Living Earth:
From plate tectonics to biodiversity and from Andes to Atlantic

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SUSTAINABLE DEVELOPMENT GOAL 15

Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

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What is biodiversity?

Origins and drivers of biodiversity

How did Amazonia and its biodiversity evolve?

Threats to biodiversity

SUSTAINABLE DEVELOPMENT GOALS

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UN Report: Nature's Dangerous Decline 'Unprecedented'; Species Extinction Rates 'Accelerating'

Biodiversity under threat!

SDG GOALS

1 NO POVERTY

AND WELL-BEING

5 GENDER EQUALITY

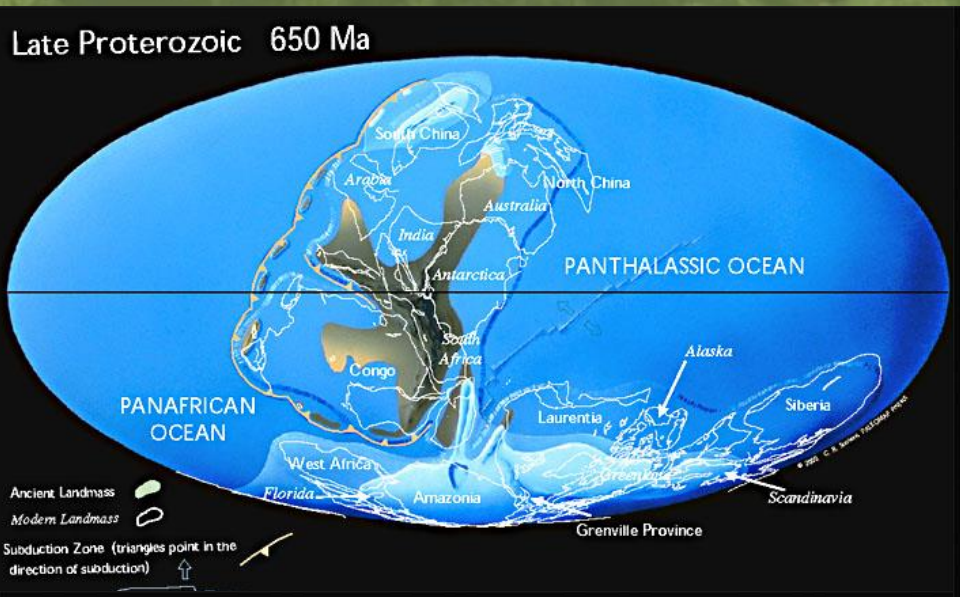
7 AFFORDABLE AND

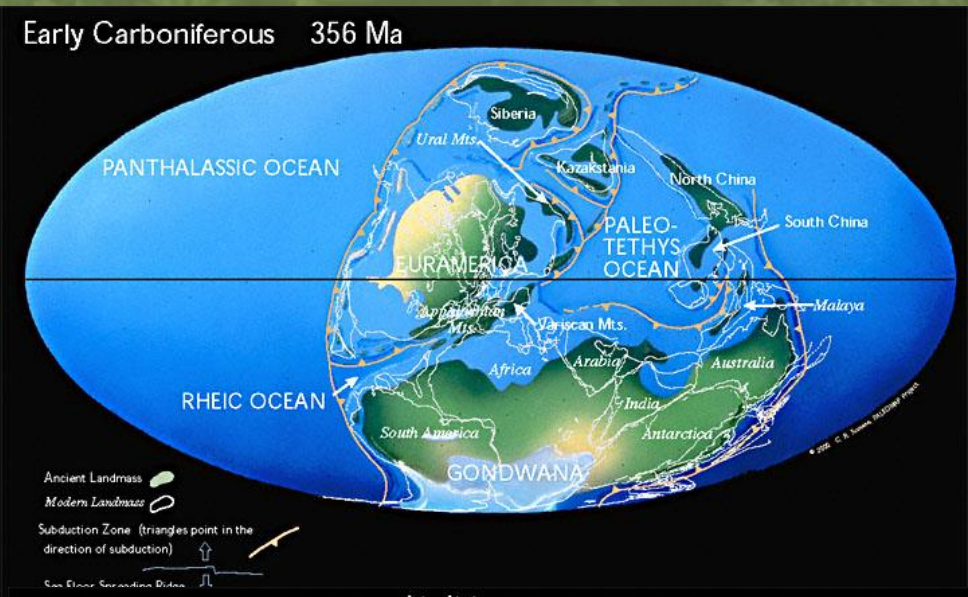
What do we know about biodiversity?

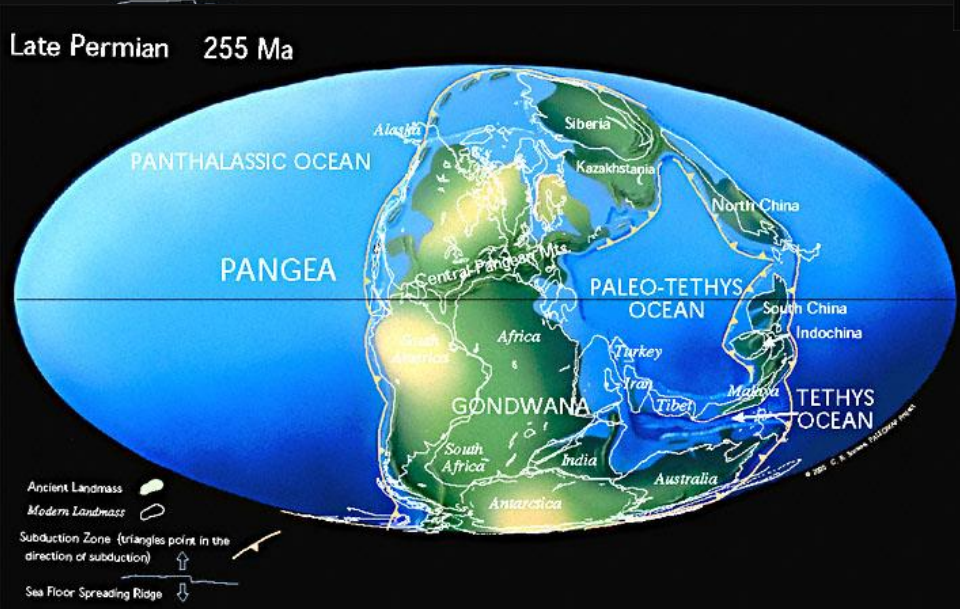
When and where did it start?
How will it end?

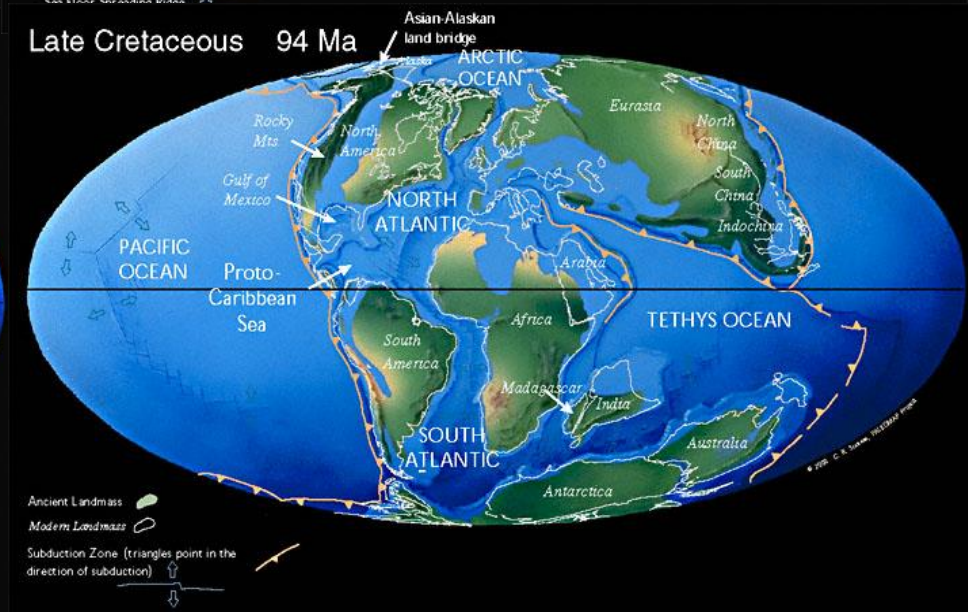
Biodiversity is a product of geological processes

