Applying hierarchical distance sampling in 'unmarked' to Iowa forest birds

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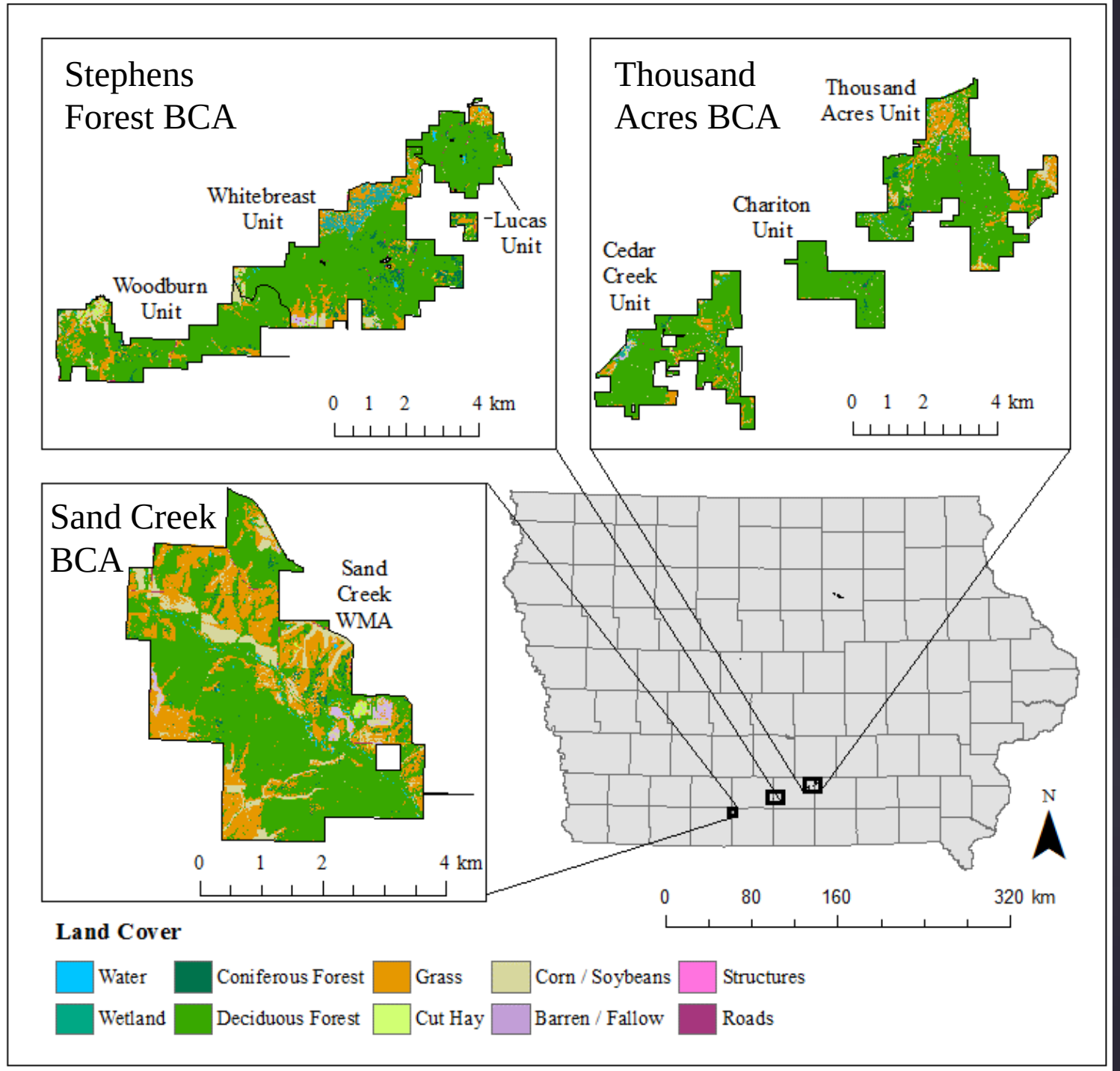
Study Objectives

