Carabid Beetle Distribution by Microhabitat

A Field Study at the Blue Wall Preserve in Landrum, SC

Luke Hetherington and Haley Clevenger

EES201 – Introduction to Geographic Information Systems – Fall 2013, Furman University, Greenville, SC

FURMAN

Abstract

Ground beetles (Family Carabidae), one of the most diverse and influential components of terrestrial ecosystems, are useful bioindicators due to their sensitivity to a wide range of environmental factors, both natural and anthropogenic. The goal of this study was to describe small scale differences in Carabid communities. Carabid beetles were captured in a site in the Furman Forest in northeast Greenville County, SC from 17 June 2013 through 1 August 2013 from wooded, ecotone, and field habitats. Forty-eight sets of pitfall traps were placed throughout the site in wooded, ecotone, and field habitats. Carabid beetles were collected from the pitfall traps three days a week in a checkerboard pattern. A weak negative correlation between soil moisture and beetle abundance was found. The most beetles were found in wooded habitat and the least in the ecotone, likely due to an edge effect. Findings were visually represented with ArcMap and ArcScene.

Introduction

The Carabidae have a high species diversity representing different morphologies and habitat preferences that Magura separated into five categories: habitat generalists, grassland-associated species, forest generalists, forest specialists, and edge-associated species (2001). The majority of Carabid beetles are classified as habitat generalists, implying their distribution results of bottom-up factors. Because of their diversity, abundance, and environmental and temporal sensitivity, Refseth argues that beetle be considered bioindicators (1980). The ground beetle plays a critical role in ecosystems and deserve consideration in conservation models. The utilization of species diversity values would improve upon the current habitat classification system.

Niemela et al. argue that small-scale Carabid distribution can be explained by active microenvironment selection (1992). The Carabidae are sensitive to the environmental factors of soil moisture, light, and temperature. They are also sensitive to the temporal (or successional) factors of leaf-litter accumulation and tree size (Worthen and Merriman 2013).

The wide range of Carabid beetle niches makes surveying the population very difficult. The two predominant methods are active by-hand collection and passive pitfall trap collection. Manual beetle collection permits specificity in the capture, but is very intensive. Pitfall traps require significantly less time and yield a larger catch; however, alone it may not accurately represent beetles filling all niches. Most Carabidae research has been conducted in the Northen boreal forest utilizing the pitfall trap method. While species descriptions are available for Southern Appalachia, comparatively little work has been done to describe the community compostion of the region.

Figure 8. Setting up a a plot in field transect C.

Methodology

This study was conducted in a field site within the Blue Wall Preserve in Landrum, SC from June through August 2013. The study site was situated adjacent to a small lake and was approximately 100 meters long and 80 wide, including field, ecotone, and wooded habitats.

Six transects were established throughout the field site, each consisting of eight plots at 10m intervals. Two transects were placed in wooded habitats, two in field habitats, and two in ecotone habitats (Figure 1). A pitfall trap instillation was placed within each sampling plot, consisting of two 0.95-L plastic containers submerged level with the ground 1 m apart, and linked by a 0.15- x 1-m drift fence made from aluminum flashing. The drift fences were aligned either parallel or perpendicular to the length of the field, alternating by plot. Each 0.95-L plastic container had 3 holes approximately 0.3 cm in diameter punched in the bottom to prevent the accumulation of rainwater and muddy debris.

The traps were opened every Monday for the duration of the study period, and were examined every 24 hours for three days before being closed for another three. Beetles were collected from two plots per transect per day in a repeating checkerboard pattern so that carabid beetles from each plot were collected once per week for seven weeks. Collected beetles were transported to Furman University and euthanized with ethyl acetate for identification. All non-carabids and beetles from non-targeted plots were released.
Soil samples were also collected for the purposes of estimating soil moisture levels throughout the field site.

