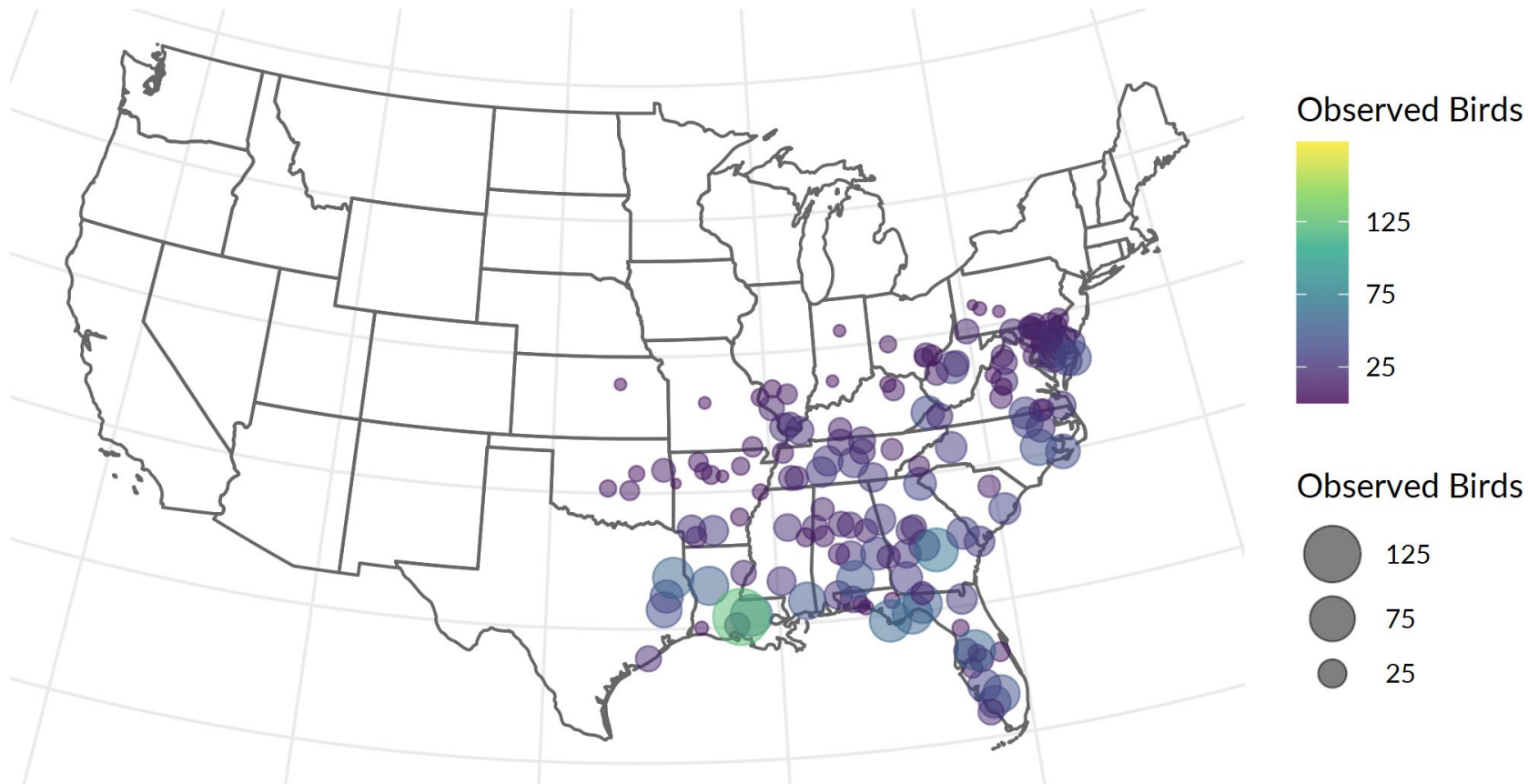


# A Computationally Efficient Spatiotemporal Generalized Linear Model

Ellen Graham

# Difficulties with Dependent Data

Carolina Wrens, 1990



# Mixed Effects Models to the Rescue!

Bird Count

Ecosystem

Spatial Effect

$$Y(s) = \beta_0 + \beta_1 \mathbf{X}(s)$$



# Computing Issues

- Lots of locations means lots of parameters
- Lots of locations means doing linear algebra is complicated

