

Lowland Rivers & Fluvial landscapes

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ACNA4007 – Physical Landscape and the Geosphere



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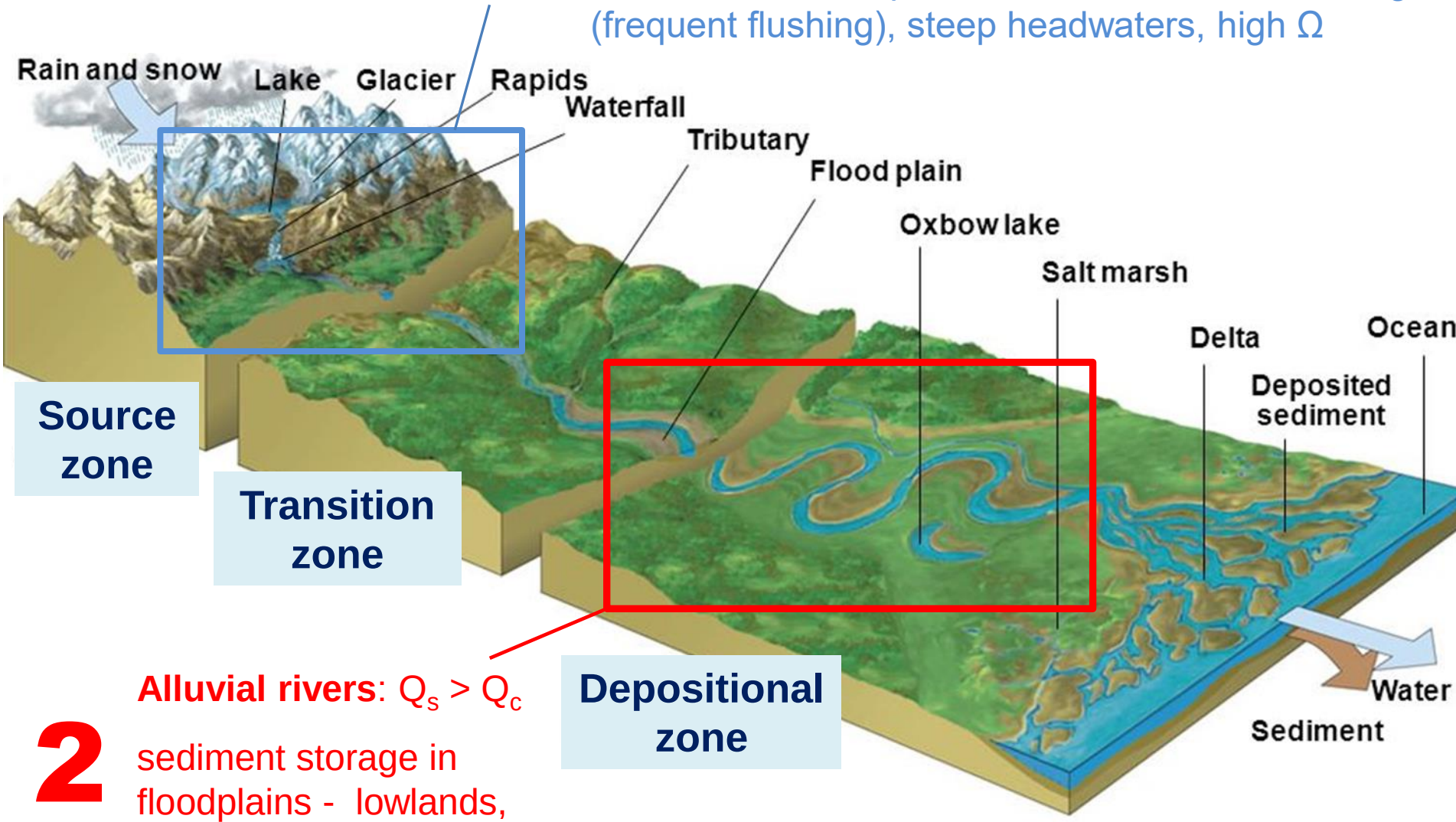
Understanding the fluvial system...

Last Lecture...

1

Bedrock rivers: $Q_c > Q_s$ (i.e. excess power)

>50% 'bedrock' exposed, minimal sediment storage (frequent flushing), steep headwaters, high Ω



Source zone

Transition zone

Depositional zone

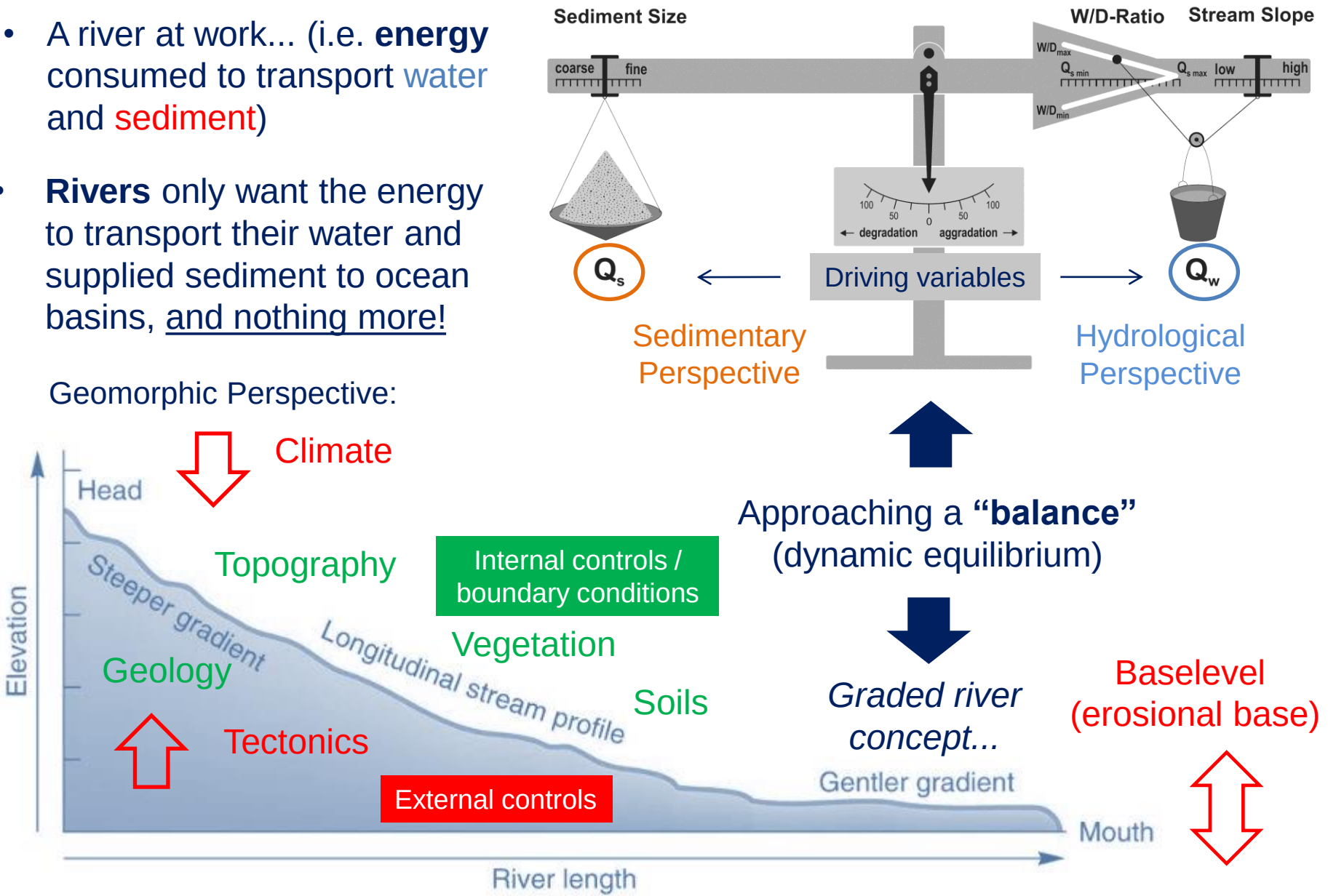
2

Alluvial rivers: $Q_s > Q_c$

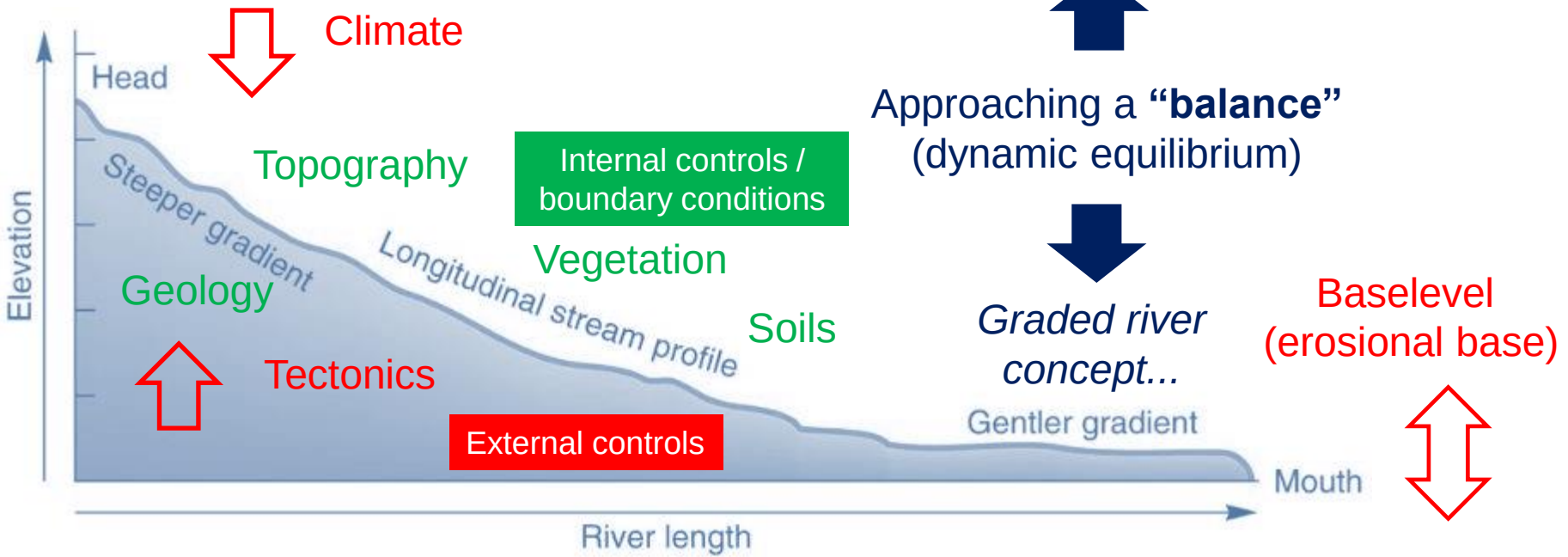
sediment storage in floodplains - lowlands, high Q , low S

Understanding the fluvial system...

- A river at work... (i.e. **energy** consumed to transport **water** and **sediment**)
- **Rivers** only want the energy to transport their water and supplied sediment to ocean basins, and nothing more!

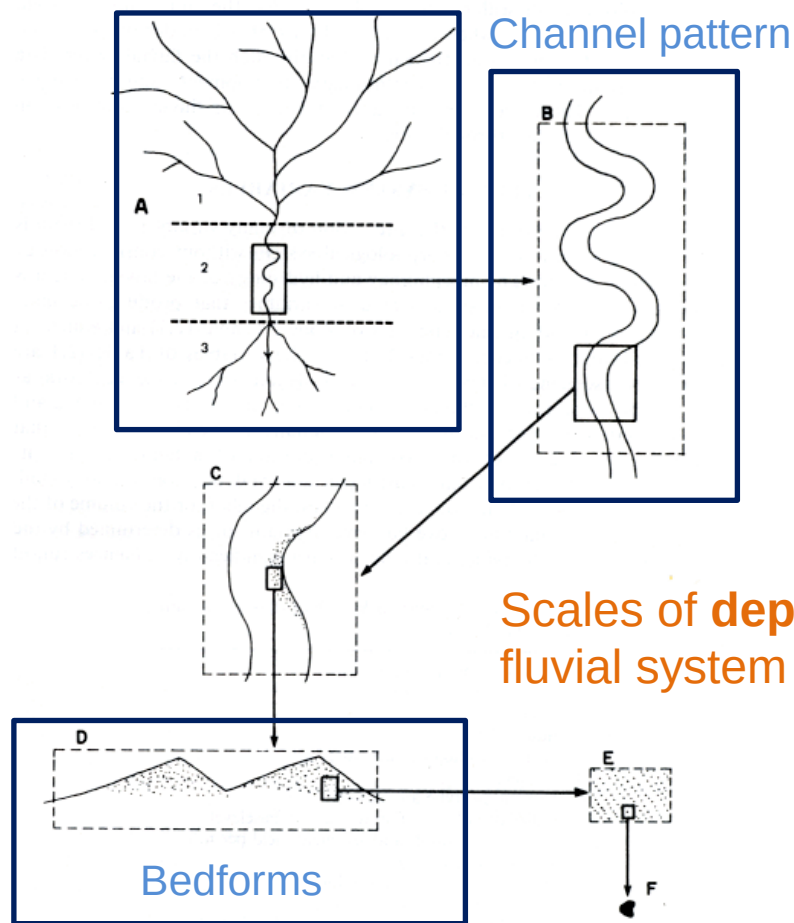


Geomorphic Perspective:



Understanding the fluvial system...

- From small to large-scale...
(from short to long timescale)

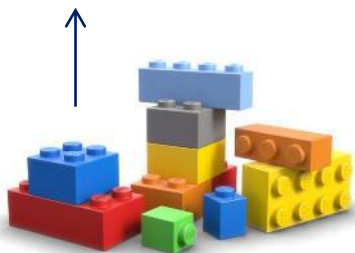


- Characteristics depend on **type of river**
(depositional style) =
Channel form



Channel
& Reach

- Depositional Environment** = specific set of **depositional elements**



Channel bars

Scales of **depositional elements** in a fluvial system



Fluvial Ripples

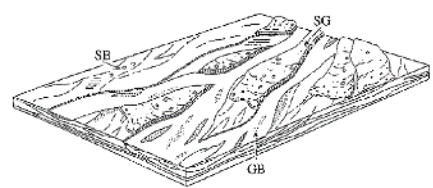


Fluvial Dunes

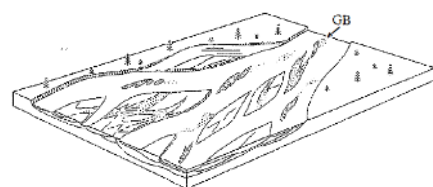
- Depositional elements** built with sedimentary characteristics (grain size, structure, lithologies etc.): **Facies**

Channel form and depositional environments

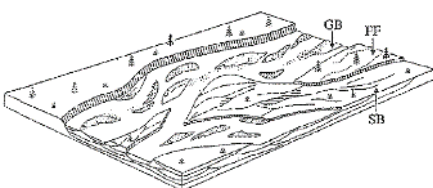
Sedimentary perspective



1 Gravel-bed braided river



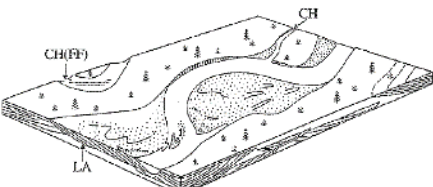
2 Gravel-bed braided river



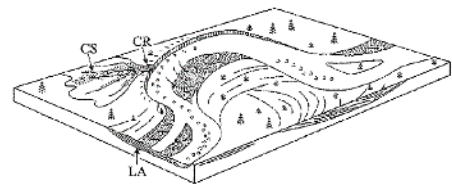
3 Deep Gravel-bed braided river



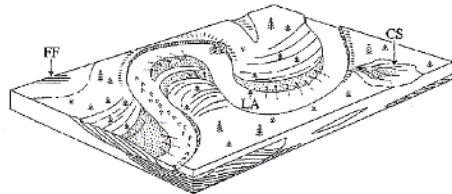
X Wandering gravel bed river



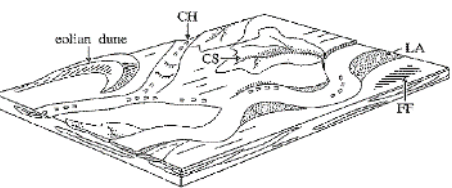
4 Gravel bed meandering river



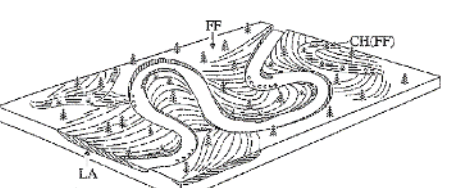
5 Gravel-sand meandering river



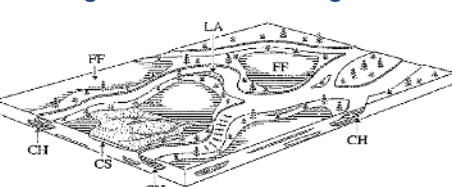
6 Sand bed meandering stream



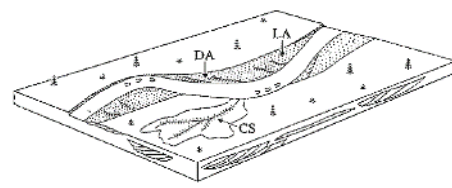
X Ephemeral sand bed meandering



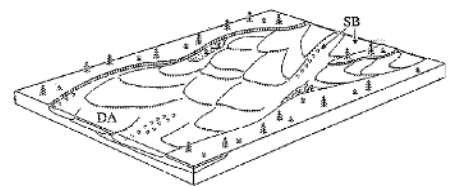
7 Fine-grained meandering river



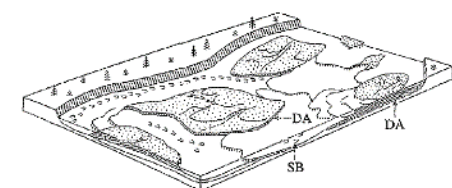
8 Anastomosed river



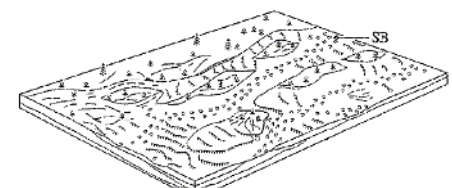
X Low-sinuosity river with alternate bars



