Science Advances
AAAS

Supplementary Materials for

Shifts in food webs and niche stability shaped survivorship and extinction at the end-Cretaceous

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Sci. Adv. **8**, eadd5040 (2022)
DOI: 10.1126/sciadv.add5040

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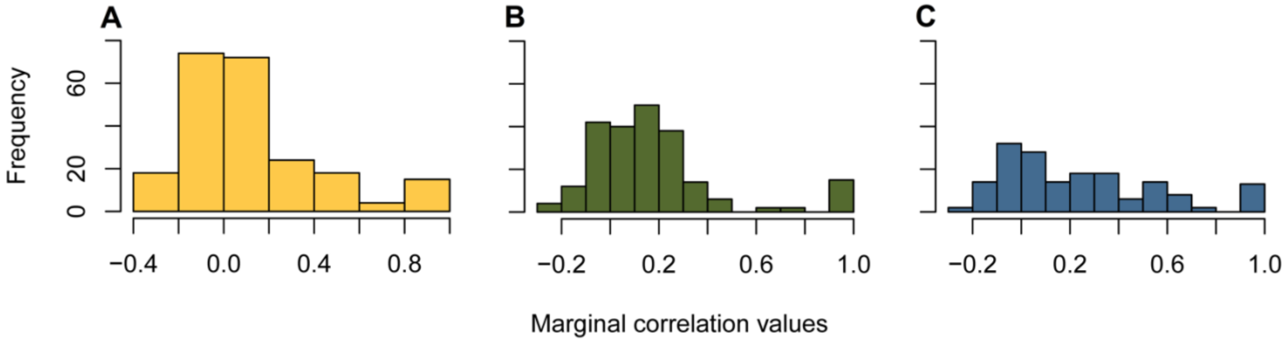
Legends for data S1 to S3

Other Supplementary Material for this manuscript includes the following:

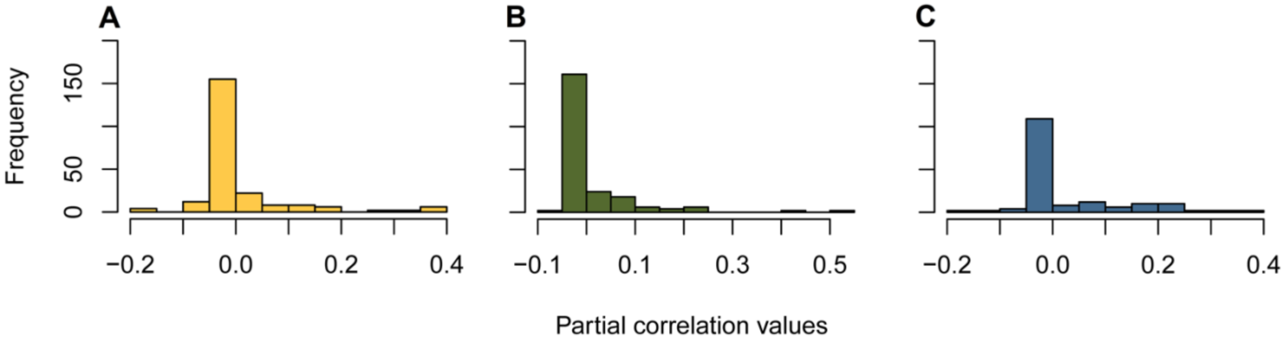
Data S1 to S3

Fig. S1.



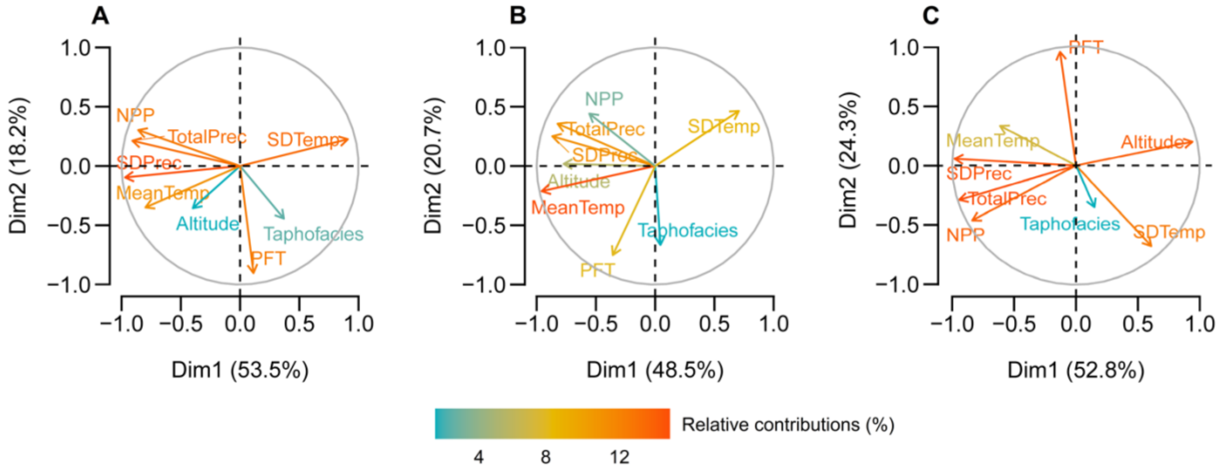
Marginal correlation coefficients. Histograms of the marginal correlation coefficients estimated between the β-diversities of different trophic guilds inhabiting North American ecosystems of the latest Cretaceous (Campanian: **A**, Maastrichtian: **B**) and early Paleogene (Danian: **C**).

