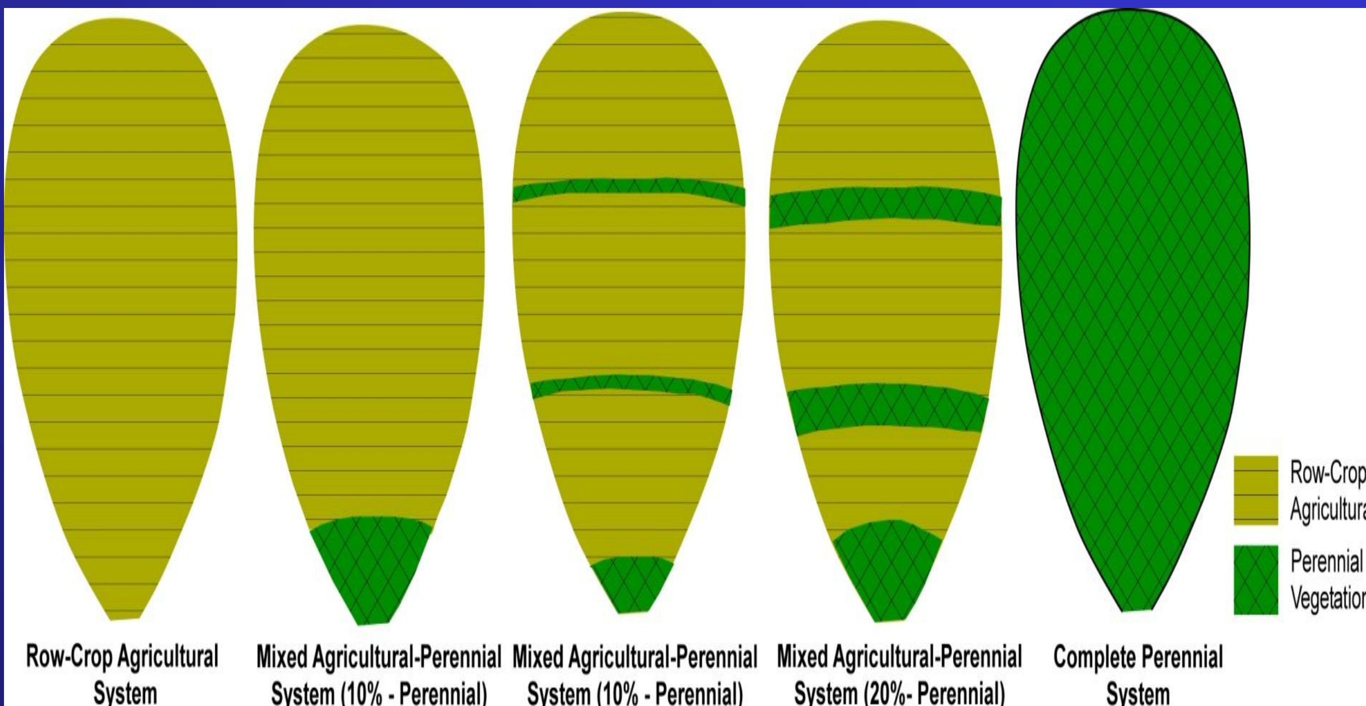
Soil Erosion Mechanics

- Processes of soil erosion
  - Detachment
    - Raindrop impact
    - Flowing water
  - Transport
    - Flowing water
    - Raindrop impact
  - Deposition

