Fig. S 1 Landscape vegetation distribution.

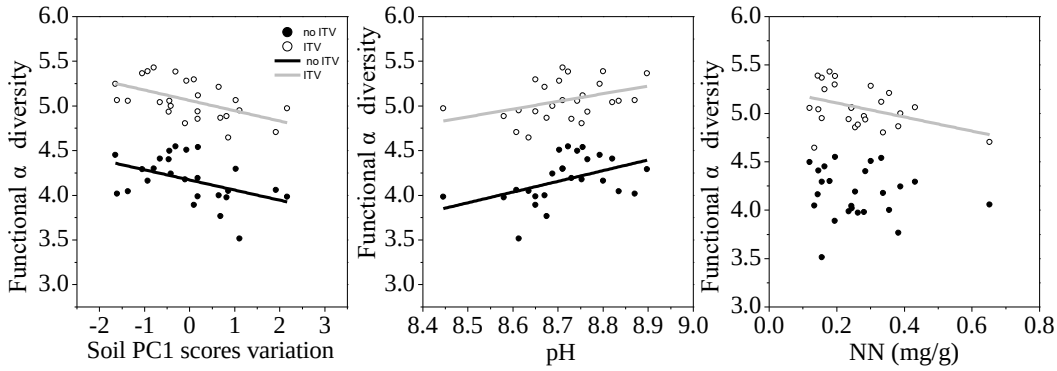

Fig. S 2 Influence of environmental heterogeneity on functional alpha diversity. The figure shows the relationship of the variation in soil PC1 scores, pH, nitrate nitrogen (NN) and functional alpha diversity at the 10 m × 10 m scale. Lines indicate the relationship between functional alpha diversity and environmental heterogeneity, which are significant correlated ($p < 0.05$). We analysed multiple traits of soil and all 5 soil single traits with functional alpha diversity of each spatial scale, we do not show the figure reflecting no significant correlation between environment heterogeneity and functional alpha diversity ($p \geq 0.05$). Black line: not including intraspecific trait variation (ITV); grey line: including ITV.

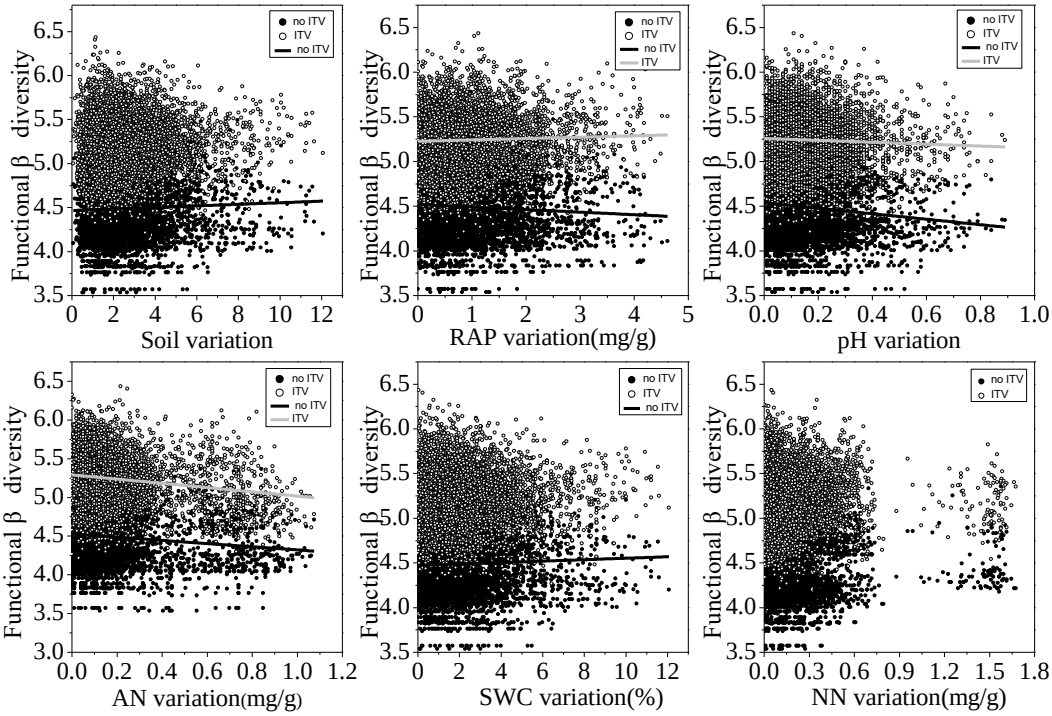

Fig. S 3 Influence of environmental heterogeneity on functional beta diversity. The figure shows the relationship of soil variation, rapidly available phosphorus (RAP), pH, ammonium nitrogen (AN), soil water content (SWC), nitrate nitrogen (NN) and functional beta diversity at the 5 m ×5 m scale. Lines indicate the relationship of functional beta diversity and environmental heterogeneity, which are significant correlated ($p < 0.05$). Black line: not including intraspecific trait variation (ITV); grey line: including ITV.

