Supplementary Materials for

The projected effect on insects, vertebrates and plants of limiting global warming to 1.5°C rather than 2°C

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This PDF file includes:

Materials and Methods
Supplementary Text
Figs. S1 to S8
Tables S1 to S6

Materials and Methods

Data, Materials and Methods are as described in (*4*) with differences noted below. This paragraph provides a brief summary of the method. Current species distribution data were obtained from the Global Biodiversity Information Facility (GBIF; (*34*)). Alternative projected climate change scenarios for the 21st century, expressed as time series of global temperature change, were used to drive a pattern scaling model, ClimGEN (*35*) in which scaled climate change patterns diagnosed from 21 alternative regional climate change patterns (corresponding to 21 alternative Coupled Model Intercomparison Project (CMIP5) General Circulation Model (GCM) patterns) for each climate change mitigation (or baseline) scenario. This is necessary because GCMs have not been run for the mitigation scenarios used in this study. We used MaxEnt (*36*) to create statistical relationships between species occurrence records and a baseline (largely 1961-1990) climate, and to calculate the present geographic climatically determined distribution of each species. Then we used the projected climates and trained models to derive potential future distribution for each species in our future climate scenarios for 30 year periods (to encompass natural climate variability), including or excluding dispersal at realistic rates (where spatially appropriate) derived from the literature, restricting dispersal to contiguous land areas. Finally we produced estimates of the proportions of species losing different proportions of their range at each level of warming.

Several processes, described in (*4*), explain how scientific rigor was ensured. These include (i) using a large number (21) global circulation model regional climate change patterns in our analysis; (ii) accounting for uncertainties in species dispersal rates (where appropriate) by presenting projections with and without realistic dispersal; (iii) cleaning the underlying biodiversity distribution data to remove outliers; whilst in the underlying bioclimatic modelling process we (iv) used a reduced set of variables to minimize potential autocorrelation; (v) used the Area under the Receiver Characteristic (sometimes known as AUC or ROC) to select species models for projection based on model performance; (vi) minimized commission errors by clipping species distributions to their biogeographic zones; (vii) minimized omission areas by applying a generous buffer around species distributions to compensate for potential data paucity within biogeographic zones.

The following updates, to the methods used in (*4*) are specific to this new study:

1. *Climate Change Scenarios*. New global temperature time-series for the four Representative Concentration Pathways (RCPs, (*37*)) were kindly provided by the UK Met Office Hadley Centre and are those used in (*38*). These encompass uncertainty in global climate models (GCMs), but other variants of these climate models could be constructed in which key variables making a dominant contribution to uncertainty in climate projection differ. Hence, to encapsulate as much of the uncertainty in model projection as possible, these time series were projected by running a simple probabilistic climate model that samples distributions of these key physical parameters (*38*). The global temperature time-series used correspond to the four RCPs, (*37*). These time-series of projected global temperature change are used to scale 21 alternative patterns of regional climate change derived from the CMIP5 model inter-comparison project (*39*) - compared with only 7 in (*4*). The patterns were obtained from the IPCC Data Distribution Centre at www.ipcc-data.org and were scaled according to the amount of

warming provided by the time series in order to create 21 new patterns of projected climate changes in future time periods (one corresponding to each general circulation model (GCM) (*35*) and combined with observational data to produce patterns of projected climate change at a fine spatial resolution of 10 arc minutes. In contrast, (*4*) used only 7 alternative GCM patterns and GCM output from the older CMIP3 archive.

2. *Increased spatial resolution*. The observational baseline climate used for pattern scaling in this study was the WorldClim database for 20 km (10 arc minutes, version 1.4, (*40*)) with anomalies from the climate model outputs applied to it. Working at increased resolution allowed a larger number of species to be modelled. This improves on the spatial resolution of 0.5° previously used.
3. *30 year time-slices selected for analysis, corresponding to different levels of warming* Projected climates were produced matching four different levels of warming in the 2080s (i.e. average of the thirty-year period 2071-2100), using the RCP global temperature time series, as follows: RCP8.5 in the 2020s is a proxy for a 1.5°C world; RCP 2.6 in the 2080s for a 2°C world; RCP 6.0 in the 2080s for the higher end of the INDC range (here 3.2°C) and RCP 8.5 in the 2080s for 4.5°C warming. The difference between the proxy and the actual temperatures in each case is less than 0.1°C. In contrast, (*4*) used the SRES A1B base line scenario and associated mitigation scenarios. The choice of time-slices versus a higher temporal resolution was made to best match the occurrence data and follows from the guidelines in (*41*)
4. *Patterns of projected climate change* thus produced are explored *as if* they occurred in 2100 (irrespective of the timescale at which that temperature rise occurs in the RCP scenarios), as the effect on the regional climate change patterns of different rates of warming can be assumed to be negligible for lower levels of radiative forcing (*35*). The validity of pattern scaling over a range of climate change scenarios spanning the levels explored in this study has recently been confirmed (*42*) but a tendency to underestimate warming over land in some GCMs was identified. Hence newly in this study, the patterns of projected climate change are produced, still in ClimGEN, but by driving it, for 4.5°C warming only, directly with regional climate change patterns taken directly from GCM run outputs corresponding to the RCP8.5 scenario and its larger forcing. This provides additional scientific rigour. The use of pattern scaled output to drive our impacts projections for biodiversity has also recently been compared with the alternative use of the output of high-resolution climate models with similar results (within the uncertainty ranges caused by using alternative GCMs for pattern scaling) (*43*).
5. *Species distribution data* were obtained from the Global Biodiversity Information Facility (GBIF; (*34*), as used in (*4*)) accessed continuously since 2015. Since our previous analysis in 2012, the database has been updated and expanded to include nearly 70000 more species of plants and animals. The new data were cleaned to remove outliers as described previously in Warren et al. 2013.
6. *Inclusion of more species in our analysis*. Both updates to the GBIF database and increased spatial resolution enabled us to include thousands more species than were available in our earlier studies. Species with fewer than 10 data points (occupied grid cells in our analysis) were excluded in order to limit the analysis to those with sufficient data to allow robust analysis. This is in line with (*4*). In summarizing the impacts of

climate change, results were summarized by taxonomic phylum or class (in the Tables and Figure panels in this paper) and, given the focus of this study on insects, also for taxonomic groups where more than 500 species had been modelled.

7. *Bioregions*. In the (*4*) method, species are assigned to one of eight bio-geographic realms for the clipping process (to minimize commission errors). In line with the increased spatial resolution of the analysis, we increased the number of bio-regions for clipping to 11 in order to properly represent and account for the unique biodiversity of the Galapagos, Madagascar and New Zealand.
8. *Incorporation of Insects and other Invertebrates*. The methodology applied to insects and arachnids was identical to that for animals, with data on current distributions taken also from the GBIF. Dispersal rates for the various insect groups were taken from the literature. See (*4*) supplementary material for a detailed discussion of dispersal rates in plants and Chordata. A study found that the change in species composition of butterfly communities was equivalent to a 72.3 (± 9.9) km northward shift between 1990 and 2008 (*44*) indicating a realistic dispersal rate of close to 2.6 km/yr for butterflies. Similarly (*45*) found that the ranges of N American butterflies had moved north 35-240 km in 30-100 years, providing a conservative average of 2.1 km/yr (most of the data in this study was concentrated in recent decades). (*46*) found that generalist British butterfly species had moving north on average by 53 km between 1970-1982 and 1985-1999, producing an average annual rate of 3.3km/yr. A similar rate of 3+/- 0.5 km/yr was found for dragonflies in the UK (*47*) (specially, a N range shift of 4+/-12 km over 25years). For other insect and invertebrate groups there is very limited information, so their dispersal rates were set to a conservative 0.1 km/yr.
9. *Inclusion of dispersal.* Aves, Mammalia, Lepidoptera and Odonata have relatively rapid dispersal rates, whilst other taxa do not show much detectable range shift at the spatial scale used in this study. Therefore, we have excluded dispersal for all but these species in the interest of space, accuracy and clarity. Furthermore, a no-dispersal scenario is primarily included as a more realistic representation that the present-day landscape contains many barriers resulting from human modification of the landscape and associated habitat fragmentation. Barriers can include roads, urban areas, and agricultural areas, but also some natural features such as deep valleys and/or rivers. The scenario also reflects the uncertainty in dispersal rates, which are incompletely known.
10. *Statistical rigour.* The rigorous statistical tests described in (ibid) were repeated here. Checks were further made on the whether the bioclimatic variables previously used were still the best to use with the new dataset using the validation metrics provided in MaxEnt (they were). At various stages in the analyses resampling was performed and curves of potential range losses were checked against previous results. This found that the results were robust to the inclusion or exclusion of individual species.

