

Predictors of bumblebee species richness in North America

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Introduction

- Bumblebees serve an important ecological niche as insect pollinators, whose numbers are currently in global decline
- The objective of this study is to show evidence that present shifts in the North American bumblebee population have occurred where both climate changes and intrinsic differences between species play a role
- Past research had shown minimum annual temperature to be the strongest predictor of widespread species richness¹
- The study observes 35 bumblebee species and their related environment throughout two periods, 1901-1974 and 1975-2010
- Decrease in the range of a given species correlates positively with a rise in annual mean temperature and the extent of the species' range

Methodology

- Data was collected from WorldClim and in-lab geographical information systems (GIS) throughout 1901-1974 (period 1) and 1975-2010 (period 2)
- Raster layers were overlaid using ArcGIS, yielding a total of 14547 quadrats covering North America (each 100km x 100km in area) containing 35 bumblebee species presence/absence and environmental data
- From a list of 19 bioclimatic variables derived from monthly temperature and rainfall values, six were chosen to evaluate best fit with species presence. Quadratic fit was used in place of linear as the AIC and R₂ were constantly higher
- The variable with the best fit was used to model change in species range
- Species were sorted into 4 quartiles from least to most wide-ranged

Results

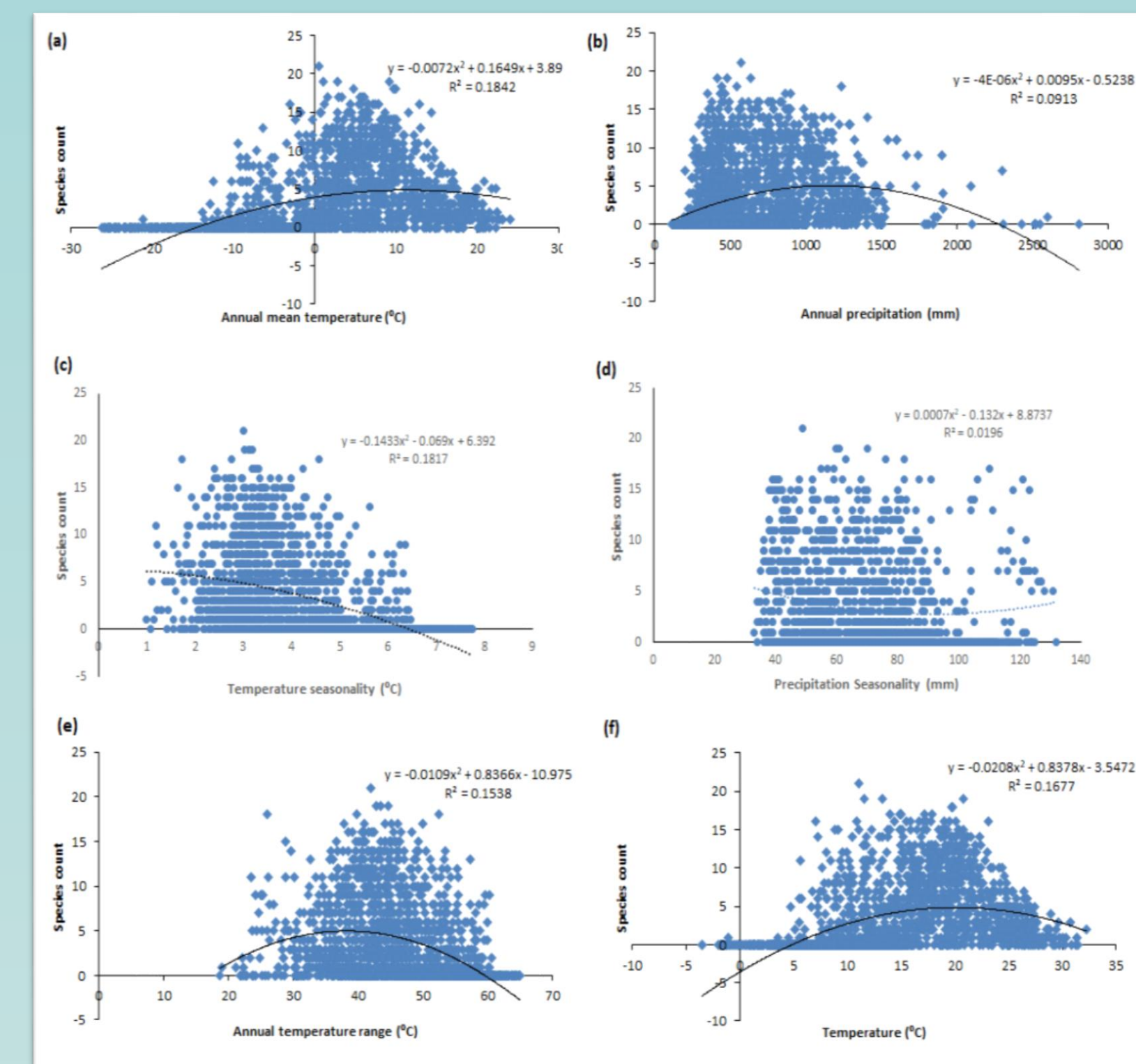


Figure 1. (a) Annual mean temperature vs. species count (b) Annual precipitation vs. species count (c) Temperature seasonality vs. species count (d) Precipitation seasonality vs. species count (e) Annual temperature range vs. species count (f) Maximum temperature during warmest period vs. species count. 14547 quadrats in North America were sampled for period 1.

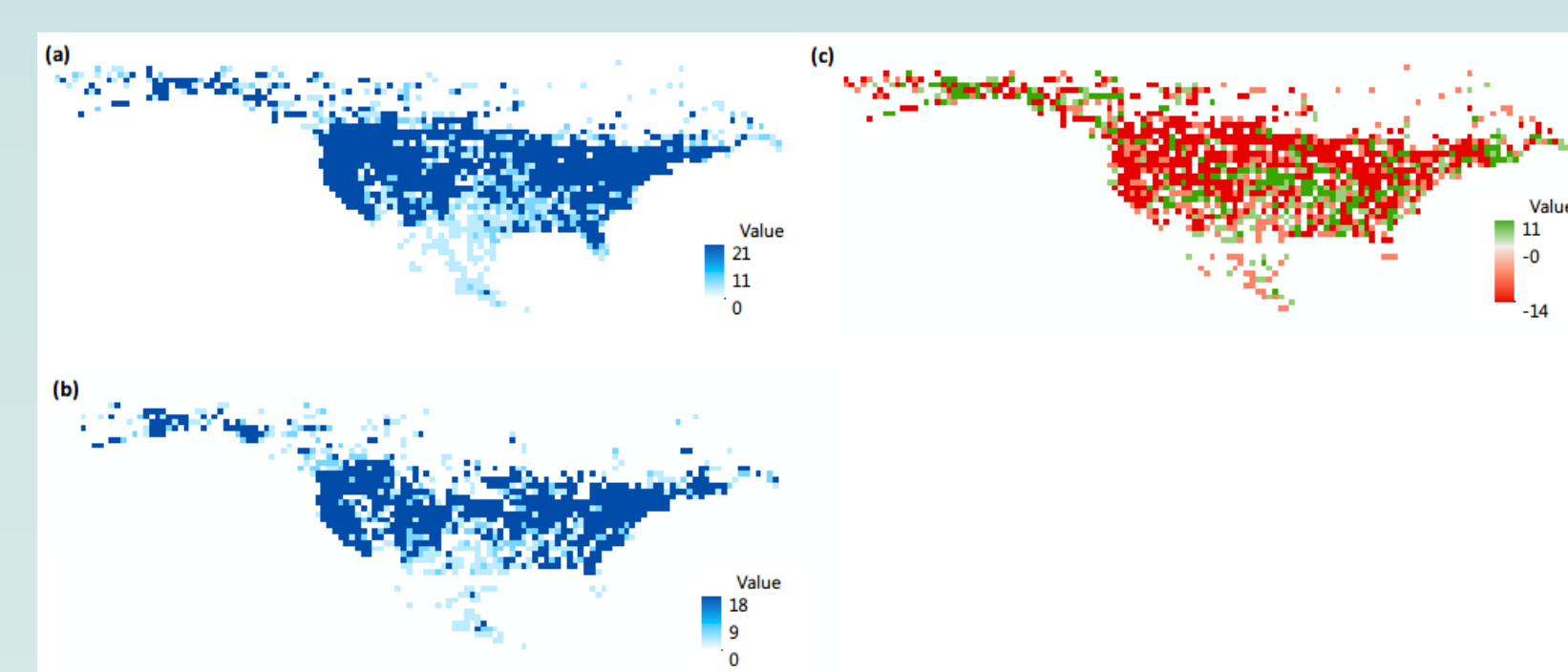


Figure 2. (a) Species count in period 1 (b) Species count in period 2 (c) Change in species count in between two periods. 14547 quadrats were sampled for periods 1 and 2.

Figure 3. Mean annual temperature across North America (a) in period 1 (b) in period 2 (c) change in between periods. 14547 quadrats were sampled.

