

¹ Supporting Information

² All data and code is stored in an online repository (www.github.com/jeffreyhanson/genetic-surrogates) to replicate analyses in this study. See the *README* file for instructions.

⁵ Figures

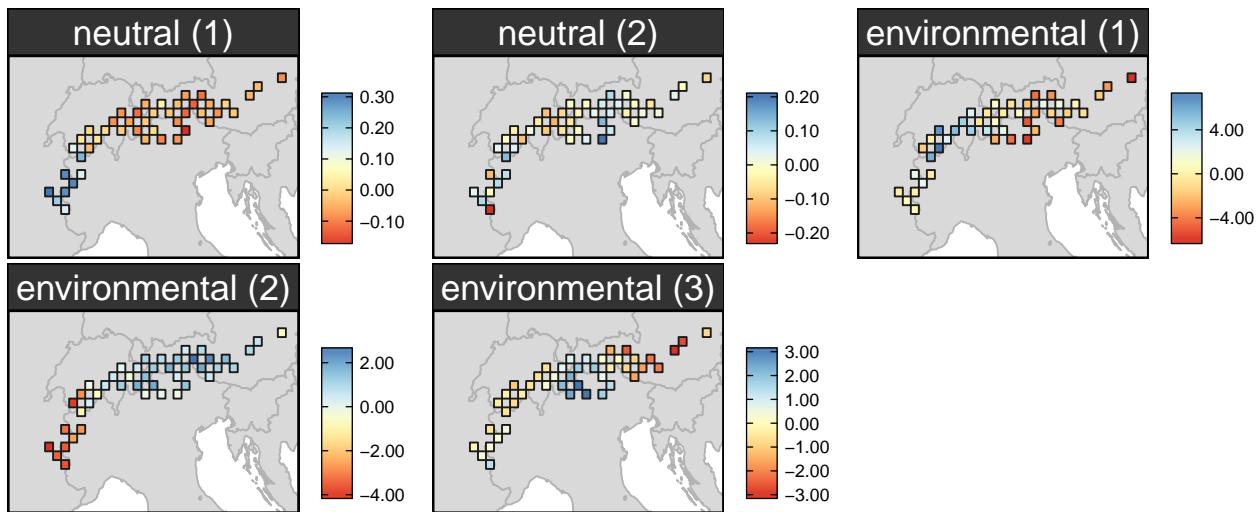


Figure S1: Distribution of environmental variation found across the geographic range of *Androsace obtusifolia*, and the distribution of its adaptive and neutral genetic variation in the study area. Each panel shows a different dimension of variation as indicated by its title. Squares represent planning units. Samples collected from the species were subject to NMDS to ordinate the main axes of adaptive (if detected) and neutral genetic variation. The bioclimatic data were clipped to planning units where the species was found, and subject to a principal components analysis to summarise the main gradients of environmental variation. The panels show the spatial distribution of the ordinated environmental and genetic data averaged to the planning-unit level. Planning units where individuals were not observed are shown in gray.

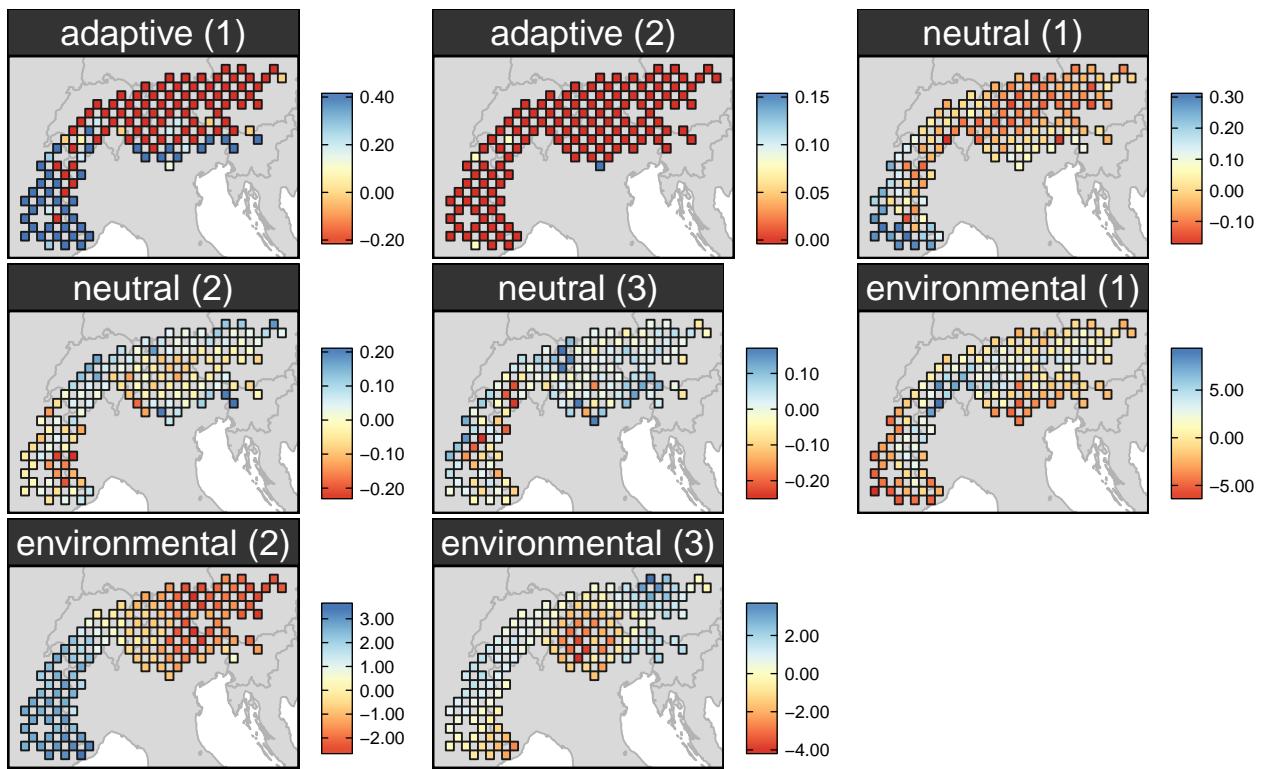


Figure S2: Distribution of environmental variation found across the geographic range of *Arabis alpina*, and the distribution of its adaptive and neutral genetic variation in the study area. See Figure S1 caption for conventions.

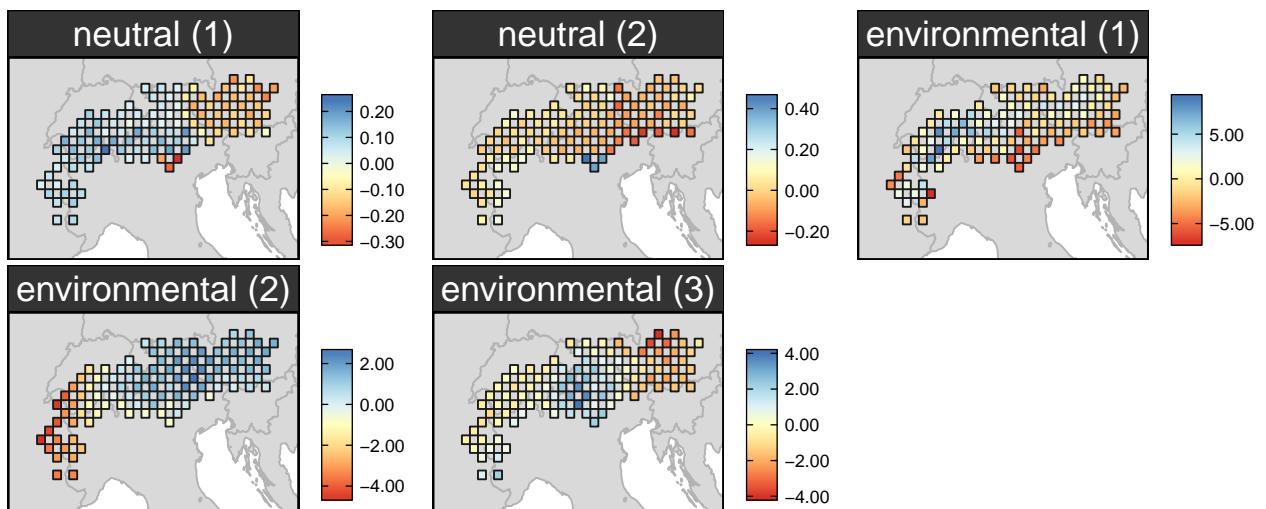


Figure S3: Distribution of environmental variation found across the geographic range of *Campanula barbata*, and the distribution of its adaptive and neutral genetic variation in the study area. See Figure S1 caption for conventions.

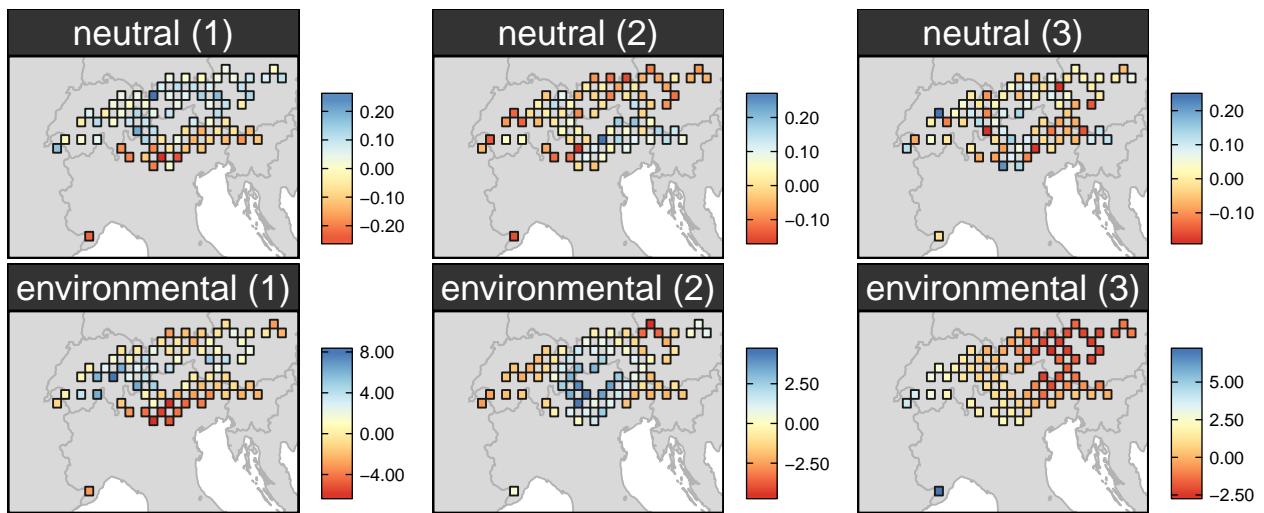


Figure S4: Distribution of environmental variation found across the geographic range of *Carex firma*, and the distribution of its adaptive and neutral genetic variation in the study area. See Figure S1 caption for conventions.

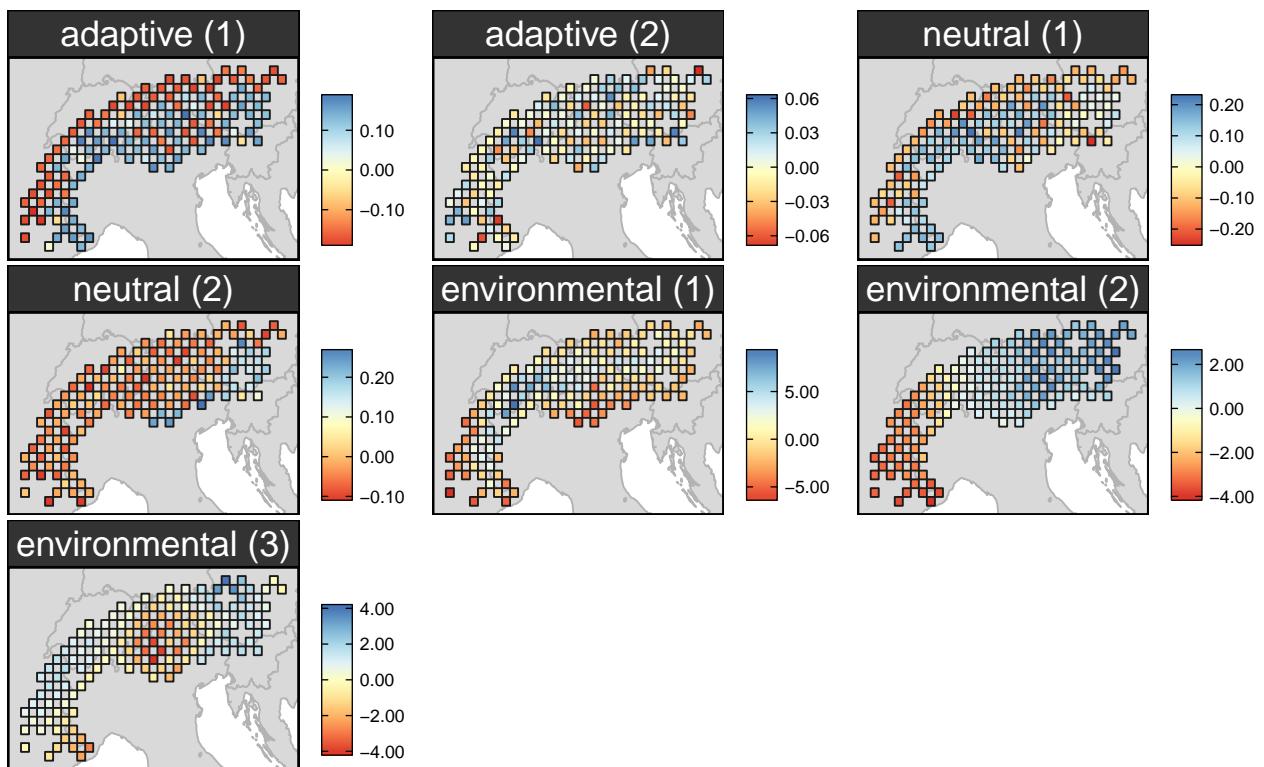


Figure S5: Distribution of environmental variation found across the geographic range of *Carex sempervirens*, and the distribution of its adaptive and neutral genetic variation in the study area. See Figure S1 caption for conventions.

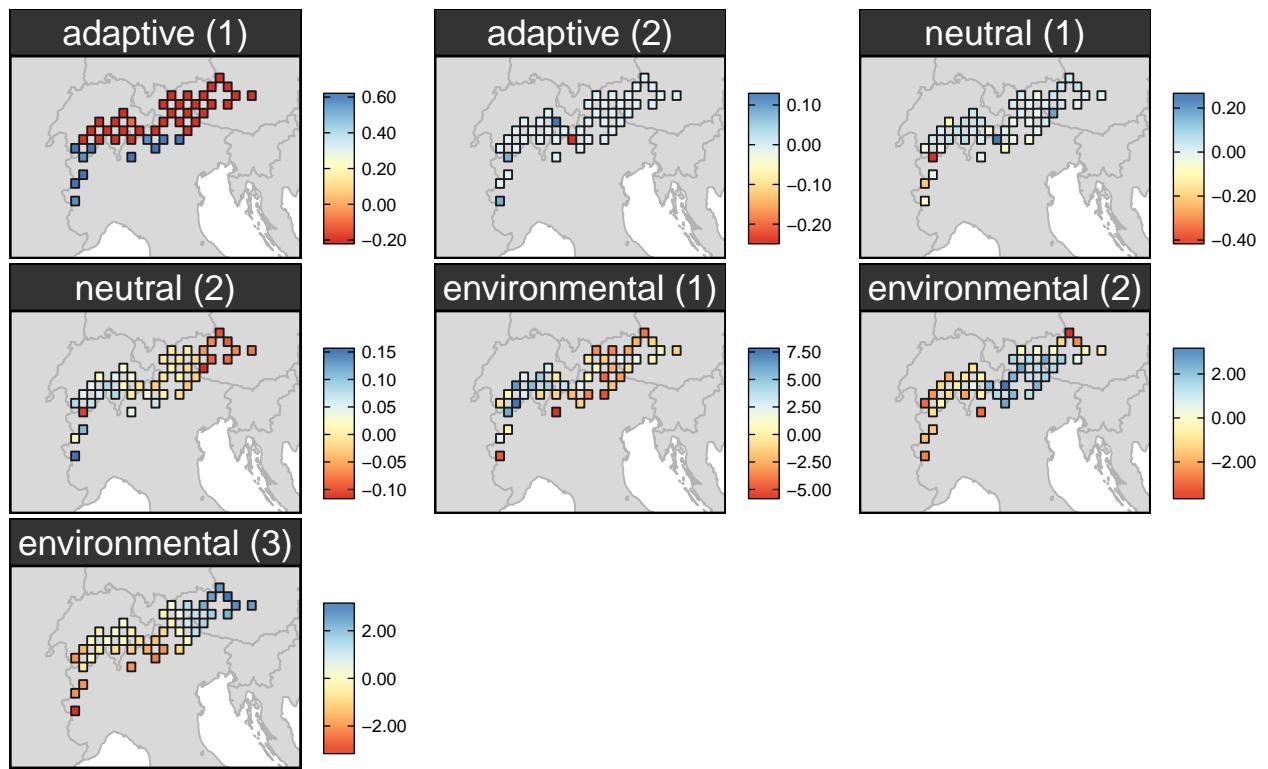


Figure S6: Distribution of environmental variation found across the geographic range of *Cerastium uniflorum*, and the distribution of its adaptive and neutral genetic variation in the study area. See Figure S1 caption for conventions.

