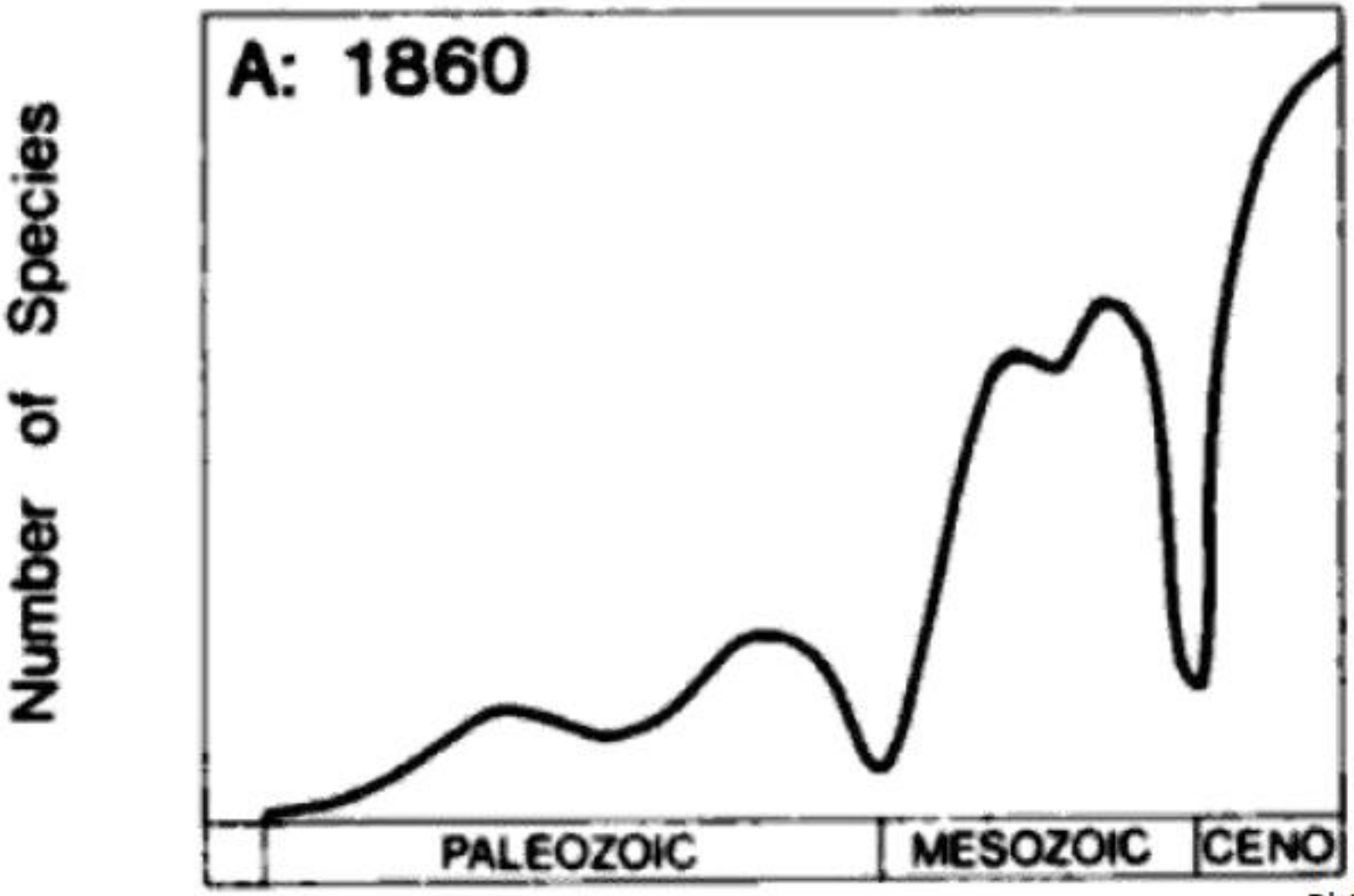
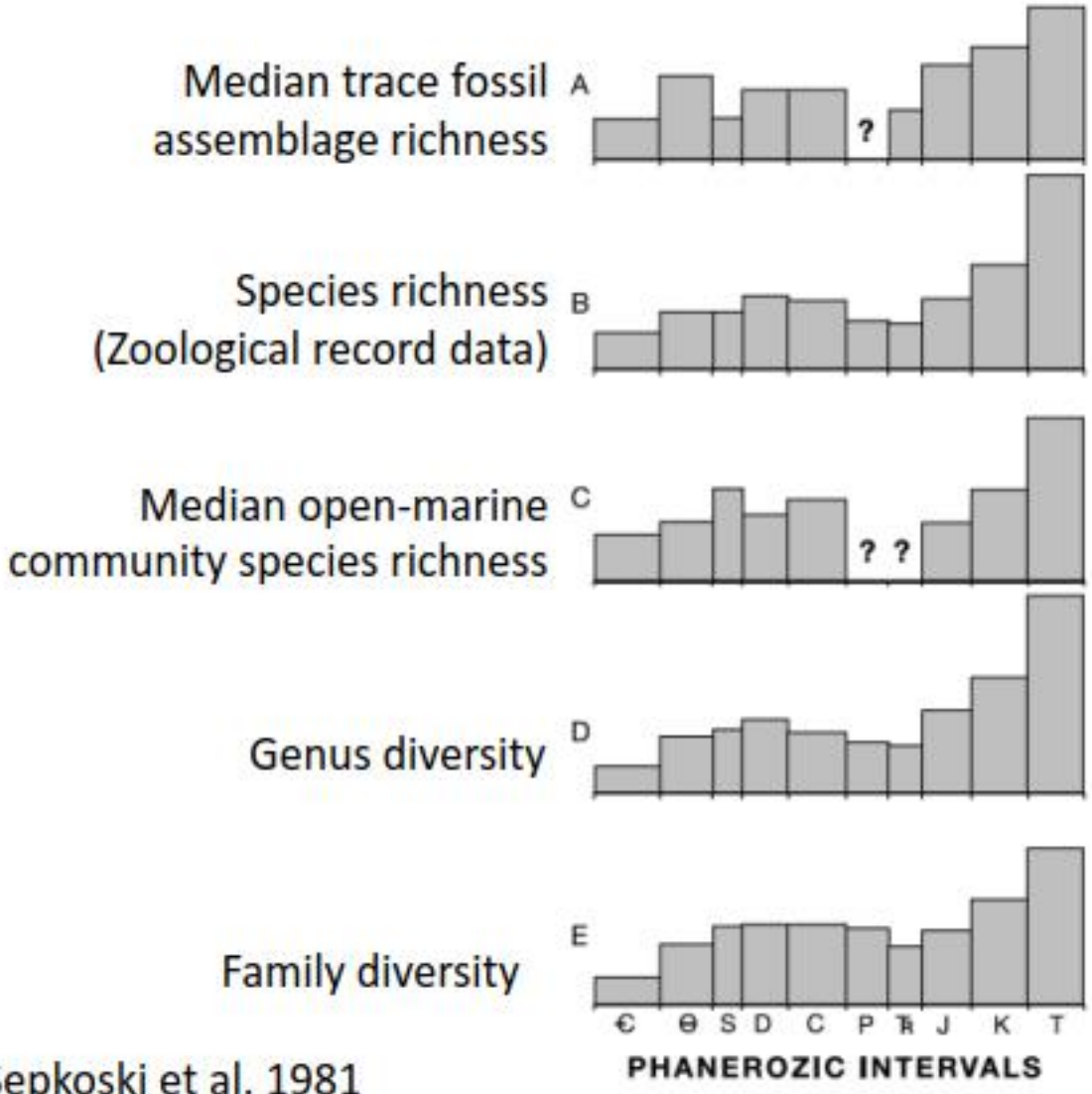
MASS EXTINCTIONS