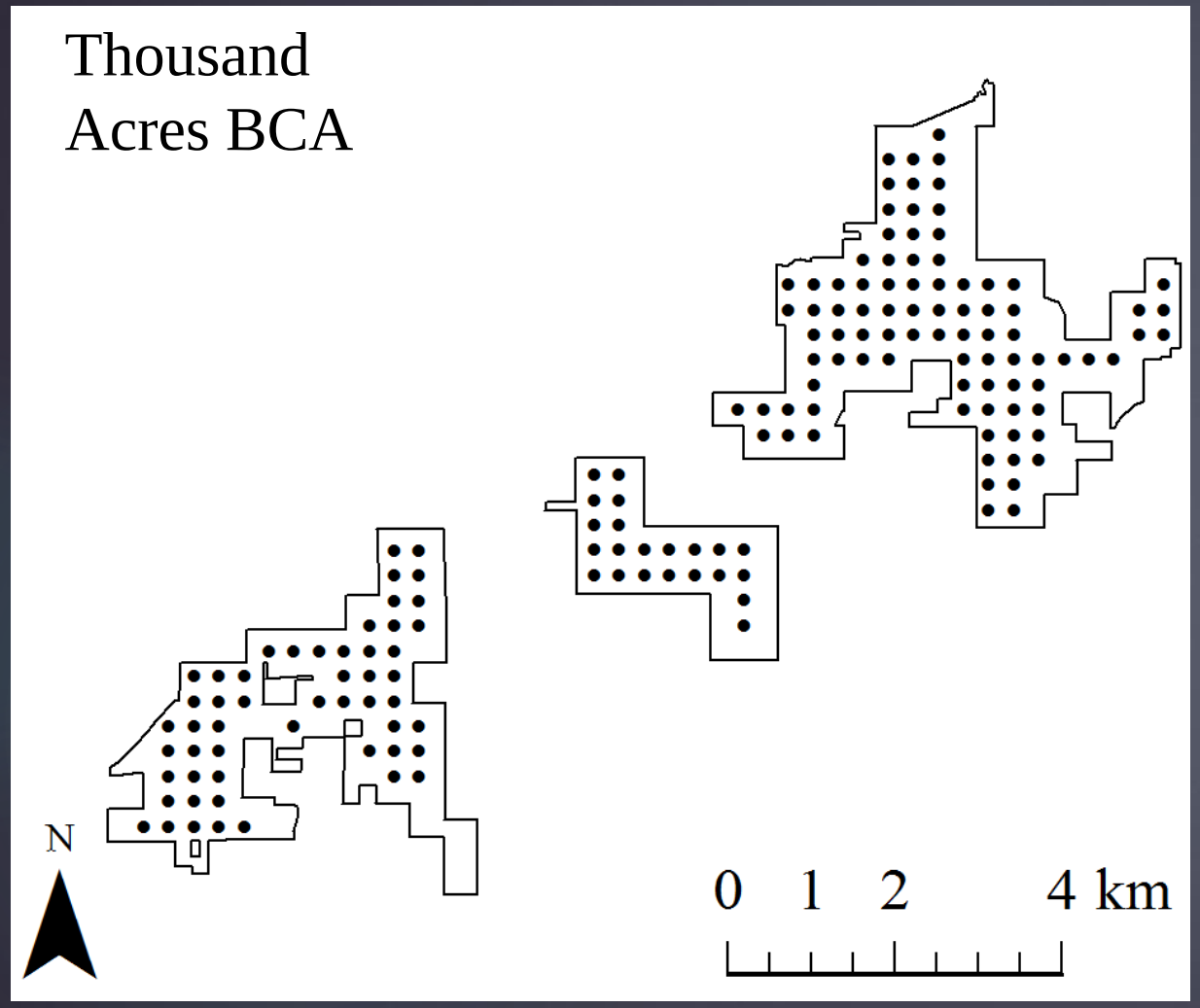

Acadian Flycatcher

- Estimate densities of bird species of conservation concern in south-central Iowa forests
- Determine relationships between habitat characteristics and bird densities to potentially inform management

