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Supplementary material

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Human-dominated land uses favour species affiliated with more extreme climates, especially in the tropics.

Appendix 1

Land-use class definitions

Table A1: Classifications of the land-use classes and land-use intensity (reproduced from Hudson et al. 2014). For the analyses in our study, to ensure all groupings in the analyses reached our target minimum threshold of 50 communities, we combined mature secondary vegetation and intermediate secondary vegetation (to become advanced secondary vegetation).

Level 1 Land Use	**Predominant Land Use**	**Minimal use**	**Light use**	**Intense use**
No evidence of prior destruction of the vegetation	Primary Vegetation	Any disturbances identified are very minor (e.g., a trail or path) or very limited in the scope of their effect (e.g., hunting of a particular species of limited ecological importance).	One or more disturbances of moderate intensity (e.g., selective logging) or breadth of impact (e.g., bushmeat extraction), which are not severe enough to markedly change the nature of the ecosystem. Primary sites in suburban settings are at least Light use.	One or more disturbances that is severe enough to markedly change the nature of the ecosystem; this includes clear-felling of part of the site too recently for much recovery to have occurred. Primary sites in fully urban settings should be classed as Intense use.
Recovering after destruction of the vegetation	Mature Secondary Vegetation	As for Primary Vegetation-Minimal use	As for Primary Vegetation-Light use	As for Primary Vegetation-Intense use
	Intermediate Secondary Vegetation	As for Primary Vegetation-Minimal use	As for Primary Vegetation-Light use	As for Primary Vegetation-Intense use
	Young Secondary Vegetation	As for Primary Vegetation-Minimal use	As for Primary Vegetation-Light use	As for Primary Vegetation-Intense use

Human-dominated land uses favour species affiliated with more extreme climates, especially in the tropics.

Human use (agricultural)	Plantation forest	Extensively managed or mixed timber, fruit/coffee, oil-palm or rubber plantations in which native understorey and/or other native tree species are tolerated, which are not treated with pesticide or fertiliser, and which have not been recently (< 20 years) clear-felled.	Monoculture fruit/coffee/rubber plantations with limited pesticide input, or mixed species plantations with significant inputs. Monoculture timber plantations of mixed age with no recent (< 20 years) clear-felling. Monoculture oil-palm plantations with no recent (< 20 years) clear-felling.	Monoculture fruit/coffee/rubber plantations with significant pesticide input. Monoculture timber plantations with similarly aged trees or timber/oil-palm plantations with extensive recent (< 20 years) clear-felling.
Human use (agricultural)	Cropland	Low-intensity farms, typically with small fields, mixed crops, crop rotation, little or no inorganic fertiliser use, little or no pesticide use, little or no ploughing, little or no irrigation, little or no mechanisation.	Medium intensity farming, typically showing some but not many of the following: large fields, annual ploughing, inorganic fertiliser application, pesticide application, irrigation, no crop rotation, mechanisation, monoculture crop. Organic farms in developed countries often fall within this category, as may high-intensity farming in developing countries.	High-intensity monoculture farming, typically showing many of the following features: large fields, annual ploughing, inorganic fertiliser application, pesticide application, irrigation, mechanisation, no crop rotation.
	Pasture	Pasture with minimal input of fertiliser and pesticide, and with low stock density (*not* high enough to cause significant disturbance or to stop regeneration of vegetation).	Pasture either with significant input of fertiliser or pesticide, or with high stock density (high enough to cause significant disturbance or to stop regeneration of vegetation).	Pasture with significant input of fertiliser or pesticide, *and* with high stock density (high enough to cause significant disturbance or to stop regeneration of vegetation).

Appendix 2

Using species' realised climatic niches based on GBIF data

Occurrence data from the Global Biodiversity Information Facility (GBIF 2015) were extracted for terrestrial vertebrate species in the PREDICTS Project database. For each of these species, T_{max}, T_{min}, Pp_{max} and Pp_{min} values (WorldClim version 1.4; Hijmans, Cameron, Parra, Jones, & Jarvis 2005) were extracted for every recorded location within GBIF. Then, for each species, the extremes (maximum or minimum) and standard deviation of these values were found, to estimate the species realised temperature or precipitation extremes and climatic variation across a species' range, respectively (we were able to do this for 3,432 species; climatic niche properties were produced with the help of C. Waldock). These species-level realised climatic niche properties were then used to calculate CWMs (to test for patterns in the responses to land use of (1) the community-average extreme climatic conditions and (2) mean range-wide climatic variation species are affiliated with), and to split the species into groups depending on their climatic affiliation (extreme value and range-wide variation; to test for patterns in the response to land use of abundances (log(x+1) transformed) of species groups with different climatic niches); this was completed, and the linear mixed-effects models were run following the same methods as used in the Main text. We also found the correlation between the species-level climatic niche properties calculated using the distribution maps and GBIF data (table A2).

The results were generally qualitatively and quantitatively very similar when running models with species' realised niches estimated from GBIF data (table A2, fig. A1–3). The main difference was that, for CWMmax(Pp_{max}), even though the direction of the effect of land use on this community-level climatic property was the same as reported in the Main text, the interaction between land use and geographic zone was not significant when using GBIF data (fig. A2).

Table A2: Correlation (Pearson's correlation coefficient, *r*) between the species-level climatic niche properties produced when using IUCN (for mammals, amphibians and reptiles) or BirdLife International (for birds) range maps (IUCN 2016, BirdLife International 2012) versus occurrence data from GBIF (GBIF 2015). The climatic niche properties include the extreme (maximum or minimum) or range-wide variation (standard deviation) in one of four climatic variables (maximum temperature of the hottest month (T_{max}), minimum temperature of the coldest month (T_{min}), precipitation of the wettest month (Pp_{max}) and precipitation of the driest month (Pp_{min})).

Climatic niche property	*r*
$MaxT_{max}$	0.799
T_{max} variation	0.562
$MinT_{min}$	0.867
T_{min} variation	0.713
$MaxP_{max}$	0.784
Pp_{max} variation	0.631
$MinP_{min}$	0.650
Pp_{min} variation	0.752

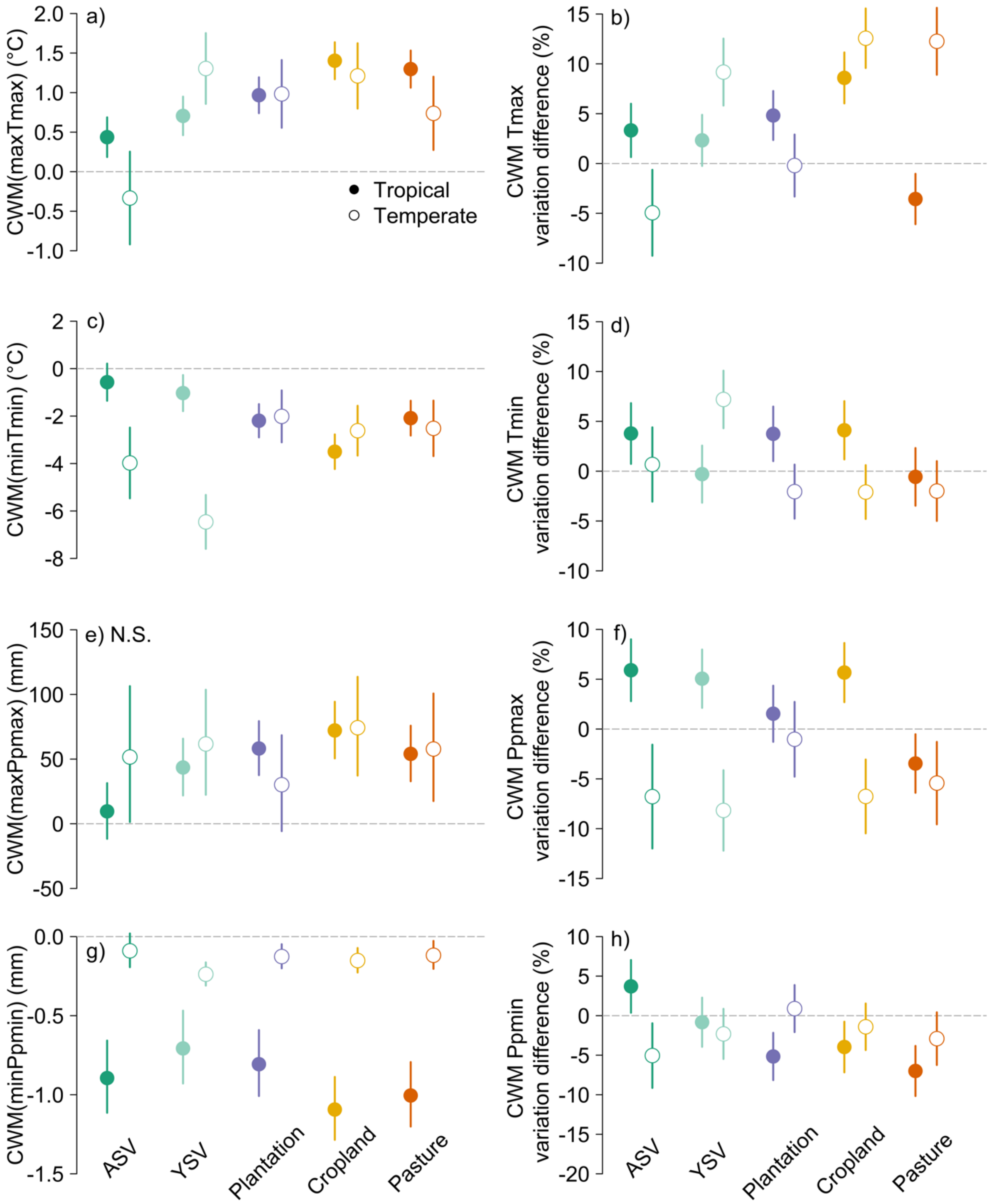

Figure A1: Geographic variation (tropical vs. temperate latitudes) in modelled differences across land uses in community weighted mean (CWM) maximum (max, a, e) or minimum (min, e, g) and range-wide variation (b, d, f, h) in maximum temperature of the hottest month (a, b), minimum temperature of the coldest month (c, d), precipitation of the wettest month (e, f) and precipitation of the driest month (g, h). All values are relative to assemblages within primary vegetation (which is represented by the dotted line). Error bars show 95% confidence intervals. ASV and YSV denote advanced and young secondary vegetation, respectively. Community weighted means were produced using data from GBIF. Transformed values were back-transformed from the log-scale used for analysis before plotting. N.S. denotes that the interaction between land use and geographic zone was not significant in that model.

