

Ecography

**ECOG-04014**

Davis, K. T., Callaway, R. M., Fajardo, A., Pauchard, A., Nuñez, M. A., Brooker, R. W., Maxwell, B. D., Dimarco, R. D., Peltzer, D. A., Mason, B., Ruotsalainen, S., McIntosh, A. C. S., Pakeman, R. J., Smith, A. L. and Gundale, M. J. 2019. Severity of impacts of an introduced species corresponds with regional eco-evolutionary experience. – *Ecography* doi: 10.1111/ecog.04014

**Supplementary material**

## Appendix 1.

### Severity of impacts of an introduced species corresponds with regional eco-evolutionary experience

Table A1. Site information. Region includes country in parentheses where regions contained sites in multiple countries. Abbreviations include *P. contorta* (PICO), basal area (BA; m<sup>2</sup> ha<sup>-1</sup>), mean annual temperature (MAT; °C), mean annual precipitation (MAP; mm), veg. (vegetation), Canada (CA), Europe (EU), Southern Hemisphere (SH), United States of America (US), Finland (FI), Scotland (SC), Sweden (SE), Argentina (AR), Chile (CL), and New Zealand (NZ).

Region	Site	PICO type	Native veg.	Longitude	Latitude	BA	Age	MAT	MAP
CA	FISI	Native forest	Forest	-127.256	59.717	17.7	22	-2.9	463
CA	FTJO	Plantation	Forest	-121.426	56.584	19.4	42	0.8	492
CA	FTNE	Native forest	Forest	-123.768	58.684	38.3	47	-2.5	473
CA	TER1	Native forest	Forest	-128.545	54.459	33.6	83	6.1	1389
CA	TER2	Native forest	Forest	-128.536	54.519	43.5	86	6.2	1371
CA	TDRV	Native forest	Forest	-124.711	58.645	17.4	121	-3.8	487
CA	TRUT	Native forest	Forest	-122.720	58.118	34.0	55	-0.8	466
EU (FI)	PUNK	Plantation	Plantation	29.193	61.567	20.2	35	3.2	665
EU (FI)	RUOT	Plantation	Plantation	23.094	60.032	36.0	28	5.3	609
EU (FI)	SOLB	Plantation	Plantation	25.006	60.352	30.0	32	4.6	655
EU (FI)	SUON	Plantation	Plantation	27.034	62.652	28.6	28	3	623
EU (SC)	K1B2	Plantation	Plantation	-2.422	55.192	53.2	29	7.5	876
EU (SC)	K1B1	Plantation	Plantation	-2.422	55.192	54.9	29	7.5	876
EU (SC)	K1B3	Plantation	Plantation	-2.422	55.192	47.6	29	7.5	876
EU (SC)	N1B1	Plantation	Plantation	-3.692	54.970	51.5	29	7.9	1169
EU (SC)	N1B2	Plantation	Plantation	-3.692	54.970	54.2	29	7.9	1169
EU (SC)	SHIN	Plantation	Plantation	-4.940	58.046	7.0	29	7.3	1166
EU (SC)	SPEY	Plantation	Plantation	-3.179	57.593	8.8	29	8	743
EU (SE)	SE01	Plantation	Plantation	16.932	62.185	19.0	43	2.6	683
EU (SE)	SE20	Plantation	Plantation	15.530	64.579	26.5	43	1.9	621
EU (SE)	SE21	Plantation	Plantation	16.144	64.086	30.5	41	1.8	571
EU (SE)	SE23	Plantation	Plantation	16.699	64.477	25.8	42	0.9	564
SH (AR)	AERO	Naturalized	Open	-71.207	-41.320	14.6	17	6.4	720
SH (AR)	ARRM	Naturalized	Open	-71.260	-41.353	21.5	14	4.6	741
SH (AR)	CABO	Naturalized	Open	-71.443	-41.888	28.2	26	8.7	950
SH (AR)	COND	Naturalized	Open	-71.237	-41.342	22.1	34	4.5	710
SH (AR)	SALM	Naturalized	Open	-71.418	-41.320	24.1	24	3.5	841
SH (CL)	CYAL	Plantation	Forest	-71.709	-45.501	9.4	11	6	760

Table A1 continued.

Region	Site	PICO type	Native veg.	Longitude	Latitude	BA	Age	MAT	MAP
SH (CL)	MALA	Plantation	Forest	-71.542	-38.424	42.5	29	6.7	1586
SH (CL)	RNCY	Plantation	Forest	-71.993	-45.539	31.4	43	5.1	958
SH (NZ)	BRHI	Naturalized	Open	171.717	-43.154	16.8	23	7.3	2241
SH (NZ)	CRBN	Naturalized	Open	171.401	-43.147	16.4	15	7.2	2348
SH (NZ)	HANM	Naturalized	Open	172.873	-42.489	18.8	28	7.8	1270
SH (NZ)	JOPA	Naturalized	Open	172.887	-42.472	35.2	24	8	1213
SH (NZ)	LERI	Plantation	Forest	173.071	-41.988	27.6	39	5	1779
SH (NZ)	MOLE	Naturalized	Open	172.884	-42.458	23.2	30	7.4	1285
US	BLBU	Naturalized	Open	-111.118	45.037	22.0	65	0.5	668
US	CHCO	Native forest	Forest	-120.069	47.978	41.9	35	3.7	541
US	CHRH	Native forest	Forest	-120.158	47.893	20.7	43	9.3	330
US	CHRL	Native forest	Forest	-120.378	47.992	27.6	72	1.4	917
US	EALK	Native forest	Forest	-121.312	43.704	37.2	41	4.3	614
US	FLLK	Native forest	Open	-117.579	48.545	42.7	69	6	639
US	FLO1	Native forest	Forest	-124.126	43.958	27.6	35	11.2	1920
US	FLO2	Native forest	Open	-124.104	44.048	28.9	29	11.1	2003
US	ION1	Native forest	Open	-117.477	48.656	25.7	70	5.5	694
US	ION3	Native forest	Open	-117.412	48.712	46.8	15	7.1	658
US	JOCA	Plantation	Forest	-111.029	45.966	6.8	16	1.7	686
US	MTBA	Native forest	Open	-121.556	43.974	30.3	66	3.8	981
US	OLY1	Native forest	Forest	-123.037	47.419	24.8	26	10.2	1564
US	OLY2	Native forest	Forest	-123.091	47.488	15.6	22	10	1643
US	POCR	Plantation	Forest	-111.150	45.297	14.4	23	0.9	689
US	SMPK	Native forest	Forest	-114.203	46.501	43.6	70	3.3	462
US	TECR	Naturalized	Open	-111.166	45.062	13.0	39	1.4	643

“Naturalized” refers to naturalized or invasive stands

Table A2. Results from ANCOVA of initial models for each response variable. Models with mean annual temperature (MAT) and mean annual precipitation (MAP) were conducted separately due to collinearity. BA is basal area. Final models only included significant variables ( $\alpha=0.05$ ), see Table A3.

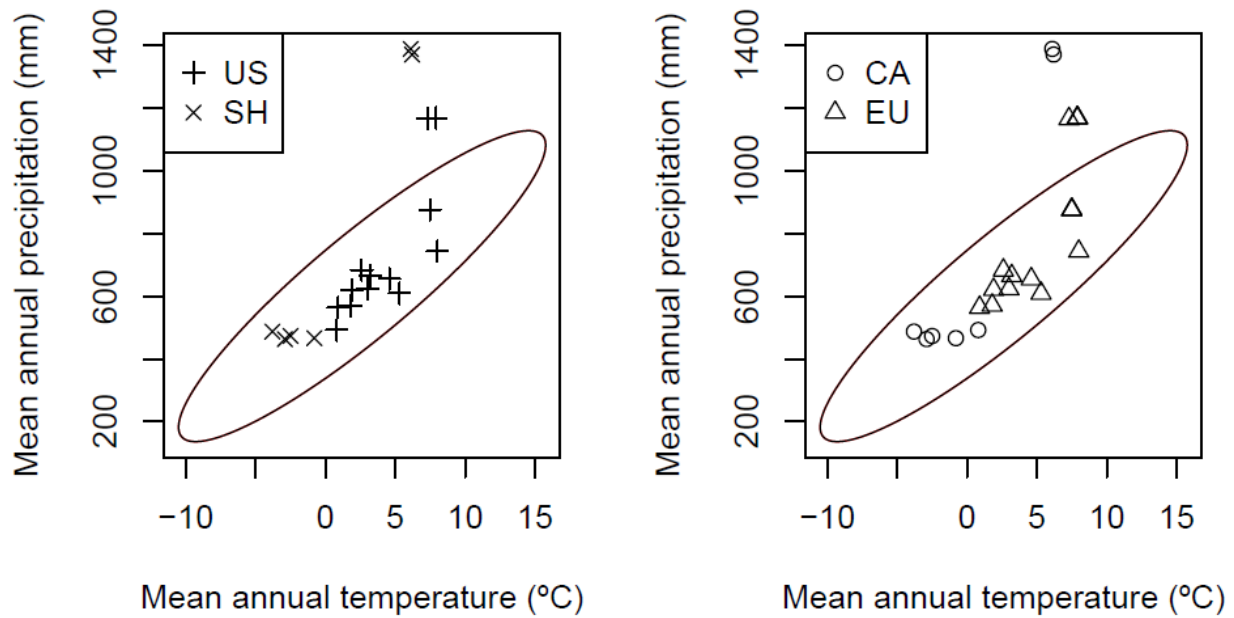
Response	Model	Residual df	Predictor	df	<i>F</i>	<i>P</i>
Richness	MAT	43	Region	3	3.678	0.019
			BA	1	8.110	0.007
			Stand age	1	0.102	0.751
			MAT	1	7.819	0.008
			Region:BA	3	1.839	0.154
	MAP	43	Region	3	2.840	0.049
			BA	1	12.204	0.001
			Stand age	1	0.741	0.394
			MAP	1	0.682	0.414
			Region:BA	3	1.325	0.279
Growth rate	MAT	43	Region	3	14.678	<0.001
			BA	1	0.114	0.737
			Stand age	1	21.835	<0.001
			MAT	1	0.178	0.675
			Region:BA	3	0.669	0.576
	MAP	43	Region	3	15.537	<0.001
			BA	1	0.081	0.777
			Stand age	1	23.664	<0.001
			MAP	1	1.691	0.201
			Region:BA	3	0.678	0.571
Litter depth	MAT	43	Region	3	3.905	0.015
			BA	1	2.547	0.118
			Stand age	1	2.517	0.120
			MAT	1	4.083	0.050
			Region:BA	3	6.360	0.001
	MAP	43	Region	3	3.471	0.024
			BA	1	1.448	0.235
			Stand age	1	3.849	0.056
			MAP	1	1.466	0.233
			Region:BA	3	5.676	0.002

