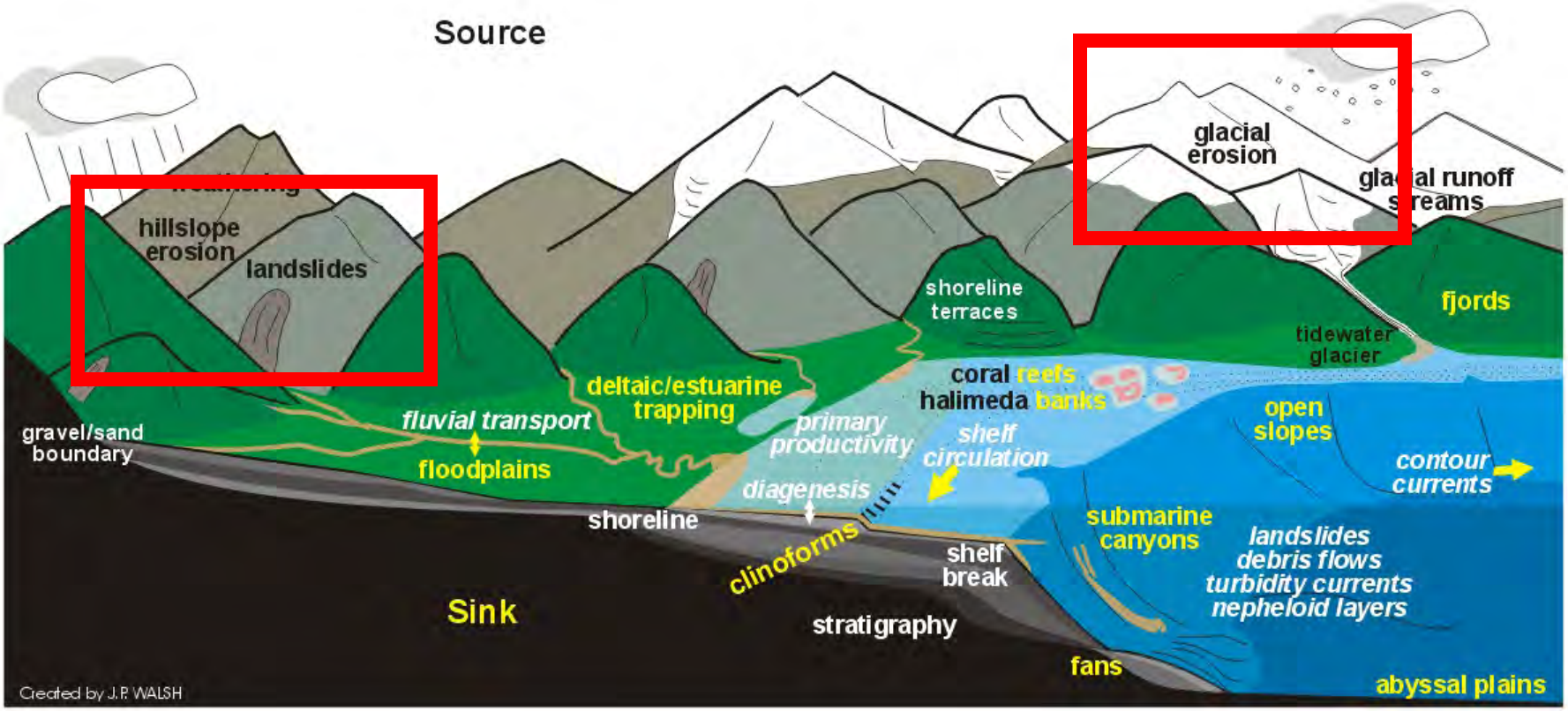
erosion

moving away from the source...



Weathering, soil & erosion...

Sediment regime: amount, size, characteristic sediment transport style in a river

governed by (not surprisingly) the amount and size of material delivered from both hillslopes and upstream

this, in turn, depends on

- erosional processes (today's lecture)
- weathering rates & style
- rock properties
- soil properties

Sediment Budget

along a stream reach:

$$I - O = \Delta S$$

Sediment inputs from upstream and across channel banks are balanced by either downstream sediment transport or changes in sediment storage.

