Ecography

ECOG-04512

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Appendix 1

Species richness for four different spatial scales and island parameter for the 60 islands studied. iso_{Gam}: distance to Gam island; iso_{buffer}: surrounding landmass in 1000 m radius. SE: standard error of estimated species richness.

Island	Island coordinates	γ_1	γ_2 (±SE)	α_1	α_2	Area (m^2)	Iso_{Gam} (m)	iso_{buffer} (ha)	Shape index	Soil depth mean (cm)
GB1	130°34'52.115"E 0°31'14.524"S	18	24.8 (±2.7)	7.25	2.25	4774.04	59.30	146.90	0.70	11.40
GB2	130°34'30.544"E 0°31'2.808"S	1	2 (±0)	1.00	1.00	7.29	56.65	71.06	0.60	0.00
GB3	130°34'6.453"E 0°31'3.816"S	17	26.6 (±3.5)	7.25	2.35	2329.91	172.07	45.80	0.61	3.72
GB4	130°34'6.641"E 0°31'4.363"S	1	2 (±0)	1.00	1.00	8.06	191.69	44.91	0.64	0.00
GB5	130°34'10.814"E 0°31'2.308"S	2	3 (±0)	2.00	2.00	20.27	136.06	47.01	0.59	0.00
GB6	130°34'7.001"E 0°30'55.021"S	8	12.6 (±1.8)	4.67	2.09	316.83	381.77	33.60	0.76	3.94
GB7	130°34'10.684"E 0°30'54.074"S	13	18.7 (±2.5)	6.50	1.95	1575.25	344.67	36.22	0.60	9.77
GB8	130°34'20.533"E 0°30'59.87"S	14	18.8 (±1.9)	6.75	2.15	1263.62	106.69	53.70	0.78	12.74
GB9	130°34'12.378"E 0°30'52.021"S	19	27.6 (±3)	9.25	2.85	1716.25	400.15	33.95	0.58	0.73
GB10	130°34'19.367"E 0°31'0.326"S	5	8.3 (±1.3)	5.00	1.40	121.47	115.03	52.69	0.67	0.00
GB11	130°34'14.995"E 0°31'0.318"S	9	11.9 (±1.3)	5.33	2.60	817.06	148.18	49.87	0.67	8.16
GB12	130°33'47.023"E 0°30'41.63"S	14	22.6 (±3)	6.75	1.90	1649.94	1091.20	21.38	0.60	2.63
GB13	130°33'39.392"E 0°30'46.509"S	10	13.7 (±1.6)	7.50	2.40	601.88	1198.45	20.51	0.58	7.66
GB14	130°35'16.783"E 0°31'0.992"S	12	17.5 (±2)	7.50	2.70	535.20	270.27	78.52	0.62	19.66
GB15	130°35'18.591"E 0°31'1.654"S	9	14	9.00	3.40	380.60	226.00	87.76	0.63	22.28

