Supplementary Material

Table S1. Complete list of plant species recorded in the Ertix River Basin wetland survey, with invasion status classification. Native and non-naturalized species were identified following Lu et al. (2018) and Lin et al. (2022). Naturalized and invasive species were validated using the *Naturalized Plants of China* (NPC; https://www.iplant.cn/npc/, accessed on 29 June 2026) and *Invasive Alien Species in China* (IASC; https://www.plantplus.cn/ias/, accessed on 29 June 2026) databases. Classification follows the frameworks of Richardson et al. (2000), Blackburn et al. (2011), and Pyšek et al. (2020).

Family	Genus	Scientific name	Authority	Invasive state
Cyperaceae	*Bolboschoenus*	*Bolboschoenus planiculmis*	(F. Schmidt) T. V. Egorova	Native
Poaceae	*Beckmannia*	*Beckmannia syzigachne*	(Steud.) Fernald	Native
Cyperaceae	*Eleocharis*	*Eleocharis palustris*	(L.) Roem. & Schult.	Native
Poaceae	*Phragmites*	*Phragmites australis*	(Cav.) Trin. ex Steud.	Native
Plumbaginaceae	*Limonium*	*Limonium gmelini*	(Willd.) Kuntze	Native
Ranunculaceae	*Ranunculus*	*Ranunculus radicans*	C. A. Mey.	Native
Poaceae	*Hordeum*	*Hordeum brevisubulatum*	(Trin.) Link	Native
Amaranthaceae	*Suaeda*	*Suaeda glauca*	(Bunge) Bunge	Native
Iridaceae	*Iris*	*Iris tectorum*	Maxim.	Native
Rosaceae	*Sibbaldianthe*	*Sibbaldianthe bifurca*	(L.) Kurtto & T. Erikss.	Native
Plantaginaceae	*Plantago*	*Plantago indica*	L.	Naturalized
Amaranthaceae	*Salsola*	*Salsola collina*	Pall.	Native
Poaceae	*Eragrostis*	*Eragrostis ferruginea*	(Thunb.) P. Beauv.	Native
Fabaceae	*Glycyrrhiza*	*Glycyrrhiza uralensis*	Fisch.	Native
Mazaceae	*Dodartia*	*Dodartia orientalis*	L.	Native
Rosaceae	*Argentina*	*Argentina anserina*	(L.) Rydb.	Native
Plantaginaceae	*Plantago*	*Plantago asiatica*	L.	Native
Juncaceae	*Juncus*	*Juncus effusus*	L.	Native
Asteraceae	*Cirsium*	*Cirsium esculentum*	(Siev.) C. A. Mey.	Native
Amaryllidaceae	*Allium*	*Allium senescens*	L.	Native
Primulaceae	*Primula*	*Primula farinosa*	L.	Native
Ranunculaceae	*Thalictrum*	*Thalictrum simplex*	L.	Native

Family	Genus	Scientific name	Authority	Invasive state
Orobanchaceae	*Odontites*	*Odontites vulgaris*	Moench	Native
Asteraceae	*Ixeris*	*Ixeris polycephala*	Cass. ex DC.	Native
Fabaceae	*Melilotus*	*Melilotus officinalis*	Pall.	Invasive
Juncaceae	*Juncus*	*Juncus gracillimus*	(Buchenau) V. I. Krecz. & Gontsch.	Native
Orchidaceae	*Gymnadenia*	*Gymnadenia conopsea*	(L.) R. Br.	Native
Cyperaceae	*Schoenoplectus*	*Schoenoplectus tabernaemontani*	(C. C. Gmel.) Palla	Native
Equisetaceae	*Equisetum*	*Equisetum hyemale*	L.	Native
Poaceae	*Puccinellia*	*Puccinellia tenuiflora*	(Griseb.) Scribn. & Merr.	Native
Ranunculaceae	*Halerpestes*	*Halerpestes sarmentosa*	(Adams) Kom.	Native
Juncaginaceae	*Triglochin*	*Triglochin palustris*	L.	Native
Cyperaceae	*Bolboschoenus*	*Bolboschoenus yagara*	(Ohwi) Y. C. Yang & M. Zhan	Native
Lamiaceae	*Mentha*	*Mentha canadensis*	L.	Native
Fabaceae	*Lathyrus*	*Lathyrus palustris subsp. palustris*		Native
Asteraceae	*Taraxacum*	*Taraxacum mongolicum*	Hand.-Mazz.	Native
Poaceae	*Calamagrostis*	*Calamagrostis epigejos*	(L.) Roth	Native
Equisetaceae	*Equisetum*	*Equisetum arvense*	L.	Native
Asteraceae	*Sonchus*	*Sonchus brachyotus*	DC.	Native
Polygonaceae	*Persicaria*	*Persicaria amphibia*	(L.) Gray	Native
Asparagaceae	*Asparagus*	*Asparagus cochinchinensis*	(Lour.) Merr.	Native
Polygonaceae	*Persicaria*	*Persicaria hydropiper*	(L.) Spach	Native
Geraniaceae	*Geranium*	*Geranium dahuricum*	DC.	Native
Poaceae	*Alopecurus*	*Alopecurus aequalis*	Sobol.	Native
Amaranthaceae	*Oxybasis*	*Oxybasis glauca*	(L.) S.Fuentes, Uotila & Borsch	Native
Asteraceae	*Pentanema*	*Pentanema britannica*	(L.) D.Gut.Larr., Santos-Vicente, Anderb., E.Rico & M.M.Mart.Ort.	Native
Apiaceae	*Sium*	*Sium suave*	Walter	Native
Rosaceae	*Potentilla*	*Potentilla chinensis*	Ser.	Native