9 Shallow perennial sand-bed braided river



10 Deep perennial sand-bed braided river



11 Distal sheetflood sand-bed river

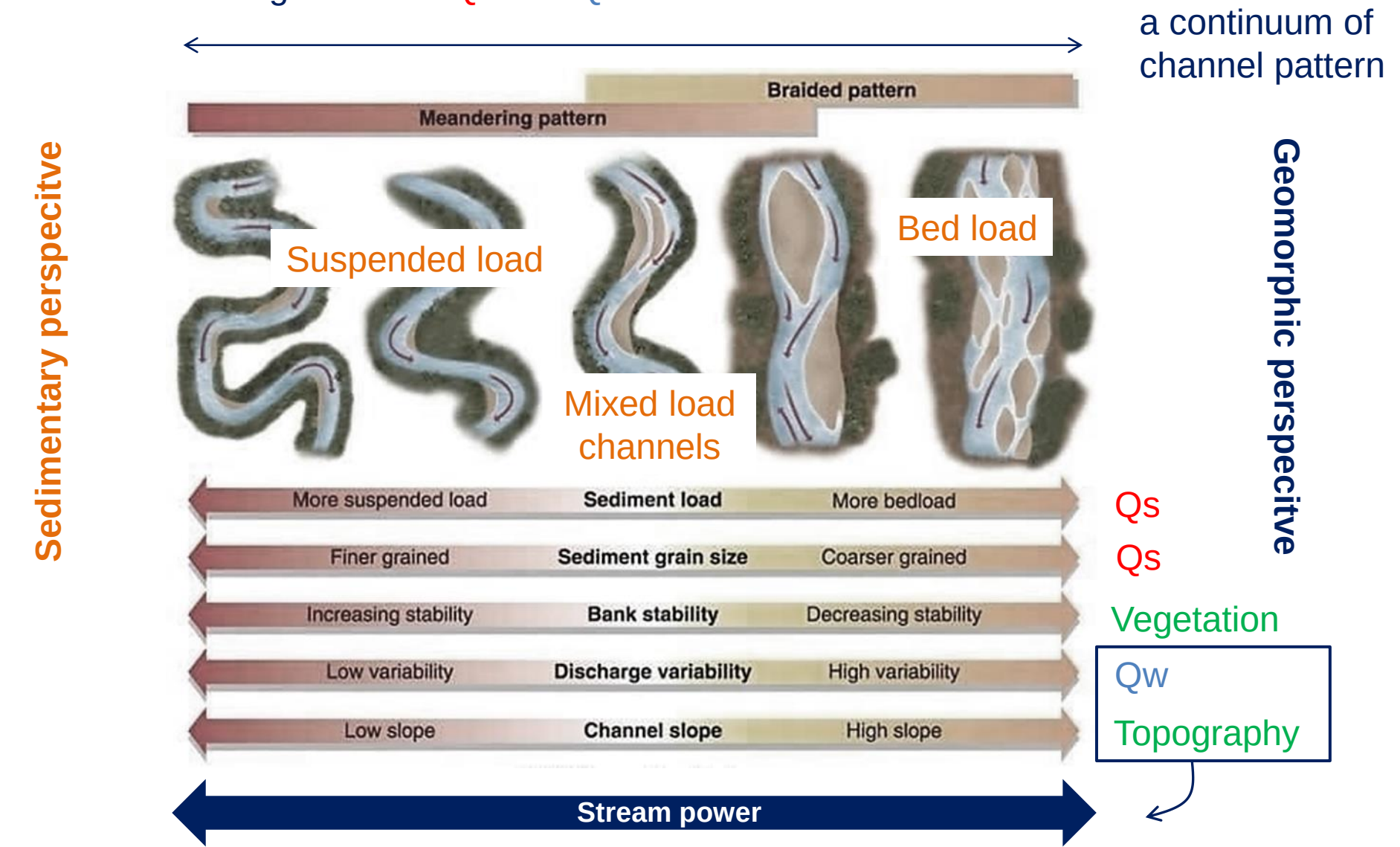


12 Flashy ephemeral sheetflood sand-bed river

Gravel-dominated Sand-dominated high-sinuosity Sand-dominated low-sinuosity

Channel form and depositional environments

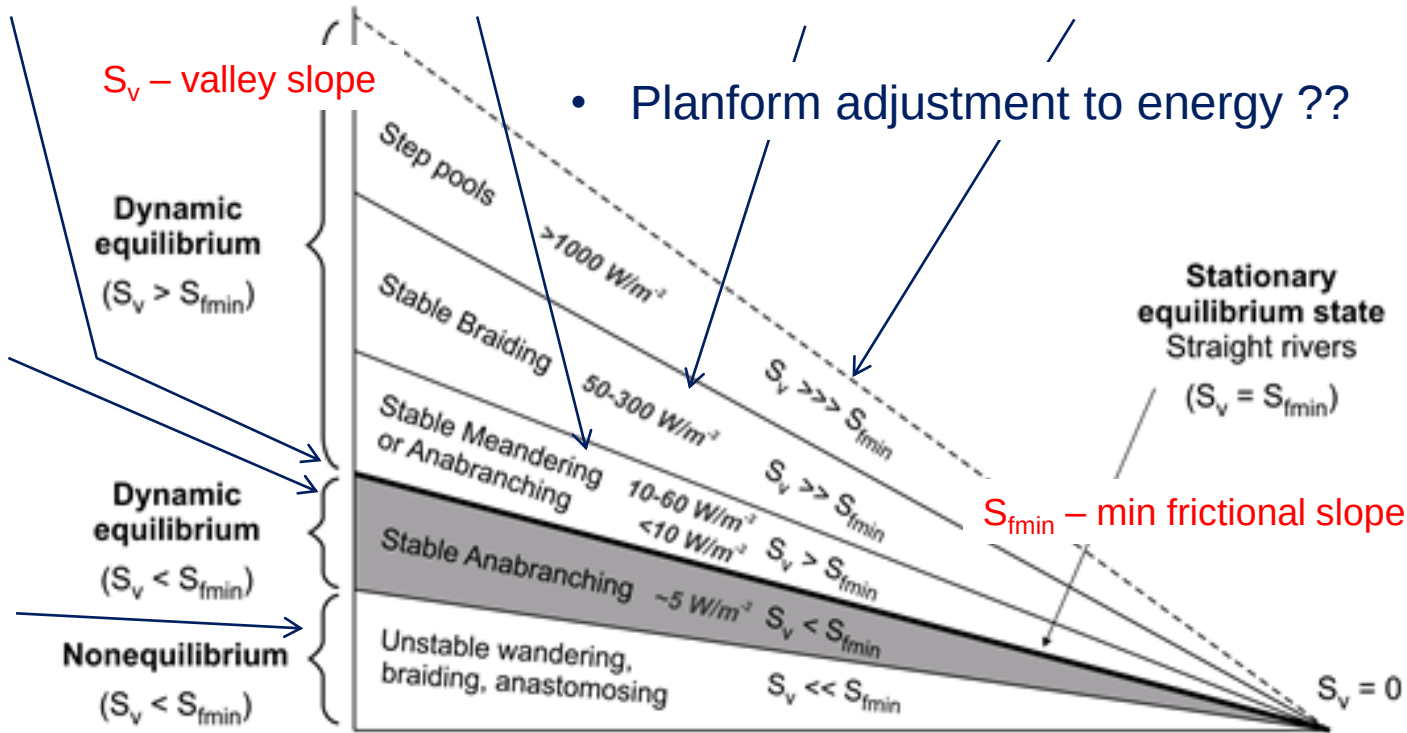
- **River planform** = adjustment to **boundary conditions (internal variables)**
+ controlling variables Q_s and Q_w



Channel form and depositional environments



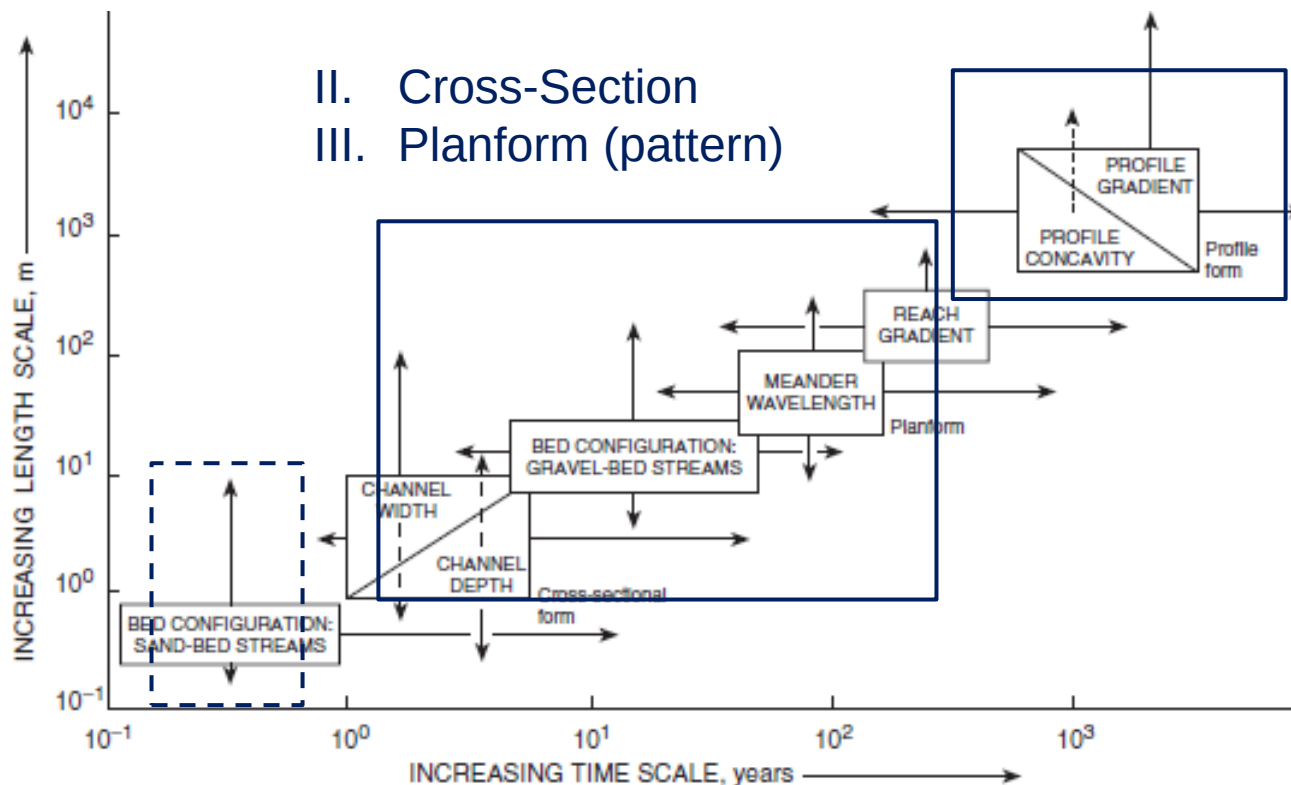
Rivers with **exactly** the energy required to move their bedload are **straight** without bedforms and are in the stationary equilibrium state



Dynamics – adjustment and change

1. Q_w , Q_s and **boundary conditions** **change downstream** – systematic change in form (pattern) and processes downstream...
2. Q_w and Q_s both fluctuate through time, and **boundary conditions** can change over long timescales - **continuous adjustment** takes place... how?

IV. Slope – Longprofile

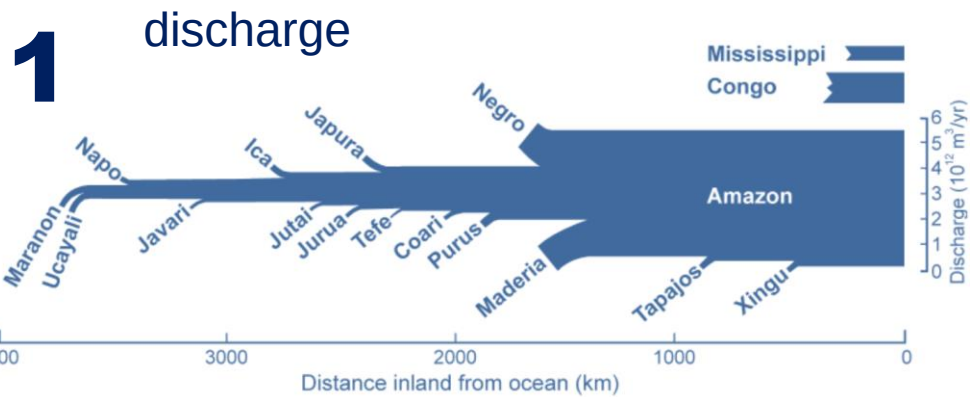
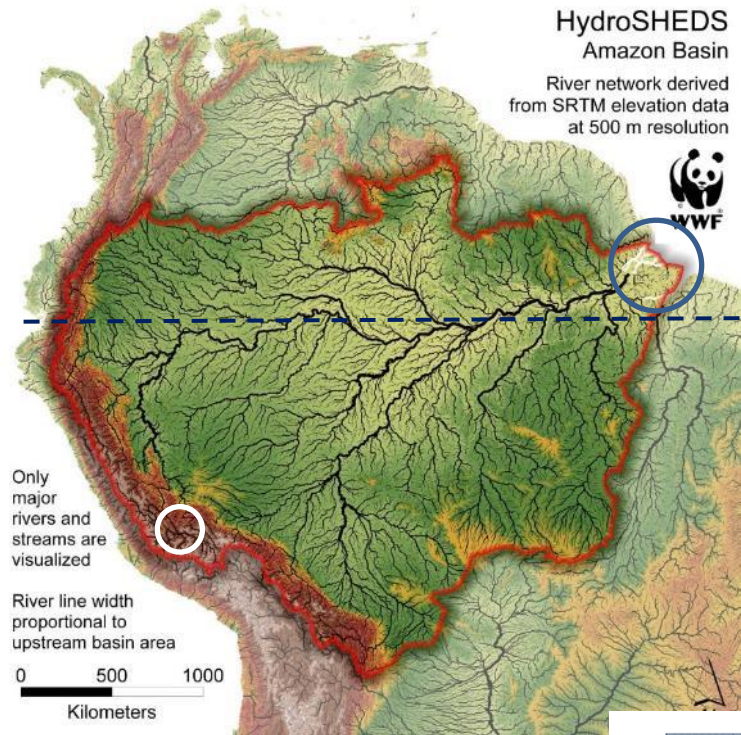


I. Bed forms and roughness

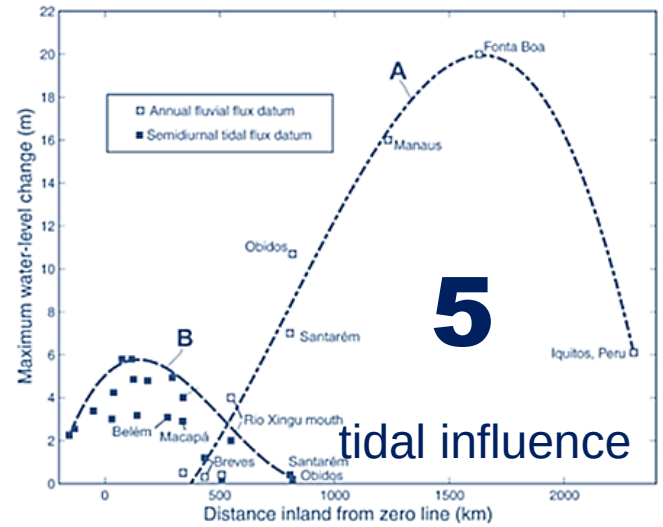
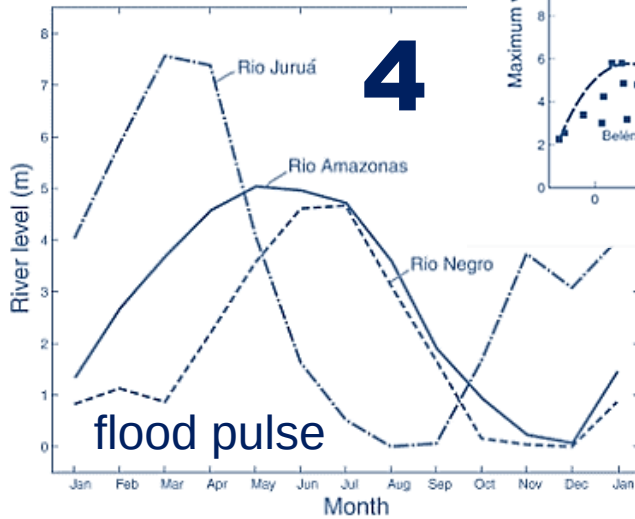
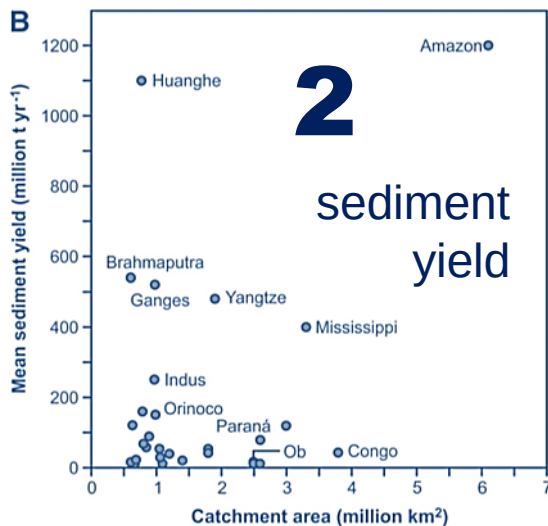
2 minutes...



Fluvial landscapes of the Amazon River Basin...



