Supporting information to the paper Mathakutha, R. et al. Invasive species differ in key functional traits from native and non-invasive alien plant species. *Journal of Vegetation Science.*

***Appendix S1** A list of all vascular plants surveyed on Marion Island*

Table S1. A list of all vascular plants surveyed on Marion Island and their invasion status. The invasion status is taken from Gremmen and Smith (2008).

Family	Species	Status
Poaceae	*Agropyron repens* (L.) Beaiv.	Non-invasive alien
	Agrostis castellana Boiss & Reut	Invasive
	Agrostis gigantea Roth	Non-invasive alien
	Agrostis magellanica Lam.	Native
	Agrostis stolonifera L.	Invasive
	Festuca rubra L.	Non-invasive alien
	Poa annua L.	Invasive
	Poa cookii Hook.f.	Native
	Poa pratensis L.	Invasive
Juncaceae	*Luzula cf. multiflora* (Ehrh) Lej.	Non-invasive alien
	Juncus scheuchzerioides Gaud.	Native
	Juncus cf. effusus L.	Non-invasive alien
Callitrichaceae	*Callitriche antarctica* Engelm.	Native
Caryophyllaceae	*Cerastium fontanum* Baumg.	Invasive
	Colobanthus kerguelensis Hook.f.	Native
	Sagina procumbens L.	Invasive
	Stellaria media (L.) Vill.	Invasive
Asteraceae	*Cotula plumosa* Hook.f.	Native
Crassulaceae	*Crassula moschata* Forst G.Forst.	Native
Brassicaceae	*Pringlea antiscorbutica* R.Br.	Native
Montiaceae	*Montia fontana* L.	Native
Ranunclulaceae	*Ranunculus biternatus* Sm.	Native
Rosaceae	*Acaena magellanica* (Lam.) Vahl	Native
Apiaceae	*Azorella selago* Hook.f.	Native
Polygonaceae	*Rumex acetosella* L.	Non-invasive alien
Cyperaceae	*Uncinia compacta* R.Br.	Native

***Appendix S2** Residence time of alien vascular plant species on Marion Island*

Table S2. Mean (± standard error) and median residence time calculated from the date of first recording to present (2018) of alien vascular plant species on Marion Island. The mean residence time of invasive species was strongly affected by two species that were introduced to the island around 1800.

Invasion status	Median residence time (years)	Mean residence time (years)
Non-invasive alien	53	44.5 ± 8
Invasive alien	53	80.3 ± 17

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Appendix S3 *Map of Marion Island and sampling localities*

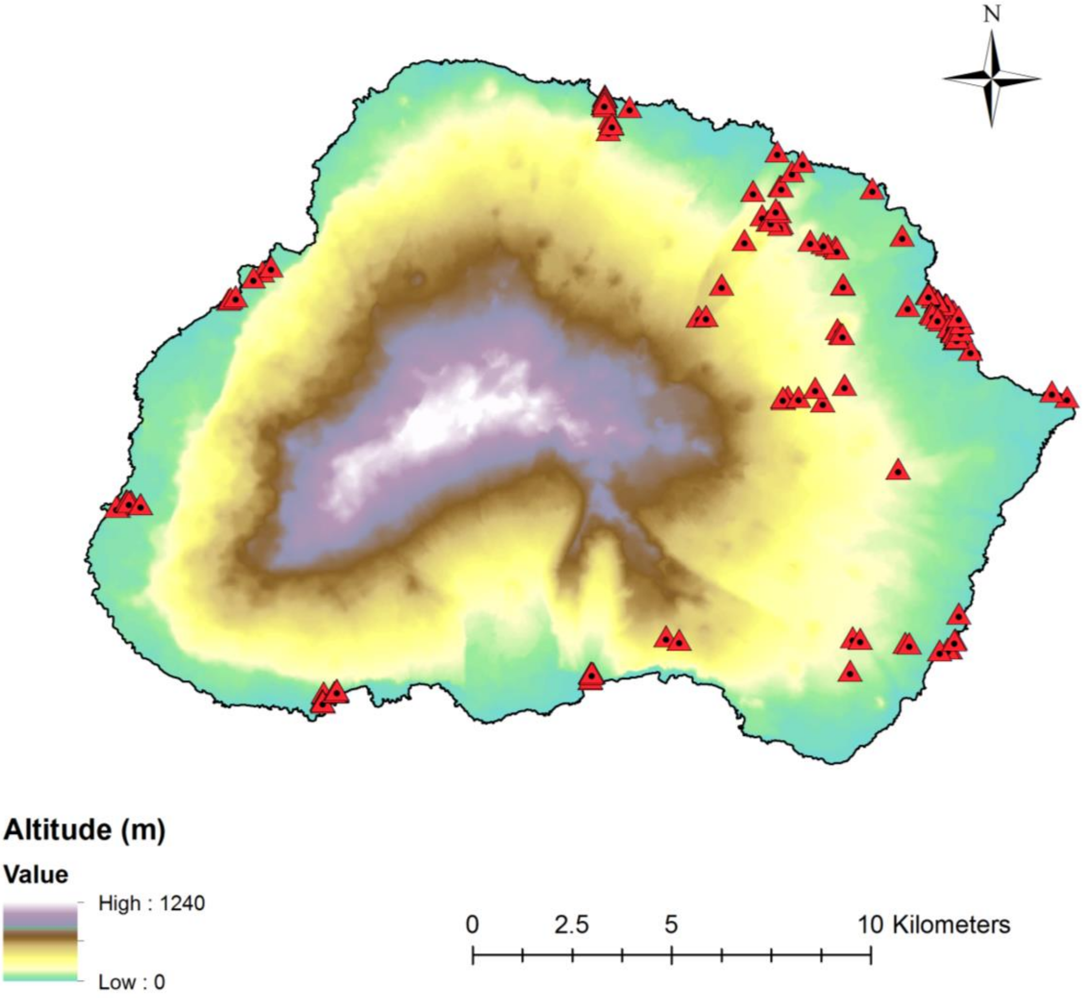

Figure S1. Map of Marion Island indicating altitude (shown by colour) and sampling localities (shown by the symbols).

Appendix S4 *Terrestrial habitats of Marion Island*

a) Coastal Saltspray Complex

b) Biotic Complex

c) Biotic Complex

d) Mire Complex

e) Drainage line

f) Slope Complex

Figure S2. Terrestrial habitats on Marion Island based on soil chemistry and vegetation. a) Coastal Saltspray Complex, b-c) Biotic Complex, d) Mire Complex, e) Drainage line, f) Slope Complex, g) Fellfield Complex.

Appendix S5 *Sampling design*

Field sampling was conducted on Marion Island in April and May 2015 and 2016. Plants were collected from different vegetation types, across altitudinal gradients and from different regions of the island (Appendix S3, Appendix S4). Areas disturbed by human activities were avoided during sampling. Up to four plants were sampled per species at each sampling locality, with trait values averaged across samples for each species in one locality. A trait value for each species was calculated by averaging data for a species' trait across all sampling localities (Appendix S7).