Family	Genus	Scientific name	Authority	Invasive state
Poaceae	*Campeiostachys*	*Campeiostachys dahurica*	(Turcz. ex Griseb.) B.R.Baum, J.L.Yang & C.Yen	Native
Polygonaceae	*Rumex*	*Rumex crispus*	L.	Native
Fabaceae	*Vicia*	*Vicia tenuifolia*	Roth	Native
Plantaginaceae	*Plantago*	*Plantago salsa*	Pall.	Native
Amaranthaceae	*Suaeda*	*Suaeda salsa*	(L.) Pall.	Native
Poaceae	*Eragrostis*	*Eragrostis pilosa*	(L.) P. Beauv.	Native
Fabaceae	*Oxytropis*	*Oxytropis glabra*	(Lam.) DC.	Native
Fabaceae	*Sophora*	*Sophora alopecuroides*	L.	Native
Fabaceae	*Trifolium*	*Trifolium repens*	L.	Invasive
Asteraceae	*Sonchus*	*Sonchus oleraceus*	L.	Invasive
Fabaceae	*Lotus*	*Lotus corniculatus*	L.	Native
Lythraceae	*Lythrum*	*Lythrum salicaria*	L.	Native
Fabaceae	*Vicia*	*Vicia sepium*	L.	Native
Cyperaceae	*Carex*	*Carex melanocephala*	Turcz.	Native
Typhaceae	*Typha*	*Typha orientalis*	C. Presl	Native
Asteraceae	*Sonchus*	*Sonchus wightianus*	DC.	Naturalized
Asteraceae	*Tragopogon*	*Tragopogon orientalis*	L.	Native
Cyperaceae	*Eleocharis*	*Eleocharis dulcis*	(Burm. f.) Trin. ex Hensch.	Native
Equisetaceae	*Equisetum*	*Equisetum diffusum*	D. Don	Native
Poaceae	*Deschampsia*	*Deschampsia cespitosa*	(L.) P. Beauv.	Native
Fabaceae	*Vicia*	*Vicia amoena*	Fisch. ex DC.	Native
Cyperaceae	*Carex*	*Carex*	L.	Native
Poaceae	*Panicum*	*Panicum bisulcatum*	Thunb.	Native
Poaceae	*Alopecurus*	*Alopecurus arundinaceus*	Poir.	Native
Asteraceae	*Tragopogon*	*Tragopogon pratensis*	L.	Native
Brassicaceae	*Lepidium*	*Lepidium obtusum*	Basiner	Native
Asteraceae	*Lactuca*	*Lactuca tatarica*	(L.) C. A. Mey.	Native
Asteraceae	*Artemisia*	*Artemisia selengensis*	Turcz. ex Besser	Native

Family	Genus	Scientific name	Authority	Invasive state
Santalaceae	*Thesium*	*Thesium chinense*	Turcz.	Native
Polygonaceae	*Polygonum*	*Polygonum aviculare*	L.	Native
Apiaceae	*Cicuta*	*Cicuta virosa*	L.	Native
Geraniaceae	*Geranium*	*Geranium wilfordii*	Maxim.	Native
Rosaceae	*Potentilla*	*Potentilla ornithopoda*	Tausch	Native
Poaceae	*Cenchrus*	*Cenchrus alopecuroides*	(L.) Thunb.	Native
Equisetaceae	*Equisetum*	*Equisetum ramosissimum var. huegelii*	(Milde) Christenh. & Husby	Native
Apocynaceae	*Cynanchum*	*Cynanchum rostellatum*	(Turcz.) Liede & Khanum	Native
Amaranthaceae	*Chenopodium*	*Chenopodium album*	L.	Native
Tamaricaceae	*Tamarix*	*Tamarix chinensis*	Lour.	Native
Asteraceae	*Lactuca*	*Lactuca sibirica*	(L.) Benth. ex Maxim.	Native
Asteraceae	*Artemisia*	*Artemisia scoparia*	Waldst. & Kit.	Native
Cyperaceae	*Carex*	*Carex korshinskyi*	Kom.	Native
Fabaceae	*Trifolium*	*Trifolium fragiferum*	L.	Naturalized
Gentianaceae	*Centaurium*	*Centaurium pulchellum var. altaicum*	(Griseb.) Kitag. & Hara	Native
Fabaceae	*Melilotus*	*Melilotus dentatus*	Prol. sibiricus O. E. Schulz	Native
Asteraceae	*Xanthium*	*Xanthium strumarium*	L.	Non-naturalized
Rosaceae	*Potentilla*	*Potentilla supina*	L.	Native
Nitrariaceae	*Peganum*	*Peganum harmala*	L.	Native
Asteraceae	*Lactuca*	*Lactuca sativa*	L.	Naturalized
Equisetaceae	*Equisetum*	*Equisetum giganteum*	L.	Non-naturalized
Juncaceae	*Juncus*	*Juncus articulatus subsp. limosus*	(Vorosch.) Vorosch.	Native
Fabaceae	*Lotus*	*Lotus krylovii*	Schischk. & Serg.	Native
Poaceae	*Avena*	*Avena fatua*	L.	Invasive
Poaceae	*Setaria*	*Setaria viridis*	(L.) P. Beauv.	Native
Asteraceae	*Artemisia*	*Artemisia argyi*	H. Lév. & Vaniot	Native
Fabaceae	*Sphaerophysa*	*Sphaerophysa salsula*	(Pall.) DC.	Native
Amaranthaceae	*Salicornia*	*Salicornia europaea*	L.	Native
Caryophyllaceae	*Gypsophila*	*Gypsophila perfoliata*	L.	Native

