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Supplementary material

Supplementary materials

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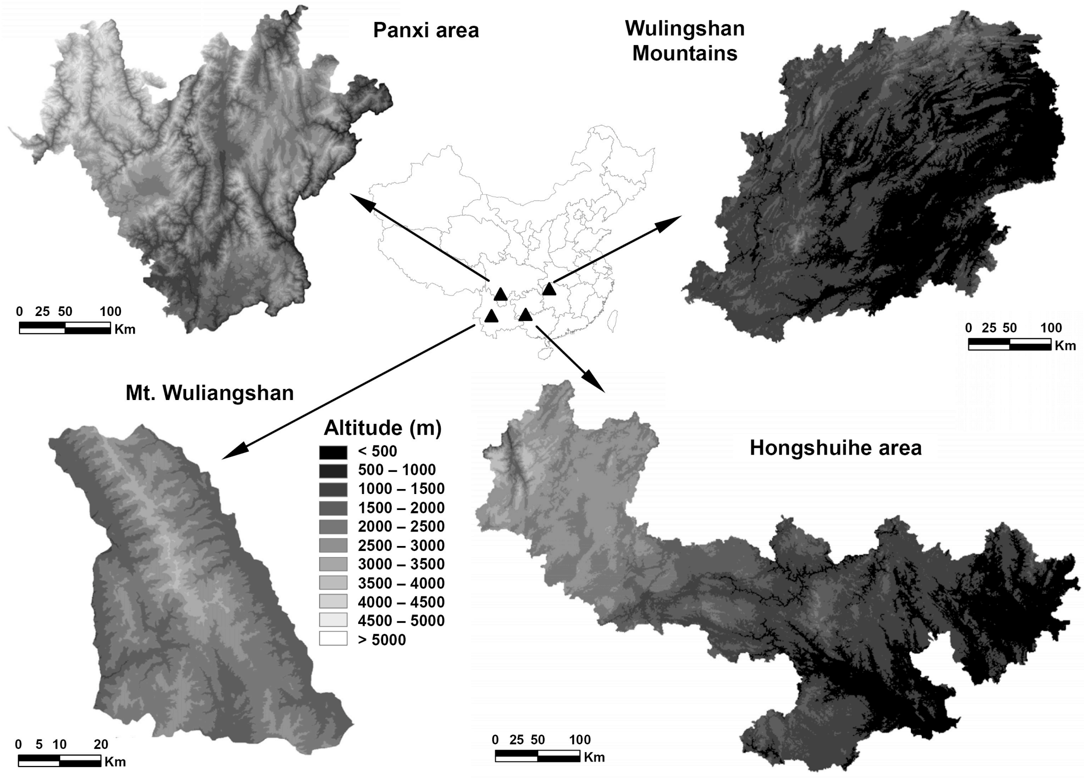
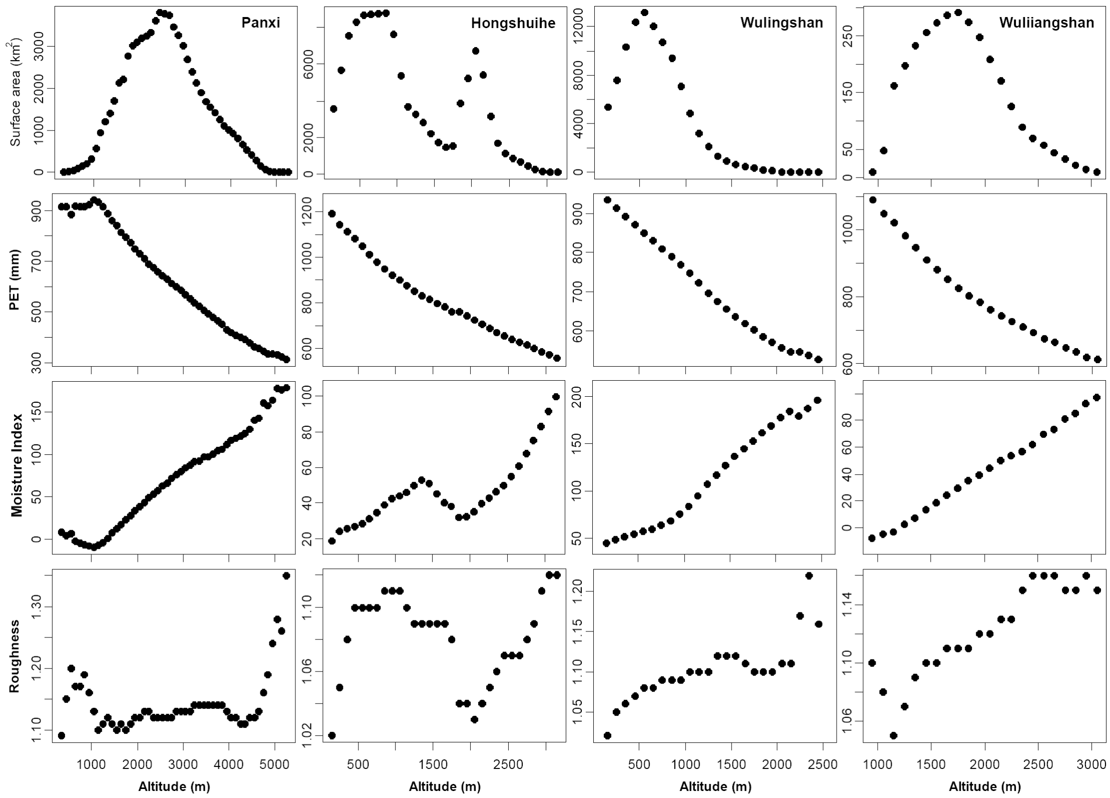
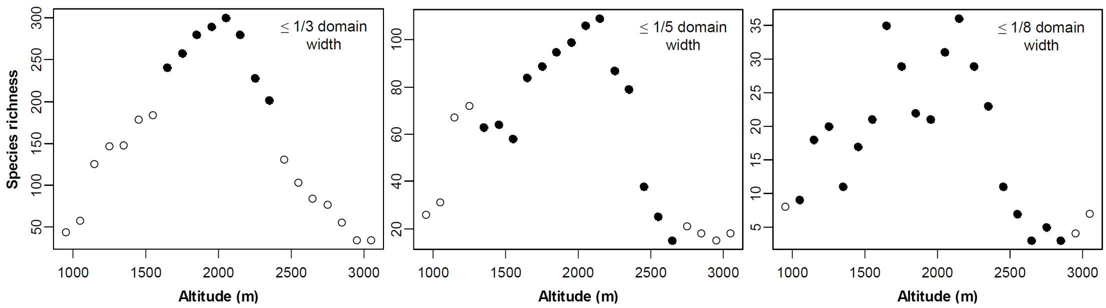