Study Area

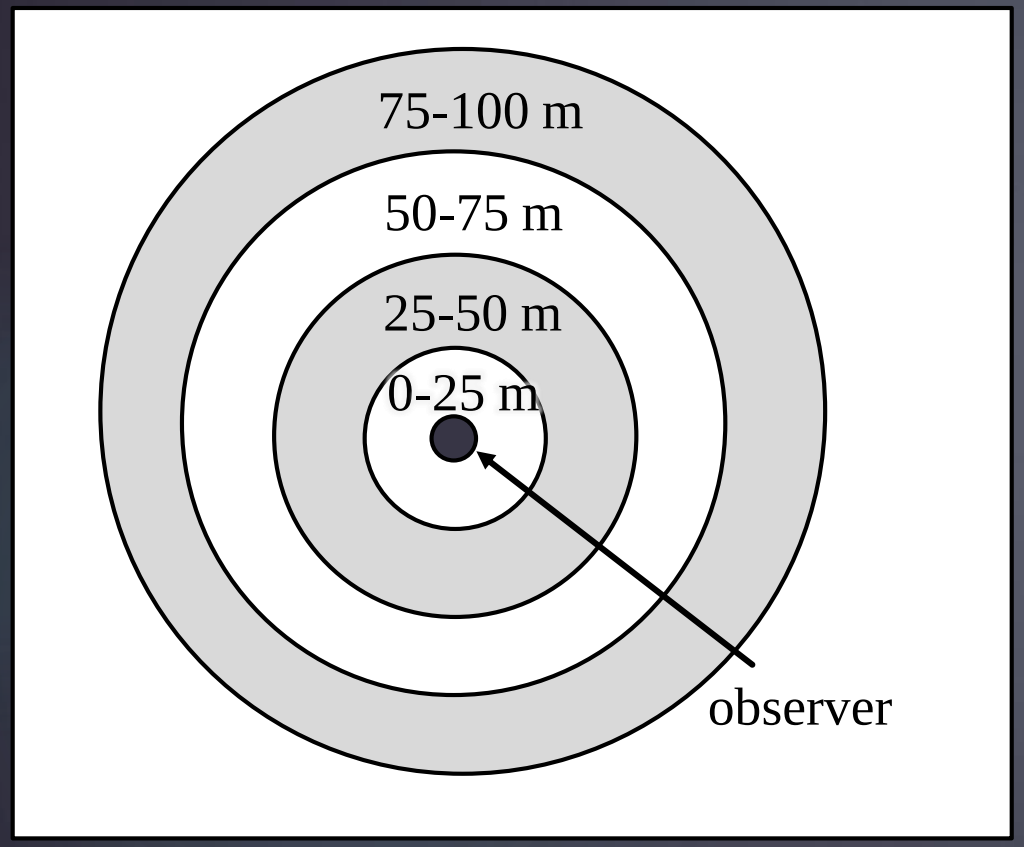

Stephens Forest BCA
Whitebreast Unit
Lucas Unit
Woodburn Unit
0 1 2 4 km
Thousand Acres BCA
Thousand Acres Unit
Chariton Unit
Cedar Creek Unit
0 1 2 4 km
Sand Creek BCA
Sand Creek WMA
0 1 2 4 km
N
0 80 160 320 km
Land Cover
Water
Coniferous Forest
Grass
Corn / Soybeans
Structures
Wetland
Deciduous Forest
Cut Hay
Barren / Fallow
Roads

Bird Point Counts



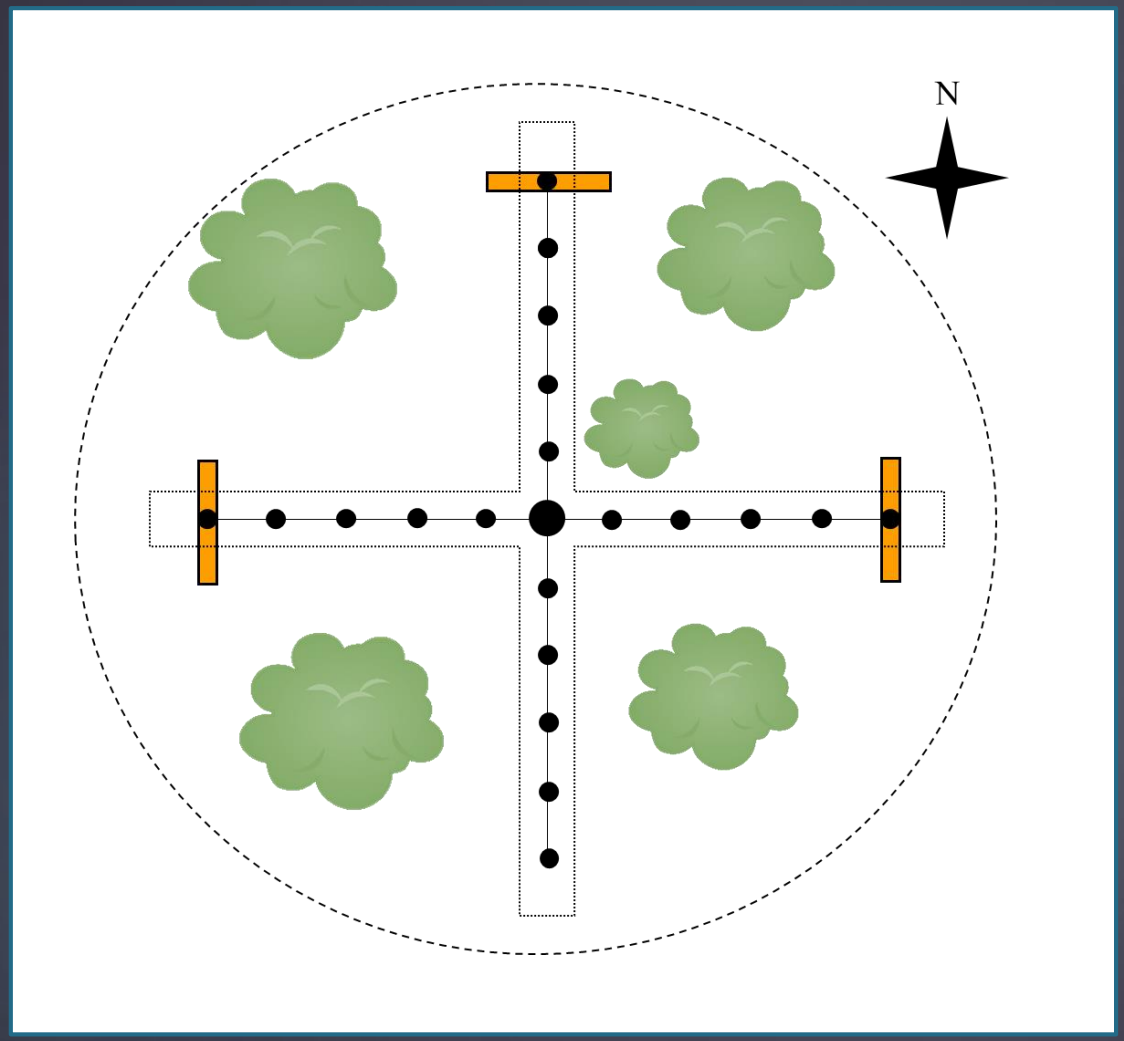
- 493 points
- 2016-2019
- Two visits/year during breeding season