Erosional Processes

Soil “Creep”

Overland Flow

Landslides

Glaciers

River incision into bedrock

Bank Erosion

Erosional Processes

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Bank Erosion

Soil creep is the gradual, non-catastrophic downslope movement of weathered material under the influence of gravity (i.e., not by flowing water).

ways to move soil:

The burrowing activity of animals results in a net downslope transport of material that in some environments can be the dominant sediment transport process.

ways to move soil:

Tree-throw can uproot rocks and also typically results in a net downslope transport of soil and broken rock.

ways to move soil:

human modifications...

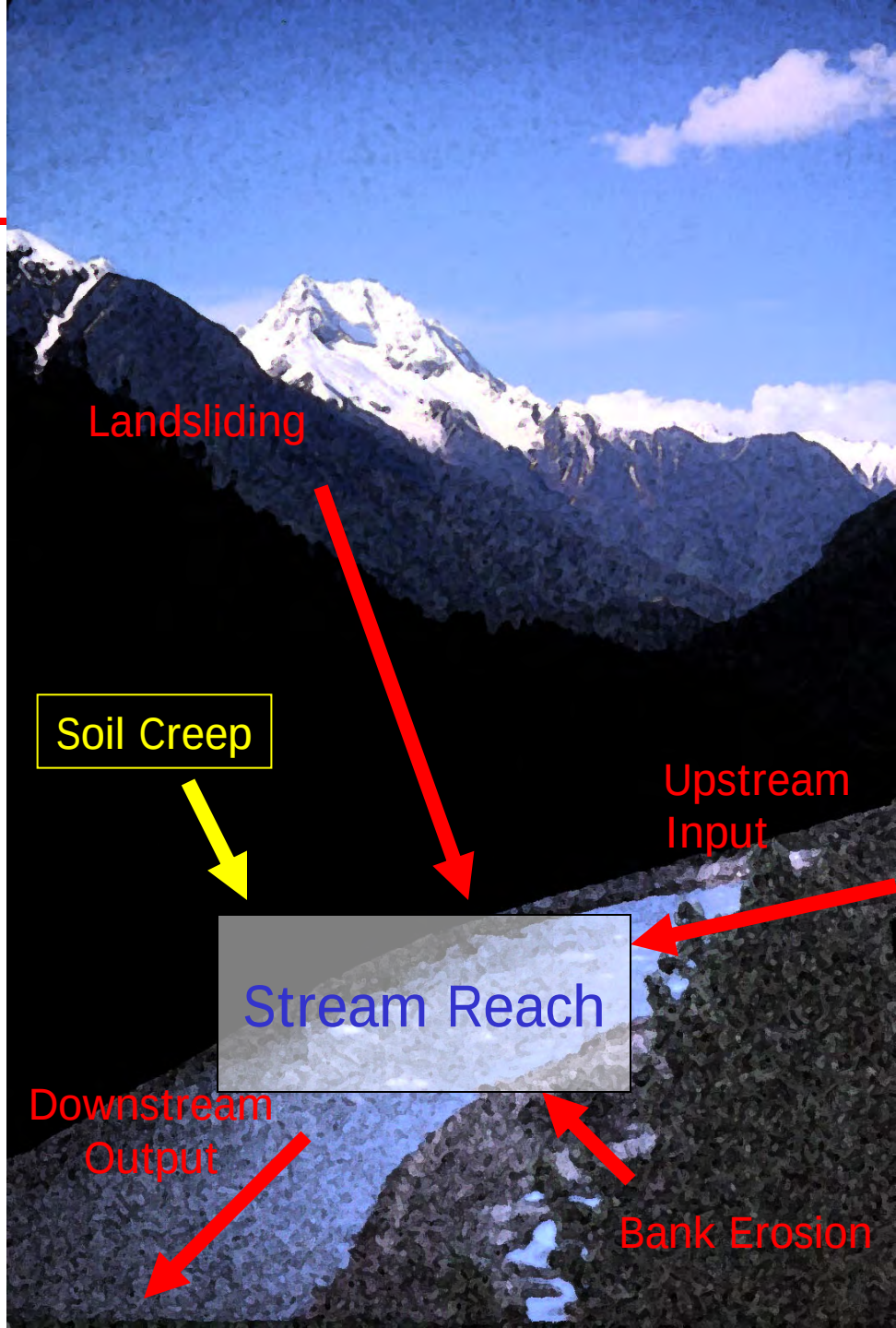
Plowing a hillslope, ca. 1935

National Archives: RG083 G 36711

Soil Creep

Slow, steady input of material across channel banks, or delivered to valley bottom.