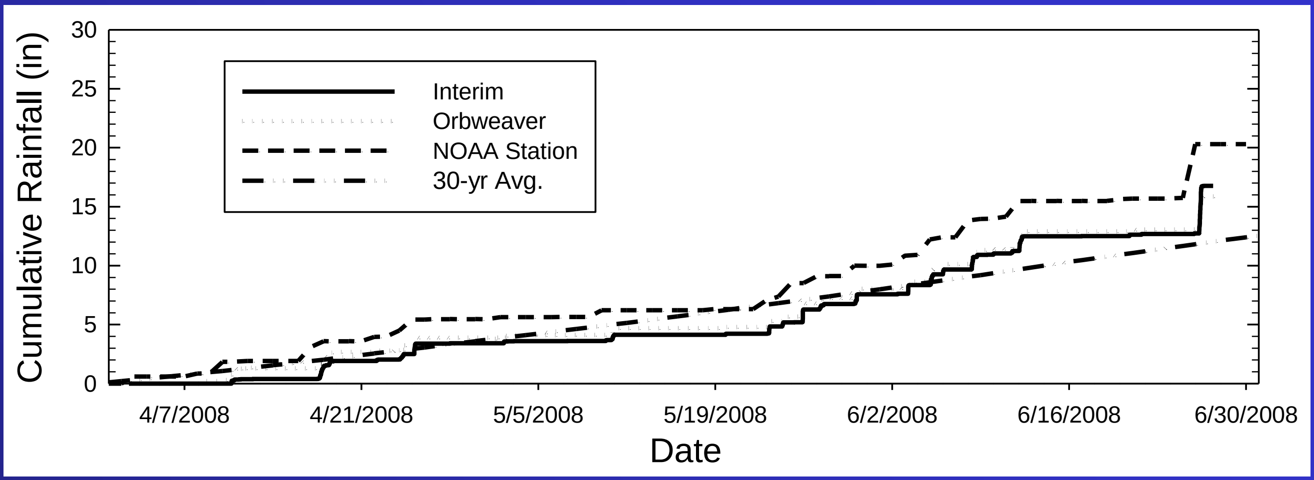
Soil Erosion Mechanics

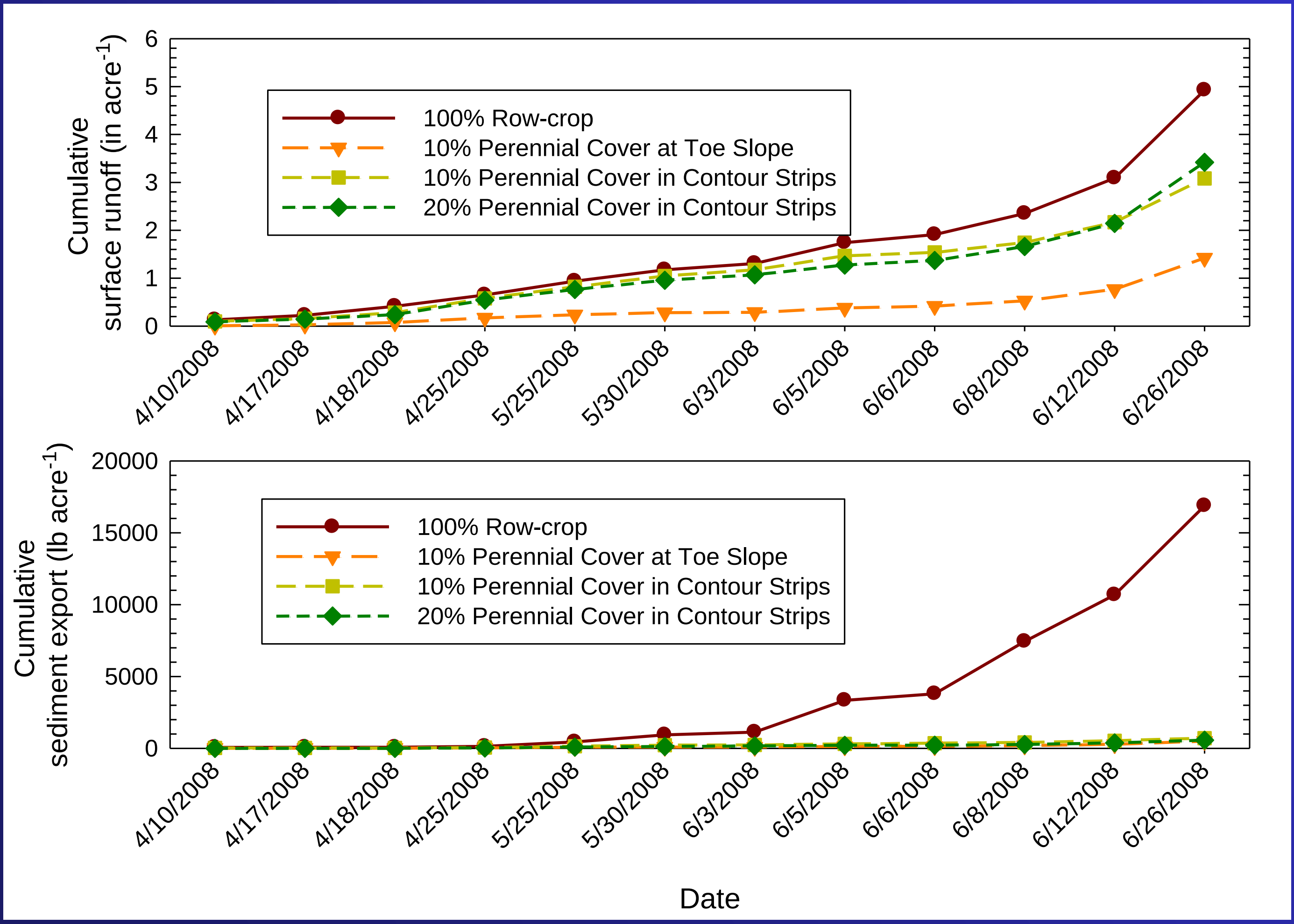
- Theoretically and practically to control erosion
  - Control detachment
  - Minimize transport
  - Control deposition location

Raindrops falling on exposed soil can break off soil particles to be lost in run-off water.



Conceptual Watershed Designs


Cumulative Rainfall (in)
30
25
20
15
10
5
0
Interim
Orbweaver
NOAA Station
30-yr Avg.
4/7/2008
4/21/2008
5/5/2008
5/19/2008
6/2/2008
6/16/2008
6/30/2008
Date


Cumulative
surface runoff (in acre^{-1})
6
5
4
3
2
1
0
100% Row-crop
10% Perennial Cover at Toe Slope
10% Perennial Cover in Contour Strips
20% Perennial Cover in Contour Strips
4/10/2008
4/17/2008
4/18/2008
4/25/2008
5/25/2008
5/30/2008
6/3/2008
6/5/2008
6/6/2008
6/8/2008
6/12/2008
6/26/2008
Cumulative
sediment export (lb acre^{-1})
20000
15000
10000
5000
0
100% Row-crop
10% Perennial Cover at Toe Slope
10% Perennial Cover in Contour Strips
20% Perennial Cover in Contour Strips
4/10/2008
4/17/2008
4/18/2008
4/25/2008
5/25/2008
5/30/2008
6/3/2008
6/5/2008
6/6/2008
6/8/2008
6/12/2008
6/26/2008
Date

Soil Erosion Mechanics

Soil erosion for different surface cover_ compared to that for moldboard plowing.