Philips 1860



Philips 1860

The Consensus Paper… Sepkoski et al. 1981



Sepkoski et al. 1981

Dolf Seilacher

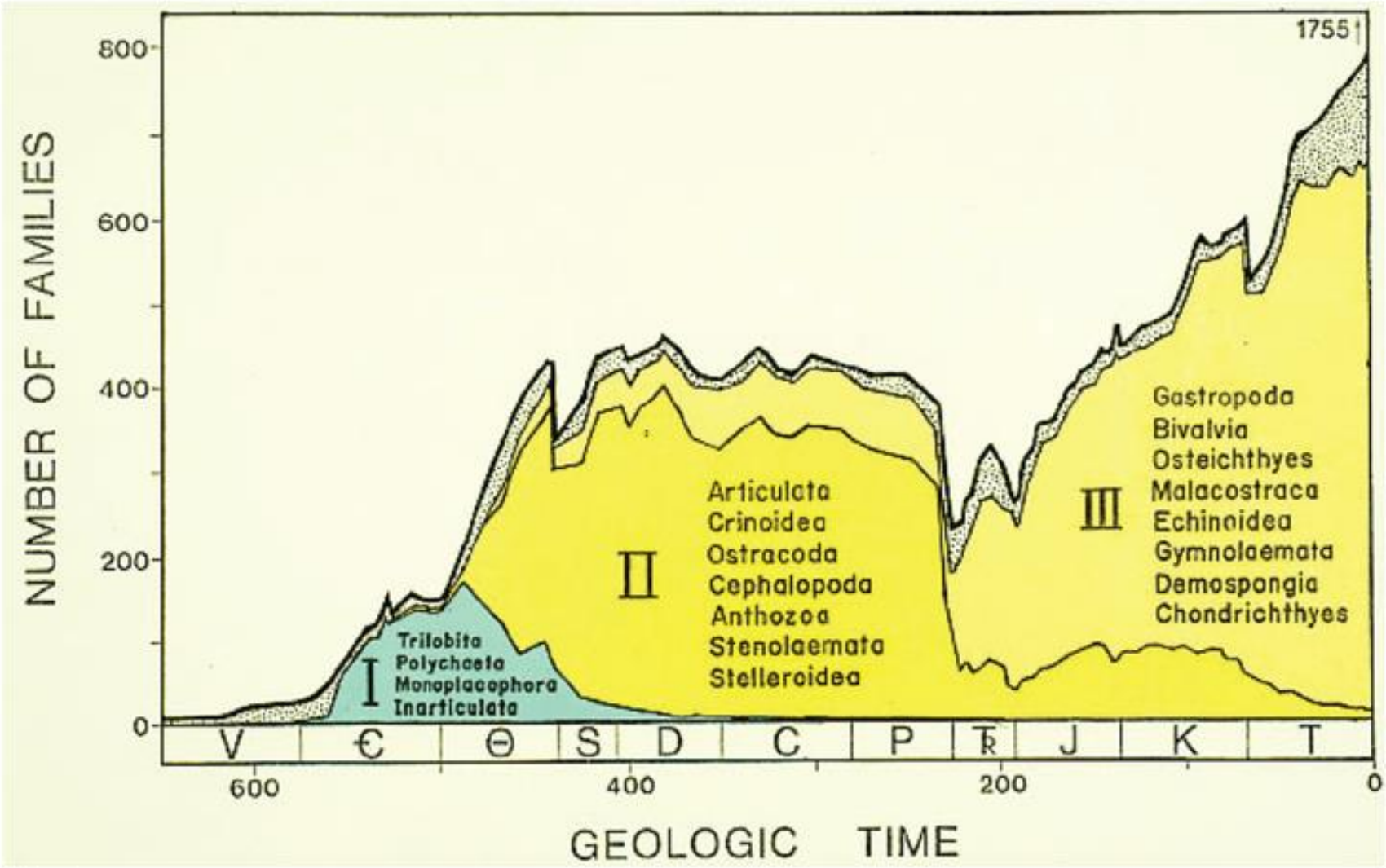
David Raup

Richard Bambach

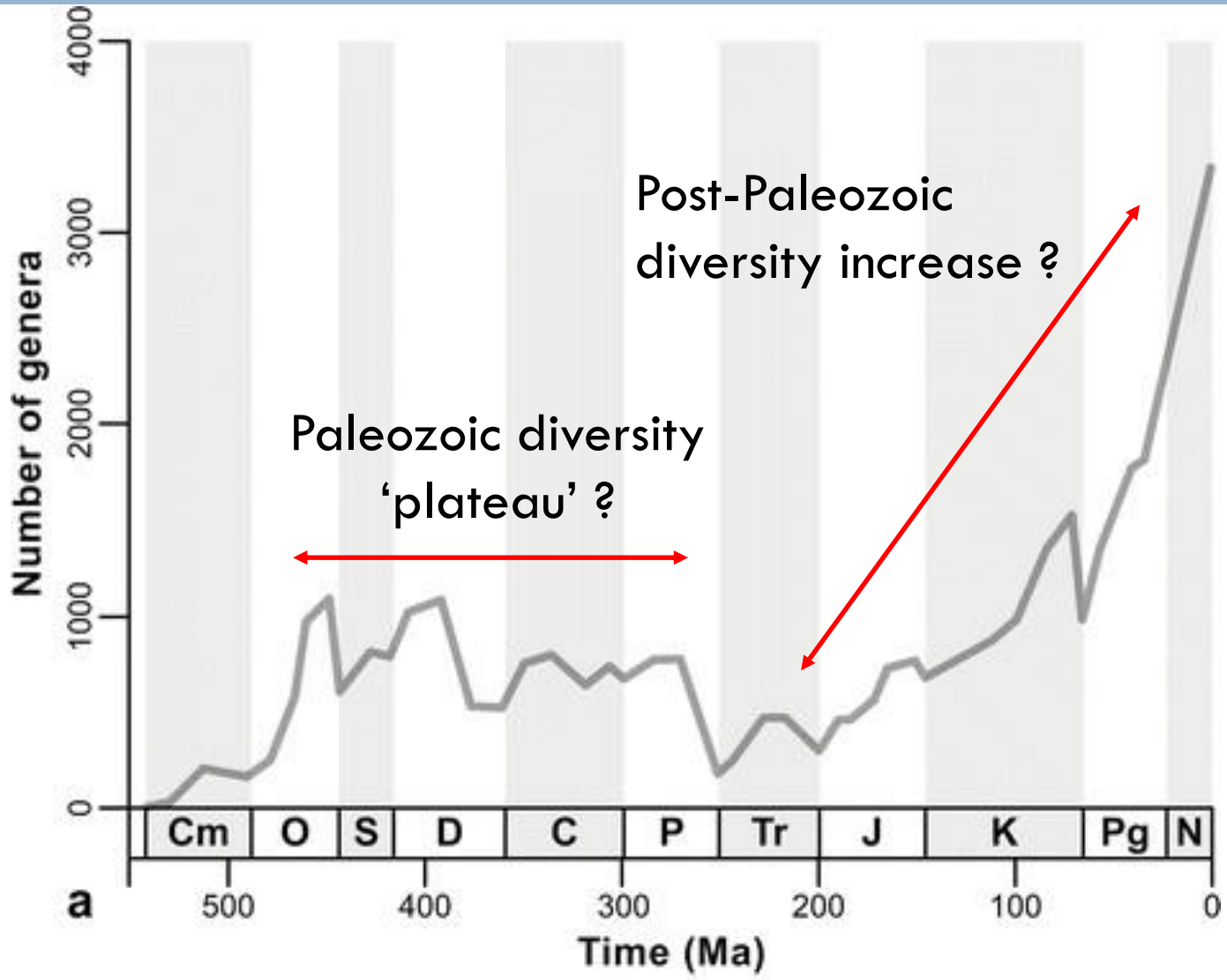
David Raup

Jack Sepkoski

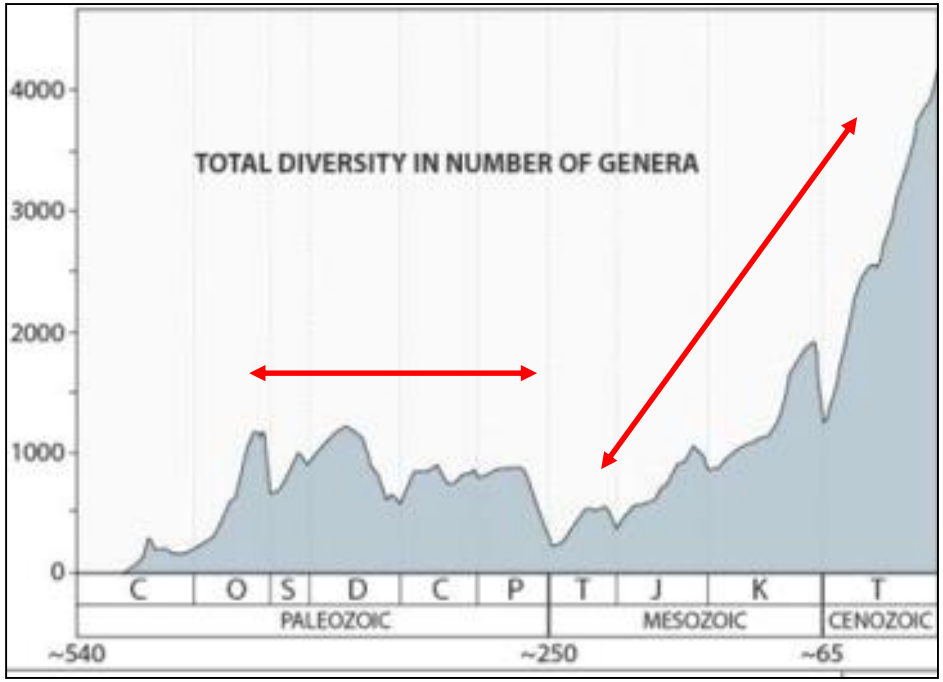
Sepkoski's curve

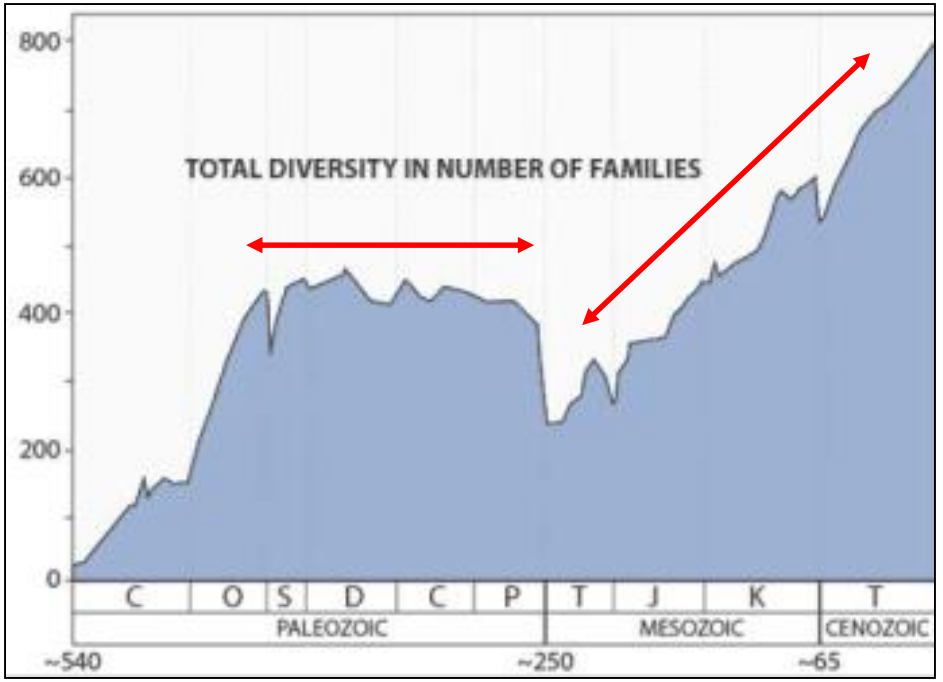


Sepkoski's curve of marine invertebrates



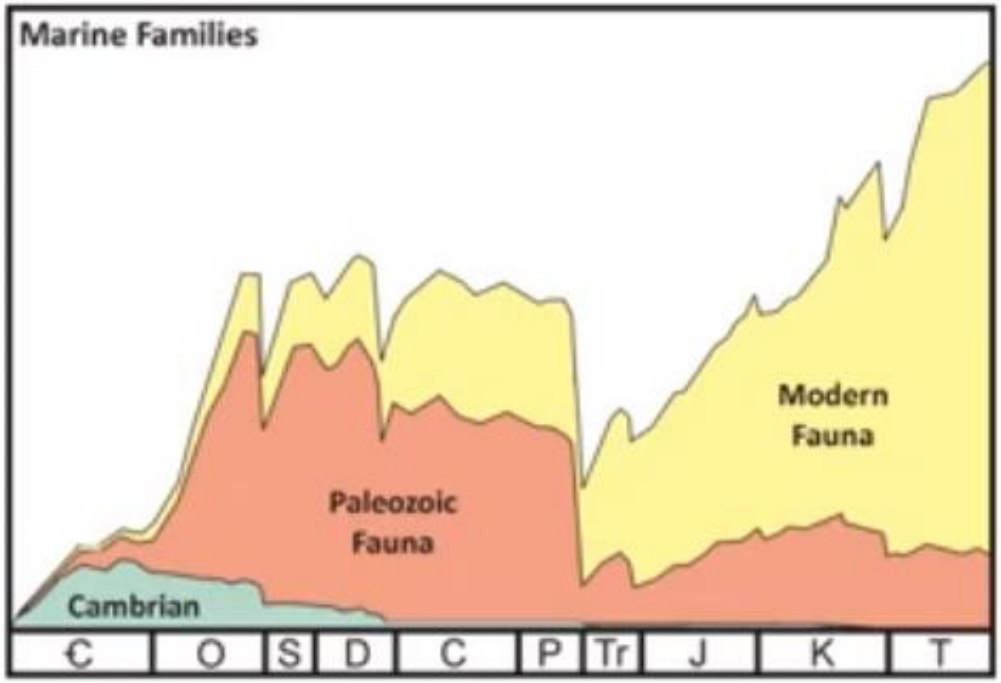
Taxonomic level

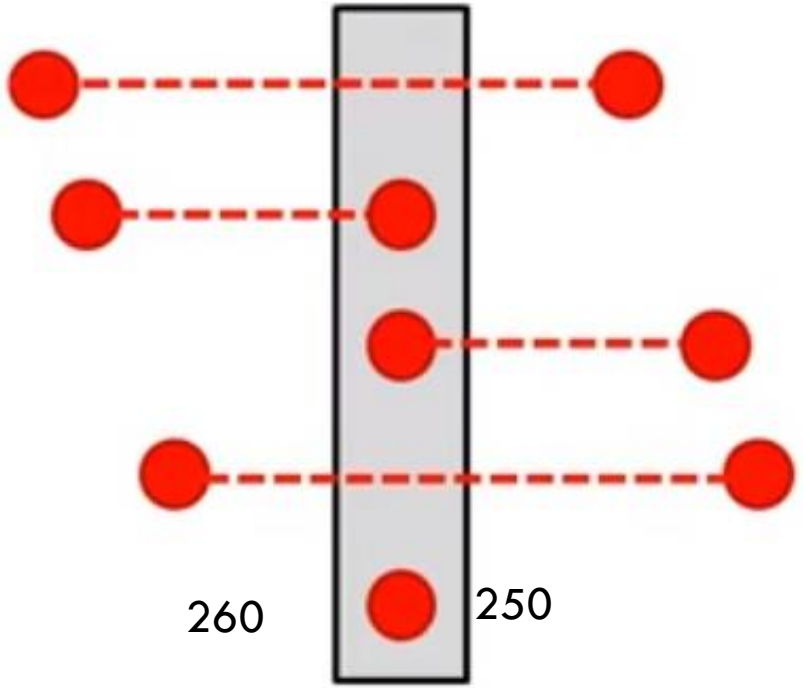




Range trough counting

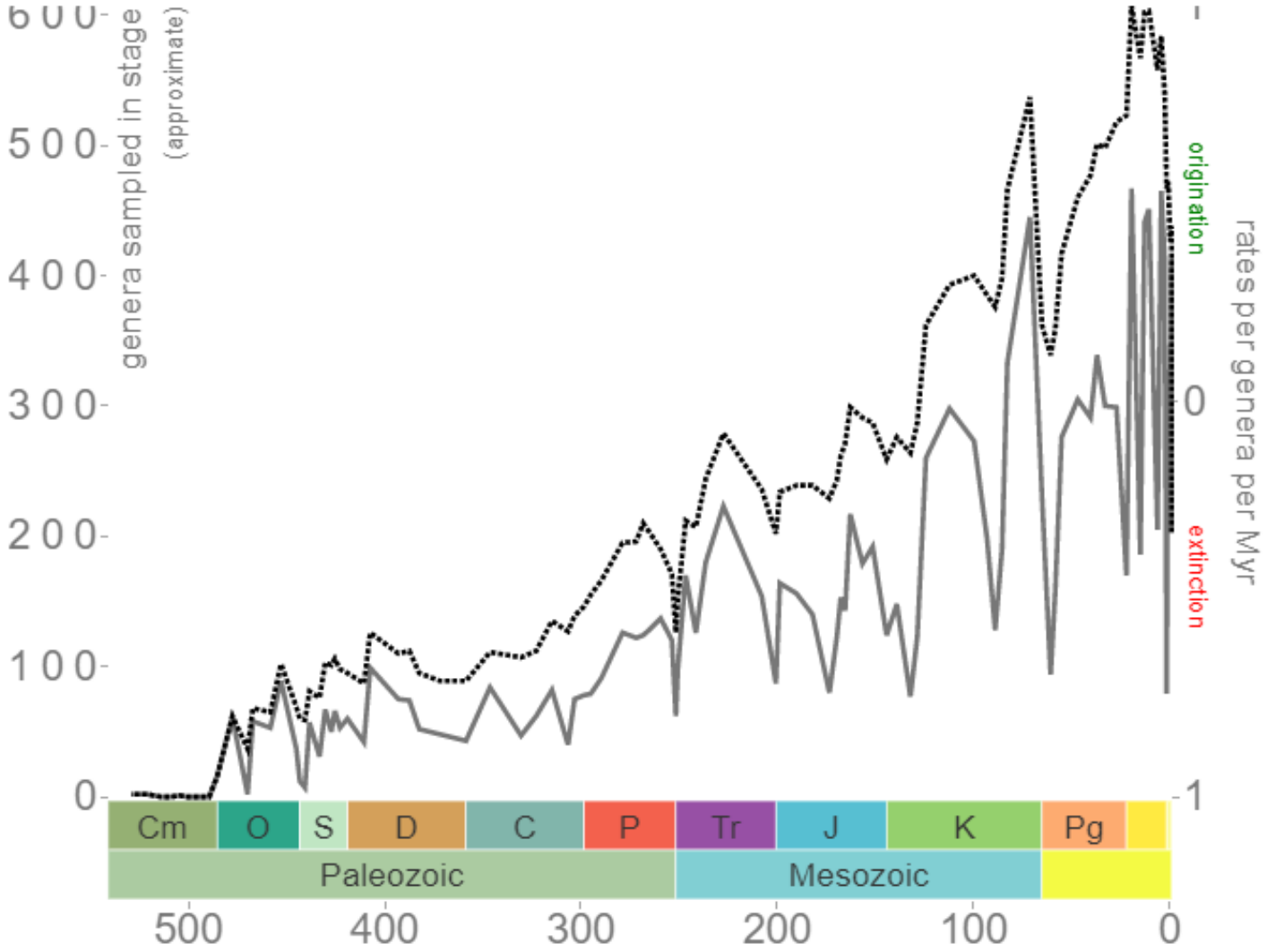
- Traditionally, diversity curves were based on ranges through FA & LA





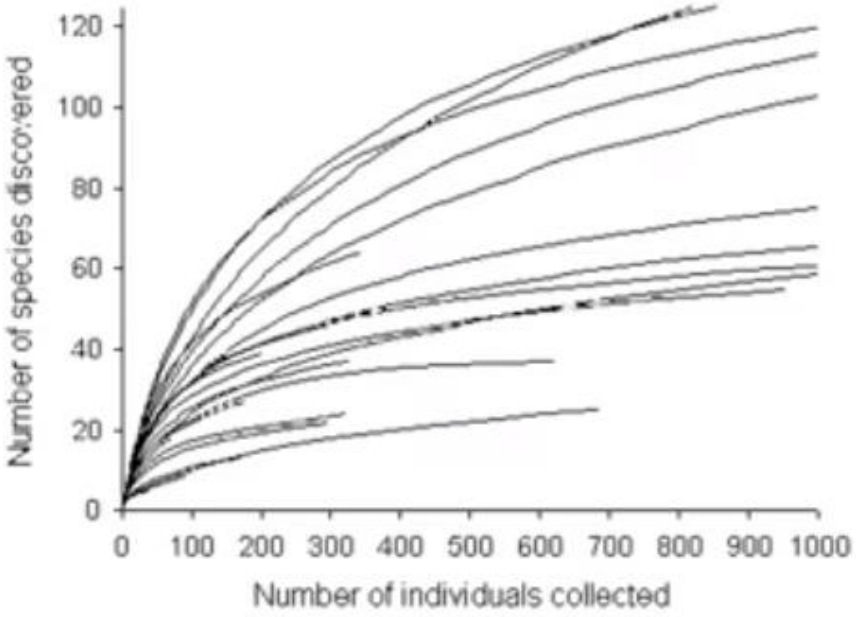
- Diversity = Sampled-in-bin diversity + Range through

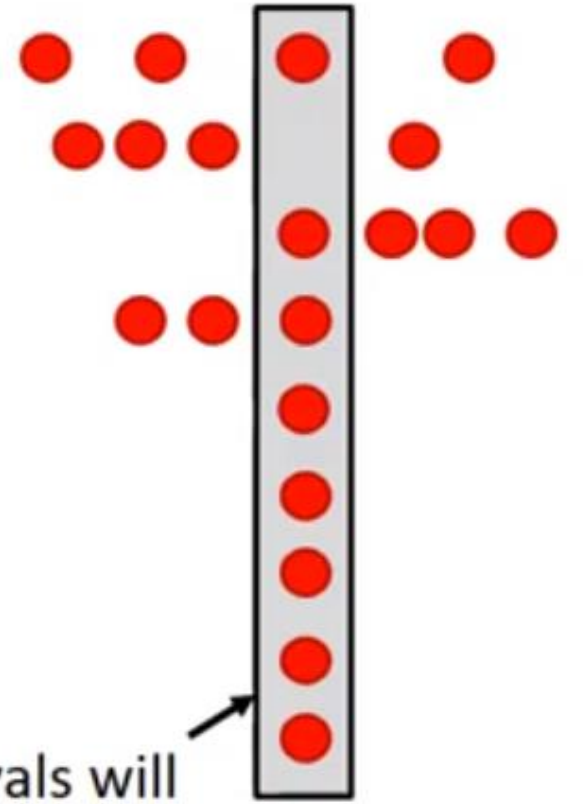
Bivalve diversity across the Phanerozoic



Diversity biases – (1) sampling intensity

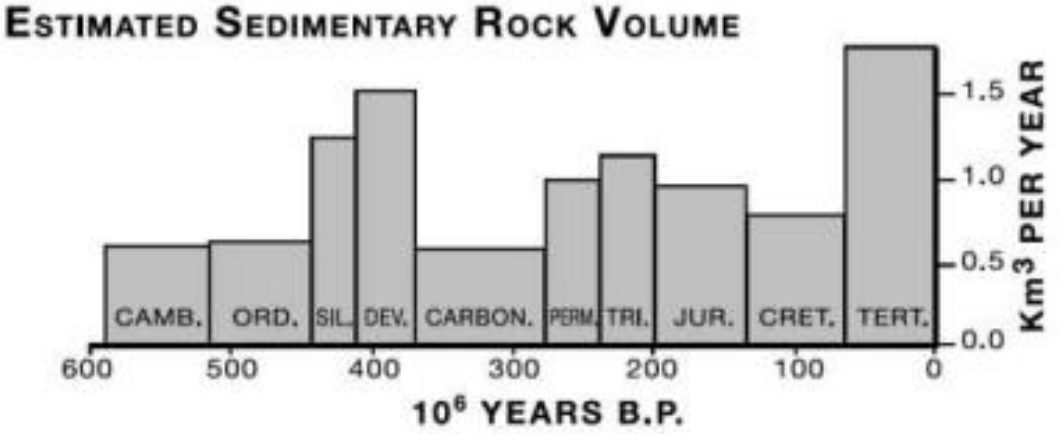
- Diversity increases with sampling intensity

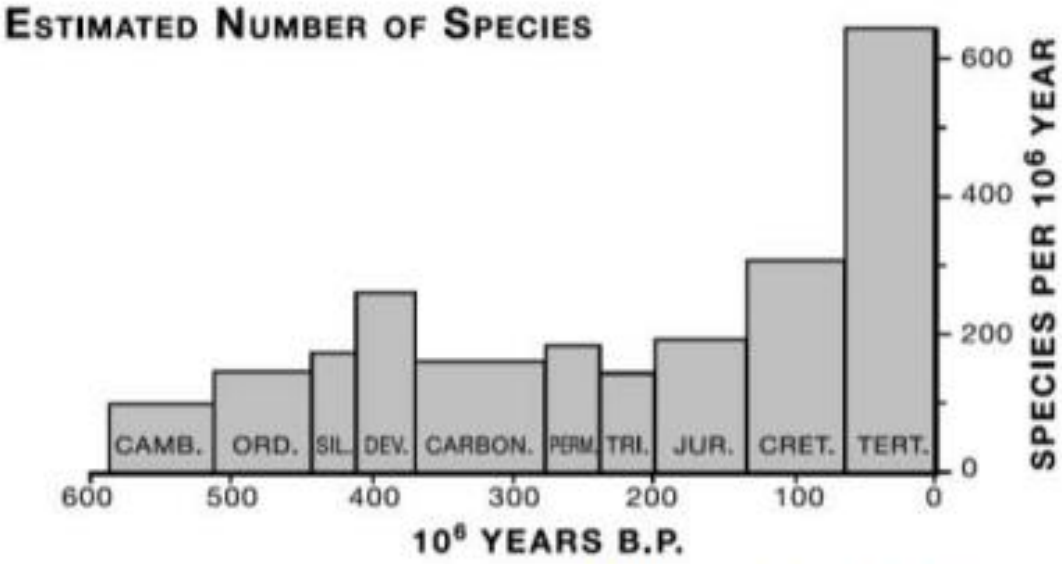




Well-sampled intervals will have many “one-timer” taxa

Sedimentary rock volume bias

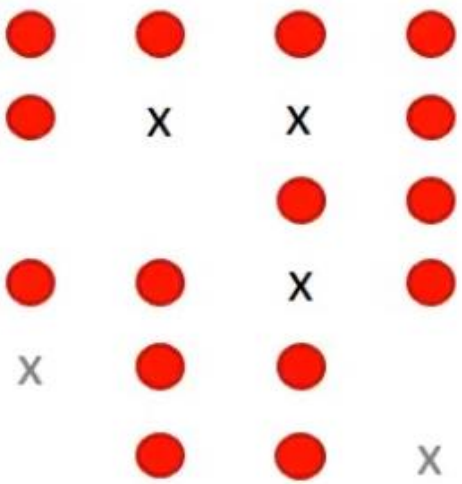


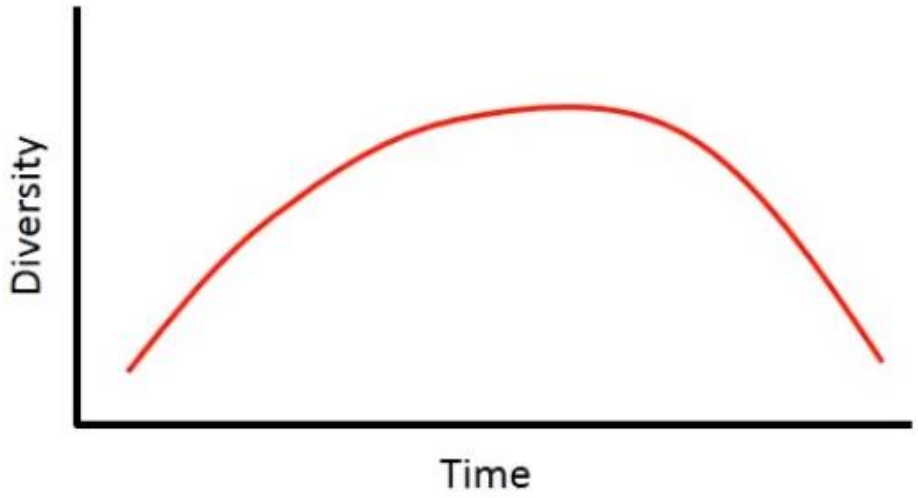


Miller 2009, after Raup 1972

Diversity biases – (2) Edge effects

- Fossil ranges contains gaps ("Lazarus taxa"), gaps before FAD and after LAD are unknown and cannot be counted

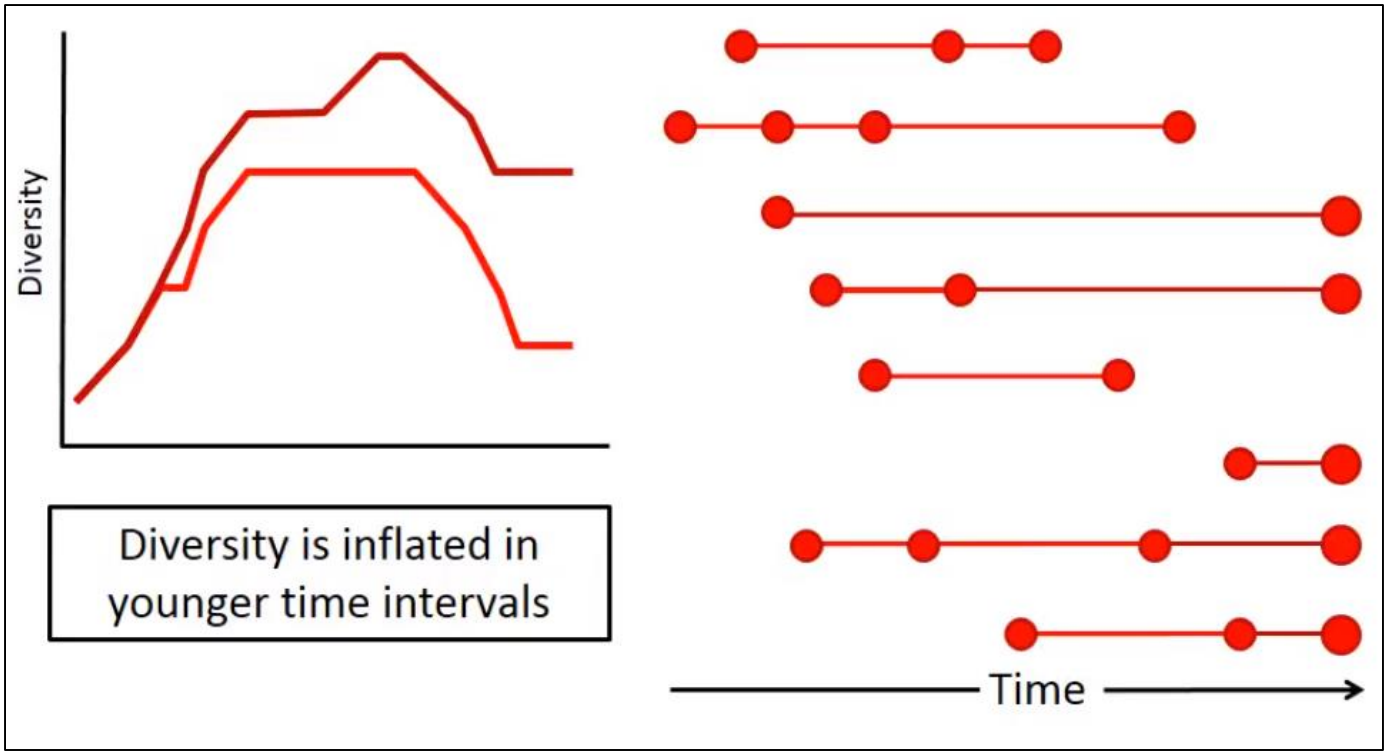




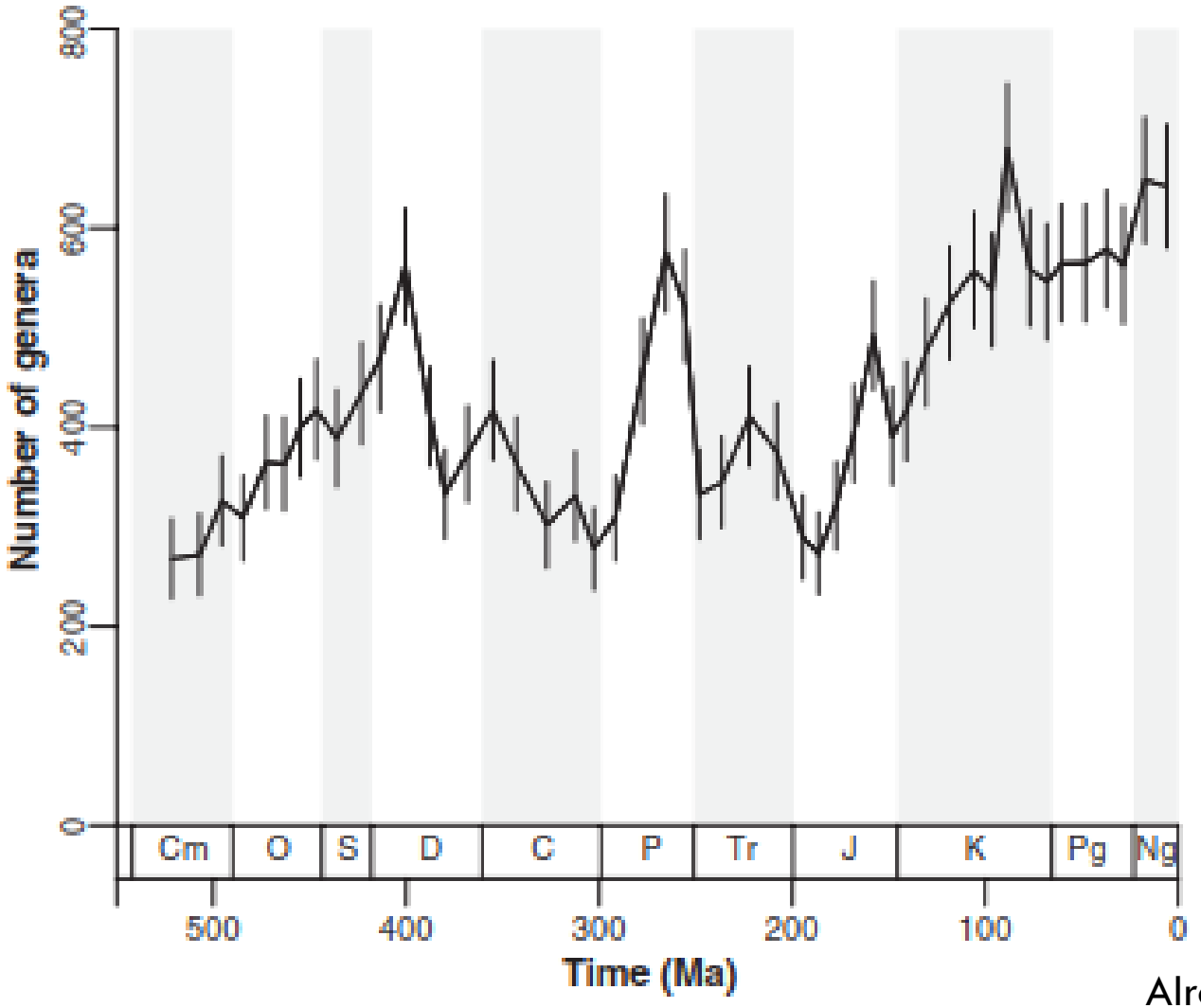
- Range-through diversity is artificially low at the edges of any time series ("edge effects")

