RADAR ANALYSIS OF BIRD MIGRATION STOPOVER SITES IN THE SOUTHEASTERN U.S.

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Introduction

- **Goal: To identify important stopover sites for migrant landbirds during spring and fall across the Southeastern US**
  - **Objective 1:** Determine the general patterns of movement across the region using the directional information derived from NEXRAD
  - **Objective 2:** Use data collected from eight NEXRAD stations to map important stopover sites within the viewshed of each radar station
  - **Objective 3:** Use the information from Objective 2 in conjunction with landscape metrics to develop statistical models of how bird density relates to habitat structure and composition
  - **Objective 4:** Use these statistical models to predict potentially important stopover sites in areas not represented by the radar

Methods

- **Objective 1: Directional Analysis**
  - Radar velocity data collected 3 hours after sunset
  - Mean direction calculated by weighting flight directions by target density at 20m altitudinal intervals
  - Program ORIANA used to calculate mean flight direction across nights for each season at each radar station

Methods

- **Objectives 2-4: Stopover Habitat Classification**
  - All data screened for bird migration, and then to remove nights with contamination by precipitation or any radar anomalies
  - Data corrected for range and solar biases using algorithms from Buler and Diehl (2009) and detection probability based on Buler and Dawson 2012.
  - For stopover modeling, all data resampled to 1km grid and subsampled to grid cells at least 5km apart to reduce spatial autocorrelation
  - Boosted Regression Trees chosen because of ability to model complex relationships between covariates and proven track record in predictive modeling
  - Parameterization of BRTs follows Elith and Leathwick 2008

Covariates

Variable name	Description	Mean value (range)
Hardwood Forest Edge	Proportion of Hardwood Forest Edge	0.2 (0.0 – 0.77)
Hardwood Forest Core	Proportion of Hardwood Forest Core	0.06 (0.0 – 1)
Pasture/Cultivated	Proportion of Pasture/Cultivated landcover class	0.19 (0.0 – 1)
Grassland	Proportion of Grassland landcover class	0.04 (0.0 – 1)
Open Space Edge	Proportion of Developed Open Space Edge	0.05 (0.0 – 0.78)
Open-space Core	Proportion of Developed Open Space Core	0.001 (0.0 – 0.9)
Developed Edge	Proportion of Developed (Low, Med, High) Edge	0.03 (0.0 – 0.76)
Developed Core	Proportion of Developed (Low, Med, High) Core	0.006 (0.0 – 1.0)
Canopy Height	Mean basal-weighted canopy height	85.32 (0.0 – 255.08)
Canopy Height Heterogeneity	Standard deviation of mean canopy height	60.38 (0.0 – 122.06)
NDVI	Mean Normalized Difference Vegetative Index	0.67 (0.0 – 0.91) (fall) 0.64 (0.0 – 0.9) (spring)
Distance to Coast	Distance to coast (km)	67.7 (0 – 287.5)
Relative Elevation	Elevation relative to surrounding landscape (3x3km window) (m)	4.39 (0.0 – 65.6)

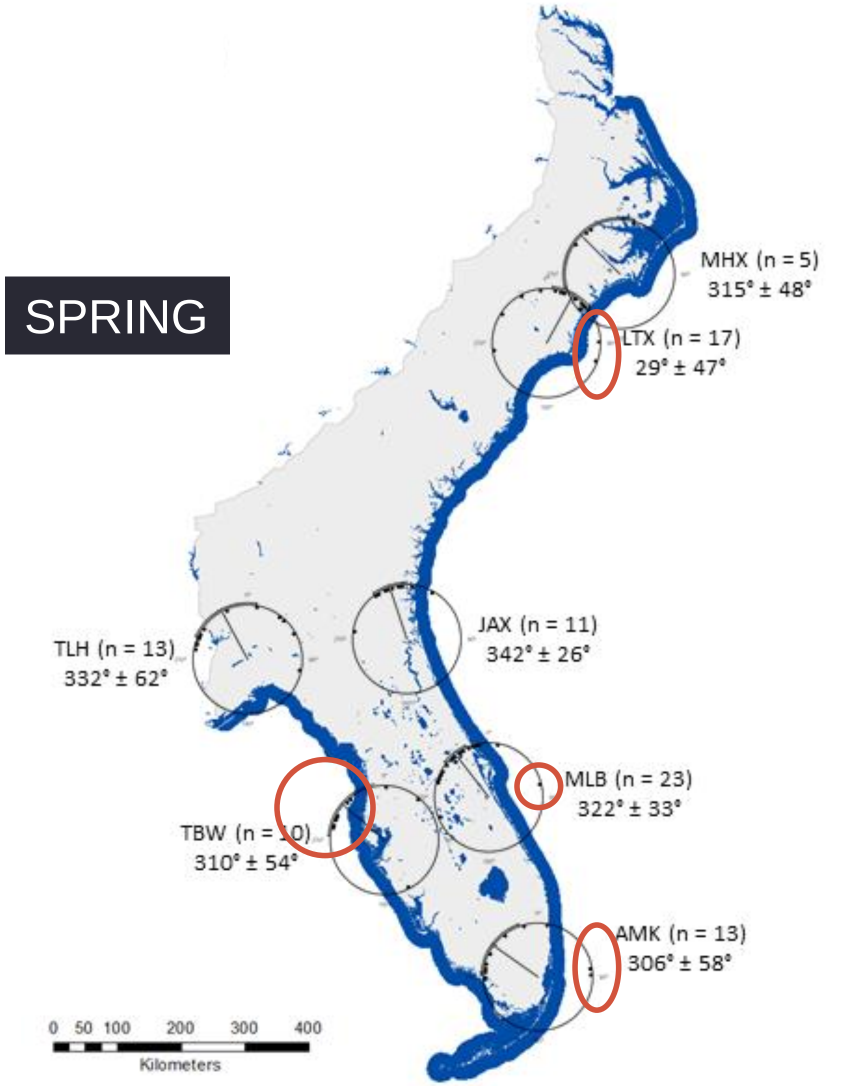
Boosted Regression Trees (BRT)

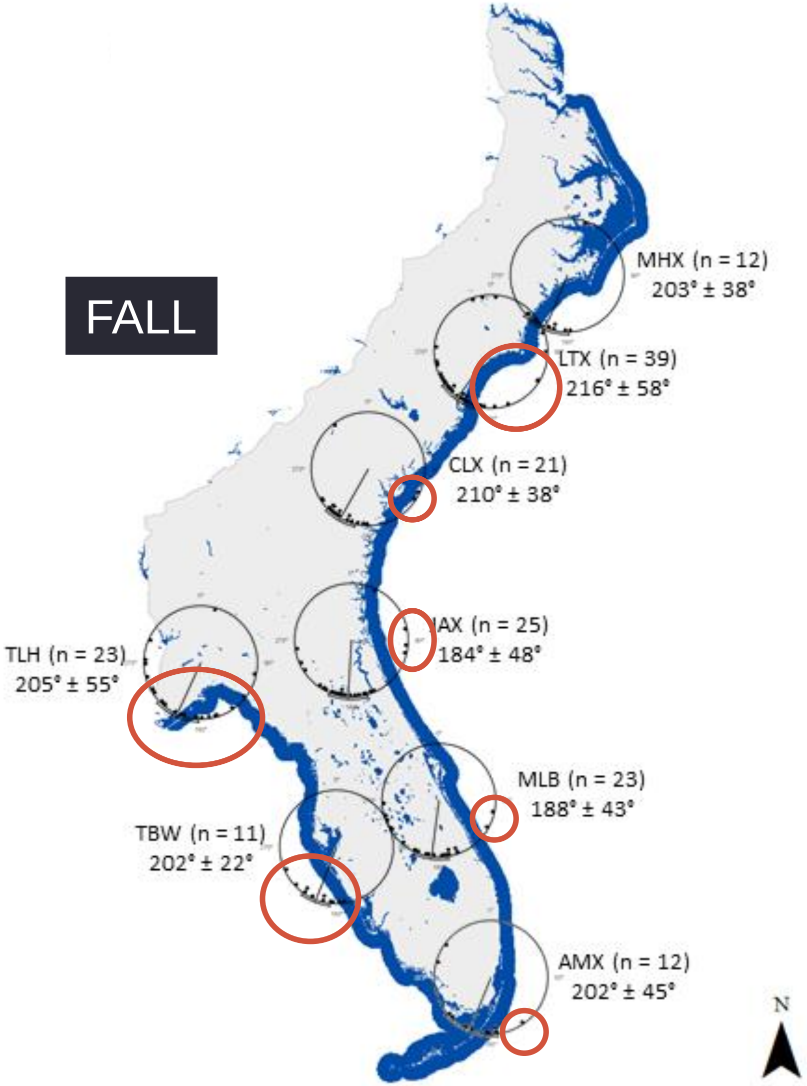
- **Background**
  - Combines statistical and machine-learning methods to increase predictive ability
  - Ability to model complex relationships, important when spatial nonstationarity is expected
  - Not as ‘black box’ as other modeling techniques
- **Parameterization** (follows Elith and Leathwick 2008)
  - Tree Complexity = 5
  - Bag Fraction = 0.75 (25% of data reserved for cross validation)
  - Learning Rate = adjusted to reach >1000 trees in final model
- Models
  - Spring and Fall for Region, BCR27 and BCR31 (total of 6 models)

