Plants

Terrestrial plants underwent an instantaneous extinction event
79% of Angiosperms went extinct

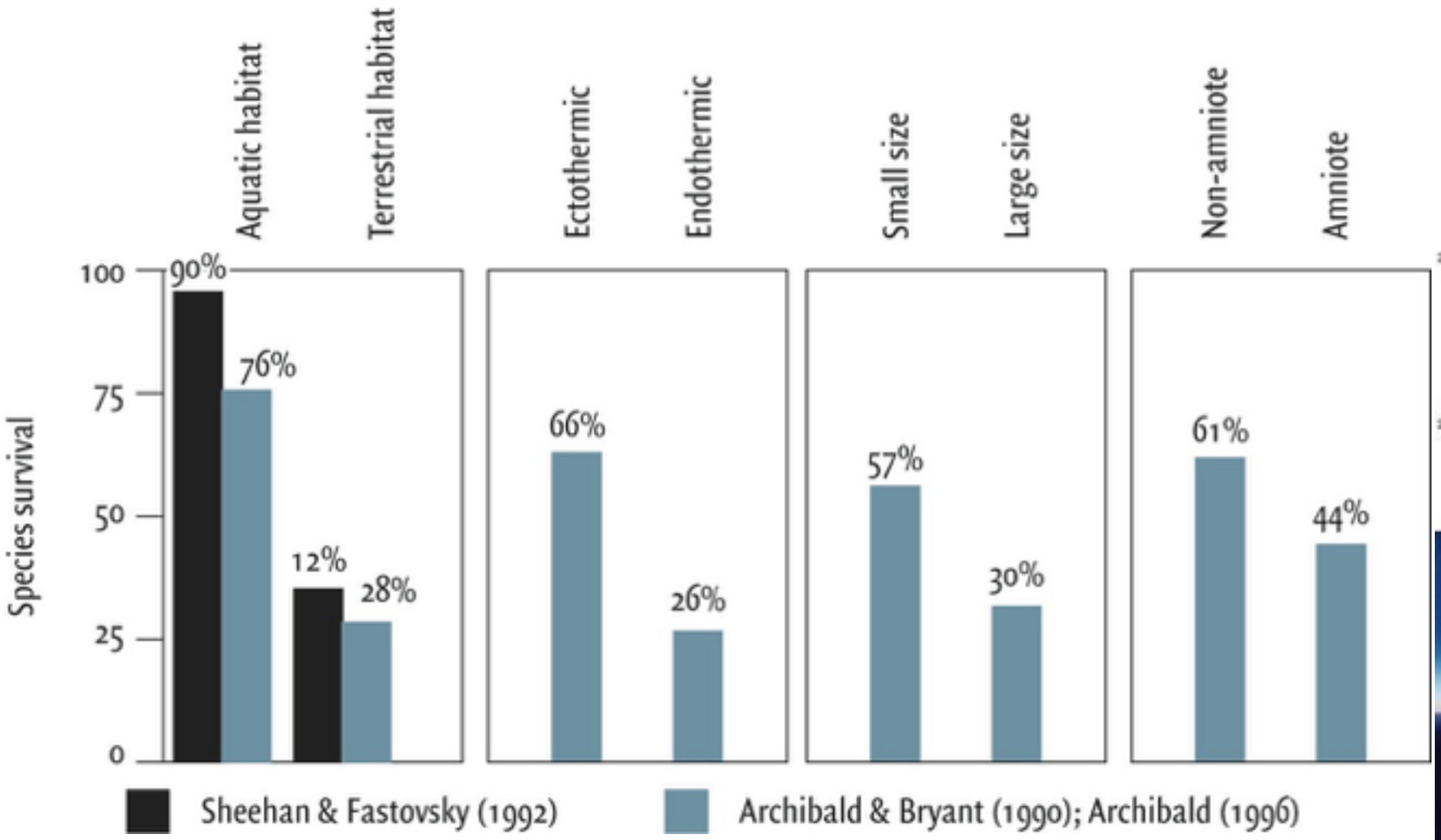
In some places, a fungus spike directly after extinction