- Plate tectonics unique to Earth -



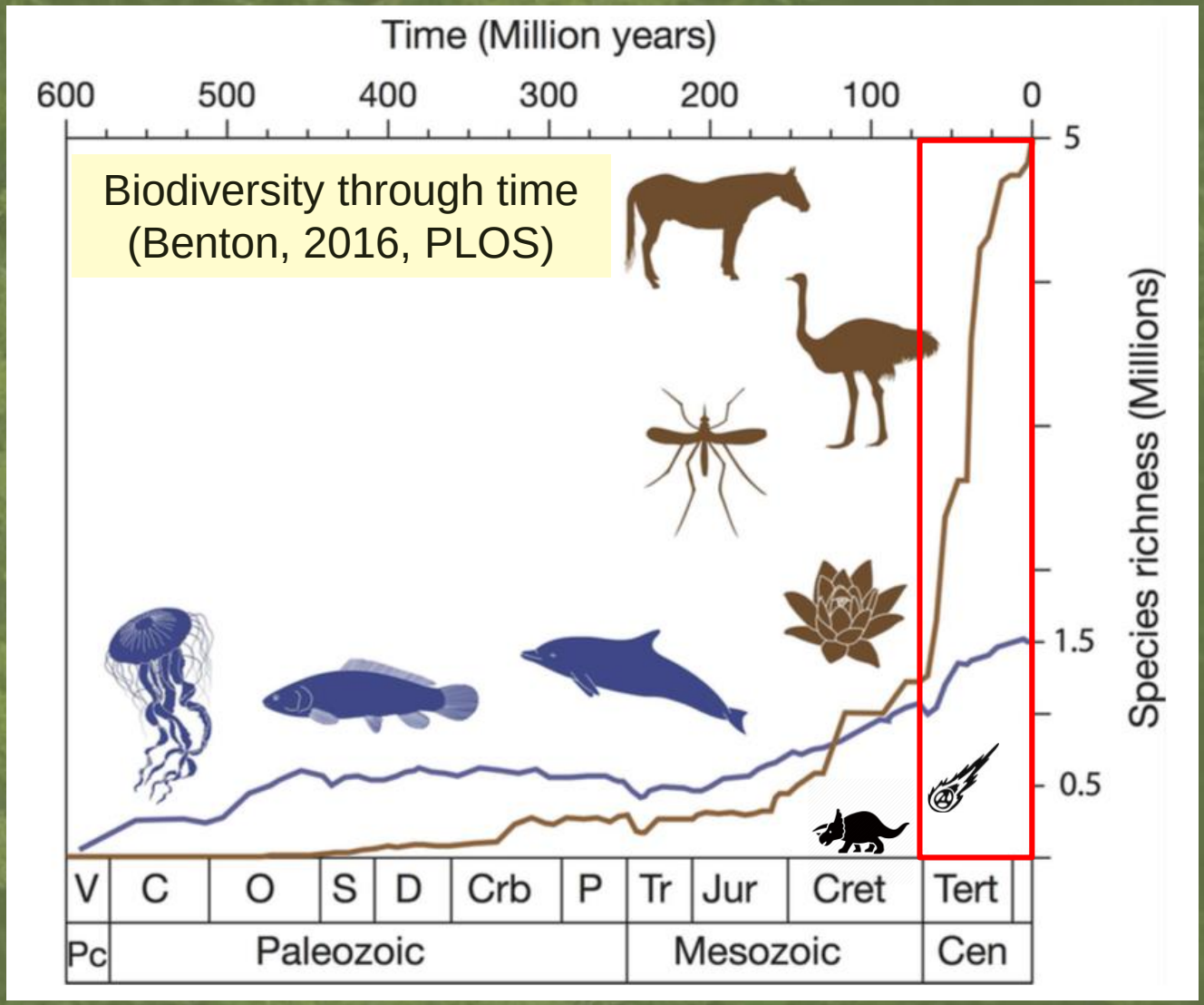




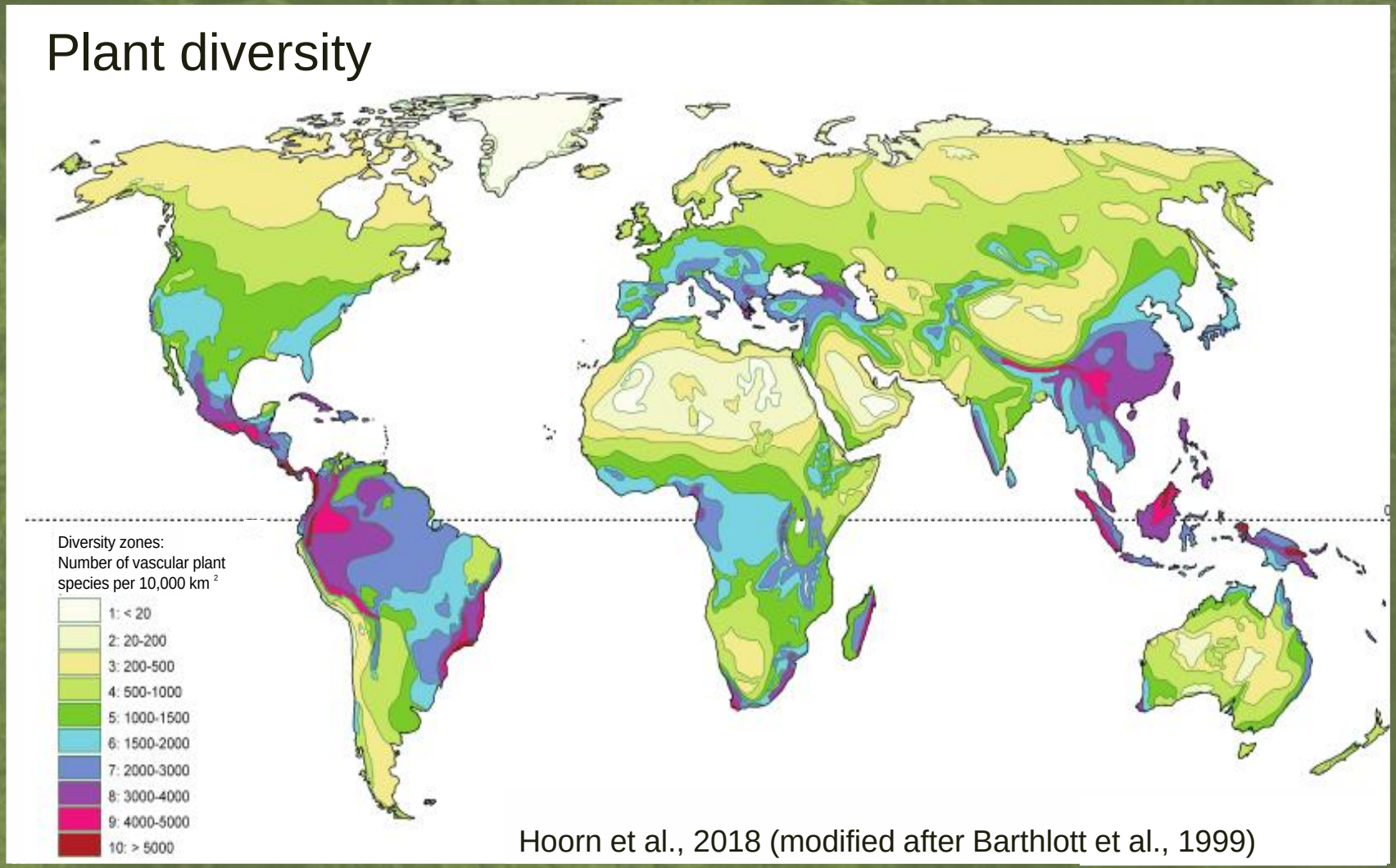


Origin of complex life c. 0.5 billion years ago

- Rise in biodiversity after 5th mass extinction -



Life on Land – Present biodiversity

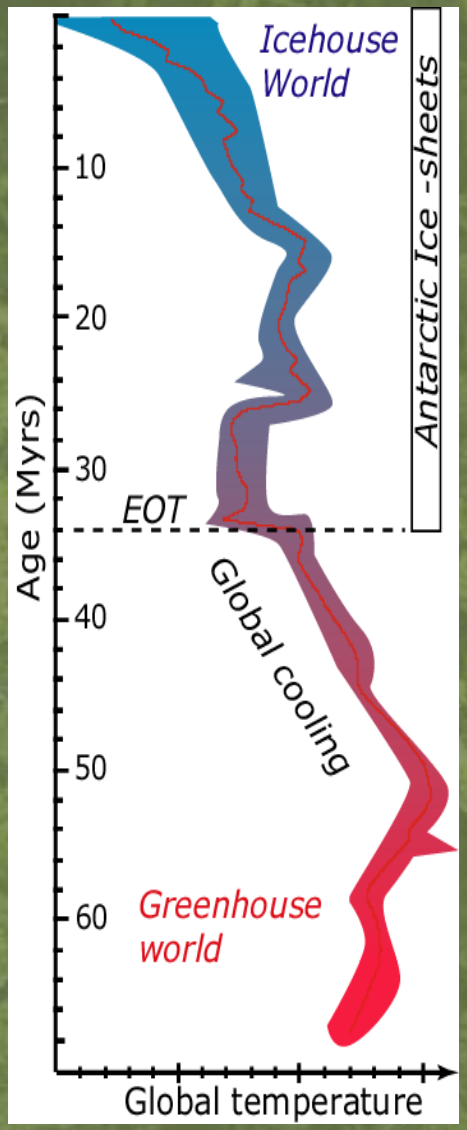


Hoorn et al., 2018 (modified after Barthlott et al., 1999)

Latitude, Topography and Climate determine Biodiversity