Surface Cover (%)	Soil Erosion (%)
10	70
20	43
30	26
40	16
50	10
75	3
100	1

Laflen et al.. 1980. Conservation tillage and soil erosion on continuously rowcropped land. P. 121-133. In Crop production with conservation tillage in the 80's. ASAE Publ. 7-81. Am. Soc. Agric. Eng. St. Joseph, MI.

Soil Erosion Mechanics

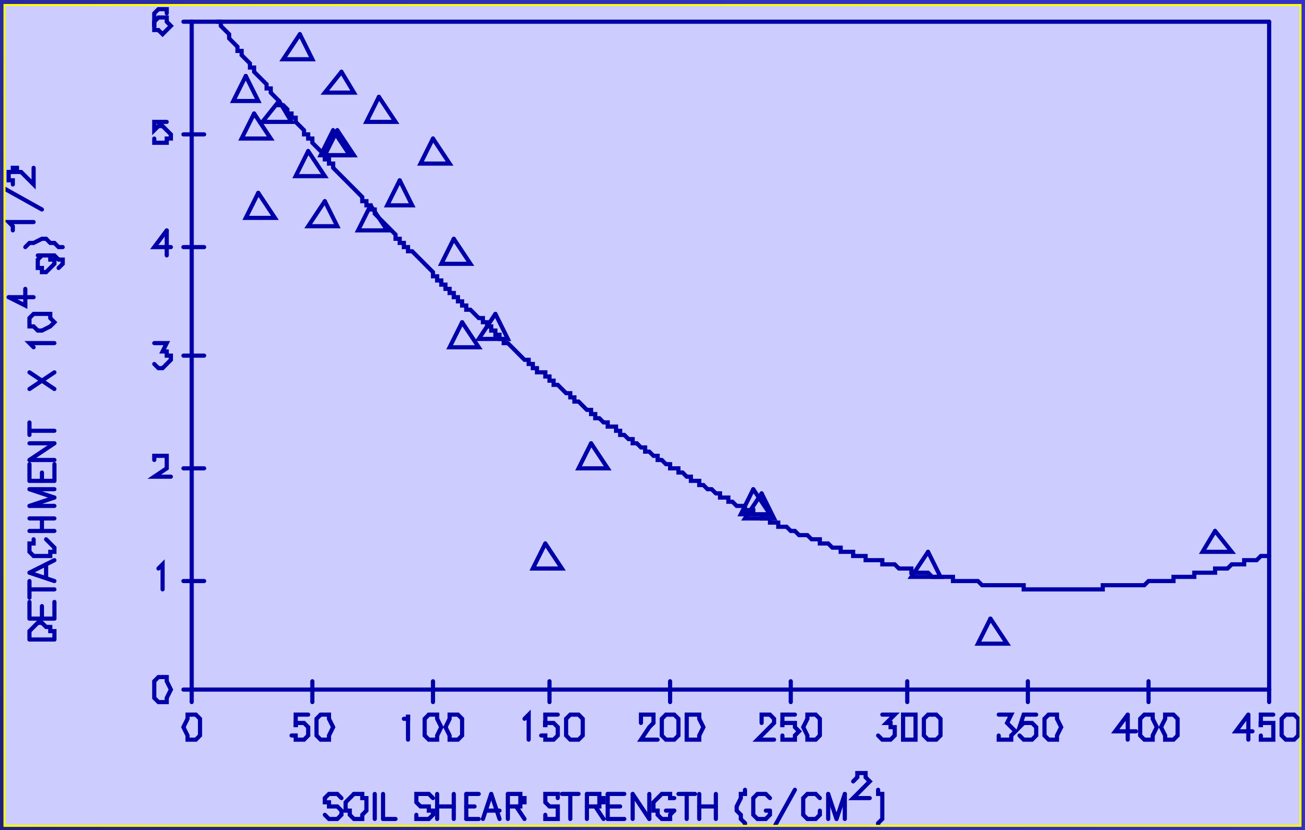
- Surface seal development
  - Raindrops serve as
    - A wetting source
      - Increases matric potential
      - Decreases effective stress
      - Decreases shear strength
    - Kinetic energy
      - Detaches particles

Soil Erosion Mechanics

- Soil detachment
  - Quantity of soil detached directly related to raindrop kinetic energy
  - Inversely related to shear strength

Al-Durrah, M.M. and J. M. Bradford. 1982. Parameters for describing soil detachment due to single waterdrop impact. Soil Sci. Soc. Am. J. 46:836-840

Francis, P.B. and **R.M. Cruse**. 1983. *Soil water matric potential effects on aggregate stability*. Soil Sci. Soc. Am. J. 47:478-581.



From Cruse, R.M. and W.E. Larson. 1977. Effect of soil shear strength on soil detachment due to raindrop impact. Soil Sci. Soc. Am. J. 41:777-781.

