The response of Hymenopteran biodiversity to major drivers of change is highly variable at the global scale

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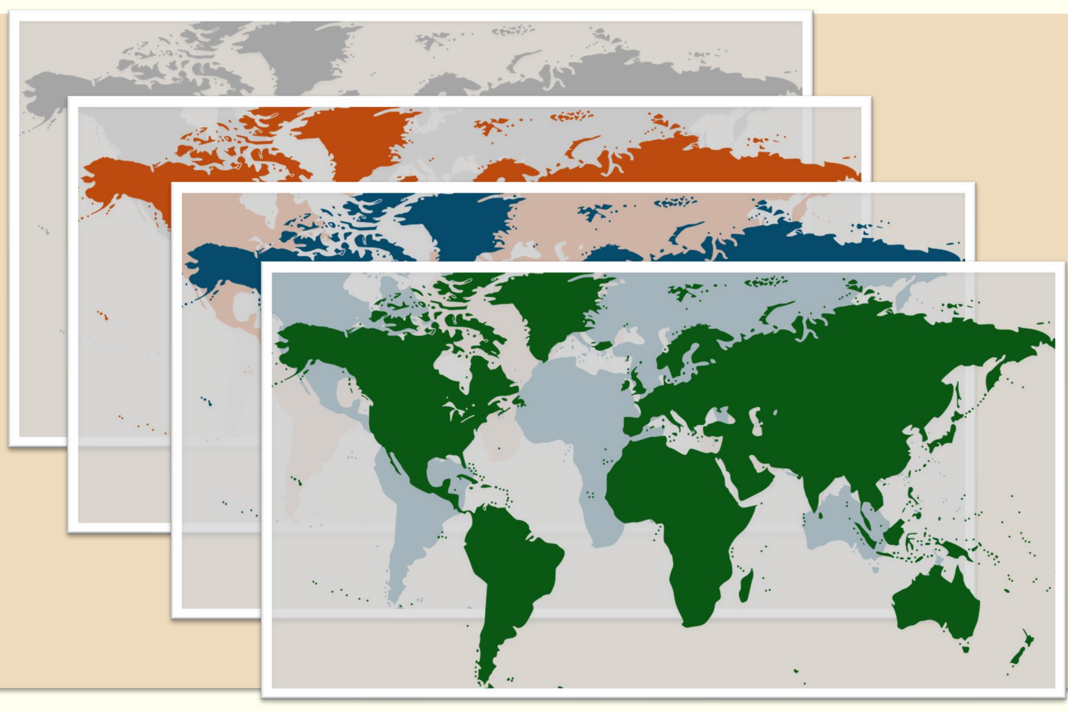
The response of bees, wasps and ants to key threats are currently unknown at the global scale.

The group Hymenoptera includes the bees, wasps, and ants and is a hugely important group of insects. They pollinate, control crop pests, disperse seeds and manage soils. As with other insect groups, the Hymenoptera have been shown to be in decline in certain regions of the world. These declines are likely due to the range of pressures that humans place on the natural world including the use of pesticides, urbanisation, and climate change to name just a few.

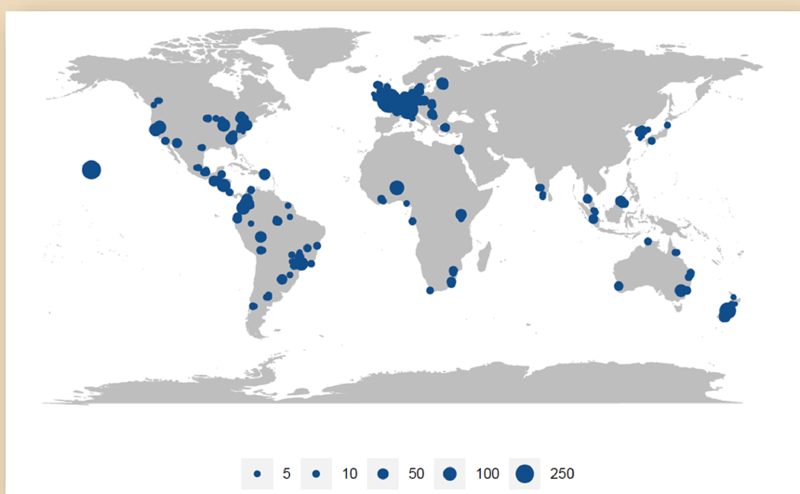
Although we know these drivers are a problem, we do not have a quantitative understanding of their impacts on Hymenopteran biodiversity at the global scale. This work, as part of the GLiTRS project (https://glitrs.ceh.ac.uk/), aims to address this knowledge gap. **Using data from the PREDICTS database, we carry out a space-for-time comparison of sites with varying levels of 13 drivers that represent the top 10 threats to Hymenoptera as identified by experts (Bladon *et al*, in prep) to determine the impact of these drivers on Hymenopteran abundance and richness.**

