



Supplementary Material for **Accelerating extinction risk from climate change**

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Materials and Methods

Literature Review

I searched for studies that predict climate change effects on two or more species using the Web of Science (search terms: "climate change" AND extinct* AND predict*; last access date: 24 March 2014), past reviews (27-31), and the literature cited in each study. I did not use studies that focused on a single species because these more focused studies might incorporate a bias toward threatened species. I excluded studies that did not make quantitative predictions about future extinctions or focused on a small geographic area such as a nature reserve. The complete list of studies can be found in Table S1. The database is available from the Dryad Digital Repository: <http://dx.doi.org/10.5061/dryad.3rv62>.

For each study, I recorded the proportion of species predicted to be threatened with extinction. I measured values on published graphs when raw data were unavailable. I also recorded the global climate change scenarios applied, geographic region, taxonomic group, if all species were endemic to the study region, and assumptions about extinction debt and dispersal, and model type. I followed standard methods (27) to extract global temperature rises for study periods from the generalized circulation models applied in each study and adjusted these values to reflect temperature change since the pre-industrial era. I used the global temperature rise, rather than local rise, whenever possible in order to predict the consequences of global efforts to stabilize greenhouse gas emissions. I assigned a global temperature rise to 92% of studies. Results did not change substantively when including the 8% of models for which only a regional temperature rise could be calculated.

I recorded each study's focal continent and taxonomic group: plants, invertebrates, fish, amphibians, reptiles, birds, and mammals. I separated studies into those that only made predictions for endemic species occurring within the study area from those that included non-endemic species that also live outside the modeled region. I recorded the number of species that faced range losses of 100%, 95%, and 80% to understand how these commonly used extinction thresholds shaped predictions. The 80% and 95% habitat loss predictions incorporate expectations of future extinction at a later date – the extinction debt (32, 33). I calculated these three categories of extinction risks from every study that provided data in a format that allowed me to extract it even if the original study did not originally report extinction risks for all three categories. I also recorded assumptions about dispersal, including no dispersal, dispersal into contiguous habitats, dispersal dependent on each species' ability, and universal dispersal regardless of distance or capacity.

I partitioned studies depending on the model used, including species distribution model, species-area model, mechanistic, and expert opinion. The most common model is the species distribution model which correlates existing species distributions with current climate and extrapolates these correlations to predict species distributions under future climates (34-36). Species-area models apply the relationship between habitat area and species richness to predict

species losses expected for smaller habitat sizes (14, 32, 33, 37, 38). Such models incorporate the long-term extinction of flora and fauna from an initial extinction debt. Mechanistic models use relationships between climate performance and species traits to predict future responses to shifting climates (23, 39-41). I included hybrid models that use a mixture of correlative approaches and mechanistic insights in this group (42, 43). Models of expert opinion classify species according to different categories of risk and then summarize these risks into a metric that is related to future extinction risk (4, 44). In some cases, I included multiple studies that analyzed the same or similar sets of species, but applied different methods (e.g., 2). Removing these studies had little effect on overall model outcomes. For instance, I removed (2) which applies a species-area relationship approach to other datasets that had been analyzed based solely on species distribution models. Removing this study resulted in a mean extinction risk of 7.8%, well within the credible intervals of the original percentage (7.9%, CIs: 6.2, 9.8). In general, model outcomes were highly insensitive to excluding particular studies.

Statistical Analyses

I logit-transformed proportions [$\ln(x/(n-x))$, where x is number of extinctions and n is total number of species] to correct for non-normality according to recommended methods for proportional meta-analysis (45, 46). I tested the sensitivity of results to decisions about data transformation. Results did not differ substantially depending on whether one used raw proportional data, a binomial model, or an arcsine transformation (Fig. S3). The logit for proportions 0 and 1 are not defined. In these cases, I followed standard practice (46) and added 0.5 as a new observation and calculated $\ln[(x+.5)/((n+1)-(x+.5))]$, which has been shown to have an insignificant effect on model outcomes (46). The resulting transformed distribution was not skewed by zeros, thus avoiding this common problem with proportional data that would otherwise require specialized methods. The distribution was significantly leptokurtic, which affects the variance but not the mean. Also, the variance among categories was unequal for some factors. To account for leptokurtic and heteroscedastic data, I used Markov chain Monte Carlo (MCMC) methods to calculate distribution-independent credible intervals and to evaluate statistical support for individual factors. I back-transformed estimated logits to the original proportions for the purposes of display.

I entered study as a random effect to control for non-independence among results recorded from the same study, and also accounted for within-study variation in the model (5). I weighted each study by the number of predictions (sample size). This weighting accounts for uncertainty by incorporating the linear decrease in expected variance of a proportion with increasing sample size. Alternative inverse variance methods were not implemented because they bias results if mean proportions fall below 20% as was the case for this study (47). Species-area models sometimes extrapolate estimates based on a subset of modeled species or habitats to all the species in the region. This extrapolated number often exceeds the modeled number by orders of magnitude and substantially overestimates model certainty. Therefore, I used the number of predicted species or habitats rather than the number of extrapolated species. I also compared results with a similar model estimated using maximum likelihood methods in the metafor package in R (46), an unweighted random effects MCMC model, and the raw median with bootstrapped estimates for comparison. Differences between the models were slight (Table S2),

suggesting a relatively minor effect of decisions regarding weighting schemes, models, and random effects.

I fitted generalized linear mixed models in the MCMCglmm package in R with the Bayesian Markov chain Monte Carlo algorithm (48) with weakly informative priors for variances (variance = 1, degree of belief = 0.002) and fixed effects (mean = 0, variance = 1e+10) as per standard methods (5, 48, 49). Generally, I ran models for 6e+4 samples with a burn-in of 5e+4, and a thinning rate of 10. I visually assessed chains and assessed the autocorrelation of all chains and adjusted thinning if substantial autocorrelation ($r > 0.1$) was detected. I also evaluated within-chain convergence using Geweke-Brooks plots from the R coda package. I assessed inter-chain convergence using the Gelman-Rubin diagnostic and increased burn-in time if models did not converge based on the correspondence of five MCMC runs. In a few cases, I needed to increase burn-in times to 1e+5 in order to reach convergence.

