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Supplementary Information for

The rise of angiosperms pushed conifers to decline during global cooling

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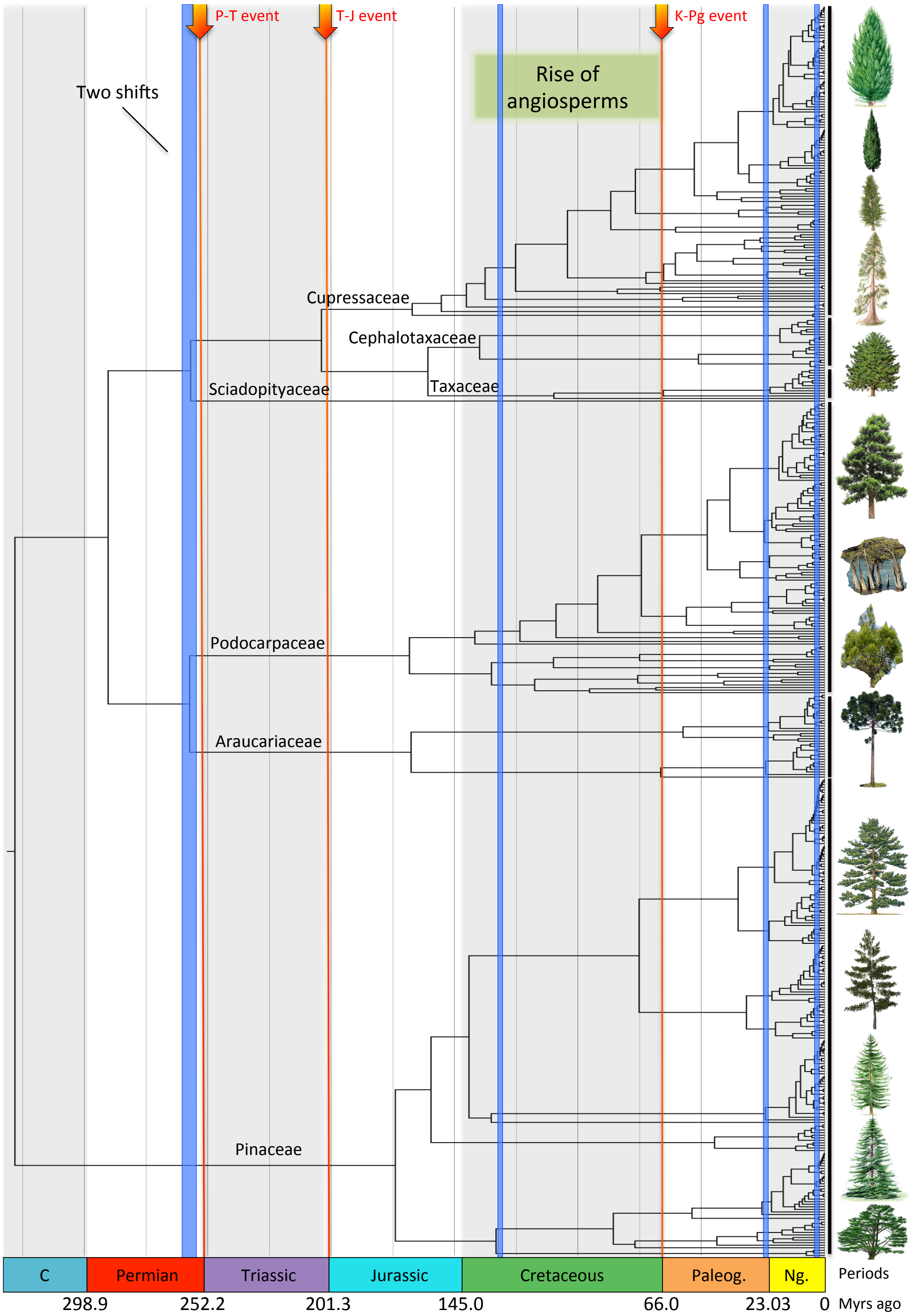

Fig. S1. Global diversification of conifers inferred from the phylogeny. Time-calibrated phylogeny of conifers and significant shifts in diversification rates inferred under an episodic birth-death model implemented in TreePar. Six shifts of diversification rates through time were identified, which are indicated with blue bars. Two shifts occurred at the end of the Permian, one during the Cretaceous terrestrial revolution (rise of angiosperms), one at the end of the Oligocene, and two shifts were found in the Pliocene and Pleistocene. C = Carboniferous, Paleog. = Paleogene, and Neog. = Neogene.