Appendix S6 *Sampling data*

Table S3. Number of sites, and number of individual plants, sampled to evaluate trait differences between native, invasive and non-invasive alien vascular plant species on Marion Island. Up to four plants were sampled per species at each sampling locality where possible, with trait values averaged across samples for each species across all sampling localities. N/A = plants that were not measured for these traits because of limited numbers of individuals or measurement limitations (e.g. small leaves).

	Plant height		**Leaf area**		**Specific leaf area**		**Leaf toughness**		**Electrolyte leakage as an indicator of frost sensitivity**		**Leaf chlorophyll content**	
Species name	Sites sampled	Individuals sampled	Sites sampled	Individuals sampled	Sites sampled	Individuals sampled	Sites sampled	Individuals sampled	Sites sampled	Individuals sampled	Sites visited	Individuals sampled
Acaena magellanica	27	97	22	76	22	76	12	45	4	16	12	45
Agropyron repens	N/A	N/A	1	4	1	4	N/A	N/A	1	4	N/A	N/A
Agrostis castellana	2	8	2	8	2	8	2	8	2	12	2	8
Agrostis gigantea	1	5	1	4	1	4	N/A	N/A	1	10	N/A	N/A
Agrostis magellanica	31	125	29	105	29	100	11	45	4	19	11	45
Agrostis stolonifera	16	63	15	54	15	54	9	39	5	20	9	39

	Plant height		**Leaf area**		**Specific leaf area**		**Leaf toughness**		**Electrolyte leakage as an indicator of frost sensitivity**		**Leaf chlorophyll content**	
Azorella selago	33	100	26	97	26	95	N/A	N/A	2	10	15	56
Callitriche antarctica	9	37	6	20	6	19	5	20	3	14	5	20
Cerastium fontanum	15	45	12	35	11	34	9	26	2	12	9	26
Colobanthus kerguelensis	13	45	12	38	12	38	1	4	2	10	7	24
Cotula plumosa	14	59	12	46	12	43	7	26	3	13	7	28
Crassula moschata	7	29	7	27	2	26	N/A	N/A	N/A	N/A	3	12
Festuca rubra	N/A	N/A	1	1	1	1	N/A	N/A	N/A	N/A	N/A	N/A
Juncus effusus	3	11	3	9	3	9	1	4	2	10	14	4
Juncus scheuchzerioides	13	53	11	42	10	36	5	20	3	14	5	20
Luzula multiflora	1	3	1	4	1	4	N/A	N/A	1	10	N/A	N/A
Montia fontana	13	51	11	38	11	36	4	16	2	10	4	16
Poa annua	17	68	14	53	14	52	6	23	4	32	6	23

	Plant height		**Leaf area**		**Specific leaf area**		**Leaf toughness**		**Electrolyte leakage as an indicator of frost sensitivity**		**Leaf chlorophyll content**	
Poa cookii	22	87	19	70	16	68	8	29	4	32	2	29
Poa pratensis	10	37	8	24	8	24	6	20	4	18	6	20
Pringlea antiscorbutica	12	43	10	32	10	32	5	18	2	10	5	18
Ranunculus biternatus	21	79	22	78	22	77	10	39	3	14	40	10
Rumex acetosella	2	10	2	9	2	9	1	4	1	12	1	4
Sagina procumbens	23	88	21	73	20	66	11	41	2	9	11	41
Stellaria media	4	13	3	9	3	9	1	4	1	10	1	4
Uncinia compacta	23	81	20	68	20	67	13	46	3	14	13	46

Appendix S7 *Trait data*

Table S4. Continuous traits with trait mean values (± standard error) and categorical traits of all study species on Marion Island, N/A = trait data not available.

Species name	**Trait**					
	Height (mm)	**Leaf area (mm^2)**	**Specific leaf area (mm^2 mg^{-1})**	**Leaf chlorophyll content (mg)**	**Leaf toughness (N)**	**Electrolyte leakage (µS g^{-1})**
Acaena magellanica	136.14 ± 7.23	2435.51 ± 289.53	14.94 ± 1.01	6.54 ± 0.01	0.152 ± 0.01	7078.26 ± 2194.57
Agropyron repens	N/A	131.92 ± 30.24	28.78 ± 5.21	N/A	N/A	8143.60 ± 3113.38
Agrostis castellana	56.4 ± 5.69	234..86 ± 10.61	23.96 ± 3.02	9.37 ± 0.01	0.498 ± 0.05	7226.30 ± 2354.94
Agrostis gigantea	215 ± 22.26	1255.37 ± 148.08	21.12 ± 4.12	N/A	N/A	4963.59 ± 1474.55
Agrostis magellanica	143.41 ± 7.87	1074.85 ± 105.78	16.04 ± 0.42	6.01 ± 0.00	0.749 ± 0.03	6597.06 ± 1121.14
Agrostis stolonifera	188.06 ± 27.84	700.31 ± 81.75	33.04 ± 1.90	11.26 ± 0.01	0.295 ± 0.01	8090.85 ± 1368.44
Azorella selago	157.78 ± 11.33	65.07 ± 5.32	8.09 ± 0.20	2.10 ± 0.00	N/A	1211.85 ± 1354.25
Callitriche antarctica	76.25 ± 7.94	90.58 ± 9.41	35.08 ± 2.46	11.17 ± 0.04	0.36 ± 0.02	4556.99 ± 144.44
Cerastium fontanum	100.78 ± 16.78	163.54 ± 40.42	19.75 ± 1.07	8.29 ± 0.01	0.3 ± 0.02	4206.32 ± 893.70
Colobanthus kerguelensis	7.69 ± 1.28	55.48 ± 3.90	15.97 ± 0.57	3.33 ± 0.01	0.869 ± 0.08	6888.50 ± 2320.92
Cotula plumosa	60.86 ± 5.96	1709.97 ± 260.35	19.92 ± 1.28	6.74 ± 0.01	0.436 ± 0.03	6332.17 ± 2133.05
Crassula moschata	19.25 ± 3.75	56.67 ± 10.57	21.19 ± 2.17	4.00 ± 0.03	N/A	N/A

