Update on climate change indicator research

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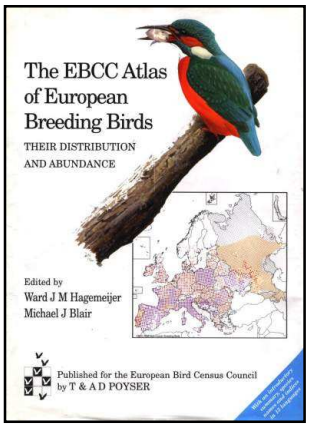
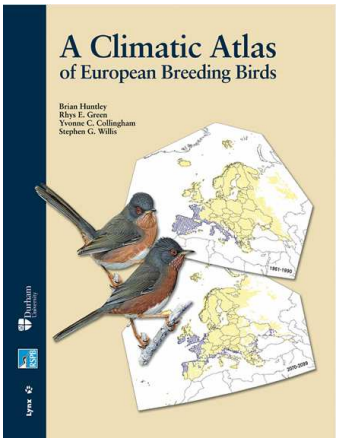
The starting point is the EBCC's Atlas and the climate envelope models fitted to distribution data for European breeding birds

Bird distributions mapped in late 1980s -- 50-km UTM squares -- presence & absence of species



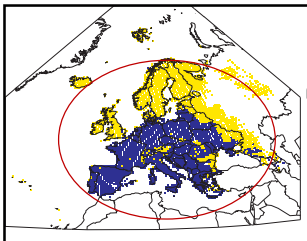
Based on the bioclimatic envelope models for each bird species, Brian Huntley *et al.*, have published the first 'Climatic Atlas' of its kind for any taxa



The Climatic Atlas used 3 bioclimate variables to model European bird distributions:

1. **'MTCO'** Mean temperature of the coldest month
2. **'GDD5'** Annual temperature sum above 5 degrees C
3. **'AET/PET'** Ratio of actual to potential evapo-transpiration

The models provided a good fit to our data (area under the curve – AUC – of a receiver operating characteristic – ROC – plot; mean AUC of the 122 species = 0.967; lowest value = 0.907).



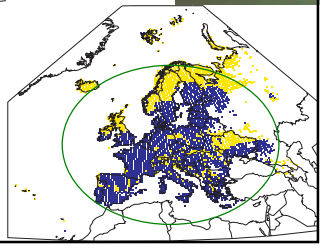
Bioclimate envelope model

Present simulated range ~1961-1990

Serin *Serinus serinus*

Future 'potential' range under a modelled climatic change scenario:

HadCM3 B2 for ~2070-2099



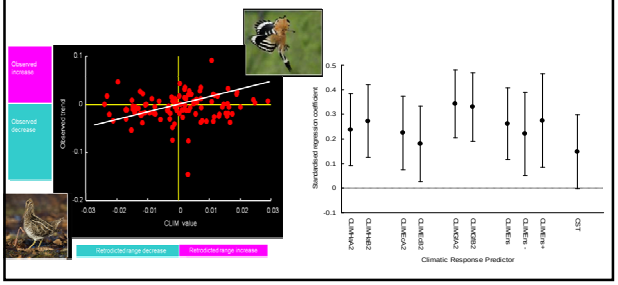
The projections describe how bird species might respond to projected climatic warming in Europe

'CLIM' value for a species is the $\log_e$ of the ratio of the extent of the future potential range to that of the recent simulated range

CLIM >0 predicts range expansion, CLIM <0 predicts range contraction

Our previous work, Gregory *et al.* (2009) PLoS ONE 4(3): e4678. doi:10.1371/journal.pone.0004678

Showed projections of change in the extent of species' geographical range (termed 'CLIM') correlated positively with observed interspecific variation in European population trends



To create a Climatic Change Indicator

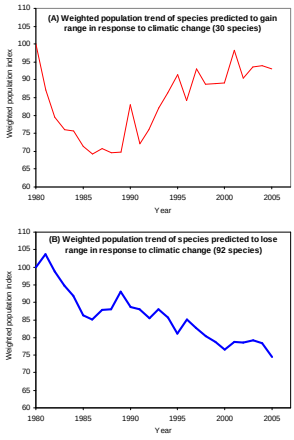
Divided species into those projected to increase in potential geographical range (CLIM+) & those projected to decrease (CLIM-)

