Supporting Information

To replicate this study, all data and code are stored in an online repository (www.github.com/jeffreyhanson/genetic-surrogates) and are available under the digital object identifier (DOI) `10.5281/zenodo.843625`. See the *README* file for instructions.

Figures

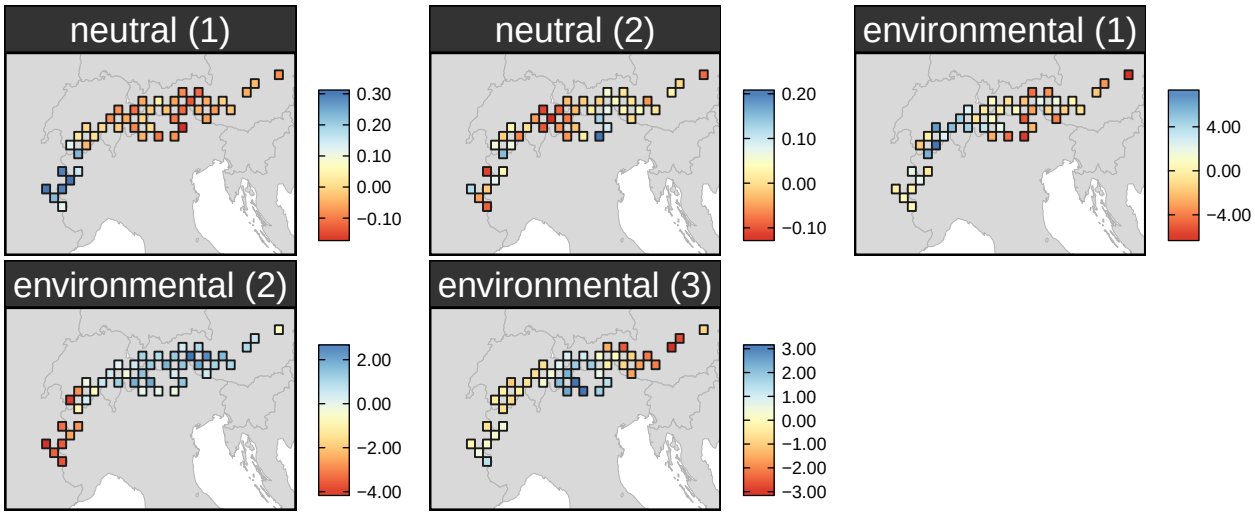

Fig. S1. Distribution of environmental variation found across the geographic range of *Androsace obtusifolia*, and the distribution of its adaptive (if detected) and neutral genetic variation in the study area. Each panel shows a different dimension of variation as indicated by its title. Squares represent 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.

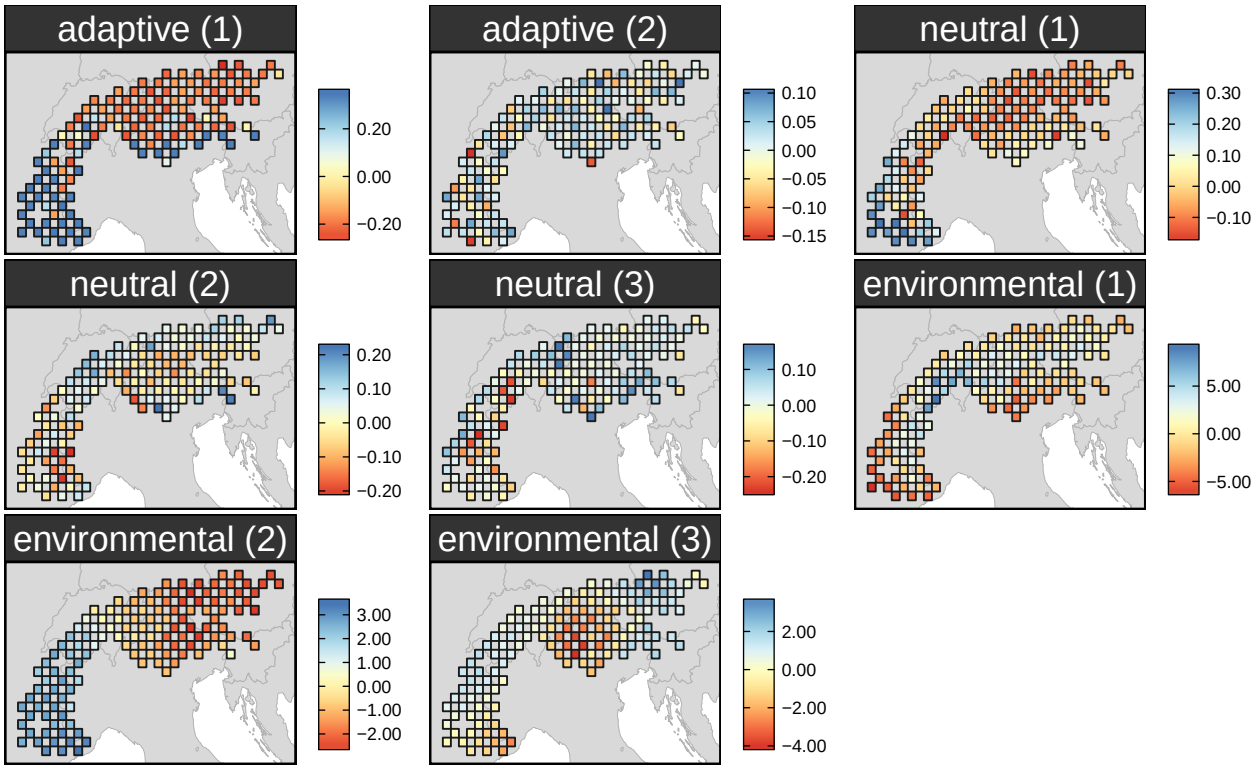

Fig. S2. Distribution of intra-specific variation for *Arabis alpina*. See Figure S1 caption for conventions.

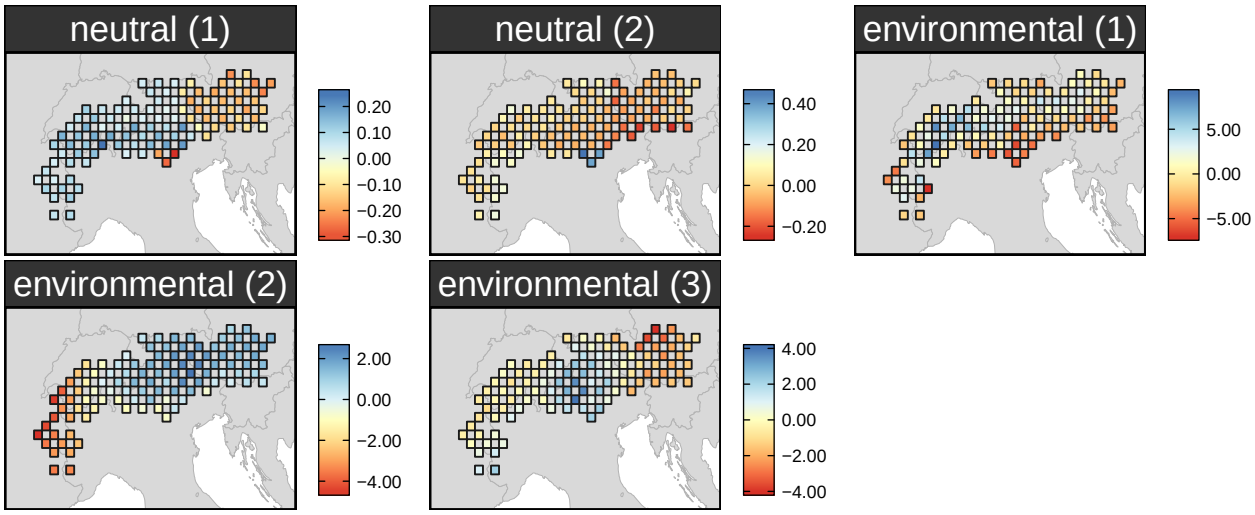

Fig. S3. Distribution of intra-specific variation for *Campanula barbata*. See Figure S1 caption for conventions.

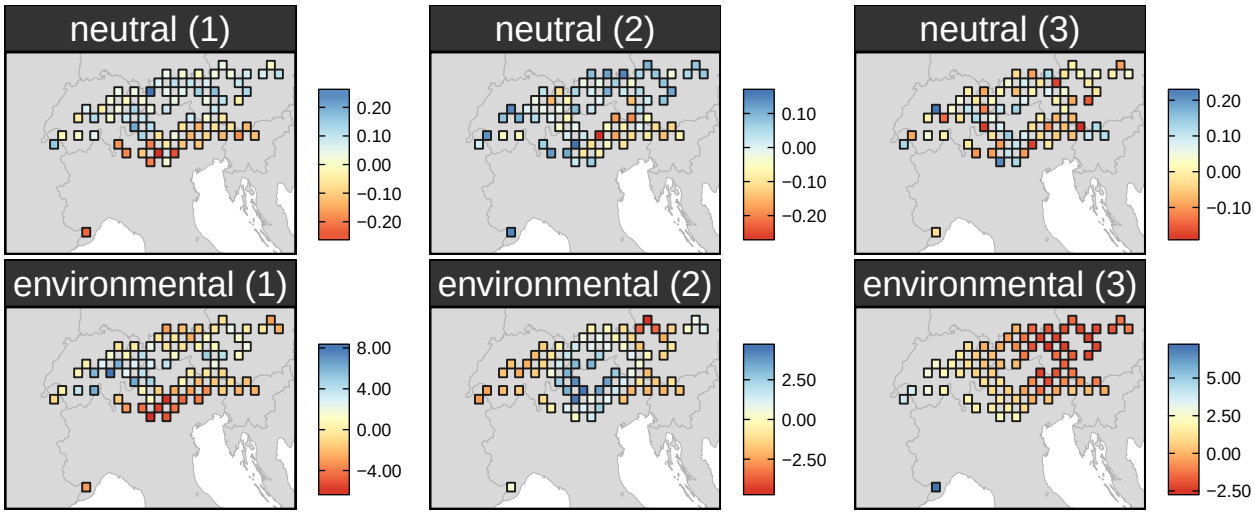

Fig. S4. Distribution of intra-specific variation for *Carex firma*. See Figure S1 caption for conventions.

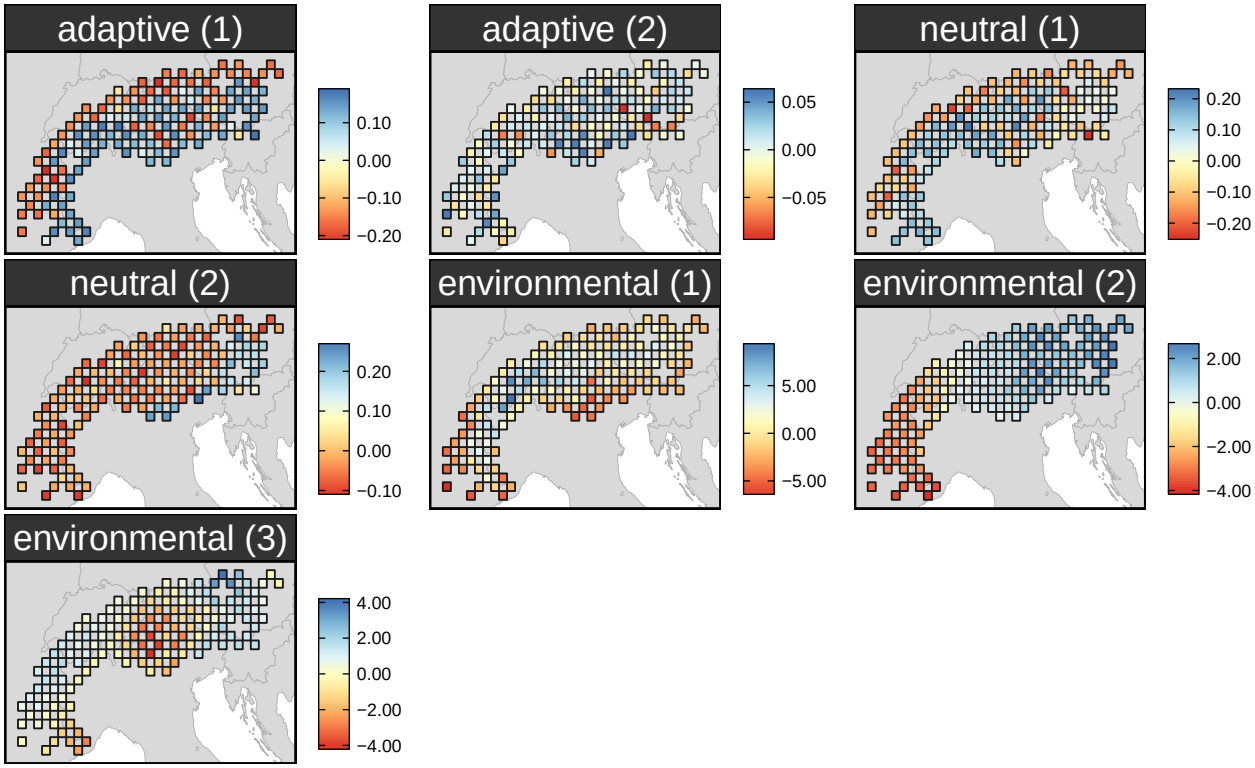

Fig. S5. Distribution of intra-specific variation for *Carex sempervirens*. See Figure S1 caption for conventions.

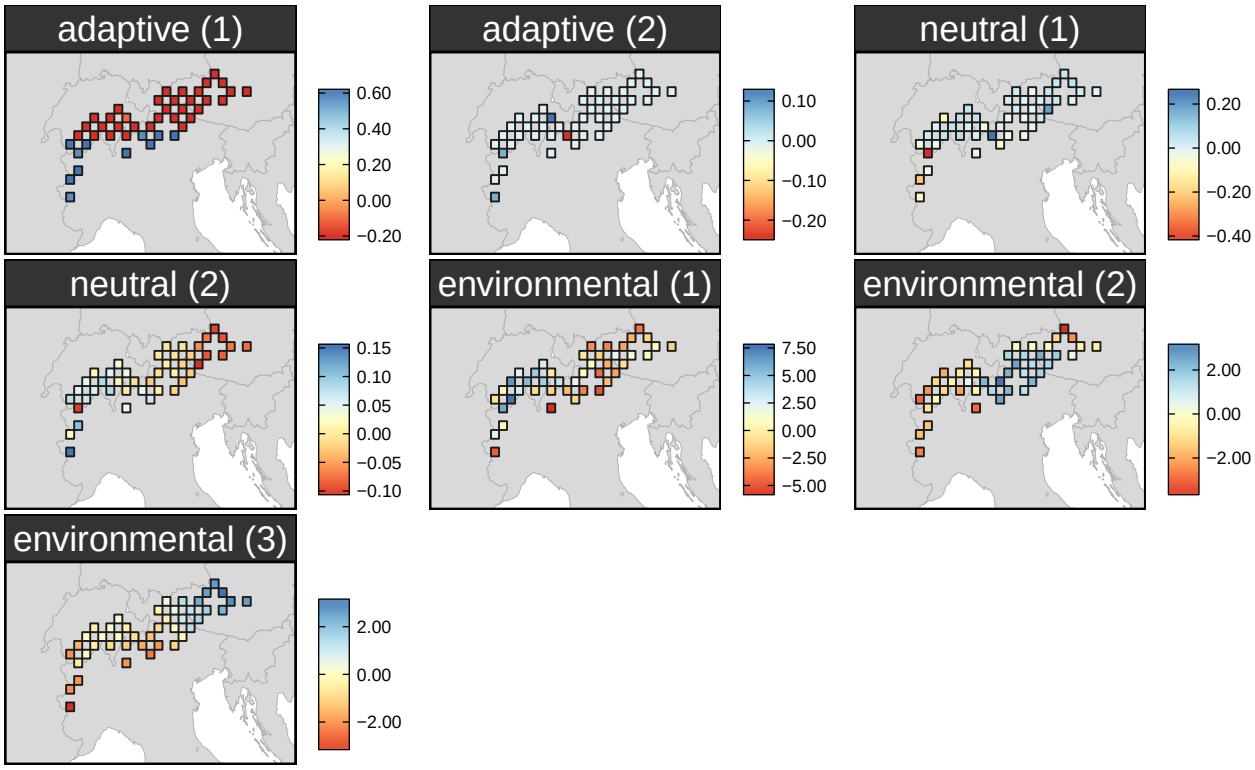

Fig. S6. Distribution of intra-specific variation for *Cerastium uniflorum*. See Figure S1 caption for conventions.

