Species distribution models predict species ranges well, but fail to predict impacts of climate change.

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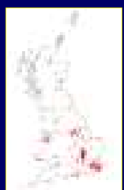
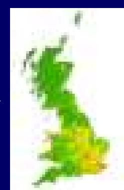
1. Introduction

Species distribution models relate records of species occurrence to environmental variables (climate, topography, habitats, vegetation etc.) to predict the distributions of species.



Species Occurrence Data

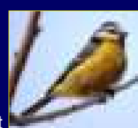
+ Environmental Data



Predicted Probability of Occurrence

They can be used to predict the effect that climate change will have on species distributions. Thomas et al. (2004) used this technique to predict that as many as half of the world's species would become extinct as a result of climate change.

Front page news in *The Guardian* newspaper on January 8th 2004.



Blue tit

However, there are number of complications in predicting future distributions: 1) uncertainty over exactly how the climate will change; 2) unknown dispersal abilities of species; 3) interactions between species; 4) potential for adaptive responses to climate change

It is difficult to assess the accuracy of the models, because the events which they are predicting have not yet happened.

One solution is to predict changes that have already occurred (Araujo et al., 2005). In this study we aimed to provide a rigorous test of distribution predictions using extensive time series data on distributions and abundances of hoverfly and bird species in Britain.

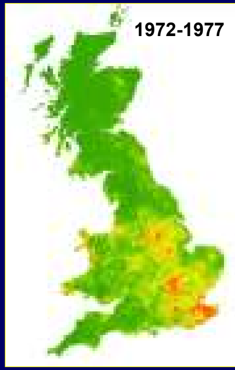
2. Methods

We used occurrence data for British bird and hoverfly species from 1968 to 2002, divided into four and five-year time periods respectively.

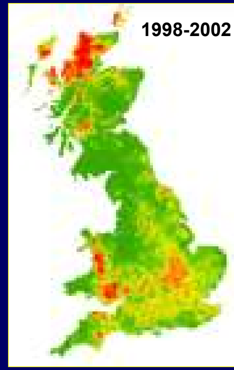
Initial models were built for every species in every time period using generalized linear models (GLMs) and a special distribution modelling technique (Maxent). Accuracy was tested by estimating the area under the Receiver Operating Characteristic curve (AUC).

The ROC curve is a plot of the proportion of true positives (presences) against the proportion of false negatives (absences) for a range of model threshold values. An AUC of 1 indicates a perfect model, while and AUC of 0.5 indicates that a model is no better than random.

These models were projected onto every other time period in line with known changes in the climate. Accuracy was tested using nationwide data from the relevant time period and also independent abundance data from a single location.



Projected future distribution of *Episyrphus balteatus*



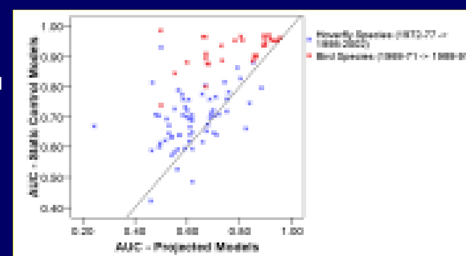
For comparison, models that were not projected in line with climate change (static control models) were tested against the same data.

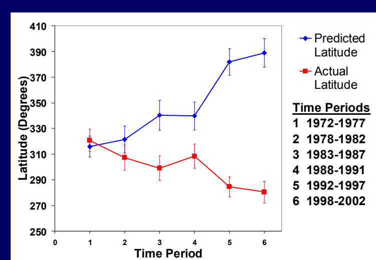
3. Results

Initial models predicted current distributions very well (mean AUCs 0.830 to 0.908). Predicted probabilities of occurrence showed a strong relationship with recorded abundance in an independent time series (GLMs with negative binomial errors: $p \leq 0.007$).

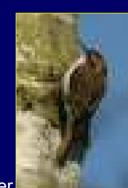
Static control (non-projected) models predicted distributions significantly better than models projected in line with known climate change, as measured using AUC (Wilcoxon matched pairs: $Z \geq 2.29$, $p \leq 0.022$). Predicted probabilities of occurrence by static control models explained a greater proportion of variance in abundance values than those for projected models.

Comparison between the accuracy of projected models (accounting for known climate changes) and of static control models (not accounting for climate changes) of hoverfly and bird species for one combination of time periods. Points represent species. The y=x line is shown for reference.





Predicted and observed average latitudinal range centroids of hoverfly species distributions over the six time periods used in the study.



Treecreeper

4. Discussion

The models predicted current distributions and abundances very well. This suggests that such predictions are very useful tools for conservation.

However, projections of future distributions that attempted to account for climate change were relatively poor.

Species may show a lag in their response to climate change owing to dispersal limitations, or they may adapt to new environments by evolution or phenotypic plasticity.

Alternatively, ranges may shift but other factors, such as interactions between species or habitat changes, may make shifts unpredictable by simple climatic models.

These results are of great importance for conservation biology because species distribution models are used to infer extinction risks and to assess the adequacy of protected areas in conserving biodiversity under the impact of climate change.

5. References

Araujo M.B., Pearson R.G., Thuiller W., Erhard, M. 2005. Validation of species–climate impact models under climate change. *Global Change Biology* 11: 1504-1513.

Thomas C.D. et al. 2004. Extinction risk from climate change. *Nature* 427: 145-148.

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