How Do Bird Populations Vary Across Britain? Spatially-explicit Integrated Population Models


Starling, *Sturnus vulgaris.*

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1. Motivation

In the UK, many wildlife species are currently in decline. An example is the Starling, *Sturnus vulgaris,* a species on the UK Red List – of highest conservation priority (Figure 1).

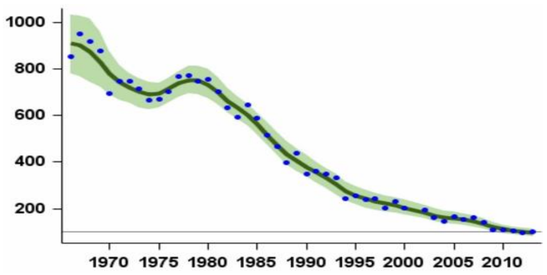


Figure 1
Starling Population, 1966-2010.

Such declines can be explained by changes in vital rates, such as annual survival probability and productivity (breeding success).

Integrated Population Models (IPMs) combine different types of data into one analysis and provide the only reliable means for estimating these vital rates for a species across a population[1,2].

Our aim is to provide a mechanistic explanation of the observed population declines at finer geographical scales than is currently possible.

2. Data

Data provided by the British Trust for Ornithology:

- Ring-recovery data: information on survival,
- Census data: information on abundance.

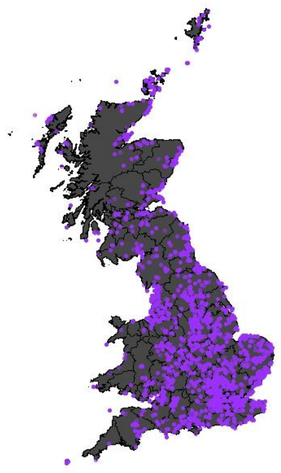


Figure 2: Location of ringing data Starlings, 1990-1999.

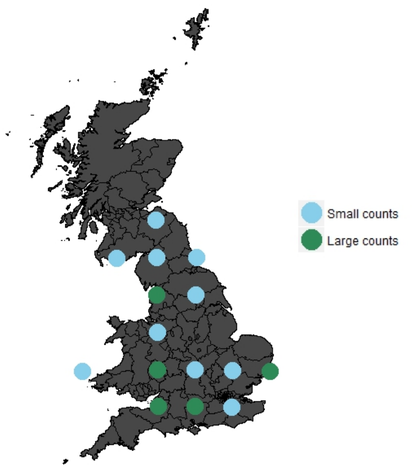


Figure 3: Census data for Starlings, 100 km squares, 1990-1999.

By combining these data in a spatially-explicit IPM we

- can estimate productivity rates (impossible otherwise),
- can better manage sparse spatial data,
- obtain more accurate results.

3. Model

Spatially-explicit Integrated Population Model

$\phi_{1,s}, \phi_{a,s}, \lambda, \rho$

Ring-recovery Model[3] + **Census Model State-space Model**

$\phi_{1,s}, \phi_{a,s}, \lambda$

+ Fast
+ Flexible
- No productivity estimates

$\phi_{1,s}, \phi_{a,s}, \rho$

Kalman Filter

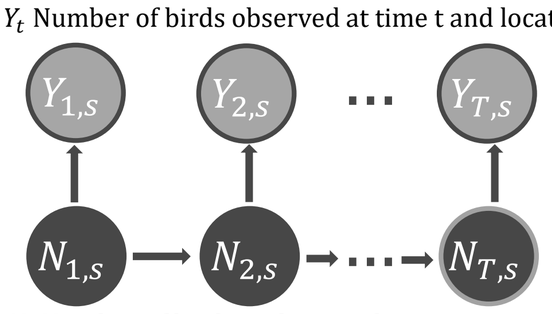
+Fast
+ Gaussian approx.
- Requires large counts

