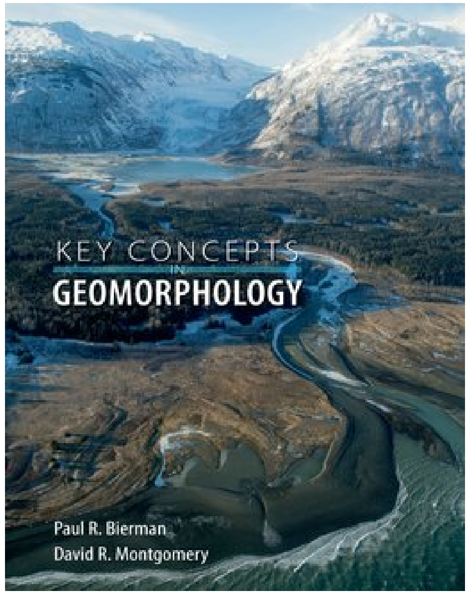
IOWA THE RIVERS OF HER VALLEYS 4.0

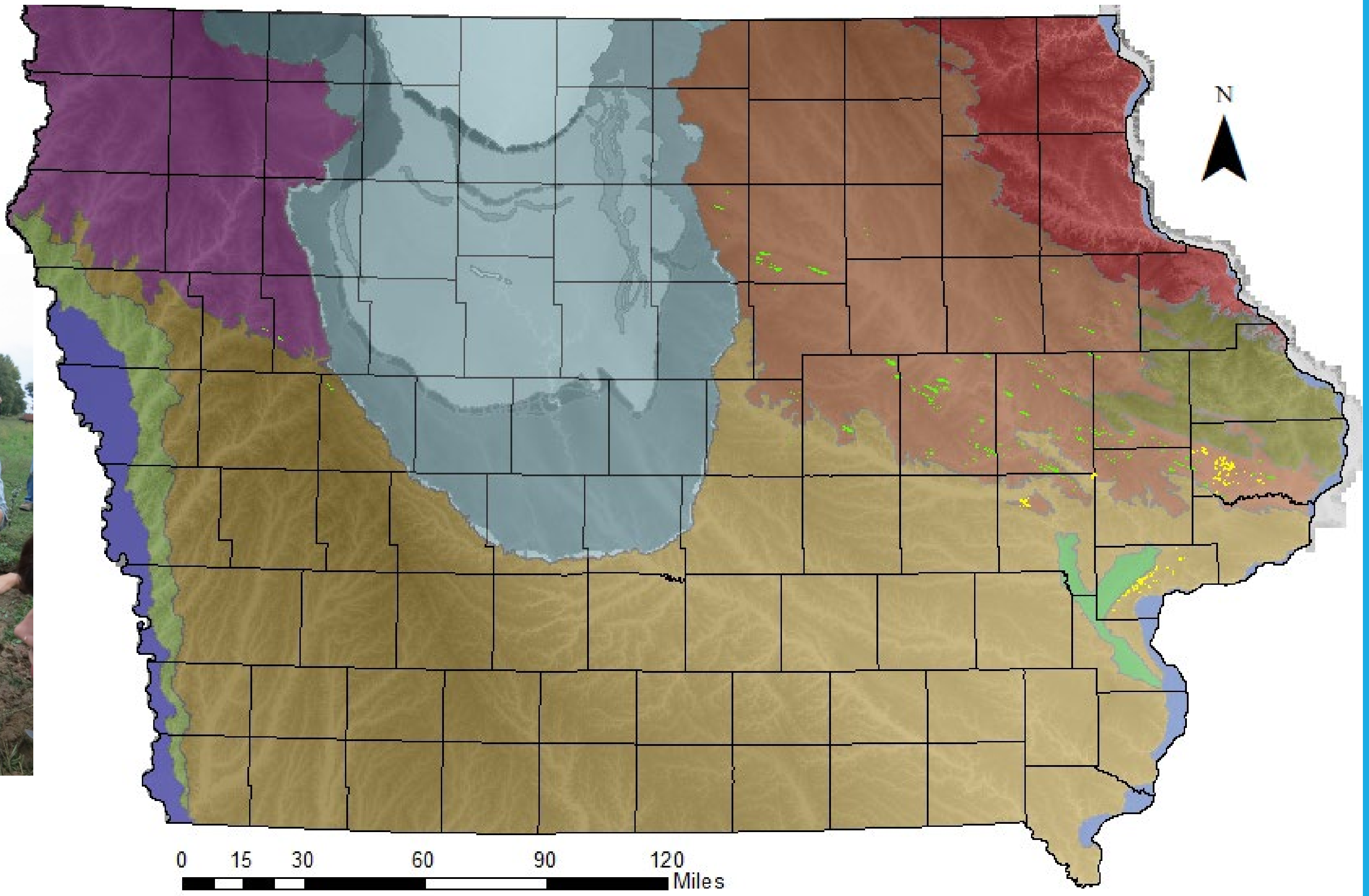
Processes, Products, Characterization, Mitigation

University of Northern Iowa

Iowa Department of Natural Resources REAP CEP

Geomorphology



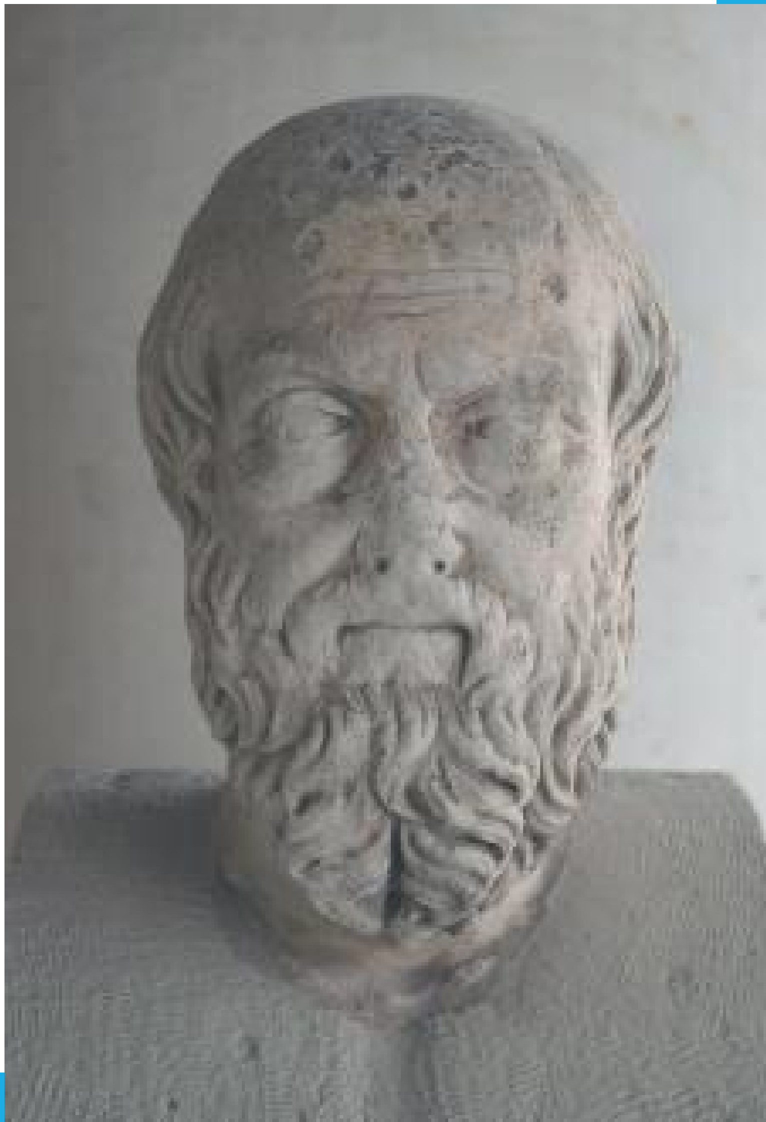


GEOMORPHOLOGY

- Simply defined ➔ the study of landforms
- More complete definition ➔ the study of landforms and landscapes, the processes that produce them, and how they evolve (change) through time

BRIEF HISTORY OF GEOMORPHIC THOUGHT

- Herodotus (485–425 BC) "Father of History"



But also recognized for his geological observations

➔ Annual flooding of the Nile River

➔ Earthquakes due to Earth's "restlessness"

Aristotle (384 – 322 BC)

- ➔ Geologically known for his recognition that there were areas of land that were once covered by the sea
- ➔ He also noted the probability that land would reappear where the sea now exists

James Hutton (1726 – 1797)

- Doctrine of Uniformitarianism – "the present is the key to the past"
- 1788 – Theory of the Earth with Proofs and Illustrations

John Playfair (1748 – 1819)

- John Playfair (1748 – 1819) younger colleague of Hutton

➔1802 – Illustrations of the Huttonian Theory of the Earth

Sir Charles Lyell (1797 – 1875)

- 1830-1872 (12 editions) – Principles of Geology

Greatly influenced by Hutton, Playfair, and Darwin

Probably did more to advance geologic knowledge in general than any one person

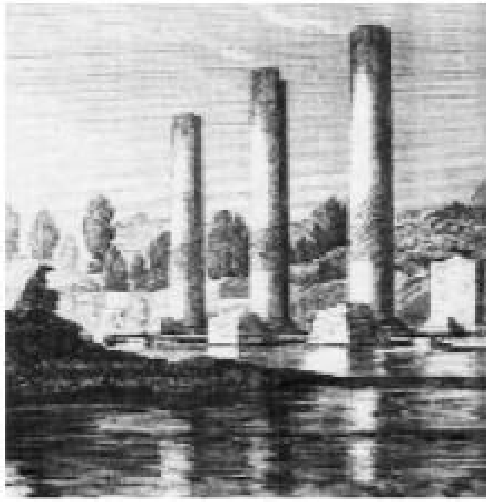


Figure 1. The Temple of Serapis was made famous among geologists by Charles Lyell, who included a sketch of it in the frontispiece of his Principles of Geology. *The dark bands on the marble pillars were formed by mollusks that drilled into them after the columns were submerged in the sea.*

Louis Agassiz (1807 – 1873)

➔ 1840 – Study on Glaciers, Agassiz advanced th
concept of an "Ice Age"

Several others anticipated his conclusions:

Bernhardi (Germany), Venetz and Charpentier (Switzerland)

Agassiz later came to the U.S. and
convinced geologists like
T.C. Chamberlin and Frank Leverett
of the former presence of a large
ice sheet in North America

Developments in North America

- 1879 – establishment of USGS; surveys of the Western U.S.
- John Wesley Powell (1834 – 1902)

➔One of the early USGS Directors

➔Organized the Western U.S. surveys

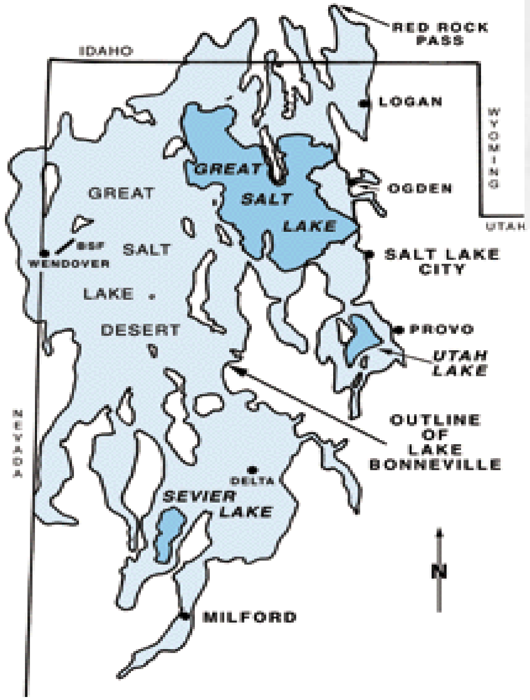
➔First conquered the rapids of the Colorado River

➔Laid the foundation for the American school of geomorphology

➔Developed the concept of base level

G. K. Gilbert (1843 – 1918) often called the father of modern American geomorphology

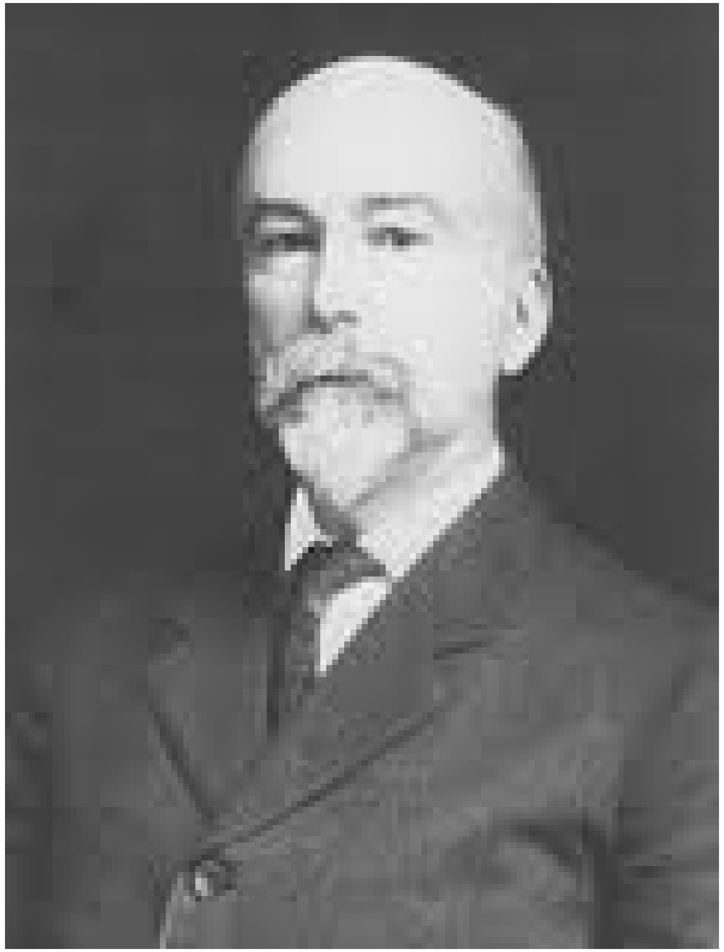
- ➔Senior Geologist with USGS 1879-1918
- ➔Mapped and interpreted the history of Pleistocene Lake Bonneville
- ➔Interpreted fault-block origin of the Basin & Range province
- ➔Wrote report on geology of the Henry Mtns. of Utah (laccolith)
- ➔conducted flume experiments



William Morris Davis (1850 – 1934)

Developed the concept of the Geomorphic Cycle (Cycle of Erosion)

This idea holds that in the evolution of Landscapes there is a systematic sequence of landforms that makes possible the recognition of stages of development

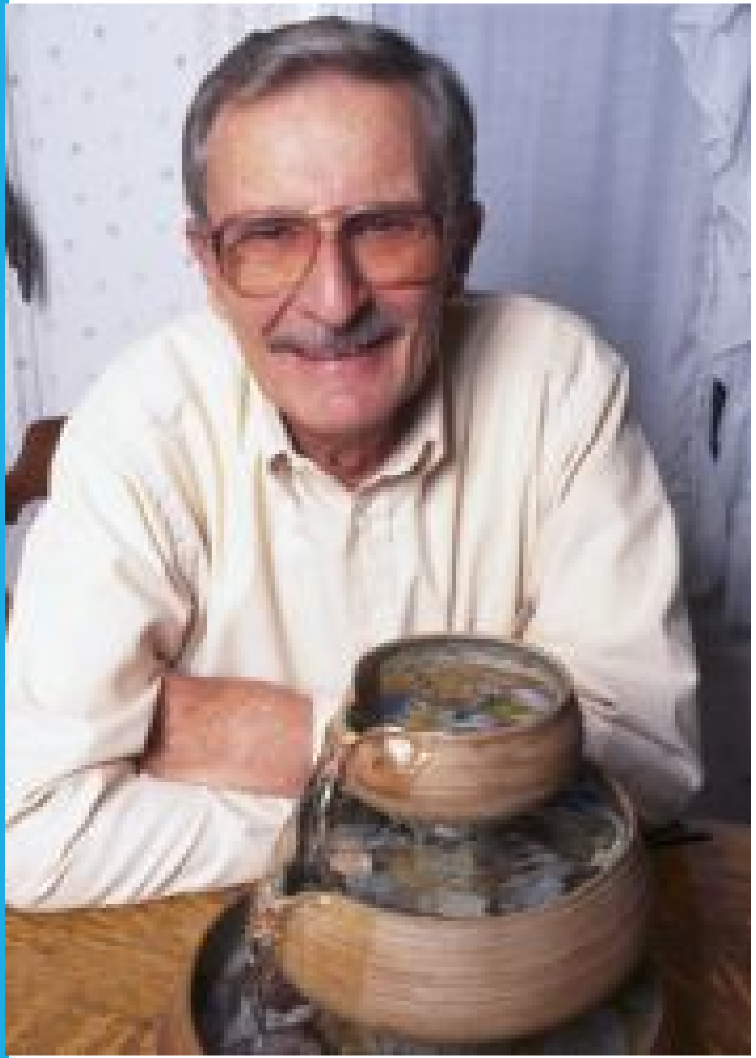
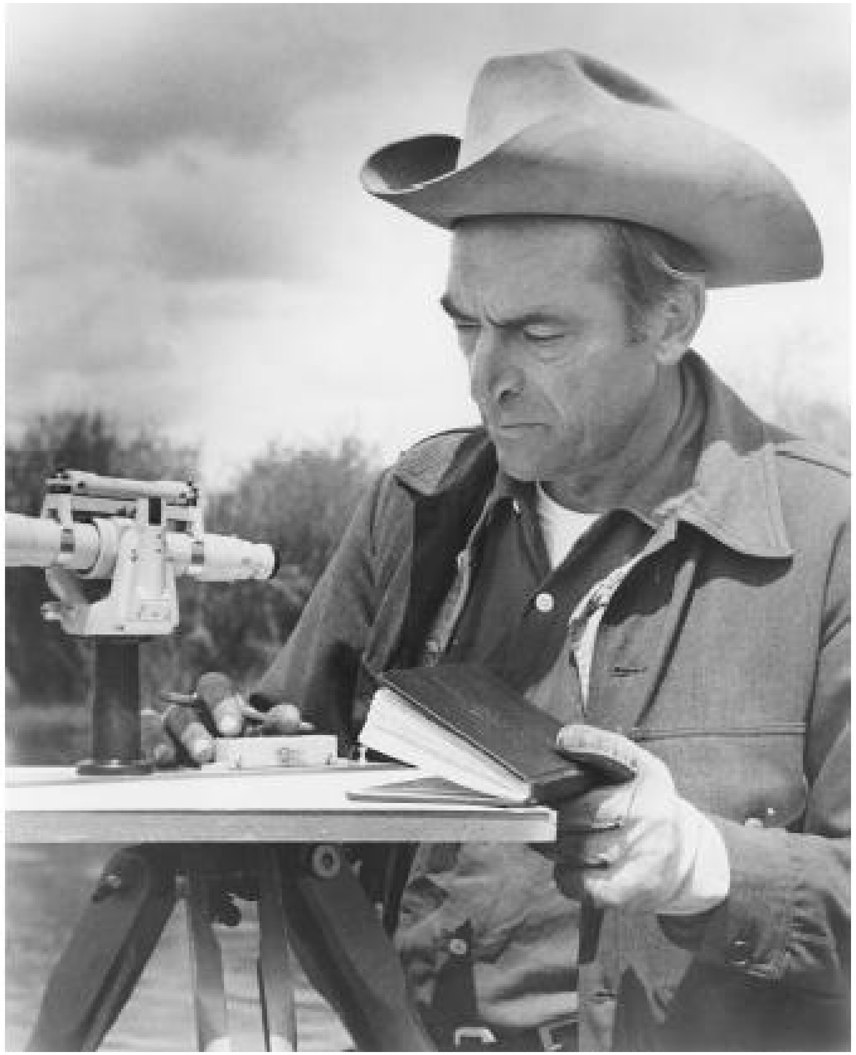


FLUVIAL GEOMORPHOLOGY

Drainage Basins

Geomorphic Hydrology

Channel development


Fluvial Geomorphology

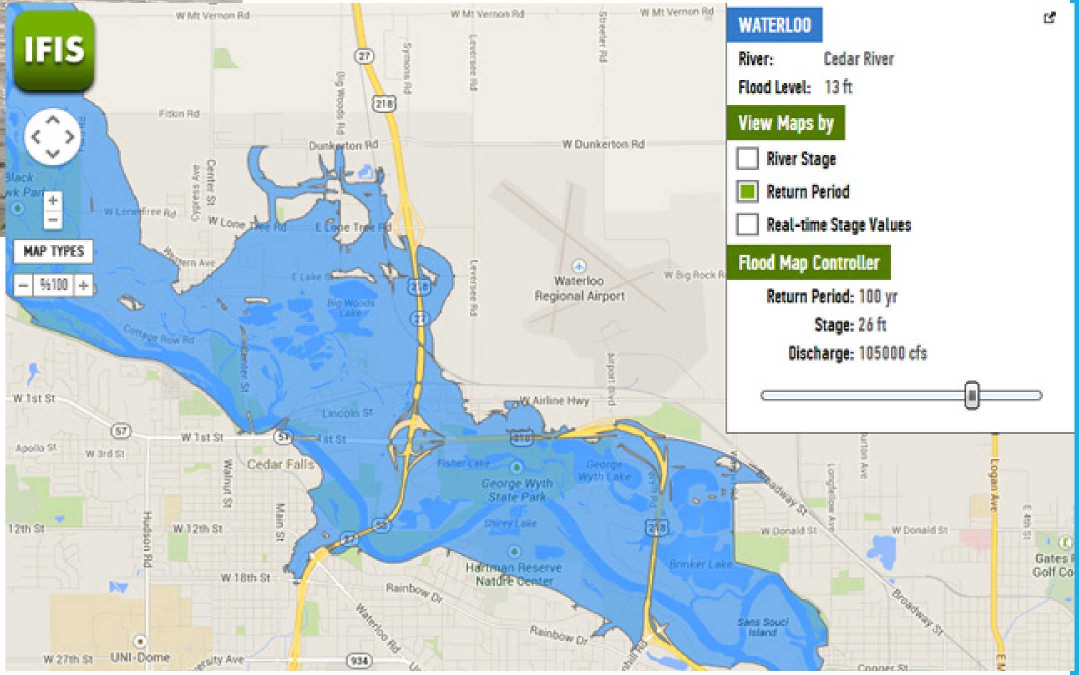
- Critically important to understanding
  - Landscape evolution
  - Human landscape connectivity

- Regional (tectonic and climatic) vs.
  Local controls (discharge, Vegetation, sediment type/load)