RESULTS

Flight Direction

Mean flight direction



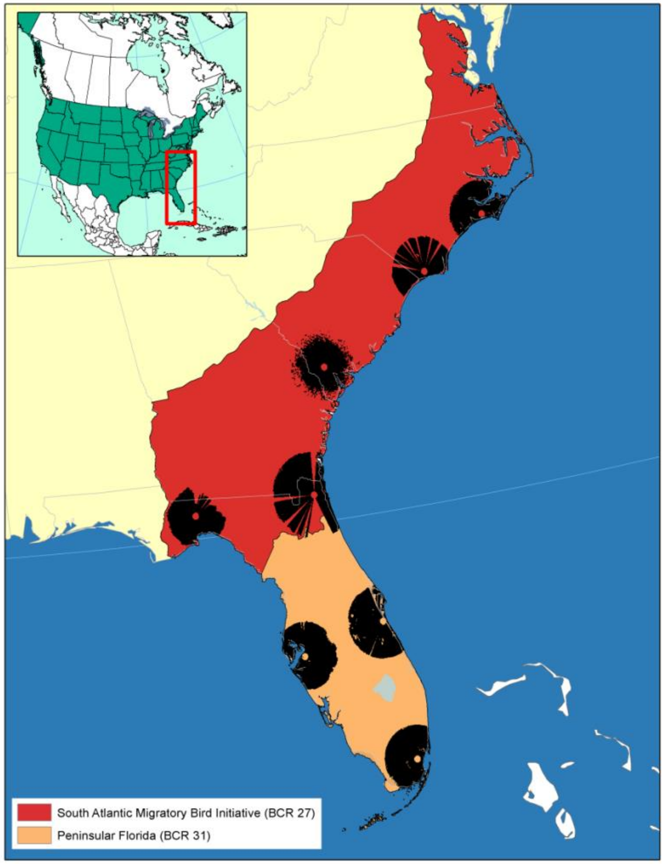


RESULTS

Observed and Modeled Stopover Habitat

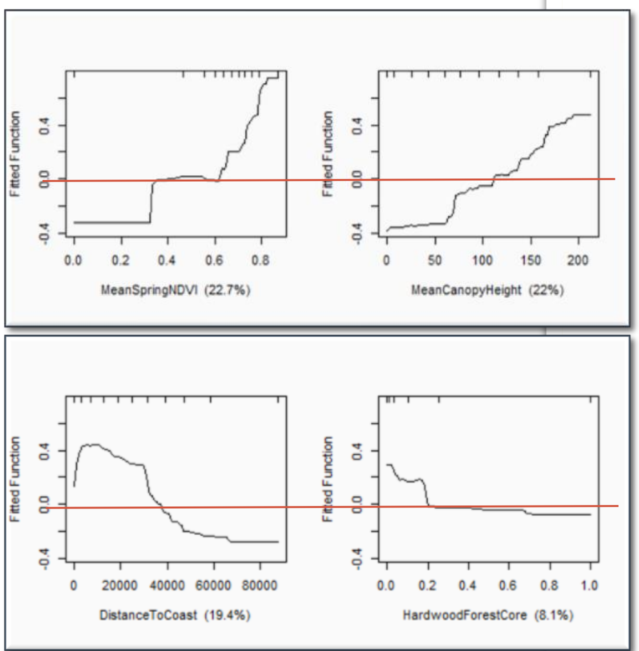
Spring (2009, 2010)

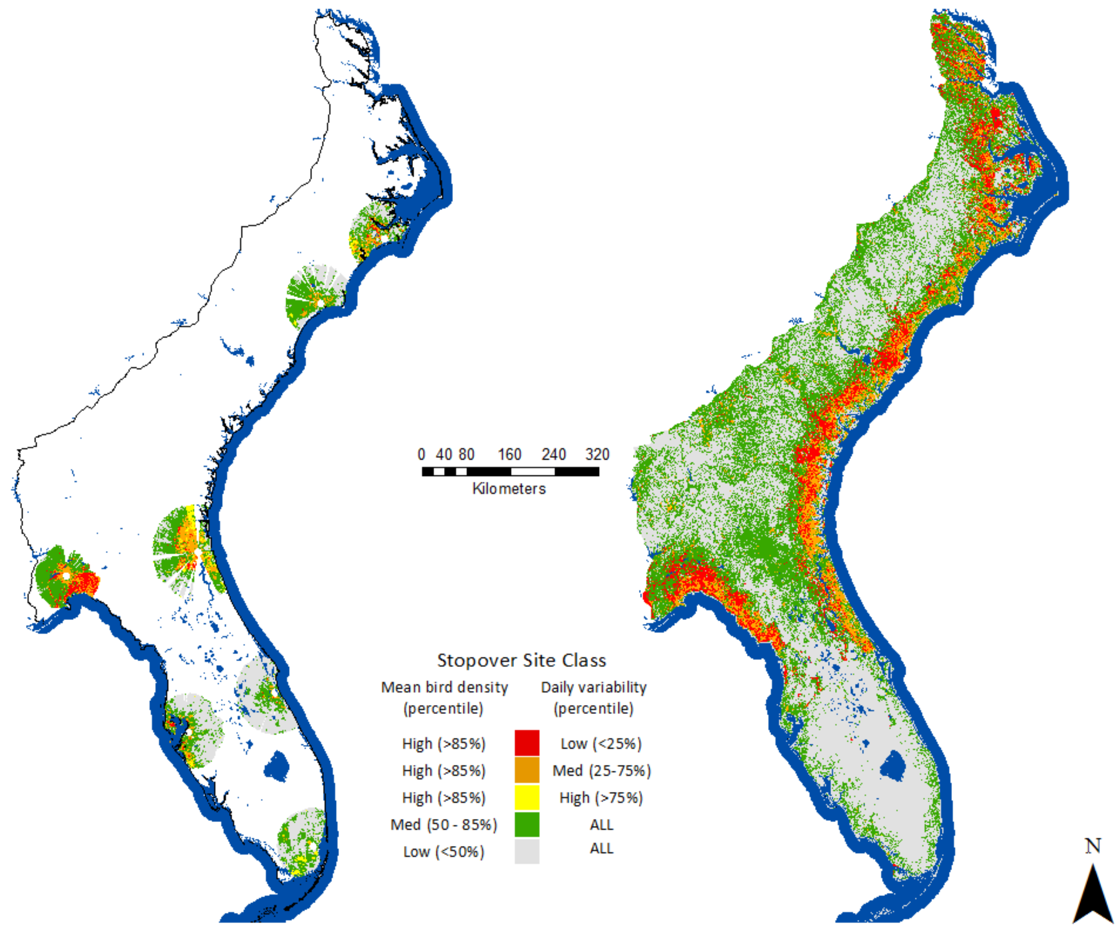
- Nights of usable data:
  - Min: 5 (Morehead City, NC)
  - Max: 23 (Melbourne, FL)
  - Mean: 13
- Area covered by radar: 18%