Bird Point Counts



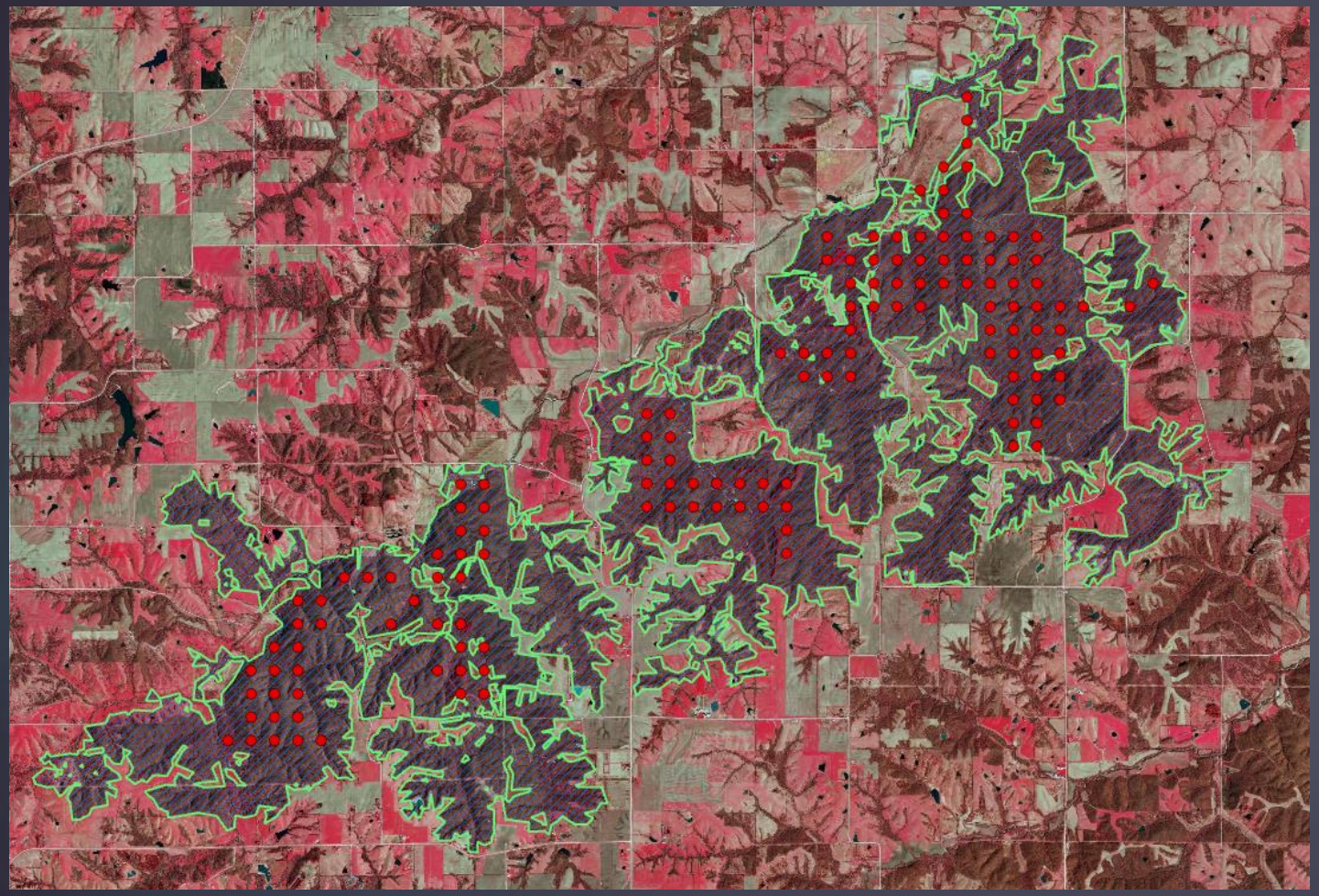
- Distance sampling
  - 4 bins
  - 100 m truncation
  - 10 minutes
  - No visual only or known female observations

Vegetation Surveys



- 493 points (same as bird surveys)
- July – August 2019
- Forestry prism sample, ground cover, shrub stems

Landscape Scale Data



- Cropscape data and ArcGIS used to estimate % forest cover within 1 and 10 km of point
- Digitized 2016-2018 Iowa Spring Color Infrared Orthophotos to get forest patch boundaries (Cropscape as an initial template)

Data Analysis Conundrum

- It is virtually impossible to detect all of the birds at a site
- Need fancy(ish) statistics to get good estimates of densities, and even fancier statistics to related density to habitat