Fig. S2.



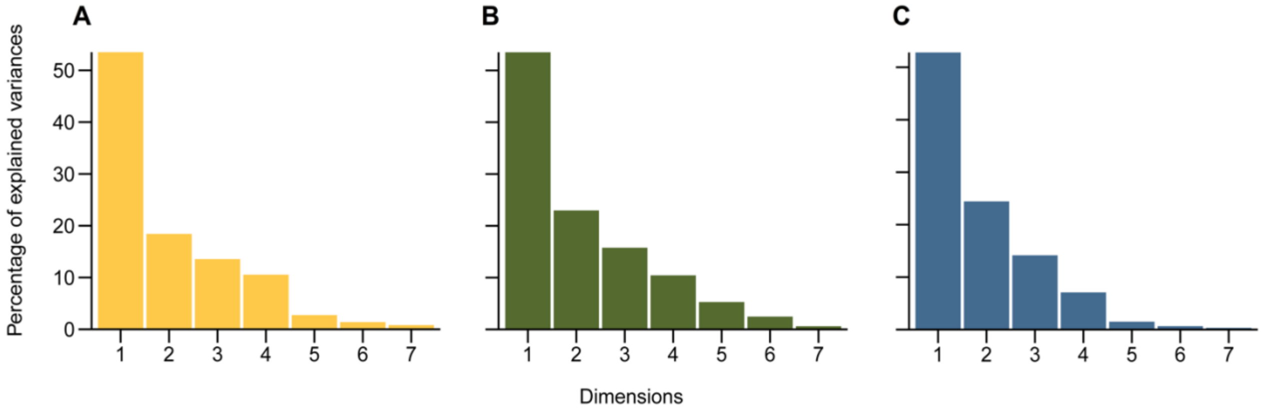
Partial correlation coefficients. Histograms of the partial correlation coefficients estimated between the β-diversities of different trophic guilds inhabiting North American ecosystems of the latest Cretaceous (Campanian: **A**, Maastrichtian: **B**) and early Paleogene (Danian: **C**).

Fig. S3.



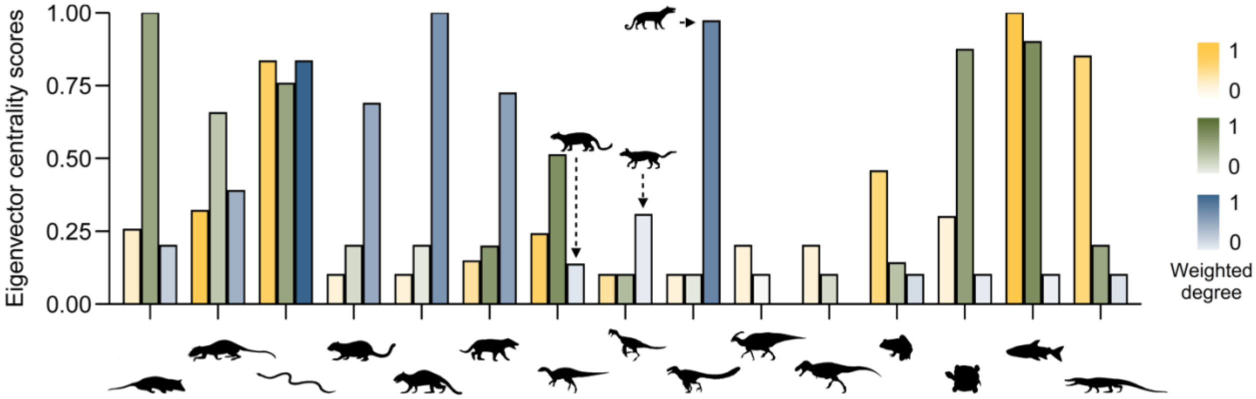
Biplots from factorial analysis of mixed data (PCAMIX). These routines were performed for eight (transformed) explanatory variables representing paleoclimatic, land-surface, and paleogeographical envelopes, as well as the human sampling effort across the Late Cretaceous (Campanian: **A**, Maastrichtian: **B**) and early Paleogene (Danian: **C**). *Mean Temp*, near-surface (1.5 m) mean annual temperature (ºC); *SDTemp*, near surface (1.5 m) annual temperature standard deviation (ºC); *TotalPrec*, annual average precipitation (mm), *SDPrec*, annual precipitation standard deviation (mm); *NPP*, net primary productivity (g C m^{-2} yr^{-1}); *PFT*, plant functional types; *Taphofacies*, the number of discrete tetrapod-bearing collections (see Materials and Methods for details).