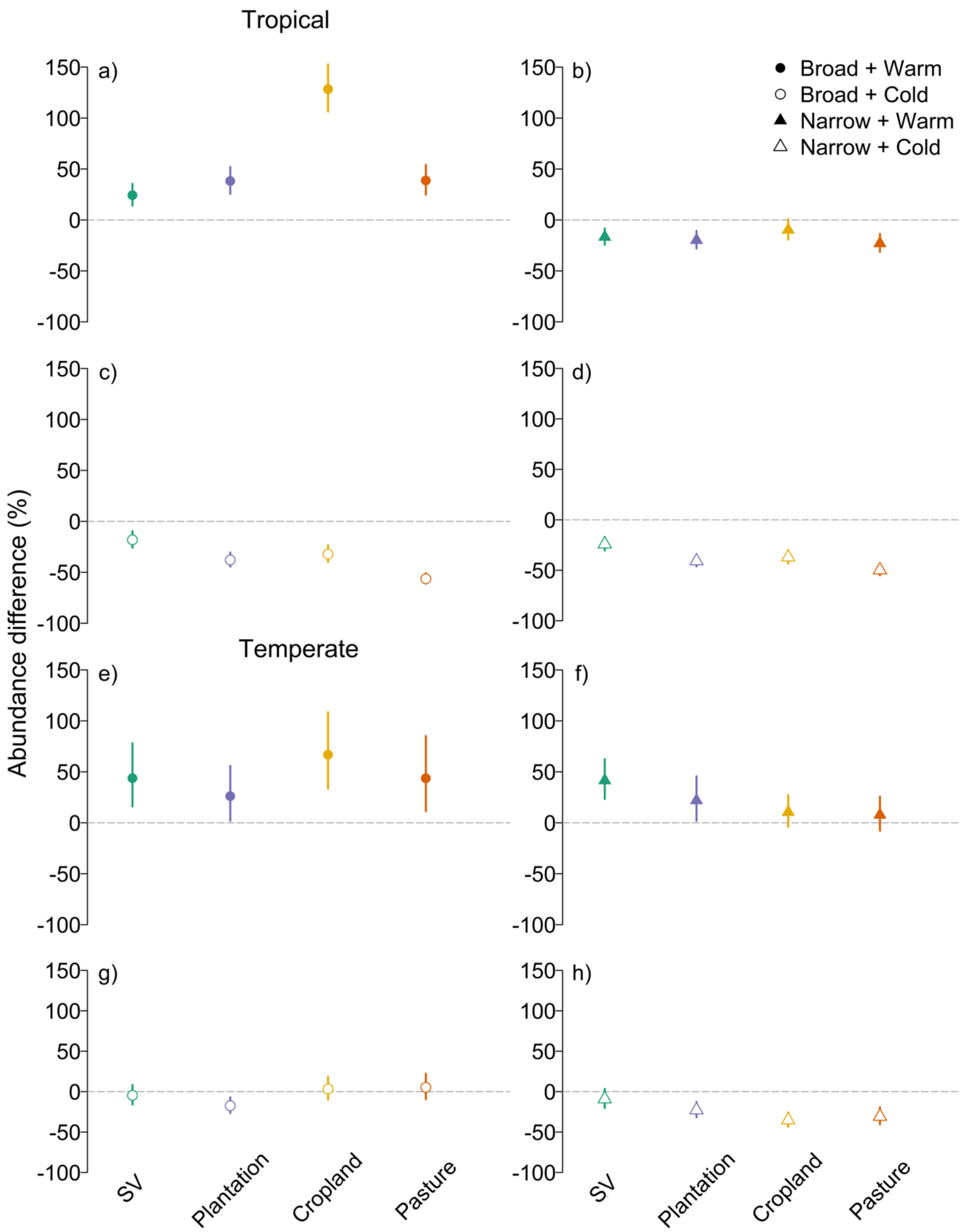

Figure A2: The total abundance of species with different thermal (T_{max}) niches at tropical (a-d) and temperate (e-h) latitudes across human-altered land uses, relative to assemblages within primary vegetation (dotted line). Species groups differ in the range-wide variation of thermal (T_{max}) conditions experienced over their range ('broad' vs. 'narrow') and maximum T_{max} value ('warm' vs. 'cold'). Error bars show 95% confidence intervals; SV denotes secondary vegetation (consisting of the young and advanced secondary vegetation land use categories). Values were back-transformed from the log-scale used for analysis before plotting. Species thermal niches were produced using data from GBIF.

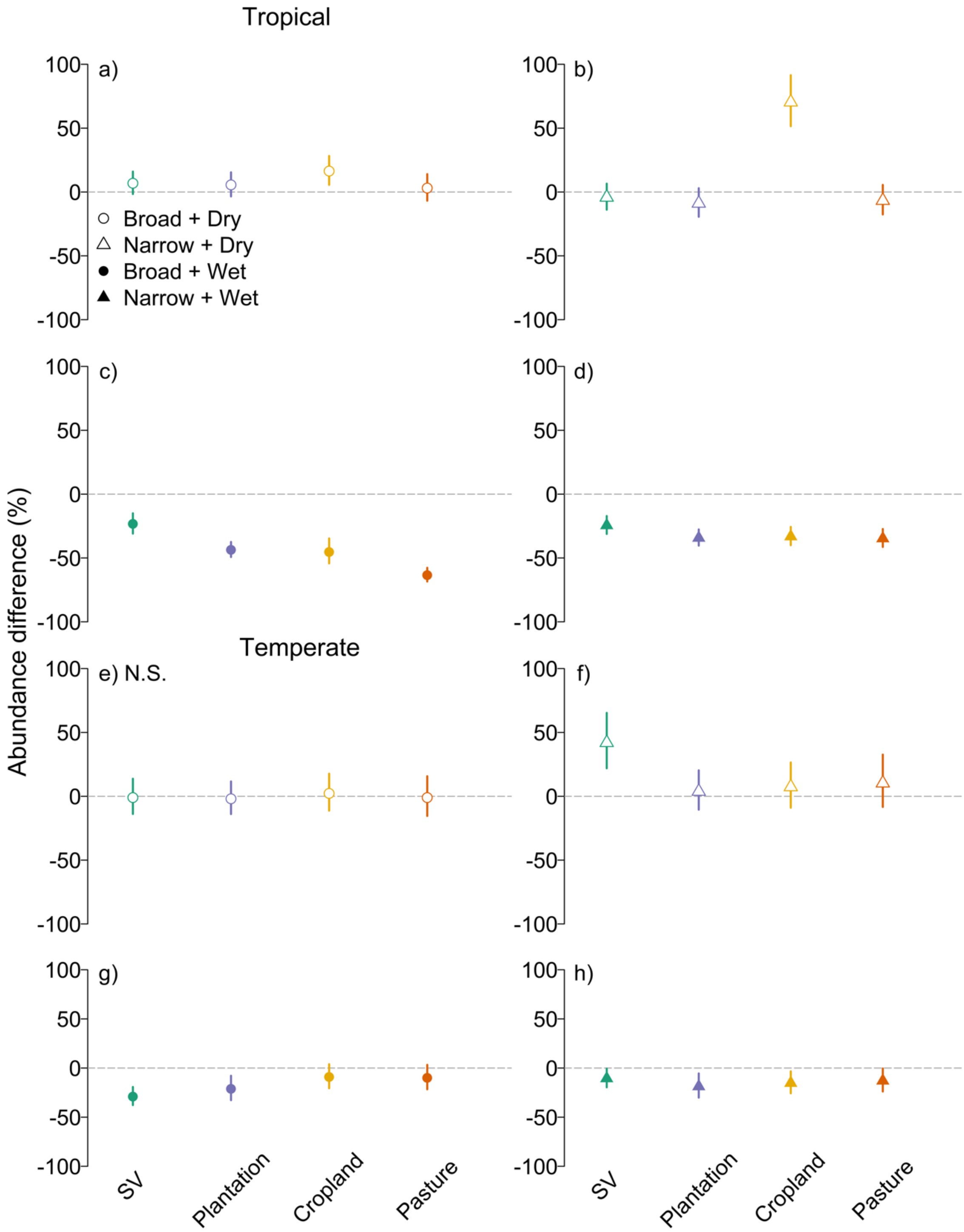

Figure A3: The total abundance of species with different precipitation niches (Pp_{min}) at tropical (a-d) and temperate (e-h) latitudes across human-altered land uses, relative to assemblages within primary vegetation (dotted line). Species groups differ in range-wide variation in precipitation (Pp_{min}) levels experienced throughout their range ('broad' vs. 'narrow') and minimum Pp_{min} values ('dry' vs. 'wet'). Error bars show 95% confidence intervals; SV denotes secondary vegetation (consisting of the young and advanced secondary vegetation land use categories). Values were back-transformed from the log-scale used for analysis before plotting. Species precipitation niches were produced using data from GBIF. N.S. denotes that the effect of land use was not significant within that species group.