# Simplifying Spatial Dependence

Spatial Dependence      Eigenvectors      Eigenvalues

$$\begin{array}{ccccc} \boxed{\Sigma} & \approx & \boxed{V} & \times & \boxed{\Lambda} \times \boxed{V^T} \\ & & (n \times m) & & (m \times m) \times (m \times n) \\ (n \times n) & & & & \end{array}$$

$m \ll n$

- Faster linear algebra
- Only  $m$  spatial effects

# An Efficient Spatial Linear Mixed Model

$$Y(s) = \beta_0 + \boldsymbol{\beta}_1 \mathbf{X} + \eta(s)$$

$\eta(s)$  = Simplified Spatial Effect

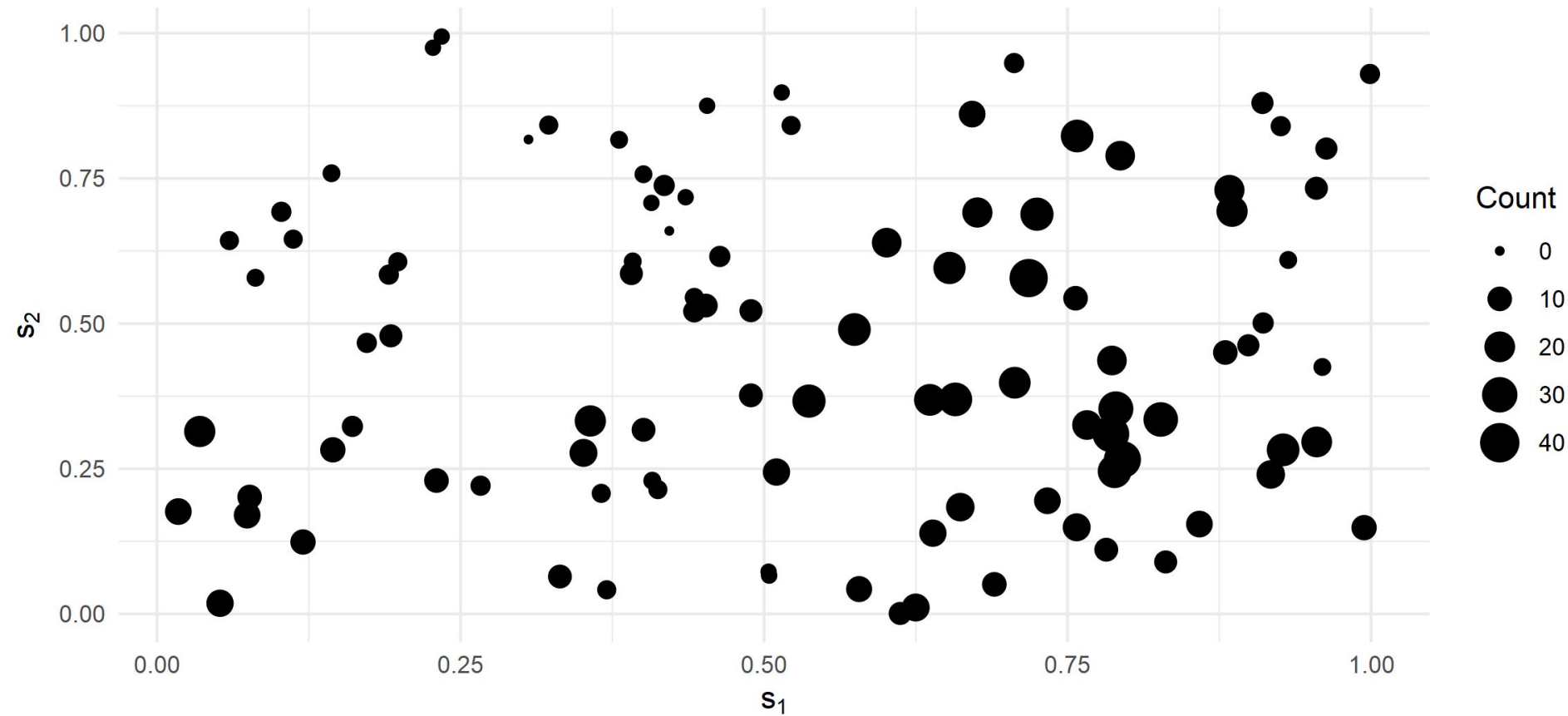
# An Efficient Spatiotemporal Linear Mixed Model