The MCMC method samples from the posterior distribution to generate 95% credible intervals. Significant differences in coefficients were assessed by evaluating if credible intervals overlapped with zero. For categorical factors, I compared models with and without the factor using the deviance information criterion (DIC), an information theoretic approach that has been modified for use with Bayesian models. When a factor decreased in its DIC greater than four relative to the reduced model, the factor was determined to contribute significantly to explaining the data (50). In order to provide an additional check on results from MCMC methods, I also estimated each model with rma.mv with a random term for individual-level variation in the R package metafor (46), which conducts an analogous random effects meta-analysis but uses restricted-error maximum likelihood instead. In all cases, I obtained similar results from metafor (e.g., Table S2, S4), providing additional confidence in MCMC estimates.

I restricted analyses to categories that included four or more studies. Thus, rare categories were not included in overall tests for significance owing to small sample size. The number of studies used for each analysis varied depending on data availability.

I also evaluated models with all pairwise interactions of factors. I was unable to estimate pairwise interactions with region or taxonomic group or more complicated interactions between three or more factors because too many of these combinations were represented by few or no studies. For the remaining pairwise interactions, I found evidence for significant pairwise interactions between pre-industrial temperature rise and endemism, extinction thresholds, and dispersal modes (Table S3; Figs. S2, S4-5).

Supplementary Text

Exploring Potential Publication Bias

Results were robust to missing studies, study year, and publication bias. To evaluate the sensitivity of results to missing studies, I simulated the unlikely event that I failed to locate a study that predicted the extinction risk of 1000 species. I assumed that this study predicted the extreme of either 0% or 100% extinction. I re-ran models and calculated estimates including the hypothetical missing studies. The mean estimated extinction risk proved to be resilient to missing studies. Adding a study on 1000 species with zero extinction risk produced an estimate close to the original result (7.7%, CI: 6.3, 10.0). Adding a study on 1000 species with 100% extinction risk increased the mean from 7.9% to 8.3%. Predicted risks did not significantly change with publication year (regression coefficient = 0.01; CIs: -0.04, 0.06), suggesting that changes in methodology or assumptions over time have not affected patterns.

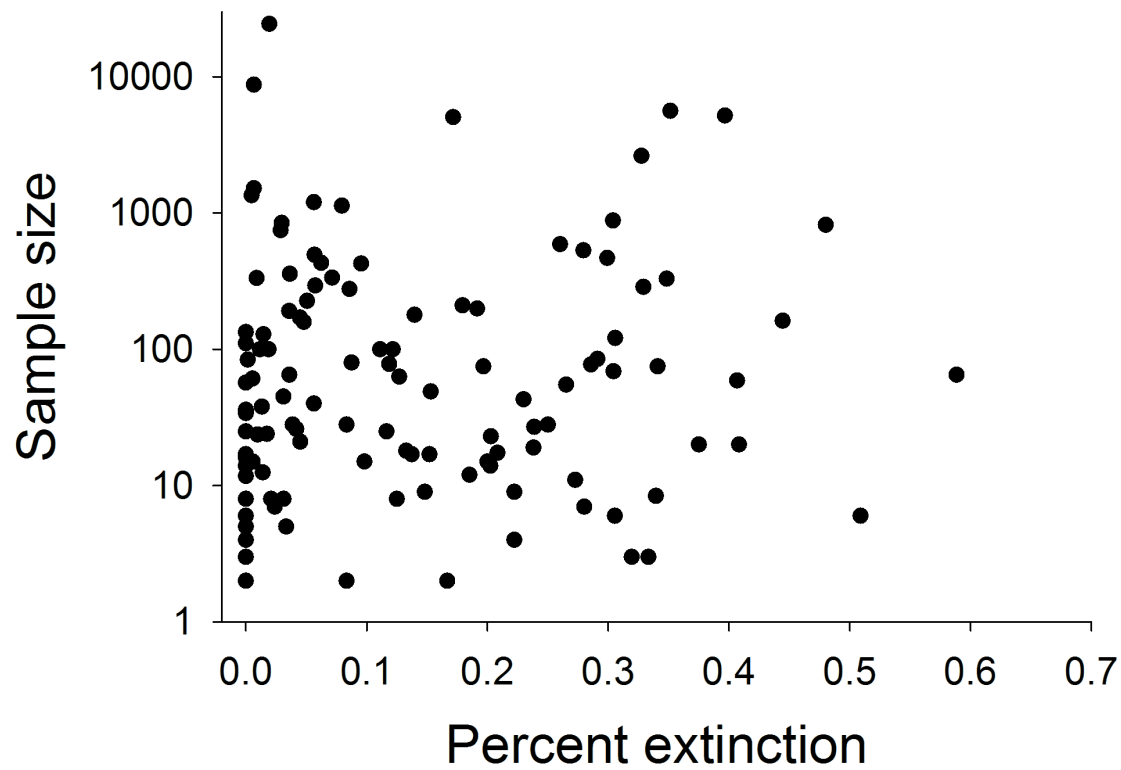
Meta-analysis results will be biased if researchers decide not to publish less replicated or less precise studies because of low statistical significance (51). Publication bias can be assessed visually through a funnel plot of precision versus effect size (52) and more quantitatively by testing for a significant negative Kendall's rank correlation between precision and effect size (53). I estimated precision by sample size rather than standard error because the latter is a function of the estimated proportion and therefore is intrinsically correlated regardless of publication bias (54, 55). Therefore, I created a funnel plot of sample size versus mean study proportion (Fig. S1). The resulting funnel plot does not suggest any evidence of publication bias, which would be indicated by fewer studies than expected in the lower left corner of low sample size and low extinction risk. I also evaluated patterns more quantitatively by examining the Kendall rank correlation between sample size and percent extinction where a negative correlation could indicate publication bias (53). However, the correlation from this study was significantly positive ($\tau = 0.18$, $P = 0.001$), rejecting publication bias and suggesting that results might be slightly conservative.

Relationship Between Extinction Risk and Projected Temperature Rise

Results suggest an accelerating increase in extinction risks with future temperature change (Fig. 2). I wanted to ensure that this relationship occurred independent of the logit transformation. I simulated proportional data derived from linear or curvilinear models with varying levels of random error. I then applied the same modeling techniques used in this study to be sure that I could differentiate between a linear and non-linear relationship. I demonstrated that data from a linear trend produces a significant negative quadratic term whereas data from a curvilinear relationship is characterized by a non-significant or positive quadratic term.