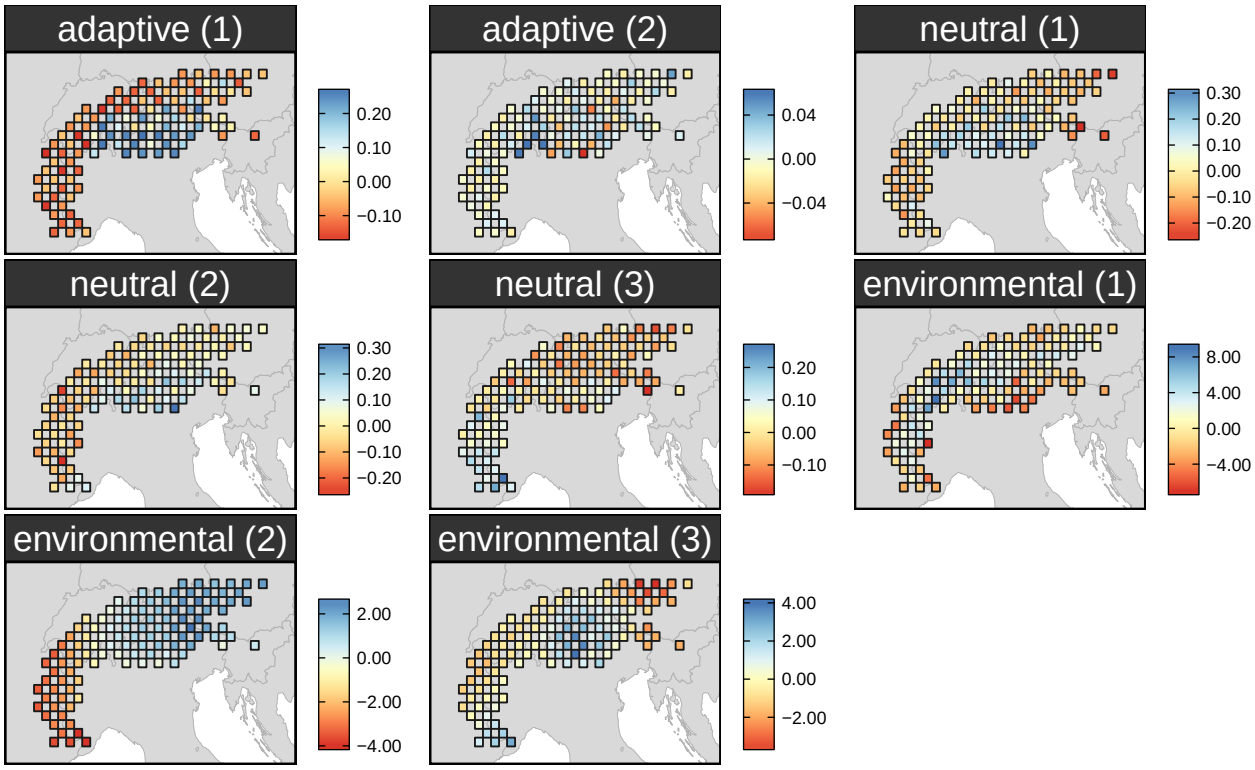

Fig. S7. Distribution of intra-specific variation for *Cirsium spinosissimum*. See Figure S1 caption for conventions.

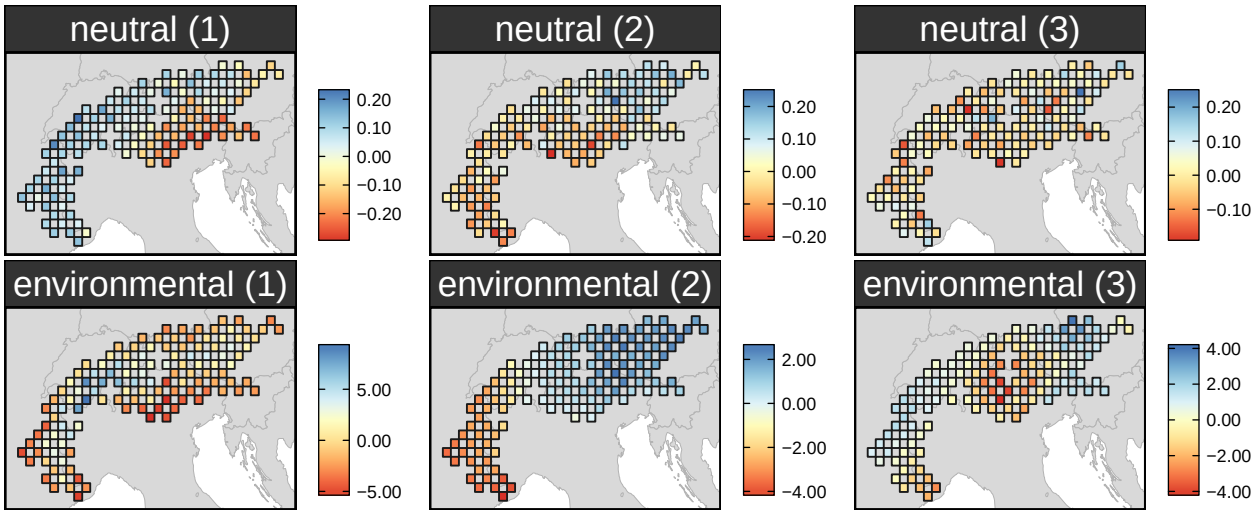

Fig. S8. Distribution of intra-specific variation for *Dryas octopetala*. See Figure S1 caption for conventions.

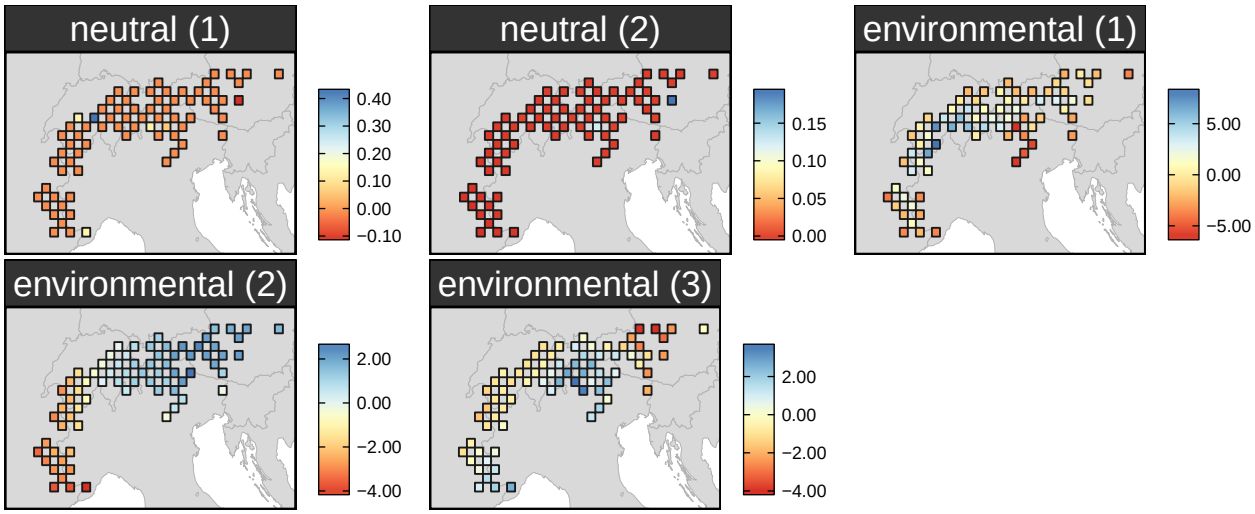

Fig. S9. Distribution of intra-specific variation for *Gentiana nivalis*. See Figure S1 caption for conventions.

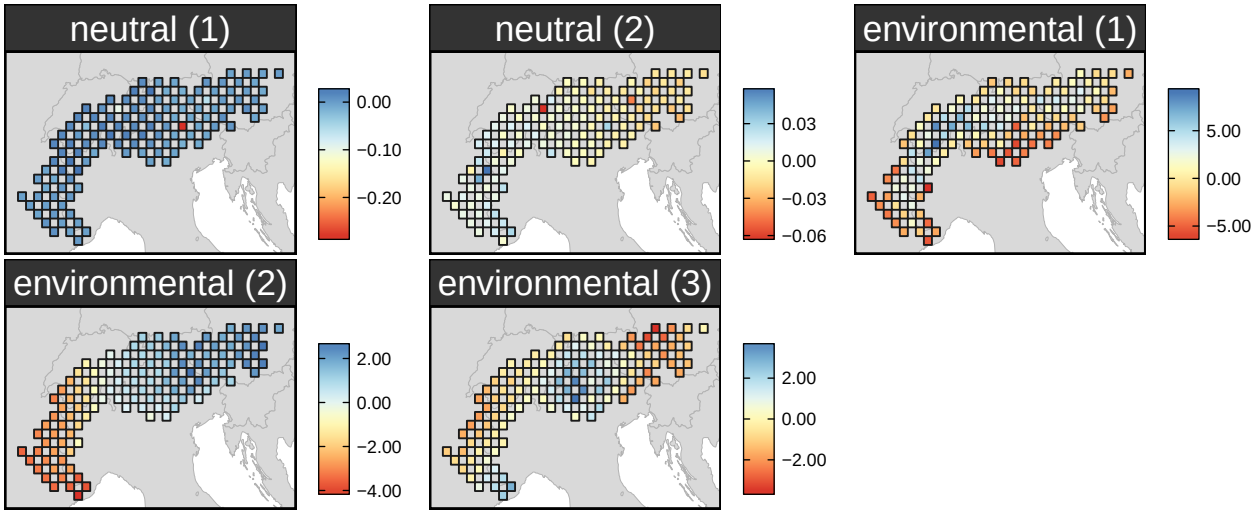

Fig. S10. Distribution of intra-specific variation for *Geum montanum*. See Figure S1 caption for conventions.

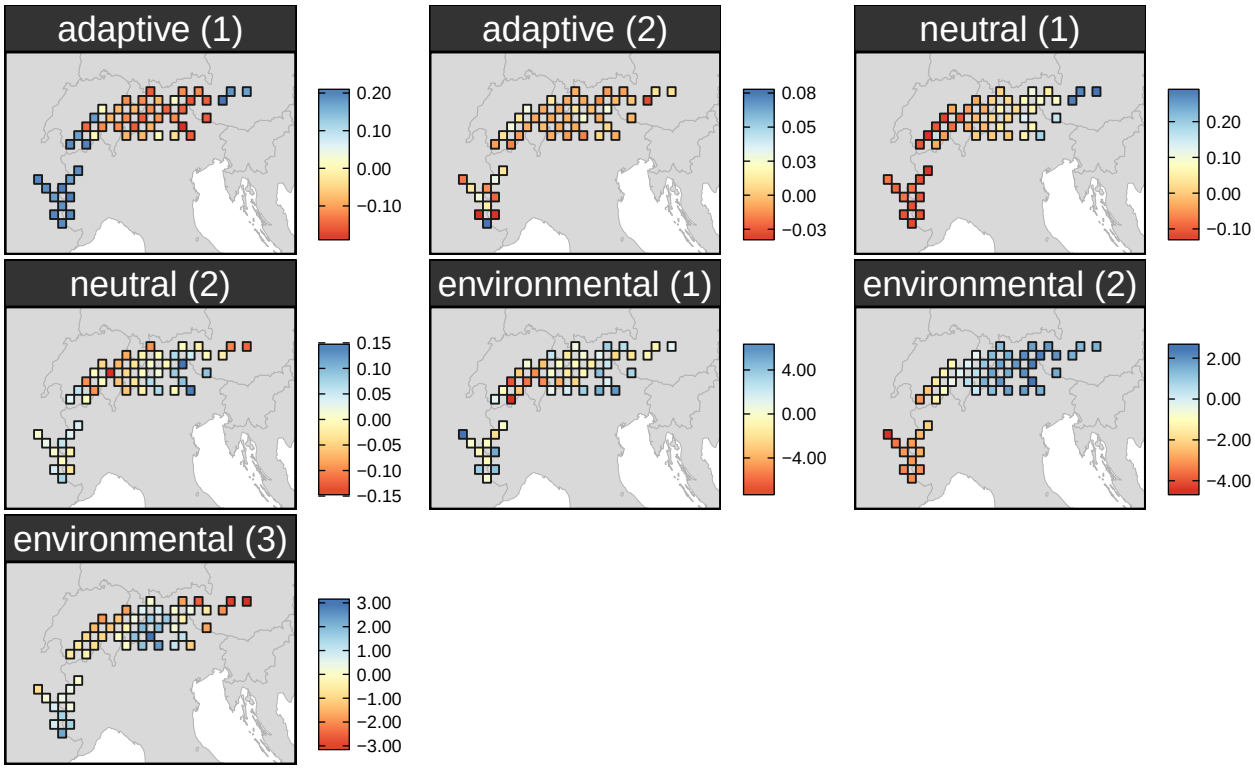

Fig. S11. Distribution of intra-specific variation for *Geum reptans*. See Figure S1 caption for conventions.

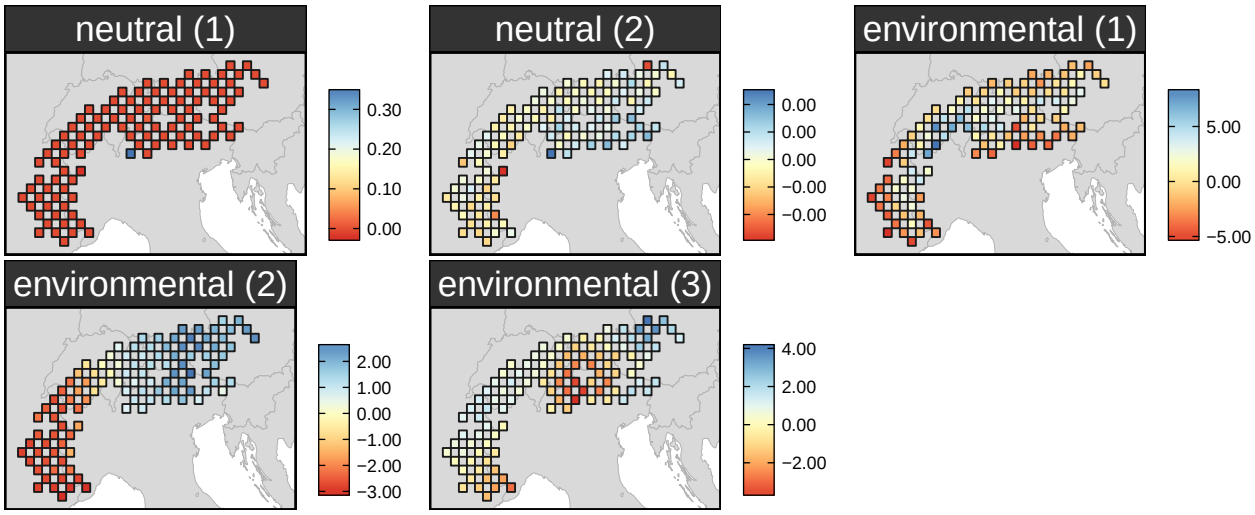

Fig. S12. Distribution of intra-specific variation for *Gypsophila repens*. See Figure S1 caption for conventions.

