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Supplementary Material

Correlated morphological and genetic patterns in *Embothrium coccineum* (Proteaceae) across climate and geography: can *Embothrium* survive patagonian climate change?

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Table S1: Raw data showing the 34 sampled locations of *Embothrium coccineum*, their geographic location in UTM coordinates, present and future climatic features for each locality (T^o_{min}, T^o_{max}, PPT_{min}, PPT_{max}), and population average for 4 morphological leaf traits (LA: leaf area, DM: dry mass, Log (SLA): Log. specific leaf area, and SF: shape factor). Numbers in first column agree with the ones in Fig. 1.

Population	UTM West Longitude	UTM North Latitude	Elevation masl	Tºmin ºC	Tºmax ºC	PPTmin mm	PPTmax mm	Future Tºmin ºC	Future Tºmax ºC	Future PPTmin mm	Future PPTmax mm	LA cm^2	DM g	Log (SLA) g/ cm^2	SF
1. Nahuelbuta	684578,3	5811239,3	630	0.50	21.50	29	289	0.80	22.50	14	287	4.88	0.06	1.92	0.25
2. Curacautín	760551,0	5753629,8	593	1.40	24.70	50	336	1.60	26.20	26	342	5.04	0.04	2.05	0.34
3. Manzanar	267146,2	5737814,5	816	1.00	25.10	52	387	0.70	26.20	31	358	6.42	0.08	1.93	0.31
4. Conguillío	261825,5	5720995,0	515	0.00	23.70	46	348	-0.60	24.50	27	322	4.19	0.04	2.06	0.39
5. Ñorquinco	303835,0	5666609,9	1063	-0.60	23.90	19	168	-2.10	23.80	13	158	4.17	0.04	2.01	0.43
6. Quillén	307604,2	5640153,7	978	-1.30	23.10	16	149	-1.80	240	12	153	8.21	0.05	2.23	0.33
7. Tromen	290972,4	5617508,5	1049	-3.80	20.00	17	159	-2.30	23.10	14	166	5.74	0.06	2.00	0.31
8. Huechulafquen	300044,5	5599236,1	1097	-3.20	20.70	16	148	-2.70	22.70	11	151	2.19	0.02	2.01	0.52
9. Lolog	298021,1	5567709,8	927	-2.10	21.40	16	143	-1.30	23.40	13	149	5.43	0.04	2.11	0.31
10. Alerce Costero	633407,3	5552567,6	660	0.30	16.70	57	314	0.50	17.40	40	343	11.34	0.12	1.97	0.39
11. Villarino	282343,4	5519131,2	846	-5.00	17.80	17	151	-3.90	20.40	14	146	4.24	0.04	2.01	0.43
12. Antillanca	742919,8	5512796,8	800	-2.00	19.30	47	284	-0.60	22.10	40	265	7.72	0.05	2.04	0.42
13. Traful	322582,4	5492424,2	704	-1.10	23.10	22	140	-0.60	24.30	16	159	2.76	0.05	2.04	0.47
14. Puerto Blest	264978,1	5442662,3	782	-0.90	21.90	37	229	0.10	23.80	29	208	8.50	0.08	2.04	0.53
15. Bariloche	306949,7	5443891,9	800	-1.60	21.70	29	166	-0.10	23.90	24	152	2.58	0.06	2.04	0.39
16. La Paloma	311242,5	5440300,8	900	-1.70	21.70	24	145	-1.80	22.30	18	135	3.34	0.02	2.13	0.51
17. Lahuen Ñadi	664357,8	5413120,9	54	3.70	19.40	69	233	4.30	21.10	58	240	13.83	0.16	1.92	0.24
18. Manso Inferior	269371,8	5392786,9	713	-0.30	22.40	56	274	-0.50	22.90	43	242	4.66	0.06	2.04	0.48
19. Senda Darwin	618861,4	5358482,8	67	4.60	18.30	84	257	4.90	19.90	68	255	11.69	0.16	1.86	0.29
20. Cucao	575159,0	5279494,4	20	2.10	13.80	75	311	3.40	15.00	64	295	12.39	0.19	1.81	0.27
21. Lago Verde	276182,7	5267025,1	520	-0.80	21.50	50	194	-1.00	22.40	40	172	8.48	0.10	1.91	0.42
22. Limonao	286196,0	5252520,8	520	-0.70	21.80	43	167	-0.40	23.40	35	156	13.86	0.12	2.06	0.39
23. Quellón	613958,1	5228980,0	144	3.35	16.05	80	284	5.20	19.80	96	294	15.07	0.22	1.83	0.20
24. Corcovado	293900,1	5178648,6	378	-4.80	18.00	22	82	-2.90	21.00	22	86	6.46	0.08	1.92	0.43
25. La Junta	721942,4	5128107,8	170	2.30	20.10	112	308	3.20	21.70	105	304	14.39	0.18	1.90	0.44
26. Mañihuales	724754,0	5016800,6	200	0.10	18.20	85	231	1.00	19.90	78	228	8.73	0.12	1.85	0.52