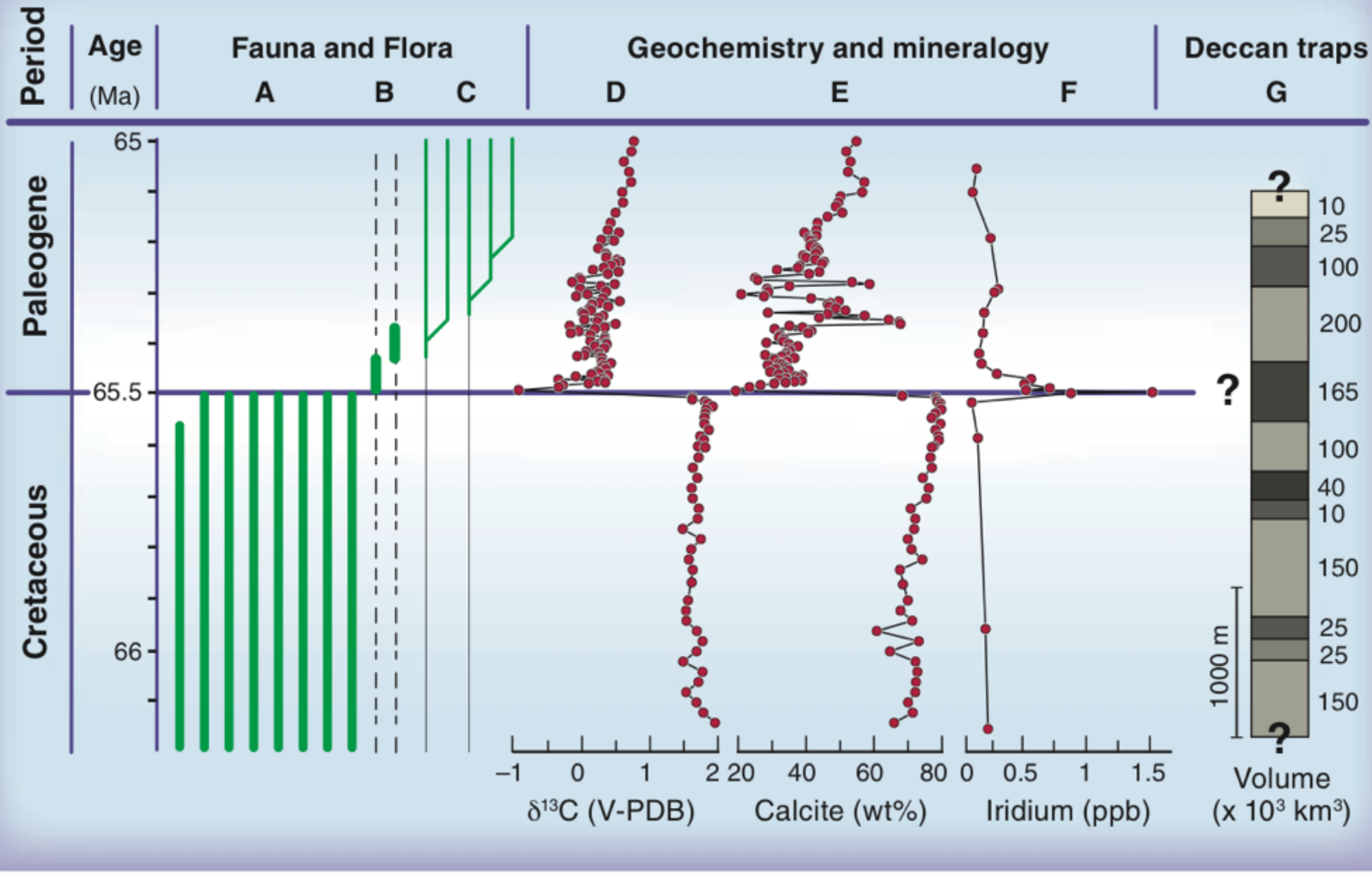
Global Fern spike soon afterwards

Animals

Dinosaurs, of course, are most famous victims
12-28% of fully-terrestrial vertebrates survive
BUT
76-90% of aquatically adapted organisms survive

Small vertebrates are favored
Ectotherms are favored
Non-amniotes favored





A) Massive extinction of species

B) Successive blooms of opportunistic species

C) Radiation of new species

Other explanations

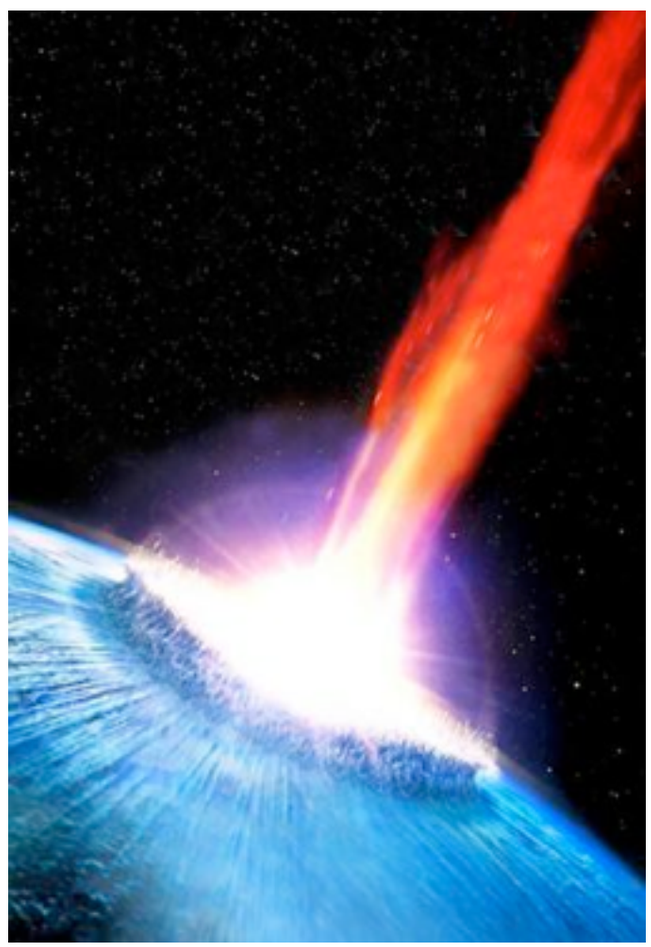
Volcanism: Could explain Ir spike, but not shocked quartz

And, you'd only expect a local Ir spike.

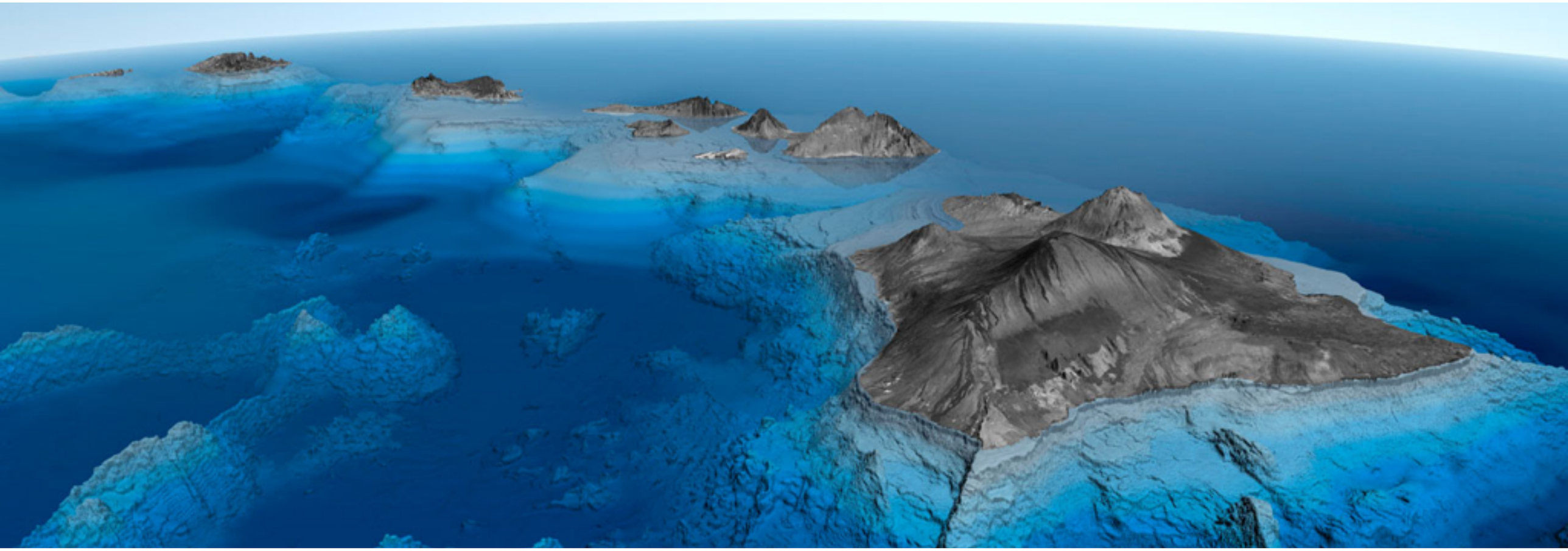
Deccan Traps: Certainly big and potentially devastating, but they were active before and after the KT without detectable effects on biota.

