Integrating citizen science data sets to estimate bird population dynamics

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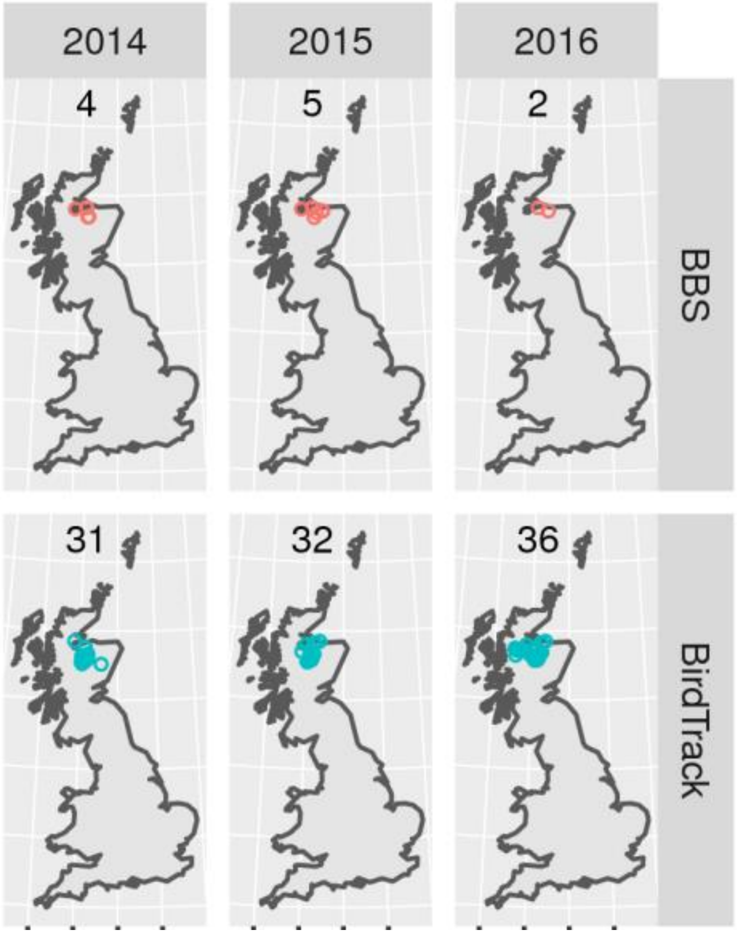
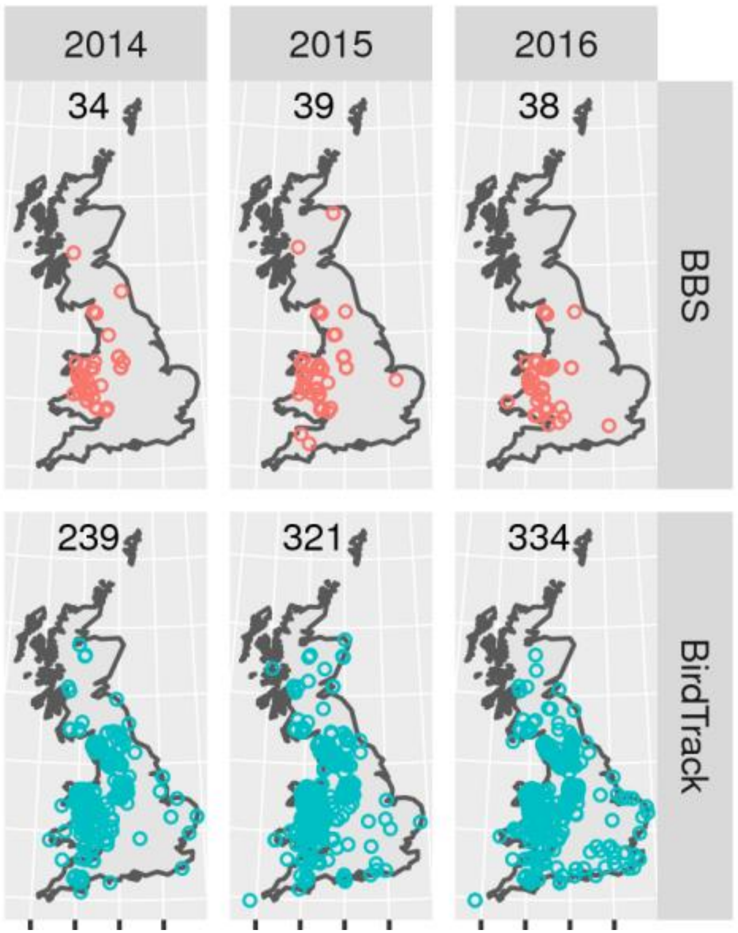
British Trust for Ornithology @_BTO

