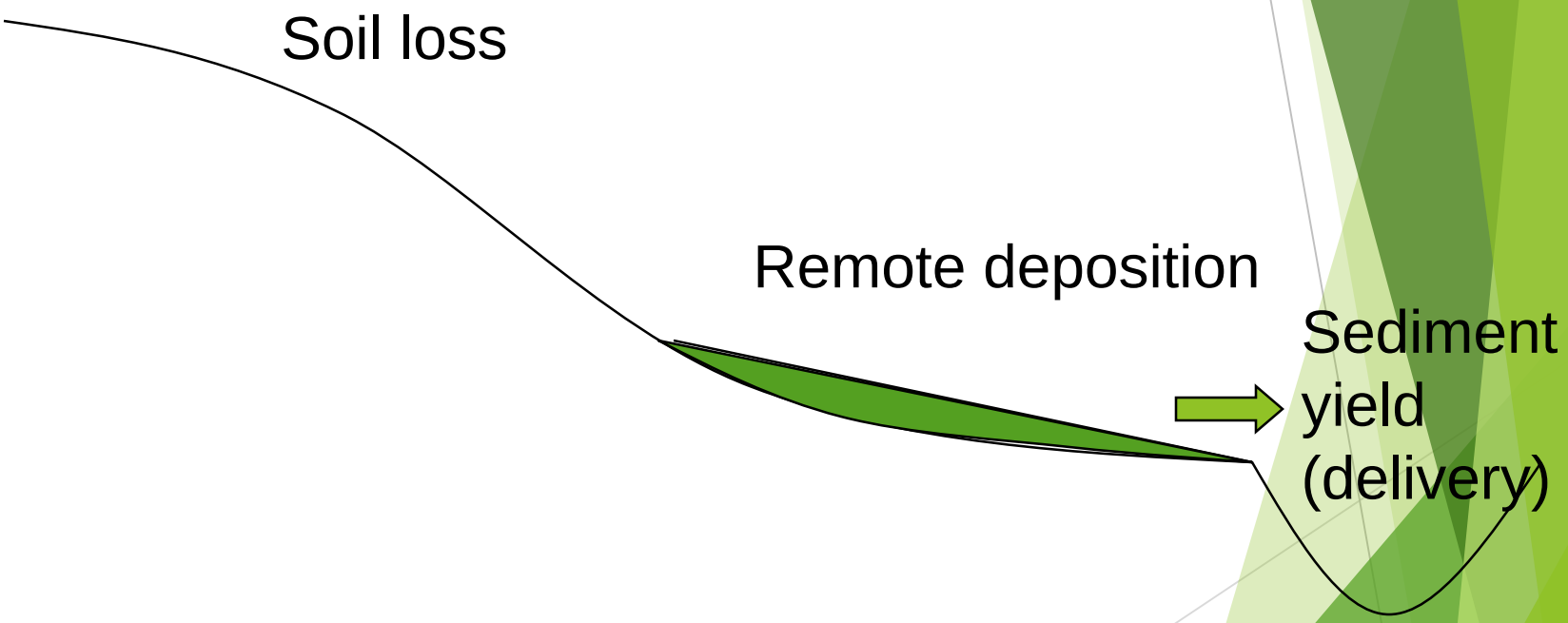
DEFINITIONS

Simple Uniform Slope



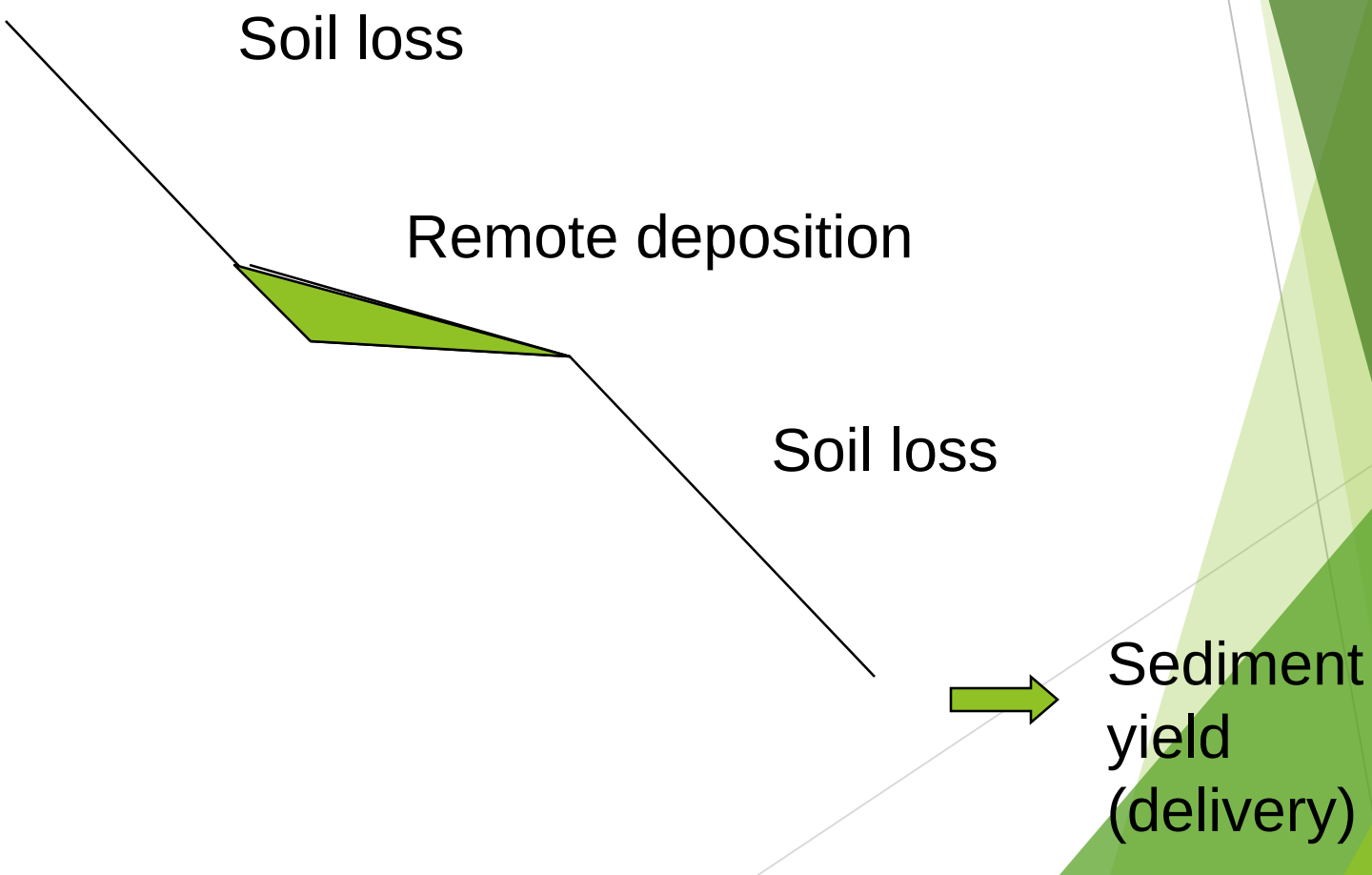
DEFINITIONS

Complex Slope



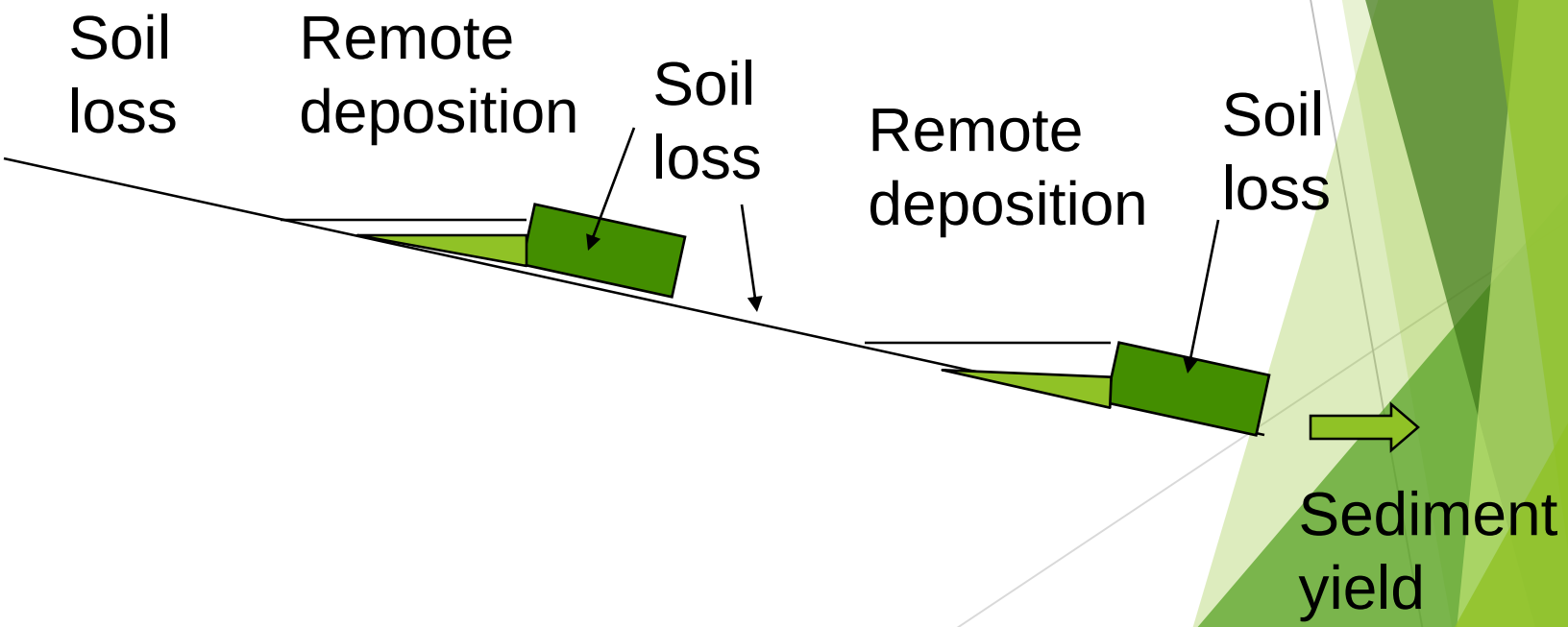
DEFINITIONS

Complex Slope

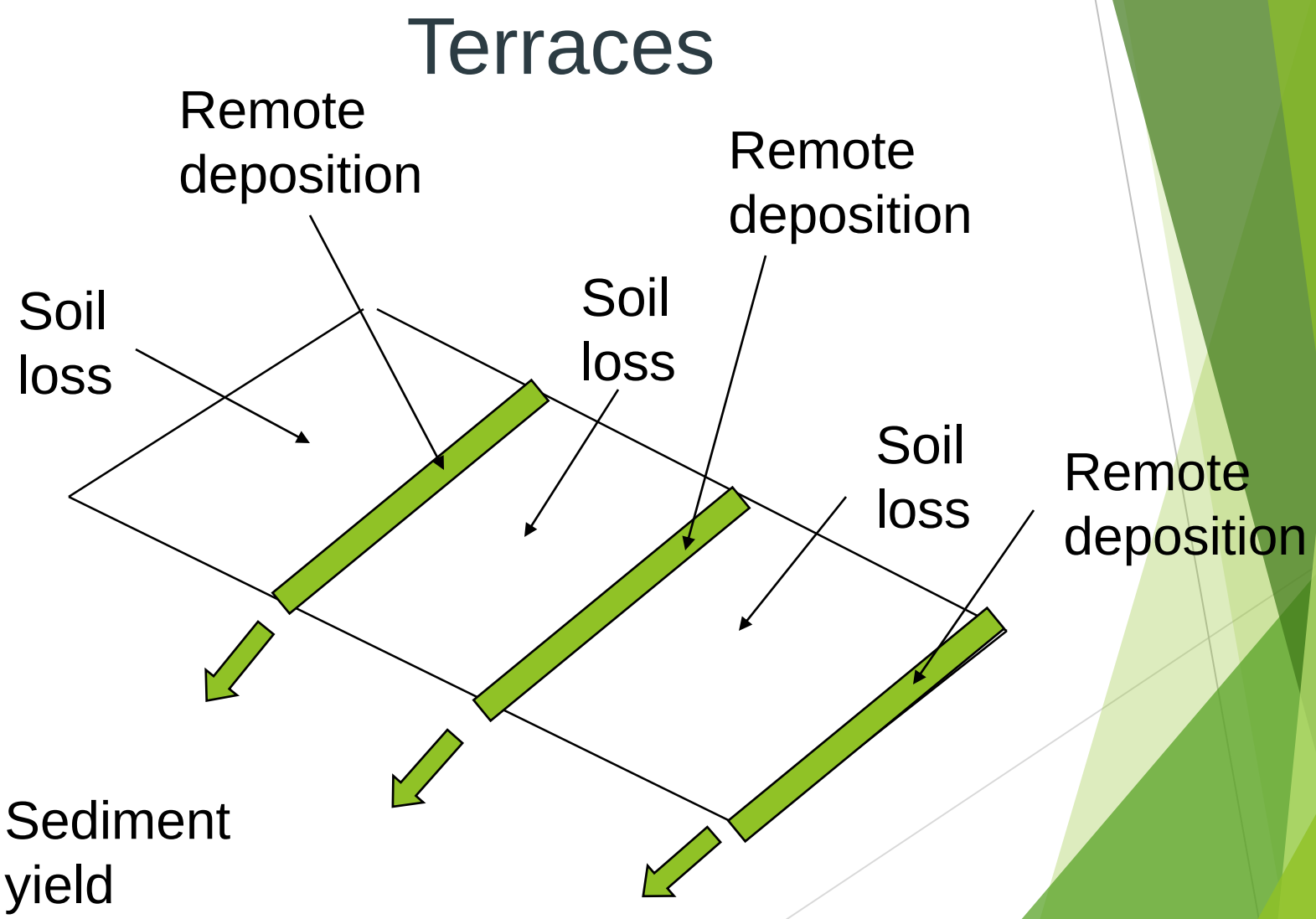


DEFINITIONS

Strips

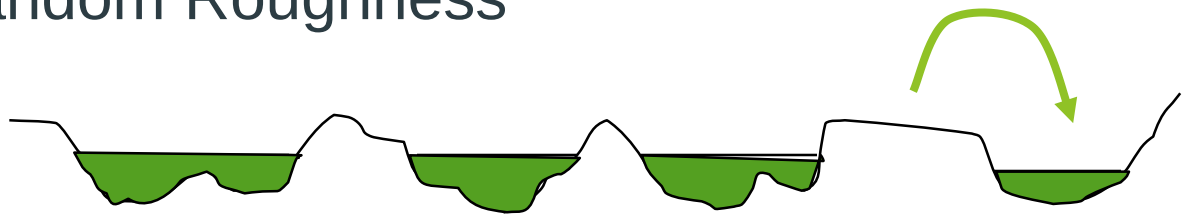


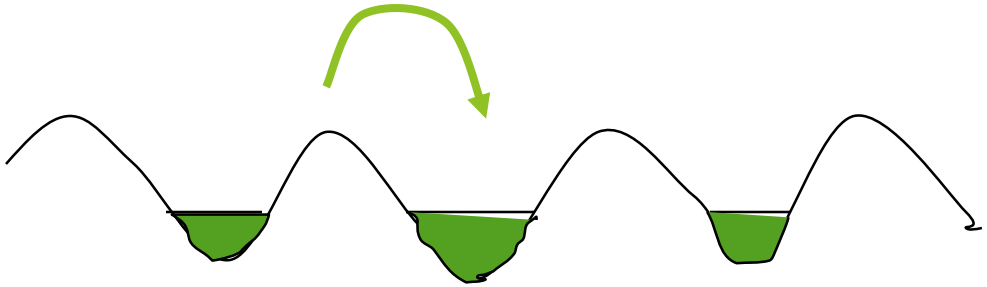
DEFINITIONS



LOCAL DEPOSITION

Random Roughness





Ridges-Furrows

Credit for Deposition

Local Deposition

- Full credit

Remote Deposition

- Partial credit
- Amount
- Location
- Spacing of terraces

EROSION IS A CONCERN

- Degrades soil resource
  - 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
