

Parallel alpine differentiation in *Arabidopsis arenosa*

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Methods S1: *Experimental cultivation conditions*

We firstly raised one generation of plants from each population in growth chambers under constant conditions. The field-collected seeds were germinated on a mixture of peat free potting compost and white river sand fraction 16-22 mm of neutral reaction in 2/3 ratio. Seedlings were re-potted at 2-4 leaves stage to 750 cm³ pots with the same substrate, young rosettes were vernalized for 11 weeks (4 °C, 8/19 hrs day/night cycle) and then transferred to standard conditions in the chamber (21/18 °C, 16/8 hrs day/night cycle, light ~300 μmol m⁻²*s⁻¹). Each plant was hand-pollinated by a mixture of pollen from the same population (~ 14 flowering plants per population were used) for a period of one week. Ripe seeds (representing a genetically variable mixture of full- and half-sibs) were harvested and stored at dark and dry place at 4 °C.

The plants used for phenotyping were raised in the Botanical Garden of the University of Innsbruck, Austria (600 m a. s. l.; 47.26773 N, 11.37898 E). Seeds from min 10 maternal plants per population were sown in May 2018 on filter papers imbibed with 5 mM potassium nitrate and submitted to 4 days of cold stratification (4°C) before transfer to a growth chamber at 25 °C under constant light (~300 μmol m⁻²*s⁻¹). Upon germination, seedlings were transferred to multi-pot trays using a mixture of peatless garden substrate and sieved sand of neutral reaction (1/1) and kept in an open-air greenhouse. Seedlings were then transplanted into individual pots (7 cm diameter, about 160 cm³) filled with a mixture of rough-texture soil (5 parts of leaf compost, 2 parts of ground soil, 1 part of horticultural lava, 2 parts of coconut fibre, 2 parts of sand and 0.2 parts of stone powder) of neutral reaction (8/10), vermiculite (1/10) and sieved sand (1/10). All plants were kept in a sheltered outdoor place in the botanical garden over winter and the rosettes with set-up buds were brought back to the open-air greenhouse in mid-March 2019. Plants were watered regularly throughout the experiment. Finally, after four weeks the phenotypic traits were collected on all plants in the full-flowering stage.

Methods S2: *Sequencing, raw data processing, variant calling and filtration*

RADseq data

One methylation-insensitive restriction enzyme (HpyCH4V) was used to generate blunt-end DNA fragments, followed by an A-tailing step combined with ligation of constructed adapters with T overhang and custom barcodes. Libraries were sequenced on an Illumina HiSeq 2500 platform using 125-bp paired-end reads at EMBL Genomics Core Facility (Heidelberg, Germany). Raw reads were demultiplexed, quality trimmed (> 30 Phred quality score) and mapped using BWA v. 0.7.3a on *Arabidopsis lyrata* reference v. 1.0.25 and the alignment was further processed with Picard Tools v. 1.119. The Genome Analysis Tool Kit v. 3.8-1 was used for simultaneous discovery and genotyping of SNPs and for calling of invariant sites following the recommended best practice (www.broadinstitute.org/gatk/). GATK performs SNP discovery and probabilistic genotype calling across all samples simultaneously, which is a more accurate than individual-based SNP calling. Namely, we used HaplotypeCaller module to call variants per individual with respect to its ploidy level (i.e., using the ploidy = 4 option which enables calling full tetraploid genotypes). Then we aggregated variants across all individuals by module GenotypeGVCFs. We retrieved SNP data for sites corresponding to the called RAD loci from a set of genome resequencing data of an additional 11 populations (mapped to the same reference and scored in the same way as described above, sequences available at Sequence Read Archive, SRA, code PRJNA484107). To do so, we extracted coordinates of the RAD loci, i.e. variant and invariant sites that were called in at least 30 % of individuals. Using these coordinates, we extracted the same sites from the filtered genomic vcf and combined both vcfs into a single file (CombineVariants). This merged raw vcf file containing the final set of 200 individuals from 57 populations was further filtered as follows: using GATK, we retained only biallelic sites that mapped to nuclear chromosome scaffolds with a minimum mapping quality of 40, which did not show mapping quality bias for the reads supporting the non-reference allele (keeping

only variants with mapping quality rank sum test value higher than -12.5) and which were present in at least 80 % of our individuals at a sequencing depth of 8× or greater. In addition, we excluded potentially paralogous sites by masking genes that showed excess heterozygosity in a set of genome-resequenced populations from throughout the range of *A. arenosa*. We also masked sites that had excess read depth that we defined as 1.6× the second mode of the read depth distribution in the same genomic dataset.

Methods S3: Coalescent simulations

We inferred the likely scenario of the origin of alpine populations using coalescent simulations performed in *fastsimcoal* v.26. We aimed to discriminate between single versus parallel origins of alpine ecotype, optionally assuming gene flow between ecotypes within each region, using population quartets involving one alpine and one foothill population from two regions. This strategy gave us four scenarios to test (single origin vs. parallel origin each with or without bi-directional between-ecotype admixture, see Fig. 1C), each of which was compared with observed data gathered for all six possible pairs of regions occupied by tetraploid populations, i.e. six quartets of populations from NT-RD, NT-FG, NT-ZT, RD-FG, RD-ZT, FG-ZT regions (i.e., 24 sets of simulations in total) and a pair of spatially closest diploids and tetraploids (VT-ZT). In order to keep the number of simulations realistic, the quartets involving diploids (VT) and other tetraploid regions were not simulated, as single origin of the tetraploid cytotype inferred previously makes origin of alpine tetraploids via independent polyploidisation from alpine VT diploids very unlikely.

Each model was fit to a multi-dimensional allele frequency spectrum calculated from putatively neutral four-fold degenerate SNPs. To gather robust allele frequency spectra, we acquired genome-wide SNP variation from a subset of sufficiently sampled populations (genome resequencing data, 8 individuals per population, 176,000 – 417,000 SNPs per population; Table S2), one alpine and one foothill per each region. We used populations for which genome resequencing data were available from a previous range-wide study (Monnahan et al. 2019, PRJNA484107) and complemented them with newly sequenced data (SRA project SUB6592572; see Table S2 for details). We extracted the four-fold degenerated SNPs (inferred based on *A. lyrata* annotation) using custom python scripts available at https://github.com/mbohutinska/ScanTools_ProtEvol, the allele frequency spectra, stored in *.dsfs files, are attached as Supplementary data file S1. Read trimming, mapping, variant calling and filtration was performed as described above for RADseq data.

For each scenario and population quartet, we performed 50 independent fastsimcoal runs to overcome local maxima in the likelihood surface. We used wide range of initial parameters (effective population size, divergence times, migration rates; see the example *.est and *.tpl files provided in the Supplementary data file S1) and assumed mutation rate of 4.3e-8 inferred for *A. arenosa* previously (Arnold et al., 2015). We then extracted the best likelihood partition for each fastsimcoal run, calculated Akaike information criterion (AIC) and summarized them across the 50 different runs. The scenario with consistently lowest AIC values within particular population quartet was preferred (Fig. S3).

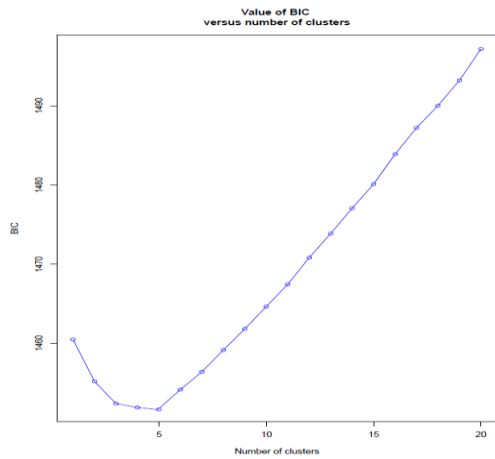


Fig. S1 Selection of plausible number of clusters (K) in K-means clustering of SNP data. Bayesian information criterion (BIC) of K-means groupings from K=1 to K=20 summarized over 1000 random starts.