Figure 1: Schematic of data collation. We identified global datasets to represent the top 10 threats to Hymenopteran biodiversity and one "catch-all" map to represent human pressures we may have missed. This resulted in 13 maps. We then extracted this information for each of the sites for which we had data from the PREDICTS database. We were unable to find appropriate data for 2 of the threats (greyed out far right).



We used global maps representing key threats alongside abundance and richness data from PREDICTS to model biodiversity responses.

1. Identify the top 10 threats to Hymenoptera through an expert elicitation process (Bladon *et al.* in prep) using the IUCN second-order threat levels.
2. Collate one or more available global threat maps that could represent each of the top 10 threats.
3. Process the maps as needed (e.g. take an average across all pesticides) and extract threat information for each of the 5,943 sites in the PREDICTS data subset.
4. Run Bayesian GLMMs using the *brms* R package to assess the impacts of each of these threats on Hymenopteran total abundance and species richness. A separate model was run for each biodiversity metric.



Top 10 threats to Hymenopteran biodiversity

1. Annual and perennial non-timber crops
2. Agricultural and forestry effluents
3. Livestock farming and ranching
4. Extreme temperatures
5. Habitat shifting and alteration
6. Droughts
7. Invasive non-native/alien species/diseases
8. Logging and wood harvesting
9. Housing and urban areas
10. Commercial and industrial areas

Responses to the various threats were highly variable.

