

# Deep-time geographic dynamics of climate shape global vascular plant diversity

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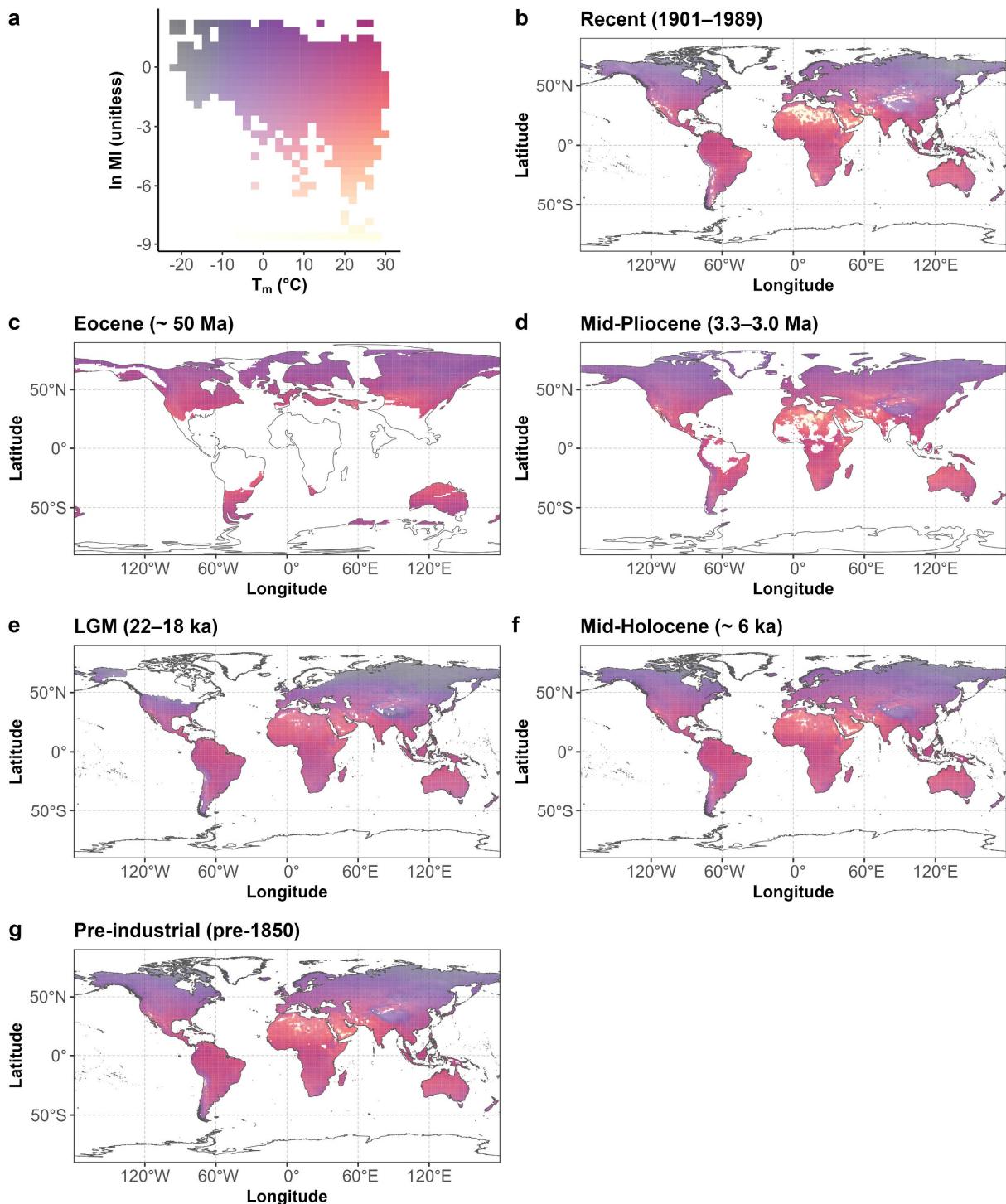
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## 9 Supplementary Information

## 10 SI 1 Supplementary Figures

11 **Fig. S1: Alternative colour gradient scheme illustrating the historical geography of recent**  
12 **climates.**

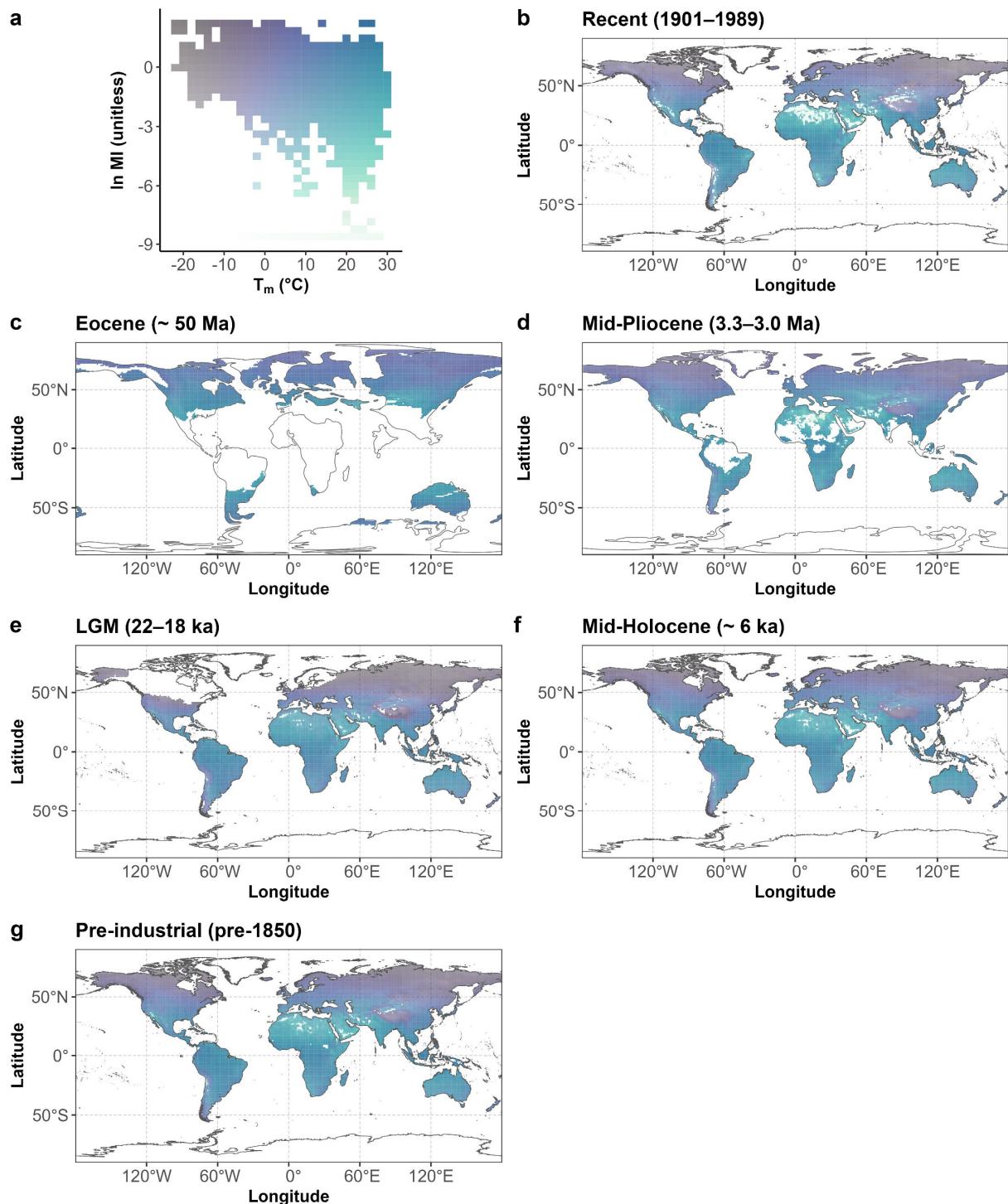


13

14 **a**, The two-dimensional climatic space defined by the recent (1901–1989) climatic conditions ( $T_m$   
15 and  $\ln MI$ ), partitioned into 30 equal intervals along each axis. Each coloured grid cell ('climatic bin')  
16 represents a unique climatic condition (405 cells in total). **b–g**, Geographic locations where those

17 recent climatic conditions existed during the recent period (1901–1989, **b**), Eocene (*ca.* 50 Ma, **c**),  
18 Mid-Pliocene (3.3–3.0 Ma, **d**), Last Glacial Maximum (LGM, 22–18 ka, **e**), Mid-Holocene (*ca.* 6 ka, **f**)  
19 and pre-industrial period (pre-1850, **g**). Uncoloured areas denote climatic conditions absent during  
20 this period. Colours correspond to those in **a**, with identical colours indicating the same climatic  
21 conditions. All maps are shown at a 1° spatial resolution.

22 **Fig. S2: Another alternative colour gradient scheme illustrating the historical geography of**  
 23 **recent climates.**

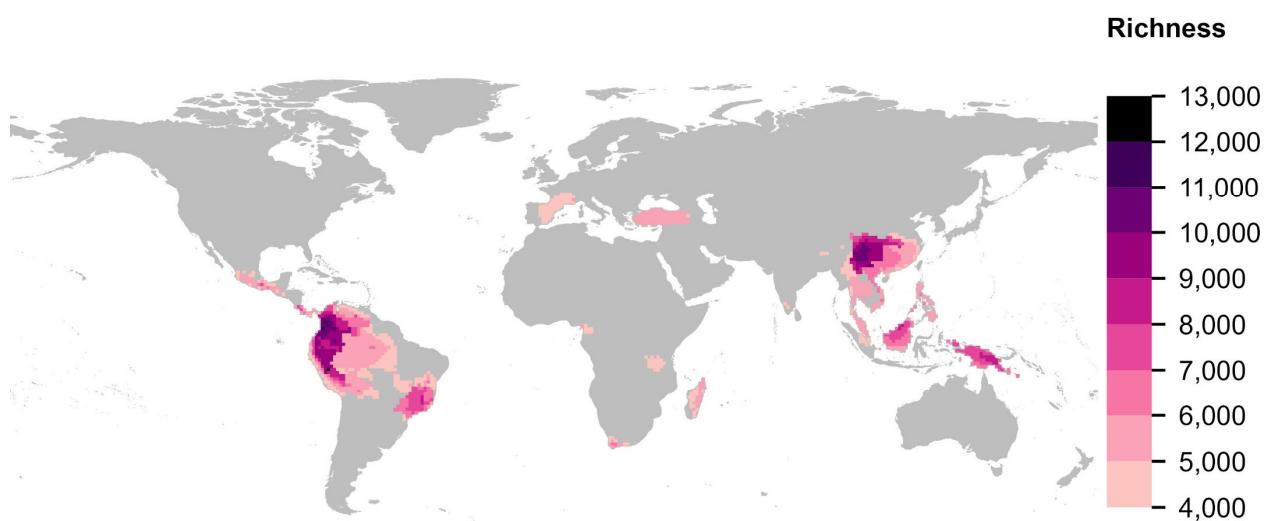


24

25 **a**, The two-dimensional climatic space defined by the recent (1901–1989) climatic conditions ( $T_m$   
 26 and  $\ln MI$ ), partitioned into 30 equal intervals along each axis. Each coloured grid cell ('climatic bin')  
 27 represents a unique climatic condition (405 cells in total). **b–g**, Geographic locations where those

28 recent climatic conditions existed during the recent period (1901–1989, **b**), Eocene (ca. 50 Ma, **c**),  
29 Mid-Pliocene (3.3–3.0 Ma, **d**), Last Glacial Maximum (LGM, 22–18 ka, **e**), Mid-Holocene (ca. 6 ka, **f**)  
30 and pre-industrial period (pre-1850, **g**). Uncoloured areas denote climatic conditions absent during  
31 this period. Colours correspond to those in **a**, with identical colours indicating the same climatic  
32 conditions. All maps are shown at a 1° spatial resolution.

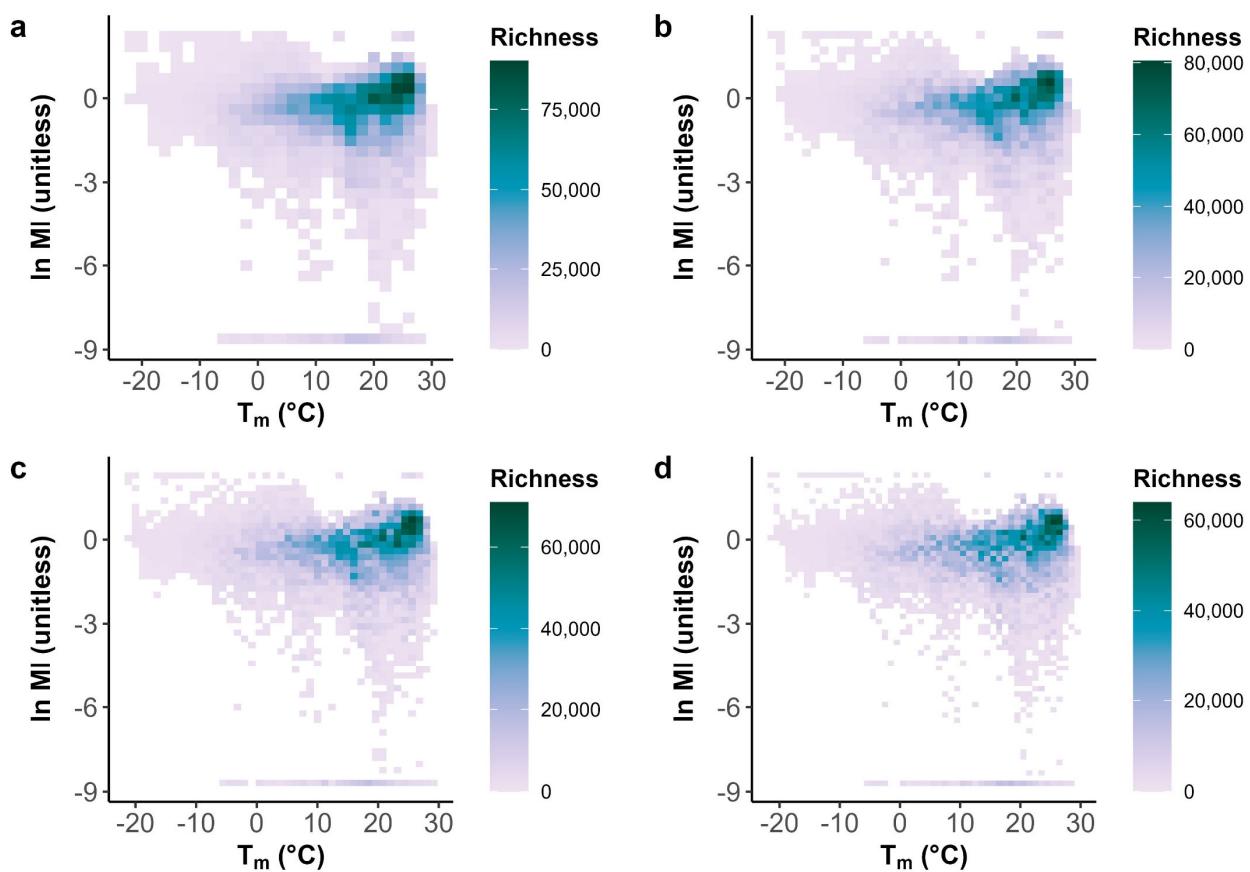
33 **Fig. S3: Global hotspots of vascular plant species richness.**



34

35 Global hotspots of vascular plant diversity, defined as regions where species richness exceeds the  
36 90th global quantile<sup>1</sup>.

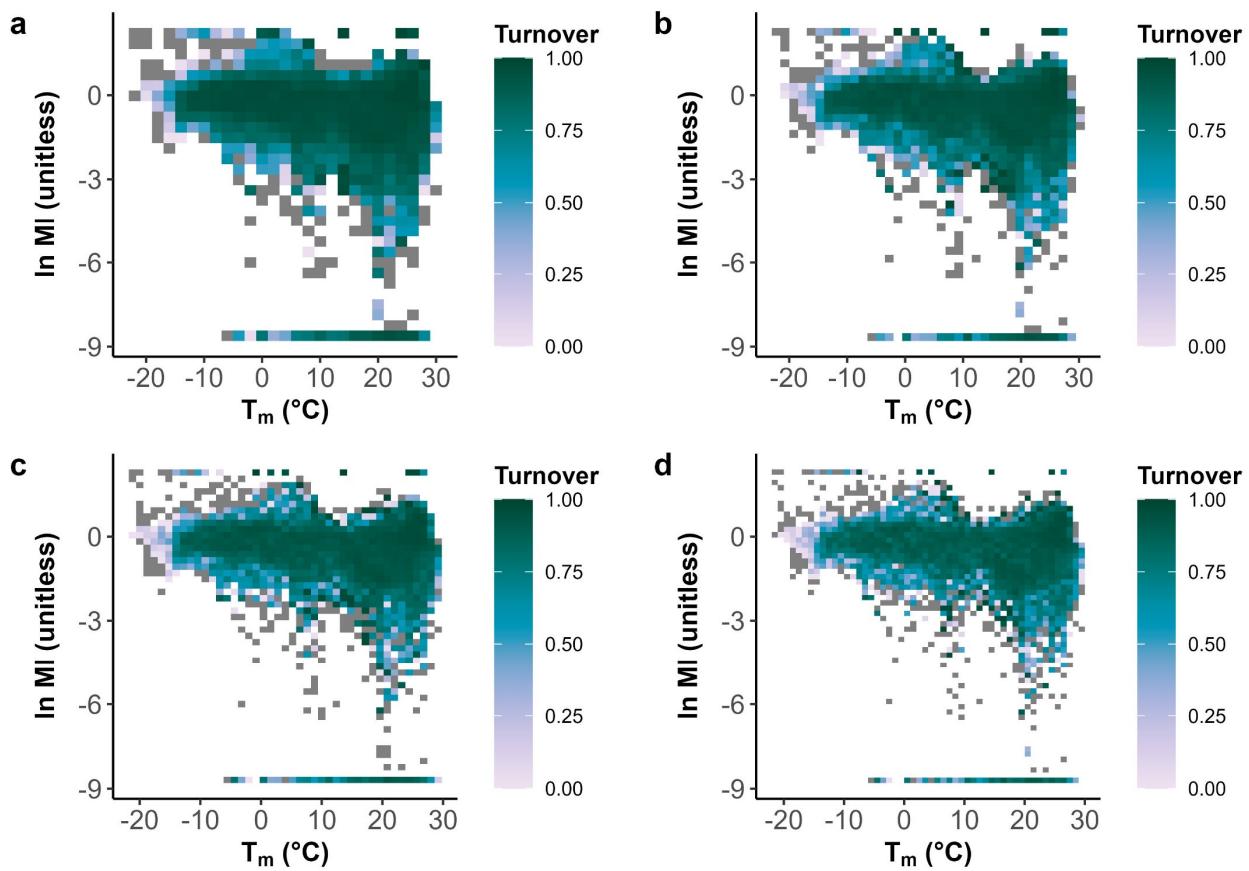
37 **Fig. S4: Vascular plant species richness in climatic space at different resolutions.**



38

39 Species richness is shown per grid cell in climatic space defined by recent climatic conditions ( $T_m$   
40 and ln MI), at four resolutions: 30 (a, 405 cells), 40 (b, 628 cells), 50 (c, 896 cells) and 60 (d, 1182  
41 cells) equal intervals along each axis. Each grid cell ('climatic bin') represents a distinct climatic  
42 condition; colours indicate species richness.  $T_m$  ( $^{\circ}$ C), recent (1901–1989) temperature index; ln MI  
43 (unitless), recent natural-log-transformed moisture index.