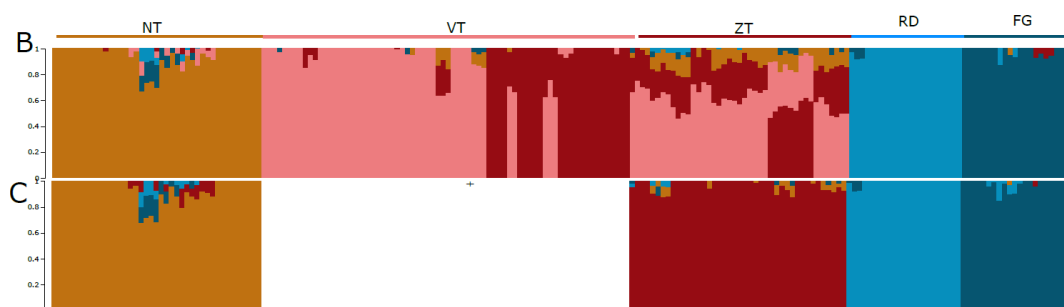
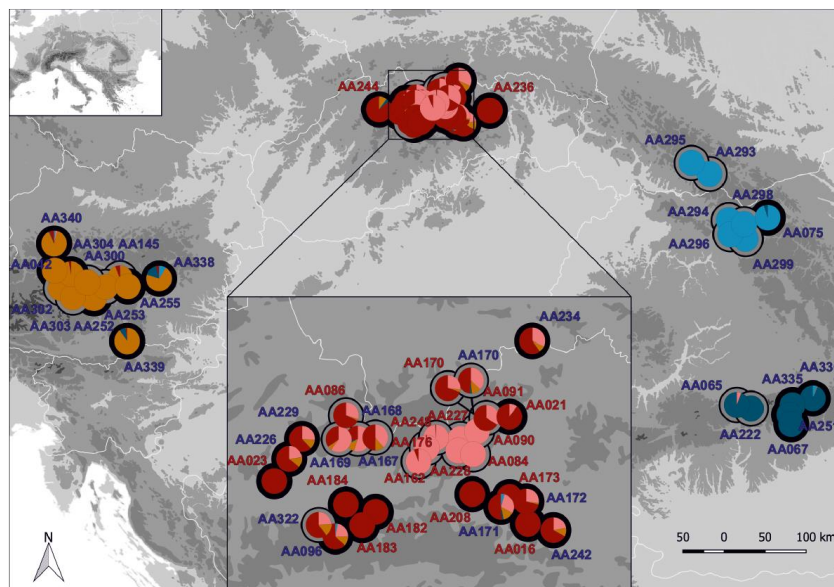


Fig. S2 Genetic structure of alpine and foothill *Arabidopsis arenosa* identified by FastStructure. (A) Geographic distribution of the five genetic groups identified by FastStructure (different colours) and the two altitudinal ecotypes (different shading of circle margins: black = foothill, gray = alpine). Pie charts reflect assignment to different FastStructure groups, population labels are coloured by ploidy level (red = diploid, blue = tetraploid). The inset depicts detailed distribution in the Western Carpathians (a diploid VT and tetraploid ZT groups) (B) Posterior probability of assignment of all sampled *A. arenosa* individuals to the five groups as inferred by FastStructure under K=5. (C) Posterior probability of assignment of the tetraploid *A. arenosa* individuals to the four groups (four tetraploid regions only) as inferred by FastStructure under K=4.

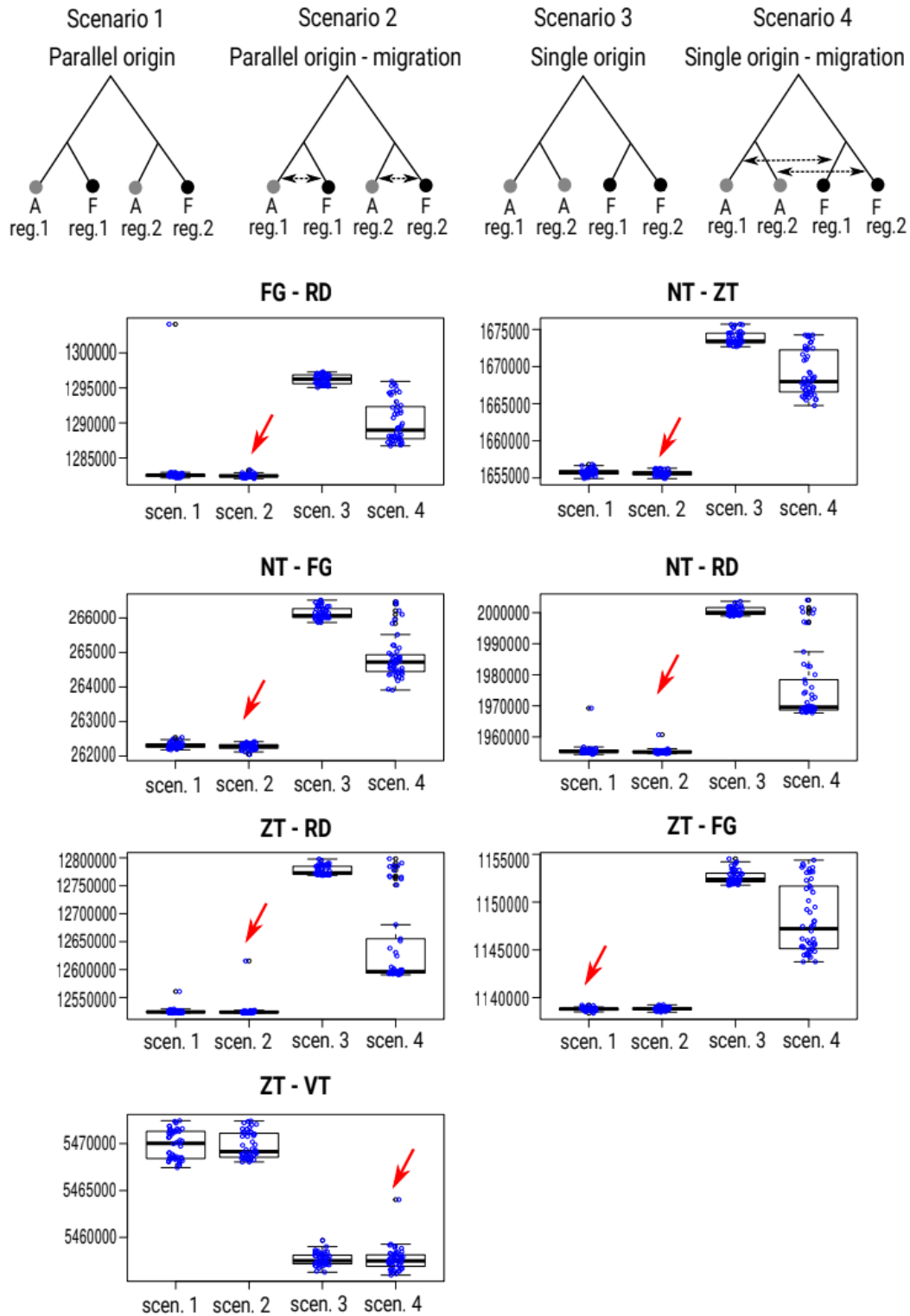


Fig. S3 Comparison of Akaike information criteria (AIC) across four scenarios approximating the origin of the alpine ecotype of *A. arenosa* in pairs of mountain regions. We iterated alpine (A) and foothill (F) pops. from the following regions (reg.): FG, NT, RD, VT and ZT. Each scenario was simulated by 50 fastsimcoal2 independent runs, the corresponding distribution of the AIC values over these 50 runs (blue dots) is summarized by the boxplots. Red arrow highlights the most likely scenario with the lowest median AIC values. The topologies of the evaluated scenarios are depicted above the corresponding plots, black dot = foothill pop. (F), grey dot = alpine pop. (A).

