New Phytologist

***New Phytologist* Supporting Information**

Article title: Determinants of geographic range size in plants
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Methods S1. Detailed methods for meta-analysis

We (SNS, ALA) screened the abstracts of the 412 articles returned by the Web of Science search and discarded those that did not mention range size (31), were solely on animal taxa (100), included fewer than 3 plant species (12), used range size as a predictor variable (e.g., of invasiveness or species richness or in conservation planning) rather than as a response variable (78), included only non-focal predictors (e.g., local abundance) of range size (15), treated range size as a categorical variable (4), examined naturalized (21) or regional (3) ranges rather than global native range, examined aggregate range sizes of multiple species in an area rather than individual species (2), or were theoretical models (21) or qualitative reviews (23) of the topic. This resulted in 102 papers retained for further inspection. We skimmed the methods for these 102, further discarding 74 because of being a qualitative review (2); lacking a range size estimate (1); using fewer than 3 species (1), aggregate range sizes of multiple species (6), non-focal predictors (6), categorical (13) or regional (8) range sizes, range size as a predictor variable (25), or phylogenetic correction (8); or lacking appropriate statistical tests between range size and the predictor variable (4). We also added three studies that were not returned by the Web of Science search but that were in our personal libraries, resulting in a total of 31 studies (encompassing 195 reported estimates of correlations between range size and a predictor variable) for which we attempted data extraction (Table S1).

We categorized predictor variables into eight broad categories: dispersal ability, mating system, ploidy, niche breadth, species' age, range position, environmental heterogeneity, and niche availability. Dispersal ability included metrics related to seed or diaspore size (e.g., length, width, mass), direct estimates of movement (e.g., average dispersal distance), and proxies for propagule pressure (e.g., reproductive frequency, time to first reproduction). The mating system category included estimates of self-pollination ability based on floral morphology or pollinator visitation, as well as genetically-based inbreeding coefficients. Estimates of niche breadth encompassed univariate and multivariate climatic niche breadth modeled from occurrence records, habitat breadth inferred from floras or occurrence records, and experimental assays across abiotic treatments. Species' age was inferred from divergence time across molecular phylogenies. Range position was usually measured based on latitude or longitude (e.g., location of northern boundary), but was sometimes expressed in terms of average climatic characteristics of the range. Metrics of environmental heterogeneity quantified variation across species' ranges in climatic variables, while predictors categorized as niche availability reflected the prevalence of particular environmental conditions in the study region. All variables were coded so that positive correlations with range size would indicate support for general hypotheses in the literature or specific hypotheses articulated by the authors. The categories ploidy and environmental heterogeneity were only represented by one study each, so we conducted sensitivity analyses with these estimates omitted (Fig. S2) or with these estimates grouped into a single category of "other predictors" (Fig. S3); qualitative conclusions about the effects of the other six categories of predictors were unaffected.

To calculate an effect size, we required the ability to glean the univariate correlation coefficient, Pearson's *r*, between range size and each predictor (or equivalently, the univariate, standardized regression coefficient, *b*). When regression coefficients were unreported or regression results were reported for raw (rather than variance-standardized) data, we converted to *r* whenever possible by taking the square root of R^2. When possible, we converted Spearman's *r*, *F*- and *t*-statistics to Pearson's *r*. When we could not convert to *r* from the information provided but univariate relationships were depicted in figures, we used WebPlotDigitizer v. 4.2 (https://automeris.io/WebPlotDigitizer) to estimate correlation coefficients from graphs. Additional reasons for discarding studies during data extraction include the following: a study using a multivariate analysis that could not be converted into univariate *r* (1); studies using non-parametric statistics (2); and studies that did not report the statistics necessary for converting to univariate *r* (4). Even when an entire study was not discarded, we often could not obtain sufficient information to retain estimates for some predictor categories (Table S1). These attritions resulted in 24 studies from which we obtained 123 estimates of Fisher's *z*, a standardized effect size metric for correlations based on *r* and sample size. Estimates were coded so that positive *z* is always consistent with the hypothesized effect on range size.