$$Y(s, t) = \beta_0 + \boldsymbol{\beta}_1 \mathbf{X} + \eta(s, t)$$

$\eta(s, t)$  = Simplified Spatial Effect + Simplified Temporal Effect

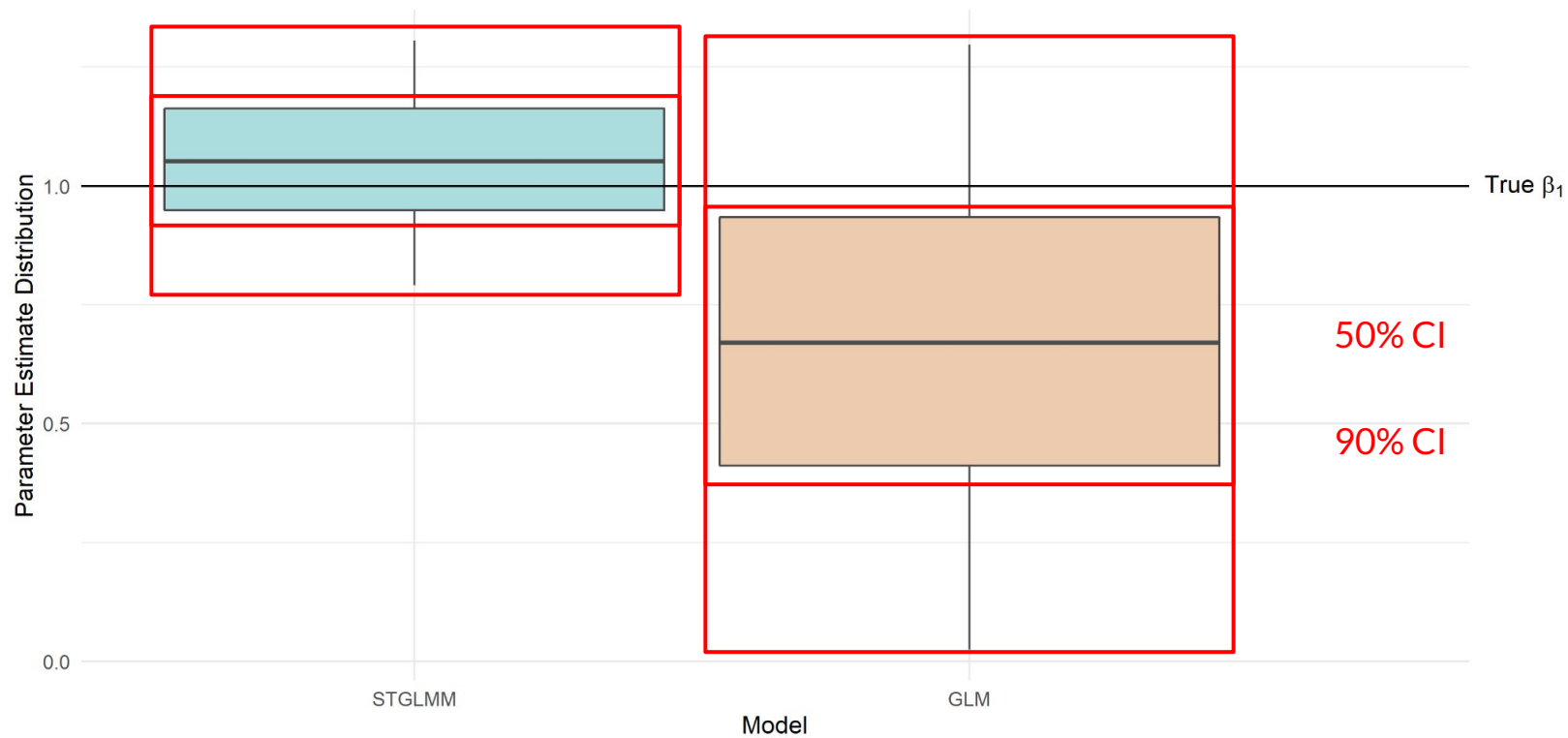
# Simulating Data

Time = 1

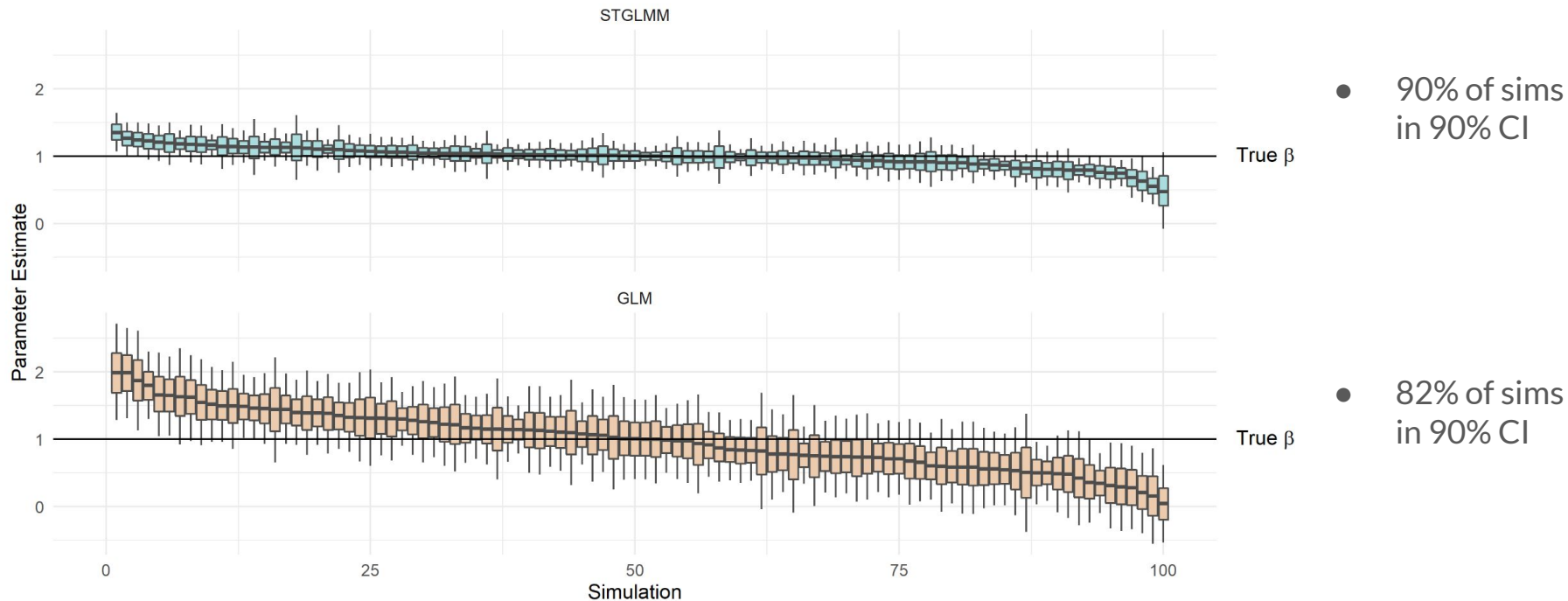