Family	Genus	Scientific name	Authority	Invasive state
Fabaceae	*Lathyrus*	*Lathyrus odoratus*	L.	Non-naturalized
Amaranthaceae	*Suaeda*	*Suaeda microphylla*	(C. A. Mey.) Pall.	Native
Amaranthaceae	*Oxybasis*	*Oxybasis urbica*	(L.) S. Fuentes	Native
Asteraceae	*Klasea*	*Klasea centauroides*	(L.) Cass. ex Kitag.	Native
Lamiaceae	*Lycopus*	*Lycopus uniflorus*	Michx.	Native
Primulaceae	*Lysimachia*	*Lysimachia maritima*	(L.) Galasso	Native
Asteraceae	*Pentanema*	*Pentanema caspicum*	(F.K.Blum ex Ledeb.) G.V.Boiko	Native
Cyperaceae	*Cyperus*		L.	Native
Poaceae	*Calamagrostis*	*Calamagrostis pseudophragmites*	(Haller f.) Koeler	Native
Fabaceae	*Trifolium*	*Trifolium pratense*	L.	Invasive
Asteraceae	*Cichorium*	*Cichorium intybus*	L.	Invasive
Fabaceae	*Medicago*	*Medicago sativa*	L.	Invasive
Malvaceae	*Althaea*	*Althaea officinalis*	L.	Naturalized
Poaceae	*Leymus*	*Leymus secalinus*	(Georgi) Tzvelev	Native
Asteraceae	*Artemisia*	*Artemisia frigida*	Willd.	Native
Convolvulaceae	*Calystegia*	*Calystegia hederacea*	Wall.	Native
Amaranthaceae	*Ceratocarpus*	*Ceratocarpus arenarius*	L.	Native
Polygonaceae	*Atraphaxis*	*Atraphaxis schischkinii*	(N.A.Ivanova ex Borodina) Yurtseva & Govaerts	Native
Orobanchaceae	*Pedicularis*	*Pedicularis sylvatica*	L.	Non-naturalized
Poaceae	*Echinochloa*	*Echinochloa crus-galli subsp. crus-galli*	NA	Native
Poaceae	*Panicum*	*Panicum sumatrense*	Roth ex Roem. & Schult.	Native
Amaranthaceae	*Bassia*	*Bassia scoparia*	(L.) A. J. Scott	Native
Fabaceae	*Medicago*	*Medicago falcata*	L.	Native
Nelumbonaceae	*Nelumbo*	*Nelumbo lutea*	Pers.	Non-naturalized
Alismataceae	*Sagittaria*	*Sagittaria sagittifolia*	L.	Non-naturalized
Polygonaceae	*Persicaria*	*Persicaria maculosa*	Gray	Native
Poaceae	*Dinebra*	*Dinebra chinensis*	(L.) P.M.Peterson & N.Snow	Native
Poaceae	*Alopecurus*	*Alopecurus japonicus*	Steud.	Native

Family	Genus	Scientific name	Authority	Invasive state
Asteraceae	*Bidens*	*Bidens tripartita*	L.	Native
Poaceae	*Hordeum*	*Hordeum bogdanii*	Wilensky	Native
Asteraceae	*Jacobaea*	*Jacobaea erucifolia subsp. argunensis*	(Turcz.) Veldkamp	Native
Orchidaceae	*Spiranthes*	*Spiranthes sinensis*	(Pers.) Ames	Native
Salicaceae	*Salix*		L.	Native
Convolvulaceae	*Cuscuta*	*Cuscuta chinensis*	Lam.	Native
Orobanchaceae	*Rhinanthus*	*Rhinanthus minor subsp. minor*	NA	Native
Rosaceae	*Potentilla*	*Potentilla flagellaris*	D. F. K. Schltdl.	Native
Asteraceae	*Cirsium*	*Cirsium vlassovianum*	Fisch. ex DC.	Native
Amaranthaceae	*Chenopodiastrum*	*Chenopodiastrum hybridum*	(L.) S. Fuentes	Invasive
Apocynaceae	*Cynanchum*	*Cynanchum acutum subsp. sibiricum*	(Willd.) Rech. f.	Native
Poaceae	*Leymus*	*Leymus racemosus*	(Lam.) Tzvelev	Native
Rubiaceae	*Galium*	*Galium hoffmeisteri*	(Klotzsch) Ehrend. & Schönb.-Tem. ex R. R. Mill	Native
Poaceae	*Chloris*	*Chloris virgata*	Sw.	Naturalized
Plantaginaceae	*Limnophila*	*Limnophila aromatica*	(Lam.) Merr.	Native
Poaceae	*Echinochloa*	*Echinochloa crus-galli*	(L.) P. Beauv.	Native
Asteraceae	*Cissampelopsis*	*Cissampelopsis buimalia*	(Buch.-Ham. ex D. Don) C. Jeffrey & Y. L. Chen	Native
Poaceae	*Setaria*	*Setaria pumila*	(Poir.) Roem. & Schult.	Non-naturalized
Cyperaceae	*Carex*	*Carex orbicularis*	Boott	Native
Juncaceae	*Juncus*	*Juncus prismatocarpus*	R. Br.	Native
Poaceae	*Neotrinia*	*Neotrinia splendens*	(Trin.) M. Nobis	Native
Cyperaceae	*Blysmus*	*Blysmus sinocompressus*	Tang & F. T. Wang	Native
Fabaceae	*Lotus*	*Lotus japonicus*	(Regel) K.Larsen	Non-naturalized
Asteraceae	*Jacobaea*	*Jacobaea vulgaris*	Gaertn.	Native
Asteraceae	*Bidens*	*Bidens pilosa*	L.	Invasive
Potamogetonaceae	*Potamogeton*	*Potamogeton distinctus*	A. Benn.	Native
Butomaceae	*Butomus*	*Butomus umbellatus*	L.	Native