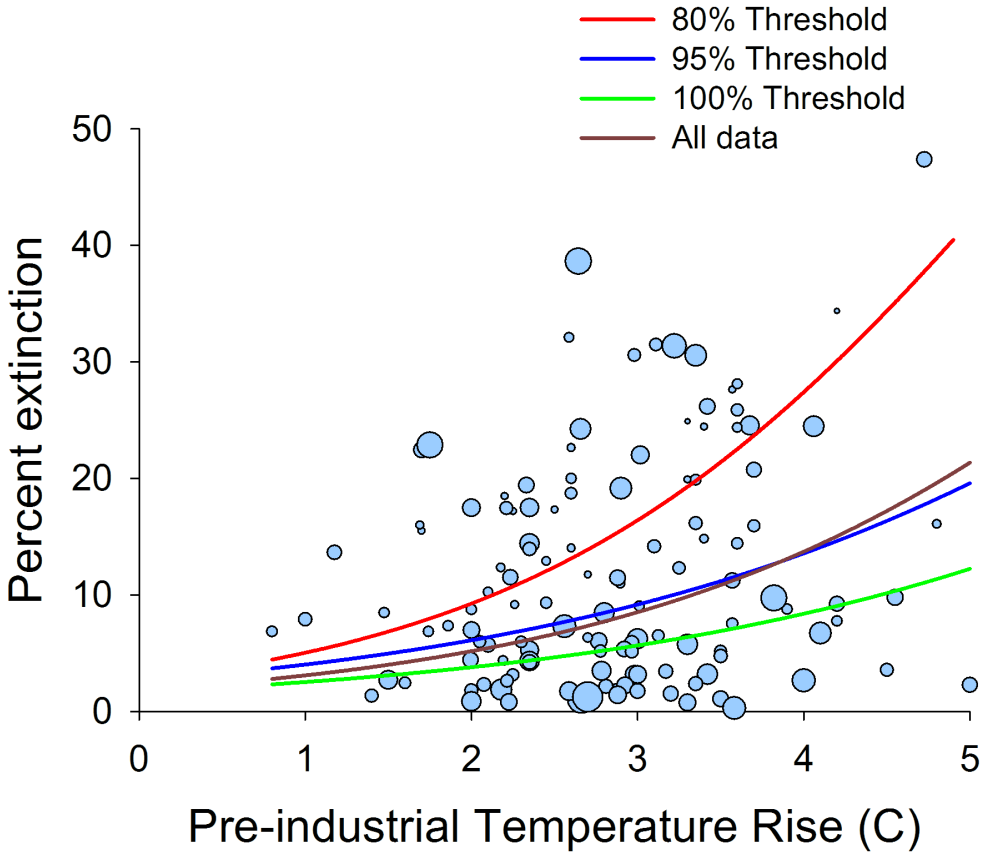
With the observed dataset, I first estimated a model with a quadratic polynomial term to evaluate potential curvature in the relationship between logit-transformed extinction risk and pre-industrial temperature rise. In this study, I found no evidence for a significant quadratic term, indicating that the curvature reflects the curvature in the original data independent of the transformations necessary to meet other assumptions of the statistical model. I also evaluated a model of raw proportions and found significant support for a model with a quadratic term (Fig. S3; quadratic term = 3.45×10^{-3} , CIs: 9.96×10^{-6} , 6.71×10^{-3}).

Fig. S1.



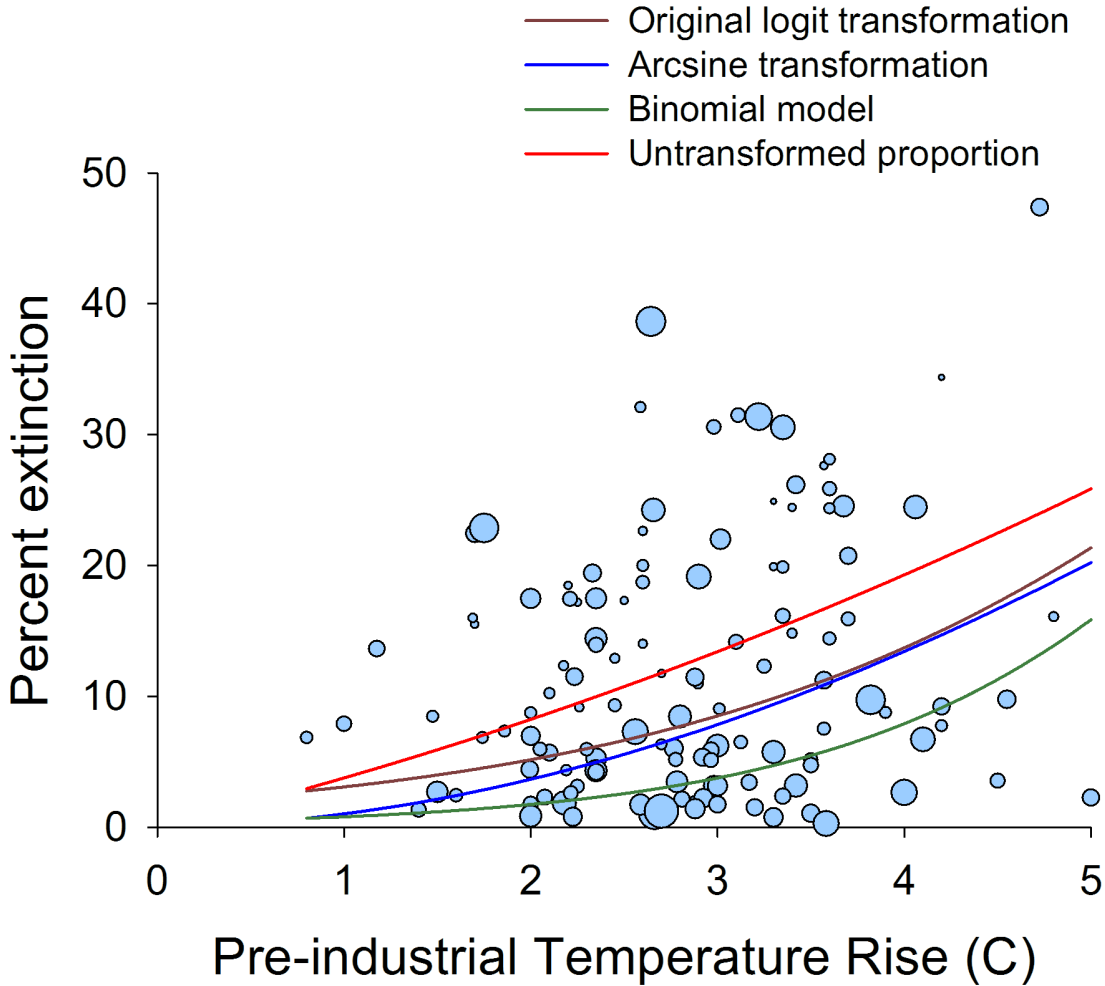
Funnel plot of sample size versus percent extinction by study. Sample size is indicated by the number of predictions (generally number of species modeled, but in some cases habitats or ecosystems; see materials and methods for a full discussion). The resulting funnel plot does not suggest any evidence of a publication bias, which would be the case if fewer studies occur in the lower left corner of low sample size and low extinction risk.