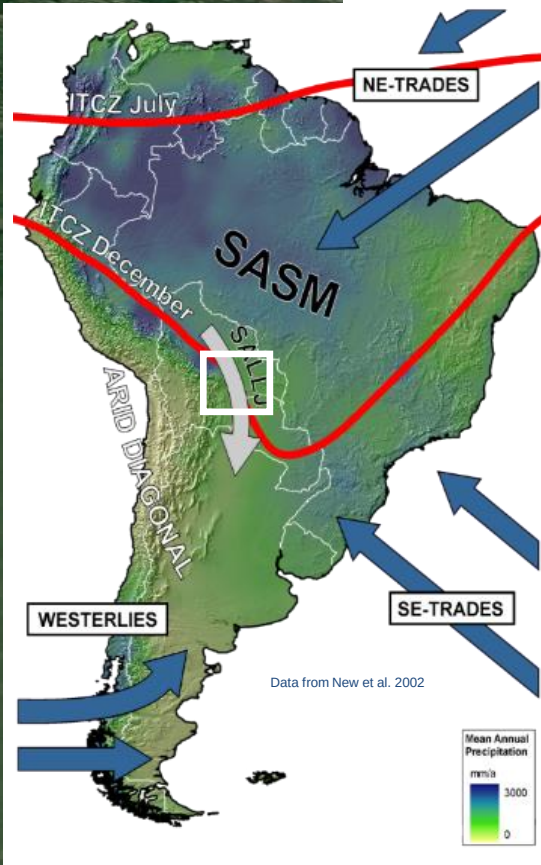
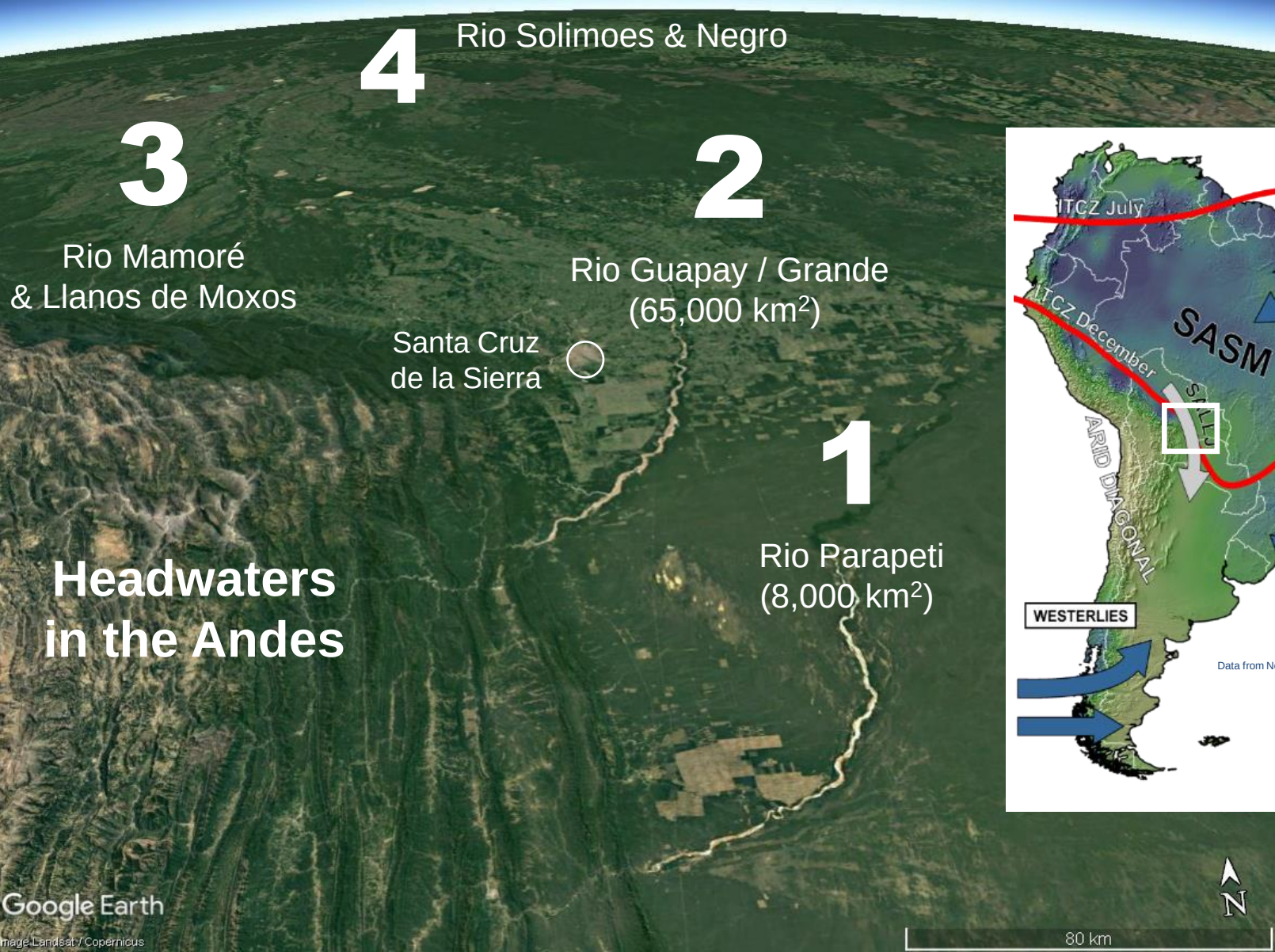
3 cross-equatorial geography

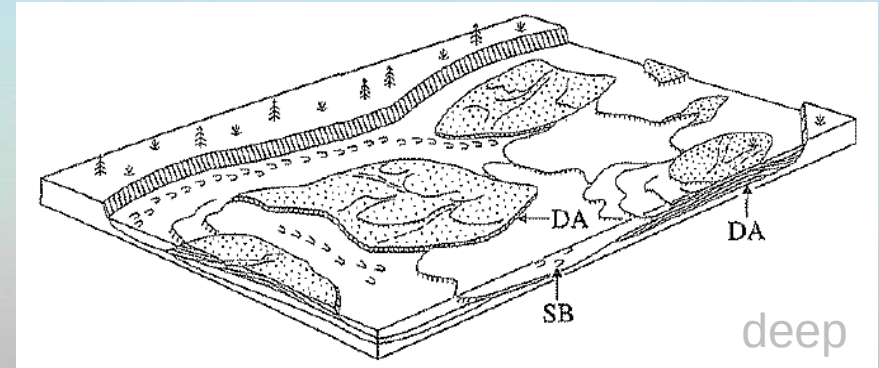
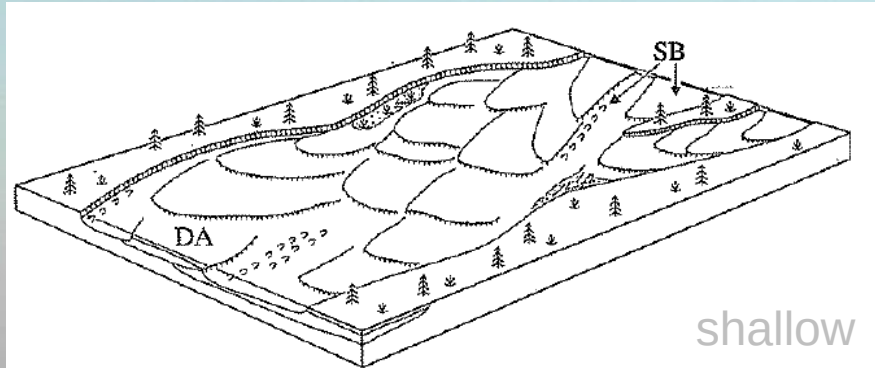


• Amazon superlatives

Source-to-sink Amazon...

Sediment dispersal and fluvial system in southernmost Amazonia = Eastern Bolivia





Downstream accretion of bars
(lateral and mid-channel)

Braided channel pattern

Sand-braided river

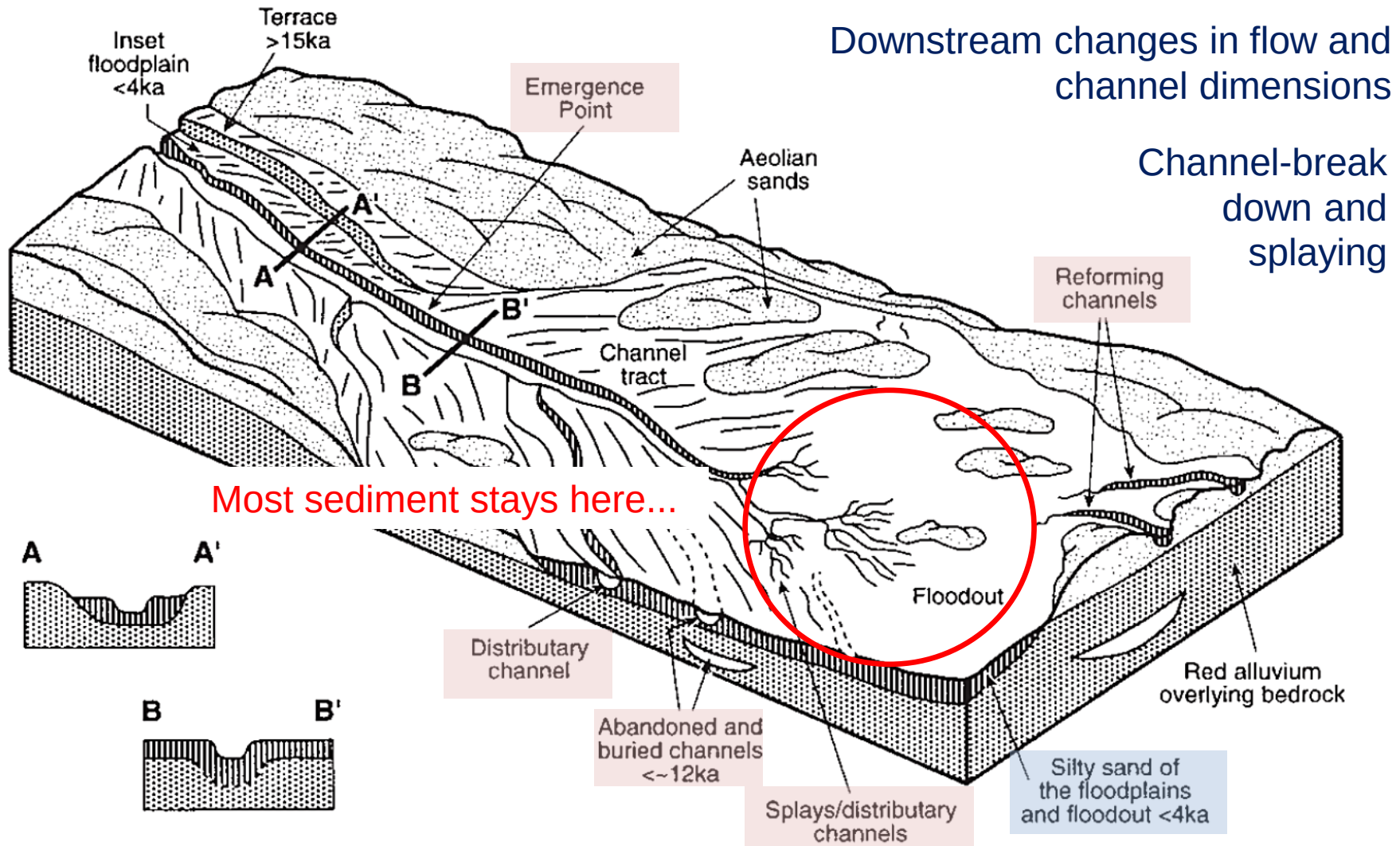
Sand bedforms

Floodout: “...**channelized** flow ceases and floodwaters spill across adjacent, **unchannelled**, alluvial surfaces”

1984
1989



Fluvial depositional environments in **floodout zones** can be subdivided into channels, floodplains (flanking the channels) and floodouts (beyond the channel termini or **emergence point**)



There are two types of floodout: **intermediate** floodouts, where un-channelled floodwaters spread out but channels reform further down-valley; and **terminal** floodouts, where un-channelled floodwaters spread out and ultimately dissipate

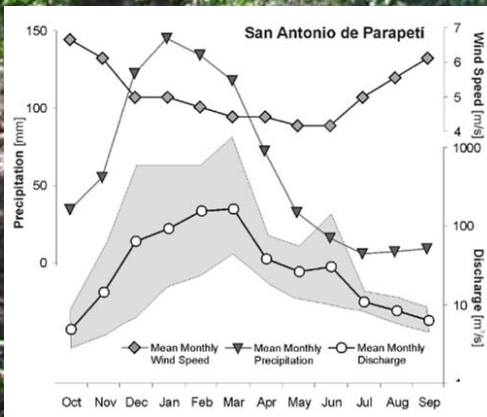
Plant transpiration

Evaporation

Bañados de Izozog
largest wetland in Bolivia
(Ramsar site)

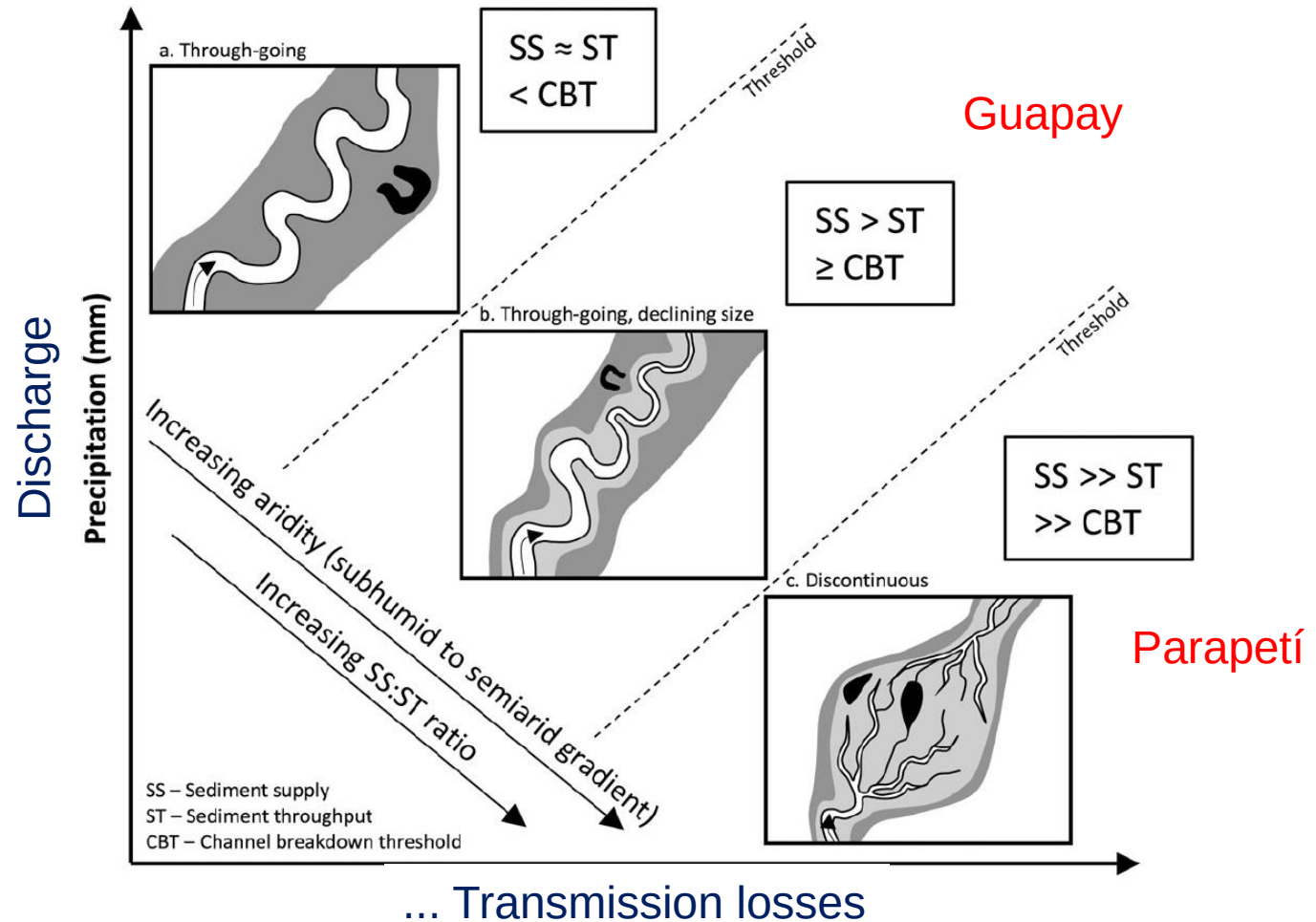
Transmission
losses

Infiltration



Mamoré

- Rivers and climate and sediment dispersal...
- Sediment routing??
- Processes of dispersal?



2 - Guapay (Grande) River



Cut-off

Meandering?

Lateral accretion
(point bar)

Bar

Braided?..

Bar

... Wandering river ??