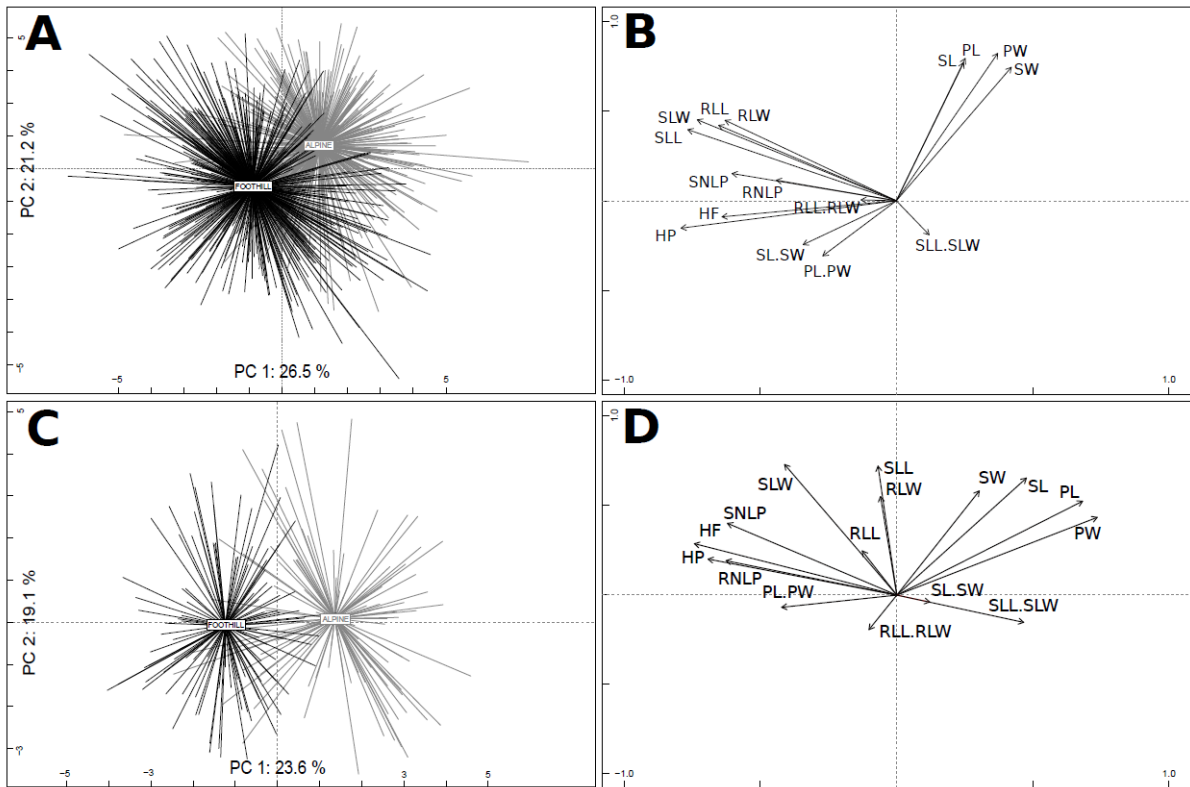
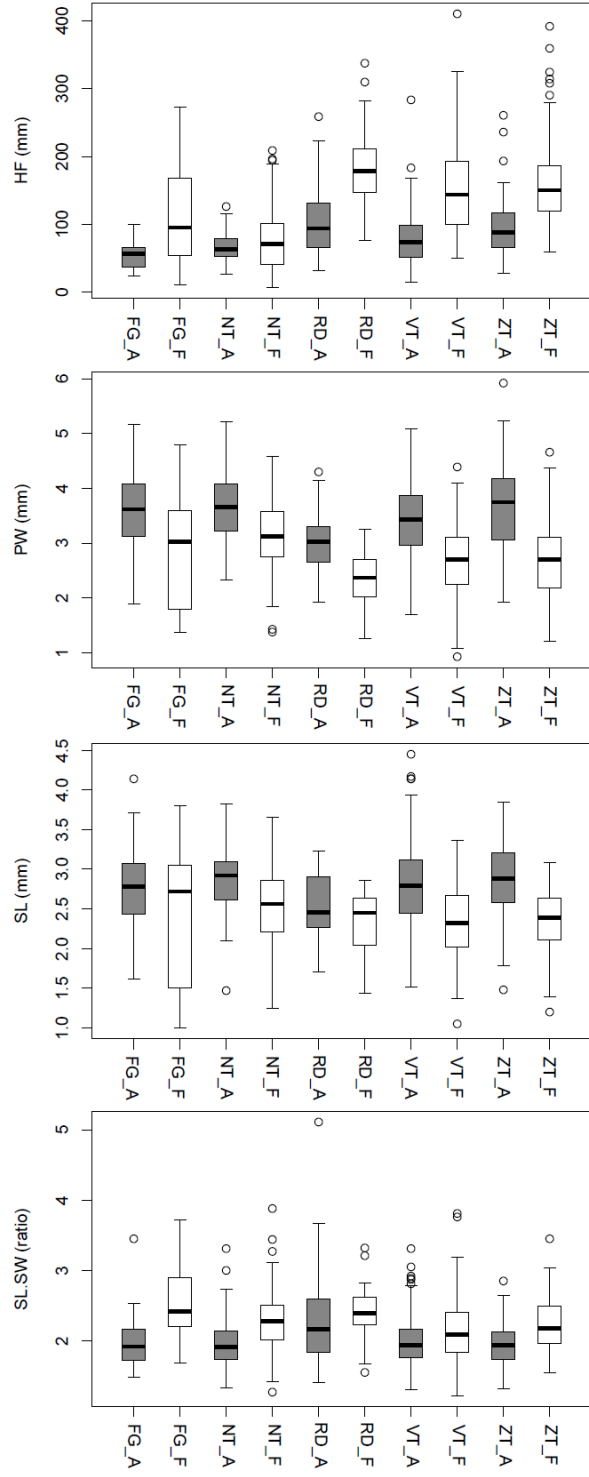
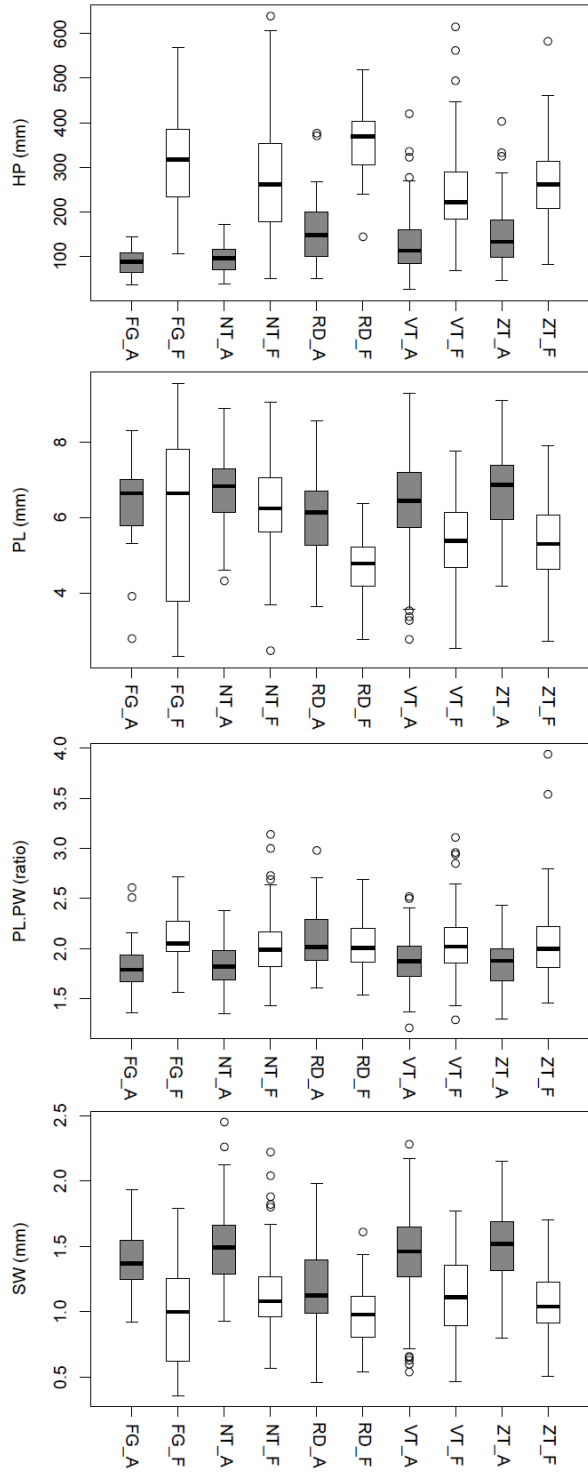


Fig. S4 Morphological differentiation among foothill (black) and alpine (gray) individuals. Principal component analysis was run using 16 morphological traits based on (A, B) 999 individuals collected in field in five regions; (C, D) 223 individuals from the common garden experiment originating from four regions. Contribution of morphological characters for (B) plants collected in the field (D) plants from common garden experiment.