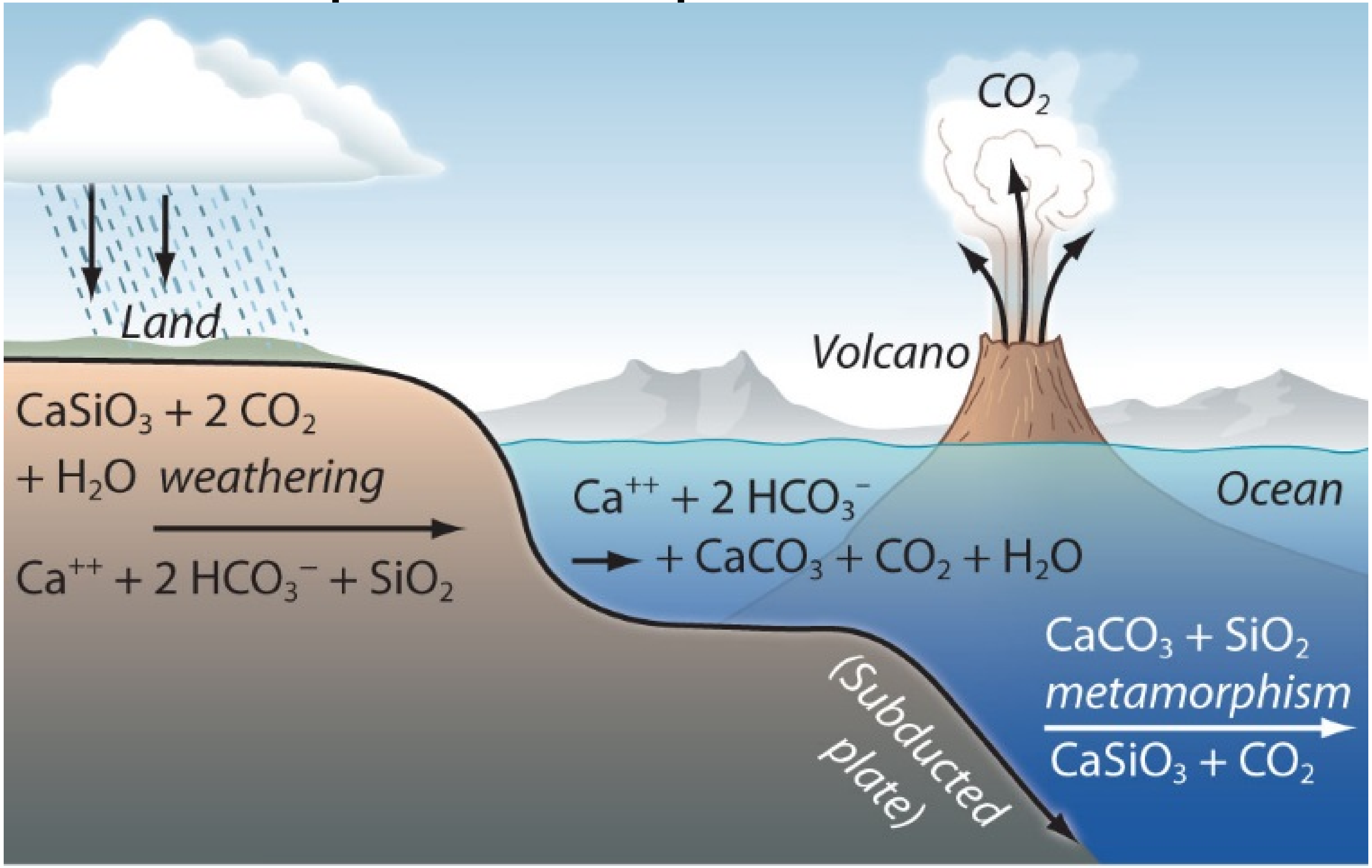
Anthropogenic vs. Natural change

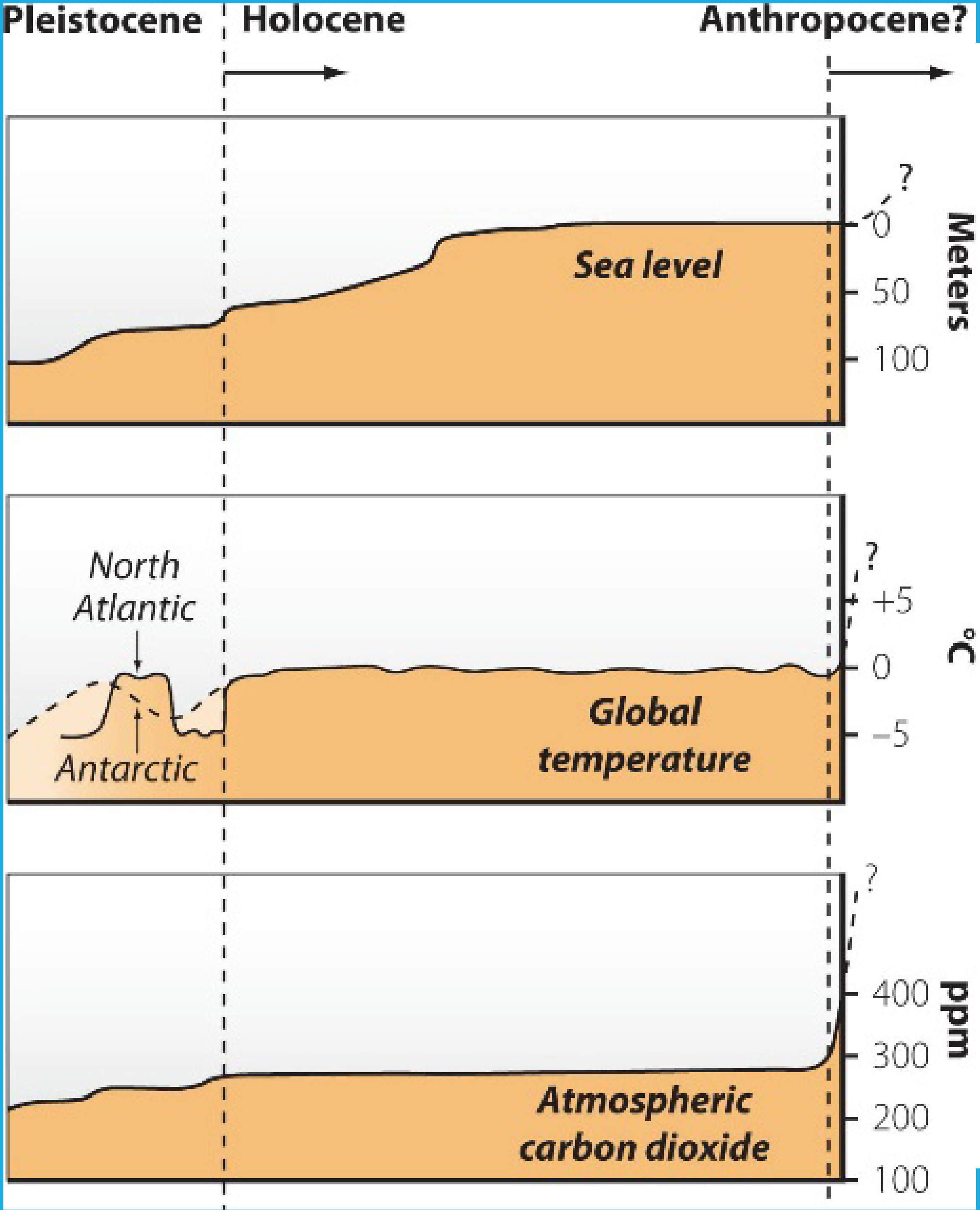
Rural to Urban connections

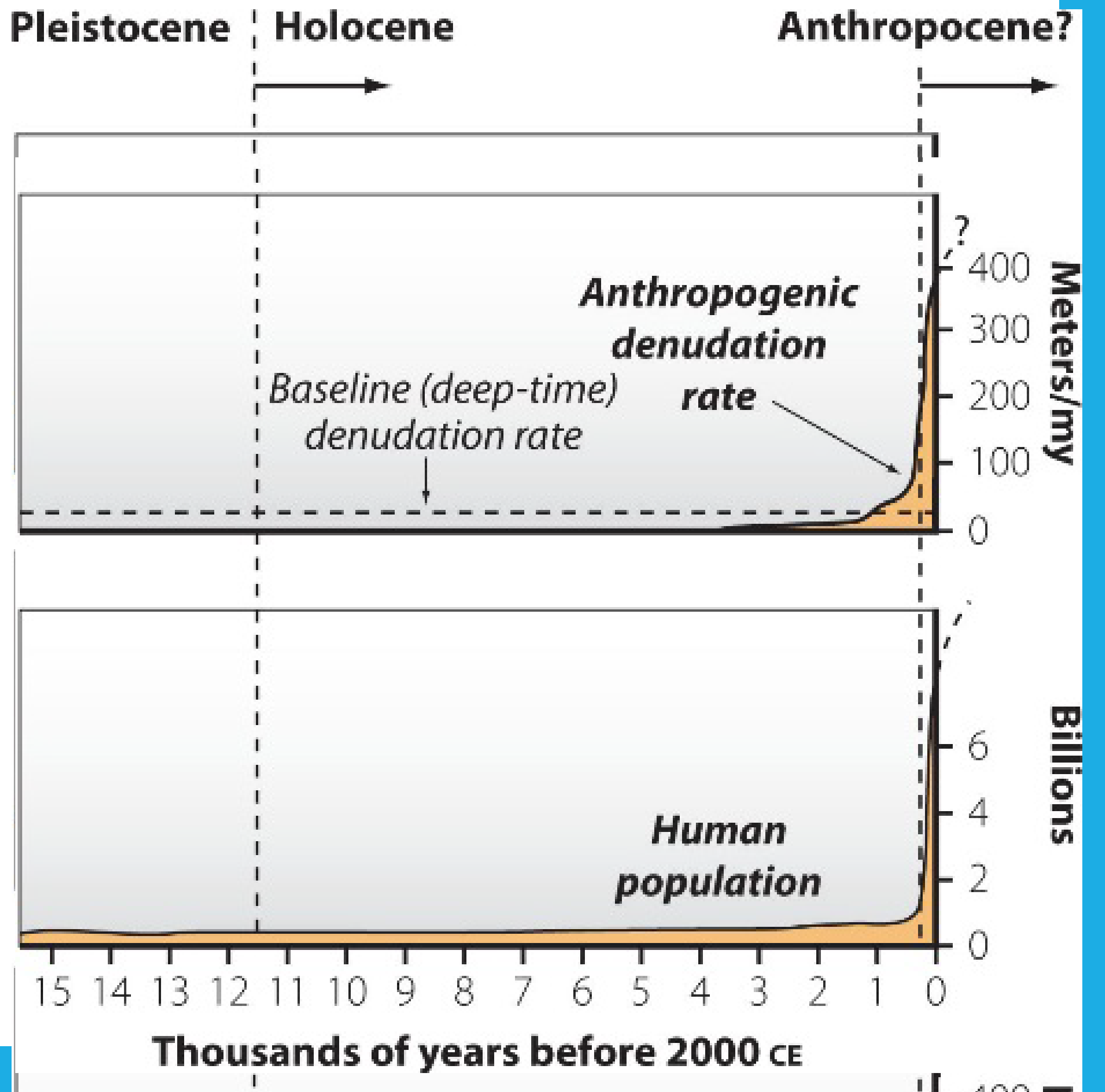
Floods


IFIS
MAP TYPES
WATERLOO
River: Cedar River
Flood Level: 13 ft
View Maps by
River Stage
Return Period
Real-time Stage Values
Flood Map Controller
Return Period: 100 yr
Stage: 26 ft
Discharge: 105000 cfs
Waterloo Regional Airport
Cedar Falls
George Wyth State Park
Hartman Reserve Nature Center
UNI-Dome
W Dunkerton Rd
W Airline Hwy
W 1st St
W 12th St
W 18th St
Rainbow Dr

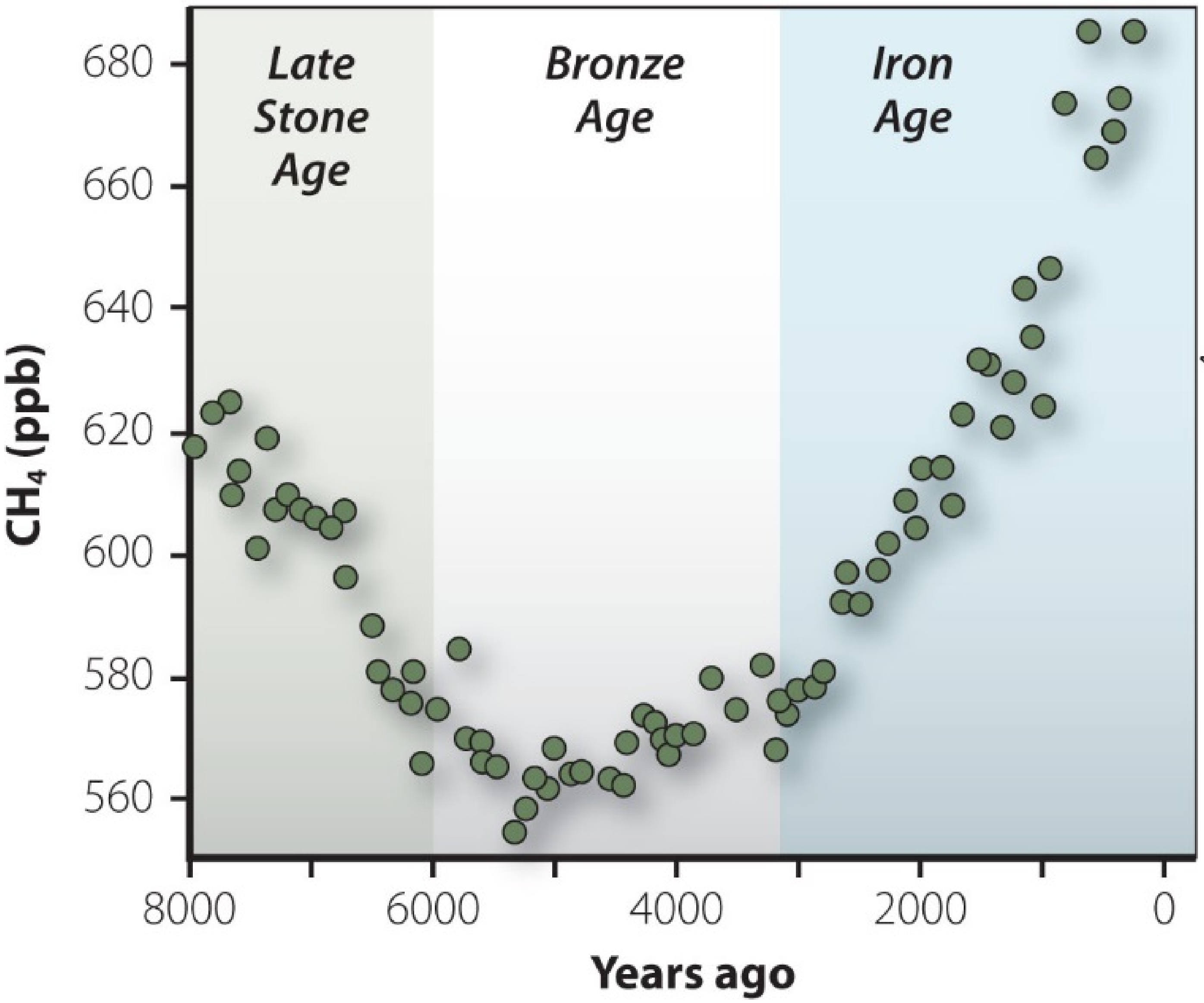
Holocene Vs. 'Anthropocene' Epochs

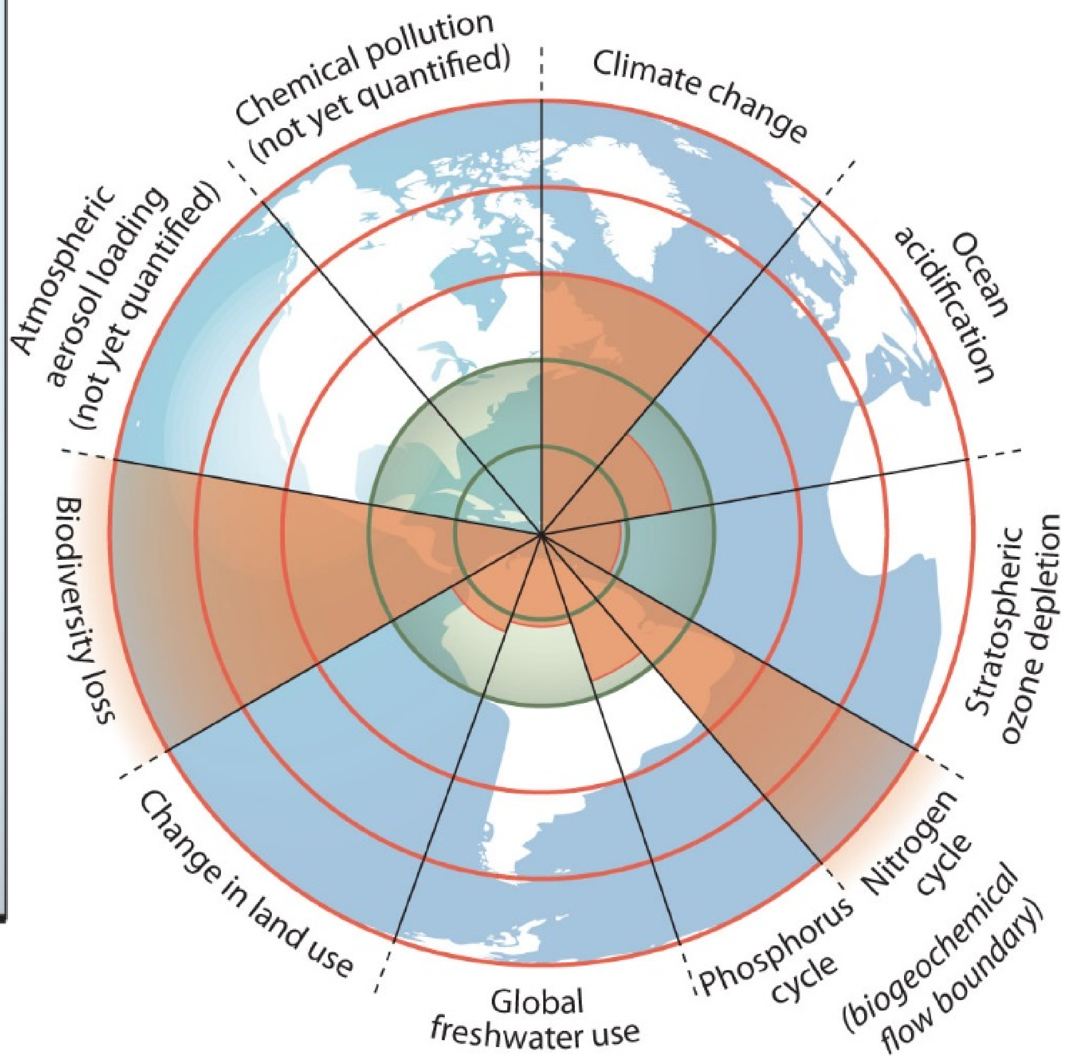



Pleistocene
Holocene
Anthropocene?
Sea level
Meters
0
50
100
?
North Atlantic
Antarctic
Global temperature
°C
+5
0
−5
?
Atmospheric carbon dioxide
ppm
400
300
200
100
?


Pleistocene
Holocene
Anthropocene?
Anthropogenic denudation rate
Baseline (deep-time) denudation rate
Meters/my
400
300
200
100
0
?
Human population
Billions
6
4
2
0
15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0
Thousands of years before 2000 CE

Ruddiman, 2008, QSR



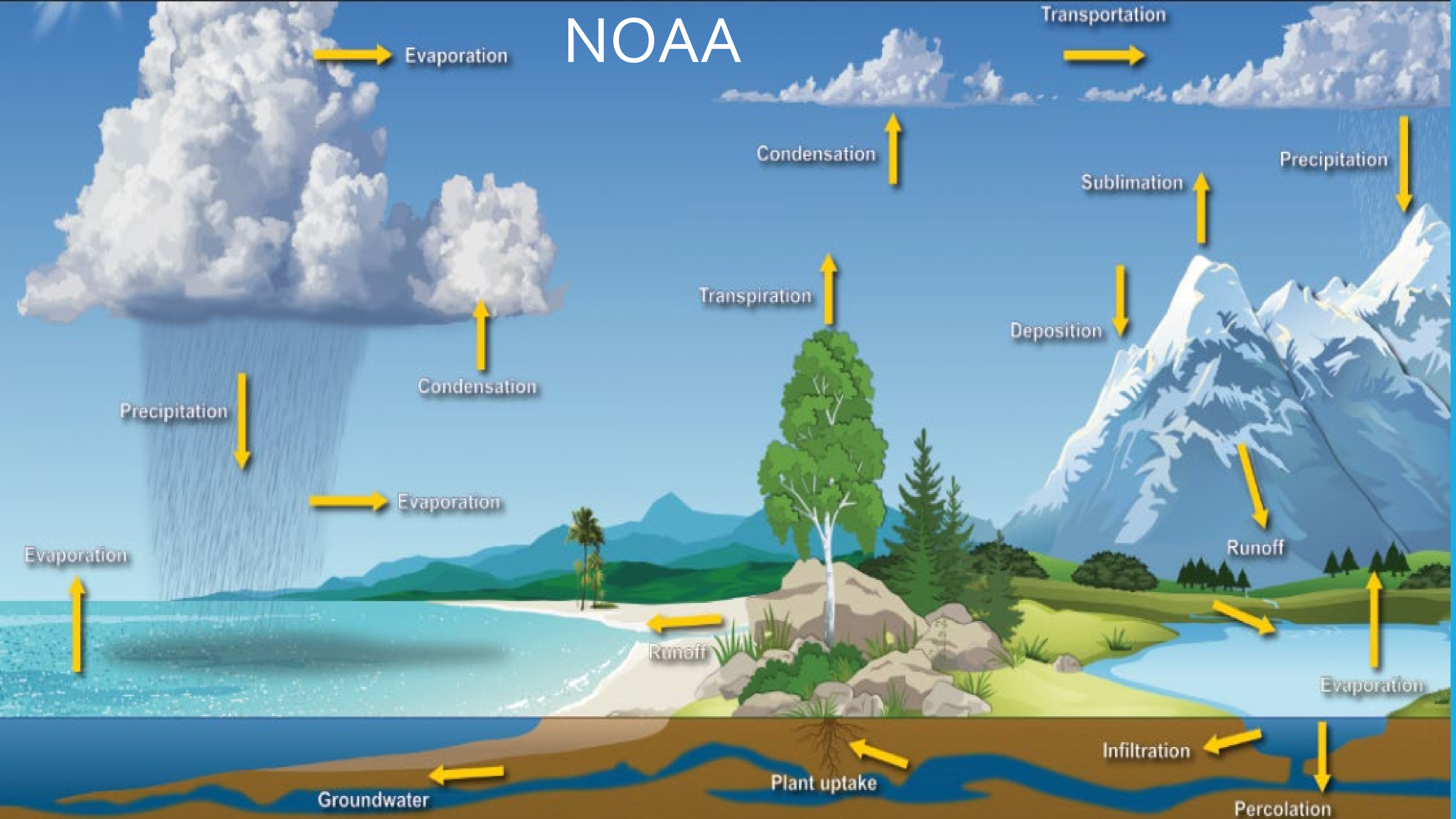


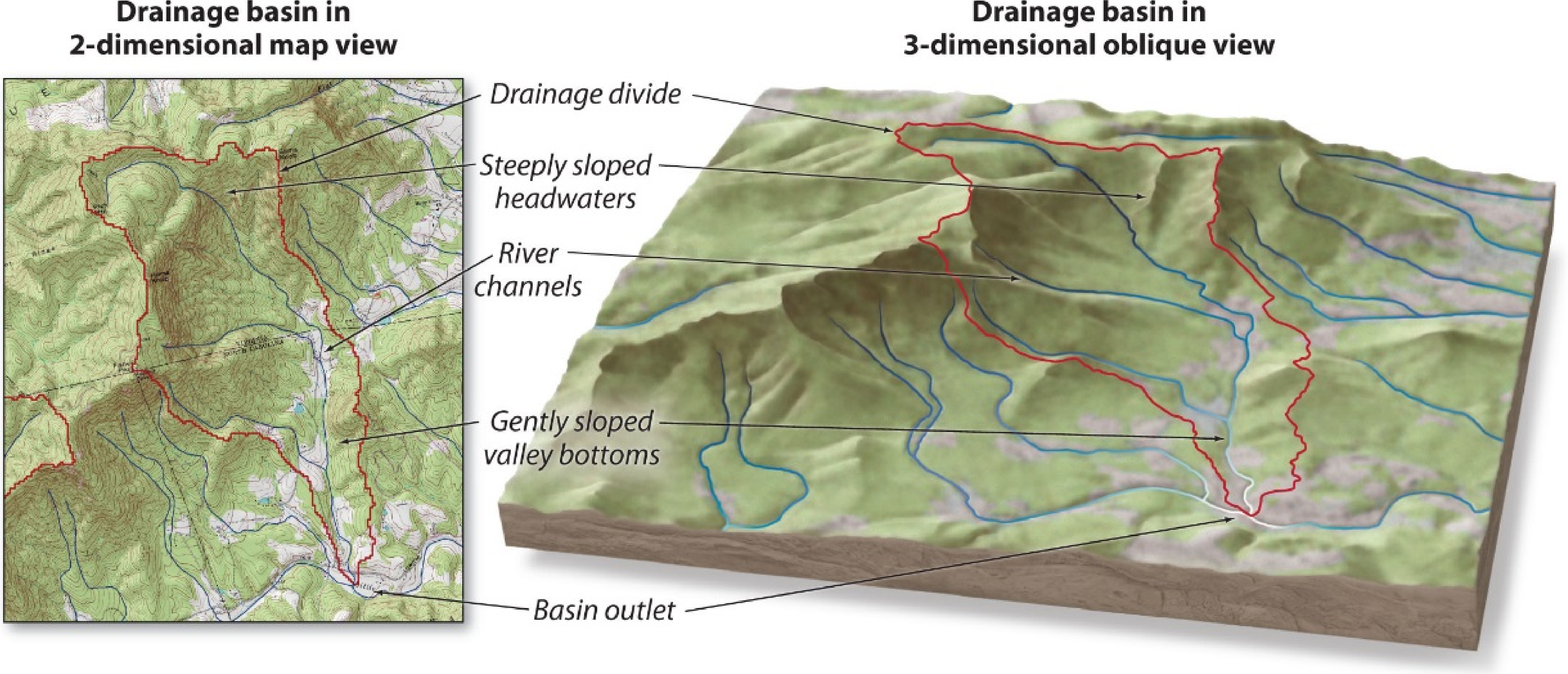
Rockstrom, 2009, Nature

Global Sedimentary Transport

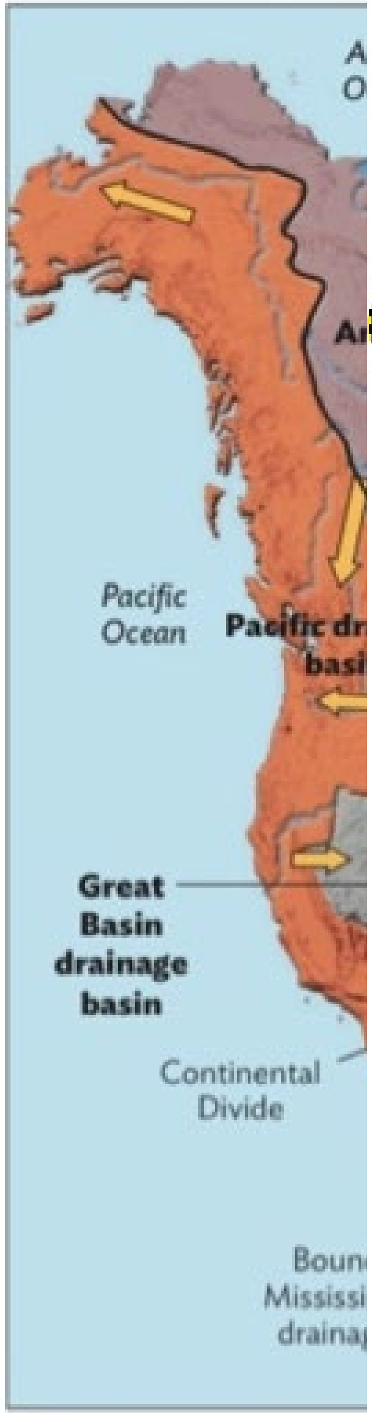
- Rivers 85 to 90%
- Glaciers 7%
- Groundwater and Waves 1 to 2 %
- Wind and Volcano less than 1%

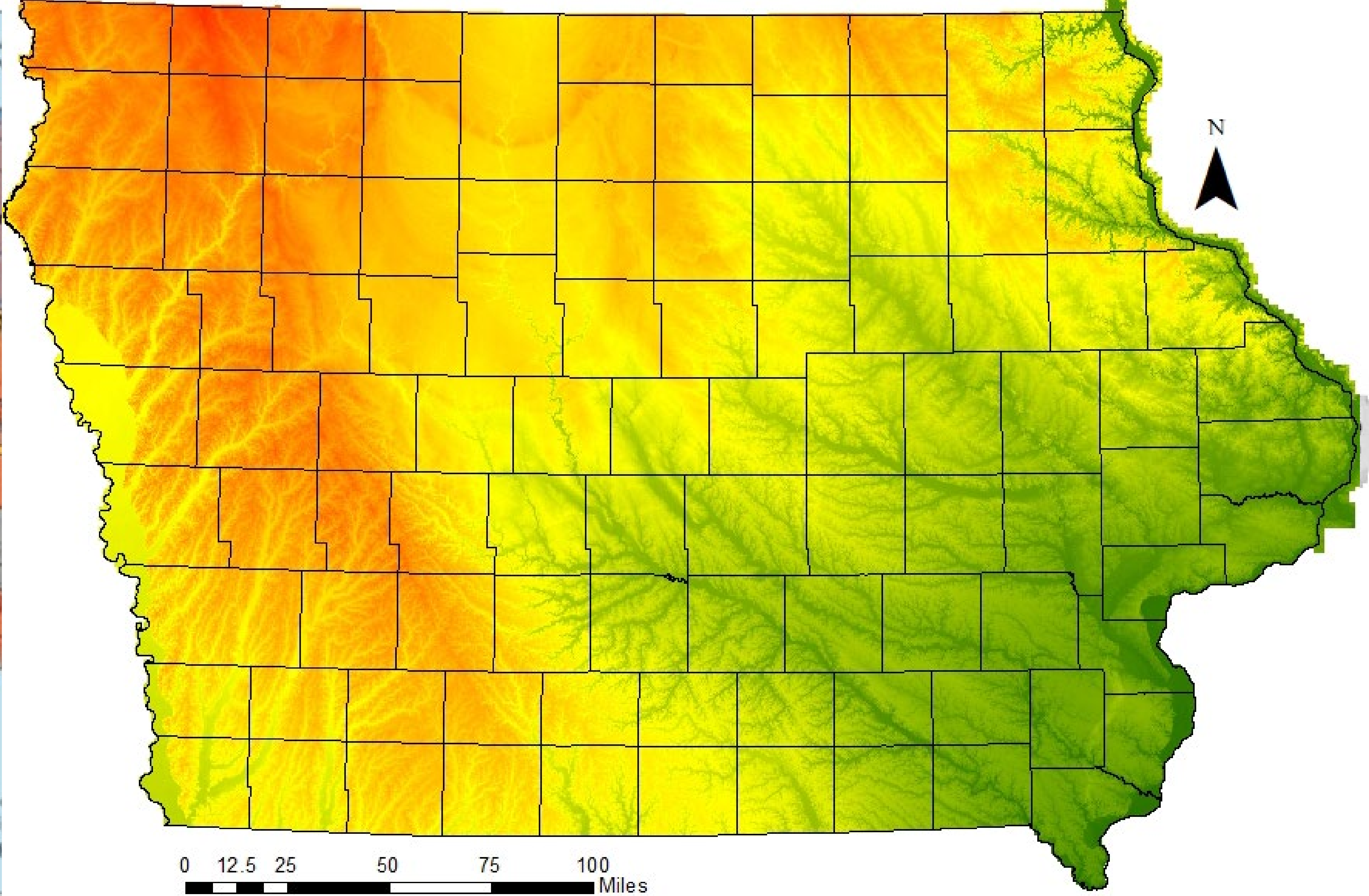
NOAA


Evaporation
Transportation
Condensation
Precipitation
Sublimation
Transpiration
Deposition
Condensation
Precipitation
Evaporation
Evaporation
Runoff
Runoff
Evaporation
Infiltration
Plant uptake
Groundwater
Percolation



Drainage basins are the upslope area draining to a point along a stream and are a primary way by which geomorphologists subdivide landscapes. Separated by **drainage divides,** rivers and streams in drainage basins convey sediment from generally steep uplands to generally less steep lowlands and then onto an outlet defined as the end of the basin. Drainage basins contain streams of various sizes as well as smaller tributary drainage basins.