- BirdTrack has c. 10x more records across space

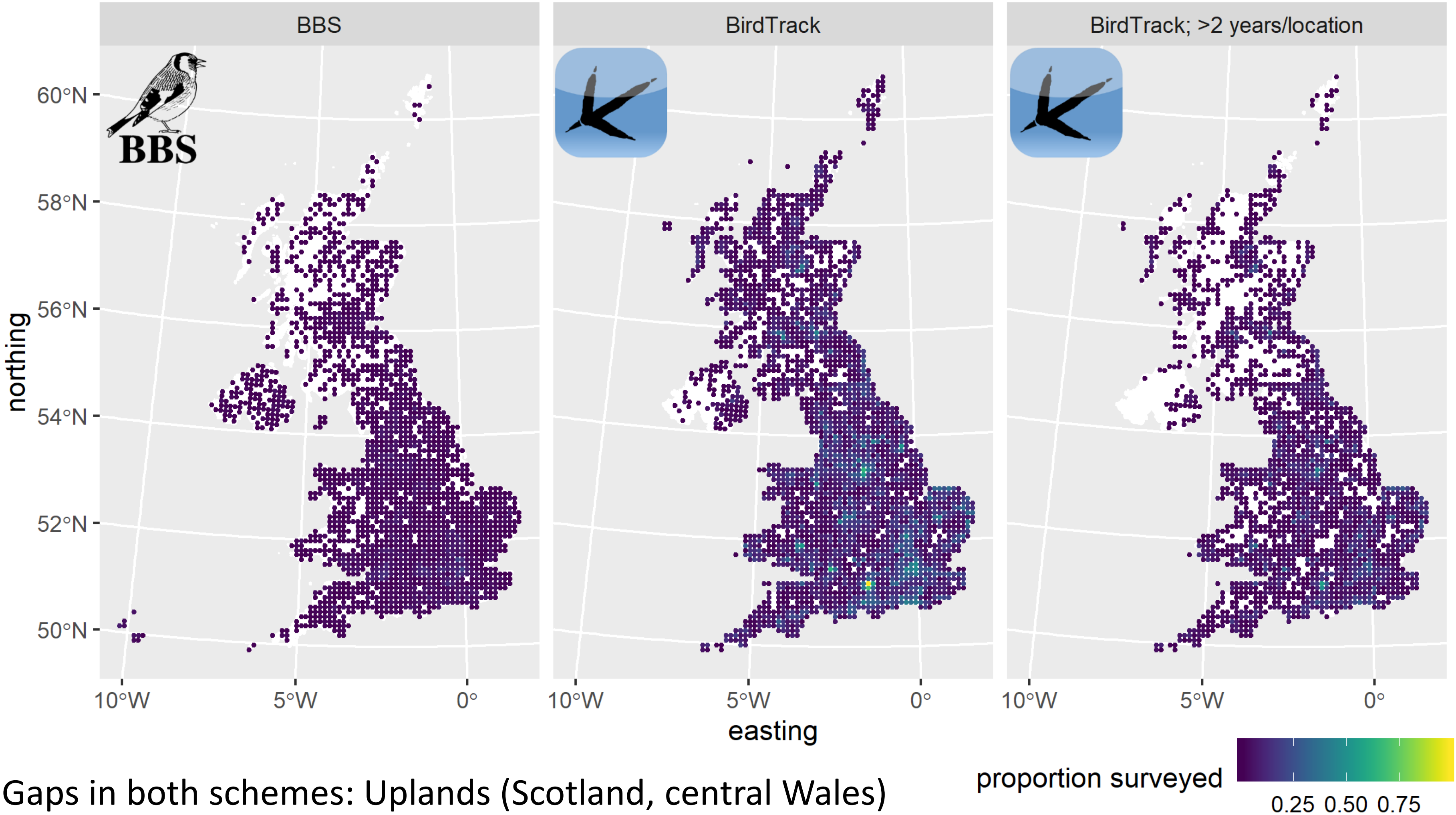
Crested Tit



Pied Flycatcher



Gaps and sample sizes

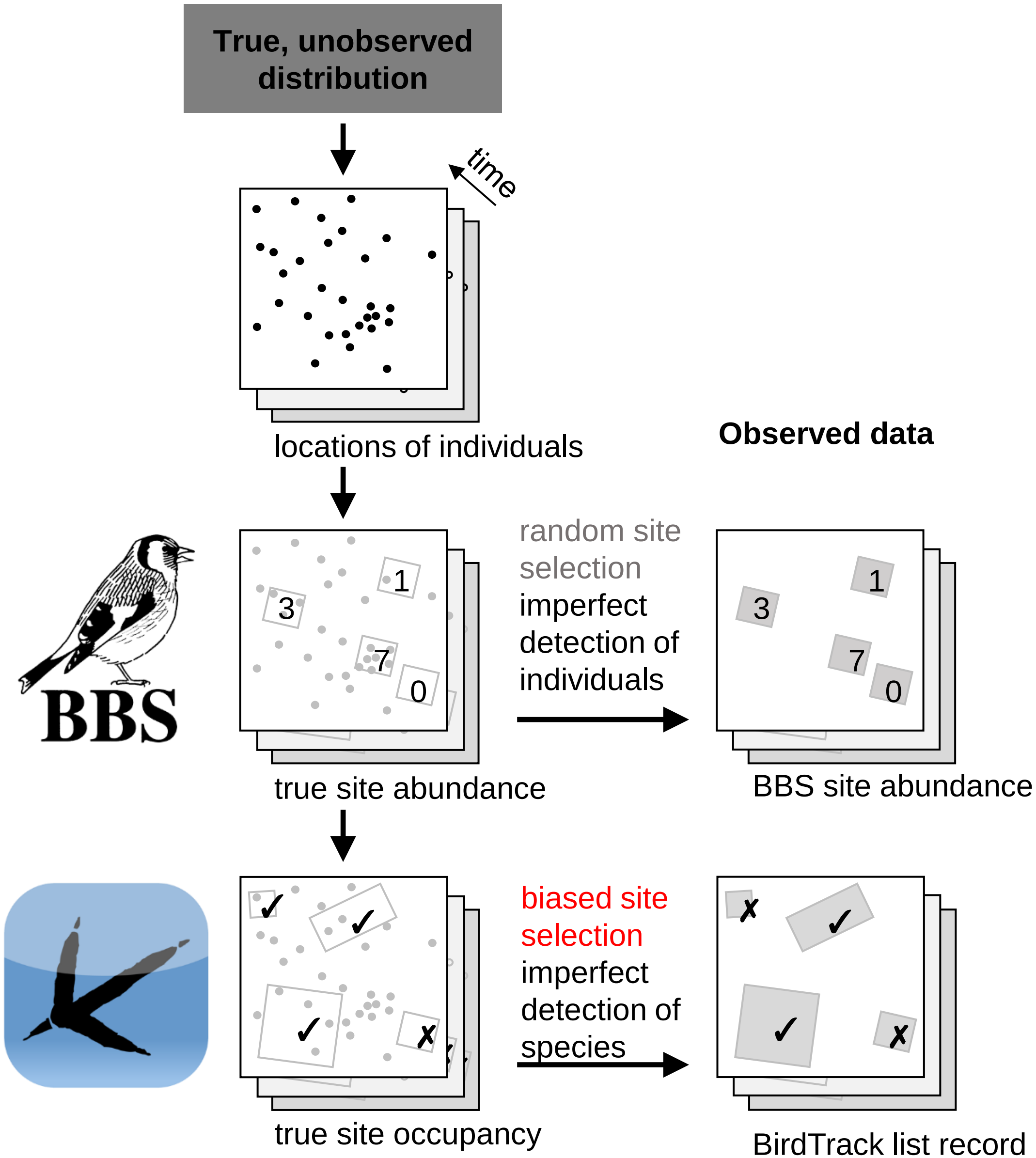


Gaps in both schemes: Uplands (Scotland, central Wales)

Gaps in BirdTrack: Rural Northern Ireland, areas w/ high-intensity agriculture

Boersch-Supan et al. 2019 Biological Conservation

Integrating structured and unstructured data sets



count data
unbiased sampling
standardized effort
but “small” sample size

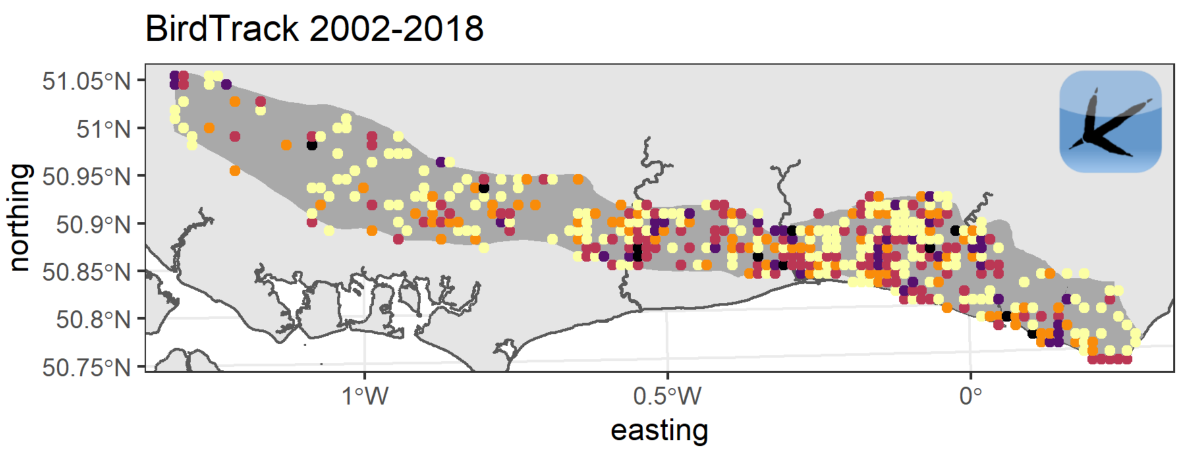
presence/absence data
biased sampling
variable effort
large(r) sample size

after Isaac et al. 2019 Trends Ecol Evol
https://doi.org/10.1016/j.tree.2019.08.006

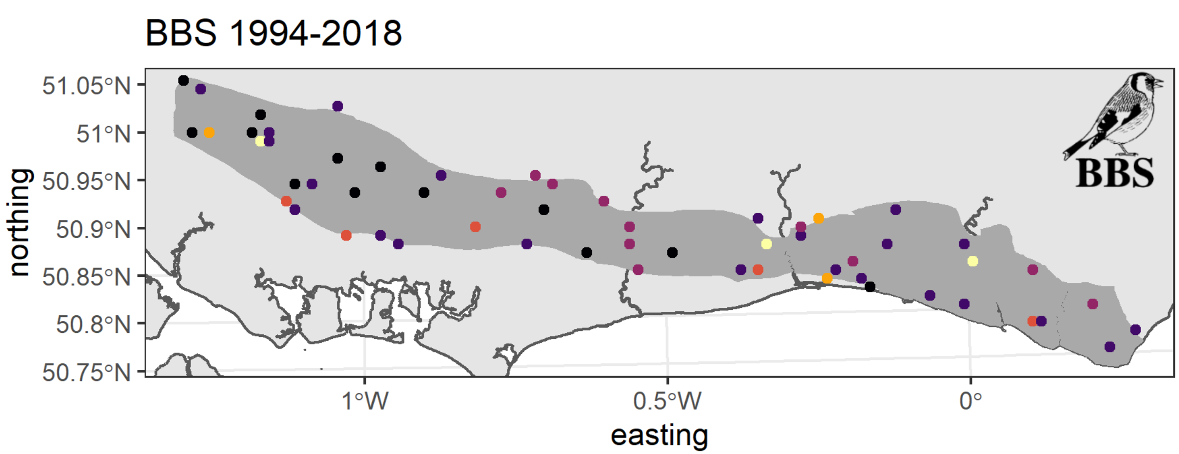
Case study: Corn Bunting in the South Downs

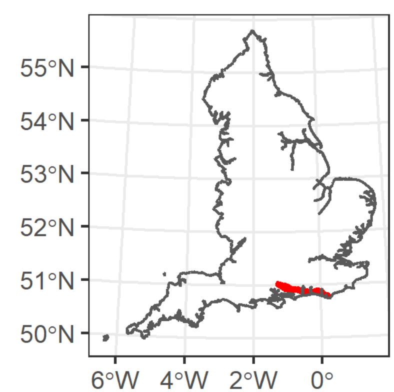
Can we use data integration to get trends for small areas?