Hidden Markov Models

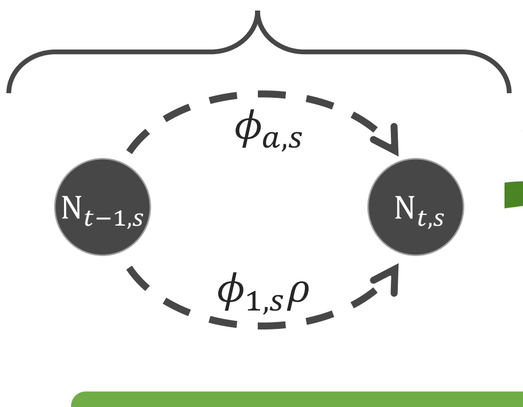
+ Flexible
+ Small counts
+ Large counts
- Can be slow

$\phi_{1,s}$ Spatially-explicit first-year survival probability
$\phi_{a,s}$ Spatially-explicit adult survival probability
λ Probability a dead ringed bird is reported
ρ Productivity rate

Y_t Number of birds observed at time t and location s



N_t Number of birds in the population at time t and location s



Novel Approach

First spatially-explicit IPM for ring-recovery and census data

Use of small datasets for the first time

4. Results

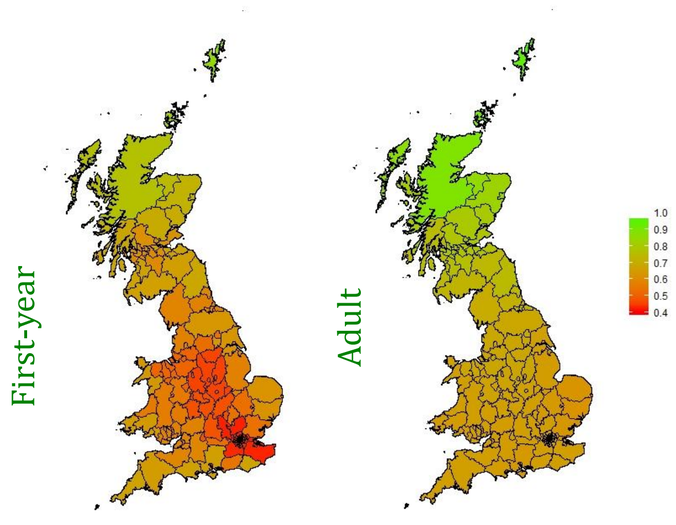


Figure 4: Spatial survival for first-year and adult Starlings as a function of latitude, longitude, and rural habitat, 1990-1999.

- Adult survival for starlings is strongly affected by latitude.
- First-year birds have a lower probability of survival.
- First-year survival is much lower in the centre of Great Britain, where there are more urban areas.

5. Impact & Future Work

- **Makes possible finer analyses within a country.**
- **Other geographical and meteorological data can be easily incorporated into our model.**
- **Applicable to many species of birds an other animals.**
- **Developing open access computer software .**

Our models can help experts to better identify areas where species have low survival in Great Britain, Europe, and North America, where such data exist. Prioritizing interventions in these areas, such as habitat protection or restoration, will allow a more efficient allocation of governmental and NGO resources and the improvement of species conservation and biodiversity management.

References:
[1] Besbeas P., Freeman S. N., Morgan B. J. T. and Catchpole E. A. 2002. Integrated mark-recapture-recovery and census data to estimate animal abundance and demographic parameters. *Biometrics*
[2] Abadi, F., Gimenez, O., Arlettaz, R., and Schaub, M. 2010. An assessment of integrated population models: bias, accuracy, and violation of the assumption of independence. *Ecology*.
[3] Jiménez-Muñoz, M., Cole D. J., Freeman S. N., Robinson R. A., Baillie S. R., and Matechou E. 2019. Estimating age-dependent survival from age-aggregated ringing data - extending the use of historical records. *Ecology and Evolution*