Family	Genus	Scientific name	Authority	Invasive state
Alismataceae	*Alisma*	*Alisma plantago-aquatica*	L.	Native
Onagraceae	*Epilobium*	*Epilobium hirsutum*	L.	Native
Cyperaceae	*Schoenoplectus*	*Schoenoplectus triqueter*	(L.) Palla	Native
Onagraceae	*Epilobium*	*Epilobium pyrricholophum*	Franch. & Sav.	Native
Brassicaceae	*Rorippa*	*Rorippa palustris*	(L.) Besser	Native
Rubiaceae	*Galium*	*Galium bungei*	Steud.	Native
Amaranthaceae	*Suaeda*	*Suaeda corniculata*	(C. A. Mey.) Bunge	Native
Asteraceae	*Aster*	*Aster tataricus*	L. f.	Native
Poaceae	*Agropyron*	*Agropyron cristatum*	(L.) Gaertn.	Native
Asteraceae	*Erigeron*	*Erigeron canadensis*	L.	Invasive
Lamiaceae	*Lycopus*	*Lycopus lucidus*	Turcz. ex Benth.	Native
Asteraceae	*Arctium*	*Arctium lappa*	L.	Native
Asteraceae	*Erigeron*	*Erigeron acris*	L.	Native
Plantaginaceae	*Veronica*	*Veronica undulata*	Wall. ex Jack	Native
Ranunculaceae	*Thalictrum*	*Thalictrum aquilegiifolium var. sibiricum*	Regel & Tiling	Native
Asteraceae	*Carduus*	*Carduus nutans*	L.	Native
Asteraceae	*Achillea*	*Achillea acuminata*	(Ledeb.) Sch. Bip.	Native
Asteraceae	*Inula*	*Inula japonica*	Thunb.	Native
Poaceae	*Dactylis*	*Dactylis glomerata*	L.	Naturalized
Rosaceae	*Filipendula*	*Filipendula digitata*	(Willd.) Bergmans	Native
Ranunculaceae	*Aconitum*	*Aconitum rotundifolium*	Kar. & Kir.	Native
Plantaginaceae	*Pseudolysimachion*	*Veronica longifolia*	L.	Native
Onagraceae	*Chamerion*	*Epilobium angustifolium*	L.	Native
Gentianaceae	*Swertia*	*Swertia obtusa*	Ledeb.	Native
Boraginaceae	*Myosotis*	*Myosotis laxa subsp. cespitosa*	(Schultz) Hyl. ex Nordh.	Native
Rosaceae	*Dasiphora*	*Dasiphora fruticosa*	(L.) Rydb.	Native
Fabaceae	*Medicago*	*Medicago minima*	(L.) Lam.	Naturalized
Amaranthaceae	*Salsola*	*Salsola praecox*	(Litv.) Iljin	Native

Table S2. Individual-based rarefaction results. For each rarefaction threshold, the number of usable quadrats (those with total native individuals ≥ the threshold), mean rarefied species richness, and Pearson correlation coefficient between elevation and rarefied richness are reported. The raw (un-rarefied) data are shown for comparison.

Rarefaction threshold	N quadrats (usable)	Mean rarefied richness	r (elevation, rarefied richness)
Raw data (no rarefaction)	158	6.5	0.33
N = 50 individuals	156	4.9	0.29
N = 100 individuals	148	5.4	0.28
N = 200 individuals	121	5.9	0.32

Table S3. Proportion of zero records for non-native predictor variables across 158 quadrats.

Predictor	Zero records (%)
Non-naturalized richness	83.5
Non-naturalized abundance	83.5
Naturalized richness	68.4
Naturalized abundance	68.4
Invasive richness	79.7
Invasive abundance	79.7

Table S4. Benjamini-Hochberg correction across the four models. All nine terms remain significant after BH correction ($\alpha = 0.05$). Core results are unchanged.

