Choice of Scale Can Change Outcomes in Ecological Studies: the Case of White-tailed Deer

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Introduction

The choice of scale (extent + grain) is critical in wildlife studies but is often overlooked. Assessing species using incorrect scales can lead to false assumptions about their responses to ecological phenomena and hinder management (1, 2). Species can show differing responses between sites as the overall configuration of landscapes change, making these difficult to broadly characterize (3). To properly manage species, data collected about the surrounding landscape must represent the scale they are most responsive to, known as the scale of effect.

White-tailed deer are particularly sensitive to changes in habitat configuration and can display dramatic shifts in their scales of response to landscape variables. Due to their ubiquity across the U.S. and relative overabundance, they have become a primary interest to wildlife managers (4). Previously, collecting biological data has required invasive methods such as GPS collaring. With the increased prevalence of camera traps (trail cameras), managers now have the opportunity to use non-invasive sampling methods that show great promise for assessing scales of effect which can influence management outcomes (5, 6).

Methods

I modeled relative abundance in relation to landscape variables assessed at five spatial extents in North Carolina. Relative abundance was calculated with wildlife occupancy models using data from the collaborative camera trap network Snapshot USA. Between 2019 and 2021, a total of 485 cameras deployed across North Carolina (Figure 1).

Four landscape variables were chosen to characterize landscape configuration: patch area, forest edge, road density, and stream density. Each landscape variable was measured across all five chosen extents (0.40, 0.66, 0.98, 1.37, and 1.82 km^2; Figure 2). Occupancy models were created including each variable-extent combination across all three years and compared using Akaike Information Criterions (AIC) with model selection. AIC values were used to locate any prevalent scales of effect indicated by peaks in model performance (Figure 3).

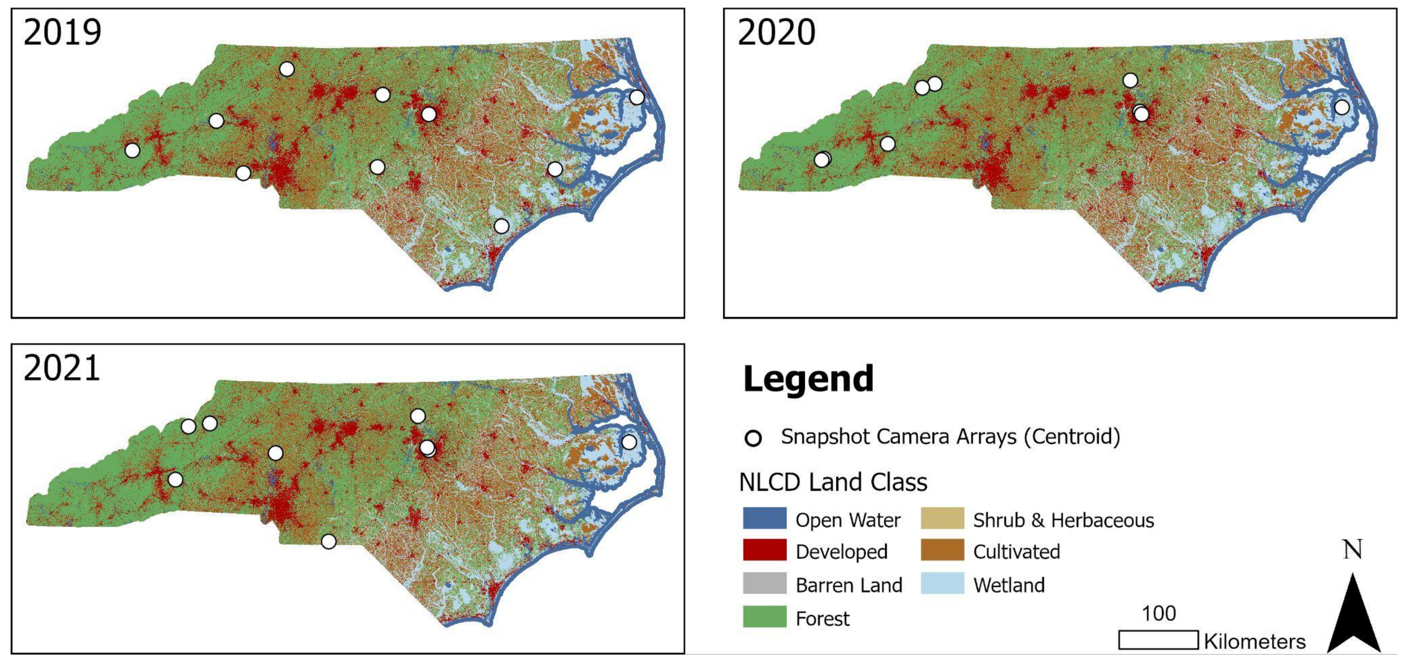

Figure 1. Snapshot camera locations by year. Points represent centroids of camera arrays. NLCD land classes are simplified and reclassified from 15 to 7 classes and clipped to the state border with a 5 km buffer.