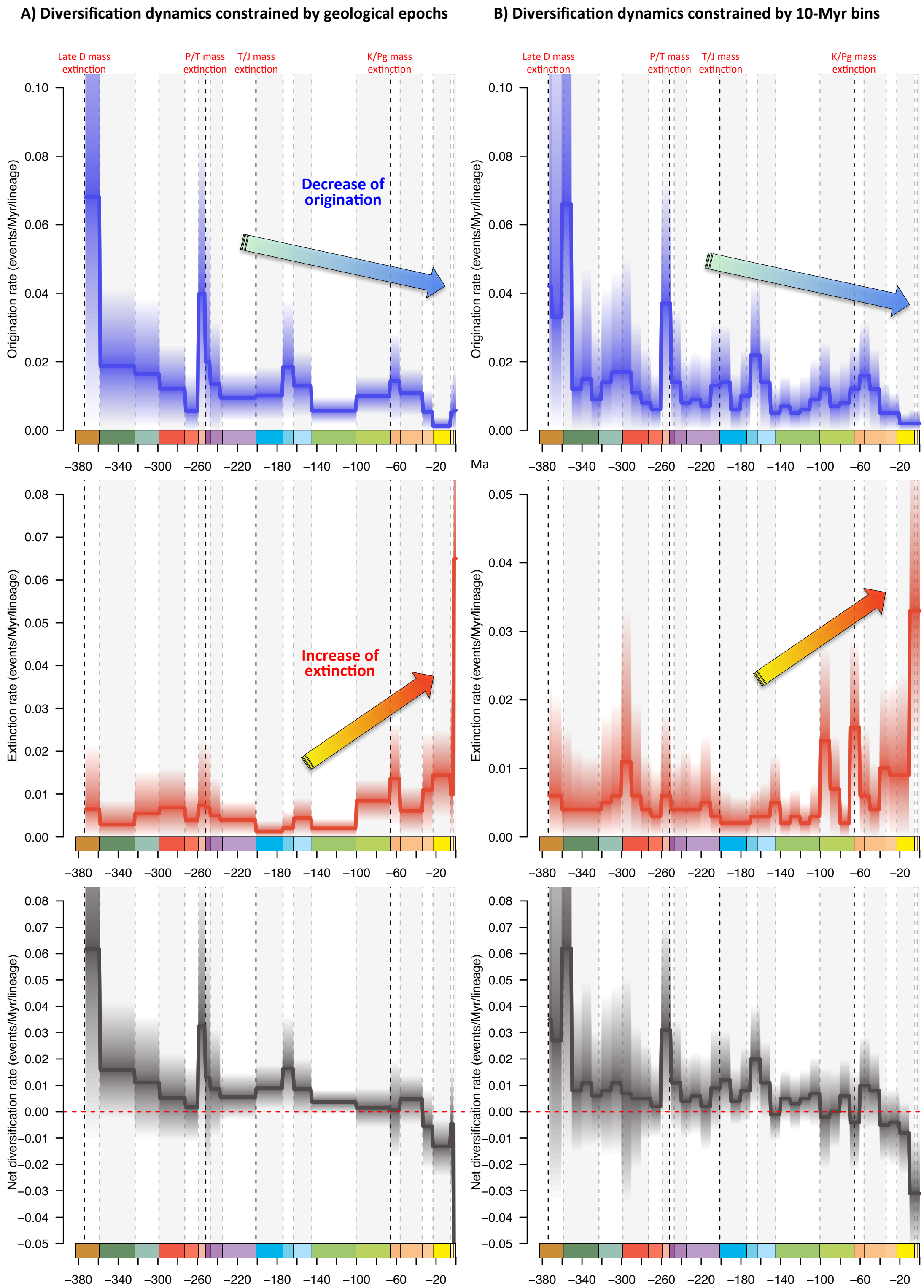

Fig. S2. Global diversification of conifers inferred from the fossil record. Rates of origination (blue), extinction (red) and net diversification rates (black; the difference between origination and extinction) inferred from a fossil-based analysis at the genus level under the Bayesian approach implemented in PyRate using (A) the geological epochs, or (B) 10-million-year bins for constraining the episodic birth-death model. Solid lines indicate mean posterior rates and the shaded areas show 95% credibility intervals. The vertical dashed lines indicate the boundaries between geological boundaries and major mass extinction events.

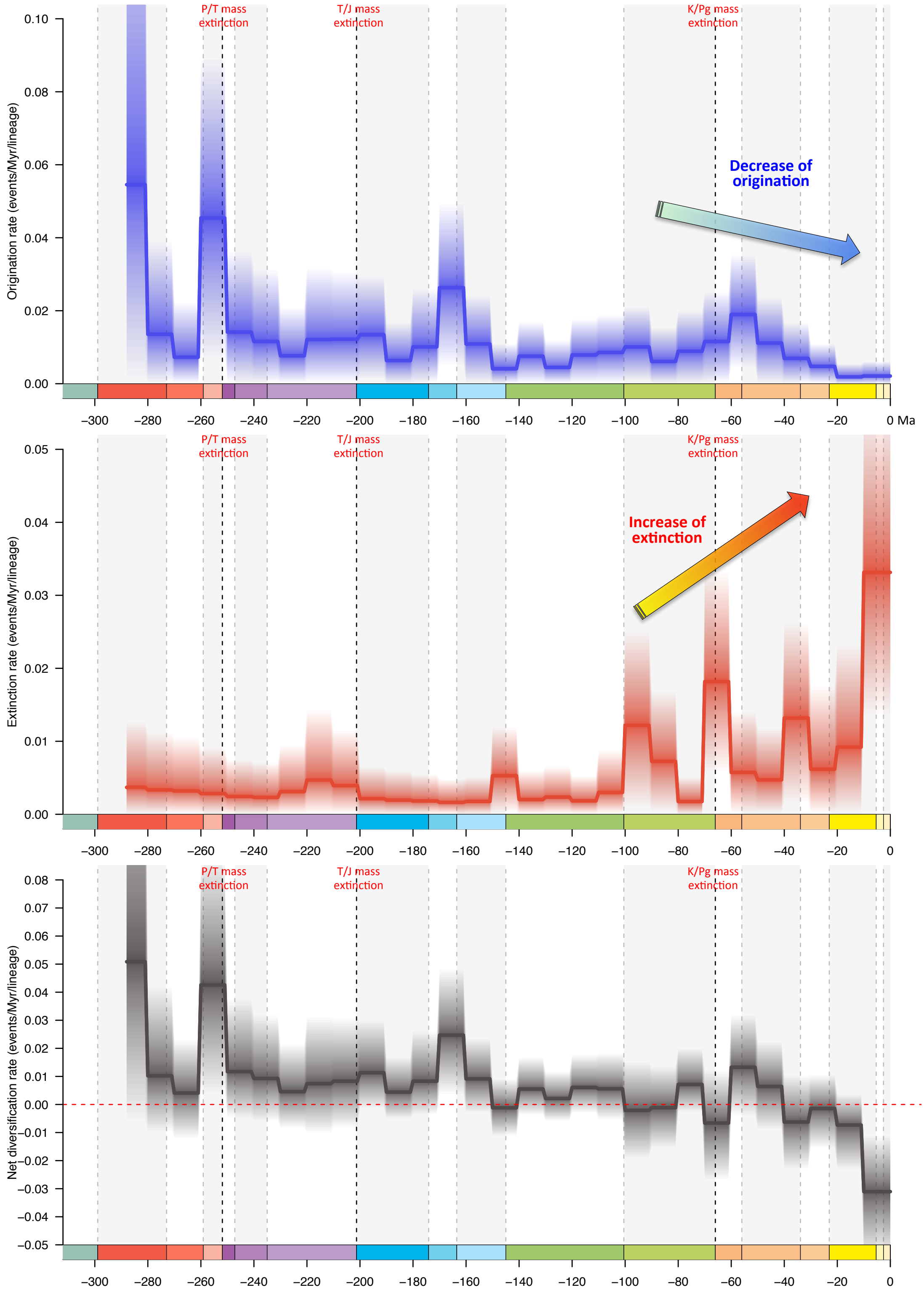

Fig. S3. Global diversification of conifers without the Cordaitales inferred from the fossil record. Rates of origination (blue), extinction (red) and net diversification rates (black; the difference between origination and extinction) inferred from a fossil-based analysis at the genus level under the Bayesian approach implemented in PyRate using 10-million-year bins for constraining the episodic birth-death model. Solid lines indicate mean posterior rates and the shaded areas show 95% credibility intervals. The vertical dashed lines indicate the boundaries between geological boundaries and major mass extinction events.