- Conventional tillage
- Rows up/down steep slopes
- Low maintenance pasture
- Disturbed land with little cover

EROSION PREDICTION AS A TOOL

- Guide management decisions
- Evaluate impact of erosion
- Inventory soil erosion
- Conservation planning

EROSION PREDICTION AS A TOOL

- Concept:
  - Estimate erosion rate
  - Evaluate by ranking
  - Evaluate against quality criteria
- Tool: RUSLE2
- Quality Criteria: Soil loss tolerance

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

OVERVIEW OF RUSLE2 (Revised Universal Soil Loss Equation-Version 2)

- Where RUSLE2 applies
- Major factors affecting erosion
- RUSLE2 factors
- RUSLE2 background

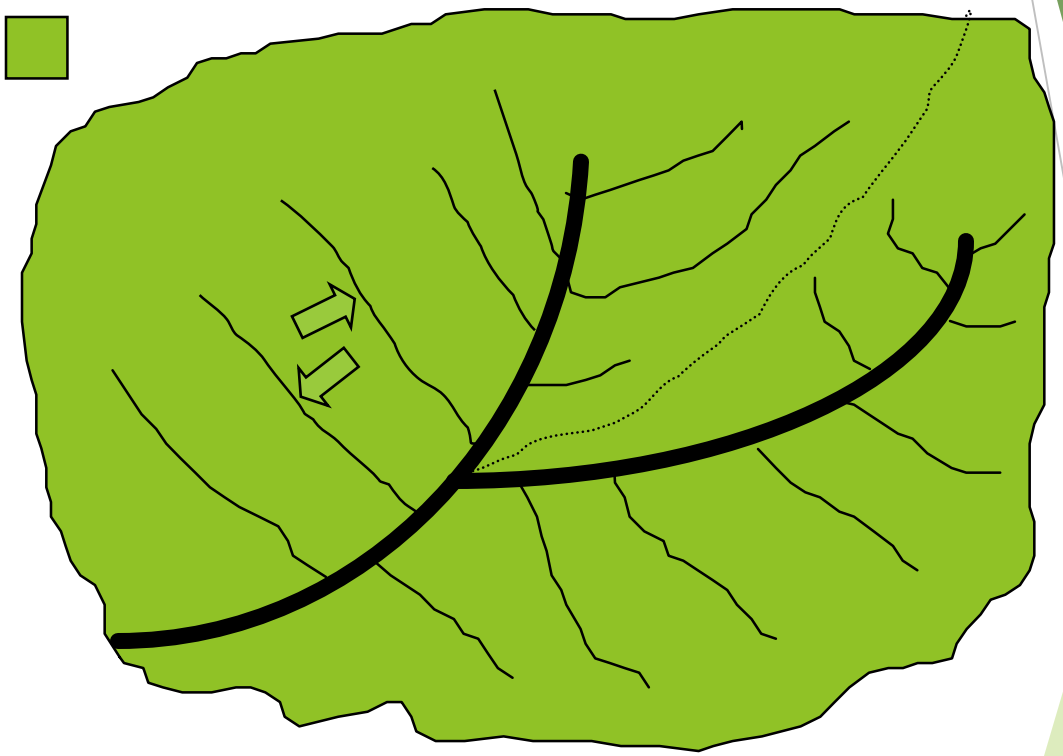
Landscape

Overland flow

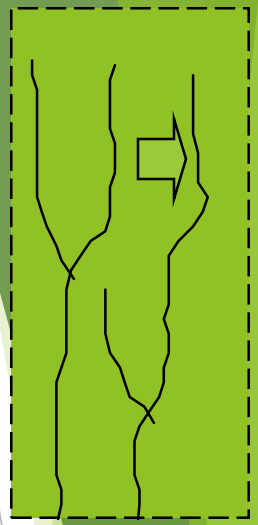
Interrill

Rill

Ephemeral Gully (Concentrated flow)



RUSLE2 Area



Erosion Types

FACTORS AFFECTING INTERILL-RILL EROSION

- Climate
- Soil
- Topography
- Land use
  - Cultural practices
  - Supporting practices

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

RUSLE FACTORS (Sediment Production)

- Climate r
- Soil k
- Topography ls
- Land Use and lscp

Management

RUSLE FACTORS

A = *f* (erodibility, erosivity)

- Erosivity – rklscp
- Erodibility - klc

RUSLE FACTORS

(Keep in mind that RUSLE2 operates on a daily basis)

