Fossils show widespread plant extinctions after asteroid wiped out dinosaurs

September 27 2023, by Matthew Carroll

Leaf fossils in rocks from the early Paleocene from a site in Mexican Hat, Montana. Credit: Peter Wilf

Sixty-six million years ago, an asteroid the size of San Francisco crashed into a shallow sea off the coast of modern-day Mexico and plunged the world into an extinction event that killed off as much as 75% of life, including the dinosaurs.

But a debate remains about how the Cretaceous-Paleogene extinction (K-Pg) impacted plant life on land, in part because global studies of the fossil record have shown that no major plant families went extinct.

A new analysis of emerging fossil data from North and South America sheds light on how plants fared during the K-Pg boundary and points to a true plant extinction, a team of scientists reported in the new journal *Cambridge Prisms: Extinction*.

"There has been a trend in the literature to say maybe this event was bad for the dinosaurs and lots of marine life, but it was fine for plants because the major groups survived," said Peter Wilf, professor of geosciences at Penn State and lead author. "Our review counters that idea, because everywhere we looked, more than half of the species went extinct."

Understanding what happened to ancient plants during the extinction requires suitable fossil-plant collections, and, for the K-Pg, these were limited previously to just a few areas in the United States, the scientists said. New fossils from Colombia and Argentina and the United States have provided a broader geographic range to study the severity, ecosystem effects and legacies of the event on plant life.

"You need really strong sampling and to know where the rocks with plant fossils are," Wilf said. "Differences in DNA among living plants are not going to tell you anything about deep-time species extinctions. You need plant fossils from before and after. You need layers of rock that show the extinction. And the more indicators you have, the more

complete your story is."

The researchers reviewed emerging fossil data from North Dakota, Colorado and New Mexico in the United States and from Colombia and Argentina. The evidence points to a significant plant species loss, greater than 50% at each site, the scientists said.

This loss of species represents a real extinction, the scientists said. Modern conservation efforts, for example, focus on saving species—like the polar bear—not the larger group that it belongs to—all bears or all mammals. Applying this to plants, the extinction of an entire modern plant family, like Fagaceae, would require killing off all the species of beeches, chestnuts and oaks.

"You really can't kill most plant families, so that argument is a bit pointless," Wilf said. "By the end-Cretaceous, each family had too many genera with too many species and individuals. Plants outweigh all animals combined, more than two hundredfold. Dinosaurs were many times less diverse and abundant than plants, and thus it was much easier to kill off nearly all major categories of them—only birds survived."

"We are reminding our colleagues that these plant species extinctions were real, very significant extinctions. In every place we look that has the record preserved, there were huge losses of plant species, followed by an amazing series of evolutionary events that made our modern world what it is."

The K-Pg extinction ushered in the rise and true dominance of flowering plants and helped establish the planet's tropical rainforests that hold most of its biodiversity, Wilf said.

"Mass extinctions are not just about taxonomic loss," said Mónica R. Carvalho, an assistant professor at the University of Michigan and co-

author on the study. "There is a transformative effect on ecosystems—what they are made of, how they operate. Fossils show that post-extinction tropical rainforests were profoundly different from their predecessors in composition, structure and ecology."

At all the locations studied, the extinction event had a transformative impact on plant life and terrestrial ecosystems, the scientists said.

"The purpose here was to update everybody that we have these different areas and to compare them," Wilf said. "This allows us to address this question of heterogeneity—was everything a monolith—was the end-Cretaceous plant extinction the same everywhere. This paper shows that is really wasn't—that very different things happened in different places."

Those differences likely were influenced by factors like distance from the impact site, the Chicxulub crater off the coast of the Yucatán Peninsula in Mexico, and how susceptible local plant life would have been to freezing conditions brought on by the global darkness following the impact.

"These extinctions partly resulted from planetary freezing and could have been particularly severe at the tropics," Wilf said. "That's an area that really doesn't like to be frozen and is also very biodiverse. This was a warm world, without much frost. The best place to be, after the initial tsunamis, shock waves and so forth passed, was near the coasts for maritime temperature buffering."

The K-Pg extinction is considered an analog for the modern biodiversity crisis because both involve massive environmental changes over a geologically instantaneous period of time, the scientists said. Global conservation assessments show that a comparable number of plant species—around 40%—are threatened with extinction now and losing them could lead to ecological impacts comparable to the K-Pg

extinction, Wilf said.

"Although the worst outcomes are still preventable, the sixth mass extinction could mirror the K-Pg event by eliminating comparable numbers of plant species in a geologic instant, to the great detriment of biodiversity, ecosystems and civilizations," Wilf said. "It could eventually transform terrestrial ecosystems while having little effect on global plant-family diversity."

More information: Peter Wilf et al, The end-Cretaceous plant extinction: Heterogeneity, ecosystem transformation, and insights for the future, *Cambridge Prisms: Extinction* (2023). DOI: 10.1017/ext.2023.13

Provided by Pennsylvania State University