Appendix 1 Geographic locations and topography of the four study areas.



Appendix 2 Altitudinal gradients of area, potential evapotranspiration (PET), moisture index, and topographic roughness of the four study areas.

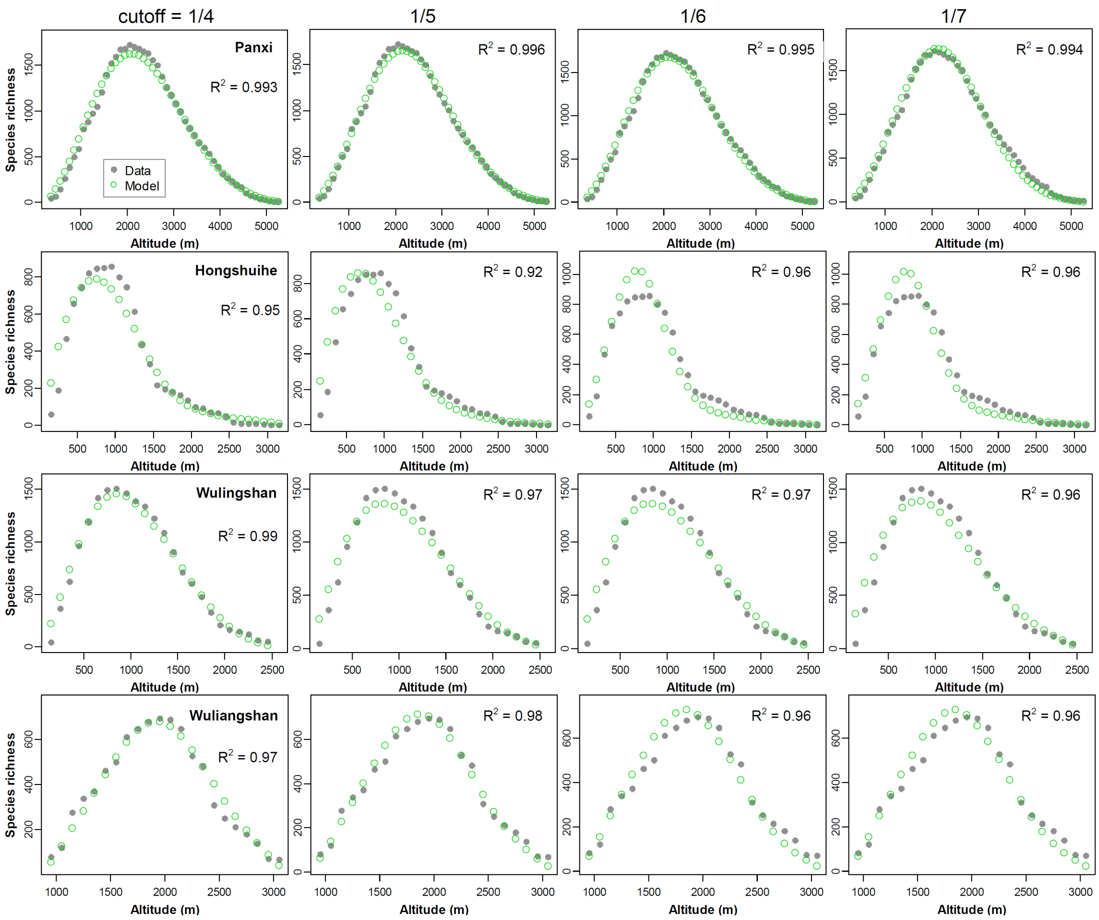


Appendix 3 Richness patterns for the species with a range size ≤ 1/3, 1/5 and 1/8 of the domain width in the Wuliangshan area, as an example. The filled circles were the data that could be used for the regression analyses with Eq. 1, given the rule that species richness data from the "edge regions" (with a width of 1/3, 1/5 or 1/8 of the domain range) must be excluded to ensure that the possible effect of geometric constrains are avoided. When the value was too large (e.g. 1/3), only a few, mid-domain richness data remained to be used for the regression analyses and thus might lack the power to estimate the full elevational scope of the underlying environmental gradient. If the value was too small (e.g. 1/8), species richness patterns tend to vary abruptly over the domain because fewer species could be included to calculate species richness. Consequently the richness patterns might also be not representative for reflecting the underlying gradient. Our results suggest that an intermediate value between 1/7 and 1/4 can be considered as a starting point that balances these limitations, in future studies (Appendixes 4 and 5). However, the optimal cutoff will depend on the specific mountain and species group under study (Table 1 in the main text).

Appendix 4 Selection of the optimal cutoff in this study, using the overall richness patterns of the four study areas as examples. For each study area, we tried cutoff values from 1/3 to 1/7 of the altitudinal domain width. For each cutoff, we used the richness pattern for "≤ cutoff species" to estimate the underlying environmental gradient (ENV), through stepwise regression with Eq. 1 (regression R^2 reported, abbreviated as R^2_{REG}). The estimated gradient was then used to model the total species richness pattern in EGCM. The R^2 between observed richness and EGCM prediction (R^2_{EGCM}), and the slopes and intercepts obtained by standardized major axis (SMA) regression were reported. The slopes and intercepts are italicized if their 95% confidence intervals (95% CI) include 0 and 1, respectively. For each mountain we selected the cutoff that resulted in the highest R^2_{EGCM} as the optimal cutoff (boldfaced). When more than one cutoff had similar R^2_{EGCM}s that were high enough (≥ 0.97), sometimes we chose the cutoff that had the SMA slope closer to 1. The cutoffs between 1/4 and 1/7 generally resulted in EGCM predictions that were strong for most species groups in most mountains and at least adequate (no R^2_{EGCM} less than 0.73) for all, and thus, selecting an optimal "cutoff" from among several "good" results is reasonable (for details, see Appendix 5). On the other hand, the R^2_{REG} generally decreased with decreasing cutoff, because less information entered the analysis. Consequently, the optimal cutoff can not be determined based on maximizing R^2_{REG} (*i.e.* based purely on "≤ cutoff species"), and can only be selected based on R^2_{EGCM} because richness patterns for larger-ranged species were determined by geometric constraints and environmental gradients together, instead of by environments alone.