Predictor	Model	Raw p	BH-adjusted p	Significant
Naturalized abundance	IV	3.40×10^{-31}	3.06×10^{-30}	Yes
Invasive abundance	IV	8.85×10^{-25}	3.98×10^{-24}	Yes
Elevation	Richness	1.68×10^{-4}	5.04×10^{-4}	Yes
Naturalized abundance	Shannon	7.53×10^{-4}	1.69×10^{-3}	Yes
Non-naturalized abundance	IV	1.53×10^{-3}	2.75×10^{-3}	Yes
Elevation	Shannon	1.74×10^{-3}	2.61×10^{-3}	Yes
Naturalized abundance	Evenness	4.09×10^{-3}	5.26×10^{-3}	Yes
Naturalized richness	Richness	7.50×10^{-3}	8.43×10^{-3}	Yes
Elevation	IV	2.09×10^{-2}	2.09×10^{-2}	Yes

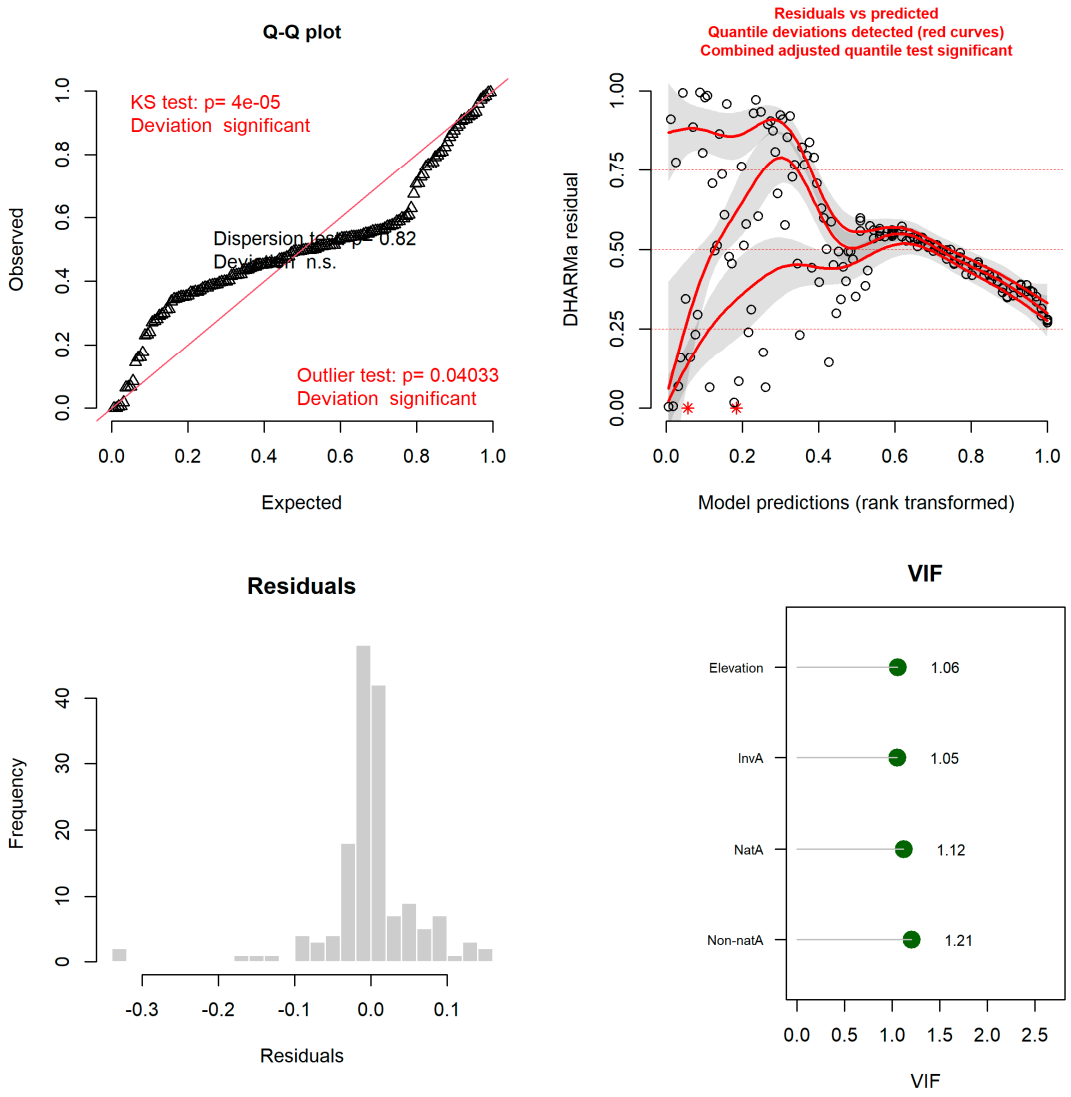


Figure S1. Model diagnostics for importance value (IV). The KS uniformity test and combined adjusted quantile test were significant for the IV model. This deviation is attributable to inherent properties of the importance value metric (values are bounded between 0 and 1, and share a compositional dependency with non-native abundance) rather than to model misspecification. Linear mixed-effects models are generally robust to moderate departures from residual normality at the sample size used here (n = 158).