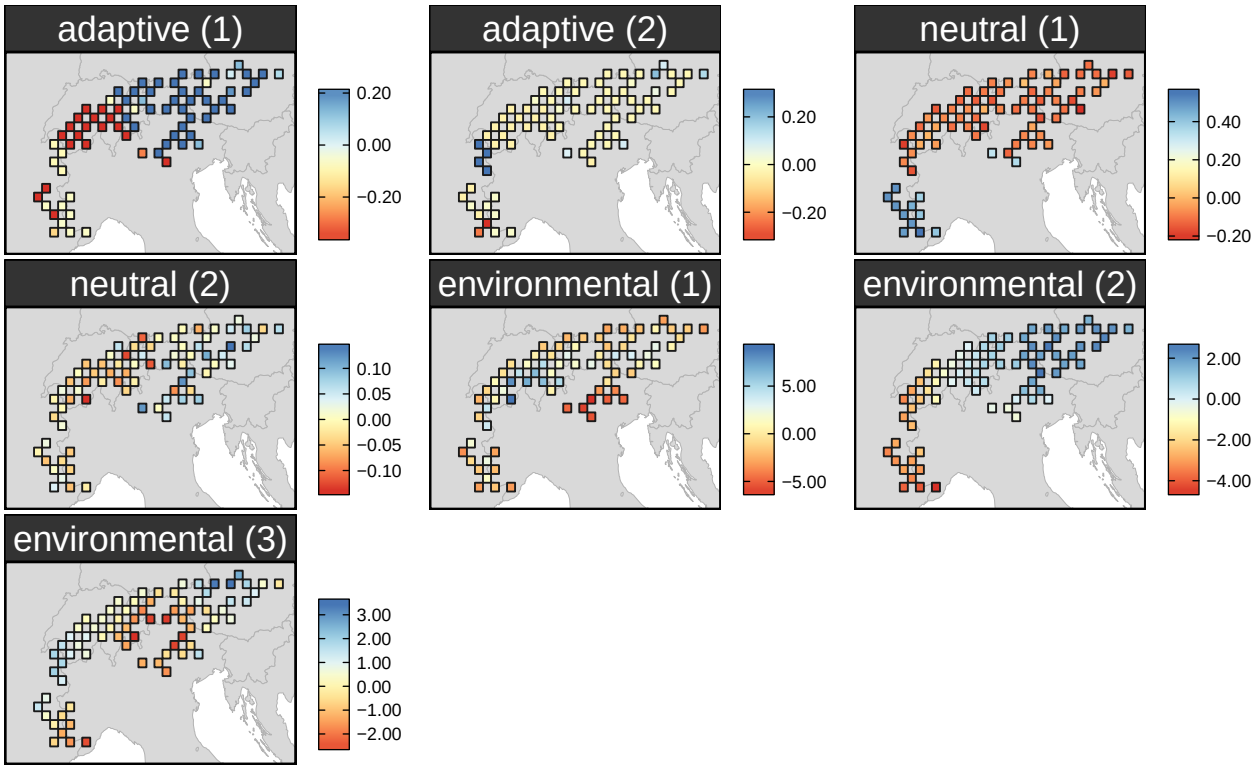

Fig. S13. Distribution of intra-specific variation for *Hedysarum hedysaroides*. See Figure S1 caption for conventions.

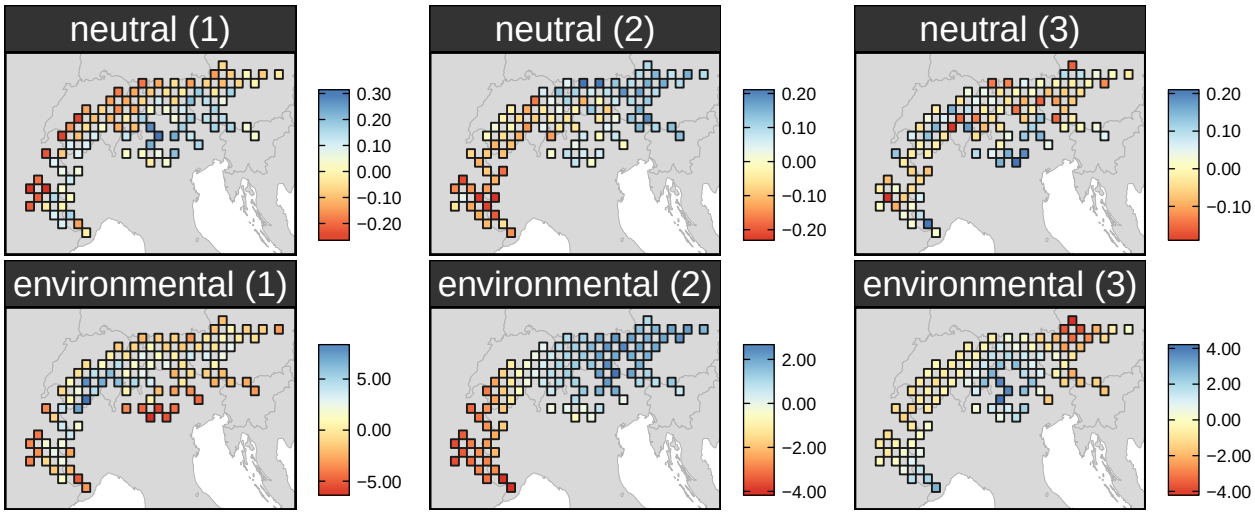

Fig. S14. Distribution of intra-specific variation for *Hornungia alpina*. See Figure S1 caption for conventions.

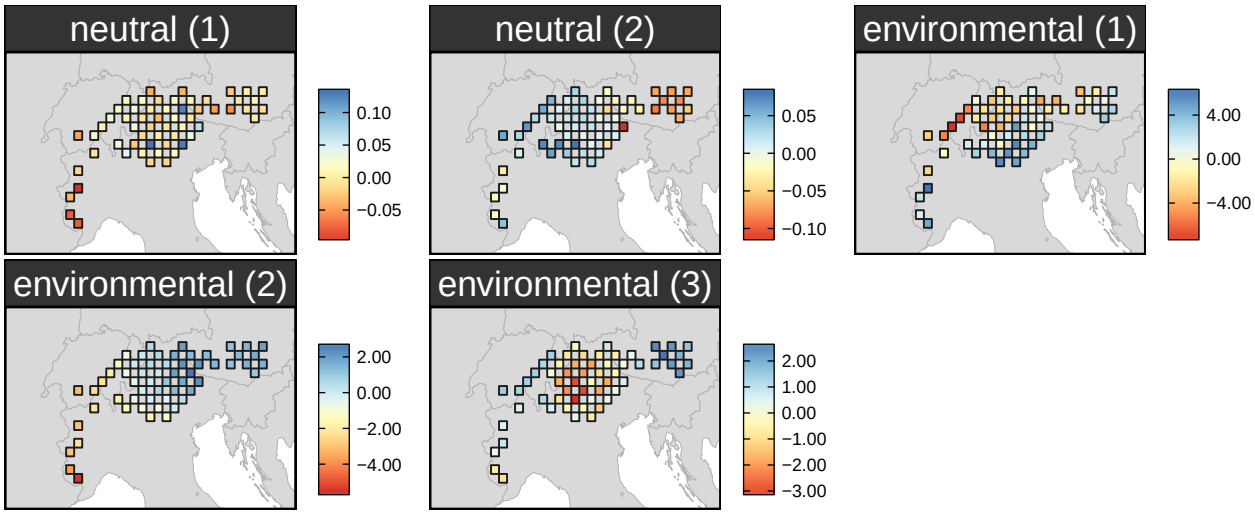

Fig. S15. Distribution of intra-specific variation for *Hypochaeris uniflora*. See Figure S1 caption for conventions.

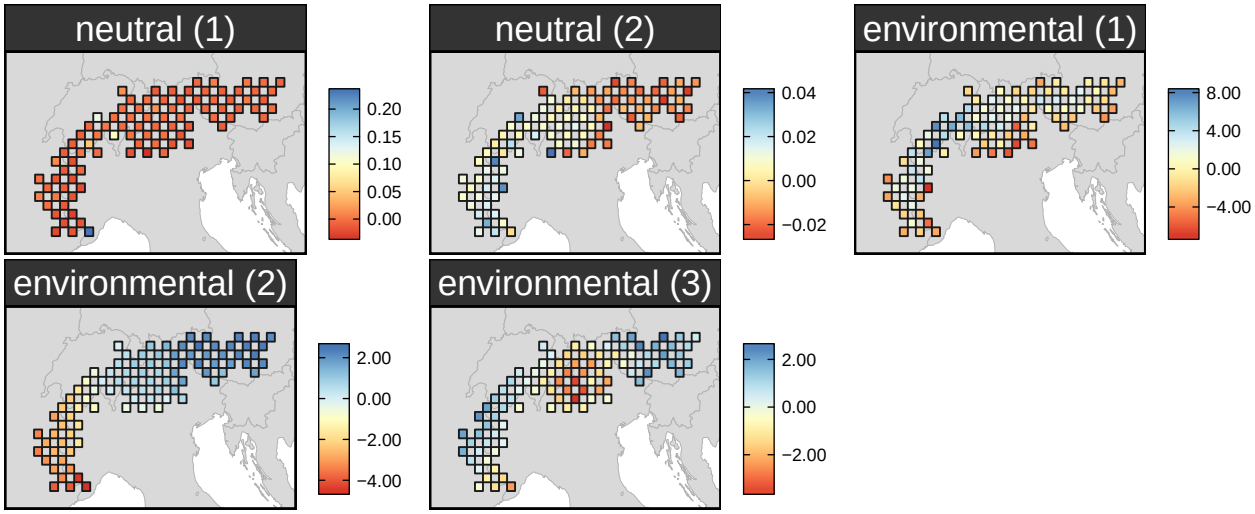

Fig. S16. Distribution of intra-specific variation for *Juncus trifidus*. See Figure S1 caption for conventions.

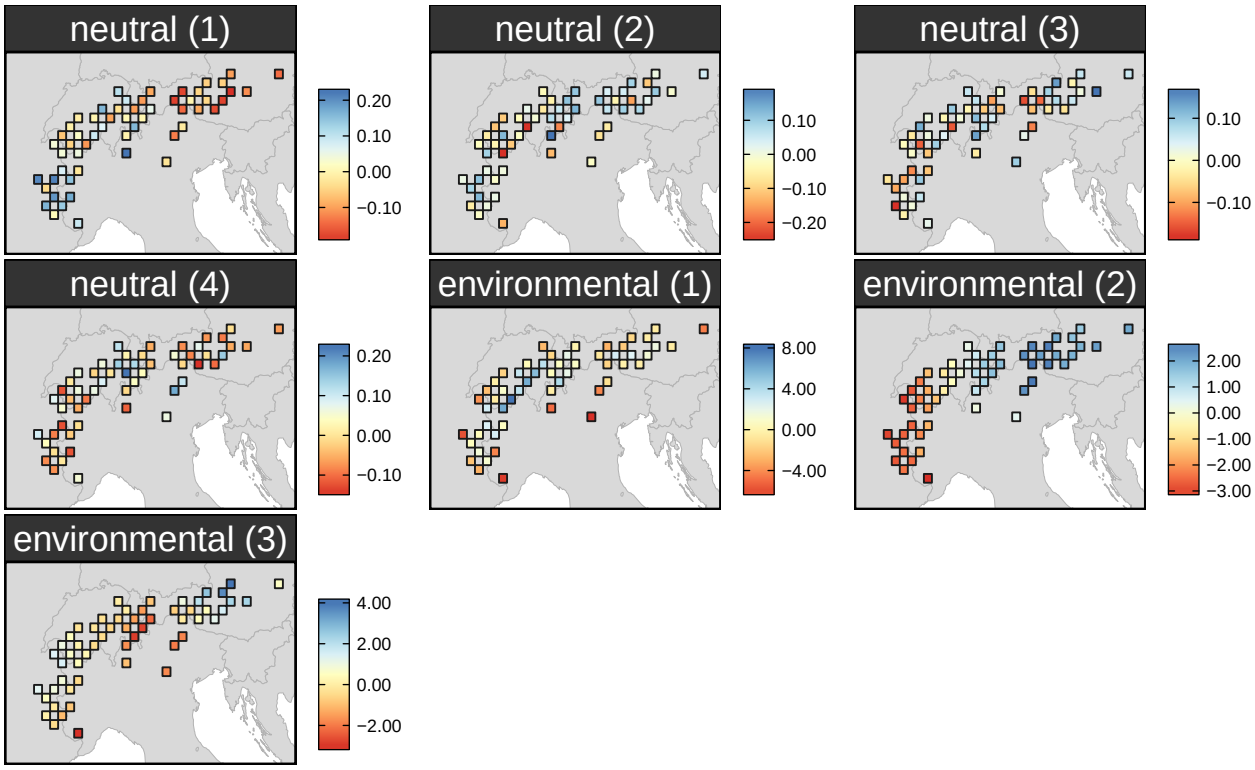

Fig. S17. Distribution of intra-specific variation for *Ligusticum mutellinoides*. See Figure S1 caption for conventions.

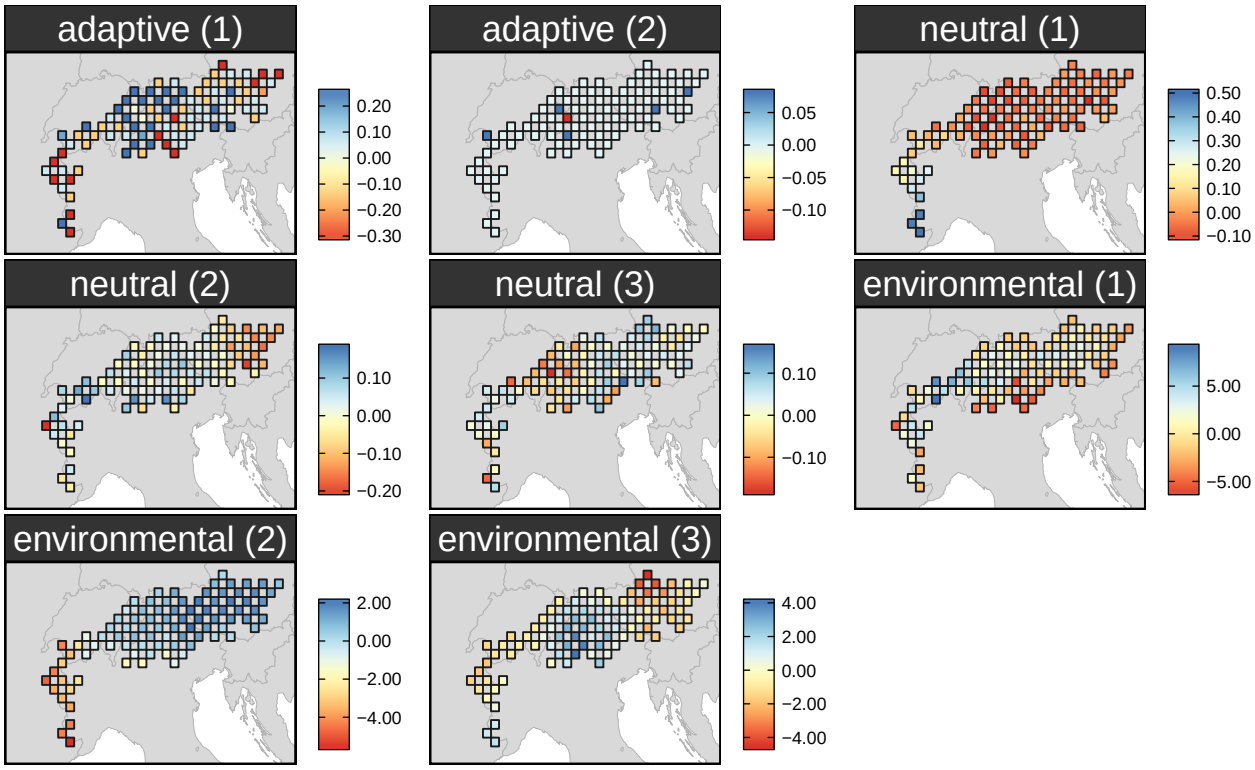

Fig. S18. Distribution of intra-specific variation for *Loiseleuria procumbens*. See Figure S1 caption for conventions.