Typical rates of 0.1 to 1 mm yr^{-1}.



Erosional Processes

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Bank Erosion

Erosion by overland flow occurs once enough flow accumulates to overcome the *erosion resistance* of the ground surface.

Precipitation that runs off as overland flow can cause substantial erosion once enough flow accumulates to incise the ground surface.

X_c is the critical distance needed to incise a channel.

Badlands environments are an extreme example where Xc may be just centimeters

Unchanneled valleys occur where the erosion resistance of the ground surface is high relative to the amount of overland flow → Xc is very large.

Entrenched channels and gullies can develop in landscapes where overgrazing decreases the erosion resistance of the valley floor

Xc was large, became smaller...

Overland Flow

Erosion by overland flow is rare in forested mountain landscapes because:

- rainfall tends to infiltrate into the ground

- the ground has substantial erosion resistance due to vegetation

Erosion by overland flow is most common in disturbed or semi-arid landscapes

Erosional Processes

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Bank Erosion

Landslides involve the downslope movement of soil and/or rock under the influence of gravity and may be either slow and gradual or rapid and catastrophic.

Bedrock landslides

earth flows: some internal deformation

typically slow

relatively little water

earth flow in NZ

Soil landslides

debris flows: lots of internal deformation

rapid

relatively high water content

fluid-like flow

Failure typically occurs along well-defined shear plane at soil-bedrock interface.

debris flows along Tolt R.

landslides

Bedrock landslides can limit the relief of mountain ranges

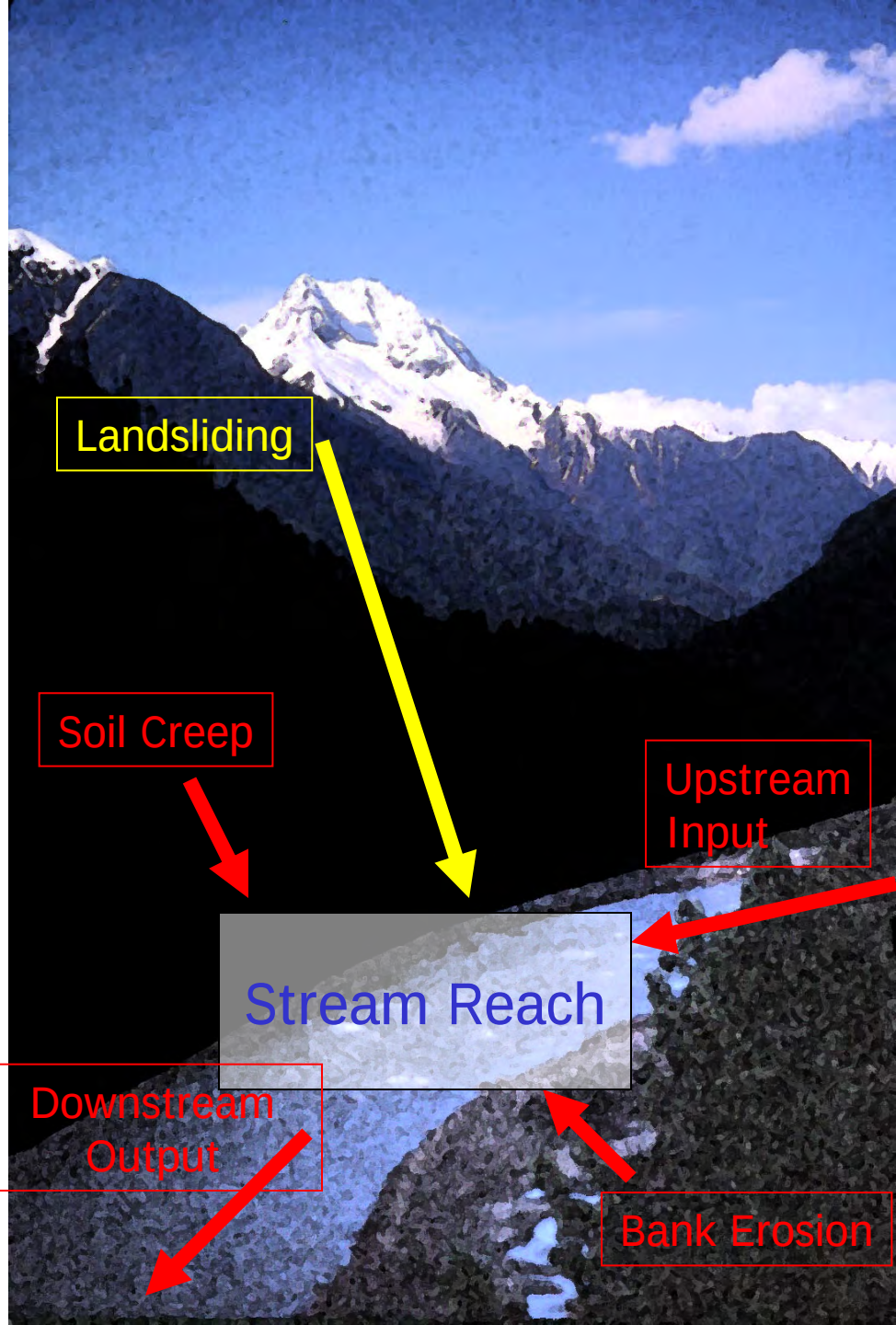
Mt. Cook, New Zealand:

top 10 meters of summit fell away in a massive landslide/avalanche on December 14, 1991.

Landsliding

Rapid, infrequent inputs of large volumes of sediment.

Rates of delivery set by landslide frequency, which is often centuries to millennia at a point.



Erosional Processes

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Bank Erosion

Glaciers can both entrain loose surface materials and gouge deeply into bedrock.

Glacial Erosion

Rapid erosion of material from above perennial snow line.

Rates can exceed 10 mm yr^{-1}.

Processes of erosion and rates depend on temperature, glacier size, precipitation rate, etc...

Erosional Processes

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Bank Erosion

Rivers can carve deeply into bedrock and such incision provides another source of sediment.

In the world there is nothing more submissive and weak than water. Yet for attacking that which is hard and strong nothing can surpass it.

- Lao-Tzu, 6th century B.C.

River Incision

Erosion = f (discharge, channel width, slope)

More water in a narrower channel down a steeper slope means faster river incision

Rates of bedrock river incision typically range from <0.01 mm yr^{-1} to 1 mm yr^{-1}, but can exceed 5 mm yr^{-1} in extreme topography.

River Incision

Erosional Processes

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River Incision

Bank Erosion

Bank erosion recycles material stored on the valley bottom, typically in the floodplain.

bank erosion

reworking valley-bottom sediments

entraining sediments delivered by other erosional processes

Rangitata R., NZ

erosion controls

climate

topography/slope

vegetation

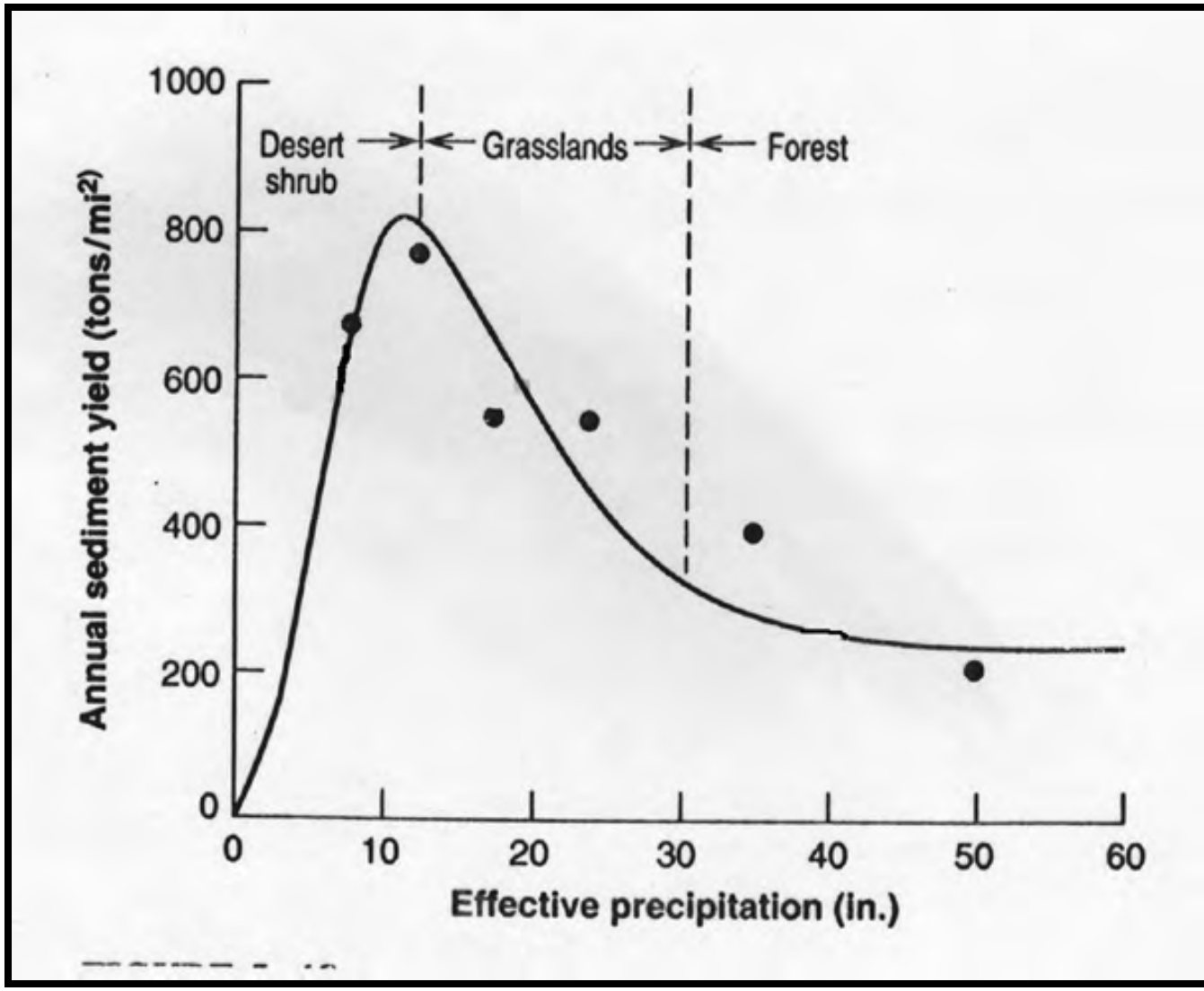
lithology/erodibility

land-use

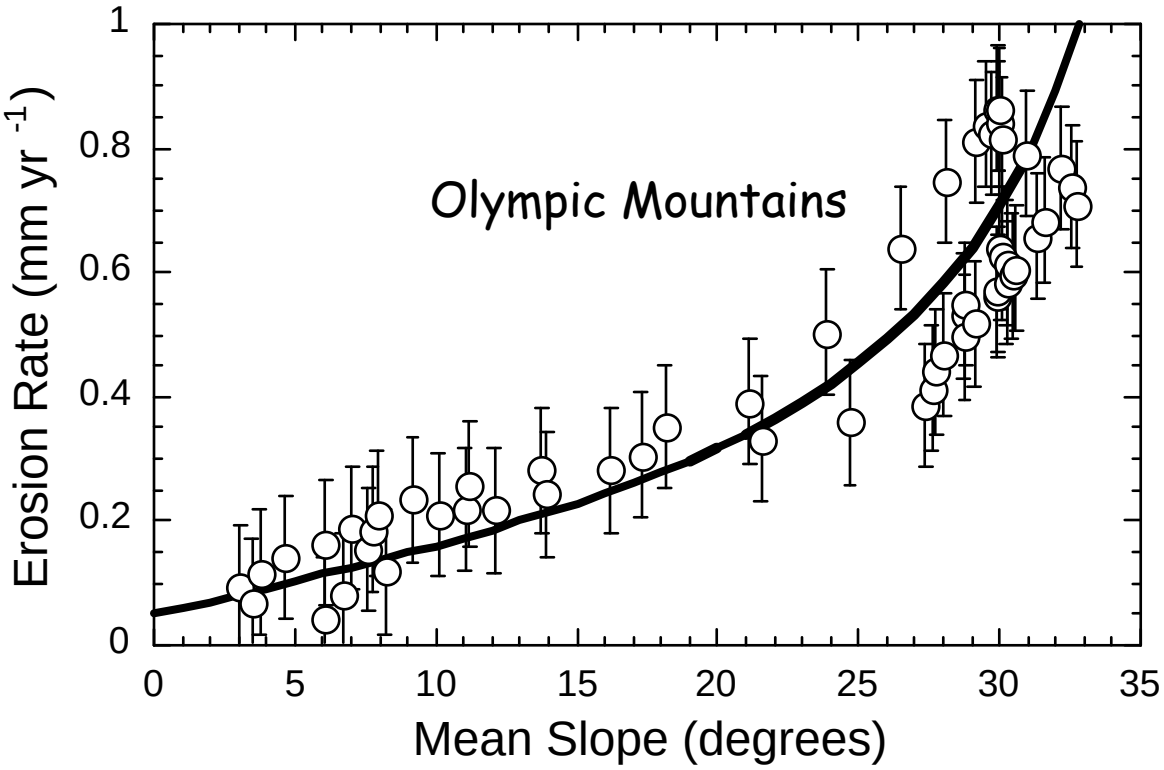
climate

precip & veg.