	Trait					
Species name	**Height (mm)**	**Leaf area (mm^2)**	**Specific leaf area (mm^2 mg^{-1})**	**Leaf chlorophyll content (mg)**	**Leaf toughness (N)**	**Electrolyte leakage (µS g^{-1})**
Festuca rubra	N/A	104.39 ± 11.14	11.97 ± 1.01	N/A	N/A	N/A
Juncus effusus	1061.43 ± 87.71	4645.51 ± 566.13	6.05 ± 0.42	3.42 ± 0.00	5.979 ± 0.73	4068.28 ± 769.88
Juncus scheuchzerioides	52.83 ± 7.38	151.23 ± 17.55	17.98 ± 1.34	6.73 ± 0.02	1.52 ± 0.16	4261.10 ± 800.38
Luzula multiflora	84.33 ± 26.59	311.88 ± 73.56	19.62 ± 0.69	N/A	N/A	8868.17 ± 4411.75
Montia fontana	31.32 ± 4.31	82.6 ± 10.16	29.4 ± 2.08	7.50 ± 0.03	0.352 ± 0.03	7989.50 ± 4101.07
Poa annua	82.3 ± 7.39	545.21 ± 53.28	29.3 ± 1.25	9.17 ± 0.01	0.354 ± 0.01	4791.75 ± 632.12
Poa cookii	361.97 ± 17.35	4940.03 ± 372.37	9.19 ± 0.31	3.59 ± 0.00	3.196 ± 0.12	2210.33 ± 830.35
Poa pratensis	205.45 ± 49.86	1135.64 ± 318.11	17.67 ± 1.41	27.33 ± 0.02	0.834 ± 0.04	3485.99 ± 475.40
Pringlea antiscorbutica	151.72 ± 10.14	15688.62 ± 1318.77	6.32 ± 0.11	2.02 ± 0.00	1.88 ± 0.11	2810.50 ± 1339.52
Ranunculus biternatus	18.12 ± 6.11	231.75 ± 51.42	27.11 ± 9.78	8.92 ± 0.11	0.573 ± 0.03	6116.41 ± 2363.67
Rumex acetosella	30.83 ± 4.17	373.29 ± 57.14	19.69 ± 1.99	8.60 ± 0.04	0.346 ± 0.03	10613.25 ± 3435.19
Sagina procumbens	25.71 ± 2.85	24.27 ± 2.66	25.07 ± 1.63	5.87 ± 0.01	0.115 ± 0.01	4633.33 ± 412.08
Stellaria media	80 ± 15.12	302.03 ± 90.12	56.75 ± 3.77	14.98 ± 0.02	0.122 ± 0.02	7844.90 ± 2849.10
Uncinia compacta	108.95 ± 6.07	788.88 ± 58.49	10.07 ± 0.26	3.32 ± 0.00	2.934 ± 0.08	4754.82 ± 1979.82

Species name	**Trait**		
	Life history	**Growth form**	**Dispersal mode**
Acaena magellanica	Perennial	Semi-woody	Ectozoochory
Agropygon repens	Perennial	Graminoid	Unassisted
Agrostis castellana	Perennial	Graminoid	Unassisted
Agrostis gigantea	Perennial	Graminoid	Unassisted
Agrostis magellanica	Perennial	Graminoid	Unassisted
Agrostis stolonifera	Perennial	Graminoid	Unassisted
Azorella selago	Perennial	Herbaceous	Unassisted
Callitriche antarctica	Perennial	Herbaceous	Unassisted
Cerastium fontanum	Annual and perennial	Herbaceous	Unassisted
Colobanthus kerguelensis	Perennial	Herbaceous	Unassisted
Cotula plumosa	Perennial	Herbaceous	Unassisted
Crassula moschata	Perennial	Succulent	Unassisted
Festuca rubra	Perennial	Herbaceous	Ectozoochory
Juncus effusus	Perennial	Graminoid	Ectozoochory
Juncus scheuchzerioides	Perennial	Graminoid	Unassisted
Luzula multiflora	Perennial	Herbaceous	Ectozoochory
Montia fontana	Annual and perennial	Herbaceous	Unassisted
Poa annua	Annual and perennial	Graminoid	Unassisted
Poa cookii	Perennial	Graminoid	Unassisted
Poa pratensis	Perennial	Graminoid	Unassisted
Pringlea antiscorbutica	Perennial	Herbaceous	Unassisted
Ranunculus biternatus	Perennial	Herbaceous	Water
Rumex acetosella	Perennial	Herbaceous	Unassisted
Sagina procumbens	Annual and perennial	Herbaceous	Unassisted
Stellaria media	Annual	Herbaceous	Unassisted
Uncinia compacta	Perennial	Graminoid	Ectozoochory

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Appendix S8 *Literature sources*

Table S5. Sources of trait data collected from literature sources and experts.

Trait	Source
Life history	(N. J. Gremmen, personal communication 20 Oct 2015, botanist)
Growth form	(Grime, Hodgson & Hunt 1987; Gremmen & Smith 2004)
Dispersal mode	(Grime et al. 1987; N. J.M. Gremmen, personal communication 20 Oct 2015)
Leaf nitrogen concentration	(Rossouw 2014)
Leaf phosphorus concentration	(Rossouw 2014)
Root diameter	(Louw 2016)
Specific root length	(Louw 2016)

Appendix S9 *Trait data from literature sources*

Table S6. Trait data available for traits collected from literature sources. X indicates that data was available.

Species name	Leaf N concentration (mg g^{-1})	Leaf P concentration (mg g^{-1})	Specific root length (mg^{-1})	Root diameter (mm)
Acaena magellanica	x	x	x	x
Agropyron repens				
Agrostis castellana				
Agrostis gigantea				
Agrostis magellanica	x	x	x	x
Agrostis stolonifera	x	x	x	x
Azorella selago	x	x	x	x
Callitriche antarctica	x	x	x	x
Cerastium fontanum	x	x	x	x
Colobanthus kerguelensis	x	x	x	x
Cotula plumosa	x	x	x	x

Species name	**Leaf N concentration (mg g^{-1})**	**Leaf P concentration (mg g^{-1})**	**Specific root length (mg^{-1})**	**Root diameter (mm)**
Crassula moschata			x	x
Festuca rubra				
Juncus effusus	x	x	x	x
Juncus scheuchzerioides	x	x	x	x
Luzula multiflora				
Montia fontana	x	x	x	x
Poa annua	x	x	x	x
Poa cookii	x	x	x	x
Poa pratensis			x	x
Pringlea antiscorbutica			x	x
Ranunculus biternatus	x	x	x	x
Rumex acetosella			x	x
Sagina procumbens			x	x
Stellaria media				
Uncinia compacta	x	x	x	x

***Appendix S10** Descriptions of traits used*

Table S7. Functional traits used to test differences between the native, non-invasive alien and invasive plant species of Marion Island. Descriptions and measurements protocol, where applicable, were taken from Pérez-Harguindeguy et al. (2013).

Plant trait	**Data type and attribute**	**Importance**	**Source/Measurement method**
Whole plant traits			
Life history	Nominal (1. Annual 2. Perennial 3. Annual and Perennial)	Characterises species according life cycles or life strategies such as behaviour, survival and lifespan.	Collated from published and unpublished literature and communication with botanical experts (Appendix S8).
Growth form	Nominal (1. Graminoid 2. Herbaceous 3. Succulent 4. Semi-woody)	Associated with ecophysiological adaptation such as protection from severe climatic conditions.	Collated from published and unpublished literature and communication with botanical experts (Appendix S8).
Plant height	Continuous (mm)	Represents reproductive size, competitive vigour, and whole-plant fecundity.	Measured as the distance from the ground to the top of the foliage of a plant.
Leaf traits			
Leaf area	Continuous (mm^2)	Indicative of photosynthetic area and ability to deal with environmental stresses such as nutrient stress or drought.	Measured as the one-sided area of a leaf using a flatbed scanner (Scanjet G4050, Hewlett-Packard, USA), and calculated through digital image analysis software (ImageJ, version 1.48).
Specific leaf area	Continuous (mm^2 mg^{-1})	An indicator of a trade-off in leaves between cheap construction cost and leaf longevity. High values	Calculated as the one-sided area of a fresh leaf divided by its dry mass