Spring Regional

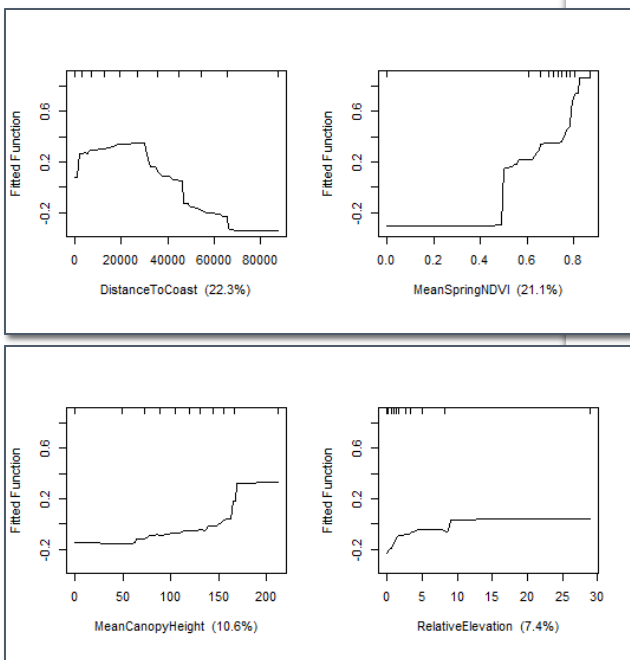
High bird densities are associated with increasing productivity (NDVI > 0.6), increasing canopy height (>10m), between 5 and 15 km from the coast and with low proportion of HWF core



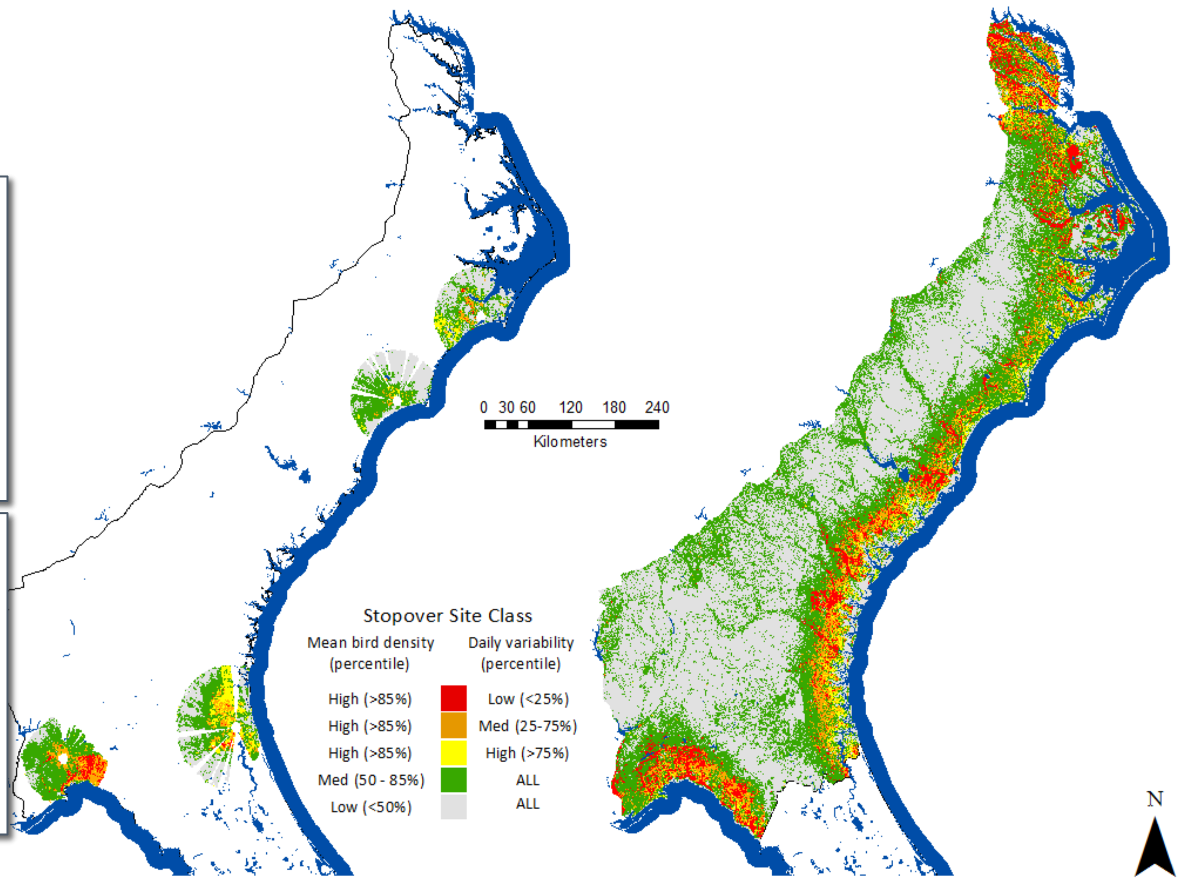


Deviance Explained: 35%

Spring
BCR 27

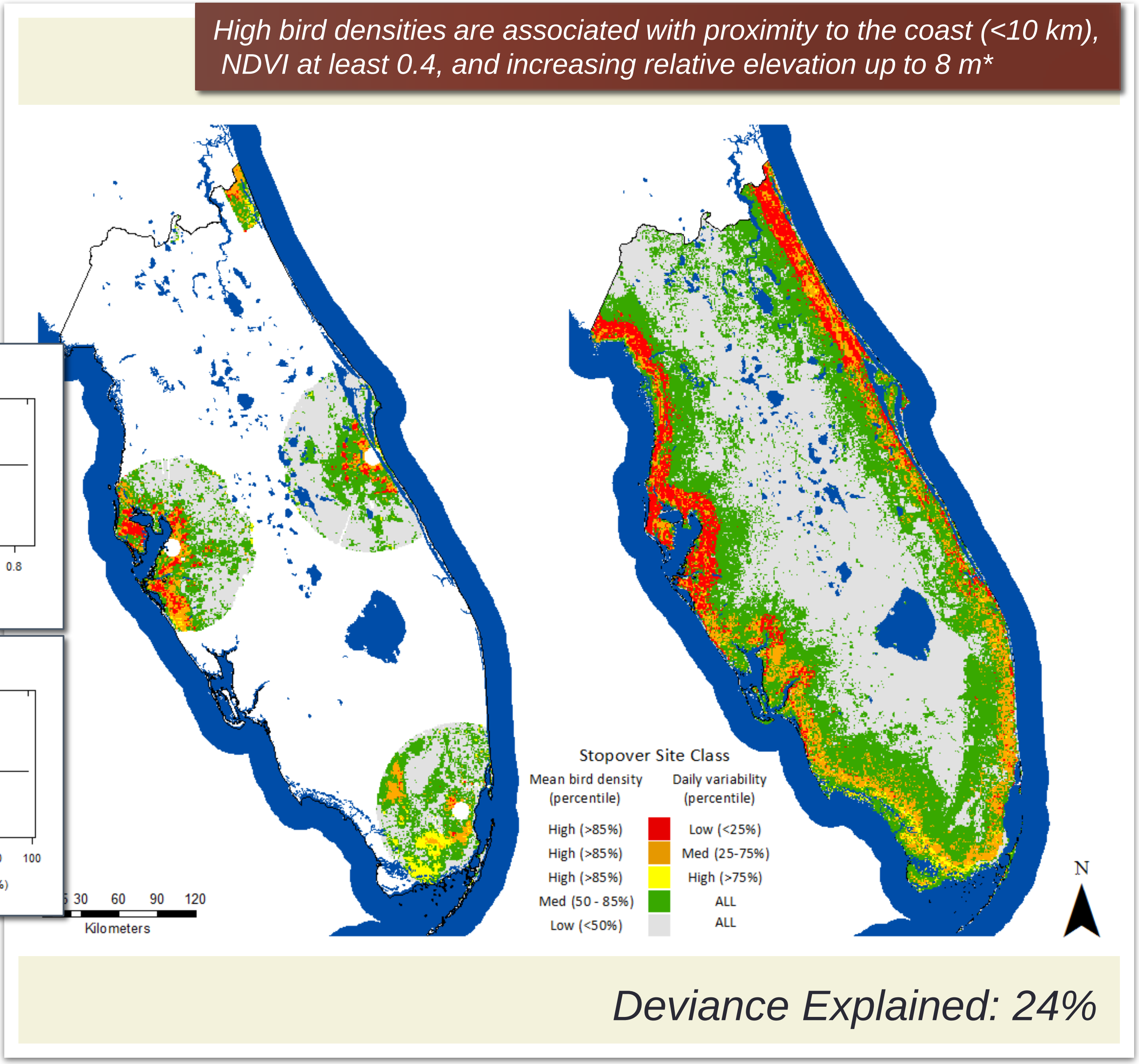


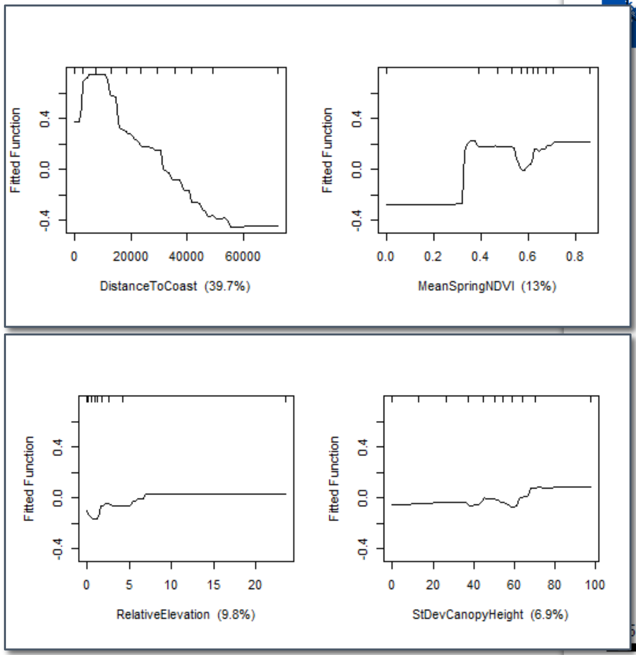
High bird densities are associated with proximity to the coast (<30 km), NDVI > 0.5, and mean canopy height > 15m