Fig. S4.



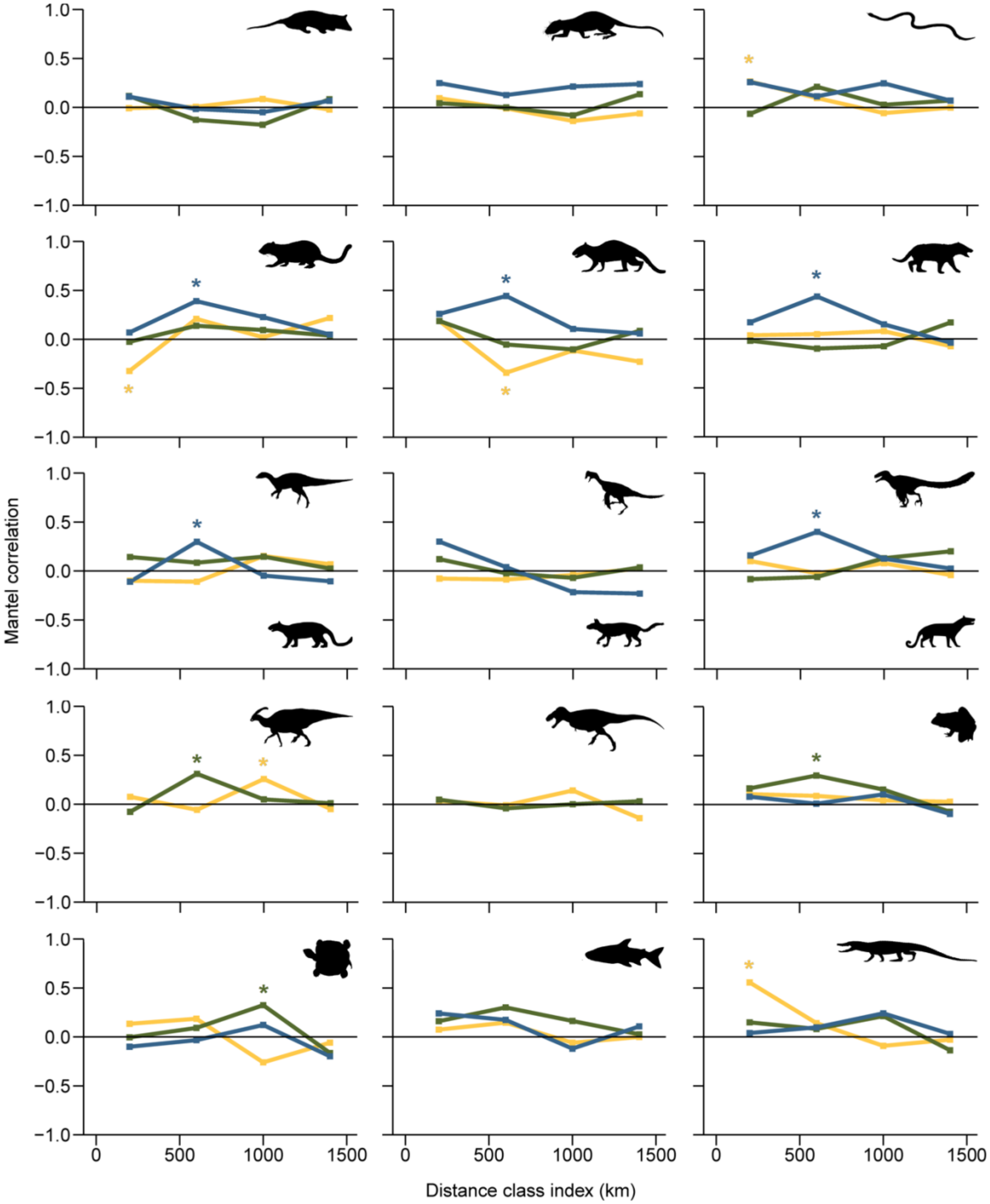
Eigenvalues from factorial analysis of mixed data (PCAMIX). Bar plots of eigenvalues on the PCAMIX of (transformed) explanatory variables (see fig. S3) representing paleoclimatic, land-surface and paleogeographical envelopes, as well as the human sampling effort across the Late Cretaceous (Campanian: **A**, Maastrichtian: **B**) and early Paleogene (Danian: **C**). Following Duarte et al. (*113*), only the first two orthogonal eigenvectors were selected to maximize the fit between β-diversity and explanatory matrices in linear regressions (see Materials and Methods for details).