Plant trait	**Data type and attribute**	**Importance**	**Source/Measurement method**
		represent high resource acquisition and growth rates but low investment in leaf construction and protection.	
Leaf toughness	Continuous (N)*	Indicator of the physical strength of leaves, i.e. protection against abiotic (e.g. wind, hail) and biotic (e.g. herbivory, trampling) mechanical damage.	Measured as the maximum force required to puncture a leaf's surface using a calibrated penetrometer (Digital force gauge FH 10, Sauter GmbH, Balingen, Germany)
Electrolyte leakage	Continuous (µS g^{-1})	Electrolyte leakage increases in leaves after freezing damage, and is thus a measure of a plant's susceptibility to frost.	Measured as the conductivity of a solution using a conductivity meter (Eutech WP 600 series meters PCD 650, Forestry Suppliers, Inc., Jackson, USA) after applying a freezing treatment to the leaves (Appendix S11)
Leaf N concentration	Continuous (mg g^{-1})*	Associated with nutritional quality	Mean values obtained from Rossouw (2014), (Appendix S8), where nitrogen was analysed using a TruSpec CHN analyser (Leco Corporation, MI, USA).
Leaf P concentration	Continuous (mg g^{-1})*	Associated with nutritional quality	Mean values obtained from Rossouw (2014) (Appendix S8), measured through Inductively Coupled Plasma–Optical Emission Spectrometry using a Vista ICP-OES Spectrometer (Varian Inc., CA, USA).
Leaf chlorophyll content	Continuous (mg)*	A direct determinant of a plant's primary production and photosynthetic potential (Curran, Dungan & Gholz 1990).	Measured using a CCM-300 chlorophyll meter (Opti-Sciences Inc., Hudson, USA). Chlorophyll values were multiplied by SLA to give a measure of chlorophyll content per unit mass (mg) per species (Appendix S11).

Plant trait	**Data type and attribute**	**Importance**	**Source/Measurement method**
			This accounted for leaf thickness.
Below-ground traits			
Specific root length	Continuous (mg $^{-1}$)*	Correlated with the acquisitive ability, growth rates and longevity of roots (also known as the below-ground analogue of SLA)	Obtained from Louw (2016) (Appendix S8). Calculated as the combined length divided by combined dry mass of roots.
Root diameter	Continuous (mm)*	Related to the penetrative force of roots on the ground and is positively correlated with root longevity.	Obtained from Louw (2016) (Appendix S8). Measured just behind the zone of elongation in the root hair zone, using a digital microscope.
Regenerative traits			
Dispersal mode	Nominal (1. Unassisted dispersal 2. External animal transport 3. Dispersal by water)	Related to dispersal distance, dispersal routes, and eventual resting place.	Collated from published and unpublished literature and personal communication with botanical experts (Appendix S8).

*Compared between native and invasive species only (i.e. excluding non-invasive alien)

Appendix S11 *Trait processing*

Whole plant and regenerative traits

Plant height was measured in the field. Plants with their foliage exposed to full sunlight were selected (Pérez-Harguindeguy et al. 2013). The height was measured as the distance from the ground to the top of the foliage of a plant.

Data on life history, growth form and dispersal mode were located through electronic searches, personal communication with experts and unpublished data sources (Appendix S8).

Leaf-level traits

Twigs or a tussock of fully expanded mature leaves from adult plants were cut from the plant and immediately placed in sealed plastic bags (following Pérez-Harguindeguy et al. 2013). Bags were breathed into before closing to enhance CO_2 concentration and air humidity to minimise transpirational water loss (Pérez-Harguindeguy et al. 2013). The plant samples were stored in dark plastic bags and brought to the laboratory. Here they were stored in a refrigerator at a temperature of c. 4°C in the dark to prevent light-induced reactions, until further processing in the laboratory (Pérez-Harguindeguy et al. 2013). Leaf traits were measured as soon as possible after collecting, typically within 24 hours (Pérez-Harguindeguy et al. 2013).

In the laboratory up to four leaves, or for plants with very small leaves up to eight leaves, were used to measure the leaf area of a single plant. Each leaf was cut from the stem, the petiole removed, and gently patted dry before measurement. A flatbed scanner (CanScan lide 25, Canon Europe/Scanjet G4050, HP USA) was used to scan the one-sided area of a leaf for the measurement of leaf area. In all cases, the leaves were flattened on the scanner to capture the entire photosynthetic area of the leaf. All leaves from the same plant were scanned together along with a standard ruler for scale, and the leaf area was calculated using the ImageJ (version 1.48) image analysis software (http://www.download82.com/download/windows/imagej/).

After the area scan, all leaves from a plant were placed in a paper envelope and dried in an oven at 50°C for at least 72 hours. Thereafter, the dry mass of the leaf sample was determined to the nearest mg. Specific leaf area (SLA) was calculated as the one-sided area of a fresh leaf, divided by its oven-dry mass.

Leaf toughness was measured as the force it takes to break a leaf surface using the a calibrated penetrometer (Digital force gauge FH 10, Sauter GmbH, Balingen, Germany). The penetrometer was placed steadily against the wall on a laboratory desk. Each leaf was held on both ends at a constant distance and slowly pushed through the penetrometer probe (the speed at which the leaf touches the probe does not influence the force reading). The maximum force reading after breaking the leaf surface was taken as the leaf toughness value. Each reading was taken from four leaves selected randomly from a plant and then averaged for that plant. This was repeated for a sample size of four plants per species for each sampling locality. The leaf toughness value was then calculated by averaging the leaf toughness for that species for all the sampling localities.

Leaf chlorophyll content (mg m^{-2}) was measured using the CCM-300 chlorophyll meter (Opti-Sciences Inc., Hudson, USA). The fluorescence ratio method was used. A sample of four plants per species per sampling locality was used. Four healthy leaves were selected at random from each plant. The average of three chlorophyll readings per leaf was used. This was repeated for four leaves per plant. These four readings were averaged for that plant and averaged for four plants per species for each sampling locality. Similar to the above traits, leaf chlorophyll content was then calculated by averaging the chlorophyll content for that species for all sampling localities. Finally, the chlorophyll values per unit area were expressed on a mass basis using SLA (mm^2 mg-^{1}) to account for the different leaf thicknesses among species. When chlorophyll content was expressed on an area basis, it correlated negatively (although not significant) with leaf nitrogen concentration (R-Squared = -0.08, P = 0.95) (Fig. S3a). Only when chlorophyll content was expressed per unit mass did the relationship between photosynthetic capacity (chlorophyll content) concur with the general trends reported for leaf traits (Wright et al. 2004), and the results were significant (R-Squared = 0.31, P = 0.02) (Fig. S3b).