Table S1. Studies of various hypothesized determinants of range size in angiosperms that were returned by a systematic literature search and for which data extraction was completed or attempted. If effect size calculation was successful, mean effect sizes (Fisher's *z*) per predictor category are reported below, with sampling variance in parentheses. NA indicates estimates that could not be incorporated in the quantitative meta-analysis, with superscripts denoting the reason (* = multivariate or non-parametric statistics, + = insufficient statistics reported, ^ = non-ordinal categorical predictor). Citations for the 24 studies with quantitative estimates are in Appendix A1. The remaining citations for 7 studies that could not be used are given in footnotes.

	Intrinsic predictors					Extrinsic predictors		
Study	Dispersal ability	Mating system	Niche breadth	Ploidy	Species' age	Environmental heterogeneity	Niche availability	Range position
Ceolin et al. 2017	0.44 (0.031)	.	0.015 (0.031)	.	0.60 (0.031)	.	0.48 (0.031)	.
Coughlan et al. 2014[a]	.	.	.	NA[*]	.	.	.	.
Eriksson & Jakobsson 1998[b]	NA[+]	.	.	.	.	.	.	.
Estrada et al. 2015[c]	NA[+]	.	NA[+]	.	.	.	.	.
Harrison et al. 2019	.	0.00 (0.13)	.	.	.	.	.	.
Ho & Costea 2018[d]	NA[*]	.	.	.	.	.	.	.
Johnson et al. 2014	.	0.18 (0.059)	.	-0.074 (0.059)	NA[+]	.	.	.
Kambach et al. 2018	.	.	1.36	.	.	.	.	.

	Intrinsic predictors					Extrinsic predictors		
Study	Dispersal ability	Mating system	Niche breadth	Ploidy	Species' age	Environmental heterogeneity	Niche availability	Range position
			(0.0056)					
Kessler 2002a	NA+	.	-0.069 (0.0028)	.	.	.	.	.
Kessler 2002b	NA^	0.45 (0.0053)	.	.	.	.	.	.
Kockemann et al.2009	.	.	0.75 (0.045)	.	.	.	.	.
Laenen et al. 2016[e]	.	NA+	.	.	.	.	.	.
Lloyd et al. 2002	0.47 (0.50)	.	.	.	.	.	.	.
Lloyd et al. 2003	1.10 (0.17)	.	0.41 (0.17)	.	.	.	.	.
Lowry & Lester 2006	.	0.090 (0.059)	.	NA+	.	.	.	.
Luna & Moreno 2010	.	.	0.060 (0.020)	.	.	.	.	.
Males 2018	.	.	0.84 (0.0018)	.	.	.	.	.
Mathews & Bonser 2005	-0.020	.	.	.	.	.	0.51	.

	Intrinsic predictors					Extrinsic predictors		
Study	Dispersal ability	Mating system	Niche breadth	Ploidy	Species' age	Environmental heterogeneity	Niche availability	Range position
	(0.023)						(0.023)	
McGlone et al. 2010	-0.010 (0.0047)	.	.	.	.	.	.	0.35 (0.0047)
Morin & Lechowicz 2011	.	.	.	.	.	.	.	0.43 (0.0017)
Mraz et al. 2016	.	.	0.50 (0.012)	.	.	.	.	.
Murray et al. 2002[f]	NA[+]	NA[+]	.	.	.	.	.	.
Nogues-Bravo et al. 2014	-0.34 (0.022)	.	0.27 (0.022)	.	.	.	.	NA[*]
Paul et al. 2009	.	.	.	.	0.28 (0.016)	.	.	.
Pither 2003	.	.	.	.	.	0.33 (0.01)	.	.
Randle et al. 2009[g]	.	NA[*]	.	.	.	.	.	.
Ruokolainen & Vormisto 2000	0.22 (0.045)	.	0.46 (0.045)	.	.	.	.	.
Sheth et al. 2014	0.17 (0.014)	.	1.00 (0.014)	.	.	.	0.66 (0.014)	.