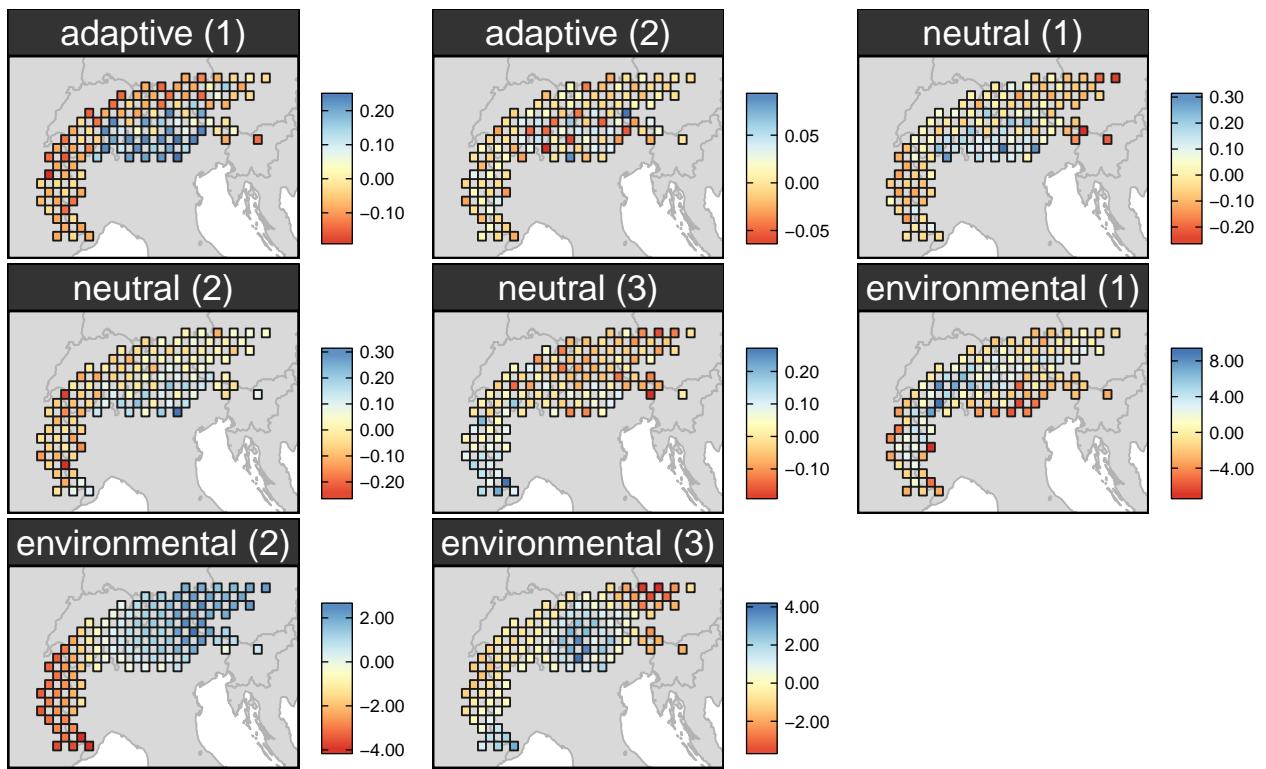


Figure S7: Distribution of environmental variation found across the geographic range of *Cirsium spinosissimum*, and the distribution of its adaptive and neutral genetic variation in the study area. See Figure S1 caption for conventions.

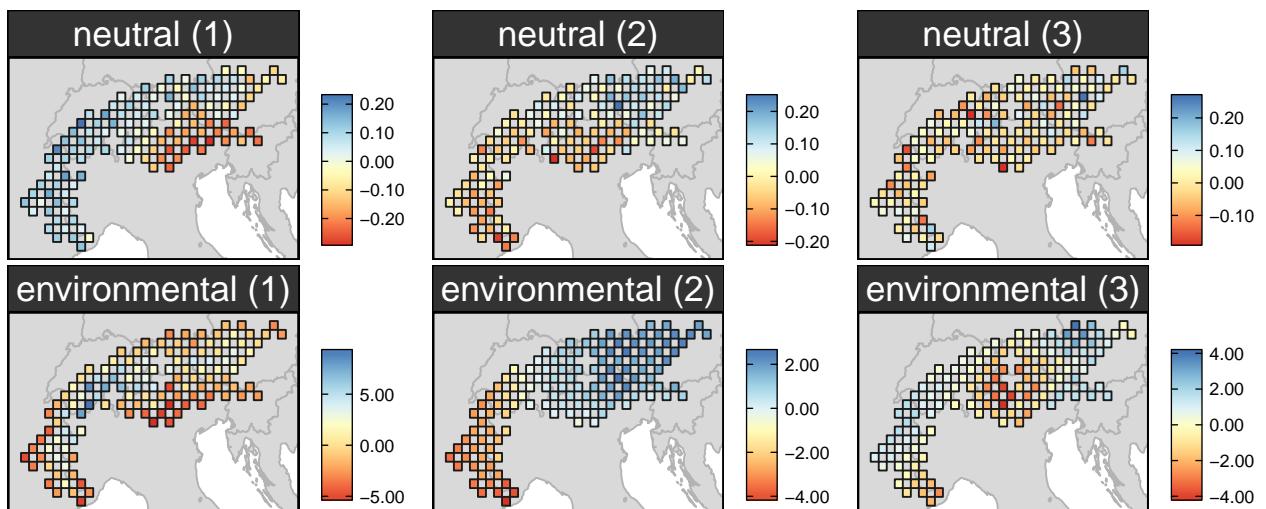


Figure S8: Distribution of environmental variation found across the geographic range of *Dryas octopetala*, and the distribution of its adaptive and neutral genetic variation in the study area. See Figure S1 caption for conventions.

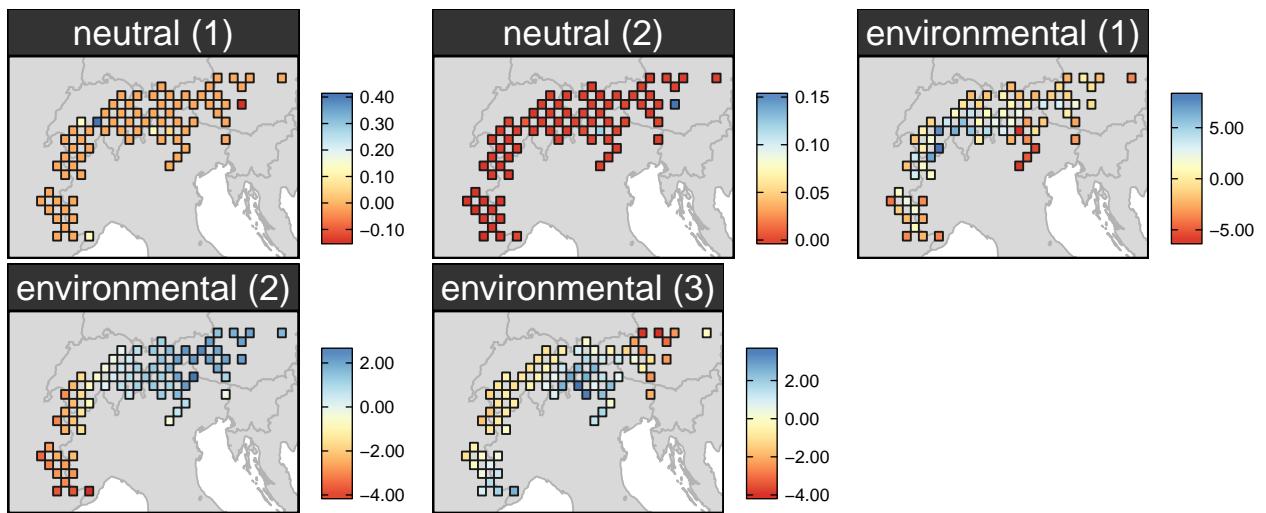


Figure S9: Distribution of environmental variation found across the geographic range of *Gentiana nivalis*, and the distribution of its adaptive and neutral genetic variation in the study area. See Figure S1 caption for conventions.

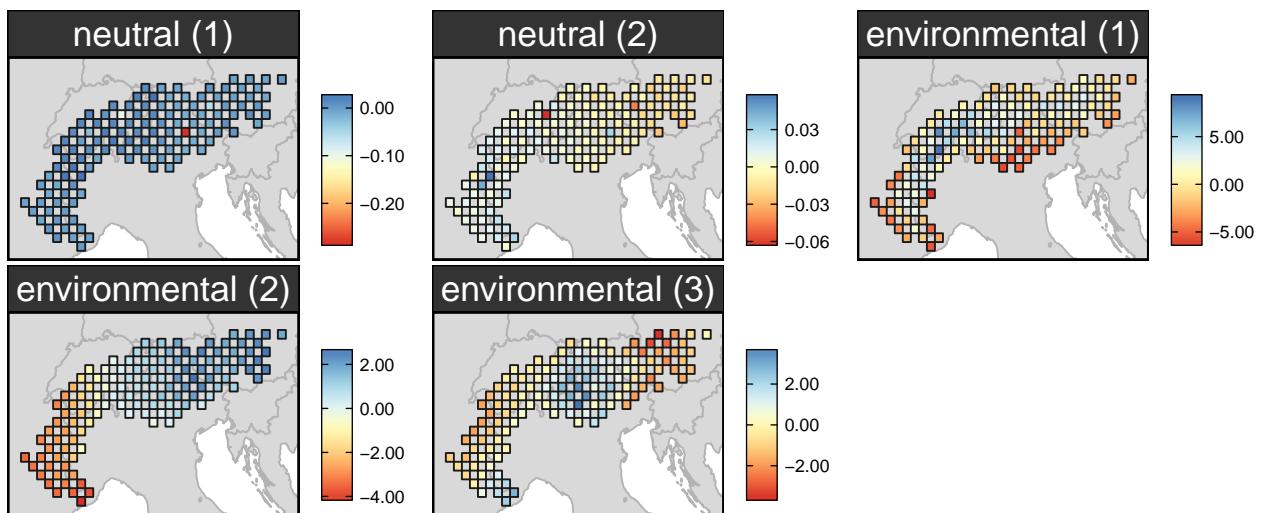


Figure S10: Distribution of environmental variation found across the geographic range of *Geum montanum*, and the distribution of its adaptive and neutral genetic variation in the study area. See Figure S1 caption for conventions.

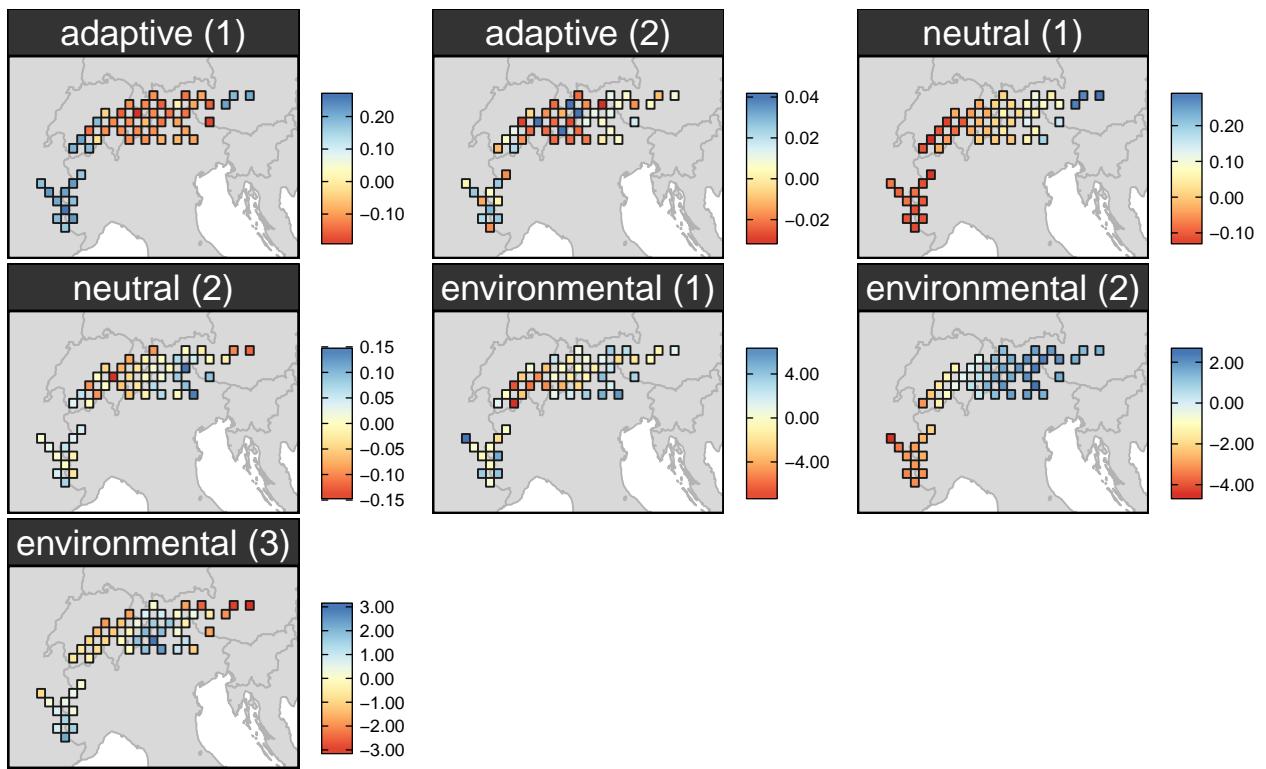


Figure S11: Distribution of environmental variation found across the geographic range of *Geum reptans*, and the distribution of its adaptive and neutral genetic variation in the study area. See Figure S1 caption for conventions.

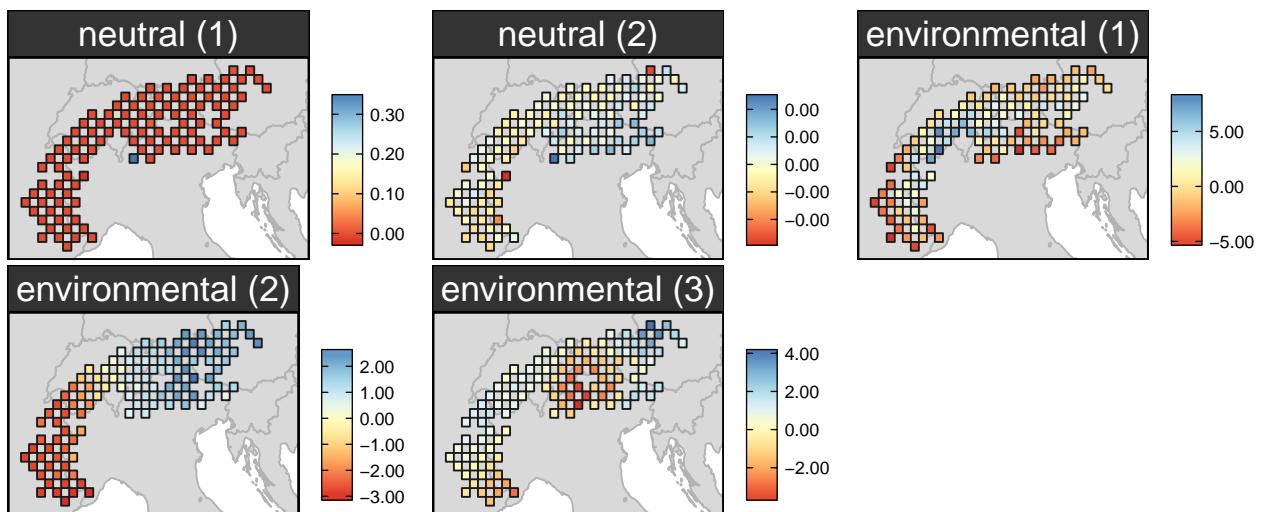


Figure S12: Distribution of environmental variation found across the geographic range of *Gypsophila repens*, and the distribution of its adaptive and neutral genetic variation in the study area. See Figure S1 caption for conventions.