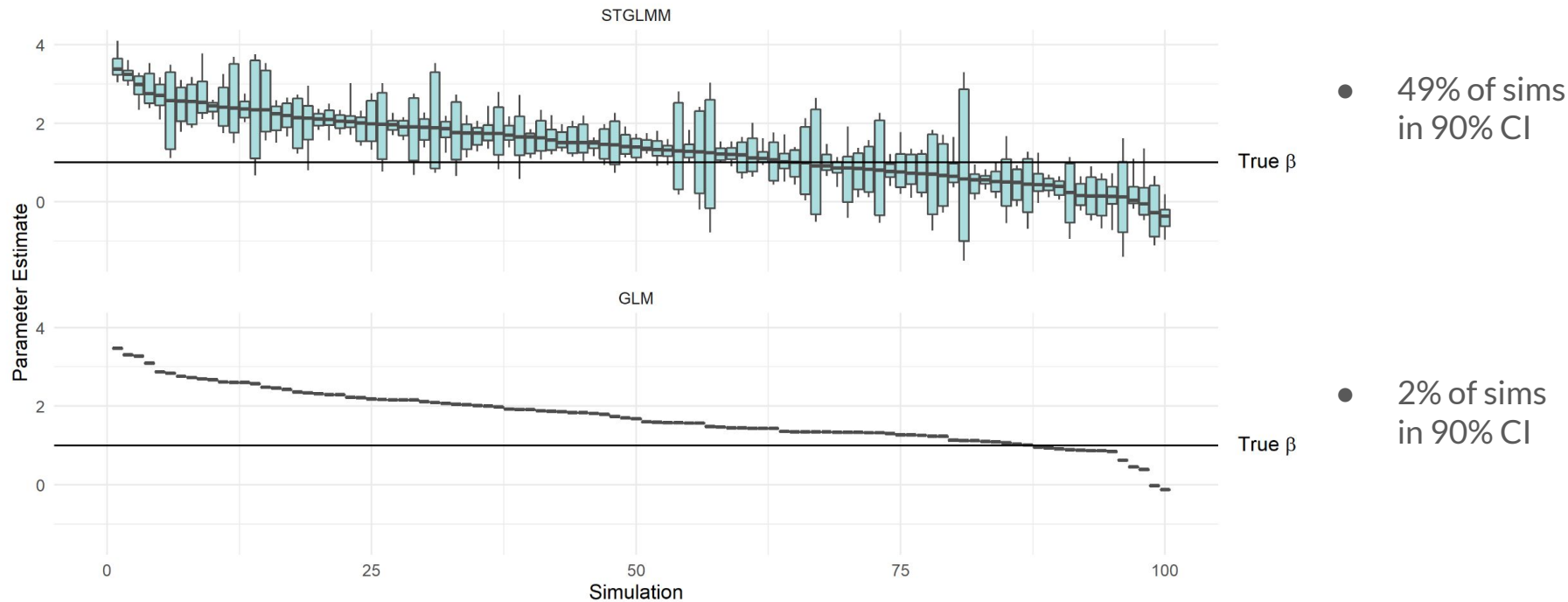
# Evaluate with Credible Intervals



# Are we Capturing the Truth: Explanatory Variable

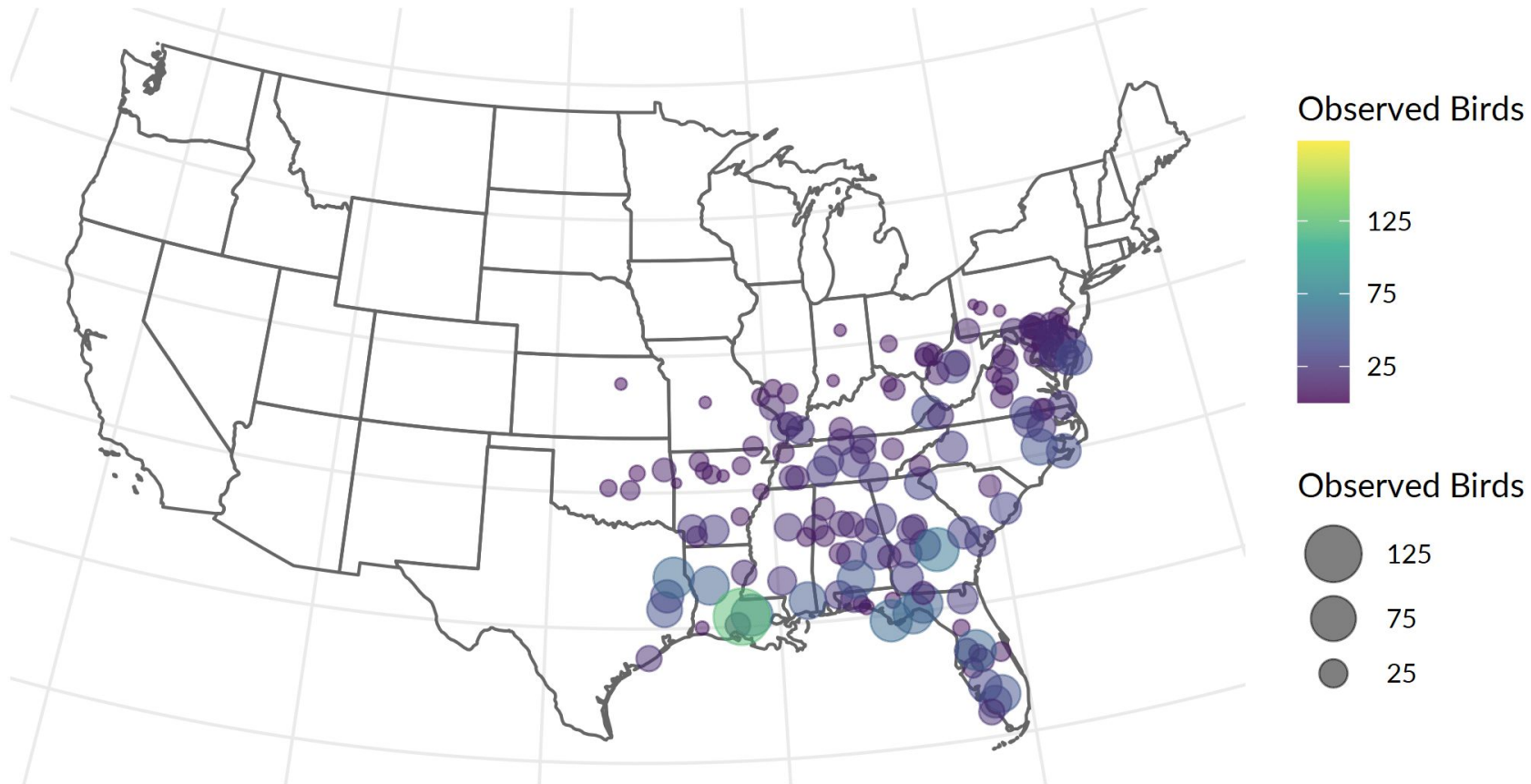


# Are we Capturing the Truth: Intercept

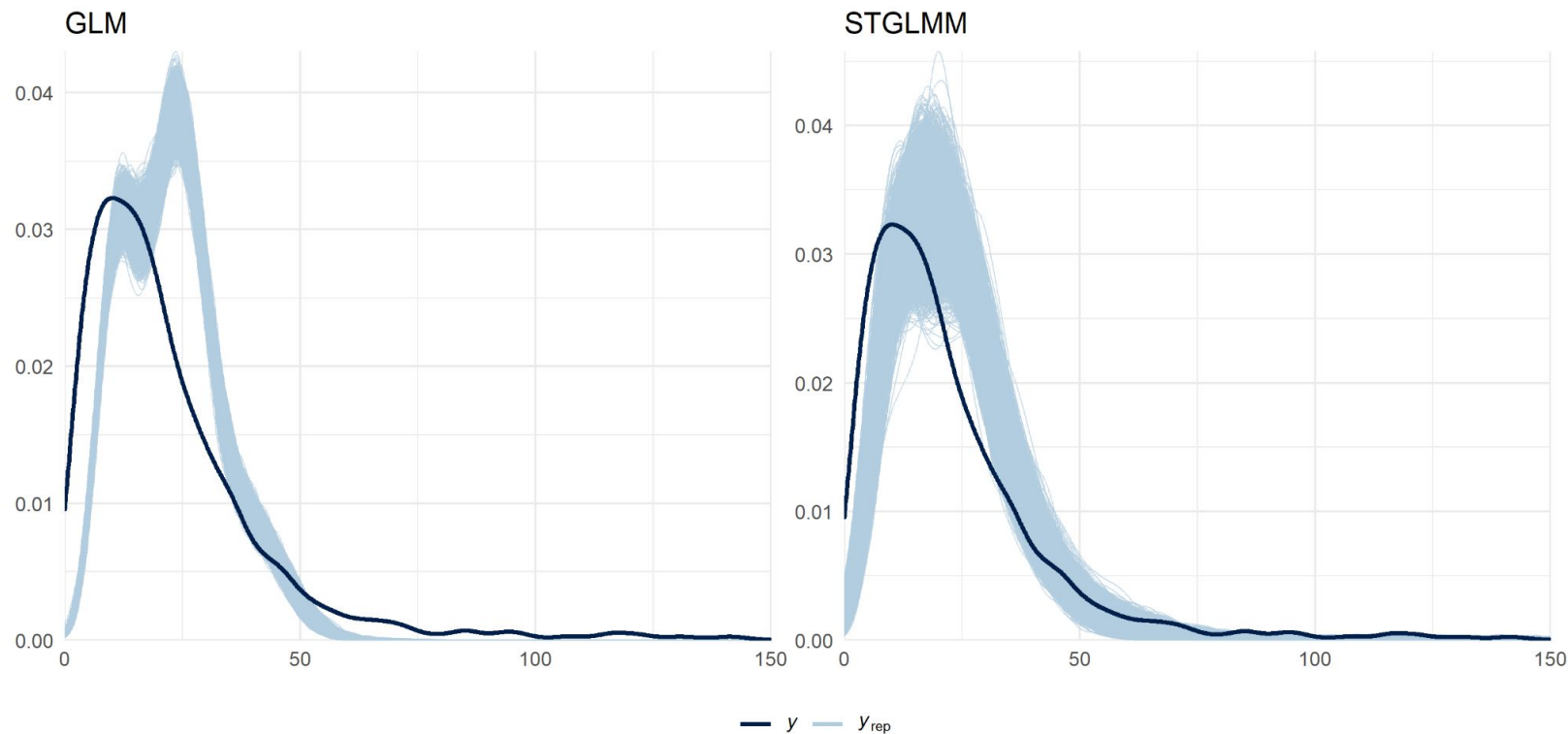


# Back to the Birds

Carolina Wrens, 1990



# Model Predictions



# Conclusions

- Model provides more reasonable variance estimates
- Takes half as long on this relatively small dataset

# Future Steps

- Spatial and temporal effect simplification underestimates variance
- Model fitting issues

# Final Remarks

- Dependent data are common, especially in ecology and epidemiology
- Assuming independence leads to wildly reduced variance estimates  
which can interfere with inference
- Working with spatiotemporal data is hard, especially at scale
- Active area of research, check back in a couple of years!



# Special Thanks:

My advisors, Professors Brianna Heggeseth and Alicia Johnson

Professor Holly Barcus

The MSCS Department

All of my friends, especially Conor Broderick