	Intrinsic predictors					Extrinsic predictors		
Study	Dispersal ability	Mating system	Niche breadth	Ploidy	Species' age	Environmental heterogeneity	Niche availability	Range position
Sonkoly et al. 2017	-0.18 (0.00063)	.	.	.	.	.	.	0.32 (0.00063)
Svenning & Skov 2004	0.28 (0.020)	.	.	.	.	.	0.63 (0.020)	0.36 (0.020)
Yu et al. 2017	.	.	0.18 (0.013)	.	.	.	.	.

[a] **Coughlan JM, Stefanović S, Dickinson TA**. **2014**. Relative resource allocation to dispersal and competition demonstrates the putative role of hybridity in geographical parthenogenesis. *Journal of Biogeography* **41**: 1603–1613.

[b] **Eriksson O, Jakobsson A**. **1998**. Abundance, distribution and life histories of grassland plants: a comparative study of 81 species. *Journal of Ecology* **86**: 922–933.

[c] **Estrada A, Meireles C, Morales-Castilla I, Poschlod P, Vieites D, Araújo MB, Early R**. **2015**. Species' intrinsic traits inform their range limitations and vulnerability under environmental change. *Global Ecology and Biogeography* **24**: 849–858.

[d] **Ho A, Costea M**. **2018**. Diversity, evolution and taxonomic significance of fruit in *Cuscuta* (dodder, Convolvulaceae); the evolutionary advantages of indehiscence. *Perspectives in Plant Ecology, Evolution and Systematics* **32**: 1–17.

[e] **Laenen B, Machac A, Gradstein SR, Shaw B, Patiño J, Désamoré A, Goffinet B, Cox CJ, Shaw J, Vanderpoorten A**. **2016**. Geographical range in liverworts: does sex really matter? *Journal of Biogeography* **43**: 627–635.

[f] **Murray BR, Thrall * Peter H., Lepschi BJ**. **2002**. Relating species rarity to life history in plants of eastern Australia. *Evolutionary Ecology Research* **4**: 937–950.

[g] **Randle AM, Slyder JB, Kalisz S**. **2009**. Can differences in autonomous selfing ability explain differences in range size among sister-taxa pairs of *Collinsia* (Plantaginaceae)? An extension of Baker's Law. *New Phytologist* **183**: 618–629.