Supplementary Text

Supplementary Results

Fig. S1 provides detail about the impacts on particular insect taxonomic groups in which more than 500 species were studied, indicating greatest range losses in Diptera, Coleoptera and Hemiptera, where ~70 to 90% lose more than half their climatic range for a global warming of 4.5°C, and lowest in Odonata, where, with dispersal, ~21% lose more than half their range. At 1.5°C warming these losses are greatly reduced to fewer than 10% of species in Diptera, Coleoptera and Hemiptera, and to negligible levels in Odonata. Risks for Hymenoptera, many of which are key pollinators, are intermediate, with almost 60% losing over half their range at 4.5°C warming and only about 5% doing so for a warming of 1.5°C. The impacts are reduced by a factor of approximately three if warming is constrained to 1.5°C rather than 2°C with the largest benefits arising for Coleoptera.

Supplementary Tables 4 and 5, and Supplementary Figure S3 indicate corresponding projections for the alternative assumption of no dispersal. The 'no' dispersal case for Mammalia, Aves, Lepidoptera and Odonata acts as a proxy for a world in which species' ability to disperse is strongly constrained by man-made obstacles such as urban areas, roads, and areas under intensive agricultural production; this would be expected to be the situation for some species and in some areas, yet not in others especially for more generalist species. This indicates greater risks if species are unable to disperse under warming of 4.5°C by 2100, reaching range losses of 57% (44-71%) of the vertebrate species, and 73% (59-83%) of the insect species. With current pledges, (a pessimistic interpretation of which approximates to a warming of ~3.2°C), this is reduced to 37% (24-53%) of the vertebrates, and 56% (42-71%) of the insects. At 2°C this is reduced further to 12% (7-22%) of the vertebrates, and 26% (11-42%) of the insects and at 1.5°C to 6% (3-12%) of the vertebrates, and 10% (3-24%) of the insects. Without the Paris Agreement, warming might reach 4.5°C by 2100, leading to projected total integrated range loss without dispersal of 53% (44-63%) for vertebrates, and 65% (55-74%) for insects. With current pledges, corresponding to warming of ~3.2°C, this is reduced to 41% (33-50%) for vertebrates, and 52% (41-62%) for insects. At 2°C this is reduced further to 27% (21-34%) for vertebrates, and 35% (26-44%) for insects and at 1.5°C to 22% (16-27%) for vertebrates, and 27% (20-34%) for insects.

Supplementary Discussion

A number of caveats are associated with the methodology, for example the potential for climatic niche change: but rates of niche change extracted from phylogeographic studies found that these were on average 200,000 times slower than rates of projected climate change (*49*). For plants and insects that are dispersed aerially, climate change might itself affect dispersal dynamics, and this is not included; negative effects are envisaged for some spiders (*50*, *51*).

Species distributions are currently assumed to be in equilibrium with the current climate. Since many species have been found to be moving in tandem, or faster, than observed changes this assumption is not unreasonable. The approach also assumes that across a species' range, the climatic tolerance does not differ between geographically separate portions of the range. This is a necessary assumption given the limitations of our data (e.g., GBIF does not contain data about geographically separate sub-species) but may not hold in all cases. The choice of bioclimatic variables most appropriate for this type of modelling has been previously established and also involves tests of statistical rigour as discussed in (Warrren et al. 2013), to which see for further discussions of assumptions.

In ecosystems that are regulated by fire, for example in savannas, Mediterranean climates and other sub-tropical ecosystems, the argument can be made that species presence is more determined by disturbance regimes than by climate. However, the disturbance regimes themselves are controlled by climate – indeed, application of a very similar MaxENT based modeling approach to the distribution of fire has been demonstrated (*52*). Hence, the dependence of species upon fire regimes may actually be captured already by the MaxENT based modelling approach, and due to the interaction between fire regimes and climate change (*53*), to account for this separately would result in at least some double counting. What is not included is the potential for extreme weather events to alter fire regimes, potentially leading to under estimation of impacts.

Of the 80 or so scenarios emerging from integrated assessment models analysed in the Fifth Assessment of the Intergovernmental Panel on Climate Change (*54*) which limit warming to 2°C or below by 2100, many contain an overshooting of the temperature goal of up to 0.2°C for up to 60 years (*55*). Hence, efforts to comply with the aspirations of the Paris Agreement are likely to incorporate some degree of temperature overshoot, with larger overshoots for longer periods (for example, an overshoot of 0.5°C for 200 years could be a potential outcome). Although we did not explicitly simulate the effects of overshooting, the implications for species is best approached by a traits based argument: the implications will depend strongly on species dispersal rates and their longevity. For species which can remain in situ for a warming of 1.5°C, which disperse very slowly, and which are long lived there may be an ability to survive a small overshooting of temperature, such as the 0.2°C mentioned above, until the climate returns to normal, although reproduction might be impacted during the overshoot period. However, for short lived species, they may be extirpated during the overshooting period, after which they would have to recolonize the area from their refugia. For species which disperse very rapidly, such as birds (Aves) or butterflies (Lepidoptera), the potential for 'over' adaptation exists in which a species might move to an area which becomes newly climatically suitable, yet need to retreat again at the end of the overshooting period.

Fig. S1. The proportion of insect and arachnid species losing more than half their climatically determined range by 2100 at specific levels of global warming. (**A**) Coleoptera (n=7630) (**B**) Diptera (n=4809) (**C**) Hymenoptera (n=5914) (**D**) Lepidoptera (n=8594) (**E**) Odonata (n=599) **(F)** Trichoptera (n=833) **(G)** Hemiptera (n=1728) **(H)** Arachnida (n=2212). Data are given including (blue) and excluding (orange) realistic dispersal and presented as mean projection across the 21 alternative regional climate model patterns utilized with error bars indicating the 10-90% range.