Unit Plot Concept

a = rk lscp

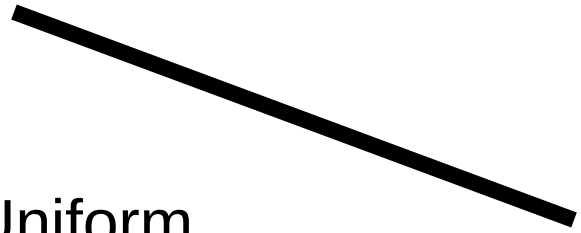
rk - Unit plot soil loss

(dimensions)

lscp - Adjusts unit plot soil loss

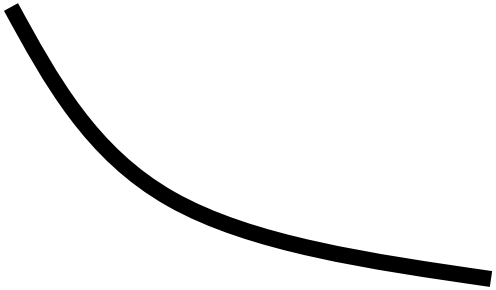
(dimensionless)

Hillslope Shape

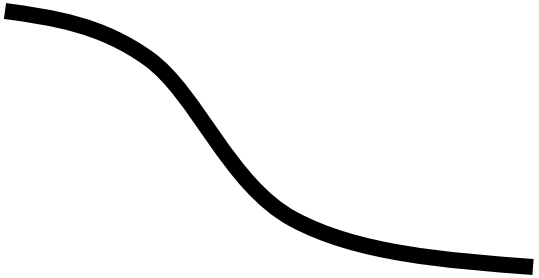


Uniform

Convex



Concave



Complex-Convex:concave

Complex-Concave:convex

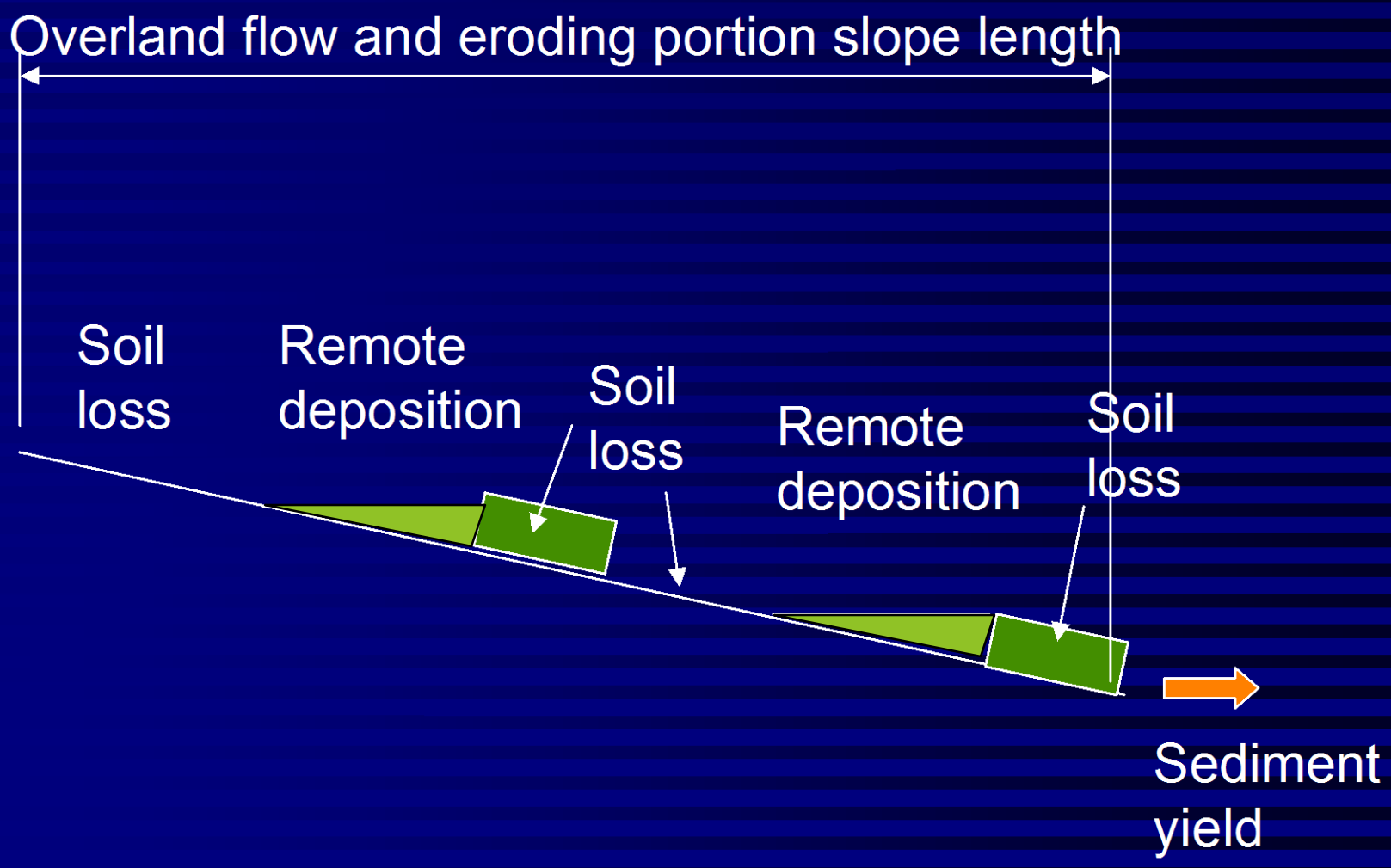
Overland Flow Slope Length

- Distance from the origin of overland flow to a concentrated flow area
- This slope length used when the analysis requires that the entire slope length be considered.