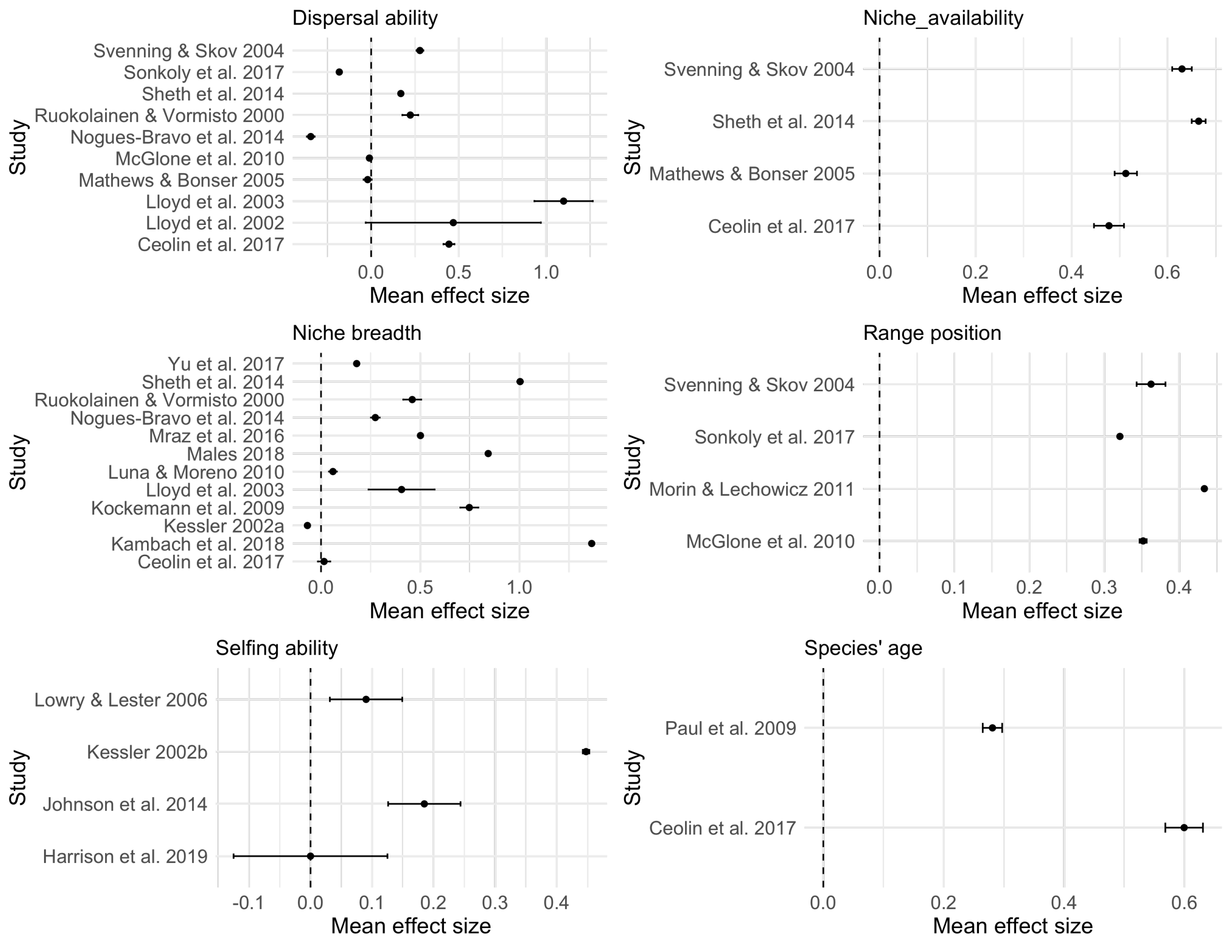

Figure S1. Mean effect size of each of 6 general categories of hypothesized predictors of range size (estimated from area- or extent- based methods) in plants. Mean effect size of each predictor is based on a standardized correlation coefficient (Fisher's *z*) averaged for each predictor type for each study, along with variance (error bars) estimated from sample size (see Supporting Information Methods S1). In some cases, error bars are very small and thus not visible. A total of 23 studies are represented here. Note: Environmental heterogeneity and ploidy were excluded from this figure because there was only one estimate representing each of these predictors.