Appendix 3

PREDICTS Project database

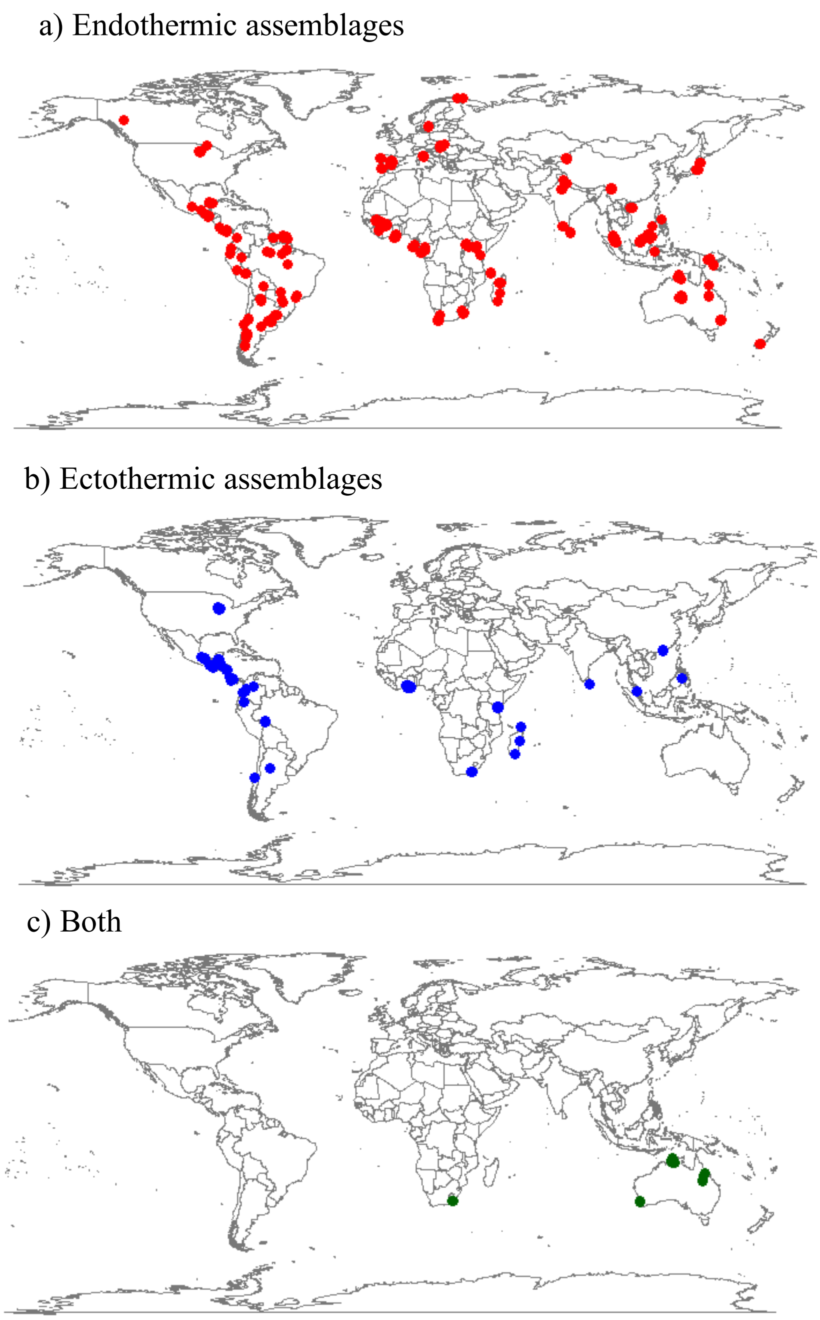

Figure A4: Locations of each study site ($n_{assemblages} = 6{,}123$) from the PREDICTS Project database included in our analyses, split into those studies that looked at a) solely endothermic vertebrates (mammals and birds), b) solely ectothermic vertebrates (reptiles and amphibians) and c) both endothermic and ectothermic vertebrates; base map from R package 'maps' v.3.3.0 (Becker & Wilks 2018).

Spatial extent of studies

Table A3: The number of assemblages in which species from each vertebrate Class were recorded and the maximum linear extent sampled for 95% of PREDICTS sites that were included in our analyses, to the nearest metre.

Taxonomic group	Number of assemblages	Bounds of maximum linear extent for 95% of sites (m)	
		Lower	Upper
Mammalia	1542	15	5000
Aves	4199	40	2000
Reptilia	785	31	1923
Amphibia	885	31	1049

Appendix 4

Community unweighted means

We also calculated CWMs that were not weighted by species abundance (termed here community unweighted means) for the mean climatic extreme values and range-wide climatic variation of each assemblage. Using these, we produced models using the same methods as with the CWMs (when split by geographic zone) to explore whether the average climatic maximum or minimum or range-wide variation of a species assemblage differed between land uses when these values were not weighted by species abundance.

Using CWMs weighted (i.e., average for an individual within a community) versus unweighted (i.e., average for a species within a community) by species abundance made very little difference to the results when testing the effect of land use and the interaction between land use and geographic zone (fig. A5).

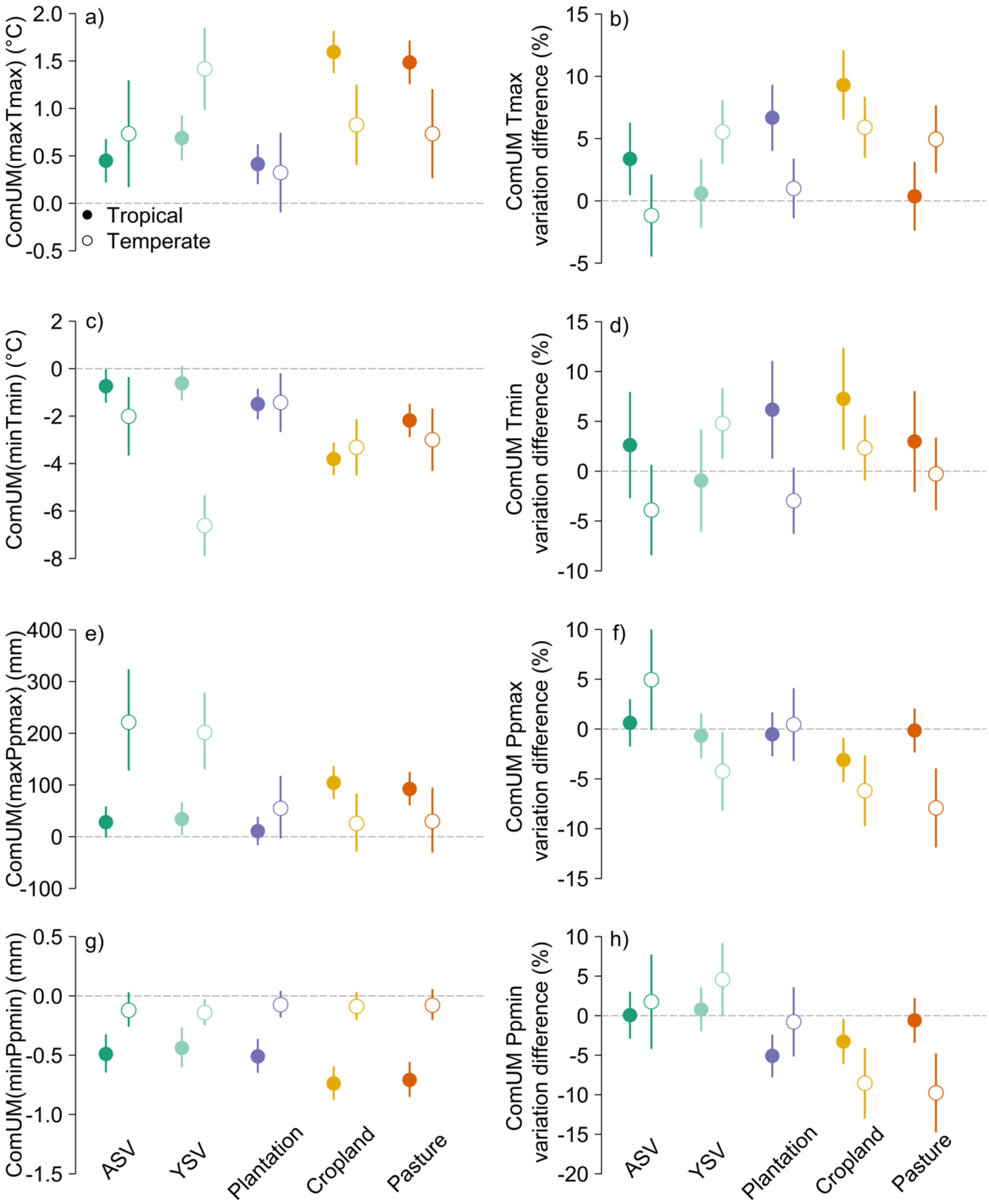

Figure A5: Geographic variation (tropical vs. temperate latitudes) in differences across land uses in community unweighted mean (ComUM) maximum (max, a, c) or minimum (min, e, g) and range-wide variation (b, d, f, h) of maximum temperature of the hottest month (a, b), minimum temperature of the coldest month (c, d), precipitation of the wettest month (e, f) and precipitation of the driest month (g, h). All values are relative to assemblages within primary vegetation (dotted line). Error bars show 95% confidence intervals. ASV and YSV denote advanced and young secondary vegetation, respectively. Transformed values were back-transformed from the log-scale used for analysis before plotting.