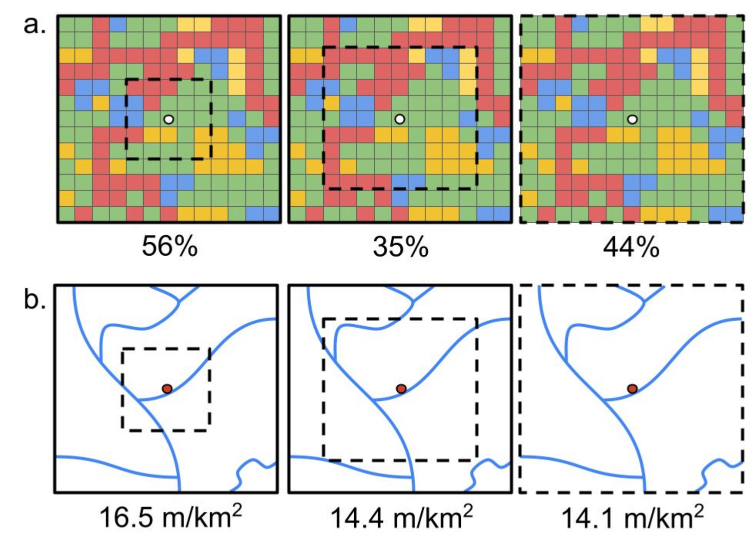

Figure 2. Conceptual diagram of measuring landscape variables across three extent classes for (a) proportion of forest cover and (b) density of streams. Dashed lines represent the extent being examined in each panel.

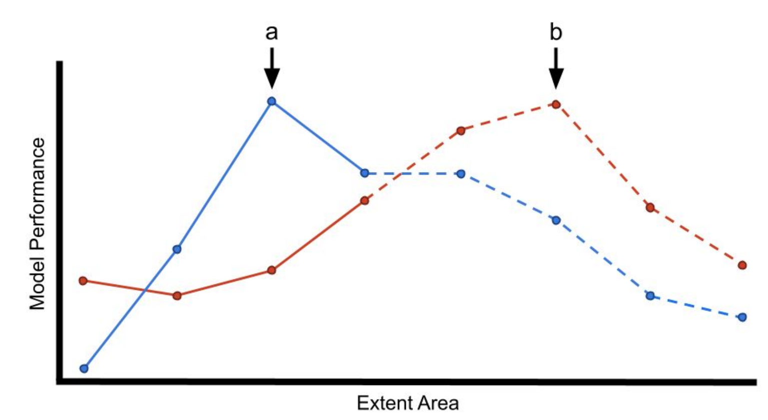

Figure 3. Model performance across multiple extents for two variables. Solid lines represent sampled extents; dashed lines represent unsampled extents. Scales of effect are (a) located and (b) unlocated.

Results

Landscape variables showed significant differences between extents and increased in range as extent area increased (Figure 4). No significant correlation was found between any variables. Road density (2019) and patch area (2020, 2021) were the best supported models across all scales. Road density and patch area showed positive relationships with extent area, while stream density showed a negative relationship with extent area. The direction and magnitude of scale relationships were largely different between years. Models tended to perform more similarly at small extents (Figure 5).