Drivers of biodiversity

Climate determines biodiversity



Zachos et al., 2008

Icehouse world

Glossotherium (and others; Rio)

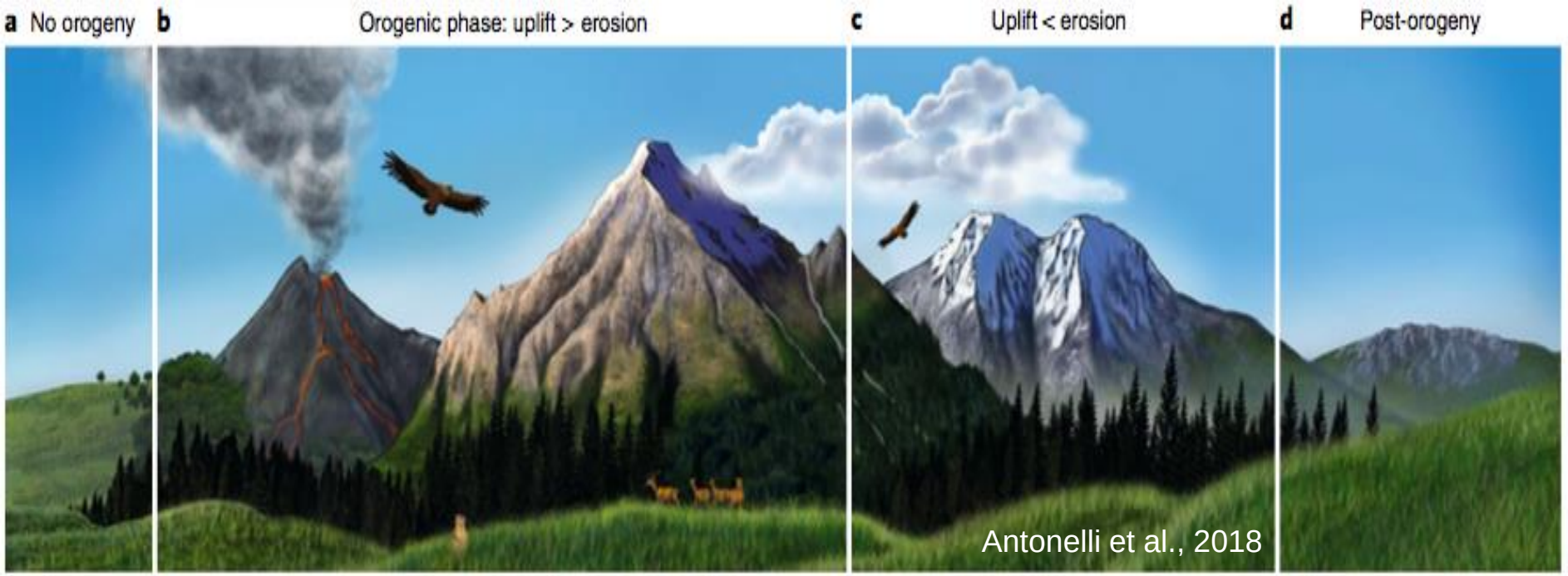
Greenhouse world

Titanoboa (si.edu)

Mountain uplift determines biodiversity

Altitudinal gradient

Relief changes & erosion



Immigration pre-adapted alpine taxa

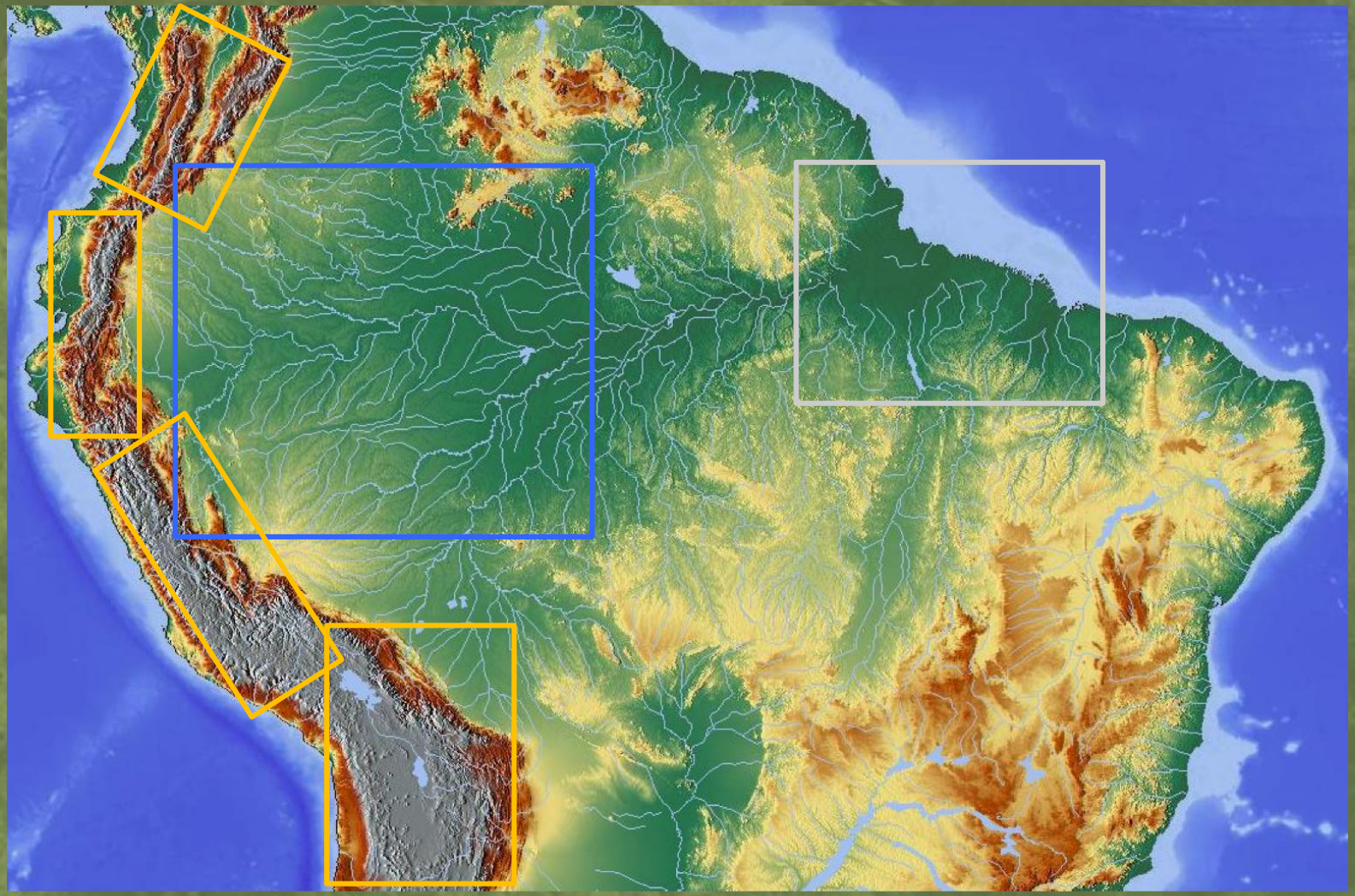
Species pump (isolation, connectivity) & refugia