Table A3. Results from final models of species richness, growth rate, and litter depth in *P. contorta* stands. All models initially included region, basal area (BA), stand age, the interaction between BA and region, and mean annual temperature (MAT) or mean annual precipitation (MAP). Separate models were conducted with either MAT or MAP due to high colinearity and the model with the highest R<sup>2</sup> is reported here. Variables that were not significant ( $\alpha=0.05$ ) were removed from the final models (Table S2). The reference level for region is the Southern Hemisphere. Other region abbreviations include Canada (CA), Europe (EU), and United States of America (US). R<sup>2</sup> is adjusted R<sup>2</sup>. df is degrees of freedom and SE is standard error.

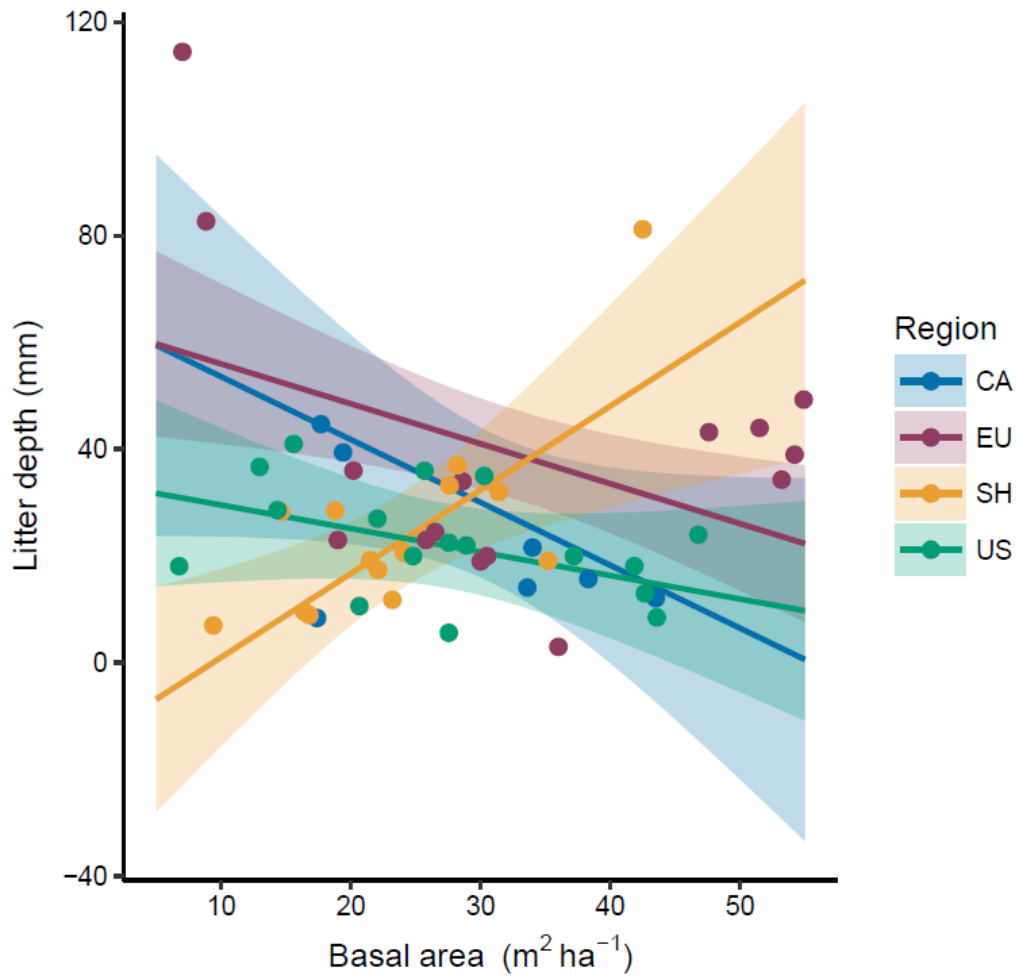
Response	R <sup>2</sup>	df	Predictor	Coefficient	SE	t-value	P
Richness	0.36	47	Intercept	9.97	1.363	7.31	<0.001
			Region CA	1.56	1.710	0.92	0.365
			Region EU	1.36	1.219	1.11	0.271
			Region US	3.78	1.133	3.33	0.002
			BA	-0.10	0.037	-2.82	0.007
			MAT	-0.38	0.149	-2.59	0.013
Growth rate	0.72	48	Intercept	1.41	0.063	22.52	<0.001
			Region CA	-0.45	0.104	-4.27	<0.001
			Region EU	-0.43	0.070	-6.17	<0.001
			Region US	-0.43	0.072	-5.93	<0.001
			Stand age	-0.01	0.002	-5.28	<0.001
			Litter depth	0.32	44	Intercept	-24.34
			Region CA	80.05	25.326	3.16	0.003
			Region EU	78.16	16.653	4.69	<0.001
			Region US	48.64	16.848	2.89	0.006
			BA	1.57	0.521	3.01	0.004
			MAT	1.97	0.817	2.41	0.020
			Region CA:BA	-2.75	0.832	-3.30	0.002
			Region EU:BA	-2.32	0.590	-3.93	<0.001
			Region US:BA	-2.01	0.629	-3.20	0.003

Table A4. Results from pairwise comparisons between regions of the three responses: species richness, *P. contorta* growth rate, and litter depth, calculated using the package “lsmeans” (Lenth 2016). Continuous predictors were held at mean values for comparisons of species richness and growth rate between regions. For litter depth there was a significant basal area (BA) by region interaction so pairwise comparisons are shown for three levels of BA at the mean value of mean annual temperature (4.9°C). See Figure A2 to visualize the interaction. The Bonferroni correction was applied to *P*-values. See Table A3 for full model results. df is degrees of freedom and SE is standard error.

Response	Contrast	Estimate	SE	df	<i>t</i>	<i>P</i>
Richness	SH-CA	-1.564	1.710	47	-0.915	1.000
	SH-EU	-1.357	1.219	47	-1.113	1.000
	SH-US	-3.776	1.133	47	-3.332	0.010
	CA-EU	0.207	1.560	47	0.133	1.000
	CA-US	-2.211	1.573	47	-1.406	0.998
	EU-US	-2.418	1.110	47	-2.179	0.206
Growth rate	SH-CA	0.446	0.104	48	4.273	0.001
	SH-EU	0.430	0.070	48	6.173	<0.001
	SH-US	0.428	0.072	48	5.932	<0.001
	CA-EU	-0.015	0.097	48	-0.156	1.000
	CA-US	-0.018	0.089	48	-0.203	1.000
	EU-US	-0.003	0.067	48	-0.043	1.000
Litter depth BA = 15 m <sup>2</sup> ha <sup>-1</sup>	SH-CA	-38.850	14.507	44	-2.678	0.062
	SH-EU	-43.401	9.247	44	-4.694	0.000
	SH-US	-18.496	8.760	44	-2.111	0.243
	CA-EU	-4.551	13.726	44	-0.332	1.000
	CA-US	20.354	13.797	44	1.475	0.884
	EU-US	24.905	8.832	44	2.820	0.043
BA = 30 m <sup>2</sup> ha <sup>-1</sup>	SH-CA	2.351	9.547	44	0.246	1.000
	SH-EU	-8.638	7.092	44	-1.218	1.000
	SH-US	11.644	6.882	44	1.692	0.586
	CA-EU	-10.989	8.371	44	-1.313	1.000
	CA-US	9.293	8.452	44	1.099	1.000
	EU-US	20.282	5.969	44	3.398	0.009
BA = 45 m <sup>2</sup> ha <sup>-1</sup>	SH-CA	43.552	16.837	44	2.587	0.078
	SH-EU	26.125	13.104	44	1.994	0.314
	SH-US	41.784	13.990	44	2.987	0.028
	CA-EU	-17.427	12.970	44	-1.344	1.000
	CA-US	-1.768	13.892	44	-0.127	1.000
	EU-US	15.659	9.061	44	1.728	0.546