Fig. S2



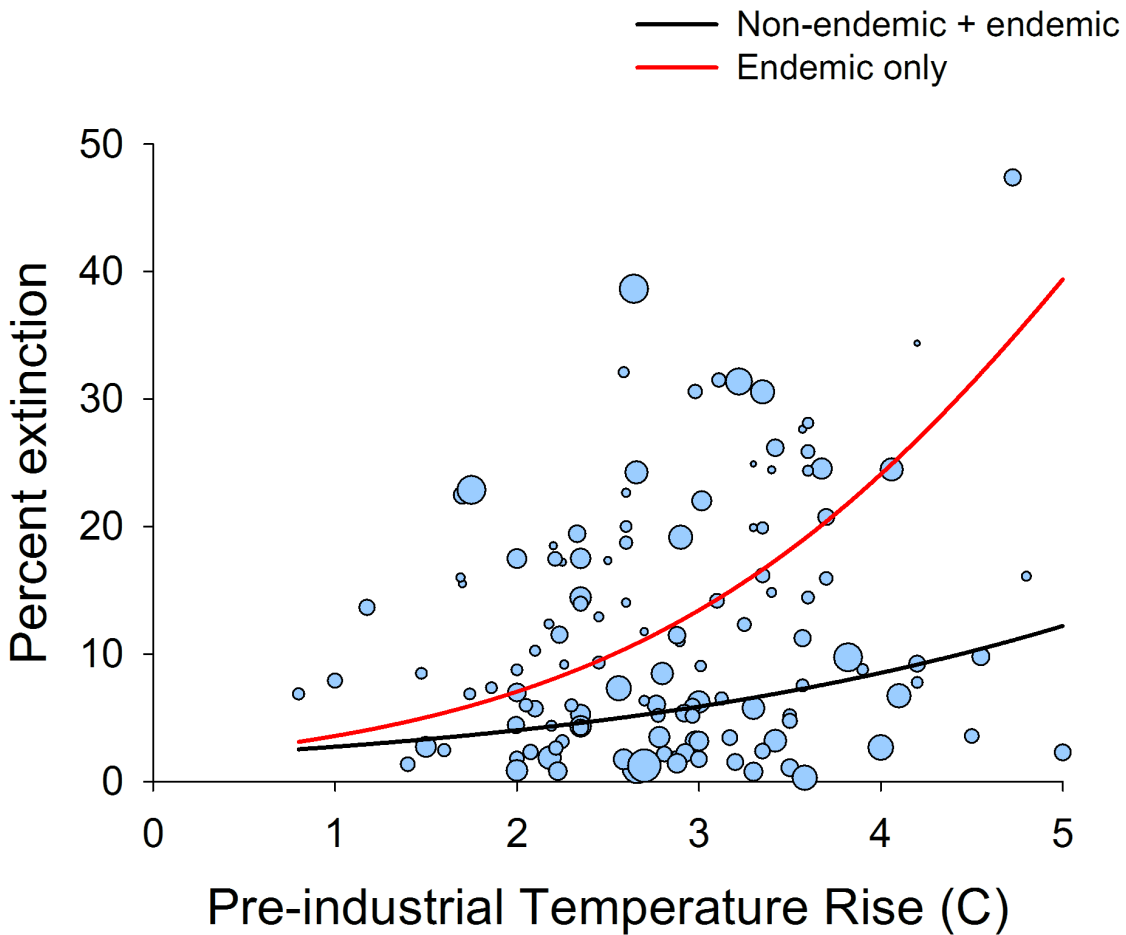
Alternative extinction thresholds bracket the predicted relationship between percent extinction risk and pre-industrial temperature rise. I detected a significant interaction between extinction thresholds and temperature rise ($\Delta \text{DIC} = 5.9$). Percent extinction risk versus pre-industrial temperature rise calculated for all data as in main text (dark red line), only results assuming 100% extinction thresholds (green line), only results assuming 95% extinction thresholds (blue line), and only results assuming 80% extinction thresholds (red line). Each relationship is estimated from the subset of studies for which these thresholds could be estimated. Because all thresholds could not be estimated for each study, estimates differ slightly in the composition and number of studies. The most conservative perspective would be that no species go extinct until they lose 100% of suitable habitat. This threshold would be an extreme view because we know that most species become extinct before all suitable habitat disappears even if these effects take a long time to manifest. Nonetheless, this analysis provides a conservative baseline to evaluate robustness of results. Alternatively, assuming an extinction threshold of 80% might prove too liberal. These two extremes bracket the relationship predicted by the main analysis that includes all data. Circles indicate the posterior means for each study from the original analysis, and their size indicates the weight of the model on a log10 scale. The smallest circle indicates a study with 2 species and the largest circle indicates a study with 24,480 species.

Fig. S3



Statistical models with different transformations of proportion data estimate similar relationships between percent extinction risk and pre-industrial temperature rise. Percent extinction risk versus pre-industrial temperature rise calculated as in the original analysis in the main text (dark red line) and using alternative methods for proportional data, including untransformed proportions (red), the arcsine transformation (blue), or using a model with binomial errors (green). Circles indicate the posterior means for each study from the original analysis, and their size indicates the weight of the model on a log10 scale. The smallest circle indicates a study with 2 species and the largest circle indicates a study with 24,480 species.