South Downs National Character Area



Years with data
- 1
- 2
- 3-5
- 6-10
- 11-20
- >20





Integrated abundance model

BTO
Looking out for birds

Latent state

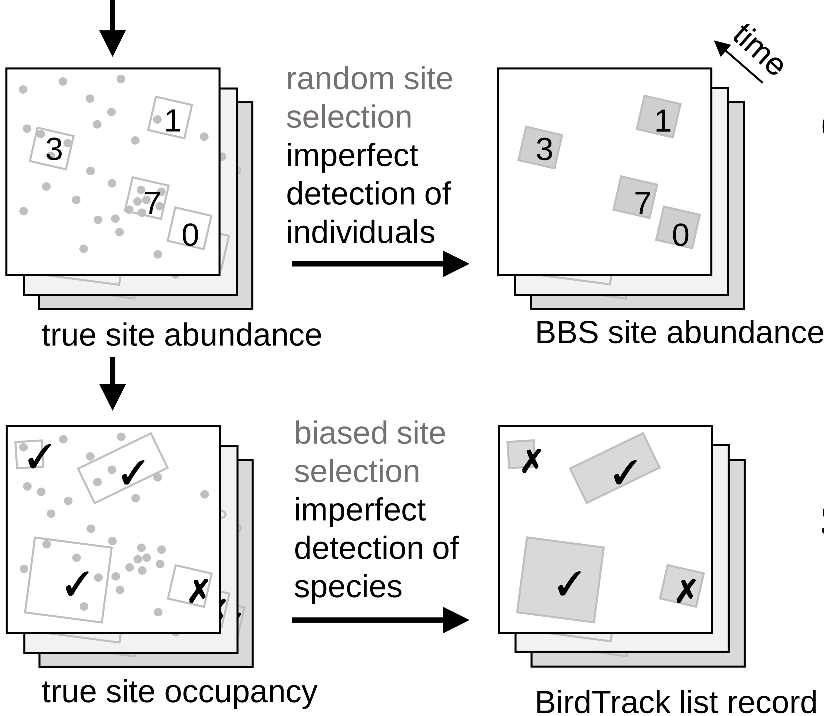
State model: True abundance = Survival + Recruitment

$$N_{j,t} = S_{j,t} + G_{j,t}$$

$$S_{j,t} \sim \text{Binomial}(N_{j,t-1}, \omega_{habitat,t})$$

$$G_{j,t} \sim \text{Poisson}(\gamma_{habitat,t})$$

Annual rates modelled as habitat specific random effect



Count observations: N-mixture model

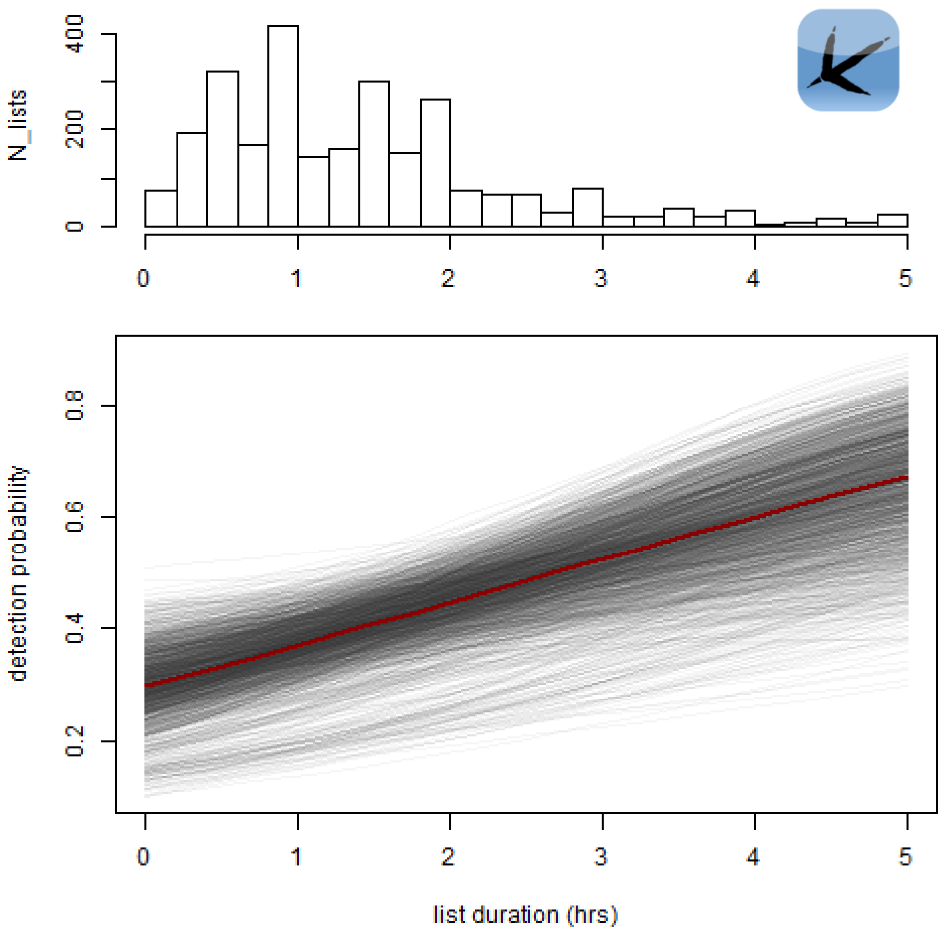
$$n_{j,t,k} \sim \text{Binomial}(N_{j,t}, p)$$

Species list observations:

$$y_{j,t,k} \sim \text{Bernoulli}(1 - (1 - p_{occ})^{N_{j,t}})$$

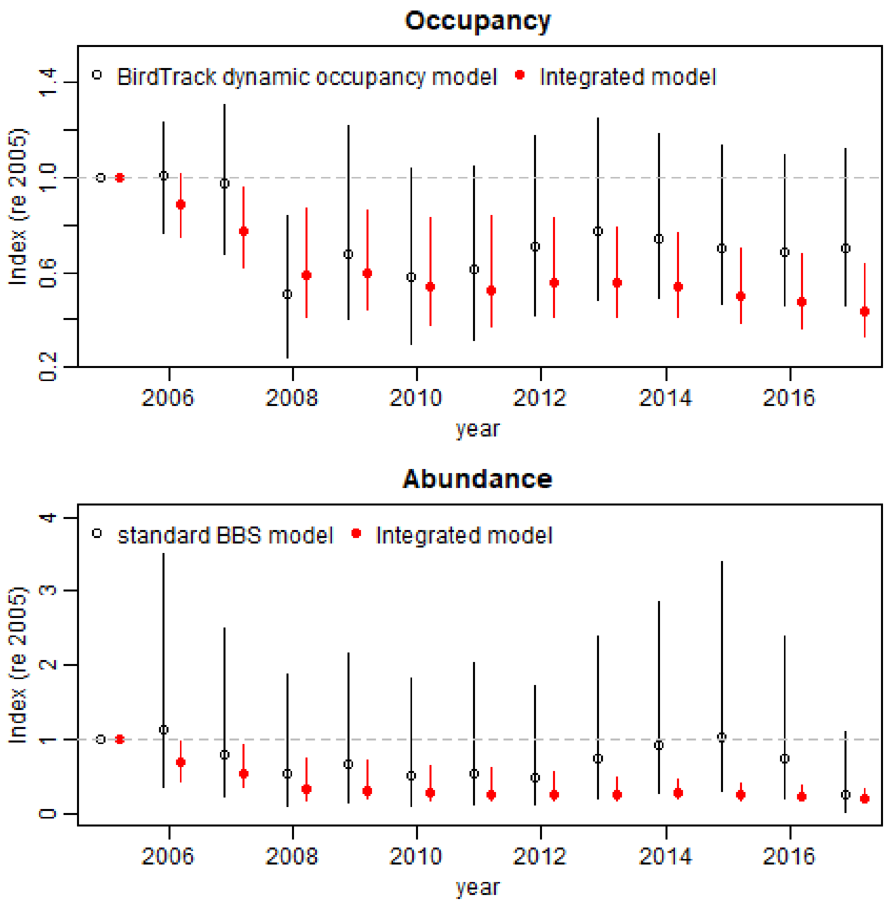
Boersch-Supan et al. in prep., Zipkin et al. 2017 Ecology
https://doi.org/10.1002/ecy.1831

Case study: Corn Buntings in the South Downs



- Integrated model accounts for heterogeneous observation effort in BirdTrack data
- Summarized BBS data for this species may not be suitable for N-mixture model
  - closure assumption not met counter to behavioural studies suggesting high song activity throughout survey period
- Distance sampling data may help, but increase computational demand

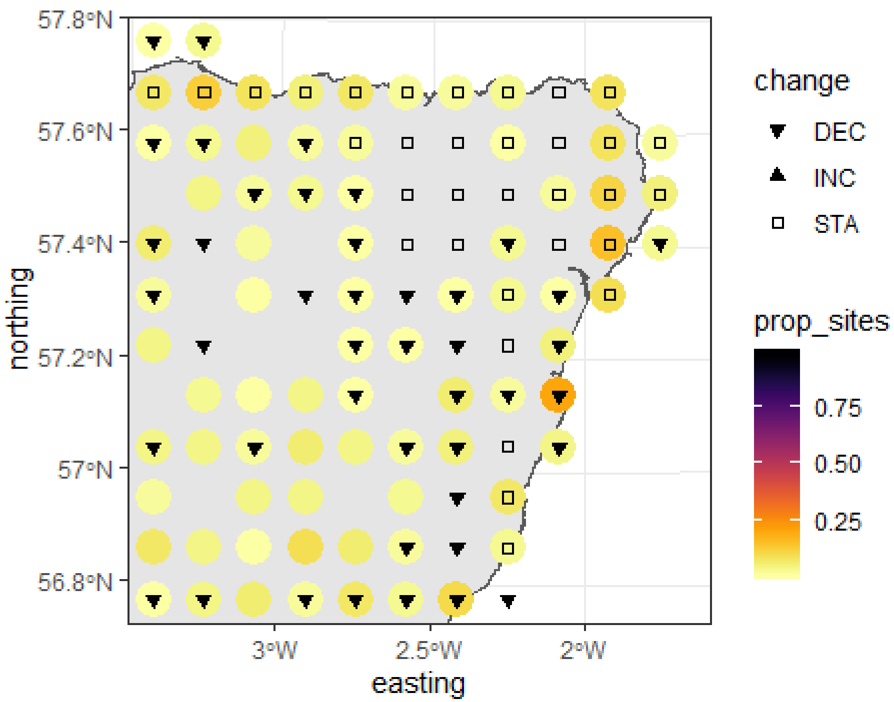
Case study: Corn Buntings in the South Downs



Precision of integrated trend estimates is better than using either dataset alone

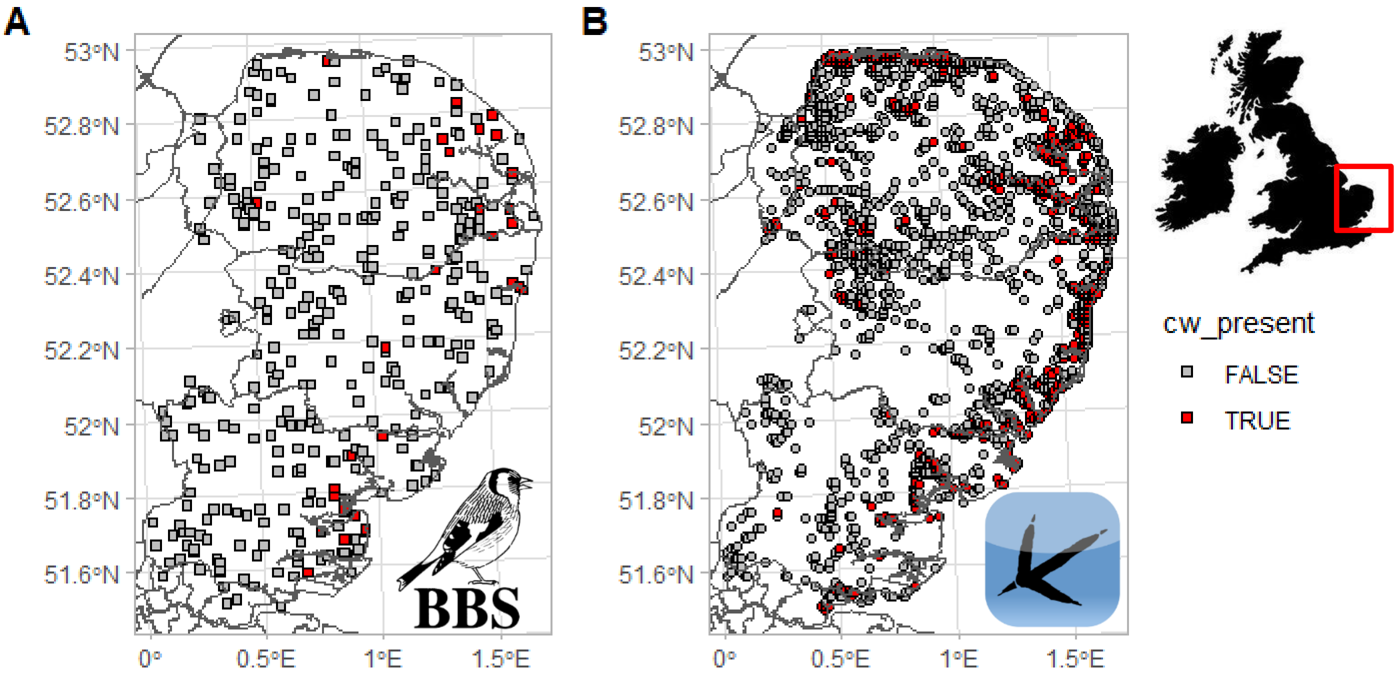
Year and habitat specific rated make the model easy to overfit.
Some contraints achieved with informative priors on survival rates derived from ringing data.

BirdTrack Gaps



Case study: Cetti's Warbler in East Anglia

Can we use data integration to get trends for colonizing/invading species?