For the measurement of electrolyte leakage as an indicator of frost tolerance, we modified the guidelines of Pérez-Harguindeguy et al. (2013). The leaves of many species on Marion Island are very small; it was thus impossible to cut circular 5-mm-diameter leaf disks. As an alternative, leaf fragments were standardized by mass rather than area. For each measurement, leaf fragments of approximately 0.04 mg were used (with the exact weight of each fragment being determined to the nearest milligram prior to treatment). For grasses, only fragments from the second tiller from the bottom of the plant were used where possible. For plants with smaller leaves, whole leaves were taken. For plants with bigger leaves, the leaves were cut to a standard length of 2 cm. For plants with compound leaves, the leaflets were cut off from the rachis. The weighed leaf fragments were placed in a plastic vial filled with 6 ml deionised water. Five pairwise samples were taken from five individuals of each species. The samples (plastic vials with the leaf fragments) were allowed to stand for a minimum of ten minutes before being rinsed by vigorously shaking the plastic vials. Water was then pipetted out of the vials, and the leaf fragments again submerged in 3 ml deionised water for a minimum of five minutes. This was followed by vigorously shaking the plastic vials again, pipetting the water out of the vials, and replacing the deionised water. The samples were then left up to ten minutes after shaking. Thereafter, one half of the vials were subjected to a control treatment which involved incubation at 20°C in an incubator. For incubation, samples were placed in a lab store rack and covered with a black plastic bag to prevent light-induced reactions. The other half of the vials was incubated at -8°C in a water bath. The water bath was filled with 50 % ethylene glycol, and cooled to -8°C. For both treatments, plant fragments were incubated for 14 hours in complete darkness (Pérez-Harguindeguy et al. 2013). After the samples were removed from the water bath and incubator they were left to reach ambient temperature, while being kept in the dark. Thereafter, a calibrated conductivity meter (Eutech WP 600 series meters PCD 650, Forestry Suppliers, Inc., Jackson, USA) was used to measure conductivity of the solution. The conductivity was calculated as the conductivity measured after the treatment (µS) divided by the mass (g) of the leaf fragments for that replicate, expressed in µS g^{-1}. The conductivity was measured for both the control and experimental treatment. The standard protocol following the guidelines by Pérez-Harguindeguy et al. (2013) is to boil samples from both treatments for 15 minutes to completely disrupt cell membranes, and measure the conductivity again. Due to practical issues, for example, solution leaking out of the vials or water entering the vials during boiling, the results were unreliable for most samples. However, when the samples that were not damaged (i.e. did not leak) for both treatments were used, we found the conductivity of the experimental treatment to be always higher than that of the control (Fig. S4), indicating that even though boiling the samples does have an effect on the conductivity measured afterwards, the trend remains the same for both the control and experimental treatment. Hence, boiling the samples after applying the treatment was not included in this study.

To obtain a measure of frost tolerance, conductivity values from both treatments were averaged for each species and electrolyte leakage (µS g^{-1}) was calculated as the conductivity measured for the -8°C solution minus the solution maintained at 20°C, to control for differences in injury when leaf fragments were cut or any experimental manipulations that may be sources of error (Pérez-Harguindeguy et al. 2013). High values of conductivity indicate significant disruption of cell membranes and thus cell injury upon freezing; thus the higher the conductivity, the greater the electrolyte leakage and thus frost sensitivity (Pérez-Harguindeguy et al. 2013).

Average trait values for physiological traits, namely leaf nitrogen (N) and phosphorus (P) concentration were obtained from Rossouw (2014) (Appendix S8) who sampled 13 vascular plant species across a range of altitudes, from the coastal lowlands to higher altitude in the island's interior, in a study investigating spatial variation in the nutrient composition of plants on Marion island. This data was collected in April and May of 2009 to 2011. All plant material was rinsed, dried at 100°C and ground. Leaf N was analysed from a subsample of plant material using TruSpec CHN analyser (Leco Coperation, MI, USA), while the concentration of P was measured by inductively coupled plasma–optical emission spectrometry in the laboratory at controlled temperature. Only the means for leaf N and P concentration obtained from living leaves of vascular plant species (Rossouw 2014) were selected for this study.

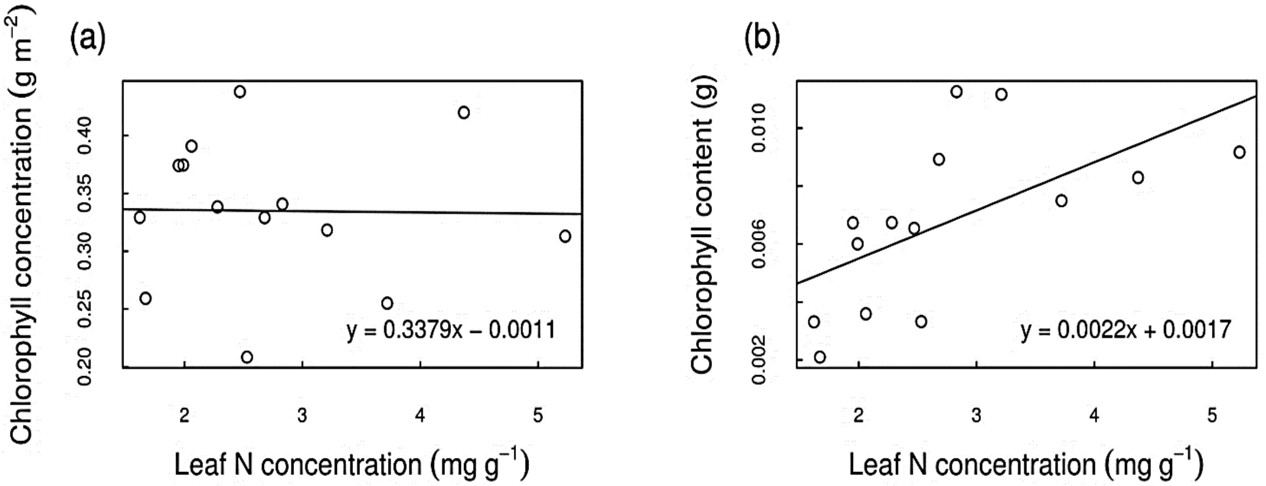

Figure S3. Regression of leaf chlorophyll content against leaf nitrogen concentration. a) Chlorophyll concentration per unit area (R-Squared = -0.08, P = 0.95), b) chlorophyll content per unit mass (R-Squared = 0.31, P = 0.02).

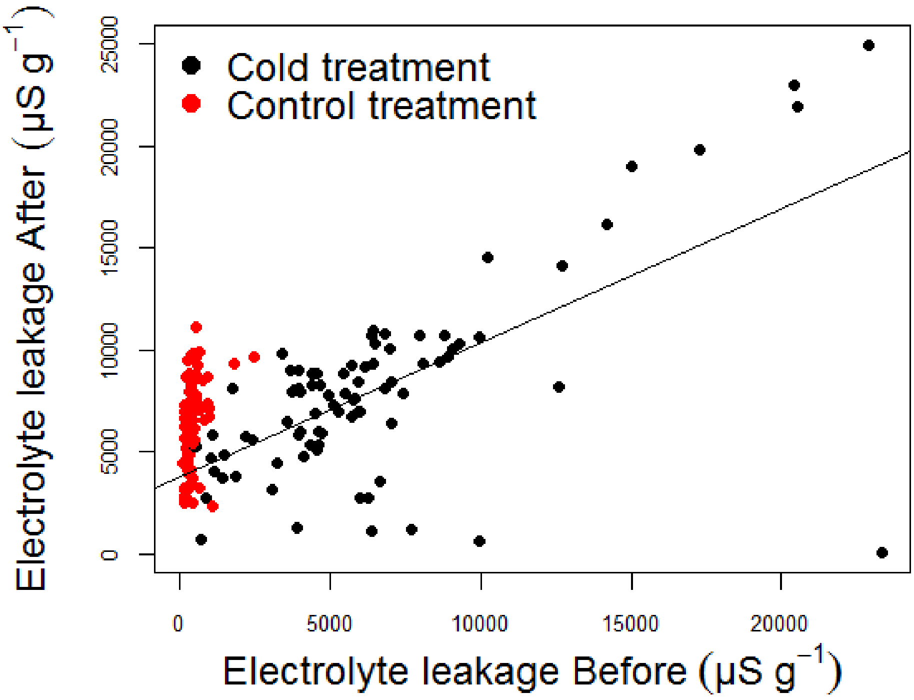

Figure S4. Electrolyte leakage measured before and after the boiling process for the cold (incubation at -8^{0}C) and control (incubation at 20^{0}C) treatment of all leaf samples that were not damaged during the boiling process.