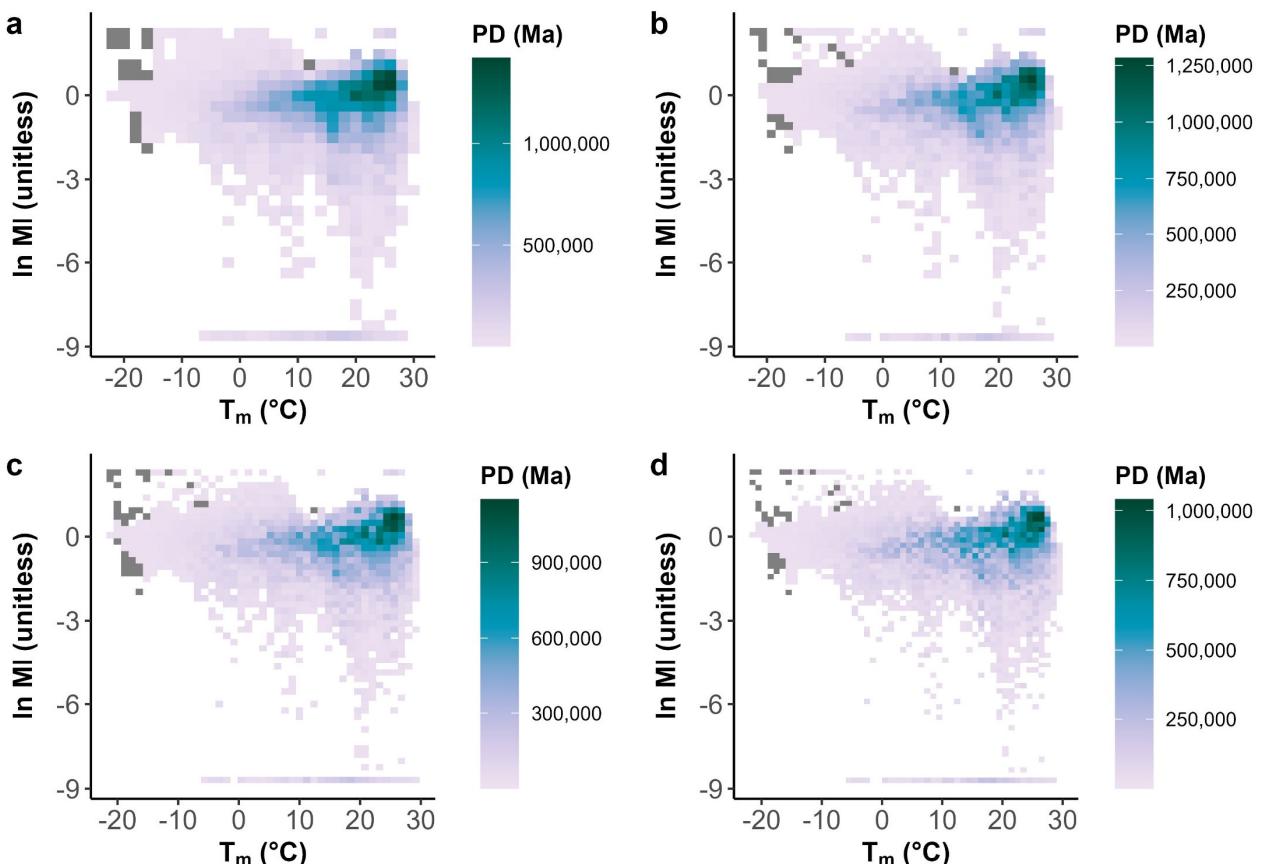
44 **Fig. S5: Vascular plant species turnover in climatic space at different resolutions.**



45

46 Species turnover (the turnover component of beta-diversity) is shown per grid cell in climatic space  
47 defined by recent climatic conditions ( $T_m$  and  $\ln MI$ ), at four resolutions: 30 (a, 405 cells), 40 (b, 628  
48 cells), 50 (c, 896 cells) and 60 (d, 1182 cells) equal intervals along each axis. Each grid cell  
49 ('climatic bin') represents a distinct climatic condition; colours indicate species richness.  $T_m$  ( $^{\circ}\text{C}$ ),  
50 recent (1901–1989) temperature index;  $\ln MI$  (unitless), recent natural-log-transformed moisture  
51 index.

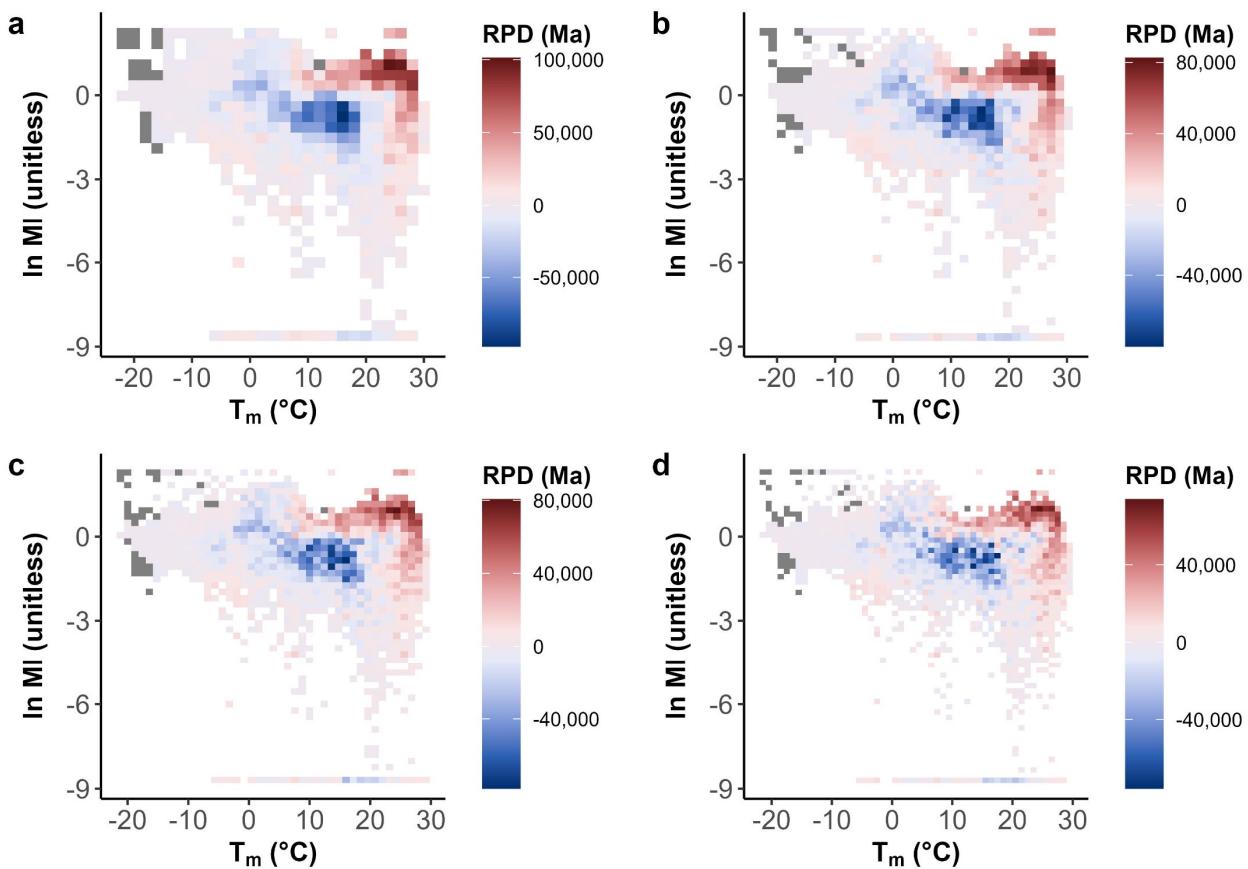
52 **Fig. S6: Phylogenetic diversity of vascular plants in climatic space at different resolutions.**



53

54 Phylogenetic diversity (Faith's phylogenetic diversity<sup>2</sup>, PD, Ma) is shown per grid cell in climatic  
 55 space defined by recent climatic conditions ( $T_m$  and  $\ln MI$ ), at four resolutions: 30 (a, 405 cells), 40  
 56 (b, 628 cells), 50 (c, 896 cells) and 60 (d, 1182 cells) equal intervals along each axis. Each grid cell  
 57 ('climatic bin') represents a distinct climatic condition; colours indicate species richness.  $T_m$  ( $^{\circ}\text{C}$ ),  
 58 recent (1901–1989) temperature index;  $\ln MI$  (unitless), recent natural-log-transformed moisture  
 59 index.

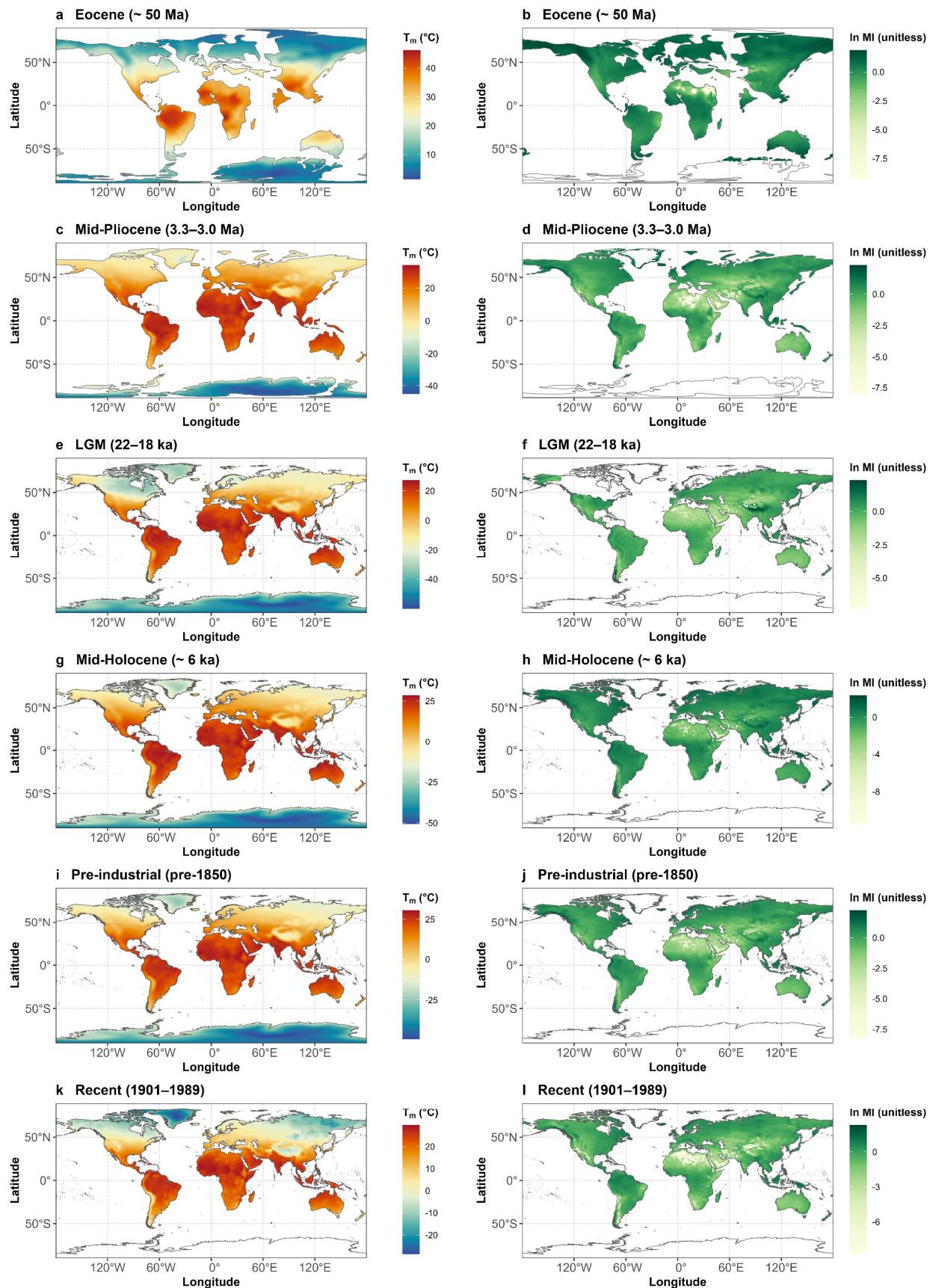
60 **Fig. S7: Relative phylogenetic diversity of vascular plants in climatic space at different**  
61 **resolutions.**



62

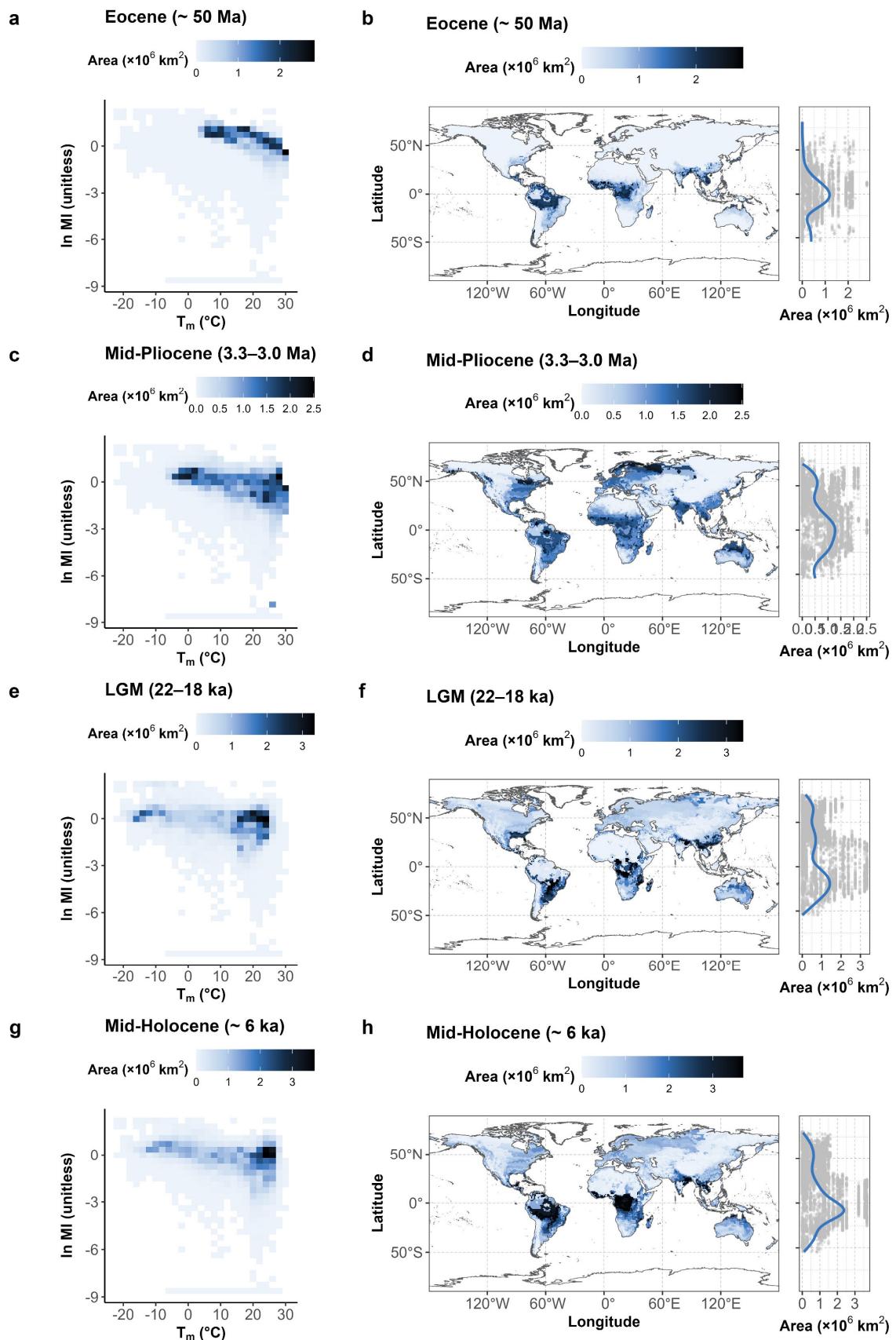
63 Relative phylogenetic diversity (calculated as the residuals from regressing phylogenetic diversity  
64 against species richness, Ma) is shown per grid cell in climatic space defined by recent climatic  
65 conditions ( $T_m$  and  $\ln MI$ ), at four resolutions: 30 (a, 405 cells), 40 (b, 628 cells), 50 (c, 896 cells)  
66 and 60 (d, 1182 cells) equal intervals along each axis. Each grid cell ('climatic bin') represents a  
67 distinct climatic condition; colours indicate species richness.  $T_m$  (°C), recent (1901–1989)  
68 temperature index;  $\ln MI$  (unitless), recent natural-log-transformed moisture index.

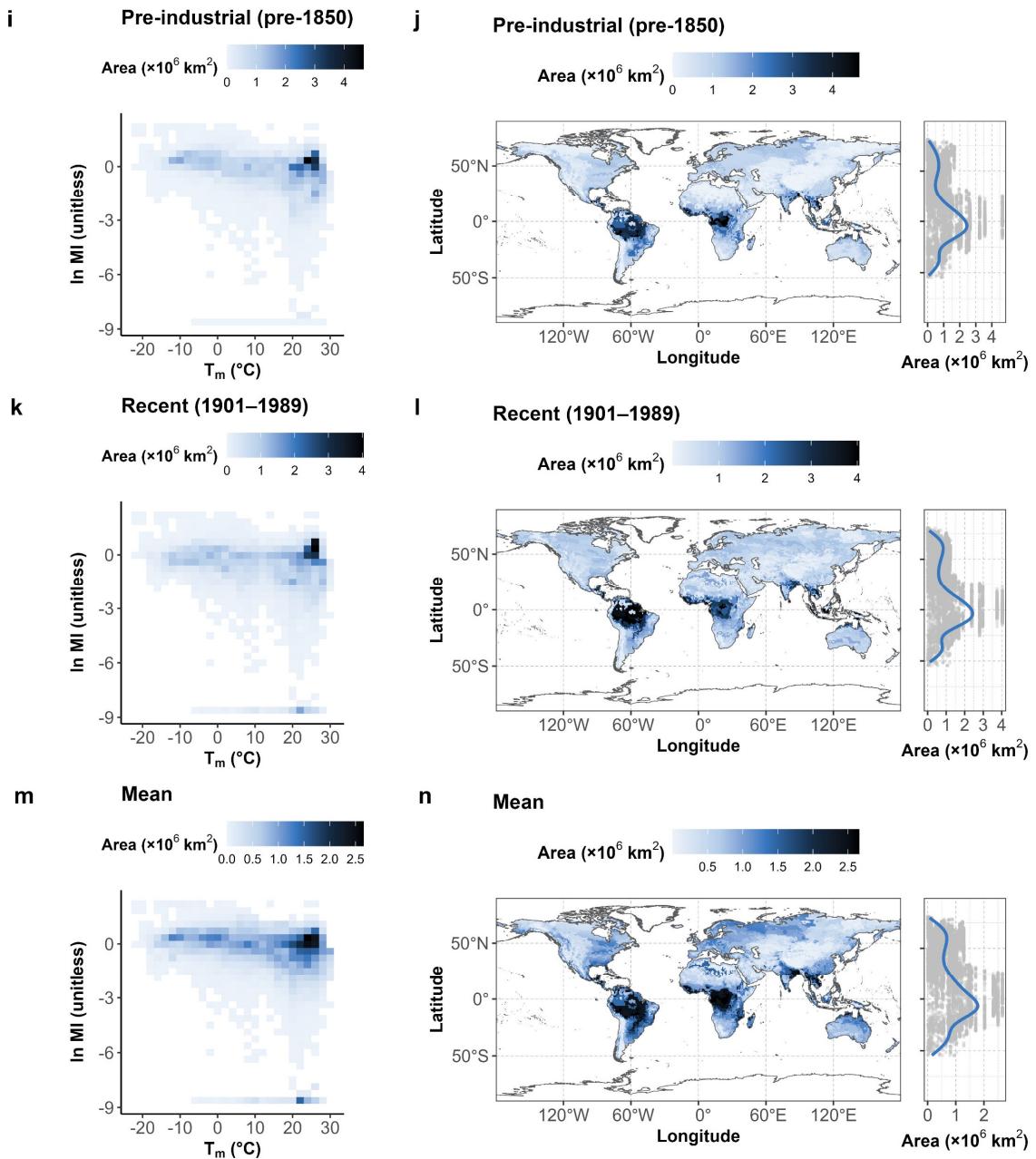
69 **Fig. S8: Global distribution of bioclimatic variables in the selected geological periods at a 1°  
70 spatial resolution.**



72 Gridded global distribution of: **a**, temperature index ( $T_m$ , °C) and **b**, natural-log-transformed moisture  
73 index ( $\ln MI$ , unitless) of the Eocene (ca. 50 Ma); **c**,  $T_m$  and **d**,  $\ln MI$  of the Mid-Pliocene (3.3–3.0  
74 Ma); **e**,  $T_m$  and **f**,  $\ln MI$  of the Last Glacial Maximum (LGM, 22–18 ka); **g**,  $T_m$  and **h**,  $\ln MI$  of the  
75 Mid-Holocene (ca. 6 ka); **i**,  $T_m$  and **j**,  $\ln MI$  of the pre-industrial period (pre-1850); **k**,  $T_m$  and **l**,  $\ln MI$  of  
76 the recent period (1901–1989).

