

Supplemental information

**The ghost of ice ages past: Impact of Last
Glacial Maximum landscapes on modern biodiversity**

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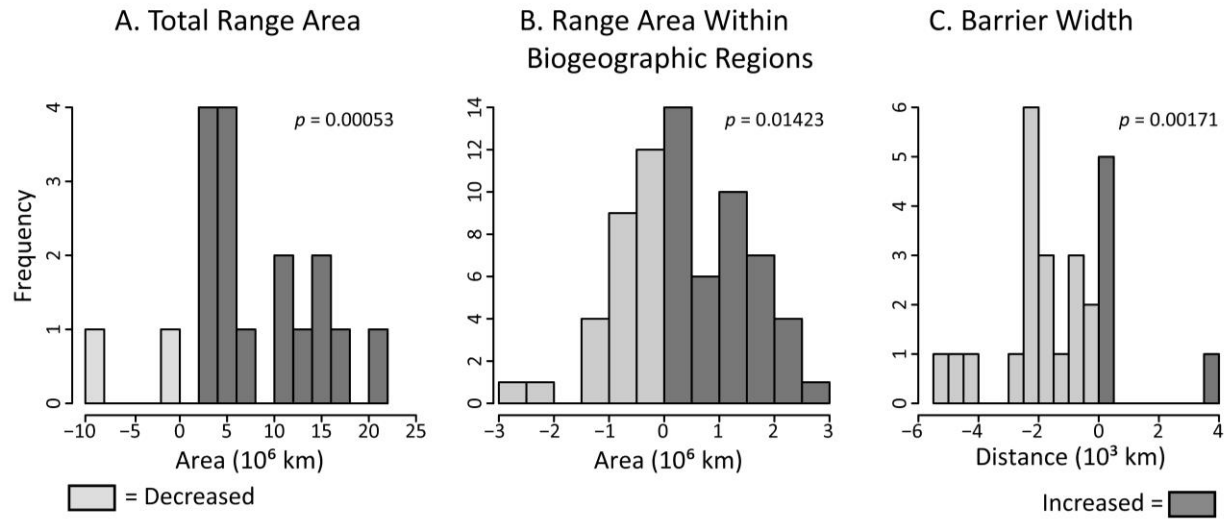


Figure S1. Pairwise change in potential range area, maximum patch size and barrier widths from LGM to modern. Based only on multi-temporal maxent climate envelope niche models.

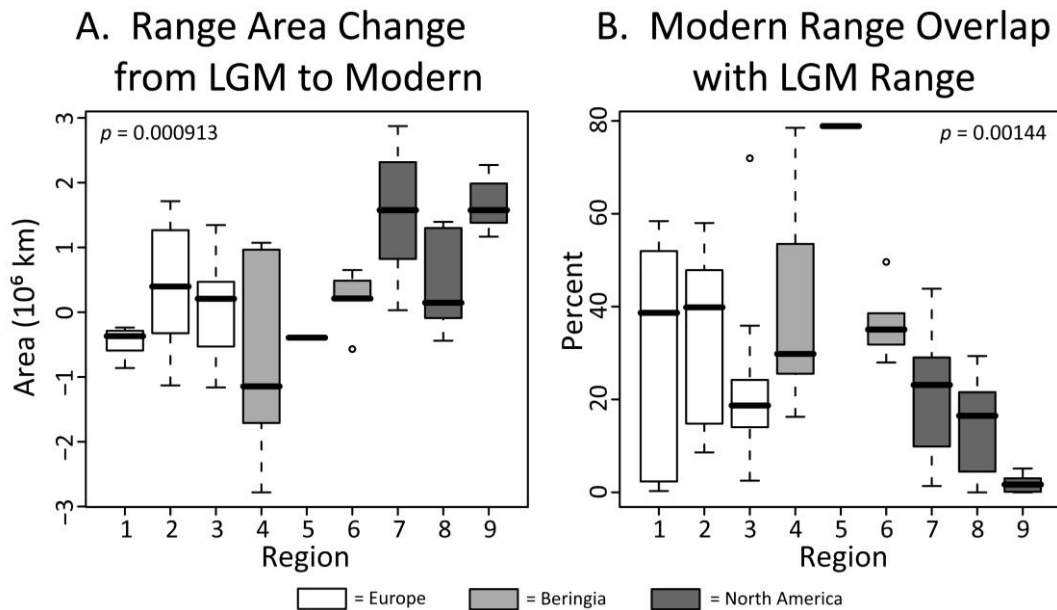


Figure S2. Pairwise change in range size and overlap between modern and LGM ranges per geographic region. Based only on multi-temporal maxent climate envelope models.