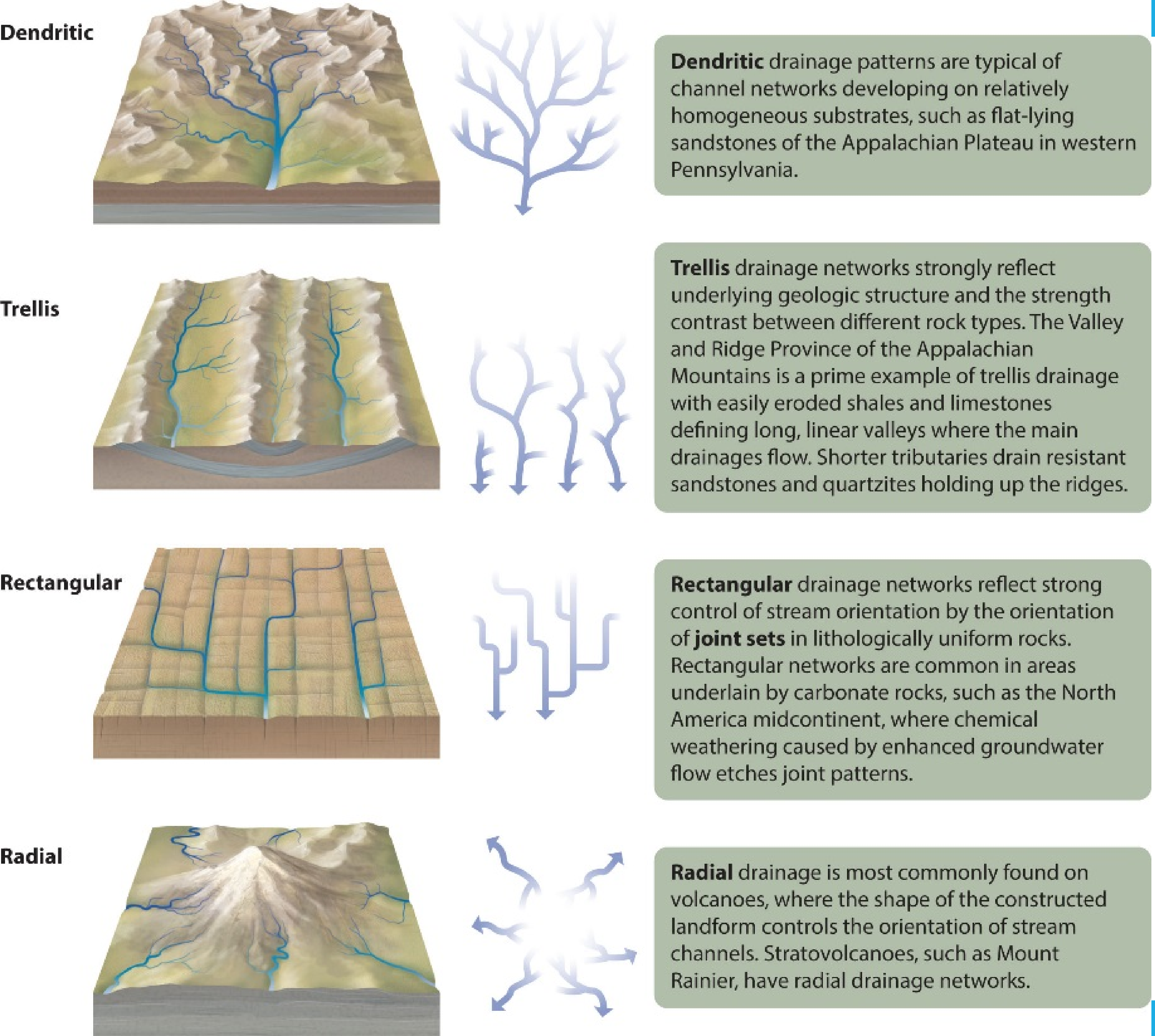

Pacific Ocean
Great Basin drainage basin
Continental Divide

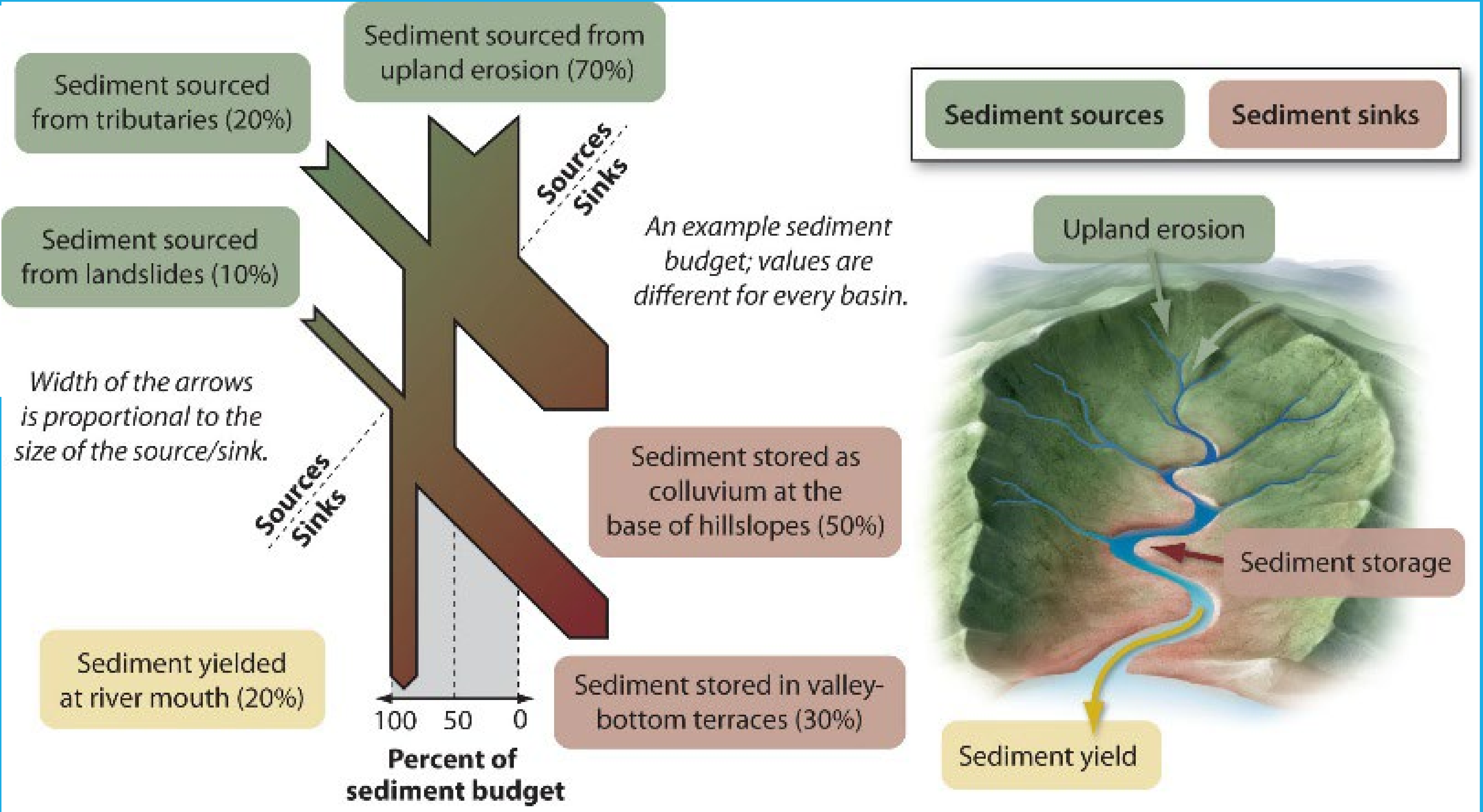

N
0 12.5 25 50 75 100
Miles

Drainage patterns

Common in Iowa

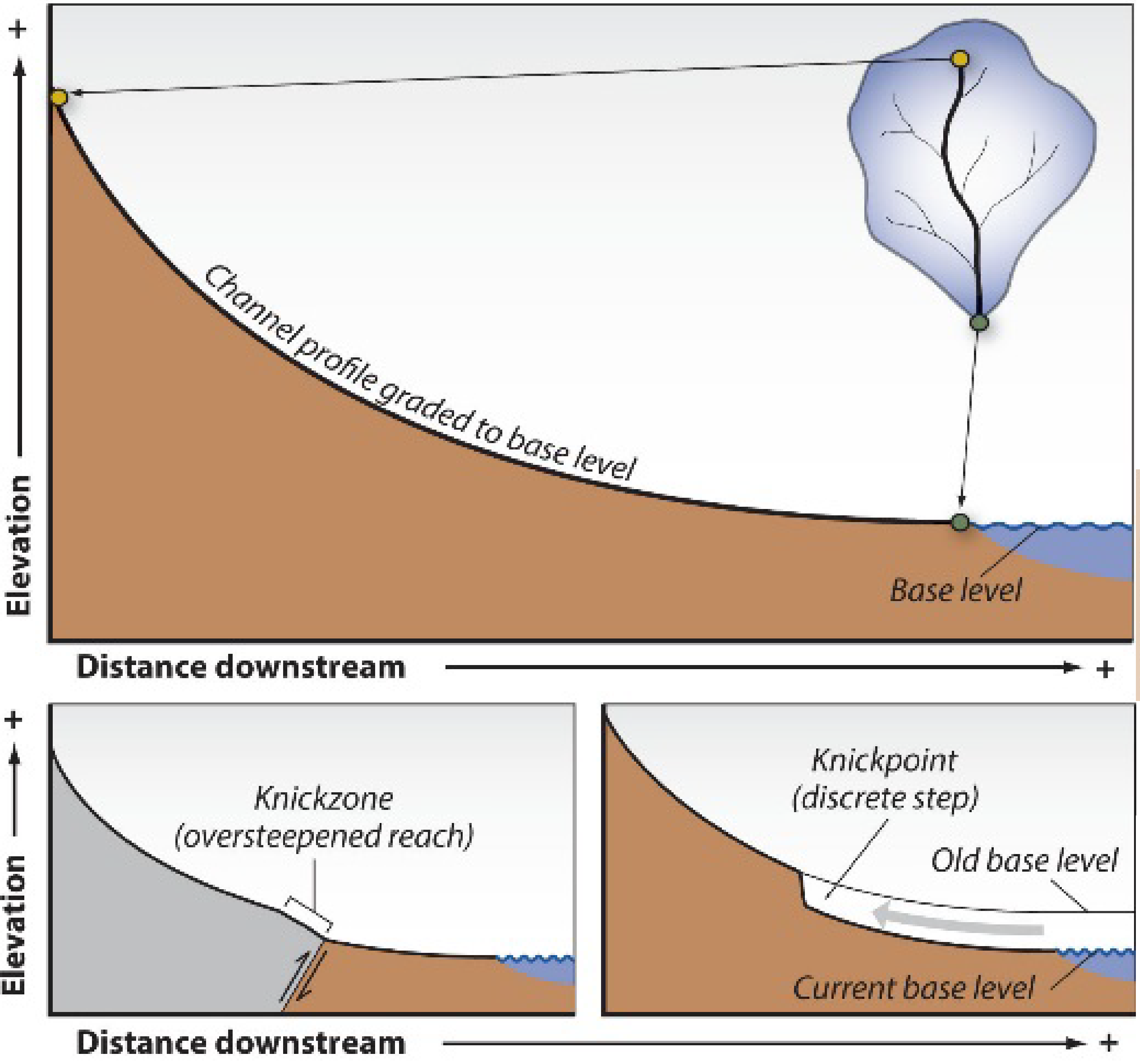
Dendritic





Sediment sourced from upland erosion (70%)
Sediment sourced from tributaries (20%)
Sediment sourced from landslides (10%)
Sources
Sinks
An example sediment budget; values are different for every basin.
Width of the arrows is proportional to the size of the source/sink.
Sources
Sinks
Sediment stored as colluvium at the base of hillslopes (50%)
Sediment yielded at river mouth (20%)
100 50 0
Percent of sediment budget
Sediment stored in valley-bottom terraces (30%)
Sediment sources
Sediment sinks
Upland erosion
Sediment storage
Sediment yield

Grade and Base level



Examining the longitudinal profile of stream channels can be geomorphically informative. Channels with gradients that smoothly decrease downstream are considered **graded.** Channels with abrupt changes in steepness are thought of as being out of equilibrium and responding to changes in external conditions such as **base-level** change. However, channels can also establish a dynamic equilibrium where steeper reaches may reflect more resistant bed material.

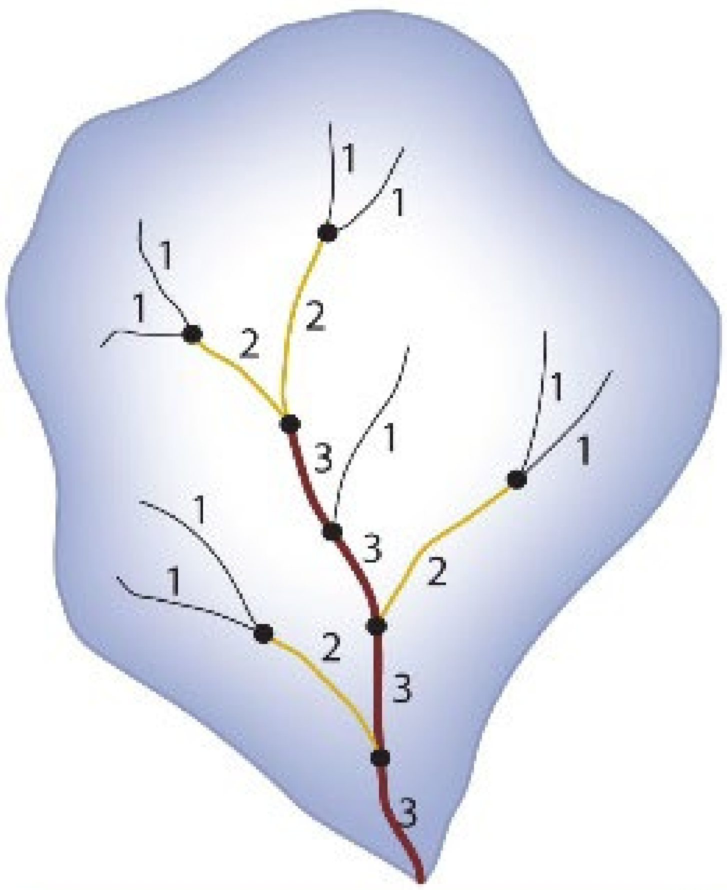
Knickzones are areas where the bed of the river is steeper than up or downstream—a cascade or area of fast water. Such oversteepened reaches can reflect faulting or the presence of strong rocks that are resistant to erosion.

Knickpoints are discrete jumps in elevation along a river's bed, or waterfalls. Such jumps commonly retreat and grow less steep over time. Knickpoints can result from base level change, faulting, resistant rocks, or the lingering effects of valley glaciation.

The concept of Grade in fluvial systems.

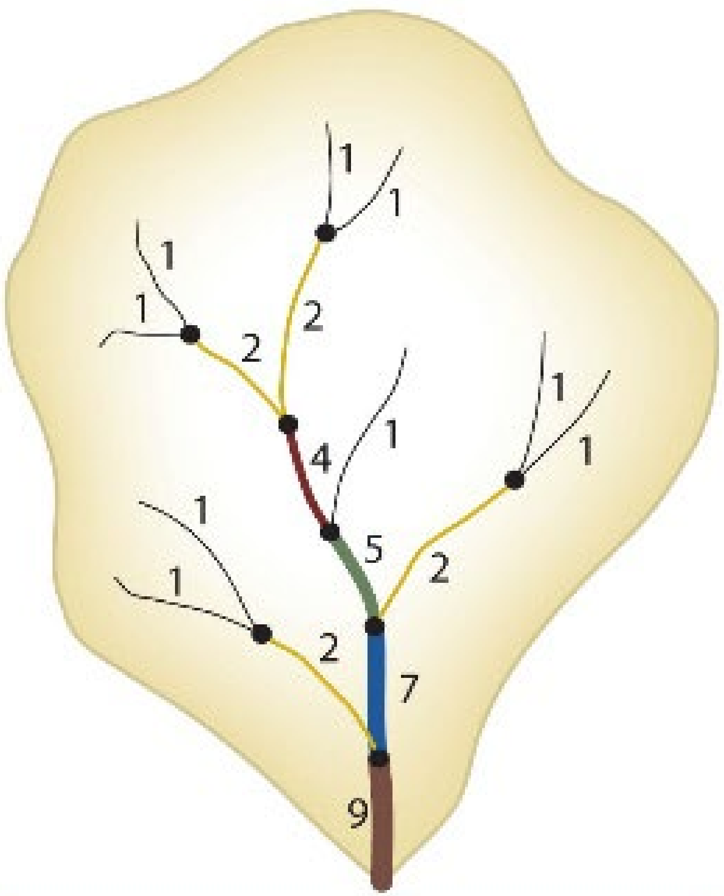
- Grade
  - A tendency for fluvial channels to exhibit long-term self regulation.
  - A sort of equilibrium in which an open system through which mater and energy flow (a river) achieves relative stability.

Strahler classification

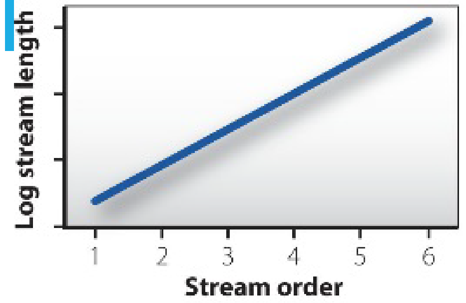


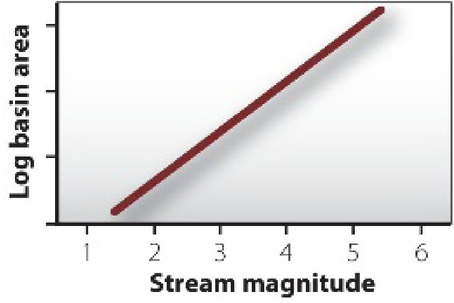
In the **Strahler** classification of stream ordering, **stream order** increases only when two streams of the same order come together. The addition of lower-order streams does not influence the order of the main stream.

Shreve classification

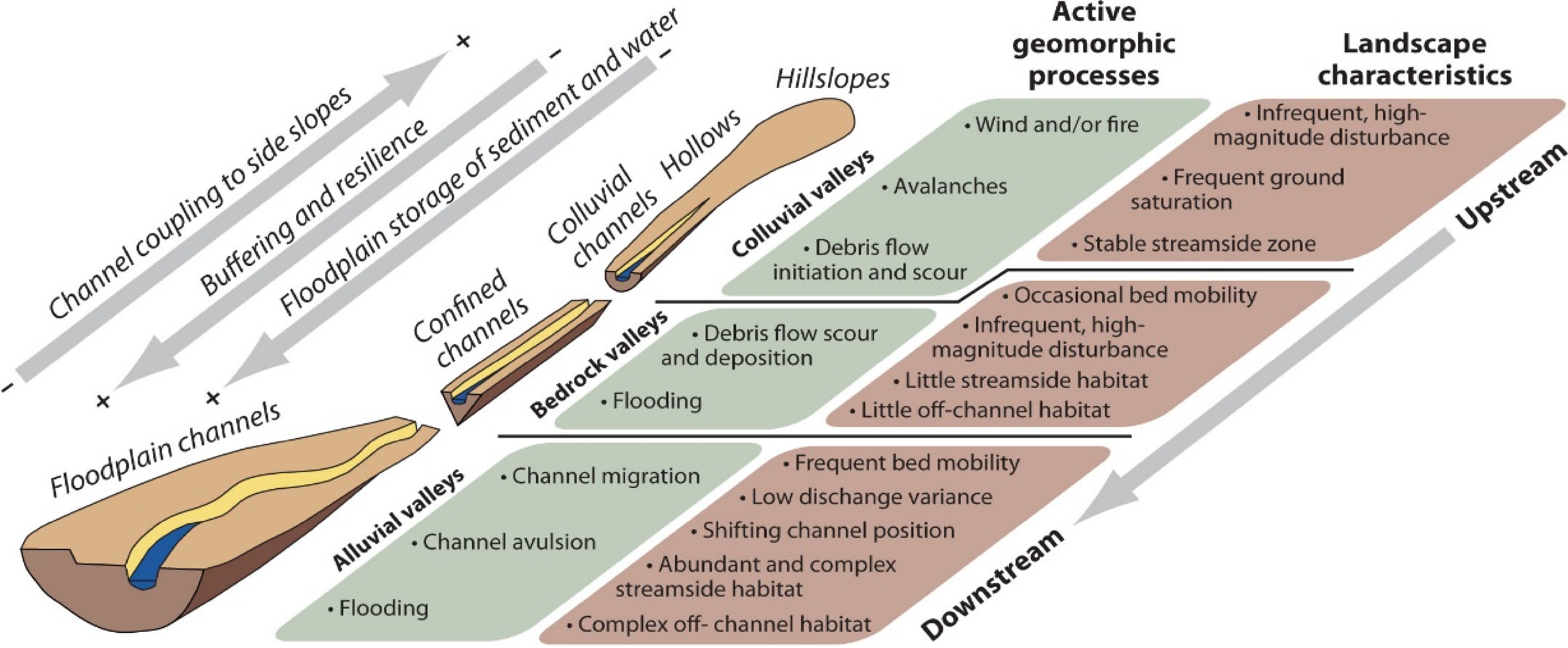


In the **Shreve** classification of stream ordering, **stream magnitude** increases every time a tributary stream enters the main stem. Thus, stream magnitude increases more rapidly in the Shreve classification than does stream order in the Strahler classification.





The ordering of streams leads to a series of relationships known as **Horton's laws** after the hydrologist, Robert Horton, who first developed such ordering schemes. When stream length and drainage basin area are plotted against stream order, there is a positive relationship. Streams of larger order or magnitude are systematically longer and have larger catchments.



Drainage basins are composed of hillslopes and channels, including unchanneled slopes high in the basin uplands and large floodplain channels in the lowland. In between are colluvial channels, just downstream of channel heads, and there can be confined channels in steep bedrock valleys. The active geomorphic processes that shape and disturb the landscape change predictably downstream, and result in a suite of landscape characteristics. Not all landscapes include all of the landforms illustrated here.

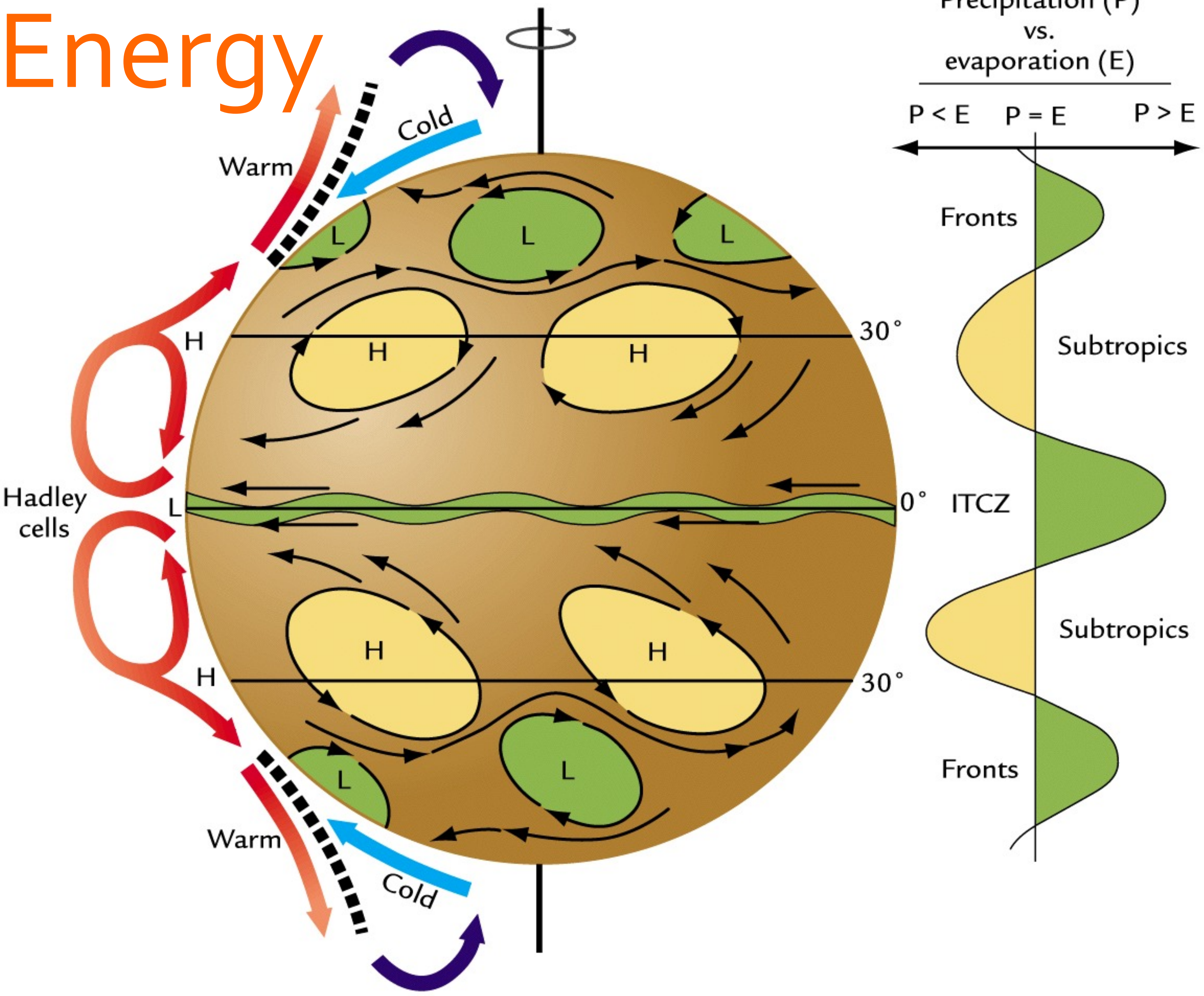
River Variables – Complex/Dynamic Systems

1. Stream velocity (m/s) or (ft/s)
2. Discharge (m^3/s) or (ft^3/s)
3. Gradient
4. Channel size and shape

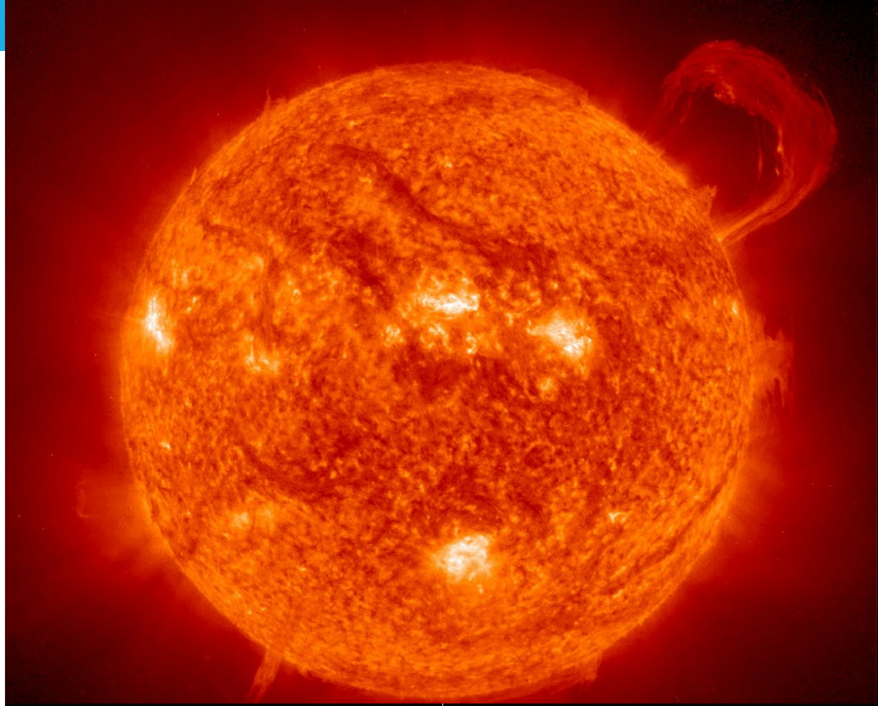
ENERGY

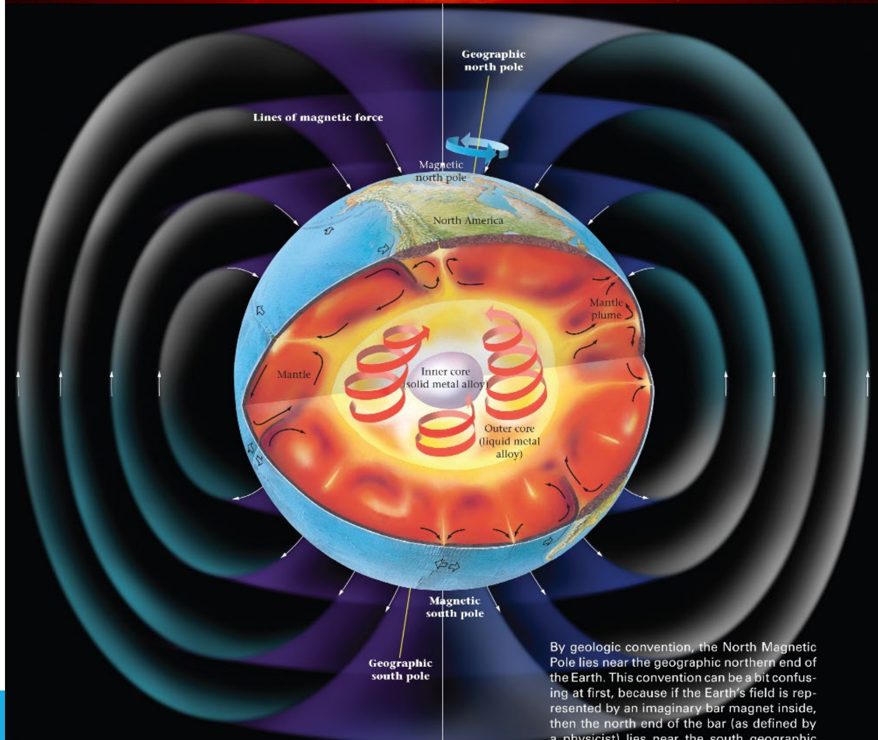
5. Sediment load
6. Geologic environment
7. Vegetation
8. Anthropogenic modification
9 Hydrologic system/climate

