Land-use change contributing almost half of future diversity change of global terrestrial vertebrates under climate change

Xiaojuan Liu[a], Xia Li[a*], Jinbao Zhang[b], Han Zhang[b], Hong Shi[c], Yuchao Yan[d], Han Zhang [a]

a. Key Lab. of Geographic Information Science (Ministry of Education), School of Geographic Sciences, East China Normal University, Shanghai 200241, P.R. China

b. School of Geography and Planning, Guangdong Key Laboratory for Urbanization and Geo-simulation, Sun Yat-sen University, Guangzhou 510275, China.
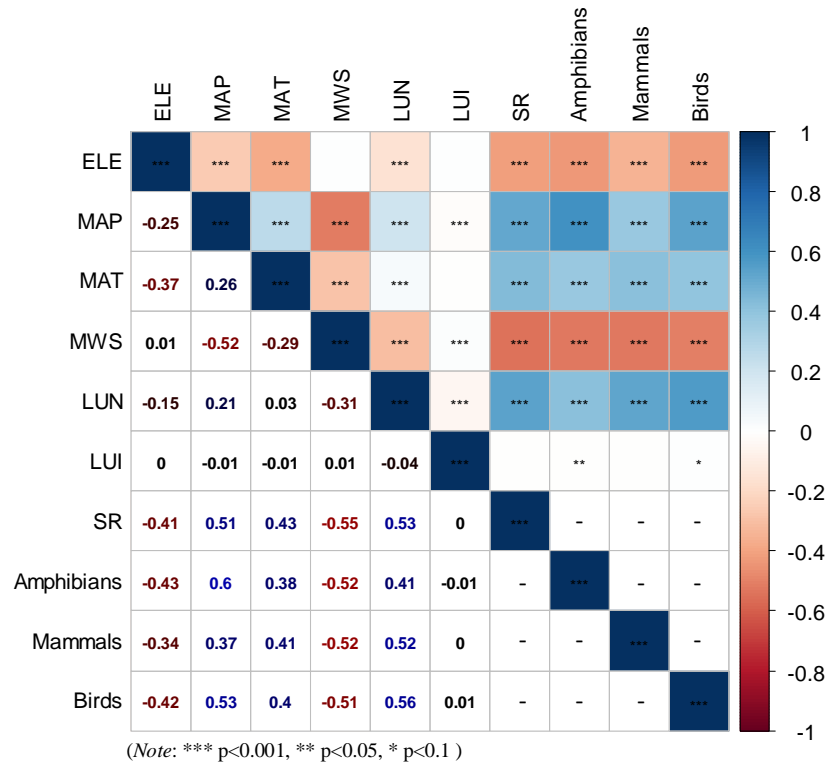
c. School of Tourism and Historical Culture, Southwest Minzu university, Chengdu 610064, P.R. China

d. Sino-French Institute for Earth System Science, College of Urban and Environmental Sciences, Peking University, Beijing 100871, P.R. China

*Corresponding authors: Xia Li (lixia@geo.ecnu.edu.cn)

Key Lab of Geographic Information Science (Ministry of Education),

School of Geographic Sciences,

East China Normal University,

500 Dongchuan Rd., Shanghai 200241, P.R. China.

Supporting Information (SI)

|	ELE	MAP	MAT	MWS	LUN	LUI	SR	Amphibians	Mammals	Birds
ELE	***	***	***		***		***	***	***	***
MAP	-0.25	***	***	***	***	***	***	***	***	***
MAT	-0.37	0.26	***	***	***		***	***	***	***
MWS	0.01	-0.52	-0.29	***	***	***	***	***	***	***
LUN	-0.15	0.21	0.03	-0.31	***	***	***	***	***	***
LUI	0	-0.01	-0.01	0.01	-0.04	***		**		*
SR	-0.41	0.51	0.43	-0.55	0.53	0	***	-	-	-
Amphibians	-0.43	0.6	0.38	-0.52	0.41	-0.01	-	***	-	-
Mammals	-0.34	0.37	0.41	-0.52	0.52	0	-	-	***	-
Birds	-0.42	0.53	0.4	-0.51	0.56	0.01	-	-	-	***

(*Note*: *** p<0.001, ** p<0.05, * p<0.1)