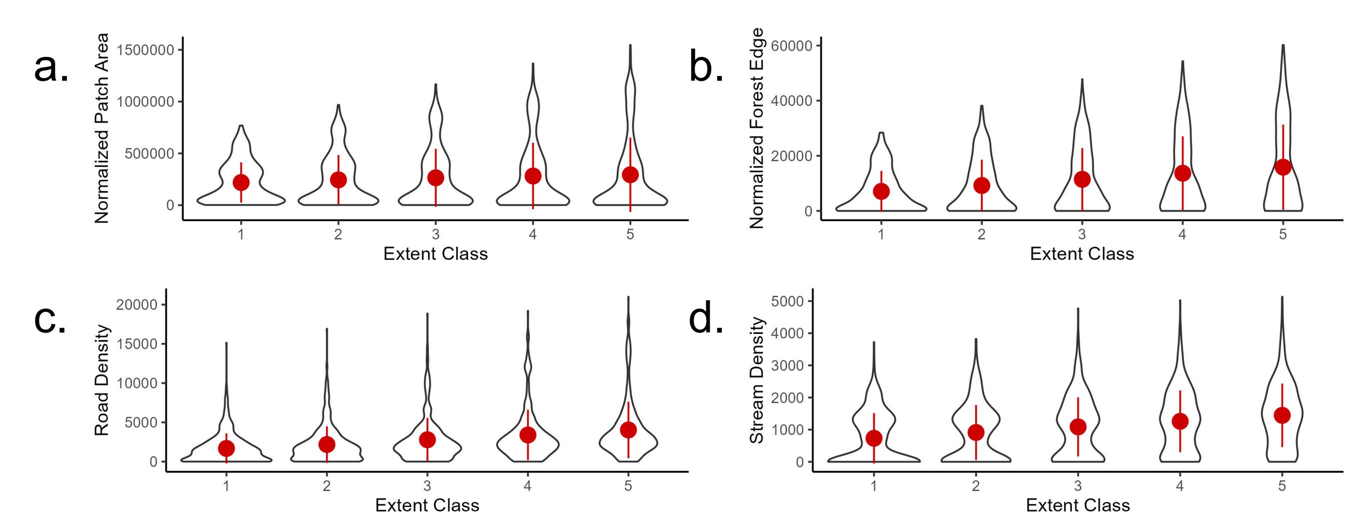

Figure 4. Violin plots displaying variation in landscape variables across five scale classes. (a) patch area, (b) forest edge, (c) road density, and (d) stream density. Points and lines represent mean and standard deviation.

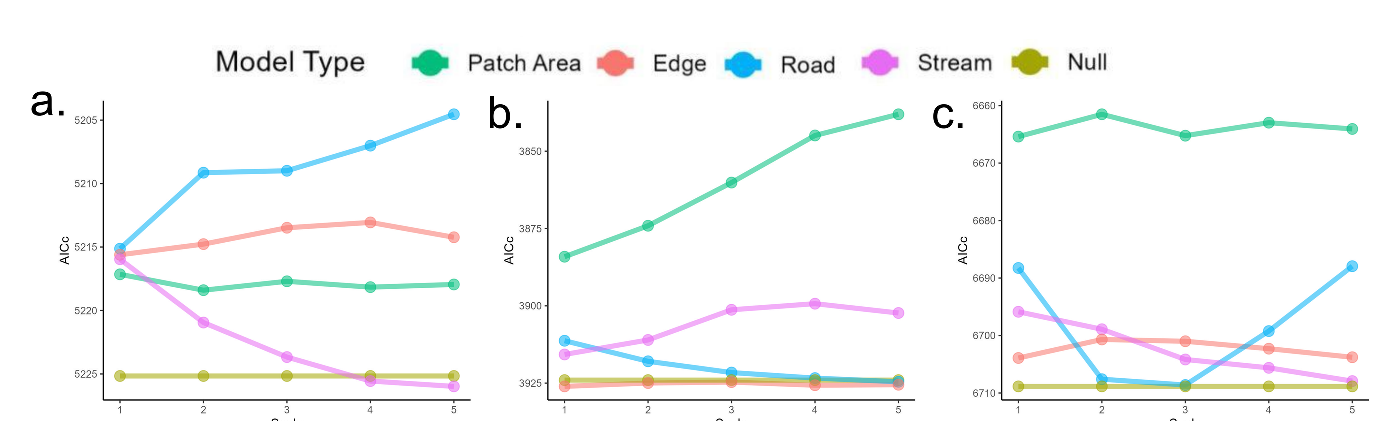

Figure 5. Visual representation of model rankings with AIC$_c$ in model groups 1–15. (a) model groups for 2019: 1–5, (b) model groups for 2020: 6–10, and (c) model groups for 2021: 11–15.

Discussion

Even across relatively small differences in measurement extent, landscape variables show stark differences in their distributions that affect the performance of deer occupancy models. A true scale of effect could not be found for any landscape variable due to the range of scales examined. The large changes in performance of certain variables between scales indicates that there may be clear scales of effect just out of sight (1, 2). For road density and patch area, I hypothesize that the scale of effect is larger than the maximum extent used here. If larger extents were included, a peak then fall in model performance would likely be seen that clearly indicates a "best" scale for assessing the population. For stream density, its scale of effect is likely smaller than the smallest extent here and would thus show a peak when sampling smaller extents.

Despite some limitations imposed by camera trap sampling methods, they show promise as an inexpensive method of assessing scales of effect in wildlife. Combined with the increased commonality of camera traps, these methods can also allow researchers to re-examine populations based on existing datasets initially collected for other purposes (5). Overall, camera trap datasets proved valuable for assessing ecological scaling, emphasizing the importance of purposefully chosen spatial extents linked to ecological processes.

Future research endeavors should seek to assess populations at more spatial scales in order to ensure the inclusion of any possible scales of effect (1, 2). Researchers should also also consider the ecological importance of their scale choices in both single and multi-scale studies, as choosing improper scales in this vein can lead to incorrect assumptions about ecology that harm scientific understanding of species (6).

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