Appendix 5

Climatic niche properties

Table A4: The correlation (Spearman rank correlation) between the community-average climatic niche properties: the climatic extreme (maximum or minimum) and range-wide variation in maximum temperature of the hottest month (T_{max}), minimum temperature of the coldest month (T_{min}), precipitation of the wettest month (Pp_{max}) and precipitation of the driest month (Pp_{min}).

	Max T_{max}	T_{max} variation	Min T_{min}	T_{min} variation	Max Pp_{max}	Pp_{max} variation	Min Pp_{min}	Pp_{min} variation
Max T_{max}								
T_{max} variation	0.625							
Min T_{min}	-0.621	-0.913						
T_{min} variation	0.696	0.889	-0.928					
Max Pp_{max}	0.491	0.356	-0.358	0.490				
Pp_{max} variation	-0.053	-0.046	0.172	0.008	0.524			
Min Pp_{min}	-0.563	-0.455	0.473	-0.468	-0.158	0.094		
Pp_{min} variation	0.002	-0.100	0.047	0.037	0.378	0.327	0.148	

Appendix 6

Species groups with different climatic niches

Table A5: The number of species within each climatic niche group included in the abundance analysis. These groups were formed by splitting around the within-study medians of climatic extreme values and range-wide variation with regards to a) maximum temperature of the hottest month (T_{max}) or b) precipitation of the driest month (Pp_{min}).

		Climatic extreme			
a)		T_{max} maximum			
		Warm		Cold	
		Tropics	Temperate	Tropics	Temperate
T_{max} variation	Wide	581	290	345	123
	Narrow	248	175	1598	593
b)		Pp_{min} minimum			
		Wet		Dry	
		Tropics	Temperate	Topics	Temperate
Pp_{min} variation	Wide	583	106	1240	431
	Narrow	323	98	626	546

Table A6: Number of assemblages within each land use for each of the four species group with distinct climatic niches (see table A4) with regards to a) maximum temperature of the hottest month (T_{max}) and b) precipitation of the driest month (Pp_{min}). Advanced and young secondary land-use classes were combined to become 'secondary land use'.

Climatic niche			Land Use					Total
			Primary vegetation	Secondary vegetation	Plantation	Cropland	Pasture	
a) T_{max}								
	Warm and broad	Tropics	1156	744	691	439	543	3573
		Temperate	709	219	258	484	274	1944
	Warm and narrow	Tropics	1250	762	844	435	517	3808
		Temperate	544	127	166	278	252	1367
	Cold and broad	Tropics	884	498	684	399	518	2983
		Temperate	568	117	214	272	257	1428
	Cold and narrow	Tropics	1362	802	865	439	552	4020
		Temperate	635	207	85	226	267	1420
b) Pp_{min}								
	Wet and broad	Tropics	524	431	457	101	140	1653
		Temperate	310	60	84	218	257	929
	Wet and narrow	Tropics	925	510	578	390	487	2890
		Temperate	539	198	81	225	263	1306
	Dry and broad	Tropics	1343	763	854	435	550	3945
		Temperate	666	224	225	484	282	1881
	Dry and narrow	Tropics	1179	561	655	415	537	3347
		Temperate	747	198	258	485	283	1971

Appendix 7

Range-wide climatic variation and range size

Table A7: The correlation between community-average range-wide climatic variation and community-average range size. The latter were acquired from Newbold et al. (2018); the methods used to estimate these range sizes are described briefly in the Main text. Range-wide climatic variation was calculated for the following climatic variables: maximum temperature of the hottest month (T_{max}), minimum temperature of the coldest month (T_{min}), precipitation of the wettest month (Pp_{max}) and precipitation of the driest month (Pp_{min}).

	Community-average range-wide climatic variation			
	T_{max}	T_{min}	Pp_{max}	Pp_{min}
Community-average range size	0.661	0.773	-0.050	0.038

Appendix 8

Comparing endotherms and ectotherms

We also tested for differences among endothermic and ectothermic assemblages, as ambient climatic conditions affect them differently due to their distinct physiologies (Deutsch et al. 2008; Frishkoff et al. 2016; McNab 2012; Senior et al. 2017).

Methods

These models were run in the same way as the models looking at geographic differences in the Main text, but with thermoregulatory strategy (endothermic vs. ectothermic) and its interaction with land use included as fixed effects instead of geographic zone. The 391 communities (5.73% of all communities) that sampled for endotherms *and* ectotherms were removed from these analyses. The secondary vegetation land-use classes were grouped together (to become 'secondary vegetation'), and pasture and cropland were grouped to become an 'agriculture' land-use class (the only grouping in this analysis that failed to reach our target minimum threshold of 50 communities was in the range-wide climatic variation analyses for ectothermic assemblages in secondary vegetation where n=34; table A8). For the final statistical models used, see table A9. We also tested for spatial autocorrelation in the residuals of all our models using Moran's I tests.

Table A8: The number of endothermic and ectothermic assemblages within each land-use type included in the models comparing these two groups. The numbers in parentheses denote the number of assemblages included in the models testing effects of land use on the community-average range-wide variation in climatic conditions.

Assemblage	Land use				Total
	Primary vegetation	Secondary vegetation	Plantation	Agriculture	
Endothermic	1697 (1456)	859 (719)	873 (661)	1638 (1433)	5067 (4289)
Ectothermic	226 (133)	56 (34)	262 (207)	121 (73)	665 (447)

Table A9: The final statistical models for the analyses of community-average climatic niches after backwards stepwise selection of fixed effects, following the methods proposed by Zuur et al. (2009). Response variables were the community weighted means (CWM) for the extremes of the four focal climatic variables (CWM(maxT_{max}), CWM(minT_{min}), CWM(maxPp$_{max}$), CWM(minPp$_{min}$)) or STD (the community weighted mean of the standard deviation of the climatic variables across the species range, which we used to calculate community-average range-wide variation) for each climatic variable (maximum temperature of the hottest month, STD_Tmax; minimum temperature of the coldest month, STD_Tmin; precipitation of the wettest month, STD_Ppmax; precipitation of the driest month, STD_Ppmin). Community weighted means for extremes of precipitation variables were log(x+1) transformed. Random intercepts included study identity (SS, added to account for differences between studies in sampling methods and response variables) and spatial block within study (SSB, to account for the spatial structure of sites sampled within each study). The explanatory variables considered as fixed effects included land use (LU), thermoregulatory strategy (EE; endothermic vs. ectothermic assemblages) and the interaction between the two ('x' between variables indicate that the interaction between those two variables was significant). In addition, the climatic variable in question at the study site and the site's elevation were also added into models as continuous covariates (for all models apart from those focusing on maximum temperature of the hottest month, where elevation was not added because it correlated strongly with maximum temperature itself; see Main text); for range-wide climatic variation analyses community weighted mean range sizes (Range) were also added as a continuous covariate; we fit linear terms for these three covariates.

Model		
Endotherms vs. ectotherms	Climatic extreme	
		CWM(maxTmax) ~ LU + EE + LUxEE + Tmax + (1|SS) + (1|SSB)
		CWM(minTmin) ~ LU + EE + LUxEE + Tmin + Elevation + (1|SS) + (1|SSB)
		CWM(maxPpmax) ~ LU + EE + Elevation + (1|SS) + (1|SSB)
		CWM(minPpmin) ~ LU + EE + LUxEE + Elevation + (1|SS) + (1|SSB)
	Climatic variation	
		STD_Tmax ~ LU + EE + LUxEE + Range + (1|SS) + (1|SSB)
		STD_Tmin ~ LU + EE + LUxEE + Tmin + Elevation + Range + (1|SS) + (1|SSB)
		STD_Ppmax ~ LU + EE + LUxEE + Range + (1|SS) + (1|SSB)
		STD_Ppmin ~ LU + EE + LUxEE + Ppmin + Elevation + Range + (1|SS) + (1|SSB)

Results

Endothermic and ectothermic assemblages differed in their climatic niches across land uses for all climatic variables apart from community-average maximum Pp_{max} (land use by thermoregulatory strategy interaction, $p<0.05$, apart for CWM(maxPp_{max}) where $p=0.34$; fig. A6, table A10). Ectothermic and endothermic assemblages differed most in agricultural land uses (pasture and cropland), in which ectothermic assemblages tended to show stronger relative shifts toward species affiliated with warmer T_{max}, whereas endothermic assemblages showed stronger shifts towards colder T_{min} affiliations (fig. A6).