Pull of Recent

- Because the living fauna is so well known, the ranges of many more recent taxa are "pulled" to the present-day

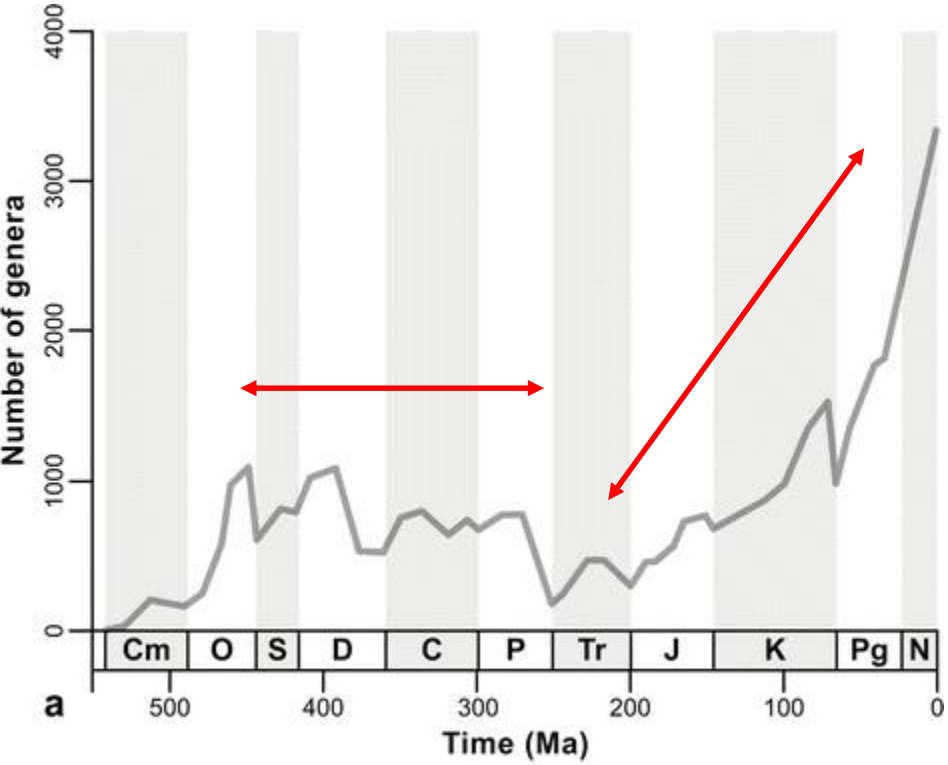


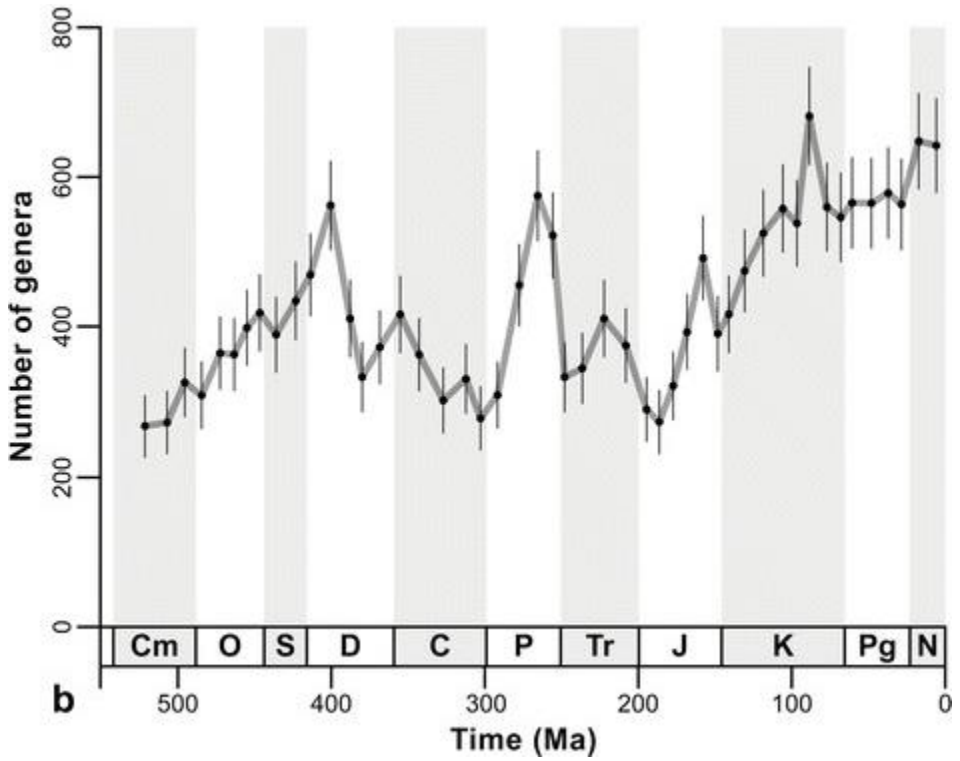
Solution - Rarefaction



Alroy et al., 2008

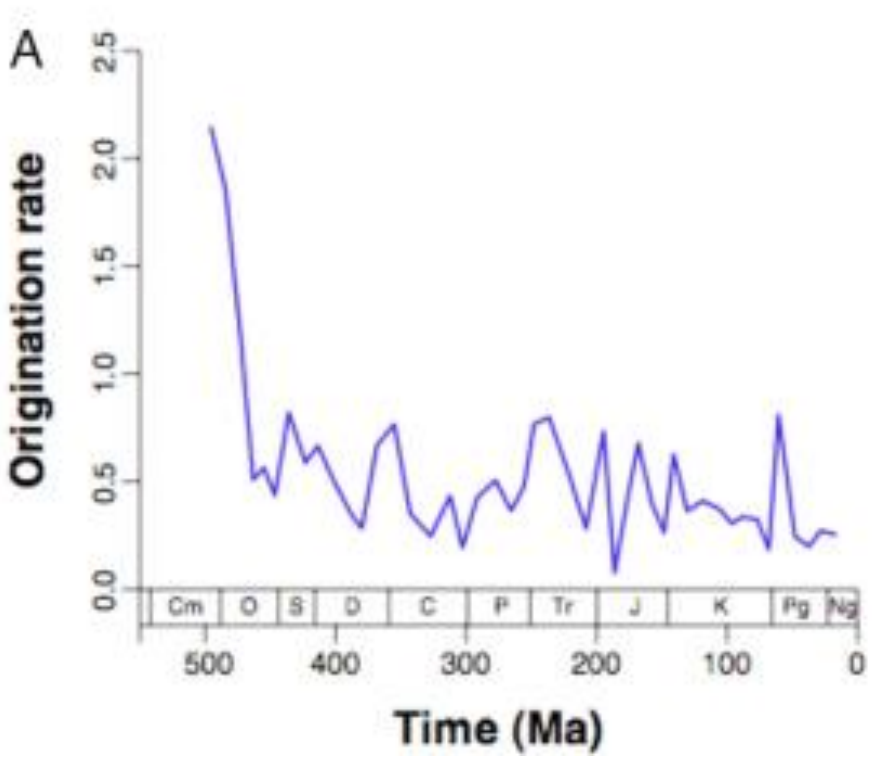
Rarefied Phanerozoic diversity trends

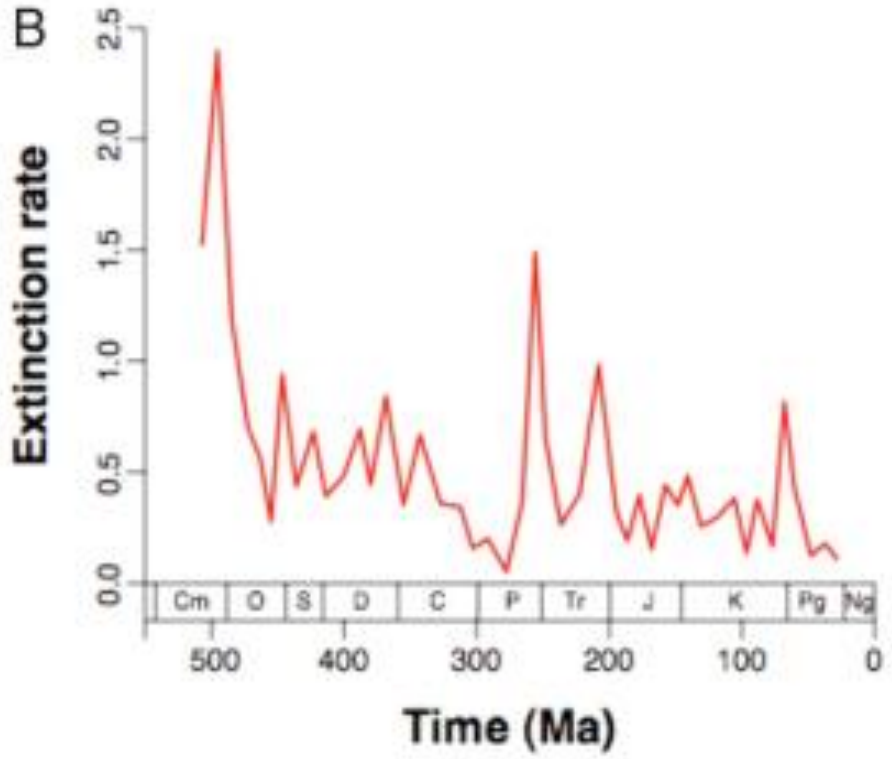




Alroy et al., 2008

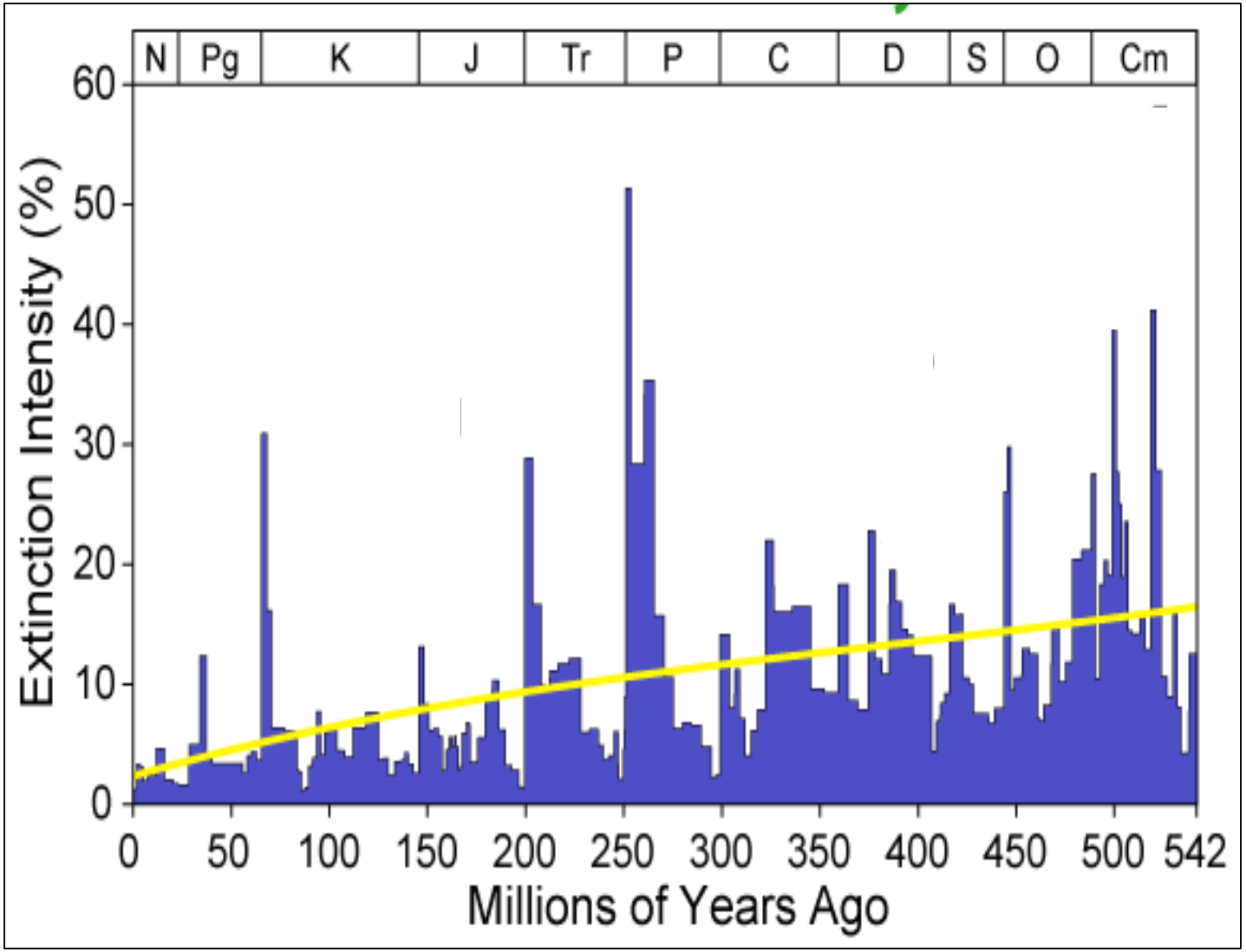
Origination and extinction rates



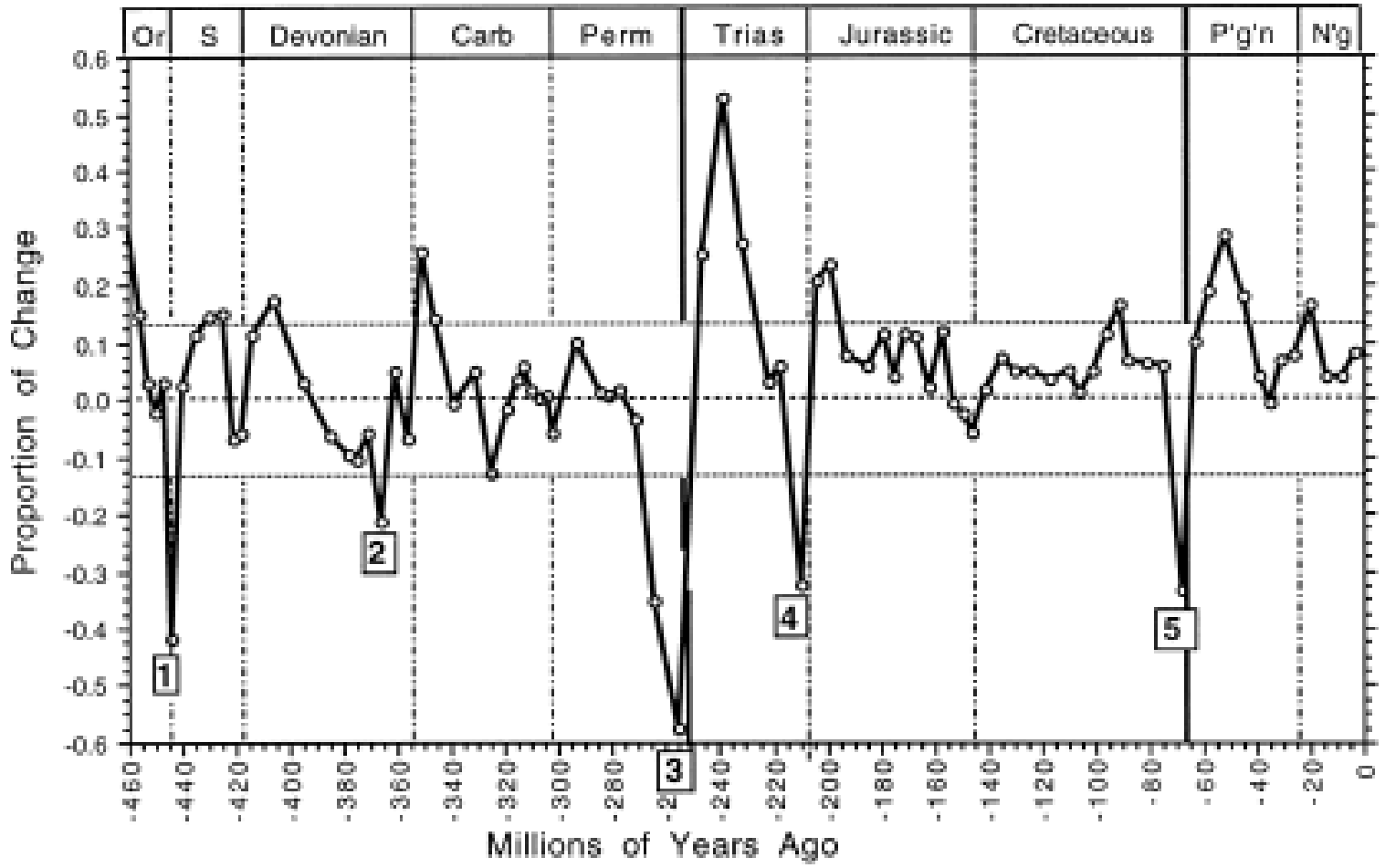


Alroy, 2008

Extinction rate over time



What are the mass extinctions?