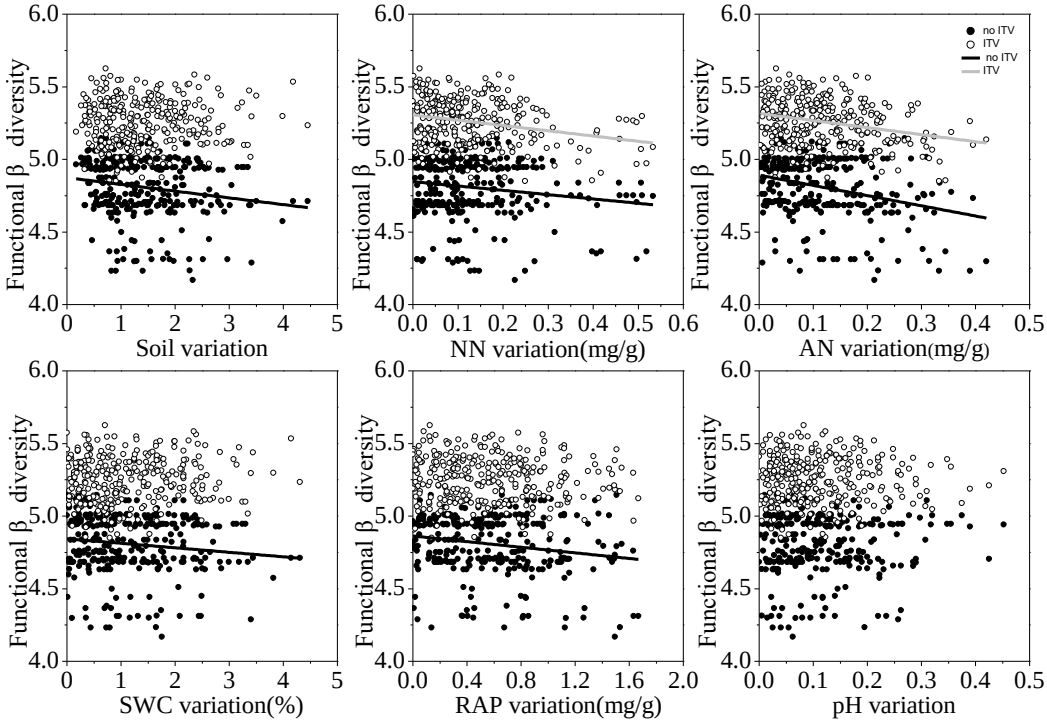

Fig. S 4 Influence of environmental heterogeneity on functional beta diversity. The figure shows the relationship of soil variation, nitrate nitrogen (NN), ammonium nitrogen (AN), soil water content (SWC), rapidly available phosphorus (RAP), pH and functional beta diversity at the 10 m ×10 m scale. Lines indicate the relationship of functional beta diversity and environmental heterogeneity, which are significant correlated ($p < 0.05$). Black line: not including intraspecific trait variation (ITV); grey line: including ITV (for SWC, RAP and pH, there are no significant relationship between them and beta diversity, therefore no grey line were exhibited).

Supplement table 1 Soil factors and species richness of each plot. The soil factors andspecies richness of the other two 50m*50m quadrats are shown in bold. SWC: soil water content; AN : ammonium nitrogen; NN: nitrate nitrogen; RAP: rapidly available phosphorus.