Detection Process

PRESENCE

Bird needs to occupy the site in the first place

AVAILABILITY

Bird needs to make itself available for detection (e.g., it sings)

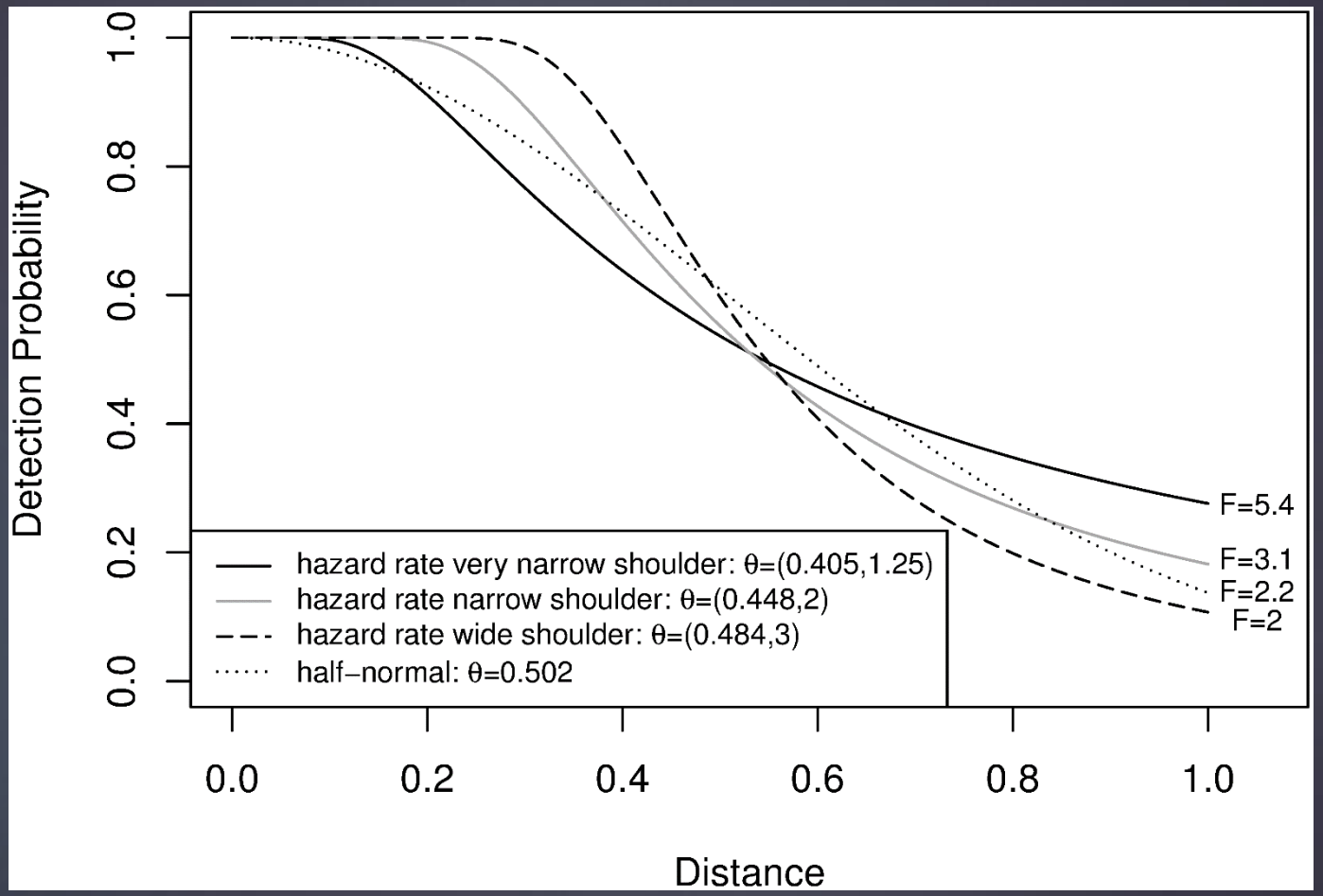
DETECTABILITY

Given the bird is available, an observer needs to detect it

Modeling detectability

- Detectability can be modeled using distance sampling
  - Most commonly used for birds and marine mammals, but can be applied to many other taxa (e.g., herps)
  - Detection probability (p) declines with distance
  - Different functions can be used to describe the decline in detection probability
  - Can include covariates (e.g., observer, wind speed)
  - R packages: ‘unmarked’, ‘detect’, ‘Distance’

Detection functions



Clark, R.G., 2016. Statistical efficiency in distance sampling. *PloS One*, *11*(3).