Habitat heterogeneity (from mountain uplift and climate change)

From Andes to Amazon

The Andes – Amazonian continuum

Andes Subandes/foreland Amazon submarine fan

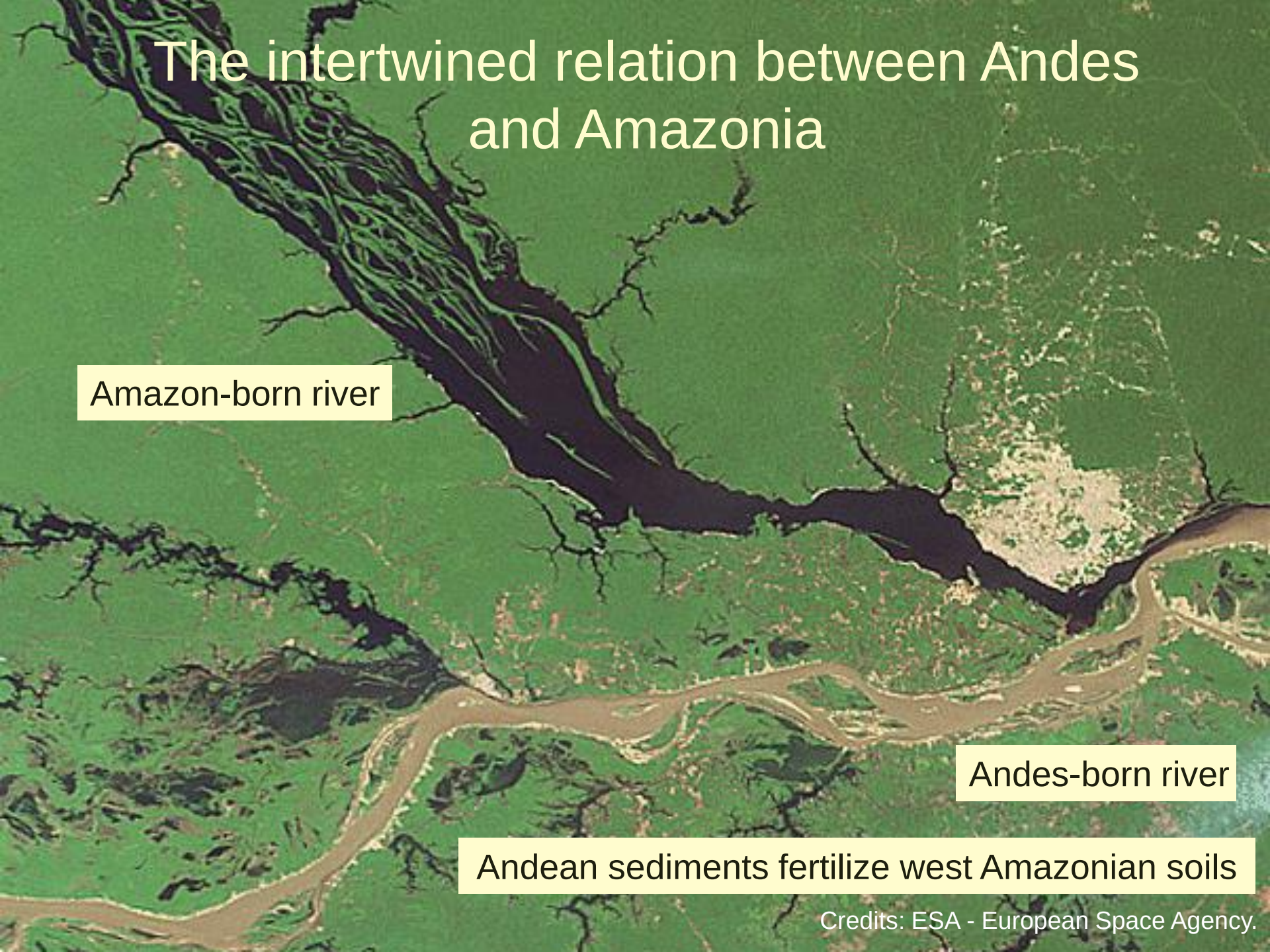


The Amazon River is the largest river basin in the world

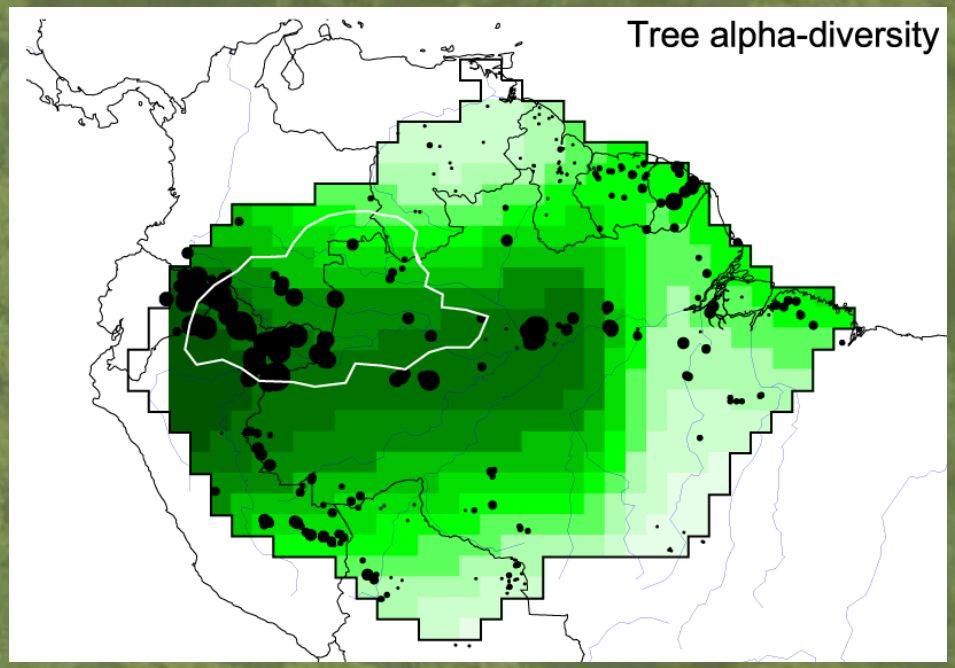
The Andes, a hotspot of biodiversity

Humboldt 250th

Humboldt's vision of Nature (1807)


The intertwined relation between Andes and Amazonia
Amazon-born river
Andes-born river
Andean sediments fertilize west Amazonian soils
Credits: ESA - European Space Agency.

Amazonia, extremely species-rich



ter Steege, 2010, ATDN & Wiley

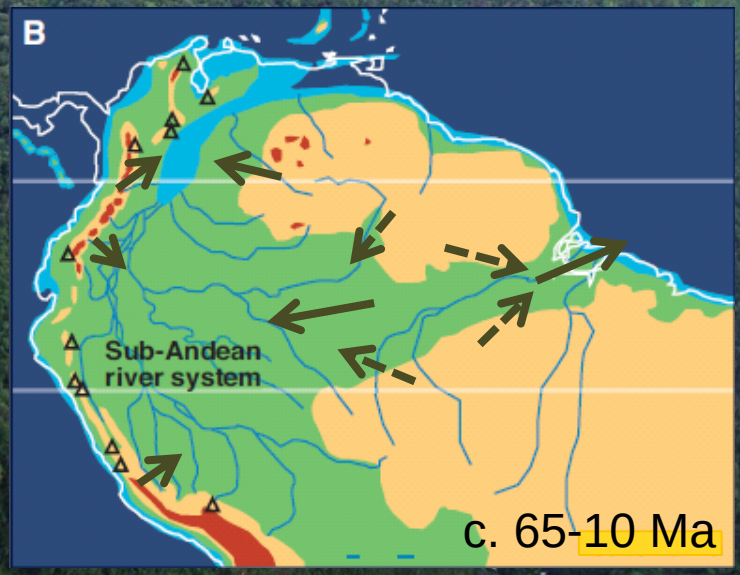
c. 16000 tree species

How and when did species richness originate?

Did humans alter forest composition since c. 12.500 BP?

Can the forest recover from human inflicted damage?