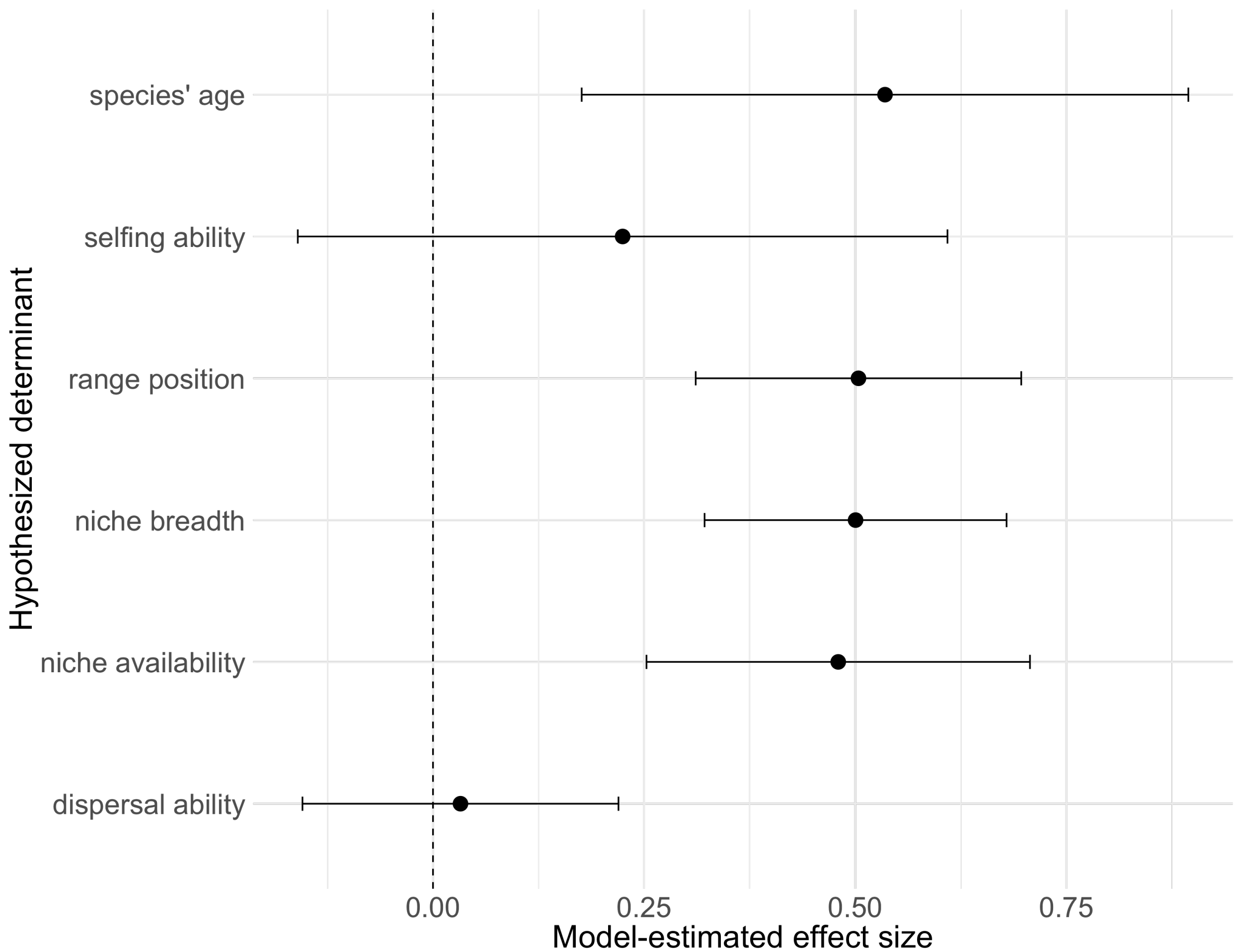

Figure S2. Relative influence, expressed as model-estimated effect size, of each of six general categories of hypothesized predictors of range size in plants, with two categories that were each represented by only a single estimate omitted from analysis. Error bars represent 95% confidence intervals. Mean effect size of each predictor is based on a meta-analytic model including general predictor as a moderator *(QM* = 263.59; *df* = 6; $P < 0.0001$) and study as a random effect. A total of 23 studies were included in this sensitivity analysis.