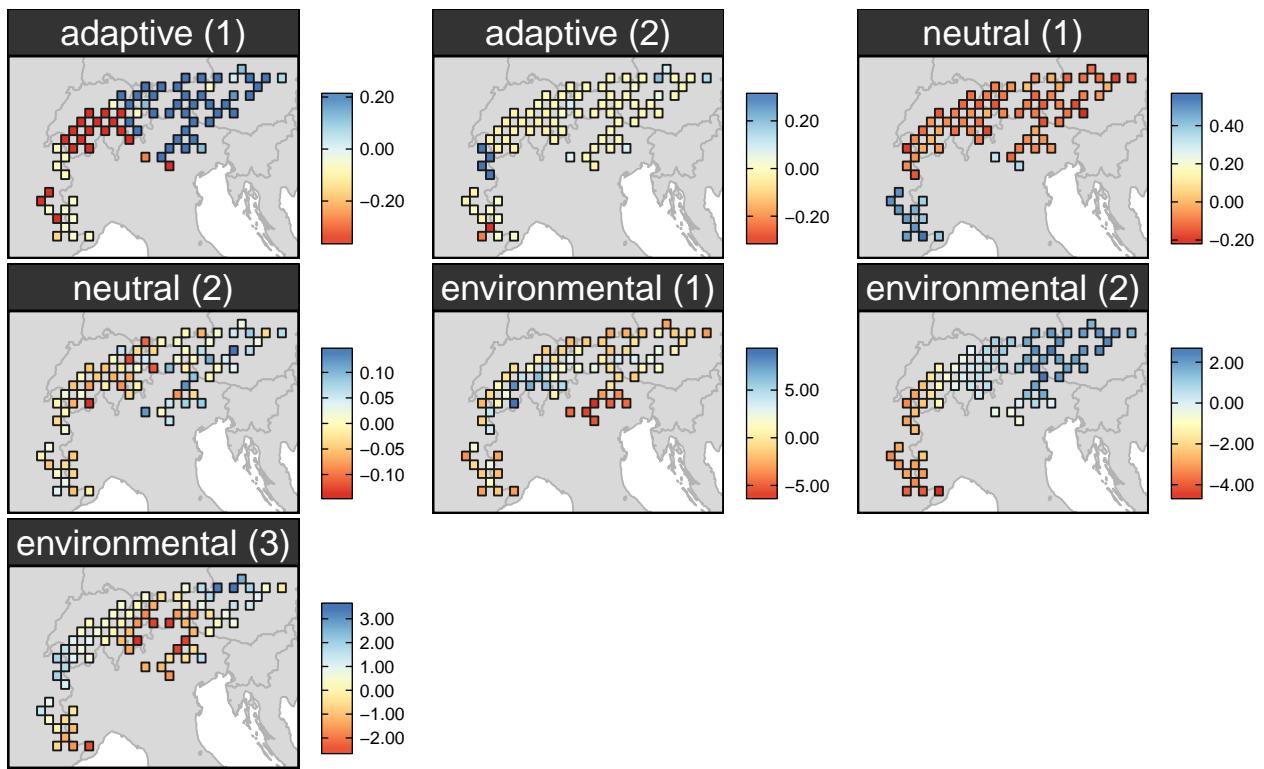


Figure S13: Distribution of environmental variation found across the geographic range of *Hedysarum hedysaroides*, and the distribution of its adaptive and neutral genetic variation in the study area. See Figure S1 caption for conventions.

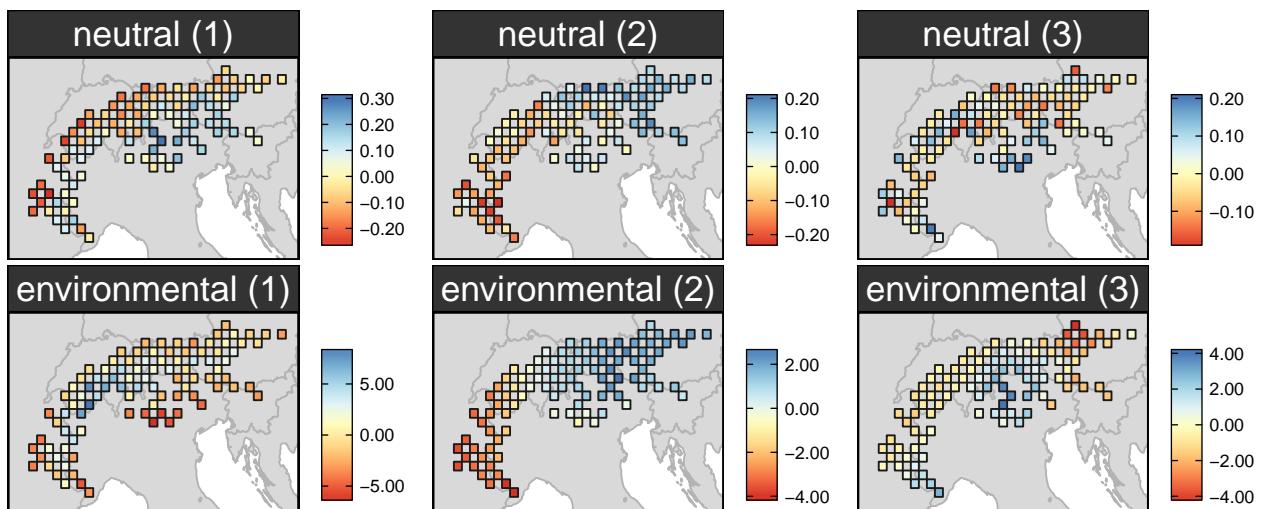


Figure S14: Distribution of environmental variation found across the geographic range of *Hornungia alpina*, and the distribution of its adaptive and neutral genetic variation in the study area. See Figure S1 caption for conventions.

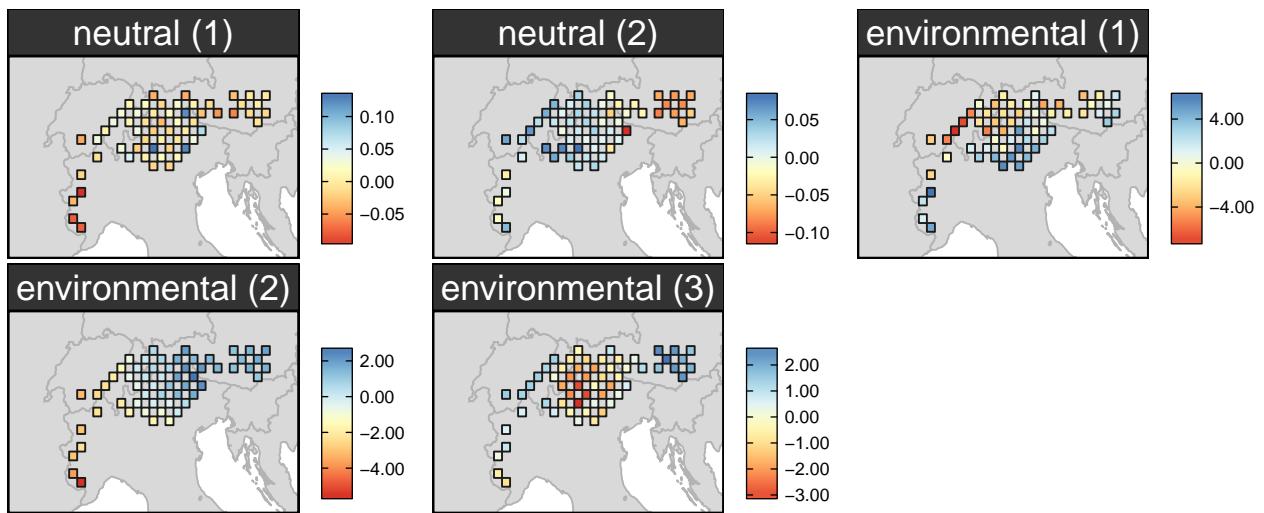


Figure S15: Distribution of environmental variation found across the geographic range of *Hypochaeris uniflora*, and the distribution of its adaptive and neutral genetic variation in the study area. See Figure S1 caption for conventions.

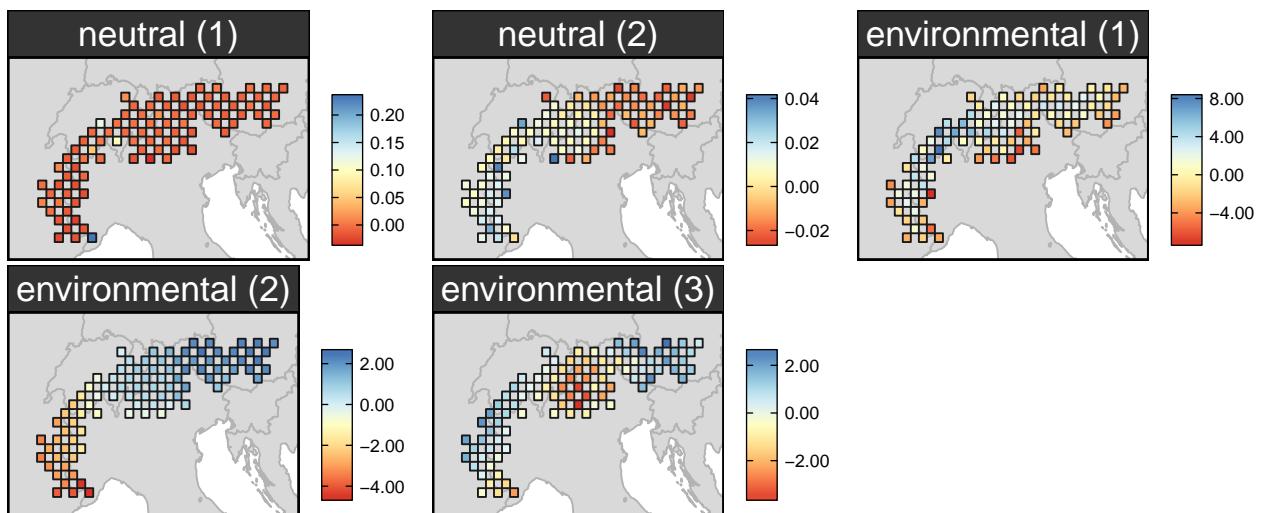


Figure S16: Distribution of environmental variation found across the geographic range of *Juncus trifidus*, and the distribution of its adaptive and neutral genetic variation in the study area. See Figure S1 caption for conventions.

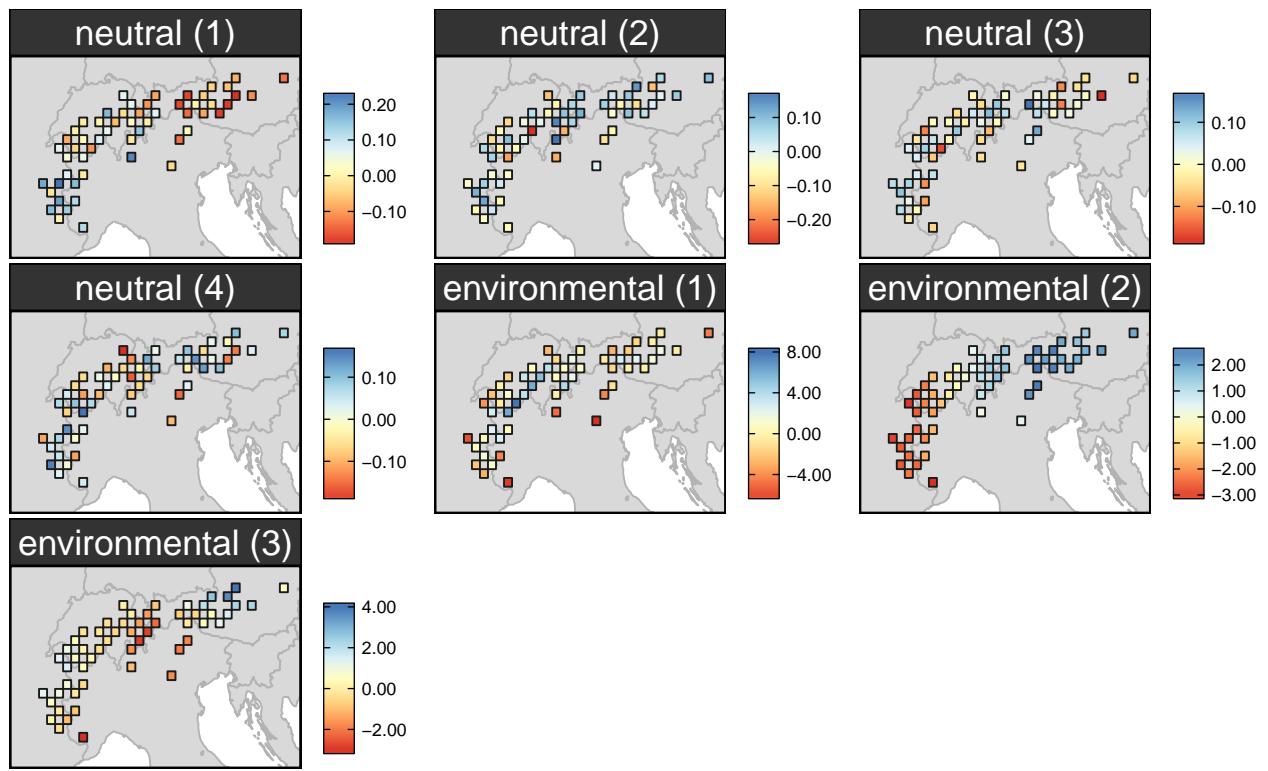


Figure S17: Distribution of environmental variation found across the geographic range of *Ligusticum mutellinoides*, and the distribution of its adaptive and neutral genetic variation in the study area. See Figure S1 caption for conventions.

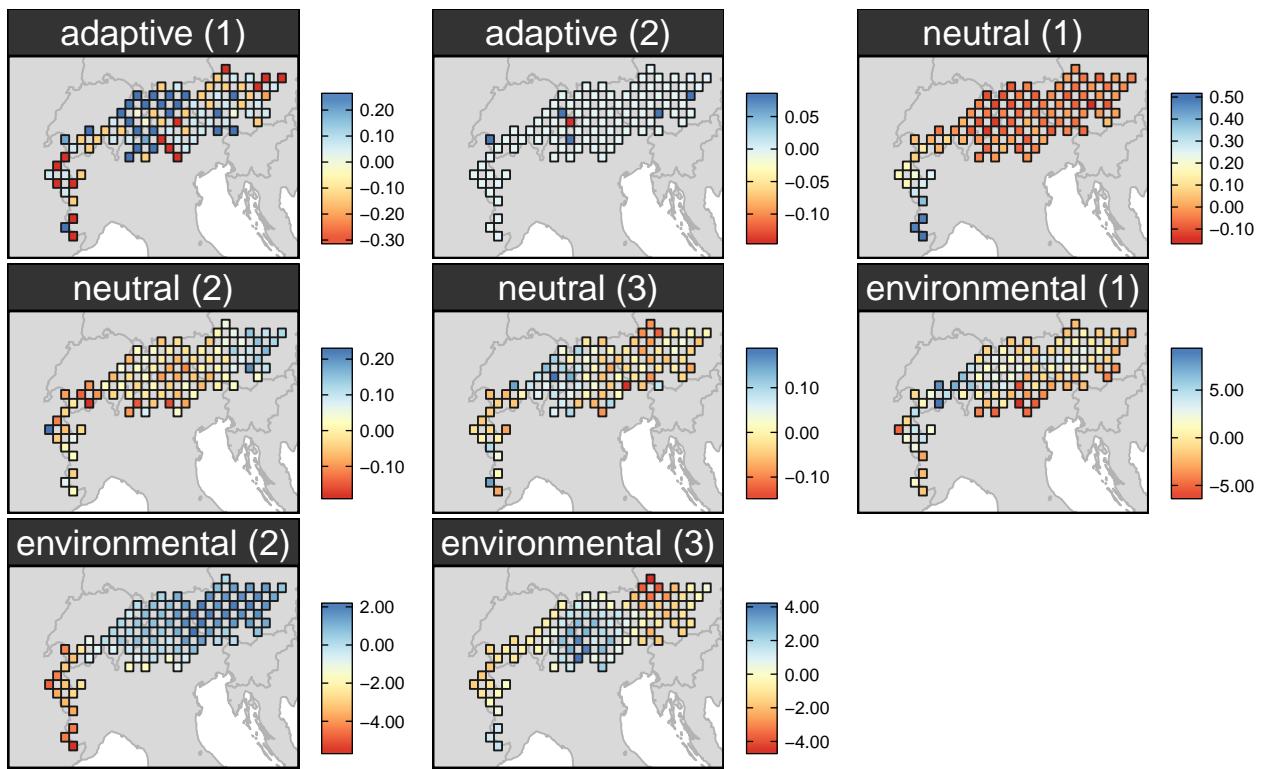


Figure S18: Distribution of environmental variation found across the geographic range of *Loiseleuria procumbens*, and the distribution of its adaptive and neutral genetic variation in the study area. See Figure S1 caption for conventions.