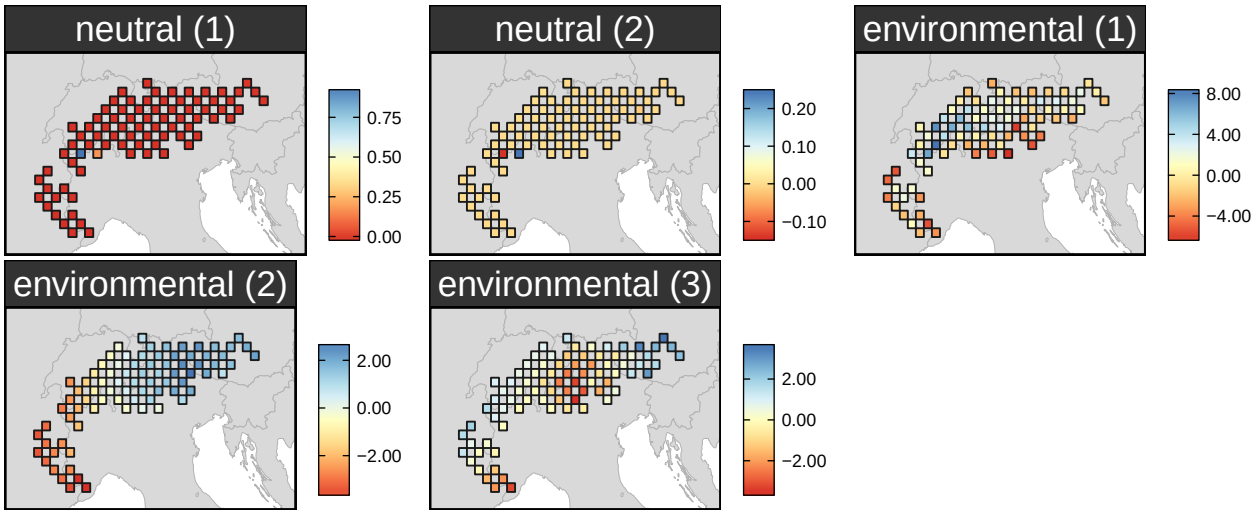

Fig. S19. Distribution of intra-specific variation for *Luzula alpinopilosa*. See Figure S1 caption for conventions.

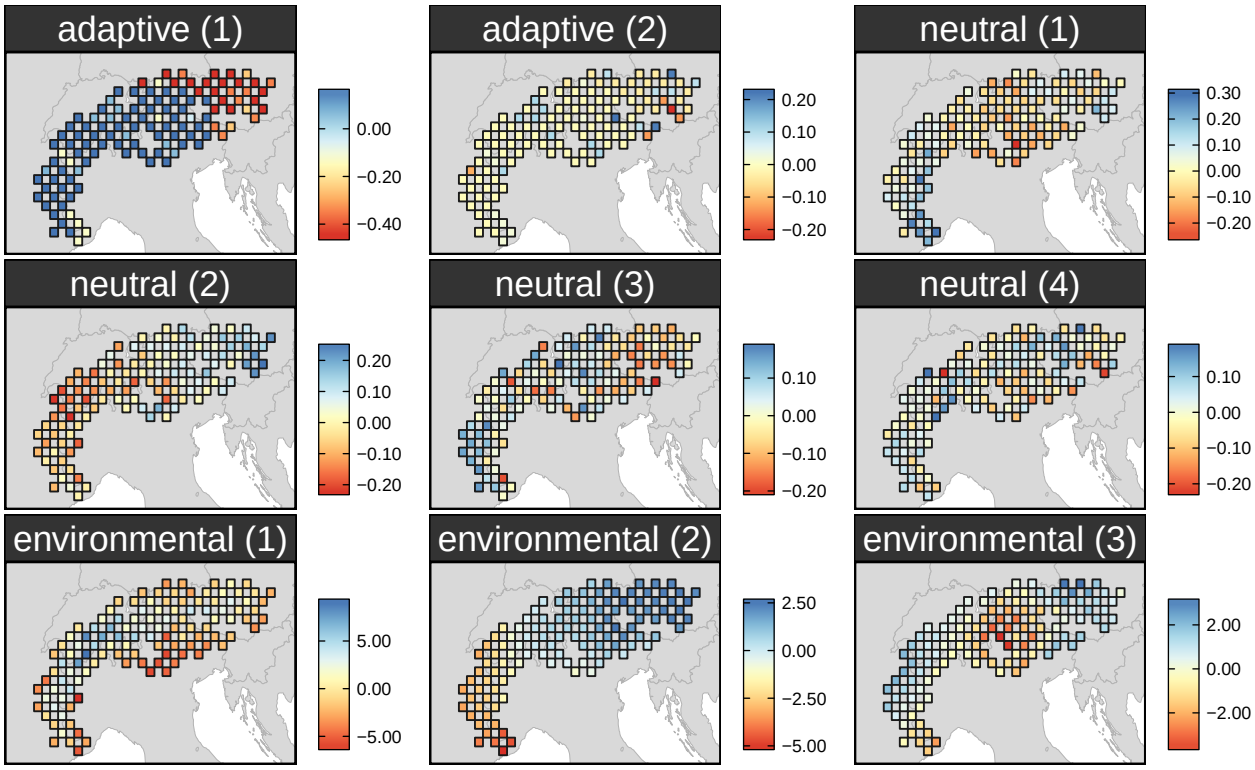

Fig. S20. Distribution of intra-specific variation for *Peucedanum ostruthium*. See Figure S1 caption for conventions.

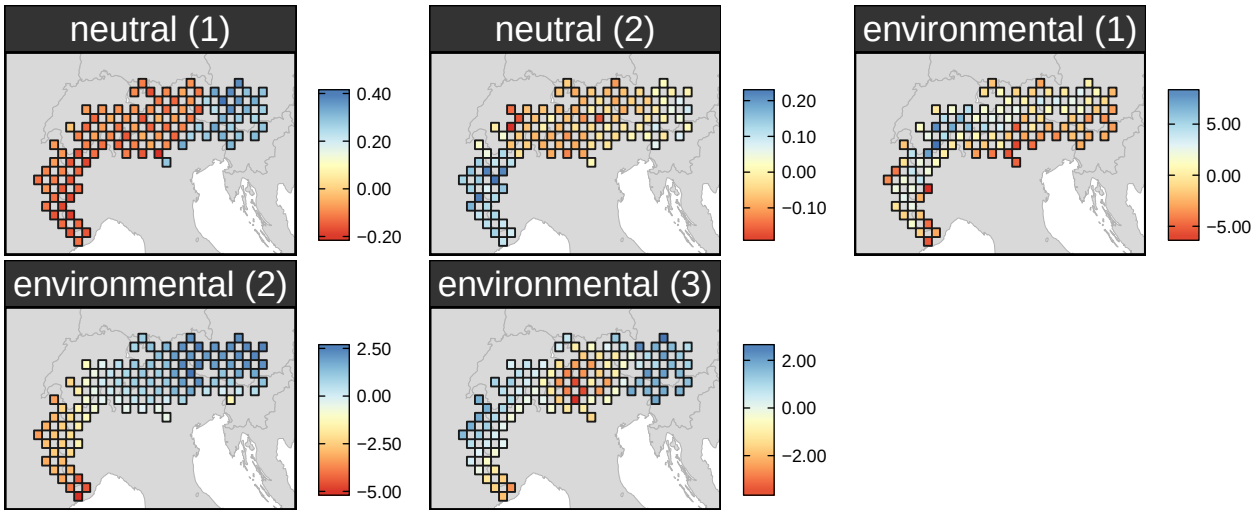

Fig. S21. Distribution of intra-specific variation for *Phyteuma betonicifolium*. See Figure S1 caption for conventions.

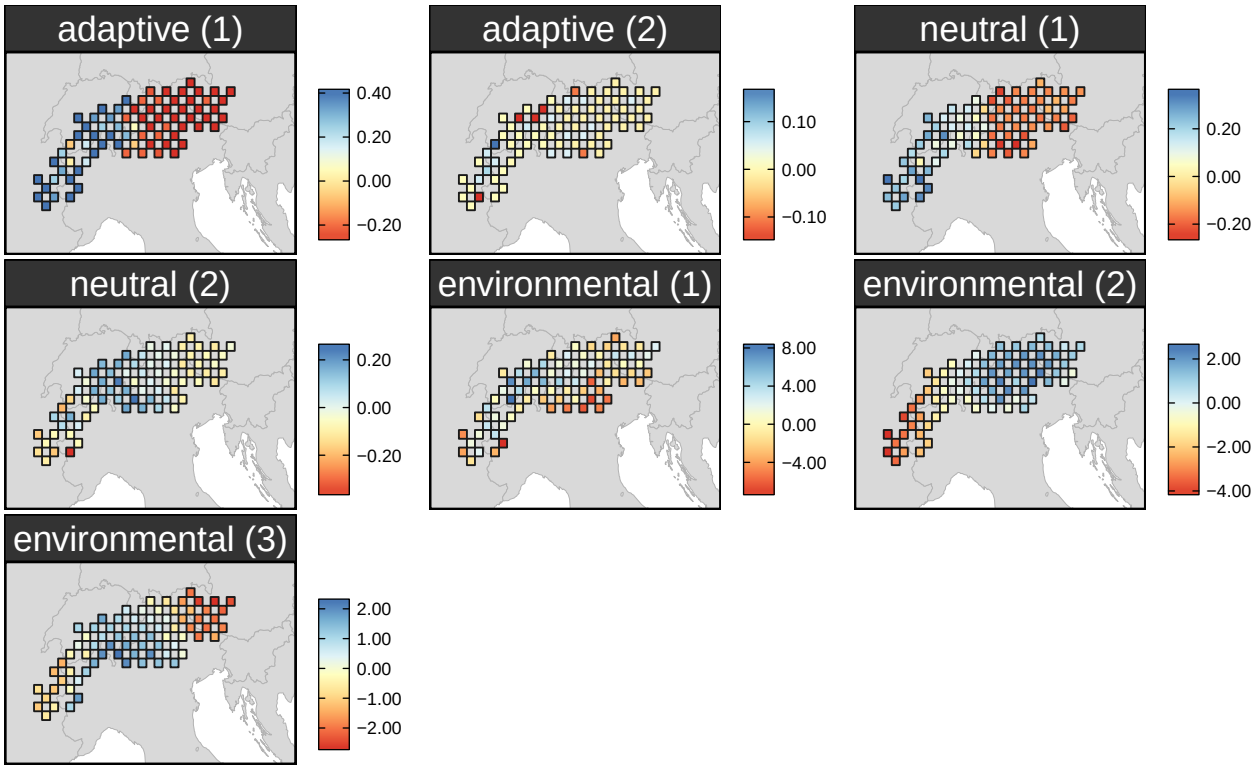

Fig. S22. Distribution of intra-specific variation for *Phyteuma hemisphaericum*. See Figure S1 caption for conventions.

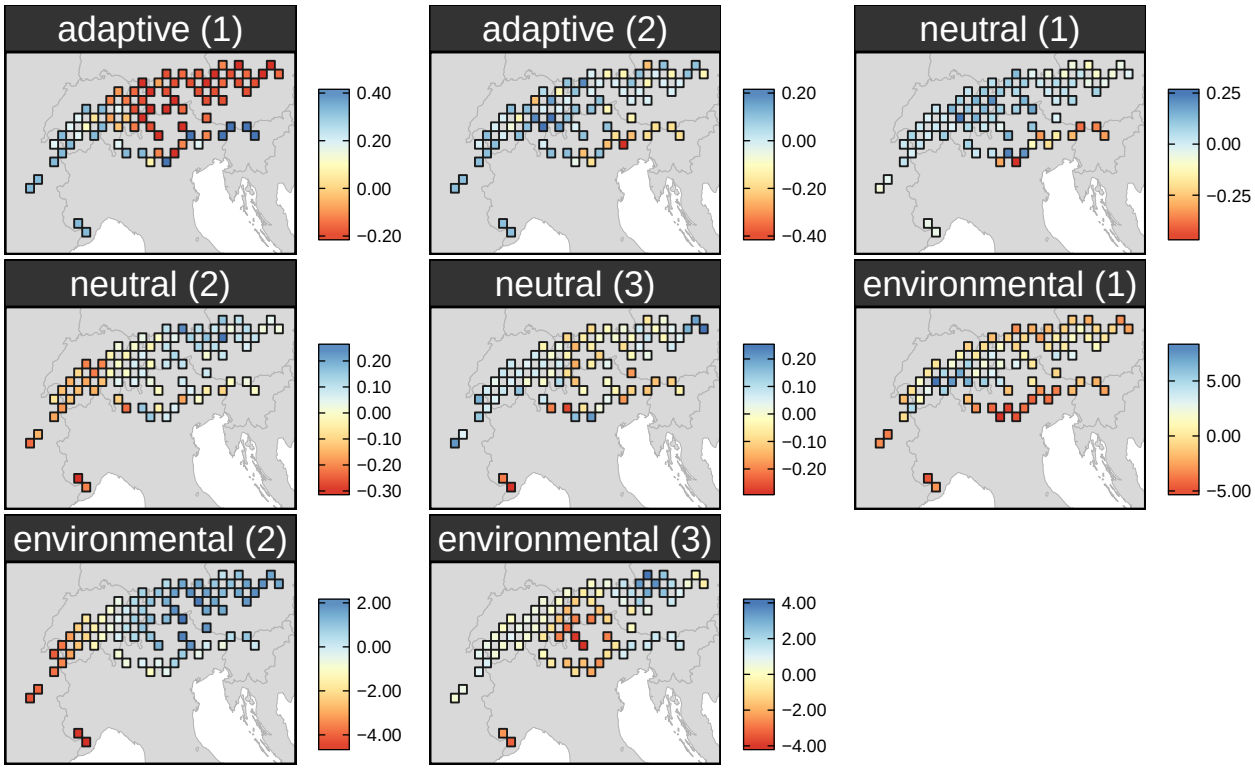

Fig. S23. Distribution of intra-specific variation for *Ranunculus alpestris*. See Figure S1 caption for conventions.

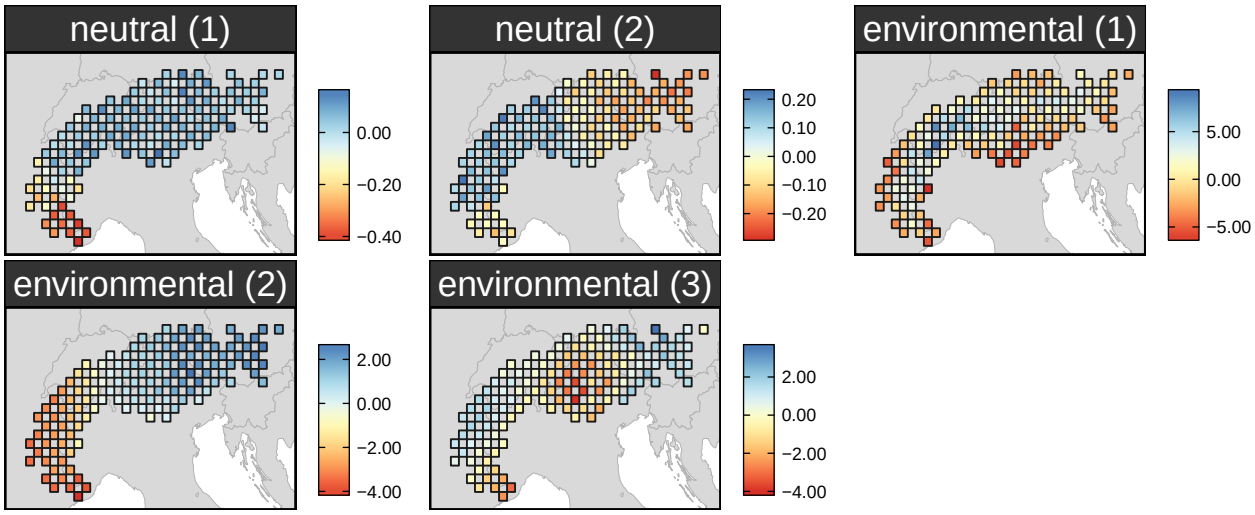

Fig. S24. Distribution of intra-specific variation for *Rhododendron ferrugineum*. See Figure S1 caption for conventions.