Soil Erosion Mechanics

Surface Seal Development

- Vibration, splashing action excellent packing mechanism
  - High bulk density surface layer
- Washed in particles to subseal layer gives very good hydraulic connection to lower layer

Raindrops falling on exposed soil can break off soil particles to be lost in run-off water.

Soil Erosion Mechanics

Surface Seal Development

- Affects soil erosion through changes in detachment and infiltration
  - Detachment rates low because of high shear strength and infiltration rates relatively high

Soil Erosion Mechanics

Surface Seal Development

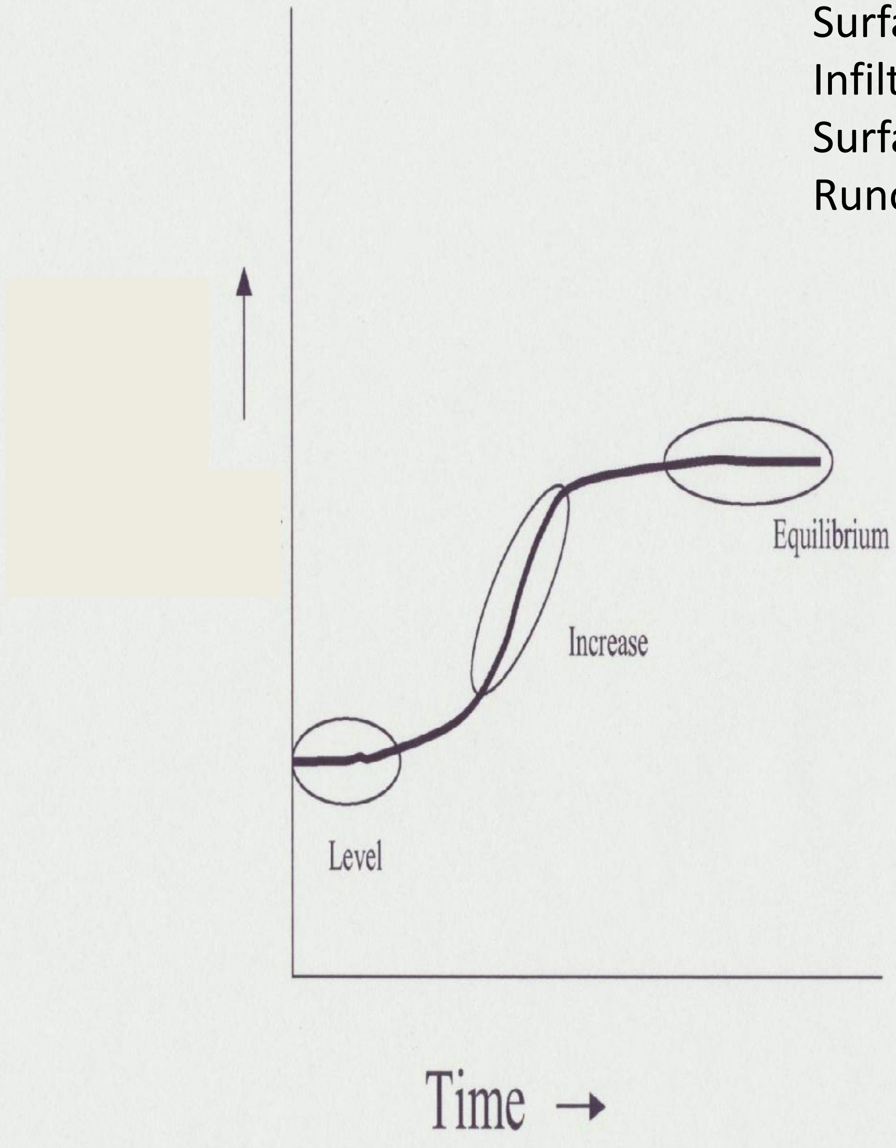
- Shear strength decreases as matric potential increases resulting in higher detachment rates
- Matric potential approaches highest value for the rainstorm
  - Low shear strength
  - High splash rates
  - Rapid seal development
  - Infiltration rates decrease
  - As seal bulk density increases, shear strength increases

Soil Erosion Mechanics

Surface Seal Development

- Matric potential immediately beneath the seal decreases due to
  - Flow of water downward away from the seal
  - Slow water movement downward through the seal from the surface
- Shear strength increases further due to effective stress increase imposed by decreasing value of matric potential
- Soil splash decreases due to increase in shear strength and may reach steady state.