Deviance Explained: 20%

Spring
BCR 31

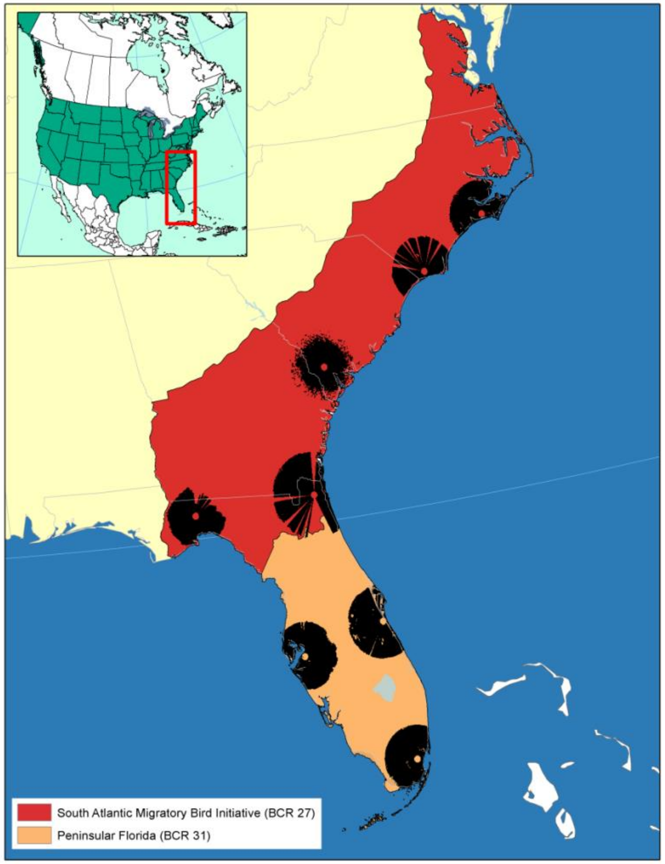




Fall (2008, 2009)

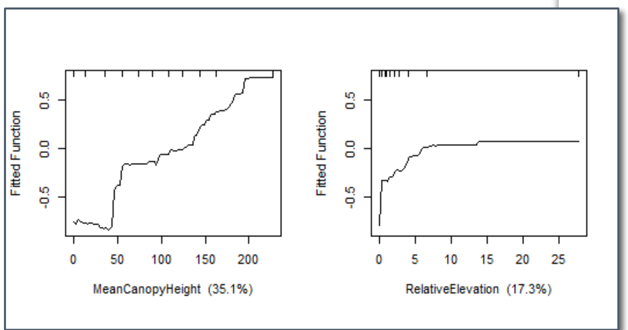
- Nights of usable data:
  - Min: 12 (Morehead City, NC & Miami, FL)
  - Max: 38 (Wilmington, NC)
  - Mean: 22

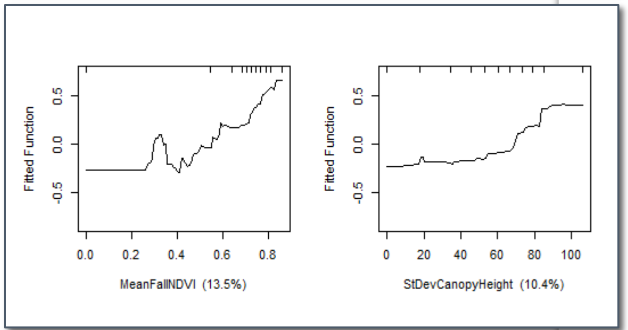
- Area covered by radar: 24%

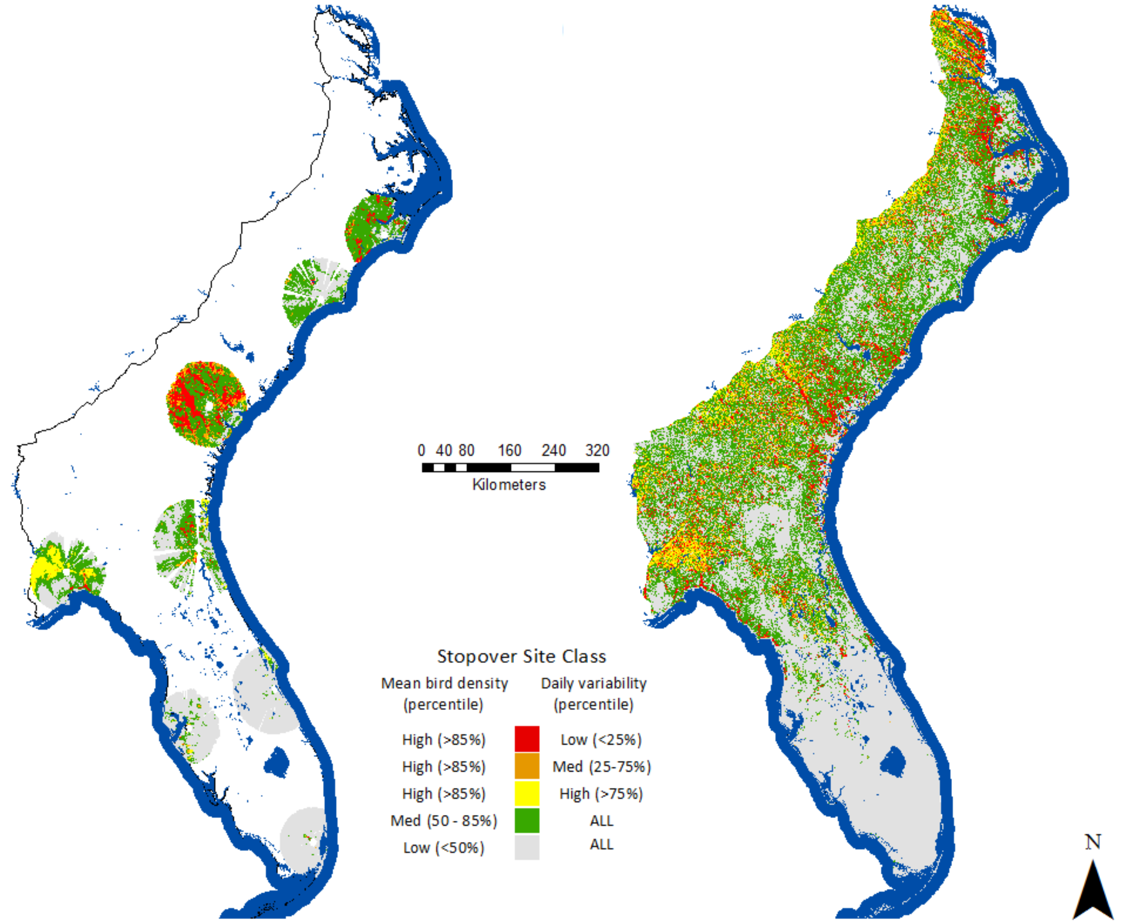


Fall Regional

High bird densities are associated with increasing canopy height (>5 m), increasing relative elevation and moderate (>0.3) to high (>0.5) NDVI and high levels of canopy heterogeneity