77 **Fig. S9: Geographic extent of climate across geological periods.**



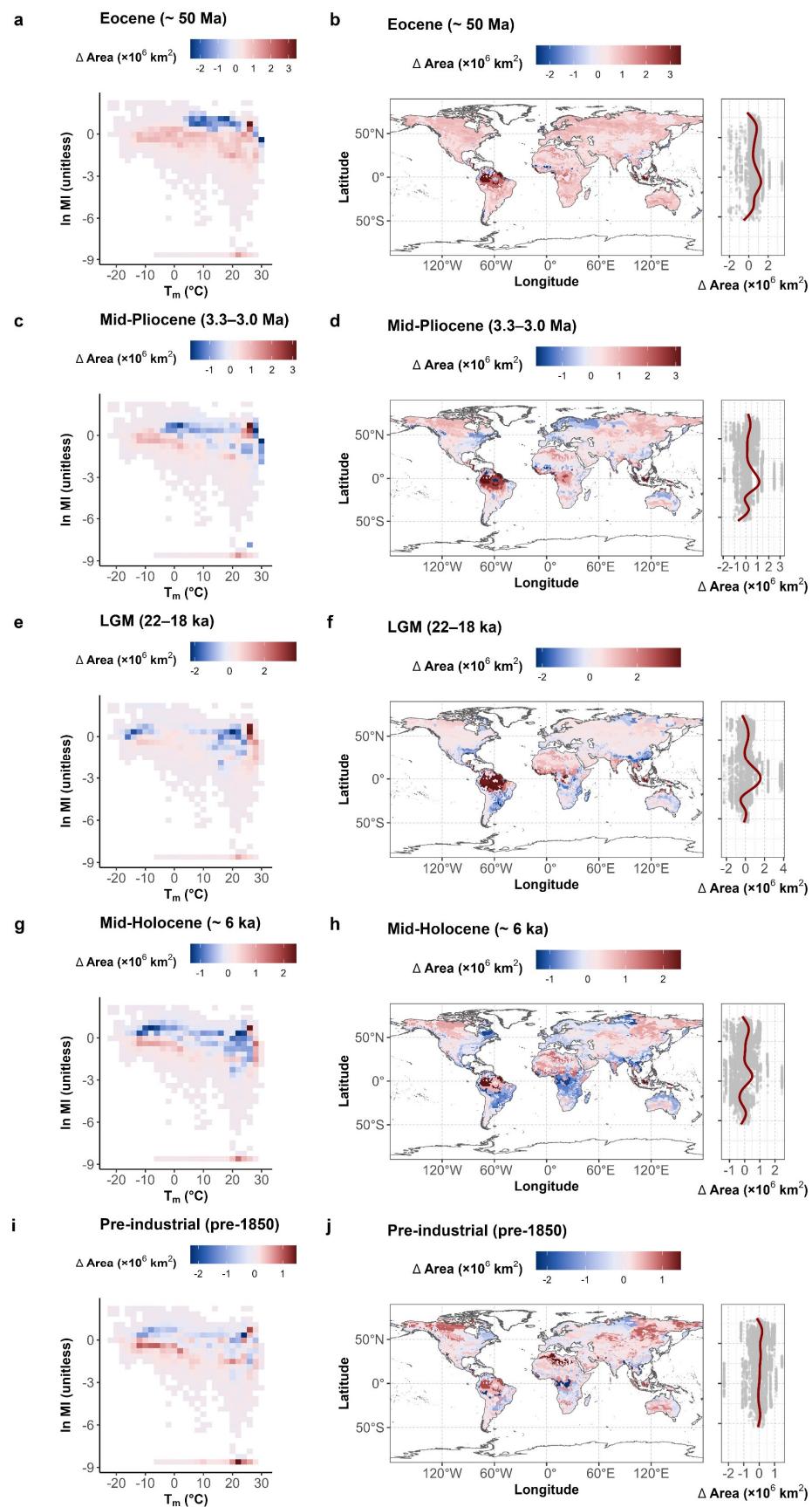


79

80 **a, c, e, g, i, k and m,** Patterns of the geographic extent of climate in climatic space across different  
 81 geological periods. The geographic extent of climate is calculated as the total land surface area  
 82 occupied by each climatic condition during the corresponding climatic period, referred to as 'Area'  
 83 ( $\text{km}^2$ ). Climatic space is defined by the recent (1901–1989) climatic conditions ( $T_m$  and  $\ln MI$ ),  
 84 partitioned into 30 equal intervals along each axis. **b, d, f, h, j, l and n,** Global patterns and  
 85 latitudinal distributions of Area in recent geographic space at a  $1^{\circ}$  spatial resolution. **a** and **b**,  
 86 Eocene (ca. 50 Ma); **c** and **d**, Mid-Pliocene (3.3–3.0 Ma); **e** and **f**, Last Glacial Maximum (LGM, 22–  
 87 18 ka); **g** and **h**, Mid-Holocene (ca. 6 ka); **i** and **j**, pre-industrial period (pre-1850); **k** and **l**, recent

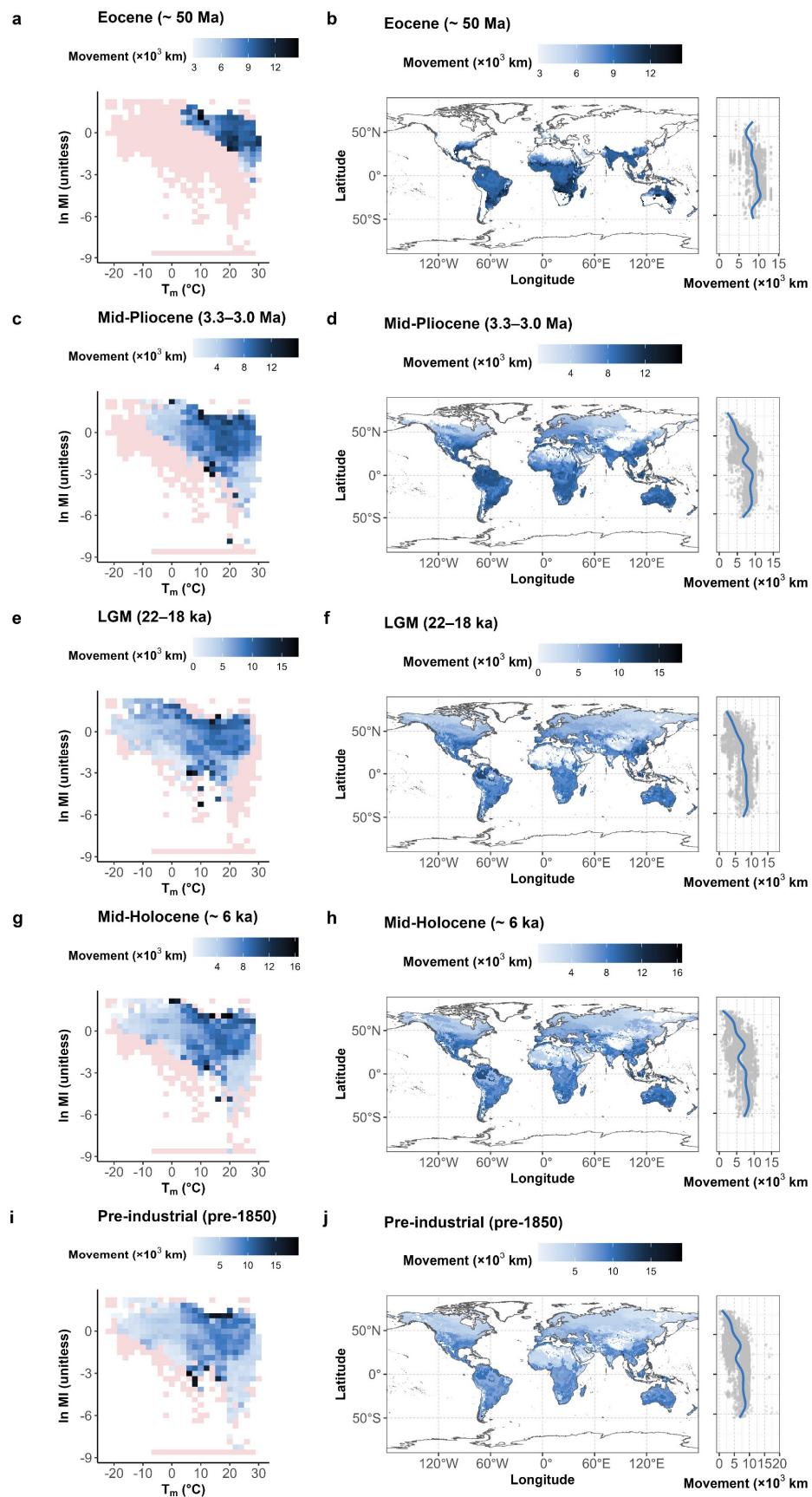
88 period (1901–1989); **m** and **n**, mean Area since the first appearance of each climatic condition  
89 across all selected climatic periods.  $T_m$  ( $^{\circ}\text{C}$ ), recent (1901–1989) temperature index;  $\ln MI$  (unitless),  
90 recent natural-log-transformed moisture index.

91 **Fig. S10: Changes in the geographic extent of recent climatic conditions from geohistorical**  
 92 **periods to the recent period.**



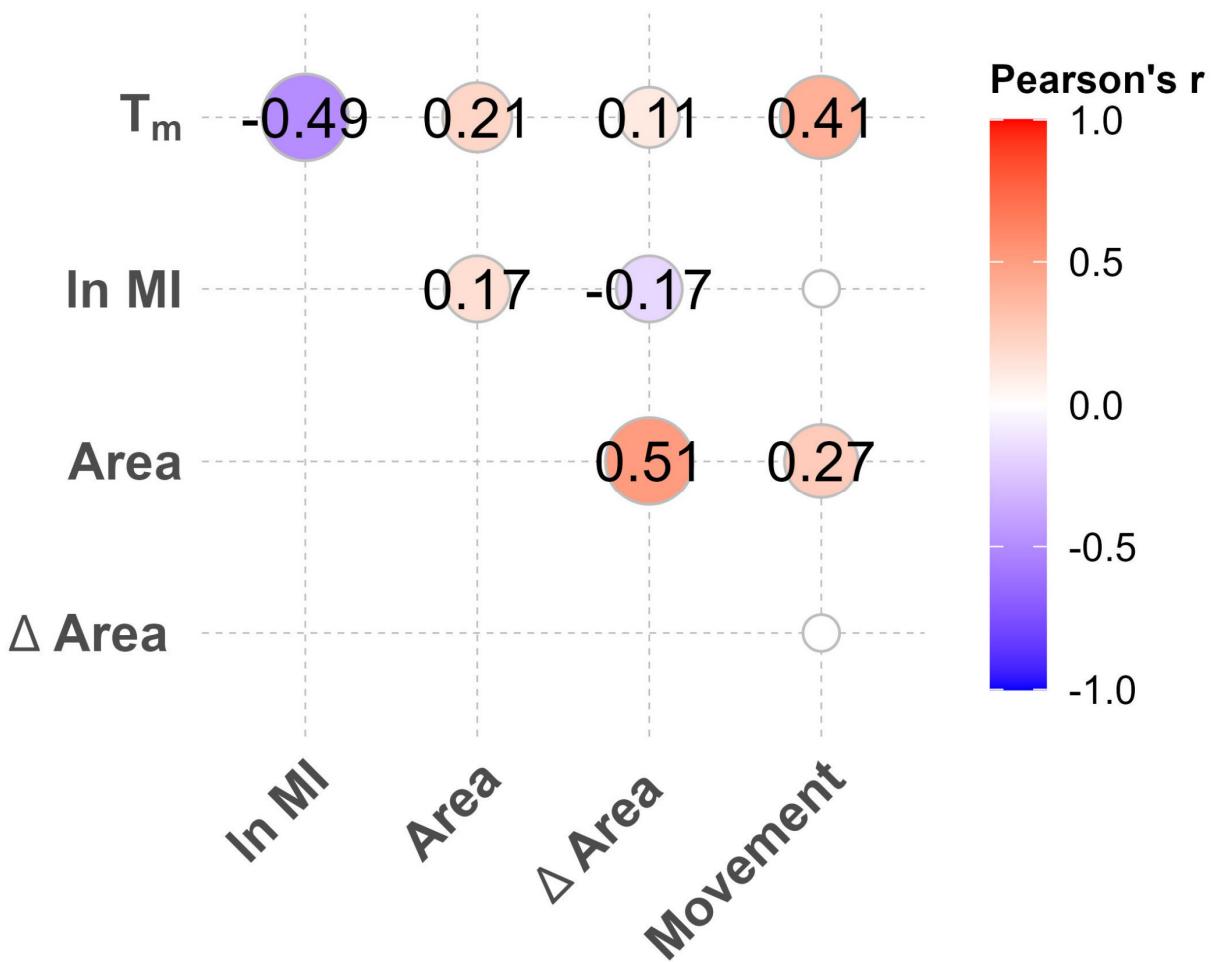
94 **a, c, e, g** and **i**, Change in total land area occupied by each climatic condition from its earliest  
95 occurrence to the recent period (referred to as  $\Delta$ Area,  $\text{km}^2$ ) in climatic space. Climatic space is  
96 defined by the recent (1901–1989) climatic conditions ( $T_m$  and  $\ln \text{MI}$ ), partitioned into 30 equal  
97 intervals along each axis. **b, d, f, h** and **j**, Global patterns and latitudinal distributions of  $\Delta$ Area in  
98 recent geographic space at a  $1^\circ$  spatial resolution. **a** and **b**, Eocene (ca. 50 Ma); **c** and **d**,  
99 Mid-Pliocene (3.3–3.0 Ma); **e** and **f**, Last Glacial Maximum (LGM, 22–18 ka); **g** and **h**,  
100 Mid-Holocene (ca. 6 ka); **i** and **j**, pre-industrial period (pre-1850).  $T_m$  ( $^\circ\text{C}$ ), recent (1901–1989)  
101 temperature index;  $\ln \text{MI}$  (unitless), recent natural-log-transformed moisture index.

102 **Fig. S11: Geographic shift of recent climatic conditions from geohistorical periods to the**  
 103 **recent period.**



105 **a, c, e, g** and **i**, Geographic shift of a climatic condition since its earliest occurrence to the recent  
106 period (Movement, km) in climatic space. Climatic space is defined by the recent (1901–1989)  
107 climatic conditions ( $T_m$  and  $\ln MI$ ), partitioned into 30 equal intervals along each axis. The blue  
108 colour gradient indicates climatic conditions shared by a geohistorical period and the recent period,  
109 while the pink background highlights climatic conditions present in the recent period but absent in  
110 the geohistorical period. **b, d, f, h** and **j**, Global patterns and latitudinal distribution of Movement in  
111 recent geographic space at a  $1^\circ$  spatial resolution. **a** and **b**, Eocene (ca. 50 Ma); **c** and **d**,  
112 Mid-Pliocene (3.3–3.0 Ma); **e** and **f**, Last Glacial Maximum (LGM, 22–18 ka); **g** and **h**,  
113 Mid-Holocene (ca. 6 ka); **i** and **j**, pre-industrial period (pre-1850).  $T_m$  ( $^\circ$ C), recent (1901–1989)  
114 temperature index;  $\ln MI$  (unitless), recent natural-log-transformed moisture index.

115 **Fig. S12: Pairwise correlation among explanatory variables.**



116

117 Pairwise Pearson's correlation coefficients among all explanatory variables. The absolute values of  
118 all coefficients are below or around 0.5, indicating a low risk of concurvity or collinearity.  $T_m$  ( $^{\circ}\text{C}$ ),  
119 recent (1901–1989) temperature index;  $\ln MI$  (unitless), recent natural-log-transformed moisture  
120 index; Area ( $\text{km}^2$ ), total land area occupied by a climatic condition in the recent period;  $\Delta$ Area ( $\text{km}^2$ ),  
121 change in total land area occupied by a climatic condition from its earliest occurrence to the recent  
122 period; Movement (km), geographic shift of a climatic condition since its earliest occurrence to the  
123 recent period.

124 **SI 2 Supplementary Tables**

125 **Table S1 | Comparison with previous global plant diversity products.** Summary of data sources <sup>a</sup>, methods for generating global plant diversity  
 126 maps <sup>b</sup>, the number of species included <sup>c</sup>, and the spatial resolution of each map <sup>d</sup>.

Data source <sup>a</sup>	Type <sup>b</sup>	Number of species <sup>c</sup>	Spatial Resolution <sup>d</sup>
Our research	Data-based	350,864	Any resolution (using 1° as an example)
Barthlott <i>et al.</i> (2005) <sup>3</sup>	Data-based	> 3,300 from different regions	10,000 km <sup>2</sup>
Kier <i>et al.</i> (2005) <sup>4</sup>	Data-based	Not available – estimated for each selected geographical unit	867 Terrestrial ecoregions of the world
Kreft & Jetz (2007) <sup>5</sup>	Model-based	> 3,300 from 1,032 geographic units	110 × 110 km (ca. 1°)
		Not available – estimated for each selected geographical unit (data-based); 1,250 (model-based)	Level 3 geo-political regions of the world and 867 ecoregions of WWF (data-based), 10 km <sup>2</sup> (model-based)
Brummitt <i>et al.</i> (2021) <sup>6</sup>	Data-based and Model-based		400 m <sup>2</sup> , 1,000 m <sup>2</sup> and 1 ha for forests, and 10 m <sup>2</sup> , 100 m <sup>2</sup> and 1,000 m <sup>2</sup> for non-forests
Sabatini <i>et al.</i> (2022) <sup>7</sup>	Model-based	53,271	
Cai <i>et al.</i> (2023) <sup>1</sup>	Model-based	298,087	7,774 km <sup>2</sup> , 23,322 km <sup>2</sup> , 69,967 km <sup>2</sup> , and 209,903 km <sup>2</sup>

World Checklist of Vascular Plants (WCVP) <sup>8</sup>	Database	357,347 accepted species (Feb–June 2024) Notice: > 340,000 species with distribution information available	Level 3 of the Biodiversity Information Standards (TDWG) geographical codes
Global Inventory of Floras and Traits (GIFT) <sup>9</sup>	Database	303,713 vascular plants (v.3.1) Notice: distribution data for some species are not available	3,627 geographic regions

**Table S2 | Climate data used for this study.** Databases and model simulations used to extract each climatic variable in different geological periods.

Project	Version	Experiment	Geological period	Model	Simulation	Ensemble	Variable	Resolution	Reference
Deep-Time Model Intercomparison Project (DeepMIP) <sup>10</sup>	Eocene (ca. 50 Ma)	r1i1p1f1	CESM1.2-CAM5 eg-r2413	× 6 CO <sub>2</sub>			elevation/surface altitude, precipitation, surface downwelling shortwave radiation, air temperature	2.5° × 1.9°	Ref <sup>11</sup>
							elevation/surface altitude, precipitation, surface downwelling shortwave radiation, air temperature		
							elevation/surface altitude, precipitation, surface downwelling shortwave radiation, air temperature		
			GFDL-CM2.1	× 4 CO <sub>2</sub> , × 6 CO <sub>2</sub>			elevation/surface altitude, precipitation, surface downwelling shortwave radiation, air temperature	3.75° × 3.71°	Ref <sup>12</sup>
							elevation/surface altitude, precipitation, surface downwelling shortwave radiation, air temperature		
	INM-CM4-8 NorESM1-F		INM-CM4-8	× 6 CO <sub>2</sub>			elevation/surface altitude, precipitation, surface downwelling shortwave radiation, air temperature	2.0° × 1.5°	Ref <sup>12</sup>
							elevation/surface altitude, precipitation, surface downwelling shortwave radiation, air temperature		
							elevation/surface altitude, precipitation, surface downwelling shortwave radiation, air temperature		
				× 4 CO <sub>2</sub>			elevation/surface altitude, precipitation, surface downwelling shortwave radiation, air temperature	2.5° × 1.9°	Ref <sup>14</sup>
							elevation/surface altitude, precipitation, surface downwelling shortwave radiation, air temperature		

				elevation/surface altitude, 100 km ×	
		CESM2		precipitation, surface downwelling 100 km	Ref <sup>16</sup>
				shortwave radiation, air temperature 100 km	
		GISS-E2-1-G		precipitation, surface downwelling 250 km ×	
	midPliocene- eoi400	Mid-Pliocene (3.3–3.0 Ma)	HadGEM3-GC3 1-LL	shortwave radiation, air temperature 250 km	Refs <sup>17,18</sup>
Paleoclimat Modeling Intercomparison Project (PMIP) <sup>15</sup>	Phase 4 (PMIP4)	NorESM1-F	--	precipitation, air temperature 250 km × 250 km	Ref <sup>19</sup>
			r1i1p1f1	elevation/surface altitude, 250 km × 250 km	
				precipitation, surface downwelling 250 km	Ref <sup>14</sup>
				shortwave radiation, air temperature	
		AWI-ESM-1-1-L R		elevation/surface altitude, 250 km ×	
		Last Glacial Maximum lgm (LGM, 22–18 ka)		precipitation, surface downwelling 250 km	Ref <sup>20</sup>
				shortwave radiation, air temperature	
		MPI-ESM1-2-LR		elevation/surface altitude, 250 km ×	
				precipitation, surface downwelling 250 km	Ref <sup>21</sup>
				shortwave radiation, air temperature	
	midHolocene	Mid-Holocene (ca. 6 ka)	AWI-ESM-1-1-L R	elevation/surface altitude, 250 km × 250 km	Ref <sup>20</sup>
				precipitation, surface downwelling 250 km	

CESM2	shortwave radiation, air temperature					
	elevation/surface altitude, precipitation, surface downwelling	100 km × 100 km	Ref <sup>16</sup>			
	shortwave radiation, air temperature					
MPI-ESM1-2-LR	elevation/surface altitude, precipitation, surface downwelling	250 km × 250 km	Ref <sup>21</sup>			
	shortwave radiation, air temperature					
	elevation/surface altitude, precipitation, surface downwelling	100 km × 100 km	Ref <sup>22</sup>			
MRI-ESM2-0	shortwave radiation, air temperature					
	elevation/surface altitude, precipitation, surface downwelling	250 km × 250 km	Ref <sup>23</sup>			
	shortwave radiation, air temperature					
NESM3	precipitation, surface downwelling	250 km × 250 km	Ref <sup>24</sup>			
	shortwave radiation, air temperature	250 km				
NorESM1-F	surface downwelling shortwave radiation	250 km × 250 km	Ref <sup>14</sup>			
NorESM2-LM	elevation/surface altitude, precipitation, air temperature	250 km × 250 km	Ref <sup>24</sup>			
Coupled Model Intercomparison	Phase 6 (CMIP6)	piControl Pre-industrial era	ACCESS-CM2 -- r1i1p1f1	elevation/surface altitude, precipitation, surface downwelling	250 km × 250 km	Ref <sup>26</sup>