SI. Figure 1 The visualization of a Pearson correlation matrix of all climate and land-use predictors and species richness. Lower, Pearson correlation coefficients. Upper, the significant levels of each Pearson correlation coefficient, *** means the level of significance p<0.001, ** and * indicate p<0.05 and p<0.1, respectively. ELE, MAP, MAT, MWS are mean elevation, mean annual precipitation, mean annual temperature and mean wind speed. LUN and LUI denote the land-use naturalness and land-use intensity. SR, amphibians, mammals and birds are species richness of vertebrate, amphibians, mammals and birds.
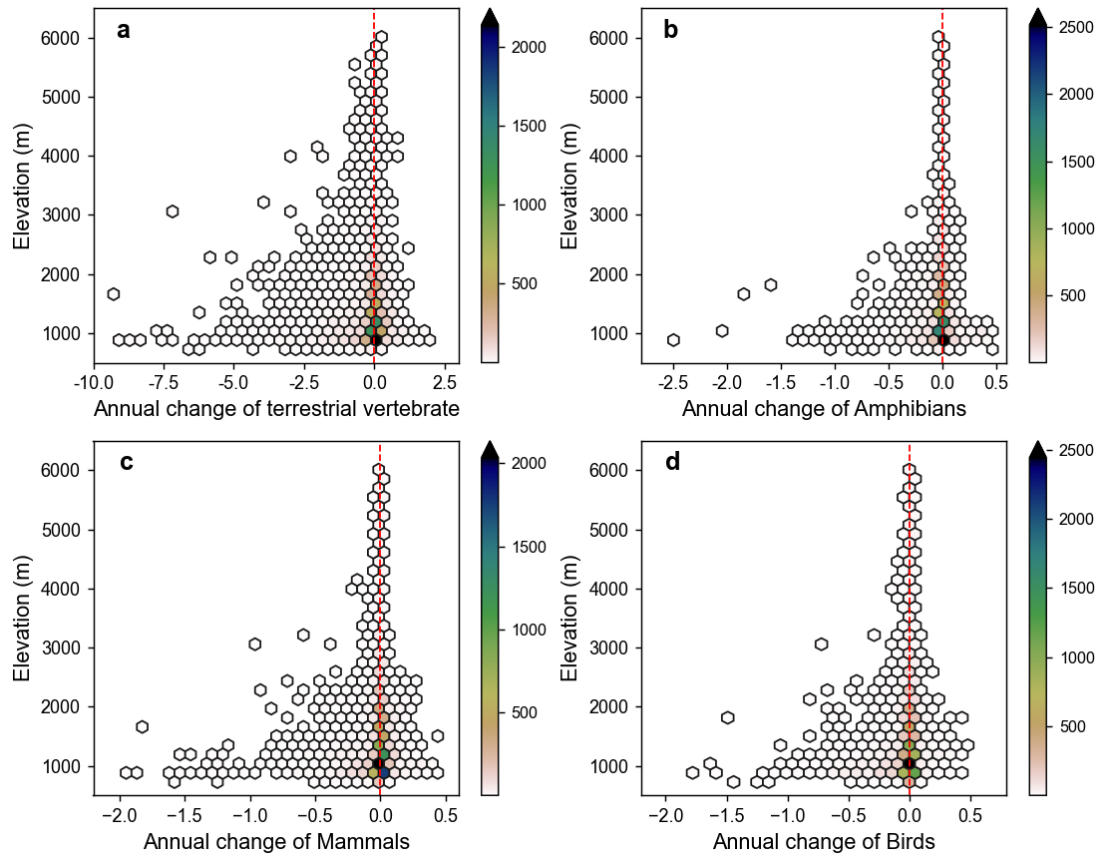
SI. Figure 2 Annual changes of species richness in elevation between 2017 and 2050 under SSP3 for a terrestrial vertebrates, b amphibians, c mammals and d birds. Colour bar shows the number of grid cells that located in annual change of richness species and latitude.
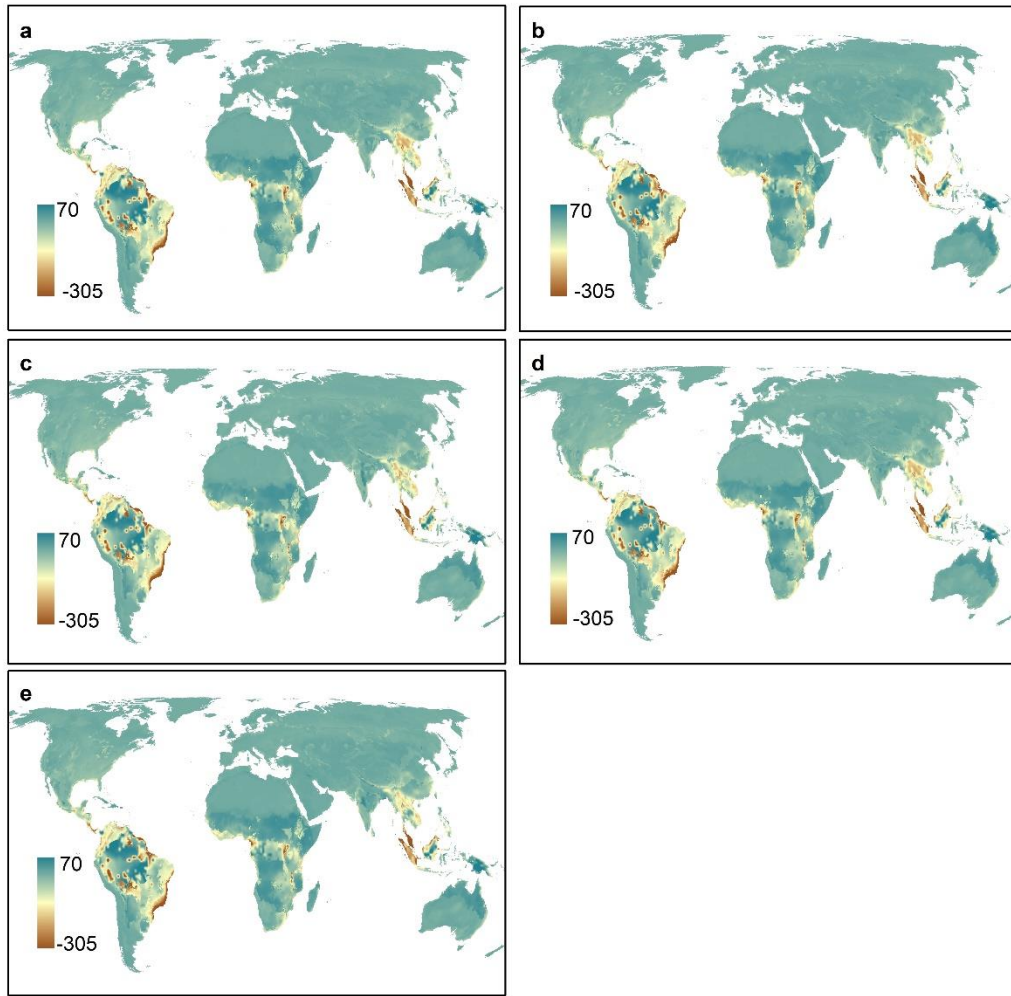
SI. Figure 3 The number of richness change of terrestrial vertebrates from the present to 2050 under SSPs. **a**: SSP1, **b**: SSP2, **c**: SSP3, **d**: SSP4, **e**: SSP5.