200 km downstream



In the Andes...
65,000 km²



30 km downstream

136 Mio t TTS (total suspended sediment) – ca. 8 g/l, up to 88 g/l concentration

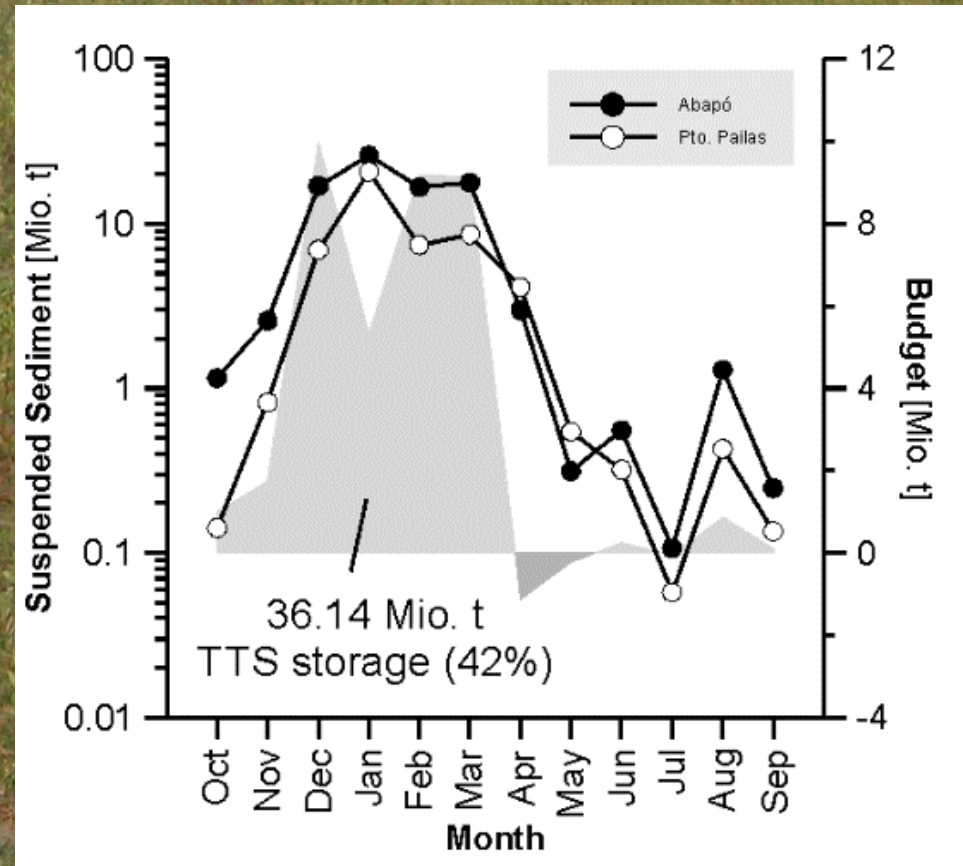
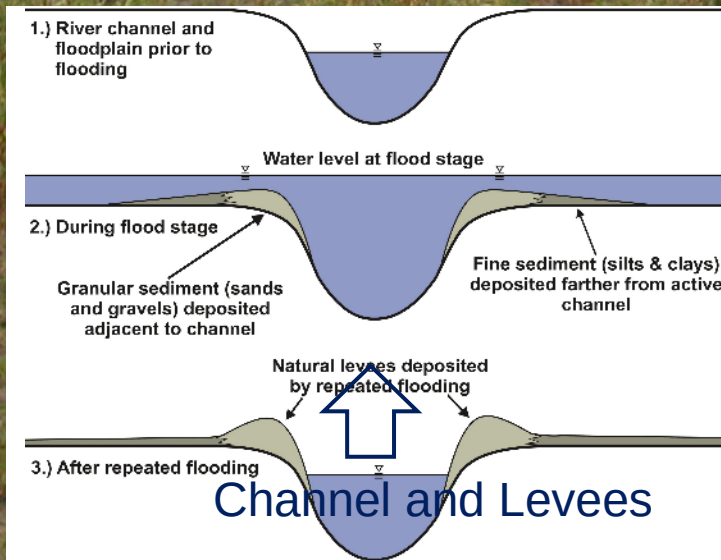


136 Mio t TTS (total suspended sediment) – ca. 8 g/l, up to 88 g/l concentration

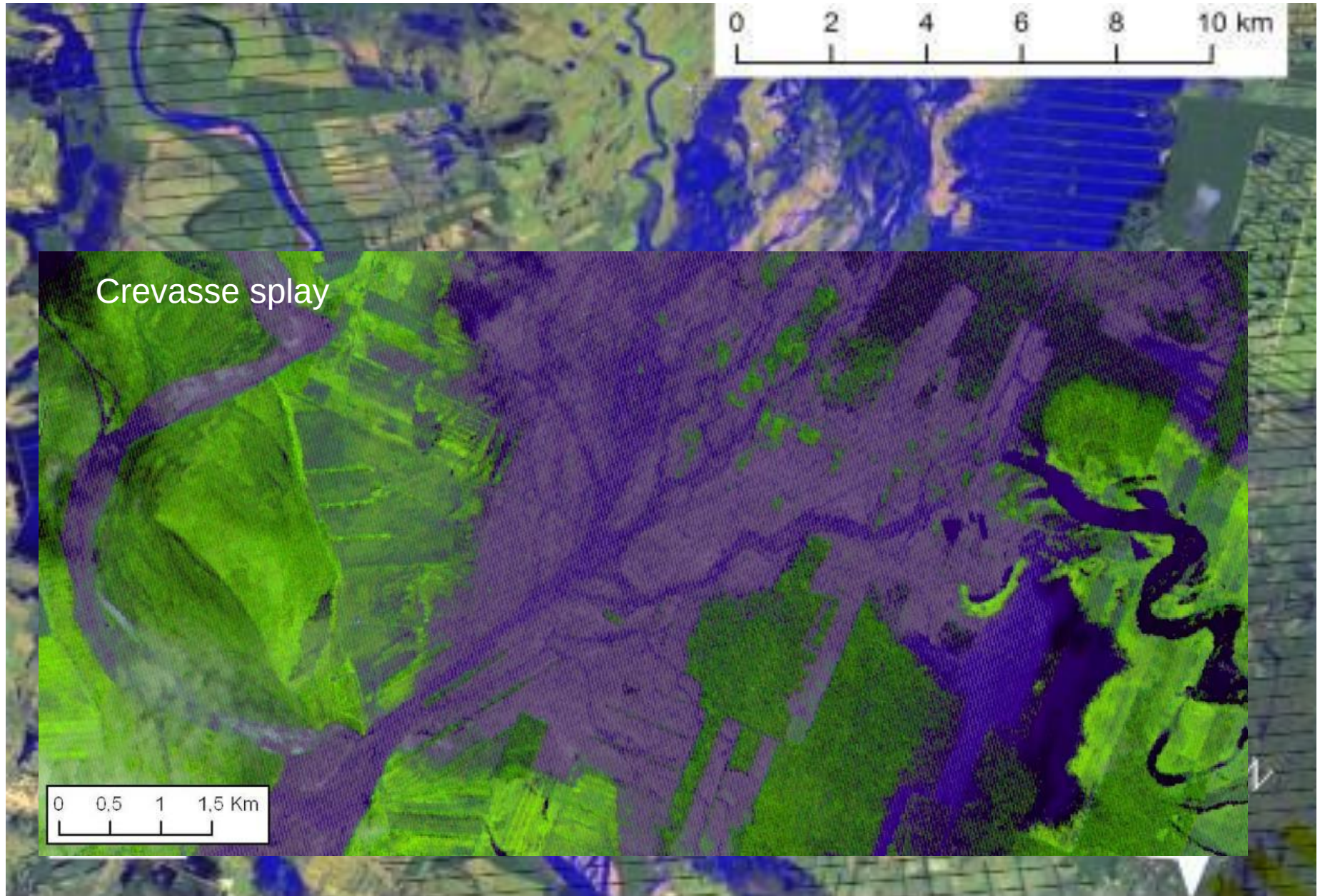
117.7±0.3 ^{14}C yrs BP
@ 5.6 m depth



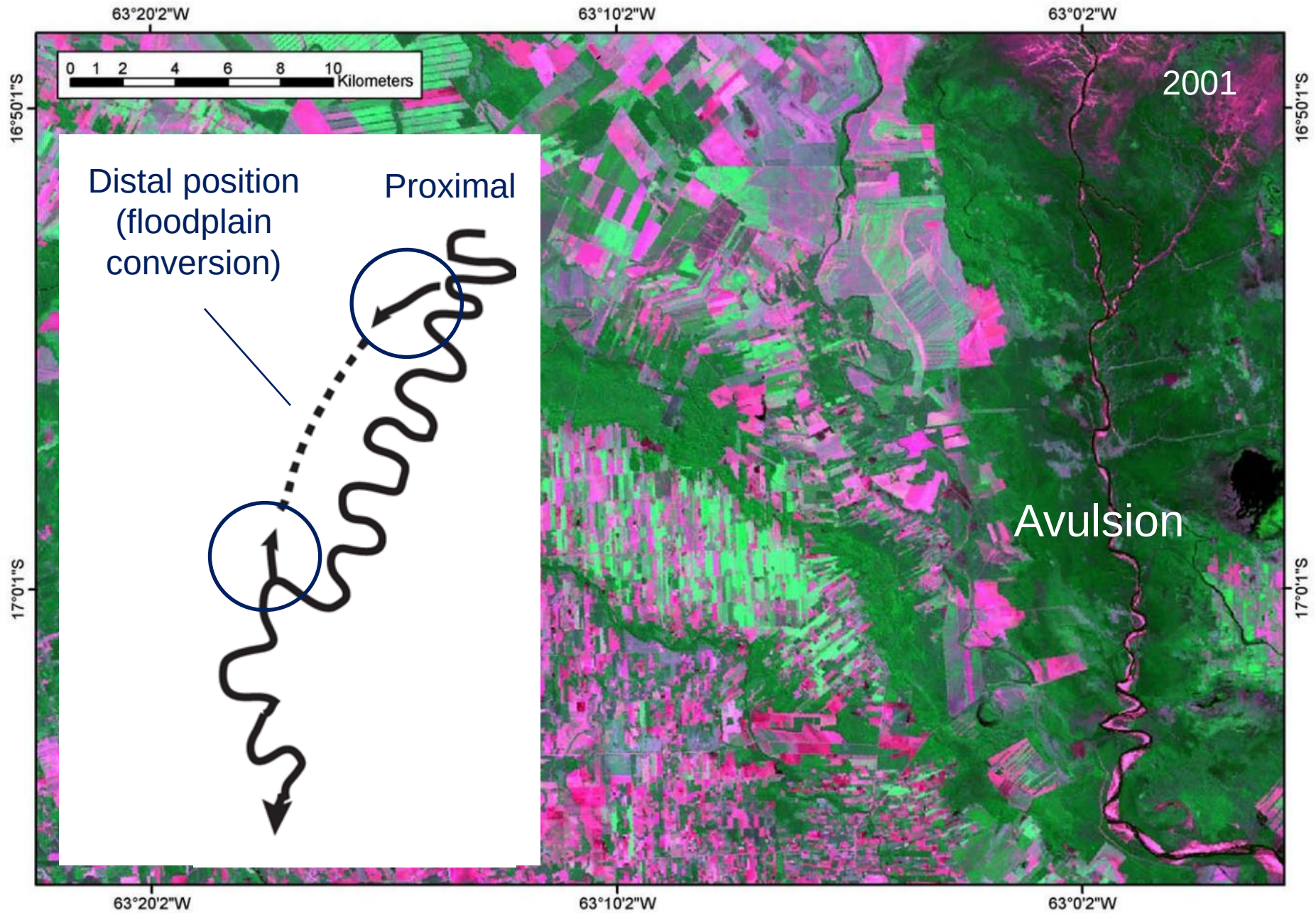
Where is all that sediment?



3 - Guapay (Grande) River



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3 - Guapay (Grande) River





3 - Guapay (Grande) River



1 km

Floodplain to
channel conversion



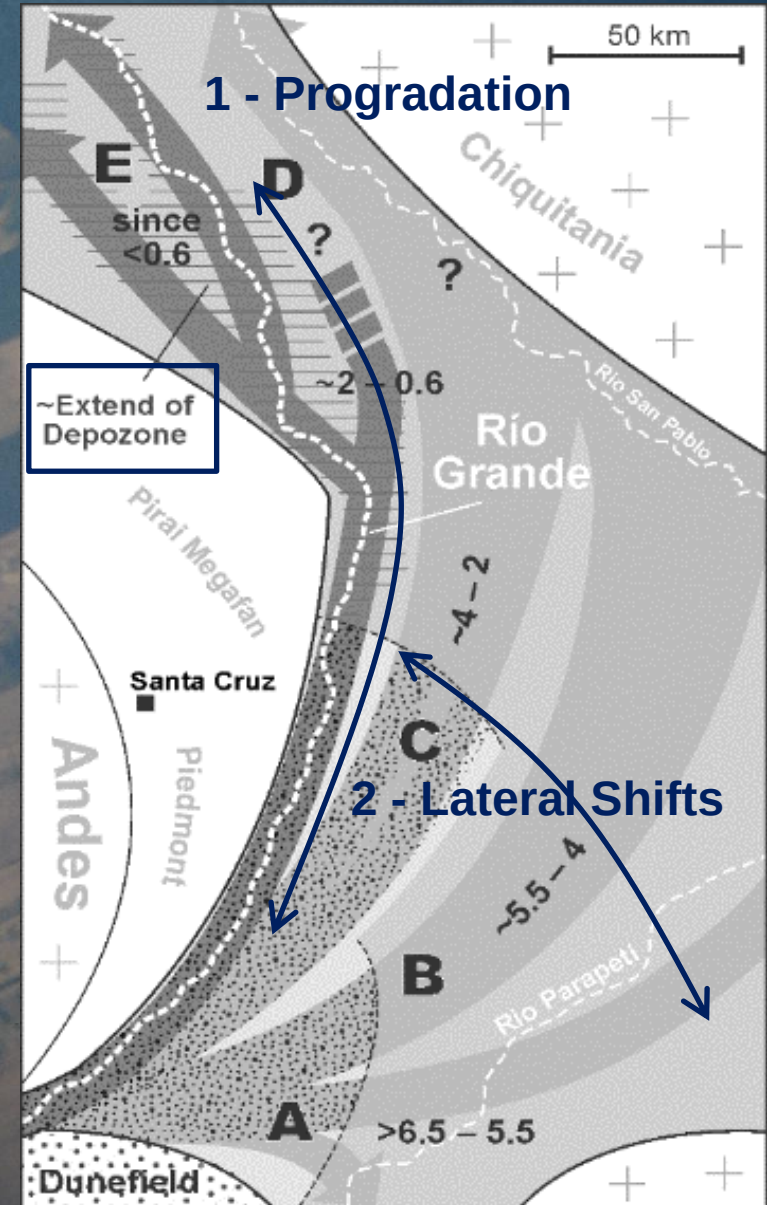
Floodplain to
channel conversion

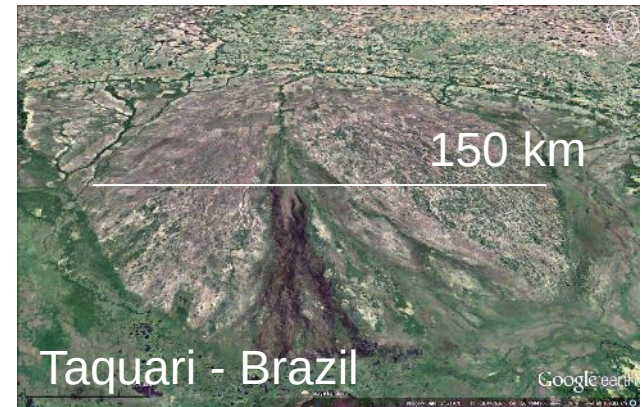
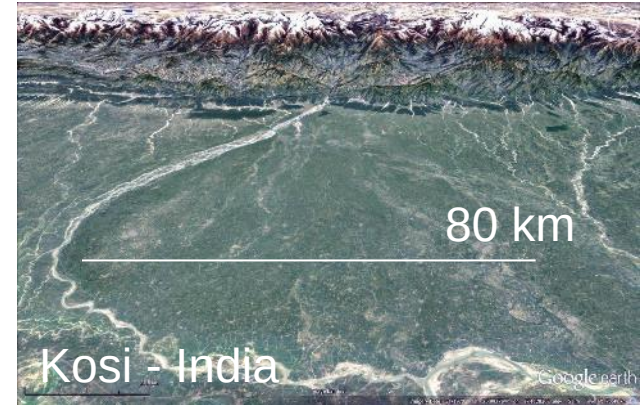
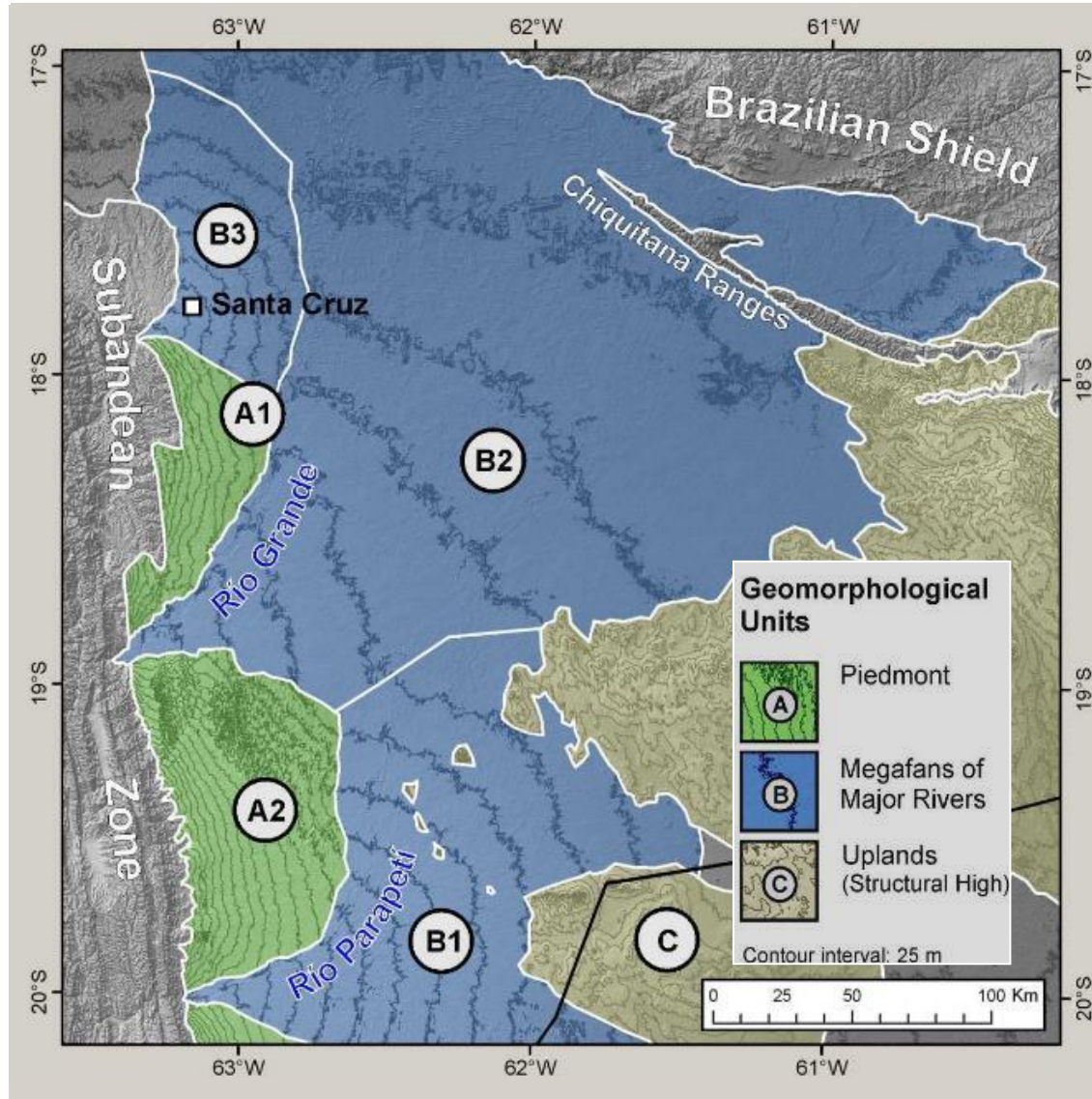