Project	(before 1850)	shortwave radiation, air temperature	
(CMIP) <sup>25</sup>		elevation/surface altitude, precipitation, surface downwelling shortwave radiation, air temperature	100 km × 100 km Ref <sup>16</sup>
	CESM2	elevation/surface altitude, precipitation, surface downwelling shortwave radiation, air temperature	250 km × 250 km Ref <sup>27</sup>
	MIROC6	elevation/surface altitude, precipitation, surface downwelling shortwave radiation, air temperature	250 km × 250 km Ref <sup>21</sup>
	MPI-ESM1-2-LR	elevation/surface altitude, precipitation, surface downwelling shortwave radiation, air temperature	100 km × 100 km Ref <sup>22</sup>
	MRI-ESM2-0	precipitation, surface downwelling shortwave radiation, air temperature	250 km × 250 km Ref <sup>23</sup>
	NESM3	precipitation, surface downwelling shortwave radiation, air temperature	250 km × 250 km Ref <sup>24</sup>
	NorESM2-LM	elevation/surface altitude, precipitation, surface downwelling shortwave radiation, air temperature	250 km × 250 km Ref <sup>24</sup>

historical	Recent period (1901–1989)	MIROC6	surface downwelling shortwave	250 km ×	Ref <sup>26</sup>
			radiation	250 km	
			surface downwelling shortwave	100 km ×	
			radiation	100 km	
			surface downwelling shortwave	250 km ×	
			radiation	250 km	
			surface downwelling shortwave	250 km ×	
			radiation	250 km	
			surface downwelling shortwave	100 km ×	
			radiation	100 km	
Climatic	Recent period (1901–1989)	NESM3	surface downwelling shortwave	250 km ×	Ref <sup>27</sup>
			radiation	250 km	
			surface downwelling shortwave	250 km ×	
			radiation	250 km	
			surface downwelling shortwave	250 km ×	
			radiation	250 km	
			surface downwelling shortwave	250 km ×	
			radiation	250 km	
			surface downwelling shortwave	250 km ×	Ref <sup>24</sup>
			radiation	250 km	
Research Unit (CRU)	version 4.09	Observation-bas ed gridded dataset	precipitation, air temperature	0.5° × 0.5°	Ref <sup>28</sup>
Time-Series					

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(TS)<sup>28</sup>

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WorldClim <sup>29</sup>	version	30	Ref <sup>29</sup>
	2.1	elevation/surface altitude	arc-second
			grid

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129

130 **Table S3 | Summary of Generalised Additive Models (GAMs) incorporating bioclimatic**  
 131 **variables and the geographic extent of climate during the Eocene (ca. 50 Ma) across multiple**  
 132 **climatic space resolutions.** Summary statistics of GAMs fitted with species richness as the  
 133 response variable. Explanatory variables include recent (1901–1989) temperature index ( $T_m$ , °C)  
 134 and natural-log-transformed moisture index (ln MI, unitless), and total land area occupied by each  
 135 climatic condition (Area, km<sup>2</sup>) during the Eocene. Different GAMs were constructed based on  
 136 climatic spaces defined by the recent climatic conditions ( $T_m$  and ln MI) at four resolutions, with  
 137 each climatic axis divided into 30, 40, 50 or 60 equal intervals. Reported metrics for each model  
 138 include concurvity,  $\chi^2$  and  $p$ -value for each explanatory variable, and explained deviance (Deviance),  
 139 predicted  $R^2$  ( $R_{pred}^2$ ) and adjusted  $R^2$  ( $R_{adj}^2$ ) of each GAM model, and the sample size (N) fitted into  
 140 each model.

30 equal interval resolution							
Predictor	Concurvity	$\chi^2$	$p$ -value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
$T_m$	0.43	1826164.57	< 0.001				
ln MI	0.29	2621414.09	< 0.001	0.92	0.91	0.90	405
Area	0.28	110054.76	< 0.001				
40 equal interval resolution							
Predictor	Concurvity	$\chi^2$	$p$ -value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
$T_m$	0.42	2528553.22	< 0.001				
ln MI	0.26	3152404.27	< 0.001	0.89	0.88	0.87	628
Area	0.26	153392.87	< 0.001				
50 equal interval resolution							
Predictor	Concurvity	$\chi^2$	$p$ -value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
$T_m$	0.40	2905884.78	< 0.001				
ln MI	0.24	3663735.85	< 0.001	0.87	0.84	0.84	896
Area	0.23	194660.03	< 0.001				
60 equal interval resolution							
Predictor	Concurvity	$\chi^2$	$p$ -value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N

Predictor	Concurvity	$\chi^2$	<i>p</i> -value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
$T_m$	0.42	3391694.10	< 0.001				
ln MI	0.23	3897622.26	< 0.001	0.84	0.80	0.79	1182
Area	0.21	159522.60	< 0.001				

141 **Table S4 | Summary of Generalised Additive Models (GAMs) incorporating bioclimatic**  
 142 **variables and the geographic extent of climate during the Mid-Pliocene (3.3–3.0 Ma) across**  
 143 **multiple climatic space resolutions.** Summary statistics of GAMs fitted with species richness as  
 144 the response variable. Explanatory variables include recent (1901–1989) temperature index ( $T_m$ , °C)  
 145 and natural-log-transformed moisture index (ln MI, unitless), and total land area occupied by each  
 146 climatic condition (Area,  $\text{km}^2$ ) during the Mid-Pliocene. Different GAMs were constructed based on  
 147 climatic spaces defined by the recent climatic conditions ( $T_m$  and ln MI) at four resolutions, with  
 148 each climatic axis divided into 30, 40, 50 or 60 equal intervals. Reported metrics for each model  
 149 include concurvity,  $\chi^2$  and *p*-value for each explanatory variable, and explained deviance (Deviance),  
 150 predicted  $R^2$  ( $R_{pred}^2$ ) and adjusted  $R^2$  ( $R_{adj}^2$ ) of each GAM model, and the sample size (N) fitted into  
 151 each model.

30 equal interval resolution							
Predictor	Concurvity	$\chi^2$	<i>p</i> -value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
$T_m$	0.61	1326565.81	< 0.001				
ln MI	0.41	1110697.66	< 0.001	0.91	0.89	0.89	405
Area	0.42	70793.87	< 0.001				
40 equal interval resolution							
Predictor	Concurvity	$\chi^2$	<i>p</i> -value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
$T_m$	0.60	1742019.22	< 0.001				
ln MI	0.37	1494216.90	< 0.001	0.89	0.85	0.85	628
Area	0.39	73973.80	< 0.001				
50 equal interval resolution							
Predictor	Concurvity	$\chi^2$	<i>p</i> -value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N

T <sub>m</sub>	0.56	2276038.16	< 0.001					
ln MI	0.35	2033348.82	< 0.001	0.86	0.82	0.81	896	
Area	0.31	89872.99	< 0.001					
<b>60 equal interval resolution</b>								
Predictor	Concurvity	$\chi^2$	p-value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N	
T <sub>m</sub>	0.59	2722005.60	< 0.001					
ln MI	0.33	2466028.68	< 0.001	0.83	0.78	0.78	1182	
Area	0.32	92430.90	< 0.001					

152 **Table S5 | Summary of Generalised Additive Models (GAMs) incorporating bioclimatic**  
 153 **variables and the geographic extent of climate during the Last Glacial Maximum (LGM, 22–18**  
 154 **ka) across multiple climatic space resolutions.** Summary statistics of GAMs fitted with species  
 155 richness as the response variable. Explanatory variables include recent (1901–1989) temperature  
 156 index (T<sub>m</sub>, °C) and natural-log-transformed moisture index (ln MI, unitless), and total land area  
 157 occupied by each climatic condition (Area, km<sup>2</sup>) during the LGM. Different GAMs were constructed  
 158 based on climatic spaces defined by the recent climatic conditions (T<sub>m</sub> and ln MI) at four resolutions,  
 159 with each climatic axis divided into 30, 40, 50 or 60 equal intervals. Reported metrics for each  
 160 model include concurvity,  $\chi^2$  and p-value for each explanatory variable, and explained deviance  
 161 (Deviance), predicted R<sup>2</sup> ( $R_{pred}^2$ ) and adjusted R<sup>2</sup> ( $R_{adj}^2$ ) of each GAM model, and the sample size  
 162 (N) fitted into each model.

<b>30 equal interval resolution</b>								
Predictor	Concurvity	$\chi^2$	p-value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N	
T <sub>m</sub>	0.25	1464573.86	< 0.001					
ln MI	0.32	701089.22	< 0.001	0.91	0.89	0.88	405	
Area	0.29	43087.69	< 0.001					
<b>40 equal interval resolution</b>								
Predictor	Concurvity	$\chi^2$	p-value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N	
T <sub>m</sub>	0.25	2092171.65	< 0.001	0.88	0.85	0.84	628	

In MI	0.28	1260857.35	< 0.001
Area	0.29	26796.12	< 0.001

#### 50 equal interval resolution

Predictor	Concurvity	$\chi^2$	p-value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
$T_m$	0.26	2525533.82	< 0.001				
In MI	0.25	1610612.17	< 0.001	0.85	0.81	0.80	896
Area	0.26	20900.22	< 0.001				

#### 60 equal interval resolution

Predictor	Concurvity	$\chi^2$	p-value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
$T_m$	0.25	3001882.59	< 0.001				
In MI	0.24	1830820.53	< 0.001	0.83	0.78	0.77	1182
Area	0.23	23292.10	< 0.001				

163 **Table S6 | Summary of Generalised Additive Models (GAMs) incorporating bioclimatic**  
164 **variables and the geographic extent of climate during the Mid-Holocene (ca. 6 ka) across**  
165 **multiple climatic space resolutions.** Summary statistics of GAMs fitted with species richness as  
166 the response variable. Explanatory variables include recent (1901–1989) temperature index ( $T_m$ , °C)  
167 and natural-log-transformed moisture index (In MI, unitless), and total land area occupied by each  
168 climatic condition (Area,  $km^2$ ) during the Mid-Holocene. Different GAMs were constructed based on  
169 climatic spaces defined by the recent climatic conditions ( $T_m$  and In MI) at four resolutions, with  
170 each climatic axis divided into 30, 40, 50 or 60 equal intervals. Reported metrics for each model  
171 include concurvity,  $\chi^2$  and p-value for each explanatory variable, and explained deviance (Deviance),  
172 predicted  $R^2$  ( $R_{pred}^2$ ) and adjusted  $R^2$  ( $R_{adj}^2$ ) of each GAM model, and the sample size (N) fitted into  
173 each model.

#### 30 equal interval resolution

Predictor	Concurvity	$\chi^2$	p-value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
$T_m$	0.40	1149298.76	< 0.001				
In MI	0.38	720379.97	< 0.001	0.91	0.91	0.90	405

Area	0.28	91266.85	< 0.001				
<b>40 equal interval resolution</b>							
Predictor	Concurvity	$\chi^2$	<i>p</i> -value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
$T_m$	0.39	1542196.05	< 0.001				
ln MI	0.35	996440.98	< 0.001	0.88	0.85	0.84	628
Area	0.30	34971.45	< 0.001				
<b>50 equal interval resolution</b>							
Predictor	Concurvity	$\chi^2$	<i>p</i> -value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
$T_m$	0.39	1855885.52	< 0.001				
ln MI	0.33	1321145.55	< 0.001	0.86	0.82	0.81	896
Area	0.25	75771.48	< 0.001				
<b>60 equal interval resolution</b>							
Predictor	Concurvity	$\chi^2$	<i>p</i> -value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
$T_m$	0.41	2161235.79	< 0.001				
ln MI	0.30	1553946.16	< 0.001	0.83	0.78	0.78	1182
Area	0.23	46616.82	< 0.001				

174 **Table S7 | Summary of Generalised Additive Models (GAMs) incorporating bioclimatic**  
175 **variables and the geographic extent of climate during the pre-industrial period (pre-1850)**  
176 **across multiple climatic space resolutions.** Summary statistics of GAMs fitted with species  
177 richness as the response variable. Explanatory variables include recent (1901–1989) temperature  
178 index ( $T_m$ , °C) and natural-log-transformed moisture index (ln MI, unitless), and total land area  
179 occupied by each climatic condition (Area, km<sup>2</sup>) during the pre-industrial period. Different GAMs  
180 were constructed based on climatic spaces defined by the recent climatic conditions ( $T_m$  and ln MI)  
181 at four resolutions, with each climatic axis divided into 30, 40, 50 or 60 equal intervals. Reported  
182 metrics for each model include concurvity,  $\chi^2$  and *p*-value for each explanatory variable, and  
183 explained deviance (Deviance), predicted  $R^2$  ( $R_{pred}^2$ ) and adjusted  $R^2$  ( $R_{adj}^2$ ) of each GAM model,  
184 and the sample size (N) fitted into each model.

30 equal interval resolution							
Predictor	Concurvity	$\chi^2$	p-value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
$T_m$	0.48	1240918.46	< 0.001				
ln MI	0.34	671161.66	< 0.001	0.91	0.90	0.89	405
Area	0.27	88409.00	< 0.001				
40 equal interval resolution							
Predictor	Concurvity	$\chi^2$	p-value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
$T_m$	0.48	1652612.87	< 0.001				
ln MI	0.33	971836.13	< 0.001	0.89	0.87	0.87	628
Area	0.23	153045.85	< 0.001				
50 equal interval resolution							
Predictor	Concurvity	$\chi^2$	p-value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
$T_m$	0.46	2047651.57	< 0.001				
ln MI	0.30	1270973.81	< 0.001	0.87	0.83	0.83	896
Area	0.21	154572.78	< 0.001				
60 equal interval resolution							
Predictor	Concurvity	$\chi^2$	p-value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
$T_m$	0.49	2470587.64	< 0.001				
ln MI	0.29	1595683.32	< 0.001	0.84	0.79	0.78	1182
Area	0.22	124551.12	< 0.001				

185 **Table S8 | Summary of Generalised Additive Models (GAMs) incorporating bioclimatic**  
 186 **variables and the geographic extent of climate during the recent period (1901–1989) across**  
 187 **multiple climatic space resolutions.** Summary statistics of GAMs fitted with species richness as  
 188 the response variable. Explanatory variables include recent (1901–1989) temperature index ( $T_m$ , °C)  
 189 and natural-log-transformed moisture index (ln MI, unitless), and total land area occupied by each  
 190 climatic condition (Area,  $\text{km}^2$ ) during the recent period. Different GAMs were constructed based on  
 191 climatic spaces defined by the recent climatic conditions ( $T_m$  and ln MI) at four resolutions, with  
 192 each climatic axis divided into 30, 40, 50 or 60 equal intervals. Reported metrics for each model

193 include concurvity,  $\chi^2$  and  $p$ -value for each explanatory variable, and explained deviance (Deviance),  
 194 predicted  $R^2$  ( $R_{\text{pred}}^2$ ) and adjusted  $R^2$  ( $R_{\text{adj}}^2$ ) of each GAM model, and the sample size (N) fitted into  
 195 each model.

30 equal interval resolution							
Predictor	Concurvity	$\chi^2$	$p$ -value	Deviance	$R_{\text{pred}}^2$	$R_{\text{adj}}^2$	N
$T_m$	0.48	1252944.99	< 0.001				
ln MI	0.21	625065.58	< 0.001	0.93	0.94	0.94	405
Area	0.24	250319.58	< 0.001				
40 equal interval resolution							
Predictor	Concurvity	$\chi^2$	$p$ -value	Deviance	$R_{\text{pred}}^2$	$R_{\text{adj}}^2$	N
$T_m$	0.43	1745430.59	< 0.001				
ln MI	0.18	877454.57	< 0.001	0.92	0.91	0.91	628
Area	0.27	352504.99	< 0.001				
50 equal interval resolution							
Predictor	Concurvity	$\chi^2$	$p$ -value	Deviance	$R_{\text{pred}}^2$	$R_{\text{adj}}^2$	N
$T_m$	0.44	2073100.64	< 0.001				
ln MI	0.16	1046454.26	< 0.001	0.90	0.90	0.90	896
Area	0.24	562136.56	< 0.001				
60 equal interval resolution							
Predictor	Concurvity	$\chi^2$	$p$ -value	Deviance	$R_{\text{pred}}^2$	$R_{\text{adj}}^2$	N
$T_m$	0.44	2360696.24	< 0.001				
ln MI	0.15	1236657.04	< 0.001	0.89	0.88	0.88	1182
Area	0.22	752415.89	< 0.001				

196 **Table S9 | Summary of Generalised Additive Models (GAMs) incorporating bioclimatic**  
 197 **variables and the average geographic extent of climate across all selected geological**  
 198 **periods at multiple climatic space resolutions.** Summary statistics of GAMs fitted with species  
 199 richness as the response variable. Explanatory variables include recent (1901–1989) temperature

200 index ( $T_m$ , °C) and natural-log-transformed moisture index (ln MI, unitless), and the mean total land  
 201 area occupied by each climatic condition since its first appearance across all selected climatic  
 202 periods (Area, km<sup>2</sup>). Different GAMs were constructed based on climatic spaces defined by the  
 203 recent climatic conditions ( $T_m$  and ln MI) at four resolutions, with each climatic axis divided into 30,  
 204 40, 50 or 60 equal intervals. Reported metrics for each model include concurnity,  $\chi^2$  and  $p$ -value for  
 205 each explanatory variable, and explained deviance (Deviance), predicted  $R^2$  ( $R_{pred}^2$ ) and adjusted  
 206  $R^2$  ( $R_{adj}^2$ ) of each GAM model, and the sample size (N) fitted into each model.

30 equal interval resolution							
Predictor	Concurvity	$\chi^2$	$p$ -value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
$T_m$	0.56	1095137.37	< 0.001				
ln MI	0.26	540113.96	< 0.001	0.90	0.88	0.87	405
Area	0.38	21689.69	< 0.001				
40 equal interval resolution							
Predictor	Concurvity	$\chi^2$	$p$ -value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
$T_m$	0.54	1441724.54	< 0.001				
ln MI	0.23	665310.71	< 0.001	0.88	0.85	0.84	628
Area	0.38	29428.30	< 0.001				
50 equal interval resolution							
Predictor	Concurvity	$\chi^2$	$p$ -value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
$T_m$	0.51	1593777.78	< 0.001				
ln MI	0.21	821338.15	< 0.001	0.86	0.82	0.81	896
Area	0.38	86385.99	< 0.001				
60 equal interval resolution							
Predictor	Concurvity	$\chi^2$	$p$ -value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
$T_m$	0.54	1830603.38	< 0.001				
ln MI	0.20	903978.79	< 0.001	0.84	0.79	0.78	1182
Area	0.35	115607.59	< 0.001				

207 **Table S10 | Relative importance of explanatory variables in Generalised Additive Models**  
 208 (**GAMs**) incorporating bioclimatic variables and the geographic extent of climate. Summary of  
 209 the relative importance of each explanatory variable in GAMs fitted across different geological  
 210 periods and multiple climatic space resolutions. Climatic space is defined by the recent (1901–1989)  
 211 climatic conditions ( $T_m$  and  $\ln MI$ ), partitioned into 30, 40, 50 or 60 equal intervals along each axis.  
 212 Species richness is the response variable. Explanatory variables include recent (1901–1989)  
 213 temperature index ( $T_m$ , °C) and natural-log-transformed moisture index ( $\ln MI$ , unitless), and total  
 214 land area occupied by each climatic condition (Area,  $\text{km}^2$ ) during different geological periods. The  
 215 method for calculating the relative importance of each explanatory variable is described in the  
 216 Methods section of the main text.