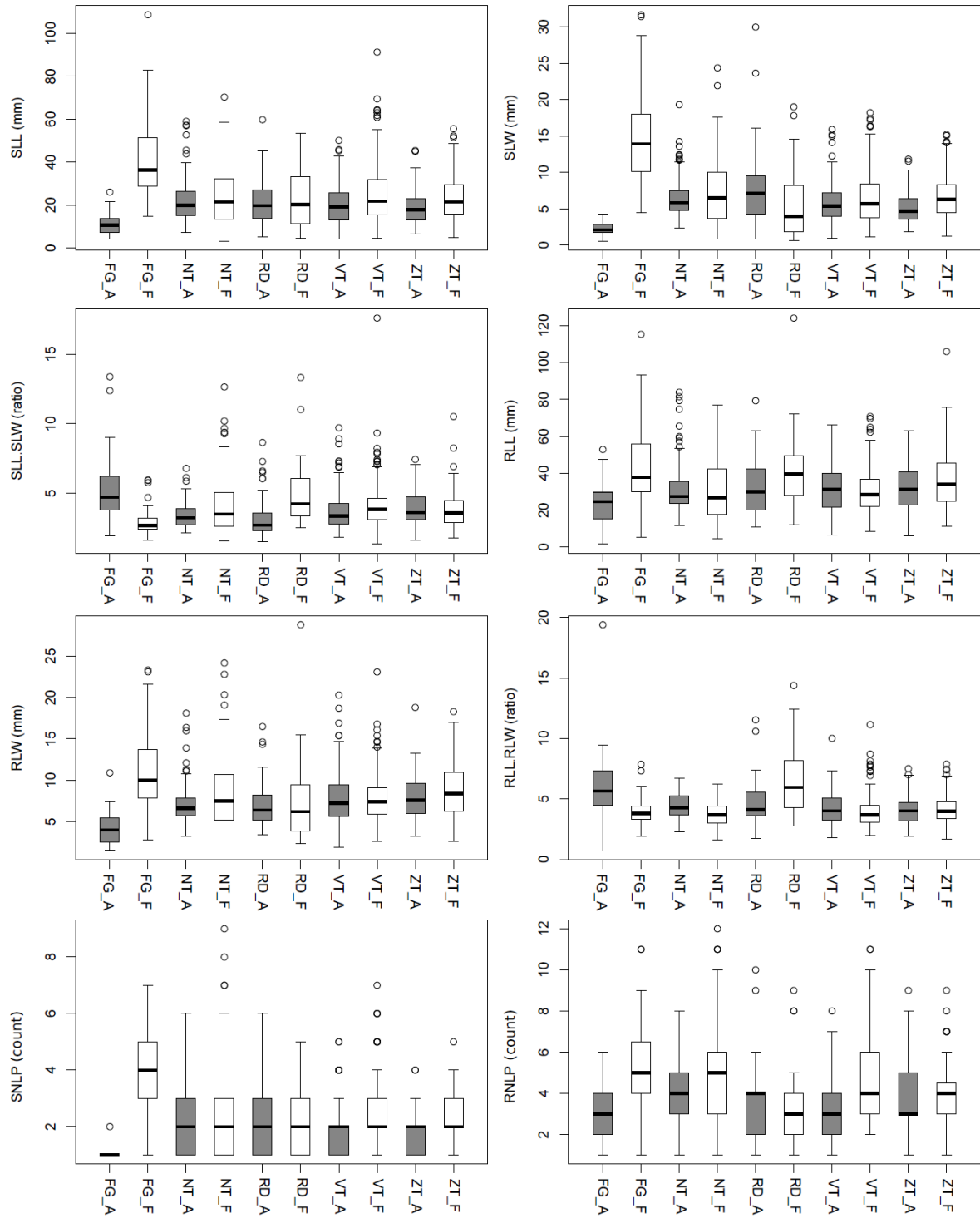


Fig. S5 Distribution of trait values in foothill (F, white) and alpine (A, gray) groups of *A. arenosa* plants sampled in field in the five regions (FG, NT, RD, VT, ZT). Original values are provided in a Supplementary data file S3.

Table S1 Details on ploidy, sampling location, habitat and genetic diversity of all populations sampled for the study.

Population code	Ecotype	Region	Ploidy	Kmeans_group	N_morphology (field)	N genetic	Common Garden experiment	State	Locality	Collected	Latitude	Longitude	Elevation	Genetic diversity	Soil pH
AA016	F	VT	2x	4	20	8	15	SK	Košický kraj: Podlesok, rocks in the entrance to Suchá Belá gorge, limestone rocks	E. Závěská, J. Kučera, F. Kolář	48.9603	20.3833	600	0.051	7.82
AA021	F	VT	2x	4	20	3		SK	Prešovský kraj: Tatranská kotlina, rocks next to the entrance to Belianska jaskyňa cave, slopes and limestone rocks in mixed forest	E. Závěská, F. Kolář	49.2289	20.3117	900		7.26
AA023	F	VT	2x	4	19	2		SK	Žilinský kraj: Bešeňová, travertine rock 1 km NNE from the church in the village, travertine rock	E. Závěská, F. Kolář	49.1073	19.4347	574		7.28
AA042	F	NT	4x	2	20	3		AT	Steiermark: Öblarn, slopes of valley of Walchenbach S of the village, rocky valley	F. Kolář	47.4508	14.0064	713		7.52
AA065	A	FG	4x	3	15	4 (BAL)	13	RO	Argeş: Făgăraş Mts, slopes above lake Balea, close to Transfăgăraş road, alpine scree	F. Kolář, G. Šrámková	45.602	24.6226	2269		5.58
AA067	F	FG	4x	3	20	4 (DRA)	13	RO	Argeş: Dâmbovicioara, river canyon W of the village, shady rocks in a canyon	F. Kolář, G. Šrámková	45.4416	25.2239	858	0.046	7.65
AA075	F	RD	4x	1	15	4		RO	Suceava: Cărlibaba, rocky slope above the road to Borşa, W of the village, shady rocks, eroded slope	F. Kolář, G. Šrámková	47.5759	25.0771	981	0.058	7.56
AA084	A	VT	2x	5	20	4 (VEL)	8	SK	Prešovský kraj: Vysoké Tatry, wet rocks and gravel in Velická Dolina ravine, between Sliezsky dom chalet and Dlhé pleso lake, alluvial gravel, wet rocks	F. Kolář, E. Závěská, S. Španiel, M. Kolník, K. Marhold	49.162	20.1542	1823	0.048	5.23
AA086	A	VT	2x	4	12	2		SK	Žilinský kraj: Zuberec, Zverovka, limestone rocks at the top of Osobitá mountain, exposed rocks, gravel	F. Kolář, E. Závěská, S. Španiel, M. Kolník, K. Marhold	49.2593	19.7218	1552		6.11
AA090	A	VT	2x	5	17	4	11	SK	Prešovský kraj: Vysoké Tatry, screes and rocks above the Zelené pleso lake up to Medený vodopád waterfall and Dlhý vodopád waterfall, scree, wet rocks	F. Kolář, E. Závěská, S. Španiel, M. Kolník, K. Marhold	49.2065	20.2151	1625	0.048	5.53

AA091	A	VT	2x	4	20	3		SK	Prešovský kraj: Ždiar, Belianské Tatry, along blue tourist path in Kopské sedlo pass, exposed rocks, eroded slope	F. Kolář, E. Záveská, S. Španiel, M. Kolník, K. Marhold	49.2299	20.219	1751		7.14
AA096	F	ZT	4x	4	19	4		SK	Žilinský kraj: Nízke Tatry, Liptovský Ján, Jánska dolina valley, S of the village, alluvial gravel, eroded slope above road	F. Kolář, S. Španiel, M. Kolník, K. Marhold; J. Mořkovská	49.0108	19.6733	744	0.045	7.15
AA145	A	NT	4x	2	19	3		AT	Steiermark: Niedere Tauern, valley and rocks along the trekking path towards Gamskogel mountain, moist valley (with Petasites sp.) and rocks	E. Záveská, S. Španiel	47.3733	14.554	1752		NA
AA162	A	VT	2x	5	20	2		SK	Prešovský kraj: Vysoké Tatry, Mlynická dolina valley, Skok waterfall, wet rocks, alluvial gravel	F. Kolář, M. Lučanová, K. Marhold, J. Smatanová, J. Mořkovská	49.1534	20.0458	1750		5.66
AA167	A	ZT	4x	4	16	3		SK	Žilinský kraj: Pribylina, Račkova dolina valley and Račkove plesá lakes, open places in grasslands disturbed by marmots	M. Lučanová, K. Marhold	49.2	19.8047	1690		5.16
AA168	A	ZT	4x	5	12	4 (TKO)	14	SK	Žilinský kraj: Zuberec, Zverovka, rocky slopes above Horné Rohácke pleso lake and on N slopes of Tri Kopy mountain, wet rocks, screes	F. Kolář, K. Marhold	49.2045	19.7352	1783	0.052	4.83
AA169	A	ZT	4x	5	12	3	15	SK	Žilinský kraj: Vysoké Tatry, northern rocky slopes under the Baníkovské sedlo saddle, wet rocks	M. Lučanová, J. Smatanová, J. Mořkovská	49.2012	19.7084	1864		5.31
AA170_2	A	VT	2x	4	28	4 (TRD)		SK	Prešovský kraj: Žiar, Tristárska dolina valley, open gravely sites, screes	F. Kolář, M. Lučanová, K. Marhold, J. Smatanová, J. Mořkovská	49.2502	20.2053	1650	0.051	6.31
AA170_4	A	ZT	4x	4	20	4 (TRT)		SK	Prešovský kraj: Žiar, Tristárska dolina valley, open gravely sites, screes	F. Kolář, M. Lučanová, K. Marhold, J. Smatanová, J. Mořkovská	49.2502	20.2053	1809	0.05	7.51
AA171	F	ZT	4x	4	19	4	15	SK	Prešovský kraj: Hranovnica, slopes above the road to Poprad town, S of the Kvetnica village, rocky eroded slope above the road and open oak forest	F. Kolář, M. Lučanová, J. Mořkovská	49.0072	20.2864	720	0.057	6.46
AA172	F	ZT	4x	4	20	3		SK	Prešovský kraj: Primovce, Primovské skaly rocks in the village, shady rocks	F. Kolář, M. Lučanová, J. Mořkovská	49.0159	20.3825	605		5.39
AA173	F	VT	2x	4	17	3		SK	Prešovský kraj: Gánovce, travertine outcrop in the village, exposed rocks	F. Kolář, M. Lučanová, J. Mořkovská	49.0299	20.3207	664		7.29