3 - Guapay (Grande) River



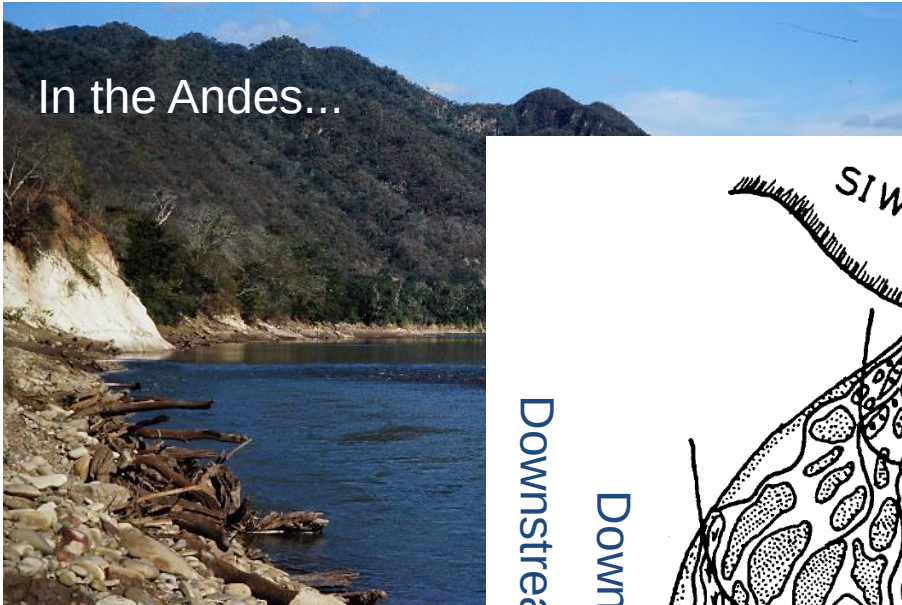
Headward extension
of channel network





Megafans - Large **D**istributary **F**luvial **S**ystems (DFS)

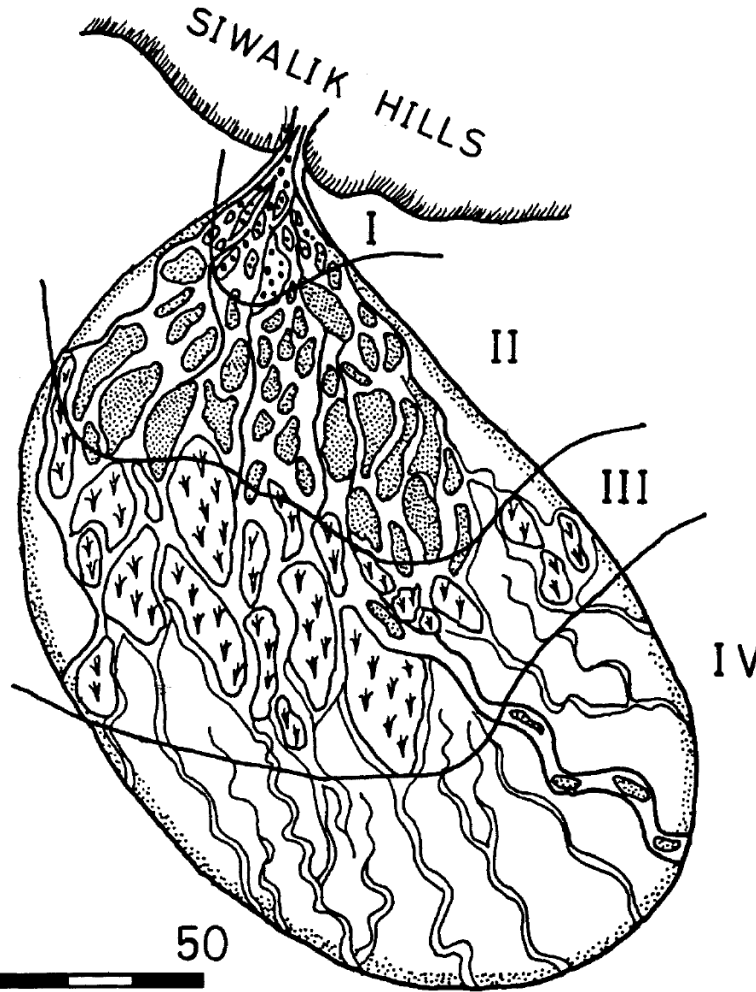
In the Andes...



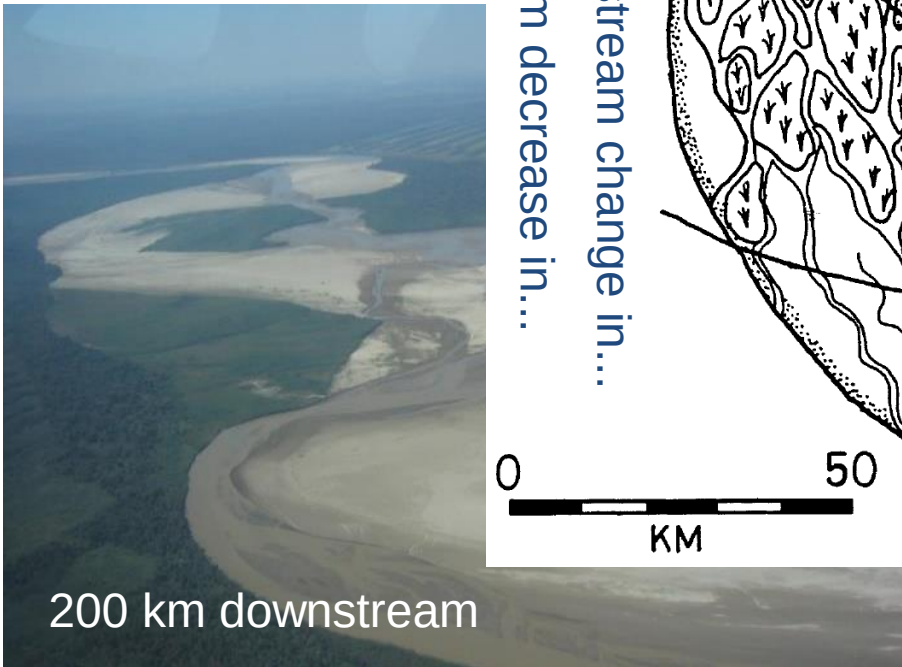
30 km downstream



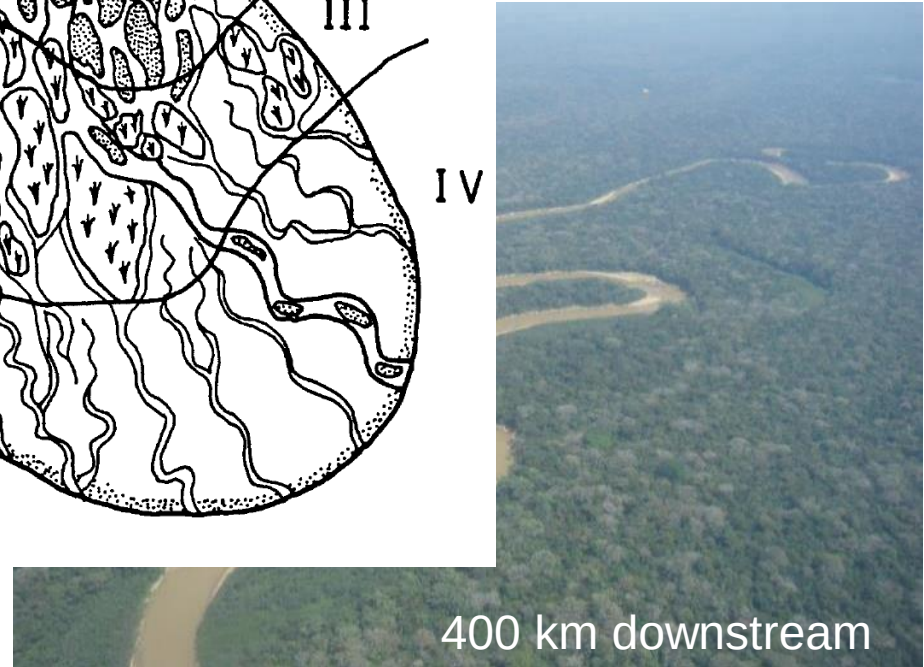
Downstream change in...
Downstream decrease in...



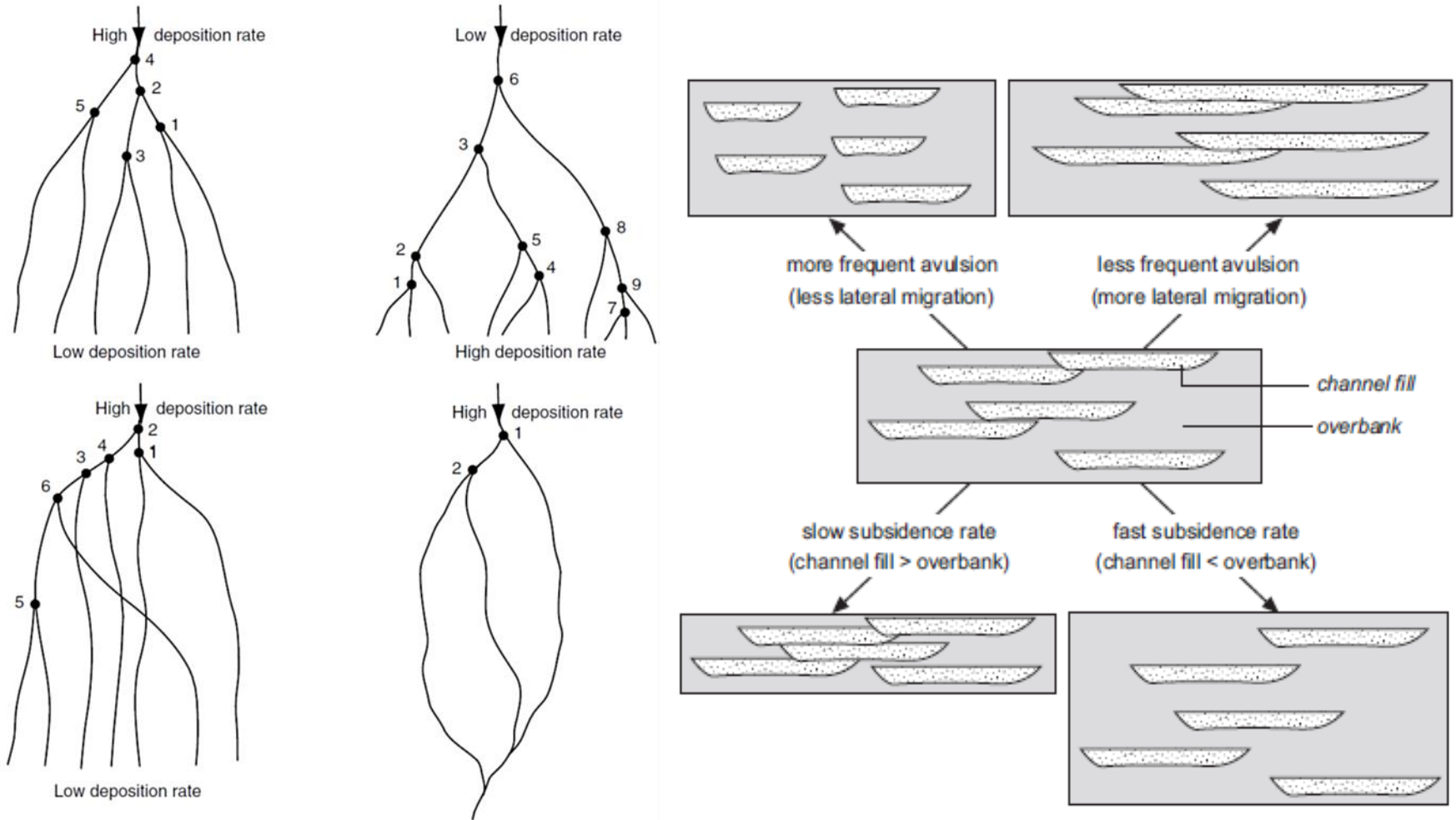
200 km downstream



400 km downstream



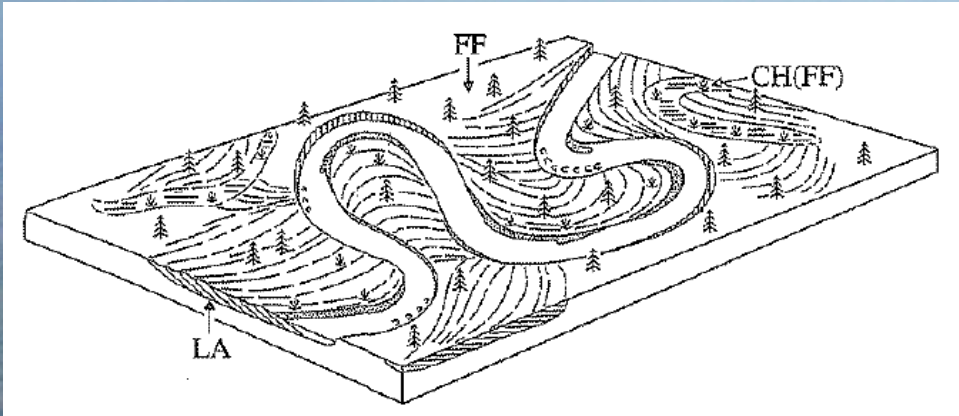
Channel filling, avulsions and the distribution of sediment



Megafan dynamics or foreland basin filling (10s of Mio. yrs):
Rates of subsidence and frequency of avulsion

2 minutes...





Floodplain lake
Overbank fines

Cut-off (soon)