27. Fachinal	710750,3	4839314,7	360	-0.80	17.50	32	102	-0.40	18.90	33	109	10.97	0.15	1.86	0.48
28. Río Leones	664264,2	4822224,2	190	0.40	16.90	70	144	0.10	17.90	65	149	13.72	0.16	1.92	0.47
29. Lago Vargas	722641,7	4714631,1	20	1.20	17.80	77	123	0.00	18.00	68	124	10.07	0.14	1.86	0.59
30. Perito Moreno	647423,9	4522383,2	350	-1.90	17.20	37	65	-1.10	18.30	37	68	10.86	0.18	1.79	0.42
31. Pto. Natales	640803,3	4409454,9	64	-2.60	16.70	26	55	-2.90	17.20	27	51	7.59	0.10	1.86	0.61
32. Pta. Arenas	665181,4	4284464,7	130	-1.30	15.65	27	57	0.50	16.70	23	44	5.48	0.07	1.87	0.66
33. BahíaInútil	377064,9	4122449,7	80	0.00	14.60	28	59	0.60	15.80	26	62	7.62	0.12	1.82	0.63
34. Lapataia	416988,8	4076941,3	70	-1.30	13.50	42	65	-1.00	14.30	43	71	6.36	0.14	1.67	0.62
Mean				-0.50	19.58	44.37	193.15	-0.03	21.02	37.44	189.53	7.91	0.10	1.95	0.43
SD				2.16	3.10	24.46	93.52	2.19	3.16	24.46	91.74	3.72	0.05	0.11	0.12

Table S2: Frequency table of the most common allele in 16 isozyme loci for the 34 studied populations of *Embothrium coccineum*