			(±3.6)							
GB16	130°35'38.096"E 0°30'45.256"S	6	10 (±1.9)	6.00	2.50	137.07	63.37	150.20	0.59	15.50
GB17	130°35'37.496"E 0°30'33.986"S	3	5 (±0.7)	3.00	2.00	18.43	5.40	133.54	0.67	0.00
GB18	130°35'35.864"E 0°30'22.88"S	8	11.4 (±1.4)	8.00	2.80	432.77	15.69	106.46	0.59	11.44
GB19	130°35'38.468"E 0°30'20.568"S	1	2 (±0)	1.00	1.00	15.10	8.52	111.52	0.64	0.00
GB20	130°35'14.153"E 0°30'55.705"S	13	18.7 (±2.1)	7.67	3.00	864.00	414.66	54.45	0.61	15.37
GB21	130°34'28.442"E 0°31'2.992"S	2	3 (±0)	2.00	2.00	10.51	1.63	68.47	0.60	0.00
GB22	130°34'51.27"E 0°31'17.771"S	14	19.7 (±2.1)	6.00	2.05	1571.48	39.82	156.79	0.67	8.59
GB23	130°34'59.55"E 0°31'11.114"S	14	22.6 (±3)	6.00	2.35	1375.63	62.99	120.73	0.66	6.08
GB24	130°35'4.149"E 0°31'2.038"S	17	24.7 (±2.5)	8.50	2.95	1862.75	257.00	76.22	0.68	11.19
GB25	130°35'15.603"E 0°30'46.099"S	8	13 (±2.6)	8.00	3.33	69.14	665.68	38.40	0.81	4.87
GB26	130°34'59.574"E 0°31'8.023"S	17	23.8 (±2.4)	7.00	2.44	3865.84	82.44	109.18	0.69	17.14
GB27	130°35'11.779"E 0°30'56.904"S	22	29.8 (±2.6)	10.50	3.50	11806.28	314.32	64.45	0.81	7.19
GB28	130°35'15.345"E 0°30'58.95"S	24	31.7 (±2.9)	8.40	2.72	4429.05	301.33	74.54	0.64	17.24
GB29	130°35'17.546"E 0°30'54.676"S	27	38.6 (±3.5)	10.00	3.20	5526.65	351.65	74.66	0.70	13.19
GB30	130°34'9.677"E 0°31'3.813"S	22	30.7 (±3.1)	8.67	3.00	8520.55	63.21	51.24	0.71	8.19
GB31	130°35'16.863"E 0°30'50.919"S	19	23.9 (±2.4)	9.00	3.27	7181.16	510.54	56.03	0.90	9.99
GB32	130°34'6.863"E 0°30'54.819"S	1	2 (±0)	1.00	1.00	13.63	397.35	32.24	0.78	0.00
GB33	130°34'6.66"E 0°30'55.563"S	0	0 (±0)	0.00	0.00	12.78	382.15	33.40	0.60	0.00
GB34	130°34'6.787"E 0°30'55.537"S	0	0 (±0)	0.00	0.00	12.01	381.02	33.51	0.59	0.00
GB35	130°34'7.41"E 0°30'54.959"S	0	0 (±0)	0.00	0.00	29.39	386.14	32.97	0.62	0.00
GB36	130°33'34.803"E 0°30'47.294"S	1	2 (±0)	1.00	0.50	16.46	1246.85	20.40	0.72	0.00
GB37	130°33'28.821"E 0°30'47.557"S	2	3 (±0)	2.00	2.00	15.94	1123.65	21.64	0.61	0.00
GB38	130°34'7.208"E 0°31'6.28"S	0	0 (±0)	0.00	0.00	3.64	148.07	47.92	0.61	0.00
GB39	130°34'7.093"E	0	0 (±0)	0.00	0.00	6.22	149.39	47.80	0.59	0.00