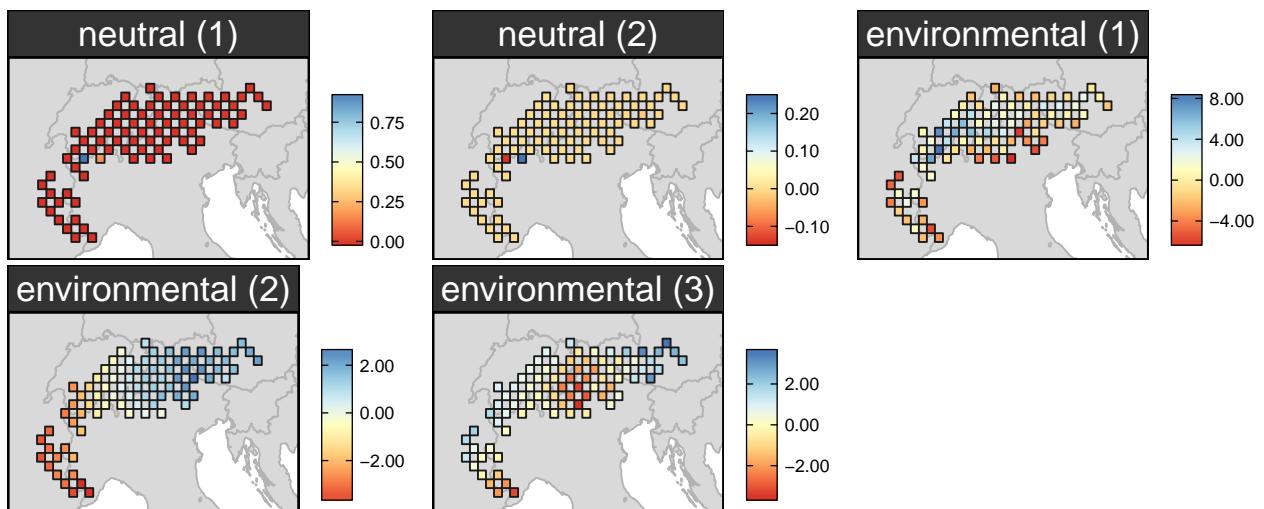


Figure S19: Distribution of environmental variation found across the geographic range of *Luzula alpinopilosa*, and the distribution of its adaptive and neutral genetic variation in the study area. See Figure S1 caption for conventions.

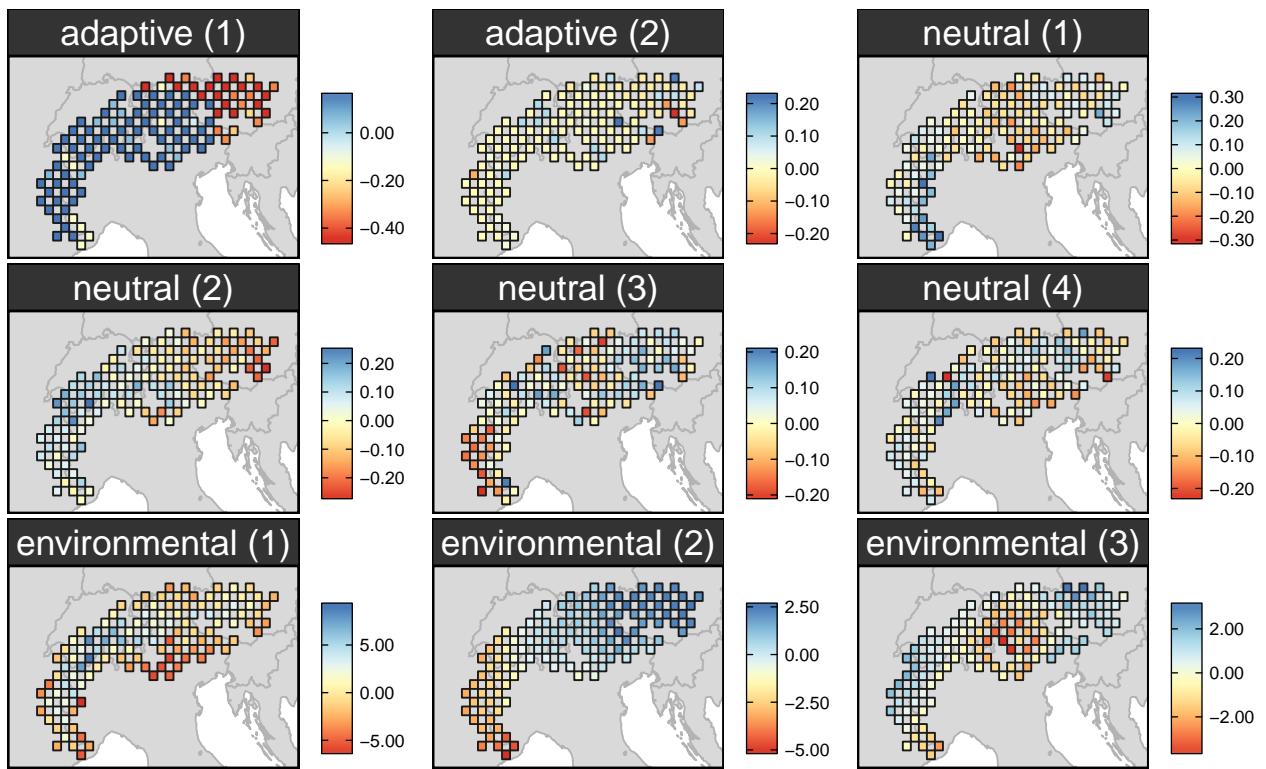


Figure S20: Distribution of environmental variation found across the geographic range of *Peucedanum ostruthium*, and the distribution of its adaptive and neutral genetic variation in the study area. See Figure S1 caption for conventions.

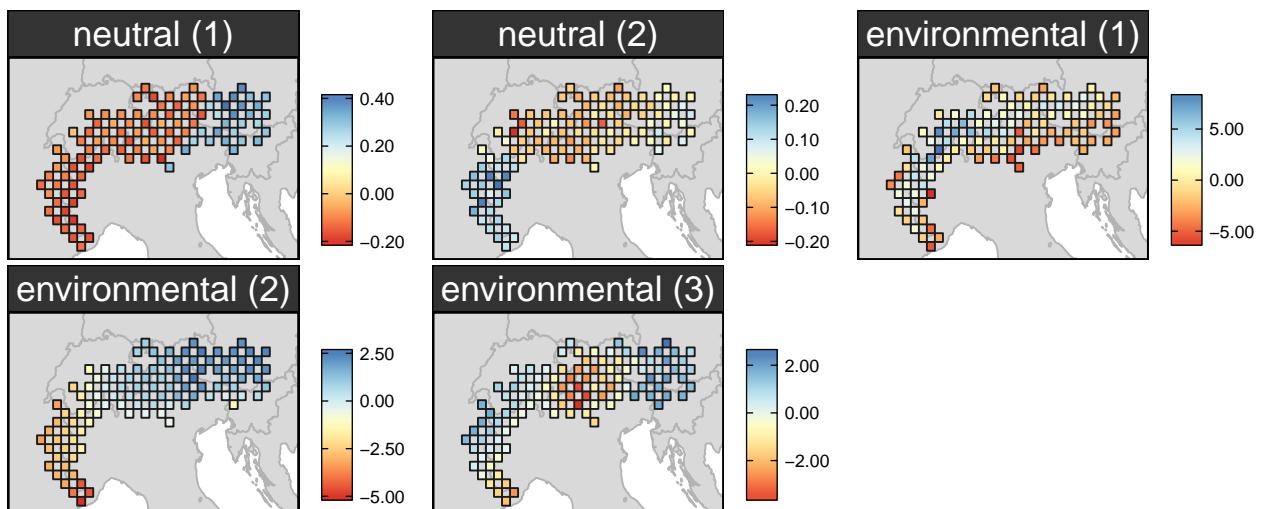


Figure S21: Distribution of environmental variation found across the geographic range of *Phyteuma betonicifolium*, and the distribution of its adaptive and neutral genetic variation in the study area. See Figure S1 caption for conventions.

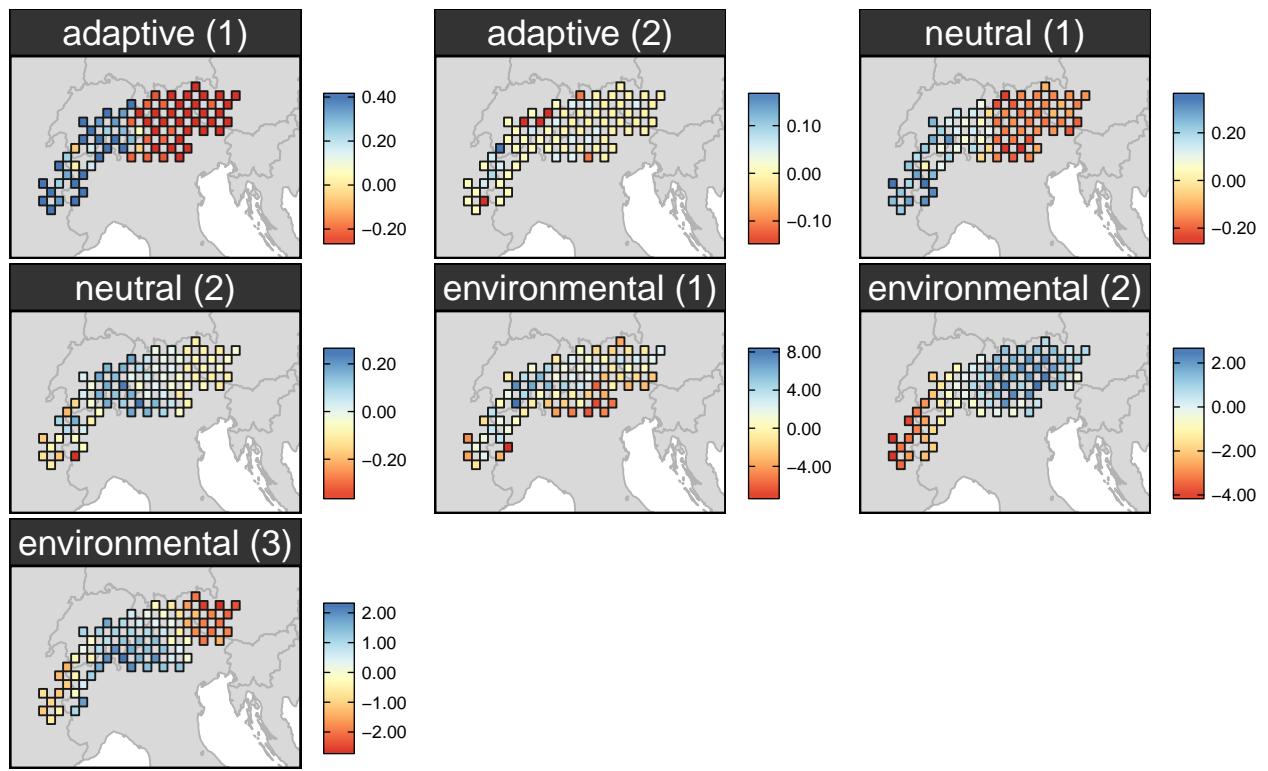


Figure S22: Distribution of environmental variation found across the geographic range of *Phyteuma hemisphaericum*, and the distribution of its adaptive and neutral genetic variation in the study area. See Figure S1 caption for conventions.

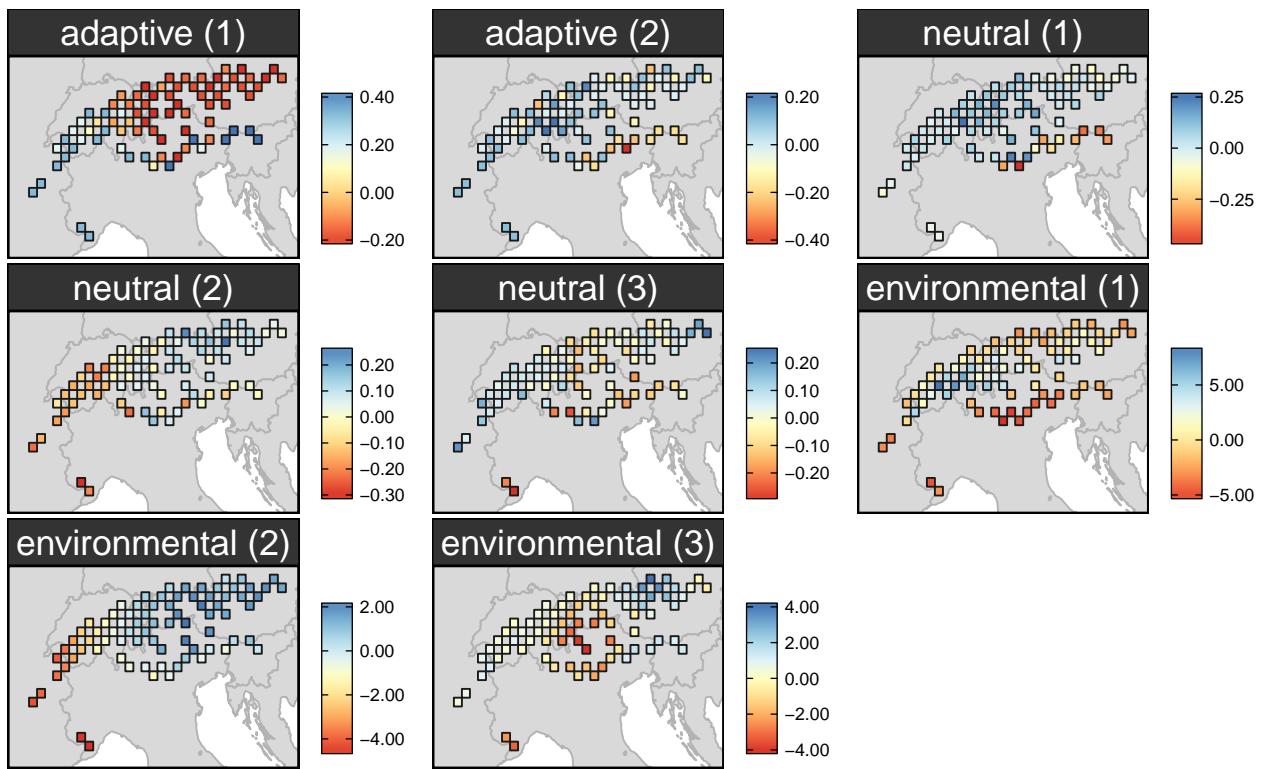


Figure S23: Distribution of environmental variation found across the geographic range of *Ranunculus alpestris*, and the distribution of its adaptive and neutral genetic variation in the study area. See Figure S1 caption for conventions.