sediment yield:
total amount of sediment generated by a particular landscape



slope


Olympic Mountains
Erosion Rate (mm yr -1)
Mean Slope (degrees)
0
0.2
0.4
0.6
0.8
1
0
5
10
15
20
25
30
35

erodibility

bedrock erodibility ranges over at least 5 orders of magnitude

land-use

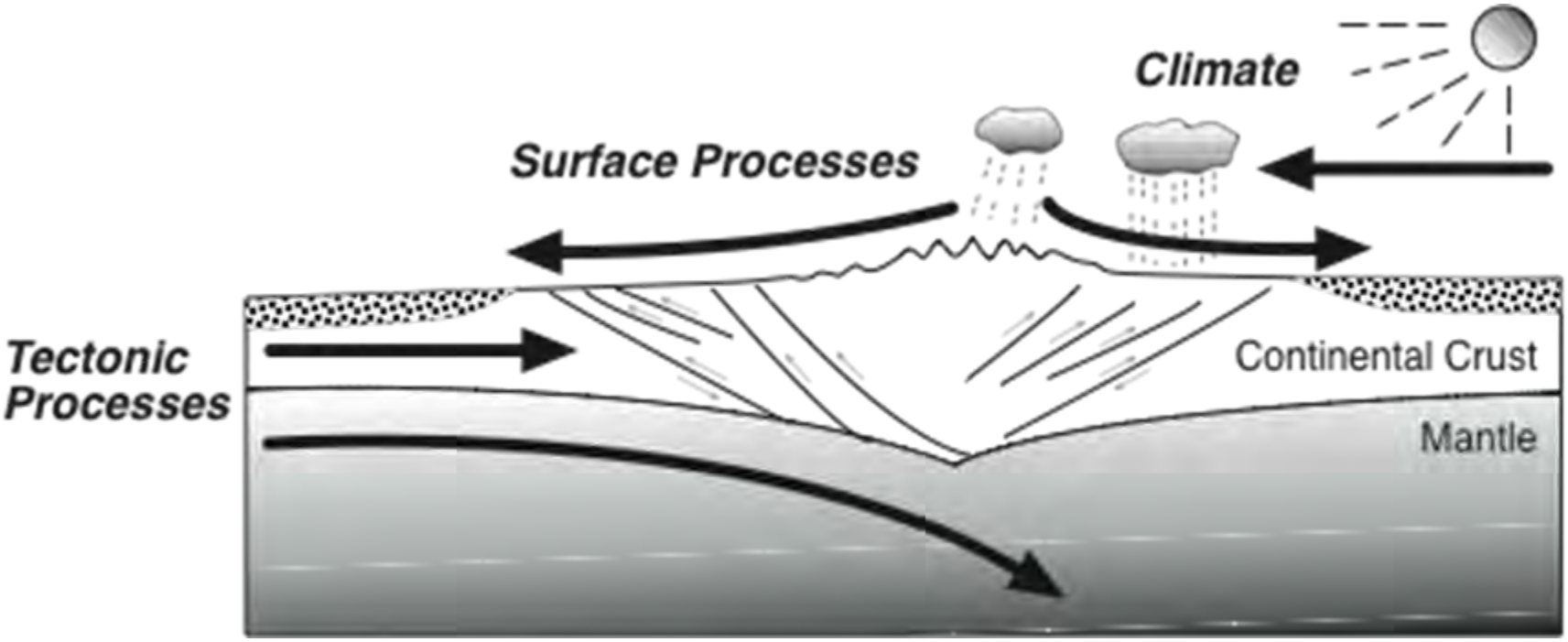
mountains: the big picture

weathering, soil formation & erosion interact

ultimately provide sediment for rivers & beaches...

a final thought:

rivers and beaches are important *sediment transfer* (material transfer) systems within larger Earth system



remember this context!