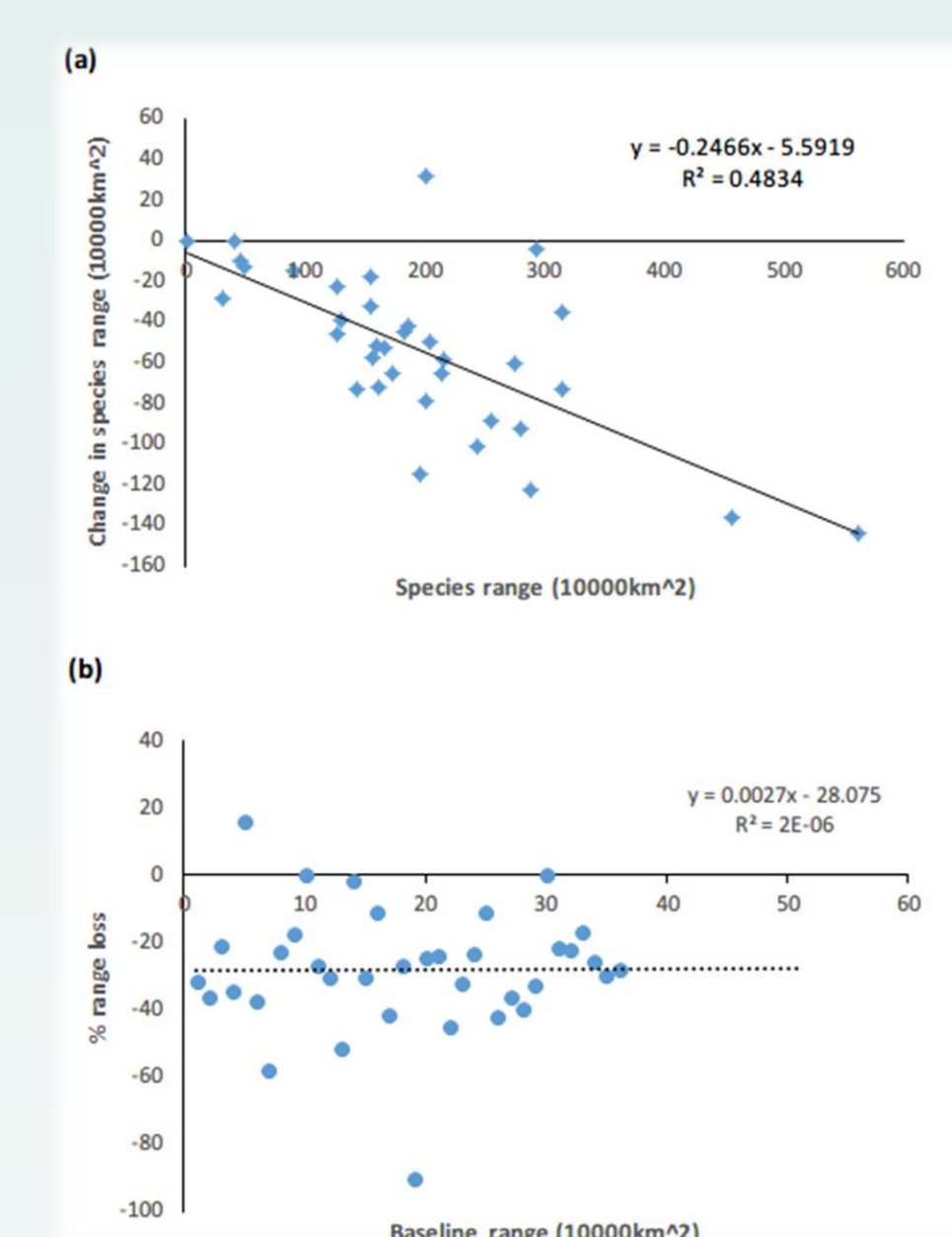
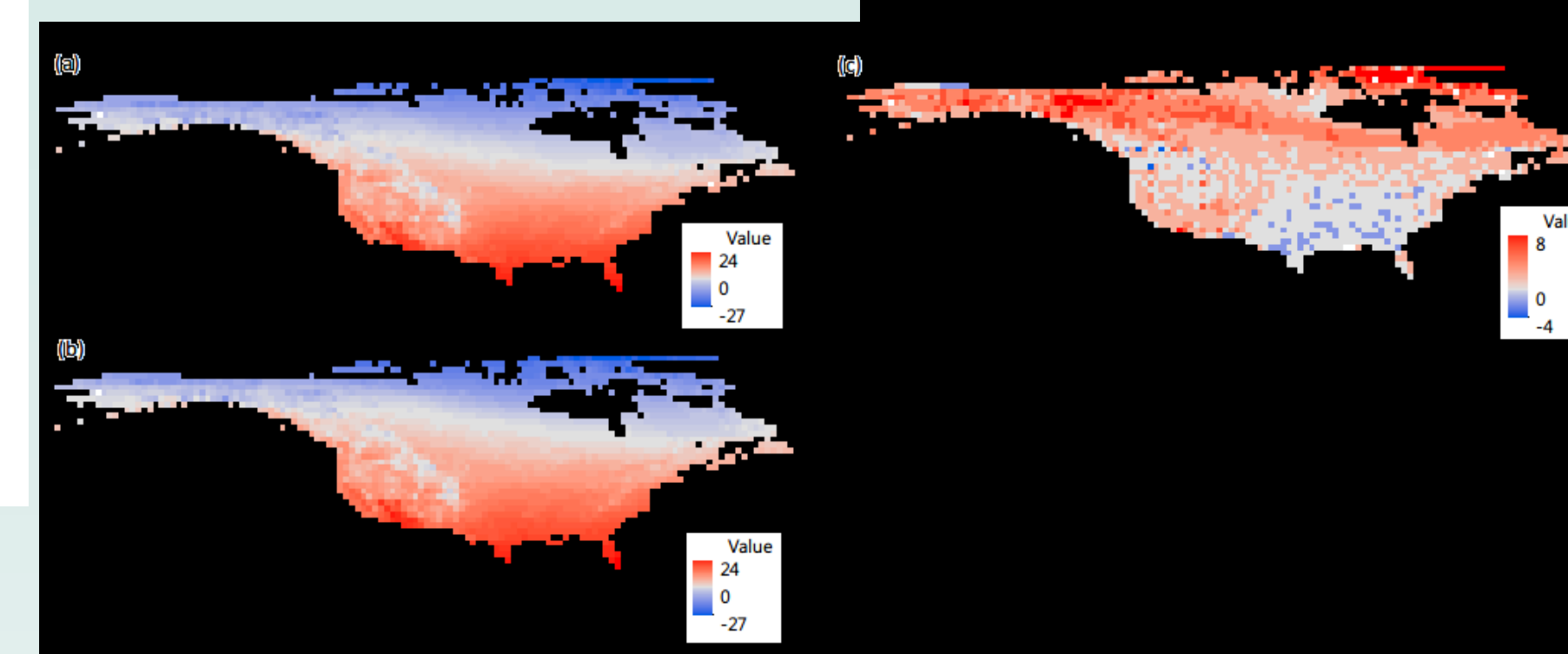