Soil Detachment
Matric Potential Gradient
Cumulative Infiltration
Surface Layer Bulk Density
Infiltration Rate
Surface Shear Strength
Runoff Rate



Soil Detachment
Matric Potential Gradient
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Surface Layer Bulk Density
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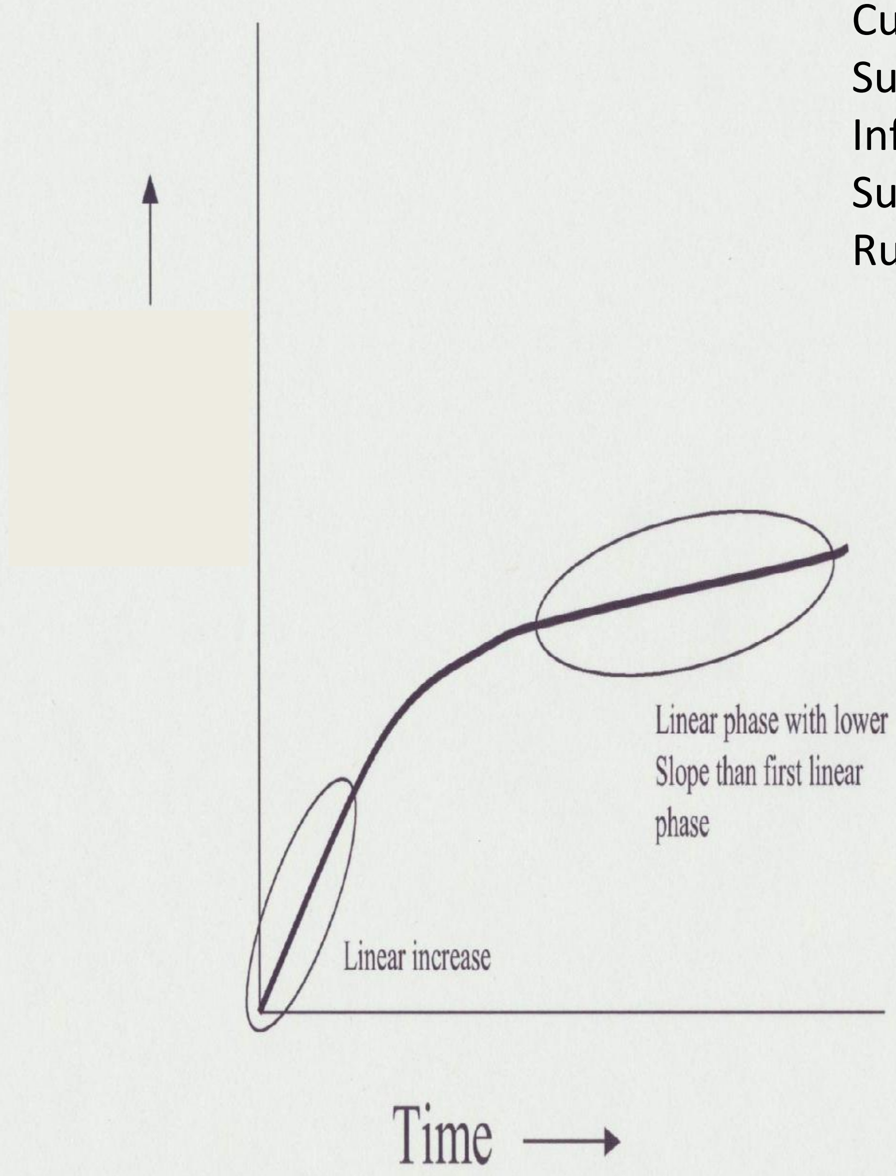

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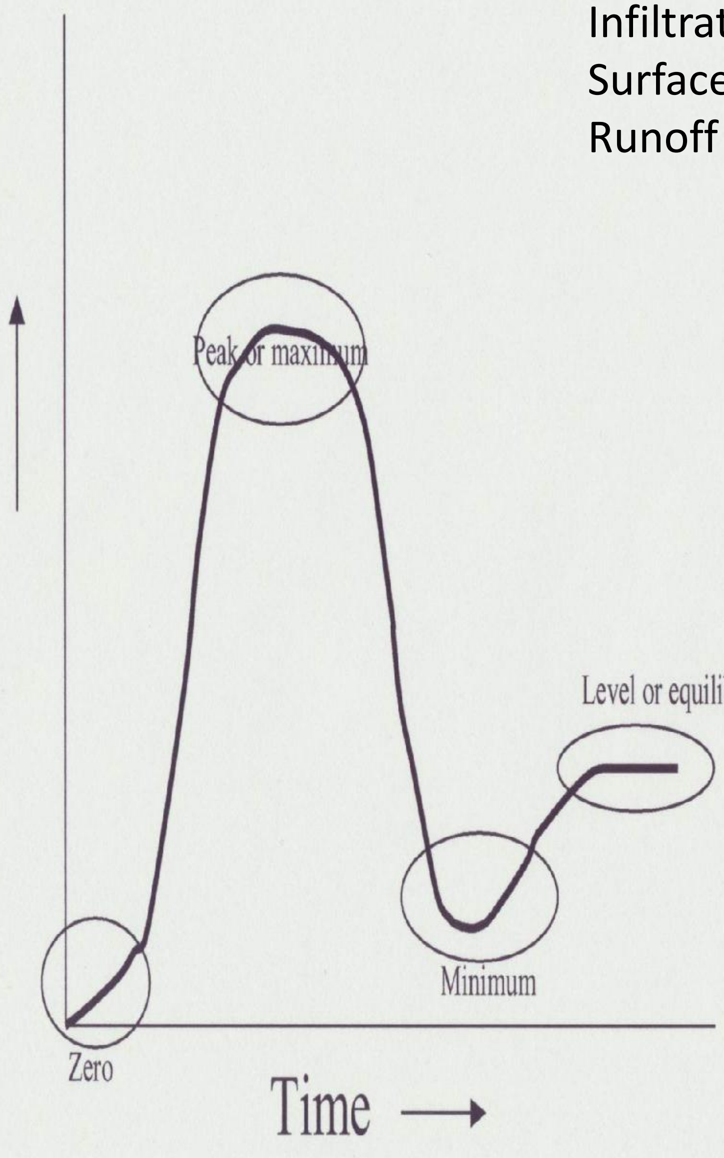

