# Abstract

# Introduction

Hierarchical GAMs provide useful models to track non-linear population change (Smith and Edwards 2021).

Hierarchical structure could be improved using spatial information because ecological patterns are almost always spatially dependent.

Semi-parametric structures of hierarchical GAM provide a potentially useful way to share information in space among discrete spatial units.

## Goal

We describe a spatial intrinsic conditionally autoregressive (iCAR) approach to fitting hierarchical GAM smooths that estimate smooth patterns of temporal change in broad-scale avian monitoring data. We demonstrate the basic model using simulated data, then apply versions of the model to examples of real data from three broad-scale avian monitoring programs. The real data are drawn from some of the key North American monitoring programs: The Breeding Bird Survey (BBS), The Christmas Bird Count (CBC), and a collection of shorebird migration surveys (SMS) that use the same monitoring protocol (International Shorebird Survey, Atlantic Canada Shorebird Survey, and the Ontario Shorebird Survey).

# Methods

## Spline structure

Hierarchical structure on the spline parameters

## Simulated data

The datasets:

1. True non-linear patterns with realized BBS data set for PIWA, simulate a moderate level of mean abundance with a mid-range peak, and show that the model can predict accurately for both the GAM parameters and the trajectories, when there is a geographical pattern to the trends and abundances.
2. Same real trajectories as above, but with very reduced number of routes in one part of the species’ range, to demonstrate the benefit of the spatial information.
3. simple linear true trajectory, to demonstrate the shrinkage and reasonably linear predictions

The models

1. Spatial GAM: Fit spatial GAM to 1, 2, and 3 above to demonstrate that the model accurately estimates the key parameters and the trajectories
2. Non-Spatial GAM: Fit non-spatial version to data 1 and 2 with same hierarchical structure.
3. Alt-Non-Spatial GAM: Fit non-spatial version to data 1 and 2 with an alternative hierarchical structure that fits a local and global smooth.

## Real Data Examples

BBS – Cerulean Warbler? Or BARS, or WOTH, or COHA?

CBC - ? – adds the effort calculation…

of effort (ξi,j,t), and an overdispersion parameter, εi,j,t. The parameters Bi and pi govern the shape of the relationship of effort to count, ranging from a straight line to a saturating curve; for P < 0, the model specifies diminishing returns as effort increases (Link et al. 2006). Bi ( ξ pi i,j,t−1 ) pi

Shorebirds – REKN? Or LEYE? – adds the seasonal smooth, and the single year-effects, and the hyperparameter as the overall summary.

# Results

# Conclusions

References Cited

Smith, A. C., and B. P. M. Edwards (2021). North American Breeding Bird Survey status and trend estimates to inform a wide range of conservation needs, using a flexible Bayesian hierarchical generalized additive model. Ornithological Applications 123.