Energy

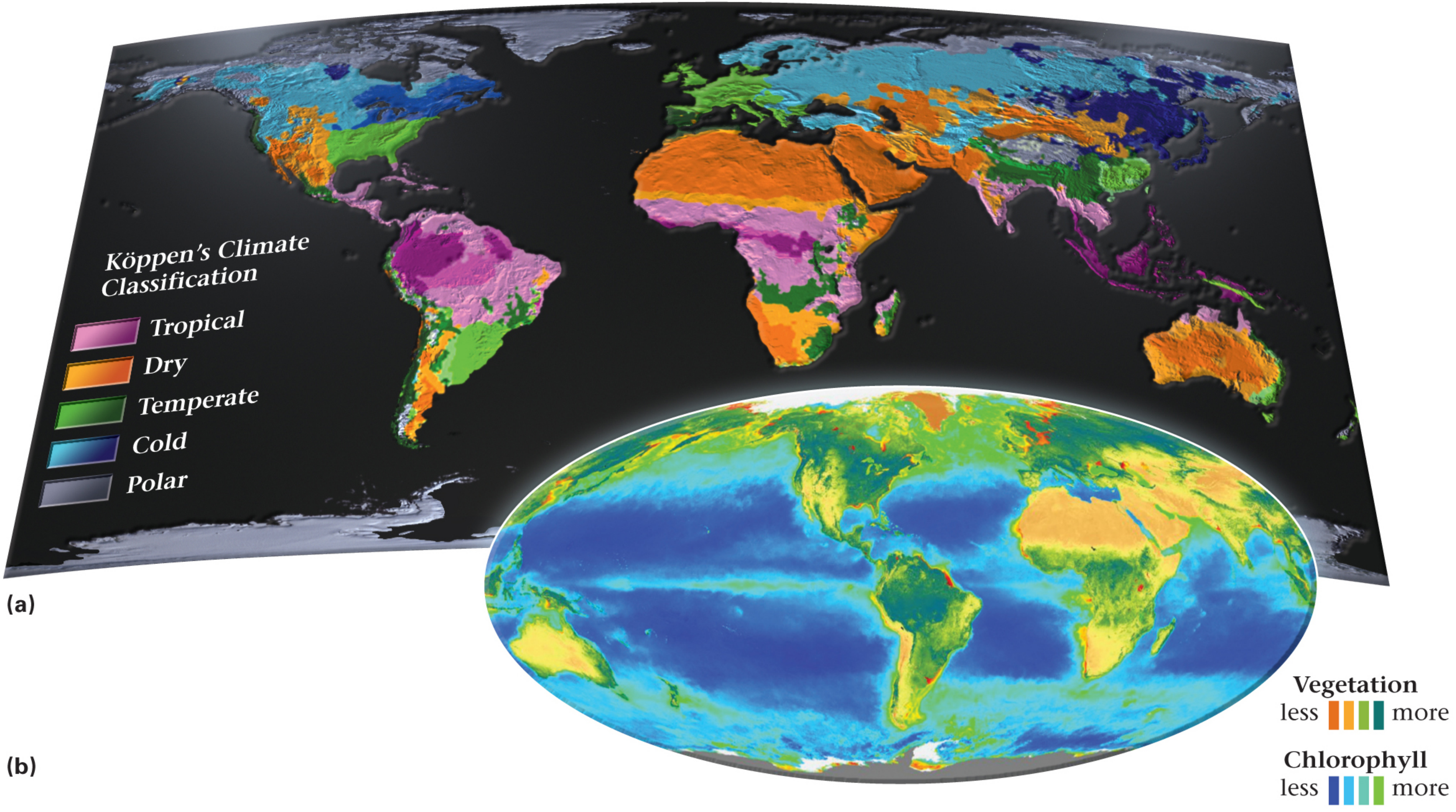


Warm
Cold
L
L
L
H
H
H
30 °
Hadley cells
L
0 °
H
H
H
30 °
L
L
Warm
Cold
Precipitation (P) vs. evaporation (E)
P < E
P = E
P > E
Fronts
Subtropics
ITCZ
Subtropics
Fronts





Geographic north pole
Lines of magnetic force
Magnetic north pole
North America
Mantle plume
Mantle
Inner core (solid metal alloy)
Outer core (liquid metal alloy)
Magnetic south pole
Geographic south pole
By geologic convention, the North Magnetic Pole lies near the geographic northern end of the Earth. This convention can be a bit confusing at first, because if the Earth's field is represented by an imaginary bar magnet inside, then the north end of the bar (as defined by


Köppen's Climate Classification
Tropical
Dry
Temperate
Cold
Polar
(a)
(b)
Vegetation
less more
Chlorophyll
less more

Energy to the Fluvial System

- The conversion of *potential energy* (solar distillation and gravity) to *kinetic energy* and *heat* powers the fluvial system.
- Most of this energy is lost to turbulent flow.
- Only 2 to 4 % of the *potential energy* of water moving downhill is converted to mechanical (erosion) work and transportation.

Variable Energy

↓

Processes

↓

Change

↓

Products/landforms

Energy considerations

- Fluvial intensity varies among
  - climatic regions
  - along temperature gradients
  - precipitation types and volumes
  - altitude
  - vegetated zones
  - seasonal change
  - Human altered landscapes
- 1/3 of the Earth's land surface does NOT have run-off to the oceans.

Energy cont.

- Concept 1. The same physical processes and laws that operate today have operated throughout geologic time, although not necessarily always with the same intensity as now. (Uniformitarianism)

- Concept 2. Geologic structures are a dominant controlling factor/variable in the evolution of landforms and they are reflected in them.

- Concept 3. To a large degree the Earth's surface relief is a product of geomorphic processes operating at differential rates.

Conservation of Mass

$$I - O = \Delta ST$$

I = Input

O = Output

ST = Storage

Conservation of Energy

Energy is neither created or destroyed, only transferred…

Potential energy

- Matter at rest

Kinetic energy

- Matter in motion

Material routing

Geomorphic systems route/move material from eroding sources to depositional sinks.

Weathering $\longrightarrow$ Erosion $\longrightarrow$ Transportation $\longrightarrow$

Deposition = *Landscape evolution & dynamics*

Force balances

Normal stress

$\rho\ g\ z \cos\theta$

Shear stress

$\rho\ g\ z \sin\theta$

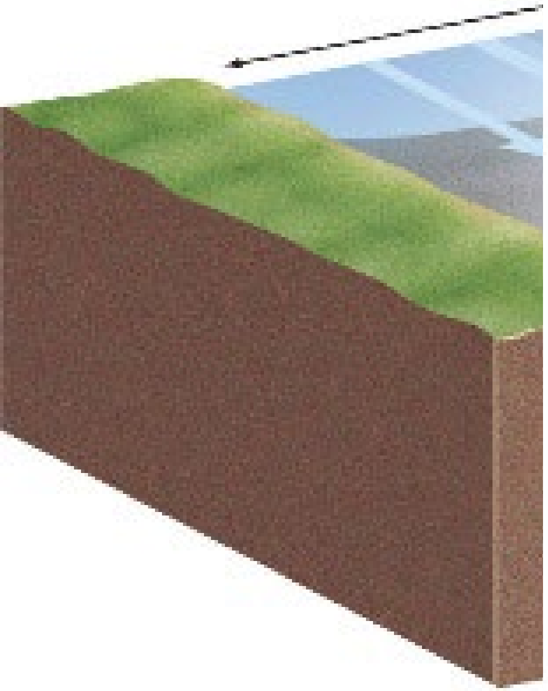
ρ = density of matter

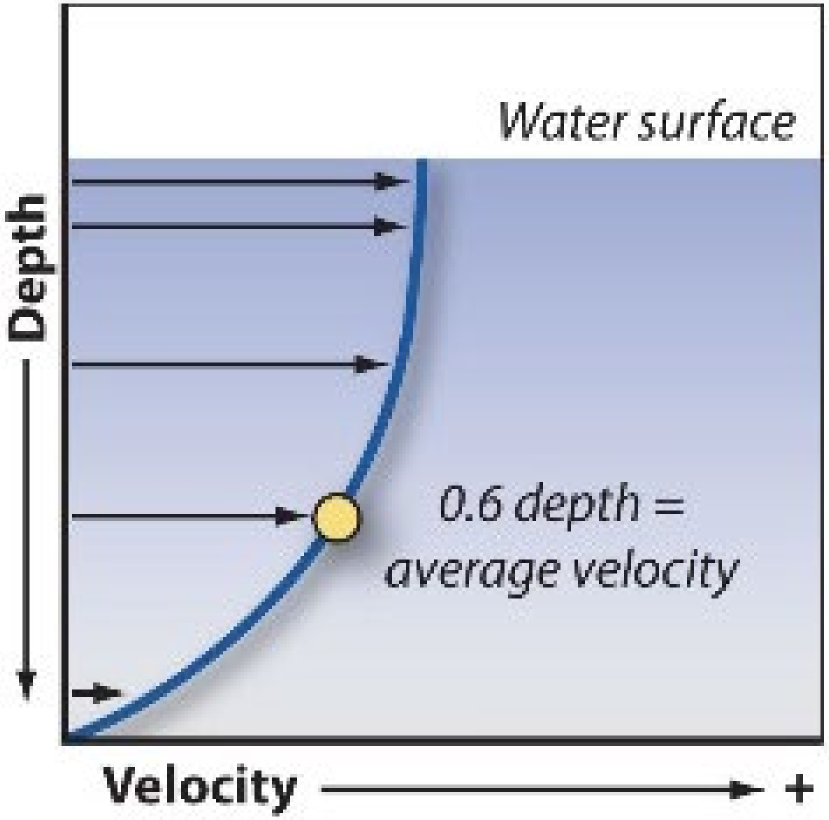
g = gravitational acceleration

z = thickness

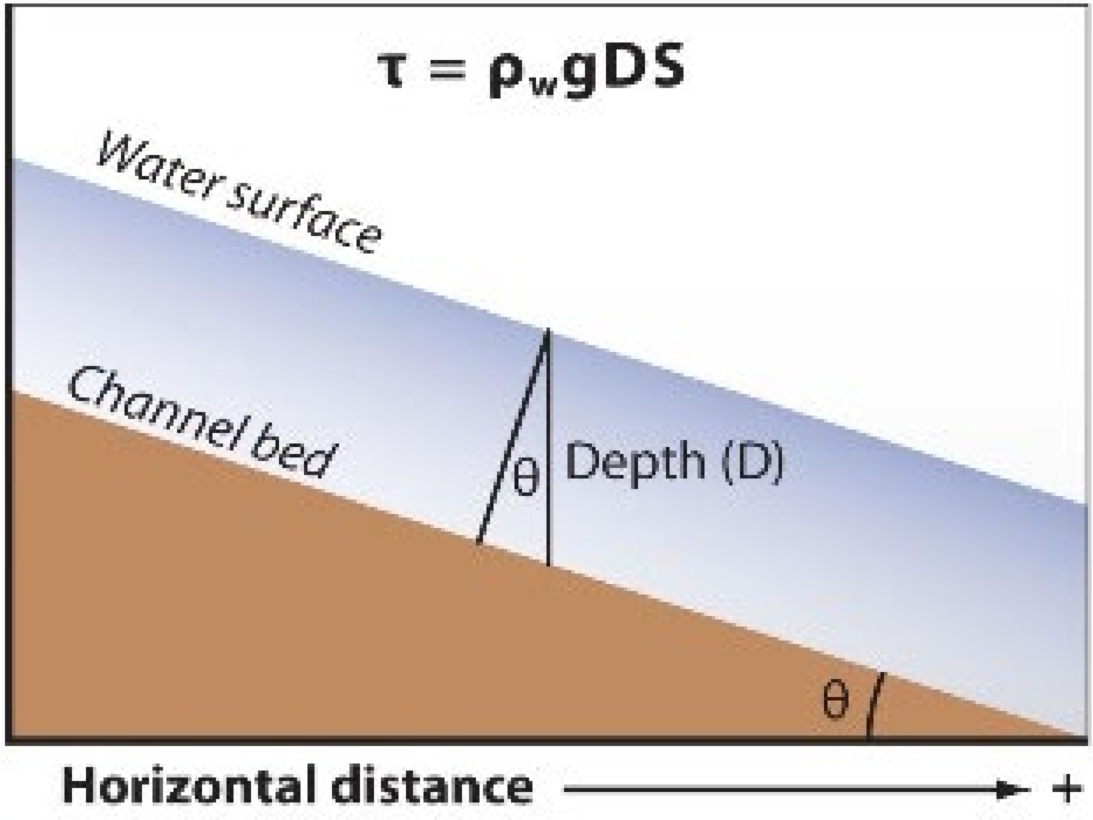
θ = angle of slope

The **discharge** (Q) of a
average depth (D), and
velocity, implicitly mea
of the channel bed in c
is the **wetted perimete**
twice the flow depth (P





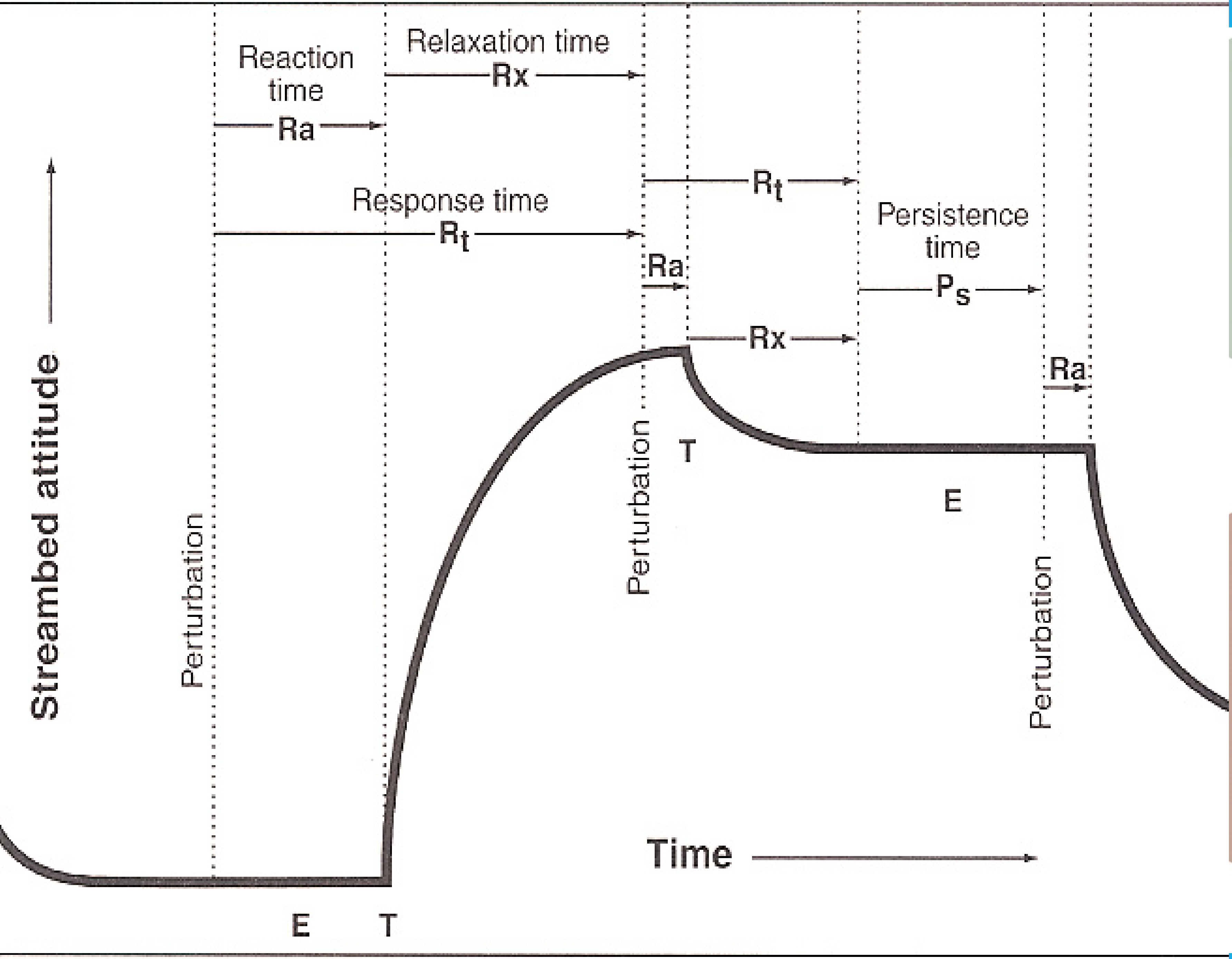
The downstream velocity of water flowing in a river increases in a logarithmic profile from the channel bed toward the surface, with the average downstream velocity at about 0.6 times the total flow depth.



The **shear stress** (τ) exerted on the channel bed by the flow is equal to the downslope component of the weight of the overlying water $\tau = \rho_w gDS$, where ρ_w is the density of water and g is the acceleration due to gravity. The small angle approximation, where $S \sim \sin\theta$, is often used.

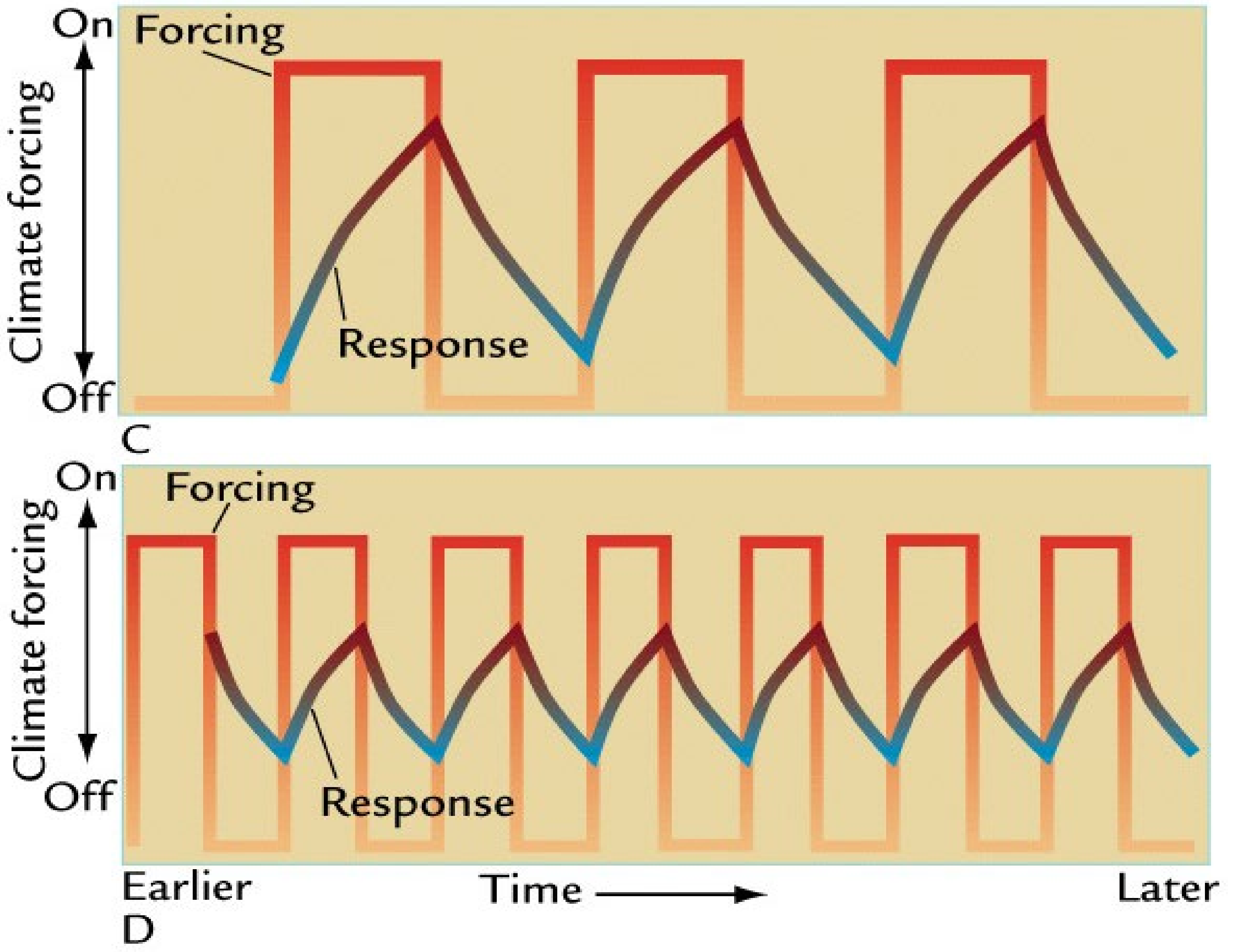
Geomorphic thresholds

Physical, Chemical and or Biological conditions that when reached or exceeded trigger a CHANGE in state or shift t a new range of average conditions.



The flux of sediment from an undisturbed drainage basin changes over the short term as rainstorms come and go, individual hillslopes fail in mass movements, and riverbanks collapse. Over the long term, the flux of sediment from a drainage basin oscillates around a mean value, producing a **dynamic steady state,** unless there are significant changes in **boundary conditions,** such as climate, vegetation cover, or uplift rate.

When boundary conditions change significantly, geomorphic systems adjust. Such adjustment does not happen instantaneously, rather it lags the change in boundary conditions, over a **response time.** In this case, deforestation and land conversion to agriculture increased the fluvial sediment flux to a new and higher dynamic steady state because soils are now disturbed by plowing and thus more vulnerable to erosion.


On
Forcing
Climate forcing
Response
Off
C
On
Forcing
Climate forcing
Response
Off
Earlier
Time
Later
D

Flowing water

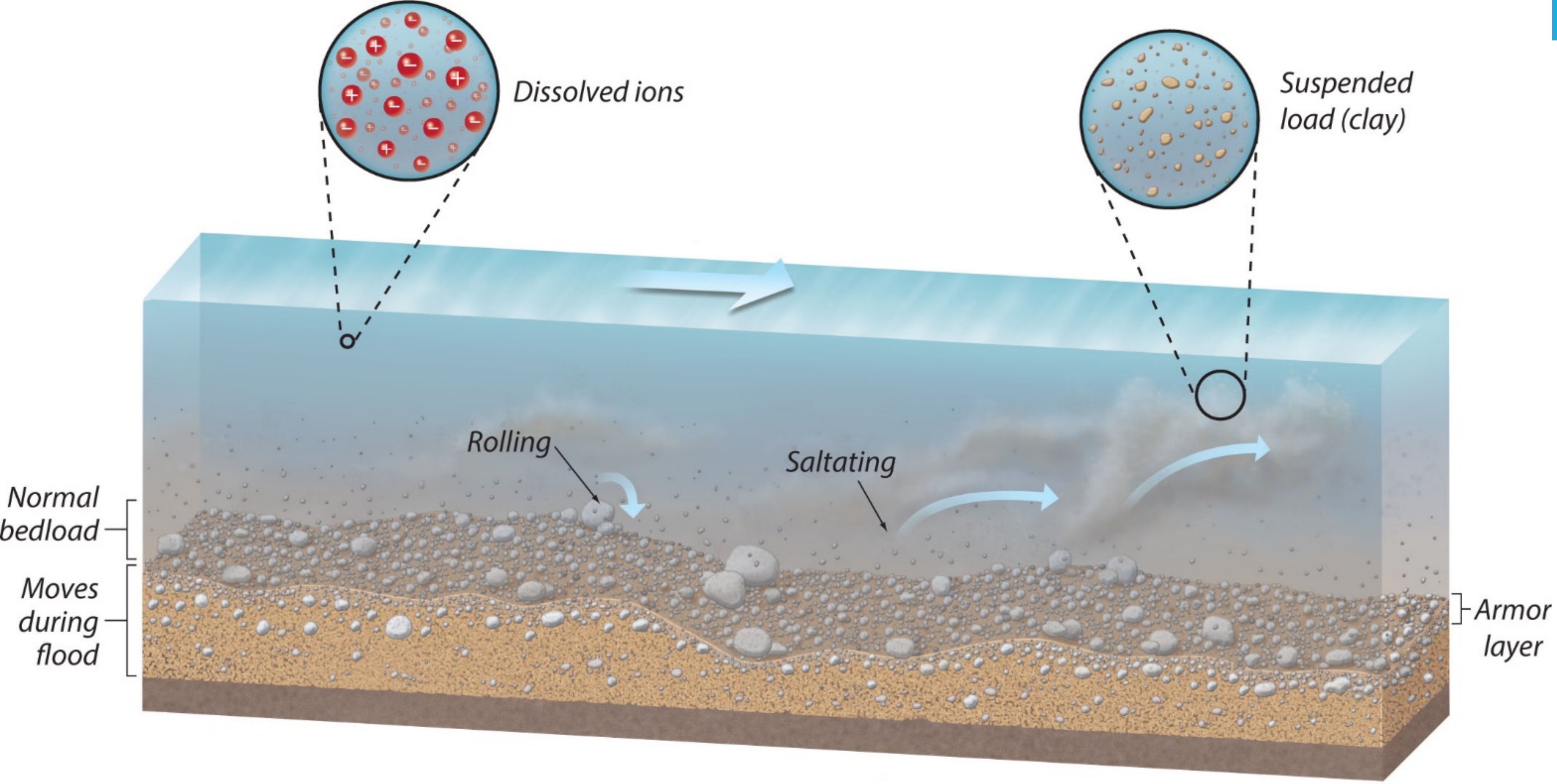
Vocabulary

- Permanent (year round discharge)
- Intermittent (seasonal discharge)
- Ephemeral (only during and after rainfall)
- Influent – (Arid/dry – loss of surficial water – low water table)
- Effluent (Humid/moist – gain in Surficial water – High water table)

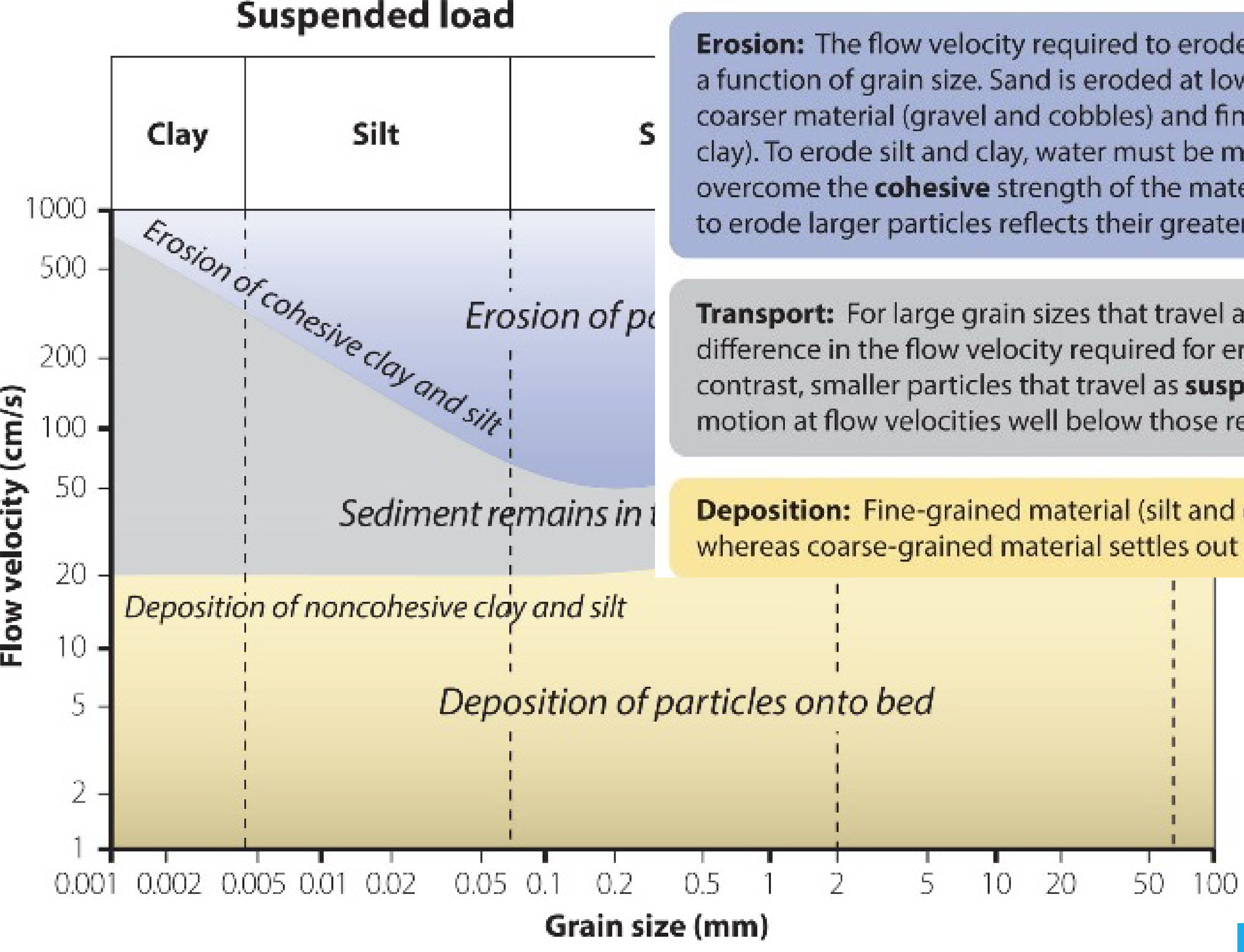
Fluvial Erosion and Transport

Sediment load

1. Dissolved load
2. Suspended load
3. Bed loads
   - Rolling
   - Sliding
   - Saltation



Streams carry material as **dissolved load, suspended load,** and **bedload.** Dissolved load is composed of ions in solution that travel at the speed of the flow. Suspended load (typically silt and clay) is composed of material suspended by turbulence in the flow and moving at the speed of the flow. Bedload moves by rolling or sliding along the channel bed and is typically composed of gravel and cobbles. Sand may travel as either suspended load or bedload, depending on the flow velocity. **Saltating** sediment is swept from the bed, then travels some distance while settling back to the channel bottom. Bedload moves intermittently and thus more slowly than the flow. Streambeds are often **armored** by a layer of large clasts due to winnowing of finer material from the bed.