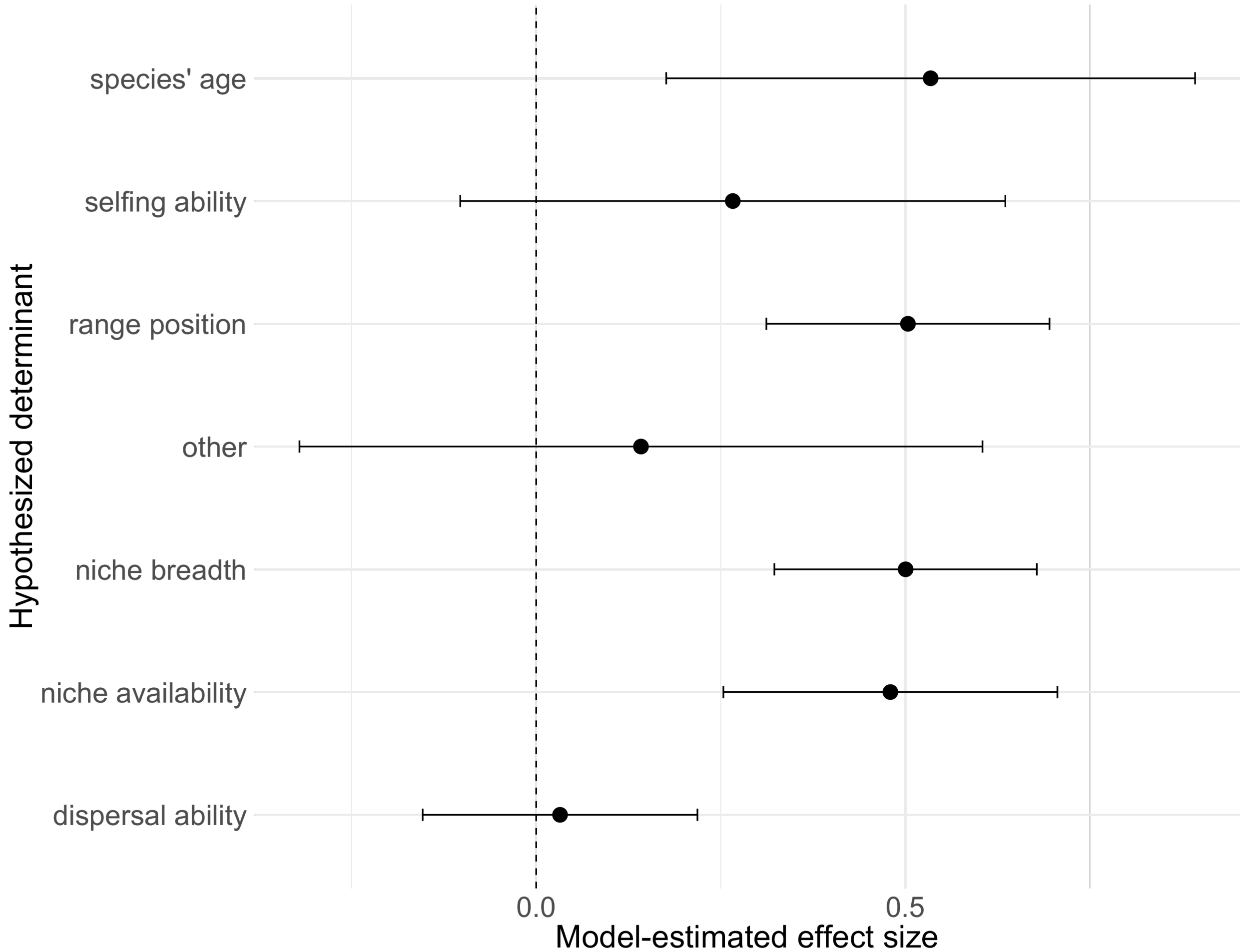

Figure S3. Relative influence, expressed as model-estimated effect size, of each of 7 general categories of hypothesized predictors of range size in plants, with two categories that were each represented by only a single estimate pooled into the "other" category. Error bars represent 95% confidence intervals. Mean effect size of each predictor is based on a meta-analytic model including general predictor as a moderator *(QM* = 264.70; *df* = 7; *P* < 0.0001) and study as a random effect. A total of 24 studies were included in this sensitivity analysis.