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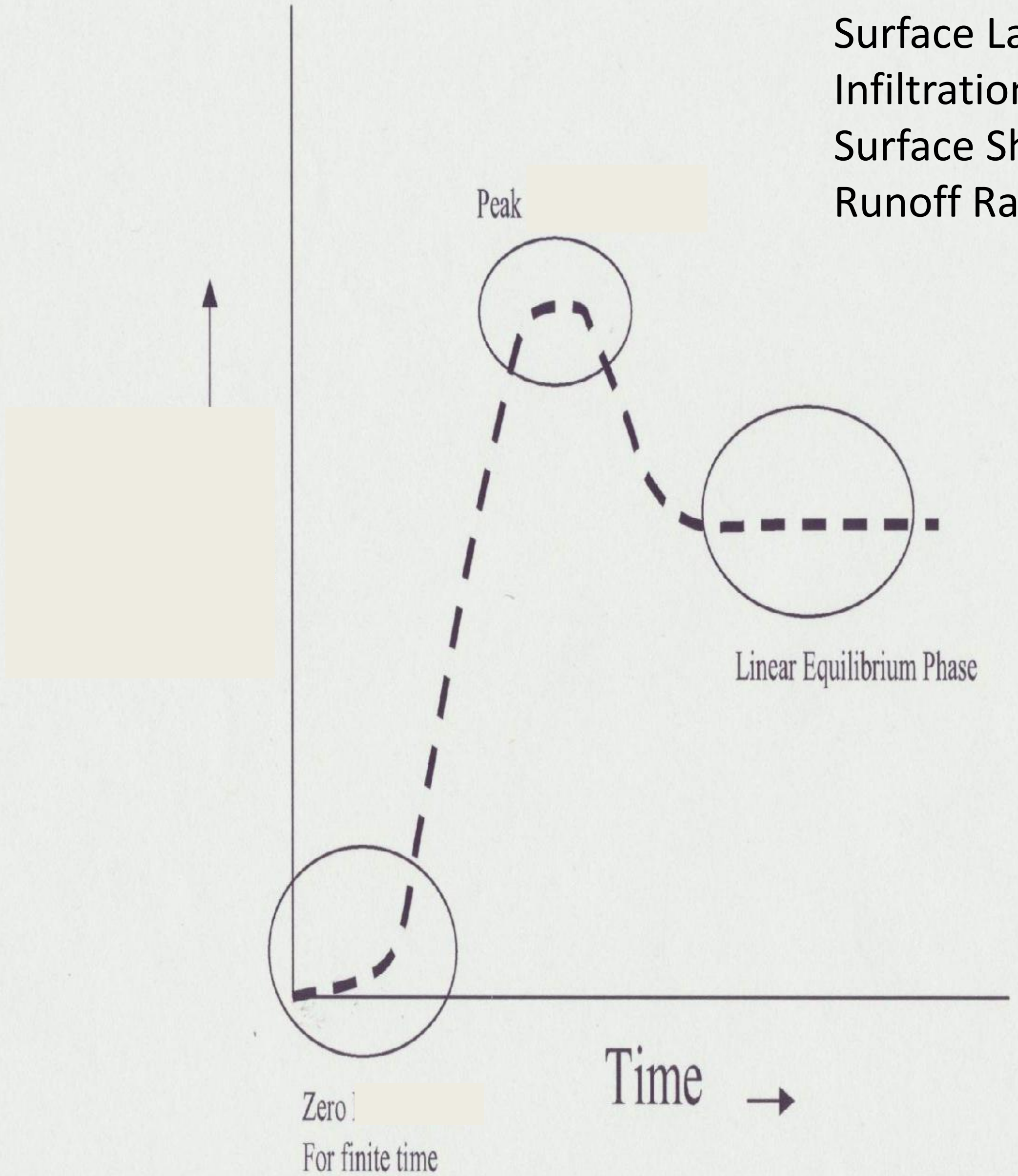