Lateral
accretion

Point bar

... Meandering River

Channel fill
Oxbow



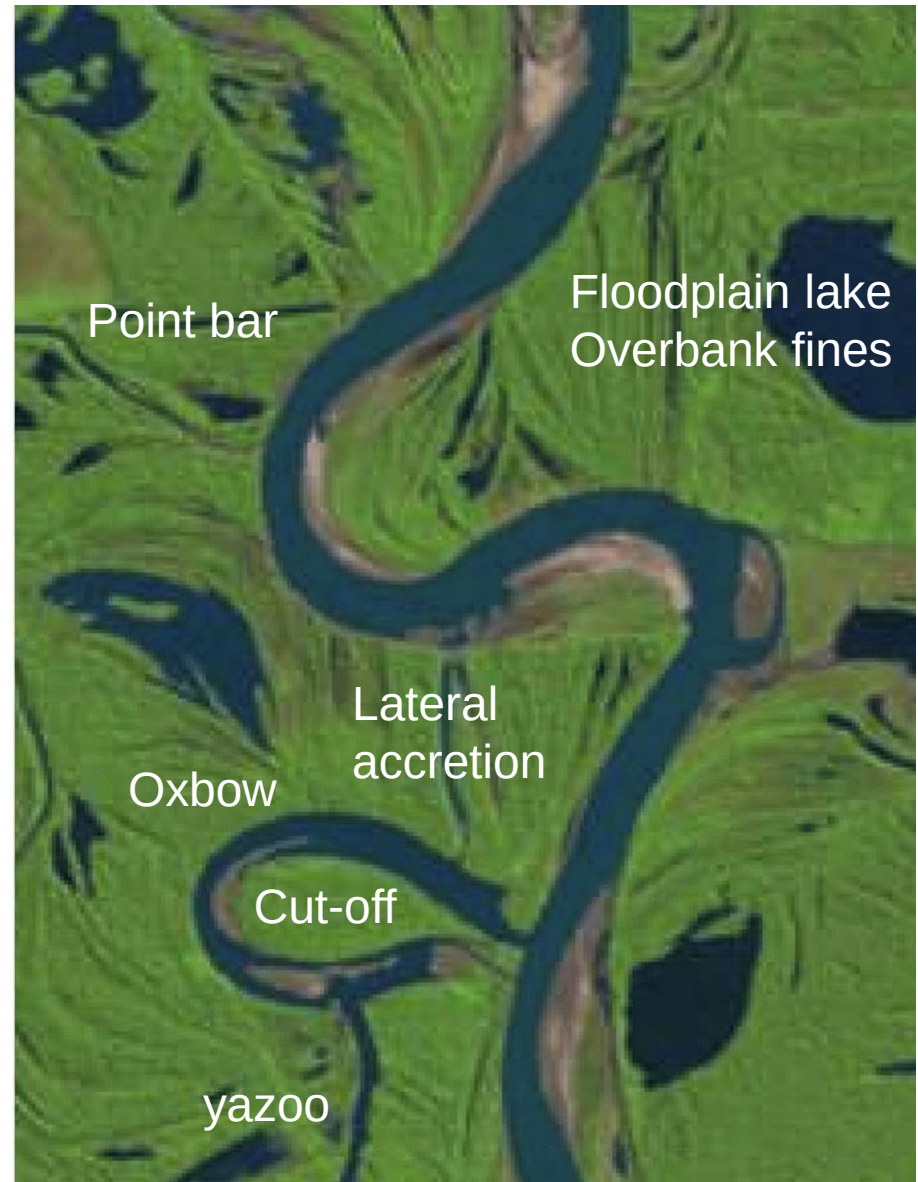
Overbank fines

Point bar
Lateral accretion

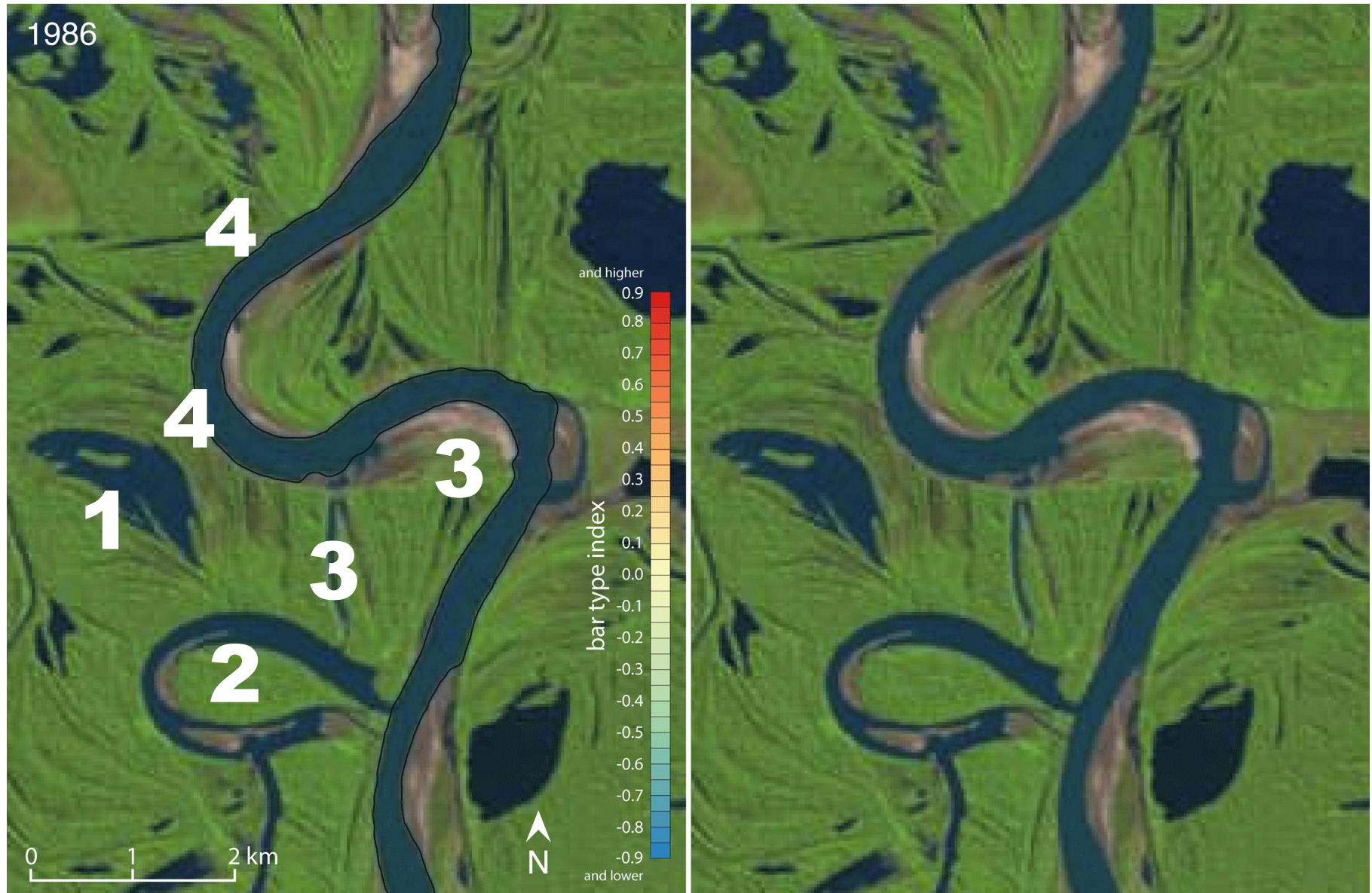
Rio Grande

Rio Mamoré

Channel fill



Meandering dynamics – forms



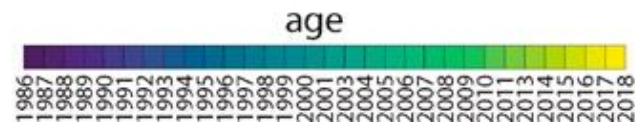
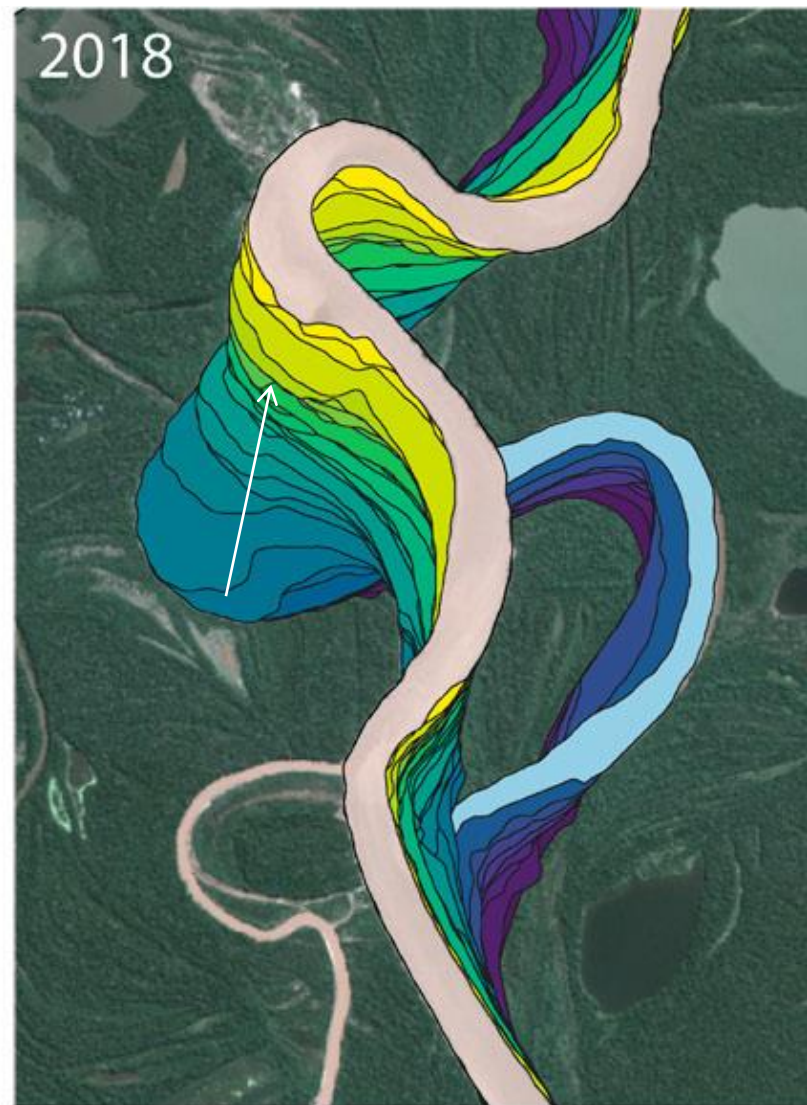
Meandering dynamics – processes and rates

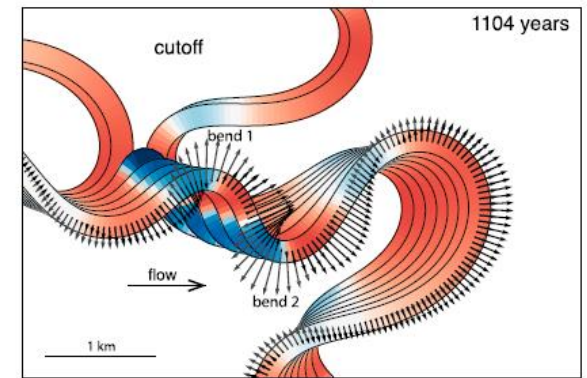
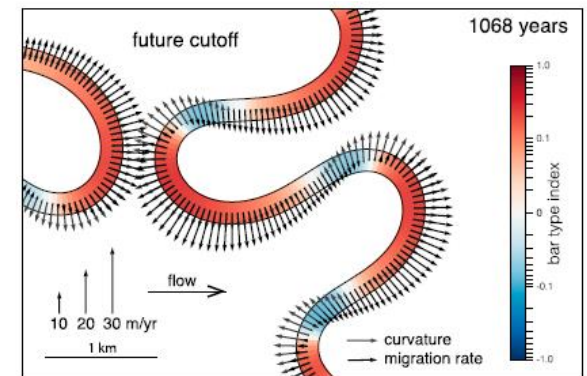
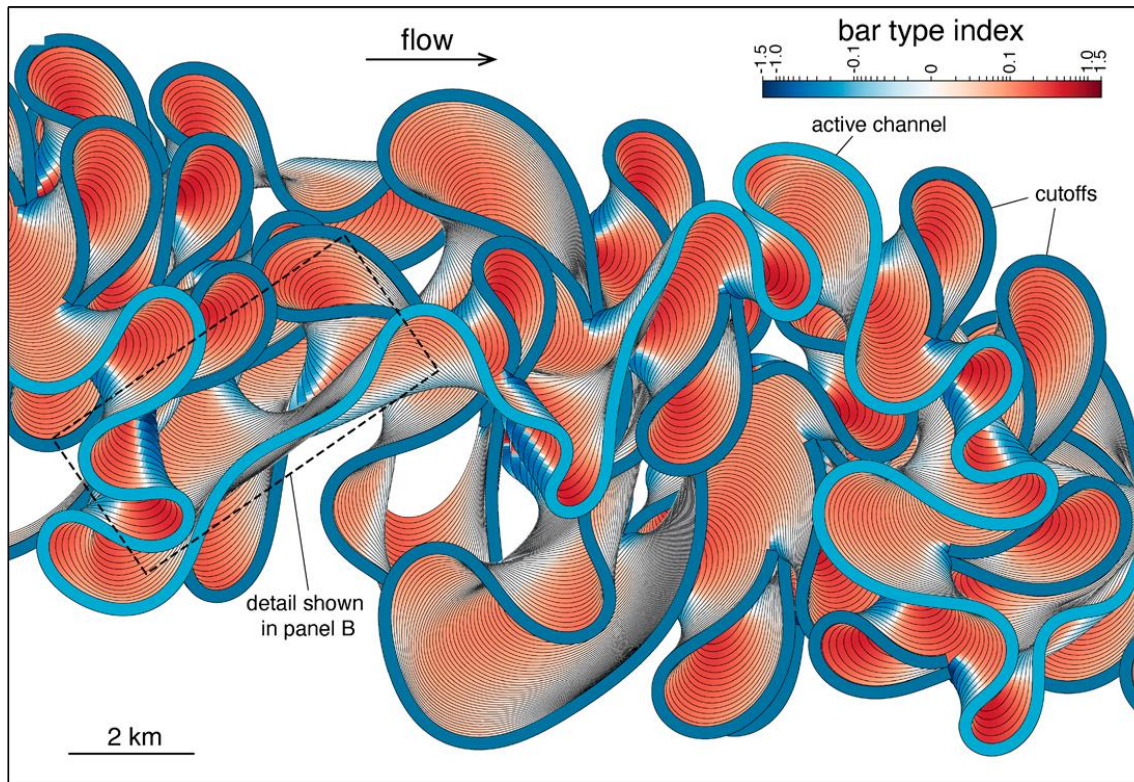


0 1 2 km

flow ↑

N ↑

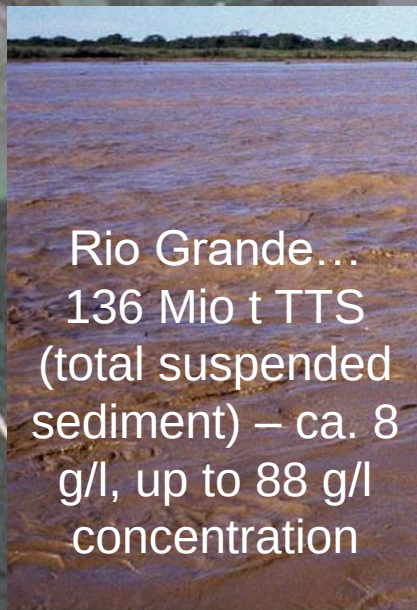
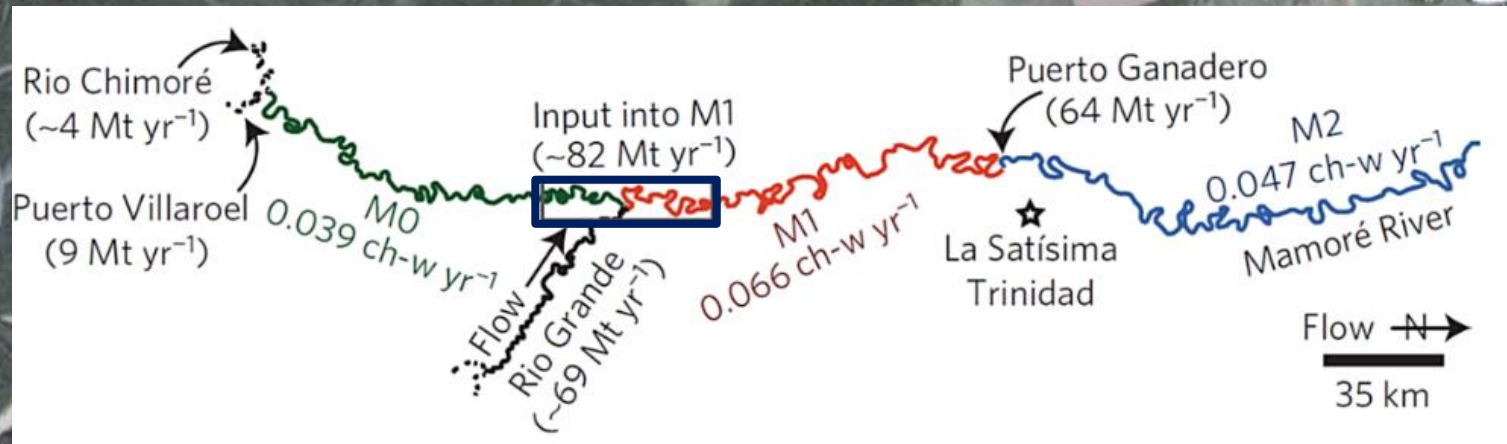




Forward numerical modelling

- What drives meandering rates – discharge/flow or sediment ?

Point bars
small

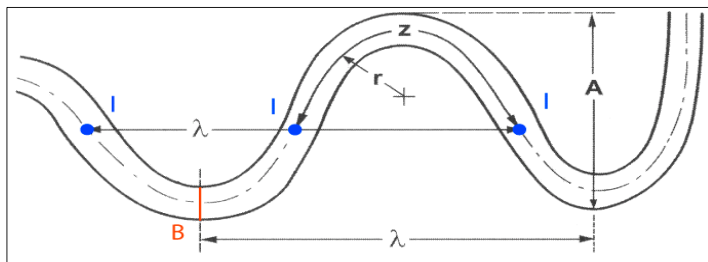
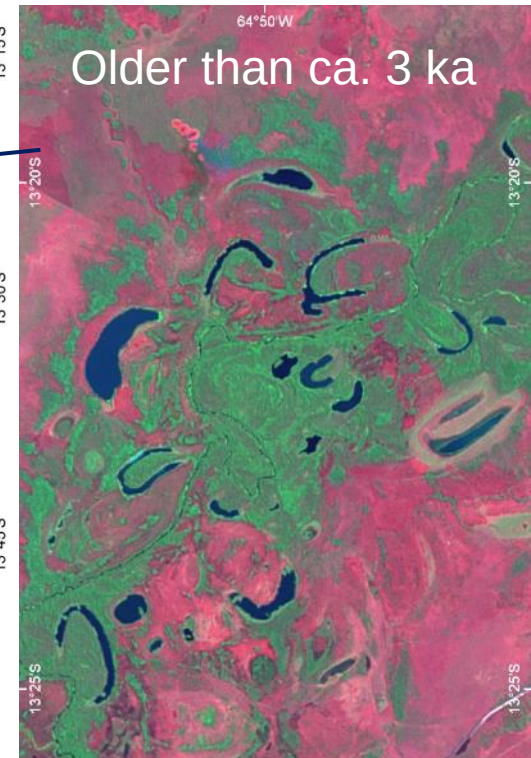
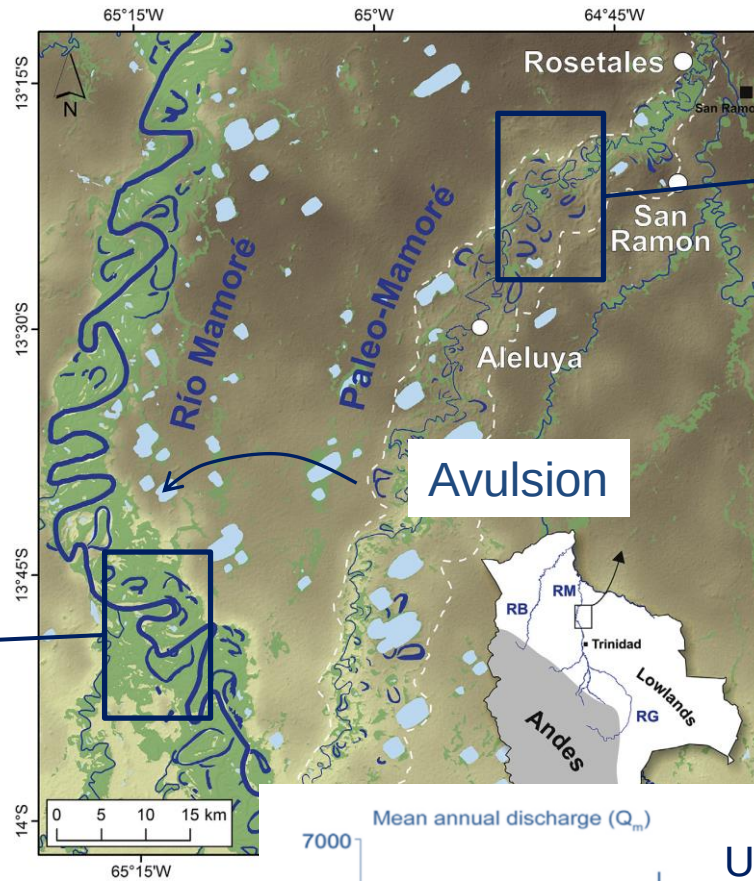
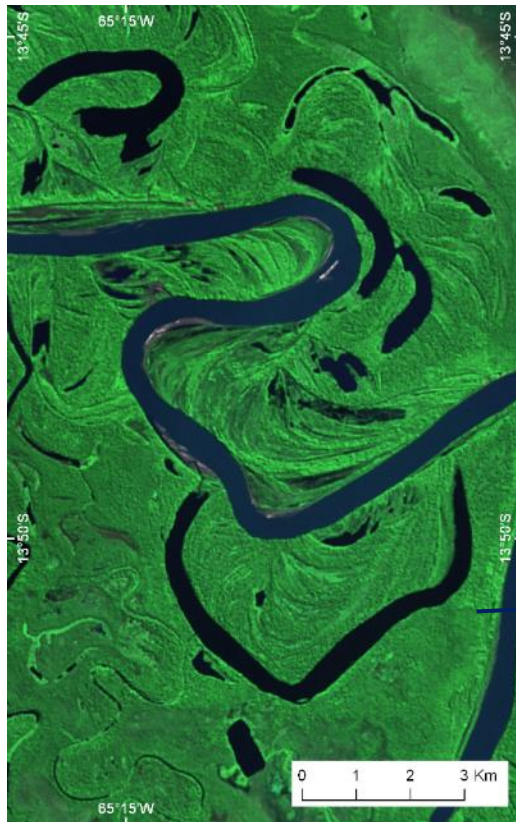