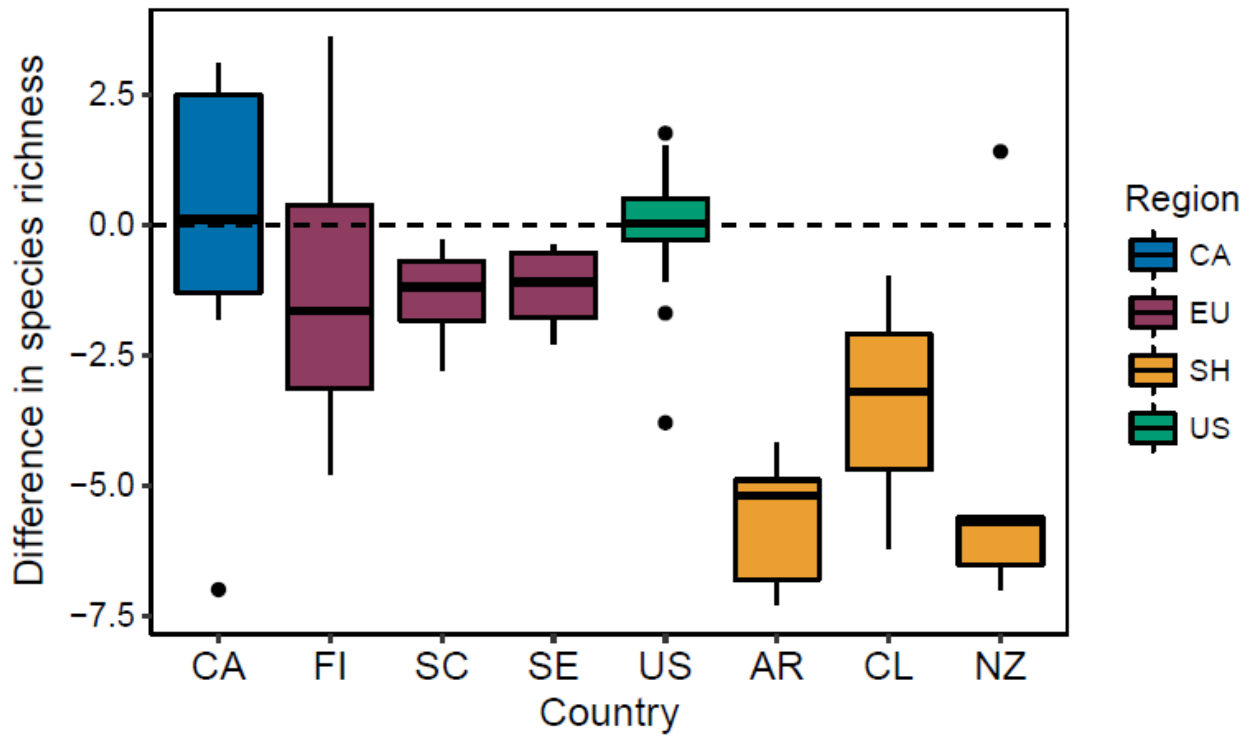


**Figure A1.** Mean annual precipitation versus mean annual temperature of the study sites within each source-destination pair (Canada (CA), Europe (EU), Southern Hemisphere (SH), United States (US)). Point shape represents region. The circle delineates the 95<sup>th</sup> quantile based on the Mahalanobis distance between points (i.e. points outside the circle are outliers in terms of climate space based on these two climate variables).

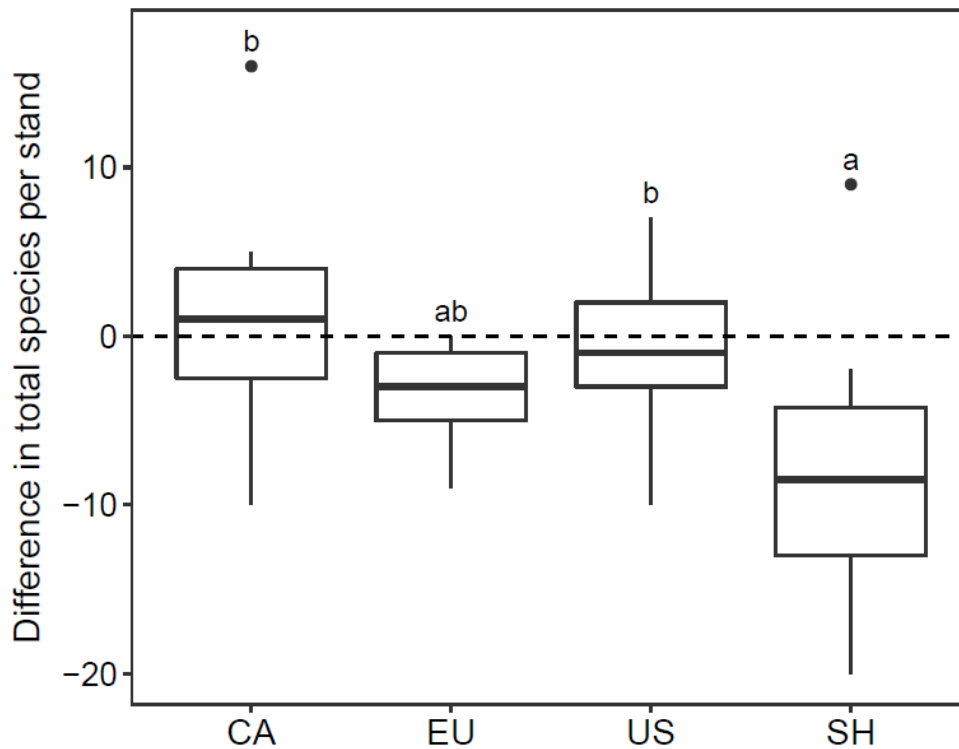


**Figure A2.** Litter depth versus basal area (BA) in *P. contorta* stands displaying the significant region by BA interaction. Although an outlier in SH does exert some influence, the BA\*Region interaction is significant when the outlier is removed and the slope is still positive for SH (although slightly less steep). Mean annual temperature was set to the mean value of 4.9°C. Shading represents 95% confidence intervals.