30 equal interval resolution				
Geological period	$T_m$	$\ln MI$	Area	Unexplained
Eocene (ca. 50 Ma)	33.48%	42.52%	15.69%	8.31%
Mid-Pliocene (3.3–3.0 Ma)	27.97%	30.72%	32.43%	8.88%
Last Glacial Maximum (LGM, 22–18 ka)	32.73%	28.20%	29.85%	9.22%
Mid-Holocene (ca. 6 ka)	27.94%	28.03%	35.39%	8.64%
Pre-industrial (pre-1850)	28.41%	27.77%	35.16%	8.67%
Recent period (1901–1989)	28.60%	27.34%	37.46%	6.60%
Mean	27.15%	27.03%	36.31%	9.51%

40 equal interval resolution				
Geological period	$T_m$	$\ln MI$	Area	Unexplained
Eocene	34.76%	39.48%	15.18%	10.58%

(ca. 50 Ma)

Mid-Pliocene (3.3–3.0 Ma)	28.15%	28.90%	31.59%	11.37%
Last Glacial Maximum (LGM, 22–18 ka)	34.46%	28.02%	25.66%	11.87%
Mid-Holocene (ca. 6 ka)	28.77%	26.54%	32.91%	11.79%
Pre-industrial (pre-1850)	29.04%	26.40%	33.84%	10.72%
Recent period (1901–1989)	30.01%	25.84%	35.67%	8.48%
Mean	27.96%	25.14%	35.04%	11.85%

#### 50 equal interval resolution

Geological period	T <sub>m</sub>	In MI	Area	Unexplained
Eocene (ca. 50 Ma)	33.23%	38.20%	15.55%	13.02%
Mid-Pliocene (3.3–3.0 Ma)	28.23%	28.95%	28.93%	13.89%
Last Glacial Maximum (LGM, 22–18 ka)	34.00%	27.65%	23.84%	14.51%
Mid-Holocene (ca. 6 ka)	28.32%	26.29%	31.33%	14.06%
Pre-industrial (pre-1850)	28.95%	26.10%	31.50%	13.45%
Recent period (1901–1989)	29.42%	25.11%	35.60%	9.88%
Mean	26.88%	24.45%	34.71%	13.96%

#### 60 equal interval resolution

Geological period	T <sub>m</sub>	In MI	Area	Unexplained
Eocene (ca. 50 Ma)	33.67%	35.90%	14.40%	16.02%
Mid-Pliocene (3.3–3.0 Ma)	28.77%	28.33%	26.38%	16.53%
Last Glacial Maximum (LGM, 22–18 ka)	34.59%	26.37%	21.98%	17.06%
Mid-Holocene (ca. 6 ka)	28.45%	25.14%	29.52%	16.89%
Pre-industrial (pre-1850)	29.64%	25.23%	28.79%	16.34%
Recent period (1901–1989)	29.51%	23.96%	35.19%	11.34%
Mean	27.12%	22.95%	33.56%	16.37%

217 **Table S11 | Summary of Generalised Linear Models (GLMs) incorporating bioclimatic**  
 218 **variables and the geographic extent of climate.** Summary of both linear GLMs and quadratic  
 219 GLMs incorporating second-order polynomial terms to account for non-linear relationships,  
 220 developed for each geological period. All models were constructed based on a climatic space  
 221 defined by the recent (1901–1989) climatic conditions (T<sub>m</sub> and In MI), partitioned into 30 equal  
 222 intervals along each axis. Species richness is the response variable. Explanatory variables include  
 223 recent (1901–1989) temperature index (T<sub>m</sub>, °C) and natural-log-transformed moisture index (In MI,  
 224 unitless), and total land area occupied by each climatic condition (Area, km<sup>2</sup>) during different  
 225 geological periods. The table reports key model statistics, including deviance, McFadden's R<sup>2</sup>,  
 226 Akaike information criterion (AIC) and sample size (N) for each model.

Geological period	Model	Deviance	McFadden's R <sup>2</sup>	AIC	N
Eocene (ca. 50 Ma)	Linear	4557951.76	0.42	4562008.83	405
	Quadratic	3350951.63	0.57	3355014.69	

Mid-Pliocene (3.3–3.0 Ma)	Linear	3794049.22	0.52	3798106.28	405
	Quadratic	2330398.35	0.70	2334461.41	
Last Glacial Maximum (LGM, 22–18 ka)	Linear	3044519.46	0.61	3048576.53	405
	Quadratic	1948587.22	0.75	1952650.29	
Mid-Holocene (ca. 6 ka)	Linear	3165583.22	0.60	3169640.28	405
	Quadratic	1781927.91	0.77	1785990.98	
Pre-industrial (pre-1850)	Linear	3455835.36	0.56	3459892.42	405
	Quadratic	1751546.27	0.78	1755609.34	
Recent period (1901–1989)	Linear	3466057.64	0.56	3470114.70	405
	Quadratic	1414545.75	0.82	1418608.81	
Mean	Linear	2836269.57	0.64	2840326.64	405
	Quadratic	1427989.61	0.82	1432052.68	

228 **Table S12 | Coefficients of explanatory variables in Generalised Linear Models (GLMs) incorporating bioclimatic variables and the**  
 229 **geographic extent of climate.** Summary of the coefficients (Estimate and *p*-value) of explanatory variables in both linear GLMs and quadratic GLMs  
 230 incorporating second-order polynomial terms to account for non-linear relationships, developed for each geological period. All models were  
 231 constructed based on a climatic space defined by the recent (1901–1989) climatic conditions ( $T_m$  and  $\ln MI$ ), partitioned into 30 equal intervals along  
 232 each axis. Species richness is the response variable. Explanatory variables include recent (1901–1989) temperature index ( $T_m$ , °C) and  
 233 natural-log-transformed moisture index ( $\ln MI$ , unitless), and total land area occupied by each climatic condition (Area,  $\text{km}^2$ ) during different  
 234 geological periods.

Geological period	Model	Coefficient	$T_m$	$T_m^2$	$\ln MI$	$\ln MI^2$	Area	Area <sup>2</sup>
Eocene (ca. 50 Ma)	Linear	Estimate	$5.54 \times 10^{-2}$	--	$2.28 \times 10^{-1}$	--	$1.55 \times 10^{-7}$	--
		<i>p</i> -value	< 0.001	--	< 0.001	--	< 0.001	--
	Quadratic	Estimate	$1.26 \times 10^{-1}$	$-3.26 \times 10^{-3}$	$7.20 \times 10^{-2}$	$-4.57 \times 10^{-2}$	$8.98 \times 10^{-7}$	$-4.04 \times 10^{-13}$
		<i>p</i> -value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Mid-Pliocene (3.3–3.0 Ma)	Linear	Estimate	$4.07 \times 10^{-2}$	--	$1.72 \times 10^{-1}$	--	$6.82 \times 10^{-7}$	--
		<i>p</i> -value	< 0.001	--	< 0.001	--	< 0.001	--
	Quadratic	Estimate	$1.10 \times 10^{-1}$	$-3.27 \times 10^{-3}$	$9.18 \times 10^{-2}$	$-1.12 \times 10^{-2}$	$2.11 \times 10^{-6}$	$-7.46 \times 10^{-13}$
		<i>p</i> -value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Last Glacial Maximum	Linear	Estimate	$4.92 \times 10^{-2}$	--	$1.83 \times 10^{-1}$	--	$6.22 \times 10^{-7}$	--

(LGM, 22–18 ka)		<i>p</i> -value	< 0.001	--	< 0.001	--	< 0.001	--
Quadratic	Estimate	$9.80 \times 10^{-2}$	$-2.17 \times 10^{-3}$	$1.61 \times 10^{-1}$	$-4.08 \times 10^{-3}$	$1.63 \times 10^{-6}$	$-3.91 \times 10^{-13}$	
	<i>p</i> -value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	
Mid-Holocene	Linear	Estimate	$4.28 \times 10^{-2}$	--	$1.68 \times 10^{-1}$	--	$5.73 \times 10^{-7}$	--
	<i>p</i> -value	< 0.001	--	< 0.001	--	< 0.001	--	
(ca. 6 ka)	Quadratic	Estimate	$1.11 \times 10^{-1}$	$-3.22 \times 10^{-3}$	$1.26 \times 10^{-1}$	$-5.27 \times 10^{-3}$	$1.46 \times 10^{-6}$	$-2.66 \times 10^{-13}$
	<i>p</i> -value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	
Pre-industrial	Linear	Estimate	$4.33 \times 10^{-2}$	--	$1.75 \times 10^{-1}$	--	$5.07 \times 10^{-7}$	--
	<i>p</i> -value	< 0.001	--	< 0.001	--	< 0.001	--	
(pre-1850)	Quadratic	Estimate	$1.26 \times 10^{-1}$	$-4.04 \times 10^{-3}$	$1.10 \times 10^{-1}$	$-6.66 \times 10^{-3}$	$1.50 \times 10^{-6}$	$-2.43 \times 10^{-13}$
	<i>p</i> -value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	
Recent period	Linear	Estimate	$4.34 \times 10^{-2}$	--	$1.88 \times 10^{-1}$	--	$5.37 \times 10^{-7}$	--
	<i>p</i> -value	< 0.001	--	< 0.001	--	< 0.001	--	
(1901–1989)	Quadratic	Estimate	$1.32 \times 10^{-1}$	$-4.21 \times 10^{-3}$	$1.88 \times 10^{-1}$	$4.04 \times 10^{-4}$	$1.88 \times 10^{-6}$	$-3.59 \times 10^{-13}$
	<i>p</i> -value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	
Mean	Linear	Estimate	$3.72 \times 10^{-2}$	--	$1.39 \times 10^{-1}$	--	$9.43 \times 10^{-7}$	--
	<i>p</i> -value	< 0.001	--	< 0.001	--	< 0.001	--	
Quadratic	Estimate	$1.06 \times 10^{-1}$	$-3.28 \times 10^{-3}$	$3.49 \times 10^{-2}$	$-1.43 \times 10^{-2}$	$2.26 \times 10^{-6}$	$-5.26 \times 10^{-13}$	
	<i>p</i> -value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	

235 **Table S13 | Summary of the Generalised Additive Models (GAMs) with species richness as**  
 236 **the response variable and climate and its deep-time geographic dynamics as explanatory**  
 237 **variables for all recent climatic conditions across multiple climatic space resolutions.**  
 238 Summary statistics of GAMs fitted with species richness as the response variable. Explanatory  
 239 variables include:  $T_m$  ( $^{\circ}\text{C}$ ), recent (1901–1989) temperature index;  $\ln \text{MI}$  (unitless), recent  
 240 natural-log-transformed moisture index; Recent Area ( $\text{km}^2$ ), total land area occupied by a climatic  
 241 condition in the recent period;  $\Delta\text{Area}$  ( $\text{km}^2$ ), change in total land area occupied by a climatic  
 242 condition from its earliest occurrence to the recent period; Movement (km), geographic shift of a  
 243 climatic condition since its earliest occurrence to the recent period. Different GAMs were  
 244 constructed based on climatic spaces defined by the recent climatic conditions ( $T_m$  and  $\ln \text{MI}$ ) at four  
 245 resolutions, with each climatic axis divided into 30, 40, 50 or 60 equal intervals. Reported metrics  
 246 for each model include concurvity,  $\chi^2$  and  $p$ -value for each explanatory variable, and explained  
 247 deviance (Deviance), predicted  $R^2$  ( $R_{\text{pred}}^2$ ) and adjusted  $R^2$  ( $R_{\text{adj}}^2$ ) of each GAM model, and the  
 248 sample size (N) fitted into each model.

30 equal interval resolution							
Predictor	Concurvity	$\chi^2$	$p$ -value	Deviance	$R_{\text{pred}}^2$	$R_{\text{adj}}^2$	N
$T_m$	0.68	485359.95	< 0.001				
$\ln \text{MI}$	0.57	243133.72	< 0.001				
Recent Area	0.84	106864.19	< 0.001	0.95	0.95	0.95	342
$\Delta\text{Area}$	0.62	35550.61	< 0.001				
Movement	0.42	41212.21	< 0.001				
40 equal interval resolution							
Predictor	Concurvity	$\chi^2$	$p$ -value	Deviance	$R_{\text{pred}}^2$	$R_{\text{adj}}^2$	N
$T_m$	0.63	656361.87	< 0.001				
$\ln \text{MI}$	0.53	341180.83	< 0.001				
Recent Area	0.76	213932.33	< 0.001	0.93	0.93	0.92	529
$\Delta\text{Area}$	0.55	37366.92	< 0.001				

Movement	0.43	28029.86	< 0.001					
<b>50 equal interval resolution</b>								
Predictor	Concurvity	$\chi^2$	<i>p</i> -value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N	
$T_m$	0.68	824598.86	< 0.001					
In MI	0.50	465665.46	< 0.001					
Recent Area	0.76	325886.77	< 0.001	0.91	0.91	0.91	751	
$\Delta$ Area	0.55	20190.12	< 0.001					
Movement	0.40	55998.89	< 0.001					
<b>60 equal interval resolution</b>								
Predictor	Concurvity	$\chi^2$	<i>p</i> -value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N	
$T_m$	0.61	885554.69	< 0.001					
In MI	0.48	591684.02	< 0.001					
Recent Area	0.77	381718.80	< 0.001	0.90	0.90	0.89	986	
$\Delta$ Area	0.55	40336.41	< 0.001					
Movement	0.39	90781.19	< 0.001					

249 **Table S14 | Summary of the Generalised Additive Models (GAMs) with species richness as**  
 250 **the response variable and climate and its deep-time geographic dynamics as explanatory**  
 251 **variables for recent climatic conditions that first appeared in the Eocene (ca. 50 Ma), across**  
 252 **multiple climatic space resolutions.** Summary statistics of GAMs fitted with species richness as  
 253 the response variable. Explanatory variables include:  $T_m$  ( $^{\circ}$ C), recent (1901–1989) temperature  
 254 index; In MI (unitless), recent natural-log-transformed moisture index; Recent Area ( $km^2$ ), total land  
 255 area occupied by a climatic condition in the recent period;  $\Delta$ Area ( $km^2$ ), change in total land area  
 256 occupied by a climatic condition from its earliest occurrence (i.e. Eocene) to the recent period;  
 257 Movement (km), geographic shift of a climatic condition since its earliest occurrence (i.e. Eocene) to  
 258 the recent period. Different GAMs were constructed based on climatic spaces defined by the recent  
 259 climatic conditions ( $T_m$  and In MI) at four resolutions, with each climatic axis divided into 30, 40, 50  
 260 or 60 equal intervals. Reported metrics for each model include concurvity,  $\chi^2$  and *p*-value for each

261 explanatory variable, and explained deviance (Deviance), predicted  $R^2$  ( $R_{pred}^2$ ) and adjusted  $R^2$   
 262 ( $R_{adj}^2$ ) of each GAM model, and the sample size (N) fitted into each model.

30 equal interval resolution							
Predictor	Concurvity	$\chi^2$	p-value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
T <sub>m</sub>	0.69	208593.97	< 0.001				
In MI	0.82	161160.60	< 0.001				
Recent Area	0.77	29935.28	< 0.001	0.92	0.92	0.90	88
$\Delta$ Area	0.79	15949.11	< 0.001				
Movement	0.47	37054.35	< 0.001				
40 equal interval resolution							
Predictor	Concurvity	$\chi^2$	p-value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
T <sub>m</sub>	0.75	156233.82	< 0.001				
In MI	0.82	146852.11	< 0.001				
Recent Area	0.87	85445.79	< 0.001	0.95	0.96	0.94	137
$\Delta$ Area	0.72	13256.22	< 0.001				
Movement	0.66	16157.92	< 0.001				
50 equal interval resolution							
Predictor	Concurvity	$\chi^2$	p-value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
T <sub>m</sub>	0.70	228305.67	< 0.001				
In MI	0.80	144820.57	< 0.001				
Recent Area	0.83	111722.55	< 0.001	0.94	0.95	0.93	195
$\Delta$ Area	0.70	19006.82	< 0.001				
Movement	0.59	16238.15	< 0.001				
60 equal interval resolution							
Predictor	Concurvity	$\chi^2$	p-value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
T <sub>m</sub>	0.66	245215.03	< 0.001				
In MI	0.77	219098.10	< 0.001	0.93	0.93	0.91	258

Recent Area	0.85	132211.70	< 0.001
ΔArea	0.72	14352.42	< 0.001
Movement	0.45	30592.89	< 0.001

263 **Table S15 | Summary of the Generalised Additive Models (GAMs) with species richness as**  
 264 **the response variable and climate and its deep-time geographic dynamics as explanatory**  
 265 **variables for recent climatic conditions that first appeared in the Mid-Pliocene (3.3–3.0 Ma),**  
 266 **across multiple climatic space resolutions.** Summary statistics of GAMs fitted with species  
 267 richness as the response variable. Explanatory variables include:  $T_m$  ( $^{\circ}$ C), recent (1901–1989)  
 268 temperature index;  $\ln MI$  (unitless), recent natural-log-transformed moisture index; Recent Area  
 269 ( $\text{km}^2$ ), total land area occupied by a climatic condition in the recent period;  $\Delta\text{Area}$  ( $\text{km}^2$ ), change in  
 270 total land area occupied by a climatic condition from its earliest occurrence (i.e. Mid-Pliocene) to the  
 271 recent period; Movement (km), geographic shift of a climatic condition since its earliest occurrence  
 272 (i.e. Mid-Pliocene) to the recent period. Different GAMs were constructed based on climatic spaces  
 273 defined by the recent climatic conditions ( $T_m$  and  $\ln MI$ ) at four resolutions, with each climatic axis  
 274 divided into 30, 40, 50 or 60 equal intervals. Reported metrics for each model include concurvity,  $\chi^2$   
 275 and  $p$ -value for each explanatory variable, and explained deviance (Deviance), predicted  $R^2$  ( $R_{\text{pred}}^2$ )  
 276 and adjusted  $R^2$  ( $R_{\text{adj}}^2$ ) of each GAM model, and the sample size (N) fitted into each model.

30 equal interval resolution							
Predictor	Concurvity	$\chi^2$	$p$ -value	Deviance	$R_{\text{pred}}^2$	$R_{\text{adj}}^2$	N
$T_m$	0.74	124085.91	< 0.001				
$\ln MI$	0.69	80856.61	< 0.001				
Recent Area	0.56	109540.94	< 0.001	0.94	0.94	0.93	140
ΔArea	0.22	497.03	< 0.001				
Movement	0.48	9512.98	< 0.001				
40 equal interval resolution							
Predictor	Concurvity	$\chi^2$	$p$ -value	Deviance	$R_{\text{pred}}^2$	$R_{\text{adj}}^2$	N
$T_m$	0.78	171294.45	< 0.001	0.94	0.95	0.93	212

In MI	0.66	127666.29	< 0.001
Recent Area	0.81	32466.22	< 0.001
ΔArea	0.60	10527.97	< 0.001
Movement	0.45	15544.55	< 0.001

#### 50 equal interval resolution

Predictor	Concurvity	$\chi^2$	p-value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
T <sub>m</sub>	0.74	248967.86	< 0.001				
In MI	0.64	180867.76	< 0.001				
Recent Area	0.71	57224.37	< 0.001	0.93	0.93	0.92	307
ΔArea	0.52	20857.56	< 0.001				
Movement	0.42	26931.11	< 0.001				

#### 60 equal interval resolution

Predictor	Concurvity	$\chi^2$	p-value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
T <sub>m</sub>	0.73	229332.72	< 0.001				
In MI	0.64	227880.25	< 0.001				
Recent Area	0.84	69952.47	< 0.001	0.90	0.89	0.88	411
ΔArea	0.63	22303.51	< 0.001				
Movement	0.40	32335.03	< 0.001				

277 **Table S16 | Summary of the Generalised Additive Models (GAMs) with species richness as**  
278 **the response variable and climate and its deep-time geographic dynamics as explanatory**  
279 **variables for recent climatic conditions that first appeared in the Last Glacial Maximum (LGM,**  
280 **22–18 ka), across multiple climatic space resolutions.** Summary statistics of GAMs fitted with  
281 species richness as the response variable. Explanatory variables include: T<sub>m</sub> (°C), recent (1901–  
282 1989) temperature index; In MI (unitless), recent natural-log-transformed moisture index; Recent  
283 Area (km<sup>2</sup>), total land area occupied by a climatic condition in the recent period; ΔArea (km<sup>2</sup>),  
284 change in total land area occupied by a climatic condition from its earliest occurrence (i.e. LGM) to  
285 the recent period; Movement (km), geographic shift of a climatic condition since its earliest  
286 occurrence (i.e. LGM) to the recent period. Different GAMs were constructed based on climatic

287 spaces defined by the recent climatic conditions ( $T_m$  and  $\ln MI$ ) at four resolutions, with each  
 288 climatic axis divided into 30, 40, 50 or 60 equal intervals. Reported metrics for each model include  
 289 concrury,  $\chi^2$  and  $p$ -value for each explanatory variable, and explained deviance (Deviance),  
 290 predicted  $R^2$  ( $R_{pred}^2$ ) and adjusted  $R^2$  ( $R_{adj}^2$ ) of each GAM model, and the sample size (N) fitted into  
 291 each model.