Paired changes from LGM to modern

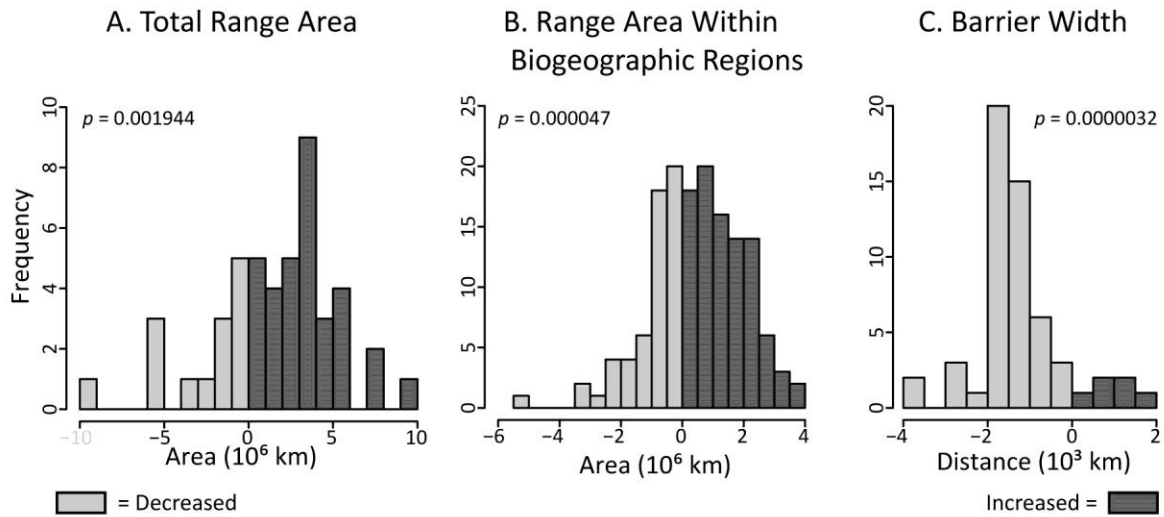


Figure S3. Pairwise change in potential range area, maximum patch size and barrier widths from LGM to modern based on ensemble models. p -values are based on paired Wilcoxon Signed Rank test.

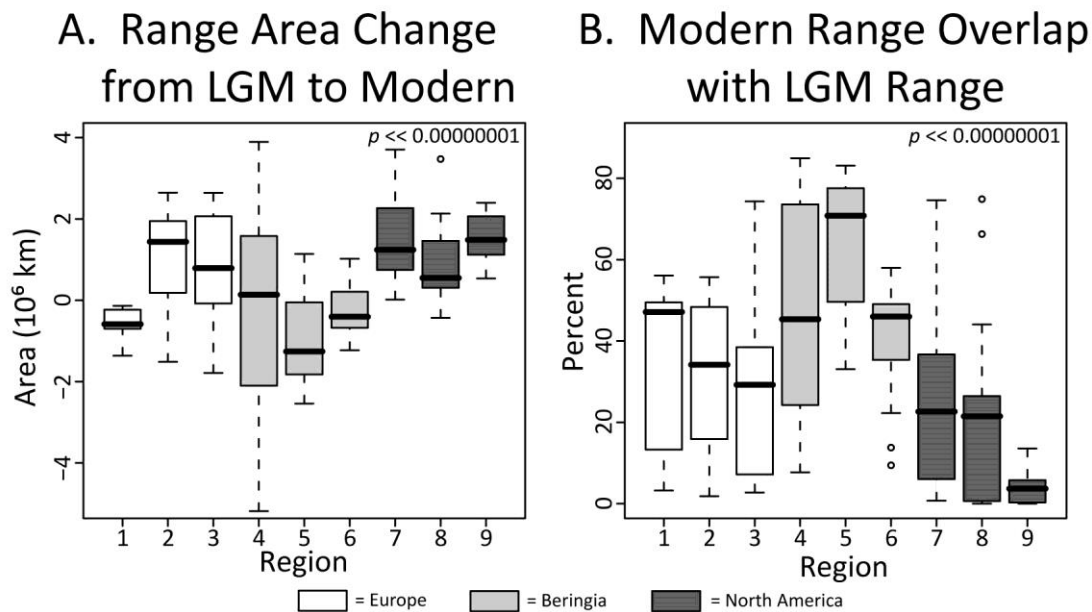


Figure S4. Pairwise change in range size and overlap based on ensemble models. p -values are based on Kruskal-Wallis test estimating the likelihood that group medians are the same.

Table S1. Comparison of ranges and barriers between LGM and modern for using output only from multi-modal Maxent models. Biogeographic Region numbers correspond to Figure 1. Barrier type codes represent: C = Inappropriate Climate; O = Ocean; I = Ice Sheet; H = Habitat/History where range terminates at least 1500 km prior to end of modeled appropriate climate.