Amazonian-born rivers have a long history

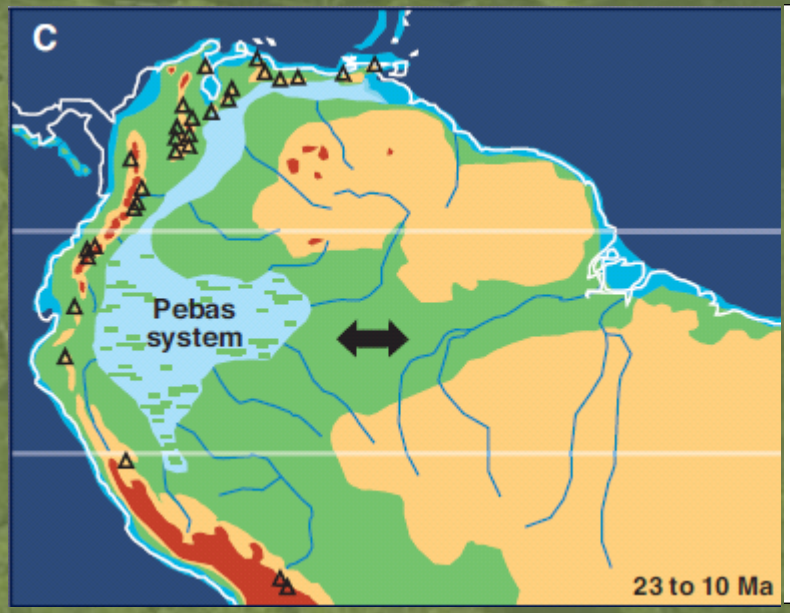


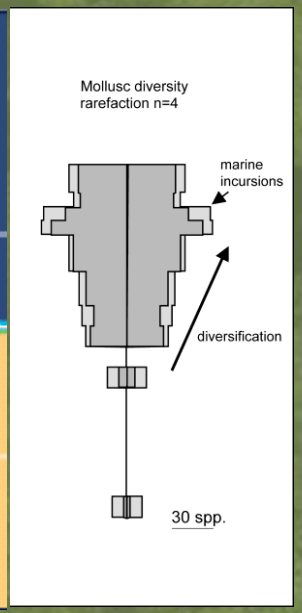
Angel Falls, Venezuela (photo L. Carillo)

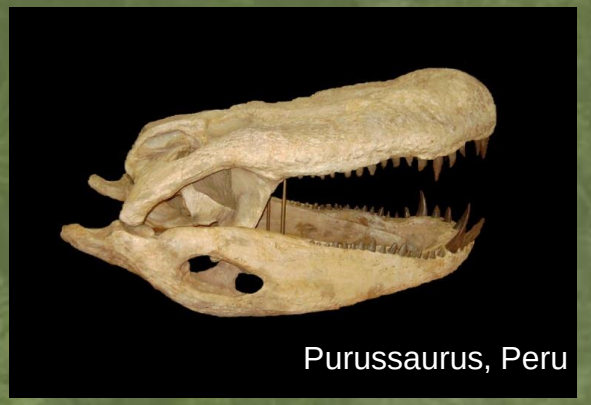
Andean influence in Amazonia

- Megawetland formation (c. 23 - 9 Ma) -

A cradle of speciation






Purussaurus, Peru


Inia, Amazon River

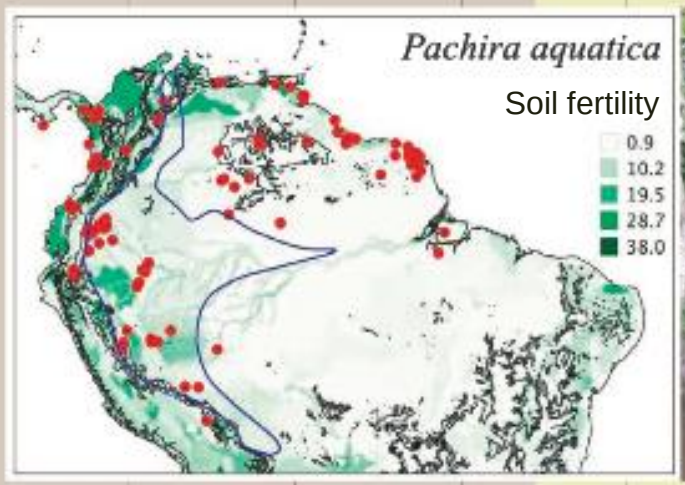

Iquitos, Peru

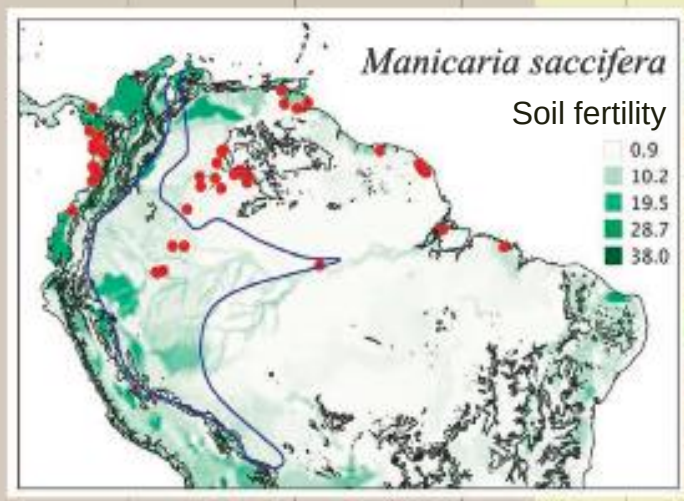
Andean fluvio-lacustrine deposits cover over a million km^2 in Western Amazonia

Evidence from the fossil record

Marine influence in Amazonia

- Relicts of coastal flora and fauna -

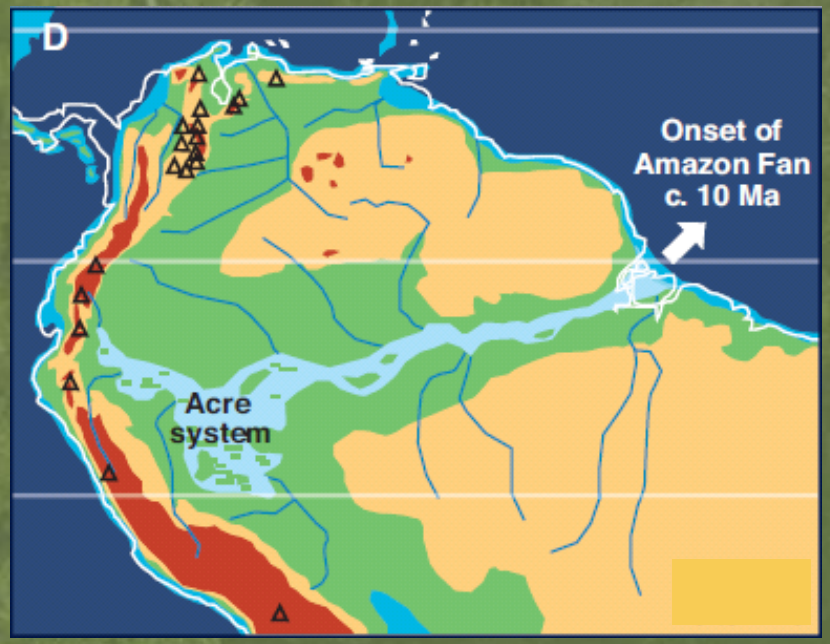




Bernal et al., 2019, J of Biogeogr.