36
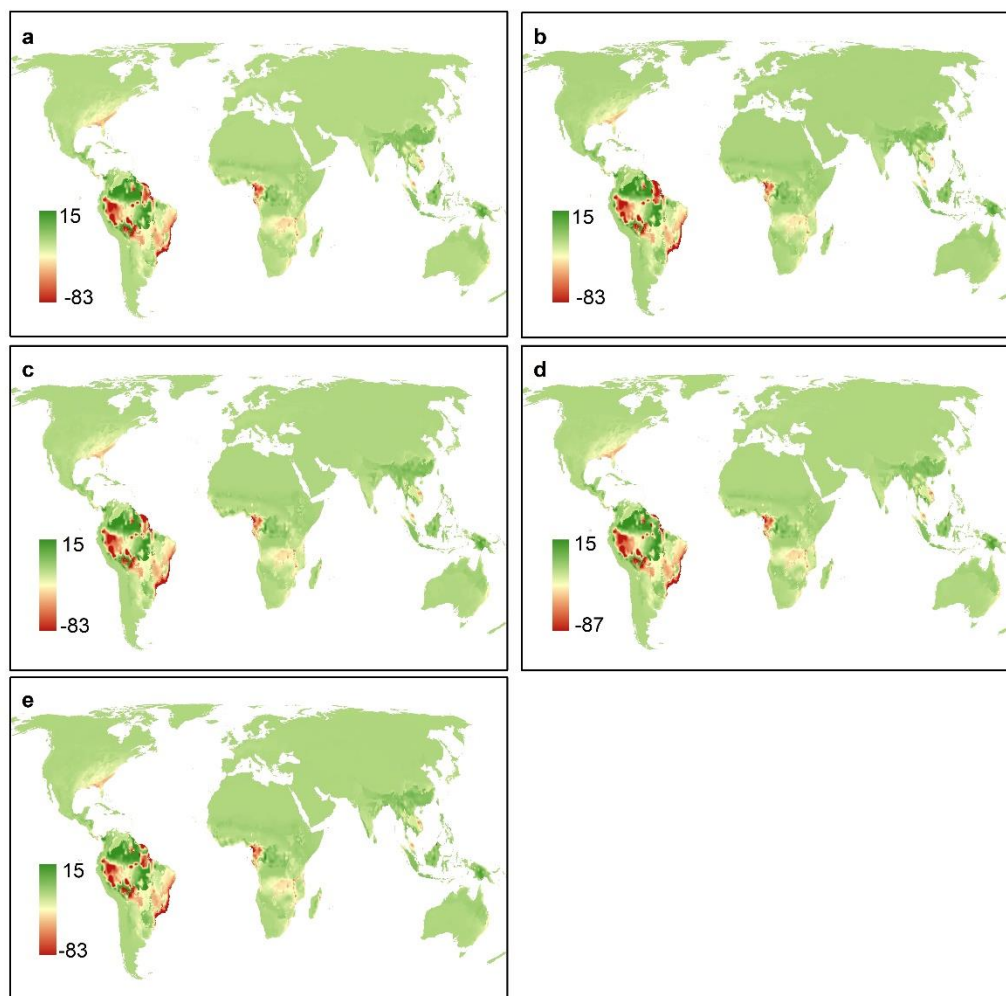
SI. Figure 4 The number of richness change of amphibians from the present to 2050 under SSPs. **a**: SSP1, **b**: SSP2, **c**: SSP3, **d**: SSP4, **e**: SSP5.