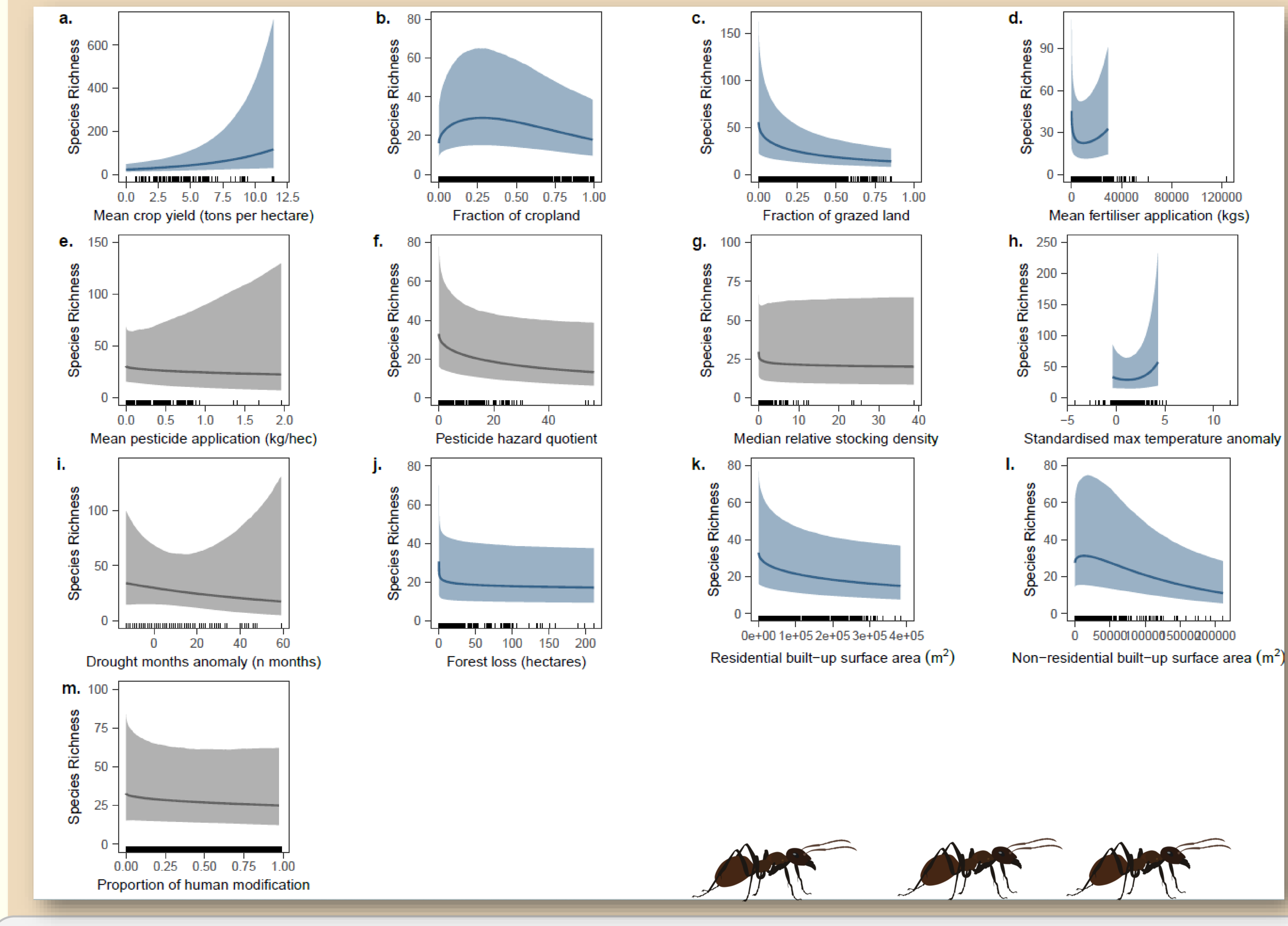


Figure 2: Plotted conditional effects of each modelled threat on Hymenopteran species richness. The shaded region represents the 95% credible interval. The rug plot at the base of each panel presents the values of that threat for each of the sites in the PREDICTS data subset. Grey lines and shaded regions are presented where CIs of the effect of the threat crossed zero.

- Negative effects were clear for fertiliser application, fraction of grazed land, and residential and non-residential built-up surface area.
- Non-linear effects were found for forest loss, proportion of human modification and fraction of cropland.

- Negative effects were clear for fraction of grazed land, forest loss, and residential and non-residential built-up area.
- Non-linear effects were found for fraction of cropland, fertiliser application, maximum temperatures and non-residential built-up surface area.