Fig. S5.



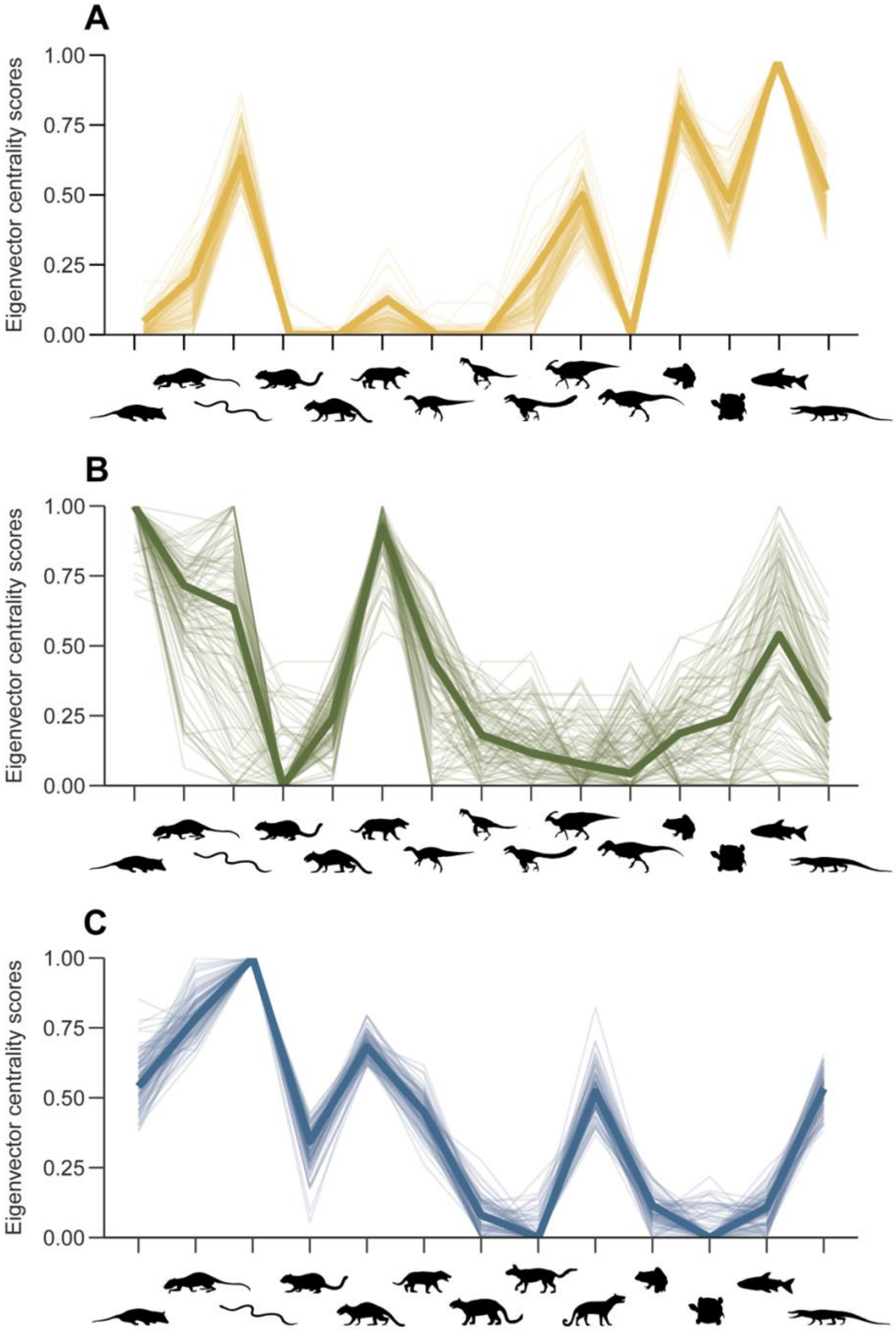
Properties of the inferred networks representing the true replacement component of β-diversity. This figure represents the eigenvector centrality scores and weighted degrees for each trophic guild in the food webs of the latest Cretaceous (Campanian: **yellow**; Maastrichtian: **green**) and early Paleogene (Danian: **blue**). The eigenvector centrality quantifies the standardized importance of each node for the overall connection of the interaction network (*51*), and the weighted degree is the sum of partial correlations between a given node and the other nodes that are directly connected to this trophic group (*50*). Silhouettes of representative animals follow Fig. 2 and were obtained from http://phylopic.org/ (see Acknowledgments).