30 equal interval resolution							
Predictor	Concruvity	$\chi^2$	$p$ -value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
$T_m$	0.87	29297.00	< 0.001				
$\ln MI$	0.86	10462.70	< 0.001				
Recent Area	0.85	4936.89	< 0.001	0.86	0.79	0.74	96
$\Delta$ Area	0.53	435.82	< 0.001				
Movement	0.54	6219.60	< 0.001				
40 equal interval resolution							
Predictor	Concruvity	$\chi^2$	$p$ -value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
$T_m$	0.90	33161.67	< 0.001				
$\ln MI$	0.86	7298.11	< 0.001				
Recent Area	0.88	9135.40	< 0.001	0.93	0.94	0.91	146
$\Delta$ Area	0.61	2011.42	< 0.001				
Movement	0.61	3888.90	< 0.001				
50 equal interval resolution							
Predictor	Concruvity	$\chi^2$	$p$ -value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
$T_m$	0.86	43972.48	< 0.001				
$\ln MI$	0.80	6645.51	< 0.001				
Recent Area	0.86	8718.15	< 0.001	0.89	0.88	0.84	197
$\Delta$ Area	0.62	2742.06	< 0.001				
Movement	0.39	6989.94	< 0.001				
60 equal interval resolution							

Predictor	Concurvity	$\chi^2$	p-value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
$T_m$	0.87	55468.33	< 0.001				
ln MI	0.77	9558.44	< 0.001				
Recent Area	0.86	14550.80	< 0.001	0.89	0.88	0.85	255
$\Delta$ Area	0.57	2113.34	< 0.001				
Movement	0.31	13362.34	< 0.001				

292 **Table S17 | Relative importance of explanatory variables in Generalised Additive Models**  
 293 **(GAMs) with species richness as the response variable and climate and its deep-time**  
 294 **geographic dynamics as explanatory variables.** Summary of the relative importance of each  
 295 explanatory variable in GAMs fitted for all recent climatic conditions, as well as separately according  
 296 to their first appearance. Species richness is the response variable. Explanatory variables include:  
 297  $T_m$  ( $^{\circ}$ C), recent (1901–1989) temperature index; ln MI (unitless), recent natural-log-transformed  
 298 moisture index; Recent Area ( $km^2$ ), total land area occupied by a climatic condition in the recent  
 299 period;  $\Delta$ Area ( $km^2$ ), change in total land area occupied by a climatic condition from its earliest  
 300 occurrence to the recent period; Movement (km), geographic shift of a climatic condition since its  
 301 earliest occurrence to the recent period. Different GAMs were constructed based on climatic spaces  
 302 defined by the recent climatic conditions ( $T_m$  and ln MI) at four resolutions, with each climatic axis  
 303 divided into 30, 40, 50 or 60 equal intervals. The method for calculating the relative importance of  
 304 each explanatory variable is described in the Methods section of the main text.

30 equal interval resolution						
Geological period	$T_m$	ln MI	Recent Area	$\Delta$ Area	Movement	Unexplained
All periods	19.68%	19.19%	26.77%	9.34%	20.05%	4.97%
Eocene (ca. 50 Ma)	20.93%	28.68%	23.22%	9.76%	9.07%	8.33%
Mid-Pliocene (3.3–3.0 Ma)	18.15%	25.46%	27.45%	2.45%	20.21%	6.29%
Last Glacial Maximum	29.47%	24.21%	16.96%	11.09%	4.26%	14.01%

(LGM, 22–18 ka)

40 equal interval resolution						
Geological period	T <sub>m</sub>	In MI	Area	ΔArea	Movement	Unexplained
All periods	20.24%	18.24%	25.90%	9.24%	19.25%	7.13%
Eocene (ca. 50 Ma)	23.53%	25.84%	25.23%	10.18%	10.57%	4.65%
Mid-Pliocene (3.3–3.0 Ma)	17.59%	25.68%	26.08%	6.47%	18.62%	5.56%
Last Glacial Maximum (LGM, 22–18 ka)	28.99%	21.79%	22.54%	14.51%	5.17%	7.00%
50 equal interval resolution						
Geological period	T <sub>m</sub>	In MI	Area	ΔArea	Movement	Unexplained
All periods	19.80%	17.71%	25.36%	9.86%	18.75%	8.52%
Eocene (ca. 50 Ma)	21.89%	24.49%	26.06%	11.10%	10.51%	5.94%
Mid-Pliocene (3.3–3.0 Ma)	18.11%	24.24%	22.87%	9.50%	18.66%	6.62%
Last Glacial Maximum (LGM, 22–18 ka)	30.20%	21.19%	19.61%	13.88%	4.25%	10.86%
60 equal interval resolution						
Geological period	T <sub>m</sub>	In MI	Area	ΔArea	Movement	Unexplained
All periods	19.85%	16.96%	24.59%	9.85%	19.12%	9.63%
Eocene (ca. 50 Ma)	22.60%	24.90%	24.78%	10.14%	10.14%	7.44%
Mid-Pliocene (3.3–3.0 Ma)	15.84%	22.54%	23.56%	9.80%	17.84%	10.44%
Last Glacial Maximum (LGM, 22–18 ka)	28.87%	20.58%	19.49%	13.07%	6.84%	11.15%

305 **Table S18 | Summary of Generalised Linear Models (GLMs) with species richness as the**  
 306 **response variable and climate and its deep-time geographic dynamics as explanatory**  
 307 **variables.** Summary of both linear GLMs and quadratic GLMs incorporating second-order  
 308 polynomial terms to account for non-linear relationships, developed for all recent climatic conditions,  
 309 as well as separately according to their first appearance. Species richness is the response variable.  
 310 Explanatory variables include:  $T_m$  ( $^{\circ}\text{C}$ ), recent (1901–1989) temperature index;  $\ln \text{MI}$  (unitless),  
 311 recent natural-log-transformed moisture index; Recent Area ( $\text{km}^2$ ), total land area occupied by a  
 312 climatic condition in the recent period;  $\Delta\text{Area}$  ( $\text{km}^2$ ), change in total land area occupied by a climatic  
 313 condition from its earliest occurrence to the recent period; Movement (km), geographic shift of a  
 314 climatic condition since its earliest occurrence to the recent period. Different GLMs were  
 315 constructed based on climatic spaces defined by the recent climatic conditions ( $T_m$  and  $\ln \text{MI}$ ) at four  
 316 resolutions, with each climatic axis divided into 30, 40, 50 or 60 equal intervals. The table reports  
 317 key model statistics, including deviance, McFadden's  $R^2$ , Akaike information criterion (AIC) and  
 318 sample size (N) for each model.

Geological period	Model	Deviance	McFadden's $R^2$	AIC	N
All periods	Linear	2865670.43	0.58	2869198.44	342
	Quadratic	1051793.47	0.85	1055331.47	
Eocene (ca. 50 Ma)	Linear	1196024.18	0.43	1197042.33	88
	Quadratic	355709.28	0.83	356737.43	
Mid-Pliocene (3.3–3.0 Ma)	Linear	669166.38	0.65	670670.58	140
	Quadratic	126914.60	0.93	128428.79	
Last Glacial Maximum (LGM, 22–18 ka)	Linear	147733.41	0.48	148620.13	96
	Quadratic	64219.10	0.77	65115.82	

319

320 **Table S19 | Coefficients of explanatory variables in Generalised Linear Models (GLMs) with species richness as the response variable and**  
 321 **climate and its deep-time geographic dynamics as explanatory variables.** Summary of the coefficients (Estimate and *p*-value) of explanatory  
 322 variables in both linear GLMs and quadratic GLMs incorporating second-order polynomial terms to account for non-linear relationships, developed for  
 323 all recent climatic conditions, as well as separately according to their first appearance. Species richness is the response variable. Explanatory  
 324 variables include:  $T_m$  ( $^{\circ}\text{C}$ ), recent (1901–1989) temperature index;  $\text{In MI}$  (unitless), recent natural-log-transformed moisture index; Recent Area ( $\text{km}^2$ ),  
 325 total land area occupied by a climatic condition in the recent period;  $\Delta\text{Area}$  ( $\text{km}^2$ ), change in total land area occupied by a climatic condition from its  
 326 earliest occurrence to the recent period; Movement (km), geographic shift of a climatic condition since its earliest occurrence to the recent period.  
 327 Different GLMs were constructed based on climatic spaces defined by the recent climatic conditions ( $T_m$  and  $\text{In MI}$ ) at four resolutions, with each  
 328 climatic axis divided into 30, 40, 50 or 60 equal intervals.

Geological period	Model	Coefficient	$T_m$	$T_m^2$	$\text{In MI}$	$\text{In MI}^2$	Recent	Recent	$\Delta\text{Area}$	$\Delta\text{Area}^2$	Movement	$\text{Movement}^2$
							Area	Area <sup>2</sup>				
All periods	Linear	Estimate	$3.24 \times 10^{-2}$	--	$1.78 \times 10^{-1}$	--	$5.21 \times 10^{-7}$	--	$-4.11 \times 10^{-8}$	--	$8.70 \times 10^{-5}$	--
		<i>p</i> -value	< 0.001	--	< 0.001	--	< 0.001	--	< 0.001	--	< 0.001	--
	Quadratic	Estimate	$1.27 \times 10^{-1}$	$-3.94 \times 10^{-3}$	$1.22 \times 10^{-1}$	$-4.05 \times 10^{-2}$	$1.51 \times 10^{-6}$	$-2.81 \times 10^{-13}$	$4.03 \times 10^{-8}$	$-3.64 \times 10^{-15}$	$2.05 \times 10^{-4}$	$-1.35 \times 10^{-8}$
		<i>p</i> -value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Eocene (ca. 50 Ma)	Linear	Estimate	$3.55 \times 10^{-3}$	--	$9.83 \times 10^{-2}$	--	$3.88 \times 10^{-7}$	--	$1.05 \times 10^{-7}$	--	$8.71 \times 10^{-5}$	--
		<i>p</i> -value	< 0.001	--	< 0.001	--	< 0.001	--	< 0.001	--	< 0.001	--

		Quadratic	Estimate	$3.94 \times 10^{-1}$	$-9.90 \times 10^{-3}$	$1.77 \times 10^{-1}$	$-3.11 \times 10^{-1}$	$7.32 \times 10^{-7}$	$-1.33 \times 10^{-13}$	$1.50 \times 10^{-7}$	$-1.83 \times 10^{-14}$	$-2.11 \times 10^{-4}$	$5.30 \times 10^{-9}$
			<i>p</i> -value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Mid-Pliocene (3.3–3.0 Ma)		Linear	Estimate	$3.66 \times 10^{-2}$	--	$1.87 \times 10^{-1}$	--	$1.54 \times 10^{-6}$	--	$-1.62 \times 10^{-7}$	--	$1.20 \times 10^{-4}$	--
			<i>p</i> -value	< 0.001	--	< 0.001	--	< 0.001	--	< 0.001	--	< 0.001	--
Last Glacial Maximum (LGM, 22–18 ka)		Quadratic	Estimate	$1.43 \times 10^{-1}$	$-4.23 \times 10^{-3}$	$1.78 \times 10^{-1}$	$-3.00 \times 10^{-2}$	$3.87 \times 10^{-6}$	$-2.16 \times 10^{-12}$	$2.53 \times 10^{-8}$	$-3.59 \times 10^{-15}$	$2.20 \times 10^{-4}$	$-1.42 \times 10^{-8}$
			<i>p</i> -value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.14	< 0.001	< 0.001
		Linear	Estimate	$7.04 \times 10^{-2}$	--	$1.07 \times 10^{-1}$	--	$1.19 \times 10^{-6}$	--	$2.25 \times 10^{-7}$	--	$-5.49 \times 10^{-5}$	--
			<i>p</i> -value	< 0.001	--	< 0.001	--	< 0.001	--	< 0.001	--	< 0.001	--
		Quadratic	Estimate	$6.88 \times 10^{-2}$	$-1.16 \times 10^{-3}$	$-3.17 \times 10^{-1}$	$-1.08 \times 10^{-1}$	$3.86 \times 10^{-6}$	$-2.54 \times 10^{-12}$	$-9.89 \times 10^{-9}$	$-5.62 \times 10^{-14}$	$5.59 \times 10^{-5}$	$-5.16 \times 10^{-9}$
			<i>p</i> -value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.38	< 0.001	< 0.001	< 0.001

330 **Table S20 | Summary of the Generalised Additive Models (GAMs) with species turnover as**  
 331 **the response variable and climate and its deep-time geographic dynamics as explanatory**  
 332 **variables for all recent climatic conditions across multiple climatic space resolutions.**  
 333 Summary statistics of GAMs fitted with turnover component of  $\beta$ -diversity as the response variable.  
 334 Explanatory variables include:  $T_m$  ( $^{\circ}\text{C}$ ), recent (1901–1989) temperature index;  $\ln \text{MI}$  (unitless),  
 335 recent natural-log-transformed moisture index; Recent Area ( $\text{km}^2$ ), total land area occupied by a  
 336 climatic condition in the recent period;  $\Delta\text{Area}$  ( $\text{km}^2$ ), change in total land area occupied by a climatic  
 337 condition from its earliest occurrence to the recent period; Movement (km), geographic shift of a  
 338 climatic condition since its earliest occurrence to the recent period. Different GAMs were  
 339 constructed based on climatic spaces defined by the recent climatic conditions ( $T_m$  and  $\ln \text{MI}$ ) at four  
 340 resolutions, with each climatic axis divided into 30, 40, 50 or 60 equal intervals. Reported metrics  
 341 for each model include concurvity,  $\chi^2$  and  $p$ -value for each explanatory variable, and explained  
 342 deviance (Deviance), predicted  $R^2$  ( $R_{\text{pred}}^2$ ) and adjusted  $R^2$  ( $R_{\text{adj}}^2$ ) of each GAM model, and the  
 343 sample size (N) fitted into each model.

30 equal interval resolution							
Predictor	Concurvity	$\chi^2$	$p$ -value	Deviance	$R_{\text{pred}}^2$	$R_{\text{adj}}^2$	N
$T_m$	0.65	63.00	< 0.001				
$\ln \text{MI}$	0.54	7.31	0.11				
Recent Area	0.84	122.41	< 0.001	0.74	0.77	0.75	297
$\Delta\text{Area}$	0.63	2.28	0.13				
Movement	0.46	61.57	< 0.001				
40 equal interval resolution							
Predictor	Concurvity	$\chi^2$	$p$ -value	Deviance	$R_{\text{pred}}^2$	$R_{\text{adj}}^2$	N
$T_m$	0.66	114.00	< 0.001				
$\ln \text{MI}$	0.51	17.04	< 0.05				
Recent Area	0.76	159.96	< 0.001	0.72	0.75	0.73	464
$\Delta\text{Area}$	0.55	7.96	< 0.001				

Movement	0.49	93.95	< 0.001				
<b>50 equal interval resolution</b>							
Predictor	Concurvity	$\chi^2$	p-value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
$T_m$	0.67	107.91	< 0.001				
In MI	0.55	18.51	< 0.01				
Recent Area	0.76	119.50	< 0.001	0.64	0.65	0.63	638
$\Delta$ Area	0.58	14.60	< 0.001				
Movement	0.49	58.31	< 0.001				
<b>60 equal interval resolution</b>							
Predictor	Concurvity	$\chi^2$	p-value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
$T_m$	0.66	127.13	< 0.001				
In MI	0.53	40.57	< 0.001				
Recent Area	0.77	94.97	< 0.001	0.57	0.63	0.62	830
$\Delta$ Area	0.57	2.57	0.14				
Movement	0.46	70.44	< 0.001				

344 **Table S21 | Summary of the Generalised Additive Models (GAMs) with species turnover as**  
 345 **the response variable and climate and its deep-time geographic dynamics as explanatory**  
 346 **variables for recent climatic conditions that first appeared in the Eocene (ca. 50 Ma), across**  
 347 **multiple climatic space resolutions.** Summary statistics of GAMs fitted with turnover component  
 348 of  $\beta$ -diversity as the response variable. Explanatory variables include:  $T_m$  ( $^{\circ}$ C), recent (1901–1989)  
 349 temperature index; In MI (unitless), recent natural-log-transformed moisture index; Recent Area  
 350 ( $km^2$ ), total land area occupied by a climatic condition in the recent period;  $\Delta$ Area ( $km^2$ ), change in  
 351 total land area occupied by a climatic condition from its earliest occurrence (i.e. Eocene) to the  
 352 recent period; Movement (km), geographic shift of a climatic condition since its earliest occurrence  
 353 (i.e. Eocene) to the recent period. Different GAMs were constructed based on climatic spaces  
 354 defined by the recent climatic conditions ( $T_m$  and In MI) at four resolutions, with each climatic axis  
 355 divided into 30, 40, 50 or 60 equal intervals. Reported metrics for each model include concurvity,  $\chi^2$

356 and  $p$ -value for each explanatory variable, and explained deviance (Deviance), predicted  $R^2$  ( $R_{pred}^2$ )  
 357 and adjusted  $R^2$  ( $R_{adj}^2$ ) of each GAM model, and the sample size (N) fitted into each model.

30 equal interval resolution							
Predictor	Concurvity	$\chi^2$	$p$ -value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
$T_m$	0.78	14.00	< 0.05				
ln MI	0.85	15.94	< 0.001				
Recent Area	0.91	61.21	< 0.001	0.89	0.86	0.82	82
$\Delta$ Area	0.80	0.63	0.43				
Movement	0.73	19.84	< 0.001				
40 equal interval resolution							
Predictor	Concurvity	$\chi^2$	$p$ -value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
$T_m$	0.77	81.62	< 0.001				
ln MI	0.86	9.20	< 0.05				
Recent Area	0.87	49.77	< 0.001	0.77	0.76	0.71	127
$\Delta$ Area	0.75	1.83	0.31				
Movement	0.74	18.76	< 0.001				
50 equal interval resolution							
Predictor	Concurvity	$\chi^2$	$p$ -value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
$T_m$	0.72	22.73	< 0.001				
ln MI	0.82	1.43	0.23				
Recent Area	0.82	45.56	< 0.001	0.52	0.60	0.54	184
$\Delta$ Area	0.71	3.20	0.07				
Movement	0.65	9.09	< 0.001				
60 equal interval resolution							
Predictor	Concurvity	$\chi^2$	$p$ -value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
$T_m$	0.72	63.45	< 0.001				
ln MI	0.79	6.74	0.13	0.60	0.66	0.61	236
Recent Area	0.85	21.21	< 0.001				

ΔArea	0.73	0.05	0.82
Movement	0.54	43.59	< 0.001

358 **Table S22 | Summary of the Generalised Additive Models (GAMs) with species turnover as**  
 359 **the response variable and climate and its deep-time geographic dynamics as explanatory**  
 360 **variables for recent climatic conditions that first appeared in the Mid-Pliocene (3.3–3.0 Ma),**  
 361 **across multiple climatic space resolutions.** Summary statistics of GAMs fitted with turnover  
 362 component of  $\beta$ -diversity as the response variable. Explanatory variables include:  $T_m$  ( $^{\circ}\text{C}$ ), recent  
 363 (1901–1989) temperature index;  $\text{In MI}$  (unitless), recent natural-log-transformed moisture index;  
 364 Recent Area ( $\text{km}^2$ ), total land area occupied by a climatic condition in the recent period;  $\Delta\text{Area}$  ( $\text{km}^2$ ),  
 365 change in total land area occupied by a climatic condition from its earliest occurrence (i.e.  
 366 Mid-Pliocene) to the recent period; Movement (km), geographic shift of a climatic condition since its  
 367 earliest occurrence (i.e. Mid-Pliocene) to the recent period. Different GAMs were constructed based  
 368 on climatic spaces defined by the recent climatic conditions ( $T_m$  and  $\text{In MI}$ ) at four resolutions, with  
 369 each climatic axis divided into 30, 40, 50 or 60 equal intervals. Reported metrics for each model  
 370 include concurvity,  $\chi^2$  and  $p$ -value for each explanatory variable, and explained deviance (Deviance),  
 371 predicted  $R^2$  ( $R_{\text{pred}}^2$ ) and adjusted  $R^2$  ( $R_{\text{adj}}^2$ ) of each GAM model, and the sample size (N) fitted into  
 372 each model.

30 equal interval resolution							
Predictor	Concurvity	$\chi^2$	$p$ -value	Deviance	$R_{\text{pred}}^2$	$R_{\text{adj}}^2$	N
$T_m$	0.80	10.01	< 0.05				
$\text{In MI}$	0.75	12.77	< 0.01				
Recent Area	0.82	46.59	< 0.001	0.76	0.77	0.74	128
$\Delta\text{Area}$	0.63	0.89	0.66				
Movement	0.52	33.66	< 0.001				
40 equal interval resolution							
Predictor	Concurvity	$\chi^2$	$p$ -value	Deviance	$R_{\text{pred}}^2$	$R_{\text{adj}}^2$	N
$T_m$	0.80	47.19	< 0.001	0.85	0.84	0.82	198

In MI	0.68	71.69	< 0.001
Recent Area	0.82	15.10	< 0.001
ΔArea	0.65	4.91	0.10
Movement	0.49	68.29	< 0.001

#### 50 equal interval resolution

Predictor	Concurvity	$\chi^2$	p-value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
$T_m$	0.76	2.36	0.12				
In MI	0.67	27.29	< 0.001				
Recent Area	0.74	40.08	< 0.001	0.61	0.63	0.60	267
ΔArea	0.60	1.12	0.29				
Movement	0.45	68.67	< 0.001				

#### 60 equal interval resolution

Predictor	Concurvity	$\chi^2$	p-value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
$T_m$	0.75	0.56	0.54				
In MI	0.67	54.01	< 0.001				
Recent Area	0.85	32.17	< 0.001	0.59	0.60	0.58	368
ΔArea	0.67	0.92	0.34				
Movement	0.42	115.65	< 0.001				

373 **Table S23 | Summary of the Generalised Additive Models (GAMs) with species turnover as**  
 374 **the response variable and climate and its deep-time geographic dynamics as explanatory**  
 375 **variables for recent climatic conditions that first appeared in the Last Glacial Maximum (LGM,**  
 376 **22–18 ka), across multiple climatic space resolutions.** Summary statistics of GAMs fitted with  
 377 turnover component of  $\beta$ -diversity as the response variable. Explanatory variables include:  $T_m$  ( $^{\circ}$ C),  
 378 recent (1901–1989) temperature index; In MI (unitless), recent natural-log-transformed moisture  
 379 index; Recent Area ( $km^2$ ), total land area occupied by a climatic condition in the recent period;  
 380  $\Delta$ Area ( $km^2$ ), change in total land area occupied by a climatic condition from its earliest occurrence  
 381 (i.e. LGM) to the recent period; Movement (km), geographic shift of a climatic condition since its  
 382 earliest occurrence (i.e. LGM) to the recent period. Different GAMs were constructed based on

383 climatic spaces defined by the recent climatic conditions ( $T_m$  and  $\ln MI$ ) at four resolutions, with  
 384 each climatic axis divided into 30, 40, 50 or 60 equal intervals. Reported metrics for each model  
 385 include concurvity,  $\chi^2$  and  $p$ -value for each explanatory variable, and explained deviance (Deviance),  
 386 predicted  $R^2$  ( $R_{pred}^2$ ) and adjusted  $R^2$  ( $R_{adj}^2$ ) of each GAM model, and the sample size (N) fitted into  
 387 each model.