	0°31'6.345"S									
GB40	130°34'6.966"E 0°31'6.537"S	0	0 (±0)	0.00	0.00	10.52	151.70	47.49	0.64	0.00
GB41	130°34'7.252"E 0°31'4.431"S	0	0 (±0)	0.00	0.00	6.57	173.71	45.72	0.60	0.00
GB42	130°34'7.829"E 0°31'4.02"S	1	2 (±0)	1.00	1.00	7.00	169.31	46.05	0.61	0.00
GB43	130°34'10.58"E 0°31'6.067"S	0	0 (±0)	0.00	0.00	4.63	58.87	50.82	0.60	0.00
GB44	130°33'36.627"E 0°30'46.95"S	0	0 (±0)	0.00	0.00	22.60	1265.85	20.44	0.71	0.00
GB45	130°35'15.361"E 0°30'45.971"S	0	0 (±0)	0.00	0.00	5.66	674.75	37.33	0.64	0.00
GB46	130°34'20.991"E 0°31'0.022"S	5	8 (±2)	5.00	2.00	77.94	137.26	53.35	0.65	0.00
GB47	130°34'20.828"E 0°31'0.302"S	0	0 (±0)	0.00	0.00	8.24	137.89	53.38	0.62	0.00
GB48	130°34'28.425"E 0°31'2.795"S	0	0 (±0)	0.00	0.00	4.34	7.30	67.70	0.60	0.00
GB49	130°34'28.094"E 0°31'2.949"S	0	0 (±0)	0.00	0.00	7.93	2.00	67.90	0.67	0.00
GB50	130°34'45.708"E 0°31'7.12"S	0	0 (±0)	0.00	0.00	11.01	171.78	102.53	0.63	0.00
GB51	130°34'45.413"E 0°31'9.299"S	0	0 (±0)	0.00	0.00	2.81	123.18	113.99	0.59	0.00
GB52	130°34'51.319"E 0°31'19.832"S	2	3 (±0)	2.00	2.00	5.75	2.41	160.87	0.60	0.00
GB53	130°34'51.217"E 0°31'19.918"S	0	0 (±0)	0.00	0.00	3.58	1.43	161.70	0.58	0.00
GB54	130°34'51.404"E 0°31'19.849"S	0	0 (±0)	0.00	0.00	3.53	0.65	161.44	0.58	0.00
GB55	130°35'4.526"E 0°31'3.507"S	6	10 (±2.9)	6.00	3.00	25.49	257.43	74.51	0.65	0.00
GB56	130°35'3.783"E 0°31'3.081"S	1	2 (±0)	1.00	1.00	6.34	286.96	72.30	0.61	0.00
GB57	130°35'2.06"E 0°30'59.367"S	0	0 (±0)	0.00	0.00	14.81	362.61	55.63	0.64	0.00
GB58	130°35'2.336"E 0°30'59.581"S	0	0 (±0)	0.00	0.00	16.77	360.80	56.48	0.65	0.00
GB59	130°34'59.79"E 0°30'58.346"S	14	17.9 (±1.7)	7.00	2.20	2620.30	328.73	54.83	0.79	7.23
GB60	130°34'11.493"E 0°31'2.615"S	0	0 (±0)	0.00	0.00	3.11	116.35	47.89	0.62	0.00

Appendix 2

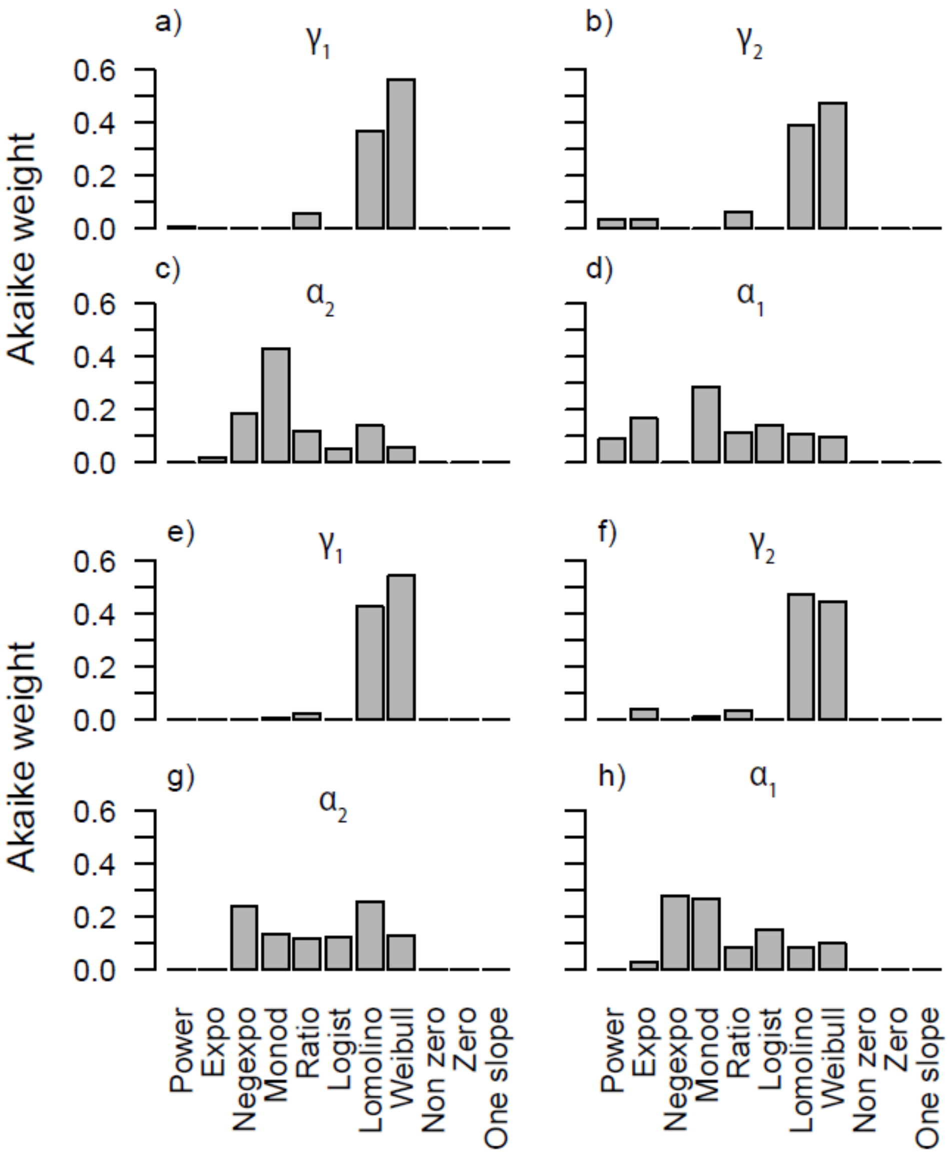
Eleven different species-area relationships used for comparison of best model at four different spatial scales according to Guilhaumon et al. (2010). S = species richness; A = island area; c, z, d, and f = fitted parameter, T = breakpoint. Area was log-transformed for the two breakpoint models and the linear model prior to model calculation.