40
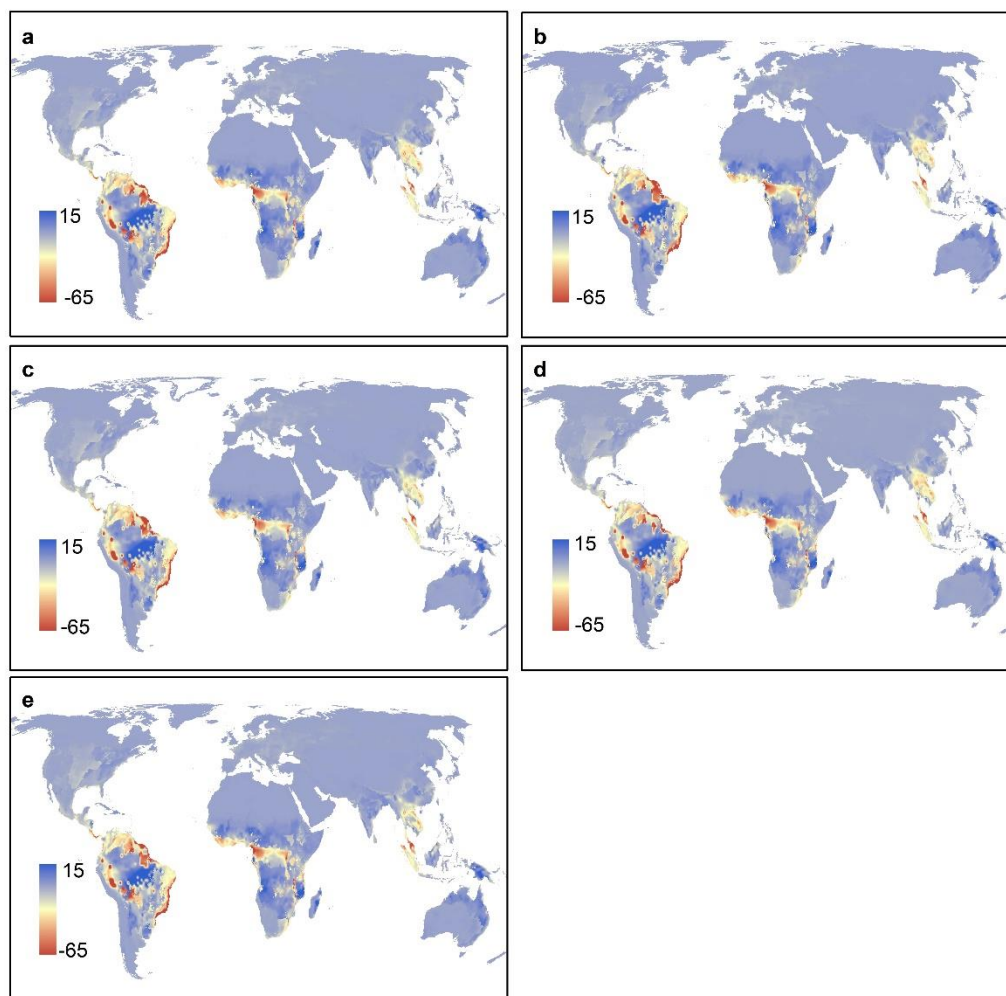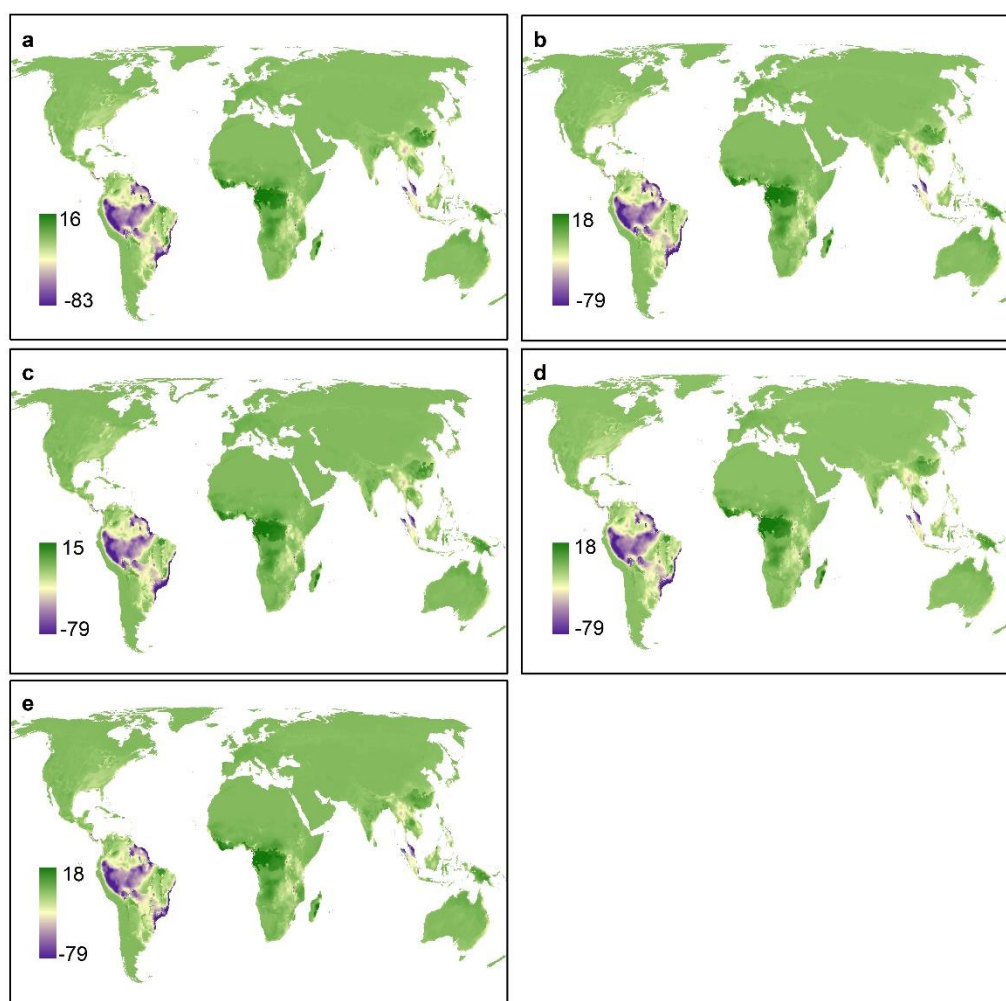
SI. Figure 5 The number of richness change of mammals from the present to 2050
under SSPs. **a**: SSP1, **b**: SSP2, **c**: SSP3, **d**: SSP4, **e**: SSP5.