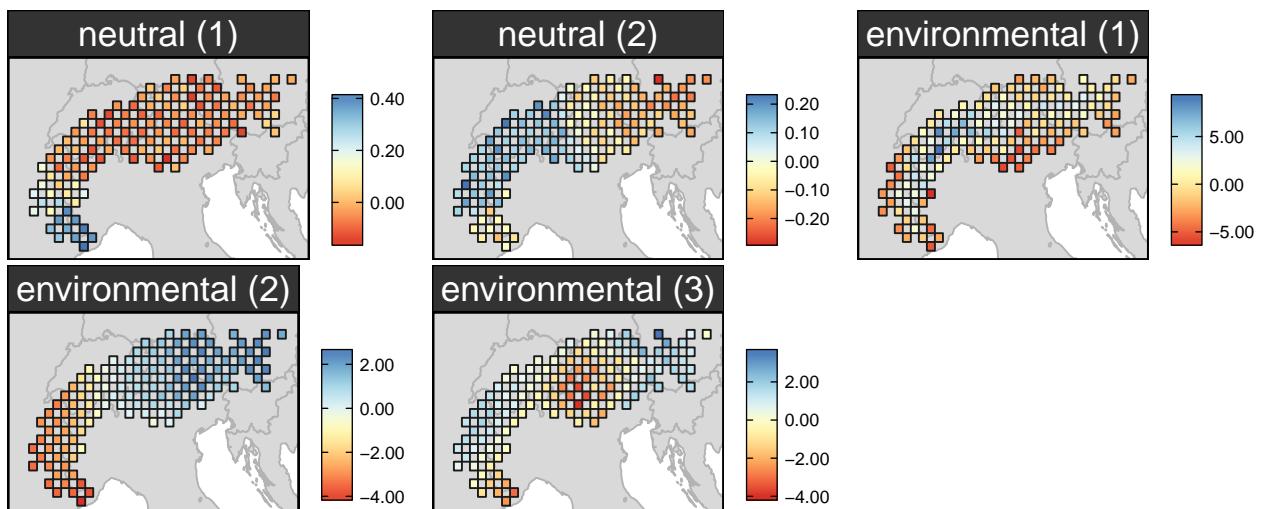


Figure S24: Distribution of environmental variation found across the geographic range of *Rhododendron ferrugineum*, and the distribution of its adaptive and neutral genetic variation in the study area. See Figure S1 caption for conventions.

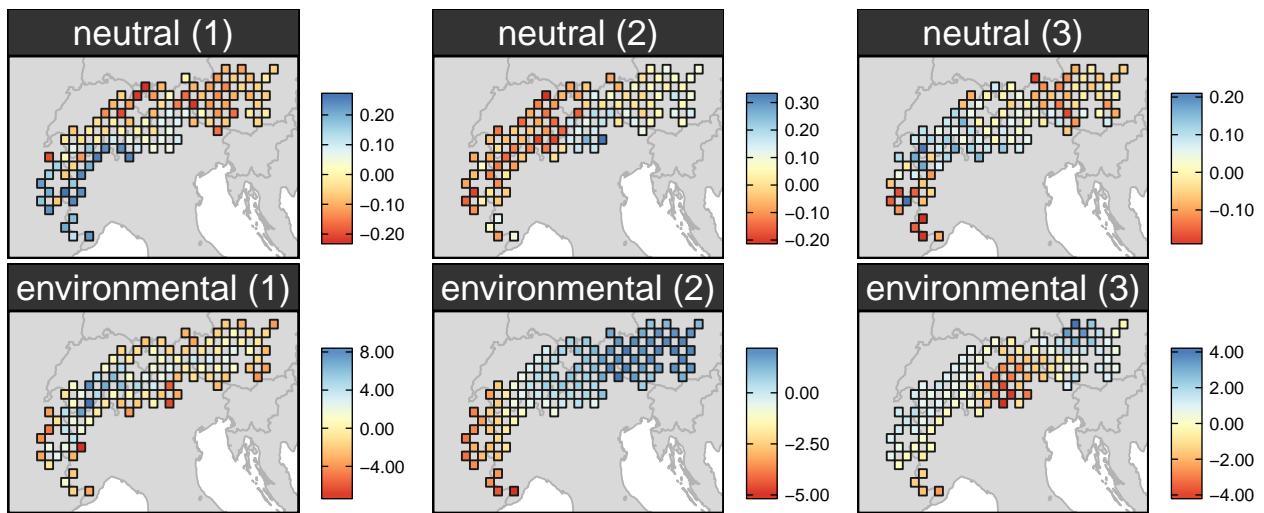


Figure S25: Distribution of environmental variation found across the geographic range of *Saxifraga stellaris*, and the distribution of its adaptive and neutral genetic variation in the study area. See Figure S1 caption for conventions.

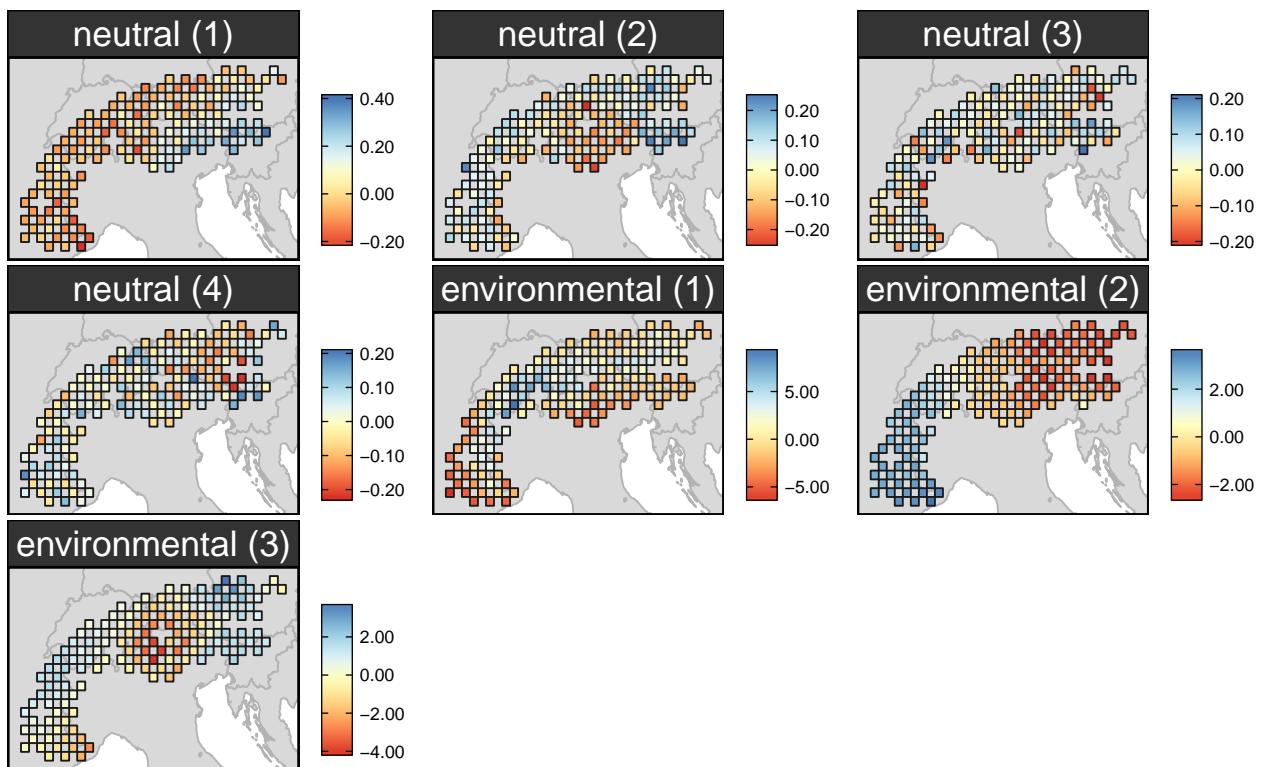


Figure S26: Distribution of environmental variation found across the geographic range of *Sesleria caerulea*, and the distribution of its adaptive and neutral genetic variation in the study area. See Figure S1 caption for conventions.

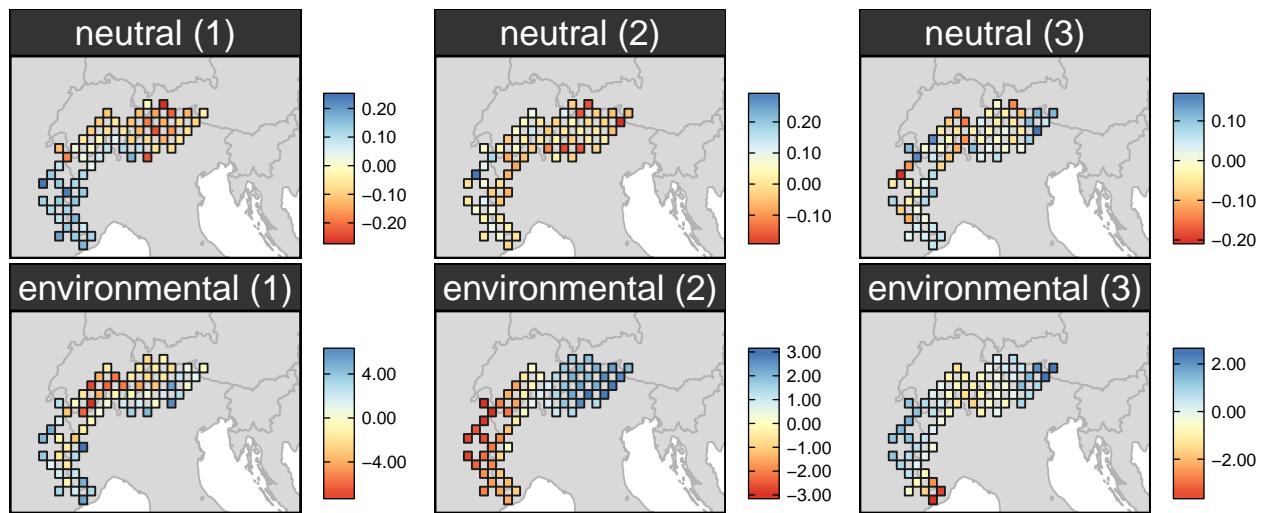


Figure S27: Distribution of environmental variation found across the geographic range of *Trifolium alpinum*, and the distribution of its adaptive and neutral genetic variation in the study area. See Figure S1 caption for conventions.

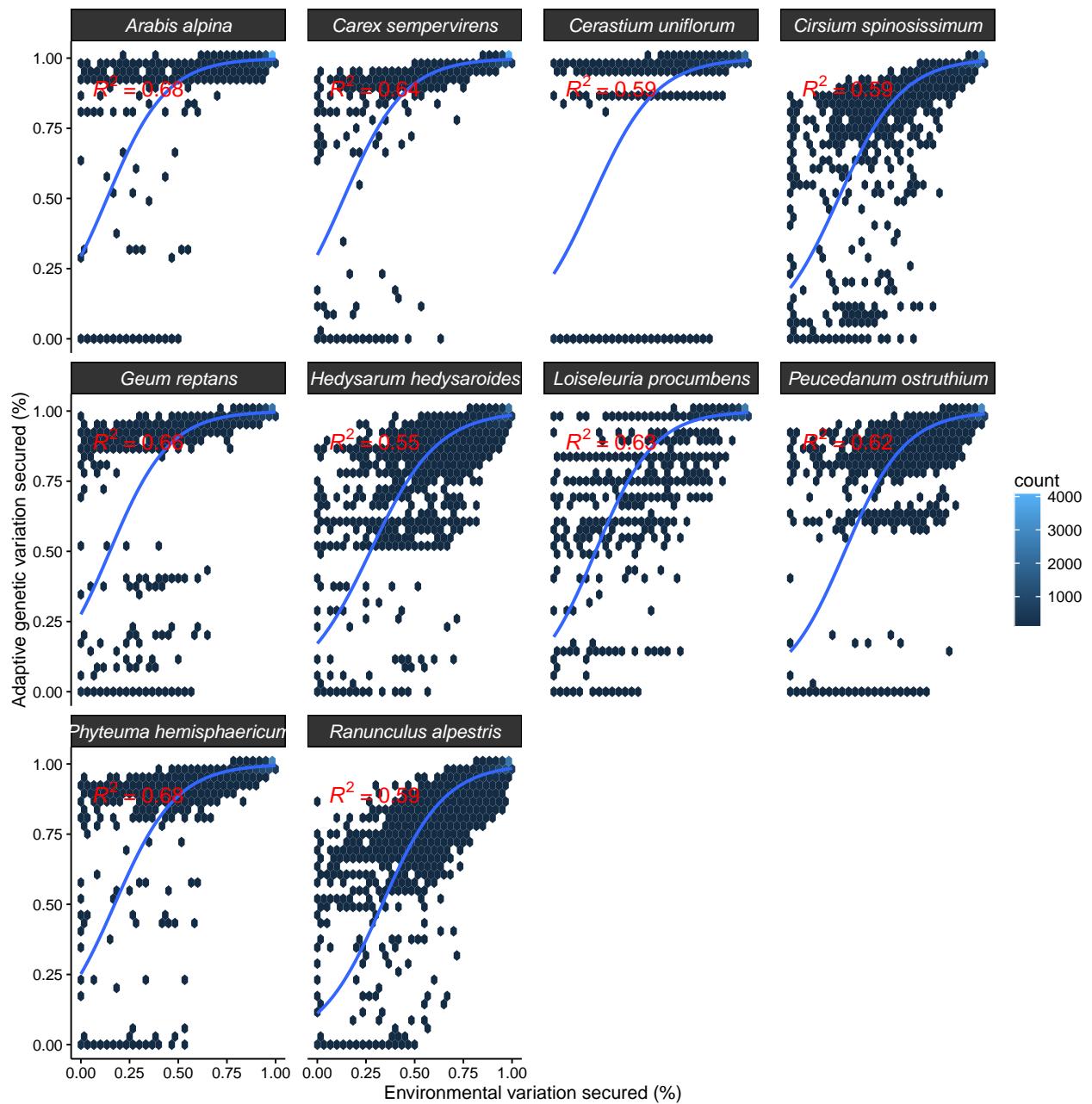


Figure S28: The relationship between the proportion of adaptive genetic variation secured in a prioritization and the proportion of environmental variation it also secures. Points represent values associated with randomly generated prioritizations. Blue lines indicate average trends computed using a generalised linear model with a logit link. Each panel shows data for a different species.

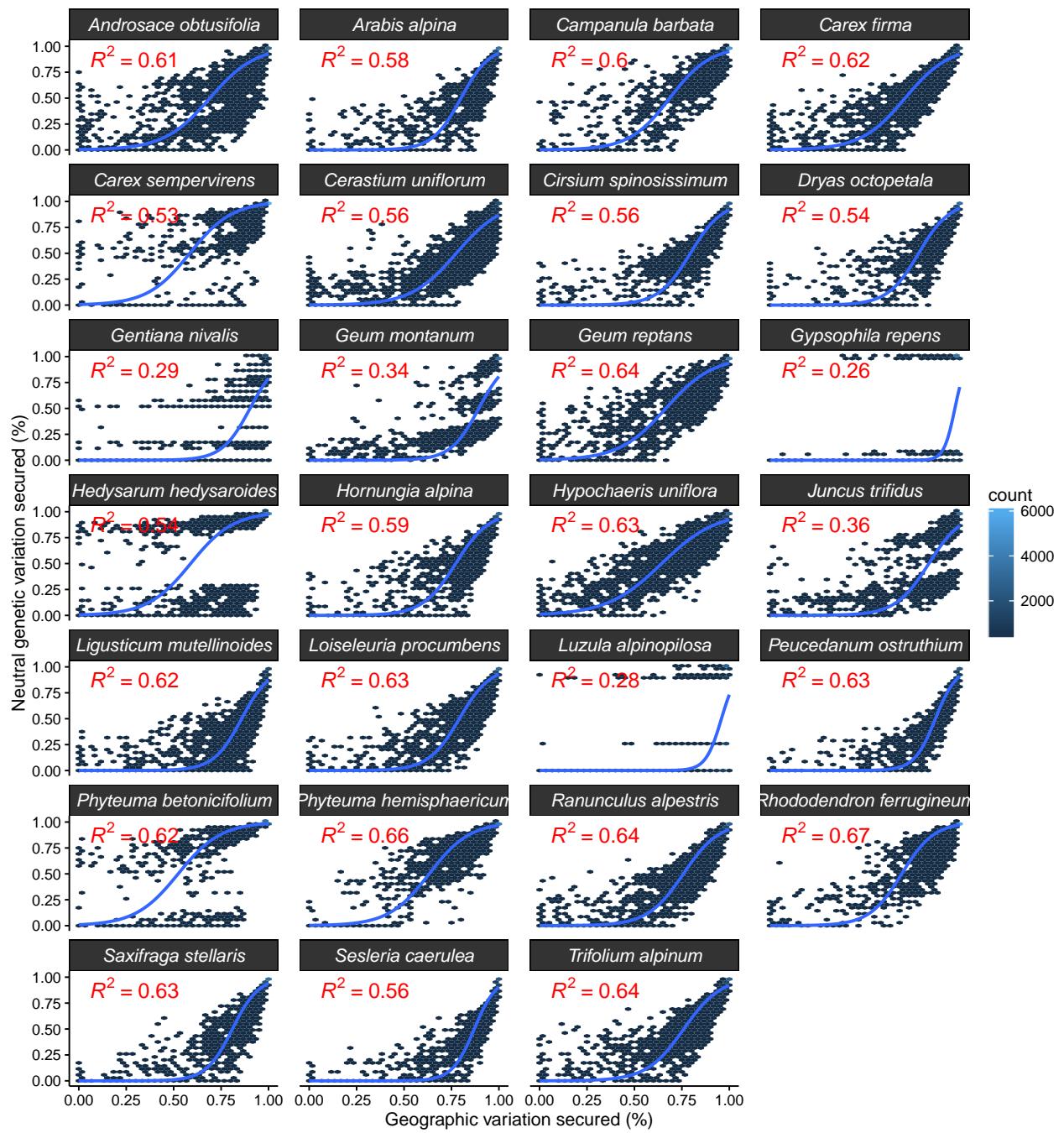


Figure S29: The relationship between the proportion of neutral genetic variation secured in a prioritization and the proportion of geographic variation it also secures. Conventions are detailed in Figure S28.