AA176	A	VT	2x	5	17	3		SK	Prešovský kraj: Vysoké Tatry, Mengusovská dolina valley, Veľké Hincovo pleso lake, open moist gravelly patches, lake shore	F. Kolář	49.1756	20.0605	1950		6.01
AA182	F	VT	2x	4	20	3		SK	Žilinský kraj: Kráľova Lehota, rock above Čierny Váh river, exposed dry rock	K. Marhold, J. Smatanová; J. Mořkovská	49.0153	19.8111	670		6.94
AA183	F	VT	2x	4	20	4		SK	Žilinský kraj: Malužiná, slope above road to the quarry, eroded slope	K. Marhold, J. Smatanová; J. Mořkovská	48.9845	19.7573	735	0.045	7.24
AA184	F	VT	2x	4	19	3		SK	Žilinský kraj: Liptovský Hrádok, slopes above Čierny Váh river, near Borová Sihot' spring, eroded slope	K. Marhold, J. Smatanová; J. Mořkovská	49.0386	19.7005	624		7.21
AA208	F	VT	2x	4	38	8	14	SK	Prešovský kraj: Svit, Baba hill, SE slopes, forest clearing in pine forest	J. Mořkovská, J. Smatanová	49.0435	20.1808	844	0.05	7.54
AA220	F	RD	4x	NA	12	0		RO	Bistrita-Năsăud: Parva, slopes above the road in a deep valley of Rebra brook at N margin of the village, open sites above road in deciduous forest	F. Kolář, M. Bohutínská	47.4024	24.5461	545		6.09
AA222	A	FG	4x	3	16	4 (LAC)	15	RO	Argeş: Făgăraş Mts., slopes above path from second bend of the Transfăgăraşan road S of the tunnel to Lacul Capra lake, calcareous rocks and scree	F. Kolář, M. Bohutínská	45.5954	24.6346	2092	0.042	7.5
AA226	F	ZT	4x	4	12	3		SK	Žilinský kraj: Prosiek, transect through Prosiecka dolina valley, N of the village, semi-shady rocks in a gorge	J. Mořkovská	49.16	19.4962	656		7.19
AA227	A	VT	2x	5	21	2		SK	Prešovský kraj: Vysoké Tatry, ca 300 meters E of Prielom saddle, along the blue marked tourist path, alpine scree	J. Mořkovská	49.1762	20.15	2070		6.94
AA228	A	VT	2x	5	17	3		SK	Prešovský kraj: Vysoké Tatry, north facing slope below Pod Polskym hrebeňom saddle, along tourist path, rocks	J. Mořkovská	49.1738	20.1391	2147		5.19
AA229	F	ZT	4x	4	15	4	15	SK	Žilinský kraj: Hutý, rocks in the entrance to Kvačianska dolina gorge, limestone rocks	E. Záveská, J. Kučera, F. Kolář	49.2076	19.5494	750	0.038	7.17
AA234	F	ZT	4x	4	19	4		SK	Prešovský kraj: Lesnica, N facing slopes of the Dunajec river canyon 1.5 km NW of the village, shady rocks in beech forest	F. Kolář, G. Šrámková, J. Smatanová	49.4117	20.4488	437	0.044	7.26
AA236	F	VT	2x	4	19	4		SK	Prešovský kraj: Lipovce, at the lowest waterfall in Kamenná Baba gorge, 1.5 km W of the village, shady limestone rocks	F. Kolář, G. Šrámková, J. Smatanová	49.0589	20.9306	659	0.042	6.82
AA242	F	ZT	4x	4	20	3		SK	Košický kraj: Spišská Nová Ves - Čingov, N facing slopes above Hornád river, 500 m WSW of the settlement, shady north-facing rock	J. Mořkovská, K. Marhold, S. Španiel, J. Smatanová	48.9402	20.4774	530		7.29

AA244	F	VT	2x	4	12	3		SK	Žilinský kraj: Šútovo, small limestone hill at E margin of the village, rocky and gravelly sunny slope	F. Kolář, A. Knotek, G. Šrámková	49.15197	19.085165	480		7.41
AA248	A	VT	2x	5	4	4		SK	Prešovský kraj: Rysy mountain, just below the summit, rocky outcrop near the summit	M. Bohutínská	49.1795	20.0881	2488	0.041	5.43
AA251	F	FG	4x	3	14	3	15	RO	Argeş: Dâmbovicioara, river canyon S of the village, gravel along the road, most likely secondary habitat, not on the rocks only below them in the gravel	E. Závěská	45.4267	25.2133	915		8.3
AA252	F	NT	4x	2	19	3	15	AT	Steiermark: Schönberg-Lachtal, along a road L 514, ca 600 m N of of Hocheggerstraße and Glattojoch Straße junction, gravel and stones along the road	F. Kolář, M. Hanzl, E. Závěská, S. Španiel	47.1826	14.3379	856		8.02
AA253	A	NT	4x	2	21	4 (SCH)	15	AT	Steiermark: Niedere Tauern, Schießbeck mountain, N exposed rocky slopes, screes and rocks, quartzite	F. Kolář, M. Hanzl, S. Španiel	47.2777	14.3219	2240	0.033	6.7
AA254	A	NT	4X	NA	0	0	15	AT	Steiermark: Seckauer Alpen: Hochreichart, northwestern crest, stabilized amphibolite screes	P. Schönswetter	47.36444	14.68083	2360		NA
AA255	F	NT	4x	2	20	4	15	AT	Steiermark: Seckauer Alpen, lower-most Ingeringgraben, 1.6 km NNW of Wasserberg castle, Ingeringbach valley, siliceous rocks	P. Schönswetter	47.2842	14.6819	970	0.052	4.72
AA293	A	RD	4x	1	4	3		UA	Zakarpatská oblast: Dragobrat, bellow the top of Blyznytsya mountain, S slope, in glacial cirque, 70 - 100 vertical meters above Ivor lakes, limestone in glacial cirque	M. Bohutínská, J. Hojka, D. Bohutínský, F. Rooks	48.2286	24.2323	1614		5.44
AA294	A	RD	4x	1	4	3		RO	Maramureş: Borşa, around the entrance to glacial cirque at E slopes of Pietrosul Rodnei mountain, along the dirt road, 5.7 km SSW of the town, rocky slope with sparse vegetation	F. Kolář, M. Bohutínská	47.6031	24.6488	1780		6.98
AA295	A	RD	4x	1	12	3		UA	Zakarpatská oblast: Svidovec, Gerisaska mountain, upper part of the glacial cirque (below the rocks) on the eastern slope, rocks and scree in glacial cirque	J. Chrtěk, K. Kabátová	48.2722	24.1623	1702		6.38
AA296	A	RD	4x	1	10	3		RO	Maramureş: Borşa, rocks at the NW facing slopes of glacial cirque at E slopes of Pietrosul Rodnei mountain, 6 km SSW of the town, rocky crevices	F. Kolář, M. Bohutínská	47.5977	24.6469	1820		5.15
AA298	A	RD	4x	1	18	4		RO	Maramureş: Borşa, NW slopes of Vârful Ciungilor mountain, in Bila stream and on the rock above spring of the stream, limestone	M. Bohutínská, J. Hojka, D. Bohutínský, F. Rooks	47.5393	24.8868	1586	0.06	6.63
AA299	A	RD	4x	1	10	2		RO	Maramureş: Borşa, NW slope of the NW glacial cirque bellow Ineu peak, glacial cirque	M. Bohutínská, J. Hojka, D. Bohutínský, F. Rooks	47.5273	24.8806	2017		7.12

AA300	A	NT	4x	2	18	4		AT	Steiermark: Pusterwald, shores of Wildsee lake below Eiskarspitz mountain, snowbed in a glacial cirque	F. Kolář, A. Knotek, S. Španiel, P. Schönschwetter, K. Hülber	47.3256	14.2304	2117	0.056	6.02
AA302	A	NT	4x	2	17	3		AT	Steiermark: Krakaudorf, screes in Sauoffensee glacial cirque, W of the lake, wet rocks and scree slope below	F. Kolář, P. Schönschwetter, K. Hülber	47.2586	14.0103	2184		6.16
AA303	A	NT	4x	2	20	2		AT	Steiermark: Krakaudorf, slope above Sauoffensee lake, stony snowbed slope	A. Knotek, S. Španiel	47.2588	14.0049	2030		5.54
AA304	F	NT	4x	2	20	3		AT	Steiermark: Aigen, rocks in Gullingtal valley, next to the bridge W of a quarry, rocks	F. Kolář, A. Knotek, S. Španiel	47.4936	14.1722	800		7.74
AA322	A	ZT	4x	4	20	3		SK	Nizke Tatry: NE slope between Krakova hola mountain and Pusté mountain, rocky sites in forest clearing	J. Mořkovská	48.9919	19.623	1472		7.07
AA330	F	FG	4x	3	13	4		RO	Brasov: Timisu de Sus, rocks above railway, ca 5 km NNE of the village, shady rocks, travertine spring	F. Kolář, M. Bohutínská, D. Požárová, F. Rooks	45.57	25.6083	797	0.063	8
AA335	F	FG	4x	3	20	3		RO	Brasov: Zărnești, narrowest part of Prăpăștiile Zărneștilor gorge, 5.5 km SW of the railway station in the town, rocks in the gorge	F. Kolář, M. Bohutínská, D. Požárová, F. Rooks	45.5253	25.2812	978		6.76
AA338	F	NT	4x	2	20	4 (HOC)		AT	Steiermark: Mautstatt, Calcareous rocks and screes near road and railroad, ca 4 km NE from the village, calcareous rocks and bank between railroad and small river	A. Knotek; D. Požárová	47.37	15.3867	560	0.044	7.61
AA339	F	NT	4x	2	18	4 (KAS)		AT	Kärnten: Sankt Paul im Lavanttal, castle ruin Rabenstein, circa 2 km S from the town, rocks and walls of castle ruins	A. Knotek; D. Požárová	46.6883	14.8717	620	0.045	7.98
AA340	F	NT	4x	2	20	4 (KOS)		AT	Oberösterreich: Mitterweißenbach, Kesselbach stream riverbank near the road from Bad Ischl to Ebensee, calcareous river bank	A. Knotek; D. Požárová	47.7469	13.6897	460	0.048	8.42