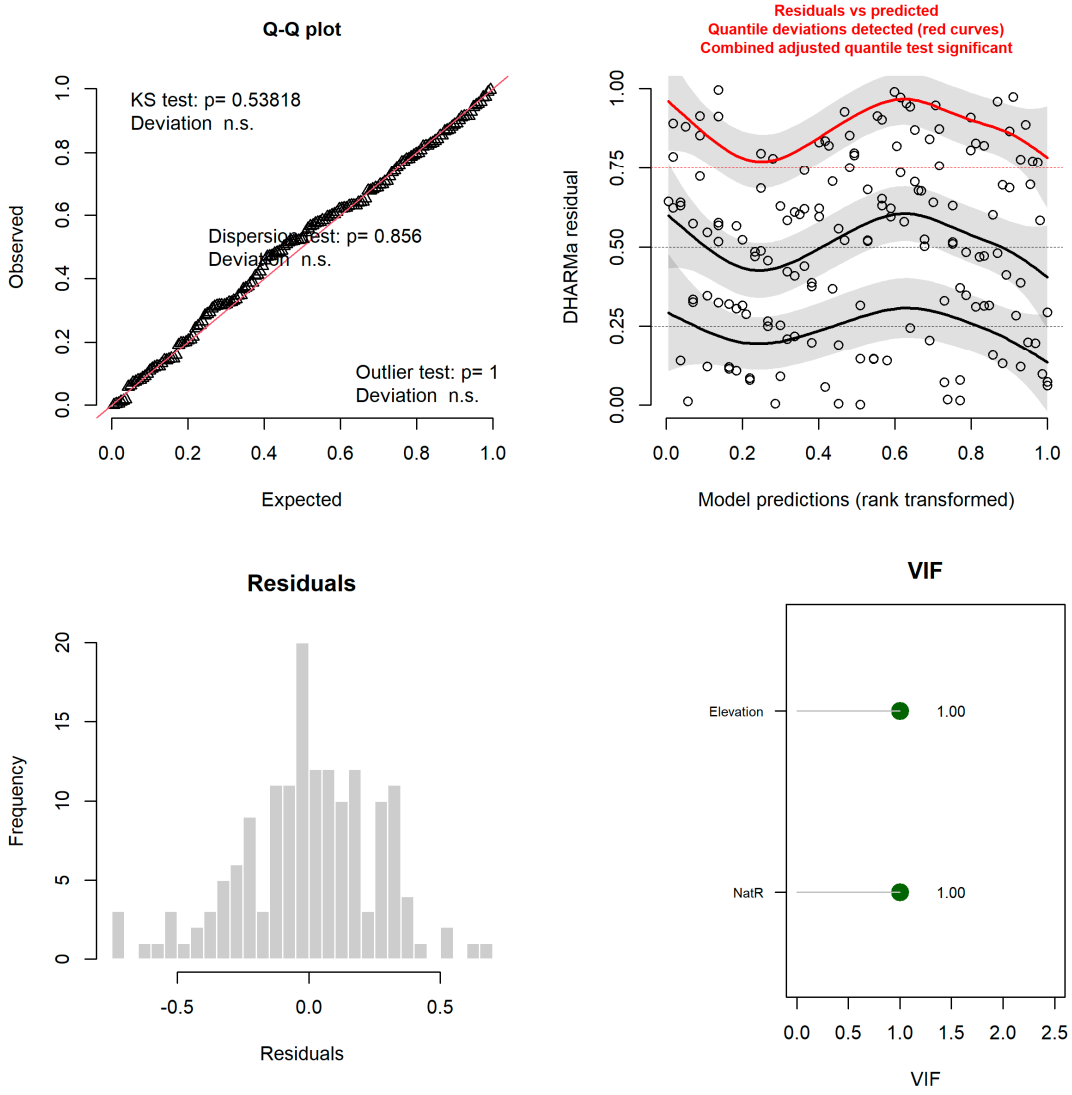


Figure S2. Model diagnostics for native richness. The combined adjusted quantile test was significant, but the Kolmogorov-Smirnov, dispersion, and outlier tests were all non-significant. The combined test aggregates deviation signals across all quantiles and is more sensitive than the individual tests; when all three individual tests pass, a significant combined test typically reflects minor deviations that are unlikely to meaningfully affect parameter estimates or inference.