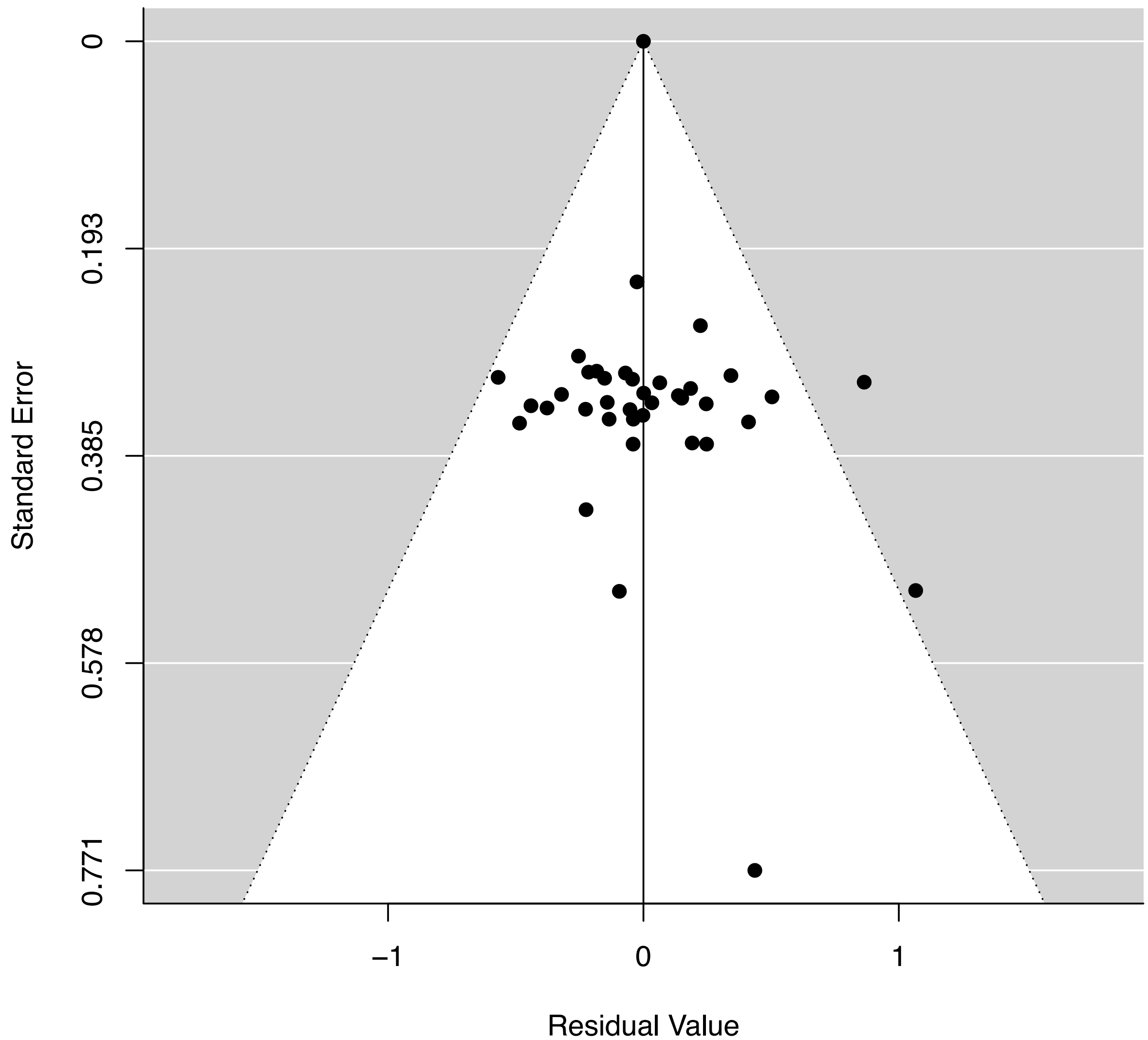

Figure S4. Funnel plot showing standard errors of effect size estimates against their residuals (i.e. after adjusting for category of predictor variable, the moderator). Smaller studies with higher standard errors were not more likely to have positive residuals (rank test, Kendell's tau = -0.13, $P = 0.24$), suggesting little publication bias among quantitative estimates.