Site	SWC(%)	pH	AN(mg/g)	NN(mg/g)	RAP(mg/g)	richness
DH-01	4.88	8.58	0.269	0.205	1.28	8
DH-02	5.83	8.46	0.254	0.22	1.772	7
DH-03	7.44	8.57	0.744	0.13	1.99	5
DH-04	7.65	8.59	0.40	0.12	2.81	7
DH-05	4.68	8.63	0.266	0.47	1.865	7
DH-06	5.98	8.67	0.22	0.08	1.745	8
DH-07	8.32	8.69	0.127	1.695	2.835	10
DH-08	7.29	8.56	0.18	0.185	1.895	7
DH-09	2.97	8.69	0.17	0.575	2.035	9
DH-10	9.19	8.64	0.924	0.23	2.475	8
DH-11	8.02	8.61	0.234	0.22	2.555	7
DH-12	6.65	8.61	0.137	0.08	1.805	7
DH-13	11.89	8.68	0.24	0.295	3.61	9
DH-14	7.29	8.66	0.143	0.19	3.435	8
DH-15	5.77	8.64	0.186	0.2	1.69	7
DH-16	4.81	8.61	0.236	0.54	1.5	7
DH-17	6.57	8.57	0.151	0.19	2.535	8
DH-18	5.96	8.59	0.455	0.17	2.08	8
DH-19	6.07	8.89	0.163	0.23	2.99	8
DH-20	5.12	8.88	0.12	0.15	1.08	8
DH-21	6.27	8.87	0.097	0.24	1.99	8
DH-22	4.48	8.83	0.104	0.17	1.715	7
DH-23	5.15	8.87	0.323	0.65	2.77	8
DH-24	5.79	8.89	0.123	0.17	1.625	6
DH-25	4.14	8.76	0.085	0.34	0.86	7
DH-26	5.02	8.78	0.464	0.18	1.615	7
DH-27	8.96	8.75	1.039	0.25	2.225	9
DH-28	4.61	8.65	0.45	0.45	2.51	6
DH-29	7.9	8.78	0.371	0.18	1.87	7
DH-30	6.63	8.76	0.256	0.08	1.85	7
DH-31	7.87	8.77	0.32	0.115	1.9	7
DH-32	7.67	8.56	0.287	0.3	1.695	8
DH-33	6.37	8.75	0.45	0.23	0.83	8
DH-34	8.85	8.66	0.466	0.44	1.025	7
DH-35	6.25	8.71	0.28	0.38	0.675	5
DH-36	6.32	8.69	0.26	0.24	1.945	10
DH-37	8.06	8.7	0.31	0.35	1.155	6
DH-38	8.36	8.6	0.34	0.03	2.005	8
DH-39	5.19	8.29	0.39	0.39	1.38	6
DH-40	4.01	8.66	0.19	0.255	0.615	6
DH-41	7.30	8.71	0.3	0.02	1.73	7
DH-42	10.45	8.3	0.19	0.405	1.765	6
DH-43	7.23	8.13	0.35	0.05	0.27	7
DH-44	5.87	8.74	0.39	0.125	1.44	8
DH-45	6.1	8.84	0.89	0.13	0.605	8
DH-46	5.83	8.8	0.615	0.365	0.725	7
DH-47	7.76	8.48	1.06	0.815	0.485	6
DH-48	11.9	8.51	0.34	0.16	2.37	7
DH-49	3.61	8.53	0.395	0.74	2.4	7