Population	Idh2	Mdh12	Mdh22	Mdh23	Mdh32	Me12	Me22	Mnr12	Mnr22	Per2	Pecat12	Pecat23	Pgi12	Pgi24	Pgm12	Pgm22	Skdh2
Nahuelbuta	1.00	1.00	0.50	0.45	0.83	1.00	1.00	1.00	0.63	0.83	1.00	0.95	1.00	0.90	1.00	0.75	0.85
Curacautín	0.82	0.73	0.25	0.75	1.00	0.98	0.87	1.00	0.17	0.90	1.00	0.80	1.00	0.50	1.00	0.87	1.00
Manzanar	1.00	0.61	0.43	0.46	0.88	1.00	0.96	1.00	0.59	1.00	1.00	0.91	1.00	0.48	0.93	0.55	0.79
Conguillío	1.00	1.00	0.38	0.62	1.00	1.00	1.00	1.00	1.00	0.91	1.00	1.00	1.00	1.00	0.98	0.78	0.33
Ñorquinco	1.00	1.00	0.73	0.27	1.00	1.00	1.00	1.00	0.32	1.00	1.00	0.80	1.00	0.53	1.00	0.80	1.00
Quillén	1.00	1.00	1.00	0.00	1.00	1.00	0.94	1.00	0.80	1.00	1.00	0.84	1.00	1.00	0.82	0.28	0.94
Tromen	1.00	0.93	0.50	0.46	1.00	1.00	1.00	1.00	0.57	0.89	1.00	1.00	1.00	0.59	0.94	0.91	0.74
Huechulafquen	1.00	0.74	1.00	0.00	1.00	0.97	0.95	1.00	0.93	0.98	1.00	0.78	1.00	1.00	0.86	0.88	0.88
Lolog	1.00	0.71	0.52	0.39	1.00	1.00	1.00	1.00	0.61	0.98	1.00	1.00	1.00	0.74	1.00	0.39	0.76
Alerce Andino	1.00	1.00	0.42	0.58	1.00	1.00	1.00	1.00	1.00	0.93	1.00	0.93	1.00	0.87	1.00	0.42	0.08
Villarino	1.00	0.93	0.17	0.59	1.00	1.00	1.00	1.00	0.86	0.83	1.00	0.91	0.88	0.69	0.85	0.83	0.85
Antillanca	1.00	0.77	0.73	0.27	0.88	1.00	1.00	1.00	0.43	0.92	0.98	0.88	1.00	0.33	1.00	0.55	0.73
Traful	1.00	1.00	0.10	0.85	1.00	1.00	0.85	1.00	1.00	1.00	1.00	0.82	1.00	0.93	0.93	0.87	0.85
Puerto Blest	1.00	0.62	0.35	0.60	1.00	1.00	1.00	1.00	0.69	1.00	1.00	0.98	1.00	0.85	1.00	0.60	0.90
Bariloche	1.00	1.00	0.00	0.65	1.00	0.93	1.00	1.00	0.53	1.00	1.00	0.87	1.00	0.90	1.00	0.83	0.72
La Paloma	1.00	1.00	0.48	0.43	1.00	1.00	1.00	1.00	0.96	1.00	1.00	1.00	1.00	0.38	1.00	0.93	1.00
Lahuen Ñadi	1.00	0.97	0.35	0.53	1.00	0.92	0.97	1.00	0.62	0.93	1.00	0.93	1.00	0.85	0.93	0.70	0.60
Manso Inferior	1.00	1.00	0.33	0.35	1.00	0.93	1.00	1.00	0.62	0.85	0.80	0.58	1.00	0.30	0.97	0.47	0.70
Senda Darwin	0.82	1.00	0.03	0.97	1.00	0.97	1.00	1.00	0.70	0.78	0.90	0.93	0.83	0.93	0.80	0.58	0.70
Cucao	0.79	1.00	0.00	1.00	0.75	1.00	1.00	1.00	0.82	1.00	1.00	0.68	1.00	1.00	0.73	0.95	1.00
Lago Verde	1.00	0.76	0.46	0.54	1.00	0.94	0.96	1.00	0.72	0.64	1.00	0.80	1.00	0.40	0.88	0.48	0.38
Limonao	1.00	1.00	0.06	0.86	1.00	1.00	1.00	1.00	1.00	0.96	1.00	0.92	1.00	0.54	1.00	0.30	0.70
Quellón	1.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	0.94	1.00	1.00	1.00	1.00	0.92	0.50	0.83
Corcovado	1.00	1.00	0.77	0.23	1.00	1.00	1.00	1.00	0.52	1.00	1.00	1.00	1.00	0.83	1.00	1.00	0.97
La Junta	0.72	0.93	0.55	0.28	1.00	0.78	1.00	1.00	0.80	1.00	0.88	0.98	1.00	0.63	0.92	0.45	0.70
Mañihuales	0.97	1.00	0.55	0.26	1.00	0.94	0.82	0.98	0.42	0.95	0.94	0.97	1.00	0.50	0.92	0.57	0.76
Fachinal	0.96	0.93	0.82	0.07	1.00	1.00	1.00	1.00	0.71	1.00	0.96	0.93	1.00	0.79	0.82	0.21	0.93
Río Leones	1.00	0.90	0.69	0.19	1.00	0.81	0.90	1.00	0.81	1.00	0.79	0.98	1.00	0.37	0.89	0.39	0.89
Lago Vargas	1.00	1.00	0.82	0.10	1.00	1.00	1.00	0.97	0.65	0.92	0.76	1.00	1.00	0.86	0.11	0.68	0.69
Perito Moreno	0.94	1.00	0.71	0.25	0.94	0.79	1.00	1.00	0.58	1.00	1.00	0.96	1.00	0.98	0.60	0.14	0.94
Pto. Natales	1.00	1.00	0.62	0.38	1.00	1.00	1.00	1.00	0.52	1.00	0.70	1.00	0.96	0.88	0.92	0.58	0.78
Pta. Arenas	1.00	0.81	0.96	0.04	1.00	1.00	1.00	0.96	0.27	0.94	0.58	0.92	1.00	0.46	0.75	0.21	0.62
Bahía Inútil	1.00	0.98	0.48	0.43	1.00	1.00	1.00	1.00	1.00	0.68	1.00	1.00	1.00	0.36	0.59	0.64	0.75