Clearly a bolide hit. Did it cause the mass extinction?

Because the most recent evidence does not suggest any decline in diversity or correlation of biotic turnover with climatic effects, it remains the most plausible scenario.

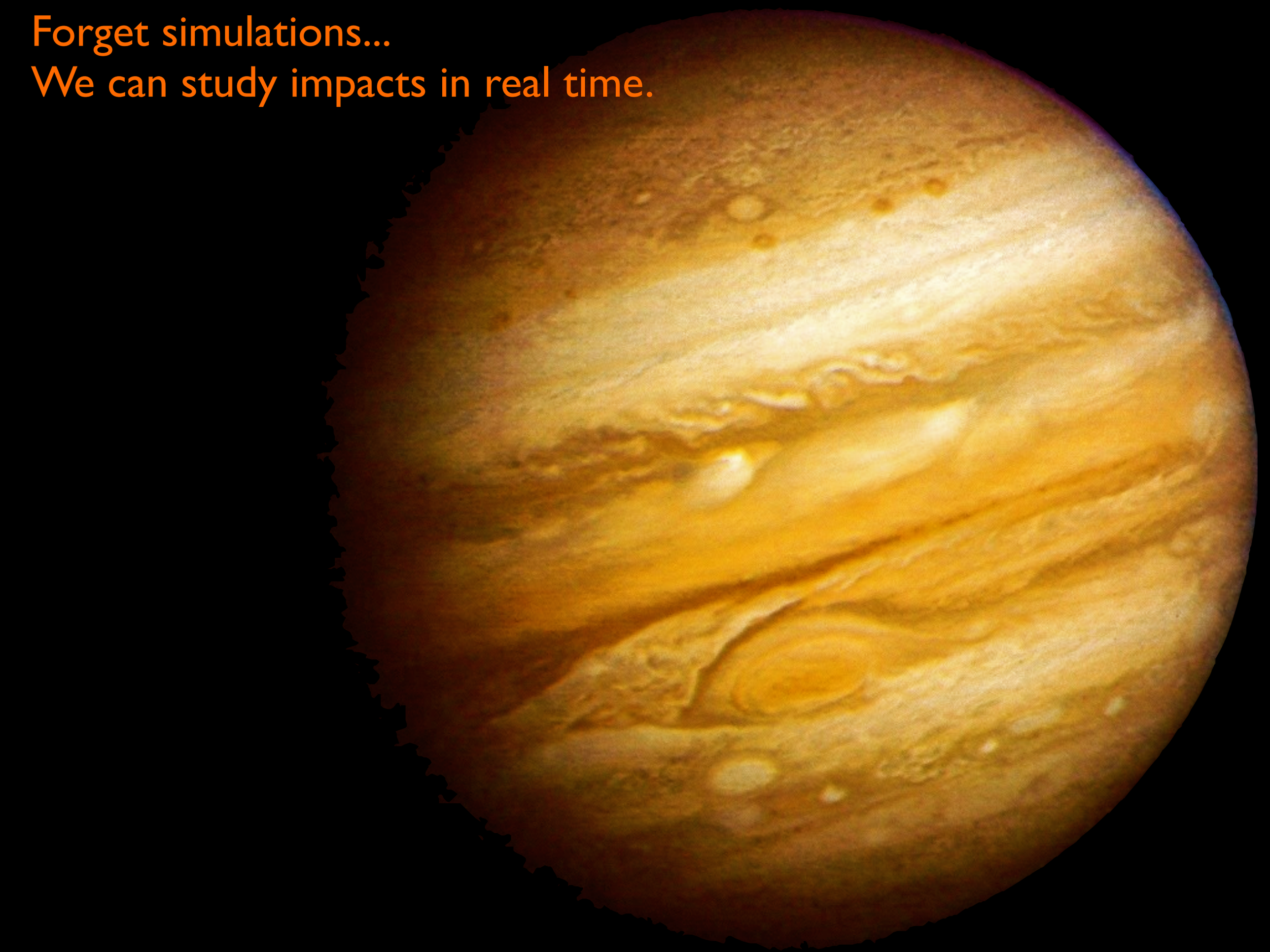


“The new analysis of the dinosaur family tree reveals that dinosaurs were disappearing even before the asteroid hit about 65.5 million years ago. Roughly **24 million years** before that impact, dinosaur extinction rates passed speciation rates, meaning that the animals were losing the ability to replace extinct species with new ones, the researchers said.” - LiveScience



“It's unclear why the dinosaurs started going extinct so early, but there are clues as to why speciation increased during certain periods, the scientists said. One idea is that rising sea levels cut into the land, fragmenting dinosaur habitats and nudging the beasts to evolve separately into new species in different areas, the researchers said.” -LiveScience

Forget simulations...
We can study impacts in real time.