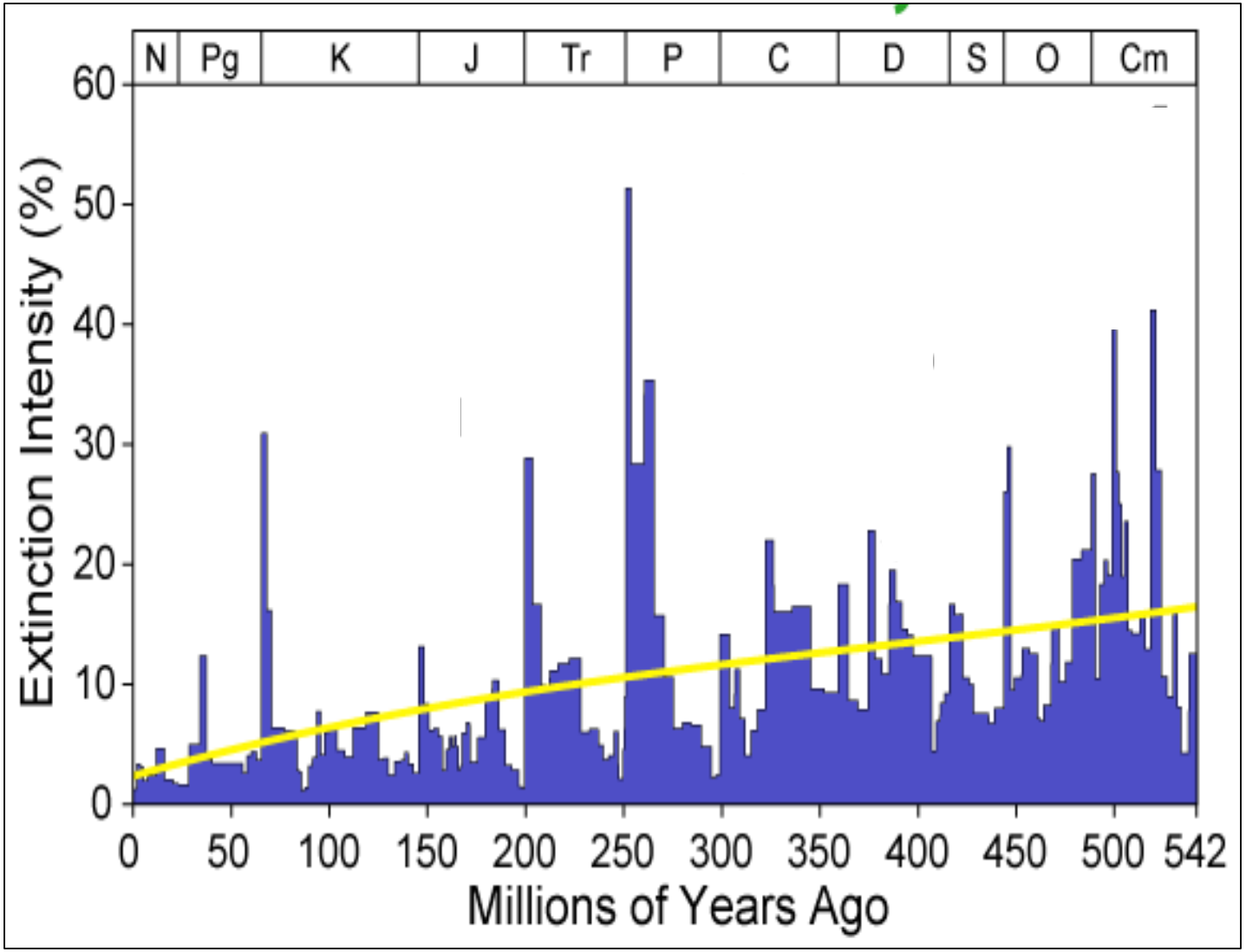


Bambach et al., 2004

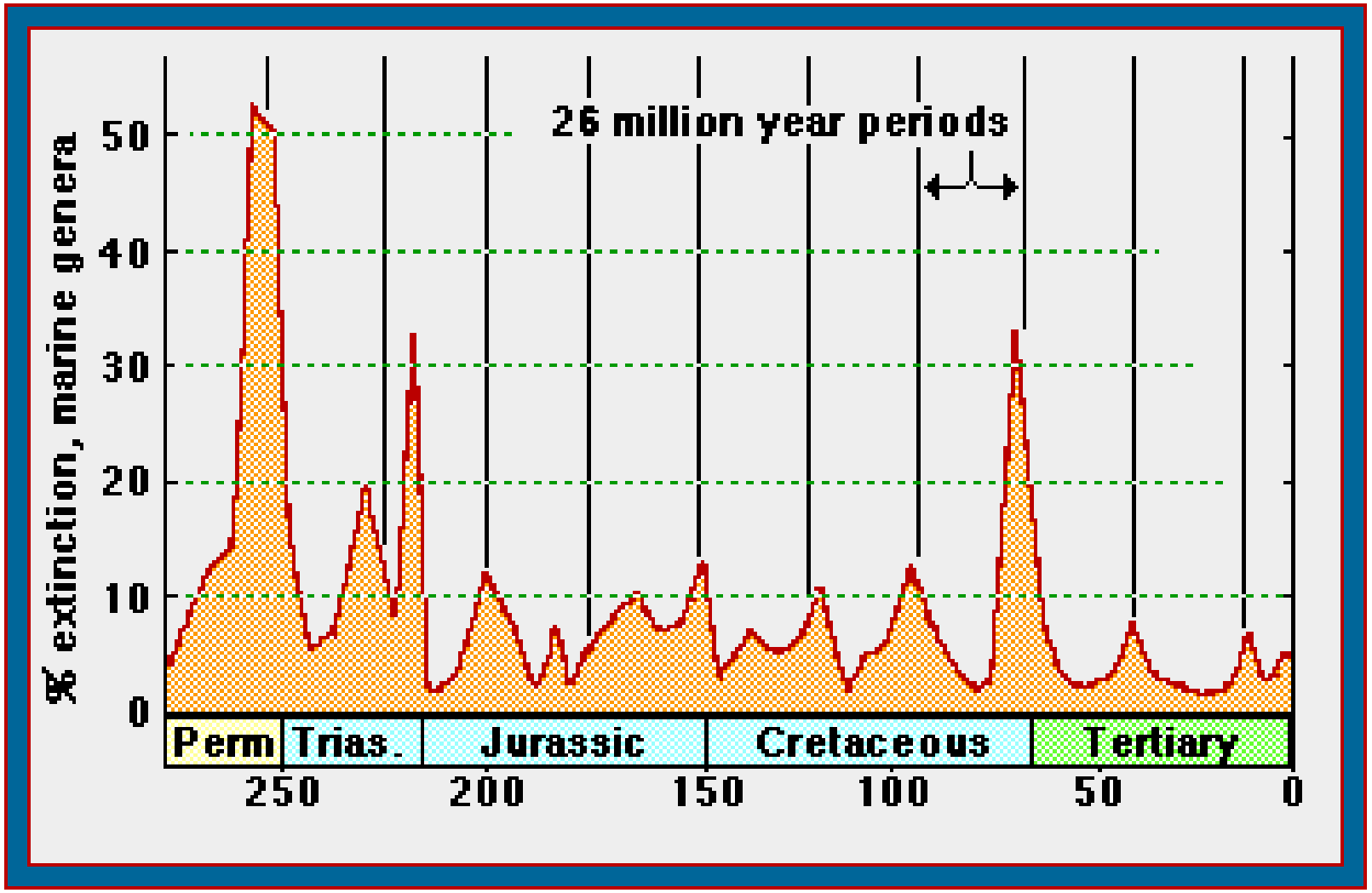
Extinction intensity

Mass Extinction Events	Families (%)	Genera (%)	Species (%)[c]
End Cretaceous	16—17	47—50	76 ± 5
End Triassic	22—23	48—53	80 ± 4
End Permian	51—57	82—84	95 ± 2
Late Devonian	19—22	50—57	83 ± 4
End Ordovician	26—27	57—60	85 ± 3

Mass & Background extinction



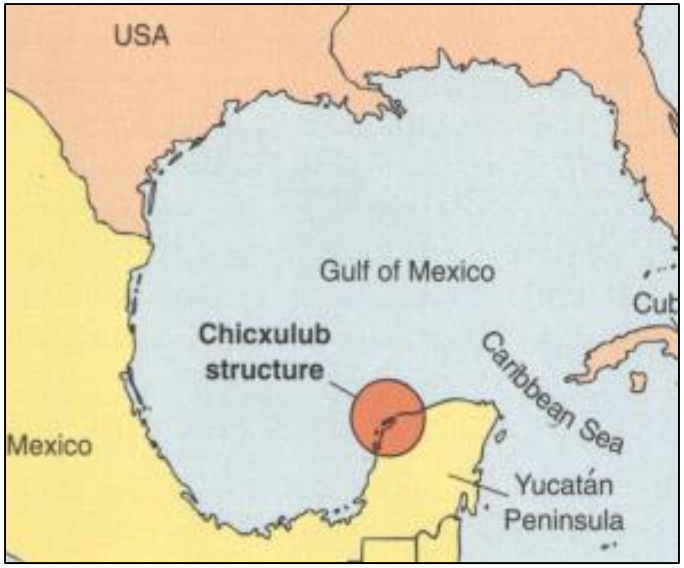
Is there a periodic cycle of mass extinctions?



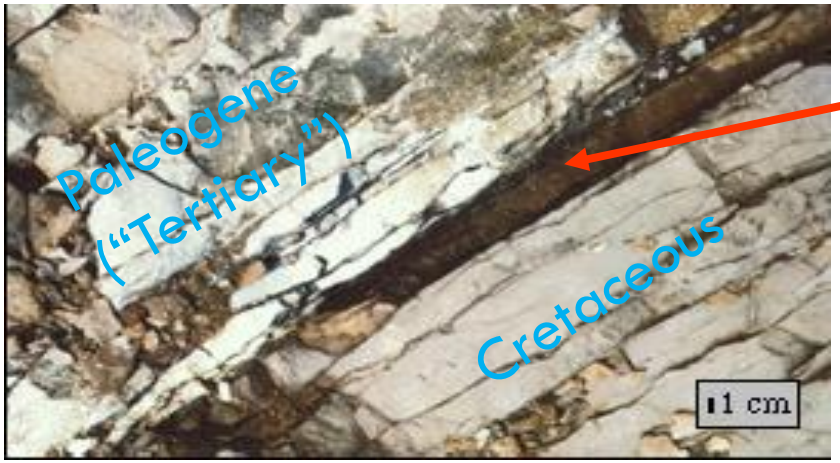
Causes of Mass extinction

- Asteroid Impact
- Flood Basalt Volcanism
- Ocean anoxia
- Climate / Sea-level change

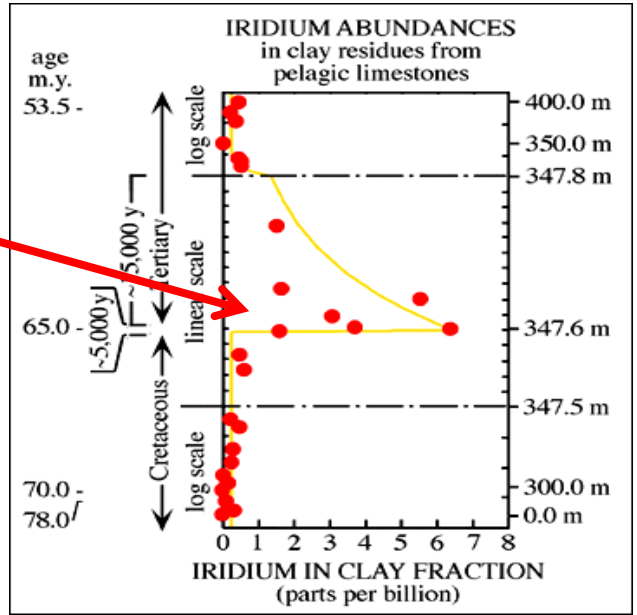
Asteroid Impact

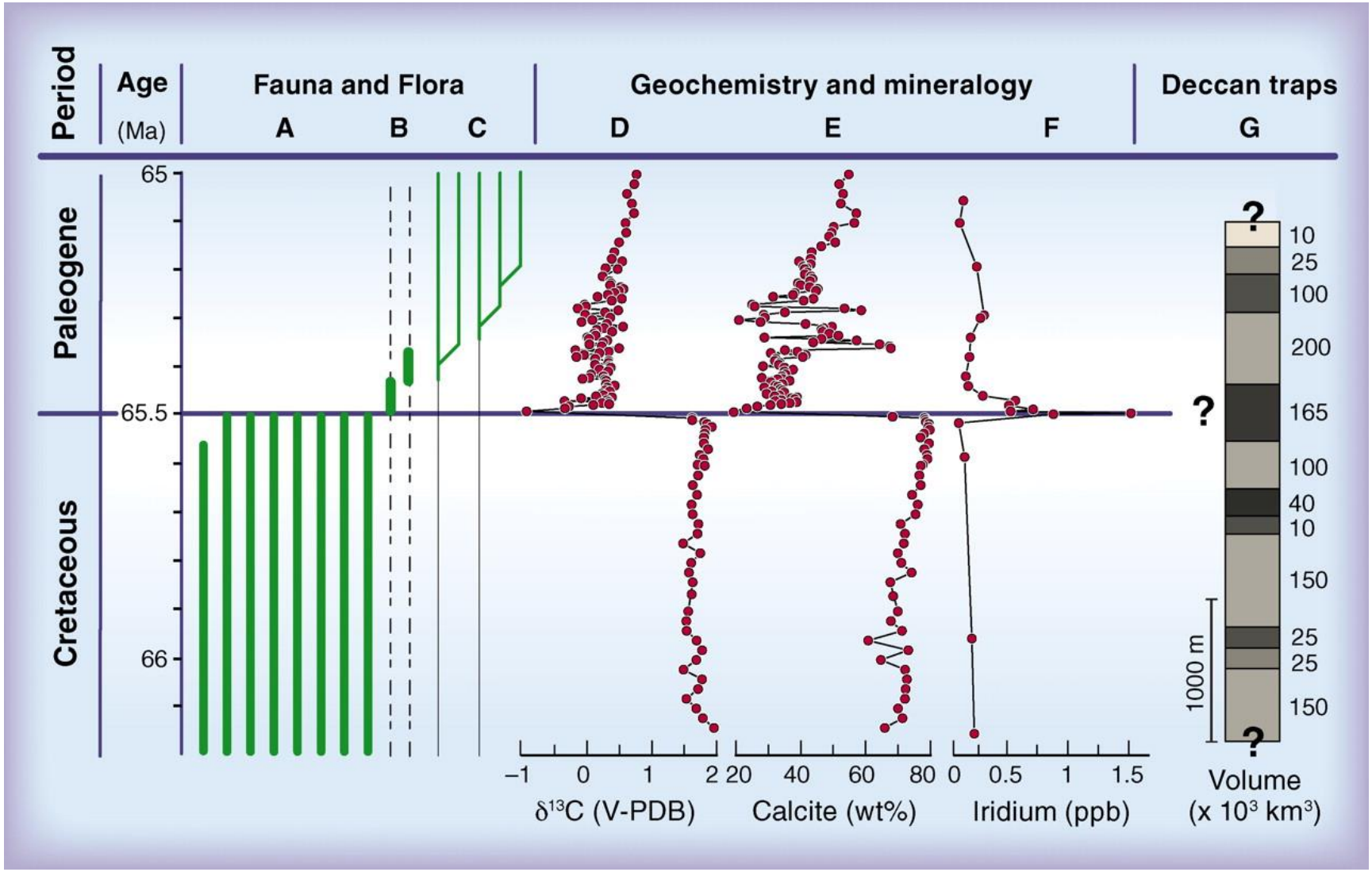


Location of Chicxulub crater (180-300 km in diameter)

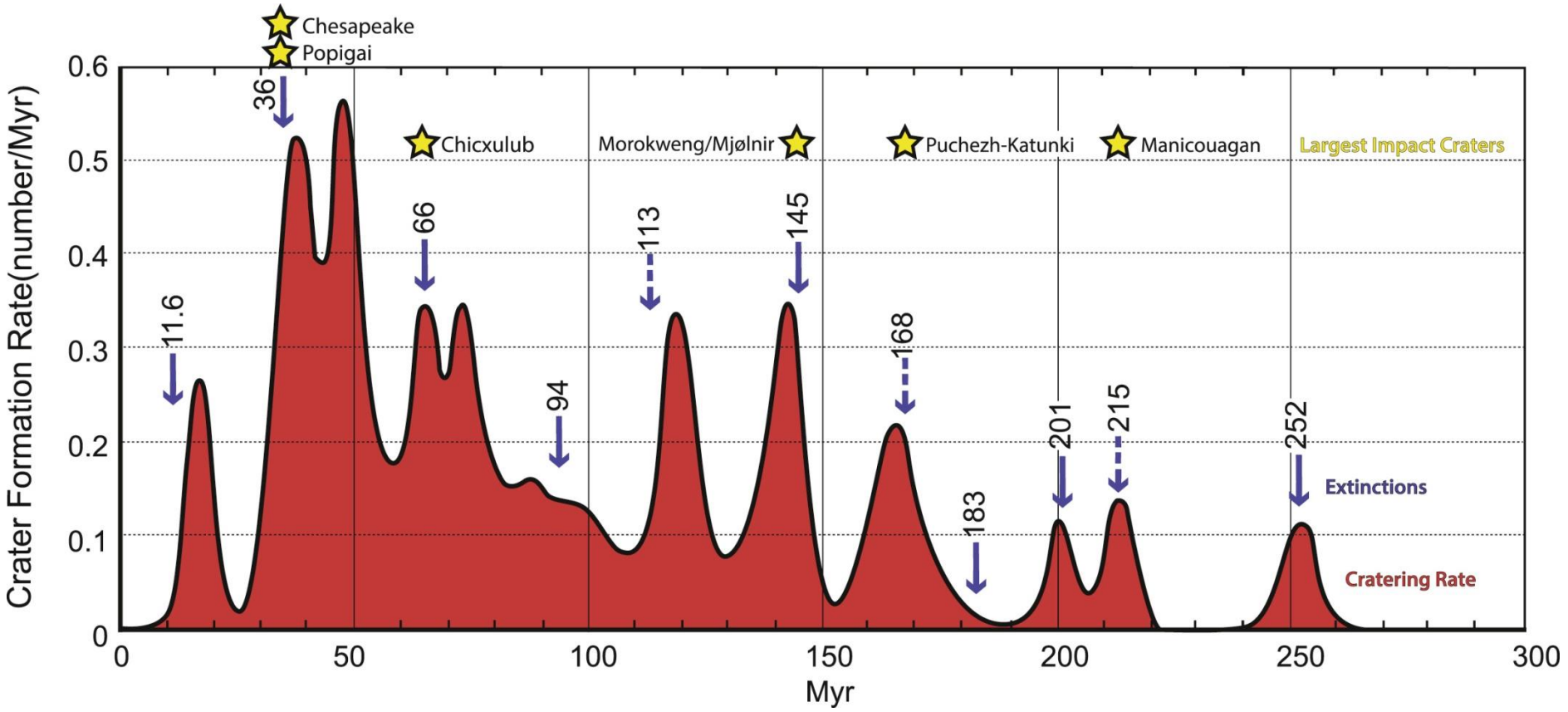


Iridium-rich boundary clay layer

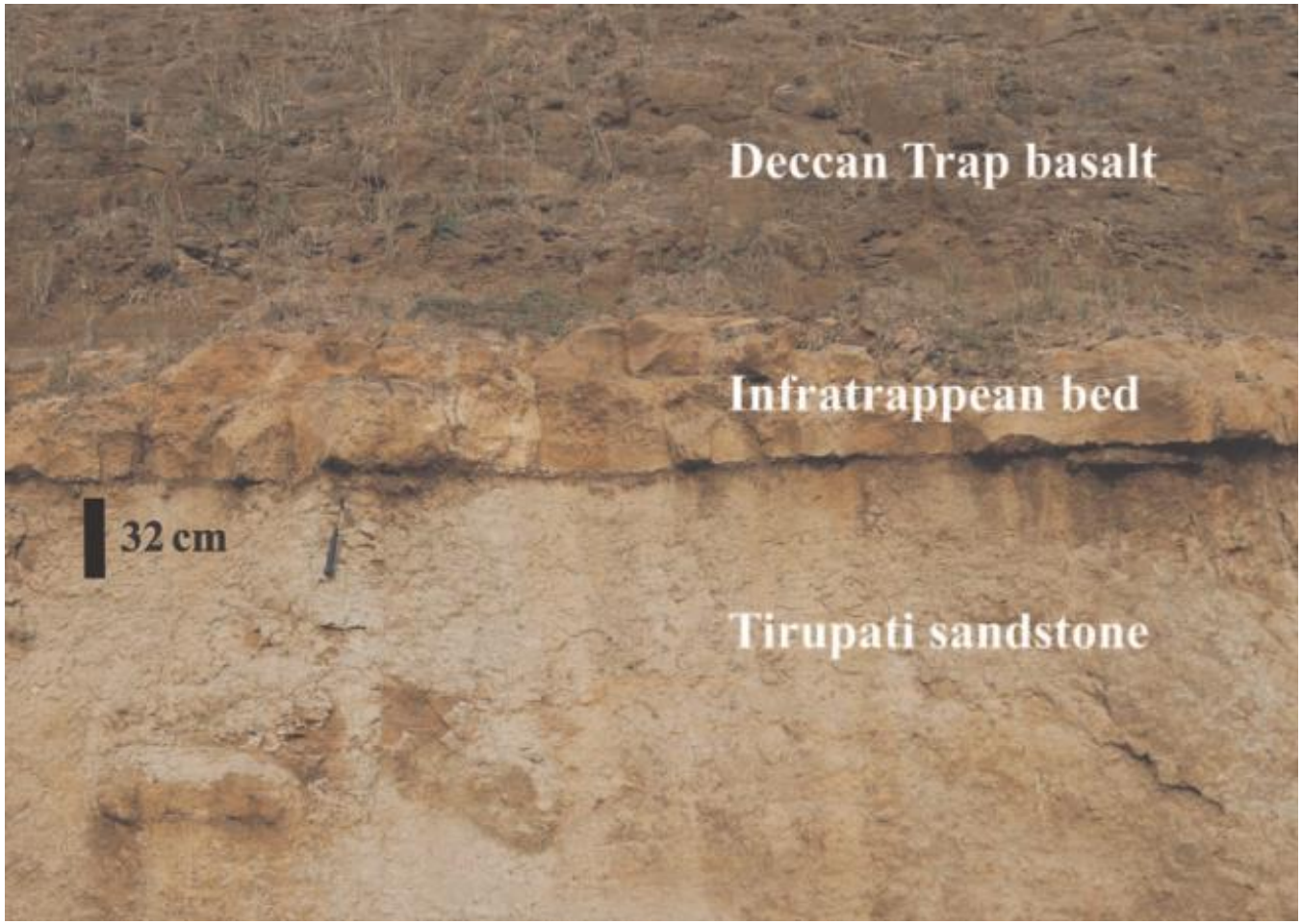



Period
Age
(Ma)
Fauna and Flora
A
B
C
Geochemistry and mineralogy
D
E
F
Deccan traps
G
Paleogene
Cretaceous
65
65.5
66
?
?
10
25
100
200
165
100
40
10
150
25
25
150
1000 m
–1
0
1
2
δ13C (V-PDB)
20
40
60
80
Calcite (wt%)
0
0.5
1
1.5
Iridium (ppb)
Volume
(x 10³ km³)