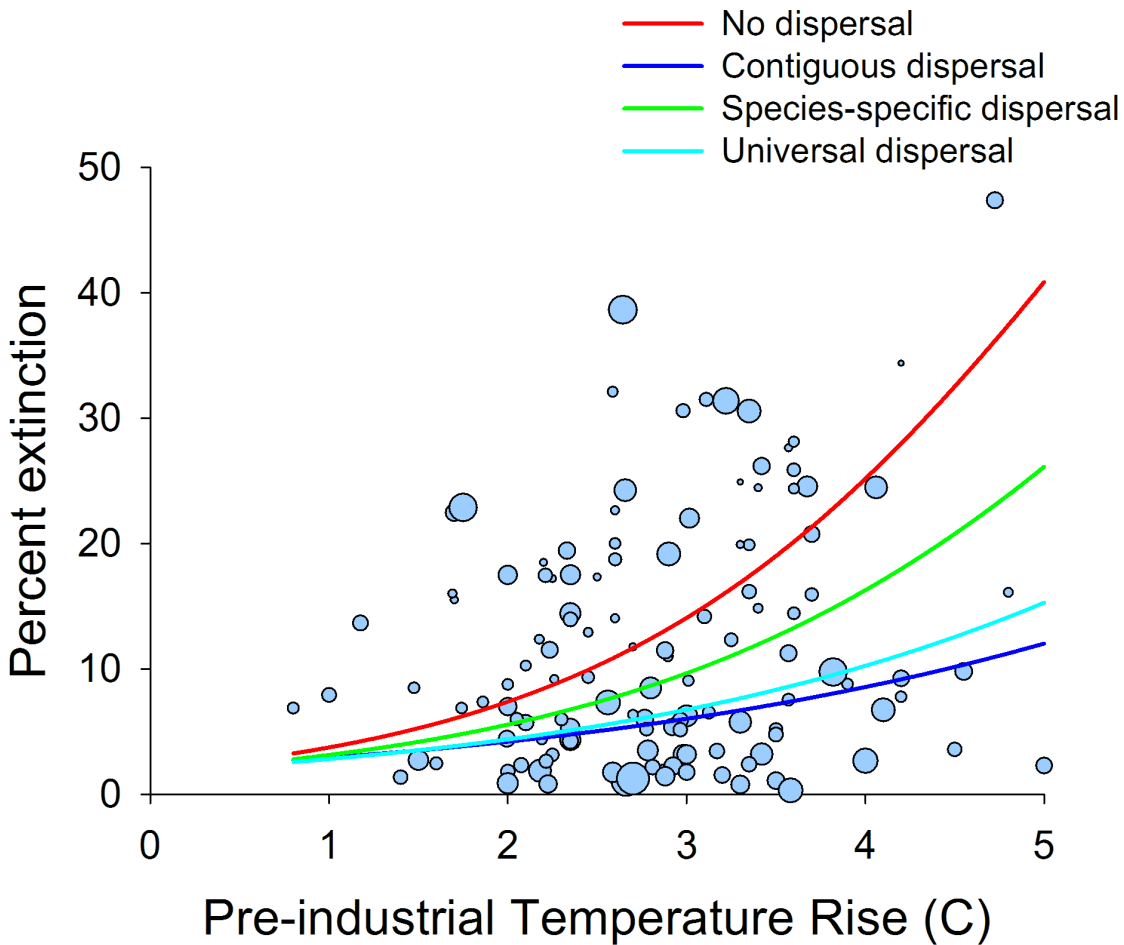
Fig. S4



Endemic-only models predict higher extinction risk with pre-industrial temperature rise than models that include both endemic and non-endemic species. I detected a significant interaction between endemism and temperature rise ($\Delta \text{DIC} = 8.2$).

Circles indicate the posterior means for each study from the original analysis and their size indicates the weight of the model on a \log_{10} scale. The smallest circle indicates a study with 2 species and the largest circle indicates a study with 24,480 species.

Fig. S5



Model assumptions about dispersal affect predicted extinction risks in response to pre-industrial temperature rise. I detected a significant interaction between dispersal assumption and temperature rise ($\Delta \text{DIC} = 6.1$). Circles indicate the posterior means for each study from the original analysis and their size indicates the weight of the model on a log10 scale. The smallest circle indicates a study with 2 species and the largest circle indicates a study with 24,480 species.

Table S1.

List of studies analyzed in meta-analysis and key assumptions

Authors	Year	Region*	Taxa [†]	Endemic	Model [‡]	Dispersal [§]	Thresholds	n	Temp. Rise
McDonald & Brown (56)	1992	N Am	mam	Y	SAR	N	0.8, 0.95, 1.0	19	3.6
Murphy & Weiss (57)	1992	N Am	mam, inv, pl	Y	SAR	N	0.8, 0.95, 1.0	7	3.6
Brereton et al. (58)	1995	Aus	mam, brd, rep, amph, inv	N	SDM	U	0.8, 0.95, 1.0	2 - 17	1.6 - 3.6
Huntley et al. (59)	1995	Eur	pl	N	SDM	U	0.8, 0.95, 1.0	8	3 - 5.4
Eaton & Scheller (60)	1996	N Am	fish	N	Mech	U	0.8, 0.95, 1.0	57	5
Hughes et al. (61)	1996	Aus	pl	Y	SDM	N	1	819	1.6 - 5.6
Johnston & Schmitz(62)	1997	N Am	mam	N	Mech	U	1	4	4.8
Iverson & Prasad (63)	1998	N Am	pl	N	SDM	U	0.8, 0.95, 1.0	80	4.55
Saetersdal et al. (64)	1998	Eur	pl	N	SDM	U	1	1521	4
Box et al. (65)	1999	N Am	pl	N	SDM	U	0.8, 0.95, 1.0	28	1
Guisan & Theurillat (66)	2000	Eur	pl	N	SDM	U	0.8, 0.95, 1.0	12	2.1 - 5.6
Zockler & Lysenko (67)	2000	Arctic	brd	Y	SDM	U	0.8, 0.95, 1.0	23	2.3 - 5.6
Peterson & Vieglais (68)	2001	N Am	brd	N	SDM	U	0.8, 0.95, 1.0	8	1.7 - 2.4
Roy et al. (69)	2001	Eur	inv	N	SDM	U	0.8, 0.95, 1.0	8	0.8 - 3.2
Beaumont & Hughes (70)	2002	Aus	inv	Y	SDM	U	0.8, 0.95, 1.0	24	1.2 - 2.9
Erasmus et al. (71)	2002	Afr	an	N	SDM	U	0.8, 1.0	179	2.35
Hill et al. (72)	2002	Eur	inv	N	SDM	N, U	0.8, 0.95, 1.0	35	2.81
Midgley et al. (73)	2002	Afr	pl	Y	SDM	N	1	330	2.4
Peterson et al. (74)	2002	N Am	mam, brd, inv	Y	SDM	N, C, U	0.9, 0.95, 1.0	334	1.7 -2.4