Below-ground traits

Specific root length (SRL) is the ratio of root length to dry mass of absorptive roots (m g^{-1}) and is correlated with the below-ground acquisitive ability, growth rates and root longevity (Pérez-Harguindeguy et al. 2013). Root diameter is expressed in mm and is related to the penetrative force of roots on the ground. Mean values for these traits were obtained from Louw (2016), where species were collected within 2 kilometres of the meteorological station and at sites of low altitude (2 to 150 m above sea level).

Appendix S12: *Multivariate analysis (principal component analysis)*

To identify general trends in functional traits of invasive and native species, and to understand in a multivariate context how these traits were related, a principal component analysis (PCA) was performed using the *prcomp* built in function in R. The dataset was first arranged into a six trait (trait mean values of continuous traits) x 26 species matrix. Missing trait values were imputed using the R package *missMDA* which performs principal component methods on incomplete data sets (Josse and Husson 2016); this was only done in cases where only up to two trait mean values were missing for a given species. Traits collected from published studies i.e. Leaf N and P concentration, SRL and root diameter were not included in the PCA because they had too many missing values. Separate analyses (two-tailed t-tests) were performed to test for overall differences in the traits of invasive and native species along the two PCA axes. Another PCA (Appendix S17) was performed for invasive and non-invasive alien species for the traits that could be measured for non-invasive aliens: height, leaf area, SLA and electrolyte leakage. Species that had more than one trait missing were excluded. This analysis was run separately because fewer traits were available for this comparison. Continuous traits were log-transformed before carrying out both ordination analyses.

Appendix S13: *Phylogenetic tree of all study species*

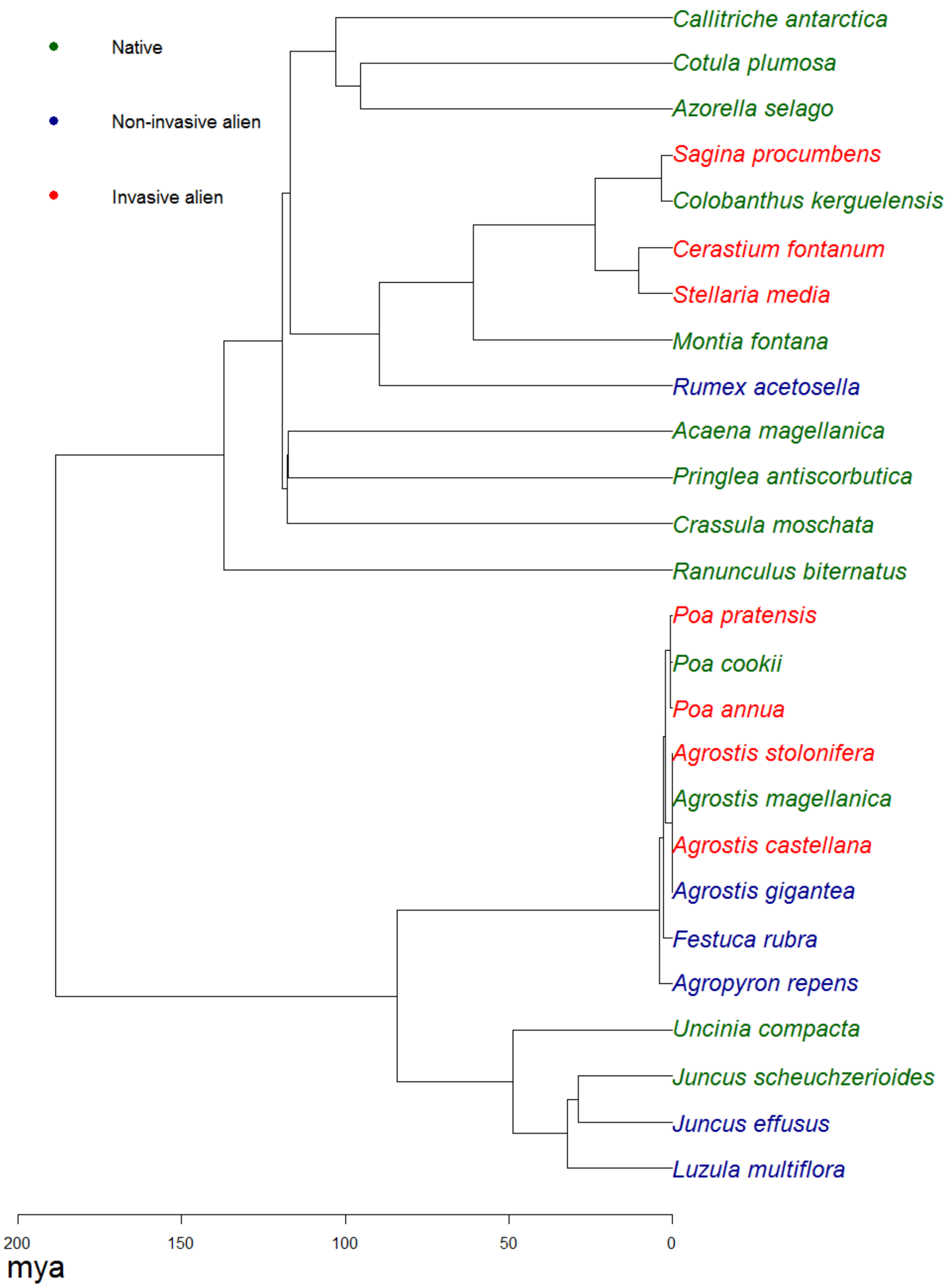

Figure S5. Phylogenetic tree of all study species, based on Zanne et al. (2014), mya = million years ago.

Appendix S14: *Univariate analysis (phylogenetic generalized least-squares models)*

For the phylogenetic generalized least-squares models (PGLS) analyses, data for some traits were obtained from published studies that did not sample non-invasive aliens. In addition, due to an ongoing eradication programme targeting non-invasive alien plants on Marion Island, it was not possible to locate several non-invasive alien species during the second sampling period. As a result, values of six traits (Appendix S10) could not be obtained for non-invasive aliens, and the invasive *vs*. non-invasive alien comparisons were not analysed for these traits. In addition, published studies did not have data for some traits for some native (maximum 8%) and invasive (maximum 43%) species (Appendix S9). For these traits, invasive *vs*. native species analyses were run using data for all available species.