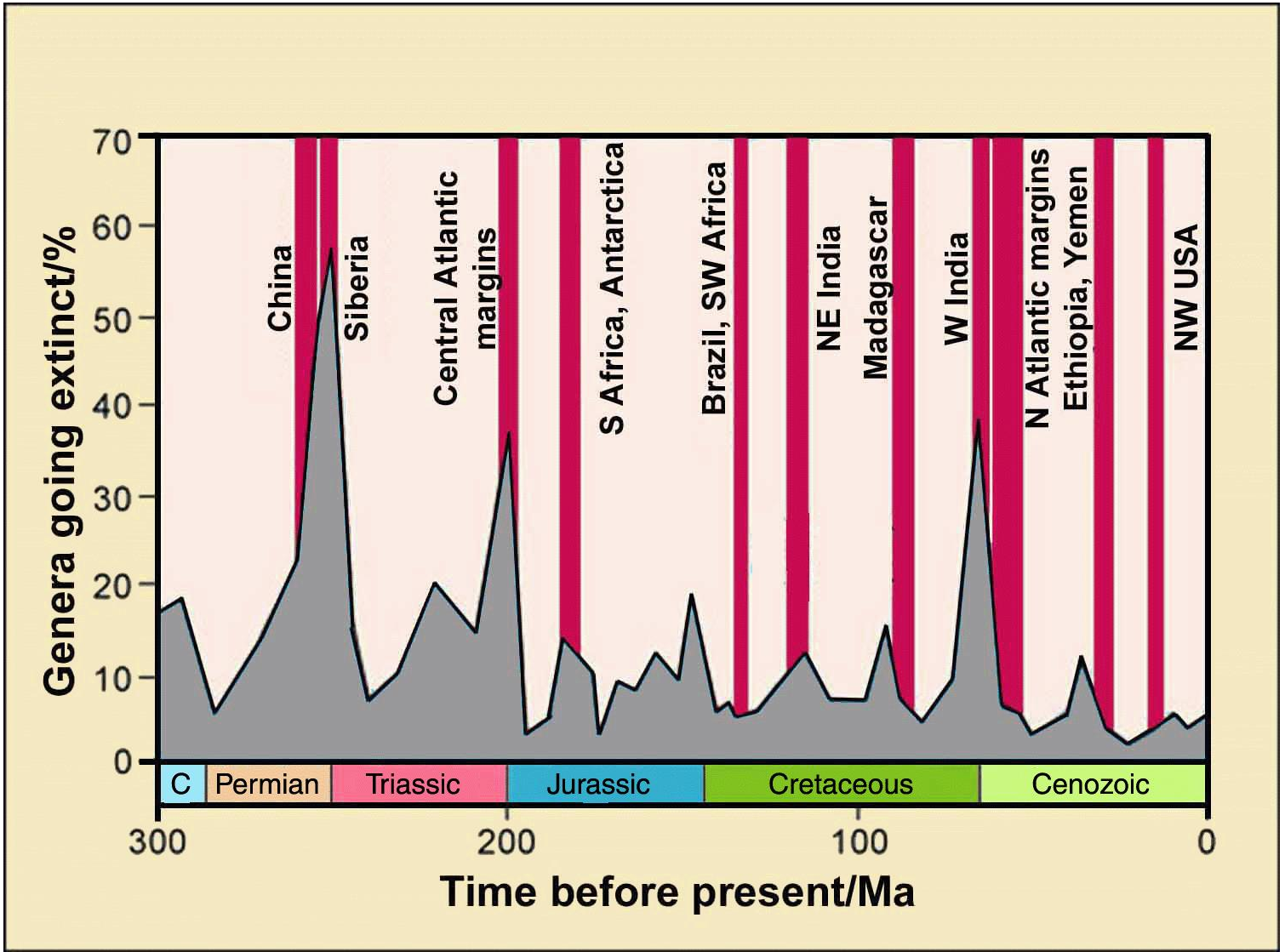
Temporal correlation between asteroid impact and mass extinction events



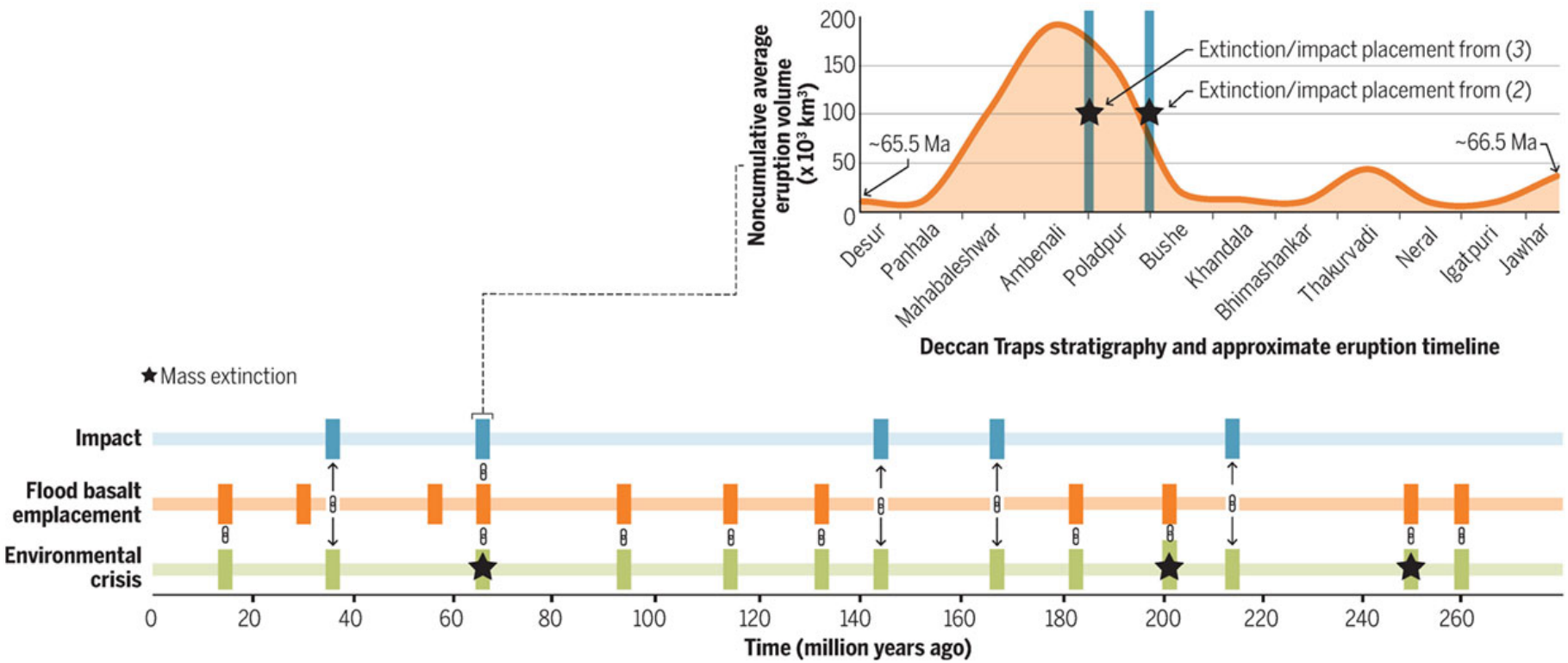
Flood Basalts



Flood Basalts



Asteroid impact, Flood basalt & Mass extinctions



Sea level change

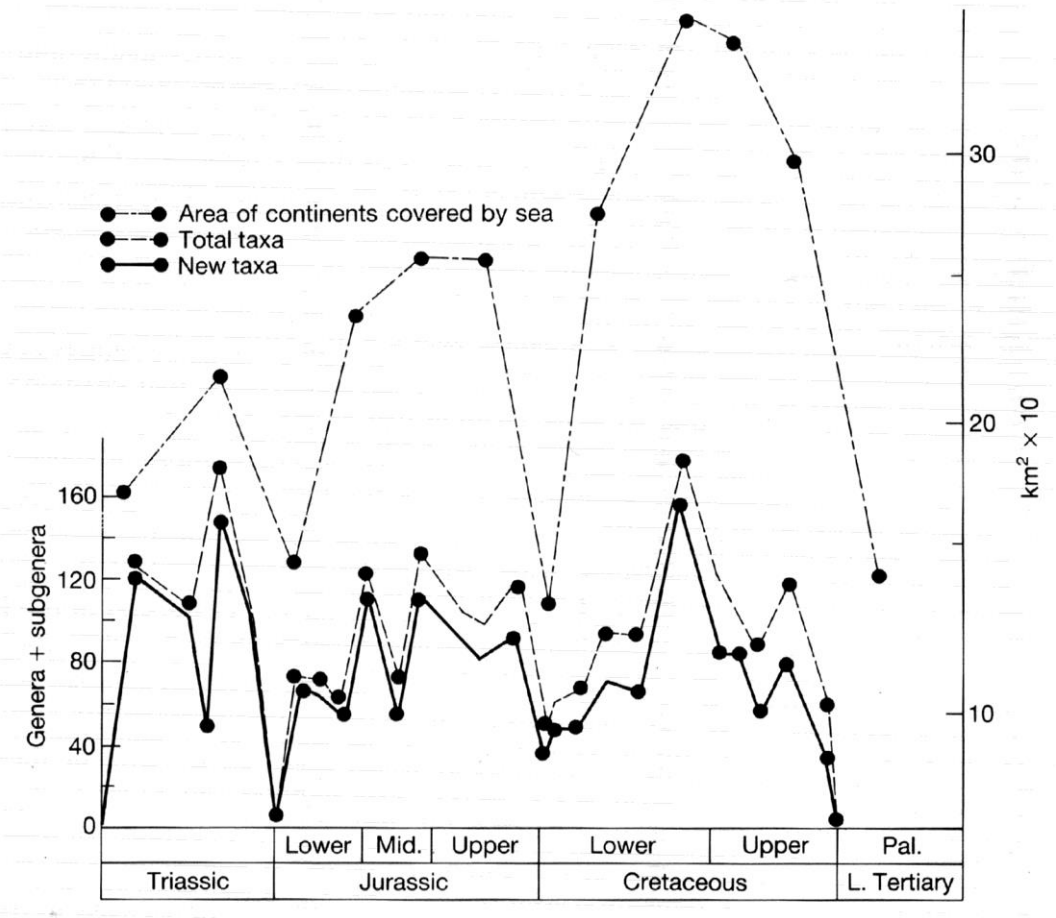
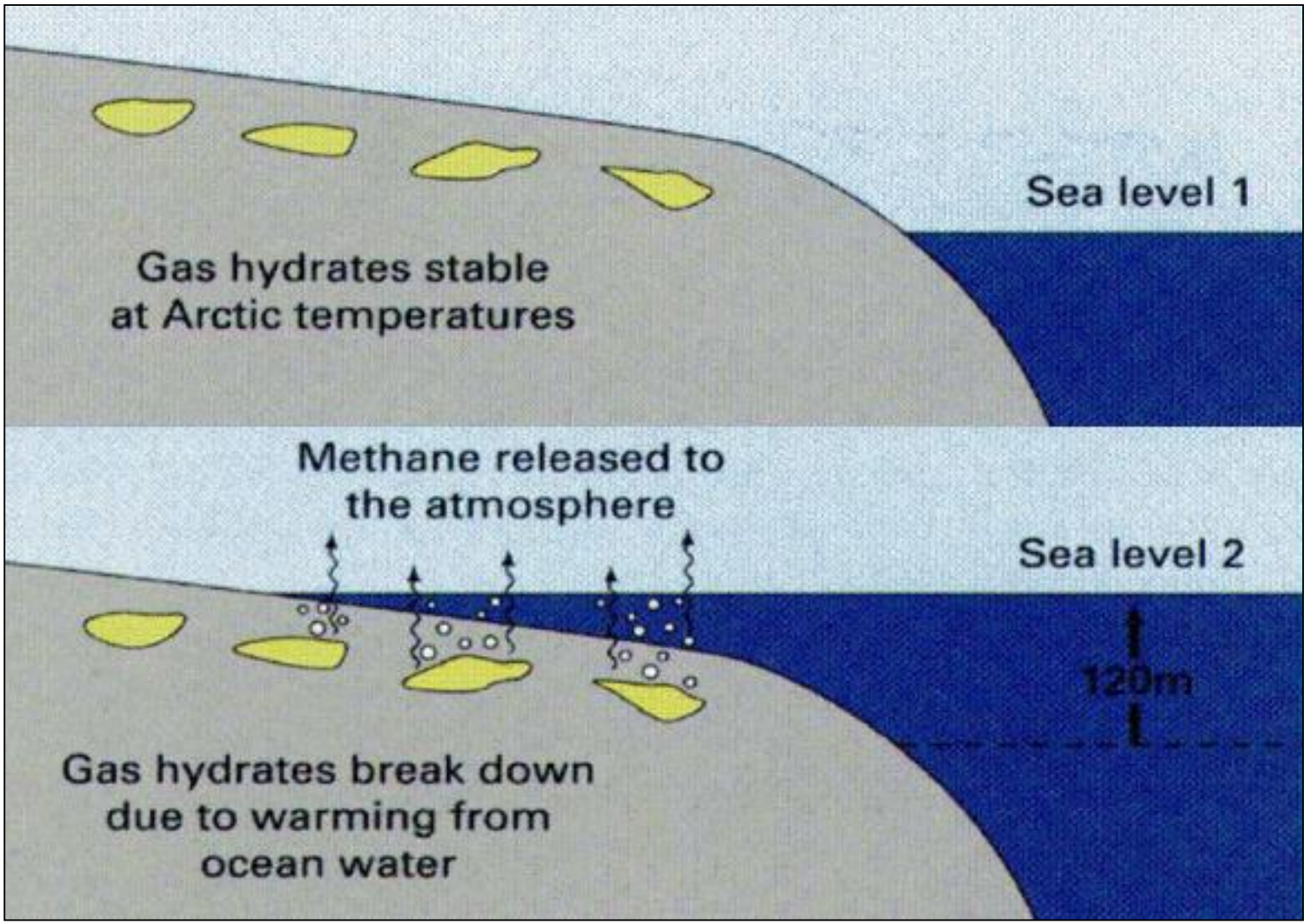
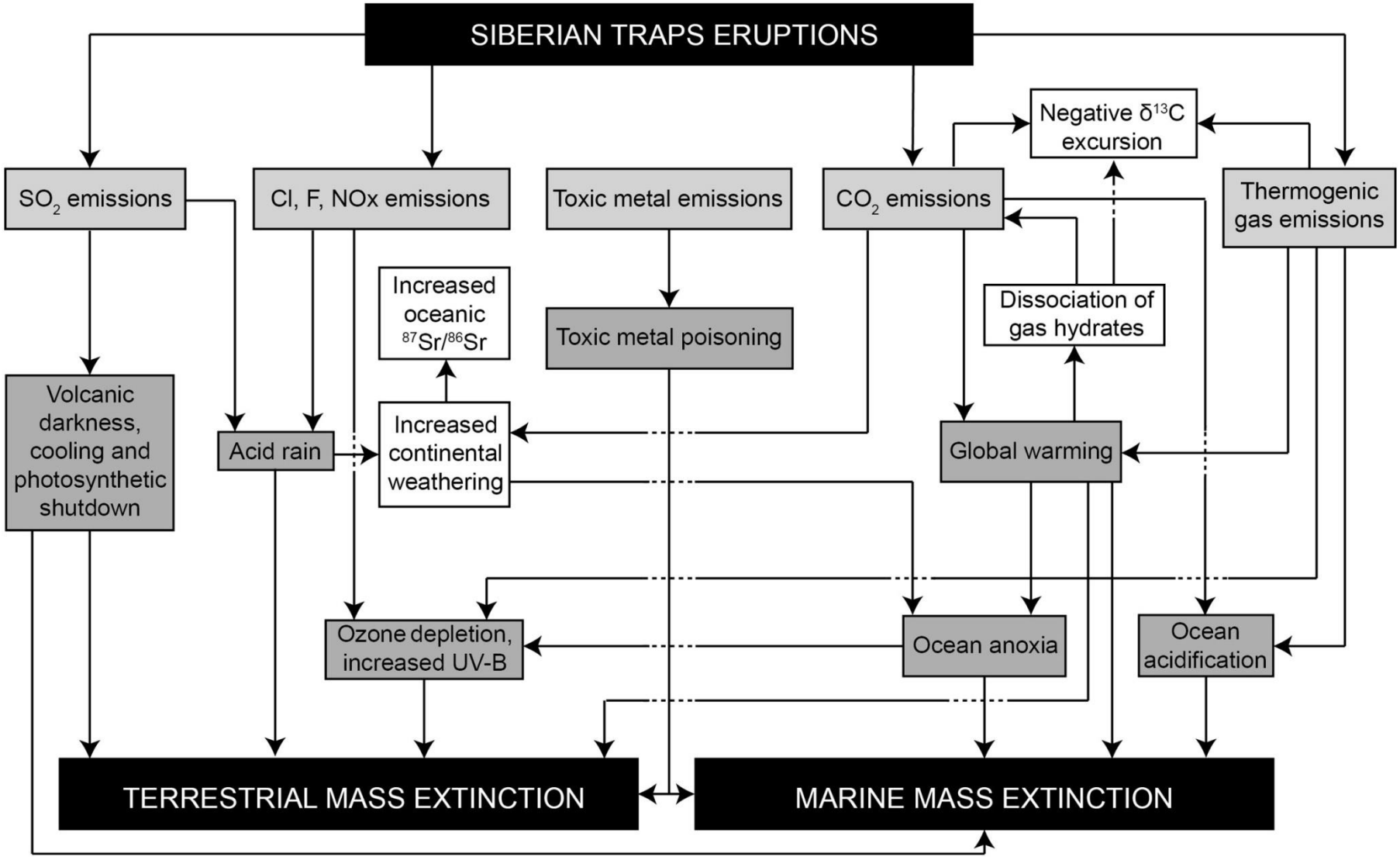


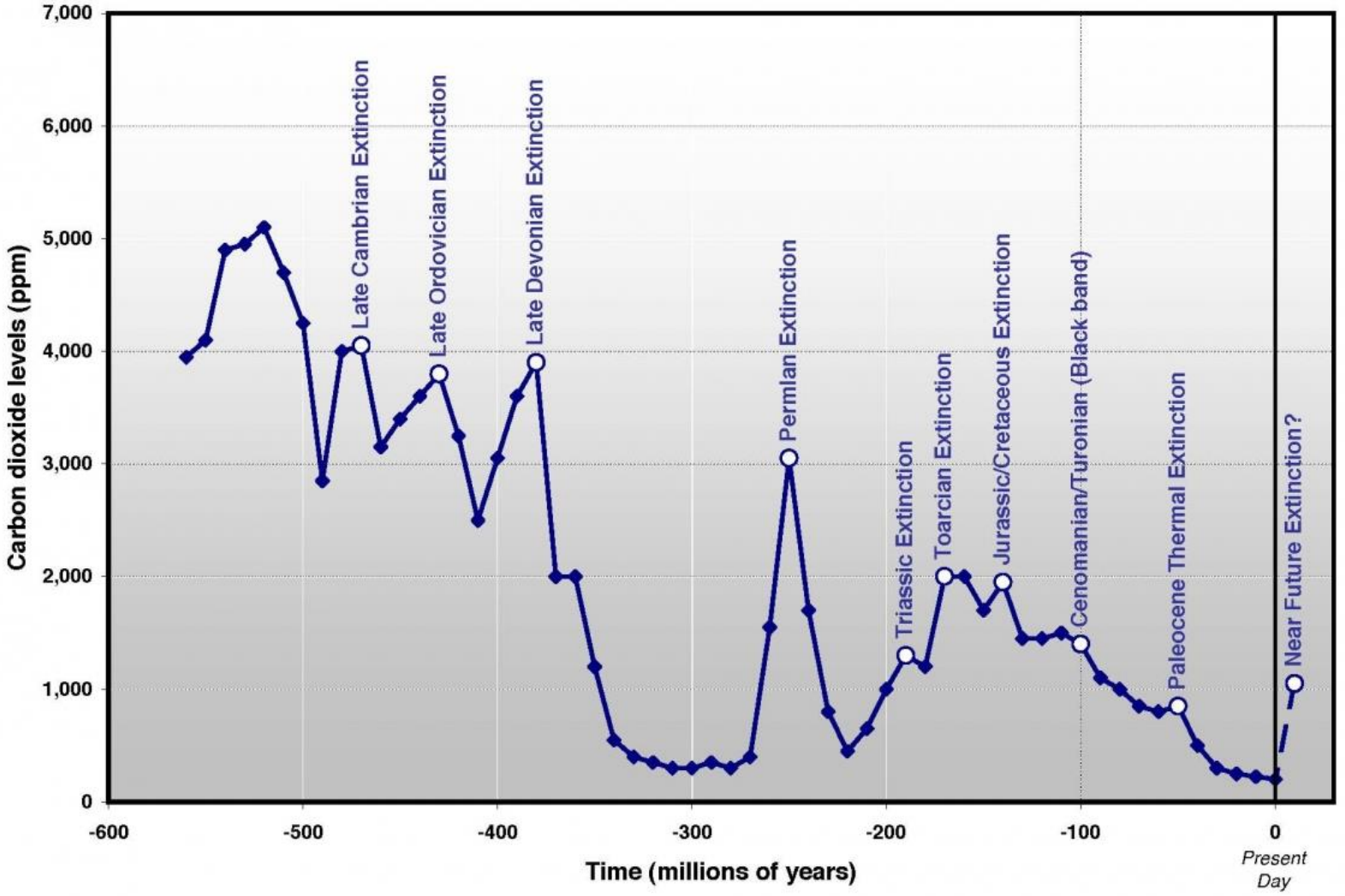
Figure 22.11 Three successive rounds of ammonite extinction were correlated with declines in the sea level (expressed here as area of continents covered by sea: when the sea is higher, it covers more of continental land). From Hallam (1983).