Table S2 Details on diversity and accession codes of genome resequenced populations used for coalescent simulations

pop code	Region	Ecotype	N indivs	N all sites called	N SNPs	Genetic diversity (π)	original code	BioSample codes (SRA)
AA300	NT	Alpine	8	3939154	361293	0.0267	WIL	SAMN13420543-50
AA339	NT	Foothill	8	2920550	262141	0.0255	KOS	SAMN09759803-09
AA065	FG	Alpine	8	3950174	349273	0.0260	BAL	SAMN13420559-66
AA067	FG	Foothill	8	2218553	176496	0.0213	DRA	SAMN09759740-47
AA299	RD	Alpine	8	3925916	417156	0.0286	INE	SAMN13420575-81
AA075	RD	Foothill	8	3917955	409493	0.0213	CAR	SAMN13420582-89
AA168	ZT	Alpine	8	3723199	354763	0.0285	TKO	SAMN09759921-28
AA171	ZT	Foothill	8	3918890	400976	0.0275	HRA	SAMN13420590-97
AA084	VT	Alpine	8	3447202	239213	0.0234	VEL	SAMN09759960-67
AA016	VT	Foothill	8	3915391	317662	0.0267	SUB	SAMN13420527-34

Table S3 Pearson pairwise correlation coefficients between the environmental parameters (upper) and morphological characters (lower) used in the analyses.

Ecology	PAR	Precipitation	Temperature	EIV_Moisture	EIV_Nutrients	soil_ph	EIV_Light	Veget_cover								
PAR		-0.69	0.54	-0.39	0.15	0.29	-0.15	0.14								
Precipitation	-0.69		-0.65	0.20	-0.45	-0.40	0.47	-0.26								
Temperature	0.54	-0.65		-0.33	0.54	0.61	-0.56	0.26								
EIV_Moisture	-0.39	0.20	-0.33		0.44	-0.10	-0.28	-0.13								
EIV_Nutrients	0.15	-0.45	0.54	0.44		0.44	-0.78	0.18								
soil_ph	0.29	-0.40	0.61	-0.10	0.44		-0.34	0.17								
EIV_Light	-0.15	0.47	-0.56	-0.28	-0.78	-0.34		-0.12								
Vegetation cover	0.14	-0.26	0.26	-0.13	0.18	0.17	-0.12									
Morphology																
HP	HP	HF	PL	PW	PL.PW	SL	SW	SL.SW	SLL	SLW	SLL.SLW	RLL	RLW	RLL.RLW	SNLP	RNLP
HP		0.69	-0.21	-0.28	0.17	-0.25	-0.36	0.24	0.50	0.43	0.05	0.41	0.37	0.12	0.41	0.30
HF	0.69		-0.24	-0.26	0.11	-0.18	-0.21	0.10	0.37	0.26	0.06	0.33	0.23	0.18	0.28	0.17
PL	-0.21	-0.24		0.80	-0.03	0.72	0.55	-0.02	0.09	0.10	-0.04	0.13	0.15	-0.03	-0.03	0.01
PW	-0.28	-0.26	0.80		-0.55	0.64	0.62	-0.19	0.01	0.03	-0.07	0.06	0.09	-0.04	-0.09	-0.03
PL.PW	0.17	0.11	-0.03	-0.55		-0.07	-0.28	0.30	0.08	0.05	0.09	0.07	0.05	0.01	0.08	0.06
SL	-0.25	-0.18	0.72	0.64	-0.07		0.71	0.03	0.05	0.07	-0.04	0.13	0.15	-0.02	-0.02	0.00
SW	-0.36	-0.21	0.55	0.62	-0.28	0.71		-0.64	-0.05	-0.06	-0.06	0.03	0.03	0.00	-0.11	-0.10
SL.SW	0.24	0.10	-0.02	-0.19	0.30	0.03	-0.64		0.13	0.16	0.03	0.09	0.11	-0.02	0.14	0.16
SLL	0.50	0.37	0.09	0.01	0.08	0.05	-0.05	0.13		0.80	0.08	0.64	0.67	0.03	0.43	0.27
SLW	0.43	0.26	0.10	0.03	0.05	0.07	-0.06	0.16	0.80		-0.40	0.53	0.58	-0.02	0.56	0.29
SLL.SLW	0.05	0.06	-0.04	-0.07	0.09	-0.04	-0.06	0.03	0.08	-0.40		0.03	-0.03	0.10	-0.31	-0.05
RLL	0.41	0.33	0.13	0.06	0.07	0.13	0.03	0.09	0.64	0.53	0.03		0.77	0.39	0.25	0.26
RLW	0.37	0.23	0.15	0.09	0.05	0.15	0.03	0.11	0.67	0.58	-0.03	0.77		-0.20	0.28	0.25
RLL.RLW	0.12	0.18	-0.03	-0.04	0.01	-0.02	0.00	-0.02	0.03	-0.02	0.10	0.39	-0.20		-0.05	-0.01
SNLP	0.41	0.28	-0.03	-0.09	0.08	-0.02	-0.11	0.14	0.43	0.56	-0.31	0.25	0.28	-0.05		0.46
RNLP	0.30	0.17	0.01	-0.03	0.06	0.00	-0.10	0.16	0.27	0.29	-0.05	0.26	0.25	-0.01	0.46	

Table S4 Average values of traits in foothill and alpine groups of *A. arenosa* plants sampled in field and in common garden experiment. The measurements are provided in a Supplementary data file S3.

Traits	Description	Category	Unit	Field data		Common garden data	
				Alpine	Foothill	Alpine	Foothill
HP	Height of the main stem	stem	mm	125.05	269	114	185
HF	Distance from the rosette to the lowest flower	stem	mm	79.73	130.57	64.3	117.1
PL	Petal length	flower	mm	6.465	5.653	6.52	5.434
PW	Petal width	flower	mm	3.475	2.815	3.55	2.668
PL.PW	Ratio Petal length / width	flower	mm	1.887	2.047	1.85	2.09
SL	Sepal length	flower	mm	2.796	2.404	2.68	2.441
SW	Sepal width	flower	mm	1.428	1.093	1.14	1.067
SL.SW	Ratio Sepal length / width	flower	mm	2.014	2.264	2.41	2.332
SLL	Stem leaf length	leaf	mm	19.96	26.49	14.6	14.606
SLW	Stem leaf width	leaf	mm	5.897	7.649	4.57	5.261
SLL.SLW	Ratio Stem length / width	leaf	mm	3.721	3.943	3.35	2.944
RLL	Rosette leaf length	leaf	mm	31.65	34.36	26.6	23.401
RLW	Rosette leaf width	leaf	mm	7.385	8.647	5.58	5.405
RLL.RLW	Ratio Rosette length / width	leaf	mm	4.43	4.082	4.86	4.511
SNLP	Stem leaf number of lobe pairs	leaf lobes	count	1.865	2.585	1.6	2.914
RNLP	Rosette leaf number of lobe pairs	leaf lobes	count	3.488	4.484	4.81	6.862

Table S5 Genetic and morphological diversity and differentiation of foothill and alpine populations of *A. arenosa* categorized according to four regions (treating VT and ZT regions together).

Grouping	Genetic data			Morphological data from field			Morphological data from common garden		
	N ¹	AMOVA (%) ²	Gen. diversity (π) ³	N ¹	Classif. ⁴	Differentiation ⁵	N ¹	Classif. ⁴	Differentiation ⁵
Grouping by region (4 regions)									
all pops.	200	19	0.048	999	48	6.81*** (2.01%)	223	58	5.04** (4.38%)
Foothill	109	21	0.049	559	70	16.58*** (8.23%)	117	68	9.00*** (13.6%)
Alpine	91	28	0.048	440	53	13.97*** (8.77%)	106	73	17.2*** (25%)
Grouping by ecotype									
VT+ZT	115	7	0.047 / 0.049	584	88	30.41*** (4.97%)	107	94	53.7*** (33.8%)

¹ N individuals

² Among-group genetic variation component (in %) as explained by hierarchical AMOVA

³ Pairwise nucleotide diversity (π) averaged over populations with ≥ 4 individuals (foothill / alpine ecotypes, respectively)

⁴ % of correct classification into ecotype / regional group as inferred by classificatory discriminant analysis of the 16 morphological characters

⁵ F-values and significance (*P < 0.05, **P < 0.01, ***P < 0.001) of permanova analysis of the 16 morphological characters

Table S6 Analysis of molecular variance (AMOVA) reflecting regional and ecotypic clustering of *A. arenosa* in total and within each region separately.