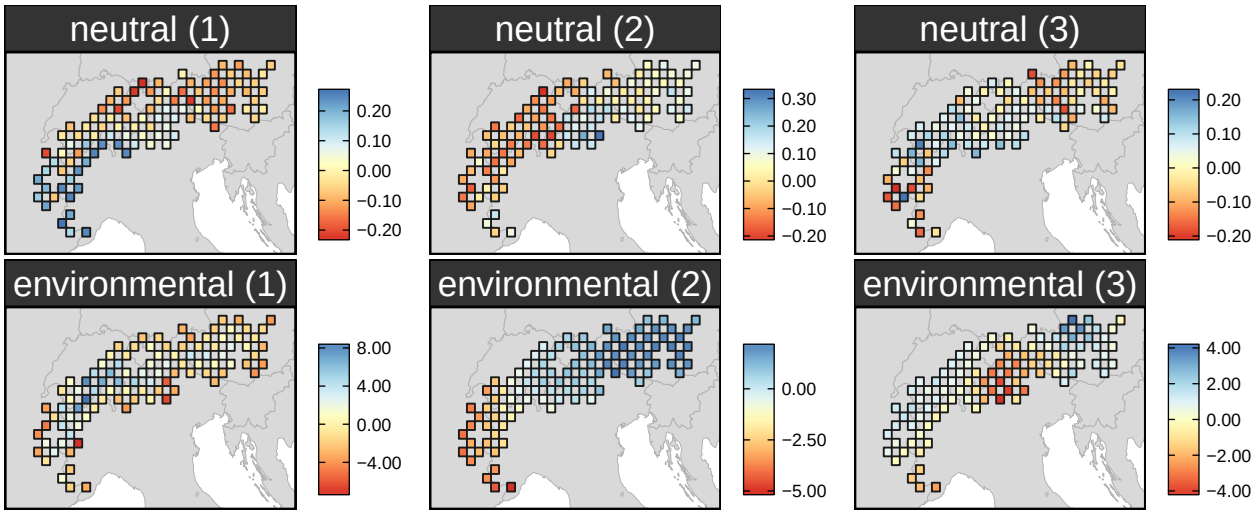

Fig. S25. Distribution of intra-specific variation for *Saxifraga stellaris*. See Figure S1 caption for conventions.

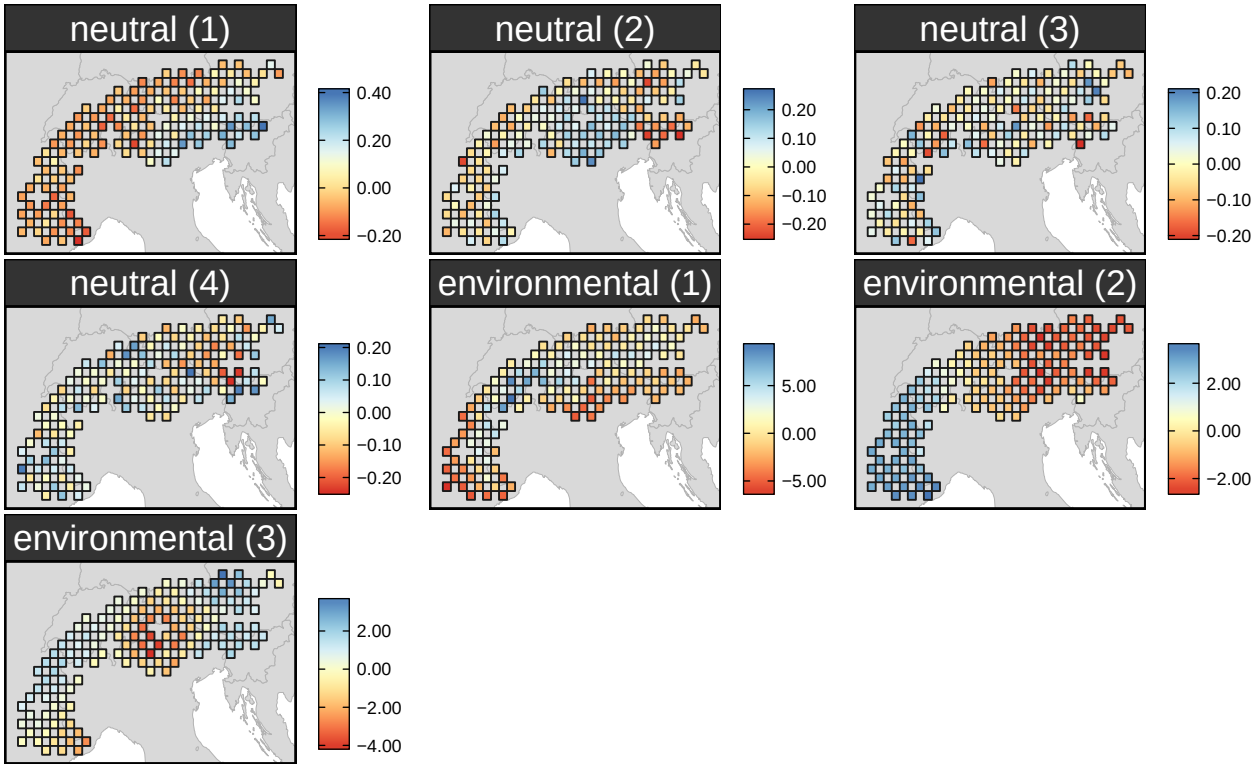

Fig. S26. Distribution of intra-specific variation for *Sesleria caerulea*. See Figure S1 caption for conventions.

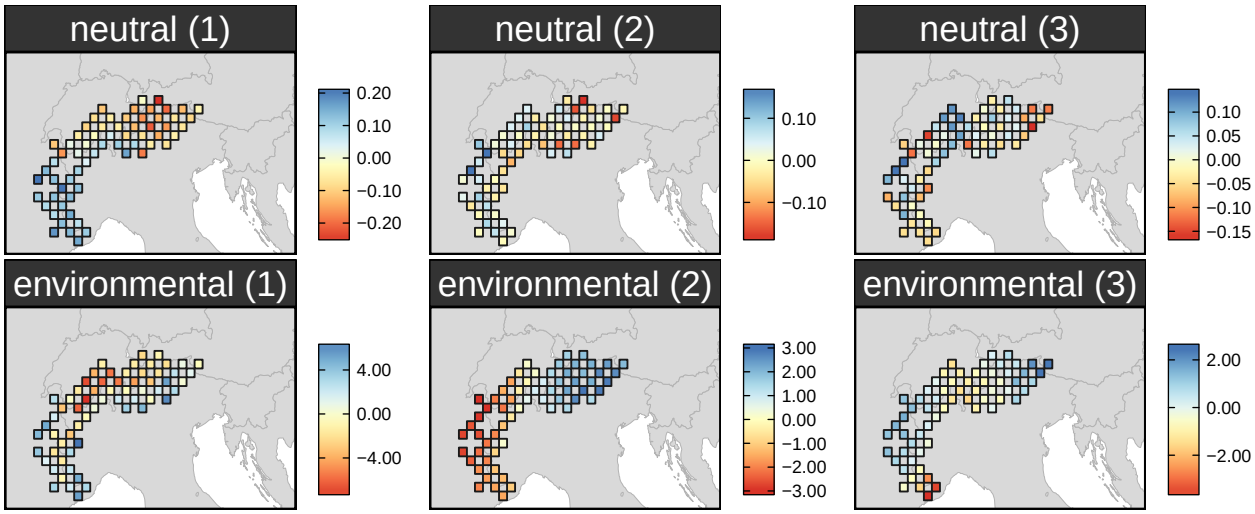

Fig. S27. Distribution of intra-specific variation for *Trifolium alpinum*. See Figure S1 caption for conventions.

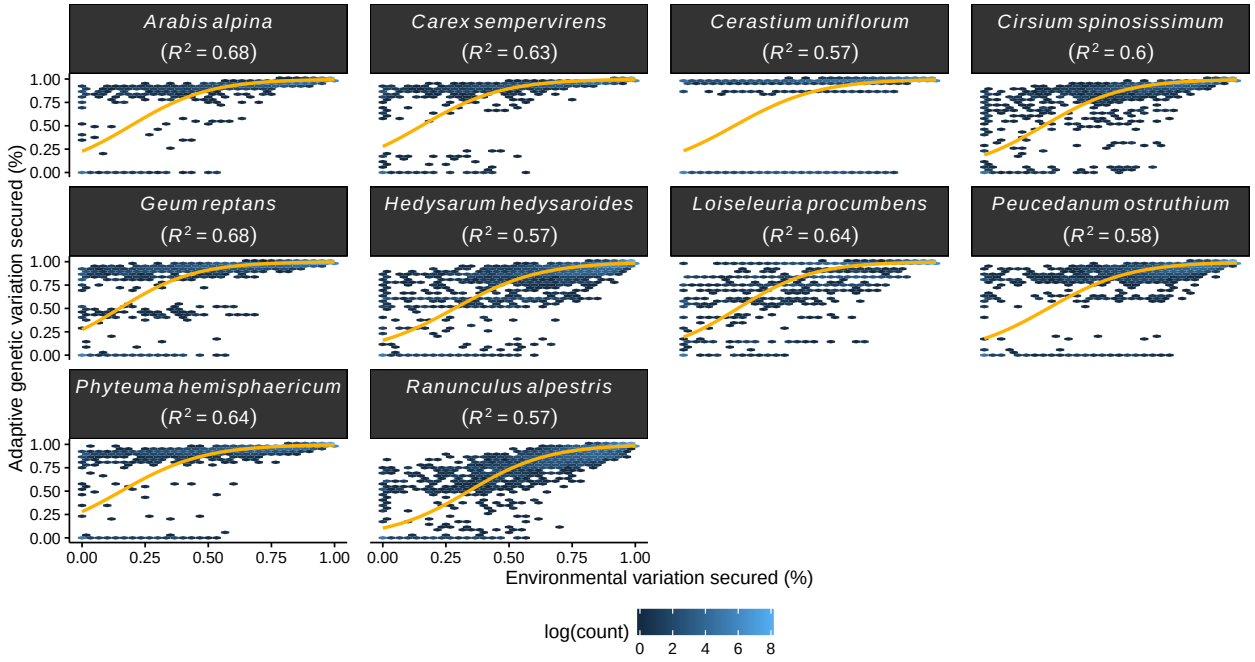

Fig. S28. The relationship between the proportion of adaptive genetic variation secured in a prioritization and the proportion of environmental variation it also secures. Points represent values associated with randomly generated prioritizations. Lines show trends fit using generalised linear models with a logit link functions. Each panel corresponds to a different species.

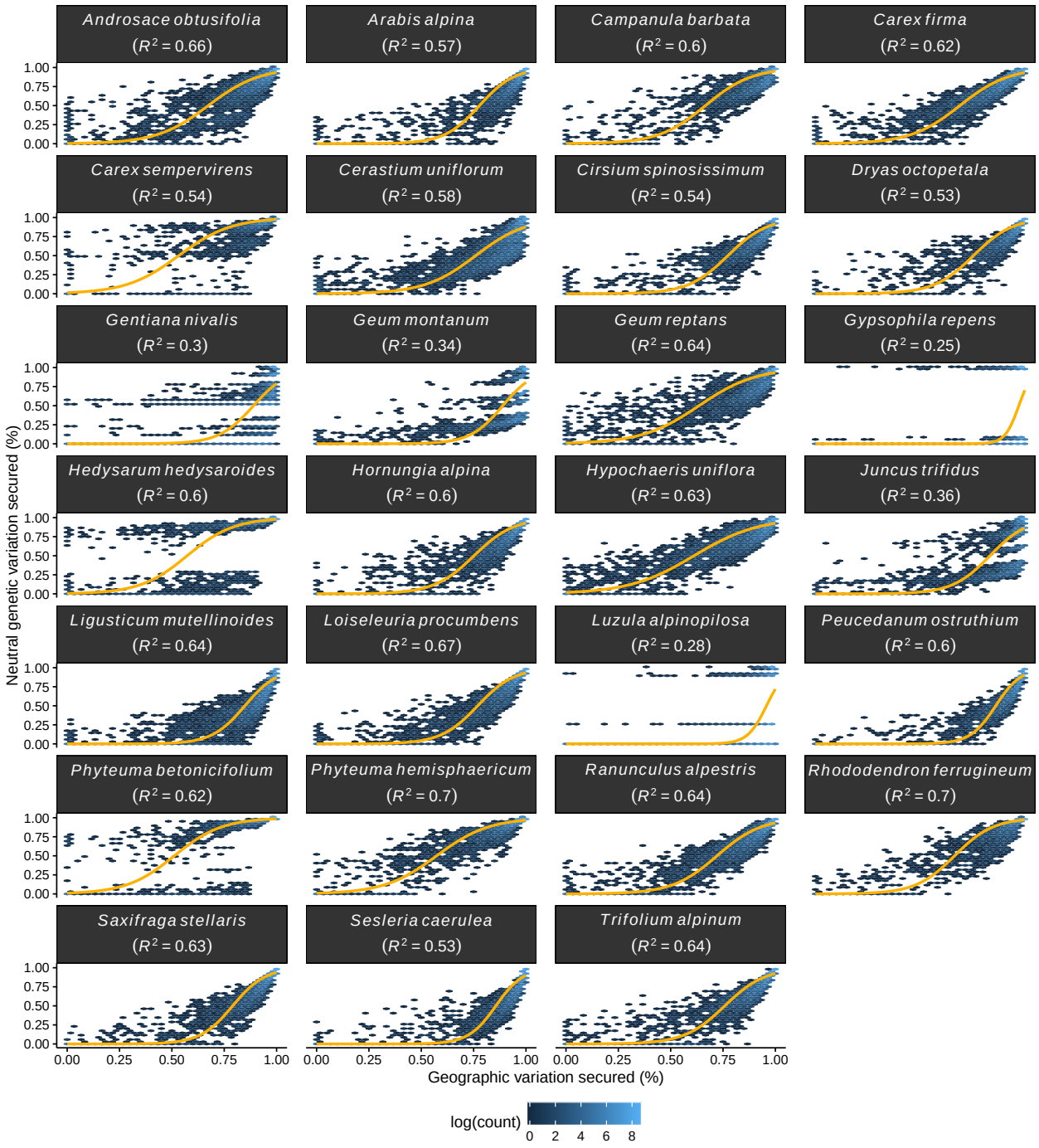

Fig. S29. The relationship between the proportion of neutral genetic variation secured in a prioritization and the proportion of geographic variation it also secures. Conventions are detailed in Figure S28.