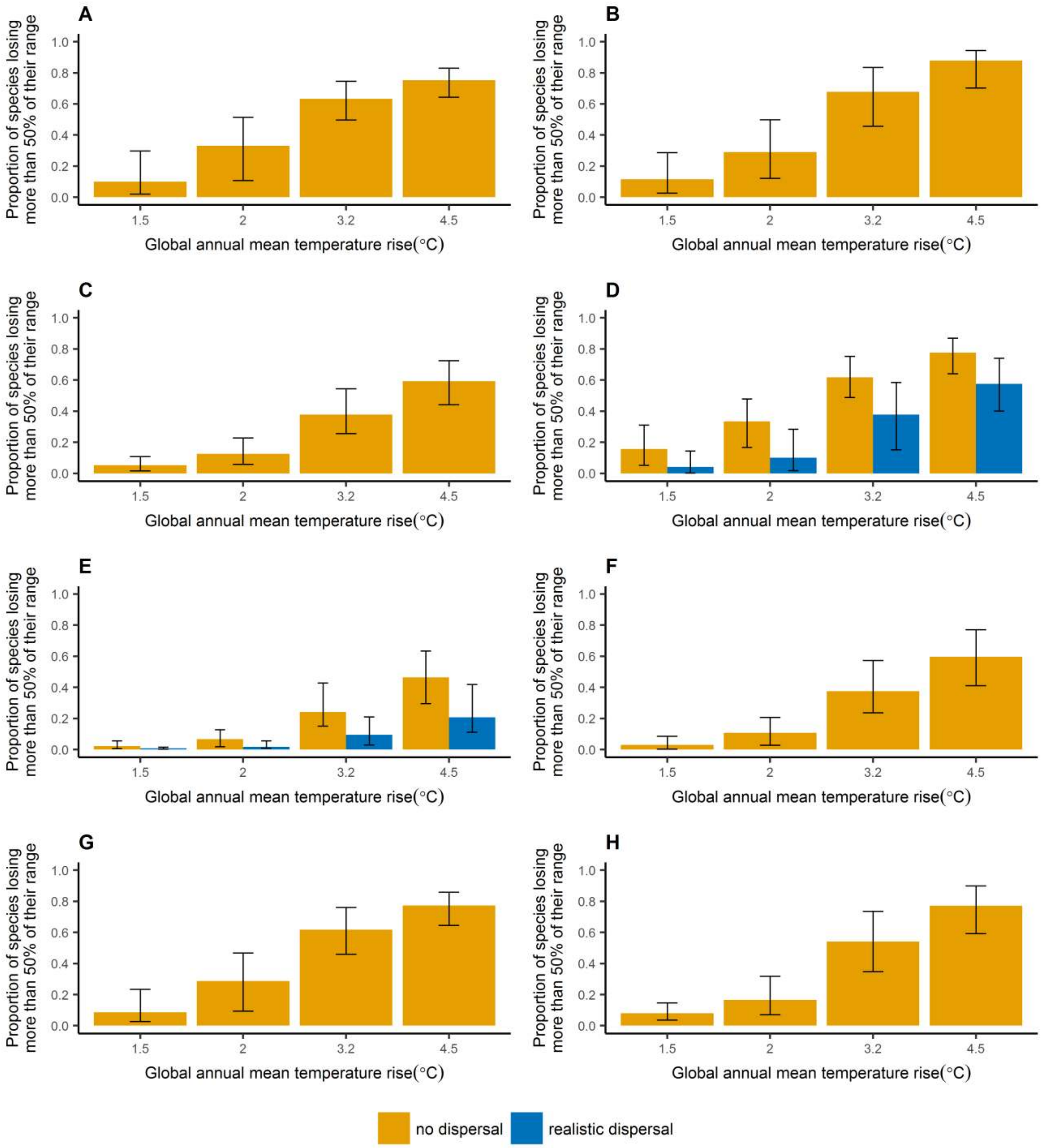
A
B
C
D
E
F
G
H
Proportion of species losing more than 50% of their range
1.0
0.8
0.6
0.4
0.2
0.0
1.5
2
3.2
4.5
Global annual mean temperature rise(°C)
no dispersal
realistic dispersal

Fig. S2. The projected climatically mediated range loss by 2100 at specific warming levels. (**A**) Lepidoptera (n=8594) (**B**) Odonata (n=599) (**C**) Aves (n=7966) (**D**) Mammalia (n=1769) including the potential for species to disperse to track their geographically shifting climate envelope. The proportion ranges from +1 (100% loss) to -1 (100% gain); values < -1 indicate more than 100% gain. X-axes represent the 0th to 100th percentile of species arranged in order of increasing range loss, normalized by the number modelled in the taxon. Losses for each species are shown as median and 10-90% range across regional climate model patterns.

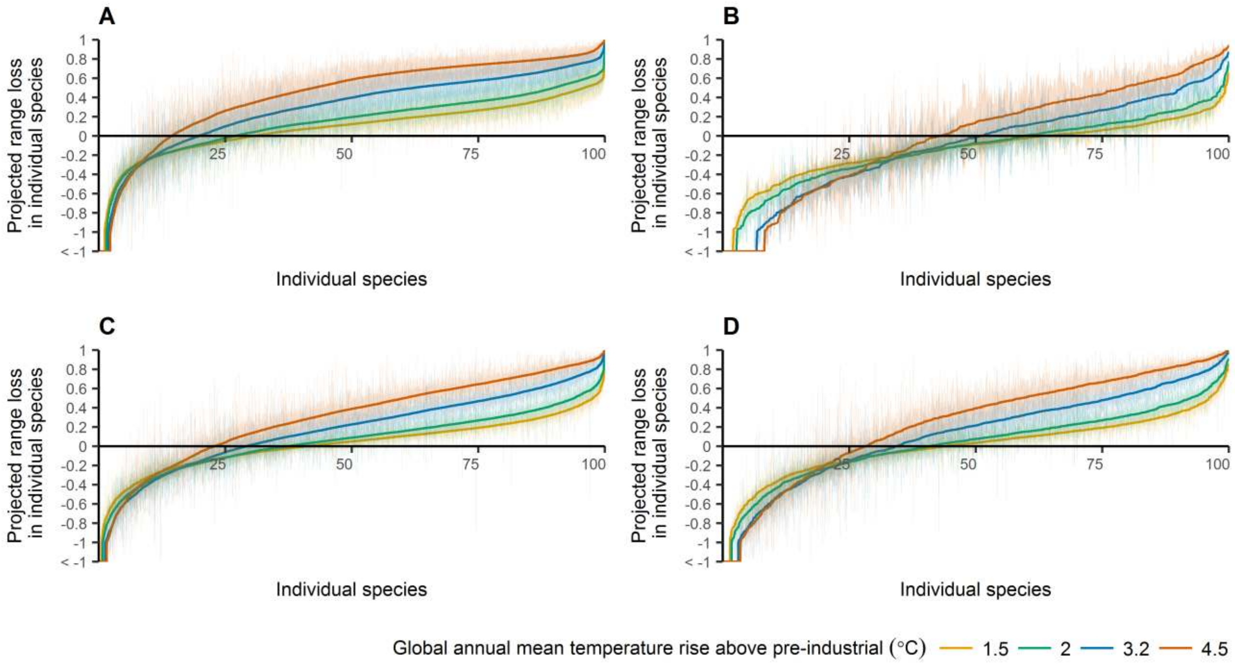

A
B
C
D
Projected range loss in individual species
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
< -1
25
50
75
100
Individual species
Global annual mean temperature rise above pre-industrial (°C)
1.5
2
3.2
4.5

Fig. S3. The projected climatically mediated range loss by 2100 for insect and arachnid groups at specific warming levels excluding the potential for species to disperse to track their geographically shifting climate envelope. (**A**) Coleoptera (n=7630) (**B**) Diptera (n=4809) (**C**) Hymenoptera (n=5914) (**D**) Lepidoptera (n=8594) (**E**) Odonata (n=599) **(F)** Trichoptera (n=833) **(G)** Hemiptera (n=1728) **(H)** Arachnida (n=2212). The proportion ranges from +1 (100% loss) to -1 (100% gain); values < -1 indicate more than 100% gain. X-axes represent the 0th to 100th percentile of species arranged in order of increasing range loss, normalized by the number modelled in the taxon. Losses for each species are shown as median and 10-90% range across regional climate model patterns.