Selecting detection functions and detection covariates for distance sampling in ‘unmarked’

Modeling availability

- At least two different sampling schemes
  - Multiple visits: N-mixture models or hierarchical distance sampling incorporate this ('unmarked' can do both)
  - Removal sampling
    - Chunk a point count into multiple time bins, once you hear a bird don't count it in later time bins (thus "removing" it)
    - Implemented for point counts in R package 'detect;' can be combined with distance sampling
- Covariates can include things like time of year and time of day
- Combining multiple visits AND removal sampling with distance in a non-Bayesian framework is difficult (no good way to do this in R)
- Reference for removal sampling in 'detect': Sólymos, P., Matsuoka, S.M., Bayne, E.M., Lele, S.R., Fontaine, P., Cumming, S.G., Stralberg, D., Schmiegelow, F.K. and Song, S.J., 2013. Calibrating indices of avian density from non-standardized survey data: Making the most of a messy situation. *Methods in Ecology and Evolution*, *4*(11), pp.1047-1058.

Incorporating availability covariates into hierarchical distance sampling in ‘unmarked’

Modeling abundance (or density)

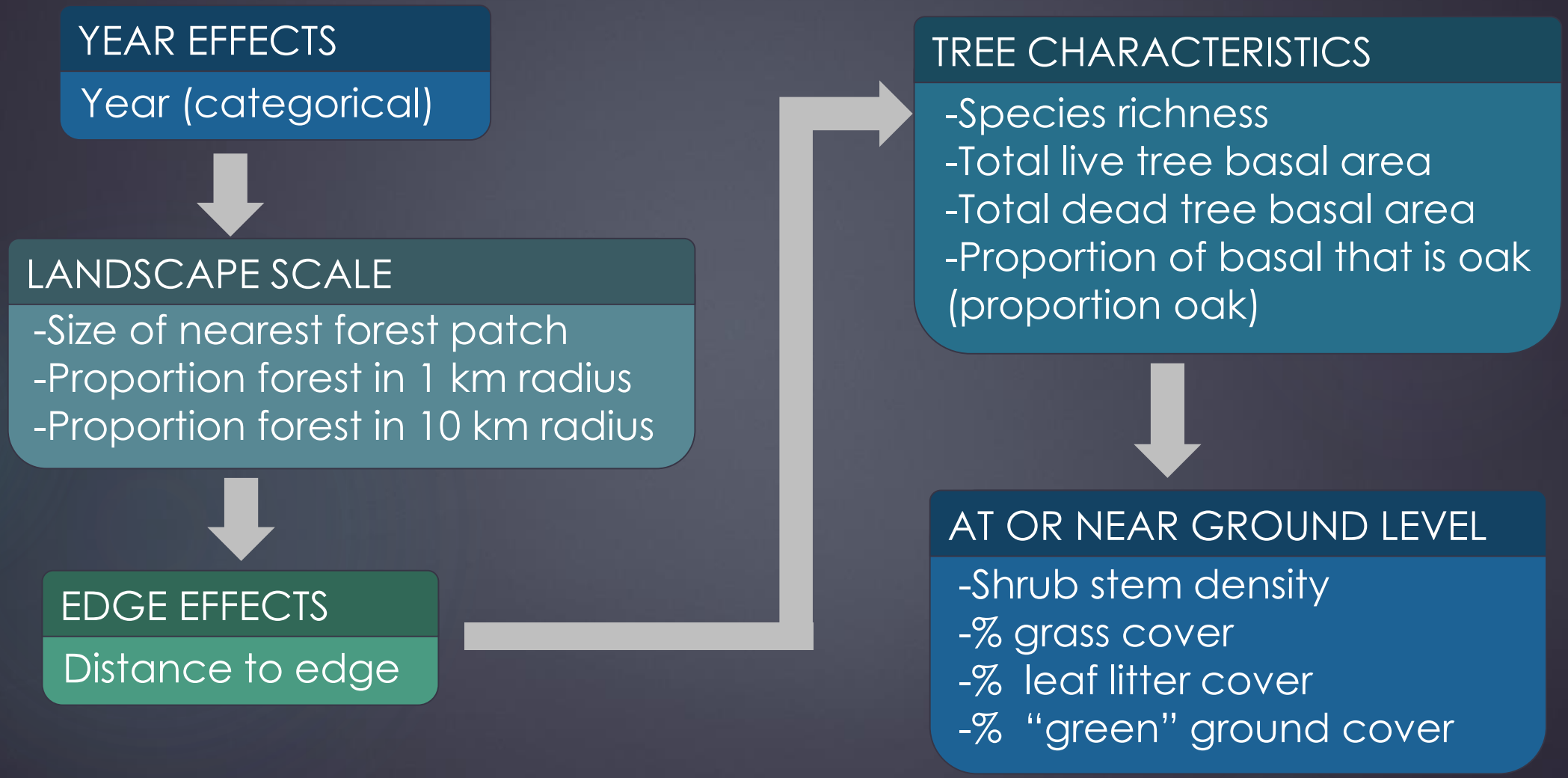
- I will focus on hierarchical distance sampling here
- Given p = P(detectable), phi = P(available), a = area sampled, and d = number detected, overall abundance in its simplest form can be calculated as:

d/(phi*p)*a

- With hierarchical distance sampling, abundance as a point scale is treated as a random variable and can accommodate covariates

- Reference for hierarchical distance sampling: Chandler, R.B., Royle, J.A. and King, D.I., 2011. Inference about density and temporary emigration in unmarked populations. *Ecology*, 92(7), pp.1429-1435.