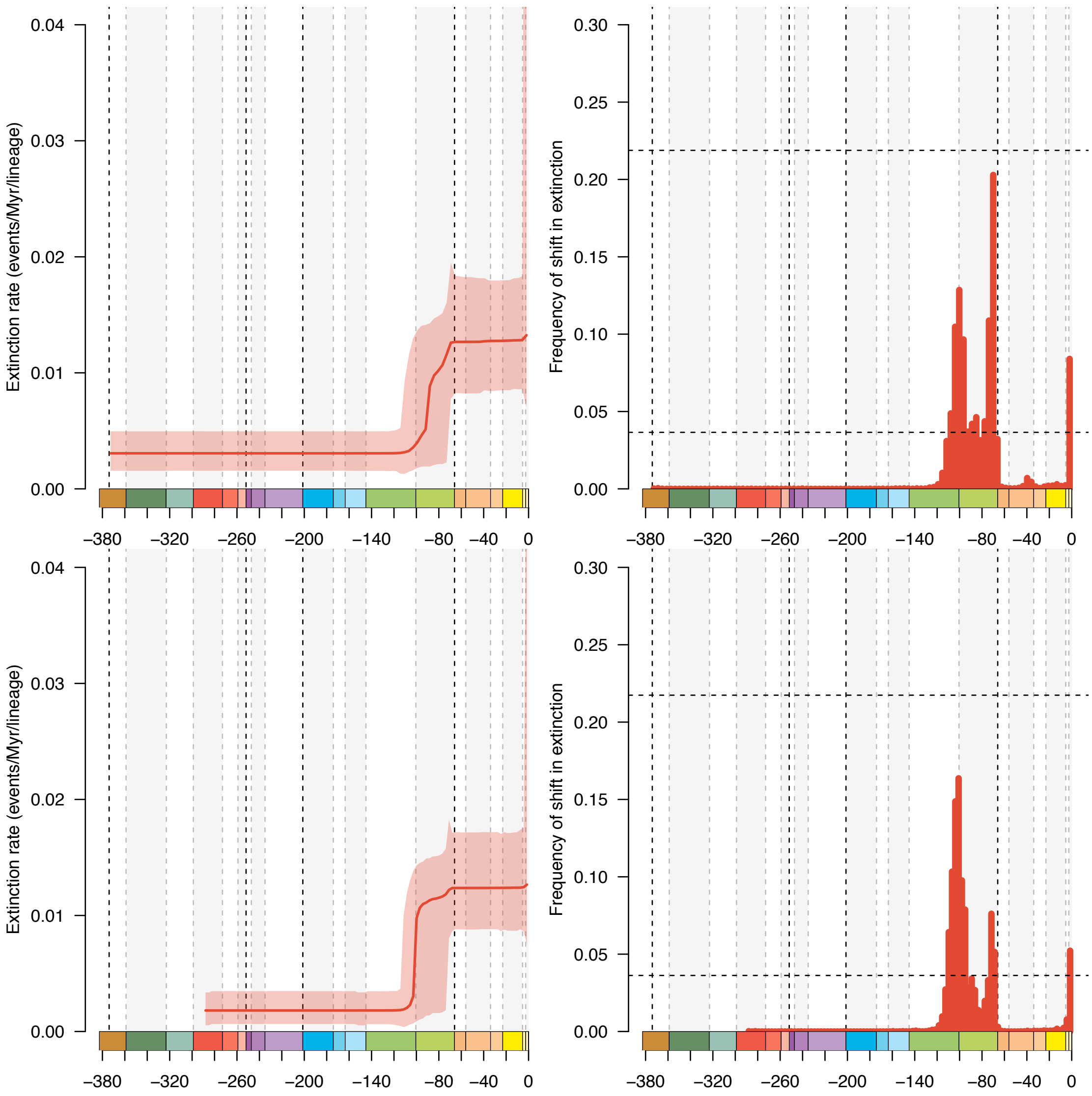

Fig. S4. Global extinction rate and shift times in extinction of conifers with (top panels) or without (bottom panels) the Cordaitales inferred from the fossil record. Rates of extinction were inferred from a fossil-based analysis at the genus level under the Bayesian approach implemented in PyRate using the reversible-jump model for estimating the rates of diversification as well as the shift times of diversification. Solid lines indicate mean posterior rates and the shaded areas show 95% credibility intervals. The vertical dashed lines indicate the boundaries between geological boundaries and major mass extinction events.