A. LGM vs. Modern Range Overlap by Region

Number of Species	Biogeographic Ranges								
	1	2	3	4	5	6	7	8	9
Overlapping Ranges	7	8	10	7	1	8	8	4	1
Segregated Ranges	4	3	0	0	0	0	0	4	6

Log Likelihood test: $p < 0.00000001$

Fisher's Exact: $p = 0.0000776$

B. LGM vs. Modern Barrier Type Frequency for Entire Holarctic Fauna

	Barrier Type							
	Modern				LGM			
	C	O	I	H	C	O	I	H
Number	13	19	4	7	12	15	17	5

Fisher's Exact for Modern vs. LGM: $p = 0.000000000012$

Fisher's Exact excluding H: $p = 0.0000000086$

Fisher's Exact excluding H, I: $p = 0.1435$

C. LGM vs. Modern Barrier Type Frequency Across Biogeographic Affinity Groups

Affinity	Time Period					
	Modern			LGM		
	C	O	I	C	O	I
European	6	7	2	7	6	4
Beringian	3	1	1	3	2	3
North American	4	11	1	2	7	10

Fisher's Exact LGM vs modern: European: $p = 0.8959$

Beringian: $p = 0.7902$

North American: $p = 0.0101$

Table S2. Extreme and median range and barrier values for modern and LGM.

	Epoch	Region	Species	Size (km ²)
Total Range Size				
Maximum	Modern		<i>Euconulus fulvus</i>	3.6 x 10 ⁷
	LGM		<i>Euconulus fulvus</i>	3.2 x 10 ⁷
Median	Modern		<i>Vertigo microsphaera</i>	5.7 x 10 ⁶
	LGM		<i>Pupilla blandi</i>	4.3 x 10 ⁶
Minimum	Modern		<i>Vertigo kurilensis</i>	3.3 x 10 ⁵
	LGM		<i>Vertigo lilljeborgi vinlandica</i>	4.2 x 10 ⁵
Maximum Patch Size				
Maximum	Modern	4	<i>Vertigo genesioides</i>	9.5 x 10 ⁶
	LGM	4	<i>Pupilla loessica</i>	9.5 x 10 ⁶
Median	Modern	3	<i>Euconulus fulvus</i>	1.6 x 10 ⁶
		2	<i>Vertigo genesii</i>	1.6 x 10 ⁶
		3	<i>Vertigo lilljeborgi</i>	1.6 x 10 ⁶
		8	<i>Euconulus fresti</i>	1.4 x 10 ⁶
	LGM	1	<i>Pupilla triplicata</i>	1.4 x 10 ⁶
		7	<i>Vertigo cristata</i> agg.	1.4 x 10 ⁶
		1	<i>Vertigo genesii</i>	1.4 x 10 ⁶
		1	<i>Vertigo pseudosubstriata</i>	2.5 x 10 ⁴
Minimum	Modern	1	<i>Vertigo pseudosubstriata</i>	2.5 x 10 ⁴
	LGM	3	<i>Vertigo alpestris</i>	6.9 x 10 ³
		3	<i>Vertigo geyeri</i>	1.4 x 10 ³
Barrier Width				
Barrier Width	Epoch	Barrier	Species	Distance (km)
Minimum	Modern	Bering Strait	<i>Vertigo hannai</i>	200
			<i>Vertigo modesta</i>	200
			<i>Vertigo oughtoni</i>	200
		James Bay	<i>Vertigo lilljeborgi vinlandica</i>	200
			<i>Vertigo ronneyensis</i>	200
		LGM	Kamchatka-E. Aleutians	700
	LGM	Kamchatka-E. Aleutians	<i>Vertigo kurilensis</i>	700
Median	Modern	E Siberia	<i>Pupilla loessica</i>	1400
		N Atlantic	<i>Vertigo lilljeborgi</i>	1400
	LGM	N Atlantic	<i>Pupilla hudsonianum</i>	2600
		Bering Sea	<i>Vertigo columbiana</i>	2600
Maximum	Modern	W NAm-Asia	<i>Vertigo perryi</i>	13,000
	LGM	C NAm-Asia	<i>Euconulus polygyratus</i>	9400

Table S3. Comparison of ranges and barriers between LGM and Modern for Ensemble models. Biogeographic Region numbers correspond to Figure 1b. Barrier type codes represent: C = Inappropriate Climate; O = Ocean; I = Ice Sheet; H = Habitat/History where range terminates at least 1500 km prior to end of modeled appropriate climate.

A. LGM vs. Modern Range Overlap by Region

LGM vs. Modern Ranges	Number of Species Biogeographic Region								
	1	2	3	4	5	6	7	8	9
Overlapping	15	14	17	16	11	16	12	11	6
Segregated	3	4	1	1	0	0	4	7	11

Log Likelihood test: $p < 0.00000001$

B. LGM vs. Modern Barrier Type Frequency for Entire Holarctic Fauna

	Modern				LGM			
	C	O	I	H	C	O	I	H
Number	25	40	4	37	26	30	28	18

Fisher's Exact for Modern vs. LGM: $p = 0.000004355$

Fisher's Exact excluding H: $p = 0.00006031$

Fisher's Exact excluding H, I: $p = 0.4607$

C. LGM vs. Modern Barrier Type Frequency Across Biogeographic Affinity Groups

Biogeographic Affinity	Modern			LGM		
	C	O	I	C	O	I
European	10	12	4	12	11	4
Beringian	5	6	0	7	5	10
North American	10	22	0	7	14	14

Fisher's Exact LGM vs modern: European: $p = 0.9314$

Beringian: $p = 0.01716$

North American: $p = 0.00008696$