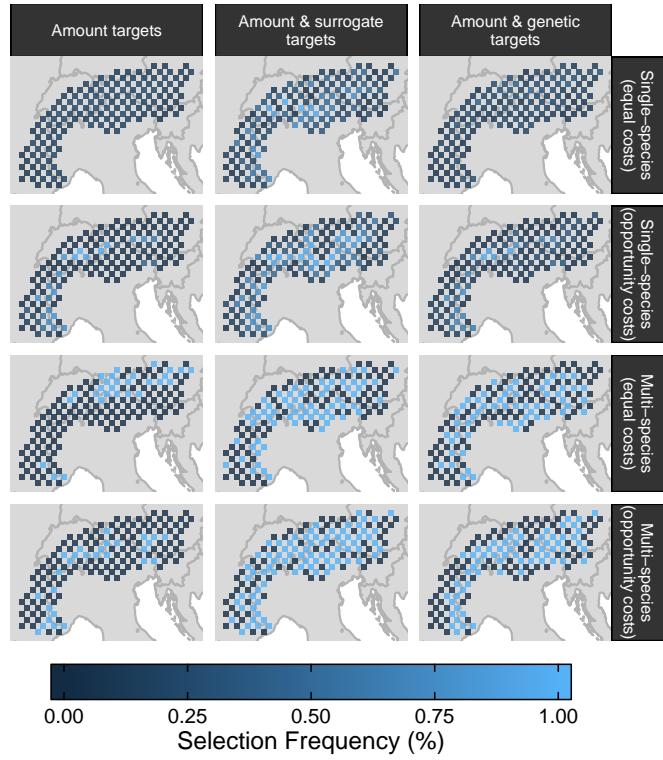


Figure S30: Planning unit selection frequencies. Squares represent planning units, and their colors indicate their selection frequency. Each column of panels shows solutions generated using different targets. Each row of panels shows solutions generated under different scenarios. Note that the selection frequencies for the single-species prioritizations are based on their frequency among prioritizations generated for each species. The selection frequencies for the multi-species prioritizations are each based on a single optimal prioritization for all species and so are binary.

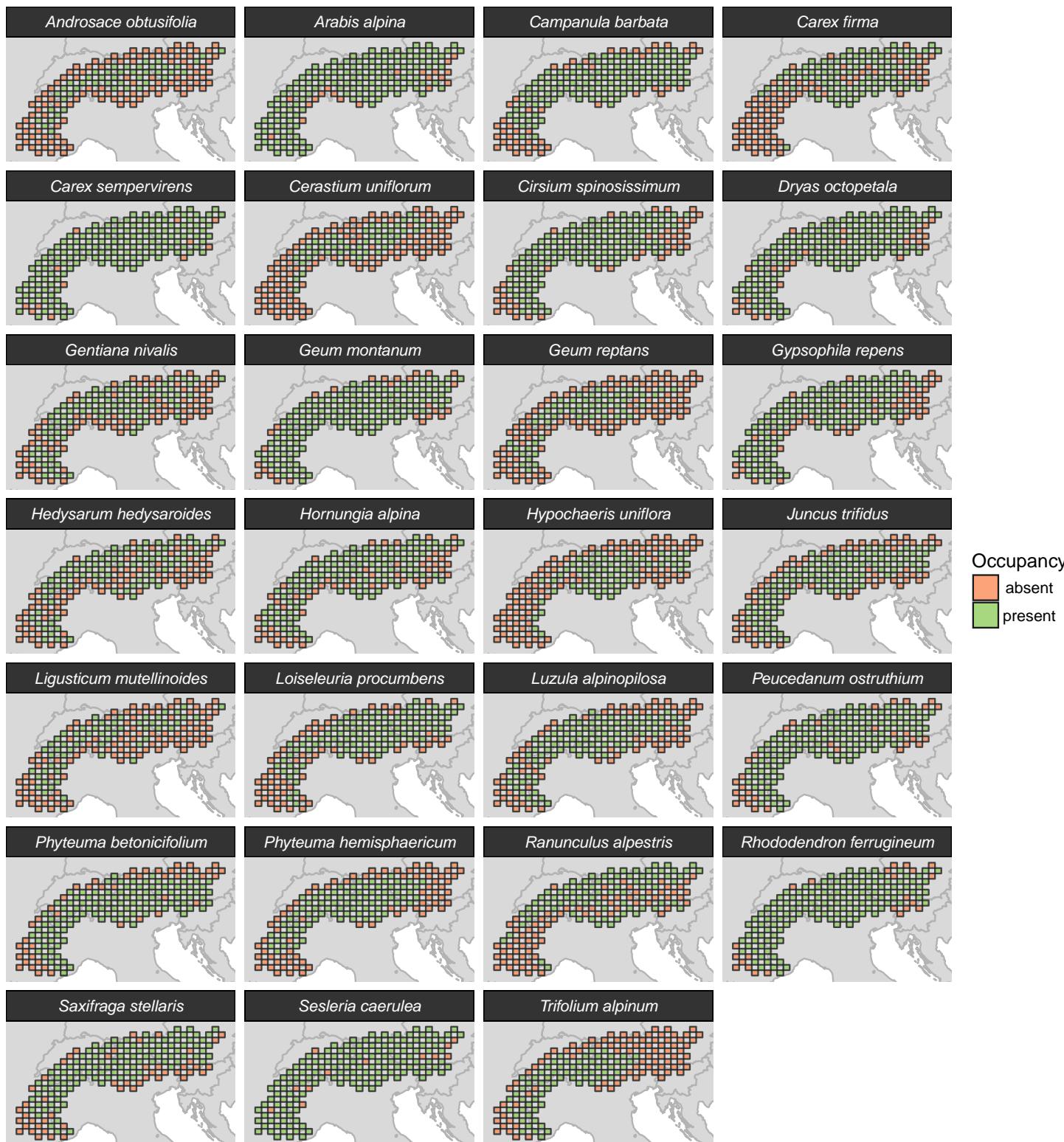


Figure S31: Species distributions. Squares represent planning units. For a given species, planning units that it was found in are shown in bright blue.

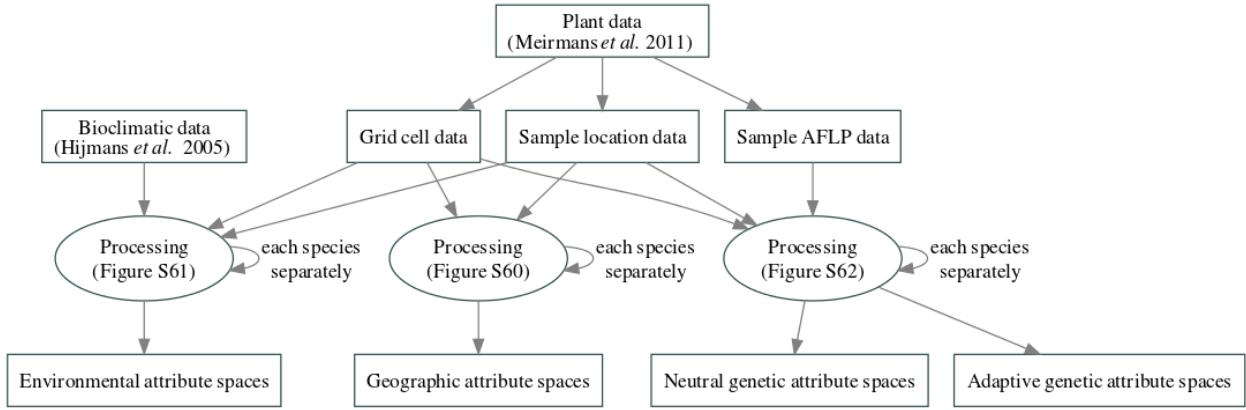


Figure S32: Overall data processing workflow. The flowcharts show the methods used to generate the environmental and geographic surrogate spaces, and the adaptive and neutral genetic spaces. Squares indicate data sets. Ellipses indicate analyses. Lines show relationships between data and analysis, and their captions describe how data was processed.

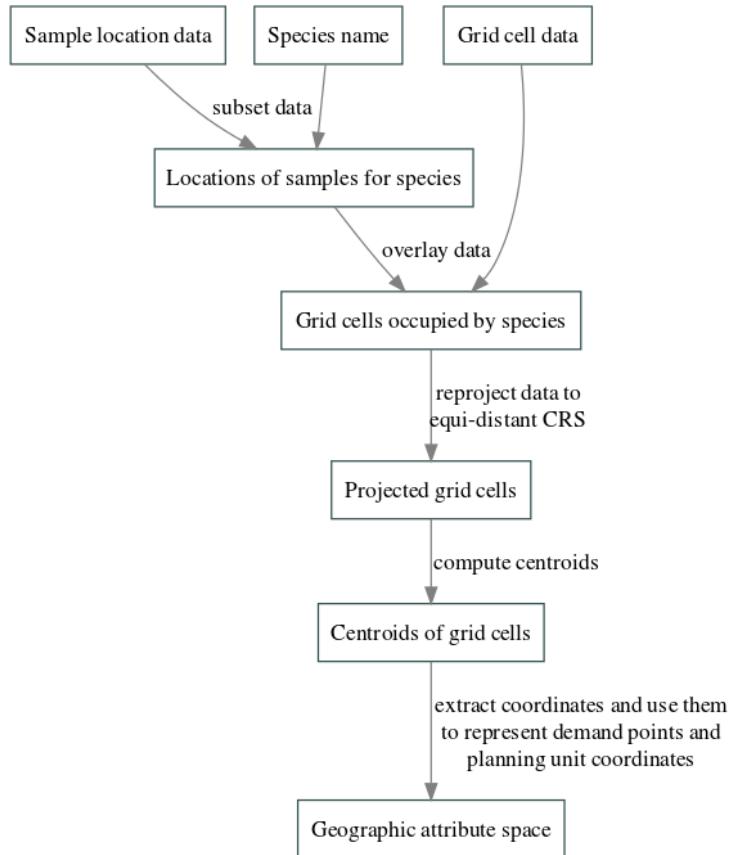


Figure S33: Geographic surrogate processing workflow. Conventions are detailed in Figure S32 caption.

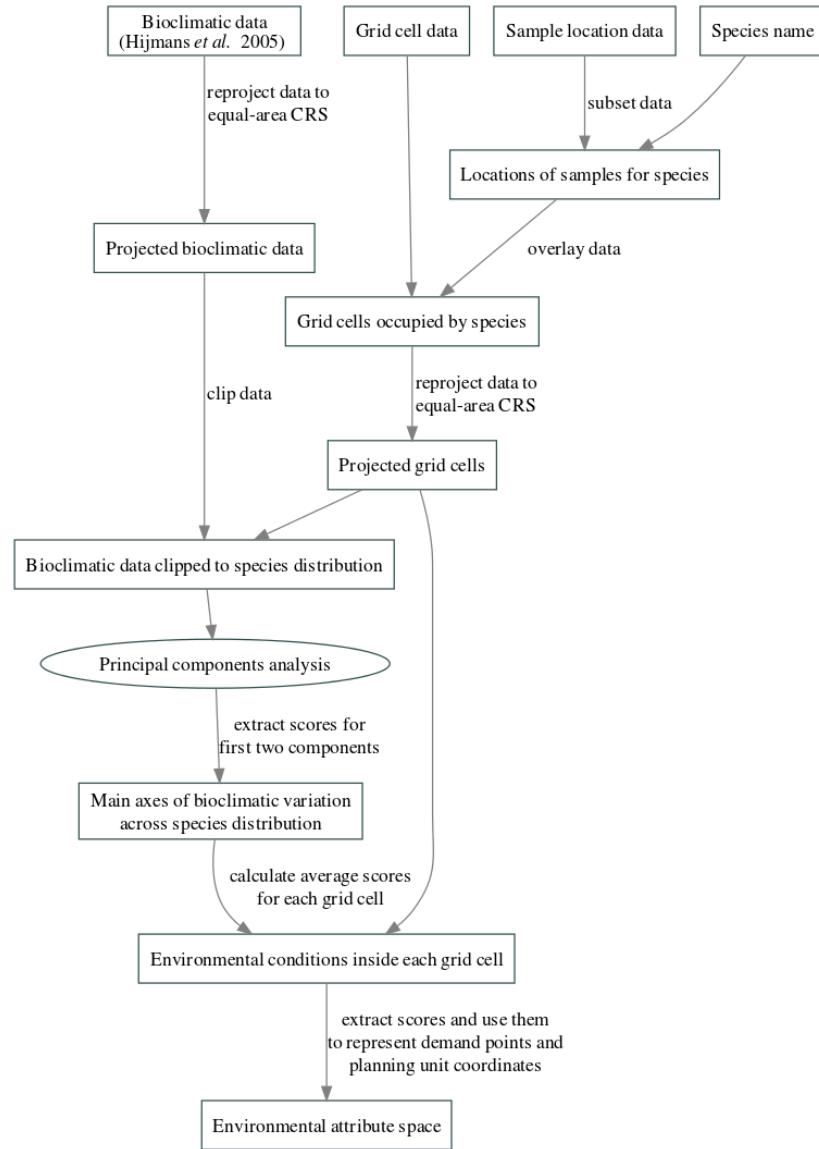


Figure S34: Environmental surrogate processing workflow. Conventions are detailed in Figure S32 caption.

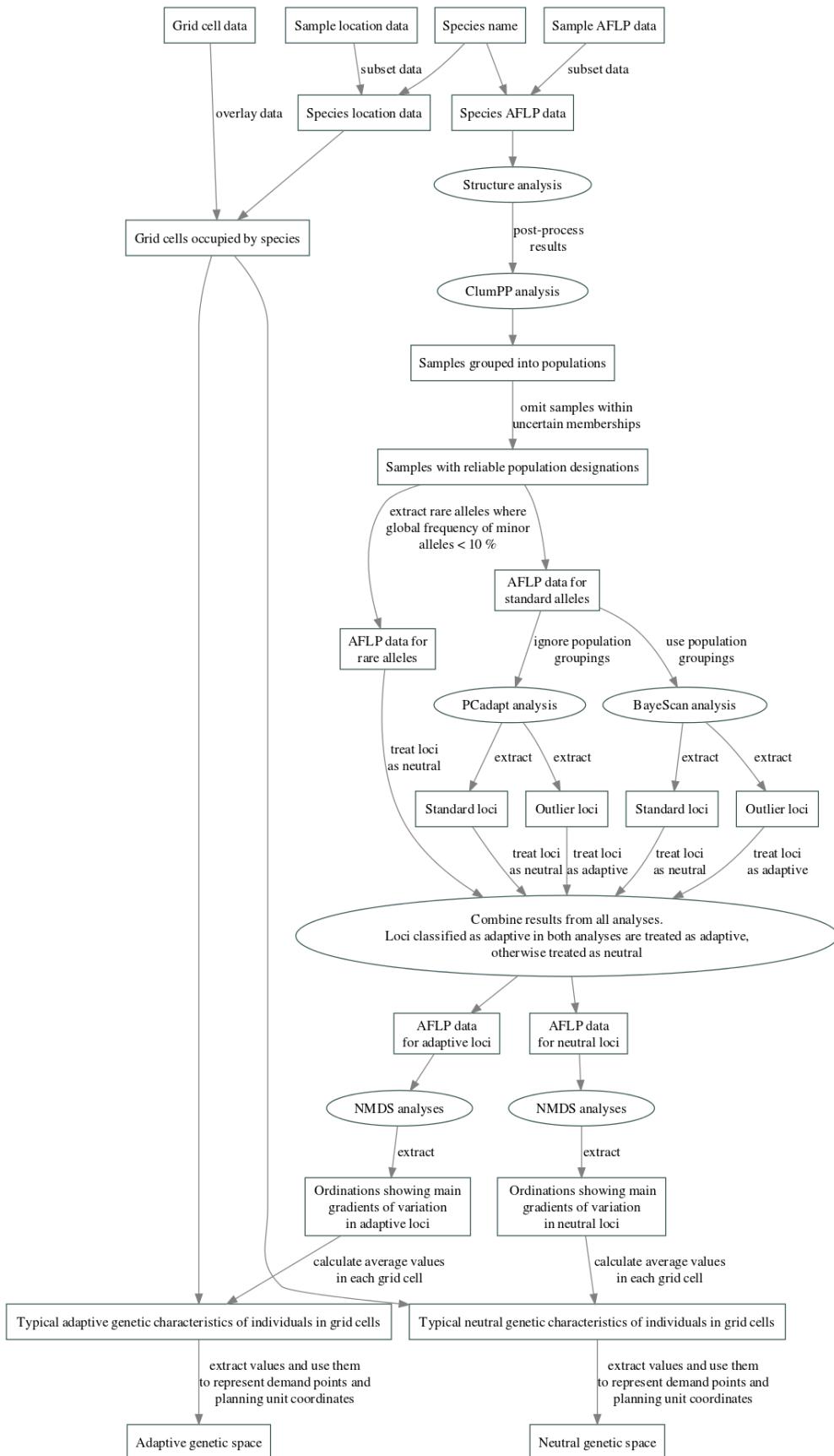


Figure S35: Genetic data processing workflow. Conventions are detailed in Figure S32 caption.