Erosion: The flow velocity required to erode material from a channel bed is a function of grain size. Sand is eroded at lower flow velocities than both coarser material (gravel and cobbles) and finer-grained material (silt and clay). To erode silt and clay, water must be moving quickly enough to overcome the **cohesive** strength of the material. The greater velocity needed to erode larger particles reflects their greater mass.

Transport: For large grain sizes that travel as **bedload,** there is little difference in the flow velocity required for erosion and deposition. In contrast, smaller particles that travel as **suspended load** can remain in motion at flow velocities well below those required to erode them.

Deposition: Fine-grained material (silt and clay) settles out in very still water, whereas coarse-grained material settles out even in swift water.

Fluvial Competence

The measure of a river's ability to transport a particular maximum particle size.

Competence is a function of:

1. Flow velocity
2. Channel shape
3. Amount of suspended load
4. Particle shape
5. Degree of sorting
6. Water temperature

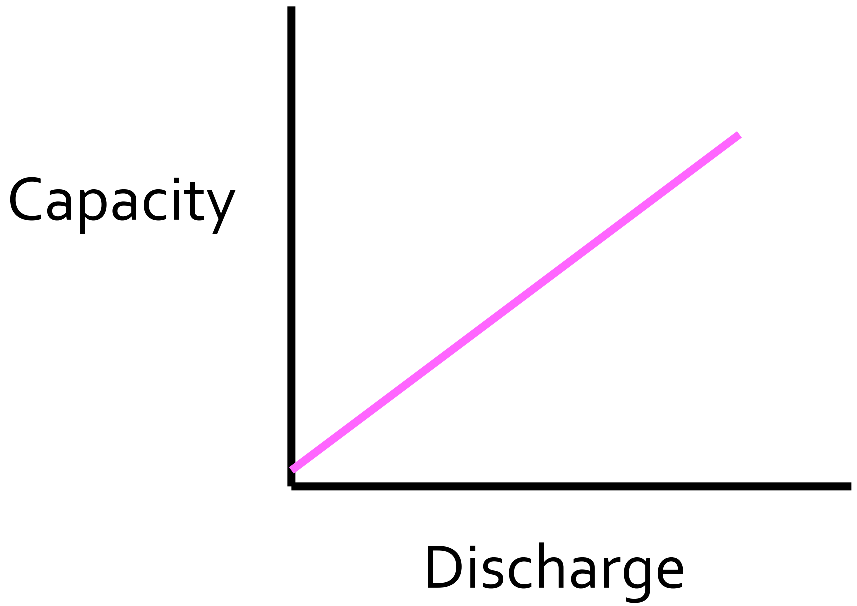
River Capacity

Theoretical maximum amount or mass of sediment that a river can transport.

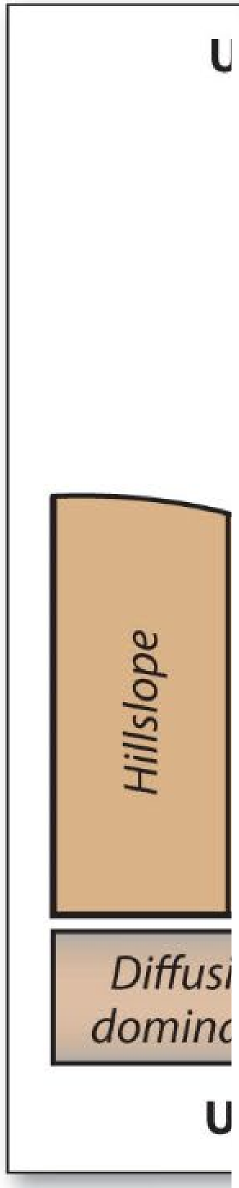
- 1. Dissolved load has no effect on the hydrologic flow of rivers
- 2. Bed load is virtually impossible to measure

Suspended load

- Is measured and determines capacity.



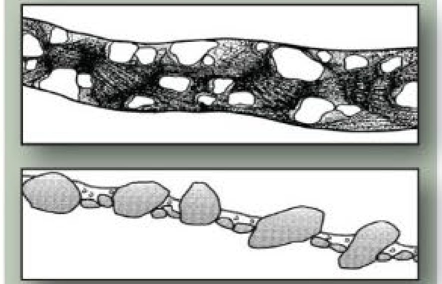
Suspended load source



Plan view / Profile

Cascade

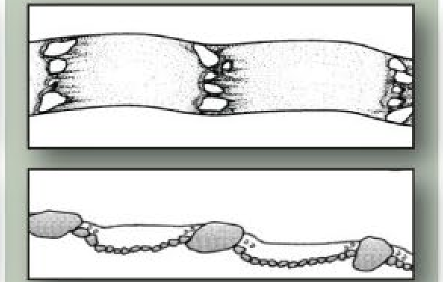
D. Montgomery



Cascade channels, typical of mountainous headwater settings, contain disorganized bed material typically consisting of cobbles and boulders. Large clasts protrude through flow.

Step-pool

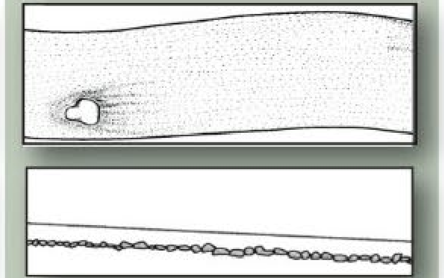
D. Montgomery



Step-pool channels contain longitudinal steps formed by large clasts organized into discrete channel-spanning accumulations. These steps separate pools containing finer material (gravel and sand).

Plane-bed

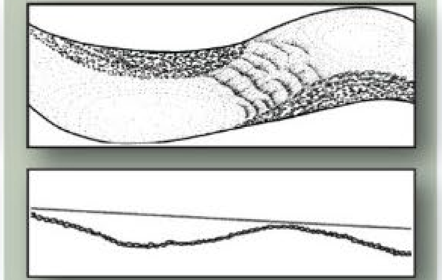
D. Thompson



Plane-bed channels are characterized by long stretches of relatively featureless bed, which is typically composed of cobbles or gravel. Large woody debris may force the localized formation of pools and bars.

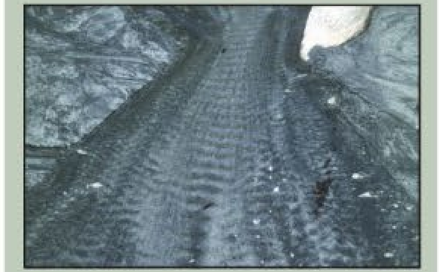
Pool-riffle

D. Montgomery

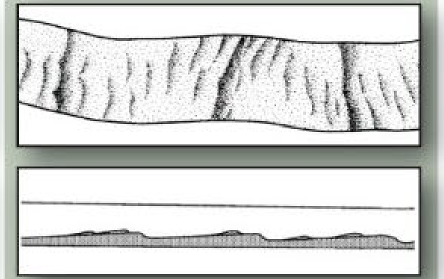


Pool-riffle channels have undulating beds with lateral bed-form oscillations that define a sequence of bars, pools, and riffles. Pool-riffle channels are often gravel-bedded and are typical of lowland valleys.

Dune-ripple



D. Montgomery



In dune-ripple channels, which are typically sand-bedded, bedforms vary with increasing flow depth and velocity, from lower-regime plane beds, to ripples, sand waves, dunes, upper-regime plane bed, and anti-dunes.

Flow Velocity / Manning's Equation

$$U = (R^{2/3} S^{1/2})/n$$

- U = Stream flow velocity
- R = Hydraulic Radius ((cross sectional area (A_{cs}) / Wetted perimeter (P_w))
- S = Water surface slope
- N = Manning roughness coefficient


n = 0.073

Froude Number / Flow Turbulence

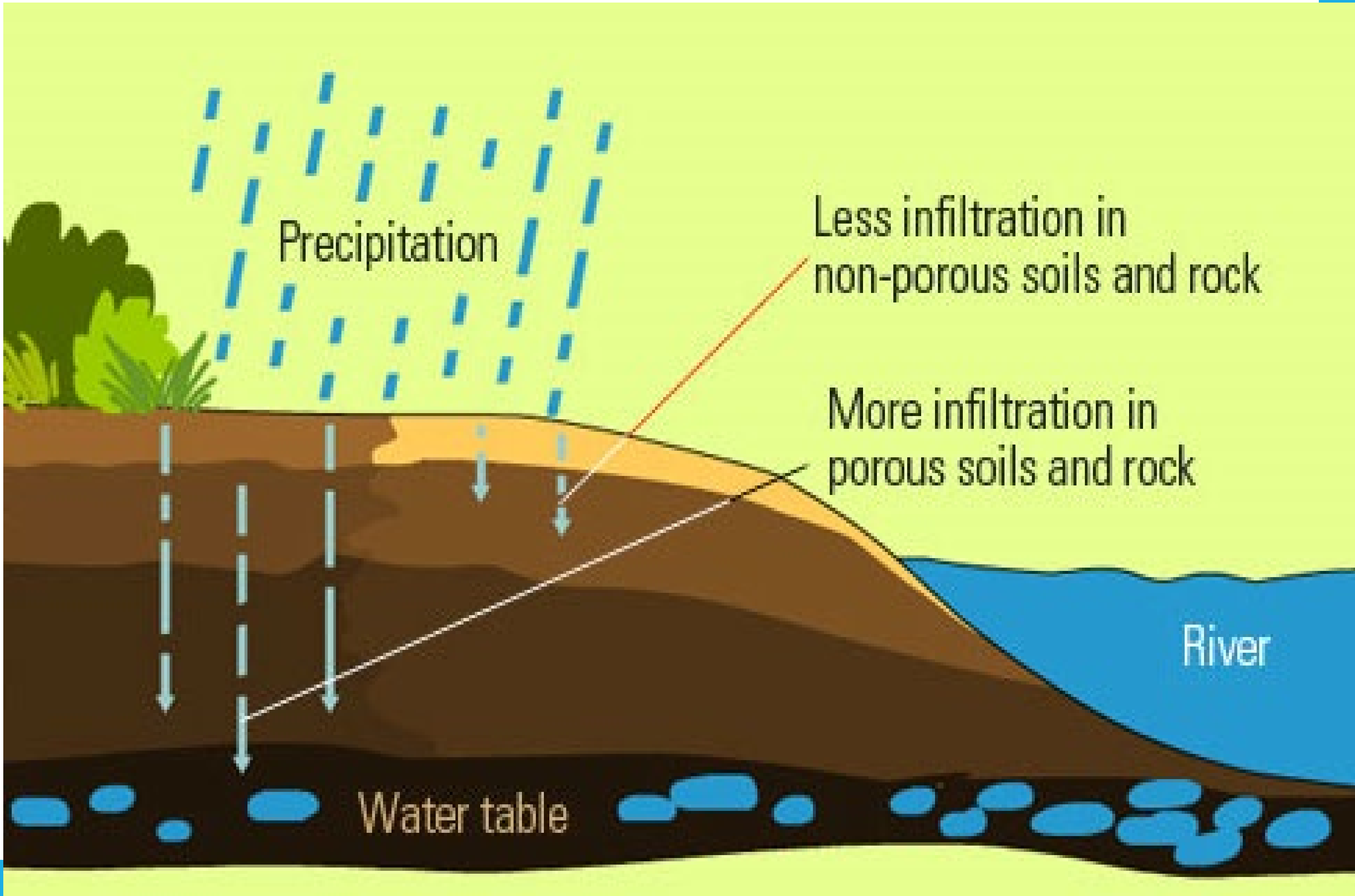
$Fr = u/(dg)^{0.5}$

- U = Flow velocity
- D = Flow Depth
- G = gravitational acceleration

- Tranquil / Subcritical flow
  - $Fr < 1$
- Critical Flow
  - $Fr = 1$
- Supercritical flow
  - $Fr > 1$

Primary Overland Flow Types

- Infiltration
- Through (Interflow)
- Sheet flow
- Channelized

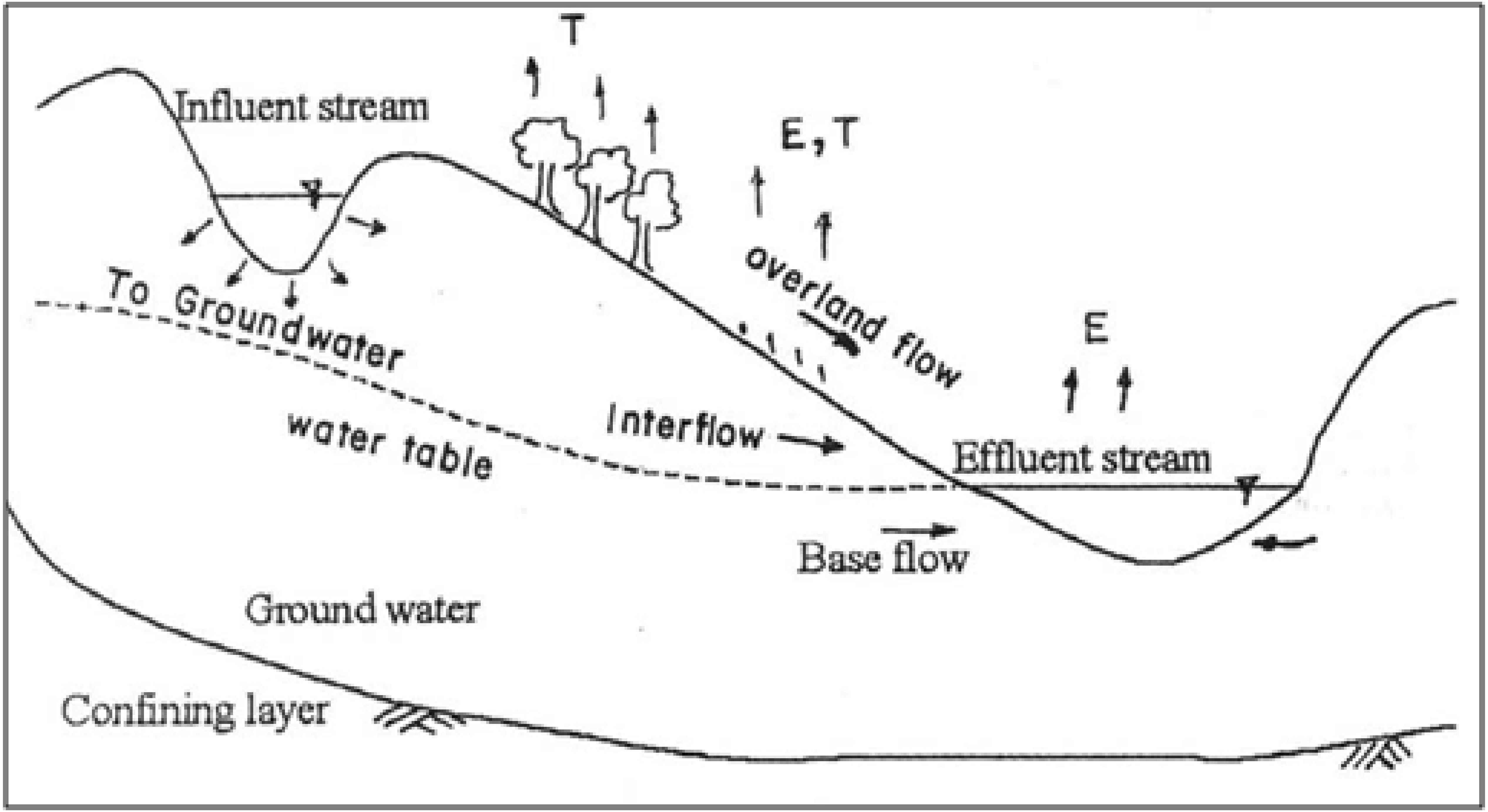


Infiltration considerations

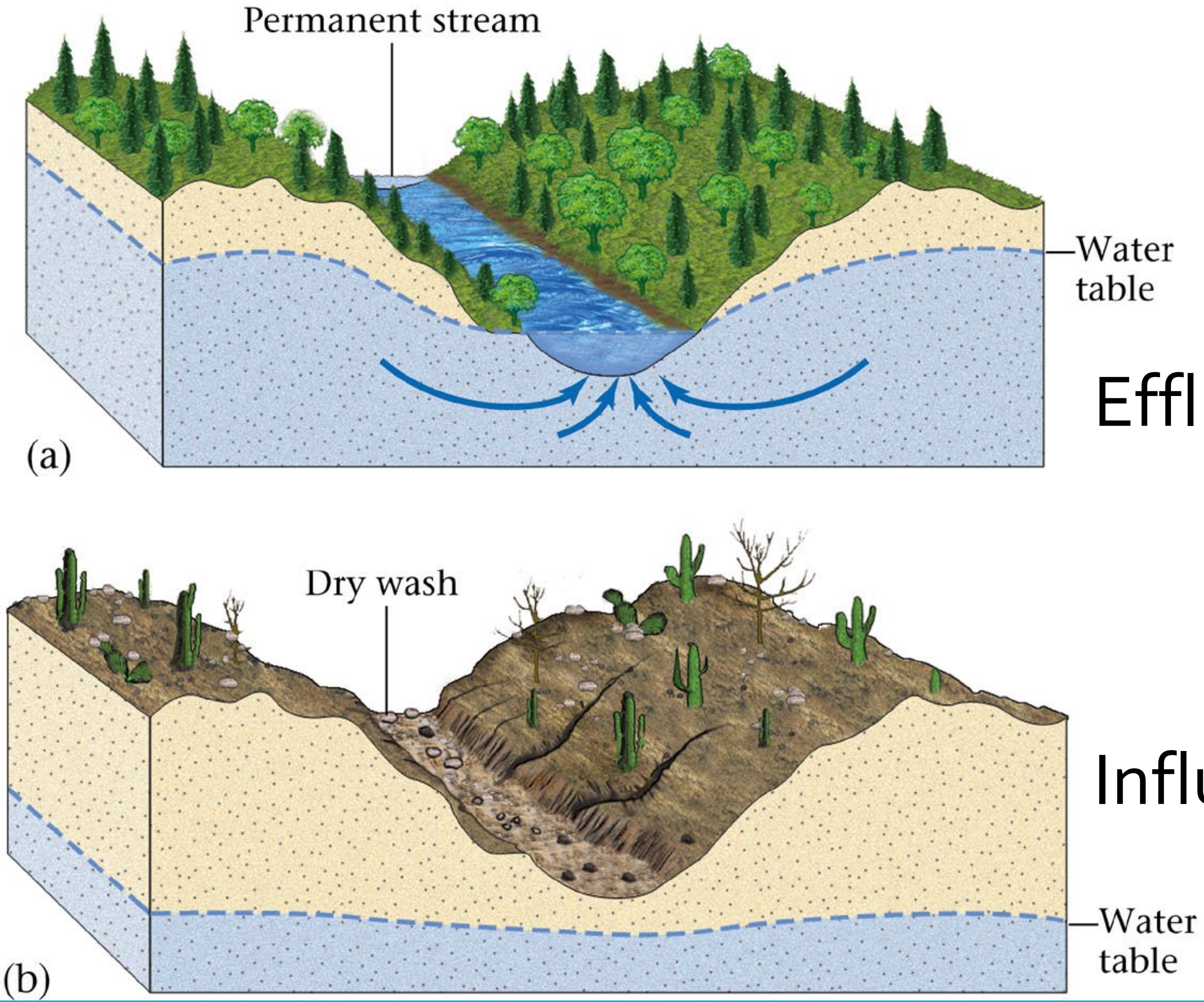
- Intense rainfall may exceed the capacity of soil to intake water, creating overland flow.
- An important factor that occurs in saturated through flow and NOT in overland flow is: Saturation adds seepage pressure increasing the probability of loose particles being transported down slope.

Through flow (Interflow)

- Rapidly flowing groundwater moving down gradient within a soil catena's interconnected cracks, burrows, root channels and soil voids with or without C or R-horizon saturation.



T
Influent stream
E, T
To Groundwater
overland flow
E
Interflow
water table
Effluent stream
Base flow
Ground water
Confining layer



Effluent

Influent

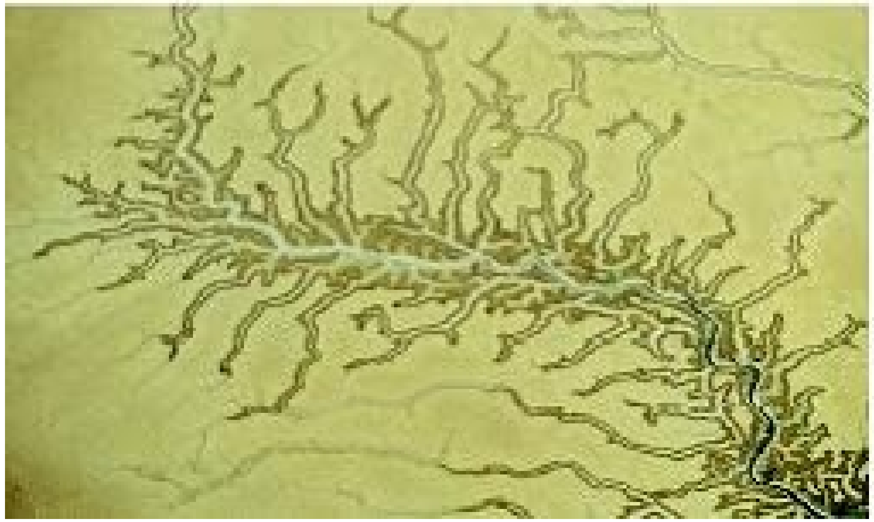
Sheet flow

- Occurs on bare low gradient surfaces, that have a scattering effect
  - suppresses impact energy and channel formation.
- Muddy water flows as a thin, slow moving surface layer.

Channel Development

- Piping and Sapping
- Rills
- Gulleys






Rill and Gully Formation

- A critical point is reached once the landscape threshold is reached and erosion is initiated.
- Piping is a function of seepage pressure in soil that aggressively undermines small pits or rill heads where seepage pressure is the greatest. Start of headward propagation.

Rills

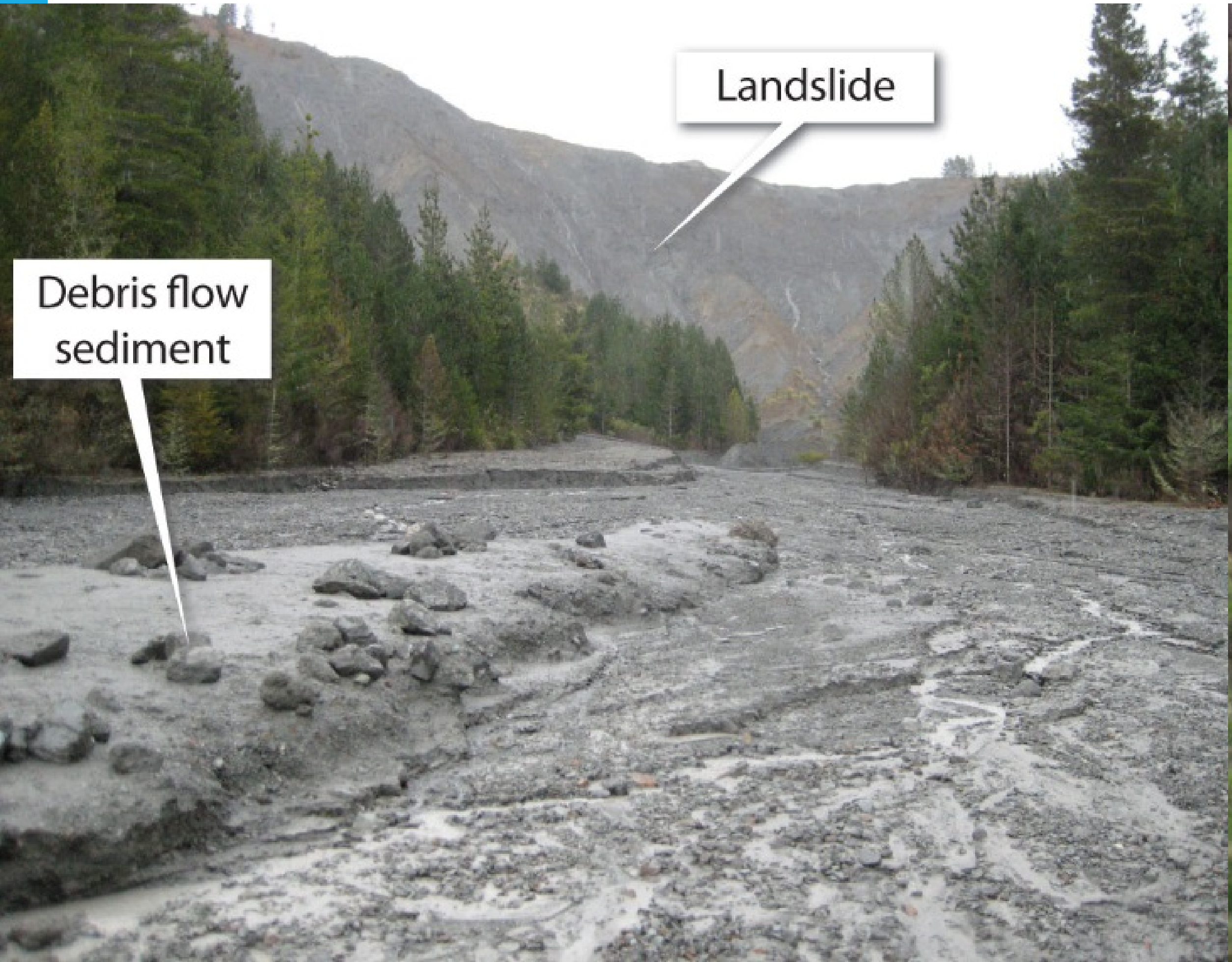
Threads of higher velocity and more turbulent current eroded small channels.