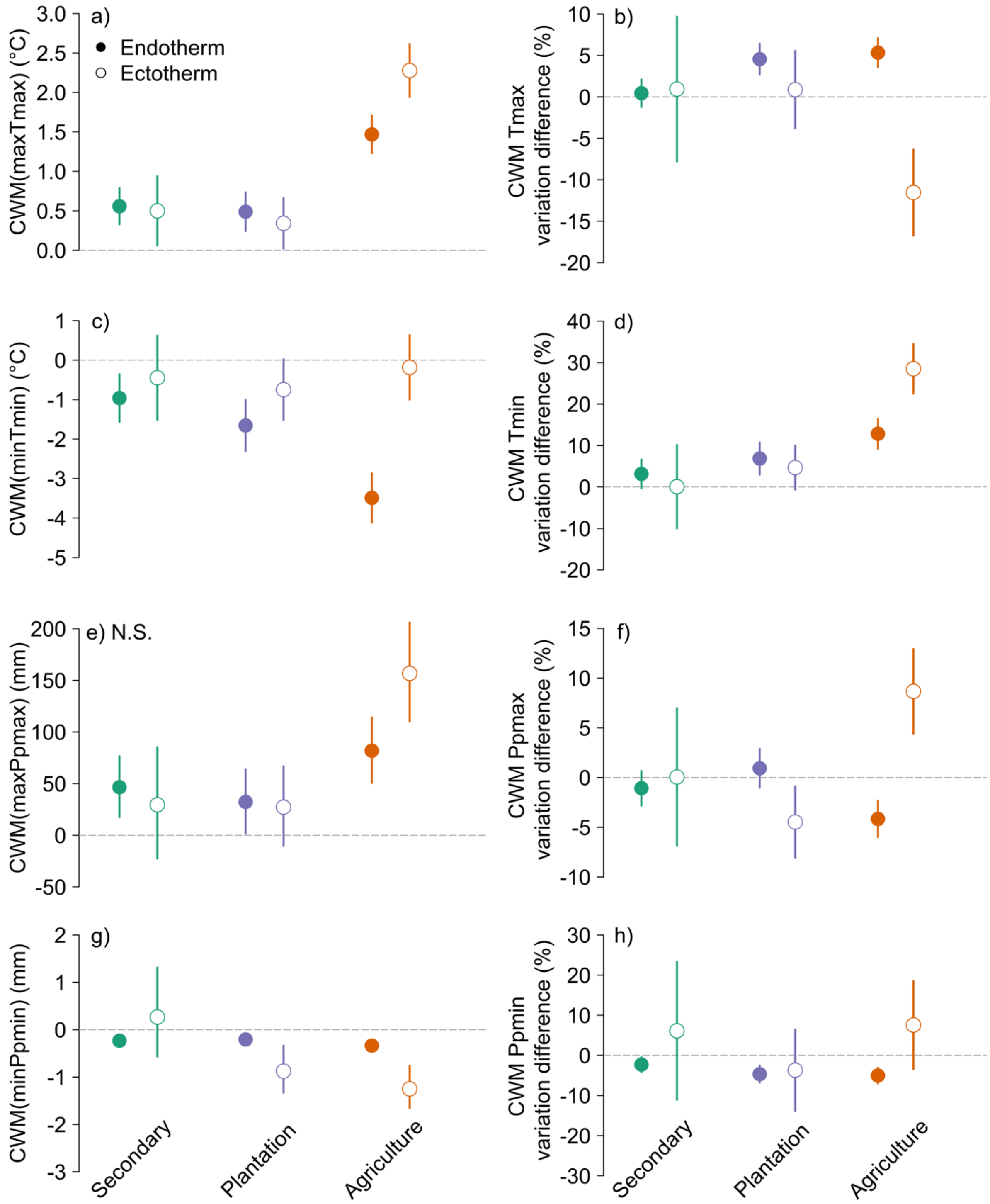

Figure A6: Variation between endothermic and ectothermic assemblages across land-use types in community weighted mean (CWM) maximum (max, a, c) or minimum (min, e, g) and range-wide variation (b, d, f, h) of maximum temperature of the hottest month (a, b), minimum temperature of the coldest month (c, d), precipitation of the wettest month (e, f) and precipitation of the driest month (g, h). Values are relative to assemblages within primary vegetation (dotted line). Error bars show 95% confidence intervals; community-average extreme or range-wide variation significantly differ from those within primary vegetation when the error bars for that land use do not cross the dotted line. Transformed values were back-transformed from the log-scale used for analysis before plotting. N.S. denotes models in which the interaction between land use and thermoregulatory strategy was not significant.

Table A10: The statistical results from the likelihood ratio tests investigating the effect of the interaction between land use and thermoregulatory strategy (endothermic vs. endothermic). Response variables were community weighted mean for the climatic extreme (maximum or minimum) or range-wide variation in one of four climatic variables (maximum temperature of the hottest month (T_{max}), minimum temperature of the coldest month (T_{min}), precipitation of the wettest month (Pp_{max}) and precipitation of the driest month (Pp_{min})).

Model (in parentheses is the fixed effect for which the statistical results are provided)	Climatic niche property	Results from likelihood ratio tests		
		χ^2	Degrees of freedom	p-value
Endotherm vs. ectotherm (interaction between land use and thermoregulatory strategy)	CWM(maxT_{max})	8.03	3,12	0.045
	T_{max} variation	143.95	3,13	<0.001
	CWM(minT_{min})	15.87	3,13	0.001
	T_{min} variation	20.57	3,14	<0.001
	CWM(maxPp_{max})	3.38	3,13	0.337
	Pp_{max} variation	19.74	3,14	<0.001
	CWM(minPp_{min})	27.52	3,13	<0.001
	Pp_{min} variation	30.17	3,14	<0.001

Table A11: Spatial autocorrelation in the community-level model residuals; a Moran's I test was applied to the residuals of the final models for each individual underlying study separately (Newbold et al. 2015), with the percentage of studies that had p<0.05 shown below. The climatic niche properties modelled were the community weighted mean for the extreme value (maximum or minimum) or range-wide variation in one of four climatic variables (maximum temperature of the hottest month (T_{max}), minimum temperature of the coldest month (T_{min}), precipitation of the wettest month (Pp_{max}) and precipitation of the driest month (Pp_{min})).

Model	Climatic niche property	Percentage of studies for which $p<0.05$
Endotherm vs. ectotherm	CWM(maxT_{max})	5.48
	T_{max} variation	3.28
	CWM(minT_{min})	8.00
	T_{min} variation	3.39
	CWM(maxPp_{max})	0
	Pp_{max} variation	8.20
	CWM(minPp_{min})	1.39
	Pp_{min} variation	6.90

Discussion

Endothermic and ectothermic assemblages differed in the magnitude, and sometimes direction, of community-average climatic niches across human-altered land uses relative to primary vegetation. Differences were often largest in agricultural land uses (cropland and pastures) and was particularly strong for thermal niche properties. For ectotherms, agriculture appears to be favouring hot-specialists (species affiliated with higher maximum temperatures and less range-wide variation in T_{max}), potentially due to the strong influence of temperature on ectotherm's basic physiological functions (Deutsch et al. 2008). Additionally, to survive hotter temperatures, ectotherms rely on access to cool microhabitats (shade or burrows) to thermoregulate (Kearney et al. 2009, Sunday et al. 2014), which may be lacking in agriculture. Endotherms affiliated with cold extremes appeared to be favoured in human-altered habitats, especially in agricultural land uses; this may be due to the strong limiting effect of cold extremes on the distributions of birds and mammals (Khaliq et al. 2017). With more data, it would be interesting to also look at the similarities/differences between wet-skinned (i.e., amphibians) and dry-skinned (i.e., endotherms and reptiles) species.

Appendix 9

Statistical model structure

Table A12: The final statistical models for the analyses of community-average climatic niches after backwards stepwise selection of fixed effects, following the methods proposed by Zuur et al. (2009). Response variables were the community weighted means for the extremes (maximum or minimum) of the four focal climatic variables (CWM(maxT_{max}), CWM(minT_{min}), CWM(maxPp_{max}), CWM(minPp_{min})) or STD (the community weighted mean of the standard deviation of the climatic variables across the species range, which we used to calculate community-average range-wide variation) for each climatic variable (maximum temperature of the hottest month, STD_Tmax; minimum temperature of the coldest month, STD_Tmin; precipitation of the wettest month, STD_Ppmax; precipitation of the driest month, STD_Ppmin). Community weighted means for extremes of precipitation variables were log(x+1) transformed. Random intercepts included study identity (SS, added to account for differences between studies in sampling methods and response variables) and spatial block within study (SSB, to account for the spatial structure of sites sampled within each study). The explanatory variables considered as fixed effects included land use (LU) and geographic zone (GZ; temperate versus tropical latitudes) and its interaction with land use; ‘x’ between variables indicate that the interaction between those two variables was significant. In addition, the climatic variable in question at the study site and the site’s elevation were also added into models as continuous covariates (for all models apart from those focusing on maximum temperature of the hottest month, where elevation was not added; see Main text); for range-wide climatic variation analyses community weighted mean range sizes (Range) were also added as a continuous covariate; we fit linear terms for these three covariates.