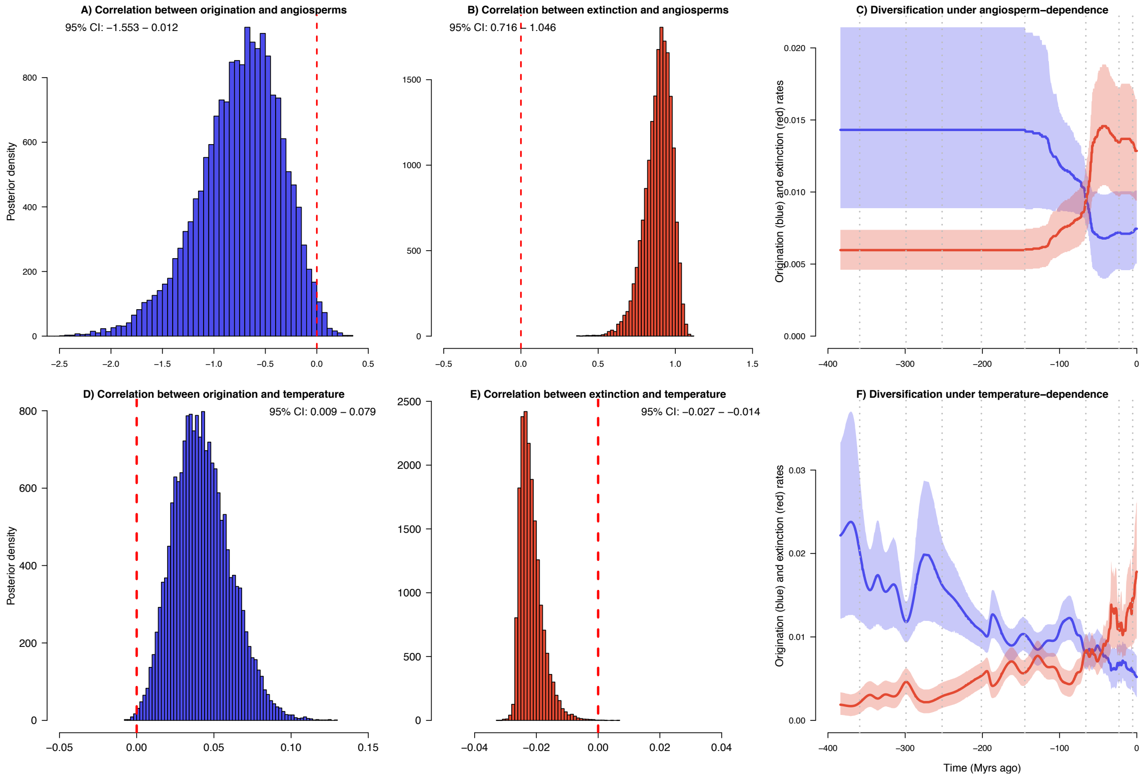

Fig. S5. Impact of angiosperm diversity and temperature on conifer extinction. Changes in angiosperm diversity do not correlate significantly with variations in speciation (A) but correlate positively with extinction rates (B), as shown by the posterior estimate of the correlation parameters. This leads to increase of extinction as angiosperms diversified (C). The variation of temperatures does correlate, although marginally, with speciation rate (D) and strongly correlates negatively with extinction rate (E). This leads to increase of extinction as the global climate became cooler in the Cenozoic (F). When histograms do not overlap with 0 (vertical dashed line), it denotes a significant correlation between the rate and the environmental variable, based on the 95% credibility intervals (CI).

Table S1. Results and model selection from the episodic diversification analyses in conifers using TreePar.

A) Results for the conifer tree of Leslie *et al.* (2012).

Models	**BD constant**	**BD with 1 shift**	**BD with 2 shifts**	**BD with 3 shifts**	**BD with 4 shifts**	**BD with 5 shifts**	**BD with 6 shifts**	**BD with 7 shifts**	**BD with 8 shifts**
NP	2	5	8	11	14	17	**20**	23	26
logL	-1455.296	-1443.783	-1436.669	-1432.748	-1428.831	-1426.795	**-1421.372**	-1419.411	-1416.874
AICc	2914.603	2897.627	2889.485	2887.766	2886.092	2888.215	**2883.602**	2885.950	2887.183
ΔAICc	31.001	14.025	5.883	4.164	2.490	4.613	**0**	2.348	3.581
***P* (LRT)**	null model	<0.0001	0.0026	0.0494	0.0496	0.2536	**0.0209**	0.2700	0.1738
r1	0.007	0.035	0.0001	0.0001	0.0002	0.001	**0.0001**	0.0005	0.0001
ε1	0.966	0.812	0.744	0.648	0.474	0.454	**0.454**	0.492	0.544
st1	-	24.4	0.1	0.1	0.1	0.1	**0.1**	0.1	0.1
r2	-	0.013	0.031	0.025	0.025	0.023	**0.023**	0.025	0.021
ε2	-	0.763	0.841	0.854	0.856	0.866	**0.867**	0.851	0.880
st2	-	-	24.4	3.2	3.2	3.2	**3.2**	3.2	3.2
r3	-	-	0.013	0.011	0.008	0.007	**0.008**	0.010	0.011
ε3	-	-	0.784	0.957	0.967	0.970	**0.970**	0.959	0.956
st3	-	-	-	24.4	24.4	24.4	**24.4**	24.4	24.4
r4	-	-	-	0.012	0.008	0.008	**0.008**	0.005	0.004
ε4	-	-	-	0.875	0.918	0.924	**0.926**	0.950	0.967
st4	-	-	-	-	133.1	133.1	**133.1**	133.1	133.1
r5	-	-	-	-	0.001	0.0002	**0.0003**	0.013	0.012
ε5	-	-	-	-	0.997	0.999	**0.999**	0.973	0.973
st5	-	-	-	-	-	256.8	**256.8**	175.6	167.1
r6	-	-	-	-	-	0.000	**0.001**	0.001	0.000
ε6	-	-	-	-	-	1.000	**1.000**	0.984	1.000
st6	-	-	-	-	-	-	**257.4**	256.8	175.6
r7	-	-	-	-	-	-	**0.0001**	0.008	0.0004
ε7	-	-	-	-	-	-	**1.000**	1.000	0.995
st7	-	-	-	-	-	-	**-**	257.4	256.8
r8	-	-	-	-	-	-	**-**	0.015	0.009
ε8	-	-	-	-	-	-	**-**	0.961	1.000
st8	-	-	-	-	-	-	**-**	-	257.4
r9	-	-	-	-	-	-	**-**	-	0.012
ε9	-	-	-	-	-	-	**-**	-	0.964

B) Results for the conifer tree of Leslie *et al.* (2018).