Gully

- A stream channel with distinct cut banks and commonly a steep head.
- agricultural practices.

John Thomas – Hungry Canyons Alliance
http://www.goldenhillsrcd.org/hungry-canyons-alliance.html

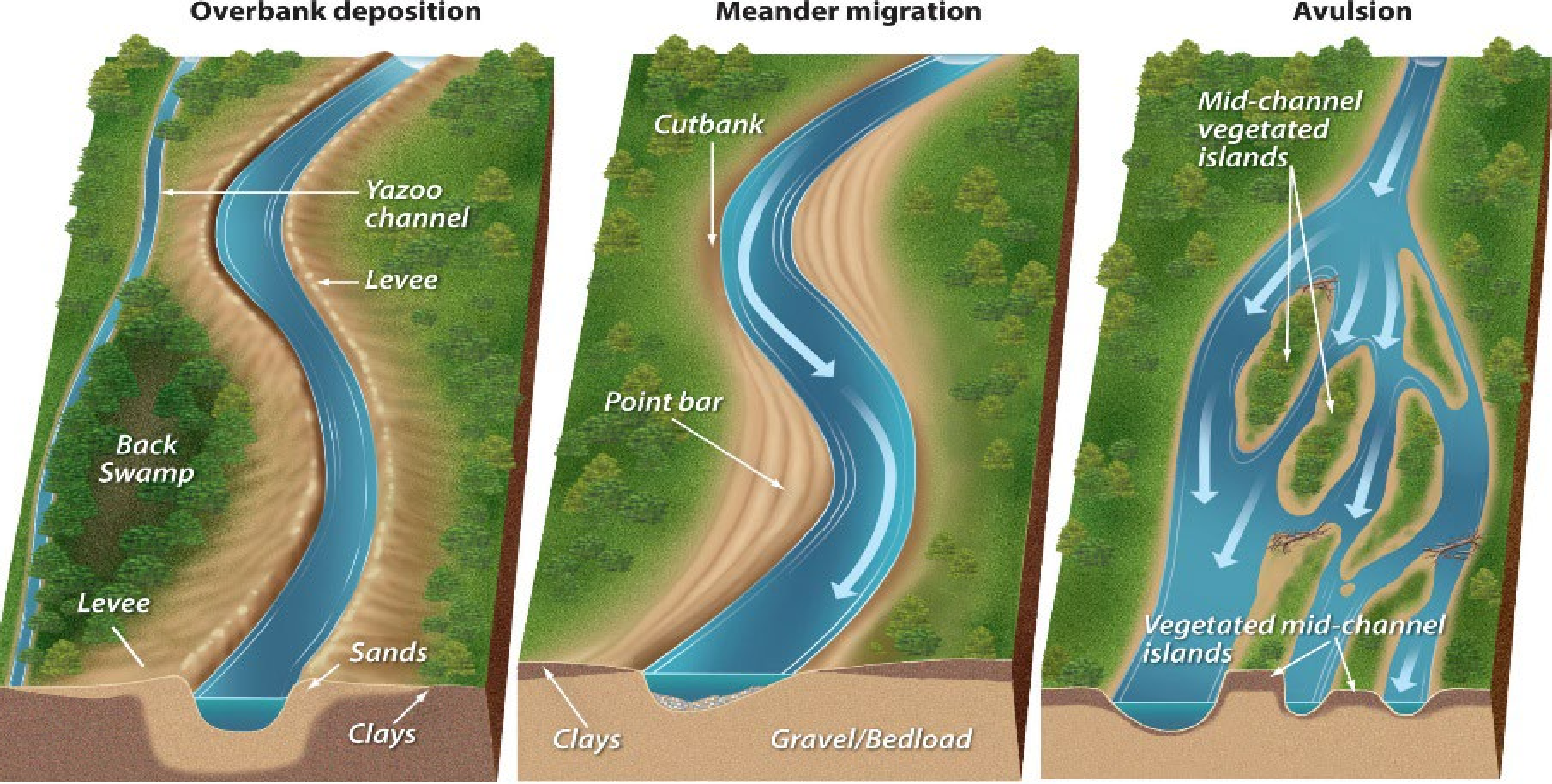
Sediment supply / Bank Stability



Bank Stability Classes

1- Stable	Streambanks are gently sloping and fully covered with protective vegetation. Little if any streambank erosion is occurring.
2- Moderately Stable	Streambanks are nearing vertical with some erosion occurring. But streambanks are still mostly covered with protective vegetation.
3- Moderately Unstable	Banks are nearly vertical, with some protective vegetative cover remaining. However signigicant sloughing and erosion are occurring.
4- Unstable	Banks are vertical, or even being undercut, with no protective vegetative cover. Numerous bank failurs are present.
Artifically Stable	Rip-rap, or other protective stabilization measures have already been implemented.

Channel Types

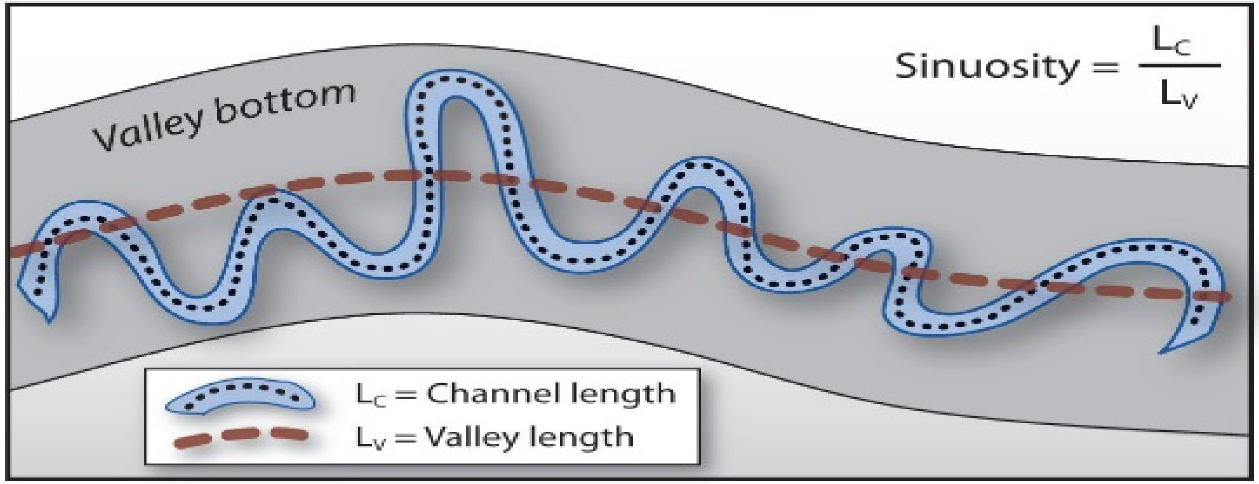


Lower Mississippi River, Louisiana

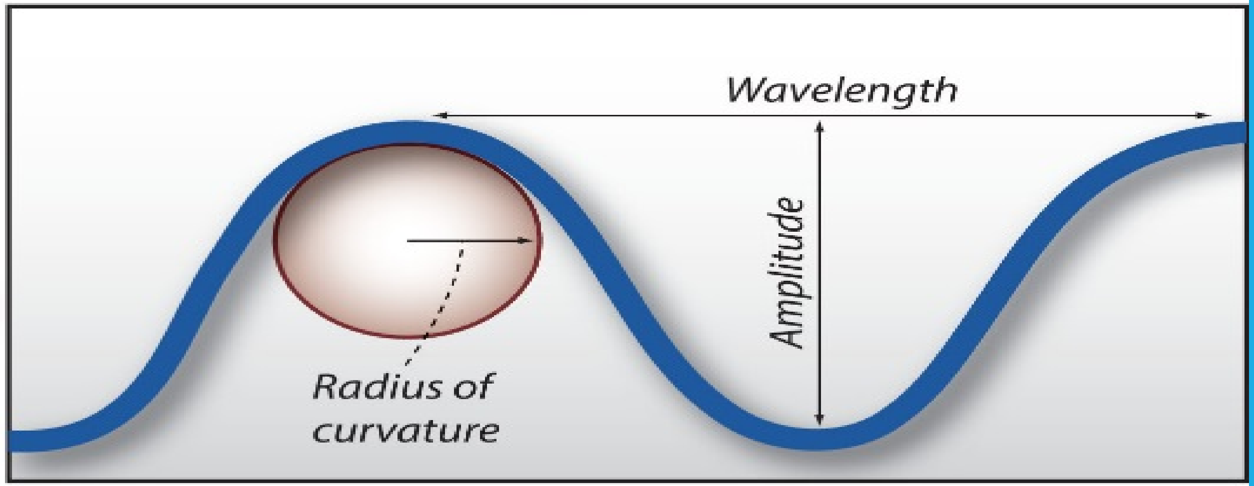
Mississippi River, Illinois

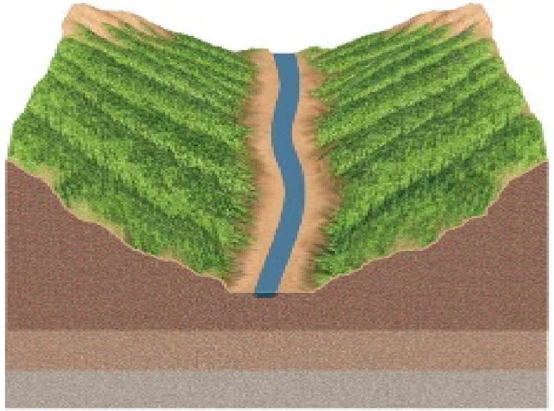
Queets River, Washington State

Channel sinuosity

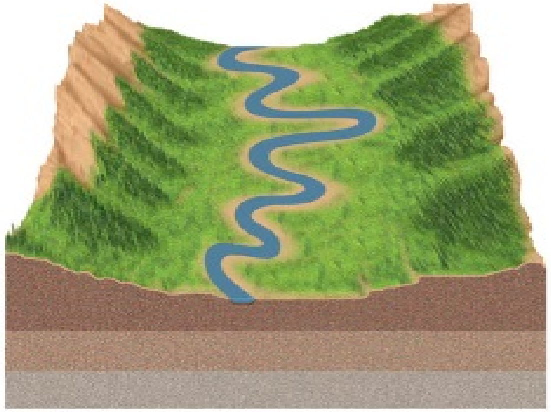


Geometry of a meander

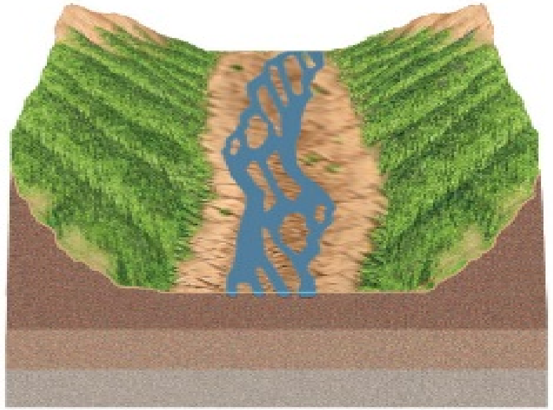




Straight
sinuosity < 1.3



Meandering
sinuosity > 1.5

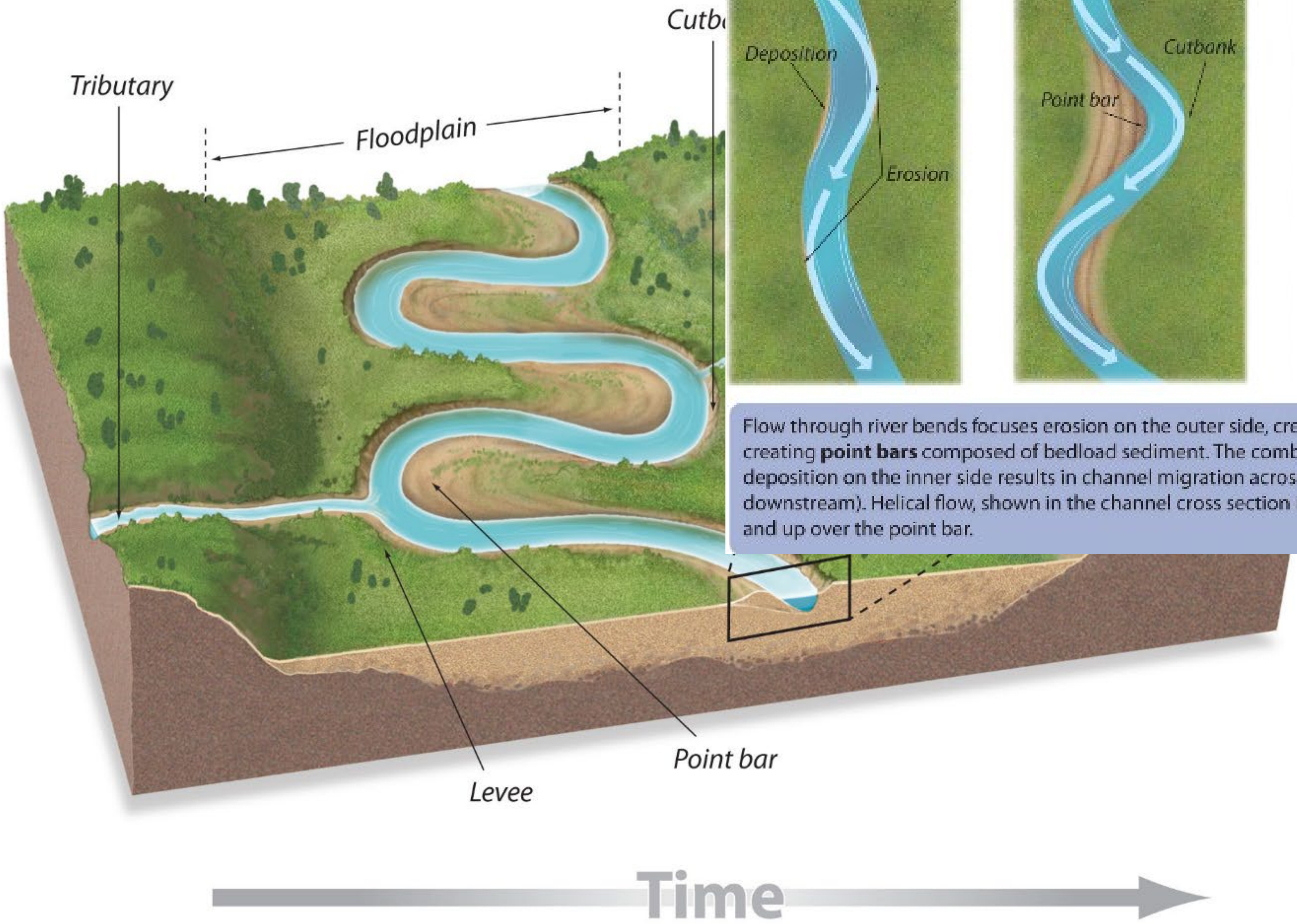


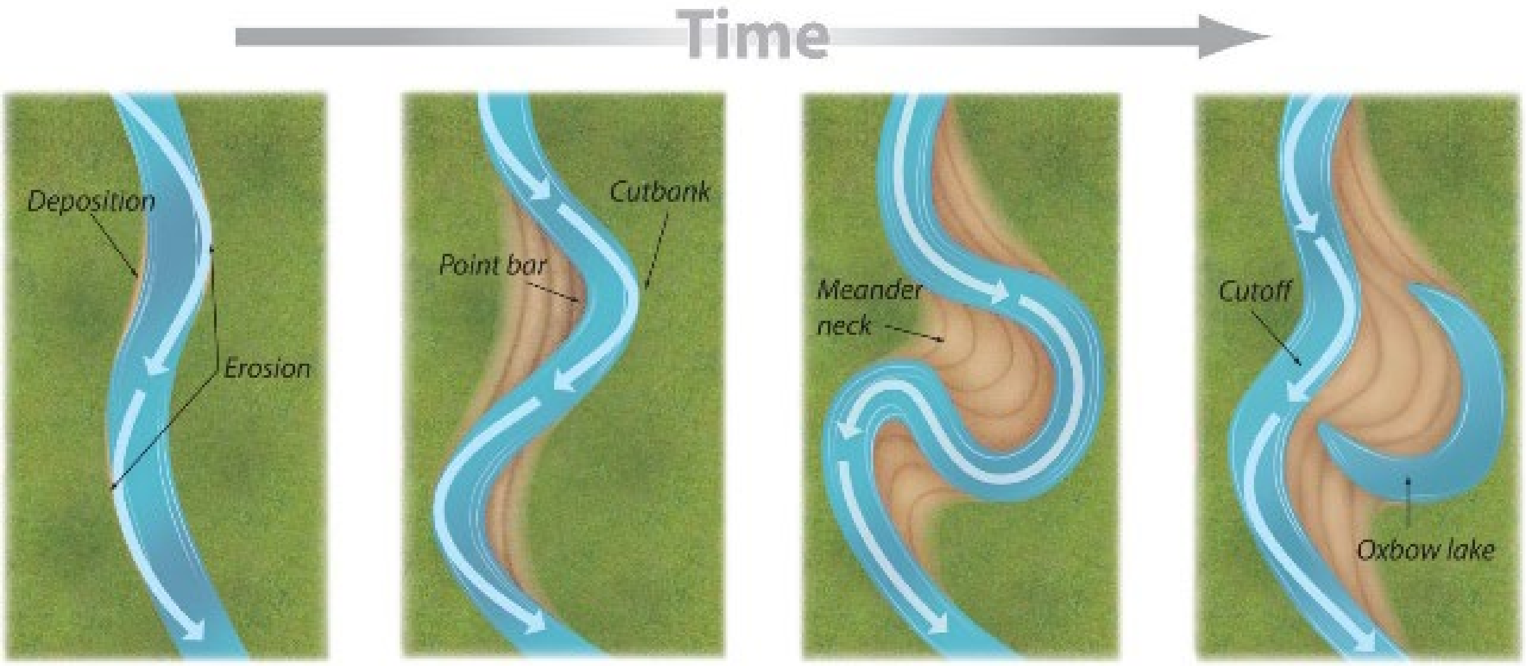
Braided
unvegetated bars

Anastomosing
vegetated islands

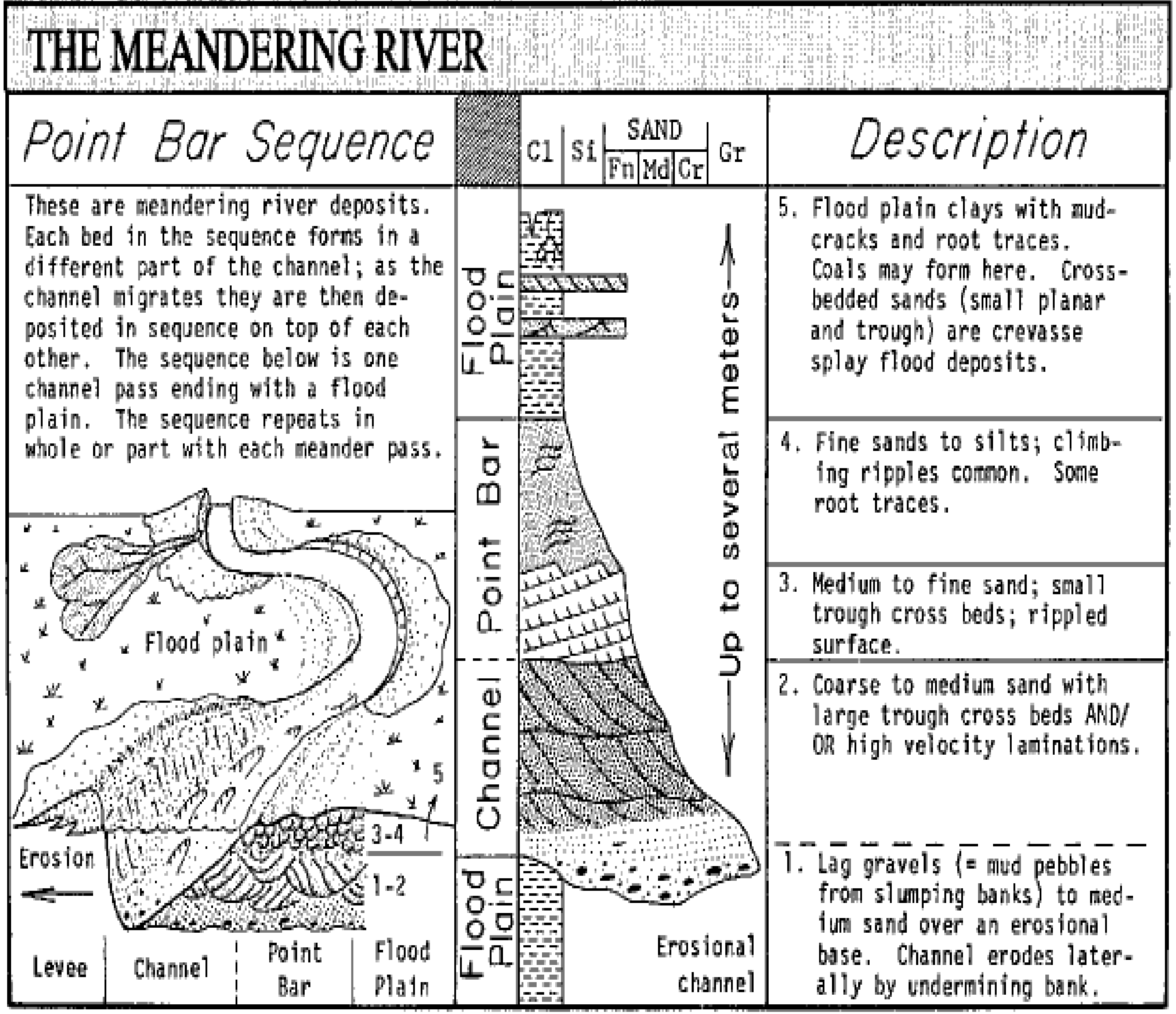
Single-thread channels exhibit either **straight** or **meandering** patterns. Straight channels are typically confined by valley walls and have **sinuosity** < 1.3, whereas meandering channels typically flow across broad floodplains and have sinuosity > 1.5. The meander belt is the zone of active meandering.

Multi-thread channels exhibit either **braided** or **anastomosing** patterns. Braided channels exhibit multiple unvegetated, frequently shifting channels that converge and diverge within a larger channelway. Anastomosing channels divide into multiple channels that flow around vegetated islands.

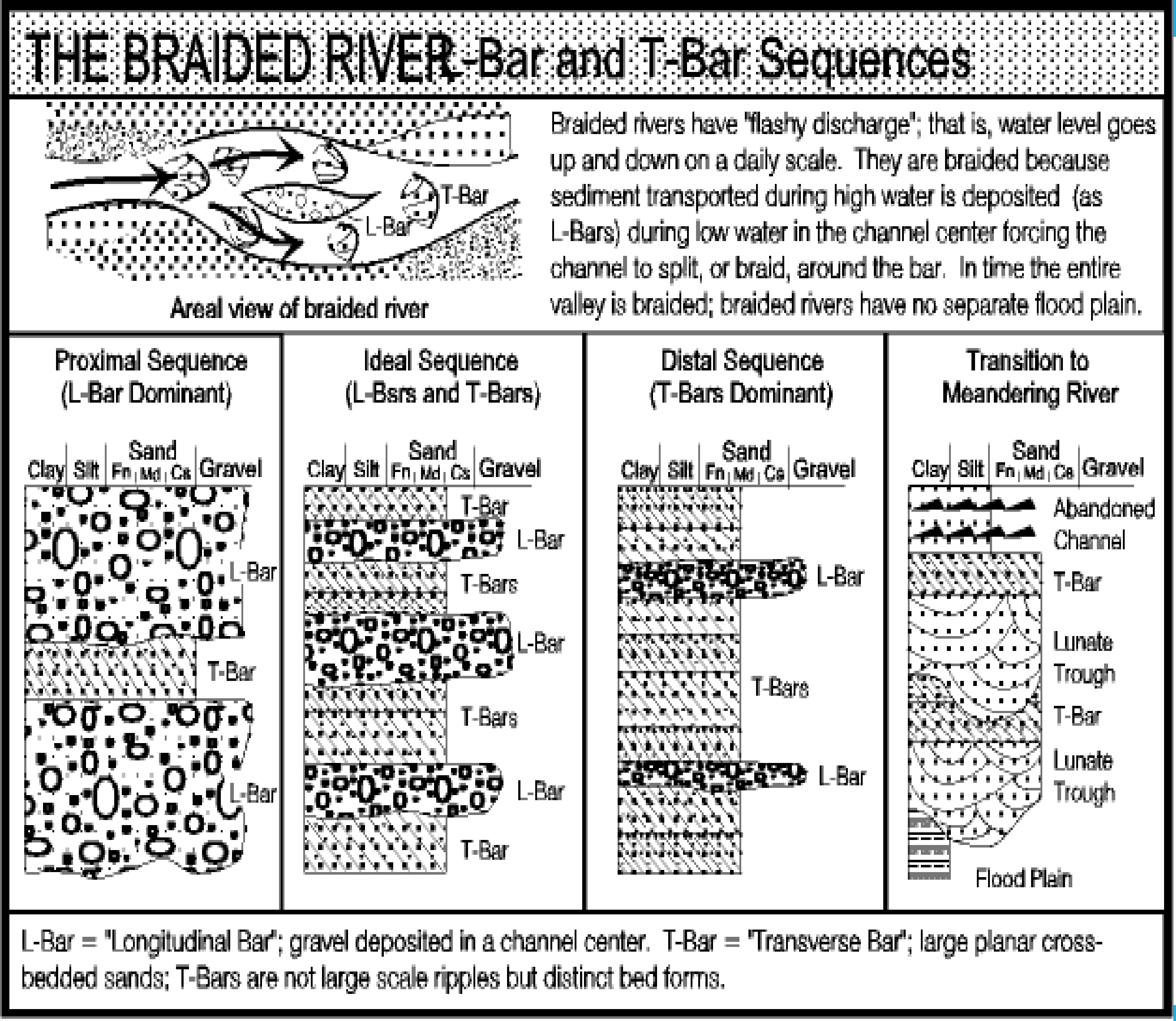




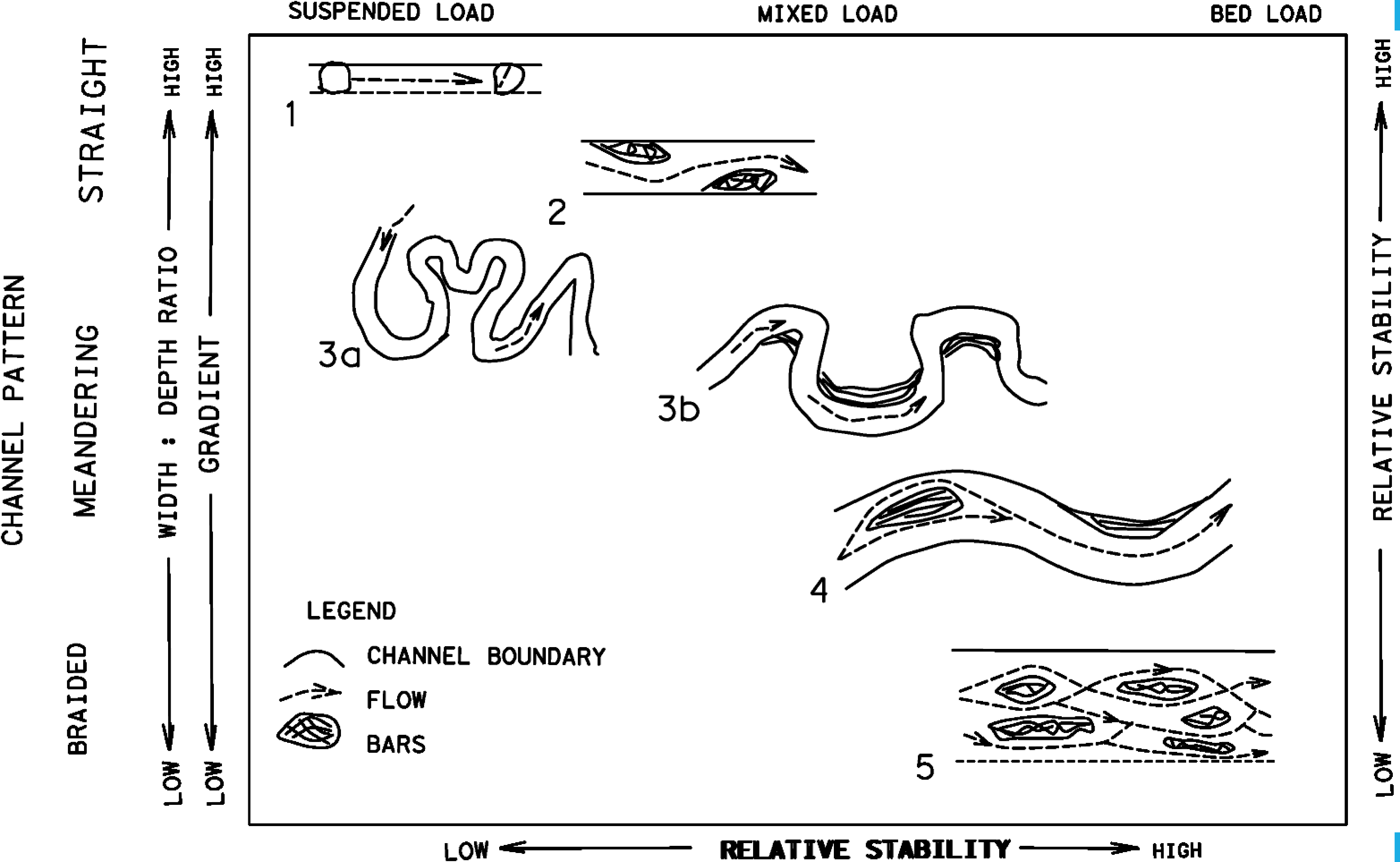
Flow through river bends focuses erosion on the outer side, creating **cutbanks,** and deposition on the inside of bends, creating **point bars** composed of bedload sediment. The combination of erosion on the outer side of bends and deposition on the inner side results in channel migration across the **floodplain** (toward the outside of bends and downstream). Helical flow, shown in the channel cross section inset, results in water flowing down along the cutbank and up over the point bar.