Abundance covariate hierarchy for my study



Acadian Flycatcher Predictions

- Forest cover at 1 km and 10 km (+)
- Patch size (+)
- Distance to edge (+)
- Live tree basal area (+)

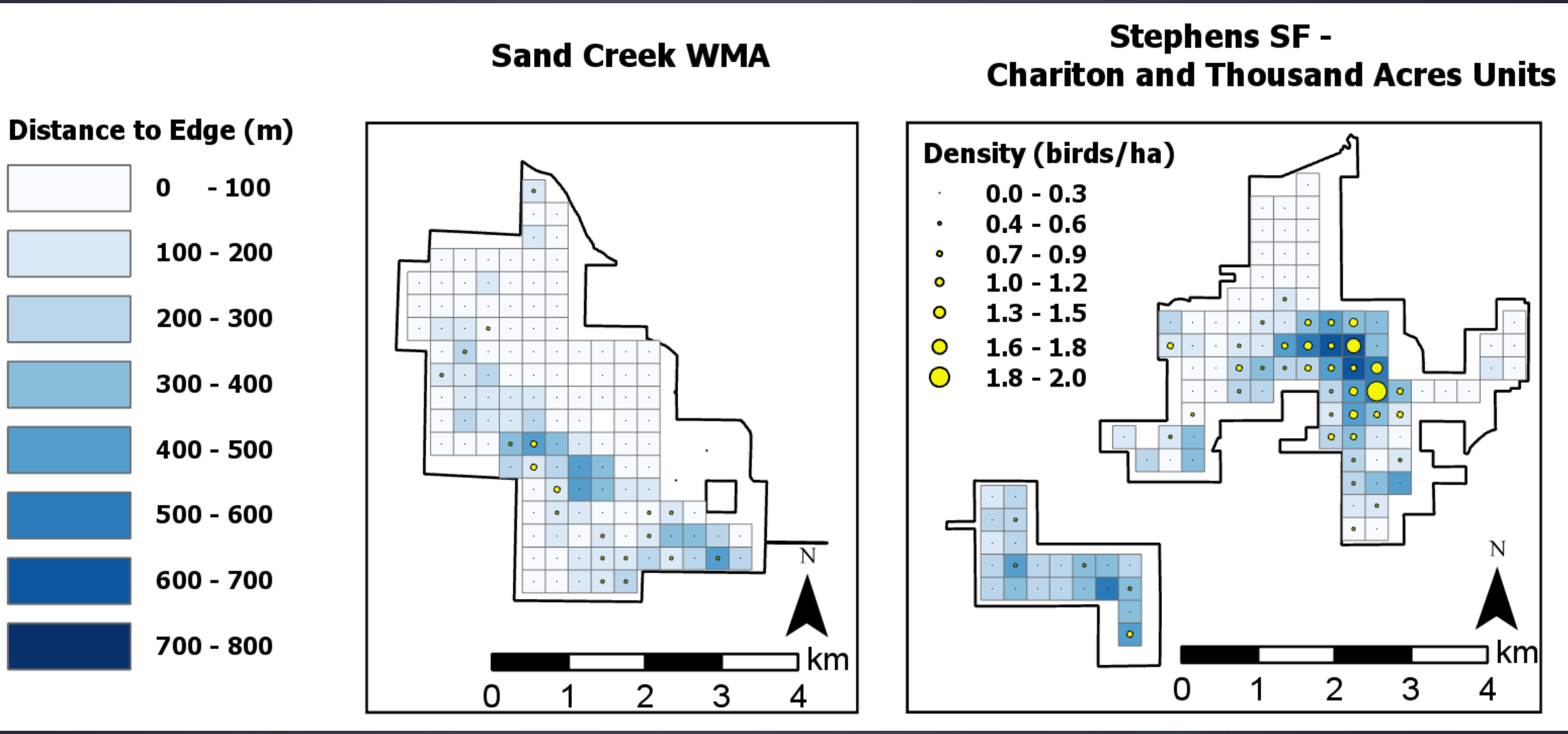
Incorporating abundance covariates into hierarchical distance sampling in 'unmarked'

- Covariate key (all numeric covariates center scaled)
  - year = survey year (factor)
  - nearest_patch_size = area of closest forest patch
  - fprop1km and fprop10km = proportion of land area covered by forest in 1 km and 10 km, respectively
  - dist_edge = distance to forest edge (before center-scaling, 0 if not in forest)
  - spp_rich = tree species richness in 1m factor prism sample
  - live_basal = basal area of all live trees in 1m factor prism sample
  - dead_basal = basal area of all dead trees in 1m factor prism sample
  - oak_prop = proportion of basal area comprised by oaks (0 if no trees)
  - grass_prop = proportion of ground covered by graminoids (e.g., grass)
  - litter_prop = proportion of ground covered by leaf litter
  - green_prop = proportion of ground covered by herbs or green leaves of small woody plants
  - shrub_dens = density of shrub stems