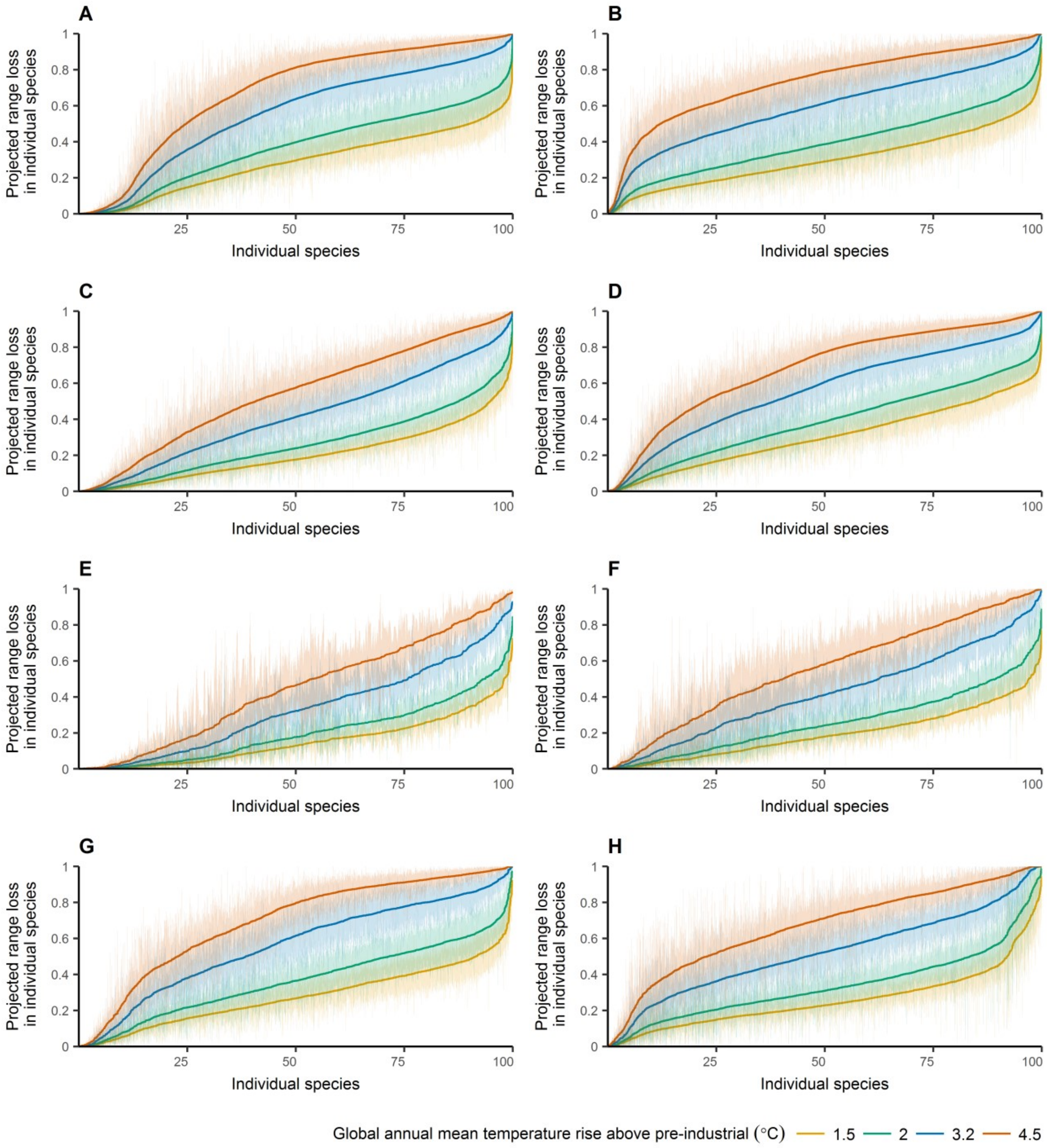

A
B
C
D
E
F
G
H
Projected range loss in individual species
0
0.2
0.4
0.6
0.8
1
Individual species
25
50
75
100
Global annual mean temperature rise above pre-industrial (°C)
1.5
2
3.2
4.5

Fig. S4. Proportion of species losing more than half their climatically determined range by 2100 at specific warming levels. (**A**) butterflies (**B**) moths (**C**) bee (Apidae), hoverfly (Syrphidae) and blowfly (Calliphoridae). Data are given including (blue) and excluding (orange) realistic dispersal and presented as mean projection across the 21 alternative regional climate model patterns utilized with error bars indicating the 10-90% range.

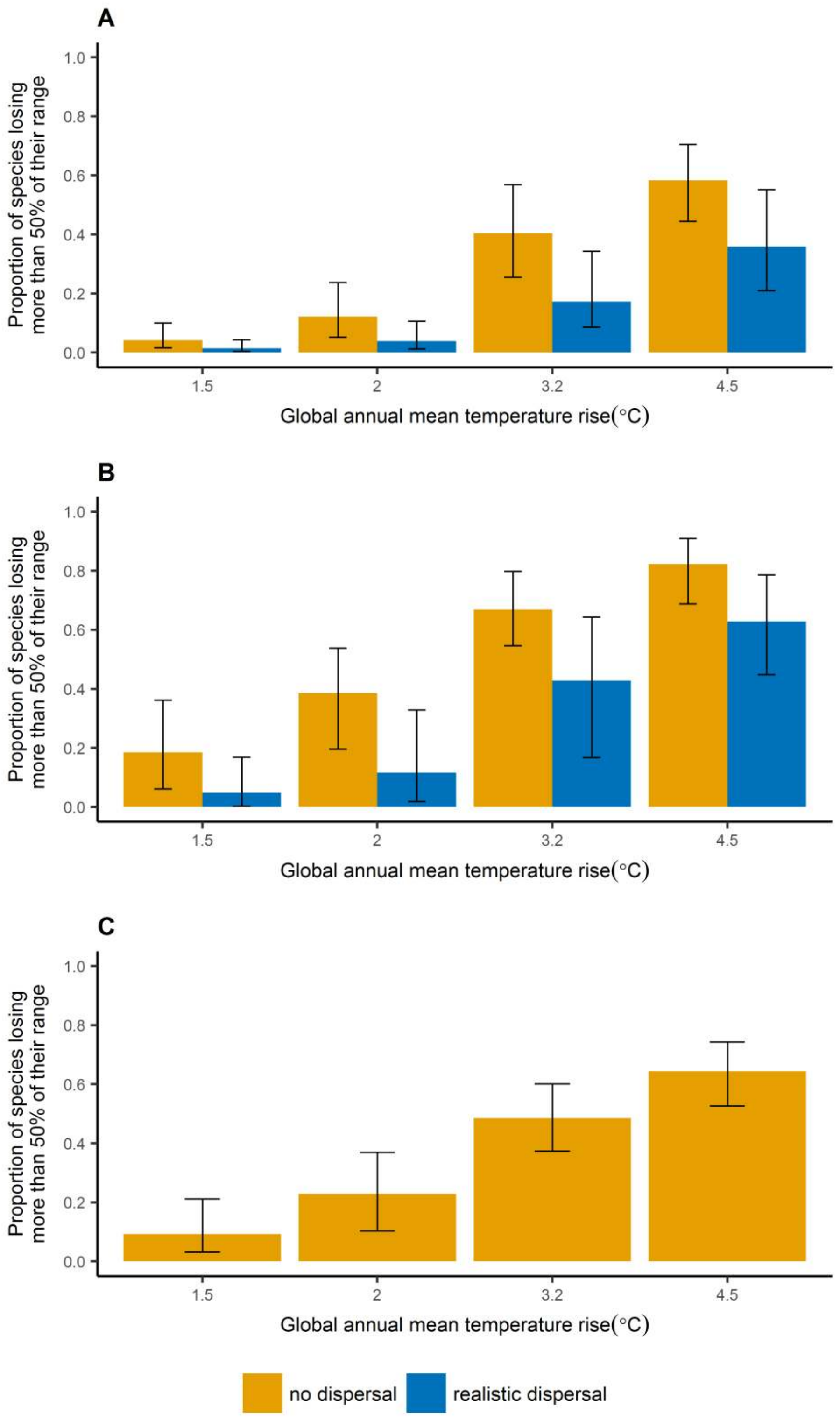

A
Proportion of species losing more than 50% of their range
1.0
0.8
0.6
0.4
0.2
0.0
1.5
2
3.2
4.5
Global annual mean temperature rise(°C)
B
Proportion of species losing more than 50% of their range
1.0
0.8
0.6
0.4
0.2
0.0
1.5
2
3.2
4.5
Global annual mean temperature rise(°C)
C
Proportion of species losing more than 50% of their range
1.0
0.8
0.6
0.4
0.2
0.0
1.5
2
3.2
4.5
Global annual mean temperature rise(°C)
no dispersal
realistic dispersal