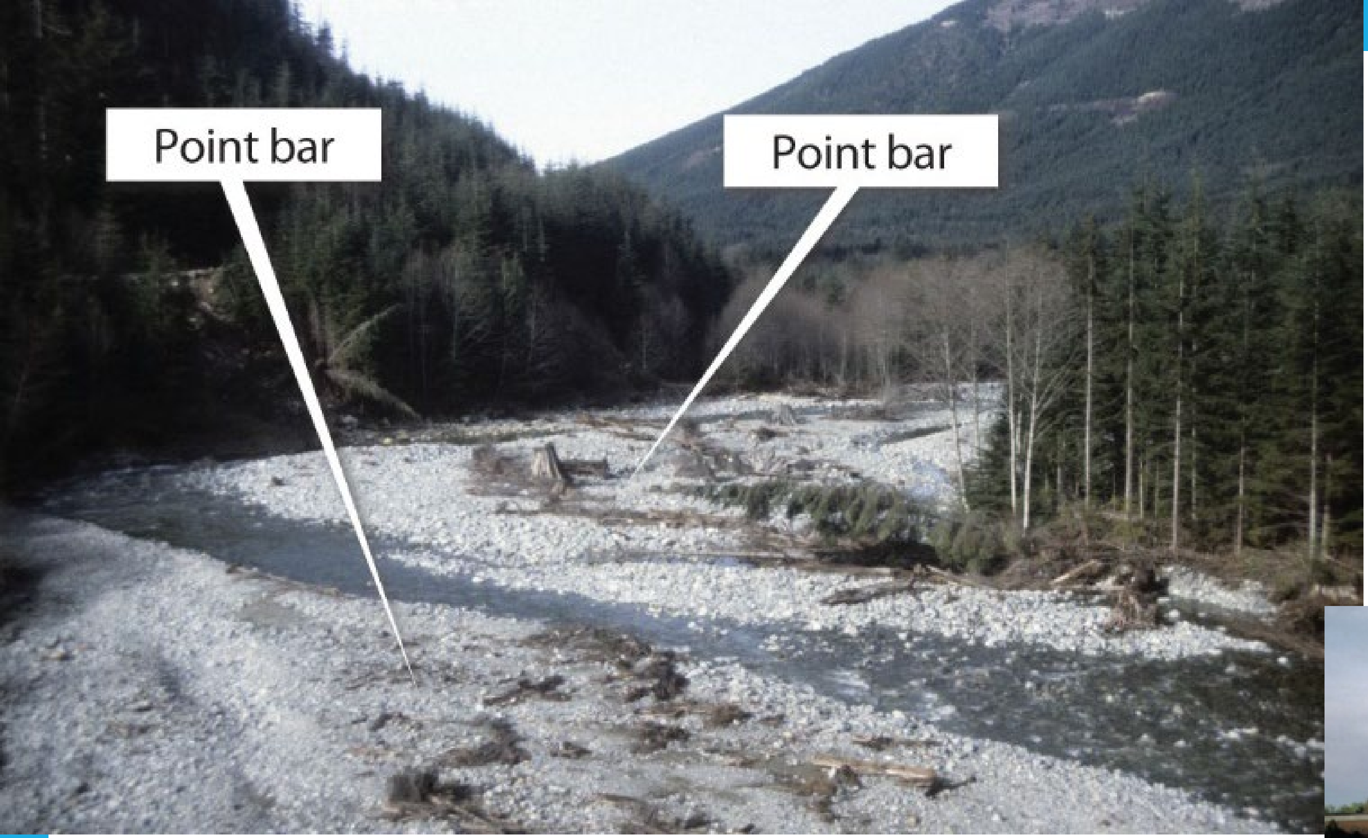


Primary sediment – fine/silt



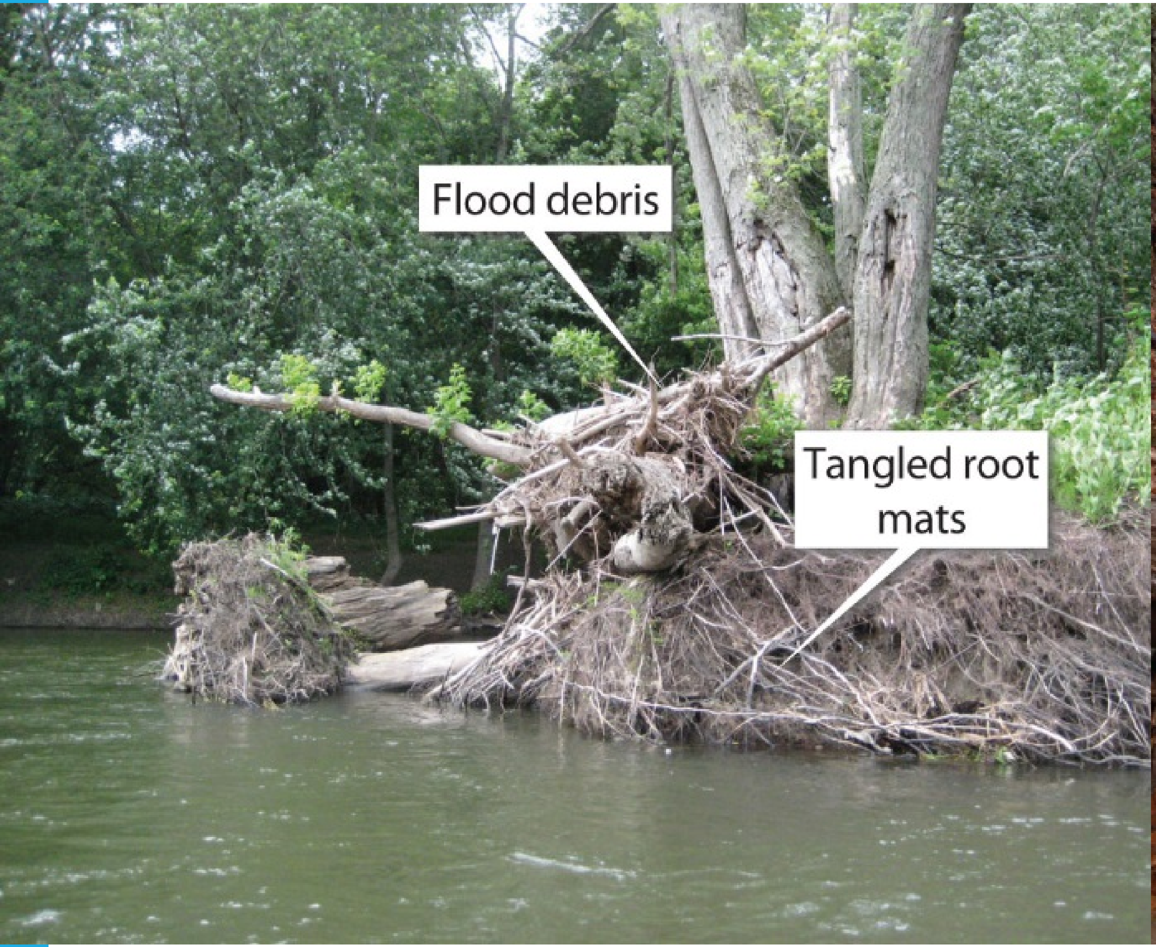
Primary Sediment – Course/gravel

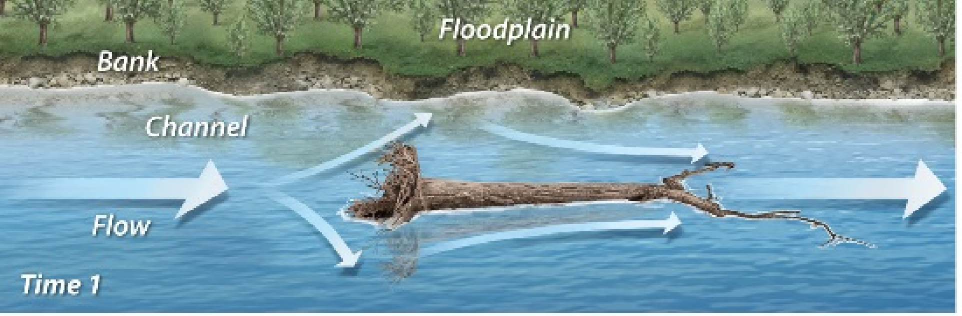

SUSPENDED LOAD
MIXED LOAD
BED LOAD
CHANNEL PATTERN
STRAIGHT
MEANDERING
BRAIDED
WIDTH : DEPTH RATIO
HIGH
LOW
GRADIENT
HIGH
LOW
1
2
3a
3b
4
5
LEGEND
CHANNEL BOUNDARY
FLOW
BARS
RELATIVE STABILITY
HIGH
LOW
LOW
RELATIVE STABILITY
HIGH


Point bar
Point bar

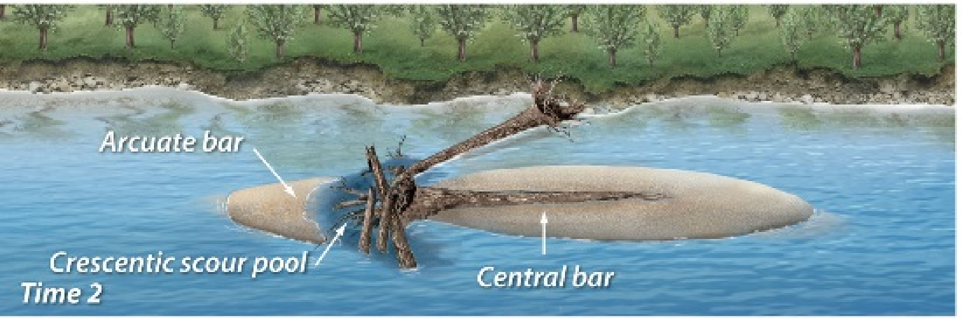

Mid-channel bar

Vegetation/Riparian System

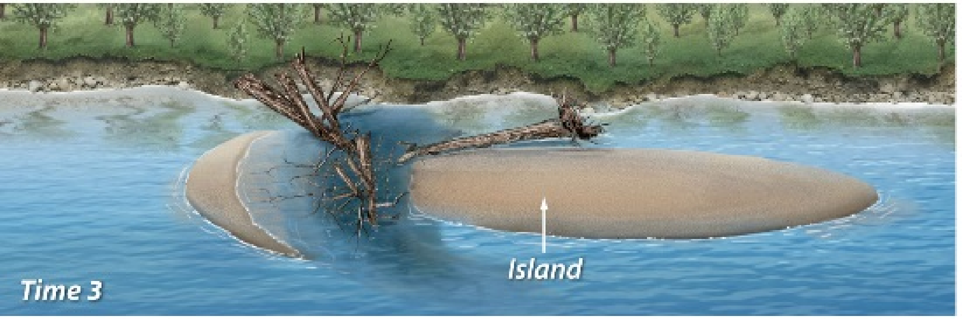




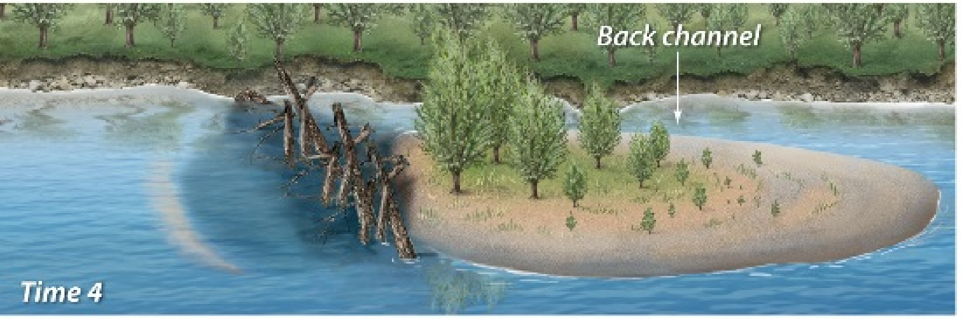
Deposition of a large, stable log (shown here with an attached rootwad) causes local flow **convergence** and **divergence** that result in bed scour (erosion) upstream and sediment deposition downstream. Faster flow around the rootwad causes scour.



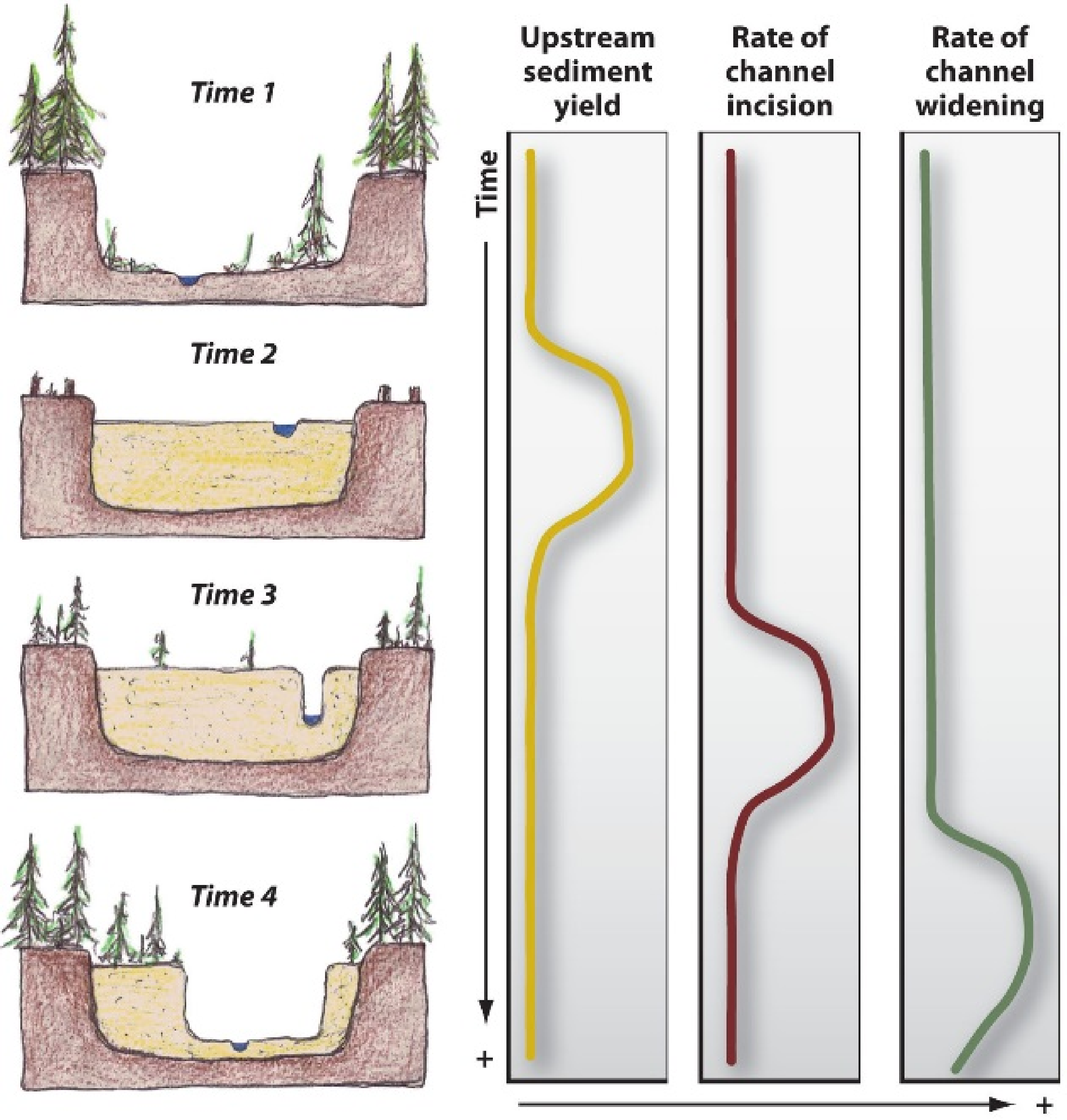
Scour around a stable, **key member** log creates a crescentic **scour pool** on the upstream side of the obstruction and deposition builds a **central bar** that buries the tree trunk on the downstream side. An arcuate bar forms as flow diverges upstream of the obstruction.



Continued scour and deposition occurs as additional debris racks up on the logjam, enlarging the scour pool. Continued deposition can build up the central bar into an island, and flow deflection can result in localized channel widening due to bank scour.



Eventually the logjam can become partially buried. It then protects the associated island from erosion, providing stable habitat where trees large enough to produce key member logs can grow even in disturbance-prone valley bottoms. The bar can eventually attach to the channel bank and become integrated into the floodplain.



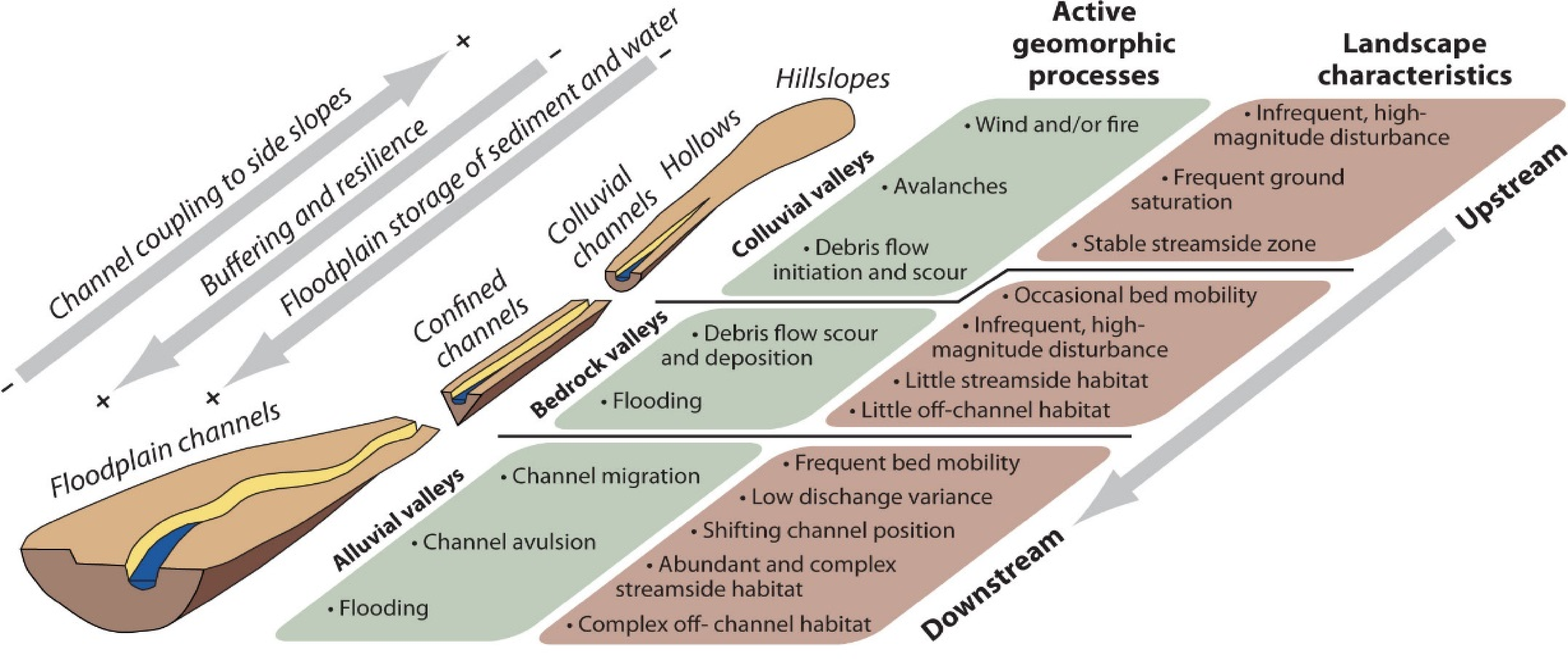
Time 1: Prior to European settlement, the drainage basin is forested and the channel is stable. Sediment yield is low.

Time 2: When the forest is cleared, **sediment yield** quickly rises as **root cohesion** is lost. Soil is exposed to rain-drop impacts and runoff, and gullying and landsliding are common. The channel is overloaded with sediment and rapidly aggrades.

Time 3: When the trees regrow, sediment yield drops quickly and the channel incises because the stream is carrying little sediment.

Time 4: With the new forest in place and incision complete, the channel begins to widen, meandering and laterally cutting away at the terrace of **legacy sediments** deposited immediately after deforestation.

The channel evolution that resulted from European landscape disturbance in North America is a prime example of **complex response.** An initial perturbation, deforestation and other land-use changes such as agriculture, changed hillslope erosion rates and sediment supply to channels. Crossing a **threshold,** channels aggraded. When forests returned, another threshold was crossed and channels incised before starting to widen. The effects of land clearance several centuries ago are still reflected in a complex and interrelated set of landscape scale process and landform changes.



Drainage basins are composed of hillslopes and channels, including unchanneled slopes high in the basin uplands and large floodplain channels in the lowland. In between are colluvial channels, just downstream of channel heads, and there can be confined channels in steep bedrock valleys. The active geomorphic processes that shape and disturb the landscape change predictably downstream, and result in a suite of landscape characteristics. Not all landscapes include all of the landforms illustrated here.

Luna Leopold

"A river or drainage basin might be considered to have a heritage, rather than an origin."

First Chief Hydrologist at the USGS

http://eps.berkeley.edu/people/lunaleopold/

https://www.usgs.gov/news/lessons-learned-legen

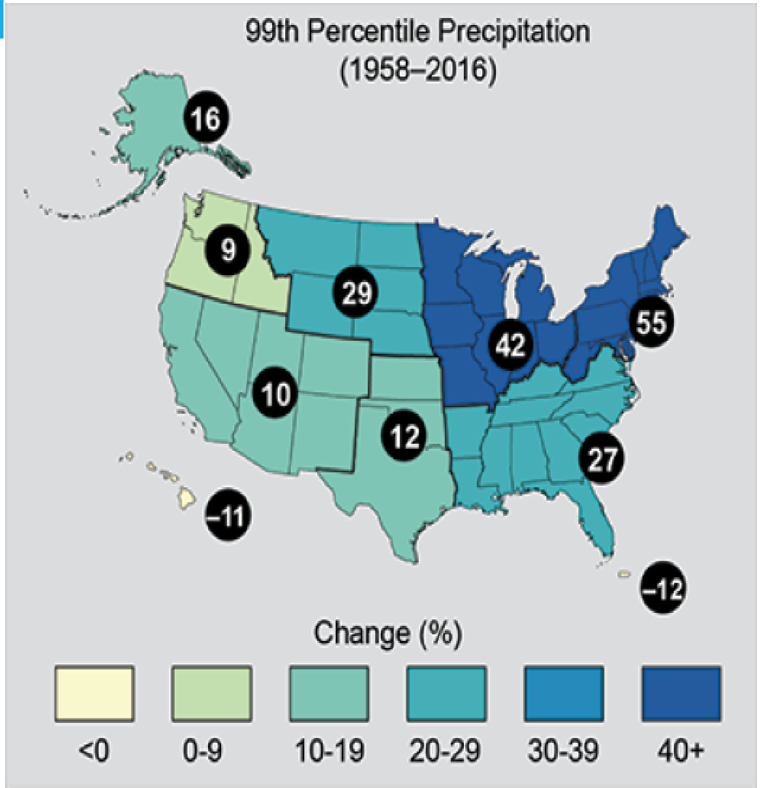
HYDROGRAPHS

Provides an important visual reflection of precipitation in a given watershed.

(A fingerprint if you will)

The Water Year

- October 1st to September 30th
- Based on recharge time.



Observed change in heavy precipitation (the heaviest 1%) between 1958 and 2016. Figure taken from The Climate Science Special Report (Easterling et al. 2017) (https://science2017.globalchange.gov/).