Study area	Cutoff	R^2_{REG}	R^2_{EGCM}	SMA slope (CI)	SMA intercept (CI)
Panxi	1/3	0.993	0.980	0.90 (0.87 ~ 0.94)	76.5 (39.8 ~ 113.2)
	1/4	0.987	0.993	0.95 (0.93 ~ 0.97)	39.3 (16.6 ~ 61.91)
	1/5	0.982	0.996	0.97 (0.95 ~ 0.99)	22.6 (5.9 ~ 39.2)
	1/6	0.980	**0.995**	***0.99 (0.97 ~ 1.01)***	***11.1 (-7.8 ~ 29.9)***
	1/7	0.946	0.994	1.03 (1.01 ~ 1.06)	-25.3 (-48.1 ~ -2.5)
Hongshuihe	1/3	0.979	0.670	*1.07 (0.86 ~ 1.33)*	*-22.1 (-128.8 ~ 84.7)*
	1/4	0.980	0.948	0.90 (0.82 ~ 0.98)	*31.3 (-3.44 ~ 66.0)*
	1/5	0.912	0.917	*0.98 (0.88 ~ 1.10)*	*4.6 (-43.9 ~ 53.1)*

	1/6	0.768	**0.961**	**1.12 (1.04 ~ 1.21)**	***-38.0 (-76.0 ~ 0.10)***
	1/7	0.803	0.956	1.11 (1.03 ~ 1.21)	*-35.7 (-75.3 ~ 4.0)*
Wulingshan	1/3	0.988	0.936	*0.99 (0.88 ~ 1.10)*	*9.6 (-91.9 ~ 111.0)*
	1/4	0.992	**0.989**	**0.94 (0.89 ~ 0.98)**	**47.8 (8.1 ~ 87.6)**
	1/5	0.949	0.973	0.87 (0.80 ~ 0.93)	100.5 (42.8 ~ 158.2)
	1/6	Same as 1/5			
	1/7	0.747	0.959	0.86 (0.79 ~ 0.94)	100.1 (29.4 ~ 170.9)
Wuliangshan	1/3	0.975	0.876	*0.97 (0.83 ~ 1.15)*	*9.5 (-60.8 ~ 79.8)*
	1/4	0.764	0.969	*0.98 (0.90 ~ 1.06)*	*7.7 (-27.6 ~ 43.0)*
	1/5	0.774	**0.980**	***1.06 (0.99 ~ 1.13)***	***-23.79 (-54.4 ~ 6.8)***
	1/6	0.784	0.962	*1.10 (1.00 ~ 1.20)*	*-36.4 (-80.2 ~ 7.3)*
	1/7	Same as 1/6			



Appendix 5 Comparison of the EGCM predictions for different cutoffs, using the overall richness pattern of each study area as examples (observed richness: black dots; EGCM model: open green circles). For the results of cutoff = 1/3, see Appendix 4. The cutoffs between 1/4 and 1/7 generally result in similar EGCM predictions that were generally strong and at least adequate (no R^2 less than 0.73) in all cases. If we did not require the best prediction, in many cases actually we could randomly select a cutoff between 1/4 and 1/7 to obtain an EGCM prediction that was nonetheless strong ($R^2_{\text{EGCM}} > 0.9$). This suggests that our assumption that “the richness patterns of small-ranged species reflect the environment gradients that shape the altitudinal distribution patterns for all species” was basically correct. Thus Step 1 simply selected the optimal “cutoff” from several “good” results, and is used to estimate the underlying environmental gradients more precisely. This step, by itself, clearly can not lead to a good prediction of the empirical richness patterns if our assumption was wrong.