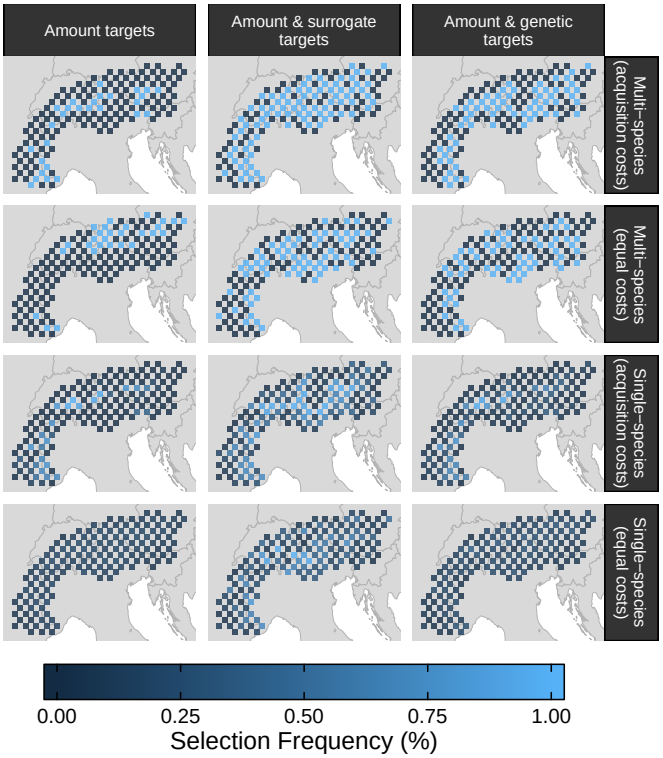

Fig. S30. Planning unit selection frequencies. Squares represent planning units, and their colors indicate their selection frequency. Each column of panels shows solutions generated using different targets. Each row of panels shows solutions generated under different scenarios. Note that the selection 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.

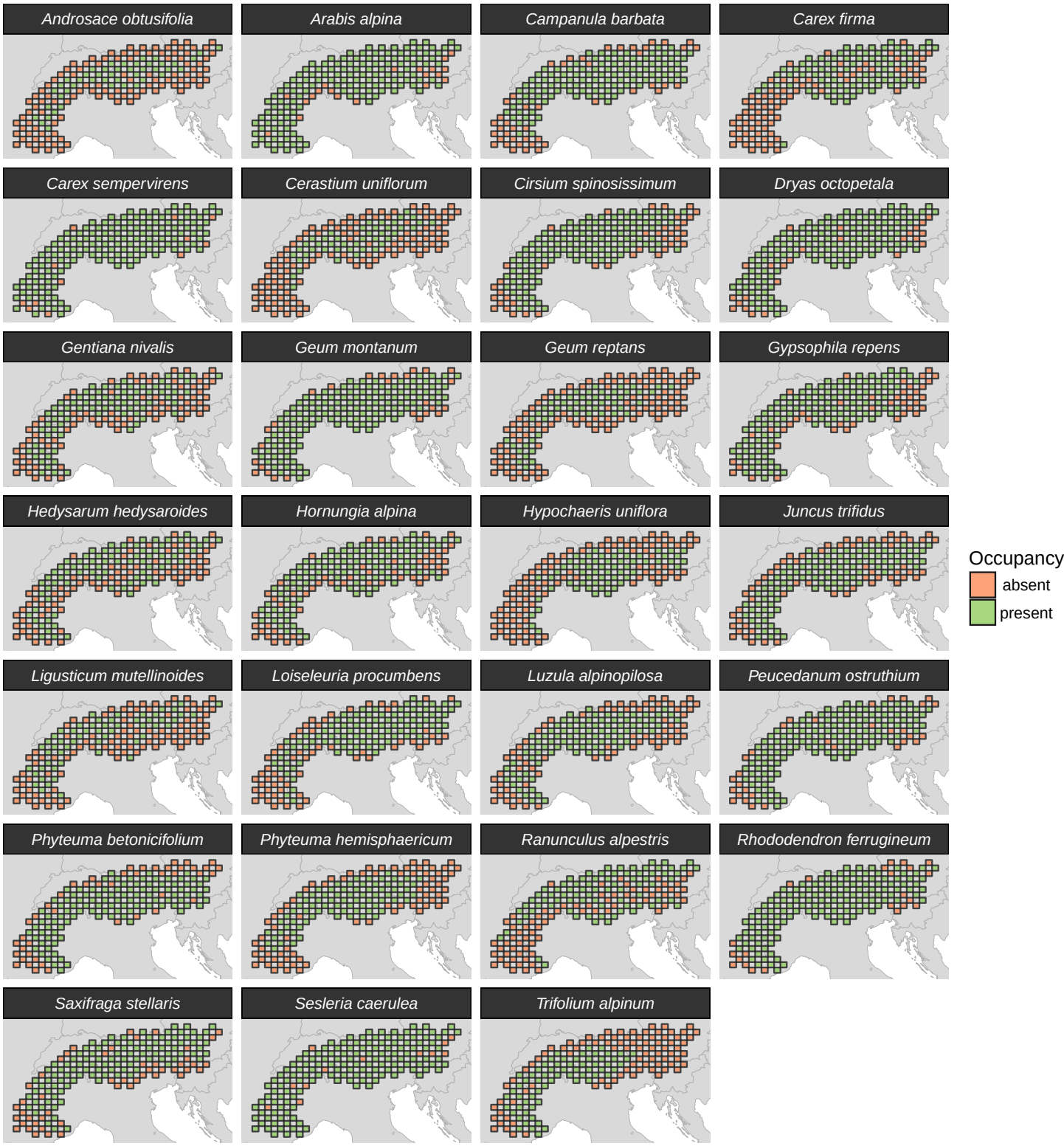

Fig. S31. Species distributions. Squares represent planning units. For a given species, planning units that it was found in are shown in green.

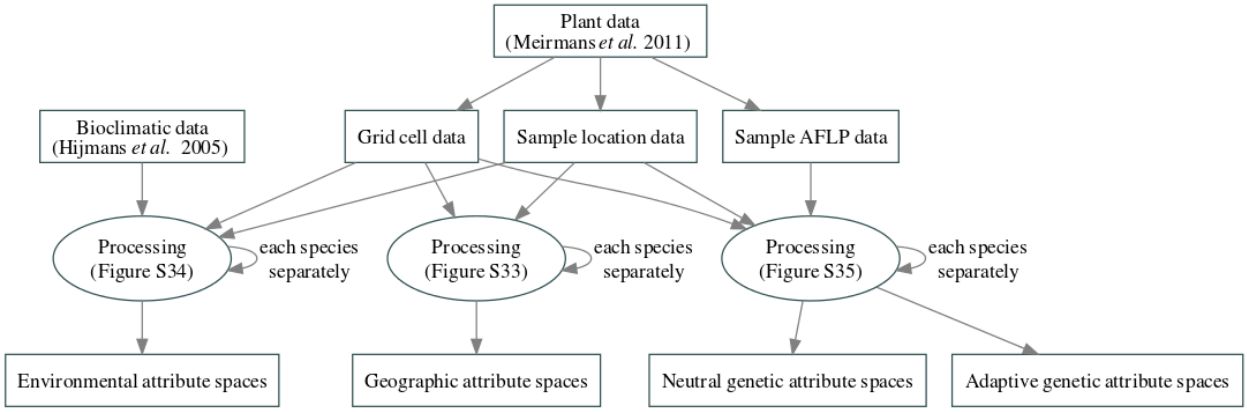

Fig. S32. Overall data processing workflow. The flowcharts show the methods used to generate the environmental and geographic surrogate spaces, and the adaptive and neutral genetic spaces. Squares indicate data sets. Ellipses indicate analyses. Lines show relationships between data and analysis, and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

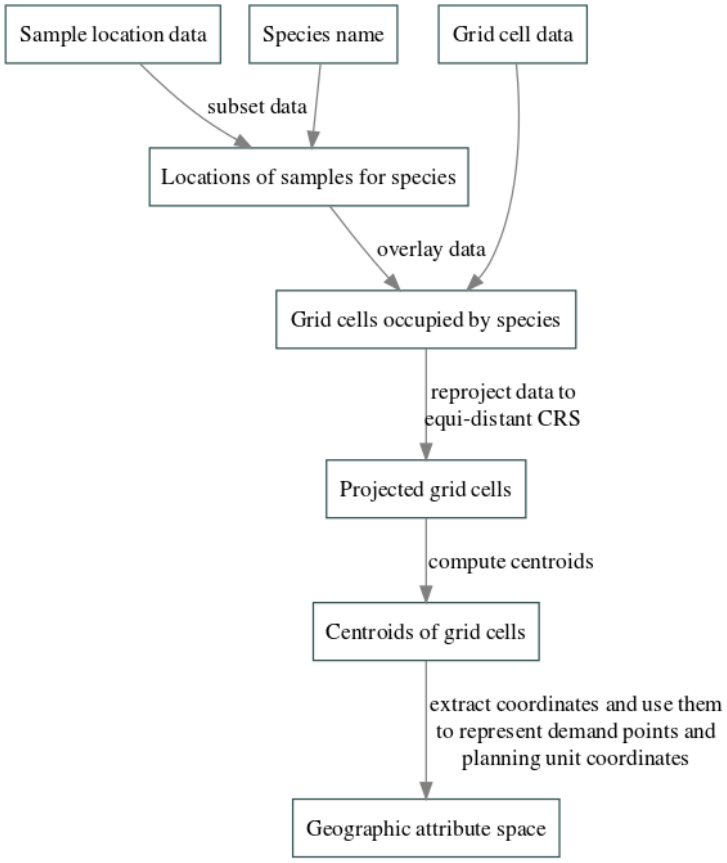

Fig. S33. Geographic surrogate processing workflow. Conventions are detailed in Figure S32 caption.

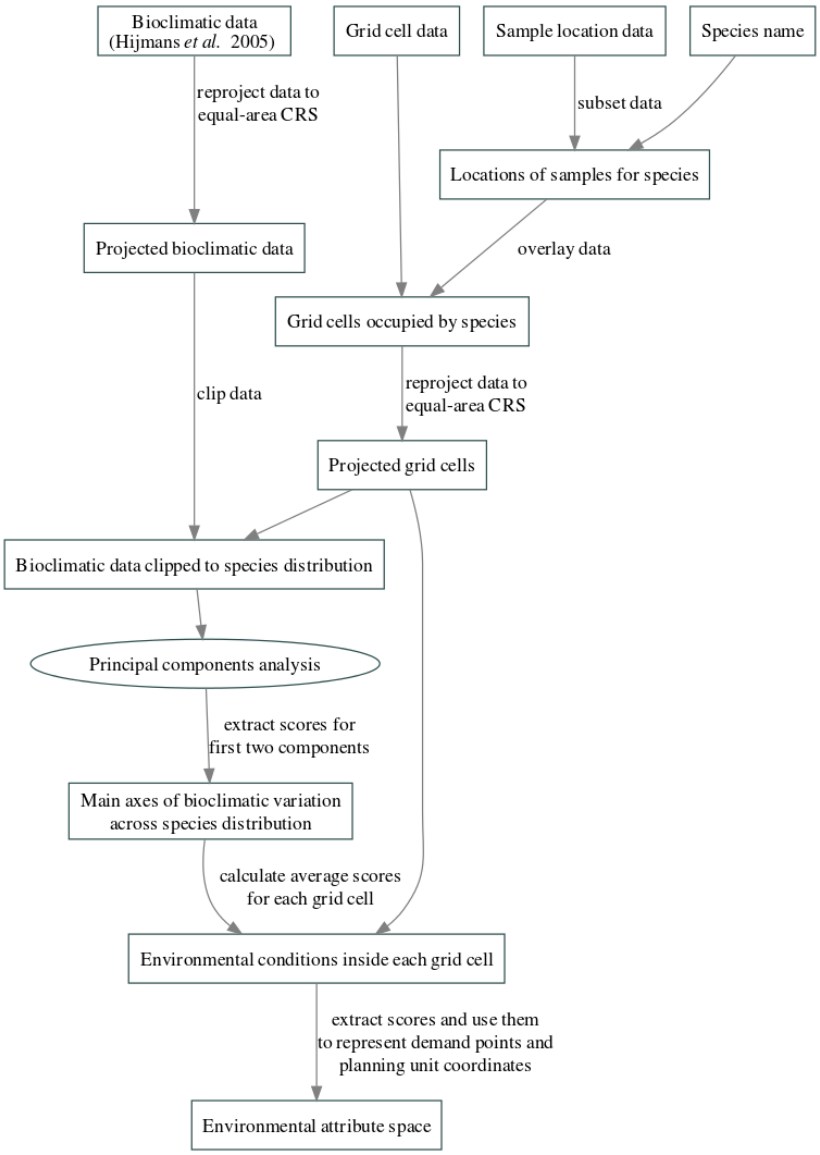

Fig. S34. Environmental surrogate processing workflow. Conventions are detailed in Figure S32 caption.

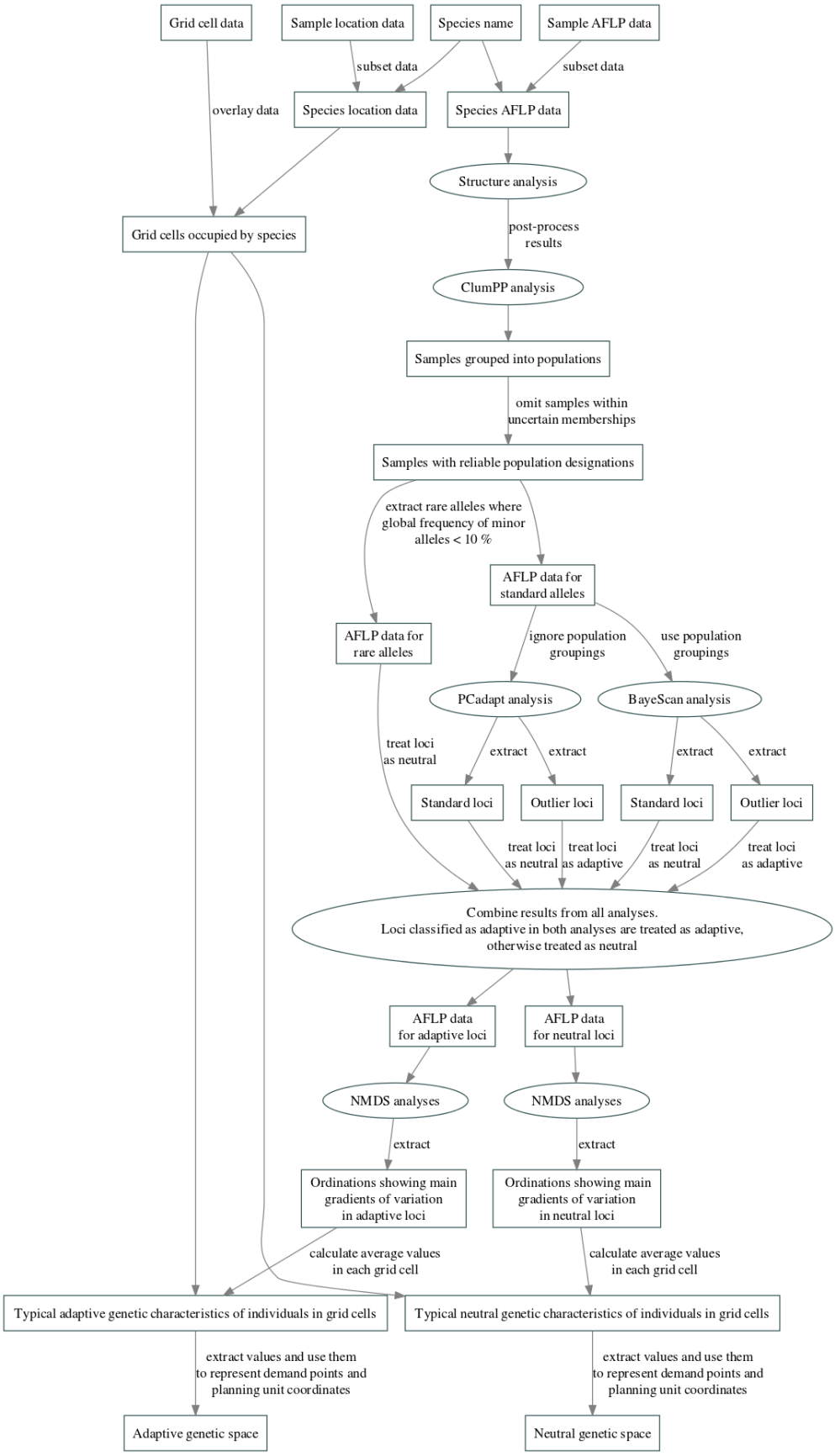

Fig. S35. Genetic data processing workflow. Conventions are detailed in Figure S32 caption.