Lapataia	1.00	0.96	0.14	0.62	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.98	0.96	0.21	1.00	0.50	0.67
Mean	0.97	0.92	0.47	0.45	0.98	0.97	0.98	1.00	0.70	0.93	0.95	0.91	0.99	0.69	0.88	0.60	0.77
SD	0.07	0.12	0.29	0.28	0.06	0.06	0.05	0.01	0.23	0.09	0.10	0.10	0.03	0.25	0.17	0.23	0.20

Note: Locus MDh-2 showed 2 equally common alleles (Mdh-22 and Mdh-23).

Table S3: Detailed PCA results

Geographic isolation	PCA reduction of geographical features allowed us to extract a pair of eigenvectors that together accounted for 90% of the variation (see Table below). Longitude and latitude loaded negatively onto the 1st PC axis, L1 (r = – 0.92, – 0.81) but elevation positively (r = + 0.68). Elevation and latitude loaded negatively onto the 2nd PC axis, L2 (r = – 0.73, – 0.53) but longitude positively (r = + 0.08). In general, L1 decreased towards the south and west, and L2 axis decreased with increasing elevation. Geo-spatial separation is effectively two-dimensional.
Climatic space	This quartet of highly inter-correlated variables revealed two PC axes that explained 88% of the variation across the range of the species. T^{o}_{min}, PPT_{min} and PPT_{max} loaded negatively onto the 1st axis, C1 (r = – 0.91, – 0.89, – 0.80, respectively), increasing with decreasing winter temperature and both precipitation measures, while the 2nd axis, C2 was mainly determined by T^{o}_{max} (r = – 0.96), decreasing with increasing summer temperature.
Morphological features	Souto et al. (2009) showed that all four leaf traits were strongly inter-correlated. As a consequence, the first two PC axes accounted for 89% of the variation. DM and LA loaded negatively onto the 1st axis M1 (r = – 0.99, – 0.89), but log(SLA) loaded positively (r = + 0.76), decreasing with leaf size and weight but increasing with leaf area. SF loaded primarily onto the 2nd axis M2 (r = + 0.94), increasing as the leaves became rounder.
Genetic characters	The variation pattern for the 16-locus genetic analysis was more complex, even after reducing each locus to bi-allelic form. We further reduced this 16-locus battery to a six-PCA description that accounted for 67% of the variation. Accentuating only the loci with loadings ≤ – 0.55 or ≥ + 0.55, we note that the 1st axis, G1 was loaded heavily by Mnr-12 (r = – 0.82), Pecat-12 (r = – 0.79), and Mdh-22 (r = + 0.68), while the 2nd axis, G2 was loaded negatively by Skdh-2 (r = – 0.64) and positively onto Mnr-22 (r = + 0.56). The 3rd axis, G3 was loaded positively by Idh-2 (r = + 0.72), and the 4th axis, G4 was loaded negatively by Per-2 (r = – 0.68). The 5th axis, G5 was loaded negatively by Me-12 (r = – 0.80), while the 6th, G6 was loaded positively by Mdh-32 (r = + 0.58) and negatively by Me-22 (r = – 0.57).