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Matric Potential Gradient
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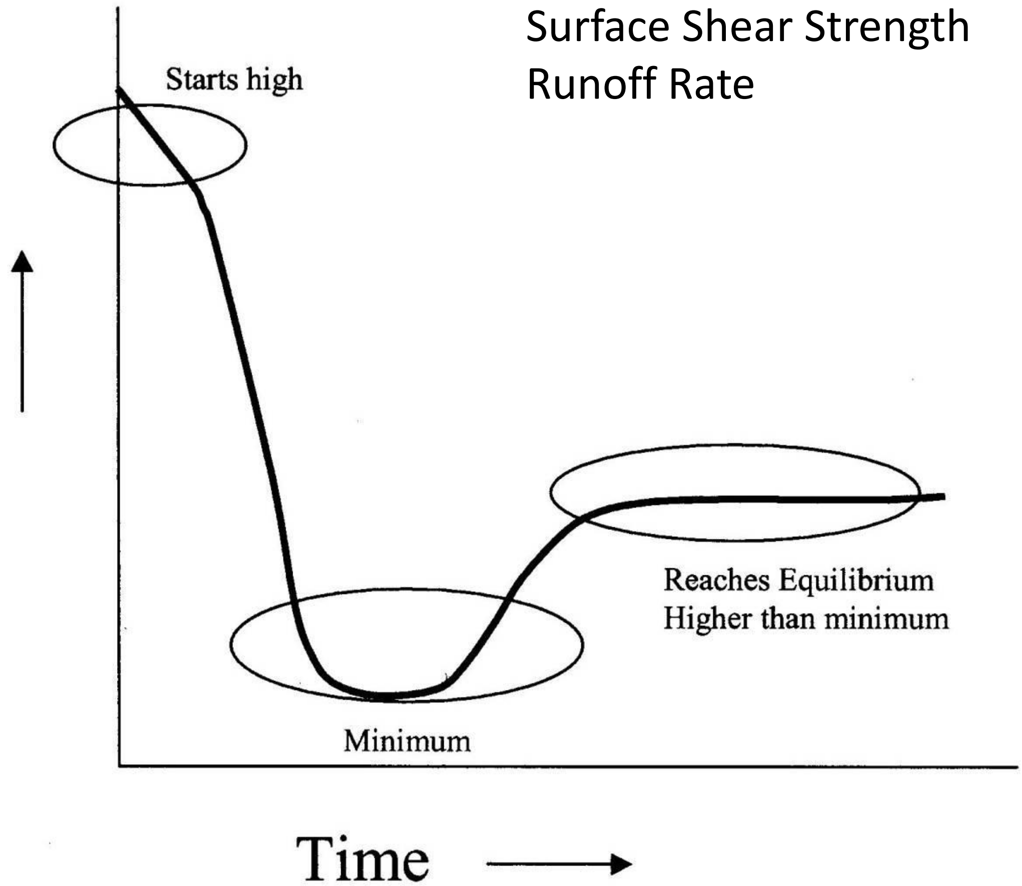
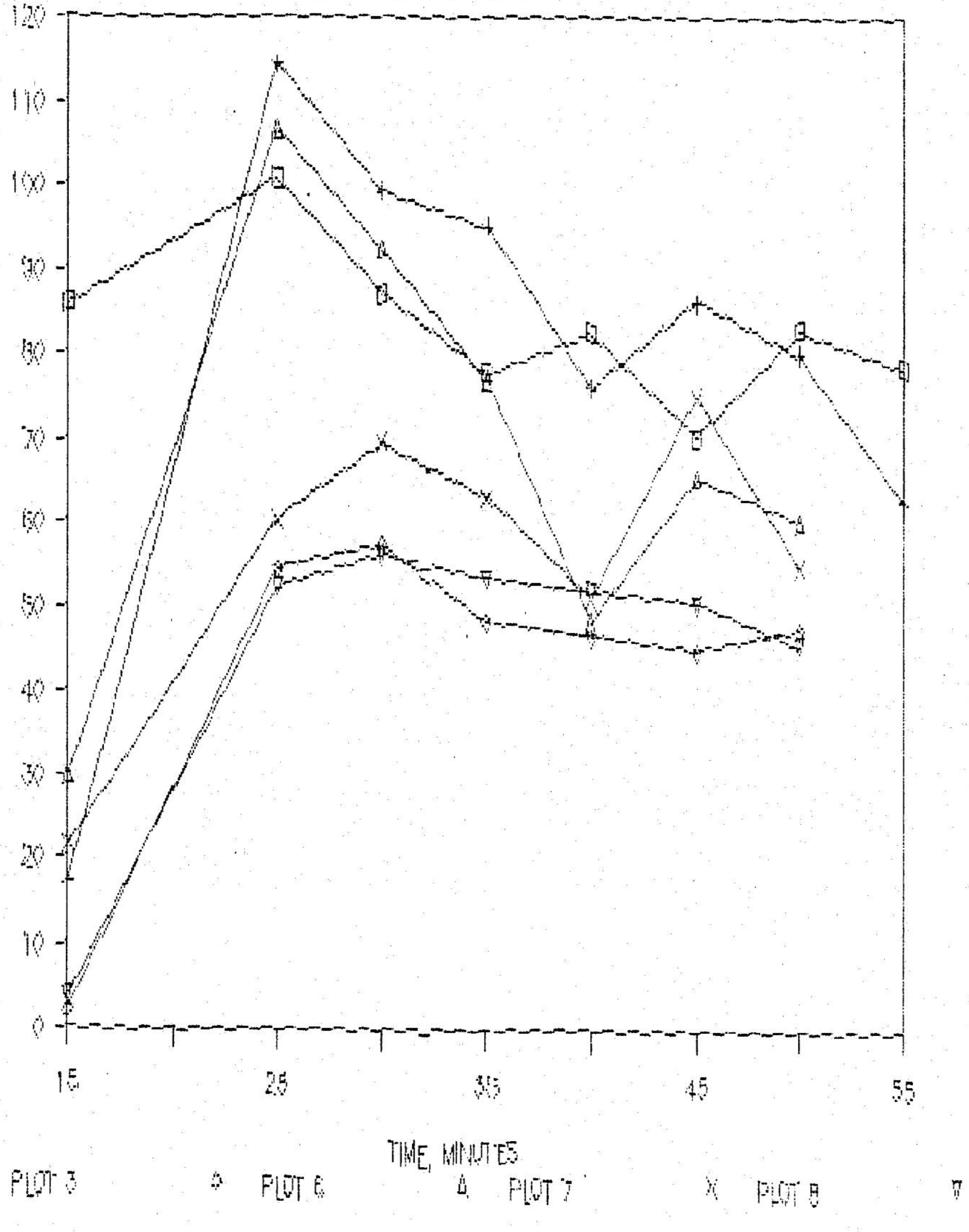