Fig. S5. The projected climatically mediated range loss by 2100 for butterflies (A, D), moths (B, E), and bee (Apidae), hoverfly (Syrphidae) and blowfly (Calliphoridae) species (C, F) under future alternative climate change scenarios in which warming reaches 1.5, 2.0, 3.2 or 4.5°C above pre-industrial levels by 2100, including (A, B, C) and excluding (D, E, F) the potential for species to disperse to track their geographically shifting climate envelope. Y axis indicates proportion of range lost such that +1 indicates 100% loss, -1 indicates 100% gain, and <-1 over 100% gain. X axis indicates 0^{th} to 100^{th} percentile of species in a given taxon arranged in order of increasing range loss normalized by the number of species modelled in that taxon. Losses for each species are shown as median and 10-90% range across regional climate model patterns as per Fig 1.

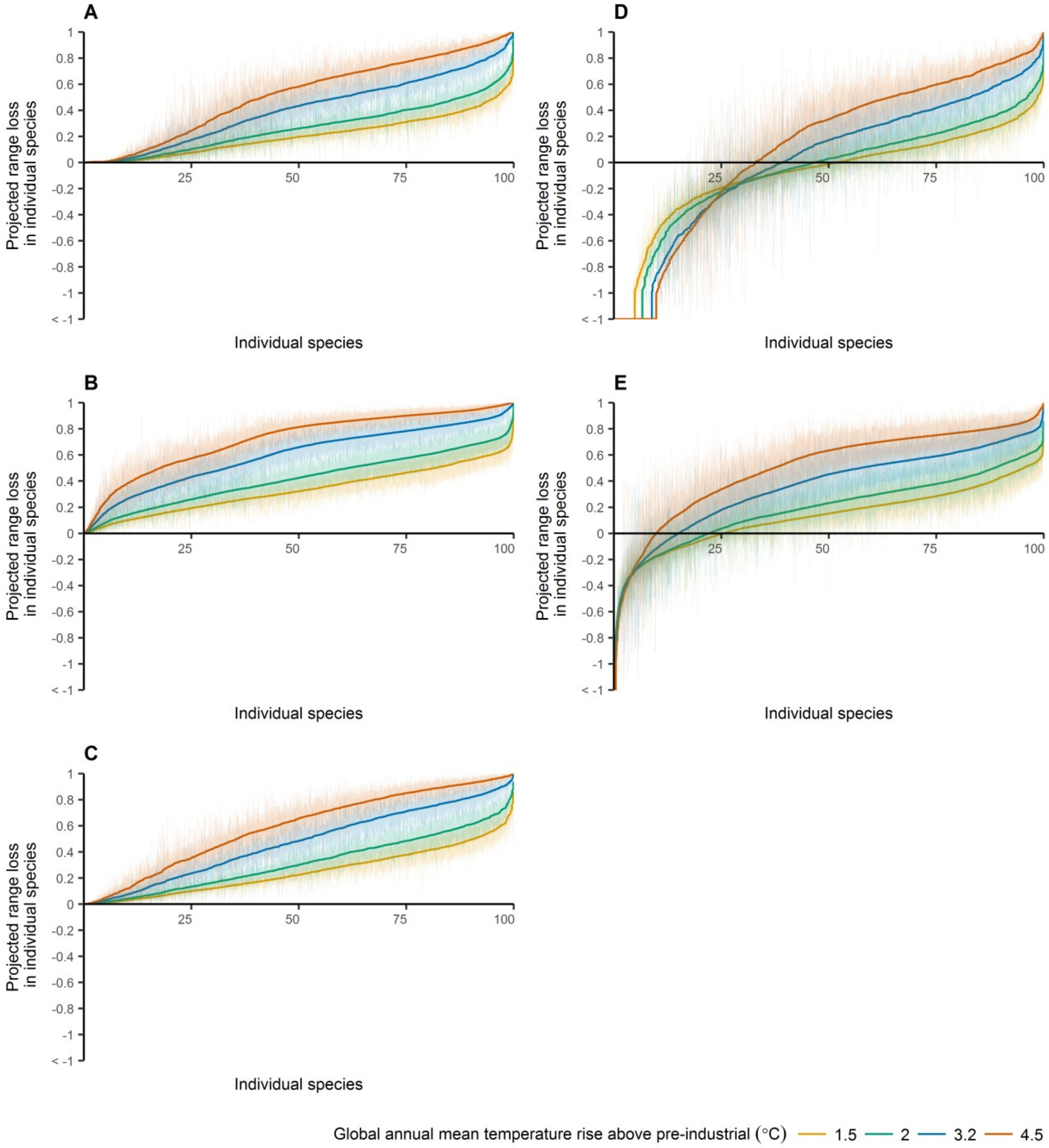
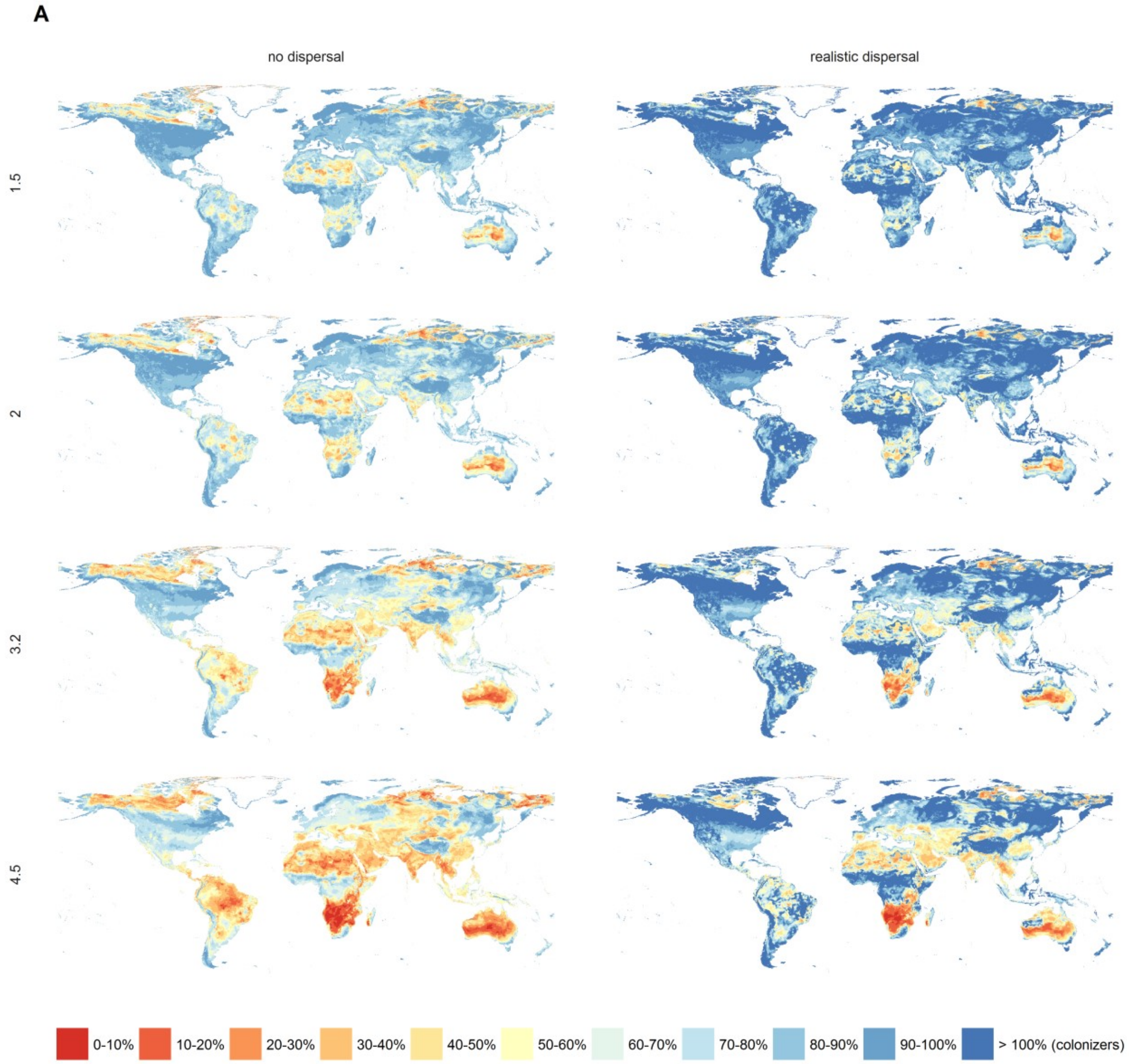
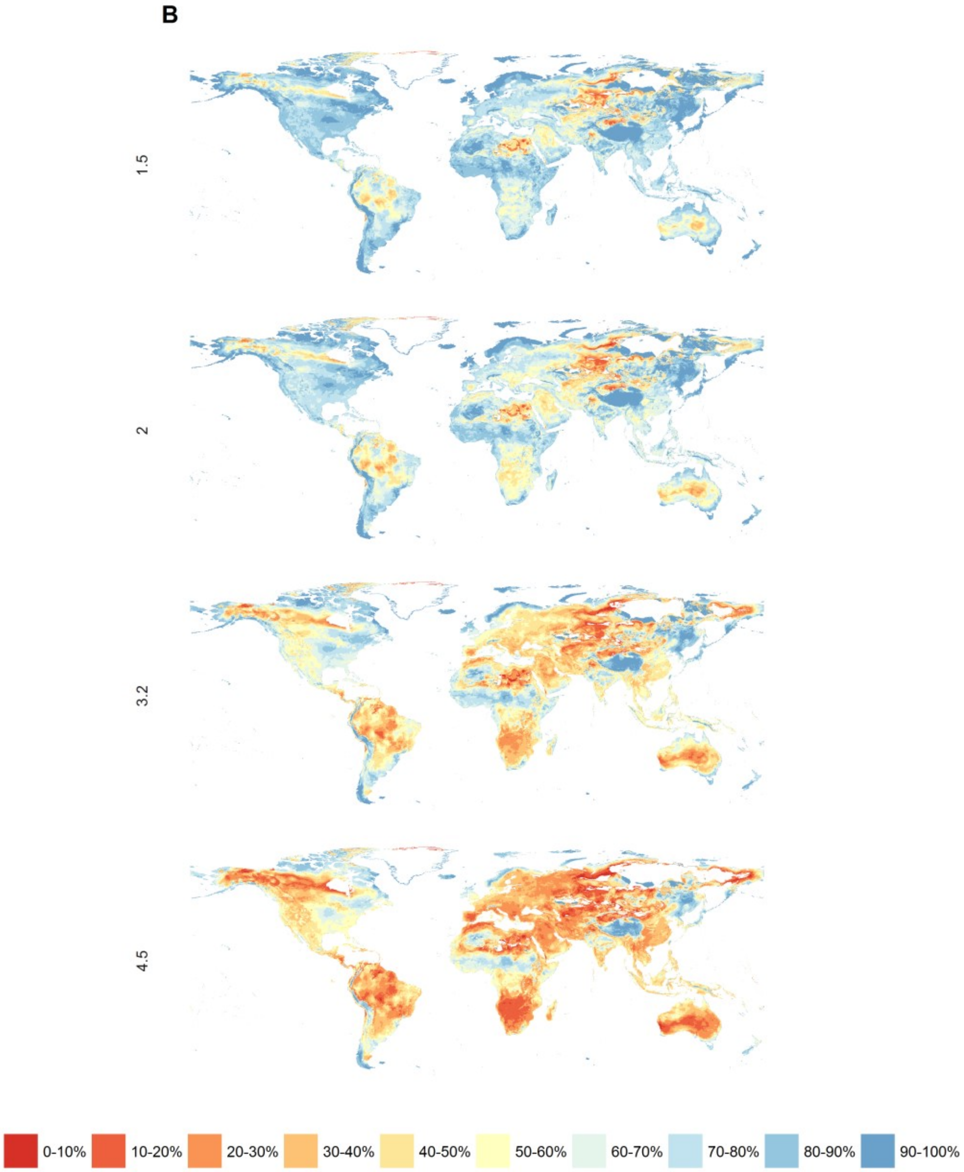