For each of the two groups, we calculated a multi-species population index (geometric mean) from population indices of individual species weighted by the absolute value of CLIM for each species

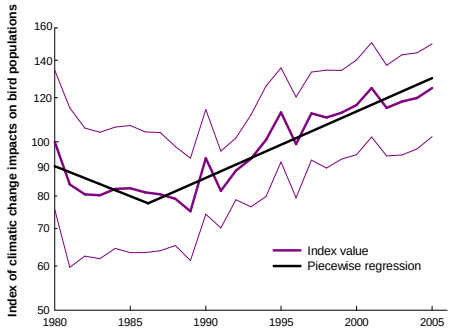
Extreme CLIM values for species (+ve or –ve) have greater influence on the line

Multi-species population indices for both groups of birds declined in the 1980s, but from the latter part of that decade, the CLIM+ index (**30 species**) increased, whilst CLIM- index (**92 species**) continued to decline

Ratio 1:3



Climatic Impact Indicator is calculated in a given year as the ratio of the index for CLIM+ species to that for CLIM- species. It declined slightly in the 1980s but has increased roughly linearly



These are European-scale projections based on climate envelope models & future modelled climate scenarios

We can look at this in another way and at a different spatial scale

We can use the climate envelope models now to look at how climate suitability has changed in recent decades where we have both observational data on trends in bird numbers & climate

Charlotte Bellamy's MSc at Durham University

Climate Suitability Trends

- Fitted a bioclimate envelope model to the European atlas data for each species (supplemented with information on ranges in North Africa, Turkey and Cyprus) using the 3 bioclimate variables. Data fitted to the 30-year period 1960-1990 (CRU TS 3.1). We have used Climatic Response Surface (CRS), GAMs & MaxEnt models; all the results here come from CRS models.
- We have included in the analysis all the PECBMS countries with their permission with >9 years of data – 19 countries.
- We use the model fitted to the 30-year bioclimatic data and apply this to the annual bioclimate data (from the same CRU dataset) to simulate climate suitability for each species in each 50-km cell in a country for the period we have species' trends. Calculate probability of occurrence.
- Then for each species in each year in each country, we regressed logit probability of occurrence against year & take the linear regression slope as the 'Climate Suitability Trend '(CST) for that species.

Climate Suitability Trends

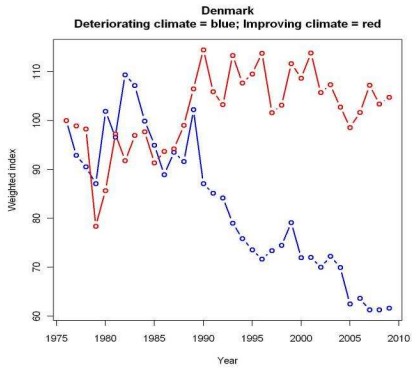
- On that basis, we divide species in each country into CST+ & CST- species

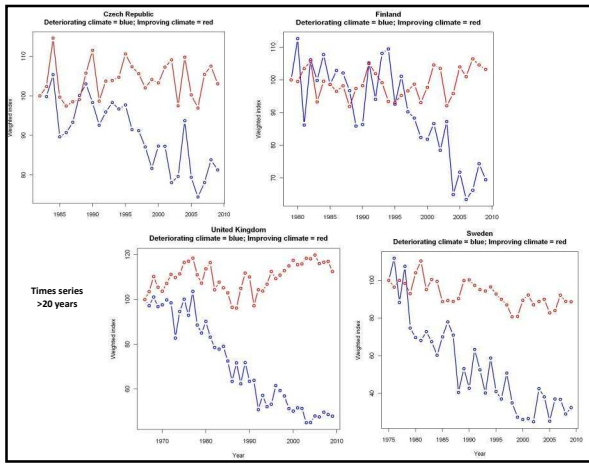
For CST+ species the climate suitability in that country is predicted to have improved in that time period