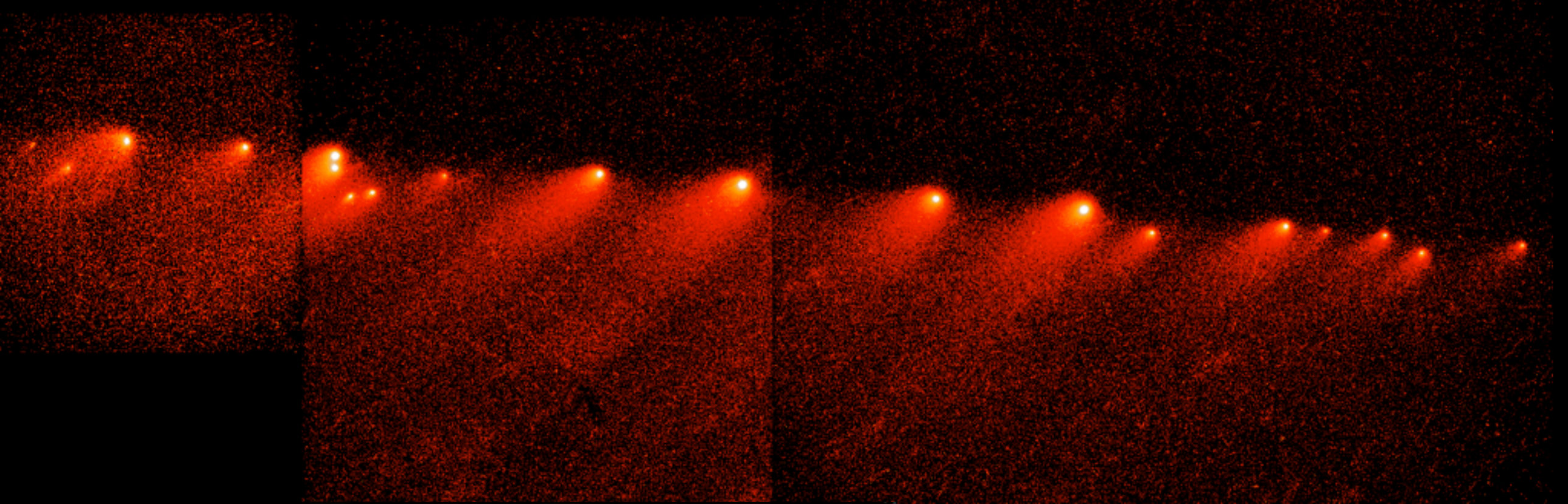
•In July 1994, the comet Shoemaker-Levy 9 was caught in Jupiter's massive gravity well.

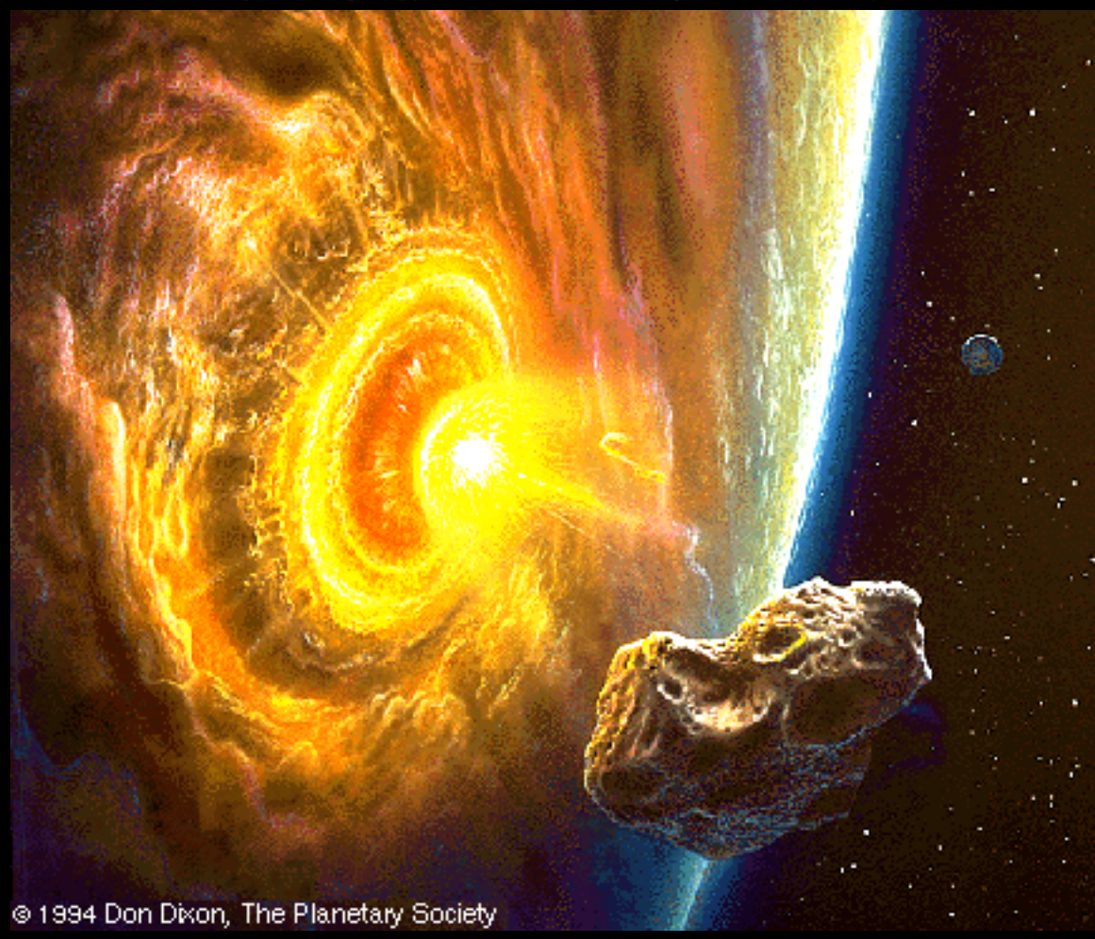
•This collision is a rare opportunity to observe an impact event in real time.

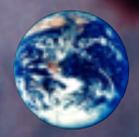
•The impactor consisted of several fragments, the largest being ca. 1 Km wide

•But Jupiter's massive gravity greatly increased the velocity of the bolides... this resulting collision is believed to be of very similar magnitude to the KT event.