c. 23 - 12 Ma

Transition towards the modern fluvial landscape



c. 9 - 5 Ma

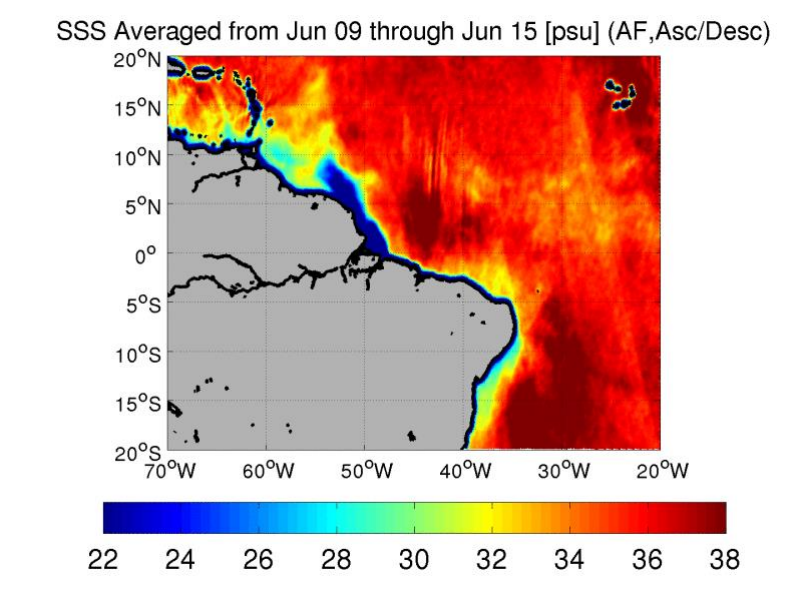
Acre – late Miocene fluvial deposits

From Andes to Atlantic

Evidence from the Atlantic

- Influences from Land at Sea -

-



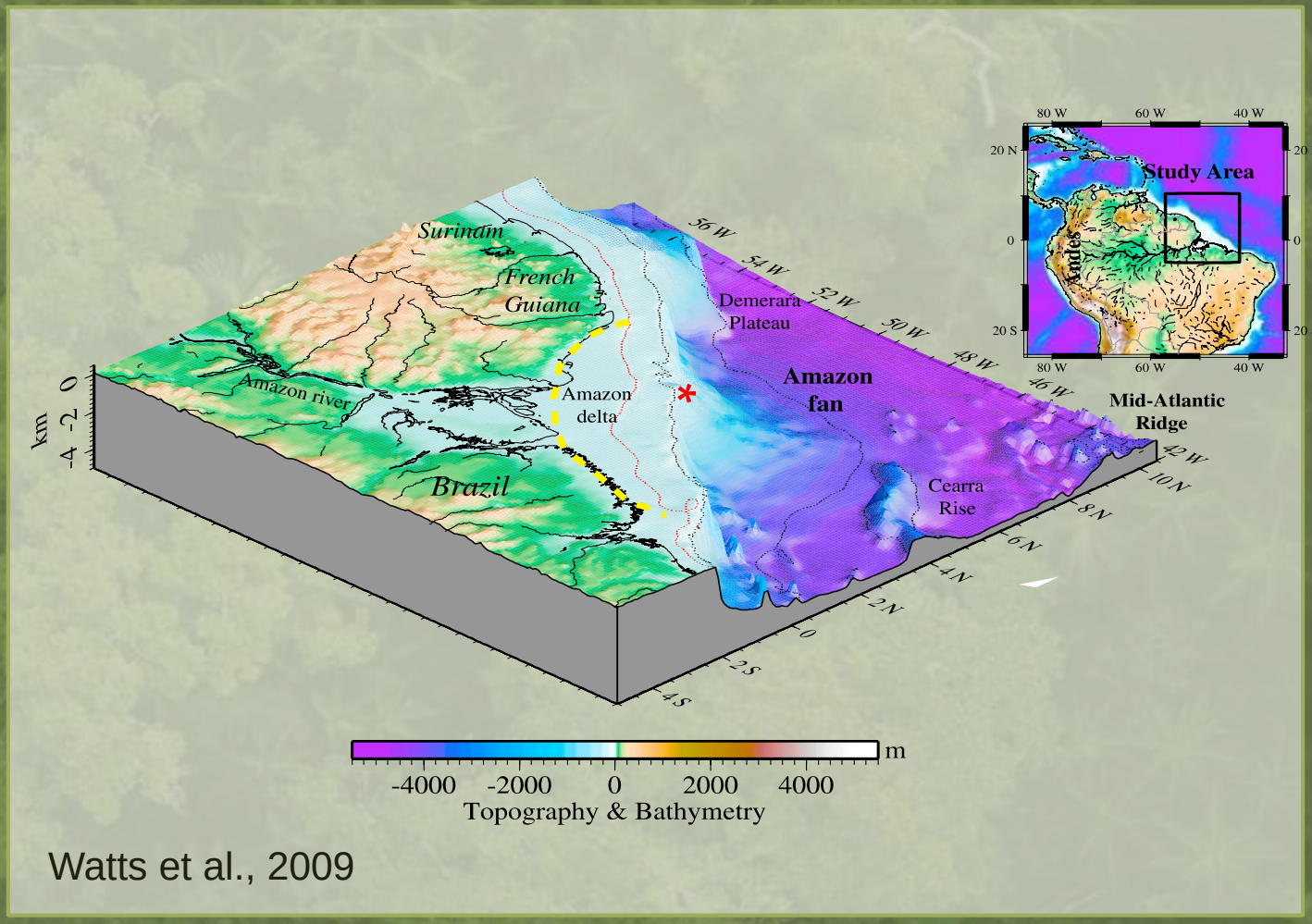
Sea surface salinity

Credits: Ifremer (2010)

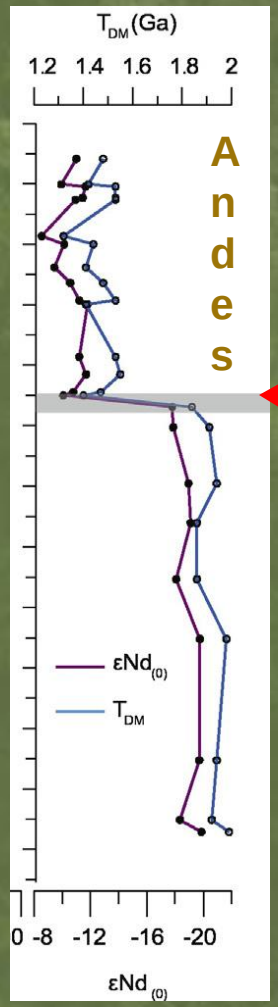
Nutrients: compost of the Ocean

Sediments: Archive of Amazon history

Onset Amazon River is marked by a change in sediment composition at c. 9.4 – 9 Ma