Appendix S15 *Trait data of vascular plant species common in the coastal areas of Marion Island*

Table S8. Mean trait values (± standard error) of vascular plant species common in the coastal areas of Marion Island, N/A = trait data not available.

	Trait				
Species name	**Height (mm)**	**Leaf area (mm^2)**	**Specific leaf area ($mm^2\ mg^{-1}$)**	**Leaf chlorophyll content (mg)**	**Leaf toughness (N)**
Acaena magellanica	84.25±41.43	1747.96±424.16	15.21±0.41	6.45±0.34	0.12±0.01
Agrostis magellanica	137.53±48.15	1210.77±162.57	20.26±1.77	7.70±0.45	0.79±0.06
Agrostis stolonifera	255.63±91.38	916.53±62.95	40.15±1.77	13.74±0.93	0.28±0.02
Azorella selago	151.32±107.18	50.24±4.09	8.99±0.34	2.06±0.22	N/A
Callitriche antarctica	61.75±32.93	104.14±8.69	34.13±1.64	11.71±0.59	0.41±0.03
Colobanthus kerguelensis	N/A	49.37±5.64	15.54±0.59	N/A	N/A
Cotula plumosa	52.8±30.94	1521.68±203.08	20.67±0.86	6.62±0.50	0.48±0.05
Crassula moschata	17.31±11.72	56.67±5.28	21.19±1.15	4.00±0.41	N/A
Juncus scheuchzerioides	48.13±32.20	47.50±41.82	15.37±0.10	4.32±0.06	1.33±0.15
Montia fontana	47.38±24.08	101.86±15.98	34.38±2.50	8.58±1.12	0.39±0.03
Poa annua	144.72±58.59	686.47±60.41	36.10±1.16	11.42±0.99	0.31±0.02
Poa cookii	300.83±	4241.83±941.19	11.45±0.46	5.54±0.15	3.71±0.13
Poa pratensis	130±78.24	N/A	N/A	N/A	0.65±0.03
Ranunculus biternatus	29.15±39.53	580.32±76.19	20.84±0.81	6.13±0.51	0.55±0.03
Sagina procumbens	42.36±45.06	28.90±1.75	25.17±2.00	5.62±0.91	0.12±0.01
Stellaria media	80±47.96	305.00±90.12	58.51±3.78	N/A	N/A
Uncinia compacta	132.89±25.99	N/A	N/A	N/A	3.11±0.10

Appendix S16: *Bivariate trait analysis (standardized major axis)*

For the Standardized major axis (SMA) analyses, we initially tested if the slope of the best fit line differed between groups (i.e. invasive *vs*. native/invasive *vs*. non-invasive alien) as an indication of differences in the nature of bivariate trait relationships (Warton et al. 2006). Where slopes between groups do not differ (as observed in this study; see results), the analysis tests if the lines fitted to the groups display a shift in elevation (y-intercept), or a shift in location on the x-axis (although these two analyses were only run if the slope of the combined data was significantly different to zero, following Warton et al. 2006) (Appendix S19). Standardized major axis regressions were analysed for most pairs of leaf traits, and for the two below-ground traits. Leaf N and P concentration were excluded from analyses because the low number of data points for invasive species, along with the higher number of measurements for native than invasive species, heavily biased the calculations of slope for invasive species.

Appendix S17: *Ordination of invasive and non-invasive vascular plant species*

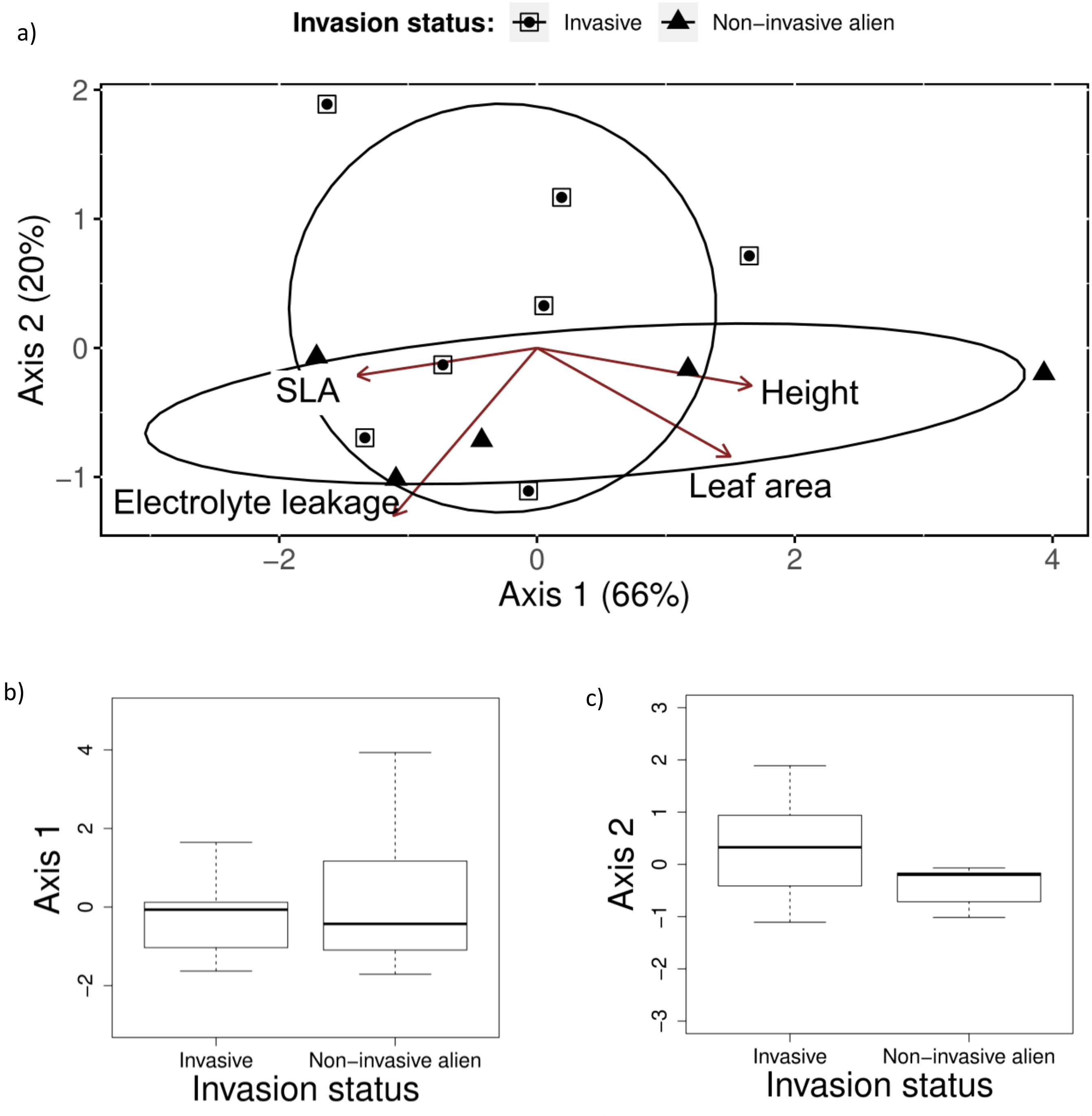

Figure S6. a) Ordination of invasive (n = 7; square symbols) and non-invasive alien (n = 4; triangle symbols) species using principal components analysis (PCA) based on four variables (trait means): height, leaf area, specific leaf area (SLA), and electrolyte leakage (as an indicator of frost sensitivity). Species are distinguished by symbols: triangles = invasive, squares = non-invasive alien. Ellipses are plotted to indicate the 95% confidence interval for each group. Axes 1 and 2 cumulatively explained 86% of the variance. b) and c) Results from -two-tailed t-tests depicting overall trait differences between invasive and native species along PCA axes 1 (t = -0.59, df = 10, P = 0.58) and 2 (t = 1.70, df = 10, P = 0.13), respectively.