Models	**BD constant**	**BD with 1 shift**	**BD with 2 shifts**	**BD with 3 shifts**	**BD with 4 shifts**	**BD with 5 shifts**	**BD with 6 shifts**	**BD with 7 shifts**	**BD with 8 shifts**
logL	-2151.33	-2145.16	**-2141.76**	-2140.45	-2138.85	-2137.56	-2135.76	-2134.95	-2134.05
AICc	4306.68	4300.43	**4299.77**	4303.37	4306.45	4310.21	4313.03	4317.89	4322.65
ΔAIC	6.91	0.66	**0.00**	3.60	6.68	10.44	13.26	18.12	22.88
ωAIC	0.016	0.367	**0.511**	0.084	0.018	0.003	0.001	0.000	0.000
***P* (LRT)**	null model	0.0063	**0.079**	0.151	0.181	0.231	0.223	0.310	0.387
r1	0.0079	0.0017	**0.0013**	0.0013	0.0012	0.0010	0.0006	0.0006	0.0004
ε1	0.9502	0.9894	**0.9895**	0.9898	0.9902	0.9918	0.9955	0.9949	0.9971
st1	-	135	**1**	1	1	1	1	1	1
r2	-	0.0065	**0.0019**	0.0019	0.0019	0.0019	0.0014	0.0013	0.0012
ε2	-	0.9907	**0.9893**	0.9892	0.9894	0.9893	0.9924	0.9927	0.9933
st2	-	-	**135**	128	124	37	37	24	24
r3	-	-	**0.0070**	0.0001	0.0069	0.0010	0.0008	0.0030	0.0041
ε3	-	-	**0.9904**	0.9891	0.9892	0.9921	0.9869	0.9867	0.9805
st3	-	-	**-**	135	128	124	44	37	37
r4	-	-	**-**	0.0070	0.0001	0.0117	0.0027	0.0011	0.0011
ε4	-	-	**-**	0.9899	0.9860	0.9784	0.9817	0.9835	0.9865
st4	-	-	**-**	-	135	128	124	44	42
r5	-	-	**-**	-	0.0059	0.0001	0.0056	0.0017	0.0001
ε5	-	-	**-**	-	0.9923	0.9866	0.9892	0.9891	0.9868
st5	-	-	**-**	-	-	135	128	124	44
r6	-	-	**-**	-	-	0.0067	0.0001	0.0179	0.0032
ε6	-	-	**-**	-	-	0.9895	0.9692	0.9691	0.9780
st6	-	-	**-**	-	-	-	135	128	124
r7	-	-	**-**	-	-	-	0.0058	0.0001	0.0119
ε7	-	-	**-**	-	-	-	0.9909	0.9754	0.9792
st7	-	-	**-**	-	-	-	-	135	128
r8	-	-	**-**	-	-	-	-	0.0058	0.0001
ε8	-	-	**-**	-	-	-	-	0.9914	0.9659
st8	-	-	**-**	-	-	-	-	-	135
r9	-	-	**-**	-	-	-	-	-	0.0063
ε9	-	-	**-**	-	-	-	-	-	0.9904

Nine models are compared, and the best-supported model is the one with six rate shifts, as determined by the lowest AICc, ΔAICc and *P* (LRT). Adding more shifts of diversification did not significantly improve the likelihood of the model. Abbreviations are denoted as follows: BD, birth-death; NP, number of parameters; logL, log-likelihood; AICc, corrected Akaike Information Criterion; ΔAICc, the difference in AICc between the model with the lowest AICc and the others; and *P* (LRT), the p-value of the likelihood ratio test. Parameter estimates are denoted as follows: r, net diversification rate (speciation minus extinction); ε, turnover (extinction over speciation); st, shift time, in which 'r1' denotes the diversification rate and 'ε1' is the turnover, both inferred between Present and the shift time 1 ('st1').

Table S2. Results of the time-dependent model of diversification on the conifers.

Models	NP	logL	AICc	ΔAICc	ωAICc	λ	α	μ	β
Bcst	1	-1994.39 ±0.794	3990.80 ±1.588	429.33	0	0.0527 ±8.66E-05	-	-	-
BcstDcst	**2**	**-1778.72 ±1.104**	**3561.47 ±2.208**	**0**	**0.336**	**0.2090 ±0.0007**	**-**	**0.2027 ±0.0007**	**-**
BTimeVar_EXPO	2	-1836.88 ±0.956	3677.79 ±1.912	116.32	0	0.1106 ±0.0002	-0.0235 ±5.35E-05	-	-
BTimeVarDcst_EXPO	3	-1836.89 ±0.956	3679.82 ±1.912	118.35	0	0.1106 ±0.0002	-0.0235 ±5.45E-05	0 ±0	-
BcstDTimeVar_EXPO	3	-1777.83 ±1.114	3561.72 ±2.227	0.25	0.296	0.2139 ±0.0008	-	0.2129 ±0.0009	-0.0003 ±6.10E-06
BTimeVarDTimeVar_EXPO	4	-1778.25 ±1.132	3564.58 ±2.265	3.11	0.071	0.2141 ±0.0015	-0.0030 ±0.0004	0.2136 ±0.0018	-0.0039 ±0.0005
BTimeVar_LIN	2	-1896.23 ±0.916	3796.48 ±1.832	235.01	0	0.0776 ±0.0003	-0.0006 ±4.29E-06	-	-
BTimeVarDcst_LIN	3	-1837.35 ±3.265	3680.75 ±6.531	119.28	0	0.1323 ±0.0044	-0.0005 ±3.47E-05	0.0825 ±0.0072	-
BcstDTimeVar_LIN	3	-1777.83 ±1.113	3561.72 ±2.226	0.25	0.296	0.2135 ±0.0007	-	0.2124 ±0.0008	-5.57E-05 ±1.36E-06
BTimeVarDTimeVar_LIN	4	-1798.09 ±2.632	3604.26 ±5.264	42.79	0	0.1581 ±0.0041	-0.0012 ±0.0003	0.1237 ±0.0057	-0.0010 ±0.0003

Models are as follows: *Bcst* has a constant speciation (Yule model); *BcstDcst* has both constant speciation and extinction; *BTimeVar* has only speciation that varies through time; *BTimeVarDcst* has speciation that varies through time and constant extinction; *BcstDTimeVar* has constant speciation and extinction that varies through time; and *BTimeVarDTimeVar* has both speciation and extinction that vary through time. Speciation and/or extinction rates are allowed to vary exponentially (denoted by EXPO), or linearly (as indicated by LIN). Values are the means and standard errors calculated from the fit of maximum likelihood models on a random sample of 100 dated trees (obtained from the dating analysis). The delta AICc (ΔAICc) and Akaike weight (ωAICc) are used to compare all the models together to select the best-fit model. *The best-fit model indicates a constant birth-death model better explains the conifer phylogeny* (time-varying models did not improve significantly the likelihood). Abbreviations: NP, number of free parameters; logL, log- likelihood; λ, speciation rate; α, rate of variation of the speciation through time; μ, extinction rate; β, rate of variation of the extinction through time.