Rio Grande...
136 Mio t TTS
(total suspended
sediment) – ca. 8
g/l, up to 88 g/l
concentration

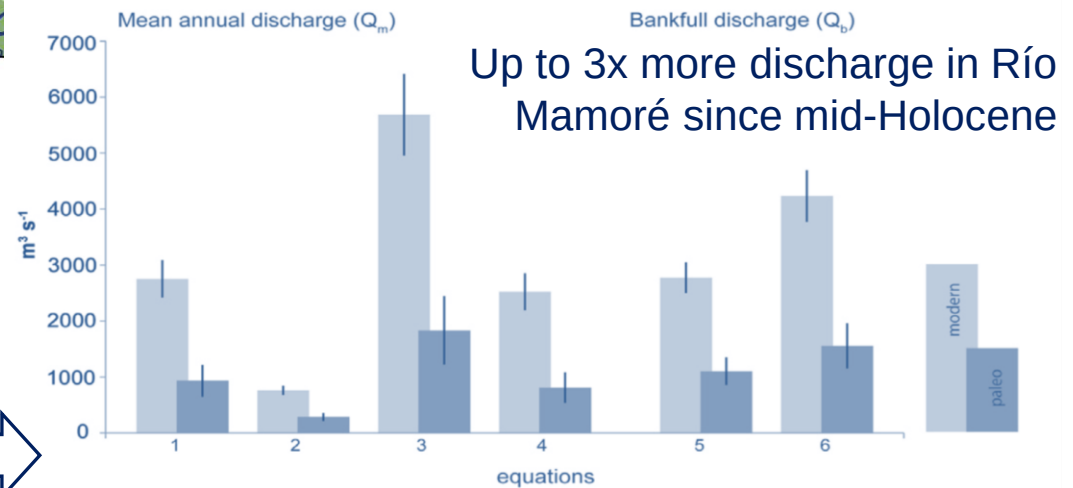
Point bars large
and long

Sediment input
from Rio Grande

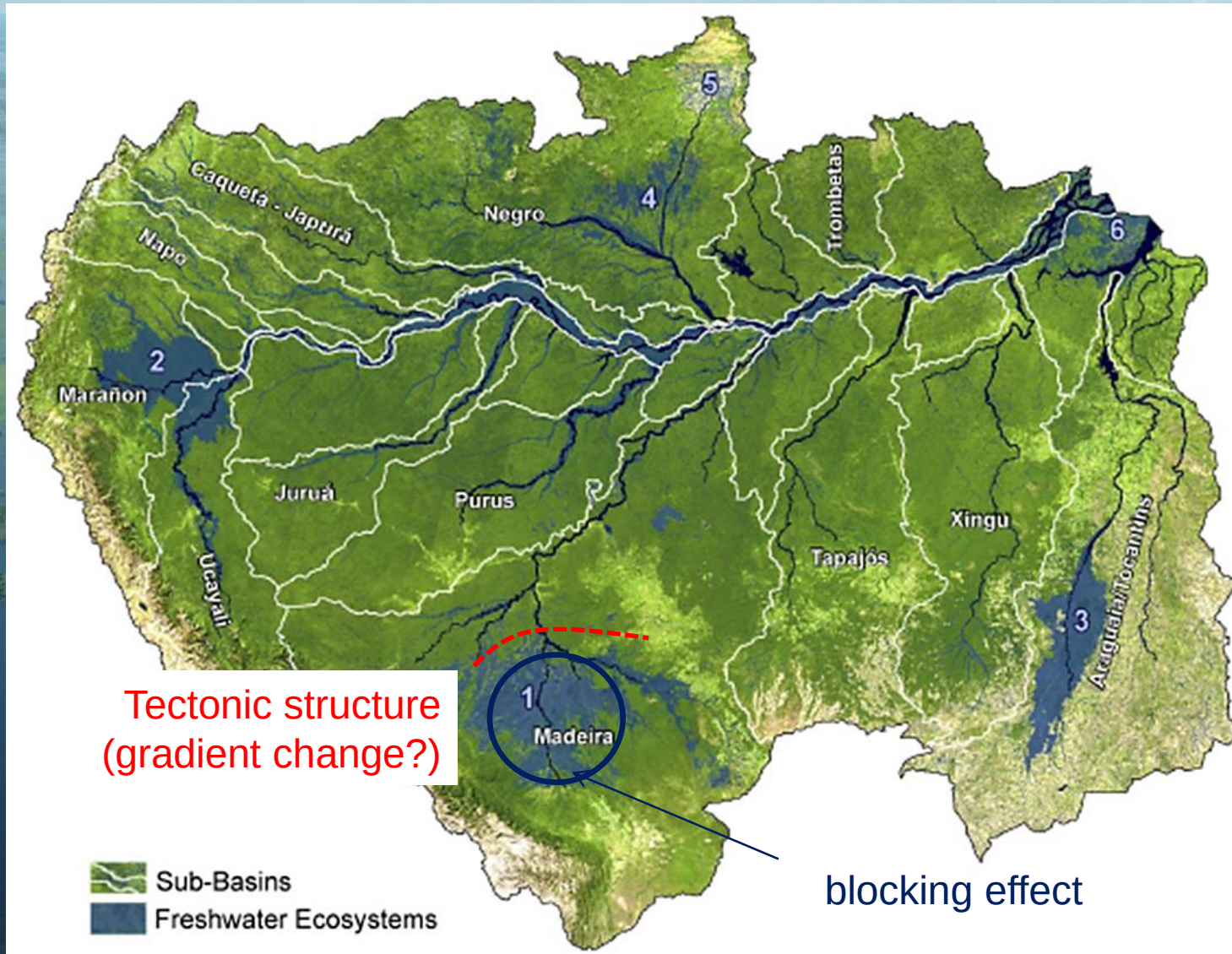
3 - Mamoré River



Relationship Q and fluvial geometry
(e.g. width, wavelength, radius...)



- Bolivian Amazon: “Llanos de Moxos” – inundation savannah...



- Bolivian Amazon: “Llanos de Moxos” – inundation savannah...

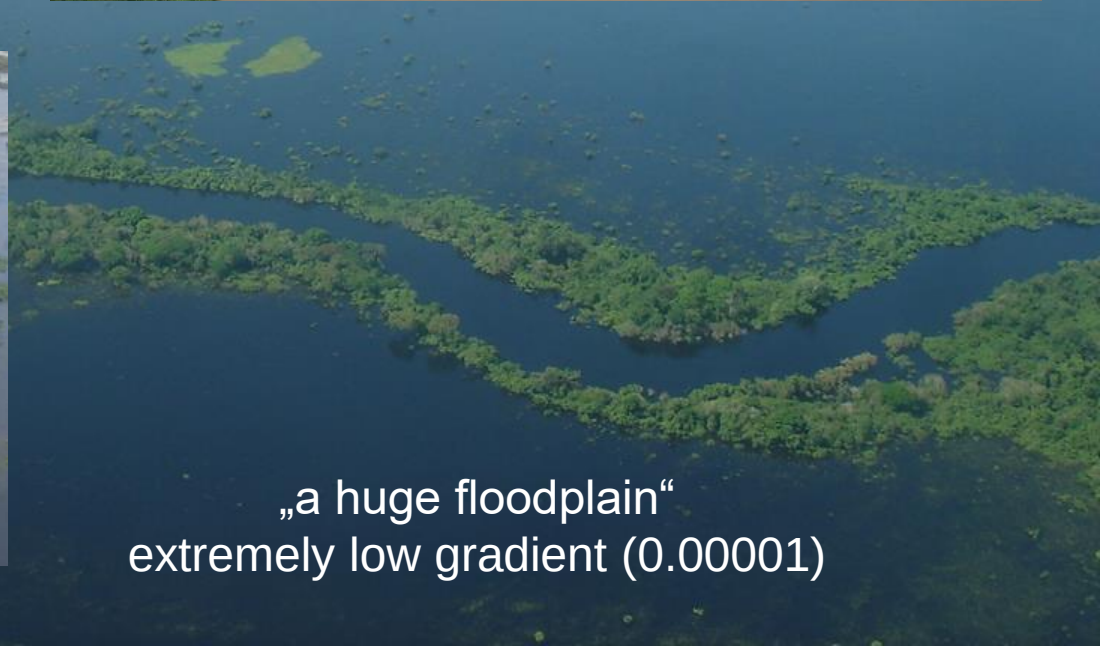
On average 40.000 km²
of inundation...



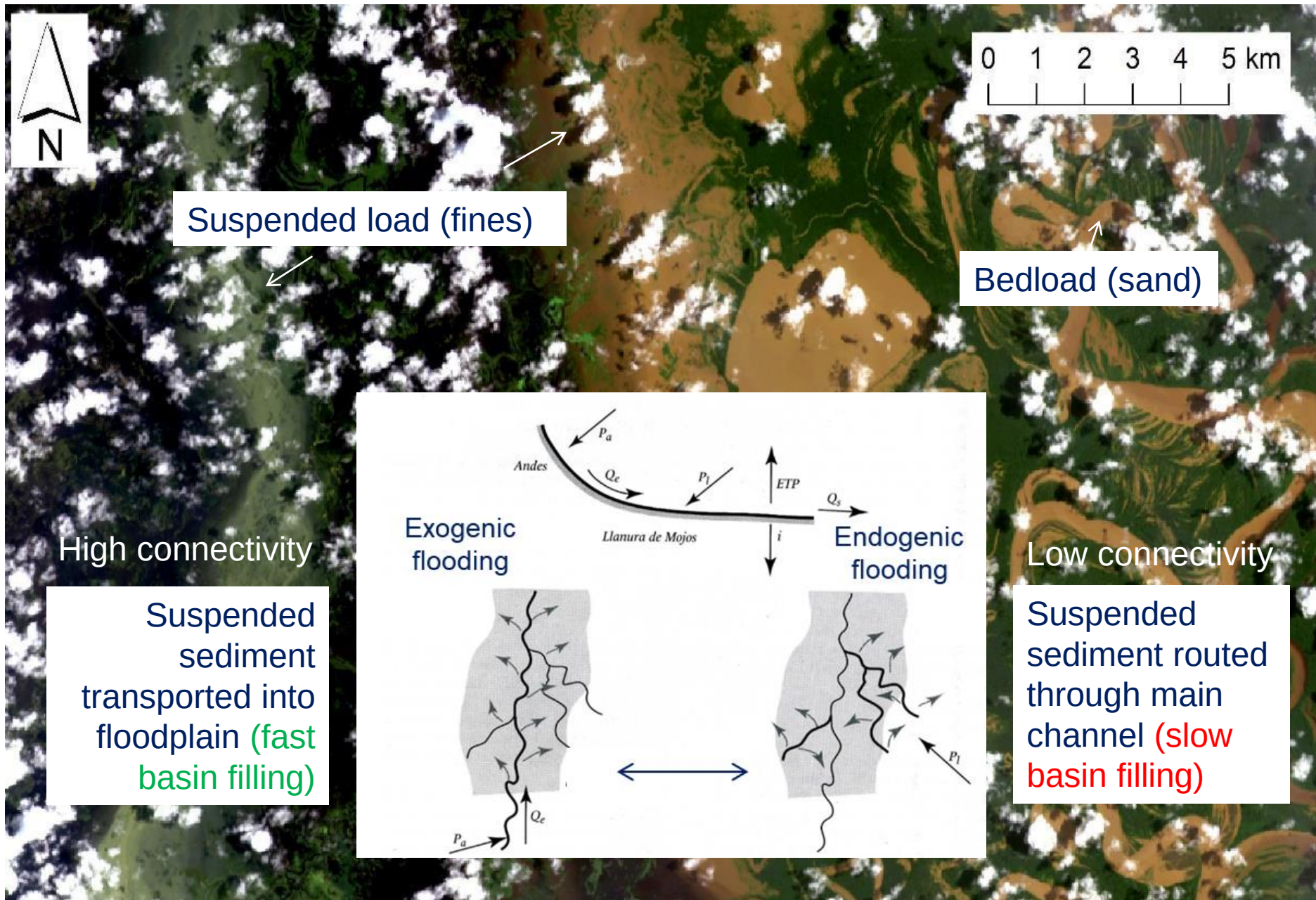
Rio Mamoré – from Andes = white water



Local rivers – from plains = clear

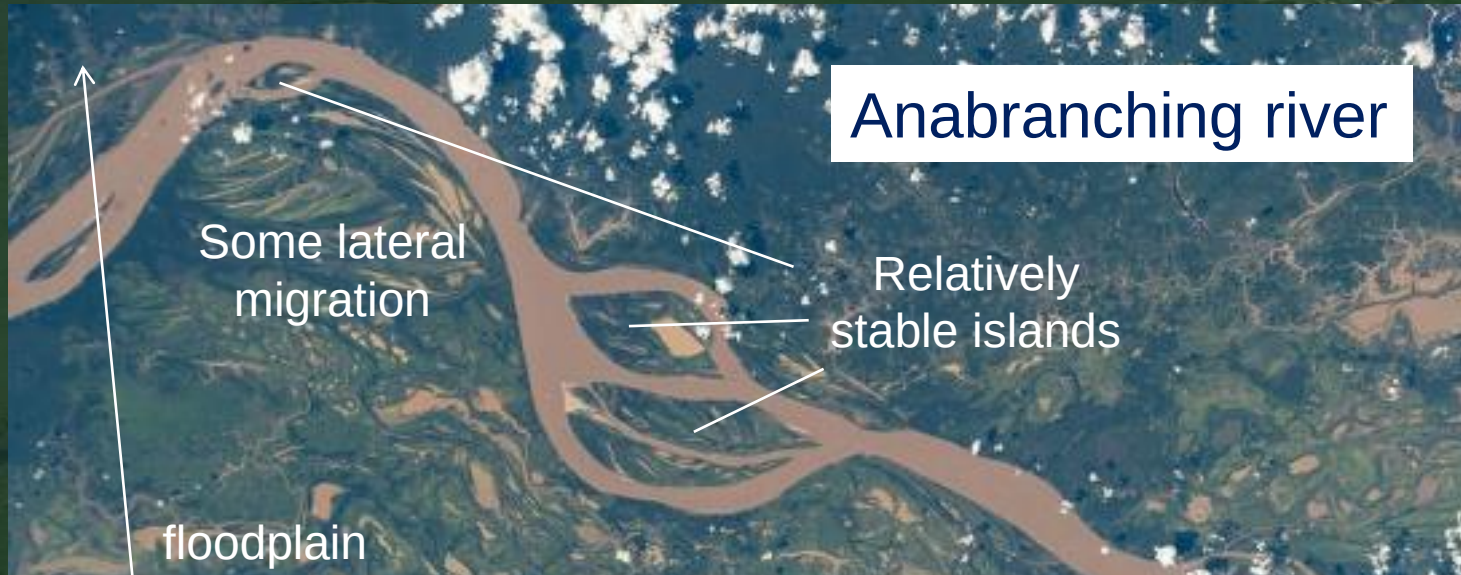


„a huge floodplain“
extremely low gradient (0.00001)



2 minutes...