1024x1024 Near-Infrared Camera
University of Hawaii 2.2-meter telescope

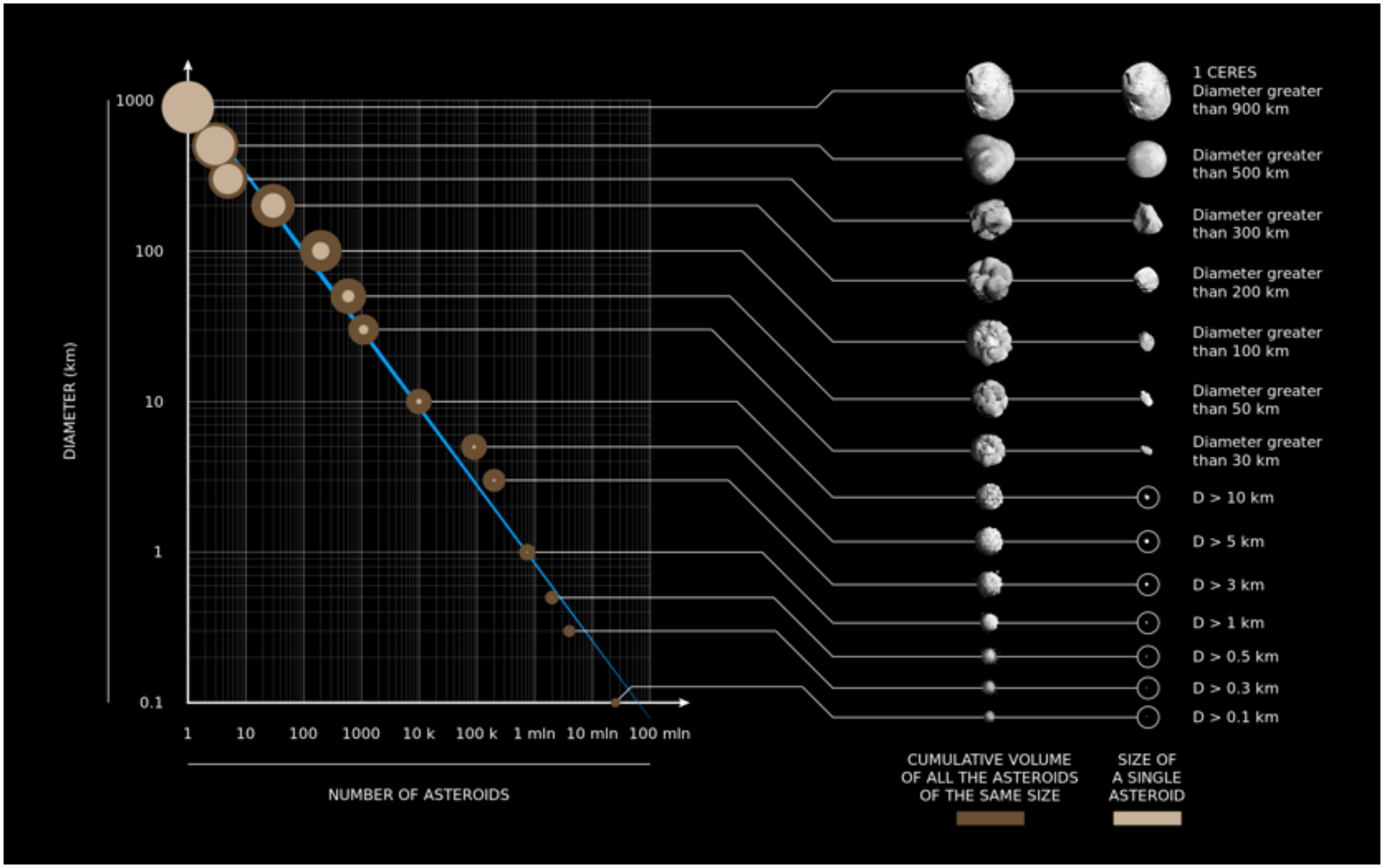



© 1994 Don Dixon, The Planetary Society



The late heavy bombardment: 4.1-3.8 Billion years ago

100 asteroids known to be > 50 km diameter
700,000 to 1.7 million w/ diameter of 1 Km or more



What if a 500 Km (300 mile) diameter bolide hit Earth?
That's 500 x the KT bolide

Modern Meteors

FELLED FOREST

BLAST ZONE

Tunguska

Modern Meteors: Russia 2013

Meteor Shower (Eastern Russia)

12-15-13

Modern Meteors: Russia 2013

Modern Meteors: Brazil

REALITY OR
ULTRA REALITY?

Extinctions reset the clock.

We owe everything to the KT bolide impact

But things were still a lot cooler before!

Are there fundamental constraints that determine ecological interactions?

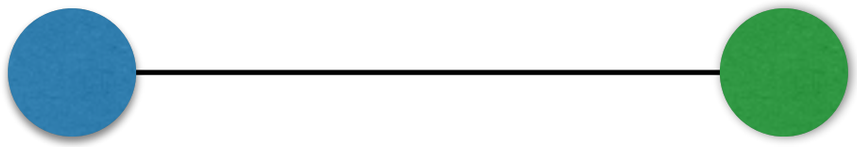
How do animal communities respond to perturbations?