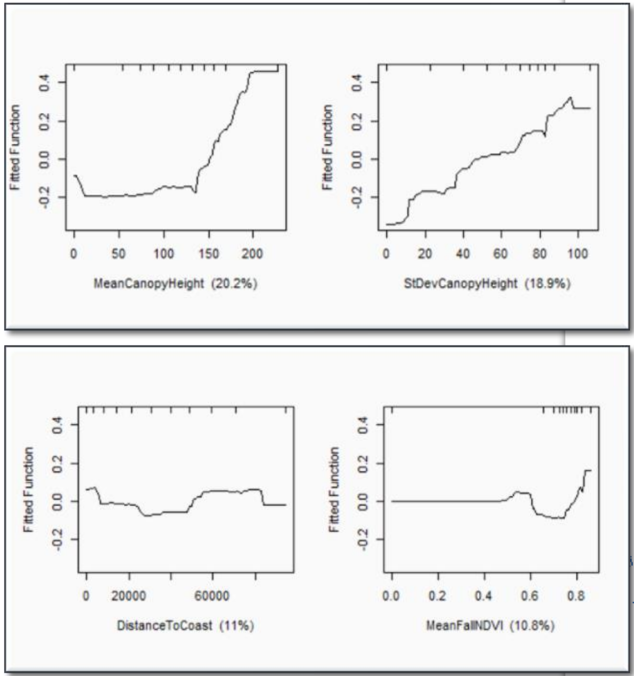


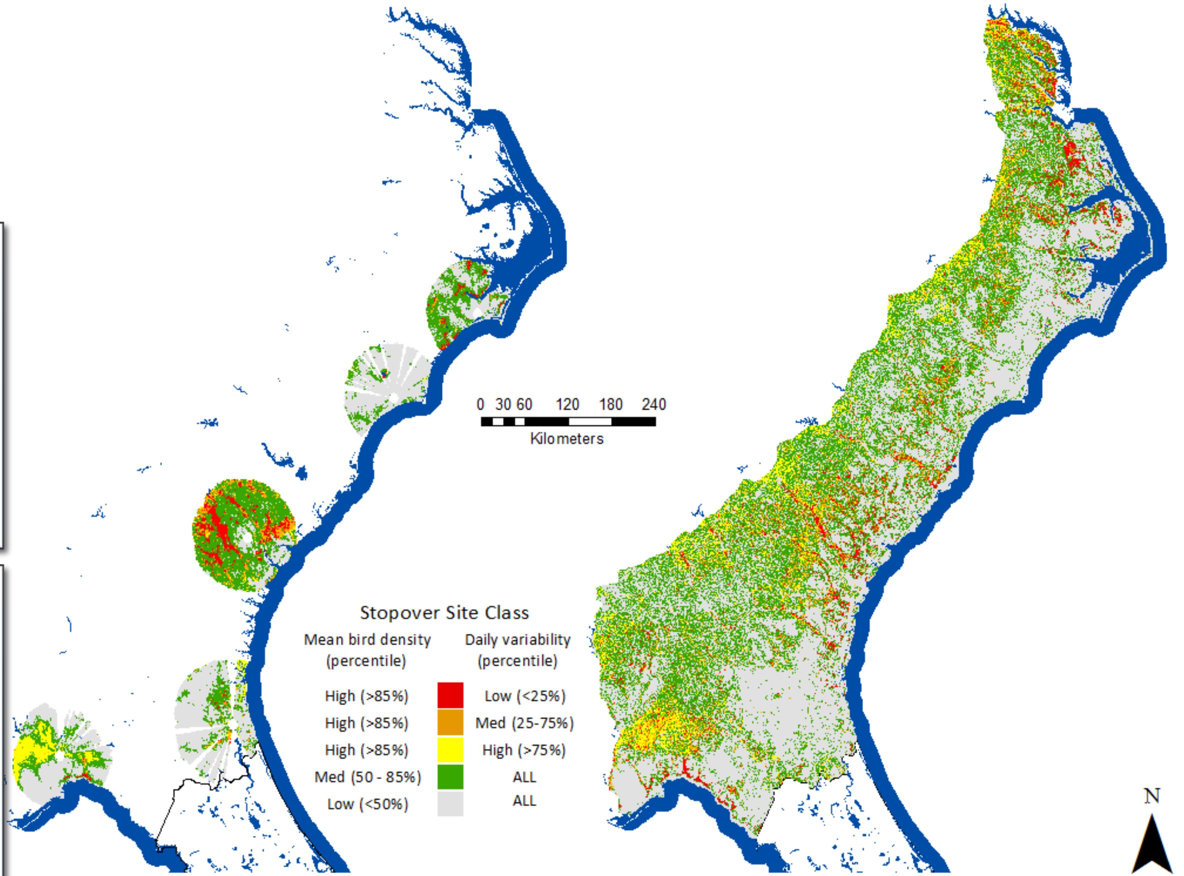


Deviance Explained: 62%

High bird densities are associated with a tall and complex forest structure, with larger trees (>15 m) and increased heterogeneity (>50). Two zones of importance were at the immediate coast to 5 km, then again 50-80 km from shore. High levels of NDVI (>0.7) were also associated with high bird density