Sea level 1
Gas hydrates stable
at Arctic temperatures
Methane released to
the atmosphere
Sea level 2
120m
Gas hydrates break down
due to warming from
ocean water

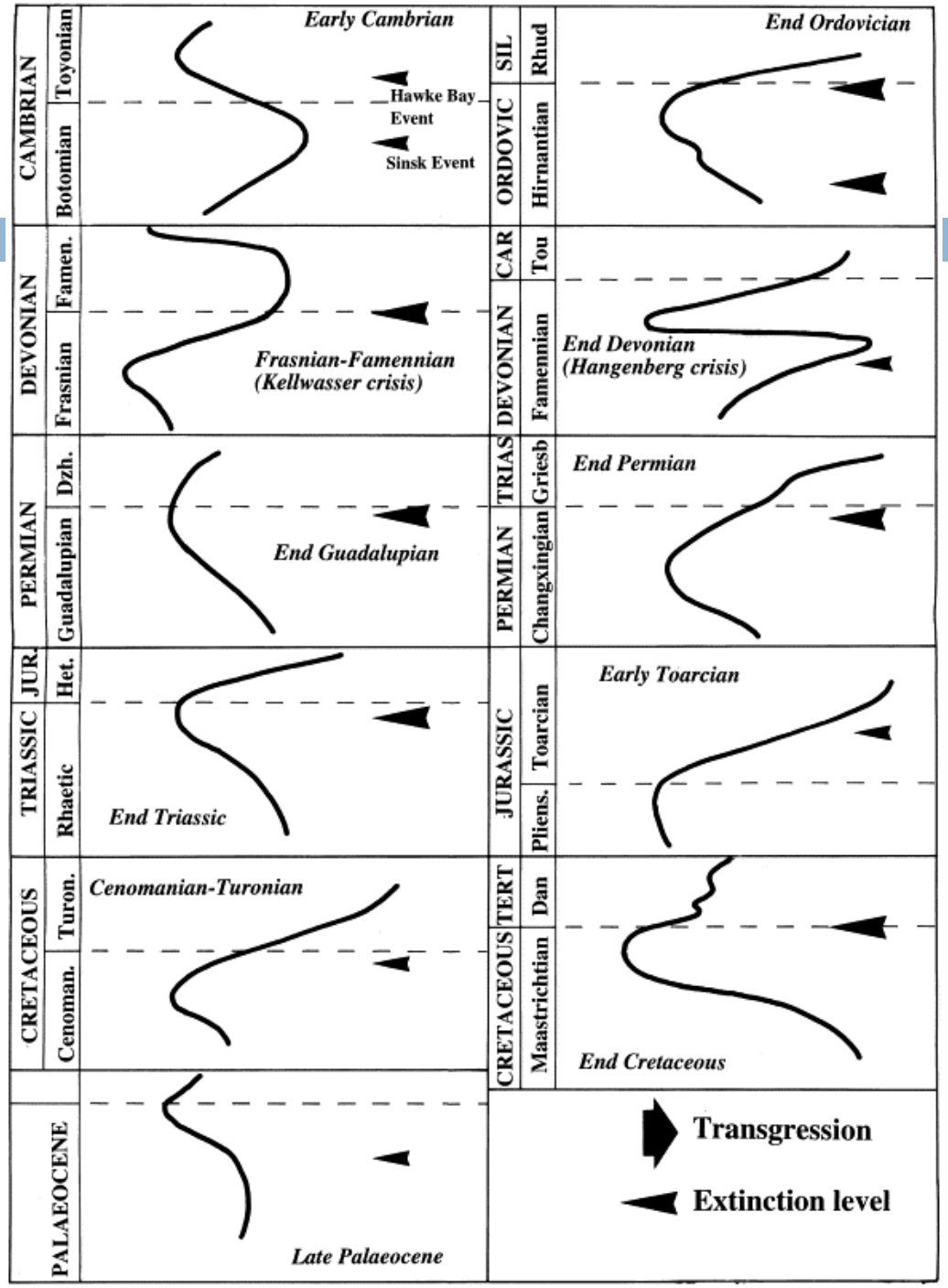
P-T extinction



CO_2 level and mass extinctions



Sea level change and mass extinctions

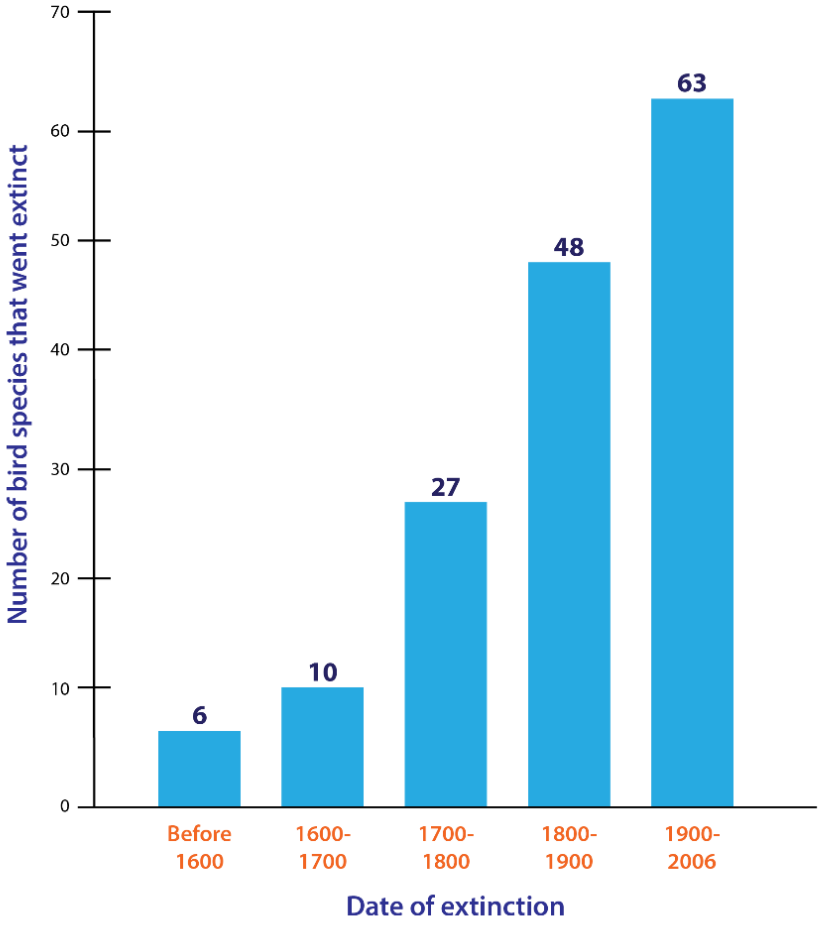


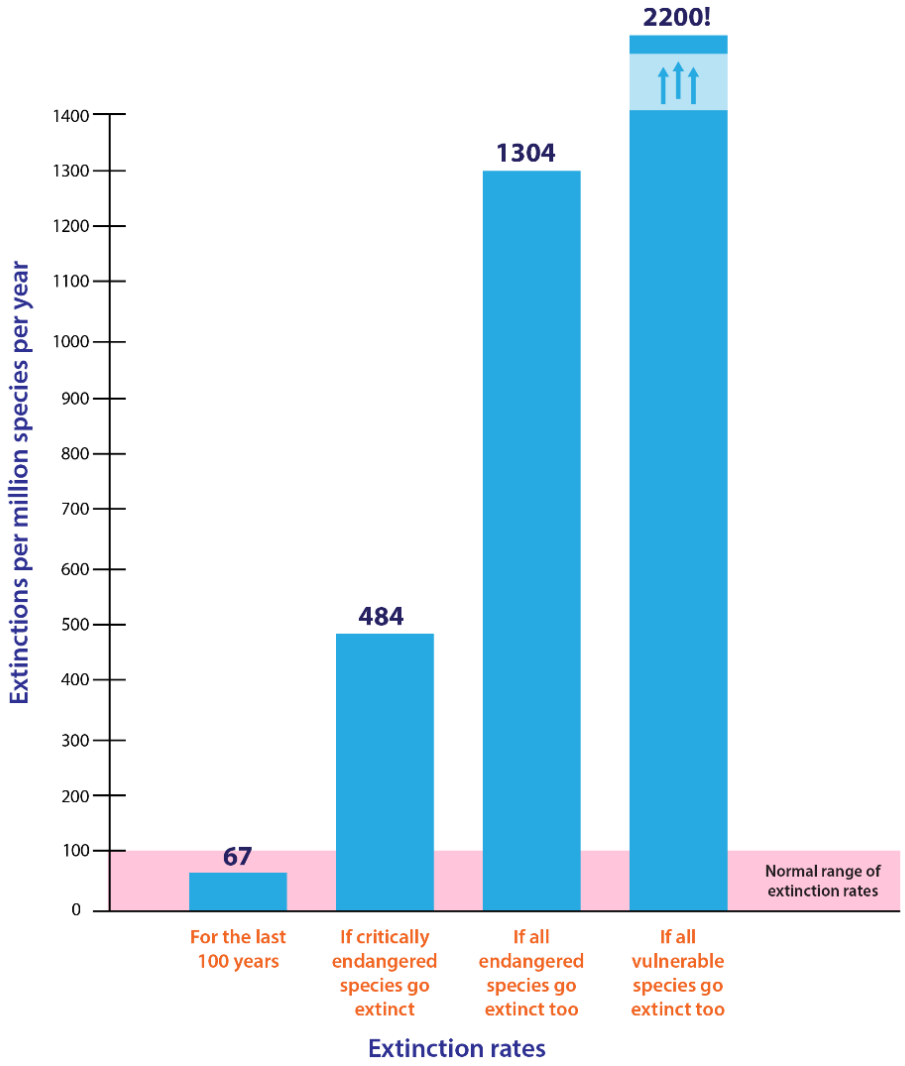
Summary of possible causes of the mass extinctions

Mass Extinction/ Cause	Sea Level Rise/Fall	Climate Change	Global Ocean Anoxia	Brackish Ocean	Bolide Impact	Volcanism
End-Ordovician	X (Fall)	X (Cool)				
End-Devonian		X (cool or warm?)	X	X	?	
End-Permian	X (Fall)	X (cool)	X	X	?	X
End-Triassic	X (Fall)	X (cool or warm?)			?	X?
End-Cretaceous	X (Fall)		X		X	X

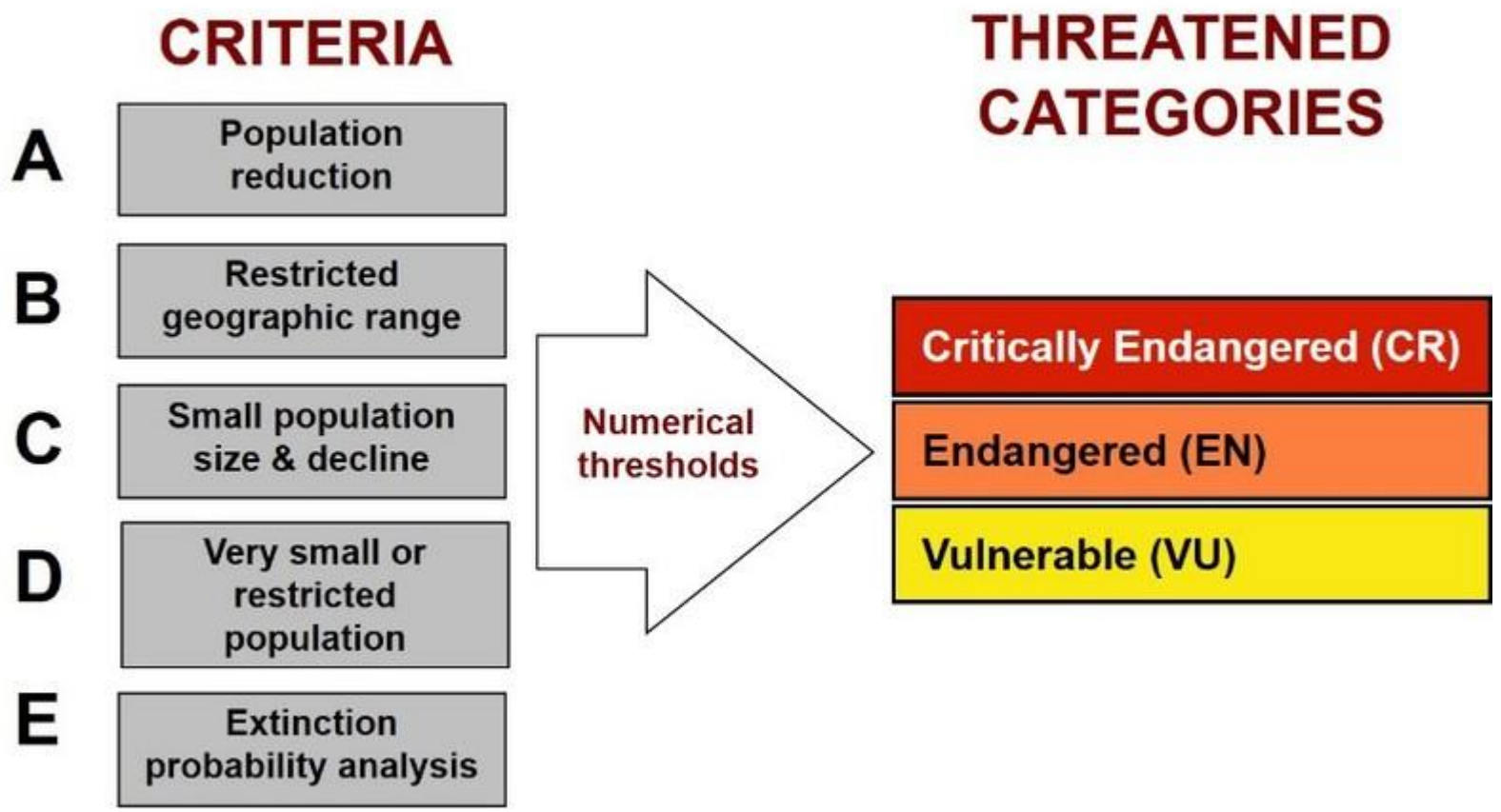
Sixth mass extinction ?

Extinction rate in birds

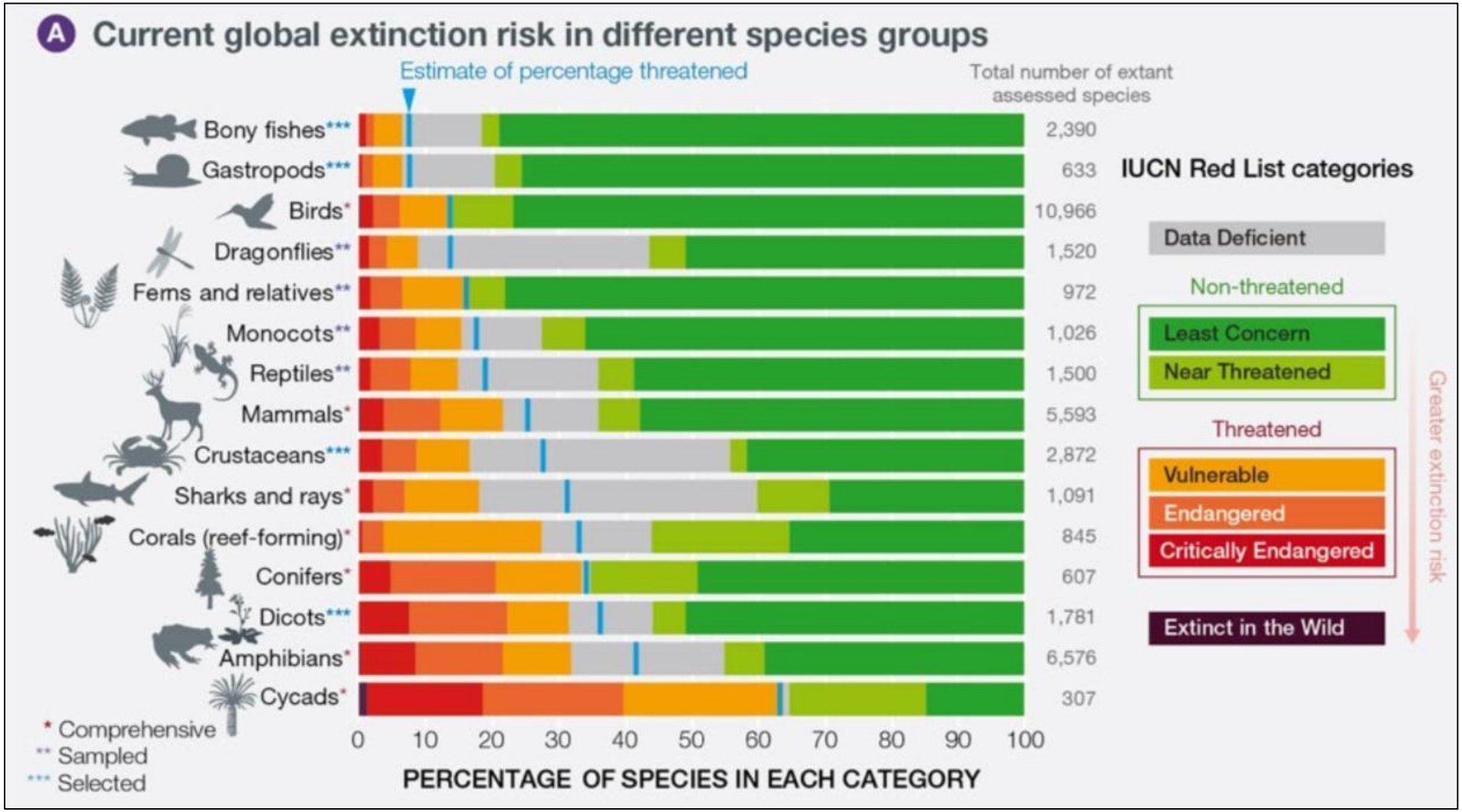




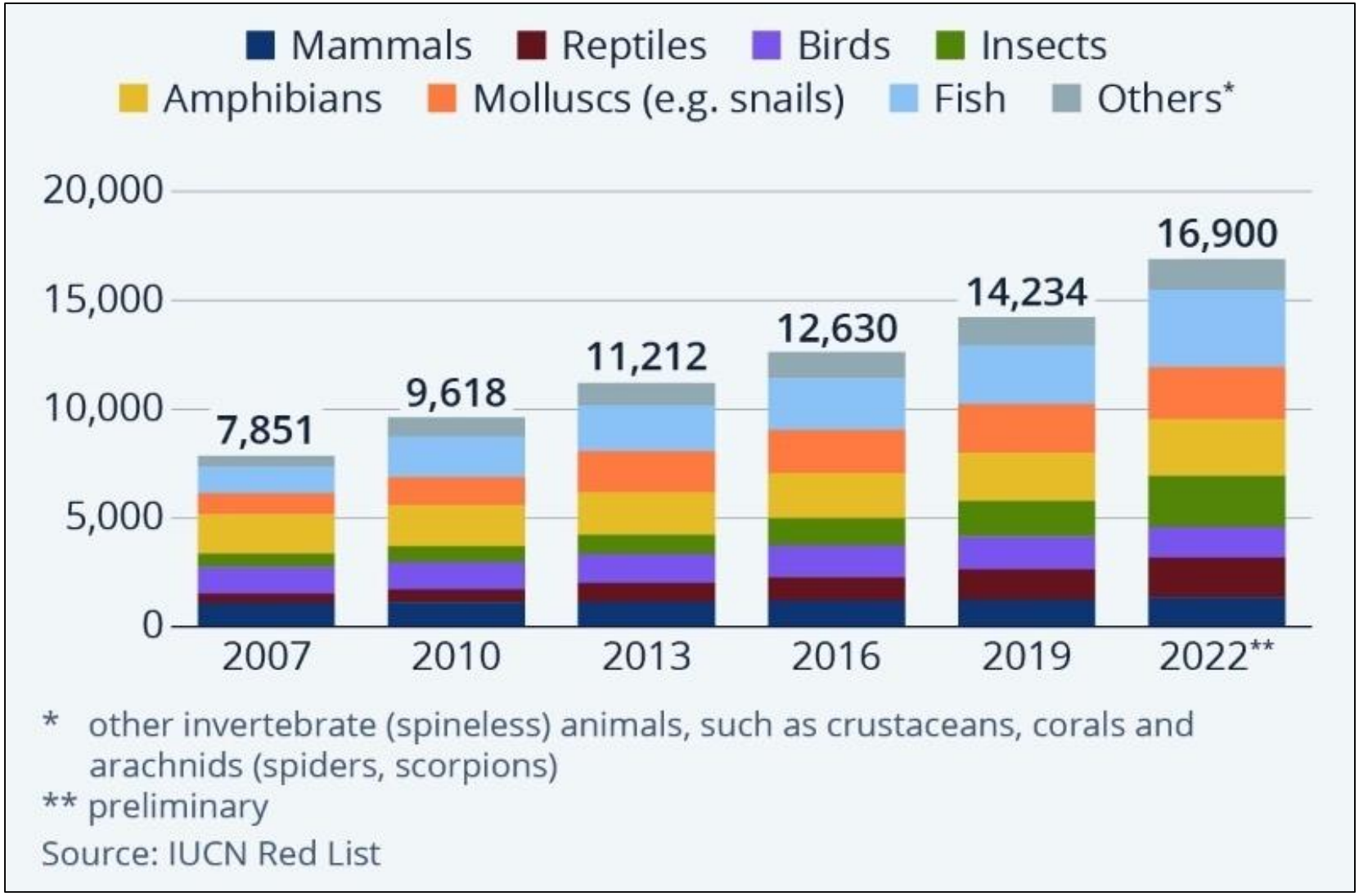
The International Union for Conservation of Nature (IUCN)