Food web reconstruction

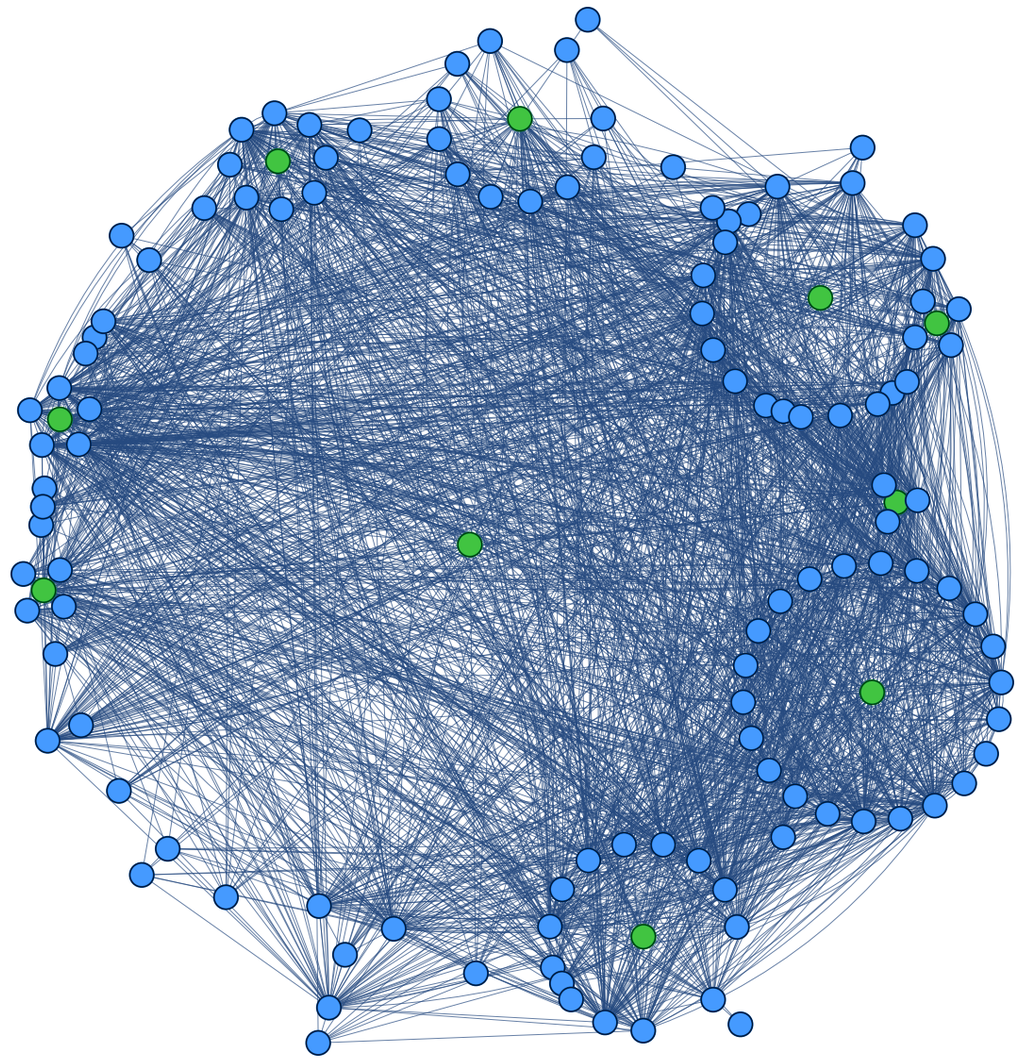
Climatic change and human impact

- Dietary, structural, and dynamic consequences

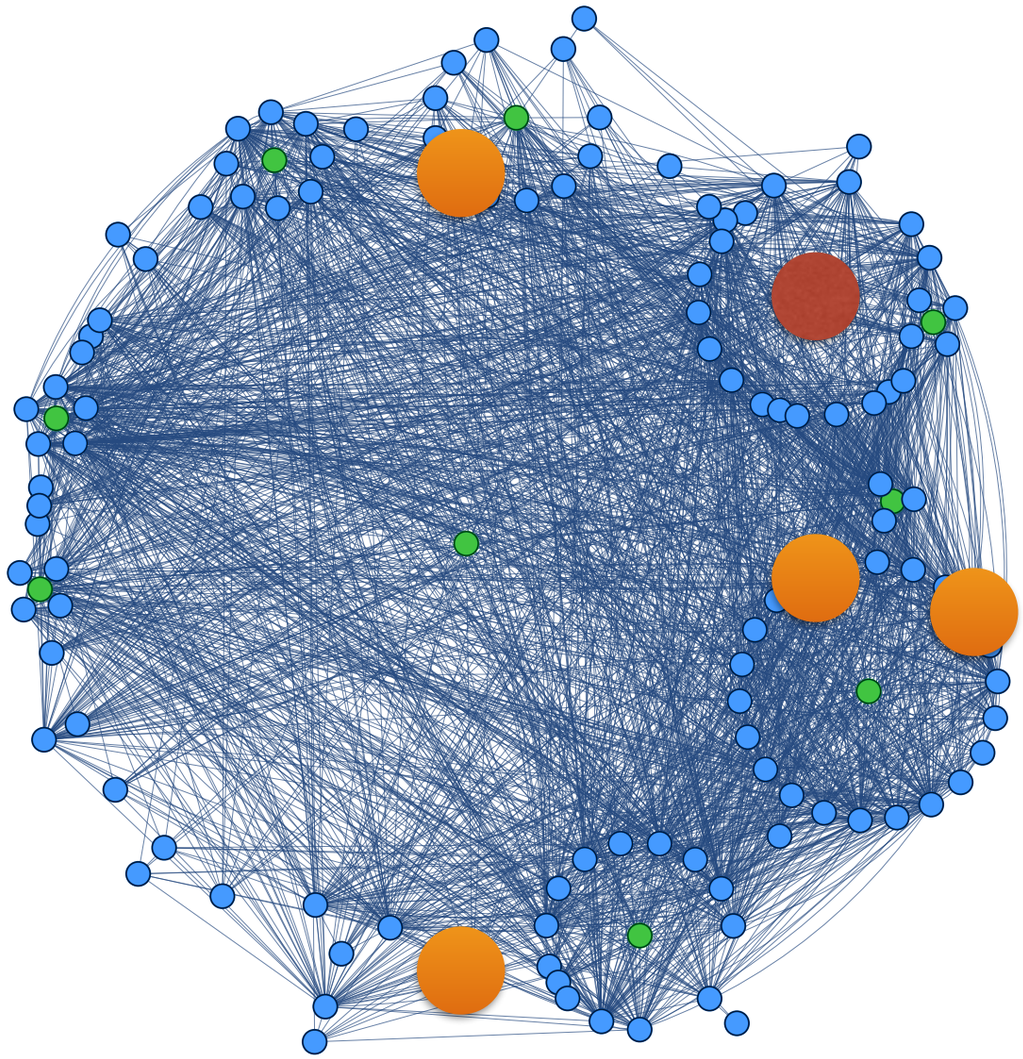
Species interactions in food webs



Structure of interactions:
-ecosystem function
-resistance/resilience
-dynamics



Have large perturbations impacted food web structure or function?