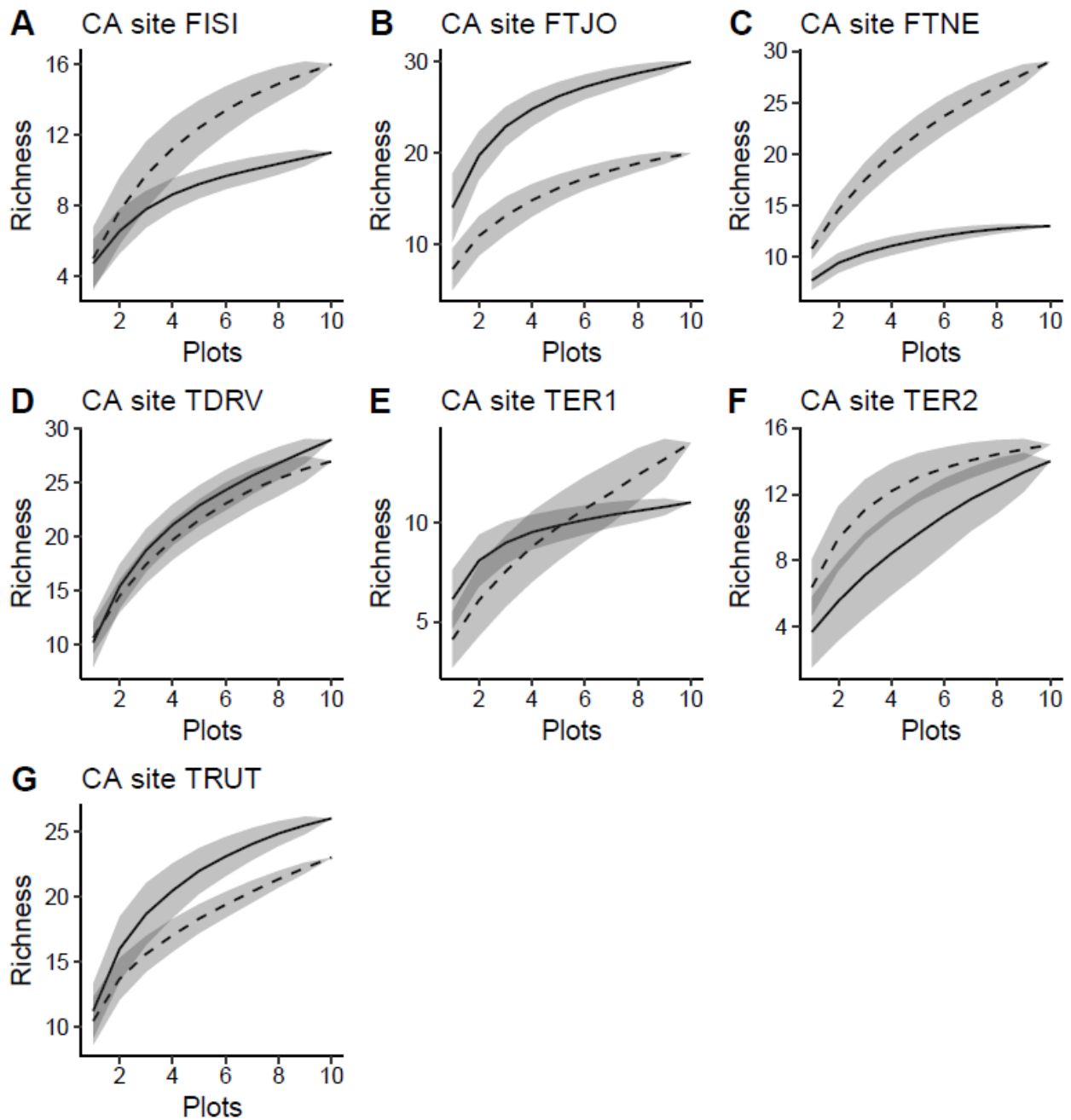




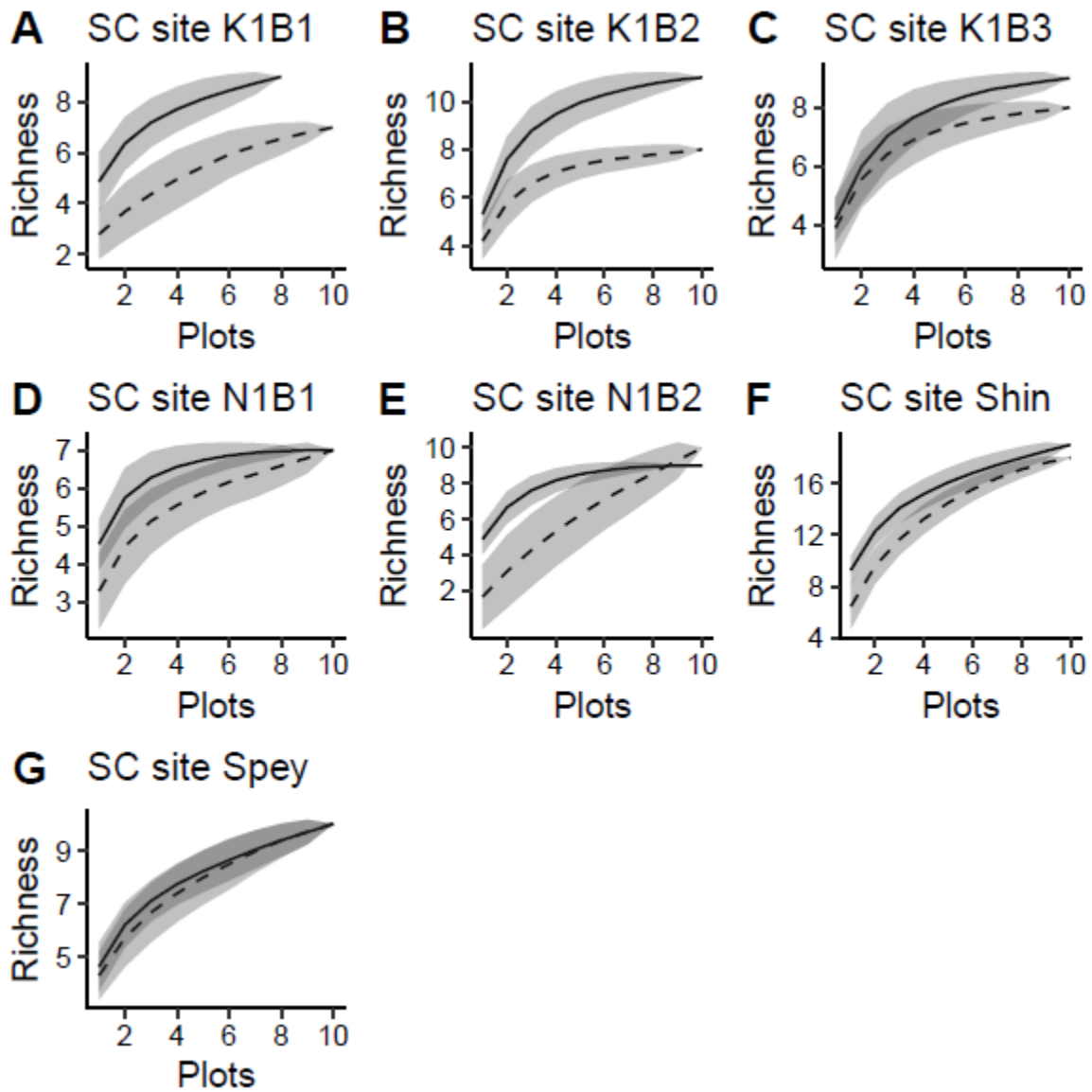
**Figure A3.** Boxplots showing the difference in plot-level plant species richness between *P. contorta* and adjacent non-*P. contorta* stands within sites. Countries include: “CA” – Canada; “FI” – Finland; “SC” – Scotland; “SE” – Sweden; “US” – United States; “AR” – Argentina; “CL” – Chile; and “NZ” – New Zealand.



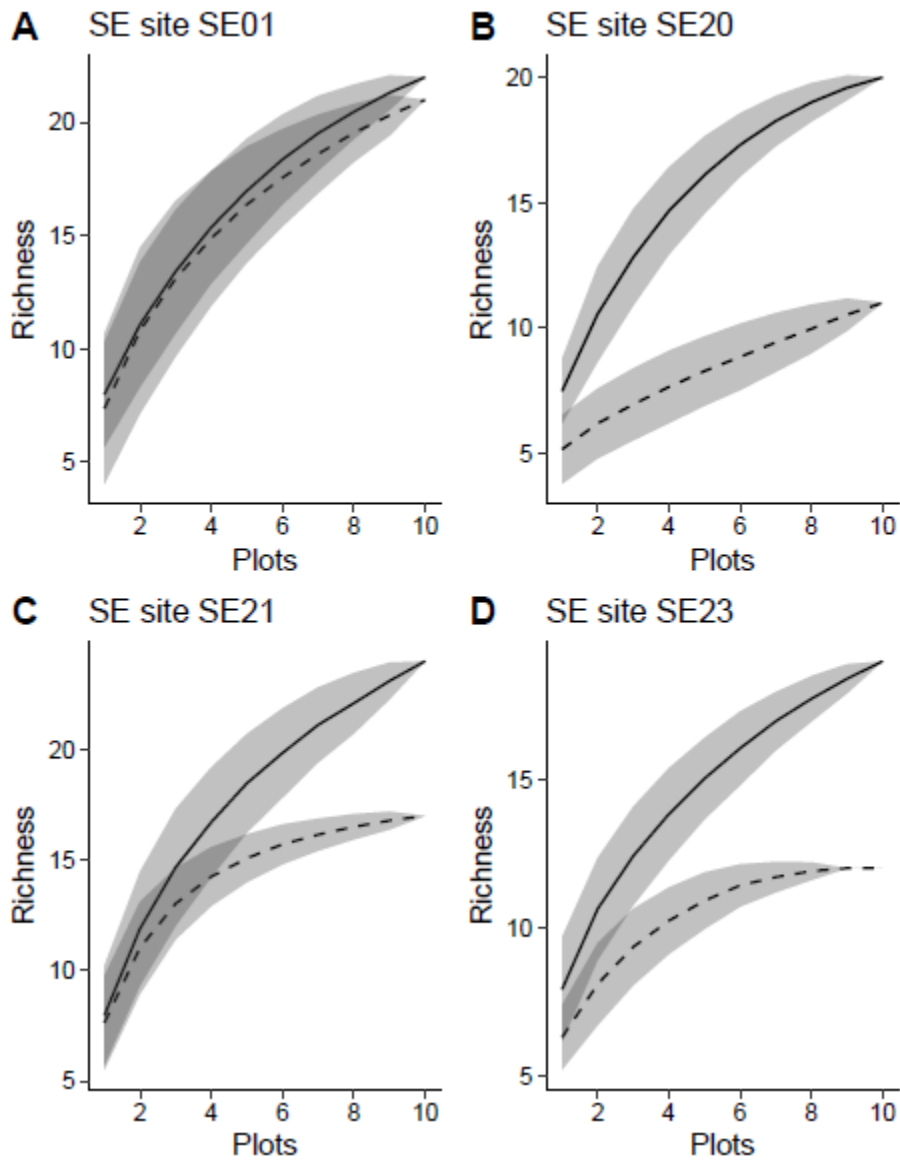
**Figure A4.** Boxplots of the difference in the total number of plant species per stand in *P. contorta* and non-*P. contorta* stands at each site (Canada (CA), Europe (EU), Southern Hemisphere (SH), United States (US)). Negative values indicate fewer species in the *P. contorta* than paired non-*P. contorta* stand within each site. Regions with a different letter above the boxes are significantly different ( $\alpha=0.05$ ) as determined by post-hoc Tukey's tests. Note that at some sites sampling effort may not have been sufficient to sample all species in that stand (Figures S5-S13).