30 equal interval resolution							
Predictor	Concurvity	$\chi^2$	$p$ -value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
$T_m$	0.88	10.47	0.07				
$\ln MI$	0.85	22.07	< 0.001				
Recent Area	0.85	67.36	< 0.001	0.83	0.83	0.80	78
$\Delta Area$	0.58	10.75	< 0.001				
Movement	0.60	17.49	< 0.001				
40 equal interval resolution							
Predictor	Concurvity	$\chi^2$	$p$ -value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
$T_m$	0.91	14.54	< 0.05				
$\ln MI$	0.84	10.54	< 0.05				
Recent Area	0.90	60.04	< 0.001	0.78	0.80	0.77	117
$\Delta Area$	0.68	0.78	0.38				
Movement	0.56	6.53	< 0.05				
50 equal interval resolution							
Predictor	Concurvity	$\chi^2$	$p$ -value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
$T_m$	0.89	32.01	< 0.001				
$\ln MI$	0.79	19.57	< 0.001				
Recent Area	0.87	106.63	< 0.001	0.79	0.80	0.77	160
$\Delta Area$	0.65	6.32	< 0.05				
Movement	0.38	25.18	< 0.001				
60 equal interval resolution							

Predictor	Concurvity	$\chi^2$	p-value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
$T_m$	0.88	37.93	< 0.001				
ln MI	0.77	42.87	< 0.001				
Recent Area	0.87	58.25	< 0.001	0.81	0.78	0.75	194
$\Delta$ Area	0.63	5.23	< 0.05				
Movement	0.34	31.93	< 0.001				

388 **Table S24 | Summary of the Generalised Additive Models (GAMs) with phylogenetic diversity**  
 389 **as the response variable and climate and its deep-time geographic dynamics as explanatory**  
 390 **variables for all recent climatic conditions across multiple climatic space resolutions.**  
 391 Summary statistics of GAMs fitted with Faith's phylogenetic diversity<sup>2</sup> as the response variable.  
 392 Explanatory variables include:  $T_m$  (°C), recent (1901–1989) temperature index; ln MI (unitless),  
 393 recent natural-log-transformed moisture index; Recent Area (km<sup>2</sup>), total land area occupied by a  
 394 climatic condition in the recent period;  $\Delta$ Area (km<sup>2</sup>), change in total land area occupied by a climatic  
 395 condition from its earliest occurrence to the recent period; Movement (km), geographic shift of a  
 396 climatic condition since its earliest occurrence to the recent period. Different GAMs were  
 397 constructed based on climatic spaces defined by the recent climatic conditions ( $T_m$  and ln MI) at four  
 398 resolutions, with each climatic axis divided into 30, 40, 50 or 60 equal intervals. Reported metrics  
 399 for each model include concurvity,  $\chi^2$  and p-value for each explanatory variable, and explained  
 400 deviance (Deviance), predicted R<sup>2</sup> ( $R_{pred}^2$ ) and adjusted R<sup>2</sup> ( $R_{adj}^2$ ) of each GAM model, and the  
 401 sample size (N) fitted into each model.

30 equal interval resolution							
Predictor	Concurvity	$\chi^2$	p-value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
$T_m$	0.64	197.55	< 0.001				
ln MI	0.56	139.60	< 0.001				
Recent Area	0.84	48.21	< 0.001	0.85	0.85	0.84	333
$\Delta$ Area	0.62	41.54	< 0.001				
Movement	0.41	37.37	< 0.001				

40 equal interval resolution							
Predictor	Concurvity	$\chi^2$	p-value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
$T_m$	0.61	325.36	< 0.001				
In MI	0.53	237.09	< 0.001				
Recent Area	0.76	55.06	< 0.001	0.83	0.83	0.82	516
$\Delta$ Area	0.55	41.80	< 0.001				
Movement	0.42	40.35	< 0.001				
50 equal interval resolution							
Predictor	Concurvity	$\chi^2$	p-value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
$T_m$	0.67	382.79	< 0.001				
In MI	0.49	247.36	< 0.001				
Recent Area	0.76	86.85	< 0.001	0.82	0.82	0.81	734
$\Delta$ Area	0.55	40.24	< 0.001				
Movement	0.40	57.51	< 0.001				
60 equal interval resolution							
Predictor	Concurvity	$\chi^2$	p-value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
$T_m$	0.63	472.51	< 0.001				
In MI	0.47	340.21	< 0.001				
Recent Area	0.77	133.54	< 0.001	0.81	0.81	0.81	968
$\Delta$ Area	0.56	54.97	< 0.001				
Movement	0.39	102.72	< 0.001				

402 **Table S25 | Summary of the Generalised Additive Models (GAMs) with phylogenetic diversity**  
403 **as the response variable and climate and its deep-time geographic dynamics as explanatory**  
404 **variables for recent climatic conditions that first appeared in the Eocene (ca. 50 Ma), across**  
405 **multiple climatic space resolutions.** Summary statistics of GAMs fitted with Faith's phylogenetic  
406 diversity<sup>2</sup> as the response variable. Explanatory variables include:  $T_m$  (°C), recent (1901–1989)  
407 temperature index; In MI (unitless), recent natural-log-transformed moisture index; Recent Area  
408 (km<sup>2</sup>), total land area occupied by a climatic condition in the recent period;  $\Delta$ Area (km<sup>2</sup>), change in

409 total land area occupied by a climatic condition from its earliest occurrence (i.e. Eocene) to the  
 410 recent period; Movement (km), geographic shift of a climatic condition since its earliest occurrence  
 411 (i.e. Eocene) to the recent period. Different GAMs were constructed based on climatic spaces  
 412 defined by the recent climatic conditions ( $T_m$  and  $\ln MI$ ) at four resolutions, with each climatic axis  
 413 divided into 30, 40, 50 or 60 equal intervals. Reported metrics for each model include concurvity,  $\chi^2$   
 414 and  $p$ -value for each explanatory variable, and explained deviance (Deviance), predicted  $R^2$  ( $R_{pred}^2$ )  
 415 and adjusted  $R^2$  ( $R_{adj}^2$ ) of each GAM model, and the sample size (N) fitted into each model.

#### 30 equal interval resolution

Predictor	Concurvity	$\chi^2$	$p$ -value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
$T_m$	0.76	92.73	< 0.001				
$\ln MI$	0.86	130.50	< 0.001				
Recent Area	0.91	10.64	< 0.05	0.94	0.94	0.92	87
$\Delta Area$	0.79	10.77	< 0.05				
Movement	0.66	0.10	0.88				

#### 40 equal interval resolution

Predictor	Concurvity	$\chi^2$	$p$ -value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
$T_m$	0.75	89.69	< 0.001				
$\ln MI$	0.82	114.57	< 0.001				
Recent Area	0.87	60.67	< 0.001	0.90	0.90	0.88	136
$\Delta Area$	0.72	0.20	0.65				
Movement	0.66	1.01	0.40				

#### 50 equal interval resolution

Predictor	Concurvity	$\chi^2$	$p$ -value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
$T_m$	0.70	99.30	< 0.001				
$\ln MI$	0.80	130.64	< 0.001				
Recent Area	0.83	83.61	< 0.001	0.89	0.89	0.87	194
$\Delta Area$	0.70	1.58	0.21				
Movement	0.59	3.99	0.09				

60 equal interval resolution							
Predictor	Concurvity	$\chi^2$	p-value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
$T_m$	0.66	127.88	< 0.001				
In MI	0.77	166.98	< 0.001				
Recent Area	0.85	95.08	< 0.001	0.87	0.87	0.86	257
$\Delta$ Area	0.72	3.04	0.08				
Movement	0.46	5.36	0.22				

416 **Table S26 | Summary of the Generalised Additive Models (GAMs) with phylogenetic diversity**  
417 **as the response variable and climate and its deep-time geographic dynamics as explanatory**  
418 **variables for recent climatic conditions that first appeared in the Mid-Pliocene (3.3–3.0 Ma),**  
419 **across multiple climatic space resolutions.** Summary statistics of GAMs fitted with Faith's  
420 phylogenetic diversity<sup>2</sup> as the response variable. Explanatory variables include:  $T_m$  (°C), recent  
421 (1901–1989) temperature index; In MI (unitless), recent natural-log-transformed moisture index;  
422 Recent Area (km<sup>2</sup>), total land area occupied by a climatic condition in the recent period;  $\Delta$ Area (km<sup>2</sup>),  
423 change in total land area occupied by a climatic condition from its earliest occurrence (i.e.  
424 Mid-Pliocene) to the recent period; Movement (km), geographic shift of a climatic condition since its  
425 earliest occurrence (i.e. Mid-Pliocene) to the recent period. Different GAMs were constructed based  
426 on climatic spaces defined by the recent climatic conditions ( $T_m$  and In MI) at four resolutions, with  
427 each climatic axis divided into 30, 40, 50 or 60 equal intervals. Reported metrics for each model  
428 include concurvity,  $\chi^2$  and p-value for each explanatory variable, and explained deviance (Deviance),  
429 predicted R<sup>2</sup> ( $R_{pred}^2$ ) and adjusted R<sup>2</sup> ( $R_{adj}^2$ ) of each GAM model, and the sample size (N) fitted into  
430 each model.

30 equal interval resolution							
Predictor	Concurvity	$\chi^2$	p-value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
$T_m$	0.74	73.23	< 0.001				
In MI	0.69	53.54	< 0.001	0.83	0.83	0.81	140
Recent Area	0.56	119.42	< 0.001				

ΔArea	0.22	4.61	0.13				
Movement	0.48	8.07	< 0.05				
<b>40 equal interval resolution</b>							
Predictor	Concurvity	$\chi^2$	p-value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
T <sub>m</sub>	0.78	253.68	< 0.001				
ln MI	0.65	223.38	< 0.001				
Recent Area	0.81	48.73	< 0.001	0.88	0.88	0.86	210
ΔArea	0.61	2.53	0.40				
Movement	0.45	0.82	0.37				
<b>50 equal interval resolution</b>							
Predictor	Concurvity	$\chi^2$	p-value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
T <sub>m</sub>	0.74	392.41	< 0.001				
ln MI	0.64	320.08	< 0.001				
Recent Area	0.71	31.27	< 0.001	0.85	0.85	0.84	305
ΔArea	0.52	28.10	< 0.001				
Movement	0.42	3.24	0.24				
<b>60 equal interval resolution</b>							
Predictor	Concurvity	$\chi^2$	p-value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
T <sub>m</sub>	0.73	266.27	< 0.001				
ln MI	0.63	236.90	< 0.001				
Recent Area	0.84	69.56	< 0.001	0.81	0.81	0.80	407
ΔArea	0.64	13.99	< 0.01				
Movement	0.39	8.88	< 0.05				

431 **Table S27 | Summary of the Generalised Additive Models (GAMs) with phylogenetic diversity**  
432 **as the response variable and climate and its deep-time geographic dynamics as explanatory**  
433 **variables for recent climatic conditions that first appeared in the Last Glacial Maximum (LGM,**  
434 **22–18 ka), across multiple climatic space resolutions.** Summary statistics of GAMs fitted with  
435 **Faith's phylogenetic diversity<sup>2</sup> as the response variable. Explanatory variables include: T<sub>m</sub> (°C),**

436 recent (1901–1989) temperature index;  $\ln \text{MI}$  (unitless), recent natural-log-transformed moisture  
 437 index; Recent Area ( $\text{km}^2$ ), total land area occupied by a climatic condition in the recent period;  
 438  $\Delta\text{Area}$  ( $\text{km}^2$ ), change in total land area occupied by a climatic condition from its earliest occurrence  
 439 (i.e. LGM) to the recent period; Movement (km), geographic shift of a climatic condition since its  
 440 earliest occurrence (i.e. LGM) to the recent period. Different GAMs were constructed based on  
 441 climatic spaces defined by the recent climatic conditions ( $T_m$  and  $\ln \text{MI}$ ) at four resolutions, with  
 442 each climatic axis divided into 30, 40, 50 or 60 equal intervals. Reported metrics for each model  
 443 include concurvity,  $\chi^2$  and  $p$ -value for each explanatory variable, and explained deviance (Deviance),  
 444 predicted  $R^2$  ( $R_{\text{pred}}^2$ ) and adjusted  $R^2$  ( $R_{\text{adj}}^2$ ) of each GAM model, and the sample size (N) fitted into  
 445 each model.

30 equal interval resolution							
Predictor	Concurvity	$\chi^2$	$p$ -value	Deviance	$R_{\text{pred}}^2$	$R_{\text{adj}}^2$	N
$T_m$	0.91	60.30	< 0.001				
$\ln \text{MI}$	0.88	8.68	0.05				
Recent Area	0.95	9.26	< 0.05	0.72	0.72	0.66	90
$\Delta\text{Area}$	0.72	0.00	0.99				
Movement	0.62	3.91	0.30				
40 equal interval resolution							
Predictor	Concurvity	$\chi^2$	$p$ -value	Deviance	$R_{\text{pred}}^2$	$R_{\text{adj}}^2$	N
$T_m$	0.90	92.99	< 0.001				
$\ln \text{MI}$	0.87	7.79	0.12				
Recent Area	0.89	31.31	< 0.001	0.77	0.77	0.73	137
$\Delta\text{Area}$	0.65	0.10	0.75				
Movement	0.61	11.60	< 0.05				
50 equal interval resolution							
Predictor	Concurvity	$\chi^2$	$p$ -value	Deviance	$R_{\text{pred}}^2$	$R_{\text{adj}}^2$	N
$T_m$	0.87	119.01	< 0.001	0.70	0.71	0.67	187

In MI	0.79	8.16	0.09
Recent Area	0.86	31.75	< 0.001
ΔArea	0.64	0.57	0.45
Movement	0.39	10.83	< 0.05

#### 60 equal interval resolution

Predictor	Concurvity	$\chi^2$	p-value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
$T_m$	0.87	181.31	< 0.001				
In MI	0.76	10.83	< 0.05				
Recent Area	0.86	68.59	< 0.001	0.74	0.74	0.72	245
ΔArea	0.59	0.77	0.38				
Movement	0.31	38.22	< 0.001				

446 **Table S28 | Summary of the Generalised Additive Models (GAMs) with relative phylogenetic**  
447 **diversity as the response variable and climate and its deep-time geographic dynamics as**  
448 **explanatory variables for all recent climatic conditions across multiple climatic space**  
449 **resolutions.** Summary statistics of GAMs fitted with relative phylogenetic diversity (calculated as  
450 the residuals from regressing phylogenetic diversity against species richness) as the response  
451 variable. Explanatory variables include:  $T_m$  ( $^{\circ}\text{C}$ ), recent (1901–1989) temperature index; In MI  
452 (unitless), recent natural-log-transformed moisture index; Recent Area ( $\text{km}^2$ ), total land area  
453 occupied by a climatic condition in the recent period;  $\Delta\text{Area}$  ( $\text{km}^2$ ), change in total land area  
454 occupied by a climatic condition from its earliest occurrence to the recent period; Movement (km),  
455 geographic shift of a climatic condition since its earliest occurrence to the recent period. Different  
456 GAMs were constructed based on climatic spaces defined by the recent climatic conditions ( $T_m$  and  
457 In MI) at four resolutions, with each climatic axis divided into 30, 40, 50 or 60 equal intervals.  
458 Reported metrics for each model include concurvity,  $\chi^2$  and p-value for each explanatory variable,  
459 and explained deviance (Deviance), predicted  $R^2$  ( $R_{pred}^2$ ) and adjusted  $R^2$  ( $R_{adj}^2$ ) of each GAM  
460 model, and the sample size (N) fitted into each model.

#### 30 equal interval resolution

Predictor	Concurvity	$\chi^2$	p-value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
T <sub>m</sub>	0.64	157.07	< 0.001				
ln MI	0.56	56.06	< 0.001				
Recent Area	0.84	15.17	< 0.001	0.53	0.53	0.49	333
ΔArea	0.62	2.94	0.45				
Movement	0.41	17.34	< 0.001				
<b>40 equal interval resolution</b>							
Predictor	Concurvity	$\chi^2$	p-value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
T <sub>m</sub>	0.61	250.31	< 0.001				
ln MI	0.53	114.22	< 0.001				
Recent Area	0.76	19.89	< 0.001	0.56	0.56	0.53	516
ΔArea	0.55	12.51	< 0.05				
Movement	0.42	36.63	< 0.001				
<b>50 equal interval resolution</b>							
Predictor	Concurvity	$\chi^2$	p-value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
T <sub>m</sub>	0.67	383.95	< 0.001				
ln MI	0.49	179.03	< 0.001				
Recent Area	0.76	64.01	< 0.001	0.55	0.55	0.53	734
ΔArea	0.55	12.45	< 0.05				
Movement	0.40	28.34	< 0.001				
<b>60 equal interval resolution</b>							
Predictor	Concurvity	$\chi^2$	p-value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
T <sub>m</sub>	0.63	478.01	< 0.001				
ln MI	0.47	218.37	< 0.001				
Recent Area	0.77	53.55	< 0.001	0.52	0.52	0.50	968
ΔArea	0.56	19.31	< 0.01				
Movement	0.39	54.78	< 0.001				

461 **Table S29 | Summary of the Generalised Additive Models (GAMs) with relative phylogenetic**  
 462 **diversity as the response variable and climate and its deep-time geographic dynamics as**  
 463 **explanatory variables for recent climatic conditions that first appeared in the Eocene (ca. 50**  
 464 **Ma), across multiple climatic space resolutions.** Summary statistics of GAMs fitted with relative  
 465 phylogenetic diversity (calculated as the residuals from regressing phylogenetic diversity against  
 466 species richness) as the response variable. Explanatory variables include:  $T_m$  ( $^{\circ}\text{C}$ ), recent (1901–  
 467 1989) temperature index;  $\ln MI$  (unitless), recent natural-log-transformed moisture index; Recent  
 468 Area ( $\text{km}^2$ ), total land area occupied by a climatic condition in the recent period;  $\Delta\text{Area}$  ( $\text{km}^2$ ),  
 469 change in total land area occupied by a climatic condition from its earliest occurrence (i.e. Eocene)  
 470 to the recent period; Movement (km), geographic shift of a climatic condition since its earliest  
 471 occurrence (i.e. Eocene) to the recent period. Different GAMs were constructed based on climatic  
 472 spaces defined by the recent climatic conditions ( $T_m$  and  $\ln MI$ ) at four resolutions, with each  
 473 climatic axis divided into 30, 40, 50 or 60 equal intervals. Reported metrics for each model include  
 474 concurvity,  $\chi^2$  and  $p$ -value for each explanatory variable, and explained deviance (Deviance),  
 475 predicted  $R^2$  ( $R_{\text{pred}}^2$ ) and adjusted  $R^2$  ( $R_{\text{adj}}^2$ ) of each GAM model, and the sample size (N) fitted into  
 476 each model.