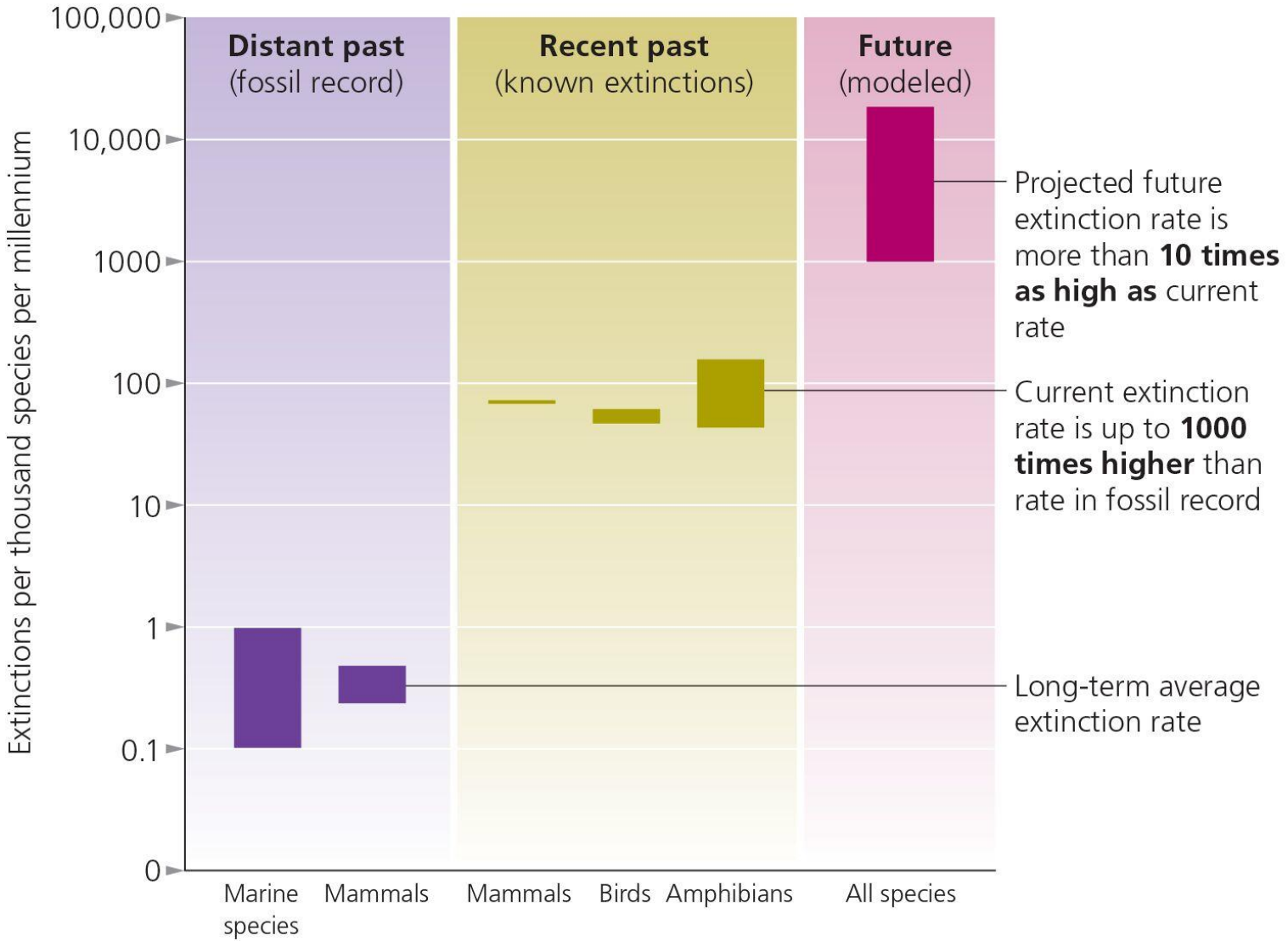
The IUCN Red List



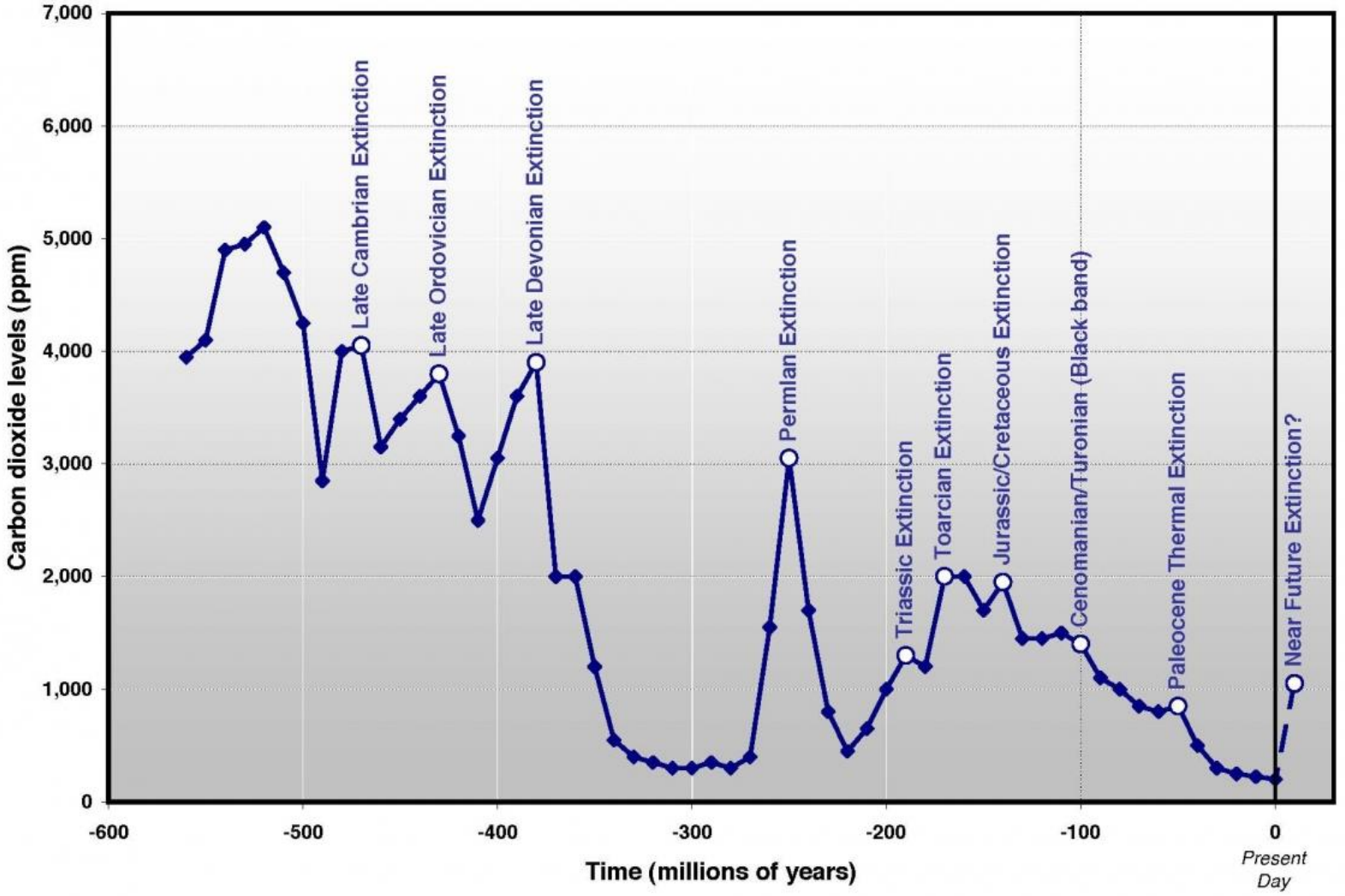
The number of 'Endangered Species' is rising



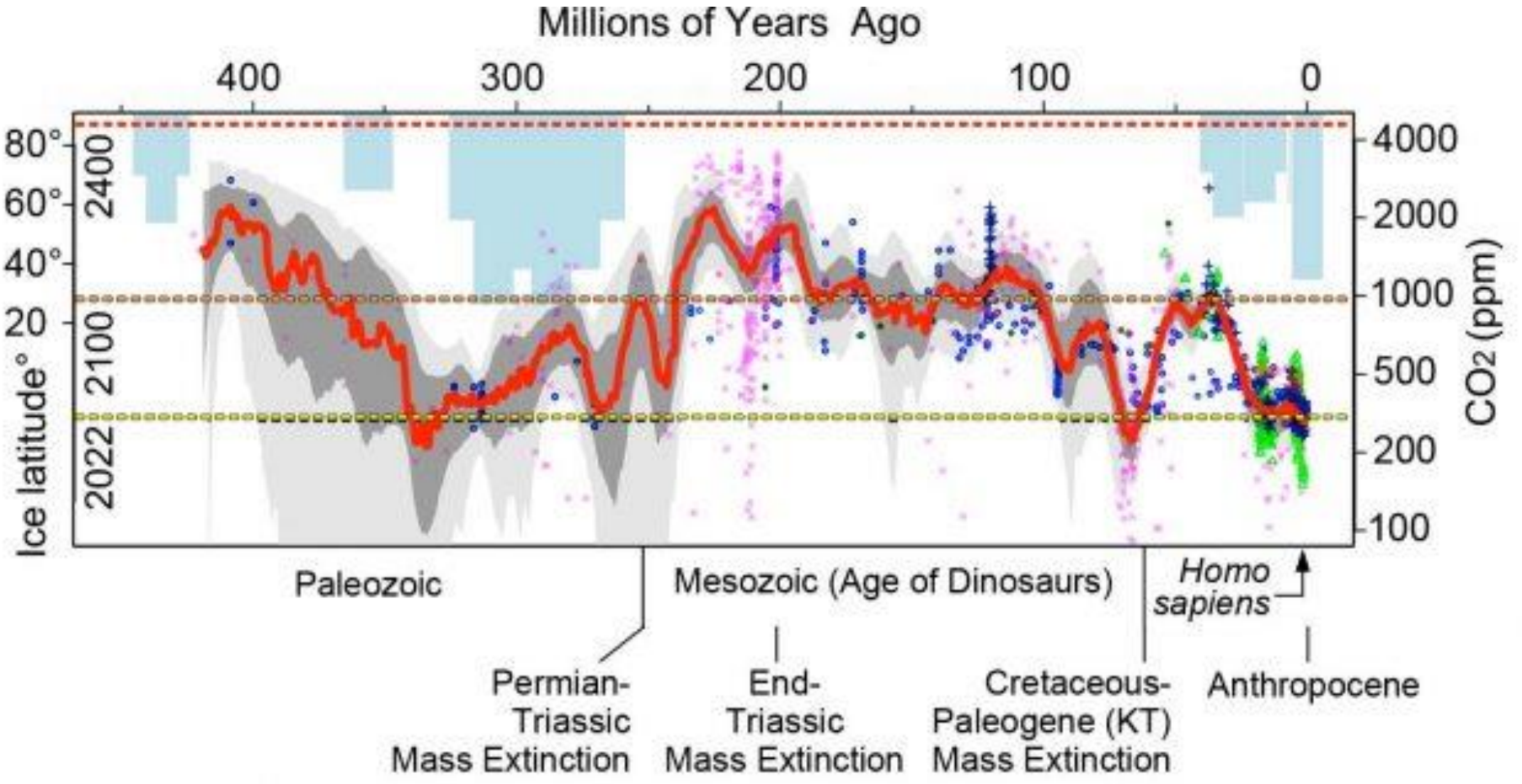
A SIXTH MASS EXTINCTION?