Integrated abundance model

Latent state

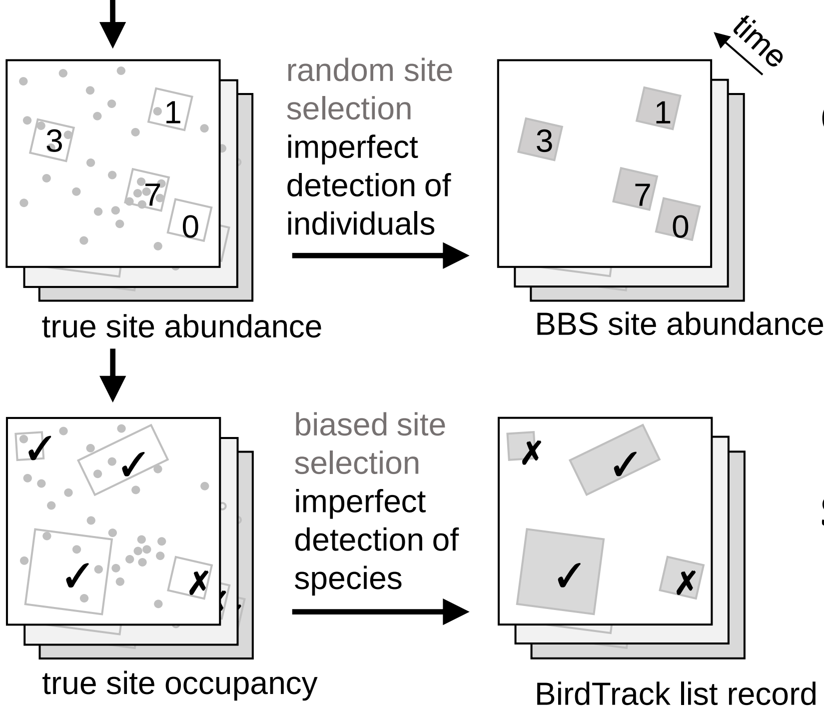
State model: True abundance = Survival + Recruitment

$$N_{j,t} = S_{j,t} + G_{j,t}$$

$$\left.\begin{array}{l} S_{j,t} \sim \text{Binomial}(N_{j,t-1}, \omega) \\ G_{j,t} \sim \text{Poisson}(\gamma) \end{array}\right\}$$

Annual rates modelled using environmental covariates, e.g.

$$\text{logit}(\omega_{j,t}) = \beta_\omega + \beta_{frost} x_{frost,j,t}$$



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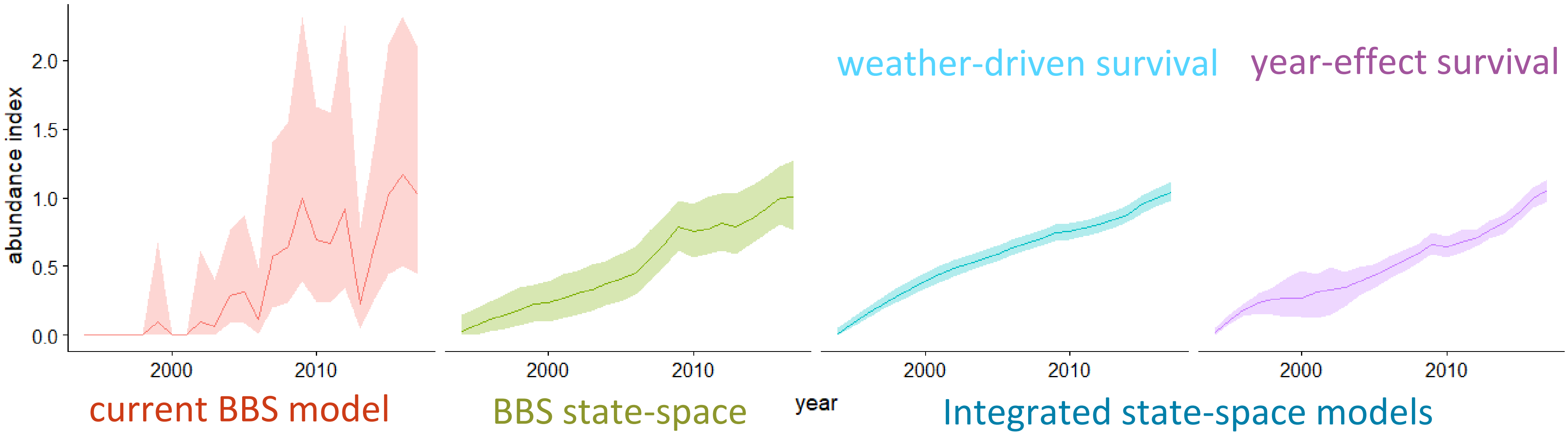
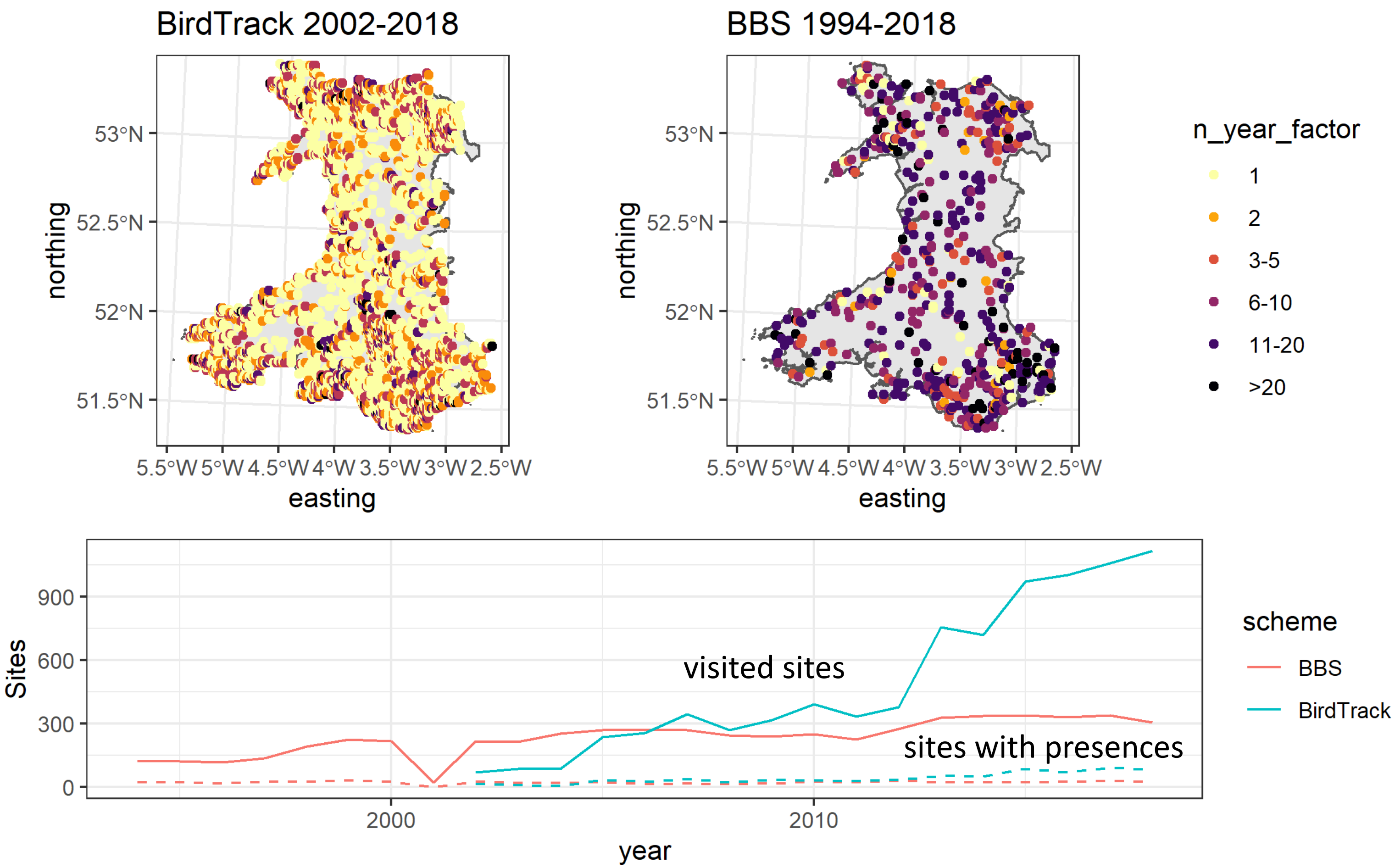