Model	Formula	Space and shape	Source
Power	$S = c \times A^{z}$	Arithmetic convex	Guilhaumon et al. 2010
Exponential	$S = c + z \times \log A$	Arithmetic convex	Guilhaumon et al. 2010
Negative exponential	$S = d/(1 - \exp(-z \times A))$	Arithmetic convex	Guilhaumon et al. 2010
Monod	$S = d/(1 + c \times A^{-1})$	Arithmetic convex	Guilhaumon et al. 2010
Rational function	$S = (c + z \times A)/(1 + d \times A)$	Arithmetic convex	Guilhaumon et al. 2010
Logistic	$S = d/(1 + \exp(-z \times A + f))$	Arithmetic sigmoid	Guilhaumon et al. 2010
Lomolino	$S = \frac{d}{1} + (z^{\log\left(\frac{f}{A}\right)})$	Arithmetic sigmoid	Guilhaumon et al. 2010
Cumulative Weibull	$S = d(1 - \exp(-z \times A^{f}))$	Arithmetic sigmoid	Guilhaumon et al. 2010
Left-horizontal function	$S = c + z \times ((\mathrm{A} - T) \times (A \geq T))$	Semi-log breakpoint	Lomolino and Weiser 2001
Continuous two-slope	$S = c + (\mathrm{A} \leq T) \times z_1 \times A + (\mathrm{A} > T) * [z_1 \log T + z_2(\mathrm{A} - T)]$	Semi-log breakpoint	Dengler 2010
Single linear regression model	$S = c + z \times A$	Semi-log linear	Dengler 2010

Dengler J. 2010. Robust methods for detecting a small island effect. – Divers. Distrib. 16: 256–266.
Guilhaumon F. et al. 2010. mmSAR: an R-package for multimodel species-area relationship inference. – Ecography 33: 420–424.
Lomolino M. V. and Weiser M. D. 2001. Towards a more general species-area relationship: diversity on all islands, great and small. – J. Biogeogr. 28: 431–445.

Appendix 3

Akaike weights of 11 different models explaining species richness on islands at four different spatial scales when all empty islands are excluded from the dataset (a–d) and when only empty islands are included that are larger than the smallest inhabited island (e–h). Spatial scale is divided into α_1 (d and h): size of a single subtransect, α_2 (c and g): size of a single transect, γ_1 (a and e): observed species richness on a given island, and γ_2 (b and f): estimated species richness (Jackknife 1) on a given island. Non zero model: continuous two-slope function, Zero: left-horizontal function, One slope: single linear regression model (see Appendix 2 for model formulas).