Grouping	dataset	SSD	MSD	% explained variance	d.f.	p
Grouping by region (5 regions: NT, VT, ZT, RD, FG)						
Regional group	all pops	0.0177	0.0044	19.60	4	< 0.001
Populations within regional group	all pops	0.0359	0.0007	39.74	52	< 0.001
Individuals within population	all pops	0.0367	0.0003	40.66	143	
Total	all pops	0.0904	0.0005	100.00	199	
Grouping by region (5 regions: NT, VT, ZT, RD, FG)						
Regional group	foothill pops	0.0111	0.0028	22.89	4	< 0.001
Populations within regional group	foothill pops	0.0156	0.0007	32.10	24	< 0.001
Individuals within population	foothill pops	0.0219	0.0003	45.01	80	
Total	foothill pops	0.0486	0.0005	100.00	108	
Grouping by region (5 regions: NT, VT, ZT, RD, FG)						
Regional group	alpine pops	0.0116	0.0029	29.80	4	< 0.001
Populations within regional group	alpine pops	0.0125	0.0005	32.04	23	< 0.001
Individuals within population	alpine pops	0.0148	0.0002	38.16	63	
Total	alpine pops	0.0389	0.0004	100.00	90	
Grouping by region (4 regions: NT, VT+ZT, RD, FG)						
Regional group	all pops	0.0174	0.0058	19.24	3	< 0.001
Populations within regional group	all pops	0.0362	0.0007	40.1	53	< 0.001
Individuals within population	all pops	0.0367	0.0003	40.66	143	
Total	all pops	0.0904	0.0005	100	199	
Grouping by region (4 regions: NT, VT+ZT, RD, FG)						
Regional group	foothill pops	0.0102	0.0034	20.87	3	< 0.001
Populations within regional group	foothill pops	0.0166	0.0007	34.12	25	< 0.001
Individuals within population	foothill pops	0.0219	0.0003	45.01	80	
Total	foothill pops	0.0486	0.0005	100	108	
Grouping by region (4 regions: NT, VT+ZT, RD, FG)						
Regional group	alpine pops	0.0108	0.0036	27.9	3	< 0.001
Populations within regional group	alpine pops	0.0132	0.0005	33.94	24	< 0.001
Individuals within population	alpine pops	0.0148	0.0002	38.16	63	
Total	alpine pops	0.0389	0.0004	100	90	
Grouping by ecotype						
Elevational group	all pops	0.0028	0.0028	3.12	1	< 0.001
Populations within elevational group	all pops	0.0508	0.0009	56.22	55	< 0.001
Individuals within population	all pops	0.0367	0.0003	40.66	143	
Total	all pops	0.0904	0.0005	100	199	
Grouping by ecotype						
Elevational group	NT region	0.0006	0.0006	4.87	1	0.085
Populations within elevational group	NT region	0.0049	0.0005	42	10	< 0.001
Individuals within population	NT region	0.0062	0.0002	53.13	29	
Total	NT region	0.0117	0.0003	100	40	
Grouping by ecotype						
Elevational group	VT + ZT region	0.0036	0.0036	7.39	1	< 0.001
Populations within elevational group	VT + ZT region	0.0156	0.0005	31.62	30	< 0.001
Individuals within population	VT + ZT region	0.03	0.0004	60.99	83	
Total	VT + ZT region	0.0493	0.0004	100	114	
Grouping by ecotype						
Elevational group	VT region	0.0011	0.0011	2.77	1	0.7393
Populations within elevational group	VT region	0.0178	0.001	45.86	17	< 0.001
Individuals within population	VT region	0.0199	0.0004	51.37	52	

Total	VT region	0.0387	0.0006	100	70	
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Elevational group	ZT region	0.0003	0.0003	3.39	1	0.7972
Populations within elevational group	ZT region	0.0041	0.0004	40.54	11	< 0.001
Individuals within population	ZT region	0.0057	0.0002	56.07	31	
Total	ZT region	0.0102	0.0002	100	43	
<hr/>						
Elevational group	RD region	0.0004	0.0004	6.35	1	0.571
Populations within elevational group	RD region	0.002	0.0004	34.94	5	< 0.001
Individuals within population	RD region	0.0034	0.0002	58.71	15	
Total	RD region	0.0058	0.0003	100	21	
<hr/>						
Elevational group	FG region	0.0006	0.0006	9.19	1	0.121
Populations within elevational group	FG region	0.0016	0.0004	24.97	4	0.043
Individuals within population	FG region	0.0041	0.0003	65.84	16	
Total	FG region	0.0062	0.0003	100	21	

Table S7 Genetic and morphological diversity and differentiation of foothill and alpine populations of *A. arenosa* from the five sampled mountain regions.

	Genetic diversity and differentiation				Field morphology			Common garden morphology		
	N ¹	AMOVA (%) ²	Genetic diversity ³	Pairwise Fst ⁴	N ¹	CDA ⁵ (%)	Differentiation ⁶	N ¹	CDA ⁵ (%)	Differentiation ⁶
Grouping by region										
All populations	200	20	0.048	0.132	999	43	6.43***	223	47	4.00*
Foothill	109	23	0.049	0.120	559	65	14.1***	117	62	6.58***
Alpine	91	30	0.048	0.139	440	48	10.75***	106	75	19.94***
Grouping by ecotype										
All regions	200	3	0.049/0.048		999	89	49.25***	223	83	108.5***
NT (Niedere Tauern)	41	n.s.	0.047/0.045	0.105/0.089	232	100	8.83**	60	63	6.52**
VT (Vysoké Tatry)	73	n.s.	0.047/0.047	0.066/0.068	380	89	17.15***	48	83	60.91***
ZT (Západné Tatry)	42	n.s.	0.046/0.051	0.049/0.045	204	90	16.36***	59	93	17.00***
RD (Rodna)	22	n.s.	0.058/0.060	-/-	85	93	3.42*	-	-	-
FG (Făgăraș)	22	n.s.	0.055/0.042	0.062/0.119	98	100	50.96***	56	95	113.61***

¹ N individuals

² Among-group genetic variation component (in %) as explained by hierarchical AMOVA

³ Pairwise nucleotide diversity (π) averaged over populations with ≥ 4 individuals (foothill / alpine ecotypes, respectively)

⁴ Pairwise Fst averaged over populations with ≥ 4 individuals (foothill / alpine ecotypes, respectively)

⁵ % of correct classification into ecotype / regional group as inferred by classificatory discriminant analysis of the 16 morphological characters

⁶ F-values and significance (*P < 0.05, **P < 0.01, ***P < 0.001) of permanova analysis of the 16 morphological characters

Table S8 Pairwise differentiation (Fst) calculated based on all RAD-sequenced populations with > 4 individuals.