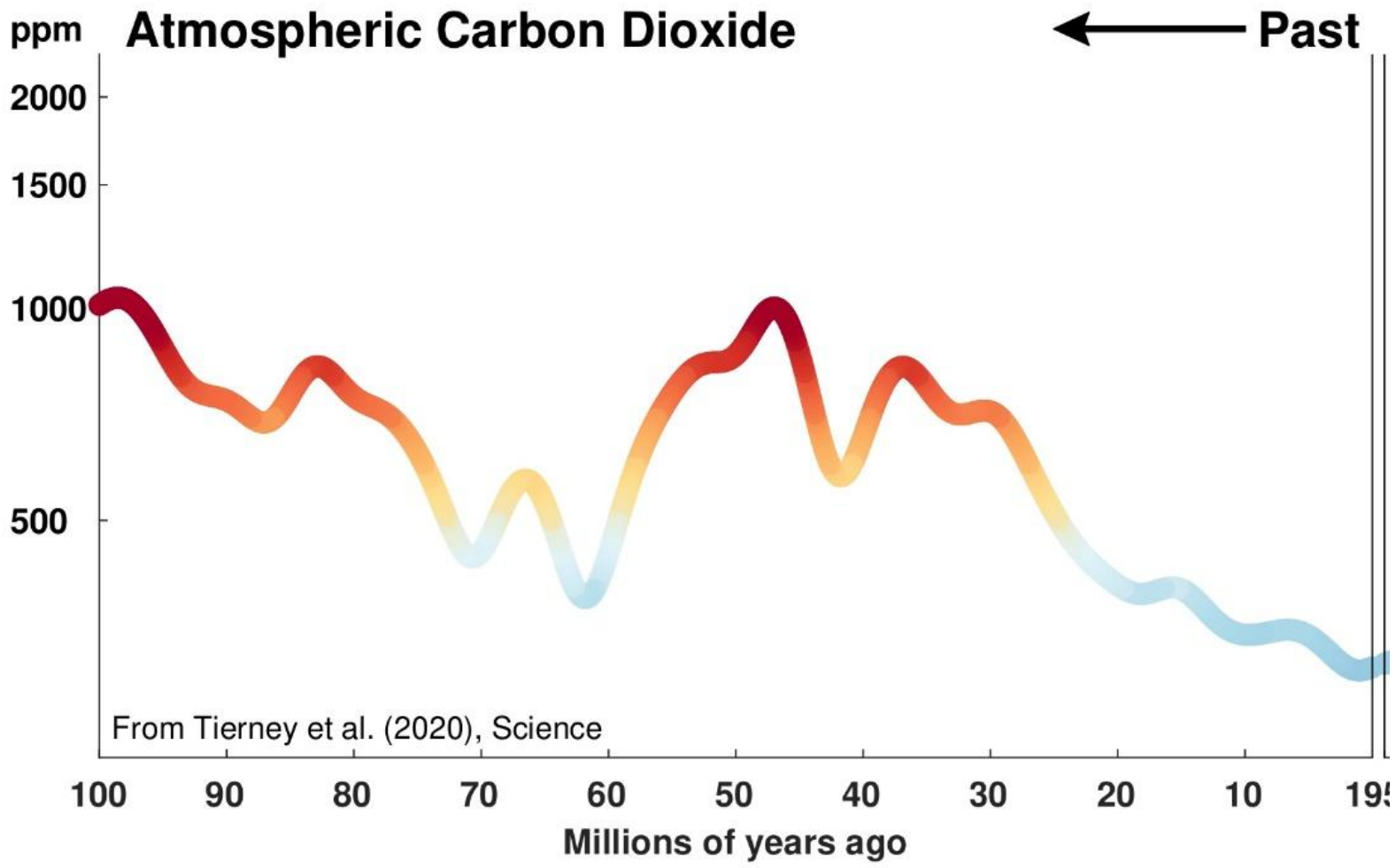
CO_2 level and mass extinctions



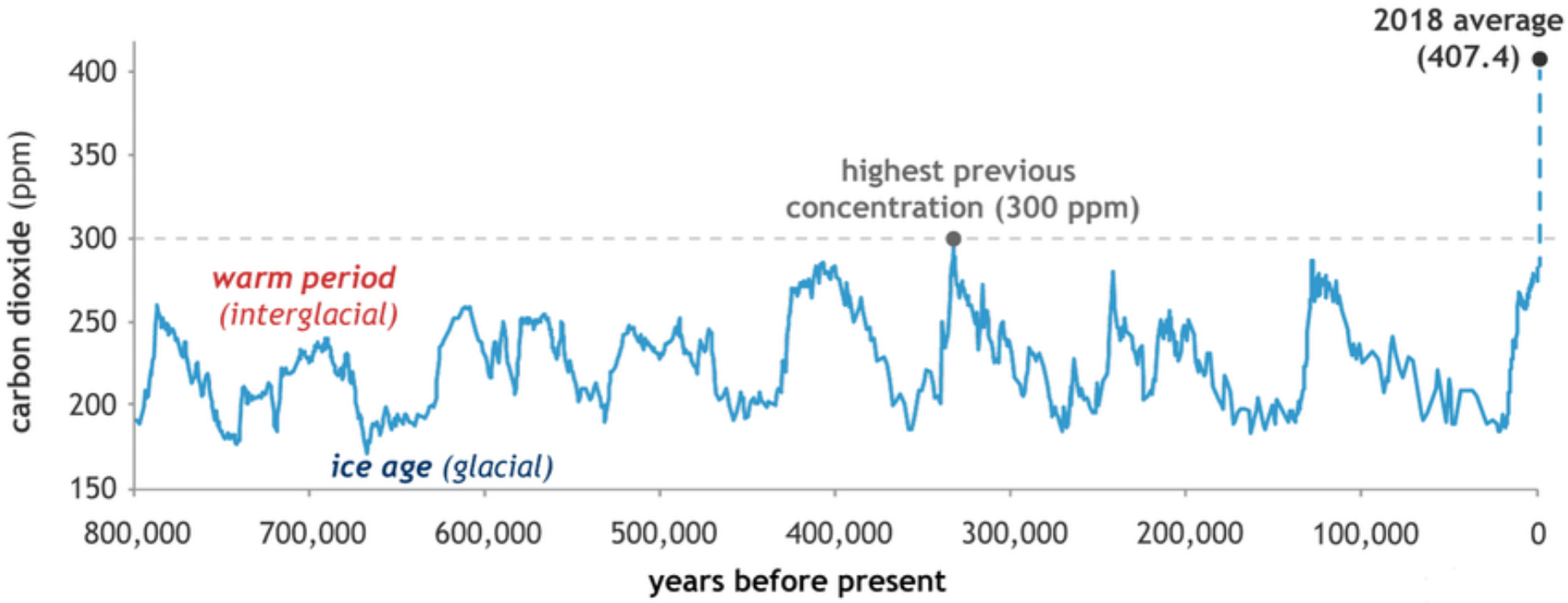
CO_2 level across the Phanerozoic



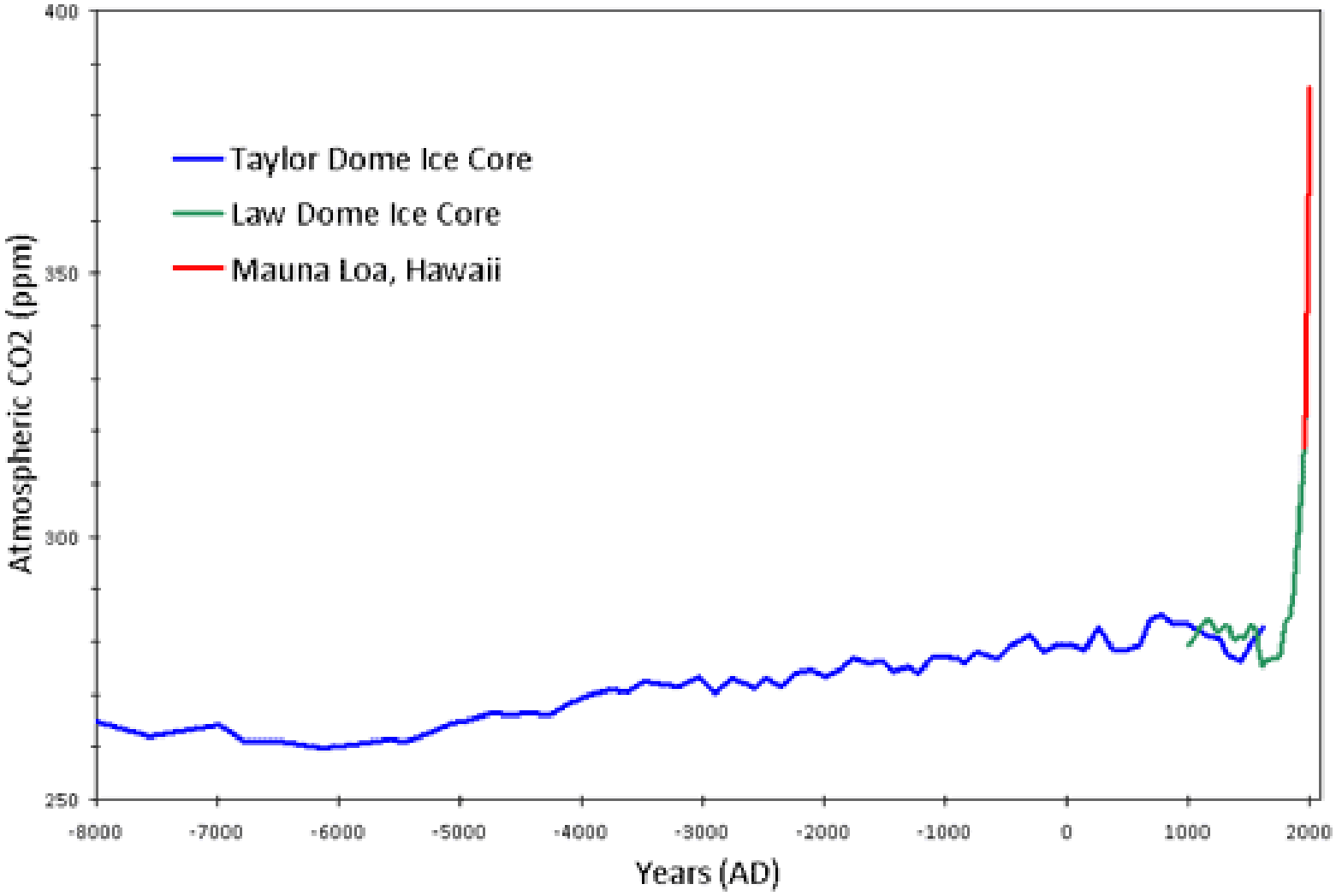
CO_2 level across the last 100 myr



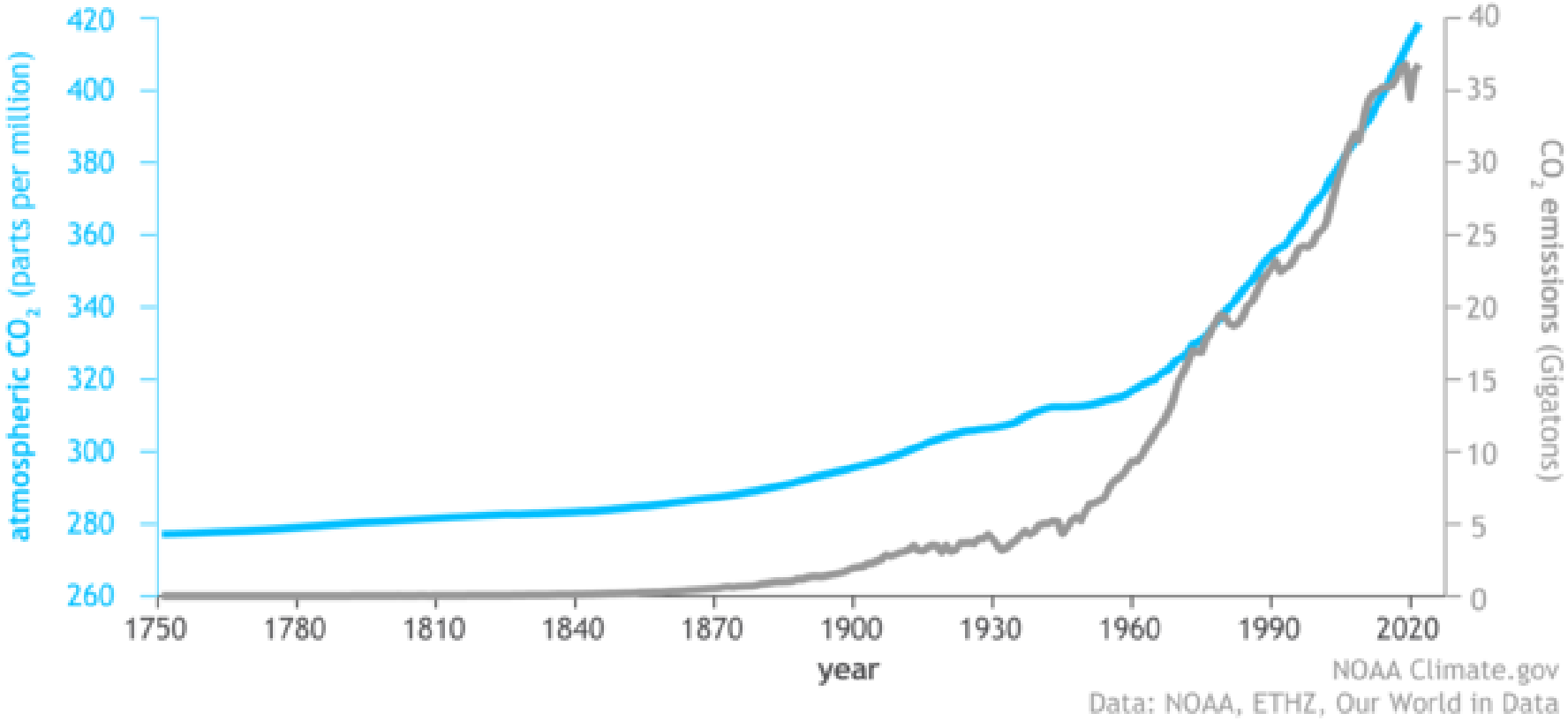
CO_2 level across the last 1000 kyr

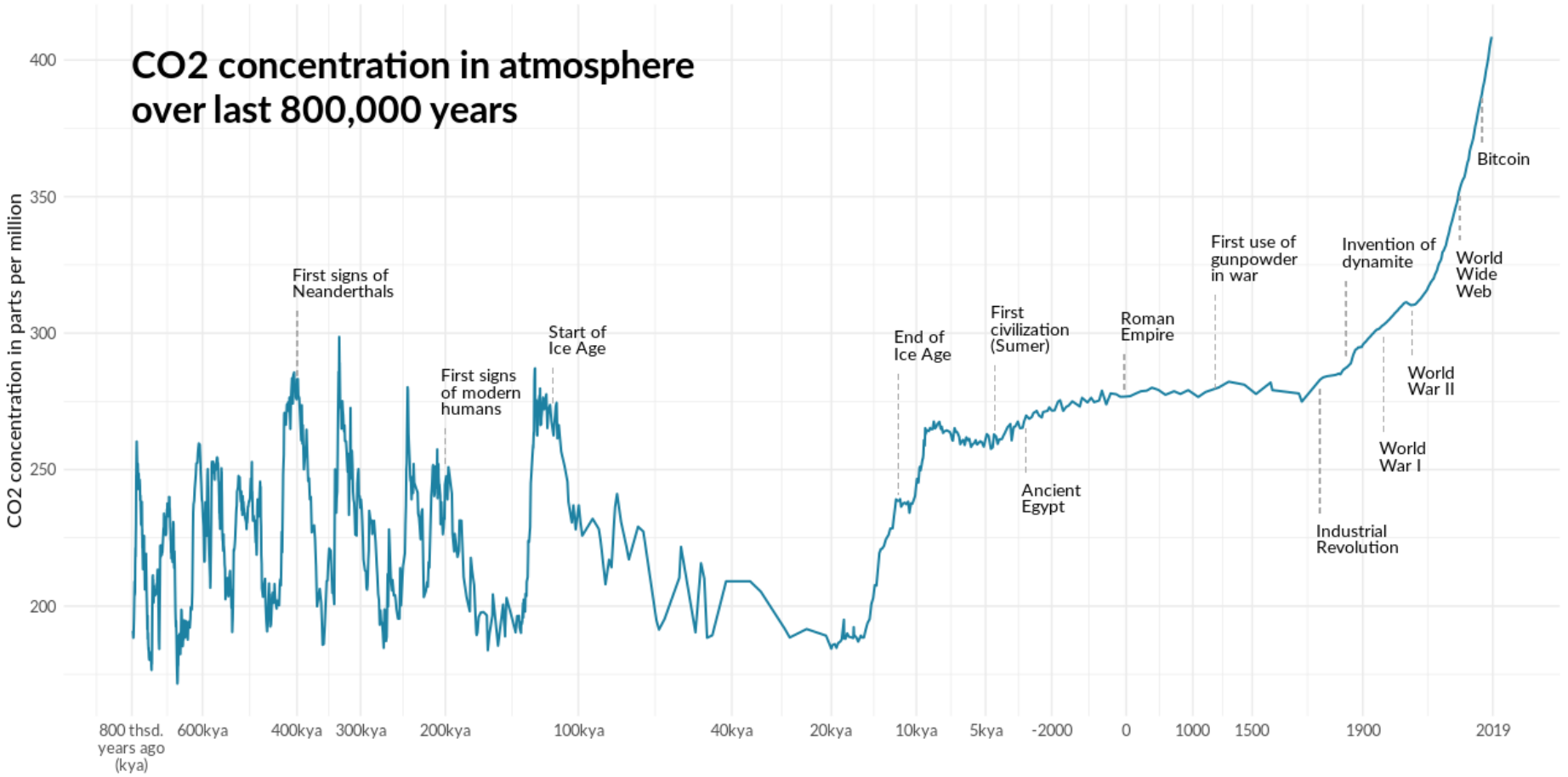


CO_2 level across the last 10,000 yr



CO_2 level across the last 250 yr

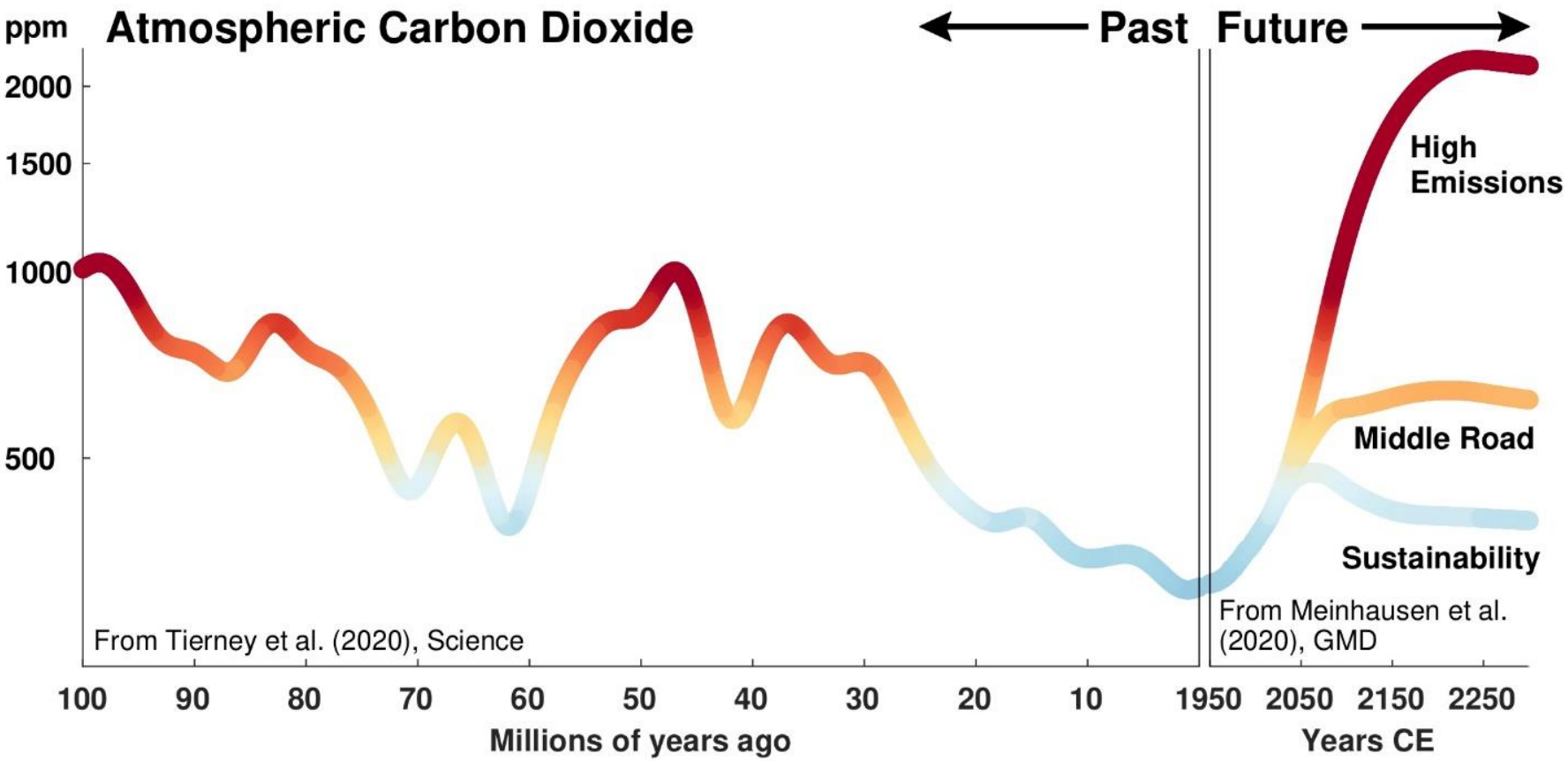




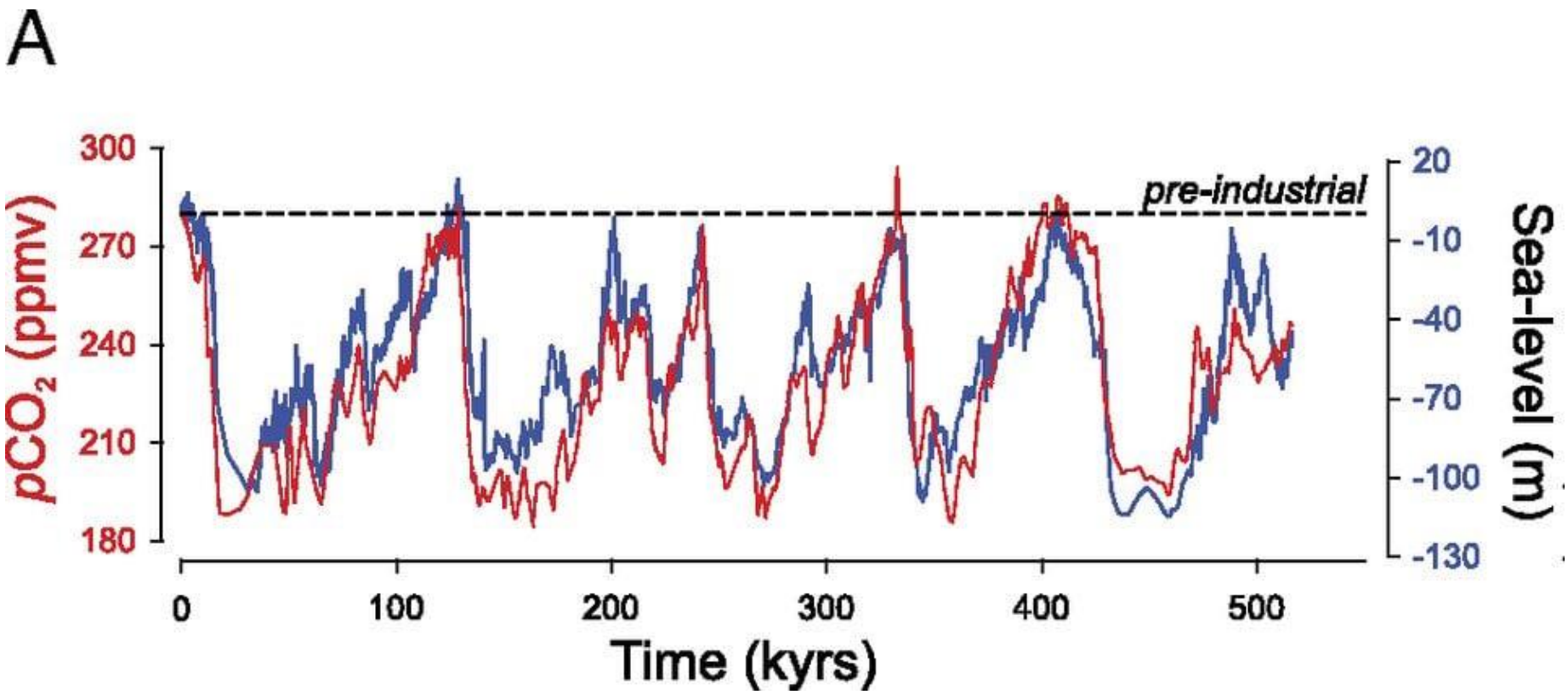
Time is warped using sqrt scale before 1900 for readability. Graphic: Gregor Aisch, vis4.net

Source: NOAA (1959-today), NASA (1850-1958), Monnin et al., Petit et al., Siegenthaler et al., Luethi et al. (800kya-1850)

CO_2 level across in the future

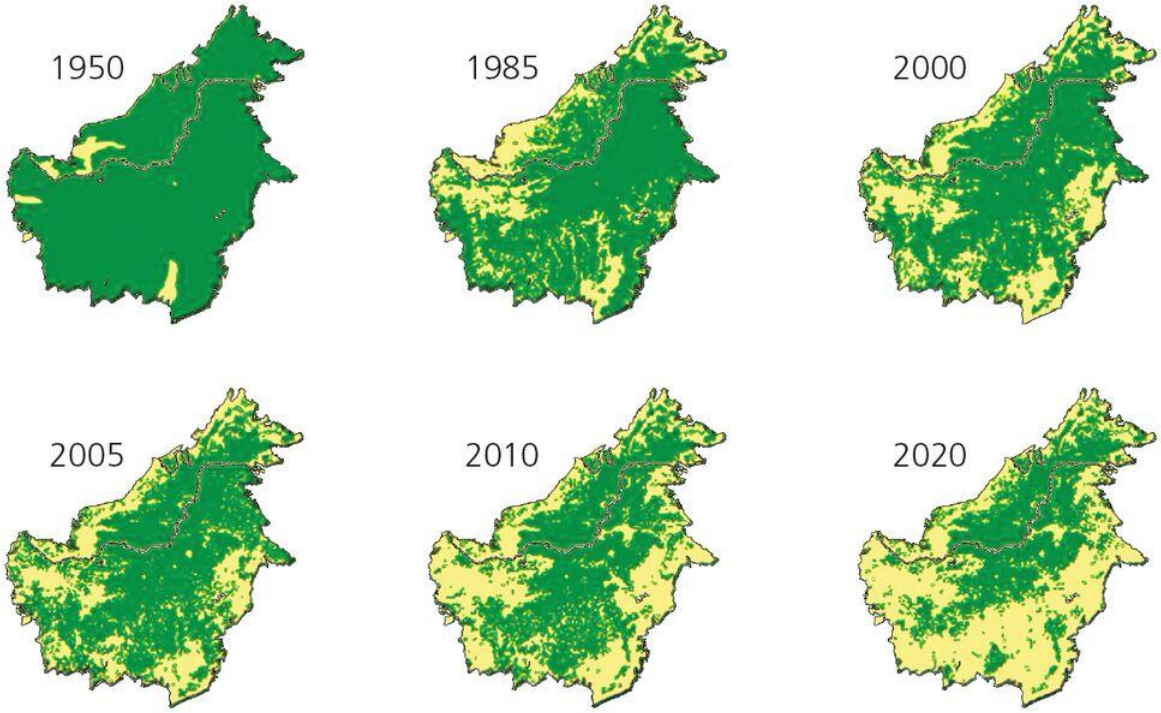


CO_2 and sea-level



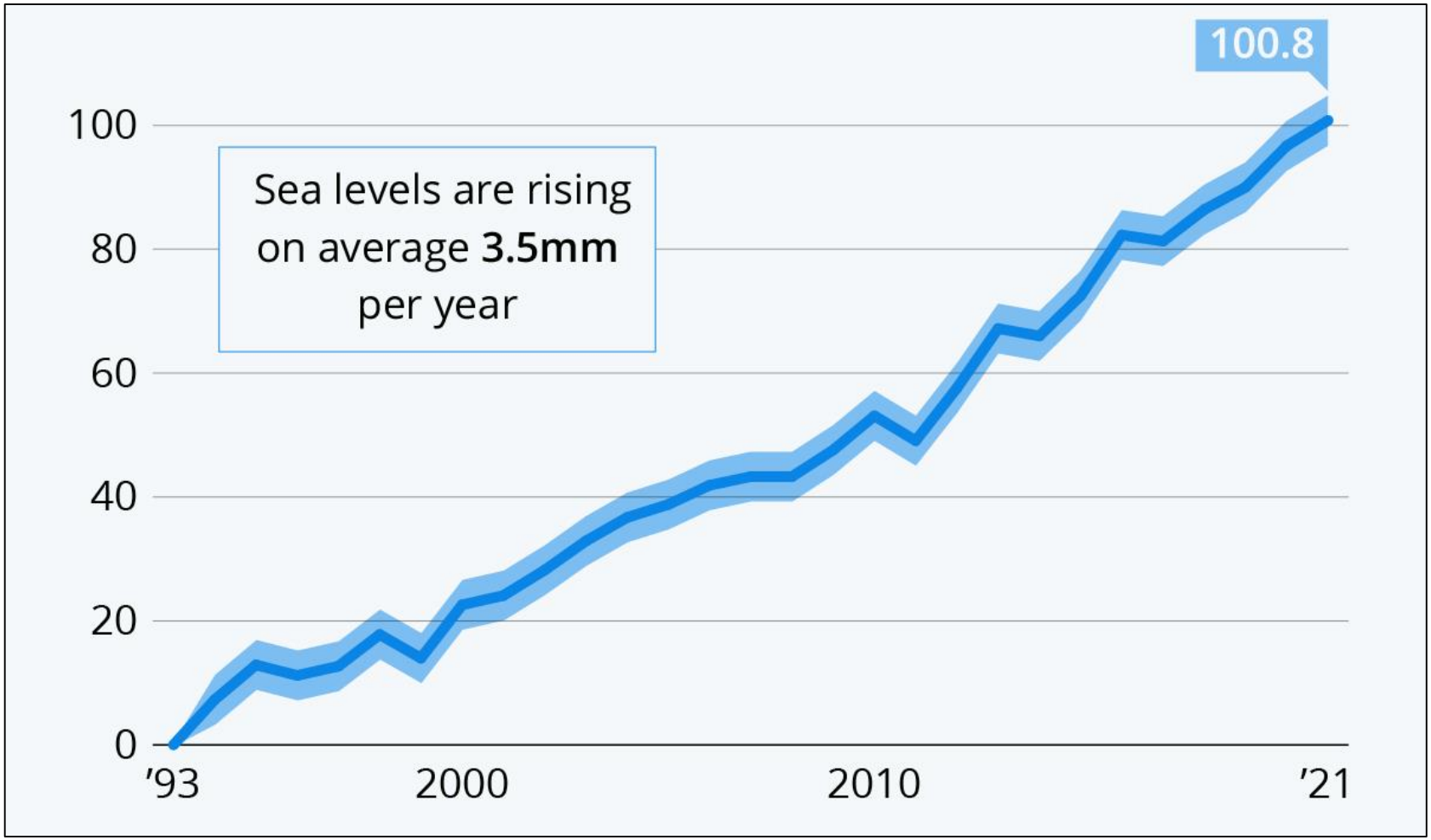
Habitat loss

A Deforestation in Borneo, Indonesia, 1950–2005, and projections toward 2020



B

Sea level rise since 1993 (in mm)



Contributors to global sea-level rise (1993-2018)