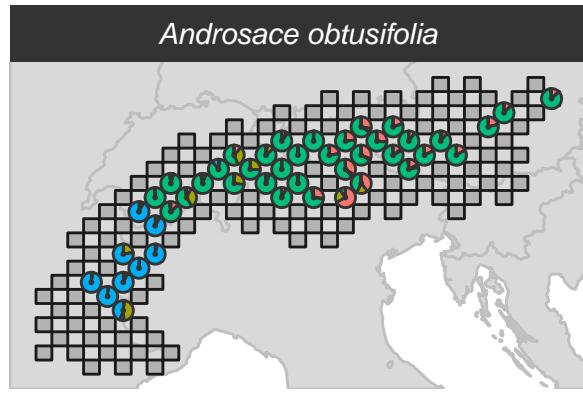


Figure S36: Distribution of *Androsace obtusifolia* populations. Squares denote planning units. Pie charts denote quadrats where individuals were sampled, and colors denote the average probability that individuals in the quadrat belong to different populations on average.

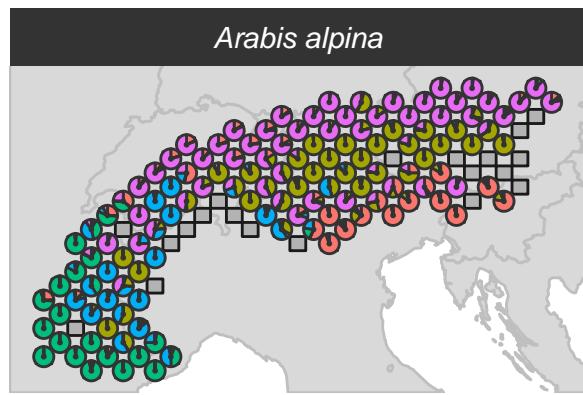


Figure S37: Distribution of *Arabis alpina* populations. See Figure S36 caption for conventions.

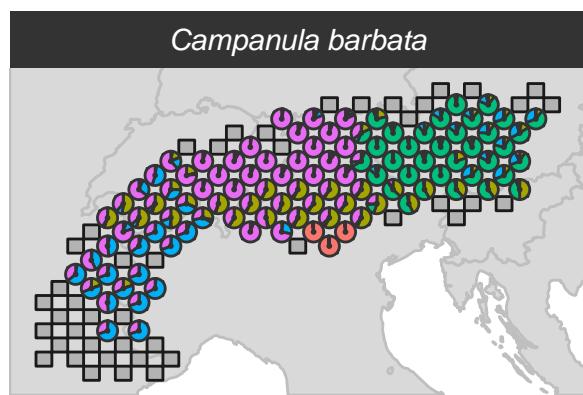


Figure S38: Distribution of *Campanula barbata* populations. See Figure S36 caption for conventions.

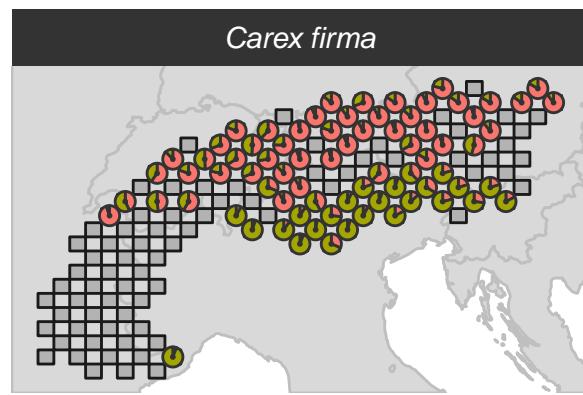


Figure S39: Distribution of *Carex firma* populations. See Figure S36 caption for conventions.

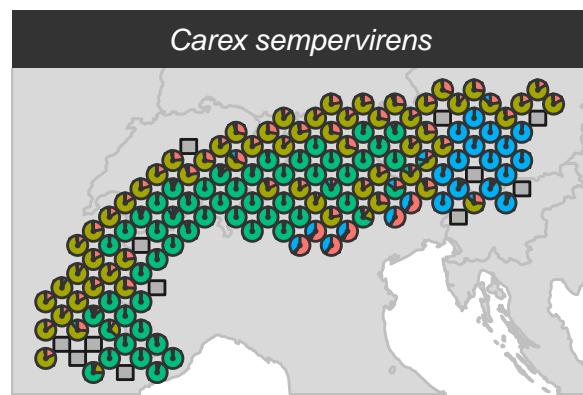


Figure S40: Distribution of *Carex sempervirens* populations. See Figure S36 caption for conventions.

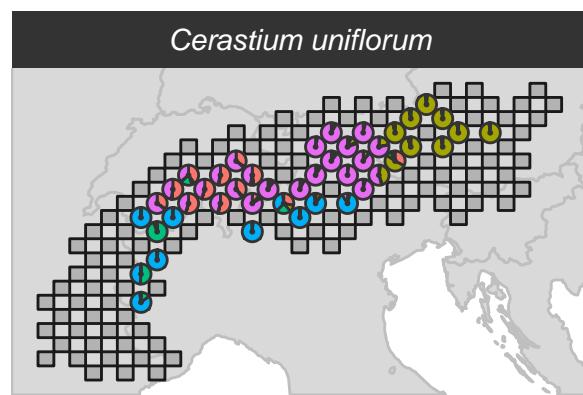


Figure S41: Distribution of *Cerastium uniflorum* populations. See Figure S36 caption for conventions.



Figure S42: Distribution of *Cirsium spinosissimum* populations. See Figure S36 caption for conventions.

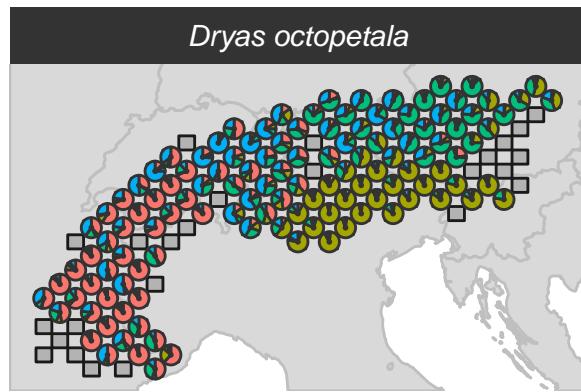


Figure S43: Distribution of *Dryas octopetala* populations. See Figure S36 caption for conventions.

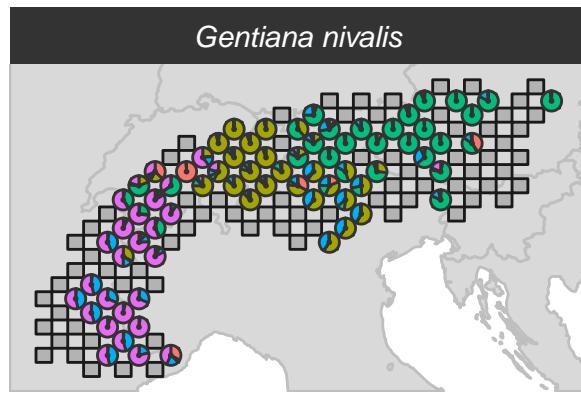


Figure S44: Distribution of *Gentiana nivalis* populations. See Figure S36 caption for conventions.

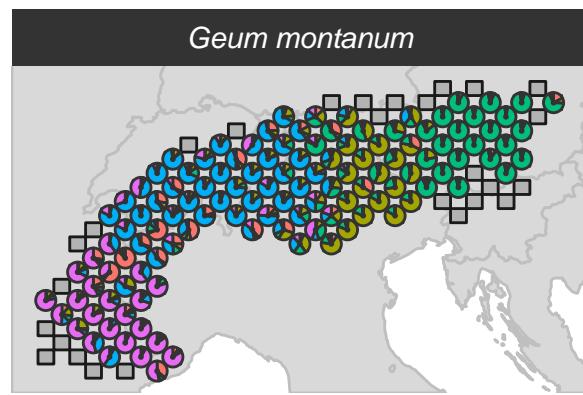


Figure S45: Distribution of *Geum montanum* populations. See Figure S36 caption for conventions.

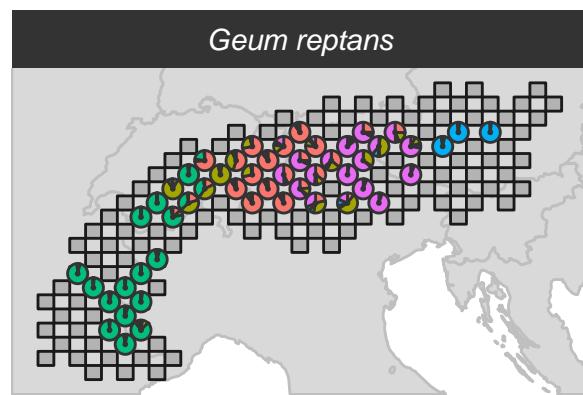


Figure S46: Distribution of *Geum reptans* populations. See Figure S36 caption for conventions.

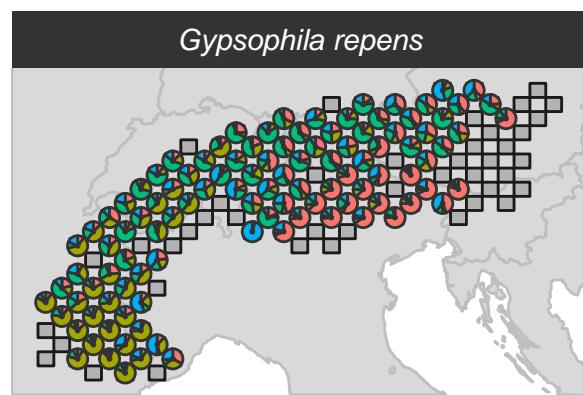


Figure S47: Distribution of *Gypsophila repens* populations. See Figure S36 caption for conventions.

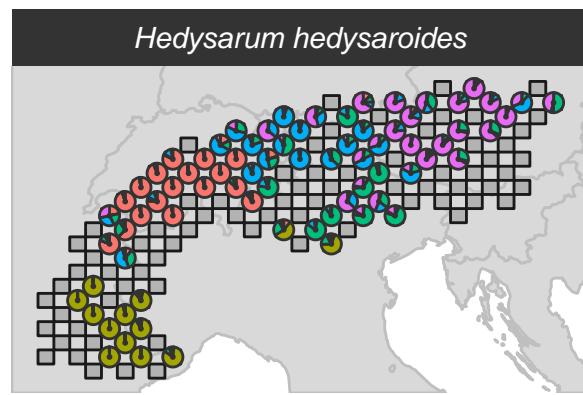


Figure S48: Distribution of *Hedysarum hedysaroides* populations. See Figure S36 caption for conventions.

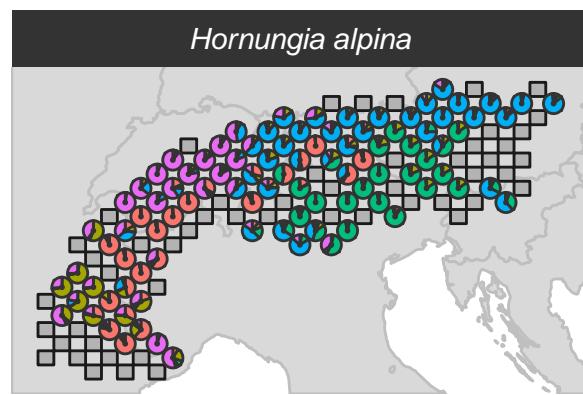


Figure S49: Distribution of *Hornungia alpina* populations. See Figure S36 caption for conventions.

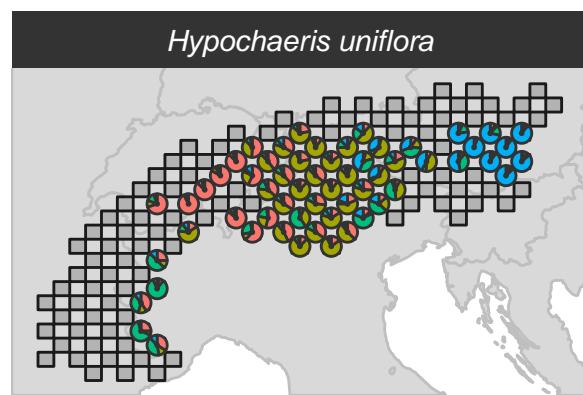


Figure S50: Distribution of *Hypochaeris uniflora* populations. See Figure S36 caption for conventions.

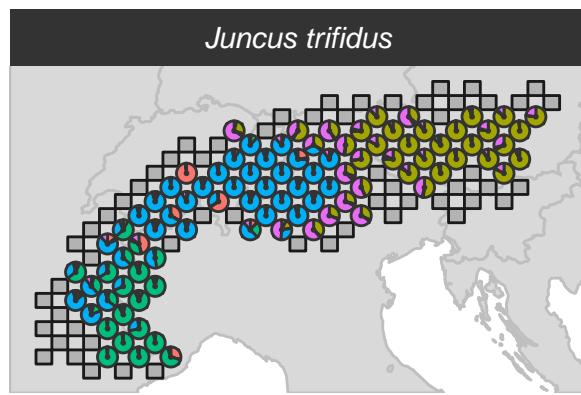


Figure S51: Distribution of *Juncus trifidus* populations. See Figure S36 caption for conventions.

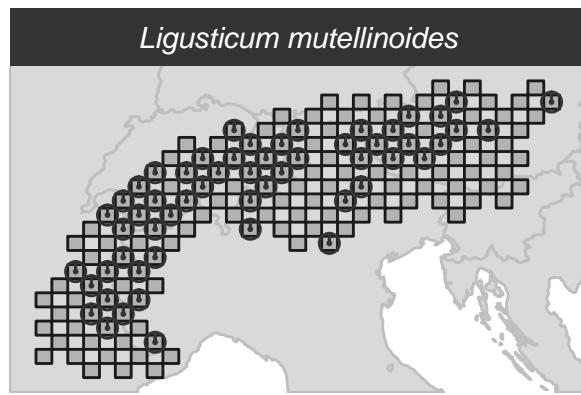


Figure S52: Distribution of *Ligusticum mutellinoides* populations. See Figure S36 caption for conventions.

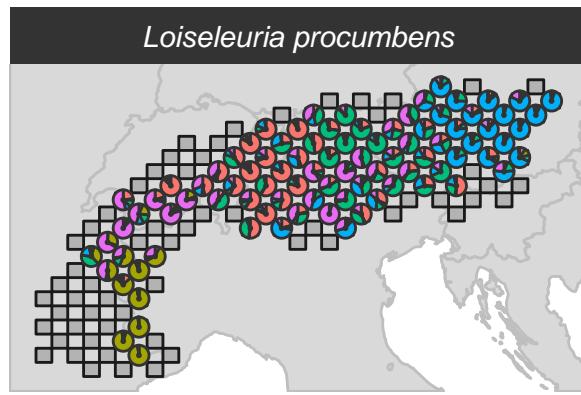


Figure S53: Distribution of *Loiseleuria procumbens* populations. See Figure S36 caption for conventions.