Berry et al. (75)	2003	Eur	brd, amph, inv, pl	N	SDM	U	1	2 - 36	2.5
Dirnböck et al. (76)	2003	Eur	pl	N	SDM	U	0.8, 0.9	85	1.1 - 2.3
Halloy & Mark(77)	2003	NZ	pl	Y	SAR	U	1	6	3.6
Harrison et al. (78)	2003	Eur	brd	N	SDM	U	0.8, 0.95, 1.0	8	0.8 - 2.5
Midgley et al. (79)	2003	Afr	pl	Y	SDM	U	0.95, 1.0	28	2.35
Mohseni et al. (80)	2003	N Am	fish	N	Mech	U	0.8, 0.95, 1.0	57	3
Peterson & Townsend (81)	2003	N Am	brd	Y	SDM	N, C, U	0.8, 0.9, 1.0	45	2.4
Siqueira & Peterson (82)	2003	S Am	pl	Y	SDM	U	0.9, 1.0	162	1.7 - 2.4
Williams et al. (10)	2003	Aus	vert	Y	SDM	U	1	65	1.6 - 7.6
Araújo et al. (83)	2004	Eur	pl	N	SDM	N, U	1	1200	2.6
Meynecke (84)	2004	Aus	mam, brd, amph, rep	Y	SDM	U	0.8, 0.95, 1.0	3	1.6 - 3.6
Miles et al. (85)	2004	S Am	pl	N	Hyb	N	1	69	1.6 - 2.9
Peck et al. (86)	2004	Mar	inv	Y	Mech	U	1	3	2.6
Peterson et al. (87)	2004	N Am	inv	N	SDM	N	0.8, 0.95, 1.0	111	2.1 - 2.4
Simmons et al. (88)	2004	Afr	brd	N	SDM	N, U	0.8, 0.95, 1.0	6	2.2
Skov & Svenning (89)	2004	Eur	pl	N	SDM	N, S	0.8, 0.95, 1.0	26	2.4 - 3.6
Thomas et al. (2)	2004	World	mam, brd, amph, rep, inv, pl	Y	SAR	N, U	1	5 - 243	1.6 - 4.1
Beaumont et al. (90)	2005	Aus	inv	Y	SDM	U	0.8, 0.95, 1.0	25	1.4
Bomhard et al. (91)	2005	Afr	pl	Y	SDM	N	0.8, 1.0	227	1.5
Chu et al. (92)	2005	N Am	fish	N	SDM	C	0.8, 0.95, 1.0	5	2.3 - 3.5
Kueppers et al. (93)	2005	N Am	pl	Y	SDM	U	0.8, 0.95, 1.0	2	2.5
McClean et al. (94)	2005	Afr	pl	N	SDM	N, U	1	5197	1.1 -2.4
Parra-Olea et al. (95)	2005	N Am	amph	Y	SDM	N, U	0.8, 0.95, 1.0	2	2.2
Shoo et al. (96)	2005	Aus	brd	N	SDM	N, U	0.8, 1.0	55	2 - 6.4

Thuiller et al. (97)	2005	Eur	pl	N	SDM	N, U	1	1350	2.4 - 4.5
Anciães & Peterson (98)	2006	S Am	brd	Y	SDM	N	0.95, 1.0	49	2.1
Bakkenes et al. (99)	2006	Eur	pl	N	SDM, SAR	N, U	1	856	1.2 - 3.0
del Barrio et al. (100)	2006	Eur	inv, pl	N	SDM	N, U		2 - 11	1.1 - 3.2
Harrison et al. (101)	2006	Eur	mam, brd, inv, pl	N	SDM	U	1	5 - 32	3.6
Huntley et al. (102)	2006	Eur	brd	N	SDM	N, U	0.8, 0.9, 1.0	426	2.8
Lawler et al. (103)	2006	W Hemi	mam	Y	SDM	N, U	0.8, 0.95, 1.0	100	2
Malcolm et al. (1)	2006	World	pl, vert	Y	SAR	N, U	NA	25	3.1
Midgley et al. (104)	2006	Afr	pl	N	SDM	N, S, U	1	336	2.4
Ohlemüller et al. (105)	2006	Eur	pl	N	SDM	N, U	0.8, 0.95, 1.0	17	2.3 - 5.1
Preston(106)	2006	N Am	fish	N	Mech	U	0.8, 0.95, 1.0	8	3.9
Schwartz et al. (107)	2006	N Am	brd, pl	N	SDM	N	0.8, 0.95, 1.0	116, 142	2.7
Svenning & Skov (108)	2006	Eur	pl	N	SDM	N, U	1	36	2.5 - 4.2
Thuiller et al. (109)	2006	Afr	pl	Y	SDM	N, U	0.8, 1.0	159	2.2 - 3.6
Thuiller et al. (110)	2006	Afr	mam	Y	SDM	N, U	0.8, 1.0	277	1.9 - 3.6
van Vuuren et al. (111)	2006	World	pl	Y	SAR	N, I, U	NA	65	1.0 - 3.5
Beaumont et al. (31)	2007	Aus	inv	Y	SDM	U	0.8, 0.95, 1.0	9	0.8
Carroll (112)	2007	N Am	mam	N	Mech	S	0.8, 0.95, 1.0	2	1.7
Gomez-Mendoza & Arriaga (113)	2007	N Am	pl	Y	SDM	U	0.8, 0.95, 1.0	34	1.8 - 2.4
Jetz et al. (114)	2007	World	brd	Y	SDM	N	1	8750	1.9 - 3.7
Levinsky et al. (115)	2007	Eur	mam	Y	SDM	N, U	1	40	2.4 - 3.6
Normand et al. (116)	2007	Eur	pl	N	SDM	N, U	0.8, 1.0	84	2.8 - 4.2
Peterson & Martinez-Meyer (117)	2007	Afr	mam	Y	SDM	N	0.8, 0.95, 1.0	17	2.1