Appendix 4

Pearson correlation matrix of five explanatory variables used for model selection and relative variable importance. Island area was log-transformed. SI: shape index; iso_{Gam}: distance to Gam island; iso_{buffer}: surrounding landmass in 1000 m radius; soil mean: mean soil depth recorded on each island.

	Area $_{[log10]}$	Iso_{buffer}	Iso_{Gam}	SI
Iso_{buffer}	0.01			
Iso_{Gam}	0.10	-0.59		
SI	0.46	-0.14	0.19	
Soil mean	0.75	0.22	-0.05	0.24

Appendix 5

Spatial autocorrelation (Moran´s I) of six variables used for model selection and relative variable importance. All variables, except the buffer surrounding landmass in 1000 m radius, were not spatially autocorrelated. Moran´s I was calculated using the function *moran.test* in the R-package *spdep* (Bivand, R. and Piras, G. 2015. Comparing implementations of estimation methods for spatial econometrics. – J. Stat. Softw, 63). Island area was log-transformed. SI: shape index; iso_{Gam}: distance to Gam island; iso_{buffer}: surrounding landmass in 1000 m radius; soil depth: mean soil depth recorded on each island.

	Moran´s I values			
Variable	Observed	Expected	Standard deviation	pvalue
Species richness	0.2	-0.02	1.38	0.08
Area	0.19	-0.02	1.33	0.09
Iso_{buffer}	0.57	-0.02	3.75	<0.01
Iso_{Gam}	0.17	-0.02	1.22	0.11
SI	-0.15	-0.02	-0.89	0.81
Soil depth	-0.01	-0.02	0.35	0.49

Appendix 6

Intercept and slope of linear quantile regression (lower 0.05 and upper 0.95 quantile) and regular single slope linear regression of species richness and island area (log_{10} transformed). p-value indicates significance level between the coefficients of the slopes of the lower and upper quantile for each spatial scale. Lower adjusted R^2 indicated greater difference between the slopes. Spatial scale is divided into α_1: size of a single subtransect, α_2: size of a single transect, γ_1: observed species richness on a given island, and γ_2: estimated species richness (Jackknife 1) on a given island.

Spatial scale	Model	Intercept	Slope	p-value	Adjusted R^2
γ_1	Quantile 0.05	-8.61	7.03	0.0143	0.91
	Quantile 0.95	-4.44	9.92		
	Regular	-7.41	8.99		
γ_2	Quantile 0.05	-6.53	5.33	0.0104	0.91
	Quantile 0.95	-3.75	7.61		
	Regular	-5.56	6.45		
α_2	Quantile 0.05	-0.54	0.4	0.0015	0.71
	Quantile 0.95	1.09	1.19		
	Regular	0.08	0.76		
α_1	Quantile 0.05	-2.00	1.63	0.0045	0.16
	Quantile 0.95	-0.7	3.55		
	Regular	-1.62	2.75		

Appendix 7

Model support of 11 different species-area relationship models at four spatial scales. Spatial scale is divided into α_1: size of a single subtransect, α_2: size of a single transect, γ_1: observed species richness on a given island, and γ_2: estimated species richness (Jackknife 1) on a given island. For model formulas and description see Appendix 2.

Spatial scale	Model	AICc	AICc weights
γ_2	Power	160.82	0.00
	Expo	146.74	0.01
	Negexpo	156.76	0.00
	Monod	145.30	0.02
	Ratio	144.60	0.02
	Logist	171.94	0.00
	Lomolino	138.35	0.48
	Weibull	138.40	0.47
	Non zero	310.61	0.00
	Zero	308.60	0.00
	One slope	317.01	0.00
γ_1	Power	104.27	0.00
	Expo	99.84	0.00
	Negexpo	99.20	0.00
	Monod	85.87	0.01
	Ratio	84.64	0.01
	Logist	123.81	0.00
	Lomolino	77.00	0.46
	Weibull	76.71	0.53
	Non zero	251.13	0.00
	Zero	252.48	0.00
	One slope	270.11	0.00
α_2	Power	70.85	0.00
	Expo	40.65	0.00
	Negexpo	30.77	0.19
	Monod	32.38	0.08
	Ratio	31.41	0.14
	Logist	32.13	0.10
	Lomolino	29.53	0.35
	Weibull	31.29	0.15
	Non zero	207.31	0.00
	Zero	212.93	0.00
	One slope	210.92	0.00
α_1	Power	-24.81	0.00
	Expo	-36.20	0.01
	Negexpo	-42.91	0.34
	Monod	-42.30	0.25
	Ratio	-40.60	0.11
	Logist	-40.03	0.08
	Lomolino	-40.74	0.11
	Weibull	-40.62	0.11
	Non zero	131.44	0.00
	Zero	136.38	0.00
	One slope	134.08	0.00