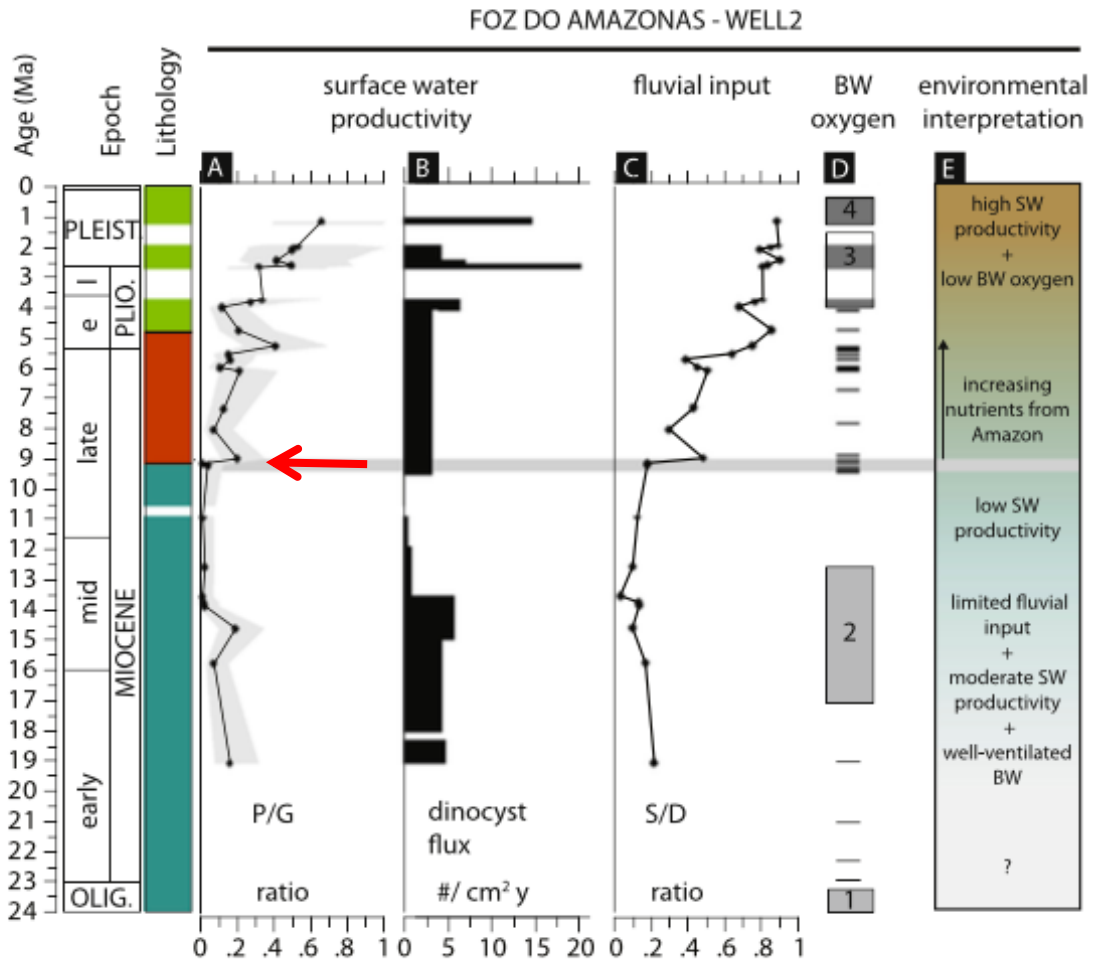
Watts et al., 2009

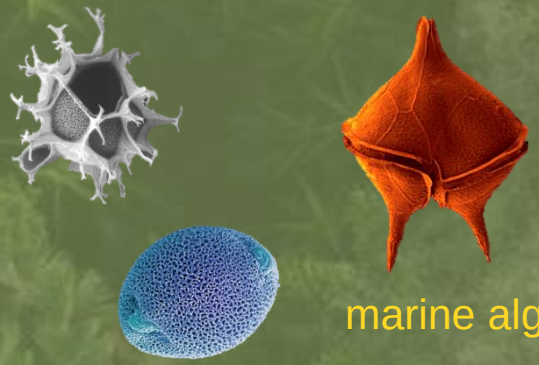


Hoorn et al., 2017

Rise in primary productivity in the Atlantic follows development of Amazon River

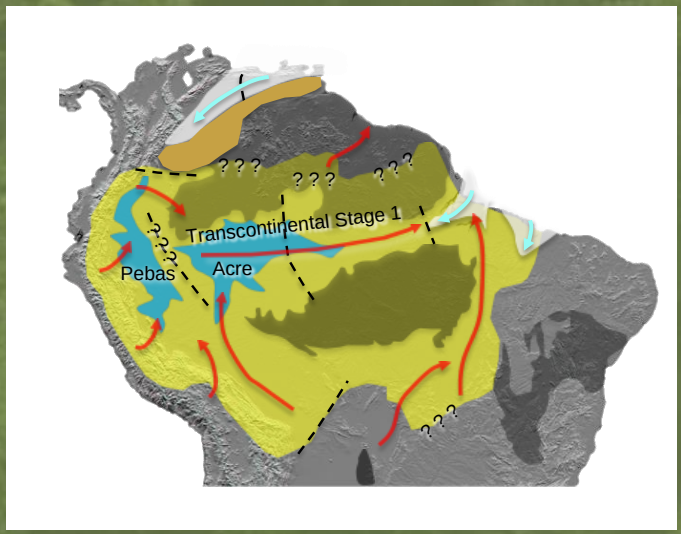
Lammertsma et al., 2018, Palaeo3





marine algae

Birth of Amazon River c. 9 - 9.4 Ma

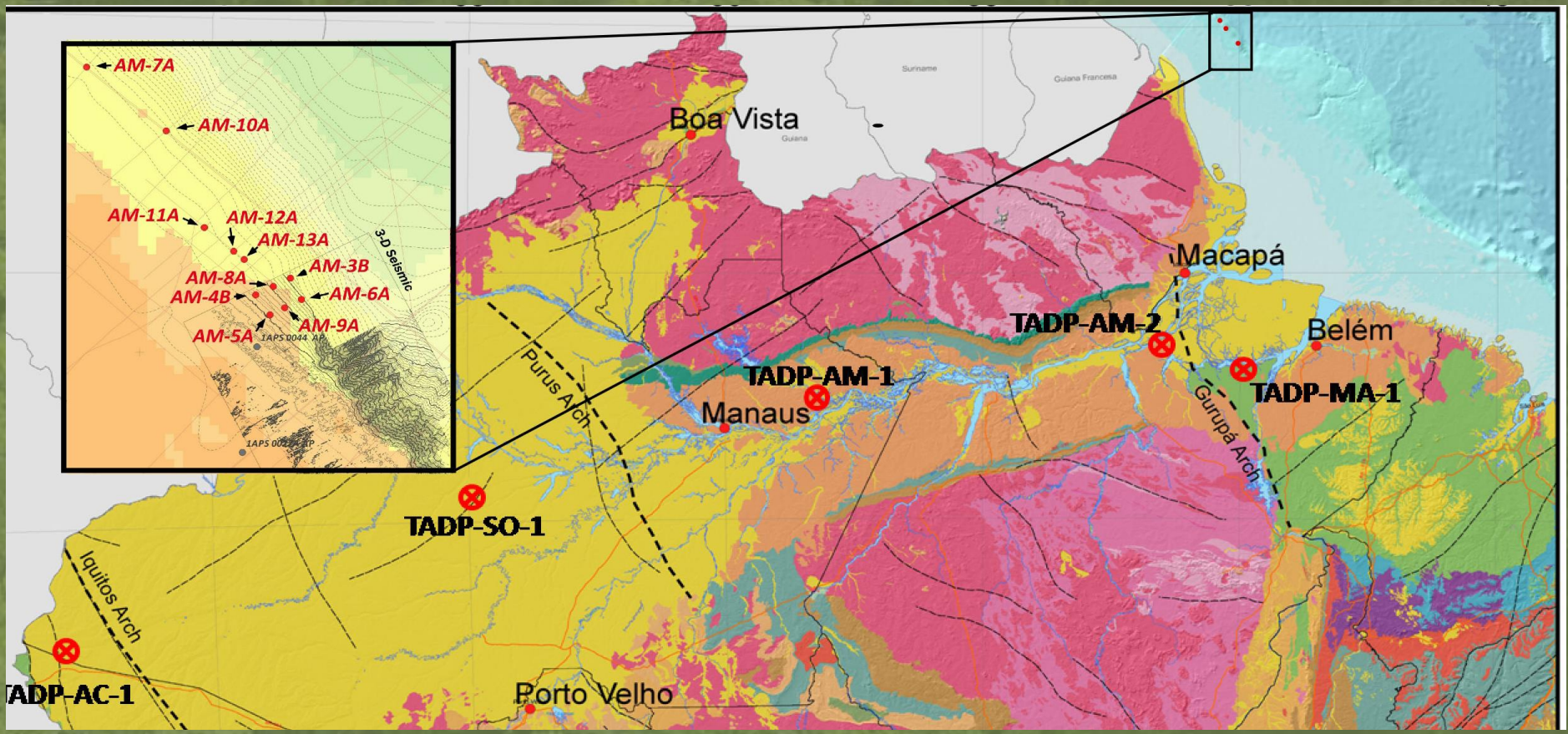


Albert et al., 2018, Neotr. Ichth.

New frontiers in deep-time biodiversity research

Trans-Amazon Drilling Project (TADP)

International collaboration (ICDP-IODP, Leg 387)



2020: Drilling scientific wells to research climate, erosion, biodiversity in Amazonia from Cretaceous to Present.

To conclude:

Amazonia’s biodiversity evolved over millions of years, following geodynamic and climatic changes

We still know little about the details of this process

Will this vulnerable system cope under human actions?

Amazonian biodiversity at risk

Hydroelectric dams may jeopardize the Amazon's future 2017

Amazon rainforest deforestation 'worst in 10 years', says Brazil 2018 BBC

Record levels of gold mining are destroying one of the most biodiverse places on Earth, study shows 2019

The Guardian

Earth's sixth mass extinction event under way, scientists warn 2017

SCIENCE

Earth Is Not in the Midst of a Sixth Mass Extinction 2017

"As scientists we have a responsibility to be accurate about such comparisons."

The Atlantic

"The recent loss of species is dramatic and serious but does not yet qualify as a mass extinction in the palaeontological sense of the Big Five."

"there are clear indications that losing species now in the 'critically endangered' category would propel the world to a state of mass extinction that has previously been seen only five times in about 540 million years. Additional losses of species in the 'endangered' and 'vulnerable' categories could accomplish the sixth mass extinction in just a few centuries."