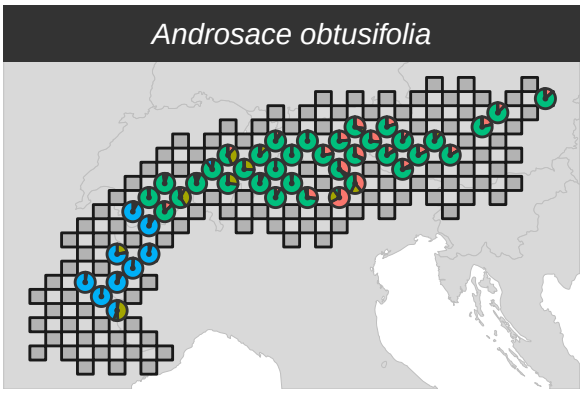

Fig. S36. Distribution of *Androsace obtusifolia* populations. Squares denote planning units. Pie charts denote quadrats where individuals were sampled, and colors denote the average probability that individuals in the quadrat belong to different populations on average.

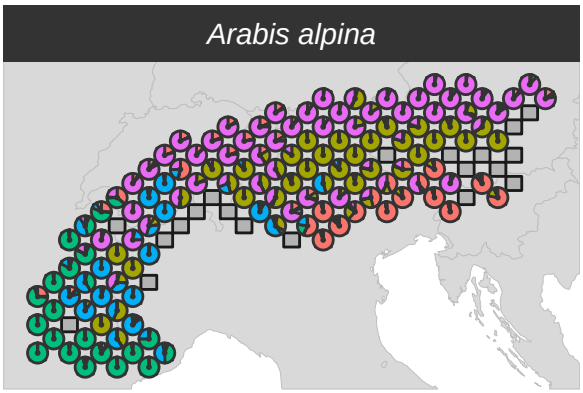

Fig. S37. Distribution of *Arabis alpina* populations. See Figure S36 caption for conventions.

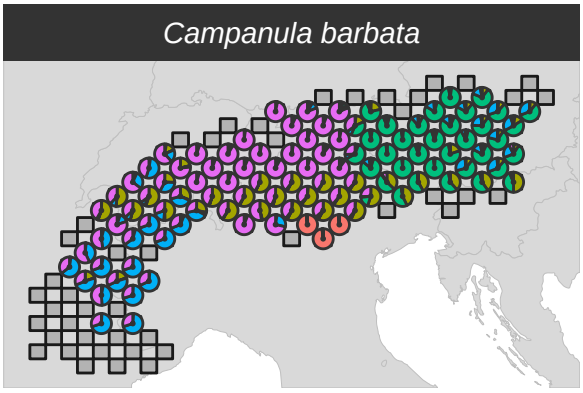

Fig. S38. Distribution of *Campanula barbata* populations. See Figure S36 caption for conventions.

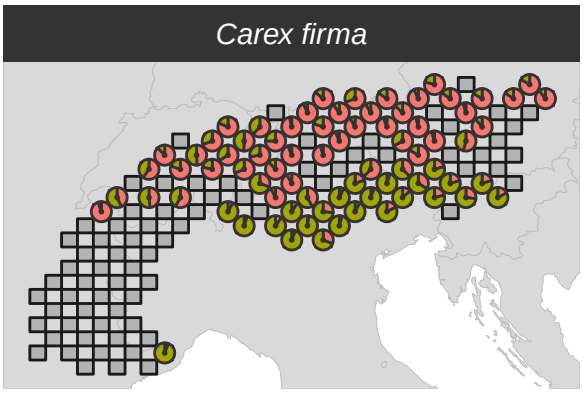

Fig. S39. Distribution of *Carex firma* populations. See Figure S36 caption for conventions.

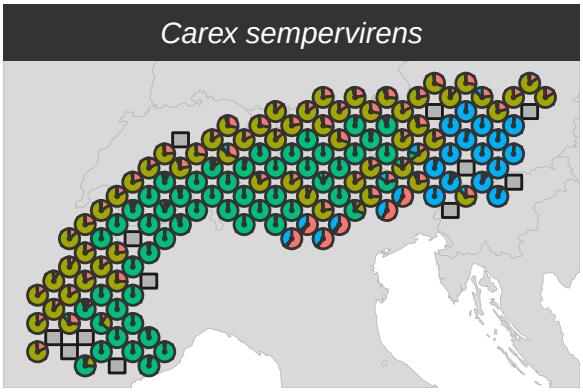

Fig. S40. Distribution of *Carex sempervirens* populations. See Figure S36 caption for conventions.

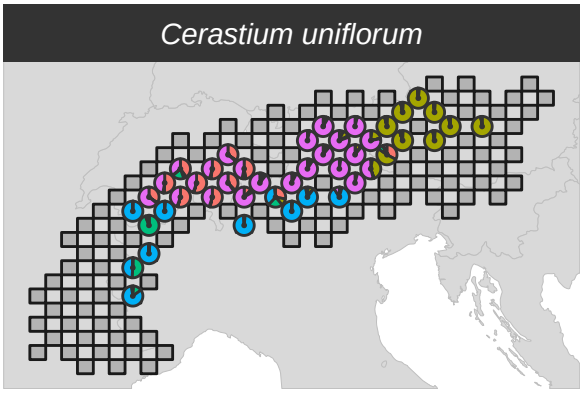

Fig. S41. Distribution of *Cerastium uniflorum* populations. See Figure S36 caption for conventions.

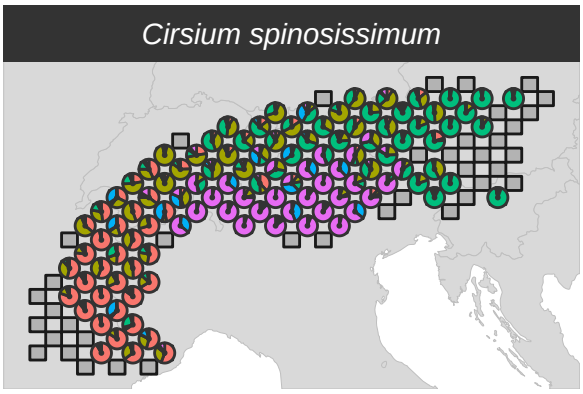

Fig. S42. Distribution of *Cirsium spinosissimum* populations. See Figure S36 caption for conventions.

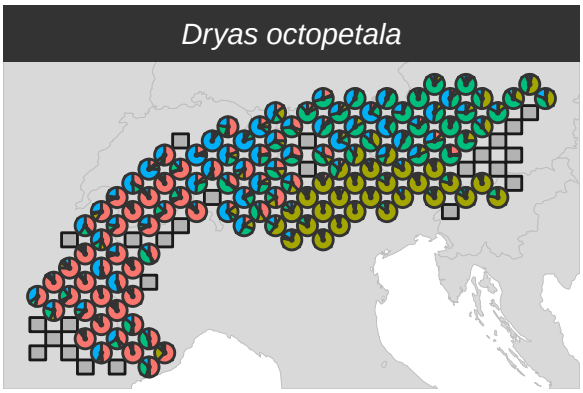

Fig. S43. Distribution of *Dryas octopetala* populations. See Figure S36 caption for conventions.

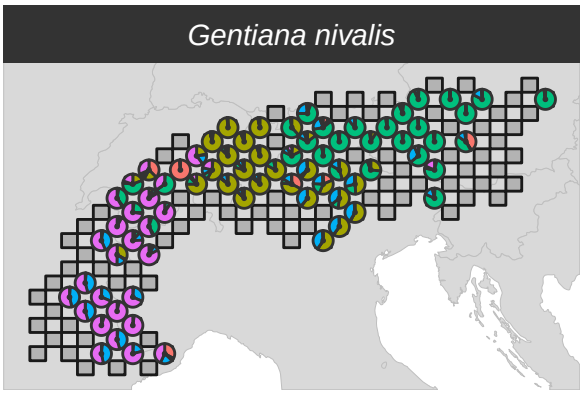

Fig. S44. Distribution of *Gentiana nivalis* populations. See Figure S36 caption for conventions.

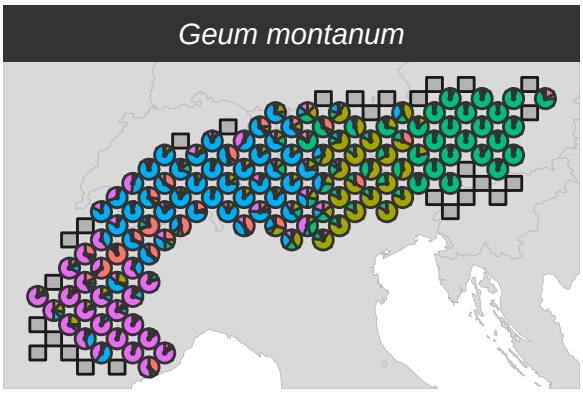

Fig. S45. Distribution of *Geum montanum* populations. See Figure S36 caption for conventions.

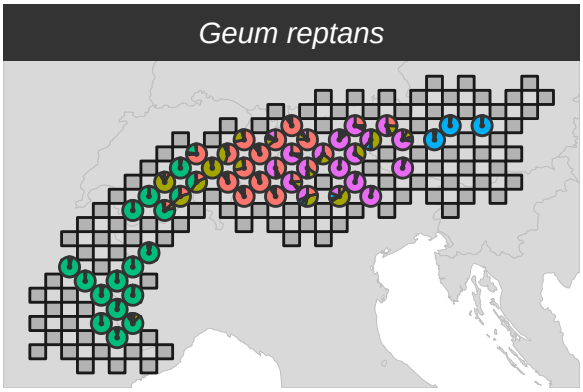

Fig. S46. Distribution of *Geum reptans* populations. See Figure S36 caption for conventions.

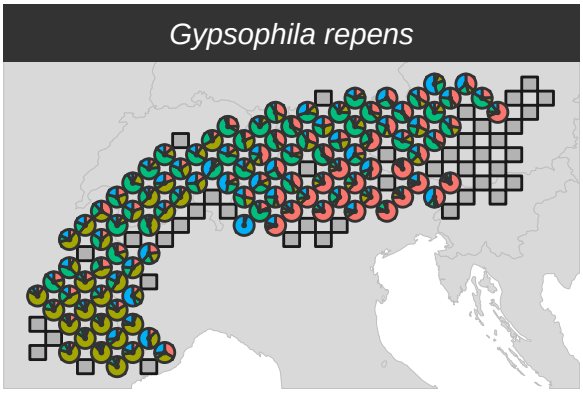

Fig. S47. Distribution of *Gypsophila repens* populations. See Figure S36 caption for conventions.

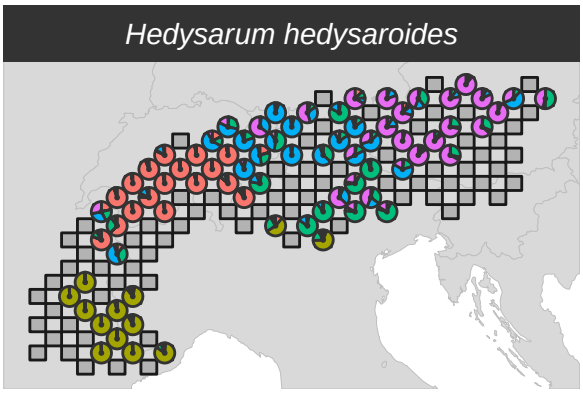

Fig. S48. Distribution of *Hedysarum hedysaroides* populations. See Figure S36 caption for conventions.

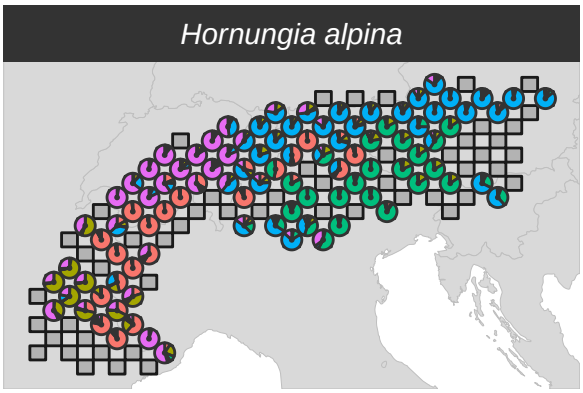

Fig. S49. Distribution of *Hornungia alpina* populations. See Figure S36 caption for conventions.

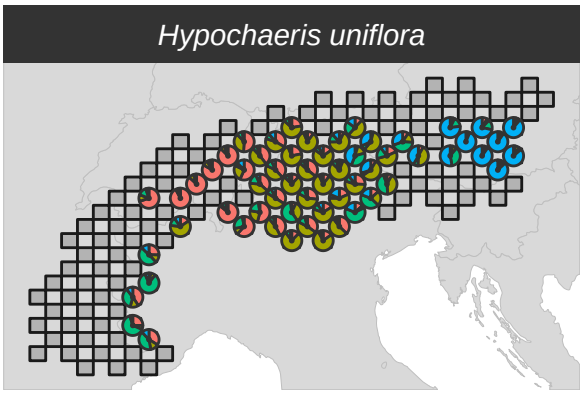

Fig. S50. Distribution of *Hypochaeris uniflora* populations. See Figure S36 caption for conventions.

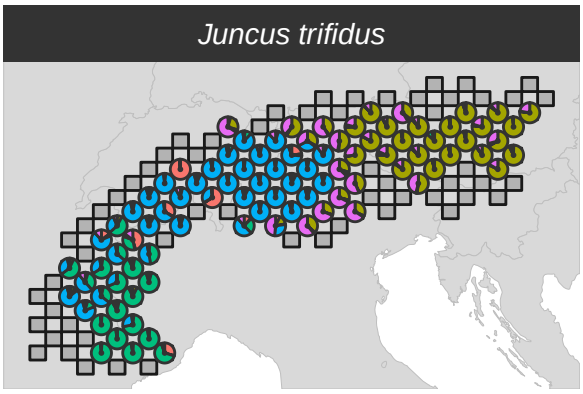

Fig. S51. Distribution of *Juncus trifidus* populations. See Figure S36 caption for conventions.

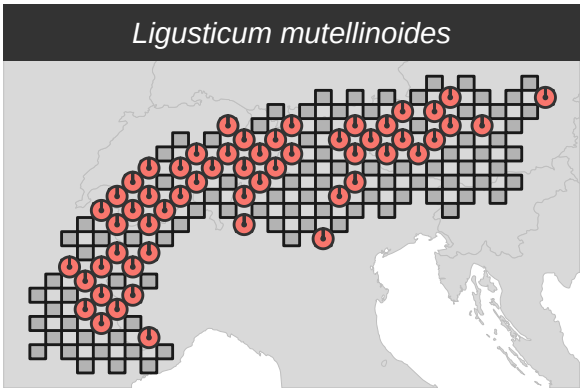

Fig. S52. Distribution of *Ligusticum mutellinoides* populations. See Figure S36 caption for conventions.