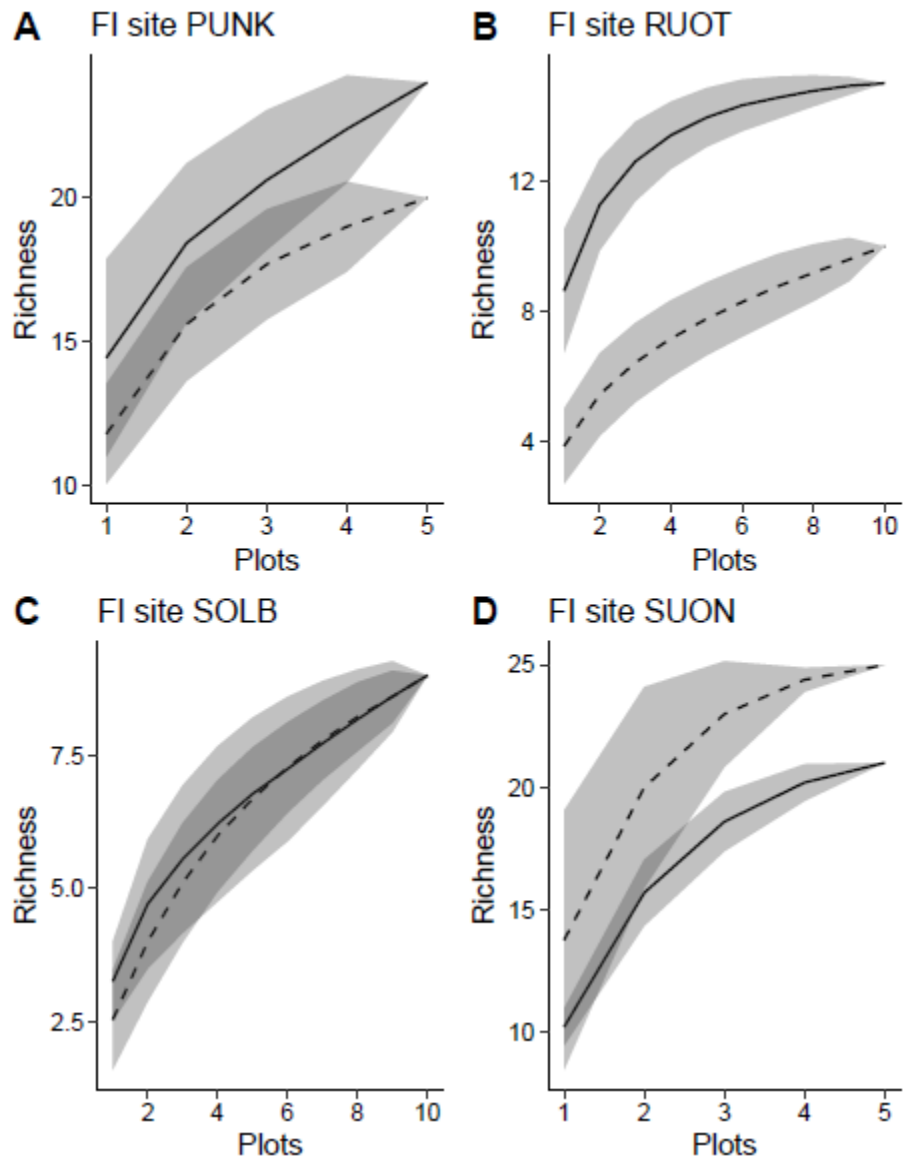
**Figure A5.** Species accumulation curves for *P. contorta* (dashed line) and non-*P. contorta* (solid line) stands at each site in Canada (CA). Shaded area is one standard deviation calculated from random permutations of the data (subsampling without replacement; Gotelli and Colwell 2001).



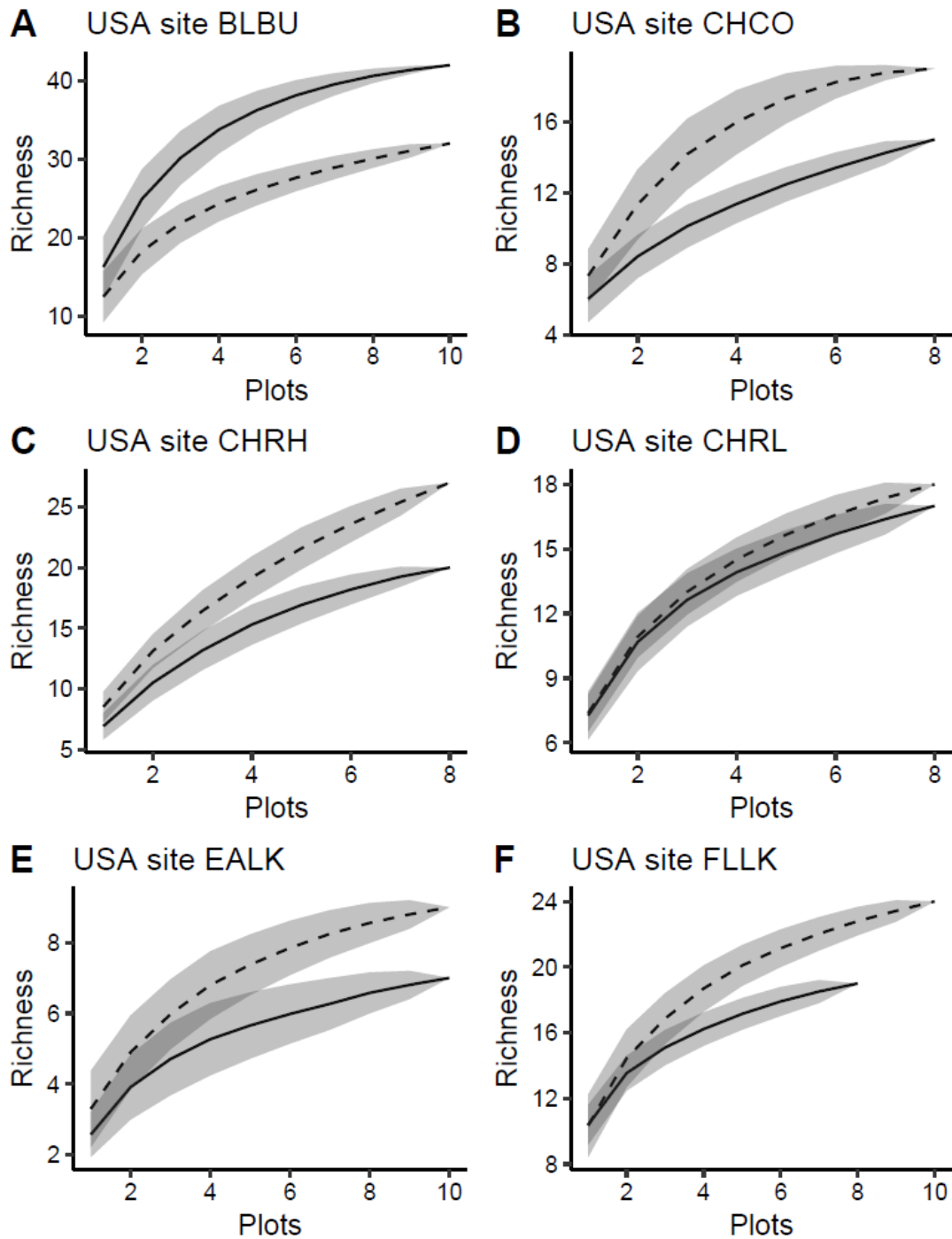
**Figure A6.** Species accumulation curves for *P. contorta* (dashed line) and non-*P. contorta* (solid line) stands at each site in Scotland (SC). Shaded area is one standard deviation calculated from random permutations of the data (subsampling without replacement; Gotelli and Colwell 2001).