Model		
Geographic zone	Climatic extreme	
		CWM(maxT_{max}) ~ LU + GZ + LUxGZ + Tmax + (1|SS) + (1|SSB)
		CWM(minT_{min}) ~ LU + GZ + LUxGZ + Tmin + Elevation + (1|SS) + (1|SSB)
		Log(CWM(maxPp_{max})+1) ~ LU + GZ + LUxGZ + Elevation + (1|SS) + (1|SSB)

	Log(CWM(minPp_{min})+1) ~ LU + GZ + LUxGZ + Elevation + (1|SS) + (1|SSB)
	Climatic variation
	STD_Tmax ~ LU + GZ + LUxGZ + Range + (1|SS) + (1|SSB)
	STD_Tmin ~ LU + GZ + LUxGZ + Tmin + Elevation + Range + (1|SS) + (1|SSB)
	STD_Ppmax ~ LU + GZ + LUxGZ + Range + (1|SS) + (1|SSB)
	STD_Ppmin ~ LU + GZ + LUxGZ + Ppmin + Elevation + Range + (1|SS) + (1|SSB)

Table A13: The final statistical models for the abundance analyses after the backwards stepwise selection of fixed effects. Response variables were the abundance (transformed using log(x+1); LogAbund) of species groups with different climatic niches (separately for maximum temperature (T_{max}) and minimum precipitation (Pp_{min})). Species within each assemblage analysed were split into 4 groups around the within-study medians of climatic extreme (maximum of T_{max} or minimum of Pp_{min}) and range-wide variation (T_{max} or Pp_{min}). For the temperature variable, groups included species with 1) warm and broad, 2) warm and narrow, 3) cold and broad or 4) cold and narrow T_{max} niches. For the precipitation variable, groups included species with 1) dry and broad, 2) dry and narrow, 3) wet and broad or 4) wet and narrow Pp_{min} niches. Random intercepts included study identity (SS, added to account for differences between studies in sampling methods and response variables) and spatial block within study (SSB, to account for the spatial structure of sites sampled within each study). Land use (LU) was always considered as an explanatory variable, so added as a fixed effect. The climatic variable in question at the study site was considered as a fixed, continuous covariate; site elevation was also considered as a continuous fixed effect for the temperate models focusing on precipitation of the driest month (see Main text); we fit linear terms for both of these covariates.

Abundance model	
Maximum temperature of the hottest month	Tropical latitudes 1) LogAbund ~ LU + Tmax + (1|SS) + (1|SSB) 2) LogAbund ~ LU + Tmax + (1|SS) + (1|SSB) 3) LogAbund ~ LU + (1|SS) + (1|SSB) 4) LogAbund ~ LU + (1|SS) + (1|SSB) Temperate latitudes 1) LogAbund ~ LU + (1|SS) + (1|SSB) 2) LogAbund ~ LU + (1|SS) + (1|SSB)

	3) LogAbund ~ LU + (1|SS) + (1|SSB)
	4) LogAbund ~ LU + (1|SS) + (1|SSB)
Precipitation of the driest month	Tropical latitudes
	1) LogAbund ~ LU + (1|SS) + (1|SSB)
	2) LogAbund ~ LU + Ppmin + (1|SS) + (1|SSB)
	3) LogAbund ~ LU + Ppmin + (1|SS) + (1|SSB)
	4) LogAbund ~ LU + Ppmin + (1|SS) + (1|SSB)
	Temperate latitudes
	1) LogAbund ~ LU + (1|SS) + (1|SSB)
	2) LogAbund ~ LU + (1|SS) + (1|SSB)
	3) LogAbund ~ LU + (1|SS) + (1|SSB)
	4) LogAbund ~ LU + Elevation + (1|SS) + (1|SSB)

Full statistical results

Table A14: The statistical results from the likelihood ratio tests investigating the effect of land use and the interaction between land use and geographic zone. Response variables were community weighted means for the climatic extreme (maximum or minimum) or range-wide variation of one of four climatic variables (maximum temperature of the hottest month (T_{max}), minimum temperature of the coldest month (T_{min}), precipitation of the wettest month (Pp_{max}) and precipitation of the driest month (Pp_{min})).

The effect for which the statistical results are provided	Climatic niche property	Results from likelihood ratio tests		
		χ^2	Degrees of freedom	p-value
Land use	Max T_{max}	238.79	5,11	<0.001
	T_{max} variation	67.12	5,11	<0.001
	Min T_{min}	170.26	5,12	<0.001
	T_{min} variation	22.56	5,12	<0.001
	Max Pp_{max}	71.74	5,10	<0.001
	Pp_{max} variation	30.07	5,11	<0.001
	Min Pp_{min}	105.07	5,11	<0.001
	Pp_{min} variation	24.38	5,13	<0.001
Interaction between geographic zone and land use	Max T_{max}	38.23	5,16	<0.001
	T_{max} variation	99.41	5,17	<0.001
	Min T_{min}	99.14	5,17	<0.001
	T_{min} variation	62.38	5,18	<0.001
	Max Pp_{max}	84.73	5,17	<0.001
	Pp_{max} variation	14.24	5,18	0.014
	Min Pp_{min}	14.39	5,17	0.013
	Pp_{min} variation	19.05	5,18	0.002

Table A15: The statistical results from the likelihood ratio tests looking at the effect of land use on the abundance of species groups with different climatic niche properties. Species groups were formed by splitting assemblages within the PREDICTS Project database around the within-study medians of climatic extreme (maximum or minimum) and range-wide variation in a) maximum temperature of the hottest month (T_{max}) or b) precipitation of the driest month (Pp_{min}).

Model	Species group	Geographic zone	Statistical results for the land use term		
			χ^2	Degrees of freedom	p-value
a) T_{max}	Broad and warm	Tropics	155.29	4,9	<0.001
		Temperate	9.32	4,8	0.053
	Narrow and warm	Tropics	35.57	4,9	<0.001
		Temperate	4.51	4,9	0.341
	Broad and cold	Tropics	236.55	4,8	<0.001
		Temperate	36.60	4,8	<0.001
	Narrow and cold	Tropics	132.30	4,8	<0.001
		Temperate	17.84	4,8	0.001
b) Pp_{min}	Broad and dry	Tropics	37.25	4,8	<0.001
		Temperate	6.71	4,9	0.152
	Narrow and dry	Tropics	191.06	4,9	<0.001
		Temperate	10.25	4,8	0.036
	Broad and wet	Tropics	184.26	4,9	<0.001
		Temperate	7.49	4,8	0.112
	Narrow and wet	Tropics	78.74	4,9	<0.001
		Temperate	17.35	4,9	0.002

Spatial autocorrelation results

We tested for spatial autocorrelation in the residuals of all our models using Moran's I tests (Newbold et al. 2018; table A16, A17).

Table A16: Spatial autocorrelation in the community-level model residuals; a Moran's I test was applied to the residuals of the final models for each individual underlying study separately, with the percentage of studies that had $p<0.05$ shown below. The climatic niche properties modelled were the community weighted means for the climatic extreme (maximum or minimum) or range-wide variation in one of four climatic variables (maximum temperature of the hottest month (T_{max}), minimum temperature of the coldest month (T_{min}), precipitation of the wettest month (Pp_{max}) and precipitation of the driest month (Pp_{min})).

Model	Climatic niche property	Percentage of studies for which p<0.05
Geographic zone	Max T_{max}	5.33
	T_{max} variation	1.54
	Min T_{min}	5.26
	T_{min} variation	4.62
	Max Pp_{max}	0
	Pp_{max} variation	9.23
	Min Pp_{min}	1.37
	Pp_{min} variation	6.25

Table A17: Spatial autocorrelation in the abundance model residuals; a Moran's I test was applied to the residuals of the abundance models for each individual underlying study separately, with the percentage of studies that had $p<0.05$ shown below. Species groups were formed by splitting assemblages within the PREDICTS Project database around the within-study medians of climatic extreme (maximum T_{max} or minimum Pp_{min}) and range-wide variation (T_{max} or Pp_{min}).

Model	Species group	Geographic zone	Percentage of studies for which p<0.05
a) T_{max}	Broad and warm	Tropics	9.76
		Temperate	8.00
	Narrow and warm	Tropics	2.78
		Temperate	11.76
	Broad and cold	Tropics	7.69
		Temperate	5.56
	Narrow and cold	Tropics	6.98
		Temperate	15.00
b) Pp_{min}	Broad and dry	Tropics	4.55
		Temperate	4.17
	Narrow and dry	Tropics	3.23
		Temperate	8.33
	Broad and wet	Tropics	11.54
		Temperate	25.00
	Narrow and wet	Tropics	9.09
		Temperate	6.25

Appendix 10

Habitat specialisation

Using species' habitat preferences extracted from IUCN (2017), a species-level habitat breadth index was produced by weighting each habitat used by its importance and suitability to the species (as recorded within IUCN 2017) and then summing these together (table A18). Habitats that were classed as of major importance to the species were given a weight of 1, while habitats that were less important or suitable (e.g., marginal habitats) were given lower weights (table A18); the index was robust to different weighting systems (A. Etard, unpublished data). Thus, higher indices represent species inhabiting a greater range of habitats. We calculated the correlation between our species-level climatic niche properties and this habitat breadth index; these correlations were all low (|r|<0.41, table A19).