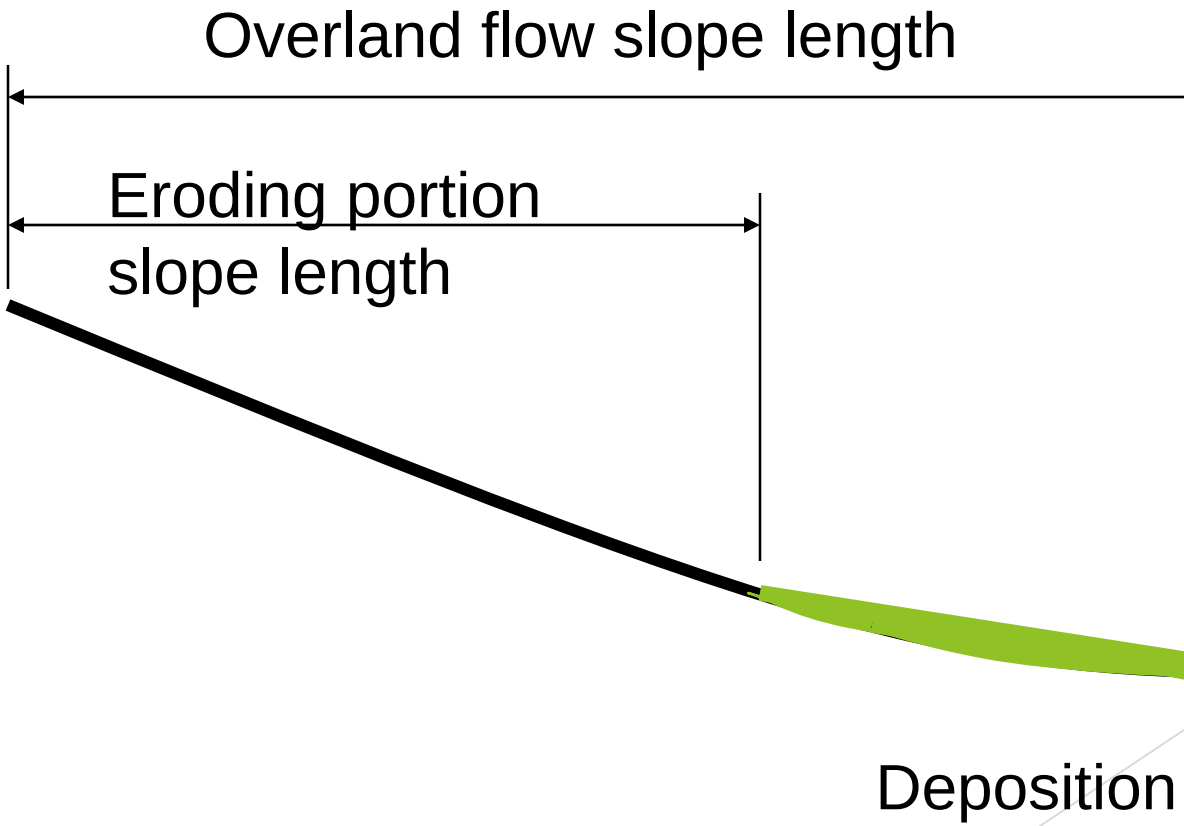
Slope Length for Eroding Portion of Slope

- Only works for simple slopes
- Traditional definition
  - Distance from origin of overland flow to concentrated flow or to where deposition begins
  - Definition is flawed for strips and concave:convex slopes
- Best approach: Use overland flow slope length and examine RUSLE2 slope segment soil loss values

Slope Lengths for Strips



Slope Length for Concave Slope



Rule of Thumb for Deposition Beginning on Concave Slopes

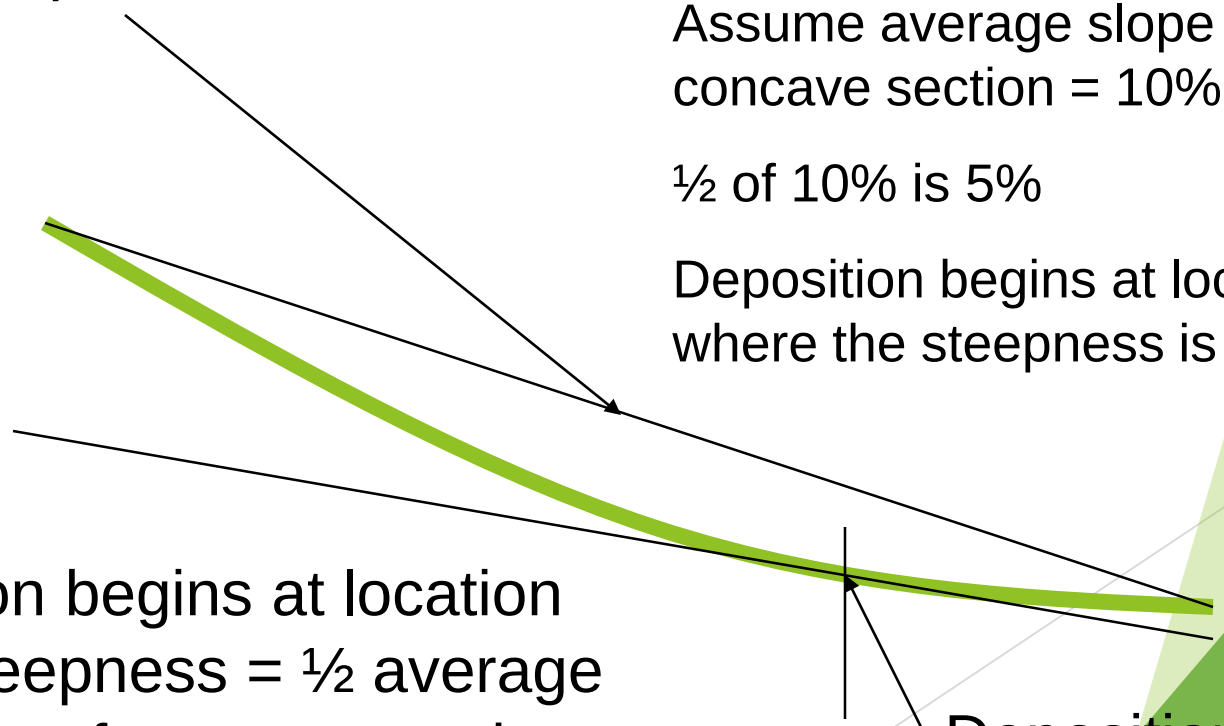
Average steepness of concave portion

Example:

Assume average slope of concave section = 10%

½ of 10% is 5%

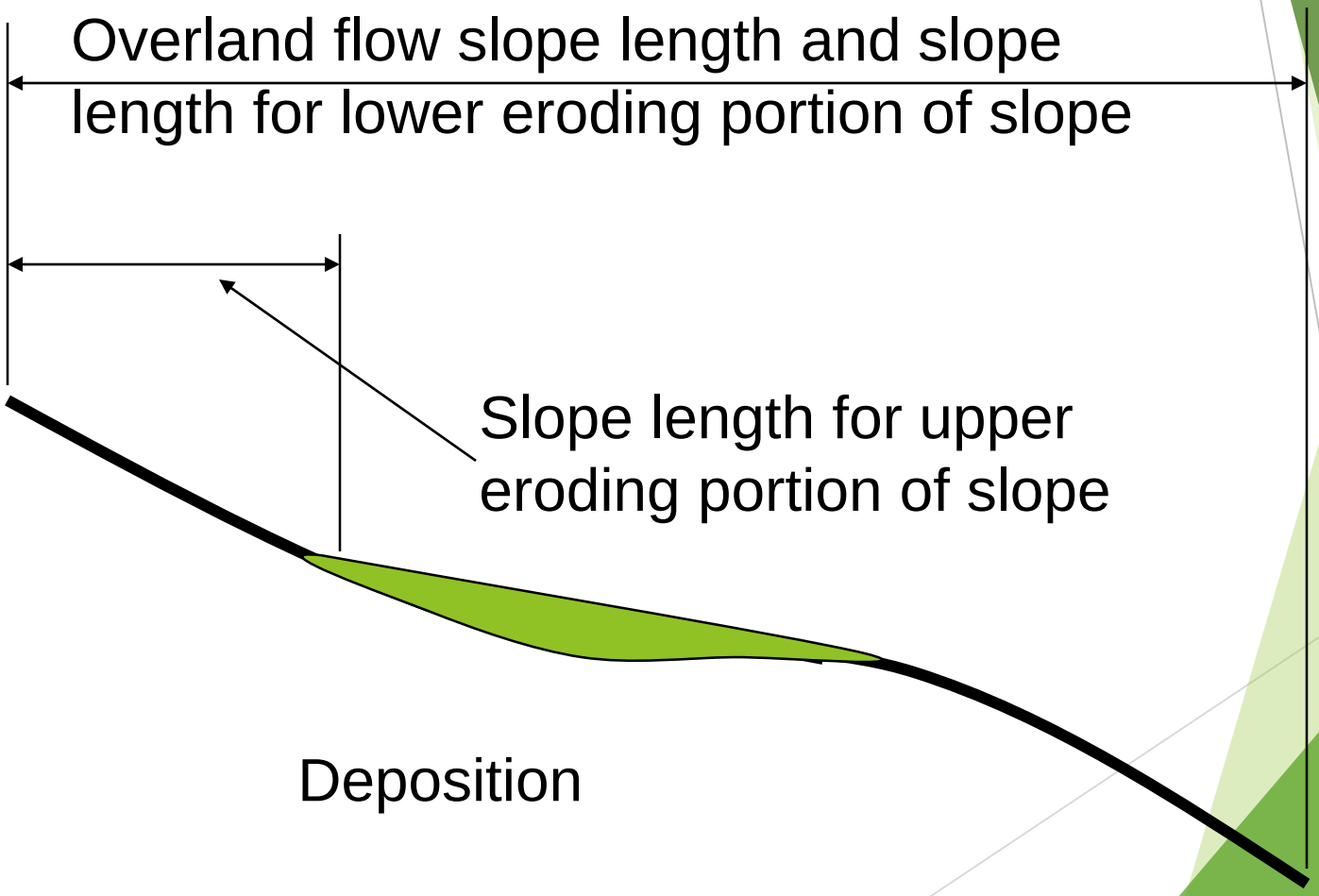
Deposition begins at location where the steepness is 5%



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

Deposition begins

Slope Length for Concave:Convex Slope



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

Land Use

- Cover-management
- Supporting practices

Cover-Management

- Vegetative community
- Crop
- Crop rotation
- Conservation tillage
- Application of surface and buried materials (mulch, manure)
- Increasing random roughness

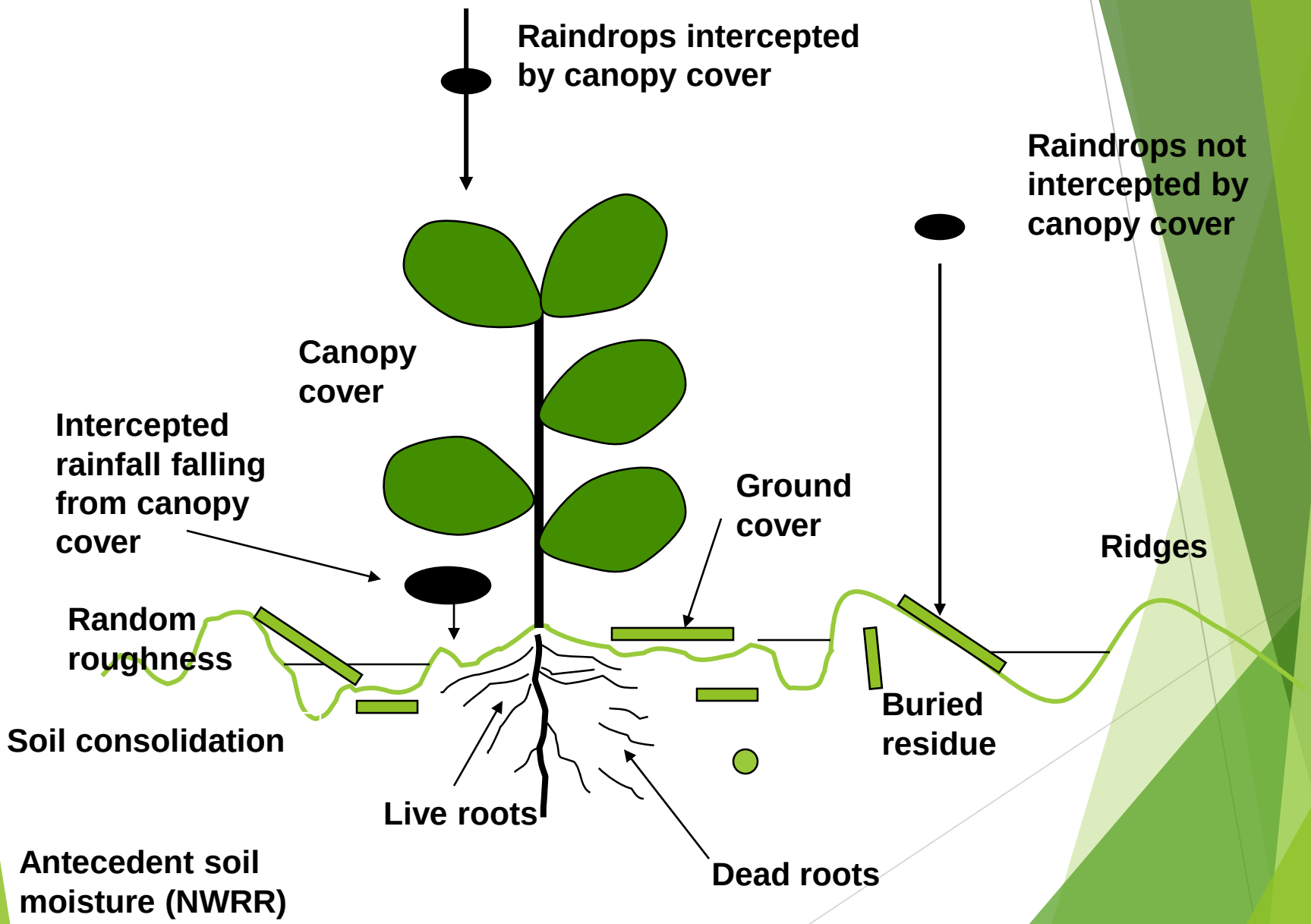
Supporting Practices

- Contouring
- Strip systems
  - Buffer, filter, strip cropping, barriers
- Terrace/Diversion
- Impoundments
- Tile drainage

Cover-Management Subfactors

- Canopy
- Ground cover
- Surface Roughness
- Ridges
- Below ground biomass
  - Live roots, dead roots, buried residue
- Soil consolidation
- Antecedent soil moisture (NWRR only)