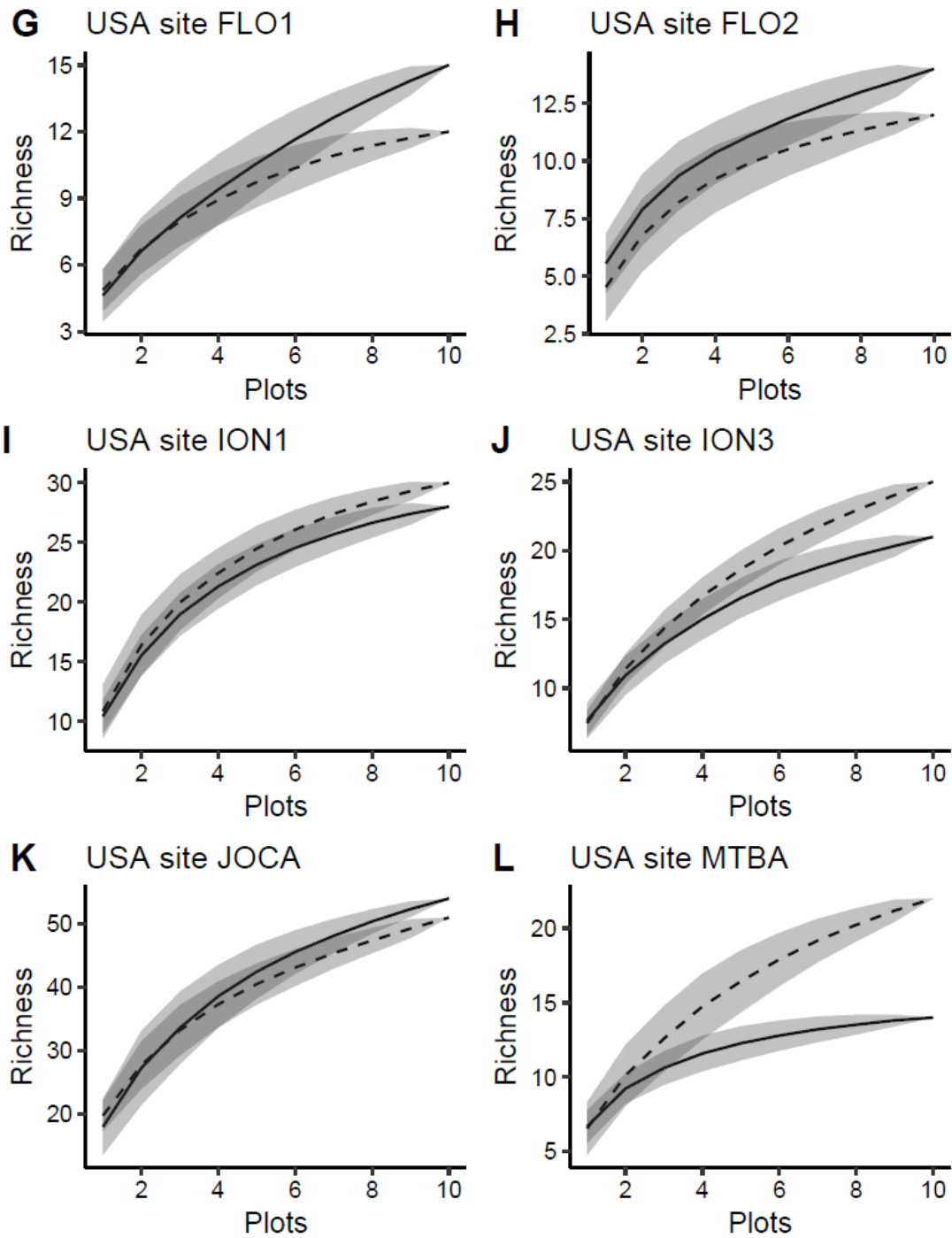
**Figure A7.** Species accumulation curves for *P. contorta* (dashed line) and non-*P. contorta* (solid line) stands at each site in Sweden (SE). Shaded area is one standard deviation calculated from random permutations of the data (subsampling without replacement; Gotelli and Colwell 2001).



**Figure A8.** Species accumulation curves for *P. contorta* (dashed line) and non-*P. contorta* (solid line) stands at each site in Finland (FI). Shaded area is one standard deviation calculated from random permutations of the data (subsampling without replacement; Gotelli and Colwell 2001).

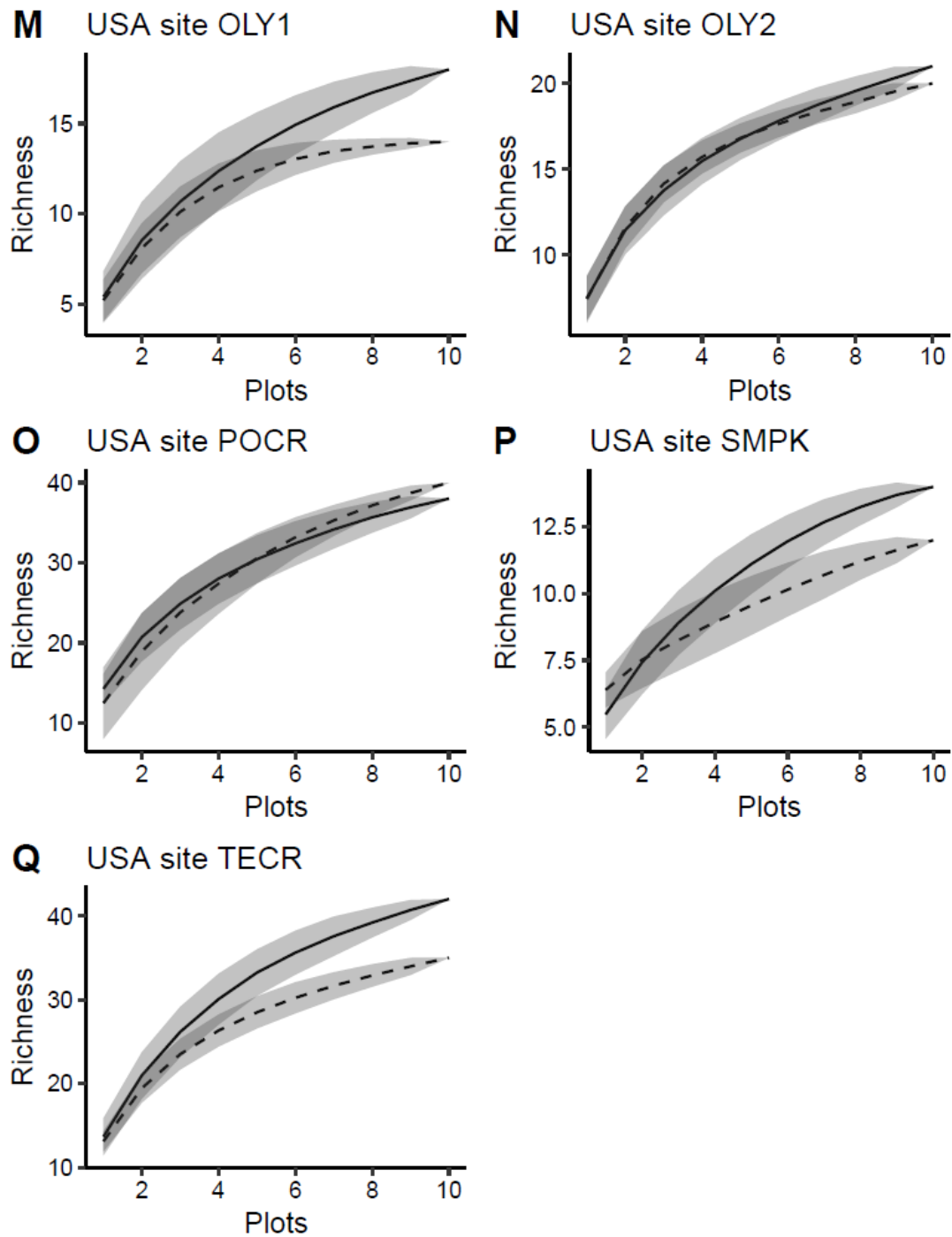


**Figure A9.** Species accumulation curves for *P. contorta* (dashed line) and non-*P. contorta* (solid line) stands at each site in the United States (USA). Shaded area is one standard deviation calculated from random permutations of the data (subsampling without replacement; Gotelli and Colwell 2001).