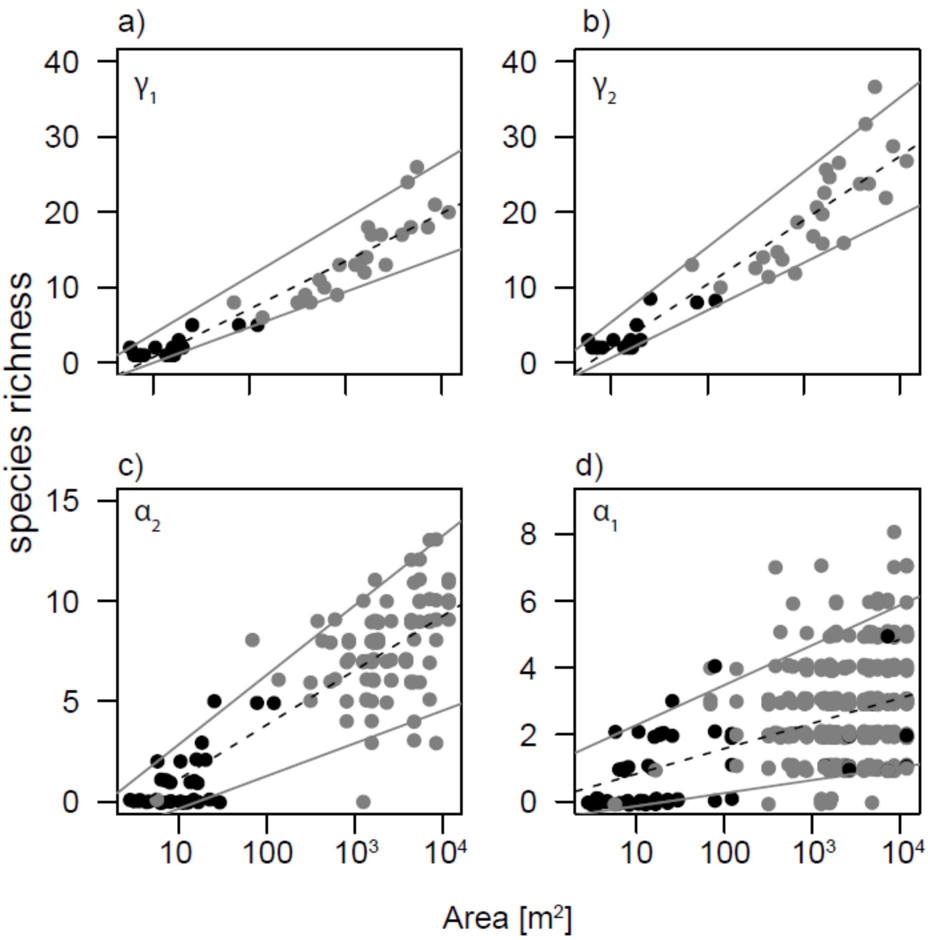
Appendix 8

Best models explaining species richness at four different spatial scales. Shown are all models with ΔAICc < 2, but at least the best five models. Generalised linear models were used with Gaussian distribution. We used Gaussian distribution as Poisson (only integers) or Gamma (no zero richness values allowed) distribution were not applicable to our dataset. Scales are divided into α_1: size of a single subtransect, α_2: size of a single transect, γ_1: observed species richness on a given island, and γ_2: estimated species richness (Jackknife 1) on a given island. SI: shape index; Iso_{Gam}: distance to Gam island; Iso_{buffer}: surrounding landmass in 1000 m radius; soil mean: mean soil depth recorded on each island. df: degrees of freedom; AICc: second-order information criterion for small sample size; Weight: weighted AICc values.