Figure 5. (a) Absolute change in species range (b) Relative change in species range, graphed against species range in period 1 14547 quadrats in North America were sampled for periods 1 and 2.

	Period 1	Period 2	Difference	P-value (α<0.05)
Mean annual temperature, North America (°C)	0.96	1.30	0.34	0.20
Mean annual temperature, bumblebee range only (°C)	6.38	6.27	-0.11	0.75
Mean species range (10000km ²)	174.55	126.45	-48.10	2.61262E-09

Figure 4. Comparison of temperature and species range between two time periods. 14547 quadrats were sampled for periods 1 and 2.



It is possible to model range change from period 1 to 2 as a function of temperature change and species range:

$$RC = -1.4763 * T - 20.2581 * Q - 1.1092$$

RC = Range change (in 10000km²)

T = Mean annual temperature change

Q = Range quartile (from 1-4, with 4 being widest ranged)

Conclusion

- Bumblebee species presence in North America appears to fit most tightly with annual mean temperature, however, the correlation is weaker than expected (R₂=0.1842); species count peaks at around 6-7 degrees Celsius
- Bumblebee range has on average declined by 481000 km², or 27% of their original range
- Among the 35 species, wide-ranged ones also experience greater absolute decline in range in response to climate change; however in terms of percentage decline, all species performed about equally
- While wide-ranged species appear to have more "protection" against extinction and require less immediate attention, they are just as subject to similar pressures as the narrow ones are
- Absolute change in bumblebee range can be modelled as a function of mean annual temperature change and prior species range (R₂=0.32).
- Mean annual temperature in North America has risen about 0.34 degrees Celsius from 1901-1974 to the 1975-2010 period; however, when only areas of bumblebee presence were counted, there is actually a -0.11 degree decrease despite bumblebee range shrinking. Neither results were statistically significant
- Nevertheless, areas of temperature rise roughly corresponded to areas of decrease in species count especially in the higher latitudes. Also, other factors including land use were left out of this analysis. Overall, further investigation may be necessary to clarify the role of temperature change.

Acknowledgements

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References

'Szabo*, N., Algar*, A. C., and J. T. Kerr. 2009. Reconciling topographic and climatic effects on widespread and range-restricted species richness. Global Ecology and Biogeography 18: 735-744.



Figure 6. Map of North America where the study is conducted.