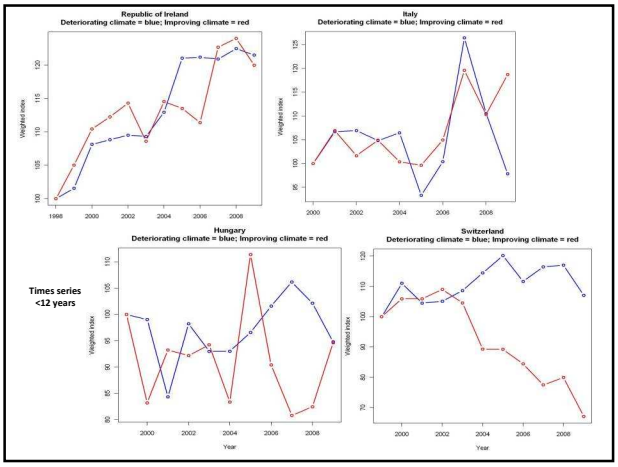
For CST- species the climate suitability in that country is predicted to have deteriorated in that time period

- For the two groups of species (CST+ & CST-), we calculate a geometric mean of their species indices with the index for each species weighted by its absolute value of CST
- If climatic change was driving bird population trends in the manner predicted by our bioclimate models, we would expect CST+ indices to increase & CST- indices to decline

Weighted multispecies population indices for CST- (blue) and CST- (red) species







What do the CST indices tell us?

- For shorter runs of data (<12 years) little pattern, but for longer runs (>20 years) there is a clear signal at a national level that bird population trends are responding to climatic change as predicted
- But we don't know how strong that effect is compared to other known drivers (habitat change, migratory behaviour, predation, disease etc)
- Yet the climate signal is strong

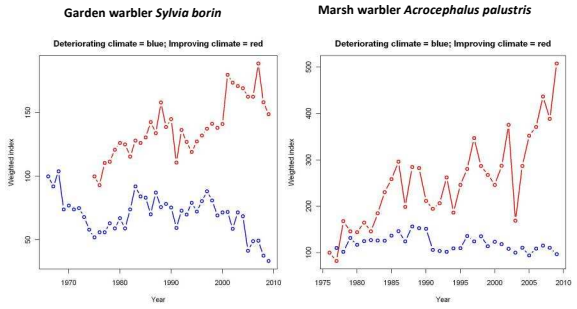
We can go further to look at species patterns in CST…

- Take trends from all those countries where species *X* is predicted to be experiencing an improving climate (CST+) & all those trends from countries where species *X* is experiencing a deteriorating climate (CST-). Set a minimum of four countries in each case.
- For each of the two groups (CST+ & CST-), we calculate a geometric mean of the species indices with the index for each country weighted by its absolute value of CST for that species

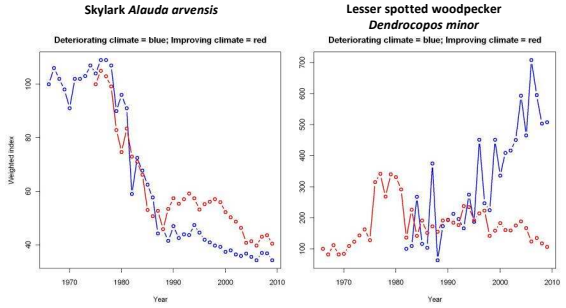
CST+ = composite species' population trend from countries where the climate suitability is predicted to have improved in that time period

CST- = composite species' population trend from countries where the climate suitability is predicted to have deteriorated in that time period

Within-species patterns of CST ☺



Within-species patterns of CST ☹



Next steps

1. Finalising & checking the analyses
2. Undertake analyses of trends in light of other factors (habitat choice, migratory behaviour etc)
3. Intention to produce a draft paper in the coming months
4. More work planned in the summer - to create new climatic change indicators (?)
5. We will keep you posted!

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