Table S4: Principal factor loadings (PCA-eigenvectors) within each of four data sets, in 34 populations of *Embothrium coccineum*: climatic axes (C1 and C2); geo-location axes (L1 and L2); morphological axes (M1 and M2); and genetic axes (G1 – G6)

Population	C1	C2	L1	L2	M1	M2	G1	G2	G3	G4	G5	G6
1. Nahuelbuta	-0.481	-1.072	1.770	0.402	0.658	-0.969	-1.257	-0.337	-0.477	-0.212	-1.619	-1.327
2. Curacautín	-1.558	-1.845	1.162	0.448	1.501	-0.837	-0.781	-3.367	-0.283	2.524	0.144	1.709
3. Manzanar	-1.790	-2.180	0.369	-0.938	0.271	-0.678	-0.319	-1.858	1.220	0.669	-0.628	-1.511
4. Conguillío	-1.122	-1.761	-0.711	-0.659	1.705	-0.445	-1.144	2.213	0.744	-1.024	-0.106	-0.155
5. Ñorquinco	0.719	-1.392	2.127	-0.664	1.510	0.061	-0.158	-1.760	0.545	-0.153	-0.863	0.595
6. Quillén	1.108	-1.170	1.365	-0.679	1.668	-1.851	0.545	-0.657	0.014	-1.777	0.164	0.063
7. Tromen	1.774	-0.508	0.629	-1.338	0.882	-0.875	-0.491	0.228	0.936	-0.001	-0.785	0.459
8. Huechulafquen	1.682	-0.627	0.369	-1.484	2.124	0.856	-0.330	-1.391	0.474	-0.950	-0.571	0.178
9. Lolog	1.392	-0.727	2.196	-0.263	1.684	-1.329	0.127	-0.349	1.534	-0.471	0.213	-0.723
10. Alerce Costero	-1.171	0.465	1.321	0.123	-0.740	-0.585	-0.579	2.618	1.237	-0.459	0.724	-1.088
11. Villarino	2.188	0.055	0.505	-0.894	1.518	0.039	-1.573	1.913	-0.783	1.205	-0.948	1.229
12. Antillanca	-0.156	-0.385	0.856	-0.260	0.958	-0.367	0.190	-1.417	1.282	1.140	-0.789	-1.697
13. Traful	0.958	-1.045	0.320	-0.098	1.767	0.328	-1.846	-0.647	0.012	-0.672	0.006	2.201
14. Puerto Blest	0.052	-0.910	1.443	-0.270	0.563	0.379	-0.545	-0.857	1.344	-0.578	-0.245	-0.400

15. Bariloche	0.802	-0.721	1.678	-0.097	1.616	-0.249	-1.336	-0.127	-0.166	-0.452	0.138	0.511
16. La Paloma	1.071	-0.696	1.745	-0.339	2.455	0.227	-1.055	-0.024	0.908	-1.039	-0.330	0.850
17. Lahuen Ñadi	-1.993	0.440	0.102	1.624	-1.928	-1.661	-0.450	0.293	0.217	-0.305	0.632	0.308
18. Manso Inferior	-0.839	-0.976	-0.551	-1.203	1.360	0.273	0.427	-0.259	0.185	2.453	0.506	-0.613
19. Senda Darwin	-2.727	0.877	-2.401	-0.013	-1.850	-0.882	-1.136	2.659	-3.347	2.223	0.212	1.197
20. Cucao	-2.048	1.608	-0.586	1.517	-2.554	-0.875	-2.813	-2.083	-3.982	0.098	-1.865	-1.957
21. Lago Verde	-0.085	-0.482	-1.394	-1.060	-0.317	0.092	0.093	1.116	1.546	3.202	0.477	-1.124
22. Limonao	0.205	-0.525	-1.672	-1.088	-0.733	-1.121	-0.957	1.272	0.881	-0.287	0.838	-0.501
23. Quellón	-2.388	1.243	0.799	1.371	-3.265	-1.680	-1.350	1.416	-0.012	-1.424	0.128	0.061
24. Corcovado	2.401	0.376	-0.509	0.012	0.288	0.261	-0.490	-0.805	0.403	-1.611	-1.028	1.055
25. La Junta	-3.079	0.353	-1.636	0.548	-2.195	-0.152	0.615	-0.428	-2.320	0.056	3.637	-0.783
26. Mañihuales	-1.343	0.745	-1.417	0.706	-0.795	1.059	1.607	-1.304	0.278	0.582	0.825	2.347
27. Fachinal	0.935	0.802	-0.357	0.434	-1.450	0.536	0.843	-0.278	0.103	-1.310	0.322	-0.680
28. Río Leones	-0.550	1.321	-2.535	-0.798	-1.738	0.031	1.839	-0.908	0.211	-0.152	2.826	0.619
29. Lago Vargas	-0.837	1.302	-0.764	1.565	-1.108	1.404	4.543	1.622	-1.969	-1.049	-2.592	0.426
30. Perito Moreno	1.336	1.037	0.236	0.919	-2.144	0.383	1.354	-0.601	-2.135	-1.730	2.171	-1.480
31. Pto. Natales	1.863	1.041	-1.723	0.285	-0.233	1.725	1.313	0.541	-0.436	-0.787	-0.363	0.782
32. Pta. Arenas	1.480	1.415	0.884	1.439	0.515	2.215	6.007	-0.033	0.255	1.107	-1.297	-0.287