	ecotype	region	ploidy	AA016	AA065	AA067	AA075	AA084	AA090	AA096	AA168	AA170_2	AA170_4	AA171	AA183	AA208	AA222	AA229	AA234	AA236	AA248	AA253	AA255	AA298	AA300	AA330	AA338	AA339	AA340
AA016	F	VT	2x	NA																									
AA065	A	FG	4x	0.16	NA																								
AA067	F	FG	4x	0.17	0.12	NA																							
AA075	F	RD	4x	0.15	0.14	0.13	NA																						
AA084	A	VT	2x	0.13	0.16	0.18	0.17	NA																					
AA090	A	VT	2x	0.14	0.17	0.19	0.17	0.03	NA																				
AA096	F	ZT	4x	0.07	0.14	0.15	0.14	0.1	0.1	NA																			
AA168	A	ZT	4x	0.08	0.13	0.15	0.14	0.05	0.06	0.06	NA																		
AA170_2	A	VT	2x	0.08	0.15	0.17	0.15	0.1	0.11	0.08	0.07	NA																	
AA170_4	A	ZT	4x	0.08	0.13	0.15	0.13	0.07	0.08	0.06	0.04	0.05	NA																
AA171	F	ZT	4x	0.06	0.12	0.13	0.12	0.08	0.08	0.05	0.04	0.07	0.04	NA															
AA183	F	VT	2x	0.06	0.17	0.18	0.16	0.14	0.15	0.06	0.09	0.09	0.09	0.08	NA														
AA208	F	VT	2x	0.04	0.16	0.16	0.14	0.12	0.12	0.06	0.07	0.07	0.06	0.05	0.05	NA													
AA222	A	FG	4x	0.21	0.12	0.17	0.19	0.22	0.23	0.19	0.18	0.21	0.18	0.18	0.22	0.21	NA												
AA229	F	ZT	4x	0.08	0.15	0.16	0.15	0.11	0.11	0.05	0.07	0.09	0.07	0.06	0.08	0.07	0.2	NA											
AA234	F	ZT	4x	0.08	0.15	0.16	0.14	0.09	0.1	0.04	0.06	0.08	0.06	0.05	0.08	0.07	0.2	0.05	NA										
AA236	F	VT	2x	0.08	0.2	0.21	0.18	0.16	0.16	0.09	0.12	0.11	0.11	0.1	0.09	0.07	0.25	0.11	0.1	NA									
AA248	A	VT	2x	0.13	0.18	0.2	0.18	0.04	0.05	0.09	0.07	0.11	0.09	0.09	0.14	0.12	0.24	0.09	0.08	0.16	NA								
AA253	A	NT	4x	0.18	0.2	0.2	0.19	0.18	0.2	0.15	0.15	0.17	0.15	0.14	0.19	0.17	0.25	0.16	0.16	0.22	0.2	NA							
AA255	F	NT	4x	0.15	0.17	0.18	0.16	0.15	0.16	0.13	0.12	0.14	0.12	0.11	0.16	0.14	0.22	0.13	0.13	0.18	0.17	0.12	NA						
AA298	A	RD	4x	0.17	0.14	0.14	0.07	0.18	0.19	0.15	0.15	0.17	0.15	0.13	0.18	0.16	0.2	0.16	0.16	0.2	0.2	0.2	0.17	NA					
AA300	A	NT	4x	0.12	0.14	0.15	0.14	0.13	0.14	0.1	0.09	0.12	0.09	0.09	0.14	0.12	0.2	0.11	0.11	0.16	0.14	0.09	0.08	0.15	NA				
AA330	F	FG	4x	0.14	0.1	0.06	0.11	0.15	0.16	0.13	0.12	0.14	0.12	0.11	0.16	0.14	0.15	0.14	0.13	0.18	0.17	0.18	0.15	0.12	0.13	NA			
AA338	F	NT	4x	0.13	0.15	0.15	0.13	0.15	0.15	0.11	0.11	0.13	0.11	0.1	0.15	0.13	0.2	0.12	0.12	0.17	0.16	0.14	0.11	0.15	0.09	0.13	NA		
AA339	F	NT	4x	0.16	0.17	0.18	0.16	0.16	0.17	0.14	0.13	0.15	0.13	0.12	0.17	0.15	0.23	0.15	0.14	0.19	0.18	0.16	0.13	0.17	0.1	0.15	0.12	NA	
AA340	F	NT	4x	0.12	0.15	0.15	0.14	0.13	0.14	0.1	0.1	0.12	0.1	0.09	0.13	0.12	0.2	0.11	0.1	0.16	0.14	0.11	0.08	0.15	0.06	0.13	0.09	0.1	NA

Table S9 Parallel and non-parallel morphological differentiation in 16 traits in foothill vs. alpine populations of *A. arenosa* based on field-collected samples and plants cultivated in common garden quantified using generalized linear model, calculated separately for each trait sampled in field and in common garden experiment.

Trait	Category	Field data						Common garden data					
		Test statistics ¹			Effect sizes ²			Test statistics ¹			Effect sizes ²		
		Ecotype ¹	Region ¹	E:R ¹	Ecotype	Region	E × R	Ecotype ¹	Region	E:R _i ¹	Ecotype	Region	E × R
HP	stem	151.74***	3.25*	2.02	0.48	0.06	0.05	47.06***	2.62	3.36	0.43	0.11	0.15
HF	stem	25.98***	11.90***	3.18*	0.16	0.23	0.08	54.14***	1.61	7.05*	0.52	0.08	0.30
PL	flower	10.60**	1.54	0.59	0.11	0.07	0.02	16.33**	0.77	2.25	0.27	0.06	0.13
PW	flower	23.62***	2.75*	0.33	0.20	0.09	0.01	19.43**	1.08	0.75	0.37	0.10	0.06
PL.PW	flower	21.79***	1.8	1.11	0.09	0.02	0.01	6.63*	0.91	0.22	0.16	0.07	0.02
SL	flower	17.38***	1.04	0.33	0.15	0.03	0.01	13.97**	3.75	5.26*	0.09	0.08	0.10
SW	flower	55.49***	3.40*	0.63	0.27	0.06	0.01	6.10*	1.28	0.22	0.03	0.02	0.11
SL.SW	flower	36.75***	4.52*	1.69	0.10	0.05	0.02	1.96	1.25	1.78	0.01	0.02	0.02
SLL	leaf	11.11**	0.55	4.92**	0.05	0.01	0.10	0.01	1.83	3.66	0.00	0.14	0.21
SLW	leaf	5.90*	1.01	10.95***	0.02	0.02	0.19	3.7	3.69	6.91*	0.07	0.18	0.25
SLL.SLW	leaf	1.49	0.57	6.83***	0.00	0.01	0.09	4.69	0.24	0.36	0.06	0.01	0.02
RLL	leaf	0.86	0.87	2.23	0.00	0.02	0.05	2.89	1.37	5.32*	0.04	0.06	0.20
RLW	leaf	7.79**	0.75	4.23**	0.03	0.02	0.08	0.36	0.1	3.08	0.01	0.00	0.15
RLL.RLW	leaf	5.17*	4.15**	5.02**	0.01	0.04	0.05	1.45	2.22	0.73	0.02	0.08	0.03
SNLP	leaf	27.17***	1.51	8.08***	0.10	0.03	0.12	16.53**	2.32	4.85*	0.20	0.09	0.18
RNLP	leaf	17.70***	0.76	3.65*	0.07	0.01	0.05	11.58**	1.22	4.71*	0.15	0.05	0.20

¹ F-values and corresponding significance levels in a generalized linear mixed-effect model are denoted. *P < 0.05, **P < 0.01, ***P < 0.001. Note only the last category passes the strict Bonferroni correction.

² Effect sizes (Eta² = η²) of ecotype, region and their interaction estimated using the linear model

Table S10 Morphological differentiation between foothill vs. alpine populations of *A. arenosa* quantified separately for each region using linear discriminant analysis (LDA). The analysis was based on in 16 traits collected in field samples and plants cultivated in common garden.

Trait	Category	Field data						Common garden data				
		All data	NT	VT	ZT	RD	FG	All data	NT	VT	ZT	FG
HP	stem	0.74	-0.36	0.33	0.45	-0.61	0.78	-0.59	-0.39	-0.48	0.28	0.38
HF	stem	0.40	0.02	0.43	0.49	-0.42	0.16	-0.62	-0.39	-0.61	0.22	0.58
PL	flower	-0.28	0.07	-0.30	-0.20	0.41	-0.10	0.44	0.66	0.47	-0.18	-0.07
PW	flower	-0.40	0.13	0.39	0.48	0.35	-0.18	0.56	0.79	0.47	-0.30	-0.16
PL.PW	flower	0.26	-0.10	0.44	0.64	0.03	0.14	-0.32	-0.49	-0.09	0.22	0.19
SL	flower	-0.36	0.12	-0.20	-0.30	0.16	-0.12	0.23	0.16	0.37	-0.11	-0.01
SW	flower	-0.52	0.20	-0.60	-0.70	0.21	-0.33	0.12	-0.07	0.25	-0.14	0.05
SL.SW	flower	0.27	-0.13	-0.60	-0.60	-0.11	0.27	0.07	0.20	0.01	0.07	-0.08
SLL	leaf	0.23	0.01	-0.30	-0.30	0.01	0.43	0.01	0.02	0.21	-0.14	0.25
SLW	leaf	0.18	0.02	-0.40	-0.01	0.17	0.35	-0.16	-0.28	0.09	-0.09	0.38
SLL.SLW	leaf	0.06	-0.04	0.01	-0.10	-0.32	-0.07	0.21	0.29	0.06	-0.06	-0.16
RLL	leaf	0.08	0.02	-0.01	-0.20	-0.16	0.28	0.14	-0.01	0.03	-0.50	0.09
RLW	leaf	0.16	-0.05	-0.10	-0.20	-0.03	0.34	0.05	-0.20	0.05	-0.40	0.14
RLL.RLW	leaf	-0.10	0.10	-0.10	0.03	-0.25	-0.06	0.10	0.10	-0.01	-0.21	-0.01
SNLP	leaf	0.27	-0.01	0.05	-0.10	0.06	0.40	-0.33	-0.15	-0.17	0.04	0.64
RNLP	leaf	0.25	-0.04	0.08	-0.01	0.04	0.22	-0.31	-0.05	-0.24	0.03	0.33

Loadings on the first (constrained) axis of linear discriminant analysis (LDA) between foothill and alpine individuals calculated for the complete dataset ('all') and each region separately based on all 16 scored traits. The traits with moderate to high contribution to the discrimination (> 0.25 absolute value of the loading coefficient) are highlighted in bold.

Supplementary data file 1 Observed allele frequency spectra, (*.dfs files), and example parameter files (*.est and *.tpl files) used for coalescent simulations in fastsimcoal

Supplementary data file 2 Vegetation samples and environmental parameters sampled at original sites of *A. arenosa* populations

Supplementary data file 3 Morphological traits of samples from field (sheet 1) and common garden (sheet 2).