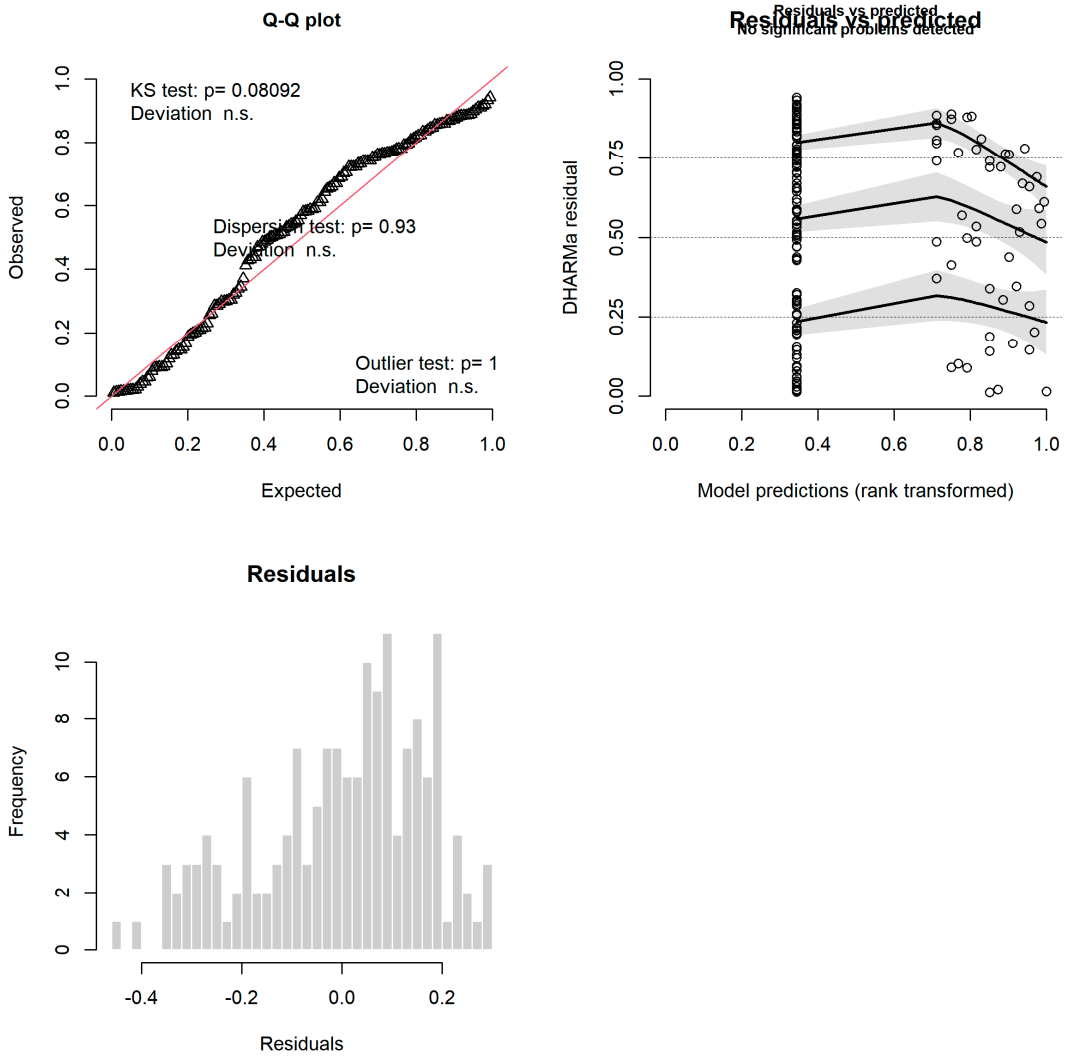


Figure S3. Model diagnostics for Pielou evenness. Only one fixed-effect predictor retained, VIF not applicable.