primary extinction

secondary extinction

systems with a higher proportion of secondary extinctions are more fragile (less robust)

Roopnarine et al. ProcRoySoc B, 2007
Mitchell et al. PNAS 2012

Permian extinction:

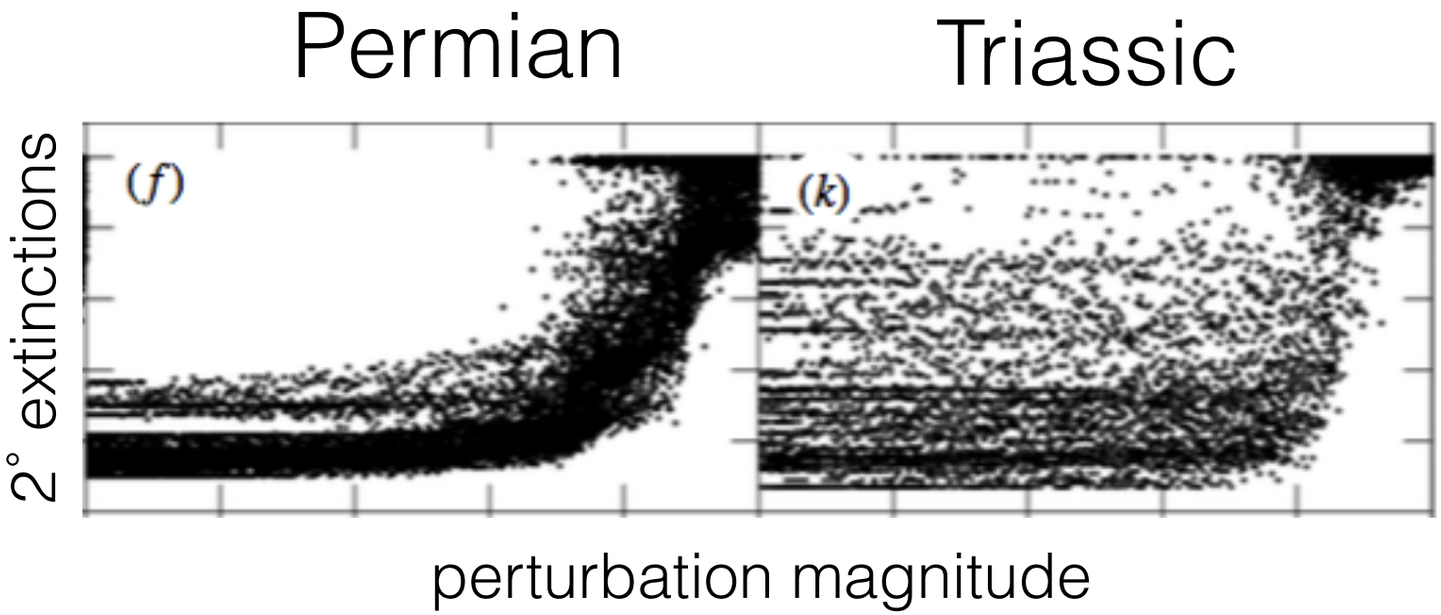
251 Million years ago
70% terrestrial vertebrates extinct
96% marine species extinct

end-Cretaceous restructuring:

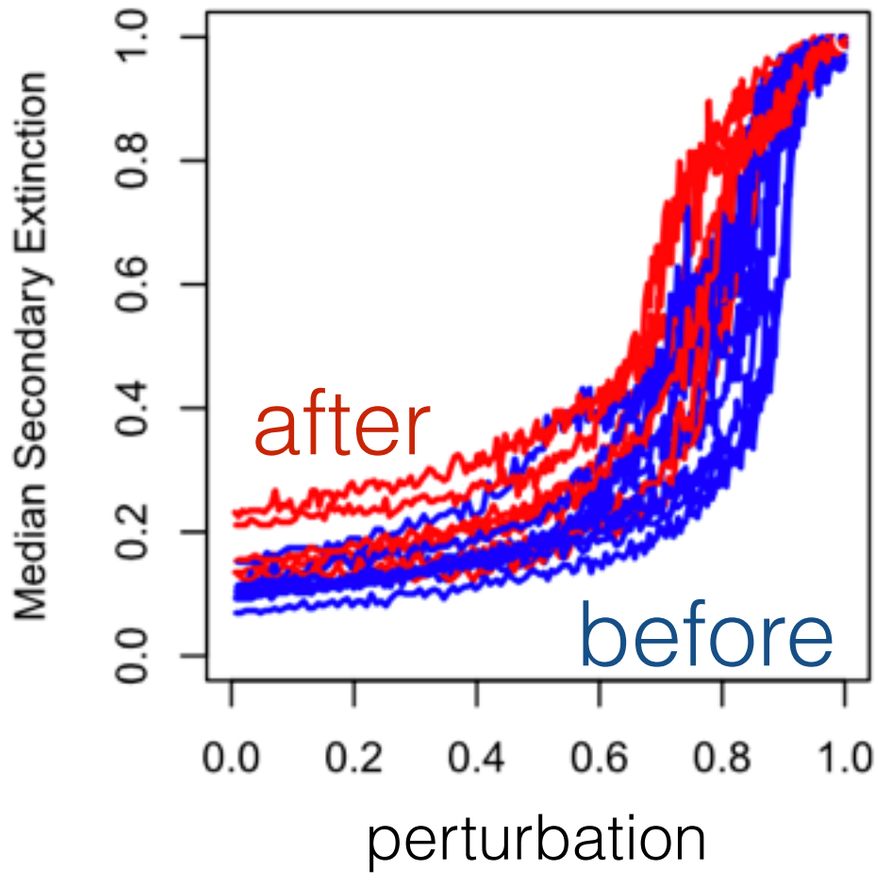
~72 Million years ago
Decrease in dinosaur richness
Less endemic taxa
Were end-Cretaceous systems less robust? Did this set the stage for the KT extinction event?