Fig. S6.



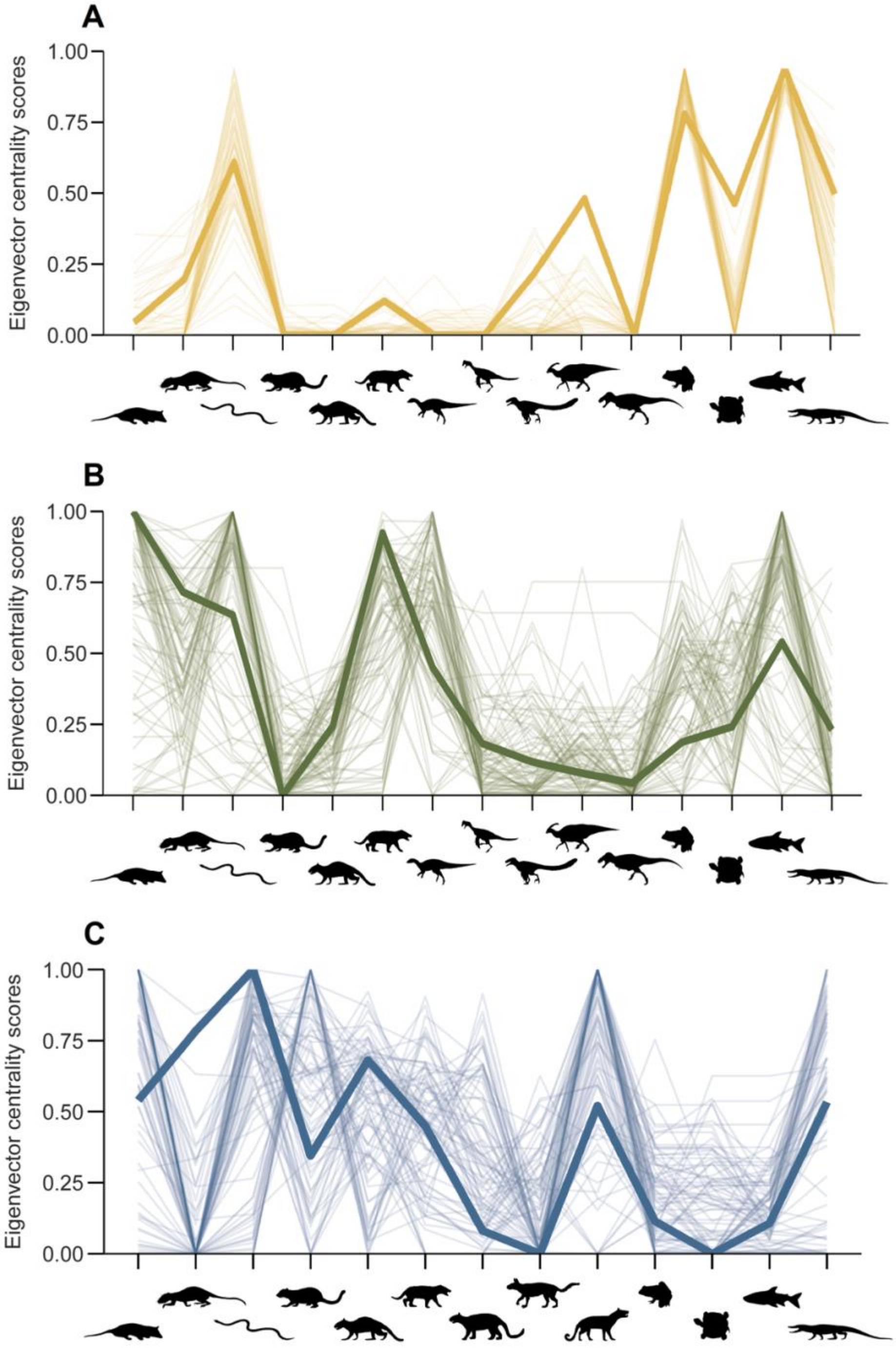
Mantel correlograms. Panels show the spatial structures of pairwise β-diversities for each trophic guild across the latest Cretaceous (Campanian: **yellow**, Maastrichtian: **green**) and early Paleogene (Danian: **blue**). Asterisks denote significant spatial autocorrelation after Holm correction for multiple testing (*117*). Silhouettes of representative animals follow Fig. 2 and were obtained from http://phylopic.org/ (see Acknowledgments).