Buckley(118)	2008	N Am	rep	Y	Mech, SDM	U	0.8, 0.95, 1.0	2	3.3
Colwel et al. I (119)	2008	S Am	inv, pl	N	SDM	N, U	1	82 - 739	3.4
Fitzpatrick et al. (120)	2008	Aus	pl	Y	SDM	N, S, U	1	100	1.6 - 4.5
Garzón et al. (121)	2008	Eur	pl	N	SDM	N, U	0.8, 0.95, 1.0	20	3.1
Huntley et al. (122)	2008	Eur	brd	N	SDM	N, U	0.9, 1.0	431	2.6 - 3.4
Iverson et al. (123)	2008	N Am	pl	N	SDM	U	0.8, 0.95, 1.0	134	1.4 - 5.2
Jarvis et al. (124)	2008	World	pl	Y	SDM	N, I, U	1	210	2.4
Laidre et al. (125)	2008	Arctic	mam	Y	Exp	S	0.8	11	NA
Loarie et al. (126)	2008	N Am	pl	Y	SDM	N, U	0.8	591	1.7 - 4.3
Luoto & Heikkinen (127)	2008	Eur	inv	N	SDM	N, U	0.8, 0.95, 1.0	100	2.4 - 3.1
Morin et al. (128)	2008	N Am	pl	Y	Mech	S	0.95	16	2.8 - 4.2
Pompe et al. (129)	2008	Eur	pl	N	SDM	U	1	845	4.1
Raxworthy et al. (130)	2008	Afr	amph, rep	N	SDM	U	1	11, 19	2.3
Ritchie & Bolitho (131)	2008	Aus	mam	N	SDM	N	0.8, 0.95, 1.0	4	1.0 - 6.6
Schweiger et al. (132)	2008	Eur	inv, pl	N	SDM	N, U	0.8, 0.95, 1.0	2	2.4 - 4.3
Sekercioglu et al. (133)	2008	World	brd	Y	SDM	U	0.8, 1.0	3349 - 8459	1.7 - 7.0
Settele et al. (134)	2008	Eur	inv	N	SDM	N, U	0.85, 0.95	294	1.8 - 4.3
Trivedi et al. (135)	2008	Eur	pl	N	SDM	U	1	20	2.4 - 3.6
Virkkala et al. (136)	2008	Eur	brd	N	SDM	U	0.8, 0.95, 1.0	27	1.7 - 2.9
Anderson et al. (137)	2009	N Am	mam	Y	Mech	S	0.8, 0.95, 1.0	2	4.2
Engler et al. (138)	2009	Eur	pl	N	SDM	N, S, U	0.9, 1.0	287	2.5 - 5.2
Hering et al. (139)	2009	Eur	inv	N	Exp	NA	NA	1134	NA
Morin et al. (140)	2009	N Am	pl	Y	SDM, Mech	U, S	0.8, 0.95, 1.0	15	2.8 - 4.2

Randin et al. (141)	2009	Eur	pl	N	SDM	U	1	78	2.1 - 4.0
Buckley et al. (23)	2010	N Am	rep, inv	Y	SDM, Mech	U	0.95	1	3.3
Heikkinen et al. (142)	2010	Eur	inv	N	SDM	N, U	0.8, 0.95, 1.0	100	2.9
Lasram et al. (143)	2010	Mar	fish	Y	SDM	U	0.8, 1.0	75	2.2 - 3.6
Li et al. (144)	2010	Asia	brd	N	SDM	N	0.8, 0.95, 1.0	63	3.6
Rebelo et al. (145)	2010	Eur	mam	N	SDM	U	0.9, 0.95, 1.0	28	2.3 - 4.8
Sinervo et al. (11)	2010	World	rep	Y	Mech	N	1	5077	2.2 - 3.6
Yates et al. (146)	2010	Aus	pl	Y	SDM	N, U	0.8, 0.95, 1.0	18	2.1 - 3.5
Balint et al. (147)	2011	Eur	inv	Y	SDM	U	1	9	2.9 - 3.8
Bond et al. (148)	2011	Aus	fish	N	SDM	U	0.8, 0.95, 1.0	43	0.8 - 1.5
Domisch et al. (149)	2011	Eur	inv	N	SDM	U	1	38	2.7 - 3.6
Early & Sax (150)	2011	N Am	amph	Y	SDM	C	1	15	2.0 - 3.1
Engler et al. (151)	2011	Eur	pl	N	SDM	U	0.8	2632	2.4 - 4.3
Evangelista et al. (152)	2011	N Am	inv	N	SDM	U	0.8, 0.95, 1.0	3	1.2 - 2.3
Garzón et al. (153)	2011	Eur	pl	N	Hyb, SDM	U	0.8, 0.95, 1.0	2	3.6
Sauer et al. (154)	2011	Eur	inv	N	SDM	U	0.8, 0.95, 1.0	23	2.9 - 3.8
Sheldon et al. (155)	2011	World	brd, rep, amph, inv	N	SDM	N, S, U	1	187 - 1258	4.1
Wenger et al. (156)	2011	N Am	fish	N	SDM	U	0.8, 0.95, 1.0	4	1.9 - 3.0
Dullinger et al. (42)	2012	Eur	pl	Y	Hyb	N, S, U	0.8, 1.0	25, 125	3.4
Fordham et al. (157)	2012	Aus	pl	Y	SDM, Hyb	U	0.8, 0.95, 1.0	5	2.0 - 3.4
Gardali et al. (158)	2012	N Am	brd	N	Exp	S	0.8	358	NA
Hof et al. (159)	2012	Eur	mam	N	SDM	N,U	0.8, 0.95, 1.0	61	2.8 - 3.6
Hughes et al. (160)	2012	Asia	mam	N	SDM	N,U	1	171	2.1 - 5.1
Ihlow et al. (161)	2012	World	rep	Y	SDM	N, U	0.8, 0.95, 1.0	199	2.7 - 3.3