Roopnarine et al. ProcRoySoc B, 2007
Mitchell et al. PNAS 2012

Permian extinction:



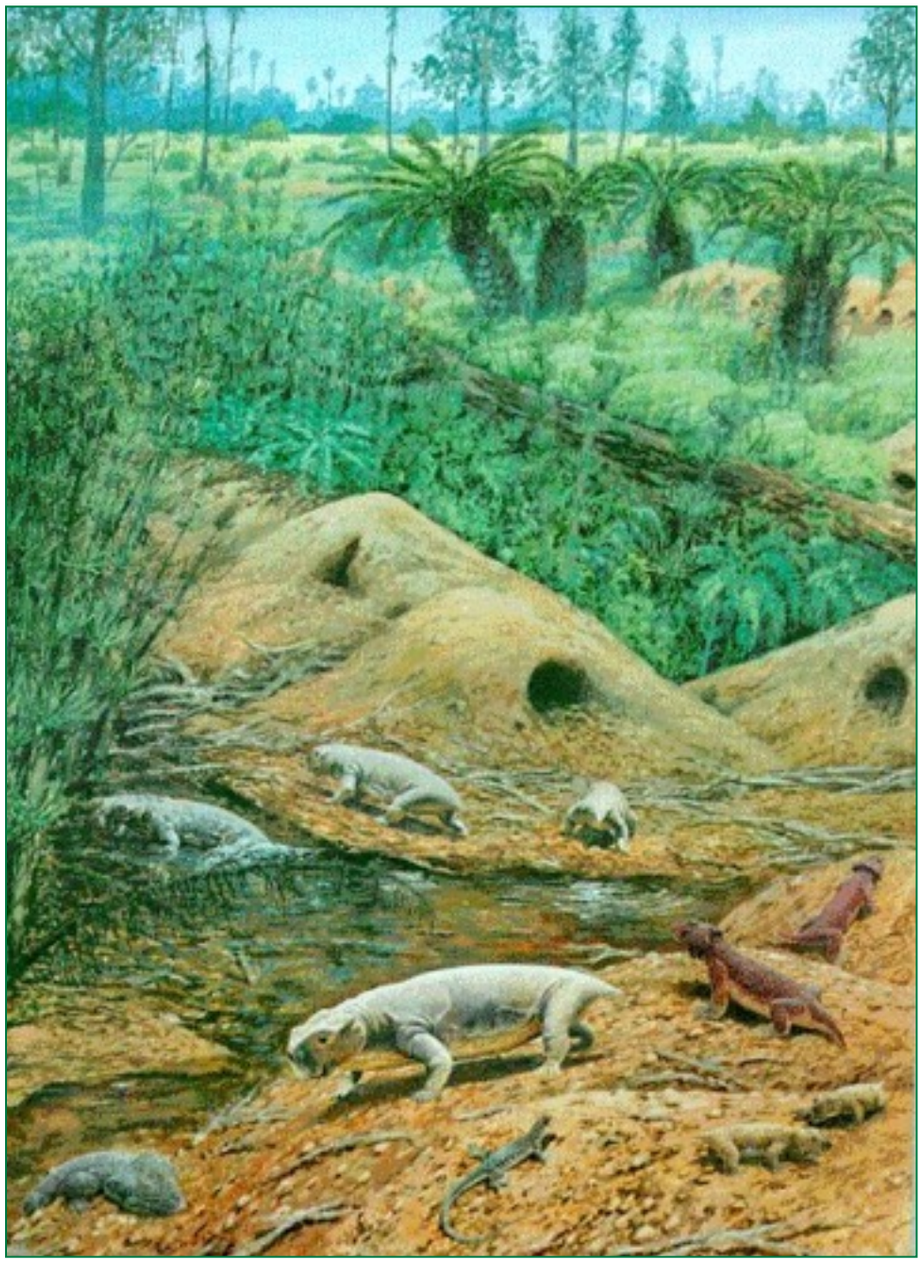
end-Cretaceous restructuring:



Perturbations and food web robustness

-Large perturbations leave less robust communities

-Declines in robustness may exaggerate extinction events



Climate change?
Humans?

Period
Predynastic
Archaic
Old Kingdom
New Kingdom
G-R
Historical
Dynasty
1
2
3
4
5
6
7-10
11-12
13-17
18
19
20
21-31
yrs BP
11950
5950
5600
5350
5050
4810
4645
4580
4455
4295
4140
4084
3735
3520
3270
3150
3035
2282
1980
1555
100
0
Today
Pr(Ext.)
1.0
0.8
0.6
0.4
0.2
0.0
Carnivora
Perissodactyla
Artyodactyla
Canis aureus
Vulpes vulpes
Lycaon pictus
Hyaena hyaena
Crocuta crocuta
Panthera leo (long maned)
Panthera leo (short maned)
Panthera pardus
Acinonyx jubatus
Loxodonta africana
Equus asinus
Equus grevyi
Equus quagga
Diceros/Ceratotherium
Sus scrofa
Phacochoerus aethiopicus
Hippopotamus amphibius
Giraffa camelopardalis
Dama mesopotamica
Camelus dromedarius
Taurotragus oryx
Tragelaphus spekei
Addax nasomaculatus
Oryx dammah
Oryx beisa
Hippotragus equinus
Kobus kob
Kobus megaceros
Alcelaphus bucelaphus
Connochaetes taurinus
Litocranius walleri
Ammodorcas clarkei
Gazella dorcas
Gazella leptoceros
Gazella soemmerringii
Capra ibex
Ammotragus lervia
Bos primigenius
Syncerus caffer

Ecology
Evolutionary Biology
Paleo-ecology

Understanding how ecosystems work, how they change over time, and what our role in these systems has been, is, and can be…

If these ideas excite you, you should follow where they lead

UC-Merced Programs:
Biology (EEB-emphasis)
Earth Systems Science

Thanks for a great semester!
You are all now official dinosaur experts.
Amaze your friends at parties.

Thanks for a great quarter!