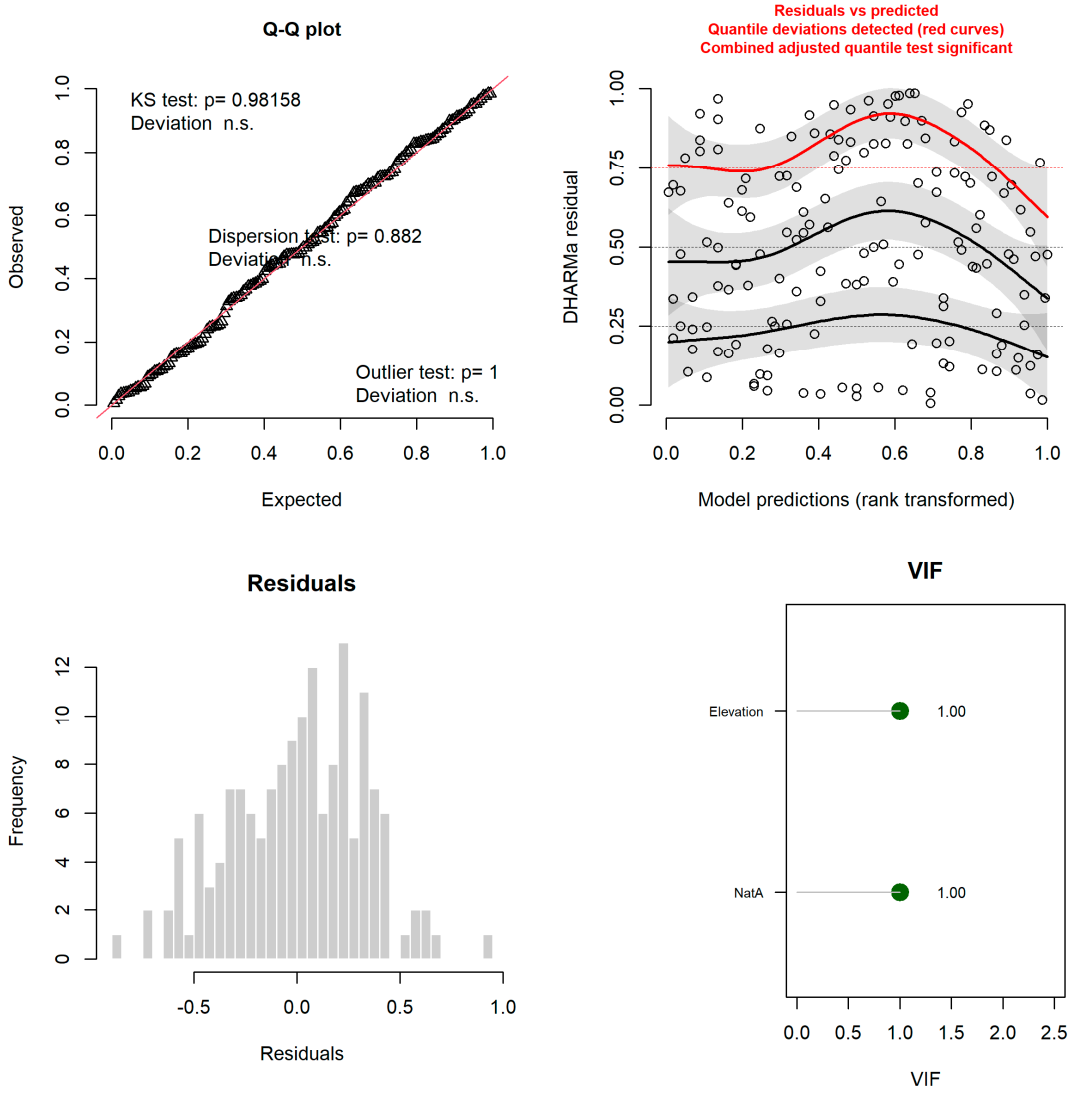


Figure S4. Model diagnostics for Shannon-Wiener diversity. The combined adjusted quantile test was significant, but the Kolmogorov-Smirnov, dispersion, and outlier tests were all non-significant. The combined test aggregates deviation signals across all quantiles and is more sensitive than the individual tests, when all three individual tests pass, a significant combined test typically reflects minor deviations that are unlikely to meaningfully affect parameter estimates or inference.

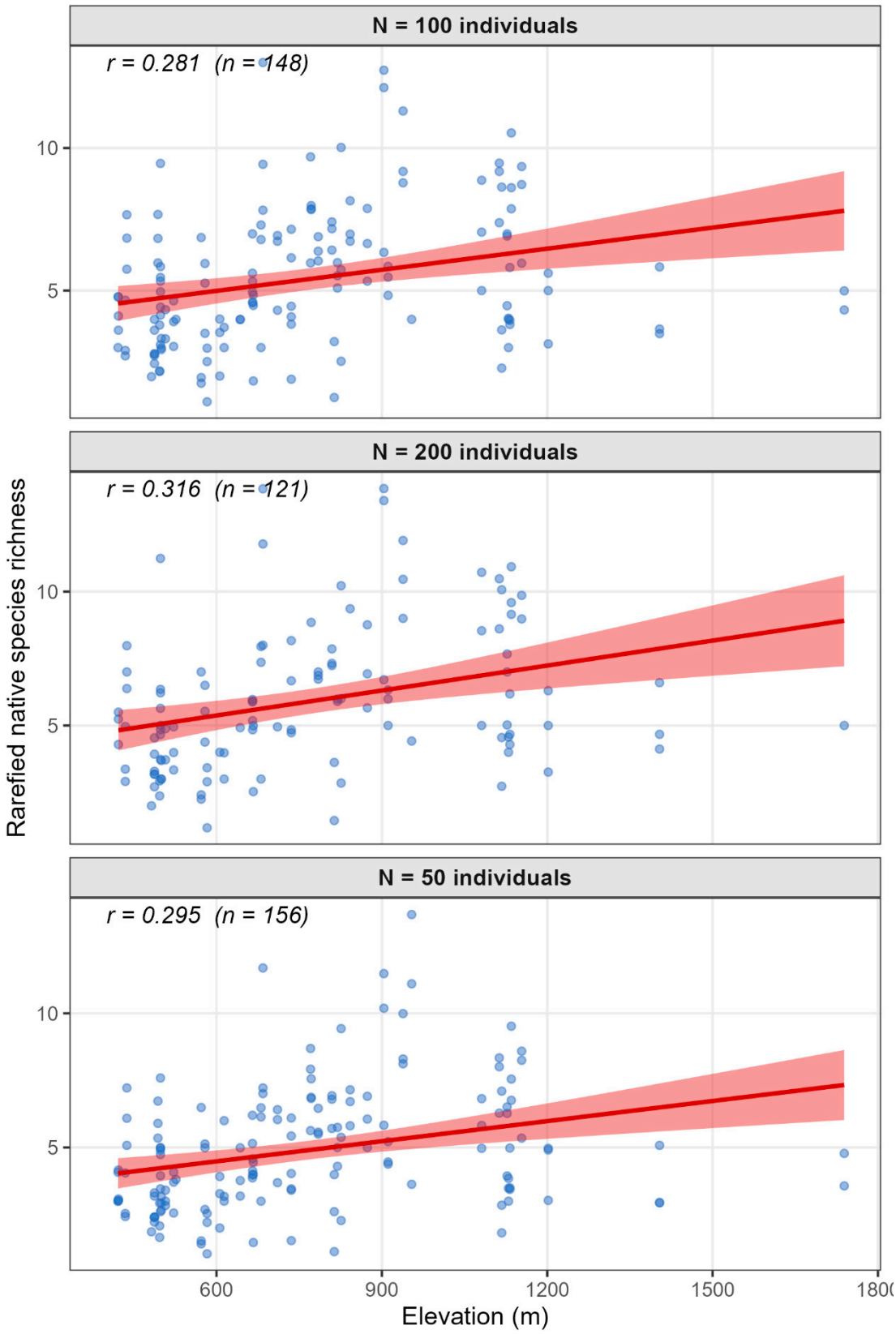


Figure S5. Individual-based rarefaction analysis testing whether the positive elevation–native species richness relationship is affected by differences in plant density across quadrats. For each quadrat, native plants were randomly resampled to a fixed number of individuals (N = 50, N = 100, N = 200; 1,000 iterations per quadrat) to remove the effect of varying total abundance on richness estimates. Red lines

show linear regressions with 95% confidence bands. The stability of the Pearson correlation coefficients (r) across all three rarefaction thresholds indicates that the elevation–richness relationship is not an artifact of differences in plant density, and that uniformly sized 1 m^2 quadrats capture species richness with comparable efficiency across the elevational gradient.