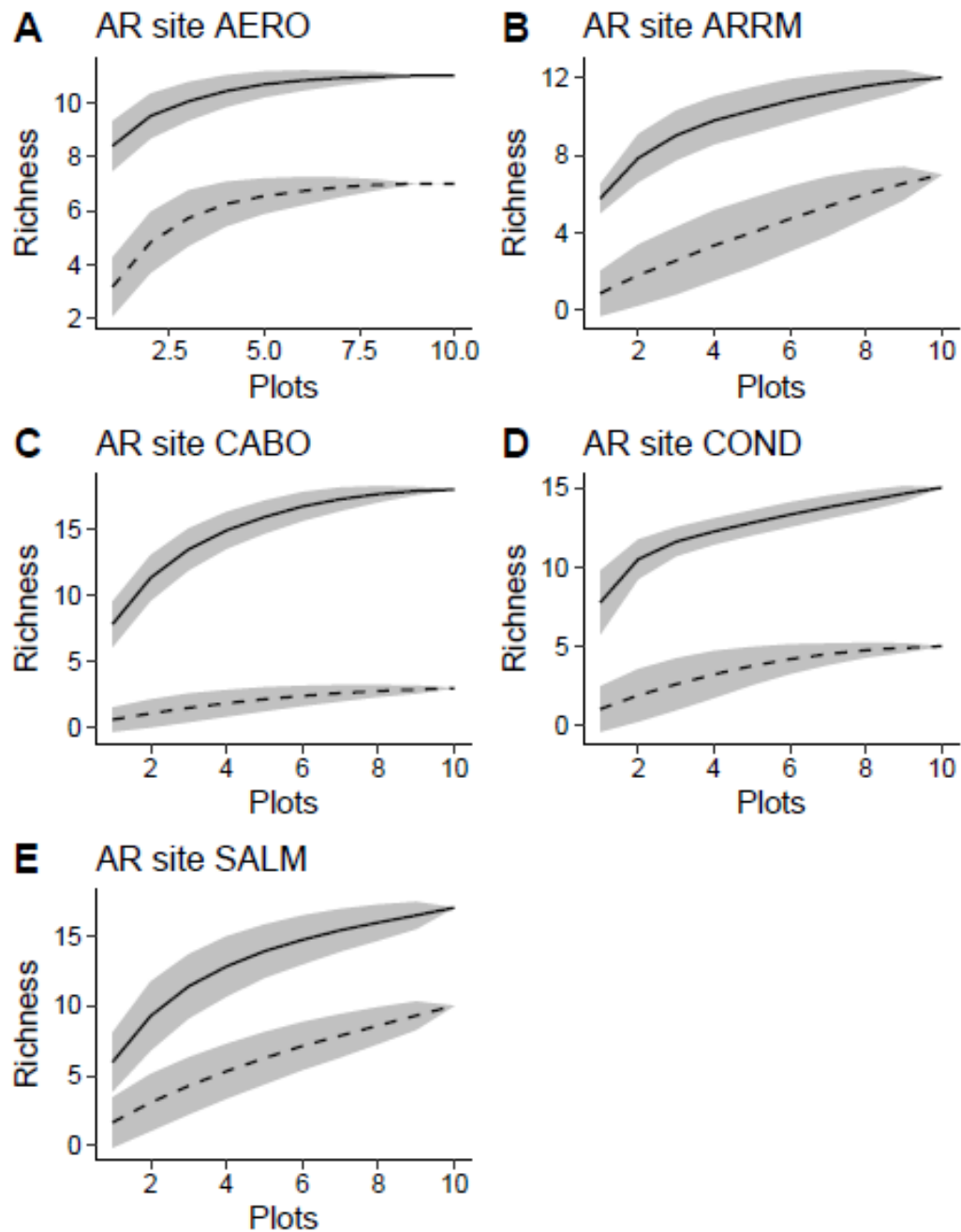


**Figure A9 continued.** Species accumulation curves for *P. contorta* (dashed line) and non-*P. contorta* (solid line) stands at each site in the United States (USA). Shaded area is one standard deviation calculated from random permutations of the data (subsampling without replacement; Gotelli and Colwell 2001).

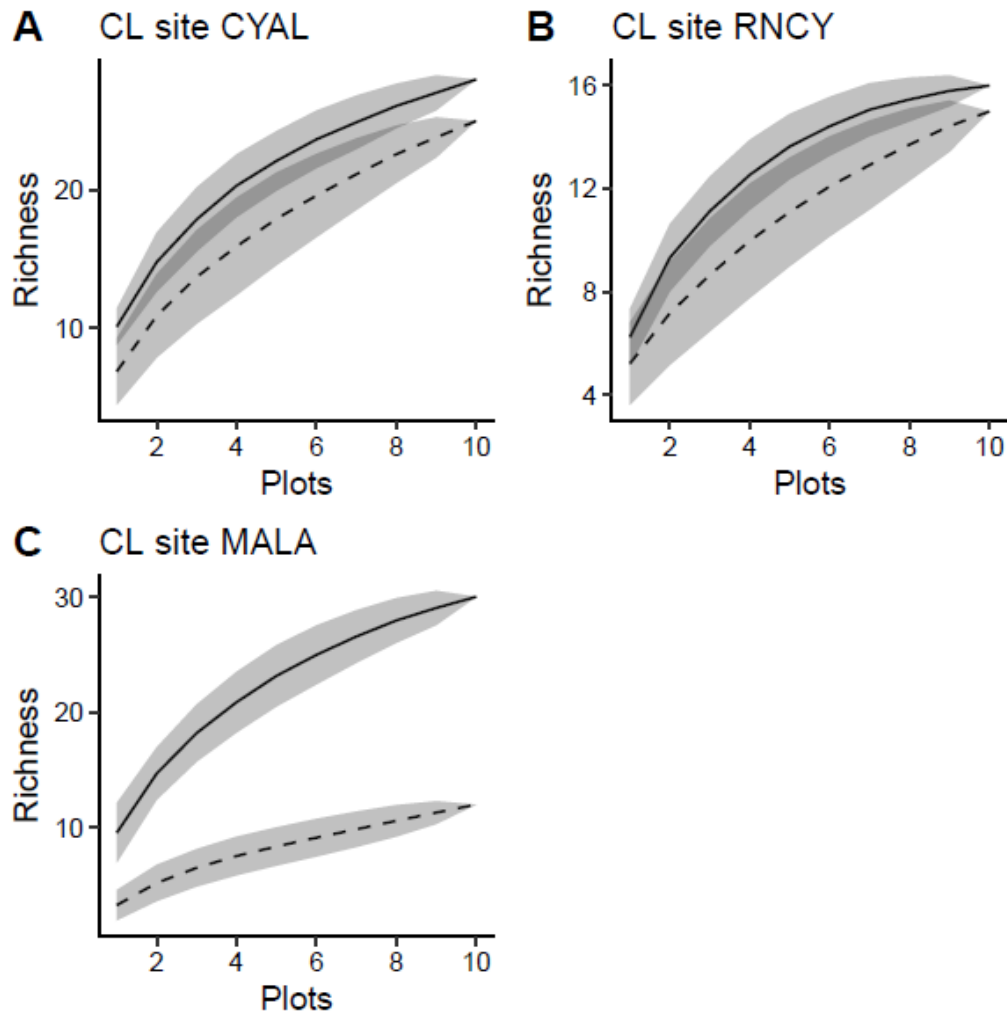




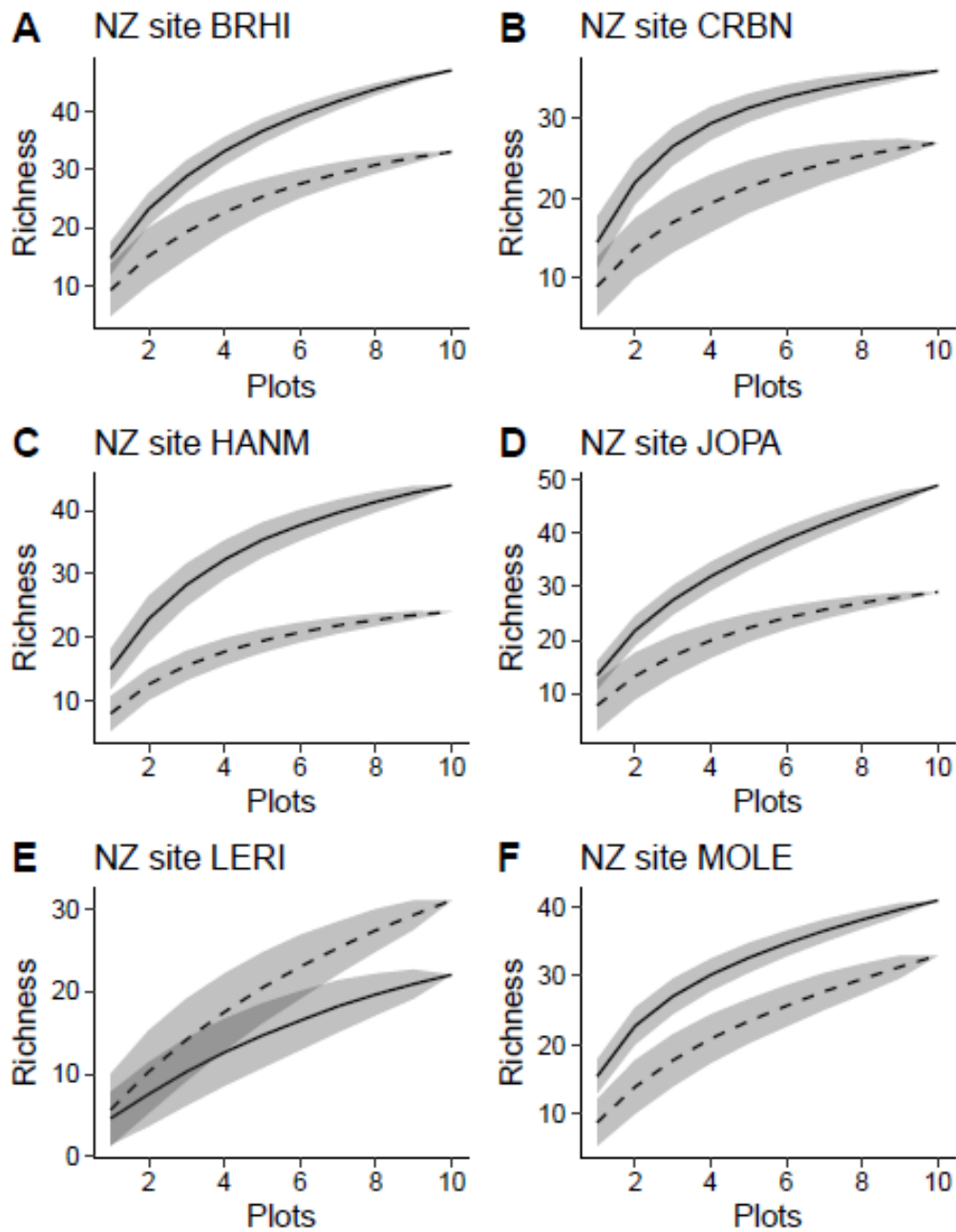
**Figure A9 continued.** Species accumulation curves for *P. contorta* (dashed line) and non-*P. contorta* (solid line) stands at each site in the United States (USA). Shaded area is one standard deviation calculated from random permutations of the data (subsampling without replacement; Gotelli and Colwell 2001).