Figure S54: Distribution of *Luzula alpinopilosa* populations. See Figure S36 caption for conventions.



Figure S55: Distribution of *Peucedanum ostruthium* populations. See Figure S36 caption for conventions.

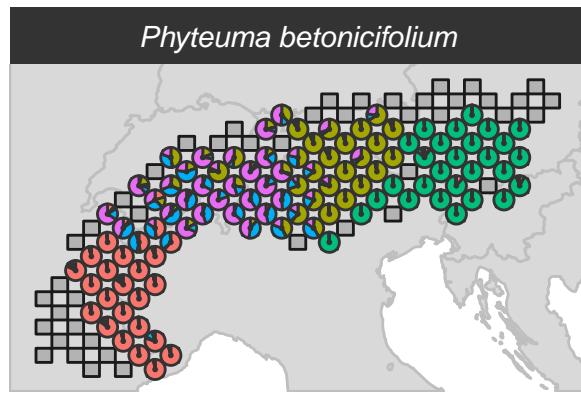


Figure S56: Distribution of *Phyteuma betonicifolium* populations. See Figure S36 caption for conventions.

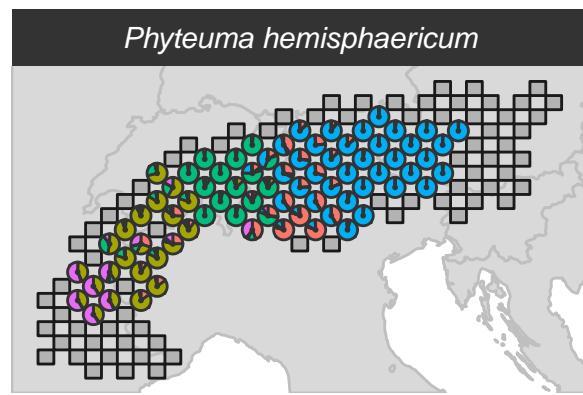


Figure S57: Distribution of *Phyteuma hemisphaericum* populations. See Figure S36 caption for conventions.

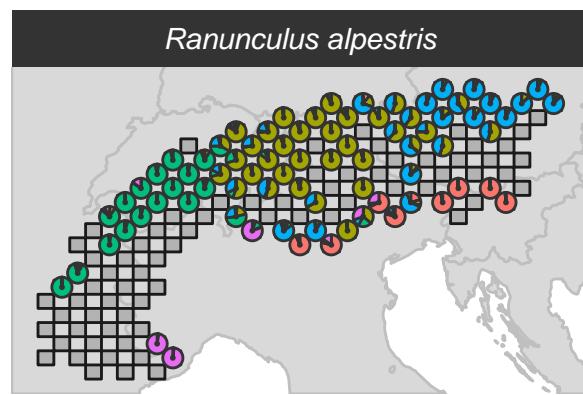


Figure S58: Distribution of *Ranunculus alpestris* populations. See Figure S36 caption for conventions.



Figure S59: Distribution of *Rhododendron ferrugineum* populations. See Figure S36 caption for conventions.

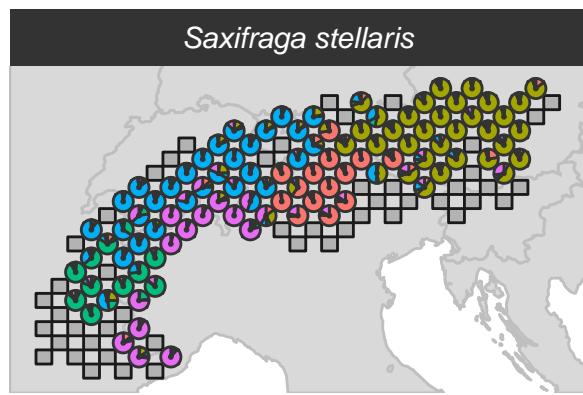


Figure S60: Distribution of *Saxifraga stellaris* populations. See Figure S36 caption for conventions.

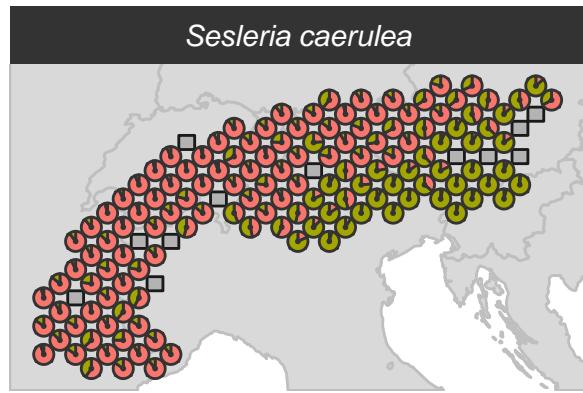


Figure S61: Distribution of *Sesleria caerulea* populations. See Figure S36 caption for conventions.

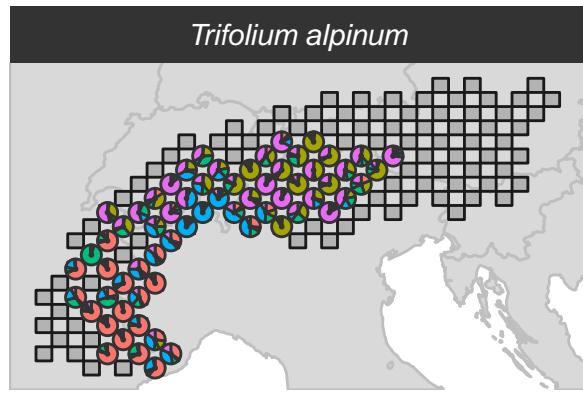


Figure S62: Distribution of *Trifolium alpinum* populations. See Figure S36 caption for conventions.

⁶ Tables

Table S2: Summary of non-metric multi-dimensional scaling (NMDS) analyses on genetic variation for each species. The analyses were used to identify the main gradients of variation in binary adaptive and neutral loci data. Bold stress values indicate NMDS analyses that have converged.

Species	Adaptive		Neutral	
	K	Stress	K	Stress
<i>Androsace obtusifolia</i>			2	0.219
<i>Arabis alpina</i>	2	<0.001	3	0.187
<i>Campanula barbata</i>			2	0.204
<i>Carex firma</i>			3	0.241
<i>Carex sempervirens</i>	2	<0.001	2	0.219
<i>Cerastium uniflorum</i>	2	<0.001	2	0.205
<i>Cirsium spinosissimum</i>	2	<0.001	3	0.197
<i>Dryas octopetala</i>			3	0.218
<i>Gentiana nivalis</i>			2	0.046
<i>Geum montanum</i>			2	0.163
<i>Geum reptans</i>	2	<0.001	2	0.188
<i>Gypsophila repens</i>			2	0.06
<i>Hedysarum hedysaroides</i>	2	<0.001	2	0.197
<i>Hornungia alpina</i>			3	0.2
<i>Hypochaeris uniflora</i>			2	0.241
<i>Juncus trifidus</i>			2	0.151
<i>Ligusticum mutellinoides</i>			4	0.212
<i>Loiseleuria procumbens</i>	2	<0.001	3	0.208
<i>Luzula alpinopilosa</i>			2	0.051
<i>Peucedanum ostruthium</i>	2	<0.001	4	0.221
<i>Phyteuma betonicifolium</i>			2	0.172
<i>Phyteuma hemisphaericum</i>	2	0.003	2	0.226
<i>Ranunculus alpestris</i>	2	0.012	3	0.221
<i>Rhododendron ferrugineum</i>			2	0.209
<i>Saxifraga stellaris</i>			3	0.202
<i>Sesleria caerulea</i>			4	0.209
<i>Trifolium alpinum</i>			3	0.212

Table S3: Summary of maximum likelihood population-effects (MLPE) models. Briefly, for each species associated with potentially adaptive loci, a model was fit to correlate dissimilarities among planning units where the species in terms of the adaptive genetic characteristics of individuals in them with dissimilarities in terms of the environmental conditions inside the planning units (denoted in the environmental column group). Similarly, for each species, a model was fit to correlate dissimilarities among the planning units in terms of the neutral genetic characteristics of individuals in them with dissimilarities in terms of the geographic position of the planning units (denoted in the geographic column group). Data shows the results from comparing each model to its corresponding null model using χ^2 tests (1 degree of freedom), and the R^2 (MR^2) and conditional R^2 (CR^2) for each model.

Species	Environmental				Geographic			
	MR^2	CR^2	χ^2	P	MR^2	CR^2	χ^2	P
<i>Androsace obtusifolia</i>					0.22	0.63	326.4	<0.001
<i>Arabis alpina</i>	0.16	0.22	1003.78	<0.001	0.13	0.41	1270.51	<0.001
<i>Campanula barbata</i>					0.32	0.69	3069.77	<0.001
<i>Carex firma</i>					0.017	0.34	43.85	<0.001
<i>Carex sempervirens</i>	<0.001	0.009	0.92	>0.99	0.019	0.13	154.32	<0.001
<i>Cerastium uniflorum</i>	0.016	0.28	13.81	0.007	0.13	0.84	418.92	<0.001
<i>Cirsium spinosissimum</i>	0.013	0.24	59.6	<0.001	0.10	0.46	800.82	<0.001
<i>Dryas octopetala</i>					0.24	0.49	2343.97	<0.001
<i>Gentiana nivalis</i>					<0.001	0.94	4.55	>0.99
<i>Geum montanum</i>					0.043	0.93	2780.07	<0.001
<i>Geum reptans</i>	0.087	0.16	82.26	<0.001	0.48	0.78	1135.31	<0.001
<i>Gypsophila repens</i>					<0.001	>0.99	268.34	<0.001
<i>Hedysarum hedysaroides</i>	0.13	0.21	291.81	<0.001	0.14	0.51	553.66	<0.001
<i>Hornungia alpina</i>					0.20	0.36	979.52	<0.001
<i>Hypochaeris uniflora</i>					0.21	0.62	448.75	<0.001
<i>Juncus trifidus</i>					0.062	0.89	1399.26	<0.001
<i>Ligusticum mutellinoides</i>					0.080	0.31	126.6	<0.001
<i>Loiseleuria procumbens</i>	0.001	0.12	2.94	>0.99	0.22	0.67	1505.51	<0.001
<i>Luzula alpinopilosa</i>					<0.001	>0.99	34.6	<0.001
<i>Peucedanum ostruthium</i>	0.046	0.31	266.91	<0.001	0.23	0.43	1857.34	<0.001
<i>Phyteuma betonicifolium</i>					0.42	0.53	2832.98	<0.001
<i>Phyteuma hemisphaericum</i>	0.14	0.18	308.32	<0.001	0.61	0.75	2832.08	<0.001
<i>Ranunculus alpestris</i>	0.090	0.22	199.12	<0.001	0.20	0.54	775.06	<0.001
<i>Rhododendron ferrugineum</i>					0.46	0.67	5667.36	<0.001
<i>Saxifraga stellaris</i>					0.25	0.46	1509.68	<0.001
<i>Sesleria caerulea</i>					0.067	0.44	826.14	<0.001
<i>Trifolium alpinum</i>					0.31	0.53	839.51	<0.001

Table S4: Summary of post-hoc analyses on generalized linear models. Briefly, two generalized linear models were fit to correlate the proportion of adaptive genetic variation and environmental variation secured, and the proportion of neutral genetic variation and geographic variation secured in a prioritization. These models also included a predictor variable indicating the species for which the prioritisations were generated, and an interaction term. Table shows the results from one-sided *post-hoc* analyses that were conducted to determine if the slopes for each species were positive (using the alternative hypothesis that slopes were less than or equal to zero; tests used a single degree of freedom; results reported in the *Z* and *P* columns). The table also shows Cragg and Uhler's pseudo- R^2 values that were calculated to show the proportion of variation explained by the slopes for each species (R^2 column).

Species	Environmental			Geographic		
	<i>Z</i>	<i>P</i>	R^2	<i>Z</i>	<i>P</i>	R^2
<i>Androsace obtusifolia</i>				8.26 ± 0.26	<0.001	0.61
<i>Arabis alpina</i>	6.51 ± 0.22	<0.001	0.68	13.33 ± 0.54	<0.001	0.58
<i>Campanula barbata</i>				9.38 ± 0.36	<0.001	0.60
<i>Carex firma</i>				8.6 ± 0.27	<0.001	0.62
<i>Carex sempervirens</i>	6.31 ± 0.22	<0.001	0.64	8.97 ± 0.38	<0.001	0.53
<i>Cerastium uniflorum</i>	6.09 ± 0.15	<0.001	0.59	8.39 ± 0.28	<0.001	0.56
<i>Cirsium spinosissimum</i>	6.09 ± 0.18	<0.001	0.59	11.84 ± 0.44	<0.001	0.56
<i>Dryas octopetala</i>				12.23 ± 0.48	<0.001	0.54
<i>Gentiana nivalis</i>				13.56 ± 0.5	<0.001	0.29
<i>Geum montanum</i>				13.52 ± 0.58	<0.001	0.34
<i>Geum reptans</i>	6.49 ± 0.18	<0.001	0.66	8.06 ± 0.25	<0.001	0.64
<i>Gypsophila repens</i>				34.83 ± 1.21	<0.001	0.26
<i>Hedysarum hedysaroides</i>	5.78 ± 0.15	<0.001	0.55	8.86 ± 0.28	<0.001	0.54
<i>Hornungia alpina</i>				11.42 ± 0.41	<0.001	0.59
<i>Hypochaeris uniflora</i>				6.94 ± 0.2	<0.001	0.63
<i>Juncus trifidus</i>				11.4 ± 0.47	<0.001	0.36
<i>Ligusticum mutellinoides</i>				13.54 ± 0.44	<0.001	0.62
<i>Loiseleuria procumbens</i>	6.6 ± 0.19	<0.001	0.63	12.29 ± 0.42	<0.001	0.63
<i>Luzula alpinopilosa</i>				24.22 ± 0.82	<0.001	0.28
<i>Peucedanum ostruthium</i>	6.41 ± 0.19	<0.001	0.62	17.94 ± 0.63	<0.001	0.63
<i>Phyteuma betonicifolium</i>				8.87 ± 0.32	<0.001	0.62
<i>Phyteuma hemisphaericum</i>	6.28 ± 0.18	<0.001	0.68	9.34 ± 0.33	<0.001	0.66
<i>Ranunculus alpestris</i>	6.22 ± 0.16	<0.001	0.59	10.61 ± 0.33	<0.001	0.64
<i>Rhododendron ferrugineum</i>				11.72 ± 0.45	<0.001	0.67
<i>Saxifraga stellaris</i>				14.41 ± 0.53	<0.001	0.63
<i>Sesleria caerulea</i>				17.24 ± 0.66	<0.001	0.56
<i>Trifolium alpinum</i>				10.23 ± 0.34	<0.001	0.64

Table S5: Summary of principal component analyses fit to the climatic variation in the species' ranges. Percentages correspond to the percent of variation described by the first three principle components.

Species	Variation explained (%)
<i>Androsace obtusifolia</i>	90.374
<i>Arabis alpina</i>	91.319
<i>Campanula barbata</i>	89.931
<i>Carex firma</i>	91.017
<i>Carex sempervirens</i>	90.212
<i>Cerastium uniflorum</i>	91.454
<i>Cirsium spinosissimum</i>	89.628
<i>Dryas octopetala</i>	90.150
<i>Gentiana nivalis</i>	90.191
<i>Geum montanum</i>	89.742
<i>Geum reptans</i>	90.255
<i>Gypsophila repens</i>	91.679
<i>Hedysarum hedysaroides</i>	89.719
<i>Hornungia alpina</i>	90.383
<i>Hypochaeris uniflora</i>	93.062
<i>Juncus trifidus</i>	91.062
<i>Ligusticum mutellinoides</i>	88.709
<i>Loiseleuria procumbens</i>	91.679
<i>Luzula alpinopilosa</i>	88.776
<i>Peucedanum ostruthium</i>	89.595
<i>Phyteuma betonicifolium</i>	89.678
<i>Phyteuma hemisphaericum</i>	88.909
<i>Ranunculus alpestris</i>	90.019
<i>Rhododendron ferrugineum</i>	89.779
<i>Saxifraga stellaris</i>	89.484
<i>Sesleria caerulea</i>	90.589
<i>Trifolium alpinum</i>	89.536