33. BahíaInútil	1.097	1.789	-0.575	1.132	-0.651	2.042	0.051	2.239	0.425	0.951	-0.665	-0.372
34. Lapataia	1.105	2.153	-3.049	-0.380	-1.344	2.644	-0.943	1.362	1.157	0.231	0.729	0.107

Table S5: Principal factor weights of the variables for current climate, based on correlations to calculate in formula [1] future climate PCA and loadings of future climate PCA.

Current climate	Factor 1	Factor 2
PPTmin/sd	$\mathbf{a_{11}}$ -0.888	$\mathbf{a_{21}}$ 0.337
PPTmax/sd	$\mathbf{a_{12}}$ -0.798	$\mathbf{a_{22}}$ -0.465
Tºmin/sd	$\mathbf{a_{13}}$ -0.906	$\mathbf{a_{23}}$ 0.155
Tºmax/sd	$\mathbf{a_{14}}$ -0.071	$\mathbf{a_{24}}$ -0.964
Population	**PCA-FC1**	**PCA-FC2**
1. Nahuelbuta	-0.305	-1.676
2. Curacautín	-1.611	-2.861
3. Manzanar	-1.553	-2.935
4. Conguillío	-0.531	-2.384
5. Ñorquinco	1.984	-1.662
6. Quillén	1.933	-1.691
7. Tromen	1.980	-1.487
8. Huechulafquen	2.387	-1.360
9. Lolog	1.738	-1.438
10. Alerce Costero	-1.466	-0.054
11. Villarino	2.870	-0.674
12. Antillanca	-0.462	-1.192
13. Traful	1.237	-1.673
14. Puerto Blest	0.083	-1.534
15. Bariloche	0.813	-1.372
16. La Paloma	1.909	-1.000

17. Lahuen Ñadi	-2.898	-0.171
18. Manso Inferior	-0.435	-1.277
19. Senda Darwin	-3.602	0.302
20. Cucao	-3.064	1.448
21. Lago Verde	0.478	-0.857
22. Limonao	0.521	-1.110
23. Quellón	-5.053	0.543
24. Corcovado	2.662	-0.385
25. La Junta	-4.675	-0.108
26. Mañihuales	-2.121	0.294
27. Fachinal	1.090	0.473
28. Río Leones	-0.574	1.054
29. Lago Vargas	-0.432	1.179
30. Perito Moreno	1.595	0.863
31. Pto. Natales	2.864	1.020
32. Pta. Arenas	1.672	1.394
33. BahíaInútil	1.392	1.630
34. Lapataia	1.404	2.163

Table S6: Canonical correlation weights of the variables for current climate in the CCA current climate-morphology, based on correlations to calculate in formula [2] CCA future climate-morphology.

Current climate	Root 1	Root 2
PCA-C1	$\mathbf{b_{11}}$	$\mathbf{b_{21}}$
	-0.398	-0.917
PCA-C2	$\mathbf{b_{12}}$	$\mathbf{b_{22}}$
	0.917	-0.398

Table S7: Canonical correlation weights of the variables for current climate in the CCA current climate-genetics, based on correlations to calculate [4] CCA future climate-genetics

Current climate	Root 1	Root 2
PCA-C1	$\mathbf{c_{11}}$	$\mathbf{c_{21}}$
	0.547	-0.837
PCA-C2	$\mathbf{c_{12}}$	$\mathbf{c_{22}}$
	-0.837	-0.547