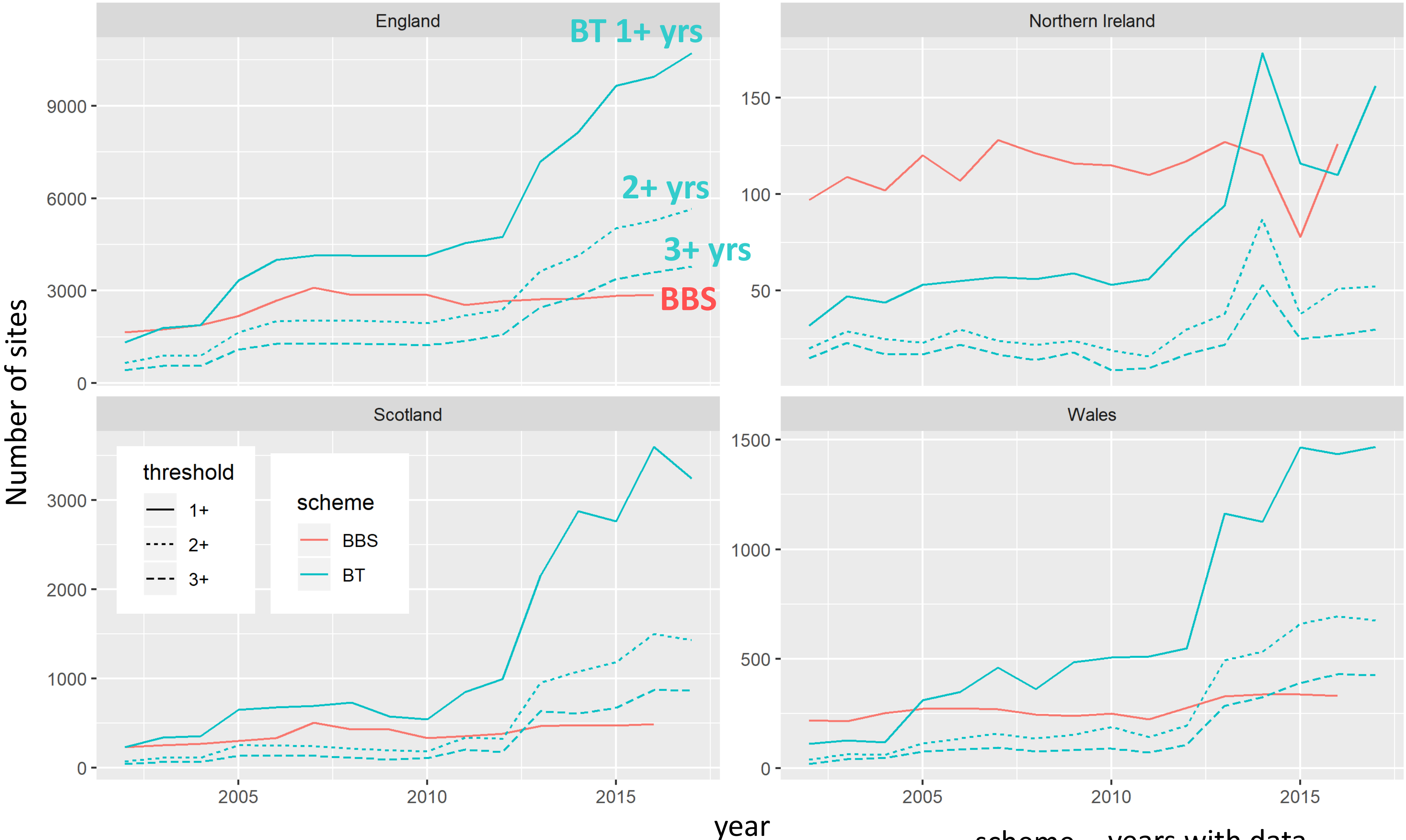
- big improvement in precision for **abundance trend**
- good agreement with independent data (Rare Breeding Birds Panel)

Case study: Pied Flycatcher in Wales

Can we use data integration to improve country trends?



Gaps and sample sizes



scheme years with data

Summary

- Opportunities of integrated modelling
  - leverage strengths of both structured and unstructured data
  - great potential to improve precision of regional bird trends (~1000-10,000 km^2)

- Challenges of integrated modelling
  - no simple, one-size-fits-all approach: models require customization for each application
  - Computational effort is high, UK-wide models not practical with Zipkin model
  - Validation is difficult
  - Some species and/or areas will be better suited than others
  - BBS design not ideal to disentangle availability vs detectability for rare species

- Implications for opportunistic scheme design
  - recording of effort is crucial
  - complete list recording
  - can we encourage recording in "boring areas"?
    - Are structured surveys easier in those areas after all?

Development opportunities

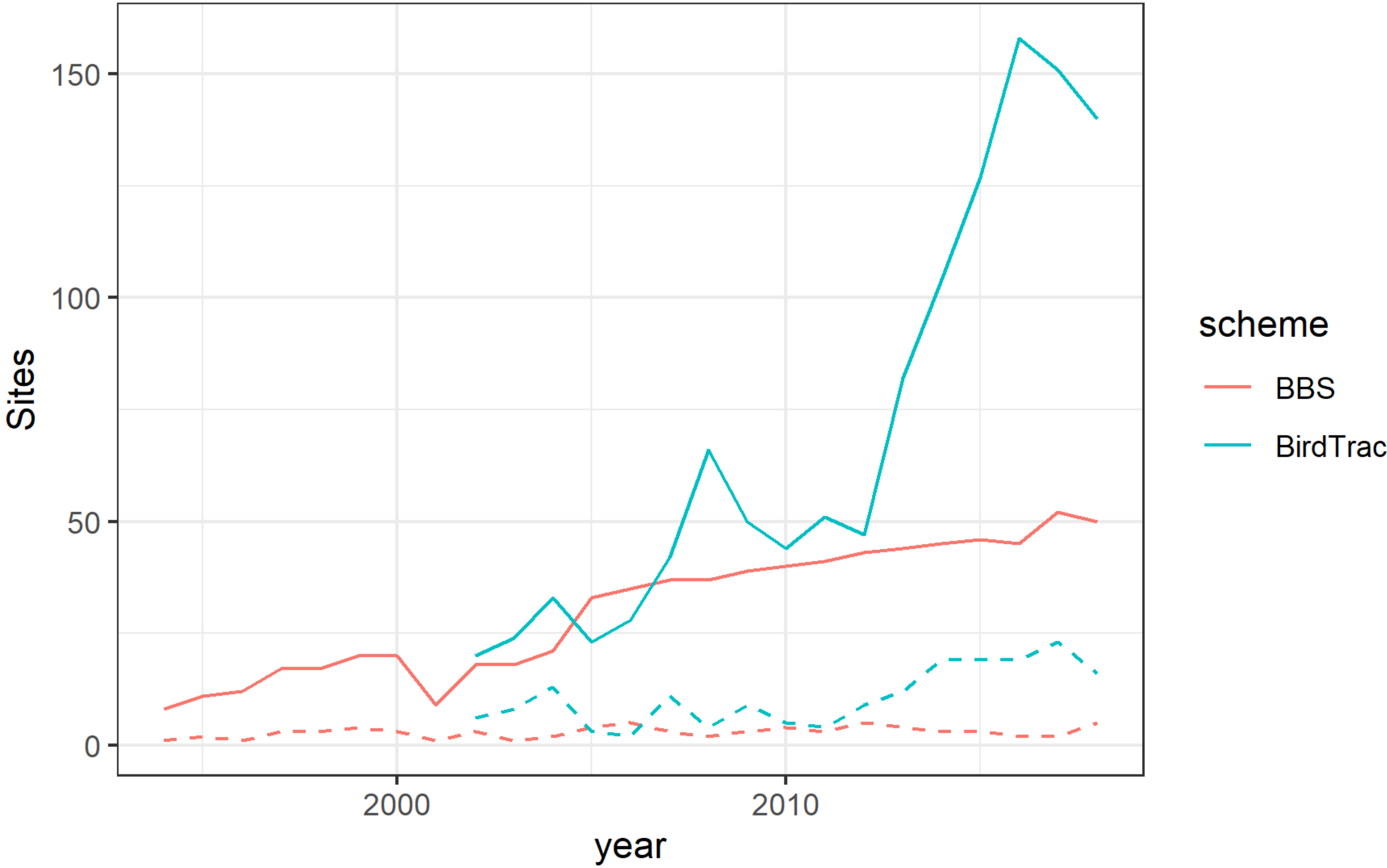
	BirdTrack	BBS	Joint
Coverage	encourage revisits, gap-filling, improve spatial metadata	Winter survey?	Winter trends?
Detectability	Observer effects (Skill scoring system)	3rd visit? Observer effects	Phenology information can potentially be shared
Population estimation	Occupancy only	Density	Occupancy & Density
Trend production/ Reporting	Formalize reporting rate trends?	Density trends	TSDA scoping study planned for FY20/21