Table A18: The weighting system used to produce a species-level habitat breadth index based on their habitat preferences (IUCN 2017). Each habitat was assigned a weight depending on its importance and suitability to the species (reproduced with permission from A. Etard). Dashes denote categories that do not exist (a habitat cannot have a classification of major importance and marginal or unknown suitability).

Suitability	Major importance		
	Yes	No	Unknown
Suitable	1.0	0.5	1.0
Marginal	---	0.3	0.3
Unknown	---	0.3	1.0

Table A19: The correlation (Pearson's correlation coefficient, *r*) between species-level climatic niche properties and their habitat breadth (using the habitat breadth index produced by A. Etard; $n_{species}$ = 3,119). The species-level climatic niche properties include the climatic extreme (maximum or minimum) or the range-wide variation in maximum temperature of the hottest month (T_{max}), minimum temperature of the coldest month (T_{min}), precipitation of the wettest month (Pp_{max}) and precipitation of the driest month (Pp_{min}).

Climatic niche property	*r*
Max T_{max}	0.409
T_{max} variation	0.360
Min T_{min}	-0.384
T_{min} variation	0.367
Max Pp_{max}	0.283
Pp_{max} variation	0.121
Min Pp_{min}	-0.119
Pp_{min} variation	-0.039

Forest specialisation

To further explore the relationship between species' climatic niches and their habitat affiliations, using the above habitat preferences (IUCN 2017), we extracted data on forest use. Forest canopies buffer climatic extremes (Barnagaud et al. 2013, Ewers and Banks-Leite 2013). Consequently, if species' climatic niches are a product of the spatial (and climatic) distribution of their critical habitats, then the loss of forest specialists from human-disturbed habitats may be a driver in the shift towards community-level realised climatic niches that encompass greater extremes in climatic variables in these human-altered sites. Therefore, to check that our results were not being driven by a loss of forest specialists, we explored the climatic niche properties of forest specialists and the influence of excluding forest specialists from the models on our results. A species was classified as a forest specialist if natural forest habitats were considered as being of 'major' importance according to the IUCN habitat classification (rather than suitable, marginal or unsuitable), otherwise the species was classified as a non forest-specialist (although because estimates are lacking for some species, we cannot say for certain a species is *not* a forest specialist). The habitats in the IUCN classification that were considered to be natural forest were: Forest – Subtropical/Tropical

Moist Lowland; Forest –Subtropical/Tropical Moist Montane; Forest – Subtropical/Tropical Dry; Forest – Temperate; Forest – Subtropical/Tropical Swamp; Forest – Boreal; Forest – Subartic; Forest – Subtropical/Tropical Mangrove Vegetation Above High Tide Level; Forest – Subantarctic.

First, we compared the difference in species-level climatic niche properties between forest specialists and non forest-specialists (Fig. A7).

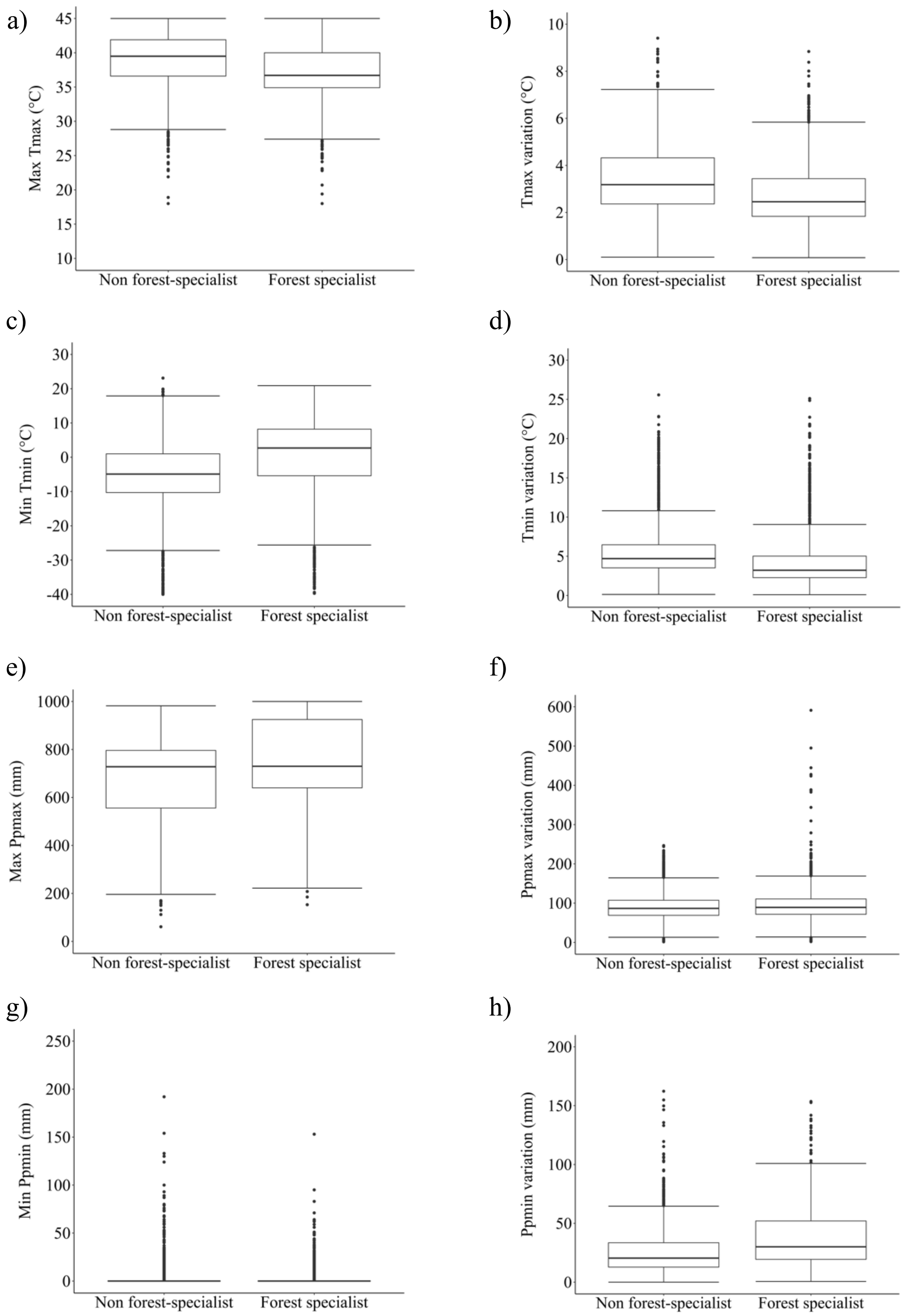

Figure A7: Comparisons between species classed as forest specialists and non forest-specialists for the following climatic niche properties: species-level climatic maximum (max, a, c) or minimum (min, e, g) and range-wide variation in (b, d, f, h) of maximum temperature of the hottest month (a, b), minimum temperature of the coldest month (c, d), precipitation of the wettest month (e, f) and precipitation of the driest month (g, h).

Second, to investigate the influence of habitat specialisation on our results, we ran two sets of simple models, run following the same method to our geographic zone models in the Main text, but excluding geographic zone and its interaction with land use. All species were included in the first set of models (fig. A8), but in the second set, species classed as forest specialists were excluded (fig. A9). Although there were some differences between species-level climatic niche properties for forest versus non forest-specialists (fig. A7), the results from the models excluding forest specialists were qualitatively and quantitatively very similar to the models including all species (fig. A8-9).