43

SI. Figure 6 The number of richness change of birds from the present to 2050 under SSPs. **a**: SSP1, **b**: SSP2, **c**: SSP3, **d**: SSP4, **e**: SSP5.

44
45
46
47

SI. Table 1 R^2 of GAM and RF methods for only climate variables and with climate and land-use variables

Biomes	Method	Terrestrial vertebrates		Amphibians		Mammals		Birds	
		Only climate variables	With climate and land-use variables	Only climate variables	With climate and land-use variables	Only climate variables	With climate and land-use variables	Only climate variables	With climate and land-use variables
TMB	RF	0.52	0.56	0.64	0.68	0.40	0.51	0.47	0.51
	GAM	0.36	0.41	0.49	0.52	0.29	0.34	0.27	0.30
TDB	RF	0.67	0.68	0.73	0.73	0.70	0.69	0.58	0.59
	GAM	0.48	0.51	0.51	0.54	0.51	0.52	0.32	0.34
TSC	RF	0.78	0.79	0.70	0.70	0.81	0.81	0.70	0.72
	GAM	0.54	0.55	0.47	0.49	0.51	0.53	0.56	0.59
TBM	RF	0.56	0.60	0.60	0.63	0.51	0.51	0.48	0.49
	GAM	0.36	0.44	0.51	0.54	0.35	0.40	0.35	0.40
TCF	RF	0.71	0.73	0.90	0.91	0.65	0.66	0.78	0.80
	GAM	0.50	0.57	0.82	0.83	0.43	0.48	0.62	0.65
BRF	RF	0.63	0.67	0.54	0.60	0.65	0.62	0.61	0.66
	GAM	0.53	0.62	0.33	0.41	0.58	0.63	0.46	0.57
TSG	RF	0.58	0.66	0.62	0.70	0.54	0.64	0.55	0.58
	GAM	0.39	0.57	0.46	0.61	0.40	0.58	0.28	0.41
TGS	RF	0.78	0.74	0.77	0.69	0.76	0.76	0.68	0.68
	GAM	0.51	0.61	0.54	0.61	0.60	0.64	0.53	0.62
FGS	RF	0.96	0.96	0.96	0.96	0.96	0.94	0.94	0.93
	GAM	0.85	0.88	0.87	0.89	0.82	0.84	0.83	0.85
MGS	RF	0.80	0.84	0.84	0.84	0.76	0.81	0.79	0.81

	GAM	0.63	0.72	0.59	0.66	0.56	0.66	0.65	0.72
TDA	RF	0.75	0.85	0.66	0.70	0.74	0.83	0.73	0.81
	GAM	0.63	0.81	0.53	0.62	0.64	0.80	0.54	0.72
MWS	RF	0.54	0.56	0.45	0.49	0.75	0.77	0.79	0.80
	GAM	0.32	0.38	0.26	0.33	0.53	0.56	0.61	0.63
DXS	RF	0.65	0.79	0.69	0.78	0.68	0.79	0.64	0.78
	GAM	0.46	0.65	0.43	0.56	0.44	0.60	0.50	0.71
MGV	RF	0.41	0.66	0.76	0.76	0.59	0.62	0.64	0.68
	GAM	0.22	0.43	0.39	0.41	0.34	0.37	0.34	0.38

50   Note: The abbreviation of terrestrial biomes can be referred to SI. Table 2.

51   **SI. Table 2** The terrestrial biomes from terrestrial ecoregions of the world (TEOW)
52   and the corresponding abbreviations

Abbreviations	Terrestrial biomes
TMB	Tropical and Subtropical Moist Broadleaf Forests
TDB	Tropical and Subtropical Dry Broadleaf Forests
TSC	Tropical and Subtropical Coniferous Forests
TBM	Temperate Broadleaf and Mixed Forests
TCF	Temperate Coniferous Forests
BRF	Boreal Forests/Taiga
TSG	Tropical and Subtropical Grasslands, Savannas, and Shrublands
TGS	Temperate Grasslands, Savannas, and Shrublands
FGS	Flooded Grasslands and Savannas
MGS	Montane Grasslands and Shrublands
TDA	Tundra
MWS	Mediterranean Forests, Woodlands, and Scrub
DXS	Deserts and Xeric Shrublands
MGV	Mangroves