Fall
BCR 27

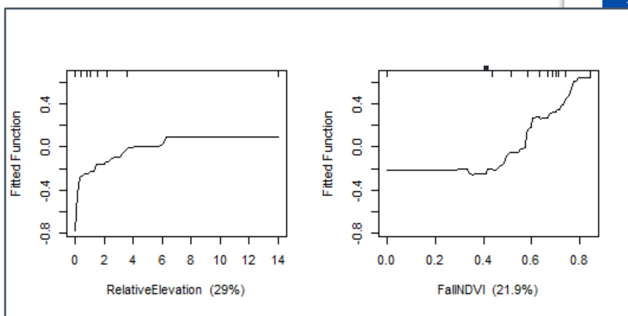


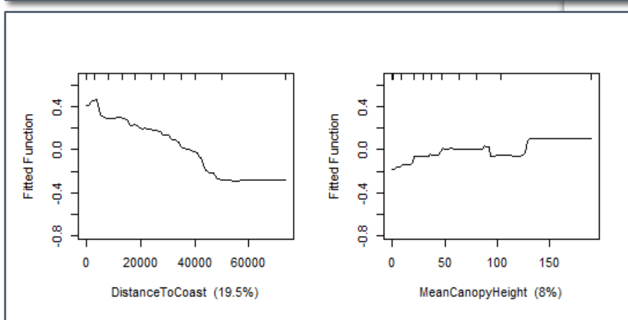


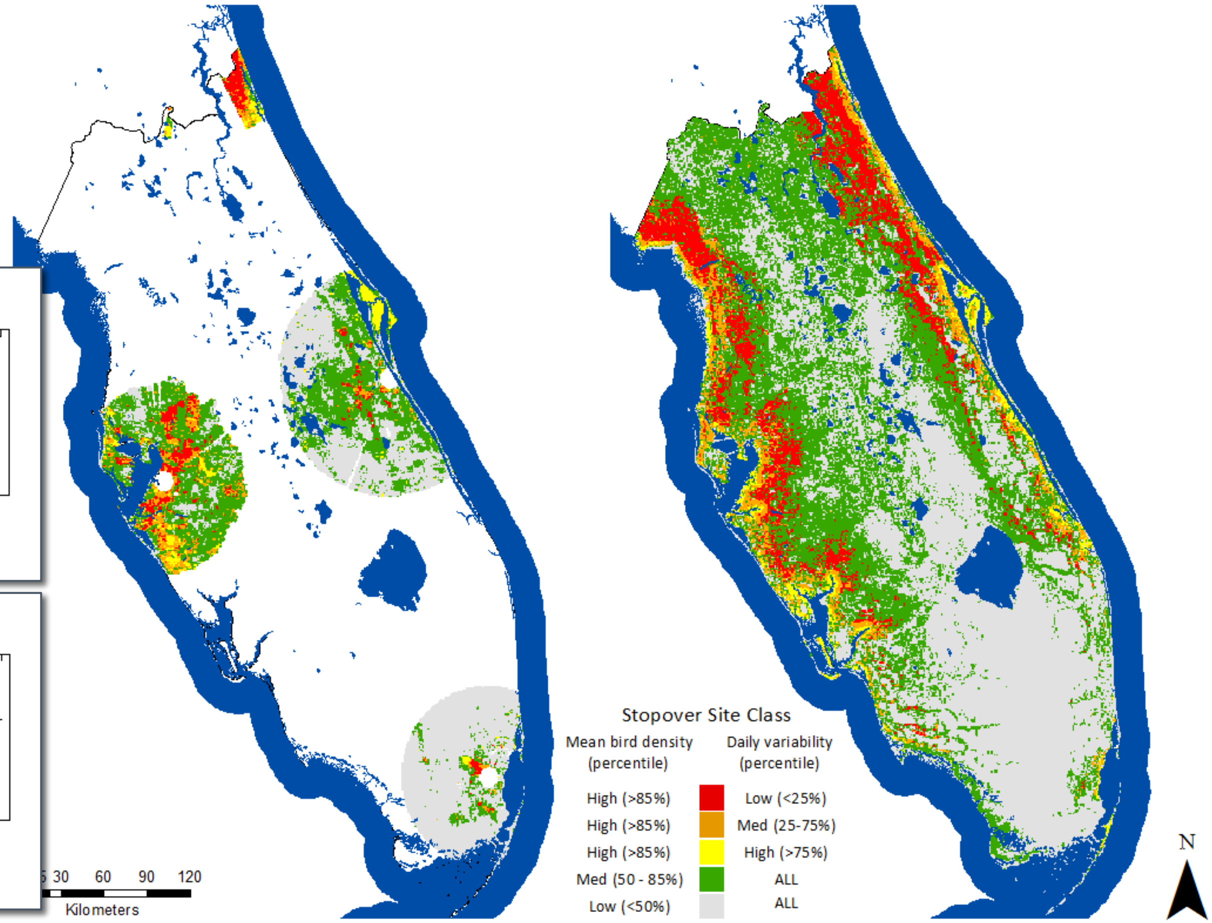
Deviance Explained: 23%

High bird stopover density is associated with increased relative elevation, moderate to high primary productivity (NDVI >0.6), and closer proximity to the coast (highest within 5 km)

Fall
BCR 31







Deviance Explained: 38%

Conclusions

- **Directional Analysis**
  - Birds tend to follow expected routes over land
  - Some examples of Trans-Atlantic flight
  - Basic route supports disparity in density during fall between BCRs
- **Stopover Habitat Identification**
  - Observed data provides the best identification for those areas within view of the radar
  - Models suggest that mean canopy height, canopy height heterogeneity, NDVI, distance to coast and relative elevation are most important predictors at the landscape scale
  - Predictive models provide guidance for conservation of important stopover sites across the broader Southeastern US
  - Spatial nonstationarity still present at both scales which may argue for some small scale modeling efforts and novel techniques

DELIVERABLES

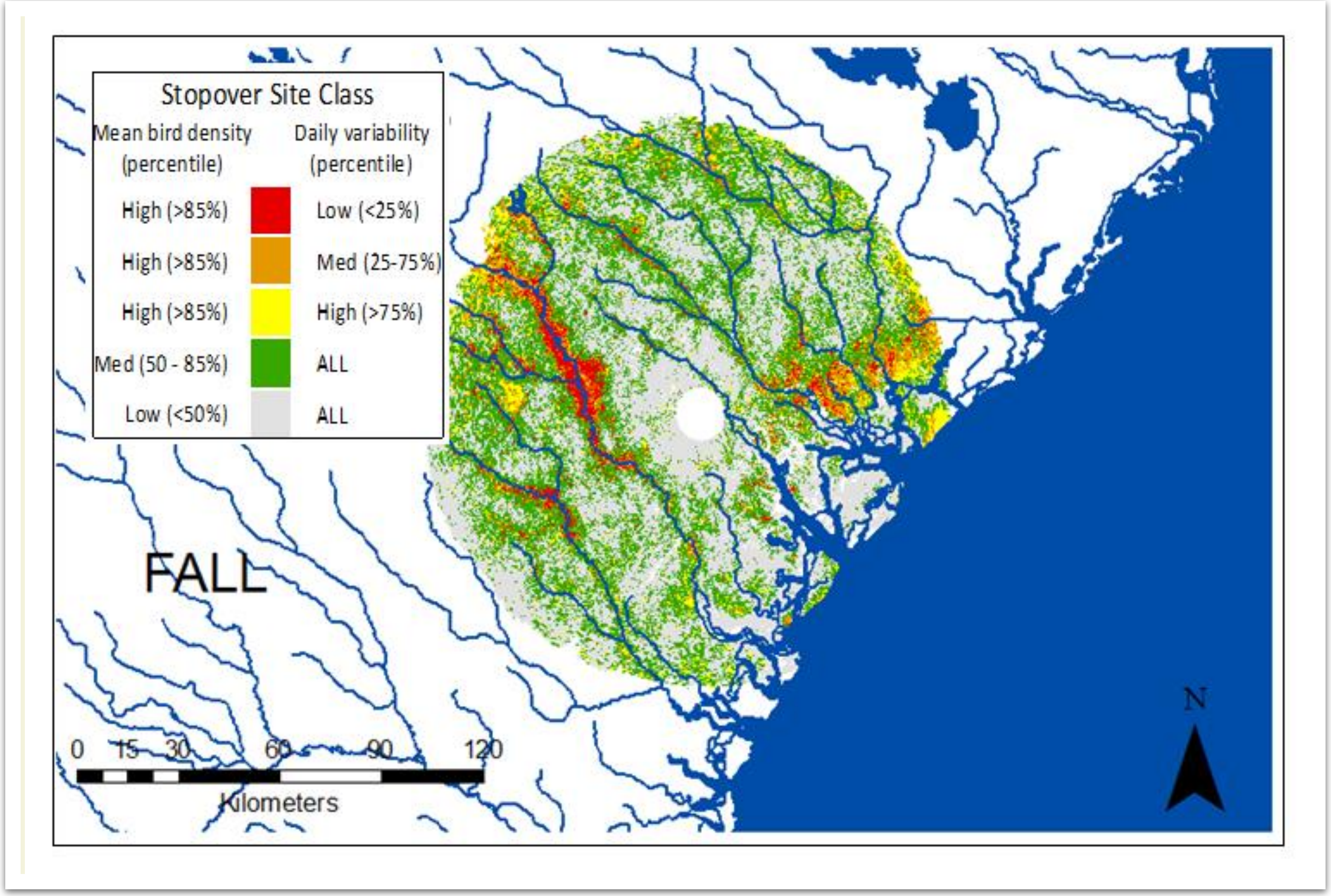
Observed Data

Spatial resolution = variable based on polar grid (250 m in length, 1° width)