Table S3. Results of the paleotemperature-dependent model of diversification on the conifers.

Models	NP	logL	AICc	ΔAICc	ωAICc	λ	α	μ	β
BTempVar_EXPO	2	-1807.44 ±0.977	3618.89 ±1.953	57.77	≈0	0.1935 ±0.0005	-0.1466 ±0.0003	-	-
BTempVarDcst_EXPO	3	-1807.44 ±0.977	3620.93 ±1.954	59.81	≈0	0.1937 ±0.0005	-0.1467 ±0.0003	7.34E-08 ±6.66E-09	-
BcstDTempVar_EXPO	**3**	**-1777.54 ±1.127**	**3561.12 ±2.253**	**0**	**0.425**	**0.2173 ±0.0009**	**-**	**0.2222 ±0.0012**	**-0.0029 ±8.19E-05**
BTempVarDTempVar_EXPO	4	-1777.57 ±1.135	3563.22 ±2.271	2.10	0.149	0.2143 ±0.0013	0.0040 ±0.0008	0.2195 ±0.0015	0.0012 ±0.0008
BTempVar_LIN	2	-1857.48 ±0.846	3718.98 ±1.692	157.86	≈0	0.1010 ±0.0002	-0.0043 ±2.85E-05	-	-
BTempVarDcst_LIN	3	-1829.74 ±1.637	3665.53 ±3.274	104.41	≈0	0.1322 ±0.0023	-0.0047 ±0.0002	0.0395 ±0.0050	-
BcstDTempVar_LIN	3	-1777.54 ±1.126	3561.12 ±2.253	0	0.425	0.2172 ±0.0009	-	0.2218 ±0.0011	-0.0006 ±2.08E-05
BTempVarDTempVar_LIN	4	-1828.28 ±1.342	3664.63 ±2.685	103.51	≈0	0.1553 ±0.0018	-0.0107 ±0.0003	0.0166 ±0.0025	-0.0044 ±0.0003

Models are as follows: *BTempVar* has only speciation that varies with past temperature; *BTempVarDcst* has speciation that varies with past temperature and constant extinction; *BcstDTempVar* has constant speciation and extinction that varies with past temperature; and *BTempVarDTempVar* has both speciation and extinction that vary with past temperature. Speciation and/or extinction rates are allowed to vary exponentially (denoted by EXPO), or linearly (as indicated by LIN). Values are the means and standard errors calculated from the fit of maximum likelihood models on a random sample of 100 dated trees (obtained from the dating analysis). The delta AICc (ΔAICc) and Akaike weight (ωAICc) are used to compare all the models together to select the best-fit model. *The best-fit model indicates a negative exponential correlation between extinction and past temperatures, suggesting that extinction decreased during warmer climate whereas extinction increased during cooler climate* (there is no effect on speciation). Note that the second best-fit model is the same model but with linear dependency, and recovers the same result. Abbreviations: NP, number of free parameters; logL, log- likelihood; λ, speciation rate; α, rate of variation of the speciation according to the paleo-environmental variable; μ, extinction rate; β, rate of variation of the extinction according to the paleo-environmental variable.

Table S4. Results of the atmospheric carbon-dependent model of diversification on the conifers.

Models	NP	logL	AICc	ΔAICc	ωAICc	λ	α	μ	β
BCarbonVar_EXPO	2	-1876.50 ±1.181	3757.02 ±2.361	194.11	≈0	0.2531 ±0.0016	-0.0034 ±1.34E-05	-	-
BCarbonVarDCST_EXPO	3	-1778.58 ±1.109	3563.22 ±2.218	0.31	0.382	0.2094 ±0.0007	0.0000 ±2.57E-06	0.2080 ±0.0010	-
BCSTDCarbonVar_EXPO	**3**	**-1778.43 ±1.114**	**3562.91 ±2.228**	**0**	**0.446**	**0.2131 ±0.0008**	**-**	**0.2152 ±0.0011**	**-0.0001 ±2.30E-0**
CarbonVarDCarbonVar_EXPO	4	-1778.42 ±1.207	3564.93 ±2.415	2.02	0.162	0.2357 ±0.0033	-0.0004 ±3.43E-05	0.2329 ±0.0039	-0.0004 ±3.70E-0
BCarbonVar_LIN	2	-1897.22 ±1.094	3798.46 ±2.188	235.55	≈0	0.1101 ±0.0004	-0.0001 ±9.08E-07	-	-
BCarbonVarDCST_LIN	3	-1803.40 ±2.339	3612.85 ±4.679	49.94	≈0	0.1930 ±0.0016	-0.0001 ±8.85E-06	0.1192 ±0.0072	-
BCSTDCarbonVar_LIN	3	-1782.25 ±1.409	3570.55 ±2.819	7.65	0.010	0.1993 ±0.0032	-	0.1900 ±0.0058	0.0000 ±3.57E-0
BCarbonVarDCarbonVar_LIN	4	-1794.10 ±1.725	3596.29 ±3.450	33.38	≈0	0.1511 ±0.0098	-0.0006 ±6.12E-05	0.1341 ±0.0097	0.0006 ±5.87E-0

Models are as follows: *BCarbonVar* has only speciation that varies with past atmospheric carbon; *BCarbonVarDcst* has speciation that varies with past atmospheric carbon and constant extinction; *BcstDCarbonVar* has constant speciation and extinction that varies with past atmospheric carbon; and *BCarbonVarDCarbonVar* has both speciation and extinction that vary with past atmospheric carbon. Speciation and/or extinction rates are allowed to vary exponentially (denoted by EXPO), or linearly (as indicated by LIN). Values are the means and standard errors calculated from the fit of maximum likelihood models on a random sample of 100 dated trees (obtained from the dating analysis). The delta AICc (ΔAICc) and Akaike weight (ωAICc) are used to compare all the models together to select the best-fit model. *The best-fit model indicates a negative exponential correlation between extinction and past atmospheric carbon concentration, suggesting that extinction decreased during warmer climate whereas extinction increased during cooler climate* (there is no effect on speciation). Note that the second best-fit model is the same model but with linear dependency, and recovers the same result. Abbreviations: NP, number of free parameters; logL, log-likelihood; λ, speciation rate; α, rate of variation of the speciation according to the paleo-environmental variable; μ, extinction rate; β, rate of variation of the extinction according to the paleo-environmental variable.