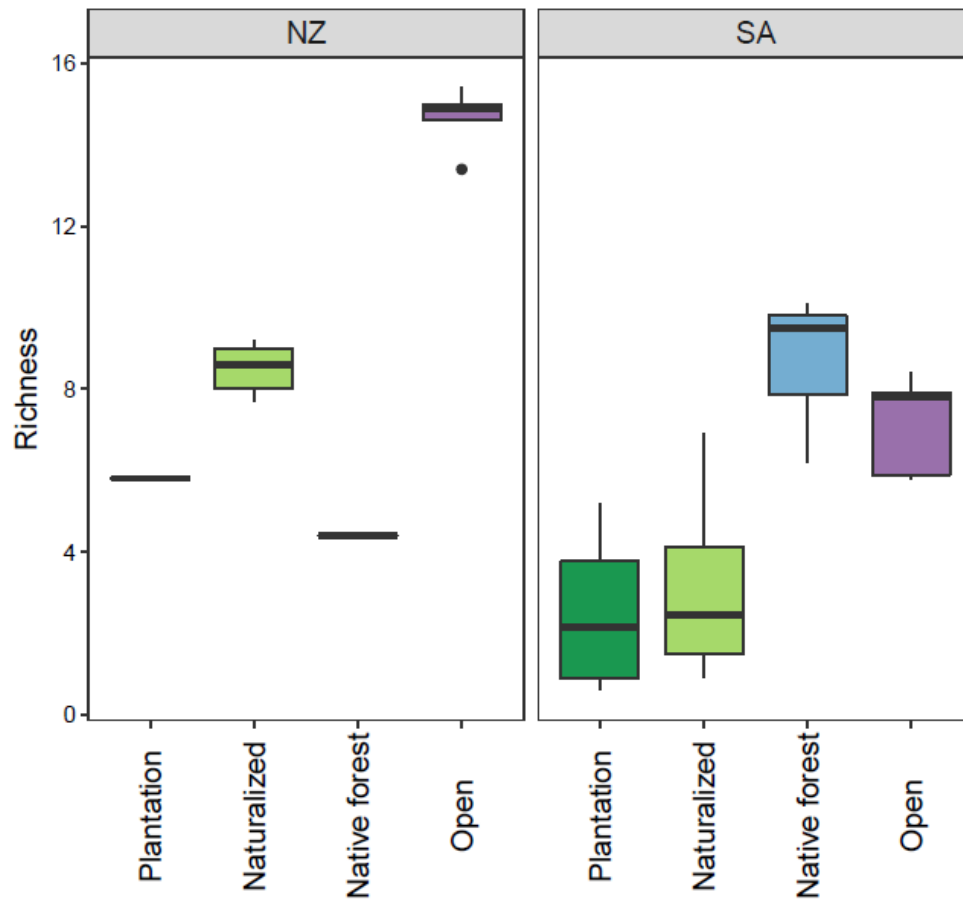
**Figure A10.** Species accumulation curves for *P. contorta* (dashed line) and non-*P. contorta* (solid line) stands at each site in Argentina (AR). Shaded area is one standard deviation calculated from random permutations of the data (subsampling without replacement; Gotelli and Colwell 2001).



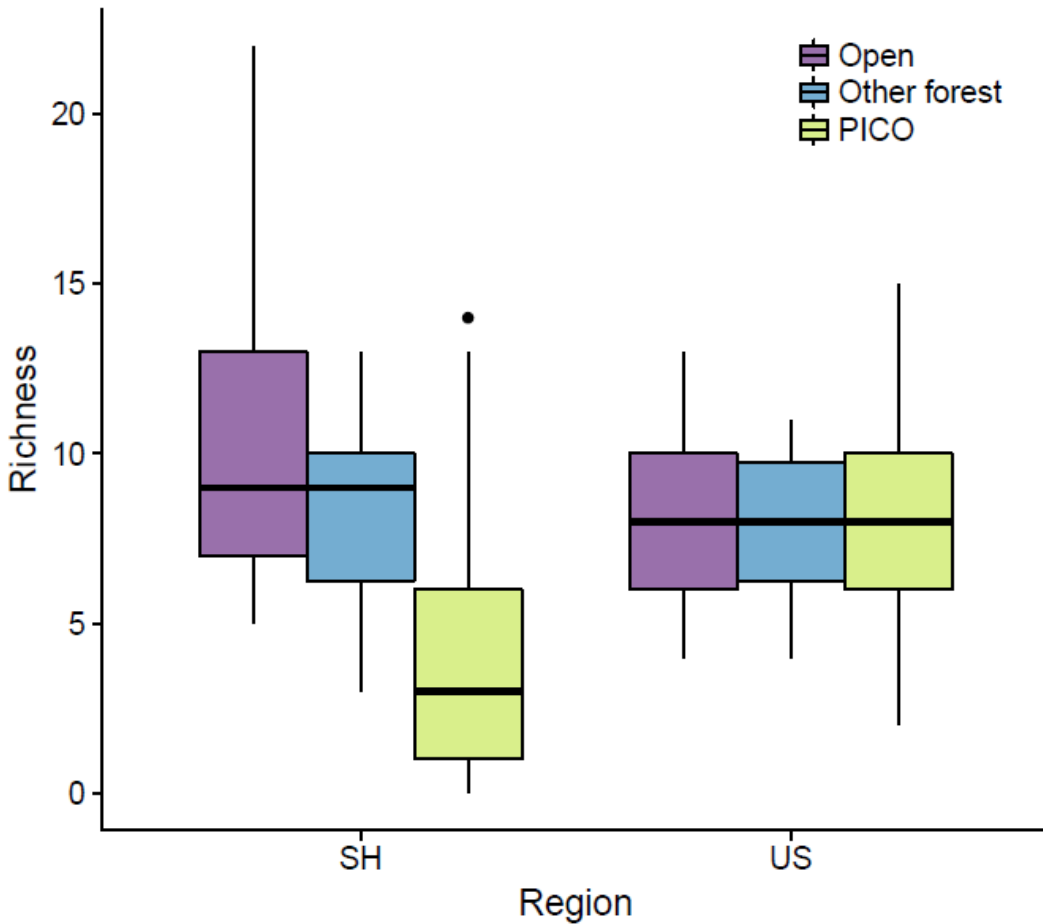
**Figure A11.** Species accumulation curves for *P. contorta* (dashed line) and non-*P. contorta* (solid line) stands at each site in Chile (CL). Shaded area is one standard deviation calculated from random permutations of the data (subsampling without replacement; Gotelli and Colwell 2001).



**Figure A12.** Species accumulation curves for *P. contorta* (dashed line) and non-*P. contorta* (solid line) stands at each site in New Zealand (NZ). Shaded area is one standard deviation calculated from random permutations of the data (subsampling without replacement; Gotelli and Colwell 2001).



**Figure A13.** Boxplots of plant species richness in different vegetation types in the Southern Hemisphere. In the main analysis all Southern Hemisphere sites were combined, here they are divided into sites from New Zealand (NZ) and South America (SA). “Plantation” refers to *P. contorta* plantations, “Naturalized” refers to naturalized or invasive stands of *P. contorta*, and “Open” refers to grassland or shrubland vegetation. Only one plantation and one native forest stand were sampled in NZ.



**Figure A14.** Boxplots of plant species richness in different vegetation types in a subset of 10 sites in the Southern Hemisphere (SH) and United States (US; 5 sites in each region). At these 10 sites all three vegetation types were sampled. Only one pair per site was used in the main analysis, however this plot demonstrates that differences in species richness between open vegetation types and forests were only notable for *P. contorta* stands in the introduced range. “Open” refers to grassland or shrubland vegetation, “Other forest” refers to plots dominated by tree species other than *P. contorta*, and “PICO” refers to stands dominated by *P. contorta*.

## **References**

- Gotelli, N. J. and Colwell, R. K. 2001. Quantifying biodiversity: procedures and pitfalls in measurement and comparison of species richness. - *Ecol. Lett.* 4: 379–391.
- Lenth, R. V. 2016. Least-Squares Means: The R Package lsmeans. – *J. Stat. Softw.* 69: 1-33.