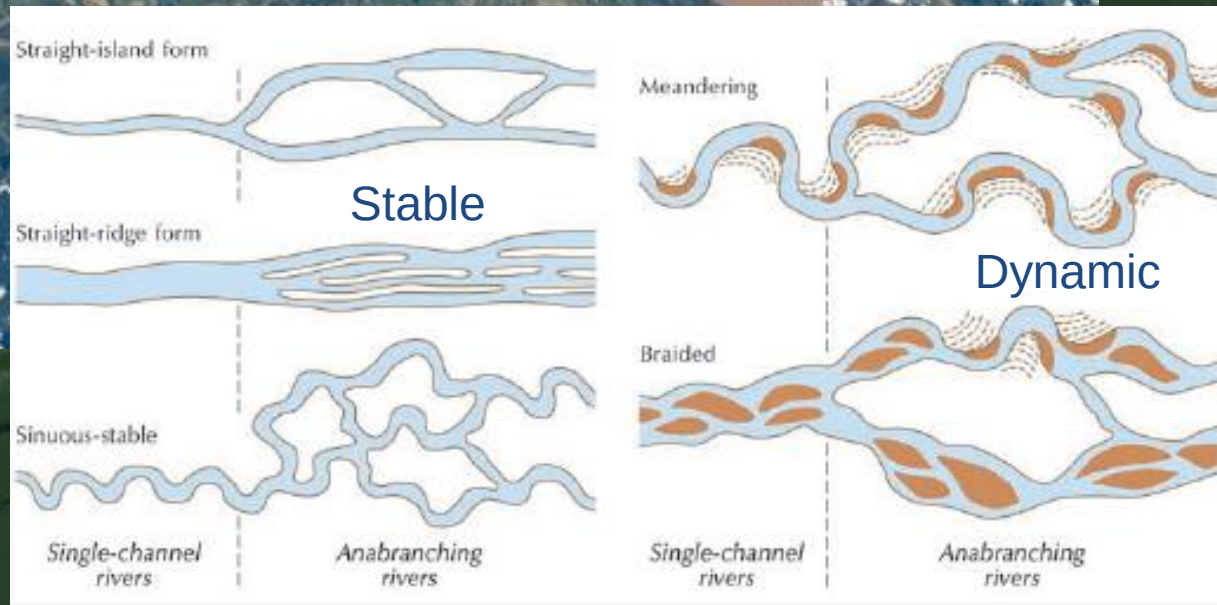
Anabranching river

Some lateral migration

Relatively stable islands

floodplain

Rio Negro



Rio Solimoes

Google Earth

Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat / Copernicus

Rio Madeira



100 km



4 – Solimoes and Negro Rivers





4 – Negro River

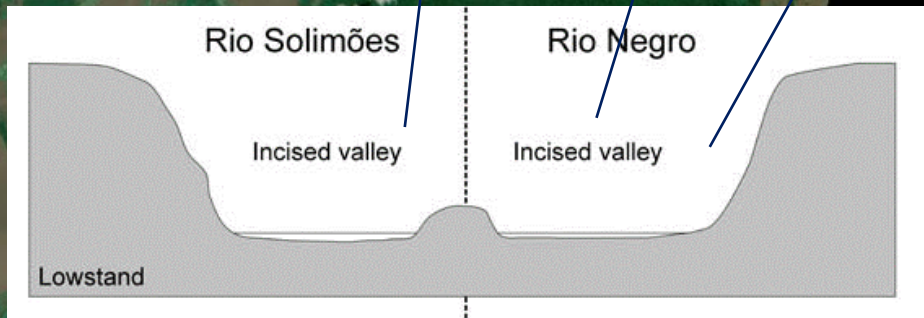
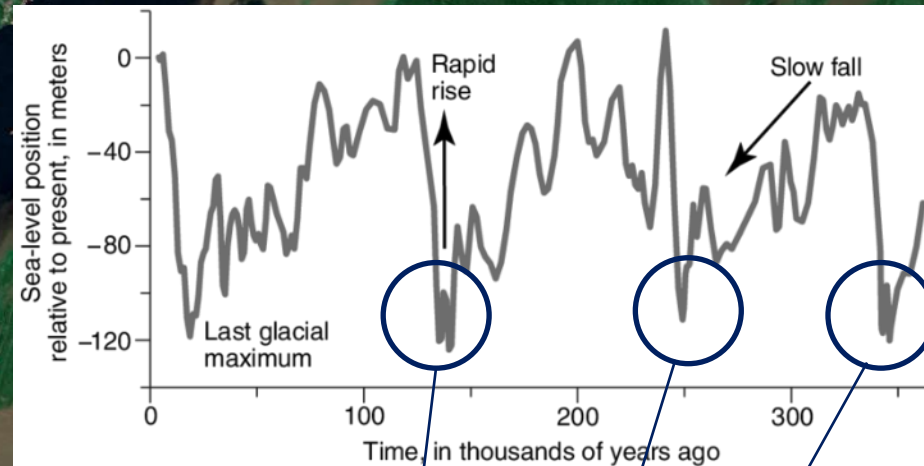
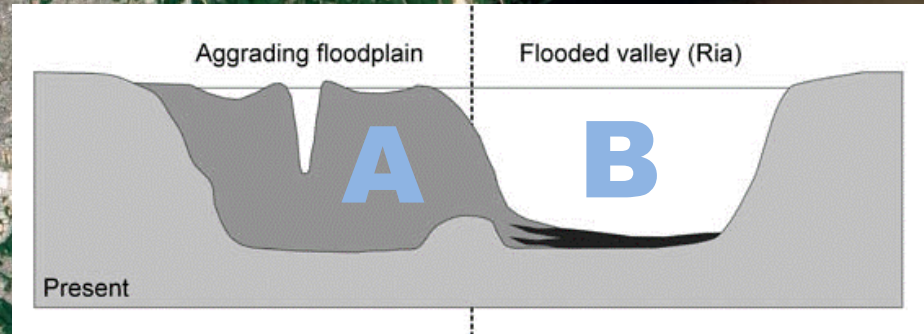
Rio Negro

Manaus

B

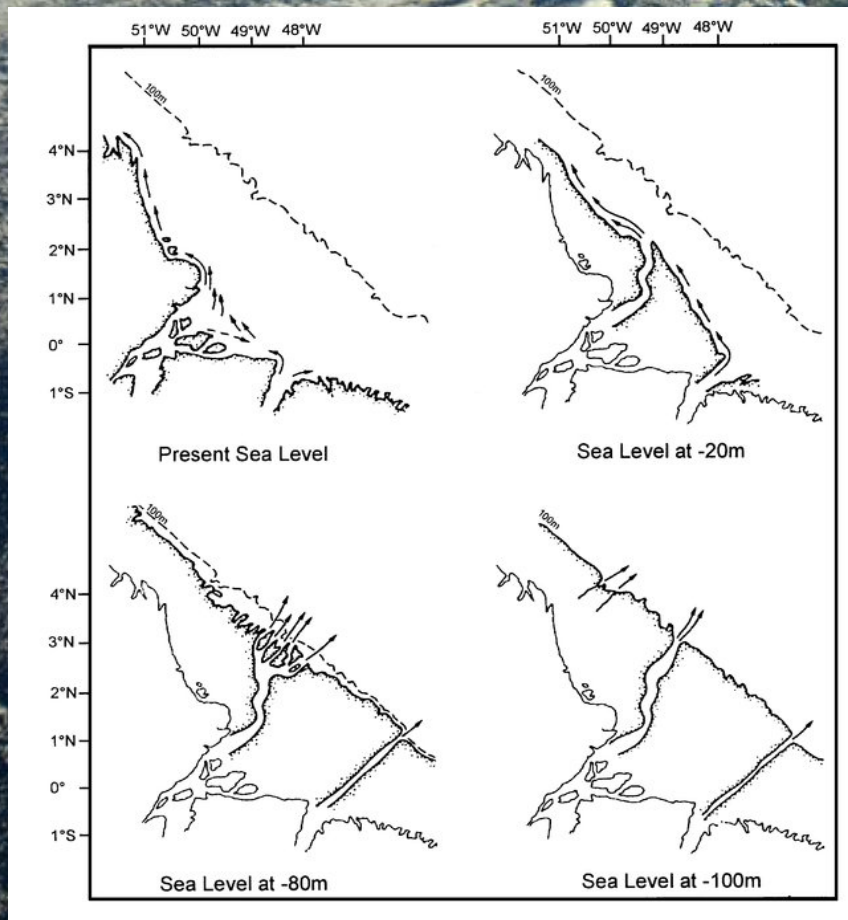
A

Rio Solimoes
(Amazon main stem)



Channel incision via base (sea) level lowering

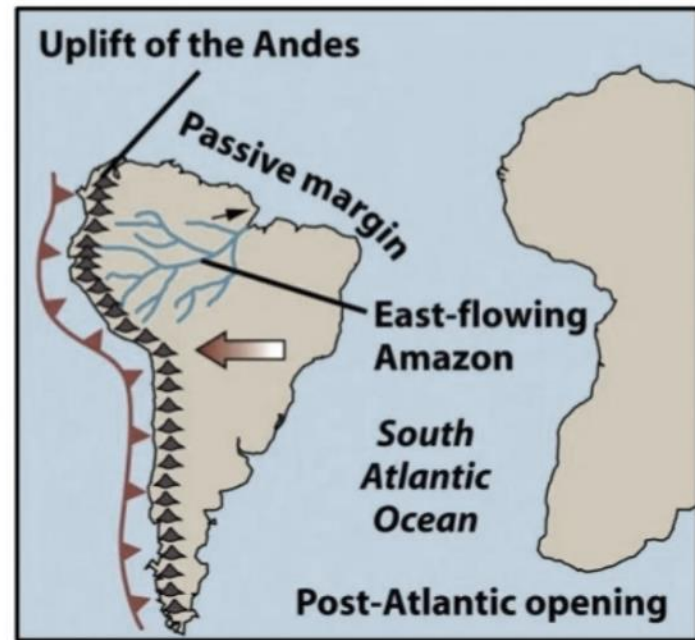
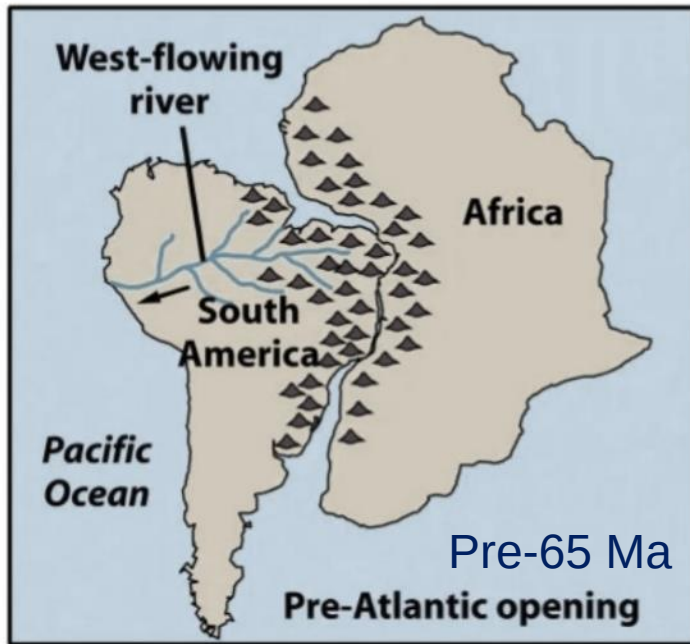
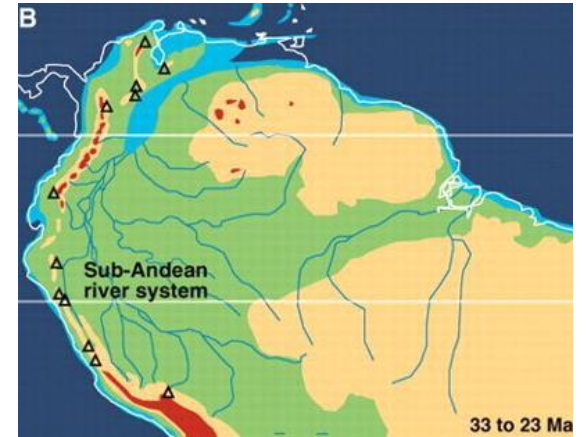
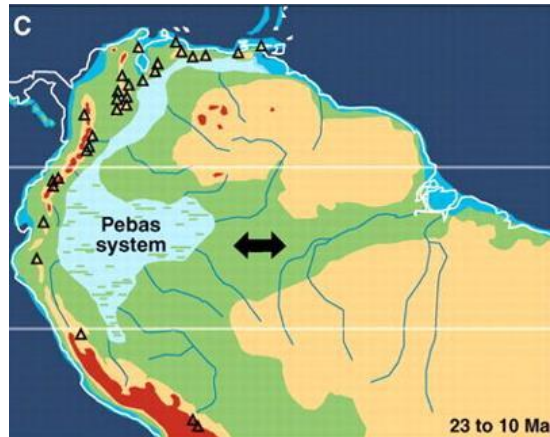
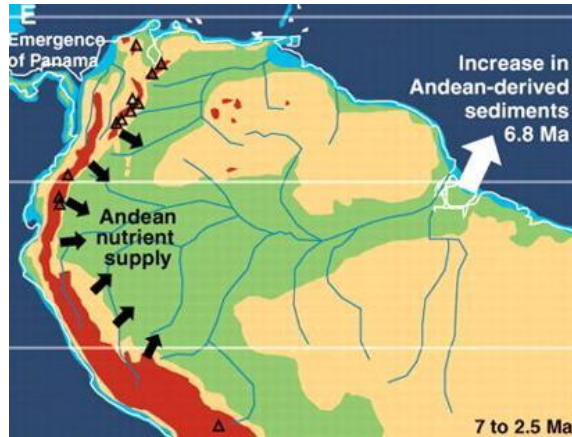
The Amazon mouth...



Sedimentary archive...

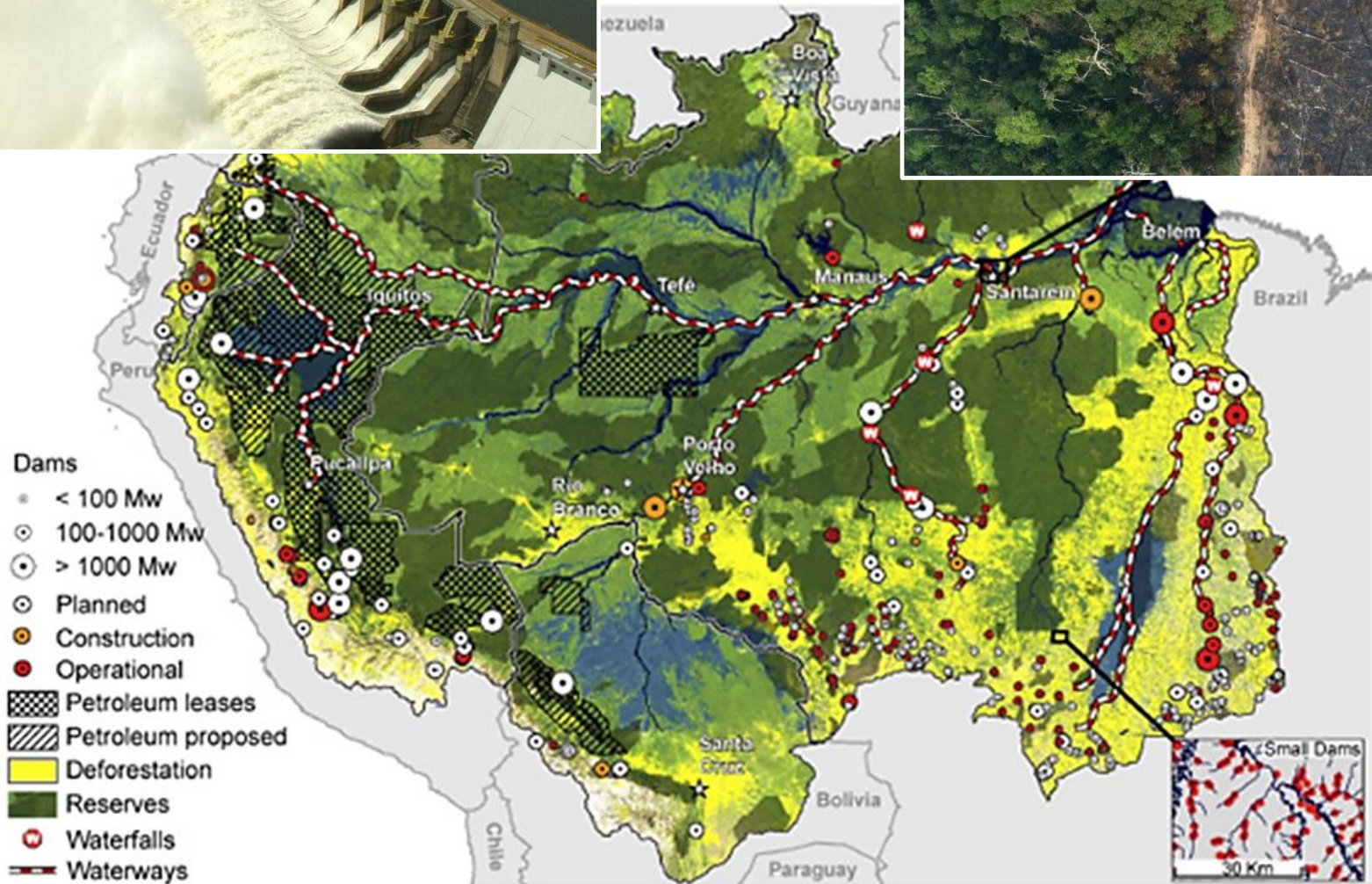
sediment plume

The past Amazon



Drainage inversion through tectonics (Atlantic Rift and Andean uplift)

The future Amazon



- Drivers of wetland degradation and the protected area network

Understanding the fluvial system...

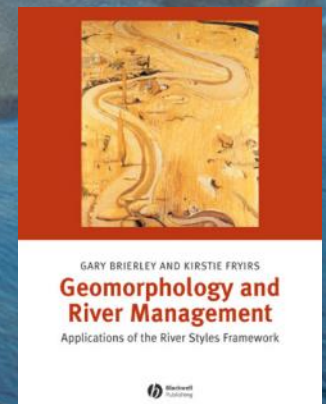
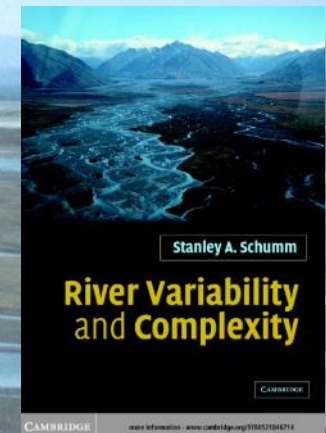
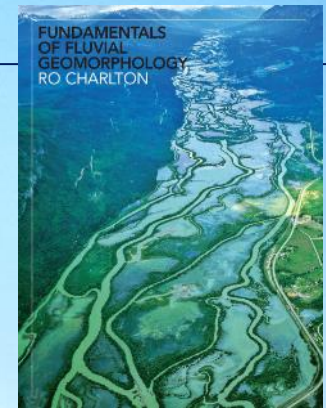
Basins and their rivers are dynamic over all temporal and spatial scales

Channels will likely have predictable trends in the downstream direction (but not always, e.g. large rivers)

- Discharge
- Sediment size
- Planform
- Slope

The dominant controls on river channel patterns are discharge and sediment supply

Rivers adjust to changes in these variables in a variety of ways



Thank you...