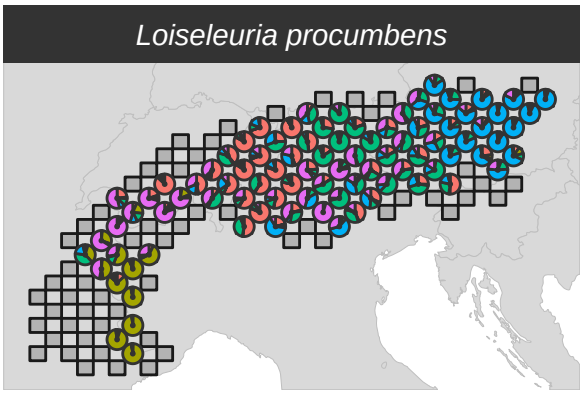

Fig. S53. Distribution of *Loiseleuria procumbens* populations. See Figure S36 caption for conventions.

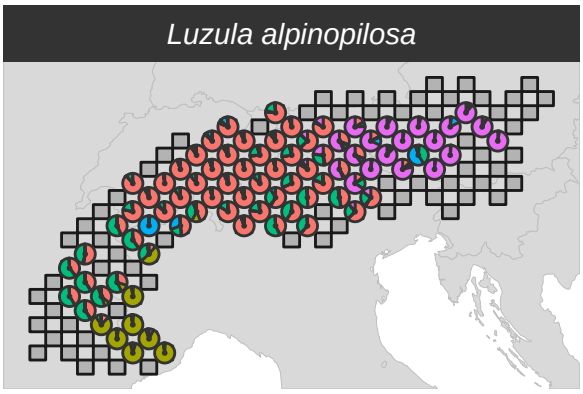

Fig. S54. Distribution of *Luzula alpinopilosa* populations. See Figure S36 caption for conventions.

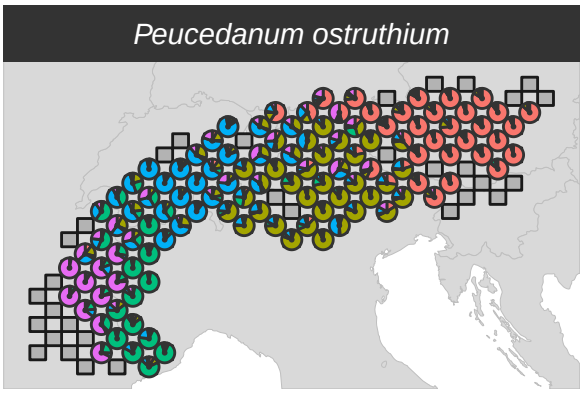

Fig. S55. Distribution of *Peucedanum ostruthium* populations. See Figure S36 caption for conventions.

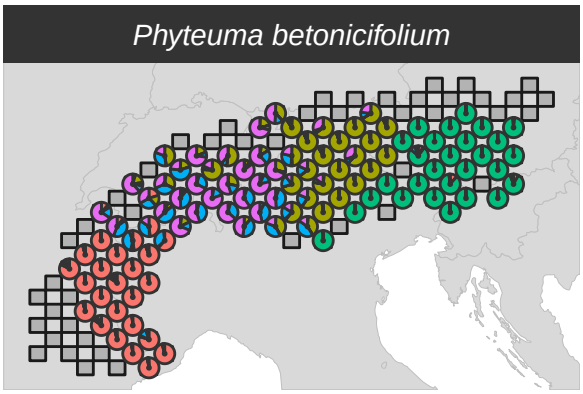

Fig. S56. Distribution of *Phyteuma betonicifolium* populations. See Figure S36 caption for conventions.

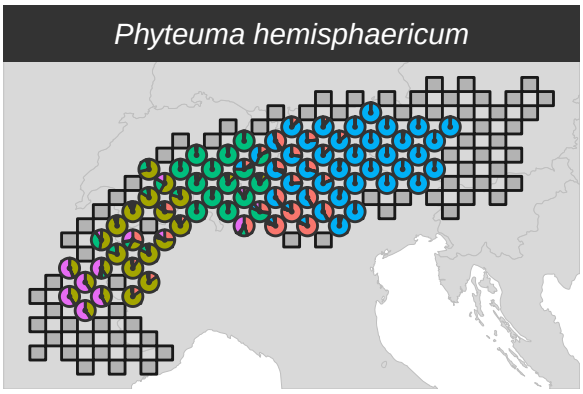

Fig. S57. Distribution of *Phyteuma hemisphaericum* populations. See Figure S36 caption for conventions.

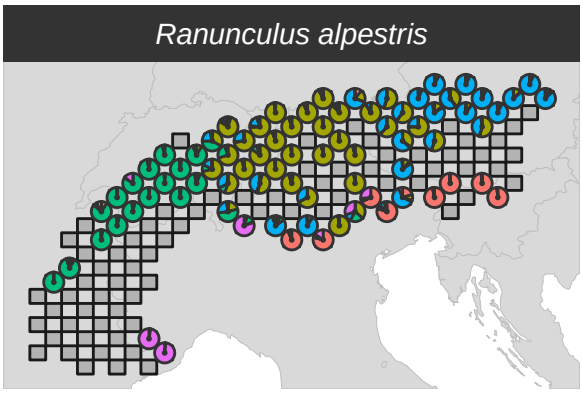

Fig. S58. Distribution of *Ranunculus alpestris* populations. See Figure S36 caption for conventions.

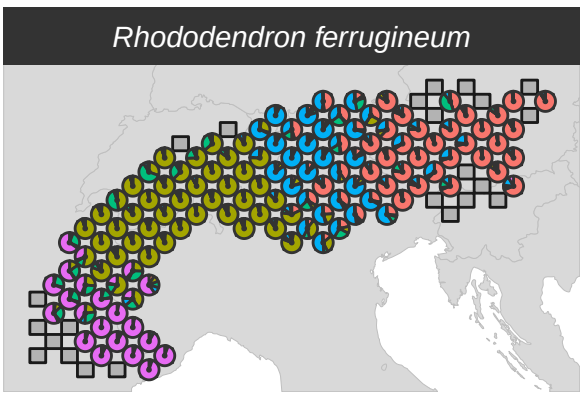

Fig. S59. Distribution of *Rhododendron ferrugineum* populations. See Figure S36 caption for conventions.

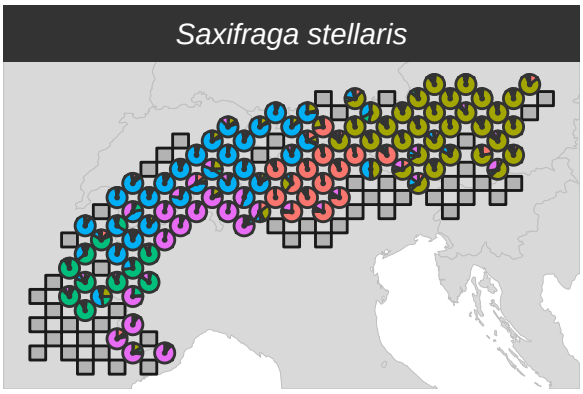

Fig. S60. Distribution of *Saxifraga stellaris* populations. See Figure S36 caption for conventions.

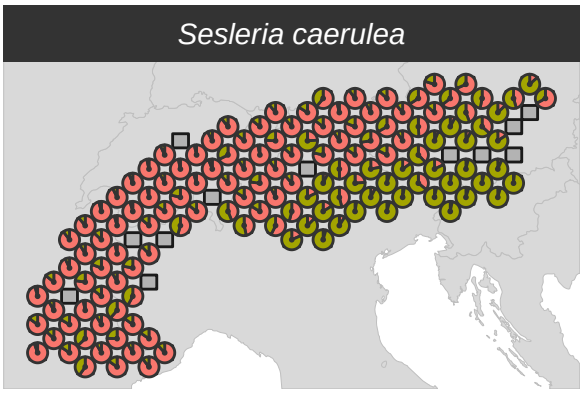

Fig. S61. Distribution of *Sesleria caerulea* populations. See Figure S36 caption for conventions.

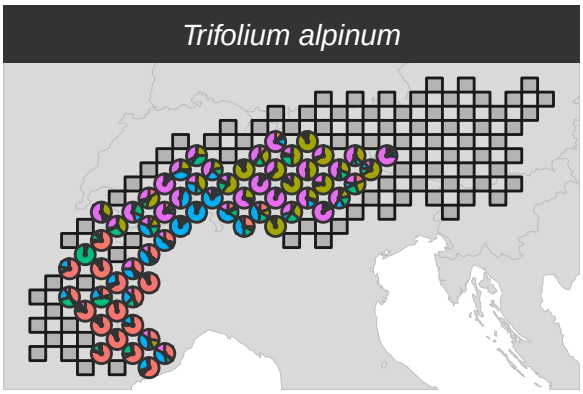

Fig. S62. Distribution of *Trifolium alpinum* populations. See Figure S36 caption for conventions.

Tables

Table S1. 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.

	Adaptive		**Neutral**	
Species	K	Stress	K	Stress
Androsace obtusifolia			2	0.218
Arabis alpina	2	<0.001	3	**0.187**
Campanula barbata			2	0.204
Carex firma			3	0.241
Carex sempervirens	2	<0.001	2	0.219
Cerastium uniflorum	2	<0.001	2	0.205
Cirsium spinosissimum	2	<0.001	3	**0.197**
Dryas octopetala			3	0.218
Gentiana nivalis			2	**0.046**
Geum montanum			2	0.163
Geum reptans	2	<0.001	2	0.188
Gypsophila repens			2	**0.06**
Hedysarum hedysaroides	2	<0.001	2	0.197
Hornungia alpina			3	0.2
Hypochaeris uniflora			2	0.241
Juncus trifidus			2	0.151
Ligusticum mutellinoides			4	0.212
Loiseleuria procumbens	2	<0.001	3	0.208
Luzula alpinopilosa			2	**0.051**
Peucedanum ostruthium	2	<0.001	4	0.221
Phyteuma betonicifolium			2	0.172
Phyteuma hemisphaericum	2	0.003	2	0.226
Ranunculus alpestris	2	**0.012**	3	0.221
Rhododendron ferrugineum			2	0.208
Saxifraga stellaris			3	0.201
Sesleria caerulea			4	0.209
Trifolium alpinum			3	0.212

Table S2. 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.

	Environmental				**Geographic**			
Species	MR^2	CR^2	χ^2	P	MR^2	CR^2	χ^2	P
Androsace obtusifolia					0.28	0.66	408.27	<0.001
Arabis alpina	0.15	0.21	989.5	<0.001	0.16	0.43	1611.53	<0.001
Campanula barbata					0.32	0.69	2880.9	<0.001
Carex firma					0.036	0.35	89.45	<0.001
Carex sempervirens	<0.001	0.011	1.67	>0.99	0.018	0.13	139.74	<0.001
Cerastium uniflorum	0.016	0.28	13.81	0.007	0.14	0.84	436.43	<0.001
Cirsium spinosissimum	0.015	0.24	68.73	<0.001	0.11	0.46	811.87	<0.001
Dryas octopetala					0.22	0.48	2040.82	<0.001
Gentiana nivalis					<0.001	0.94	3.72	>0.99
Geum montanum					0.041	0.93	2496.3	<0.001
Geum reptans	0.093	0.14	91.89	<0.001	0.42	0.75	921.34	<0.001
Gypsophila repens					<0.001	>0.99	234.03	<0.001
Hedysarum hedysaroides	0.13	0.21	291.81	<0.001	0.23	0.55	832.02	<0.001
Hornungia alpina					0.20	0.37	941.47	<0.001
Hypochaeris uniflora					0.22	0.62	422.7	<0.001
Juncus trifidus					0.061	0.88	1311.63	<0.001
Ligusticum mutellinoides					0.088	0.34	142.65	<0.001
Loiseleuria procumbens	0.001	0.12	2.94	>0.99	0.27	0.67	1643.99	<0.001
Luzula alpinopilosa					<0.001	>0.99	34.2	<0.001
Peucedanum ostruthium	0.046	0.31	266.91	<0.001	0.22	0.42	1677.68	<0.001
Phyteuma betonicifolium					0.39	0.52	2488.9	<0.001
Phyteuma hemisphaericum	0.14	0.18	308.32	<0.001	0.58	0.71	2419.26	<0.001
Ranunculus alpestris	0.090	0.22	199.11	<0.001	0.22	0.54	805.66	<0.001
Rhododendron ferrugineum					0.50	0.67	5807.85	<0.001
Saxifraga stellaris					0.28	0.48	1623.69	<0.001
Sesleria caerulea					0.053	0.44	633.32	<0.001
Trifolium alpinum					0.36	0.55	970.49	<0.001

Table S3. 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).

	Environmental			**Geographic**		
Species	Z	P	R^2	Z	P	R^2
Androsace obtusifolia				8.18 ± 0.24	<0.001	0.66
Arabis alpina	6.38 ± 0.2	<0.001	0.68	11.98 ± 0.48	<0.001	0.57
Campanula barbata				8.97 ± 0.33	<0.001	0.60
Carex firma				8.53 ± 0.25	<0.001	0.62
Carex sempervirens	6.23 ± 0.21	<0.001	0.63	7.98 ± 0.32	<0.001	0.54
Cerastium uniflorum	5.96 ± 0.15	<0.001	0.57	8.21 ± 0.26	<0.001	0.58
Cirsium spinosissimum	6.27 ± 0.19	<0.001	0.60	10.55 ± 0.39	<0.001	0.54
Dryas octopetala				10.63 ± 0.42	<0.001	0.53
Gentiana nivalis				12.08 ± 0.45	<0.001	0.30
Geum montanum				12.87 ± 0.55	<0.001	0.34
Geum reptans	6.6 ± 0.18	<0.001	0.68	7.3 ± 0.23	<0.001	0.64
Gypsophila repens				30.31 ± 1.08	<0.001	0.25
Hedysarum hedysaroides	5.88 ± 0.16	<0.001	0.57	8.93 ± 0.28	<0.001	0.60
Hornungia alpina				10.44 ± 0.37	<0.001	0.60
Hypochaeris uniflora				6.48 ± 0.18	<0.001	0.63
Juncus trifidus				11.15 ± 0.45	<0.001	0.36
Ligusticum mutellinoides				12.75 ± 0.4	<0.001	0.64
Loiseleuria procumbens	6.65 ± 0.19	<0.001	0.64	11.43 ± 0.37	<0.001	0.67
Luzula alpinopilosa				22.16 ± 0.76	<0.001	0.28
Peucedanum ostruthium	6.08 ± 0.18	<0.001	0.58	16.43 ± 0.59	<0.001	0.60
Phyteuma betonicifolium				8.76 ± 0.32	<0.001	0.62
Phyteuma hemisphaericum	6.06 ± 0.18	<0.001	0.64	8.01 ± 0.25	<0.001	0.70
Ranunculus alpestris	6.33 ± 0.17	<0.001	0.57	9.41 ± 0.28	<0.001	0.64
Rhododendron ferrugineum				10.78 ± 0.4	<0.001	0.70
Saxifraga stellaris				12.96 ± 0.44	<0.001	0.63
Sesleria caerulea				15.32 ± 0.59	<0.001	0.53
Trifolium alpinum				10.39 ± 0.35	<0.001	0.64

Table S4. 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 (%)**
Androsace obtusifolia	90.374
Arabis alpina	91.319
Campanula barbata	89.931
Carex firma	91.017
Carex sempervirens	90.212
Cerastium uniflorum	91.454
Cirsium spinosissimum	89.628
Dryas octopetala	90.150
Gentiana nivalis	90.191
Geum montanum	89.742
Geum reptans	90.255
Gypsophila repens	91.679
Hedysarum hedysaroides	89.719
Hornungia alpina	90.383
Hypochaeris uniflora	93.062
Juncus trifidus	91.062
Ligusticum mutellinoides	88.709
Loiseleuria procumbens	91.679
Luzula alpinopilosa	88.776
Peucedanum ostruthium	89.595
Phyteuma betonicifolium	89.678
Phyteuma hemisphaericum	88.909
Ranunculus alpestris	90.019
Rhododendron ferrugineum	89.779
Saxifraga stellaris	89.484
Sesleria caerulea	90.589
Trifolium alpinum	89.536