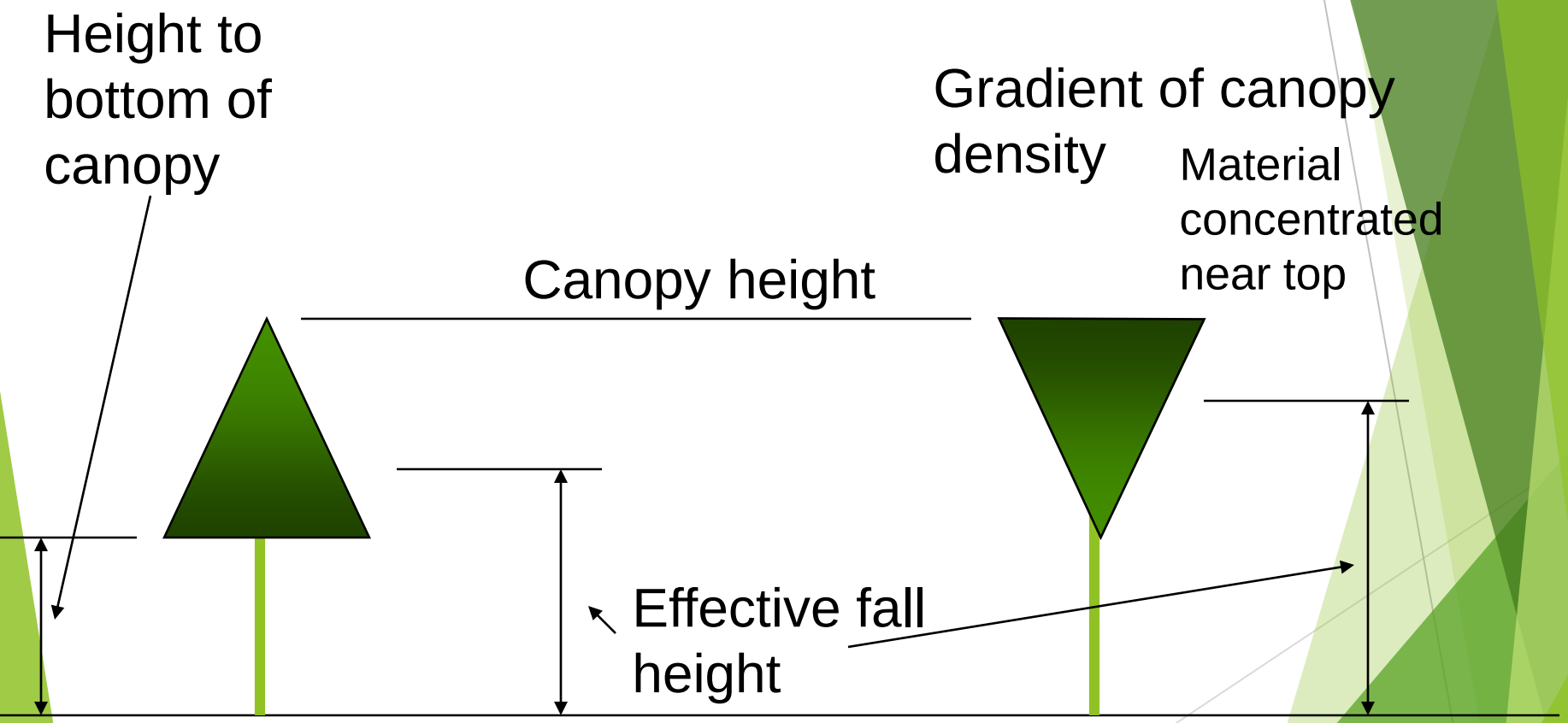
Cover-Management Effects



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

Effective Fall Height



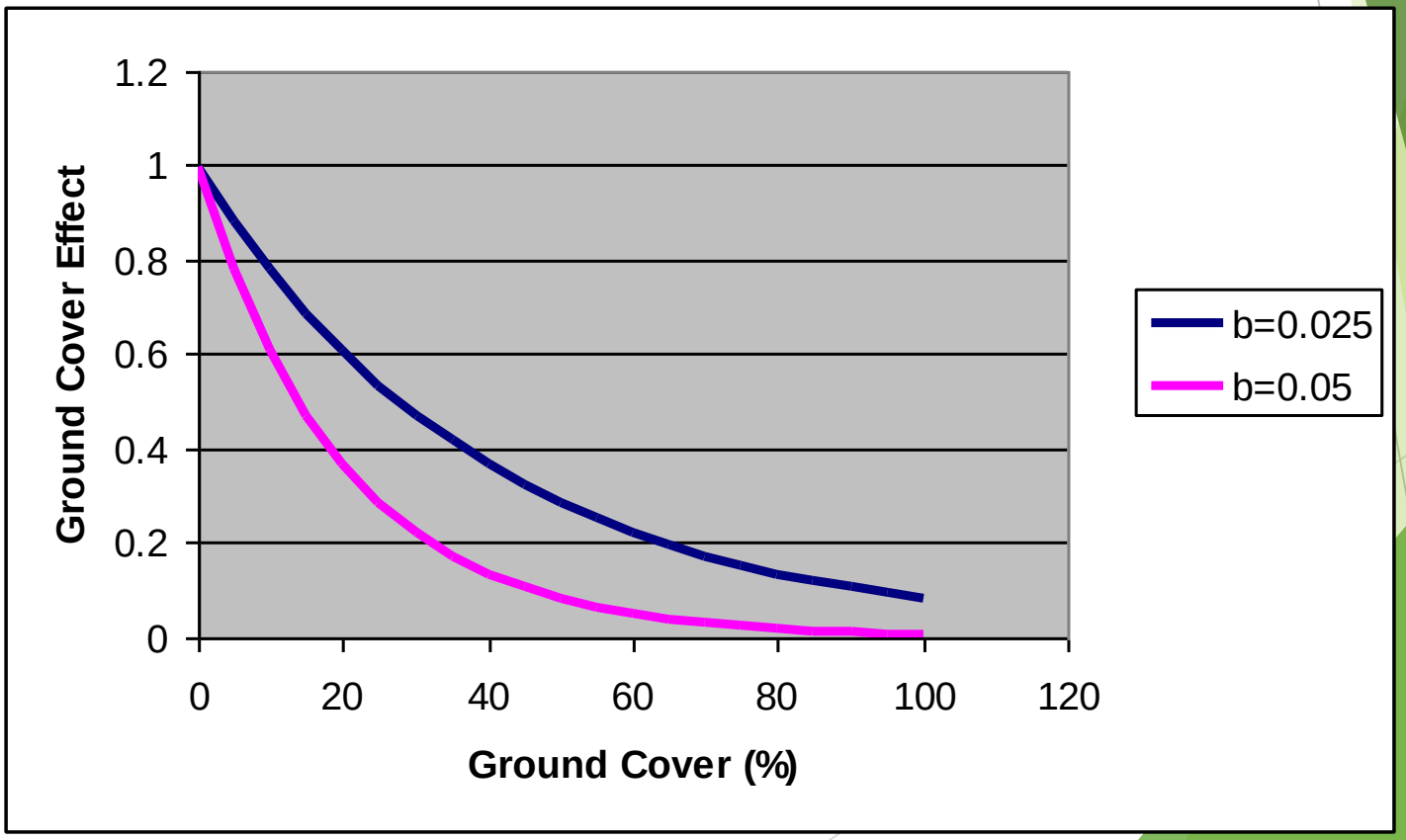
Ground Cover

- 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

Ground Cover Effect

Eff = exp(-b x %grd cov)

b greater when rill erosion more dominant than interrill erosion



Ground Cover

- Live cover depends on type of vegetation, production level, and stage
- Residue
  - Amount added by senescence, flattening, and falling by decomposition at base
  - Decomposition
    - Rainfall amount
    - Temperature