Tipling / BTO

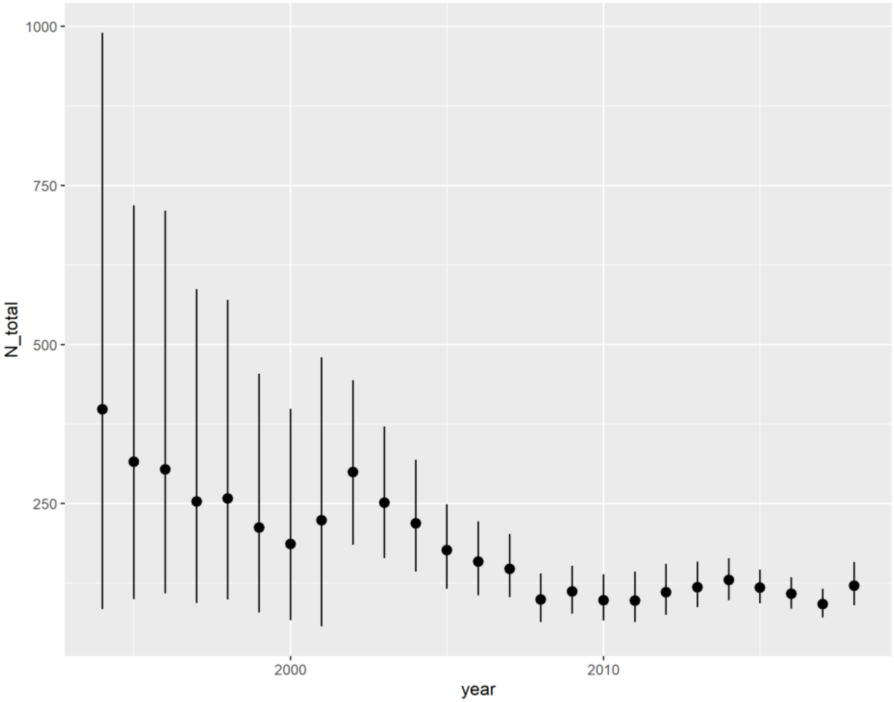
ACKNOWLEDGEMENTS

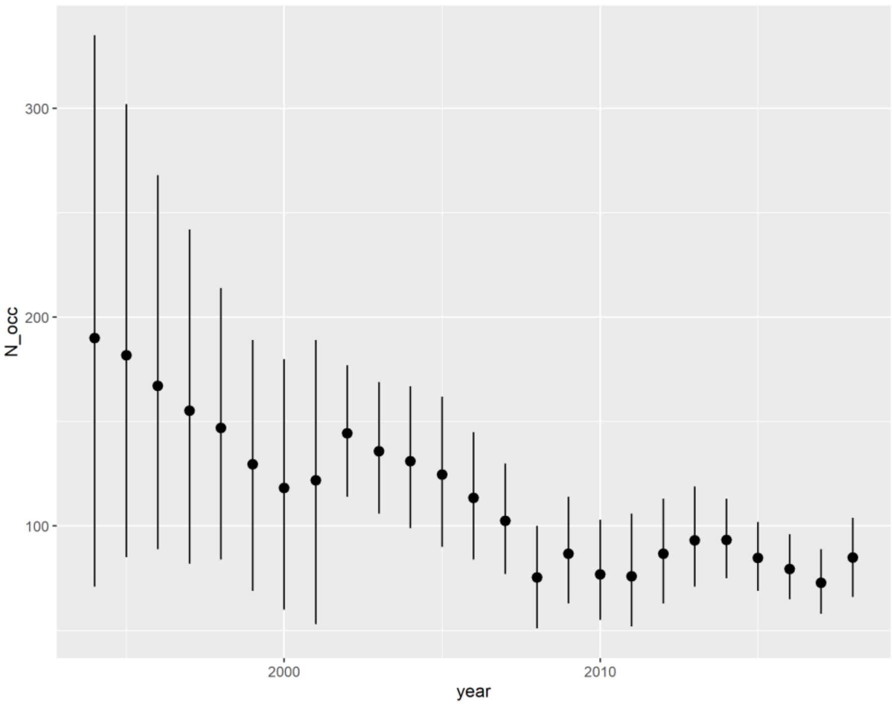
This analysis was only possible with the dedication of the thousands of **BBS volunteers** and **BirdTrack users** and the **survey partners**. Funding was provided by the **contributors to the BTO BirdTrack Appeal**, and **JNCC** under the **Terrestrial Surveillance Development and Analysis Partnership.** Computations were conducted on **NERC**'s JASMIN data analysis platform.

South Downs sample sizes

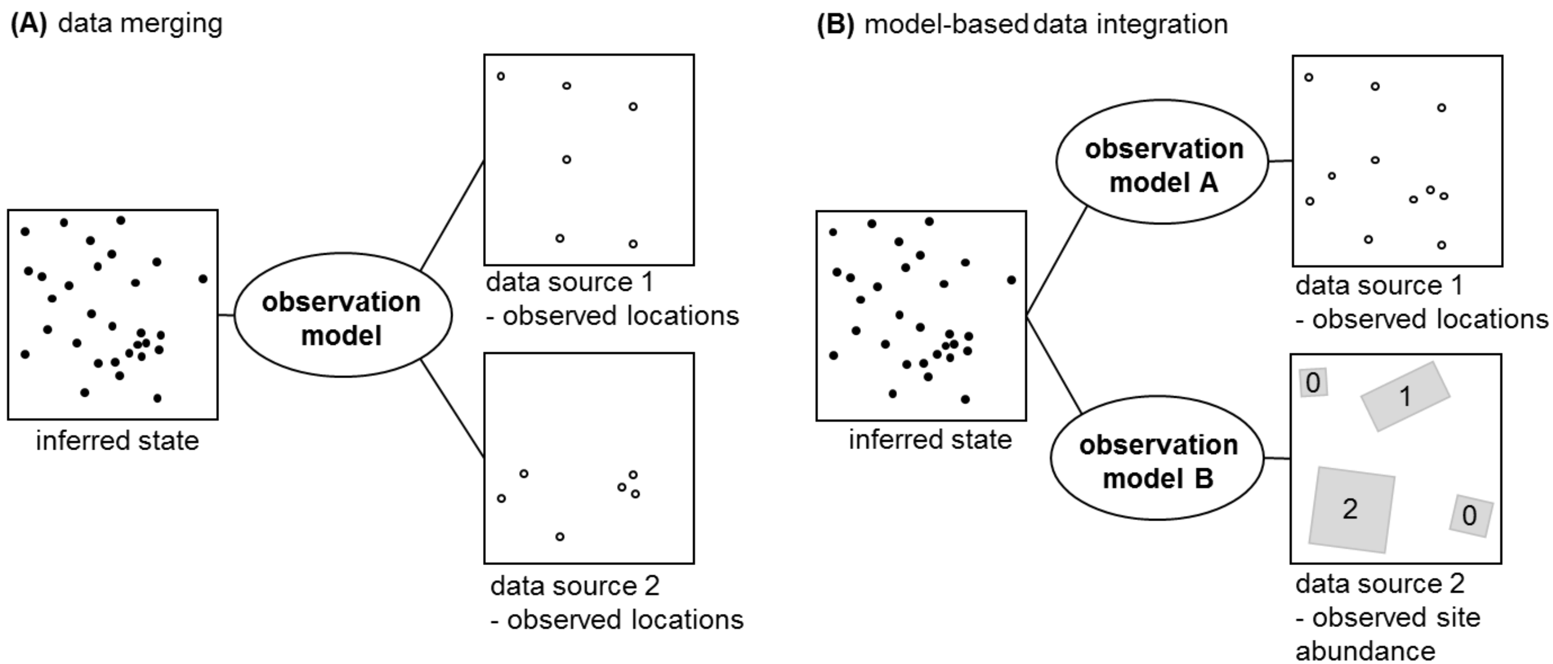


Corn Bunting model fitted to full time-series





How do we integrate these data?