Layer package

Shapefile

Each station individually



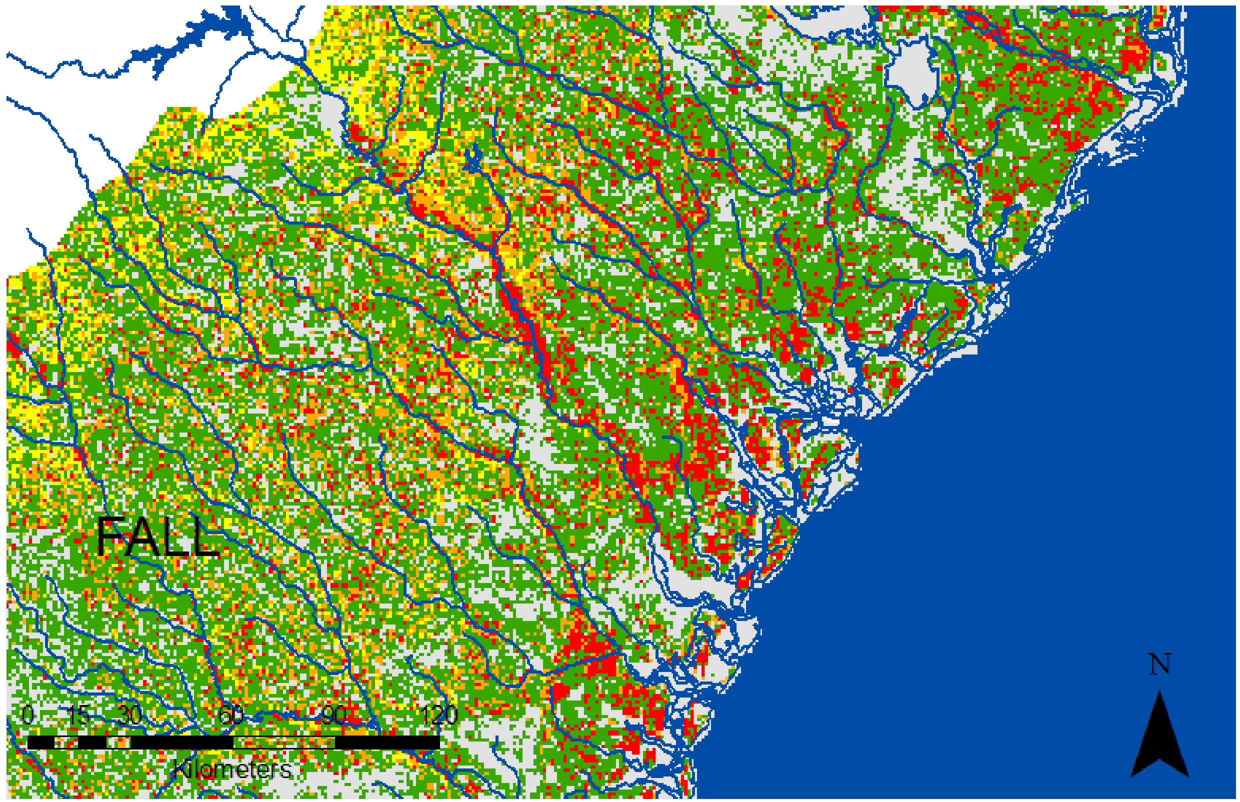
Modeled Data

Spatial resolution = 1 km

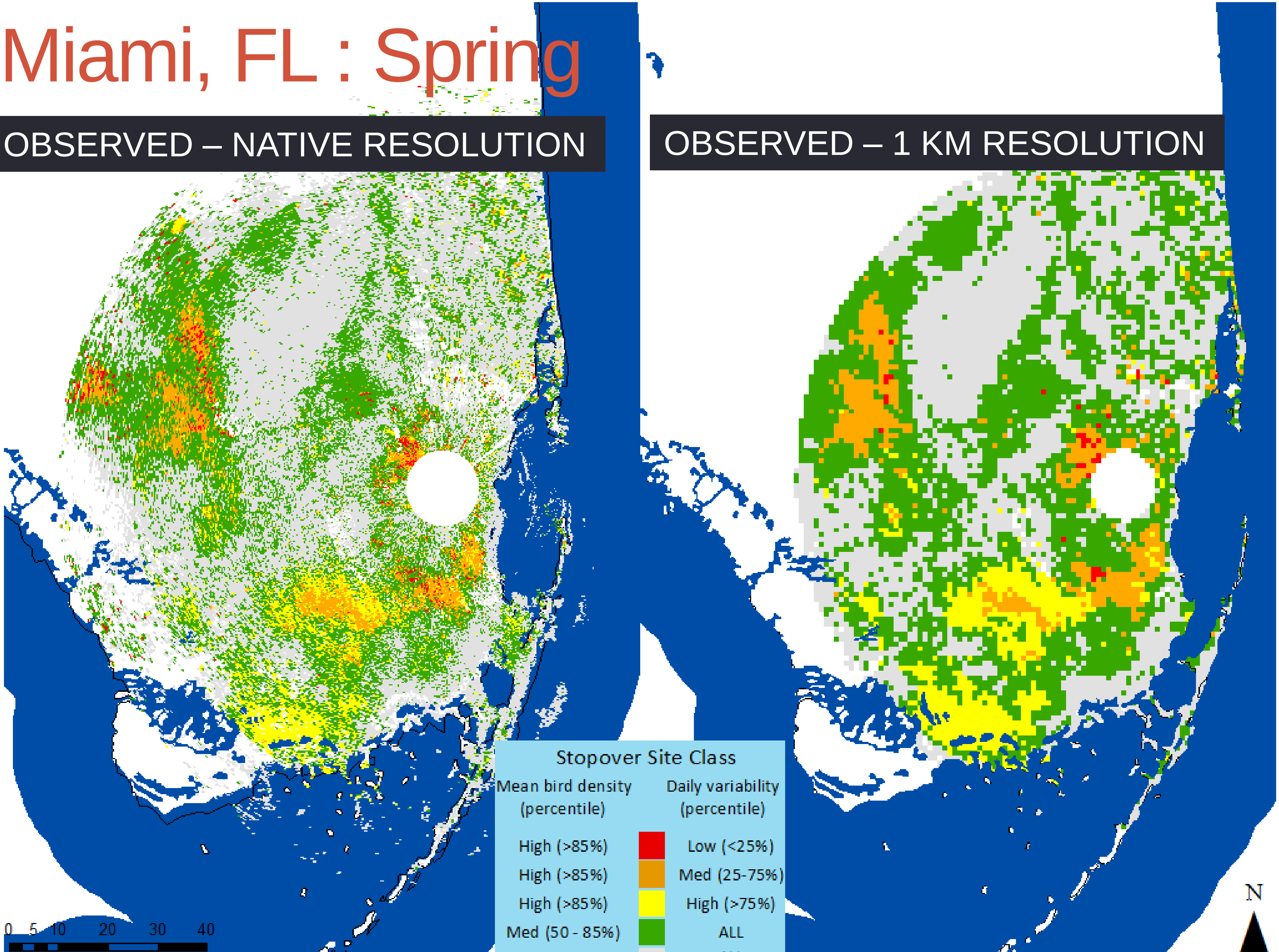
Regional and BCR-specific model outputs

Spring and Fall

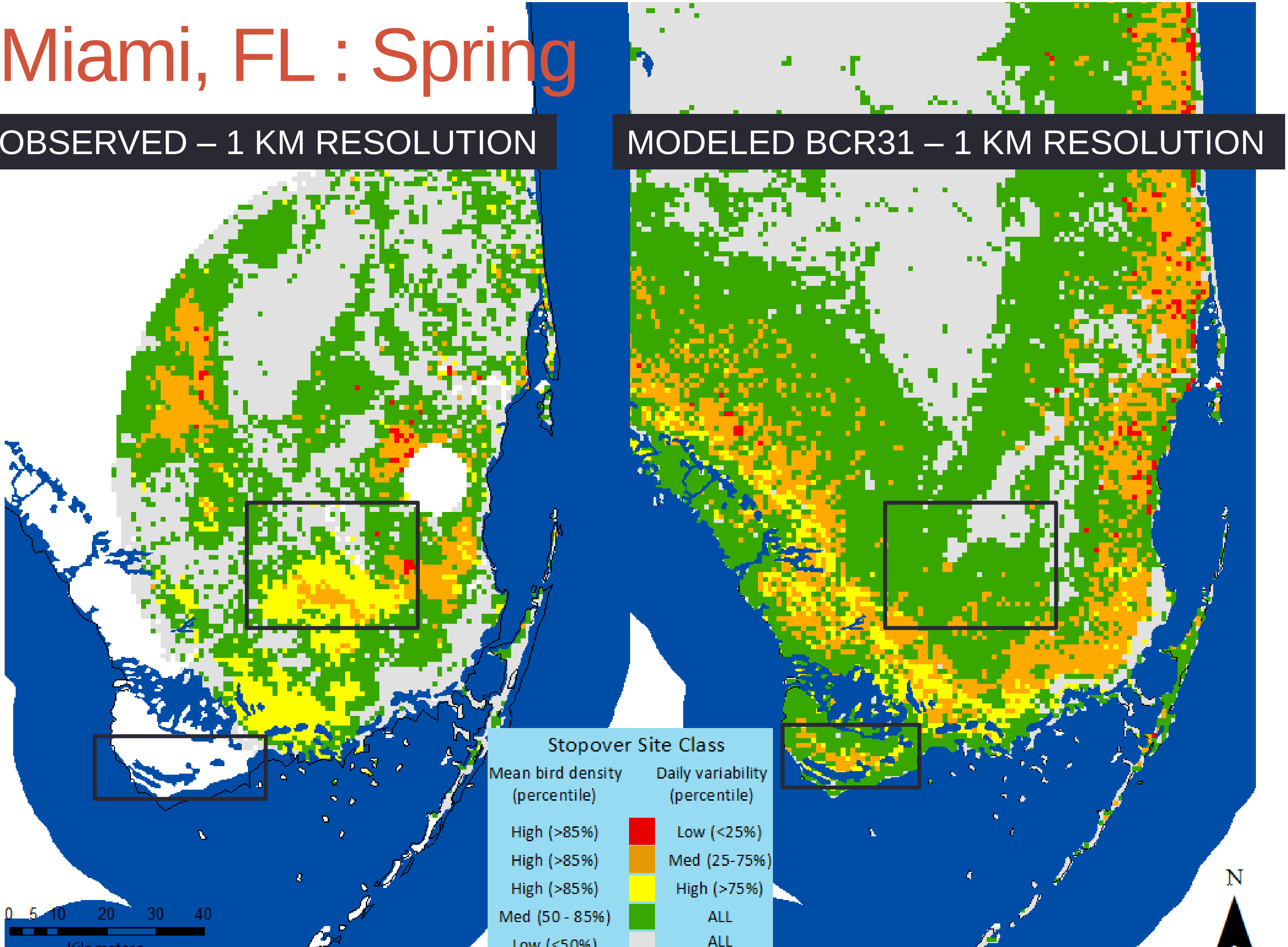
Attributes include observed values for all cells where data was observed