***Appendix S18** Trait differences between native and invasive species common in the coastal areas of Marion Island*

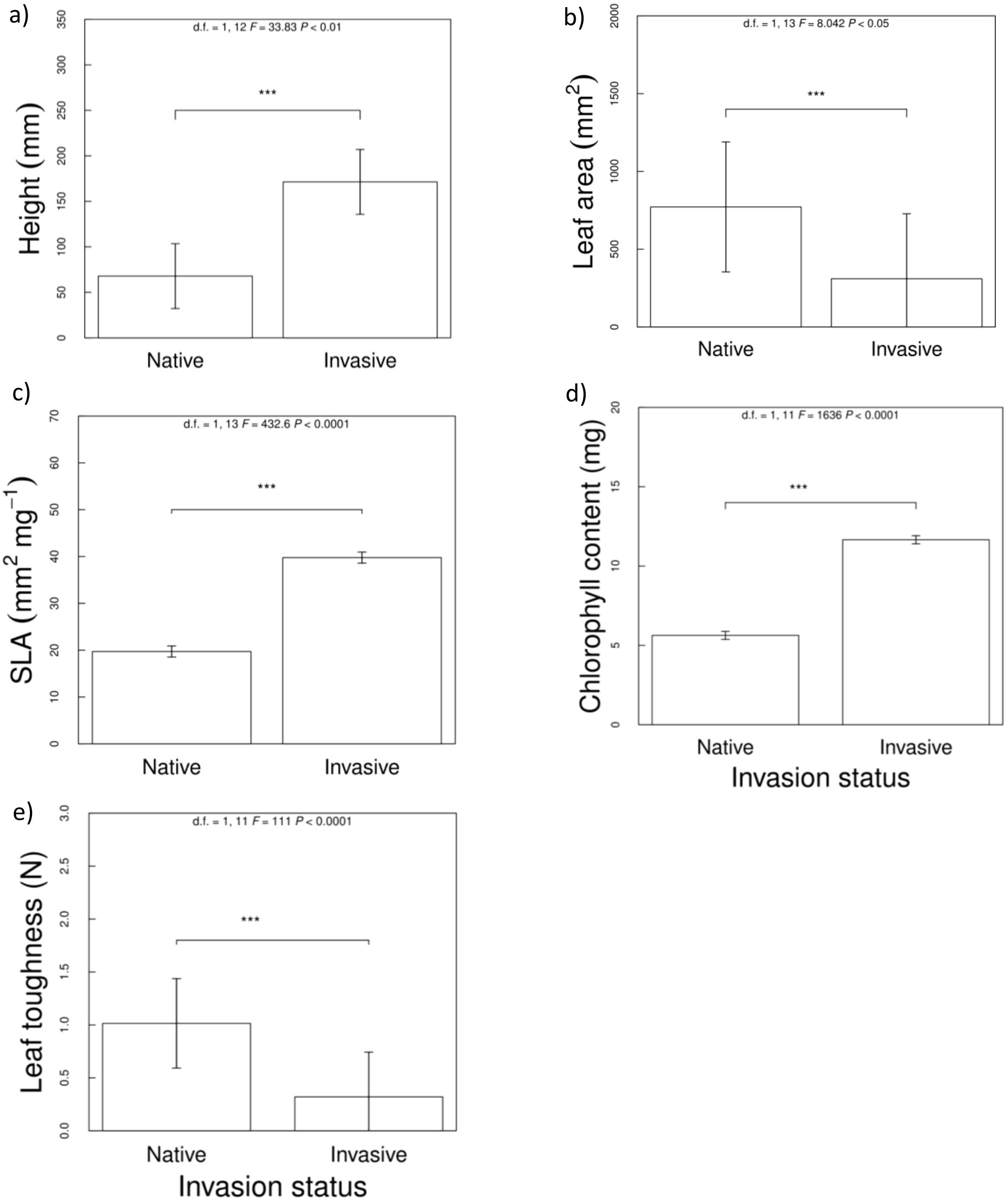

Figure S7. Bar graphs showing phylogenetically-corrected trait differences (± standard error) from phylogenetic generalized least-squares models comparing native and invasive plant species that are common in the coastal areas of Marion Island. a) Height, b) leaf area, c) specific leaf area, d) leaf chlorophyll content, e) leaf toughness. The horizontal lines indicate the significance of pair-wise comparisons between native and invasive species. F ratios (*F*), degrees of freedom (*d.f.*), and significant levels (*$P < 0.05$, **$P < 0.001$, ***$P < 0.0001$) are shown. Raw phylogenetically corrected trait values (y-axis) are plotted here for ease of interpretation, but statistics were conducted on transformed data to meet assumptions of phylogenetic generalized least-squares models.

Appendix S19 *Results of standardized major axis regression analysis for vascular plant species on Marion Island*

Table S9. Results of standardized major axis regression (SMA) analysis of pairwise combinations of leaf area, specific leaf area (SLA), electrolyte leakage as an indicator of frost sensitivity, leaf chlorophyll content, leaf toughness, specific root length (SRL) and root diameter for up to 26 vascular plant species on Marion Island. Bolded values indicate significant differences.

Trait pair	*n*	r^2	*P*	Slope	Slope homogeneity (*P*)	Shift in elevation (*P*)	Shift along slope (*P*)
leaf area & SLA	26	0.202	**0.047**	-3.410	0.806	0.322	0.176
leaf area & electrolyte leakage	23	0.012	0.652	-4.097	0.873	0.109	0.612
leaf area & chlorophyll content	20	0.0061	0.743	2.742	0.806	0.012	0.113
leaf area & leaf toughness	18	0.201	0.062	1.617	0.626	0.188	0.080
SLA & electrolyte leakage	24	0.464	**0.001**	1.264	0.728	**0.009**	0.252
SLA & chlorophyll content	20	0.574	**<0.001**	0.956	0.881	0.528	**0.003**
SLA & leaf toughness	17	0.568	**<0.001**	-0.534	0.880	0.578	**0.023**
electrolyte leakage & chlorophyll content	19	0.244	**0.032**	0.734	0.863	0.078	**0.032**
electrolyte leakage & leaf toughness	18	0.354	**0.009**	-0.380	0.726	**0.010**	0.184
chlorophyll content & leaf toughness	18	0.273	**0.026**	-0.530	0.639	0.842	**0.002**
SRL & root diameter	17	0.591	**<0.001**	-1.891	0.503	0.314	0.209

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