Isaacs et al. in revision at TREE, see also Miller et al. 2019 MEE, Zipkin et al 2019 Ecology, Pacifici et al. 2019 Ecology

Data

- **BBS**
  - Abundance trends: maximum annual count per site
  - Occurrence trends: detection-nondetection based on max. count
- **BirdTrack**
  - species detection-nondetection
  - complete, timed lists with a 1km grid reference
  - recorded in BBS survey window (April – June)
  - Locations with <2 lists removed for trend calculation
    - n_{lists} = 321,901; $n_{locations}$ = 22568
- **Analysis timeframe:** 2005 – 2016
- **Species set:** 141 species that are reasonably covered by BBS

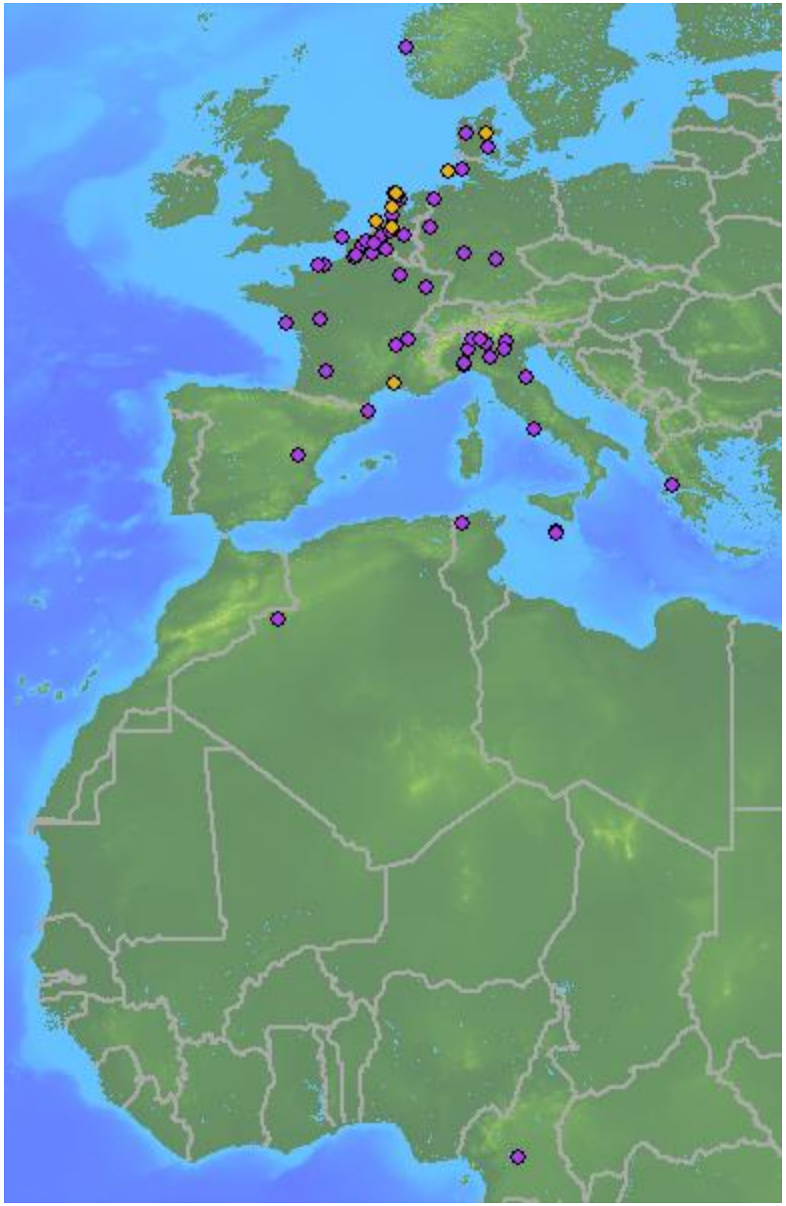
Boersch-Supan et al. submitted

Constant Effort Ringing Sites - CES

- BTO issues ringers permits and oversees training in the UK
- Qualified ringers are free to ring selected sites
- CES is a site-specific structured scheme
  - Sites are volunteer-selected
  - mainly reedbed, scrub, woodland
  - regular habitat management
  - 12 annual capture events, 10 days apart May-August
  - same nets in same positions
  - no lures, bait, etc.
  - all captured birds are processed, focus on 24 songbird species

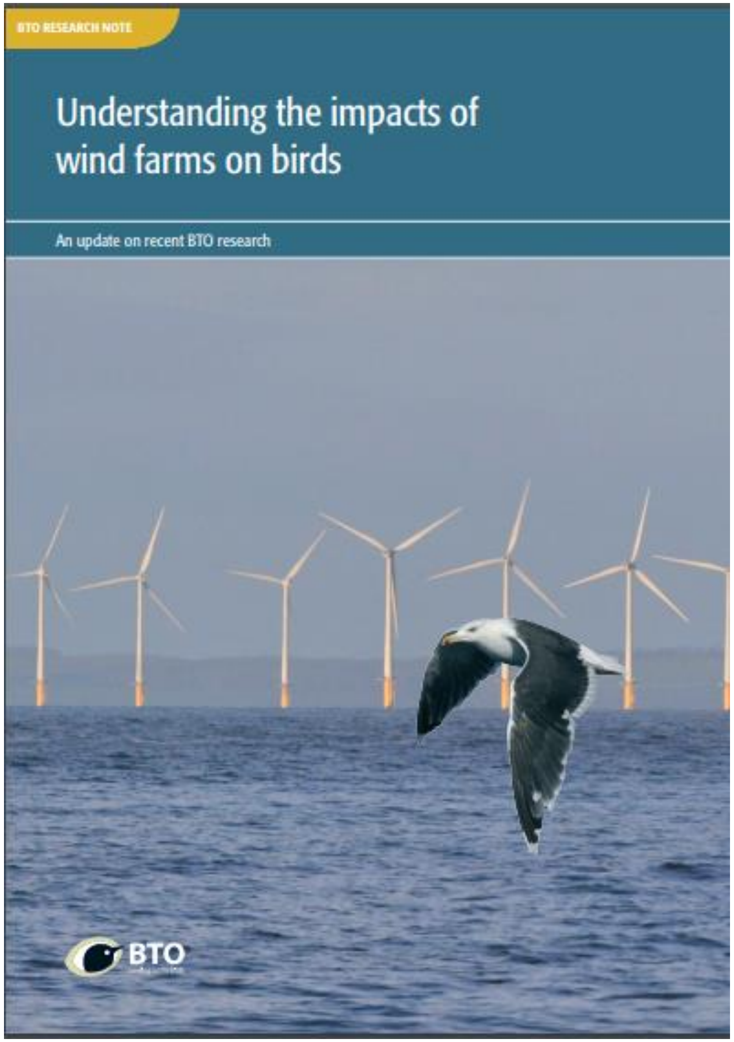
Migration

- Original knowledge from ring recoveries/resights
- Now increasingly Geolocator/GPS tagging
  - e.g. Nightingales, Cuckoos, Nightjars, Gulls, Skuas



Small scale Movements

- GPS/accelerometer tags
- Altimeter, LIDAR measurements
- Current focus on gulls
- Foraging ranges of Urban Gulls
- 3D space use of gulls in wind farms to assess collision risks



Thaxter et al. 2018 Mar Ecol Prog Ser, Smith-Ross et al. 2016 J Appl Ecol, Johnston et al. 2014 J Appl Ecol