30 equal interval resolution							
Predictor	Concurvity	$\chi^2$	$p$ -value	Deviance	$R_{\text{pred}}^2$	$R_{\text{adj}}^2$	N
$T_m$	0.69	192.95	< 0.001				
$\ln MI$	0.82	118.19	< 0.001				
Recent Area	0.80	11.44	< 0.05	0.81	0.81	0.78	87
$\Delta\text{Area}$	0.73	1.16	0.29				
Movement	0.53	7.65	< 0.05				
40 equal interval resolution							
Predictor	Concurvity	$\chi^2$	$p$ -value	Deviance	$R_{\text{pred}}^2$	$R_{\text{adj}}^2$	N
$T_m$	0.75	221.22	< 0.001				
$\ln MI$	0.82	221.46	< 0.001	0.83	0.83	0.80	136
Recent Area	0.87	8.93	0.06				

ΔArea	0.72	5.32	0.20
Movement	0.66	3.72	0.06

50 equal interval resolution							
Predictor	Concurvity	$\chi^2$	p-value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
T <sub>m</sub>	0.70	318.68	< 0.001				
In MI	0.80	232.70	< 0.001				
Recent Area	0.83	15.48	< 0.001	0.77	0.77	0.74	194
ΔArea	0.70	0.58	0.45				
Movement	0.59	2.71	0.24				
60 equal interval resolution							
Predictor	Concurvity	$\chi^2$	p-value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
T <sub>m</sub>	0.66	252.31	< 0.001				
In MI	0.77	157.38	< 0.001				
Recent Area	0.85	5.59	< 0.05	0.69	0.69	0.66	257
ΔArea	0.72	9.25	0.12				
Movement	0.46	1.98	0.35				

477 **Table S30 | Summary of the Generalised Additive Models (GAMs) with relative phylogenetic**  
478 **diversity as the response variable and climate and its deep-time geographic dynamics as**  
479 **explanatory variables for recent climatic conditions that first appeared in the Mid-Pliocene**  
480 **(3.3–3.0 Ma), across multiple climatic space resolutions.** Summary statistics of GAMs fitted with  
481 relative phylogenetic diversity (calculated as the residuals from regressing phylogenetic diversity  
482 against species richness) as the response variable. Explanatory variables include: T<sub>m</sub> (°C), recent  
483 (1901–1989) temperature index; In MI (unitless), recent natural-log-transformed moisture index;  
484 Recent Area (km<sup>2</sup>), total land area occupied by a climatic condition in the recent period; ΔArea (km<sup>2</sup>),  
485 change in total land area occupied by a climatic condition from its earliest occurrence (i.e.  
486 Mid-Pliocene) to the recent period; Movement (km), geographic shift of a climatic condition since its  
487 earliest occurrence (i.e. Mid-Pliocene) to the recent period. Different GAMs were constructed based  
488 on climatic spaces defined by the recent climatic conditions (T<sub>m</sub> and In MI) at four resolutions, with

489 each climatic axis divided into 30, 40, 50 or 60 equal intervals. Reported metrics for each model  
 490 include concurvity,  $\chi^2$  and  $p$ -value for each explanatory variable, and explained deviance (Deviance),  
 491 predicted  $R^2$  ( $R_{pred}^2$ ) and adjusted  $R^2$  ( $R_{adj}^2$ ) of each GAM model, and the sample size (N) fitted into  
 492 each model.

30 equal interval resolution							
Predictor	Concurvity	$\chi^2$	$p$ -value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
$T_m$	0.79	54.18	< 0.001				
ln MI	0.75	69.90	< 0.001				
Recent Area	0.81	5.19	< 0.05	0.73	0.73	0.69	140
$\Delta$ Area	0.59	36.49	< 0.001				
Movement	0.51	1.17	0.28				
40 equal interval resolution							
Predictor	Concurvity	$\chi^2$	$p$ -value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
$T_m$	0.78	120.94	< 0.001				
ln MI	0.65	105.55	< 0.001				
Recent Area	0.81	17.03	< 0.001	0.74	0.74	0.71	210
$\Delta$ Area	0.61	42.19	< 0.001				
Movement	0.45	15.69	< 0.001				
50 equal interval resolution							
Predictor	Concurvity	$\chi^2$	$p$ -value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N
$T_m$	0.74	160.61	< 0.001				
ln MI	0.64	103.56	< 0.001				
Recent Area	0.71	47.79	< 0.001	0.70	0.70	0.67	305
$\Delta$ Area	0.52	35.96	< 0.001				
Movement	0.42	16.54	< 0.001				
60 equal interval resolution							
Predictor	Concurvity	$\chi^2$	$p$ -value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N

T <sub>m</sub>	0.73	194.06	< 0.001					
ln MI	0.63	114.24	< 0.001					
Recent Area	0.84	34.78	< 0.001	0.65	0.65	0.62	407	
ΔArea	0.64	52.50	< 0.001					
Movement	0.39	17.71	< 0.001					

493 **Table S31 | Summary of the Generalised Additive Models (GAMs) with relative phylogenetic**  
494 **diversity as the response variable and climate and its deep-time geographic dynamics as**  
495 **explanatory variables for recent climatic conditions that first appeared in the Last Glacial**  
496 **Maximum (LGM, 22–18 ka), across multiple climatic space resolutions.** Summary statistics of  
497 GAMs fitted with relative phylogenetic diversity (calculated as the residuals from regressing  
498 phylogenetic diversity against species richness) as the response variable. Explanatory variables  
499 include: T<sub>m</sub> (°C), recent (1901–1989) temperature index; ln MI (unitless), recent  
500 natural-log-transformed moisture index; Recent Area (km<sup>2</sup>), total land area occupied by a climatic  
501 condition in the recent period; ΔArea (km<sup>2</sup>), change in total land area occupied by a climatic  
502 condition from its earliest occurrence (i.e. LGM) to the recent period; Movement (km), geographic  
503 shift of a climatic condition since its earliest occurrence (i.e. LGM) to the recent period. Different  
504 GAMs were constructed based on climatic spaces defined by the recent climatic conditions (T<sub>m</sub> and  
505 ln MI) at four resolutions, with each climatic axis divided into 30, 40, 50 or 60 equal intervals.  
506 Reported metrics for each model include concurvity,  $\chi^2$  and *p*-value for each explanatory variable,  
507 and explained deviance (Deviance), predicted R<sup>2</sup> (R<sub>pred</sub><sup>2</sup>) and adjusted R<sup>2</sup> (R<sub>adj</sub><sup>2</sup>) of each GAM  
508 model, and the sample size (N) fitted into each model.

30 equal interval resolution							
Predictor	Concurvity	$\chi^2$	<i>p</i> -value	Deviance	R <sub>pred</sub> <sup>2</sup>	R <sub>adj</sub> <sup>2</sup>	N
T <sub>m</sub>	0.91	3.38	0.23				
ln MI	0.88	5.27	< 0.05		0.14	0.14	0.08
Recent Area	0.95	4.64	< 0.05				90
ΔArea	0.72	0.01	0.94				

Movement	0.62	0.08	0.78					
<b>40 equal interval resolution</b>								
Predictor	Concurvity	$\chi^2$	<i>p</i> -value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N	
T <sub>m</sub>	0.90	40.20	< 0.001					
ln MI	0.87	35.50	< 0.001					
Recent Area	0.89	5.96	0.08	0.45	0.46	0.37	137	
ΔArea	0.65	0.05	0.83					
Movement	0.61	6.64	0.14					
<b>50 equal interval resolution</b>								
Predictor	Concurvity	$\chi^2$	<i>p</i> -value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N	
T <sub>m</sub>	0.87	41.92	< 0.001					
ln MI	0.79	42.50	< 0.001					
Recent Area	0.86	2.06	0.15	0.33	0.34	0.28	187	
ΔArea	0.64	0.01	0.92					
Movement	0.39	3.08	0.08					
<b>60 equal interval resolution</b>								
Predictor	Concurvity	$\chi^2$	<i>p</i> -value	Deviance	$R_{pred}^2$	$R_{adj}^2$	N	
T <sub>m</sub>	0.87	74.10	< 0.001					
ln MI	0.76	55.39	< 0.001					
Recent Area	0.86	17.00	< 0.001	0.39	0.39	0.34	245	
ΔArea	0.59	4.51	0.35					
Movement	0.31	4.73	< 0.05					

509 **Table S32 | Spatial auto-correlation test for Generalised Additive Models (GAMs)**  
 510 **incorporating bioclimatic variables and the geographic extent of climate at multiple climatic**  
 511 **space resolutions.** Summary of spatial autocorrelation tests for the residuals of GAMs fitted across  
 512 different geological periods. Species richness is the response variable. Explanatory variables  
 513 include recent (1901–1989) temperature index (T<sub>m</sub>, °C) and natural-log-transformed moisture index  
 514 (ln MI, unitless), and total land area occupied by each climatic condition (Area, km<sup>2</sup>) in different

515 geological periods. Different GAMs were constructed based on climatic spaces defined by the  
 516 recent climatic conditions ( $T_m$  and  $\ln MI$ ) at four resolutions, with each climatic axis divided into 30,  
 517 40, 50 or 60 equal intervals. Potential spatial autocorrelation was assessed using Moran's  $I$  test on  
 518 the residuals of each GAM. Moran's  $I$  index and corresponding  $p$ -value of each GAM are presented  
 519 in the table.

30 equal interval resolution		
Geological period	Moran's $I$	$p$ -value
Eocene (ca. 50 Ma)	0.26	< 0.001
Mid-Pliocene (3.3–3.0 Ma)	0.29	< 0.001
Last Glacial Maximum (LGM, 22–18 ka)	0.33	< 0.001
Mid-Holocene (ca. 6 ka)	0.30	< 0.001
Pre-industrial (pre-1850)	0.28	< 0.001
Recent period (1901–1989)	0.32	< 0.001
Mean	0.30	< 0.001
40 equal interval resolution		
Geological period	Moran's $I$	$p$ -value
Eocene (ca. 50 Ma)	0.33	< 0.001
Mid-Pliocene (3.3–3.0 Ma)	0.34	< 0.001
Last Glacial Maximum (LGM, 22–18 ka)	0.40	< 0.001

Mid-Holocene (ca. 6 ka)	0.40	< 0.001
Pre-industrial (pre-1850)	0.34	< 0.001
Recent period (1901–1989)	0.38	< 0.001
Mean	0.39	< 0.001

#### 50 equal interval resolution

Geological period	Moran's <i>I</i>	<i>p</i> -value
Eocene (ca. 50 Ma)	0.38	< 0.001
Mid-Pliocene (3.3–3.0 Ma)	0.39	< 0.001
Last Glacial Maximum (LGM, 22–18 ka)	0.43	< 0.001
Mid-Holocene (ca. 6 ka)	0.41	< 0.001
Pre-industrial (pre-1850)	0.36	< 0.001
Recent period (1901–1989)	0.40	< 0.001
Mean	0.40	< 0.001

#### 60 equal interval resolution

Geological period	Moran's <i>I</i>	<i>p</i> -value
Eocene (ca. 50 Ma)	0.36	< 0.001
Mid-Pliocene (3.3–3.0 Ma)	0.35	< 0.001

Last Glacial Maximum (LGM, 22–18 ka)	0.40	< 0.001
Mid-Holocene (ca. 6 ka)	0.39	< 0.001
Pre-industrial (pre-1850)	0.34	< 0.001
Recent period (1901–1989)	0.37	< 0.001
Mean	0.38	< 0.001

520 **Table S33 | Spatial auto-correlation test for Generalised Additive Models (GAMs) with**  
 521 **species richness as the response variable and climate and its deep-time geographic**  
 522 **dynamics as explanatory variables.** Summary of spatial autocorrelation tests for the residuals of  
 523 GAMs fitted for all recent climatic conditions, as well as separately according to their first  
 524 appearance. Species richness is the response variable. Explanatory variables include:  $T_m$  ( $^{\circ}C$ ),  
 525 recent (1901–1989) temperature index;  $\ln MI$  (unitless), recent natural-log-transformed moisture  
 526 index; Recent Area ( $km^2$ ), total land area occupied by a climatic condition in the recent period;  
 527  $\Delta Area$  ( $km^2$ ), change in total land area occupied by a climatic condition from its earliest occurrence  
 528 to the recent period; Movement (km), geographic shift of a climatic condition since its earliest  
 529 occurrence to the recent period. Different GAMs were constructed based on climatic spaces defined  
 530 by the recent climatic conditions ( $T_m$  and  $\ln MI$ ) at four resolutions, with each climatic axis divided  
 531 into 30, 40, 50 or 60 equal intervals. Potential spatial autocorrelation was assessed using  
 532 Moran's  $I$  test on the residuals of each GAM. Moran's  $I$  index and corresponding  $p$ -value of each  
 533 GAM are presented in the table.

30 equal interval resolution		
Geological period	Moran's $I$	$p$ -value
All periods	0.17	< 0.001
Eocene	0.01	0.38

(ca. 50 Ma)

Mid-Pliocene  
(3.3–3.0 Ma) 0.10 < 0.05

Last Glacial Maximum  
(LGM, 22–18 ka) 0.04 0.22

#### 40 equal interval resolution

Geological period	Moran's <i>I</i>	<i>p</i> -value
All periods	0.24	< 0.001
Eocene (ca. 50 Ma)	-0.14	0.99
Mid-Pliocene (3.3–3.0 Ma)	0.06	0.07
Last Glacial Maximum (LGM, 22–18 ka)	-0.05	0.80

#### 50 equal interval resolution

Geological period	Moran's <i>I</i>	<i>p</i> -value
All periods	0.27	< 0.001
Eocene (ca. 50 Ma)	-0.02	0.58
Mid-Pliocene (3.3–3.0 Ma)	0.03	0.17
Last Glacial Maximum (LGM, 22–18 ka)	0.01	0.39

#### 60 equal interval resolution

Geological period	Moran's <i>I</i>	<i>p</i> -value
All periods	0.23	< 0.001
Eocene (ca. 50 Ma)	-0.01	0.59

Mid-Pliocene (3.3–3.0 Ma)	0.02	0.22
Last Glacial Maximum (LGM, 22–18 ka)	–0.05	0.87

534 **Table S34 | Spatial auto-correlation test for Generalised Additive Models (GAMs) with**  
 535 **species turnover as the response variable and climate and its deep-time geographic**  
 536 **dynamics as explanatory variables.** Summary of spatial autocorrelation tests for the residuals of  
 537 GAMs fitted for all recent climatic conditions, as well as separately according to their first  
 538 appearance. Turnover component of  $\beta$ -diversity is the response variable. Explanatory variables  
 539 include:  $T_m$  ( $^{\circ}$ C), recent (1901–1989) temperature index;  $\ln MI$  (unitless), recent  
 540 natural-log-transformed moisture index; Recent Area ( $km^2$ ), total land area occupied by a climatic  
 541 condition in the recent period;  $\Delta Area$  ( $km^2$ ), change in total land area occupied by a climatic  
 542 condition from its earliest occurrence to the recent period; Movement (km), geographic shift of a  
 543 climatic condition since its earliest occurrence to the recent period. Different GAMs were  
 544 constructed based on climatic spaces defined by the recent climatic conditions ( $T_m$  and  $\ln MI$ ) at four  
 545 resolutions, with each climatic axis divided into 30, 40, 50 or 60 equal intervals. Potential spatial  
 546 autocorrelation was assessed using Moran's  $I$  test on the residuals of each GAM. Moran's  $I$  index  
 547 and corresponding  $p$ -value of each GAM are presented in the table.

30 equal interval resolution		
Geological period	Moran's $I$	$p$ -value
All periods	0.07	< 0.05
Eocene (ca. 50 Ma)	–0.17	0.98
Mid-Pliocene (3.3–3.0 Ma)	–0.05	0.79
Last Glacial Maximum (LGM, 22–18 ka)	0.02	0.34

40 equal interval resolution		
Geological period	Moran's <i>I</i>	<i>p</i> -value
All periods	0.06	< 0.05
Eocene (ca. 50 Ma)	-0.07	0.85
Mid-Pliocene (3.3–3.0 Ma)	0.02	0.28
Last Glacial Maximum (LGM, 22–18 ka)	-0.08	0.87
50 equal interval resolution		
Geological period	Moran's <i>I</i>	<i>p</i> -value
All periods	0.01	0.27
Eocene (ca. 50 Ma)	-0.05	0.82
Mid-Pliocene (3.3–3.0 Ma)	0.10	< 0.01
Last Glacial Maximum (LGM, 22–18 ka)	-0.03	0.66
60 equal interval resolution		
Geological period	Moran's <i>I</i>	<i>p</i> -value
All periods	-0.02	0.82
Eocene (ca. 50 Ma)	-0.10	0.99
Mid-Pliocene (3.3–3.0 Ma)	-0.01	0.62
Last Glacial Maximum (LGM, 22–18 ka)	-0.11	0.99

548 **Table S35 | Spatial auto-correlation test for Generalised Additive Models (GAMs) with**  
 549 **phylogenetic diversity as the response variable and climate and its deep-time geographic**  
 550 **dynamics as explanatory variables.** Summary of spatial autocorrelation tests for the residuals of  
 551 GAMs fitted for all recent climatic conditions, as well as separately according to their first  
 552 appearance. Faith's phylogenetic diversity<sup>2</sup> is the response variable. Explanatory variables include:  
 553  $T_m$  (°C), recent (1901–1989) temperature index;  $\ln MI$  (unitless), recent natural-log-transformed  
 554 moisture index; Recent Area ( $\text{km}^2$ ), total land area occupied by a climatic condition in the recent  
 555 period;  $\Delta\text{Area}$  ( $\text{km}^2$ ), change in total land area occupied by a climatic condition from its earliest  
 556 occurrence to the recent period; Movement (km), geographic shift of a climatic condition since its  
 557 earliest occurrence to the recent period. Different GAMs were constructed based on climatic spaces  
 558 defined by the recent climatic conditions ( $T_m$  and  $\ln MI$ ) at four resolutions, with each climatic axis  
 559 divided into 30, 40, 50 or 60 equal intervals. Potential spatial autocorrelation was assessed using  
 560 Moran's  $I$  test on the residuals of each GAM. Moran's  $I$  index and corresponding  $p$ -value of each  
 561 GAM are presented in the table.

30 equal interval resolution		
Geological period	Moran's $I$	$p$ -value
All periods	0.25	< 0.001
Eocene (ca. 50 Ma)	0.04	0.24
Mid-Pliocene (3.3–3.0 Ma)	0.11	0.02
Last Glacial Maximum (LGM, 22–18 ka)	–0.07	0.83
40 equal interval resolution		
Geological period	Moran's $I$	$p$ -value
All periods	0.34	< 0.001
Eocene (ca. 50 Ma)	0.11	< 0.05

Mid-Pliocene (3.3–3.0 Ma)	0.01	0.39
Last Glacial Maximum (LGM, 22–18 ka)	–0.05	0.81
<b>50 equal interval resolution</b>		
Geological period	Moran's <i>I</i>	<i>p</i> -value
All periods	0.32	< 0.001
Eocene (ca. 50 Ma)	0.12	< 0.01
Mid-Pliocene (3.3–3.0 Ma)	0.14	< 0.001
Last Glacial Maximum (LGM, 22–18 ka)	–0.00047	0.46
<b>60 equal interval resolution</b>		
Geological period	Moran's <i>I</i>	<i>p</i> -value
All periods	0.31	< 0.001
Eocene (ca. 50 Ma)	0.14	< 0.001
Mid-Pliocene (3.3–3.0 Ma)	0.04	0.12
Last Glacial Maximum (LGM, 22–18 ka)	0.05	0.10

562 **Table S36 | Spatial auto-correlation test for Generalised Additive Models (GAMs) with relative**  
 563 **phylogenetic diversity as the response variable and climate and its deep-time geographic**  
 564 **dynamics as explanatory variables.** Summary of spatial autocorrelation tests for the residuals of  
 565 GAMs fitted for all recent climatic conditions, as well as separately according to their first  
 566 appearance. Relative phylogenetic diversity (calculated as the residuals from regressing  
 567 phylogenetic diversity against species richness) is the response variable. Explanatory variables

568 include:  $T_m$  ( $^{\circ}\text{C}$ ), recent (1901–1989) temperature index;  $\ln \text{MI}$  (unitless), recent  
 569 natural-log-transformed moisture index; Recent Area ( $\text{km}^2$ ), total land area occupied by a climatic  
 570 condition in the recent period;  $\Delta\text{Area}$  ( $\text{km}^2$ ), change in total land area occupied by a climatic  
 571 condition from its earliest occurrence to the recent period; Movement (km), geographic shift of a  
 572 climatic condition since its earliest occurrence to the recent period. Different GAMs were  
 573 constructed based on climatic spaces defined by the recent climatic conditions ( $T_m$  and  $\ln \text{MI}$ ) at four  
 574 resolutions, with each climatic axis divided into 30, 40, 50 or 60 equal intervals. Potential spatial  
 575 autocorrelation was assessed using Moran's  $I$  test on the residuals of each GAM. Moran's  $I$  index  
 576 and corresponding  $p$ -value of each GAM are presented in the table.

#### 30 equal interval resolution

Geological period	Moran's $I$	$p$ -value
All periods	0.39	< 0.001
Eocene (ca. 50 Ma)	0.01	0.38
Mid-Pliocene (3.3–3.0 Ma)	0.18	< 0.001
Last Glacial Maximum (LGM, 22–18 ka)	–0.10	0.91

#### 40 equal interval resolution

Geological period	Moran's $I$	$p$ -value
All periods	0.45	< 0.001
Eocene (ca. 50 Ma)	0.02	0.34
Mid-Pliocene (3.3–3.0 Ma)	0.27	< 0.001
Last Glacial Maximum (LGM, 22–18 ka)	–0.00021	0.45

50 equal interval resolution		
Geological period	Moran's <i>I</i>	<i>p</i> -value
All periods	0.48	< 0.001
Eocene (ca. 50 Ma)	0.06	0.08
Mid-Pliocene (3.3–3.0 Ma)	0.29	< 0.001
Last Glacial Maximum (LGM, 22–18 ka)	0.11	< 0.01
60 equal interval resolution		
Geological period	Moran's <i>I</i>	<i>p</i> -value
All periods	0.44	< 0.001
Eocene (ca. 50 Ma)	0.02	0.28
Mid-Pliocene (3.3–3.0 Ma)	0.19	< 0.001
Last Glacial Maximum (LGM, 22–18 ka)	0.11	< 0.01

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