Renwick et al. (162)	2012	Eur	brd	N	SDM	U	0.8, 0.95, 1.0	4	1.1 - 4.2
Romo et al. (163)	2012	Eur	inv	Y	SDM	U	0.8, 0.95, 1.0	6	1.9 - 3.6
Schloss et al. (16)	2012	W Hemi	mam	Y	Mech	S	1	493	3.3
Albouy et al. (164)	2013	Mar	fish	Y	SDM	U	1	59	3.7
Bambach et al. (165)	2013	S Am	pl	N	SDM	N, U	0.8, 0.95, 1.0	14	2.7 - 3.6
Cabral et al. (166)	2013	Afr	pl	Y	Hyb	S	0.8, 0.95, 1.0	8	1.9
Domisch et al. (167)	2013	Eur	inv	N	SDM	U	0.8, 0.95, 1.0	191	2.7 - 3.3
Foden et al. (4)	2013	World	brd, amph, inv	Y	Exp	S	NA	797 - 9856	1.9 - 3.7
Fordham et al. (43)	2013	Aus	inv	N	SDM, Hyb, Mech	U	0.8, 0.95, 1.0	2	2.0 - 3.4
Gallardo & Aldridge (168)	2013	Eur	inv	Y	SDM	U	0.8, 0.95, 1.0	2	2.2 - 2.3
Jones et al. (169)	2013	Mar	fish	N	SDM	U	1	17	2.3
Khanum et al. (170)	2013	Asia	pl	N	SDM	U	1	3	2.3
Li et al. (171)	2013	Asia	mam, brd, rep, amph	Y	SDM	N, U	0.8, 0.95, 1.0	9 - 24	3.3
Martínez-Freiría et al. (172)	2013	Afr	rep	Y	SDM	N, U	0.8, 0.95, 1.0	21	2.0 - 3.0
Moyle et al. (44)]	2013	N Am	fish	N	Exp	S	NA	121	NA
Sánchez-Guillén et al. (173)	2013	Eur	inv	Y	SDM	U	0.8, 0.95, 1.0	7	2.3 - 3.8
Warren et al. (3)	2013	World	an, pl	Y	SDM	N, S, U	0.9, 0.99	5382, 43578	2.0 - 4.0
Saupe et al. (174)	2014	Mar	inv	Y	SDM	U	0.8, 0.95, 1.0	14	1.6

Key: * Regions include Africa (Afr), Arctic, Asia, Australia (Aus), Europe (Eur), Marine (Mar), New Zealand (NZ), North America (N Am), South America (S Am), the Western Hemisphere (W Hemi), and the world. †Taxonomic groups include amphibians (amph), animals (an), birds (brd), invertebrates (inv), fish, mammals (mam), plants (pl), reptiles (rep), and vertebrates (vert). ‡ Model classifications include expert (Exp), hybrid (Hyb), mechanistic (Mech), species-area relationship (SAR), and species distribution models (SDM). § Dispersal assumptions include none (N), intermediate (I), contiguous (C), species-specific (S), and universal (U).

Table S2.

Estimates of overall extinction risk

Model	Mean (95% intervals)
1. Random effects, weighted, MCMC	7.9 (6.2, 9.8)
2. Random effects, weighted, restricted error maximum likelihood*	7.9 (6.3, 9.8)
2. Random effects, unweighted, MCMC	8.0 (6.5, 9.8)
3. Raw median	6.2 (3.6, 12.1) [†]

* estimated from the rma.mv function in R package metafor with individual level variation.

[†] bootstrapped confidence intervals rather than Bayesian credible intervals.

Table S3.

Δ DIC between models with and without pairwise interactions.

	Pre-industrial temp. rise	Endemic	Extinction debt	Dispersal mode	Model Type	Note – The Deviance Information Criterion provides a commonly accepted measure of
Pre-industrial temp. rise						
Endemic	8.2					
Extinction debt	5.9	-3.1				
Dispersal mode	6.1	1.1	-5.5			
Model type	1.6	4.0	-6.7	-2.2		

fit for Bayesian models. A Δ DIC > 4 is generally suggested to indicate support for a model (50). I highlighted pairwise interactions that met this criterion in bold text. Owing to no data or small sample sizes for many individual cells, I could not estimate interactions with region or taxonomic group.

Table S4. Factors contributing to variance in model predictions

Factors	Mean (95% credible intervals)	Model support based on DIC (MCMC) and omnibus test (QM_{df}, metafor)[†]
Expected climate change		Δ DIC = 180.1
Pre-industrial temp. rise*	0.53 (0.46, 0.62)	$QM_6 = 172.6$, $P < 0.001$
Region		
North America	5.1 (3.5, 7.6)	
Europe	6.3 (4.5, 8.8)	
Asia	9.2 (2.4, 28.5)	Δ DIC = 12.6
Africa	11.6 (6.8, 18.2)	$QM_6 = 26.5$, $P < 0.001$
Oceans	12.7 (4.6, 33.1)	
Australia-New Zealand	13.9 (9.0, 21.4)	
South America	23.0 (12.9, 39.7)	
Endemic species		
Only endemic to study area	7.3 (5.9, 9.0)	Δ DIC = 8.3
Plus non-endemic species	4.6 (3.7, 5.6)	$QM_1 = 11.2$, $P < 0.001$
Taxonomy		
Amphibians	12.9 (8.1, 19.8)	
Reptiles	9.0 (5.5, 13.7)	
Invertebrates	8.8 (6.3, 12.0)	Δ DIC = 0.7
Mammals	8.6 (5.9, 13.1)	$QM_6 = 9.9$, $P = 0.128$
Fish	7.6 (3.4, 16.1)	
Plants	7.3 (5.5, 9.4)	
Birds	6.3 (4.5, 9.1)	

Extinction threshold

100%	5.3 (4.1, 6.7)	$\Delta \text{DIC} = 144.1$
95%	8.5 (6.5, 11.0)	$\text{QM}_2 = 136.1, P < 0.001$
80%	14.5 (11.5, 18.3)	

Dispersal model

Universal dispersal	6.3 (4.9, 7.9)	$\Delta \text{DIC} = 68.5$
Contiguous dispersal	6.4 (3.2, 12.6)	$\text{QM}_3 = 62.2, P < 0.001$
Species-specific dispersal	9.6 (6.6, 12.7)	
No dispersal	12.4 (9.5, 15.7)	

Modeling technique

Species distribution model	7.1 (5.6, 9.0)	$\Delta \text{DIC} = 3.4$
Mechanistic	8.5 (5.6, 12.9)	$\text{QM}_3 = 8.6, P = 0.035$
Expert	18.0 (5.7, 45.9)	
Species-area relationship	22.2 (10.3, 45.4)	

* I first tested for a quadratic effect of pre-industrial temperature rise. After finding this effect non-significant, I removed it from the model.

† Significant results are highlighted in bold.

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