Interaction of Ground Cover and Canopy

- Canopy over ground cover is considered to be non-effective
- As fall height approaches zero, canopy behaves like ground cover

Random Roughness

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

Random Roughness

- Standard deviation of micro-elevations
- Roughness at tillage function of:
  - Implement
  - Roughness at time of disturbance and tillage intensity
  - Soil texture
  - Soil biomass
- Decays with:
  - Rainfall amount
  - Interrill erosion

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

Dead Biomass Pools

- Killing vegetation converts live standing to dead standing and live roots to dead roots
- 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 base causes standing residue to fall

Decomposition of Dead Biomass

- Function of:
  - Rainfall
  - Temperature
  - Type of material
  - Standing residue decays much more slowly

Below ground biomass

- Live roots
  - Distributed non-uniformly within soil
- Dead roots
- Buried residue
  - Half of material decomposed on surface is added to upper 2 inches
  - Incorporated biomass

Effect of Below Ground Biomass

- Roots mechanically hold the soil
- Add organic matter that improves soil quality, reduces erodibility, increases infiltration
- Affect rill erosion more than interrill erosion
- Effect of roots considered over upper 10 inches
- Effect of buried residue over upper 3 inches, but depth decreases to 1 inch as soil consolidates (e.g. no-till)

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

Width of Disturbance

- Width of disturbance taken into account in surface cover, random roughness, and soil consolidation

Antecedent Soil Moisture (NWRR)

- Soil loss depends on how much moisture previous cropping systems have removed from soil

Supporting Practices

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

Contouring/Cross Slope Farming

- Redirects runoff
- Fail at long slope lengths
- Effectiveness depends on ridge height
  - (no ridge height—no contouring effect)

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 that form ridges
  - Decay of ridges

Critical Slope Length

- If slope length longer than critical slope length, contouring fails allowing excessive rill erosion
- Function of:
  - Storm severity, slope steepness, cover-management, EI distribution
- Critical slope length extensions below strips depend on degree that strip spreads runoff
- Terraces are used if changing cover-management or strips are not sufficient
- Soil disturbance required to restore failed contouring

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

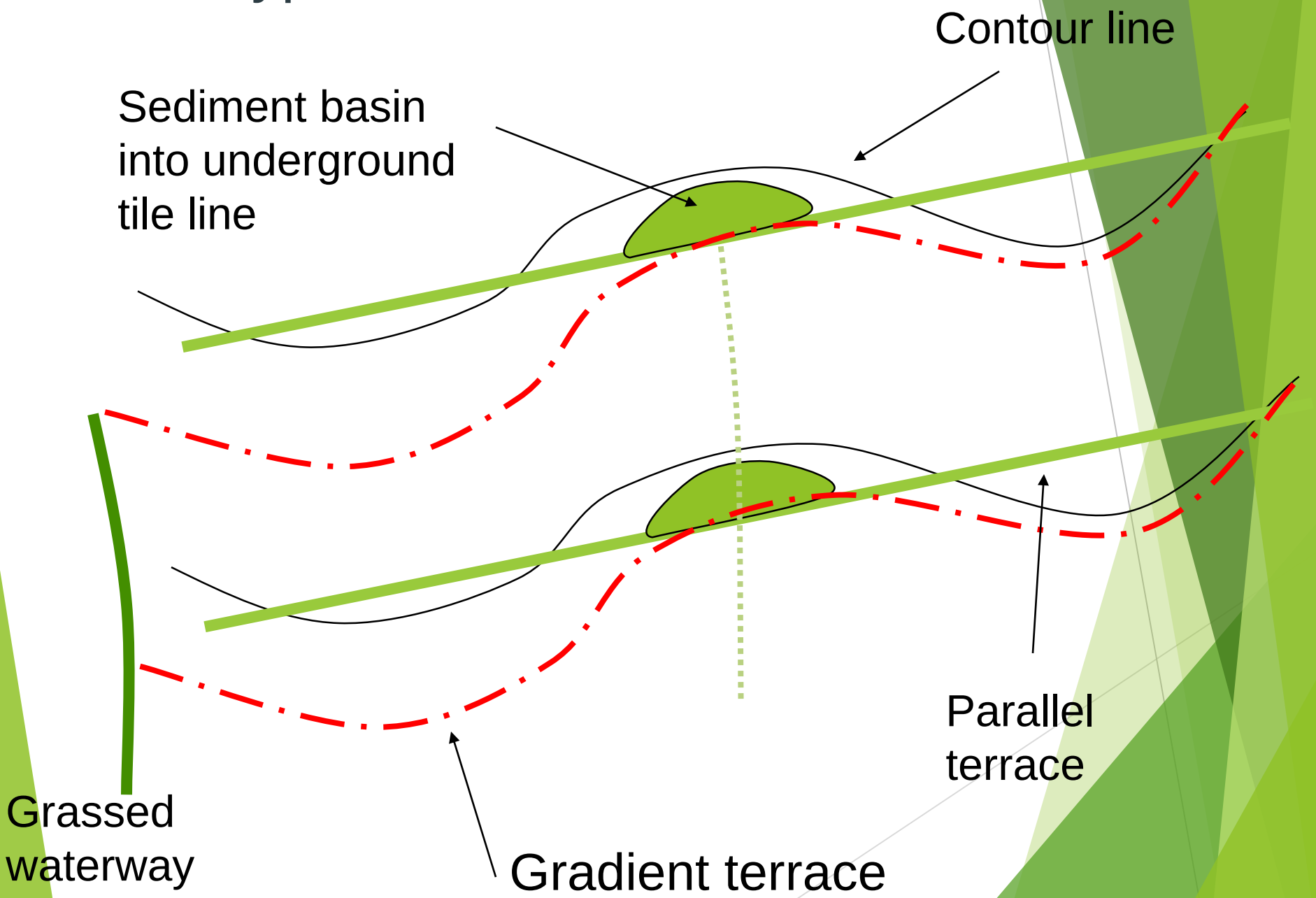
Rotational Strip Cropping

- 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 not effect on slope length
- Benefit:
  - Shorten slope length and trap sediment
  - Runoff management system
- Evenly spaced
  - May or may have a terrace at bottom
- Maintenance required to deal with deposition

Types of Terraces



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

Benefit of Deposition

- Depends on type of deposition
  - Local deposition gets full credit
  - Remote deposition gets partial credit
- Credit for remote deposition
  - Depends on location on hillslope
  - Deposition at end gets almost no credit

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