Fig. S7.



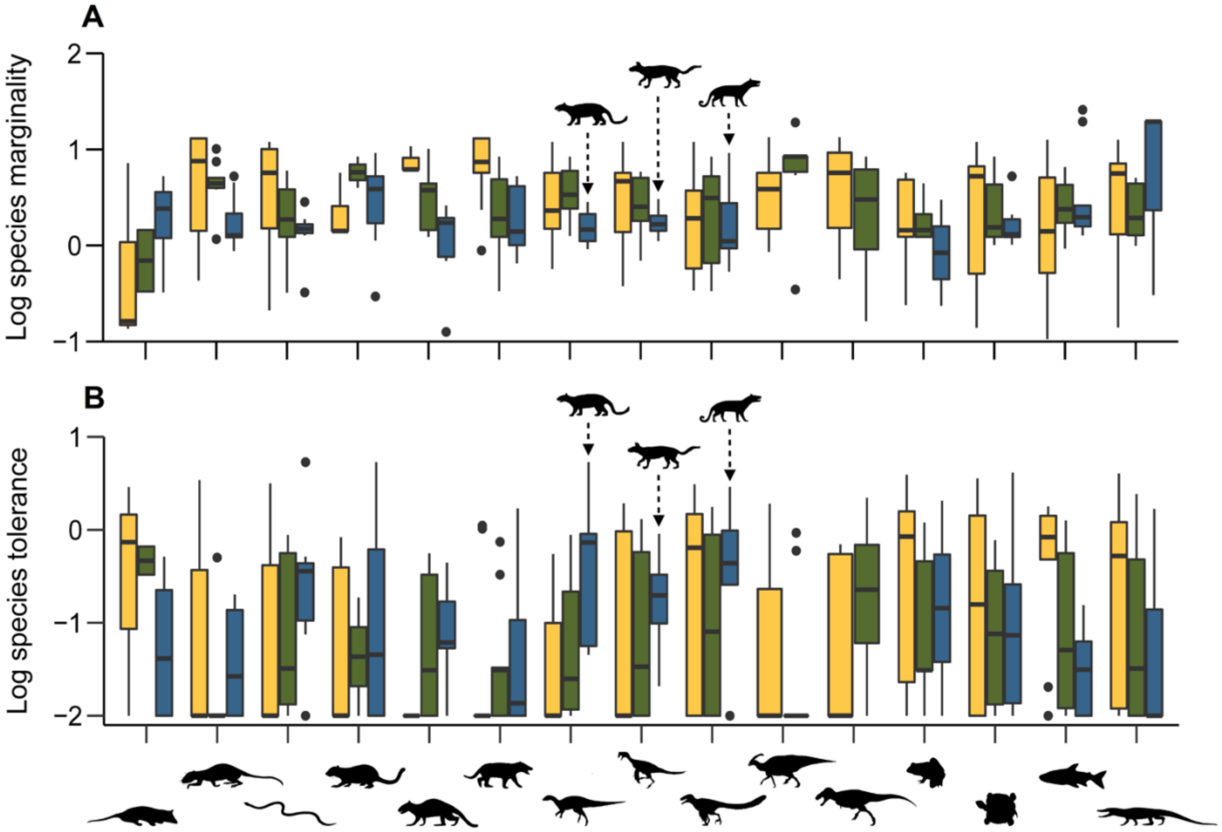
Sensitivity analysis based on a random resampling of fossil localities. Panels represent the eigenvector centrality values of the 99 randomly selected interaction networks (thin lines) compared to the original full model (bold lines) for the food webs of the Late Cretaceous (Campanian: **A**, Maastrichtian: **B**) and early Paleogene (Danian: **C**). Silhouettes of representative animals follow Fig. 2 and were obtained from http://phylopic.org/ (see Acknowledgments).

Fig. S8.