A
B
C
D
E
Projected range loss in individual species
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
< -1
25
50
75
100
Individual species
Global annual mean temperature rise above pre-industrial (°C)
1.5
2
3.2
4.5

Fig. S6. Projected species richness loss under future alternative climate change scenarios in which warming reaches 1.5, 2.0, 3.2 or 4.5°C above pre-industrial levels by 2100. Panels indicate results for proportion of species remaining for (**A**) Chordata (n=12640), with and without dispersal at realistic rates (**B**) Plantae (n=73224) (C) Insecta (n=31536).


A
no dispersal
realistic dispersal
1.5
2
3.2
4.5
0-10%
10-20%
20-30%
30-40%
40-50%
50-60%
60-70%
70-80%
80-90%
90-100%
> 100% (colonizers)


B
1.5
2
3.2
4.5
0-10%
10-20%
20-30%
30-40%
40-50%
50-60%
60-70%
70-80%
80-90%
90-100%

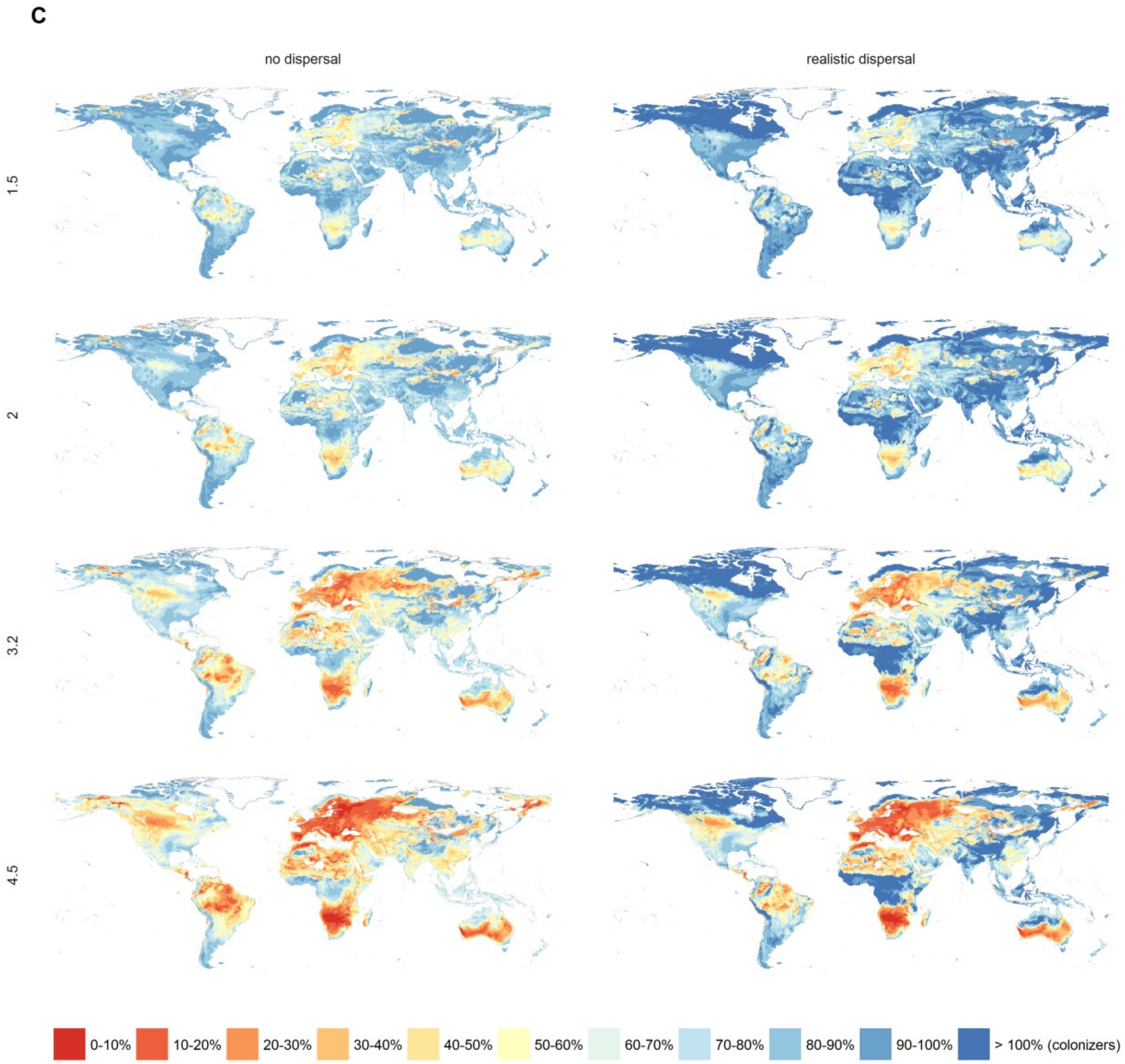

C
no dispersal
realistic dispersal
1.5
2
3.2
4.5
0-10%
10-20%
20-30%
30-40%
40-50%
50-60%
60-70%
70-80%
80-90%
90-100%
> 100% (colonizers)

Fig. S7. Projected proportion of terrestrial species losing more than half their range shown as a function of annual global mean temperature rise above pre-industrial levels.

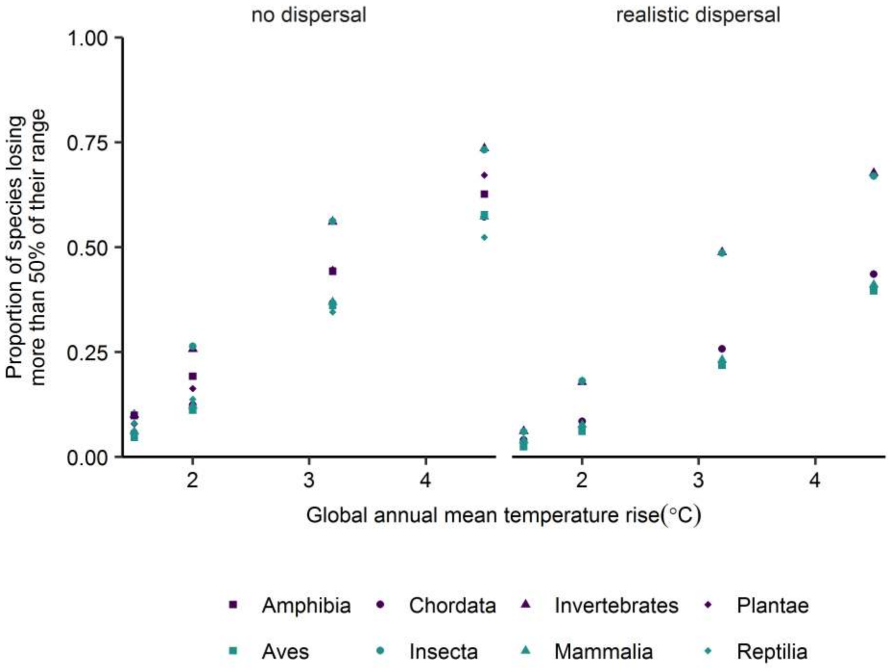

no dispersal
realistic dispersal
Proportion of species losing more than 50% of their range
1.00
0.75
0.50
0.25
0.00
2
3
4
Global annual mean temperature rise(°C)
■ Amphibia
● Chordata
▲ Invertebrates
◆ Plantae
■ Aves
● Insecta
▲ Mammalia
◆ Reptilia

Fig. S8. Projected integrated range loss within taxa as a function of annual global mean temperature rise above pre-industrial levels.

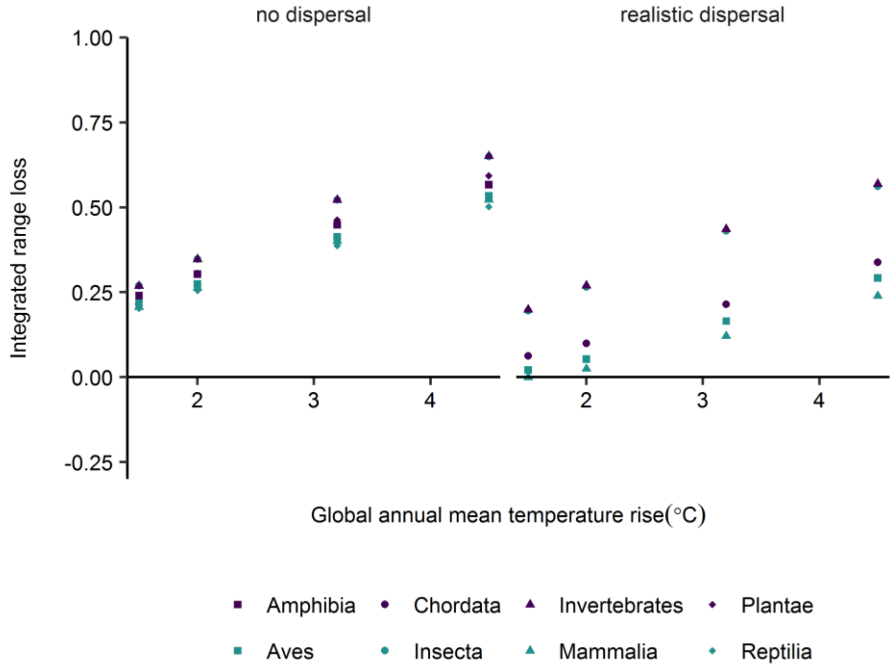

no dispersal
realistic dispersal
Integrated range loss
1.00
0.75
0.50
0.25
0.00
-0.25
2
3
4
2
3
4
Global annual mean temperature rise(°C)
■ Amphibia
● Chordata
▲ Invertebrates
◆ Plantae
■ Aves
● Insecta
▲ Mammalia
◆ Reptilia

Table S1. Sources of dispersal rates for Lepidoptera and Odonata

Taxonomic group	Lepidoptera	Odonata
Dispersal rate	3.0 km/yr (range 2.5-3.5)	3.0 km/yr
Citations	(*44–46*, *48*)	(*47*)

Table S2. Proportions of taxa projected to lose over 50% of their climatic range in 2100 under future alternative climate change scenarios in which warming reaches 1.5, 2.0, 3.2 or 4.5°C above pre-industrial levels by 2100 and species disperse at realistic rates to track their geographically shifting climate envelope. Data indicate the mean and 10-90% range across the alternative regional climate patterns explored.