53

SI. Table 3 The random forest importance of climate and land-use factors

Biomes	TMD	TDB	TSC	TBM	TCF	BRF	TSG	TGS	FGS	MGS	TDA	MWS	DXS	MGV
Terrestrial vertebrates														
ELE	0.10	0.02	0.11	0.09	0.15	0.07	0.04	0.06	0.07	0.09	0.49	0.03	0.02	0.02
MAP	0.42	0.30	0.31	0.08	0.11	0.11	0.11	0.01	0.20	0.05	0.02	0.08	0.03	0.25
MAT	0.16	0.45	0.28	0.29	0.55	0.18	0.06	0.23	0.60	0.28	0.04	0.20	0.18	0.12
MWS	0.07	0.08	0.26	0.40	0.08	0.17	0.05	0.24	0.03	0.03	0.07	0.41	0.09	0.12
LUN	0.13	0.10	0.04	0.13	0.10	0.46	0.74	0.44	0.10	0.54	0.38	0.22	0.65	0.39
LUI	0.13	0.04	0.00	0.01	0.02	0.02	0.01	0.02	0.00	0.00	0.00	0.07	0.03	0.10
Amphibians														
ELE	0.14	0.14	0.08	0.13	0.73	0.09	0.03	0.05	0.03	0.12	0.49	0.07	0.04	0.02
MAP	0.55	0.25	0.40	0.25	0.02	0.12	0.26	0.04	0.65	0.11	0.04	0.06	0.02	0.38
MAT	0.11	0.43	0.29	0.31	0.21	0.21	0.09	0.44	0.25	0.50	0.16	0.25	0.23	0.31
MWS	0.05	0.06	0.19	0.23	0.01	0.16	0.06	0.19	0.05	0.01	0.08	0.09	0.07	0.25
LUN	0.04	0.02	0.04	0.07	0.02	0.41	0.57	0.25	0.02	0.25	0.23	0.43	0.46	0.03
LUI	0.11	0.09	0.01	0.01	0.00	0.01	0.00	0.02	0.00	0.00	0.00	0.11	0.18	0.01
Mammals														
ELE	0.0	0.03	0.06	0.11	0.35	0.08	0.08	0.02	0.13	0.08	0.45	0.01	0.04	0.04
MAP	0.21	0.30	0.39	0.08	0.14	0.17	0.09	0.05	0.09	0.06	0.02	0.10	0.03	0.27
MAT	0.22	0.4	0.34	0.30	0.19	0.23	0.06	0.72	0.65	0.27	0.09	0.61	0.23	0.29
MWS	0.07	0.11	0.17	0.45	0.11	0.16	0.04	0.13	0.04	0.04	0.10	0.20	0.09	0.30
LUN	0.14	0.11	0.03	0.06	0.18	0.37	0.71	0.08	0.09	0.54	0.33	0.06	0.53	0.08
LUI	0.27	0.02	0.01	0.01	0.04	0.00	0.03	0.00	0.00	0.01	0.00	0.01	0.09	0.03
Birds														
ELE	0.11	0.07	0.04	0.03	0.07	0.11	0.07	0.20	0.03	0.07	0.49	0.15	0.04	0.07
MAP	0.42	0.37	0.37	0.14	0.15	0.08	0.21	0.04	0.50	0.10	0.04	0.13	0.03	0.33
MAT	0.22	0.30	0.12	0.45	0.69	0.17	0.18	0.22	0.15	0.26	0.08	0.50	0.07	0.21
MWS	0.14	0.18	0.41	0.24	0.04	0.17	0.09	0.08	0.13	0.03	0.01	0.15	0.13	0.23
LUN	0.11	0.05	0.04	0.14	0.05	0.46	0.45	0.45	0.16	0.53	0.39	0.06	0.72	0.12
LUI	0.01	0.03	0.01	0.00	0.00	0.01	0.01	0.01	0.02	0.01	0.00	0.02	0.01	0.04

Note: The abbreviation of terrestrial biomes can be referred to **SI Table 2**.