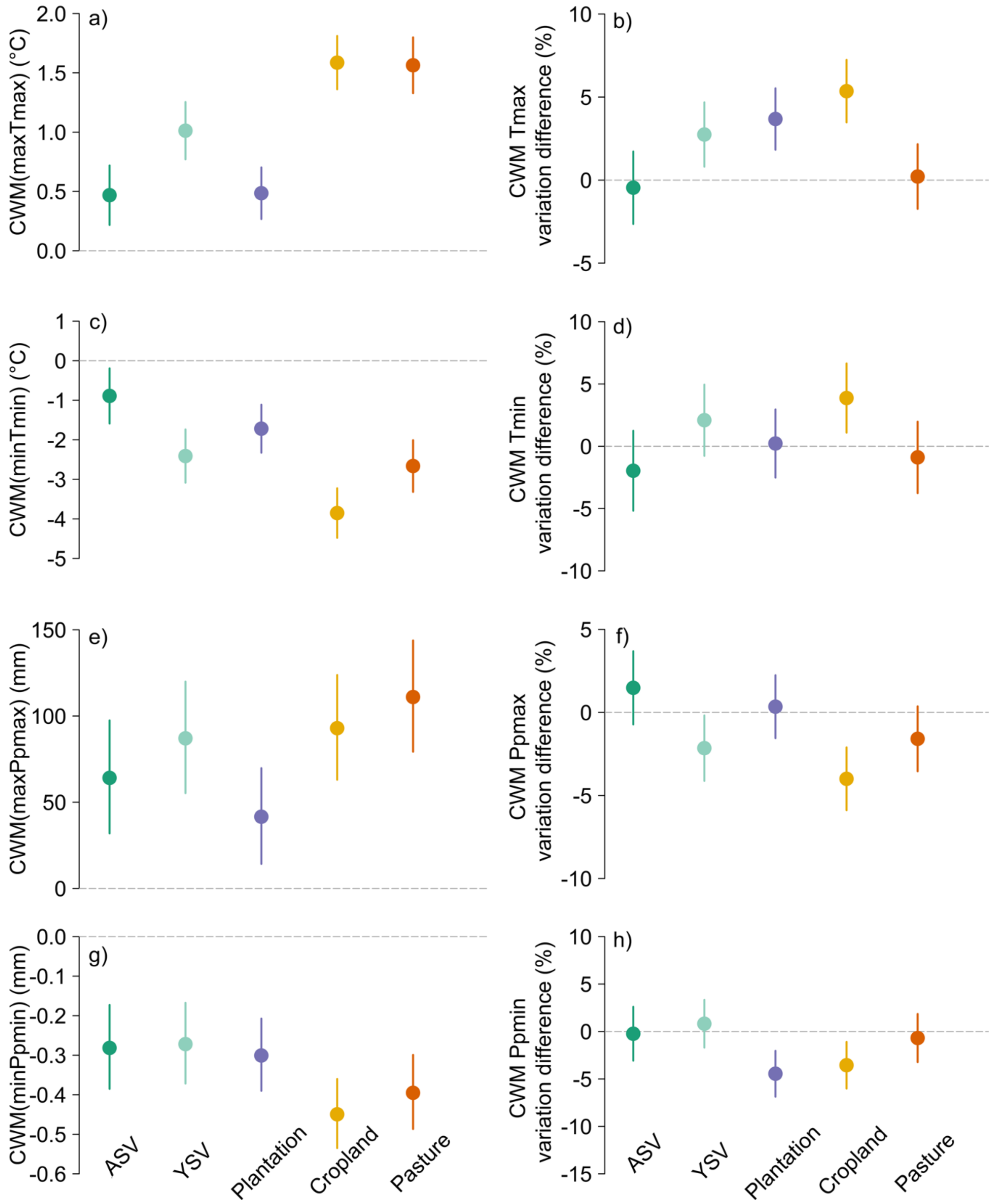

Figure A8: Difference across land uses in community weighted mean (CWM) maximum (max, a, c) or minimum (min, e, g) and range-wide variation (b, d, f, h) in maximum temperature of the hottest month (a, b), minimum temperature of the coldest month (c, d), precipitation of the wettest month (e, f) and precipitation of the driest month (g, h). All values are relative to assemblages within primary vegetation (which is represented by the dotted line). Error bars show 95% confidence intervals; community-average extreme value (maximum or minimum) or range-wide variation significantly differ from those within primary vegetation when the error bars for that land use do not cross the dotted line. ASV and YSV denote advanced and young secondary vegetation, respectively. Transformed values were back-transformed from the log-scale used for analysis before plotting.

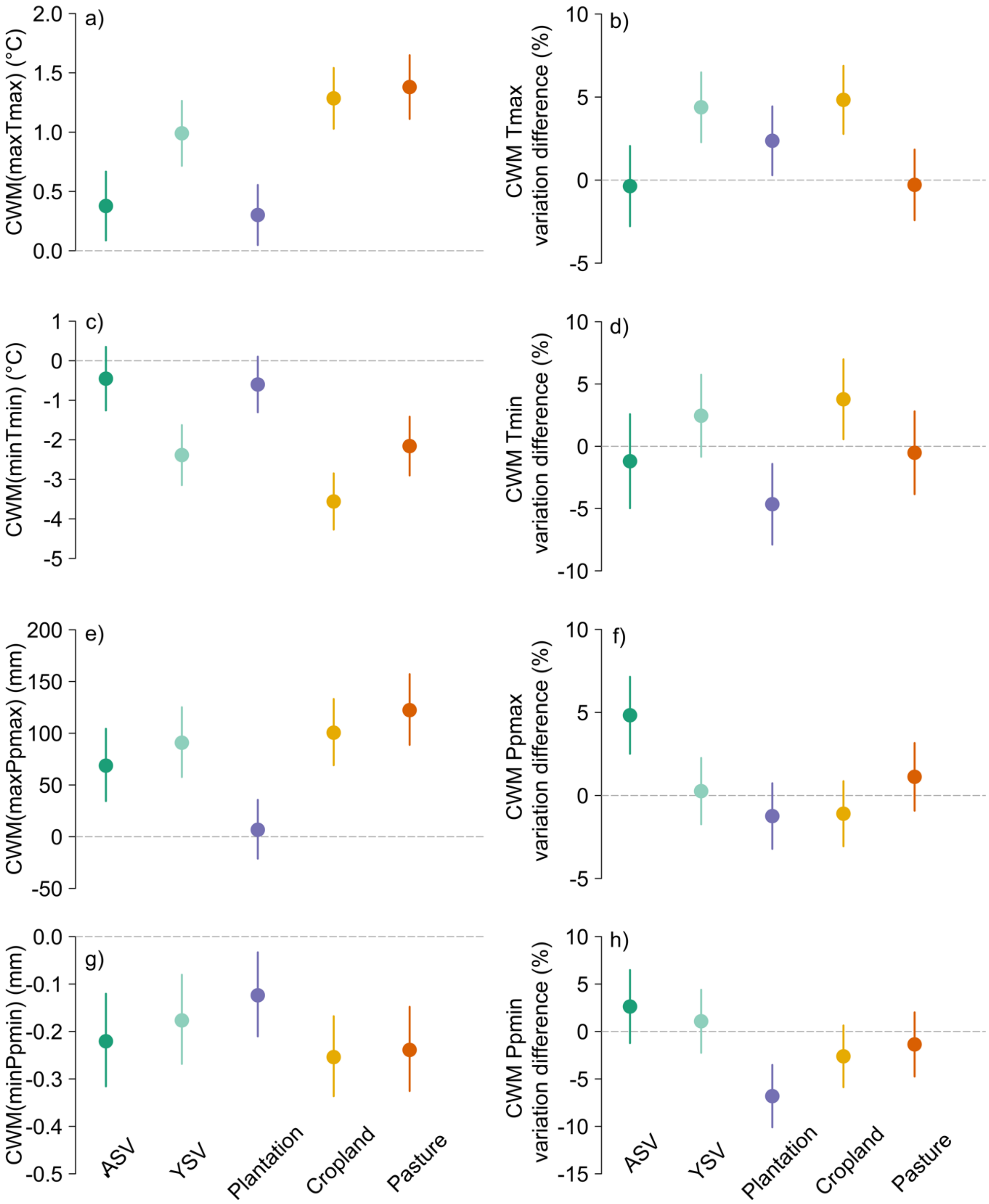

Figure A9: Difference across land uses, when forest specialists are excluded, in community weighted mean (CWM) maximum (max, a, c) or minimum (min, e, g) and range-wide variation (b, d, f, h) in maximum temperature of the hottest month (a, b), minimum temperature of the coldest month (c, d), precipitation of the wettest month (e, f) and precipitation of the driest month (g, h). All values are relative to assemblages within primary vegetation (which is represented by the dotted line). Error bars show 95% confidence intervals; community-average extreme value or range-wide variation significantly differ from those within primary vegetation when the error bars for that land use do not cross the dotted line. ASV and YSV denote advanced and young secondary vegetation, respectively. Transformed values were back-transformed from the log-scale used for analysis before plotting.

Appendix 11

Migratory birds

For migrating species, using entire distributions may lead to unreliable/inaccurate estimates of realised climatic niches owing to their potential ability to use movement to avoid certain climatic conditions (Robinson et al. 2009). Thus, when producing community-level climatic properties (Main text), we compared the results with and without migratory birds included (migratory status was derived from BirdLife International's World Bird Database; BirdLife International 2018; table A20). There were 2,158 non-migratory and 551 migratory species of bird within those species included in our analyses (BirdLife International 2018). When we excluded the migratory species and recalculated the community weighted means (CWMs) for each climatic niche property, the values were highly correlated with the CWMs that included migratory species (table A20).

Table A20: Correlation (Pearson correlation coefficient, *r*) between the community weighted means produced with and without migratory bird species included for each community-level climatic niche property. The climatic niche properties included the community weighted means for the climatic extreme (maximum or minimum) or range-wide variation experienced across a species' range in one of four climatic variables (maximum temperature of the hottest month (T_{max}), minimum temperature of the coldest month (T_{min}), precipitation of the wettest month (Pp_{max}) and precipitation of the driest month (Pp_{min})). Migratory data were extracted from BirdLife International's World Bird Database (BirdLife International 2018).

Climatic niche property	*r*
Max T_{max}	0.930
T_{max} variation	0.943
Min T_{min}	0.954
T_{min} variation	0.917
Max Pp_{max}	0.850
Pp_{max} variation	0.943
Min Pp_{min}	0.998
Pp_{min} variation	0.983

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