Scale	Model	df	AICc	Weight
γ_1	Area $_{[log10]}$ + SI	4	316.74	0.15
	Area $_{[log10]}$ + Iso_{buffer}	4	316.99	0.13
	Area $_{[log10]}$	3	317.01	0.13
	Area $_{[log10]}$ + SI + Iso_{buffer}	5	317.45	0.11
	Area $_{[log10]}$ + Iso_{Gam}	4	317.89	0.09
	Area $_{[log10]}$ + SI + Iso_{Gam}	5	318.19	0.07
γ_2	Area $_{[log10]}$ + Iso_{buffer}	4	269.88	0.17
	Area $_{[log10]}$	3	270.11	0.16
	Area $_{[log10]}$ + Iso_{Gam}	4	270.25	0.14
	Area $_{[log10]}$ + SI	4	271.57	0.07
	Area $_{[log10]}$ + SI + Iso_{buffer}	5	271.81	0.07
	Area $_{[log10]}$ + Iso_{Gam} + Iso_{buffer}	5	271.82	0.07
α_2	Area $_{[log10]}$ + soil mean	4	207.13	0.38
	Area $_{[log10]}$ + soil mean + Iso_{Gam}	5	209.47	0.12
	Area $_{[log10]}$ + soil mean + SI	5	209.50	0.12
	Area $_{[log10]}$ + soil mean + Iso_{buffer}	5	209.50	0.12
	Area $_{[log10]}$	3	210.92	0.06
α_1	Area $_{[log10]}$ + soil mean	4	132.05	0.28
	Area $_{[log10]}$ + soil mean + Iso_{buffer}	5	133.87	0.11
	Area $_{[log10]}$	3	134.08	0.10
	Area $_{[log10]}$ + SI + soil mean	5	134.26	0.09
	Area $_{[log10]}$ + soil mean + Iso_{Gam}	5	134.35	0.09

Appendix 9

Species richness and island area (empty islands excluded, compare with Fig. 2 in main document) at four different sampling scales (a – d) with normal regression line (dashed) and 0.95 and 0.05 quantiles (grey) shown. Sampling scale is divided into α_1: size of a single subtransect, α_2: size of a single transect, γ_1: observed species richness on a given island, and γ_2: estimated species richness (Jackknife 1) on a given island. Points in black indicate absence of soil at the sampling scale and points in grey indicate presence of soil.



Appendix 10

Absolute (a) and proportional (b) difference between observed species richness and expected species richness for four island classes. Expected species richness was generated by applying a null model based on incidence data (according to Burns, K. C. et al. 2009. The small-island effect: fact or artefact? – Ecography 32: 269–276. (a) Absolute differences between observed and expected richness are higher on very small islands than on intermediate islands and raise again for the very largest islands. The higher differences for small islands compared to intermediate island sizes hint towards the presence of the small-island effect. (b) The presence of the small-island effect in the dataset becomes particularly obvious when comparing the proportional differences between the island classes. Small islands support proportionally less species than the lager island classes. The change between large differences and small differences in the proportions occurs at around 100 m^2, which correspond to the area range of the small-island effect identified by fitting sigmoidal species-area relationships to the dataset (Fig. 3a in main document).

The applied null model can be used to test for the unambiguous presence of the small-island effect irrespective of artefacts possibly arising by axis-transformation. To construct the null model, we fitted sigmoidal models using the incidences of all species on the islands. We used the generated species occurrence probabilities for each island to assign the species randomly to the islands and extracted the resulting species richness values. This procedure was repeated 1000 times and the mean species richness for each island calculated. We then grouped islands into four island size classes (class 1: islands < 10 m^2; class 2: islands > 10 m^2 and < 100 m^2; class 3: islands >100 m^2 and < 1000 m^2; class 4: islands > 1000 m^2) and tested whether the mean species richness values of the random communities differed from the observed values within the island size classes (Burns et al. 2009).