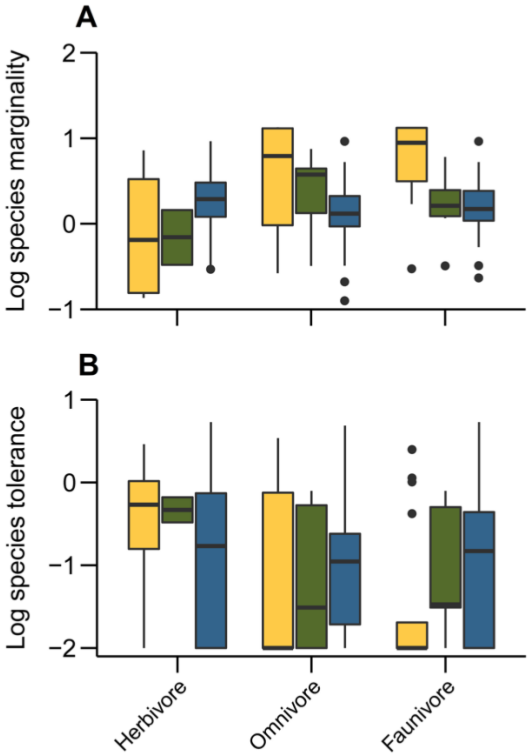
Sensitivity analysis based on a random resampling of taxa. Panels represent the eigenvector centrality values of the 99 randomly selected interaction networks (thin lines) compared to the original full model (bold lines) for the food webs of the Late Cretaceous (Campanian: **A**, Maastrichtian: **B**) and early Paleogene (Danian: **C**). Silhouettes of representative animals follow Fig. 2 and were obtained from http://phylopic.org/ (see Acknowledgments).

Fig. S9.



Ecospace occupancy dynamics after a random resampling of species. Boxplots show the distribution of the *log*-scaled species marginality (**A**) and tolerance (**B**) for each trophic group across the latest Cretaceous (Campanian: **yellow**, Maastrichtian: **green**) and early Paleogene (Danian: **blue**). The lower the species marginality (i.e., niche position), the less different its habitat preferences are from the average paleoenvironmental conditions. The greater the species tolerance (i.e., niche breadth), the more widely a species occurs across broad paleoenvironmental ranges, respectively. Boxplot bold lines indicate the median, whereas the boxes and whiskers are the interquartile range (IQR) and the maximum and minimum up to 1.5×IQR, respectively. Silhouettes of representative animals follow Fig. 2 and were obtained from http://phylopic.org/ (see Acknowledgments).

Fig. S10.



Ecospace occupancy dynamics of mammalian faunas. Boxplots show the distribution of the *log*-scaled species marginality (**A**) and tolerance (**B**) for mammal communities across the end-Cretaceous (Campanian: **yellow**, Maastrichtian: **green**) and early Paleogene (Danian: **blue**). Data on Mesozoic mammals was too sparse to yield meaningful comparisons when analyzing body size and feeding habits separately. The lower the species marginality (i.e., niche position), the more widely distributed a species is and the less different its habitat preferences are from the average paleoenvironmental conditions. The greater the species tolerance (i.e., niche breadth), the more often a species occurs across broad paleoenvironmental ranges, respectively. Boxplot bold lines indicate the median, whereas the boxes and whiskers are the interquartile range (IQR) and the maximum and minimum up to 1.5×IQR. Kruskal-Wallis tests and associated multiple comparisons (*131*) exploring measurable shifts in ecospace occupancy patterns are available in table S4.

Table S1.

Habitat	Body size	Trophic habit	Taxa
Aquatic	Small	Faunivore	Chondrichthyes (*Lonchidion*), Actinopterygii (*Cyclurus*)
		Omnivore	Chelonia (*Baena*), Actinopterygii (*Estesesox*)
	Medium	Faunivore	Crocodylomorpha (*Brachychampsa*), Choristodera (*Champsosaurus*)
Amphibious	Small	Faunivore	Anura (*Scotiophryne*)
Terrestrial	Very small	Herbivore	Multituberculata (*Cimolomys*, *Ptilodus*)
		Faunivore	Squamata (*Coniophis*, *Chamops*)
		Omnivore	Enantiornithes (*Avisaurus*), Multituberculata (*Mesodma*)
	Small	Herbivore	Ornithopoda (*Orodromeus*), Multituberculata (*Catopsalis*)
		Faunivore	Theropoda (Alvarezsauridae)
		Omnivore	Eutheria (*Loxolophus*, *Chriacus)*
	Medium	Herbivore	Marginocephalia (*Pachycephalosaurus*), Multituberculata (*Taeniolabis*)
		Faunivore	Theropoda (Dromaeosauridae), Mesonychia (*Ankalagon*)
		Omnivore	Theropoda (Oviraptorosauria, Ornithomimosauria)
	Large	Herbivore	Ornithopoda (*Parasaurolophus*), Marginocephalia (*Triceratops*)
		Faunivore	Theropoda (*Albertosaurus*, *Tyrannosaurus*)

Trophic delineations used in this study and examples of representative taxa (for a comprehensive list, see data S2–S3) from the Campanian–Danian of North America (see Materials and Methods for details).

