**Level one: Occupancy of county *i* during decade *s***

: occupancy of county *i* during decade *s*

For the first decade, occupancy of county *i* is defined as follows:

where is an intercept, is a spatially structured random effect, and is the unstructured random effect associated with county *i.*

The spatially structured random effect comes from a CAR model:

,

where …(define all terms).

For the remaining decades,

where is the “persistence probability” for county *i* in decade *s*, and is the “colonization” probability for county *i* in decade *s.*

Persistence and colonization probabilities are modeled as follows:

where are decade-specific intercepts, are random county effects in decade *s*, and are slopes for the responses of persistence and colonization probabilities to neighborhood occupancy in the previous decade .is a county- and decade-specific covariate for the proportion of first-order neighboring counties to county *i* that are occupied at decade *s*-1.

**Second Level: Occupancy within a decade**

“The initial county occupancy probabilities for each decade (*i.e.* for *t=1* within each decade *s*) were assumed to be i.i.d. Bernoulli r.v. conditional on cell occupancy status ( and with having a prior distribution uniform between 0 and 1.”’

For later decades, the use probabilities were defined conditionally on last year’s status (as well as occupancy status ) and dynamic parameters such as:

where is the exploitation probability (the probability of continued use of county *i* between year *t* and year *t+1* within a decade *s*) and is the appropriation probability (the probability of county *i* being used in year *t+1* after not having been used in year *t*).

The exploitation and appropriation probabilities are modeled as follows:

where are random county effects and are random year effects.

**3rd Level: Observation process**

Occupancy for survey *c* by collector *k*

where the survey-specific detection probabilities are modeled as follows:

where is the random observer effect for observer *k*, and is a structured random effect for county *i*. “The spatially structured random effects for county *i*  are defined similarly as presented for occupancy using a CAR model (introduced to account for variation in detection probability caused primarily by spatial variation in abundance)”.