DH-50	8.36	8.58	0.245	0.16	1.17	8
DH-51	10.1	8.59	0.31	0.1	0.17	6
DH-52	5.5	8.62	0.43	0.34	0.785	7
DH-53	6.2	8.73	0.42	0.33	1.58	7
DH-54	6.28	8.74	0.3	0.18	1.31	7
DH-55	4.57	8.74	0.45	0.705	1.365	8
DH-56	5.5	8.81	0.3	0.16	0.68	8
DH-57	7.53	8.61	0.4	0.19	2.345	7
DH-58	4.96	8.77	0.31	0.135	1.155	6
DH-59	5.98	8.87	0.3	0.385	1.835	6
DH-60	7.14	8.76	0.3	0.27	0.66	7
DH-61	6.4	8.83	0.26	0.205	0.575	6
DH-62	8.59	8.84	0.25	0.09	1.185	8
DH-63	5.43	8.8	0.3	0.18	0.805	7
DH-64	2.46	8.78	0.35	0.23	1.325	7
DH-65	6.36	8.69	0.24	0.37	2.225	7
DH-66	4.47	8.68	0.44	0.63	1.345	6
DH-67	4.06	8.73	0.4	0.385	2.98	6
DH-68	3.56	8.8	0.38	0.325	3.78	7
DH-69	3.31	8.87	0.32	0.1	2.45	5
DH-70	3.39	8.62	0.37	0.15	3.92	6
DH-71	2.94	8.63	0.515	0.09	2.425	5
DH-72	4.52	8.55	0.3	0.31	3.435	5
DH-73	6.47	8.7	0.35	0.2	4.785	7
DH-74	14.52	8.65	0.18	0.595	1.505	6
DH-75	6.28	8.72	0.31	0.53	2.915	8
DH-76	3.3	8.7	0.31	0.16	0.645	7
DH-77	4.57	8.64	0.25	0.38	0.85	8
DH-78	4.71	8.69	0.35	0.11	0.67	8
DH-79	5.48	8.81	0.52	0.12	1.18	7
DH-80	9.36	8.66	0.32	0.12	1.495	8
DH-81	8.87	8.69	0.2	0.11	2.555	9
DH-82	6.45	8.8	0.3	0.18	2.525	5
DH-83	8.01	8.81	0.3	0.14	0.6	9
DH-84	7.14	8.77	0.54	0.1	2.075	8
DH-85	4.15	8.72	0.3	0.17	2.17	6
DH-86	5.83	8.74	0.35	0.21	2.005	8
DH-87	5.03	8.83	0.26	0.205	1.36	7
DH-88	5.68	8.74	0.33	0.145	1.985	6
DH-89	4.52	8.72	0.32	0.12	0.595	6
DH-90	4.19	8.7	0.34	0.13	1.72	5
DH-91	3.31	8.92	0.28	0.12	2.5	6
DH-92	4.37	8.97	0.36	0.12	2.2	5
DH-93	7.91	9.01	0.28	0.185	1.73	8
DH-94	3.31	9.02	0.345	0.505	1.455	8
DH-95	5.43	8.97	0.31	0.205	4.66	5
DH-96	3.54	8.89	0.31	0.1	0.945	8
DH-97	3.96	8.88	0.35	0.46	1.42	8
DH-98	5.16	8.82	0.62	0.145	1.58	7
DH-99	8.02	8.92	0.32	0.165	1.575	6
DH-100	6.27	8.95	1.16	0.13	1.48	8
RE1-1	1.87	7.86	0.241	0.01	4.329	12
RE1-2	1.97	8.08	0.325	0.56	1.136	13
RE1-3	2.7	7.94	0.247	0.04	1.12	13
RE2-1	2.67	8.48	0.229	0.16	2.01	14

RE2-2	1.35	8.37	0.414	0.11	1.308	12
RE2-3	2.68	8.43	0.23	0.09	1.246	12

Supplement table 2 The species of this study.

Species name	Family	Growth form	Average height(cm)	Canopy diameter(cm)
Reaumuria soongarica	Tamaricaceae	undershrub	10.35	72.51
Salsola passerina	Chenopodiaceae	subshrub	8.58	24.39
Anabasis brevifolia	Chenopodiaceae	subshrub	11.62	29.17
Nitraria sibirica	Zygophyllaceae	subshrub	51.5	80.39
Kalidium foliatum	Chenopodiaceae	undershrub	22.14	30.14
Kalidium cuspidatum	Chenopodiaceae	undershrub	20.17	32.51
Salsola arbuscula	Chenopodiaceae	undershrub	46.73	54.19
Salsola collina	Chenopodiaceae	subshrub	18.26	19.65
Salsola abrotanoides	Chenopodiaceae	herbaceous	22.86	20.33
Achnatherum splendens	Gramineae	herbaceous	33.19	32.76
Cleistogenes squarrosa	Gramineae	herbaceous	15.48	14.1
Zygophyllum mucronatum	Zygophyllaceae	herbaceous	17.22	9.33
Bassia dasyphylla	Chenopodiaceae	herbaceous	4.77	15.4
Artemisia scoparia	Asteraceae	herbaceous	46.18	28.85

Supplement table 3 PCA loadings of each functional trait on PCA 1 axis and PCA 2 axis. Traits which significantly correlated with PCA axes are highlighted in bold. H: height; CR: canopy range; LA: leaf area; SLA: specific leaf area; LL: leaf length; LDMC: leaf dry matter content; SDMC:stem dry matter content; RDMC: root dry matter content.

traits	PC1	PC2
H	-0.205	0.309
CR	-0.405	-0.018
LA	**-0.836**	-0.137
SLA	**-0.862**	-0.222
LL	**-0.651**	0.305
LDMC	**-0.706**	-0.224
SDMC	0.087	**0.881**
RDMC	-0.114	**0.717**
LNC	-0.628	0.067
LCC	-0.528	-0.320
SNC	**0.818**	-0.010

SCC	-0.134	0.107
RNC	**0.719**	-0.289
RCC	-0.451	-0.123
LPC	0.600	0.386

Supplement table 4 PCA loadings of each soil factors on PCA 1 axis. SWC:soil water content; AN: ammonium nitrogen; NN: nitrate nitrogen; RAP: rapidly available phosphorus.

Soil factors	PC1 loadings
SWC	0.752
pH	-0.798
AN	0.101
NN	0.283
RAP	-0.053