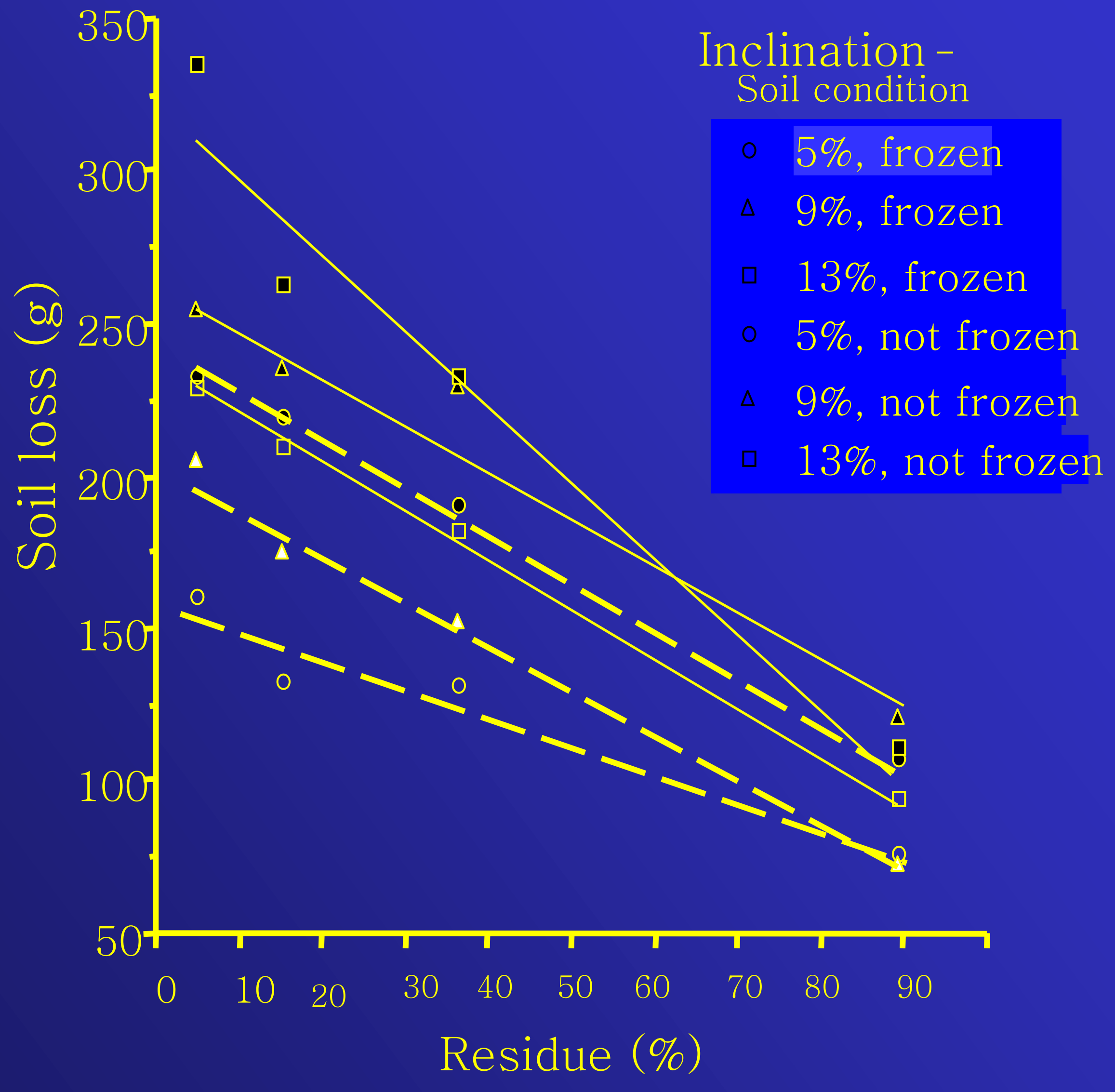
INTERRILL EROSION VS TIME

KEITH SILT LOAM



Soil Erosion Mechanics

- Shear strength changes with time
- With bare conditions, surface processes are very dynamic
- Frozen subsurface/compacted subsurface conditions
  - Matric potential increases with rainfall
  - Surface seal ‘tries’ to develop, but can’t – limited infiltration
  - Water ponds above layer - matric potential remains zero
  - Shear strength reaches minimum and remains at minimum; cohesion equals shear strength



Average soil eroded vs. % residue cover for six combinations of slope and frozen subsurface (solid lines) or not frozen (dashed lines) treatments.