Relicts of natural history also needs our protection in the museums

Reflection

Biodiversity on Land (as we know it), formed after 5th mass extinction, c. **65 my of evolution**

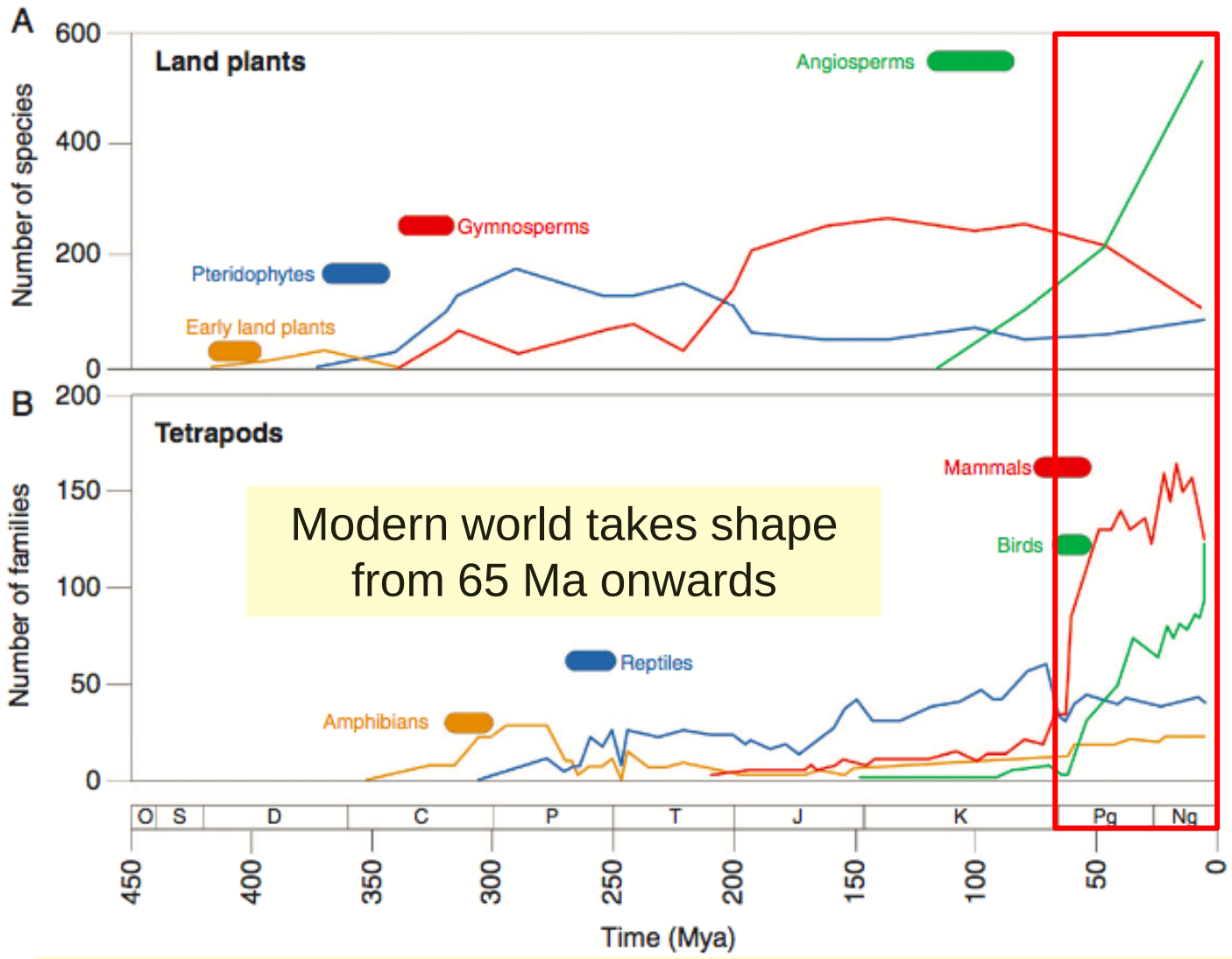
Now: an unprecedented fast decline on a scale of hundreds of years

This is something to act on to reverse this trend...

Thank you!

Muito obrigada!

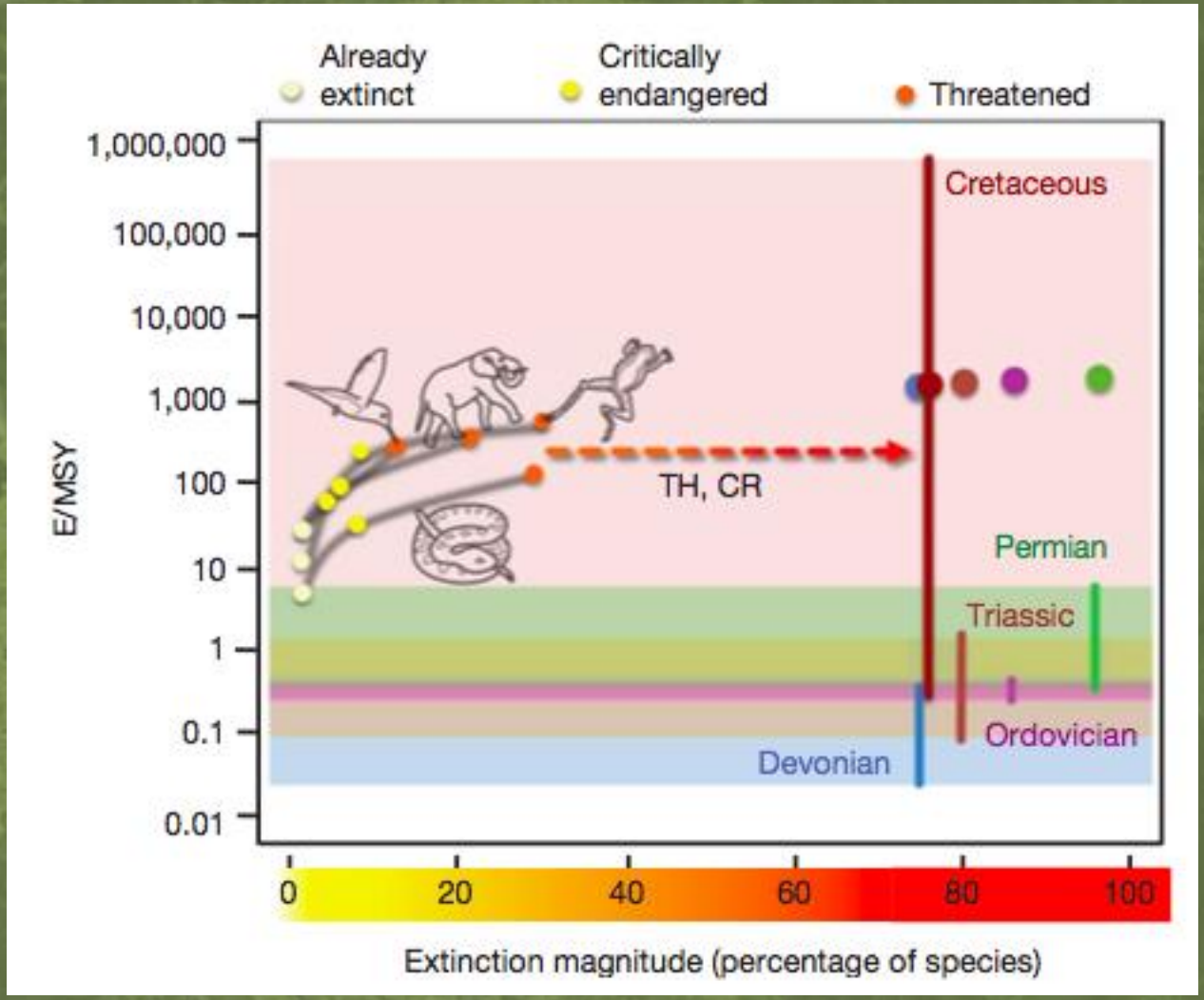
Rise of life on Earth c. 0.5 billion years ago



Modern world takes shape from 65 Ma onwards

Diversity through time, land organisms (Katz, 2018, Ann. Bot)

TH = Threatened
CR = Critically endangered
E\MSY = Extinction per million species-years
definition of mass extinction:



Barnosky et al., 2011 (Nature).