Table S2.

Trophic groups	**H (*p*-value)**	**Significant comparisons after Dunn's test**
Very small terrestrial herbivore	5.21 (0.07)	
Very small terrestrial omnivore	2.31 (0.32)	
Very small terrestrial faunivore	**31.83 (0.00)**	Campanian *vs.* Maastrichtian
Small terrestrial herbivore	**7.61 (0.02)**	
Small terrestrial omnivore	**9.42 (0.01)**	
Small terrestrial faunivore	**8.64 (0.01)**	Maastrichtian *vs.* Danian
Medium terrestrial herbivore	4.77 (0.09)	
Medium terrestrial omnivore	1.64 (0.44)	
Medium terrestrial faunivore	2.25 (0.32)	
Large terrestrial herbivore	0.24 (0.62)	
Large terrestrial faunivore	1.29 (0.26)	
Small amphibious faunivore	0.74 (0.69)	
Small aquatic omnivore	**8.30 (0.02)**	Maastrichtian *vs.* Danian
Small aquatic faunivore	1.26 (0.53)	
Medium aquatic faunivore	**21.94 (0.00)**	Maastrichtian *vs.* Danian

Results for the Kruskal-Wallis tests and associated multiple comparisons (*131*) exploring differences in ecospace occupancy patterns in terms of species realized niche position across the K/Pg event and among different time intervals (Campanian, Maastrichtian, Danian). Significant values are given in bold font.

Table S3.

Trophic groups	**H (*p*-value)**	**Significant comparisons after Dunn's test**
Very small terrestrial herbivore	0.22 (0.90)	
Very small terrestrial omnivore	1.39 (0.50)	
Very small terrestrial faunivore	**8.75 (0.01)**	Campanian *vs.* Maastrichtian
Small terrestrial herbivore	2.46 (0.29)	
Small terrestrial omnivore	**5.77 (0.05)**	
Small terrestrial faunivore	4.26 (0.12)	
Medium terrestrial herbivore	**10.24 (0.01)**	
Medium terrestrial omnivore	1.99 (0.37)	
Medium terrestrial faunivore	**7.69 (0.02)**	
Large terrestrial herbivore	0.23 (0.62)	
Large terrestrial faunivore	3.18 (0.07)	
Small amphibious faunivore	2.81 (0.24)	
Small aquatic omnivore	0.08 (0.96)	
Small aquatic faunivore	2.33 (0.31)	
Medium aquatic faunivore	5.14 (0.06)	

Results for the Kruskal-Wallis tests and associated multiple comparisons (*131*) exploring differences in ecospace occupancy patterns in terms of species realized niche breadth across the K/Pg event and among different time intervals (Campanian, Maastrichtian, Danian). Significant values are given in bold font.

Table S4.

Trophic groups	H (*p*-value)	Significant comparisons after Dunn's test
Species marginality		
Herbivore	**12.03 (0.00)**	Maastrichtian *vs.* Danian
Omnivore	**7.13 (0.03)**	Maastrichtian *vs.* Danian
Faunivore	**17.60 (0.00)**	Campanian *vs.* Maastrichtian
Species tolerance		
Herbivore	**7.54 (0.02)**	Maastrichtian *vs.* Danian
Omnivore	0.97 (0.61)	
Faunivore	**8.49 (0.01)**	Campanian *vs.* Maastrichtian

Results for the Kruskal-Wallis tests and associated multiple comparisons (*131*) exploring differences in ecospace occupancy patterns for mammal communities across the K/Pg event and among different time intervals (Campanian, Maastrichtian, Danian). Significant values are given in bold font.

Table S5.

	Experiment	CO_2 *ppmv*	CH_4 *ppbv*	N_2O *ppbv*	Solar Constant $W\ m^{-2}$
Campanian	*tdpwc*	1,120	760	270	1,356.16
Maastrichtian	*tdihb*	1,120	760	270	1,357.18
Danian	*tdlua*	1,120	760	270	1,357.61

Summary of the GCM-derived paleoclimatic simulations. Details are available in full in Lunt et al. (*44*), Valdes et al. (*45*), and Farnsworth et al. (*121*). Simulations can be retrieved from the BRIDGE Group (https://www.paleo.bristol.ac.uk/resources/simulations/).

Data S1 to S3. (separate file)

List of statistical routines (Data S1) and cleaned fossil datasets from the Paleobiology Database (Data S2 to S3) are available on Zenodo (https://doi.org/10.5281/zenodo.7221223).