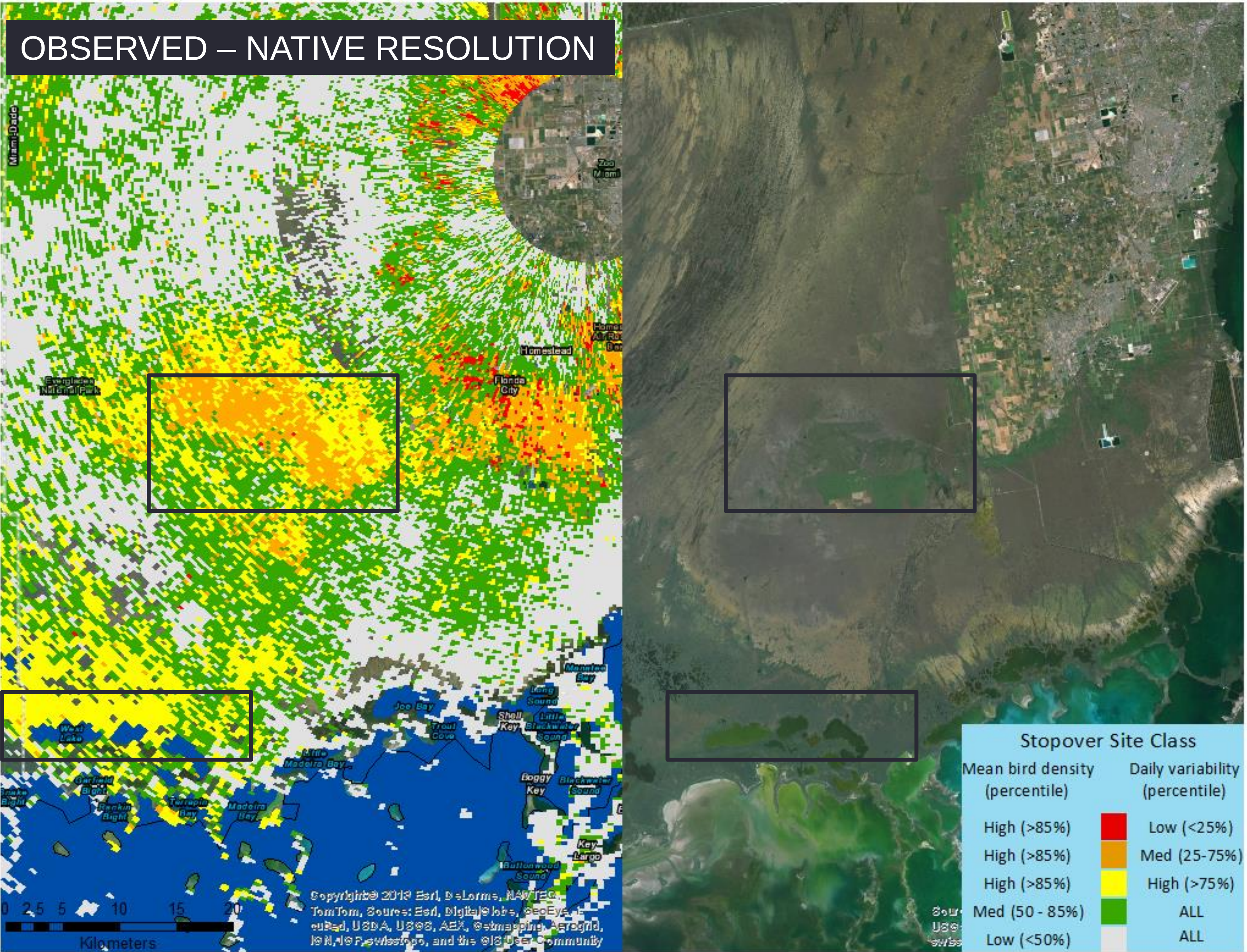
Miami, FL : Spring



Miami, FL : Spring

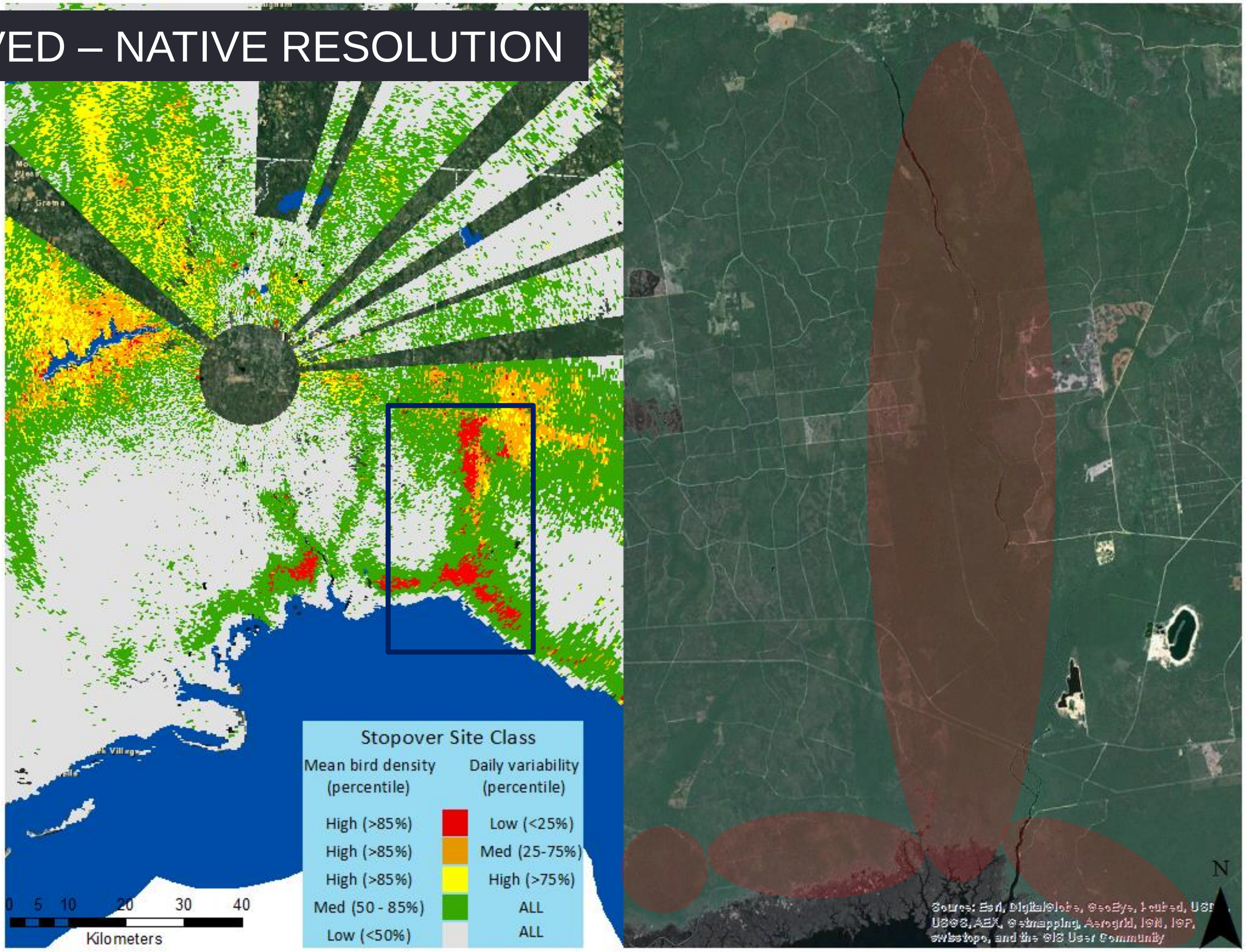


OBSERVED – NATIVE RESOLUTION



Tallahassee, FL : Fall

OBSERVED – NATIVE RESOLUTION



Future Directions

- Modeling
  - Spatial nonstationarity still an issue
  - Some options include ensemble modeling such as STEM

- Groundtruthing
  - Need to verify models in the field
  - Various methods, from traditional field surveys to using eBird data

Acknowledgements

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