Table S5. Results of the angiosperm-dependent model of diversification on the conifers.

Models	NP	logL	AICc	ΔAICc	ωAICc	λ	α	μ	β
BAngioVar_EXPO	2	-1923.01 ±0.715	3850.04 ±1.430	291.03	≈0	0.0127 ±4.23E-05	1.8557 ±0.0036	-	-
BAngioVarDcst_EXPO	3	-1776.54 ±1.125	3559.13 ±2.250	0.12	0.193	0.2305 ±0.0009	-0.0711 ±0.0011	0.2171 ±0.0009	-
BcstDAngioVar_EXPO	**3**	**-1776.48 ±1.123**	**3559.01 ±2.246**	**0**	**0.205**	**0.2161 ±0.0007**	**-**	**0.2023 ±0.0007**	**0.0772 ±0.0012**
BAngioVarDAngioVar_EXPO	4	-1776.32 ±1.111	3560.73 ±2.222	1.72	0.087	0.1801 ±0.0048	0.2444 ±0.0299	0.1650 ±0.0049	0.3525 ±0.0340
BAngioVar_LIN	2	-1921.44 ±0.770	3846.90 ±1.540	287.89	≈0	0.0097 ±3.50E-05	0.0646 ±0.0001	-	-
BAngioVarDcst_LIN	3	-1776.53 ±1.125	3559.11 ±2.251	0.10	0.195	0.2305 ±0.0009	-0.0159 ±0.0003	0.2171 ±0.0008	-
BcstDAngioVar_LIN	3	-1776.49 ±1.123	3559.03 ±2.245	0.02	0.203	0.2161 ±0.0008	-	0.2022 ±0.0007	0.0162 ±0.0003
BAngioVarDAngioVar_LIN	4	-1776.02 ±1.122	3560.12 ±2.244	1.11	0.118	0.1579 ±0.0074	0.0650 ±0.0082	0.1448 ±0.0072	0.0945 ±0.0106

Models are as follows: *BAngioVar* has only speciation that varies with the proportion of angiosperms; *BAngioVarDcst* has speciation that varies with the proportion of angiosperms and constant extinction; *BcstDAngioVar* has constant speciation and extinction that varies with the proportion of angiosperms; and *BAngioVarDAngioVar* has both speciation and extinction that vary with the proportion of angiosperms. Speciation and/or extinction rates are allowed to vary exponentially (denoted by EXPO), or linearly (as indicated by LIN). Values are the means and standard errors calculated from the fit of maximum likelihood models on a random sample of 100 dated trees (obtained from the dating analysis). The delta AICc (ΔAICc) and Akaike weight (ωAICc) are used to compare all the models together to select the best-fit model. *The best-fit model indicates a positive exponential correlation between extinction and the proportion of angiosperms, suggesting that extinction increased when angiosperms diversified whereas extinction decreased during angiosperms were absent* (there is no effect on speciation). Note that the second best-fit model is the same model but with linear dependency, and recovers the same result. Abbreviations: NP, number of free parameters; logL, log- likelihood; λ, speciation rate; α, rate of variation of the speciation according to the paleo-environmental variable; μ, extinction rate; β, rate of variation of the extinction according to the paleo-environmental variable.

Table S6. Results of all birth-death model of diversification on the conifer tree of Leslie *et al.* (2018).

Models	NP	logL	AICc	ΔAICc	ωAICc	λ	α	μ	β
BCSTDAngioVar_LIN	**3**	**-2148.64**	**4303.32**	**0.00**	**0.161**	**0.1642**	**-**	**0.1477**	**0.0175**
BCSTDAngioVar_EXPO	3	-2148.64	4303.32	0.01	0.161	0.1642	-	0.1477	0.1117
BAngioVarDCST_EXPO	3	-2148.85	4303.74	0.42	0.131	0.1792	-0.0966	0.1636	-
BAngioVarDCST_LIN	3	-2148.86	4303.76	0.44	0.129	0.1789	-0.0164	0.1635	-
BAngioVarDAngioVar_EXPO	4	-2148.25	4304.57	1.26	0.086	0.1168	0.3501	0.1001	0.4996
BAngioVarDAngioVar_LIN	4	-2148.25	4304.58	1.26	0.086	0.1127	0.0565	0.0935	0.0750
BCSTDTimeVar_EXPO	3	-2150.14	4306.32	3.00	0.036	0.1628	-	0.1611	-0.0005
BCSTDTimeVar_LIN	3	-2150.15	4306.34	3.02	0.036	0.1626	-	0.1607	-0.0001
BTimeVarDTimeVar_LIN	4	-2149.21	4306.49	3.17	0.033	0.1647	-0.0005	0.1625	-0.0007
BCSTDCST	2	-2151.33	4306.68	3.36	0.030	0.1582	-	0.1503	-
BCSTDTempVar_LIN	3	-2150.60	4307.23	3.92	0.023	0.1633	-	0.1639	-0.0005
BCSTDTempVar_EXPO	3	-2150.60	4307.24	3.92	0.023	0.1634	-	0.1642	-0.0032
BTimeVarDTimeVar_EXPO	4	-2149.95	4307.98	4.66	0.016	0.1647	-0.0029	0.1630	-0.0040
BCarbonVarDCST_EXPO	3	-2151.08	4308.21	4.89	0.014	0.1578	0.0001	0.1578	-
BCSTDCarbonVar_EXPO	3	-2151.10	4308.23	4.92	0.014	0.1612	-	0.1609	-0.0001
BCSTDCarbonVar_LIN	3	-2151.10	4308.24	4.92	0.014	0.1611	-	0.1606	0.0000
BTempVarDTempVar_EXPO	4	-2150.62	4309.32	6.00	0.008	0.1653	-0.0121	0.1625	-0.0156
BTempVarDTempVar_LIN	4	-2154.74	4317.55	14.24	1.31E-04	0.1667	-0.0052	0.1474	-0.0050
BCarbonVarDCarbonVar_LIN	4	-2156.00	4320.07	16.76	3.72E-05	0.1979	-0.0001	0.1993	-0.0001
BCarbonVarDCarbonVar_EXPO	4	-2160.16	4328.40	25.08	5.77E-07	0.2595	-0.0012	0.2371	-0.0012
BTempVar_EXPO	2	-2173.29	4350.60	47.28	8.72E-12	0.1528	-0.1297	-	-
BTempVarDCST_EXPO	3	-2173.29	4352.62	49.30	3.18E-12	0.1527	-0.1296	0.0000	-
BTempVarDCST_LIN	3	-2189.98	4386.00	82.68	1.79E-19	0.1070	-0.0045	0.0163	-
BCarbonVarDCST_LIN	3	-2197.34	4400.72	97.40	1.14E-22	0.1470	-0.0001	0.0527	-
BTimeVar_EXPO	2	-2202.55	4409.13	105.81	1.70E-24	0.0918	-0.0202	-	-
BTempVar_LIN	2	-2202.60	4409.21	105.89	1.64E-24	0.0913	-0.0039	-	-
BTimeVarDCST_EXPO	3	-2202.55	4411.15	107.83	6.20E-25	0.0918	-0.0202	0.0000	-
BTimeVarDCST_LIN	3	-2211.73	4429.51	126.19	6.39E-29	0.0903	-0.0008	0.0251	-
BTimeVar_LIN	2	-2234.40	4472.81	169.50	2.53E-38	0.0713	-0.0007	-	-
BCarbonVar_EXPO	2	-2244.92	4493.87	190.55	6.76E-43	0.1759	-0.0028	-	-
BCarbonVar_LIN	2	-2255.61	4515.24	211.92	1.55E-47	0.1043	-0.0001	-	-
BAngioVar_LIN	2	-2267.09	4538.19	234.88	1.61E-52	0.0140	0.0856	-	-
BAngioVar_EXPO	2	-2275.53	4555.08	251.77	3.45E-56	0.0132	1.6815	-	-
BCST	1	-2339.83	4681.66	378.35	1.13E-83	0.0487	-	-	-