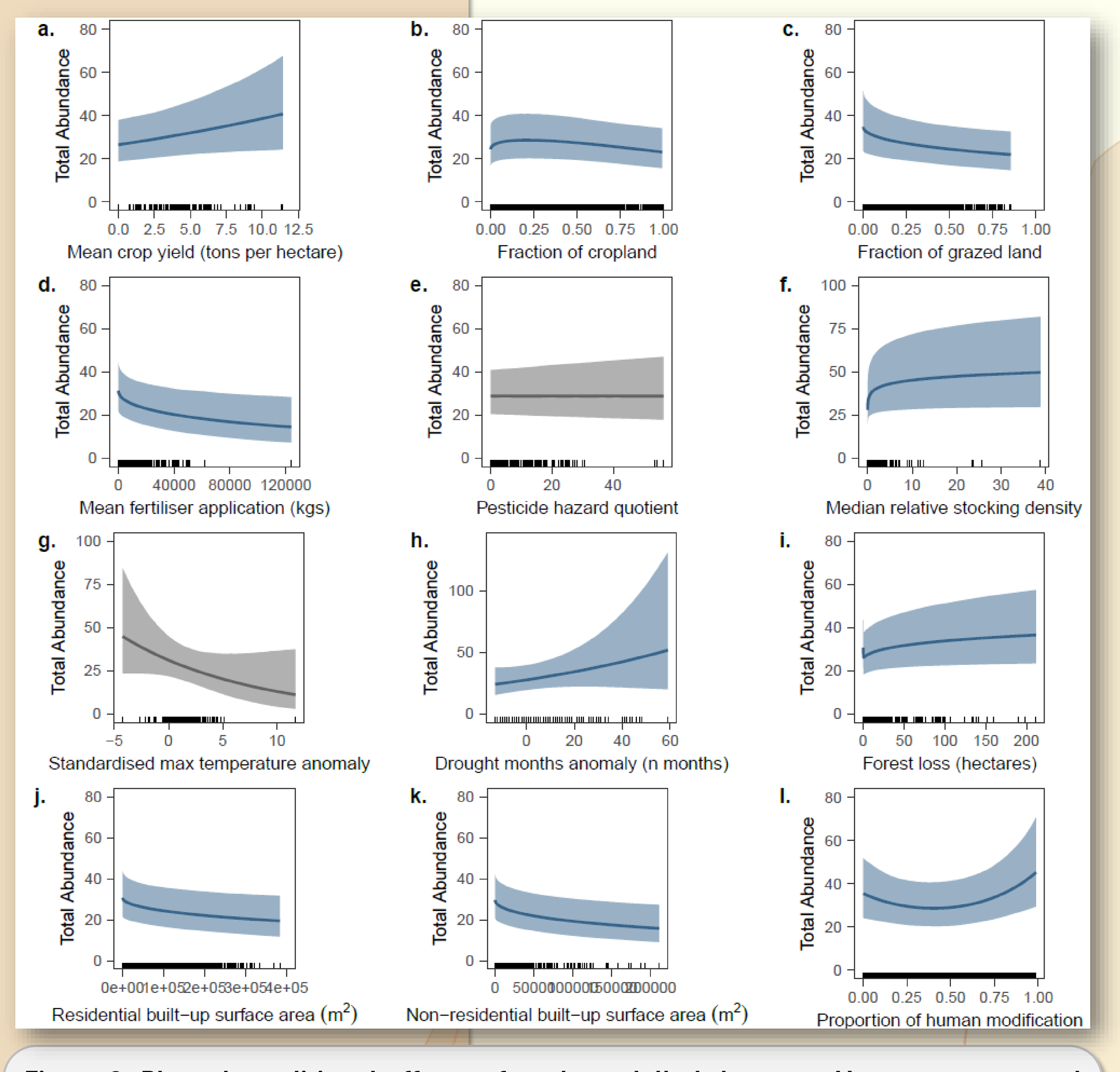


Figure 3: Plotted conditional effects of each modelled threat on Hymenopteran total abundance. The shaded region represents the 95% credible interval. The rug plot at the base of each panel presents the values of that threat for each of the sites in the PREDICTS data subset. Grey lines and shaded regions are presented where CIs of the effect of the threat crossed zero.

There is still more to be done!

1. Separate out the data for bees, wasps and ants and determine whether responses to these threats differ by taxonomic group.
2. Expand the analysis to assess other insect Orders including Lepidoptera (butterflies and moths), Coleoptera (beetles), Hemiptera (true bugs), Diptera (the flies) and others where data are available.
3. Expand the selection of threats assessed to include more than just the top 10. Threats not currently covered here include fire and fire suppression, storms and flooding, wood and pulp plantations, airborne pollutants, roads and railroads, excess energy and others.

The fraction of grazed land, fertiliser application and amount of built-up area showed consistent negative impacts on Hymenopteran biodiversity.

Not all threats resulted in a negative responses, this may be a result of a mismatch between data resolutions.

References

Bladon *et al* (in prep) What's driving insect decline? A comparison of methods to identify and prioritise threats in a data deficient and hyper-diverse taxon.

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