Acadian Flycatcher Results

- Forest cover at 10 km (+)
- Patch size (-)
- Distance to edge (+)
- Live tree basal area, spp. richness, proportion oak(+)
- Shrub density and grass cover (-)
- Litter cover (+)

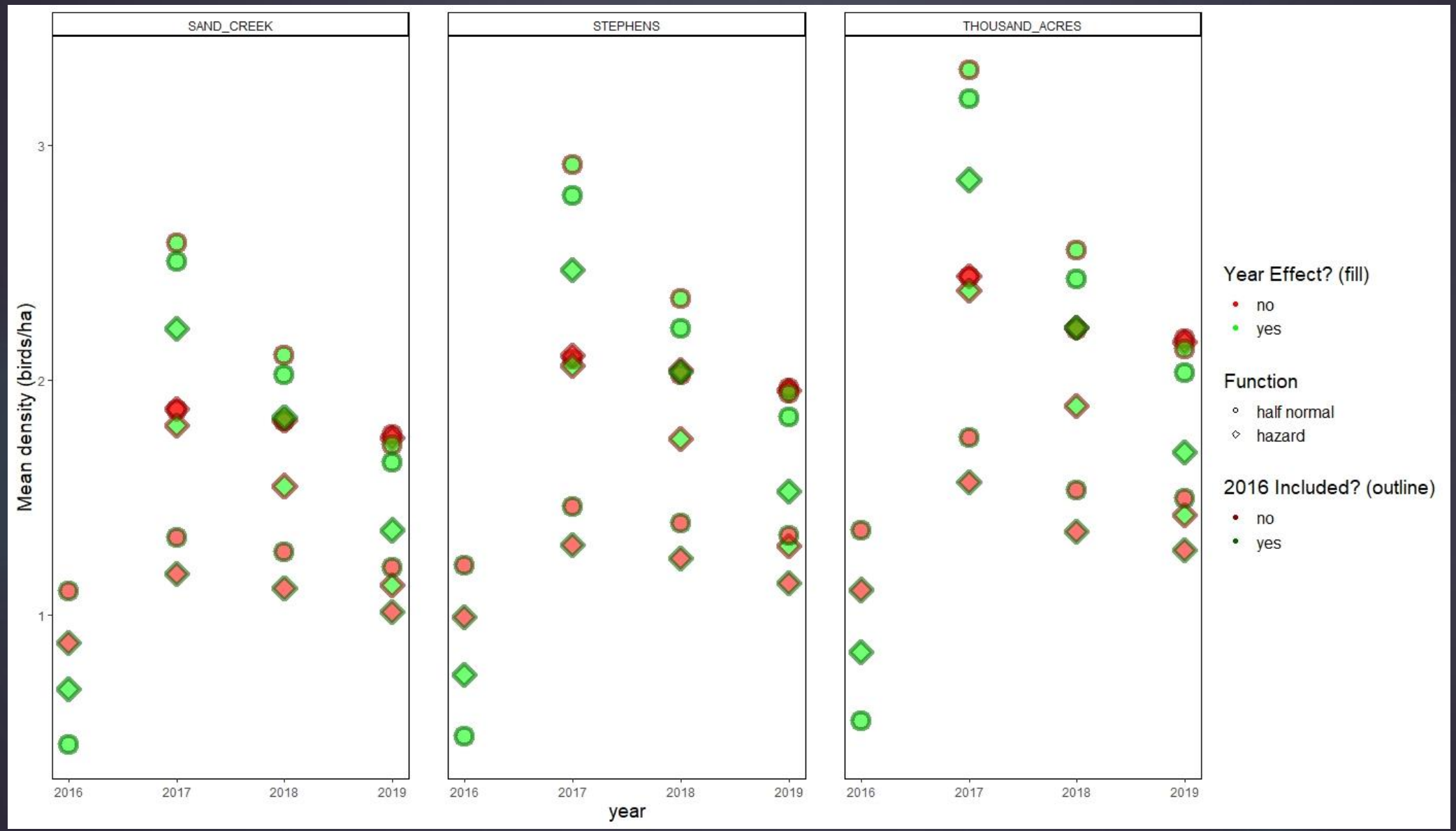
Displaying results in ArcGIS



Issues

- Four years worth of data; 2016 had two observers that didn't observe during any other year; makes models with observer and year difficult
  - Hazard function: singular Hessian (no variance/covariance matrix, so no precision estimate)
  - Half normal: doesn't always fit as well as hazard, and sometimes I don't get estimates for one of my observers
- Some species are too loud for distance sampling (detectability doesn't decline with distance); going to try N-mixture and see how that goes
- Getting precision on density estimates for year-area combinations (i.e., subset points in a single year)
  - Data aren't quite distributed Poisson (lower variance at a point scale)
  - Might try bootstrapping

Looking at confounded observer-year effects



Future Directions

- Adding in a midstory foliage density component to my model hierarchy
- Using point-scale density estimates from a variety of species to 1st) estimate diversity at a point-scale 2nd) use those diversity estimates to determine relationships between diversity and habitat

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