Date	*Grundy Center* ppt (inches)
7/10/2000	5.91
4/25/2008	4.35
8/29/2015	*4.11*
9/4/2018	*3.98*
8/6/2018	*3.76*
5/30/2013	*3.56*
9/11/2006	3.36
7/27/1990	3.22
7/1/2018	*3.17*
9/13/1991	3.16

Date	*Vinton* ppt (inches)
8/12/2016	*6.04*
5/30/2008	4.15
6/15/1982	3.98
6/12/2015	*3.8*
11/4/2003	3.49
7/1/2014	*3.33*
7/9/1993	3.29
6/17/1990	3.25
8/8/1991	3.18
4/18/2013	*2.93*

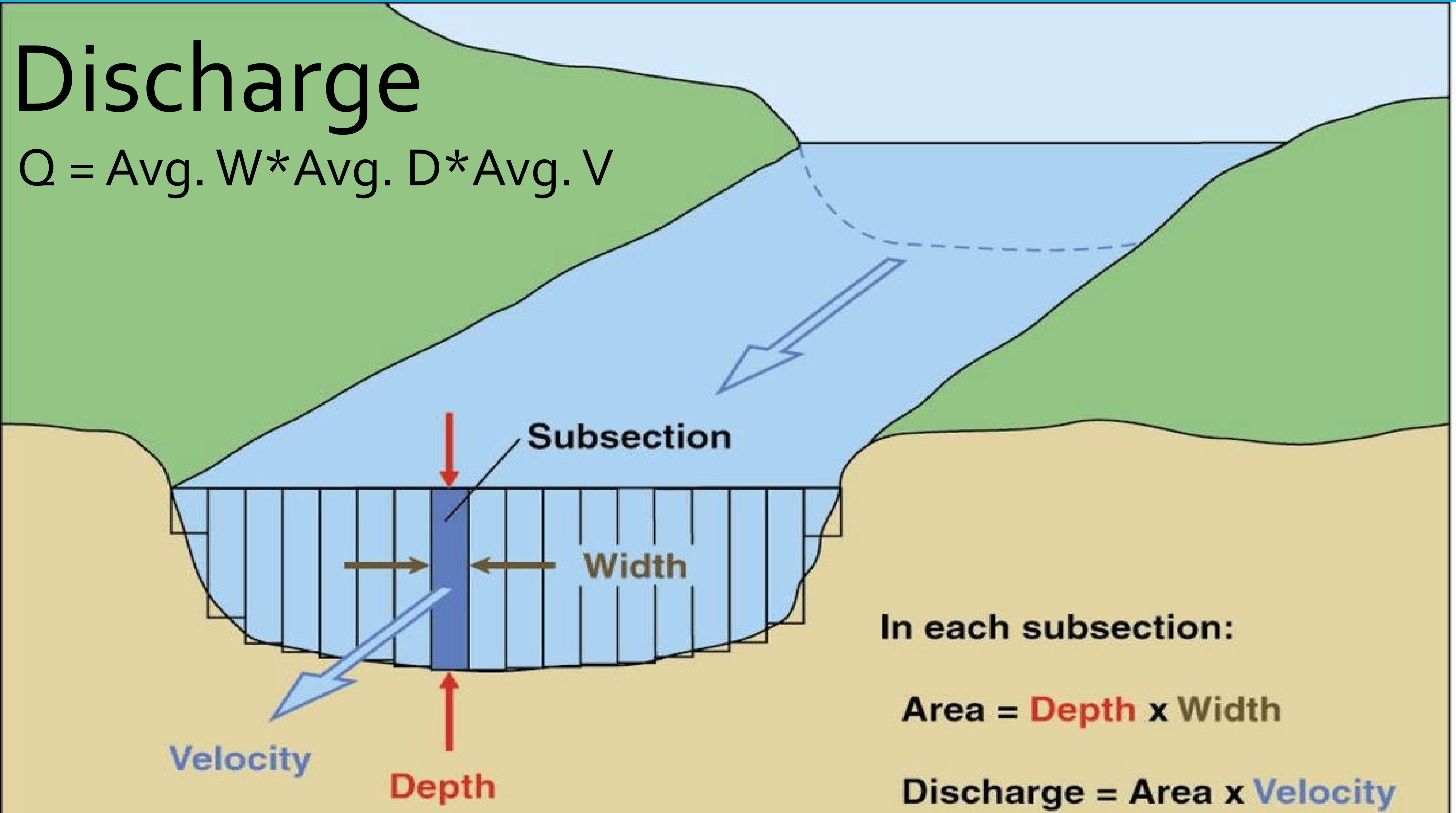
Date	*Cedar Rapids* ppt (inches)
6/17/1990	4.42
8/12/2016	*4.14*
7/17/2007	3.85
6/12/2015	*3.75*
4/18/2013	*3.66*
6/10/2018	*3.36*
8/26/1987	3.28
4/14/2014	*3.16*
6/15/1982	3.11
7/18/1982	3.1

(Data source: http://www.prism.oregonstate.edu/)

IIHR Hydroscience & Engineering Iowa Flood Center

Discharge

Q = Avg. W*Avg. D*Avg. V



Stream Flow Measurement

- Gauging stations
  - Distributed in rivers throughout the world
  - Monitor stream discharge, water surface level, and the amount of suspended sediment
  - Continuously or periodically
- Discharge = (Water Velocity * Channel Area)

https://waterdata.usgs.gov/ia/nwis/rt CF = https://waterdata.usgs.gov/ia/nwis/uv?site_no=05464000

https://waterdata.usgs.gov/ia/nwis/rt

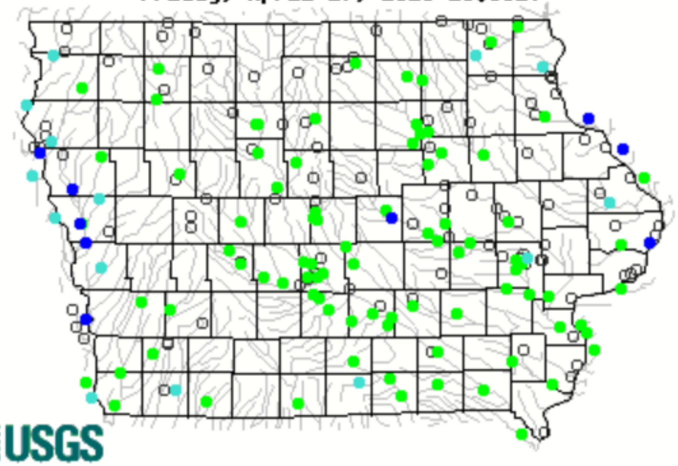
uni chas tech

Most Visited GeoReM - Database o...

Daily Streamflow Conditions

Select a site to retrieve data and station information.

Friday, April 17, 2020 16:30ET



USGS

Explanation

- High
- > 90th percentile
- 76th - 90th percentile
- 25th - 75th percentile
- 10th - 24th percentile
- < 10th percentile
- Low
- Not ranked

The colored dots on this map depict streamflow conditions as a percentile, which is computed from the period of record for the current day of the year. Only stations with at least 30 years of record are used.
The **gray circles** indicate other stations that were not ranked in percentiles either because they have fewer than 30 years of record or because they report parameters other than streamflow. Some stations, for example, measure stage only.

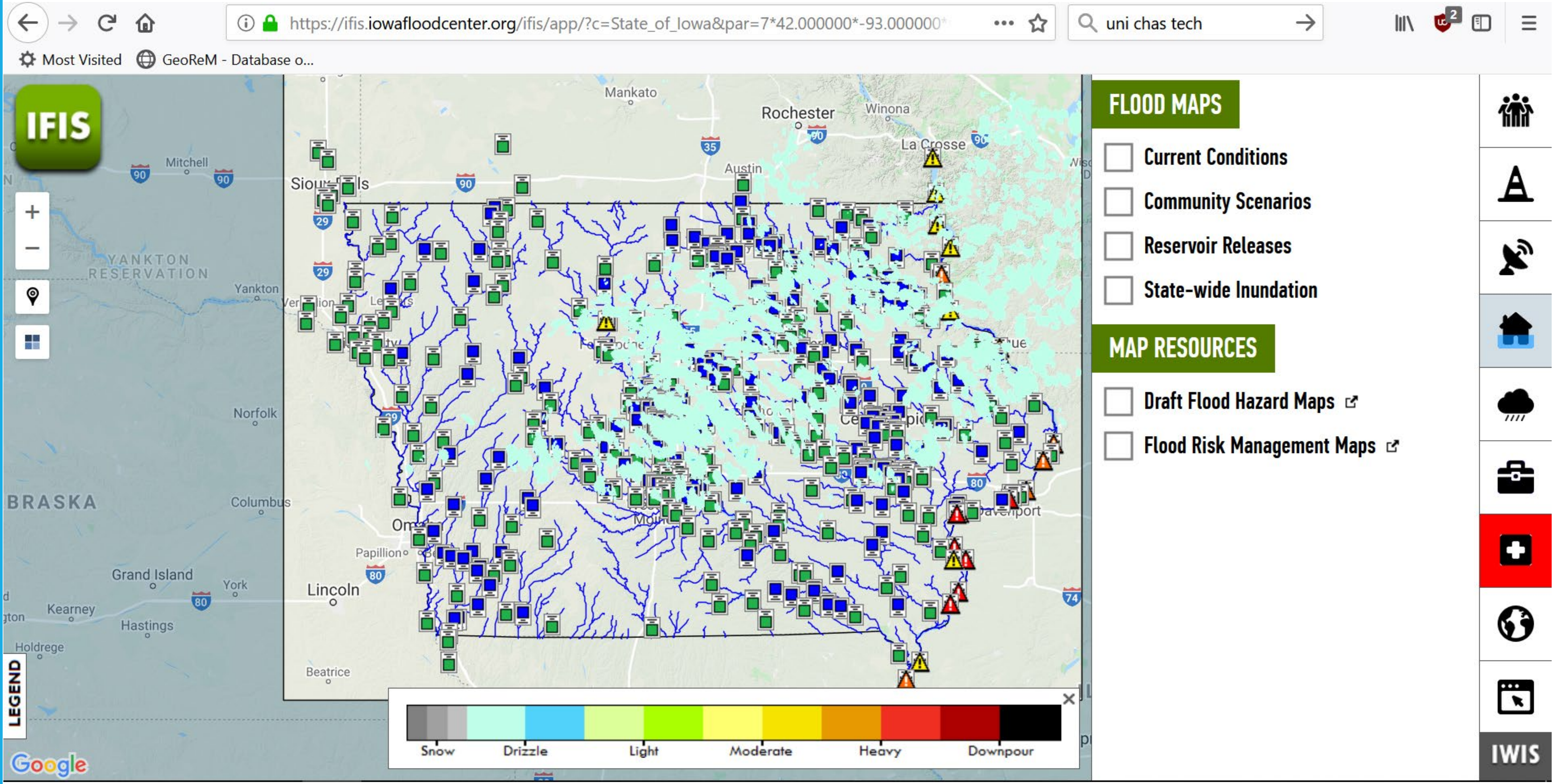
Statewide Streamflow Current Conditions Table

Real-time data typically are recorded at 15-60 minute intervals, stored onsite, and then transmitted to USGS offices every 1 to 4 hours, depending on the data relay technique used. Recording and transmission times may be more frequent during critical events. Data from real-time sites are relayed to USGS offices via satellite, telephone, and/or radio and are available for viewing within minutes of arrival.

All current conditions data are **provisional and subject to revision**.

Build Current Conditions Table	Show a custom current conditions summary table for one or more stations.
Build Time Series	Show custom graphs or tables for a series of recent data for one or more stations.

Iowa Flood Information System

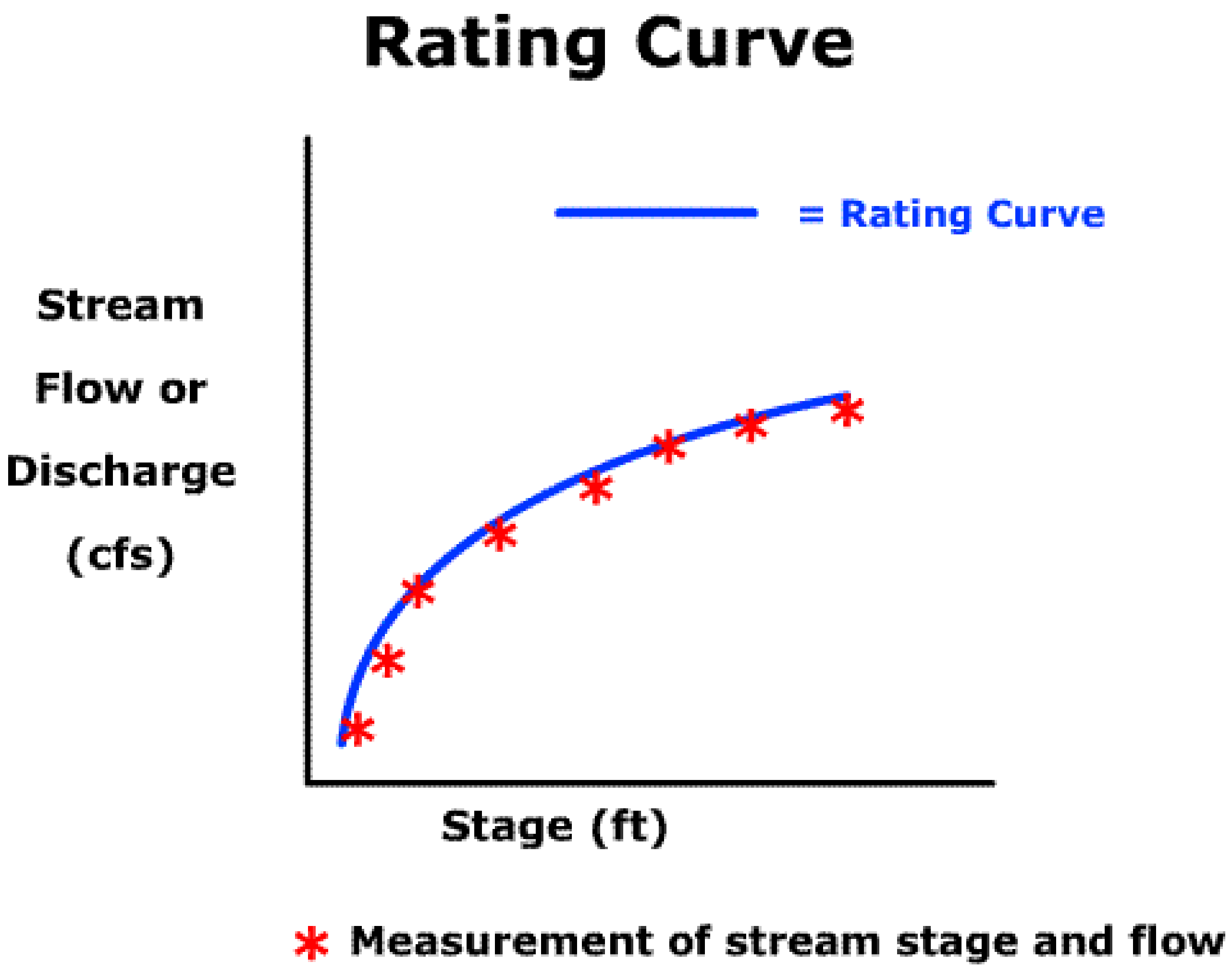


Rating curves

- Once the discharge is determined for a variety of rainfall events, a rating curve may be produced.

Then

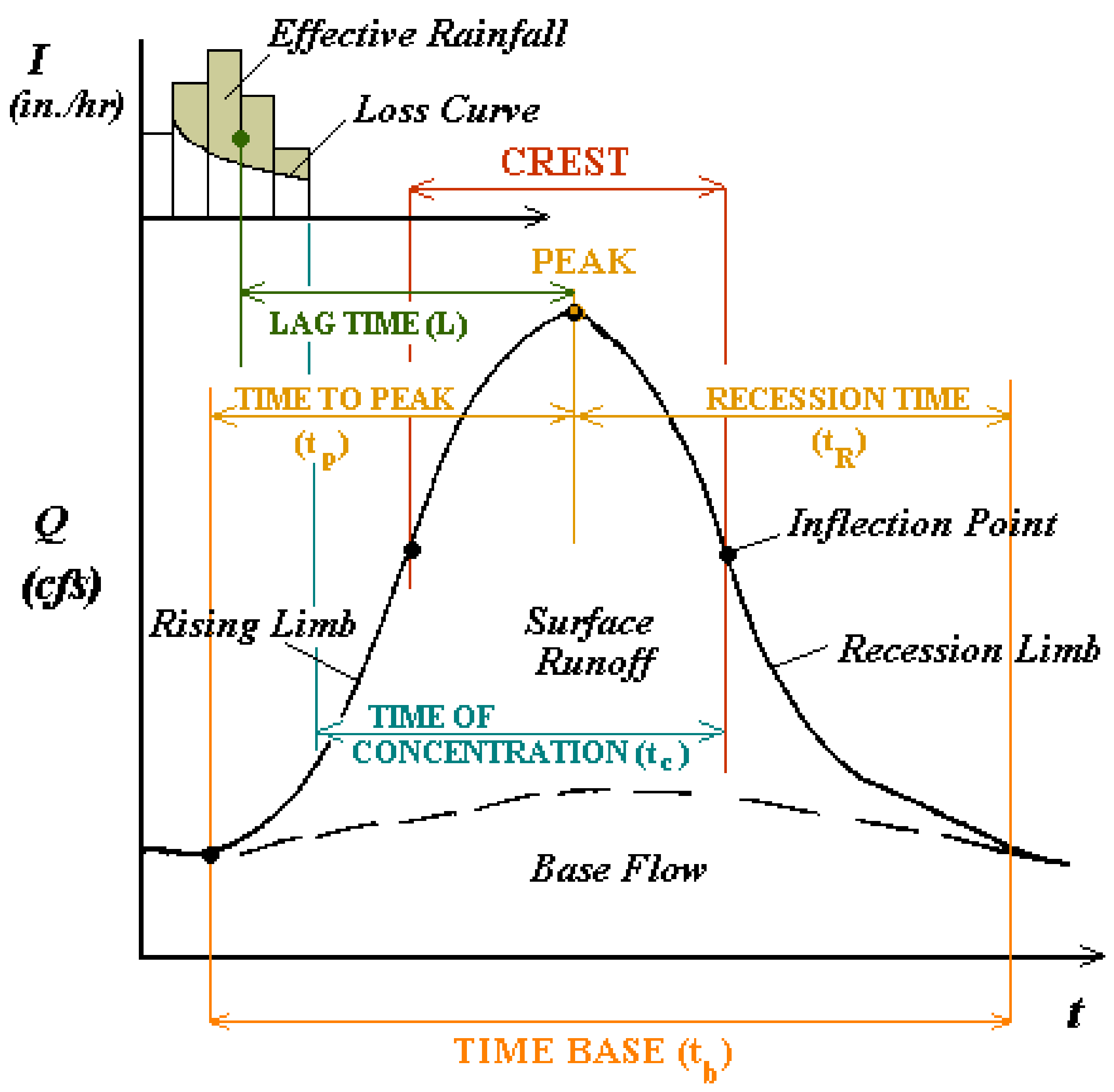
- Discharge may be determined by simply measuring the water surface

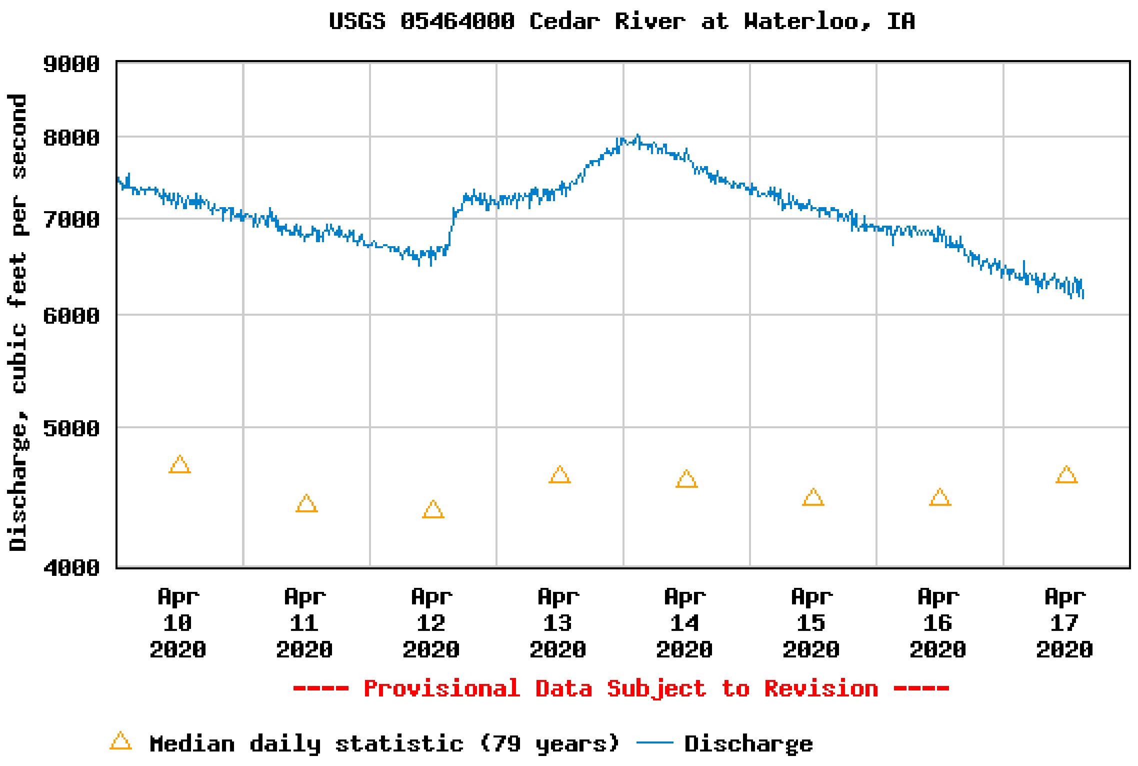


Hydrographs

- Plot Discharge vs. Time
- By connecting the two low points on a hydrograph it is possible to separate baseflow (groundwater) and storm surge from a rainfall event.
- Helpful in determining flood crests as well as contaminate plum migration

Properties of Hydrographs

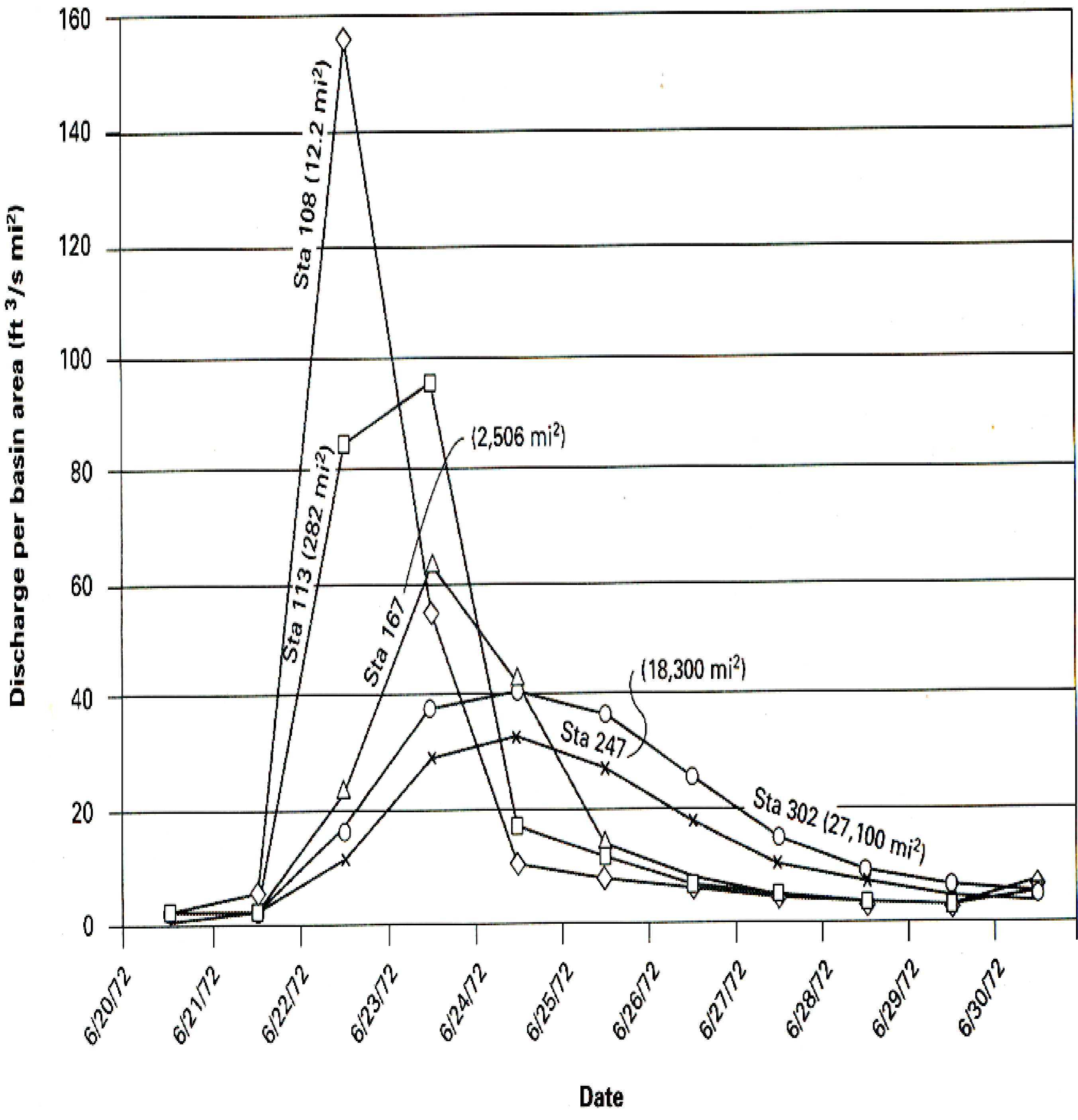




Hydrographs

- Low-ordered streams will appear 'flashy'

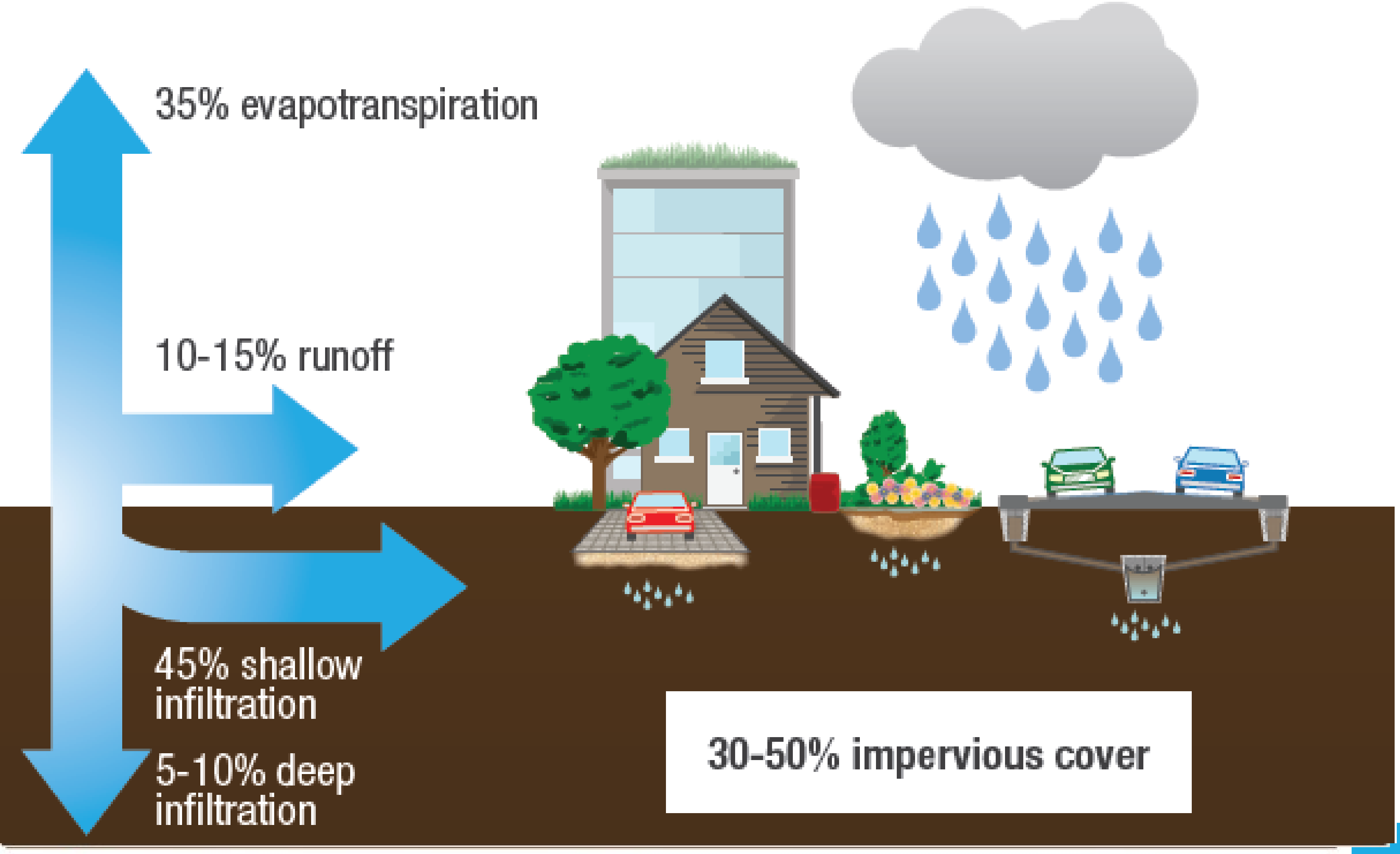
- High-ordered stream will appear 'gradual'



Urban Hydrology

Development with Low Impact Development

https://wiki.sustainabletechnologies.ca/wiki/Urbanization



River Restoration – Iowa DNR

https://www.iowadnr.gov/Environmental-Protection/Water-Quality/River-Restoration/River-Restoration-Toolbox