Warming level (°C)	**Invertebrates** (%)	**Chordata** (%)	**Plantae** (%)	**Insecta** (%)	**Mammalia** (%)	**Aves** (%)	**Lepidoptera** (%)	**Odonata** (%)
1.5	6 (1-18)	4 (2-9)	8 (4-15)	6 (1-18)	4 (2-7)	2 (1-6)	4 (0-14)	1 (0-2)
2	18 (6-35)	8 (4-16)	16 (9-28)	18 (6-35)	8 (4-14)	6 (3-13)	10 (2-29)	2 (1-6)
3.2	49 (31-66)	26 (16-40)	44 (29-63)	49 (31-65)	23 (15-38)	22 (13-35)	38 (15-58)	10 (3-21)
4.5	68 (52-80)	44 (31-59)	67 (50-80)	67 (52-79)	41 (29-57)	4 (28-54)	58 (40-74)	21 (11-42)

Table S3. Total projected integrated range loss across in 2100 all species studied for various taxa under future alternative climate change scenarios in which warming reaches 1.5, 2.0, 3.2 or 4.5°C above pre-industrial levels by 2100 and species disperse at realistic rates to track their geographically shifting climate. Data indicate the mean and 10-90% range across the alternative regional climate patterns explored.

Warming level (°C)	**Invertebrates** (%)	**Chordata** (%)	**Plantae** (%)	**Insecta** (%)	**Mammalia** (%)	**Aves** (%)	**Lepidoptera** (%)	**Odonata** (%)
1.5	20 (11-29)	6 (-1-14)	24(18-30)	20 (11-28)	0 (-9-8)	2 (-6-10)	8 (-5-21)	-14 (-23--4)
2	27 (16-37)	10 (1-20)	30(23-38)	27 (16-37)	2 (-8-13)	5 (-5-15)	14 (-2-29)	-14 (-26--2)
3.2	44 (30-56)	21 (9-34)	46(36-57)	43 (30-55)	12 (-2-26)	16 (3-30)	28 (9-45)	-11 (-29-7)
4.5	57 (43-69)	34 (20-48)	59(48-70)	56 (43-68)	24 (7-40)	29 (14-44)	41 (21-59)	-2 (-24-20)

Table S4. Proportions of taxa projected to lose over 50% of their climatic range in 2100 under future alternative climate change scenarios in which warming reaches 1.5, 2.0, 3.2 or 4.5°C above pre-industrial levels by 2100 and the potential for species to disperse geographically to track their shifting climate envelope is excluded. Data indicate the mean and 10-90% range across the alternative regional climate patterns explored.

Warming level (°C)	**Invertebrata** (%)	**Chodata** (%)	**Plantae** (%)	**Insecta** (%)	**Mammalia** (%)	**Aves** (%)	**Reptilia** (%)	**Amphibia** (%)
1.5	10 (3-23)	6 (3-12)	8 (4-15)	10 (3-24)	6 (4-11)	5 (2-10)	8 (5-14)	10 (5-20)
2	26 (11-41)	12 (7-22)	16 (9-28)	26 (11-42)	12 (7-21)	11 (6-20)	14 (8-24)	19 (11-33)
3.2	56 (41-71)	37 (24-53)	45 (30-63)	56 (42-71)	37 (23-53)	36 (23-51)	35 (23-52)	44 (29-62)
4.5	74 (59-84)	57 (44-71)	67 (51-81)	73 (59-83)	57 (43-70)	58 (45-71)	52 (39-68)	63 (47-76)

Warming level (°C)	**Coleoptera** (%)	**Diptera** (%)	**Hymenoptera** (%)	**Lepidoptera** (%)	**Odonata** (%)	**Trichoptera** (%)	**Hemiptera** (%)	**Arachnida** (%)
1.5	10 (2-30)	12 (3-29)	5 (2-11)	16 (5-31)	2 (1-6)	3 (0-9)	9 (3-23)	8 (4-15)
2	33 (11-51)	29 (12-50)	13 (6-23)	33 (17-48)	7 (2-13)	11 (3-21)	29 (9-47)	17 (7-32)
3.2	63 (50-75)	68 (46-83)	38 (26-54)	62 (49-75)	24 (15-43)	38 (24-57)	62 (46-76)	54 (35-74)
4.5	75 (64-83)	88 (70-94)	59 (44-72)	78 (64-87)	46 (30-63)	60 (41-77)	77 (65-86)	77 (59-90)

Table S5. Total projected integrated range loss across all species studied for various taxa under future alternative climate change scenarios in which warming reaches 1.5, 2.0, 3.2 or 4.5°C above pre-industrial levels by 2100 and the potential for species to disperse geographically to track their shifting climate envelope is excluded. Data indicate the mean and 10-90% range across the alternative regional climate patterns explored.

Warming level (°C)	**Invertebrates** (%)	**Chordata** (%)	**Plantae** (%)	**Insecta** (%)	**Mammalia** (%)	**Aves** (%)	**Reptilia** (%)	**Amphibia** (%)
1.5	27 (19-34)	22 (16-27)	24 (18-30)	27 (20-34)	21 (16-26)	22 (17-27)	20 (15-27)	24 (17-31)
2	35 (26-44)	27 (21-34)	31 (23-39)	35 (26-44)	26 (20-33)	27 (22-34)	26 (19-33)	30 (22-39)
3.2	52 (41-62)	41 (33-50)	46 (36-57)	52 (41-62)	40 (32-49)	41 (33-50)	39 (29-49)	45 (35-56)
4.5	65 (55-75)	53 (44-63)	59 (49-70)	65 (55-74)	52 (43-62)	53 (44-63)	50 (39-62)	57 (45-68)

Warming level (°C)	**Coleoptera** (%)	**Diptera** (%)	**Hymenoptera** (%)	**Lepidoptera** (%)	**Odonata** (%)	**Trichoptera** (%)	**Hemiptera** (%)	**Arachnida** (%)
1.5	28 (21-36)	30 (22-39)	20 (15-26)	31 (23-38)	15 (10-20)	20 (13-26)	28 (20-35)	26 (18-34)
2	37 (27-47)	39 (29-49)	27 (20-34)	39 (30-48)	20 (14-27)	26 (18-34)	36 (27-46)	34 (24-43)
3.2	55 (44-66)	59 (46-70)	42 (32-51)	56 (46-66)	33 (23-43)	42 (31-54)	56 (44-66)	52 (40-63)
4.5	68 (58-76)	73 (62-83)	54 (44-64)	68 (58-77)	44 (33-56)	56 (43-68)	69 (59-78)	67 (55-78)

Table S6. Proportions of taxa projected to gain over 50% of their climatic range in 2100 under future alternative climate change scenarios in which warming reaches 1.5, 2.0, 3.2 or 4.5°C above pre-industrial levels by 2100 and species disperse at realistic rates to track their geographically shifting climate.

Warming Level (°C)	**Invertebrates** (%)	**Chordata** (%)	**Insecta** (%)	**Mammalia** (%)	**Aves** (%)	**Lepidoptera** (%)	**Odonata** (%)
1.5	1 (2-1)	4 (6-2)	1 (2-1)	7 (10-5)	4 (7-3)	4 (6-2)	11 (14-7)
2	1 (2-1)	5 (8-3)	1 (2-1)	9 (13-6)	6 (10-3)	4 (8-3)	14 (20-10)
3.2	2 (3-1)	6 (10-4)	2 (3-1)	11 (17-8)	7 (12-4)	5 (9-3)	21 (31-15)
4.5	2 (3-1)	6 (9-4)	2 (3-1)	12 (18-8)	6 (11-4)	5 (10-3)	21 (32-14)