Models are ranked according to the lowest AICc score and the highest Akaike weight (ωAICc). Model names: *Bcst* has a constant speciation (Yule model); *BcstDcst* has both constant speciation and extinction; *BTimeVar* has only speciation that varies through time; *BTimeVarDcst* has speciation that varies through time and constant extinction; *BcstDTimeVar* has constant speciation and extinction that varies through time; and *BTimeVarDTimeVar* has both speciation and extinction that vary through time. *BTempVar* has only speciation that varies with past temperature; *BTempVarDcst* has speciation that varies with past temperature and constant extinction; *BcstDTempVar* has constant speciation and extinction that varies with past temperature; and *BTempVarDTempVar* has both speciation and extinction that vary with past temperature. *BCarbonVar* has only speciation that varies with past atmospheric carbon; *BCarbonVarDcst* has speciation that varies with past atmospheric carbon and constant extinction; *BcstDCarbonVar* has constant speciation and extinction that varies with past atmospheric carbon; and *BCarbonVarDCarbonVar* has both speciation and extinction that vary with past atmospheric carbon. *BAngioVar* has only speciation that varies with the proportion of angiosperms; *BAngioVarDcst* has speciation that varies with the proportion of angiosperms and constant extinction; *BcstDAngioVar* has constant speciation and extinction that varies with the proportion of angiosperms; and *BAngioVarDAngioVar* has both speciation and extinction that vary with the proportion of angiosperms. Speciation and/or extinction rates are allowed to vary exponentially (denoted by EXPO), or linearly (as indicated by LIN). Values are the estimated parameter for the maximum clade credibility tree of Leslie *et al.* (2018). The delta AICc (ΔAICc) and Akaike weight (ωAICc) are used to compare all the models together to select the best-fit model. *The best-fit model indicates a positive linear correlation between extinction and the proportion of angiosperms, suggesting that extinction increased when angiosperms diversified whereas extinction decreased during angiosperms were absent* (there is no effect on speciation). Note that the second best-fit model is the same model but with linear dependency, and recovers the same result. Abbreviations: NP, number of free parameters; logL, log- likelihood; λ, speciation rate; α, rate of variation of the speciation according to the paleo-environmental variable; μ, extinction rate; β, rate of variation of the extinction according to the paleo-environmental variable.

Table S7. Model selection for the conifer tree of Leslie *et al.* (2018) with the phylogeny-based diversification models.

Models	NP	logL	AICc	ΔAICc	ωAICc	λ	α	μ	β
Bcst DTimeVar	3	-2150.14	4306.32	3.00	0.154	0.1628	-	0.1611	-0.0005
Bcst DTempVar	3	-2150.60	4307.23	3.92	0.098	0.1633	-	0.1639	-0.0005
BCarbonVar Dcst	3	-2151.08	4308.21	4.89	0.060	0.1578	0.0001	0.1578	-
Bcst DAngioVar	**3**	**-2148.64**	**4303.32**	**0.00**	**0.689**	**0.1642**	**-**	**0.1477**	**0.0175**

Four models are compared, and each was previously selected in reciprocal series of time-dependent models (a model with varying extinction, *BcstDTimeVar*, was the best-fit), or of temperature-dependent models (a model with varying extinction, *BcstDTempVar*, was the best-fit), or of atmospheric carbon-dependent models (a model with varying speciation, *BCarbonVarDcst*, was the best-fit), and of angiosperm-dependent models (a model with varying extinction, *BcstDAngioVar*, was the best-fit). Values are the estimated parameter for the maximum clade credibility tree of Leslie *et al.* (2018). The delta AICc (ΔAICc) and Akaike weight (ωAICc) allow comparing the models to select the best-fit model. The best-fit model is the model with the extinction rate positively correlated with the proportion of angiosperms, suggesting that extinction increased when angiosperms diversified whereas extinction decreased when angiosperms were absent (no effect on speciation). Abbreviations: NP, number of free parameters; logL, log- likelihood; λ, speciation rate; α, rate of variation of the speciation according to the paleo-environmental variable; μ, extinction rate; β, rate of variation of the extinction according to the paleo-environmental variable.