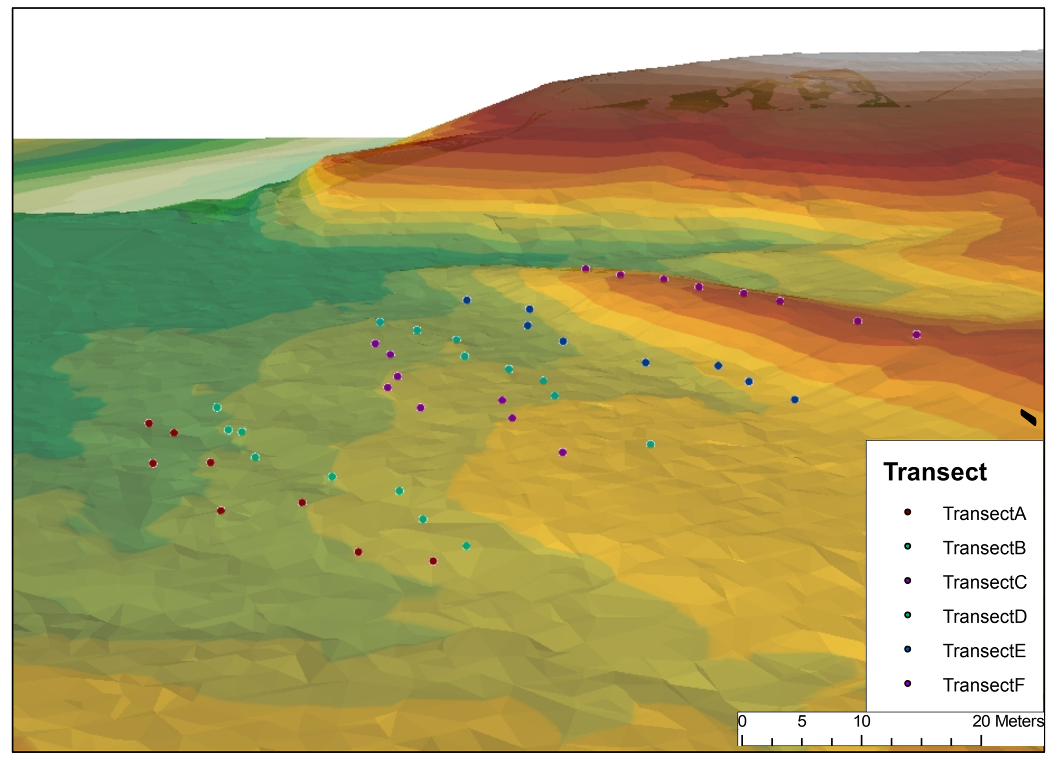

Figure 1. Topographic map of field site displaying sampling plots by transect. Transects A/F are wooded habitats, C/D are field habitats, and B/E are ecotone habitats.

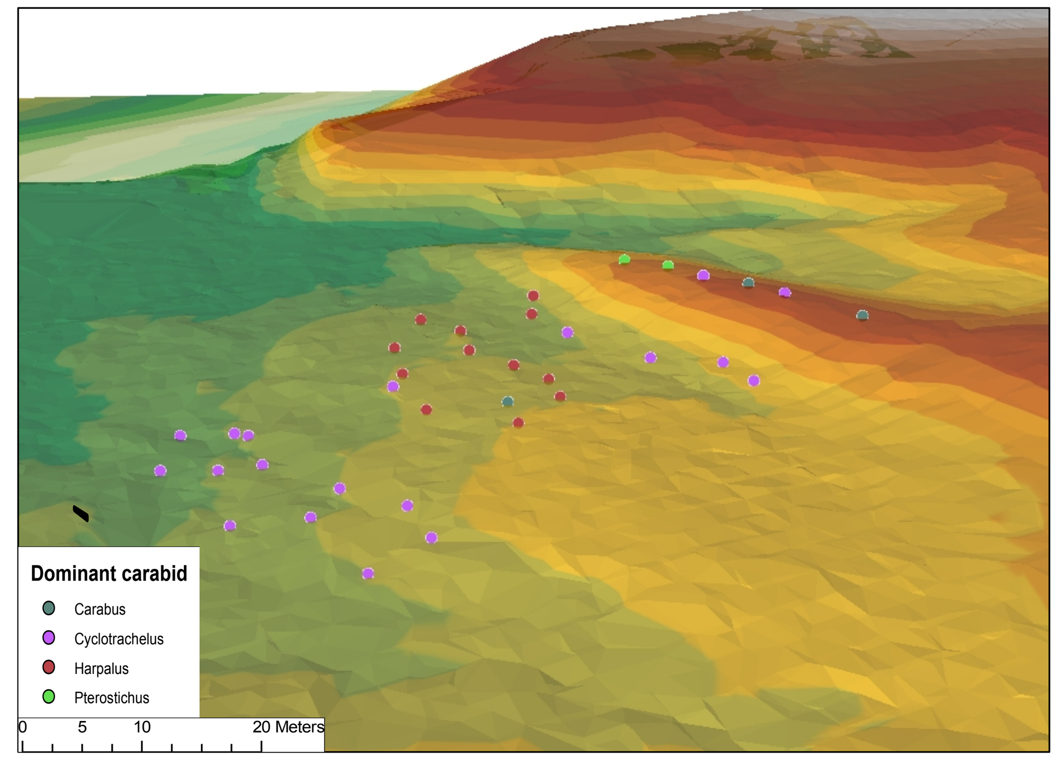

Figure 2. Topographic map of field site displaying dominant *Carabidae* species by genus by sampling plot.

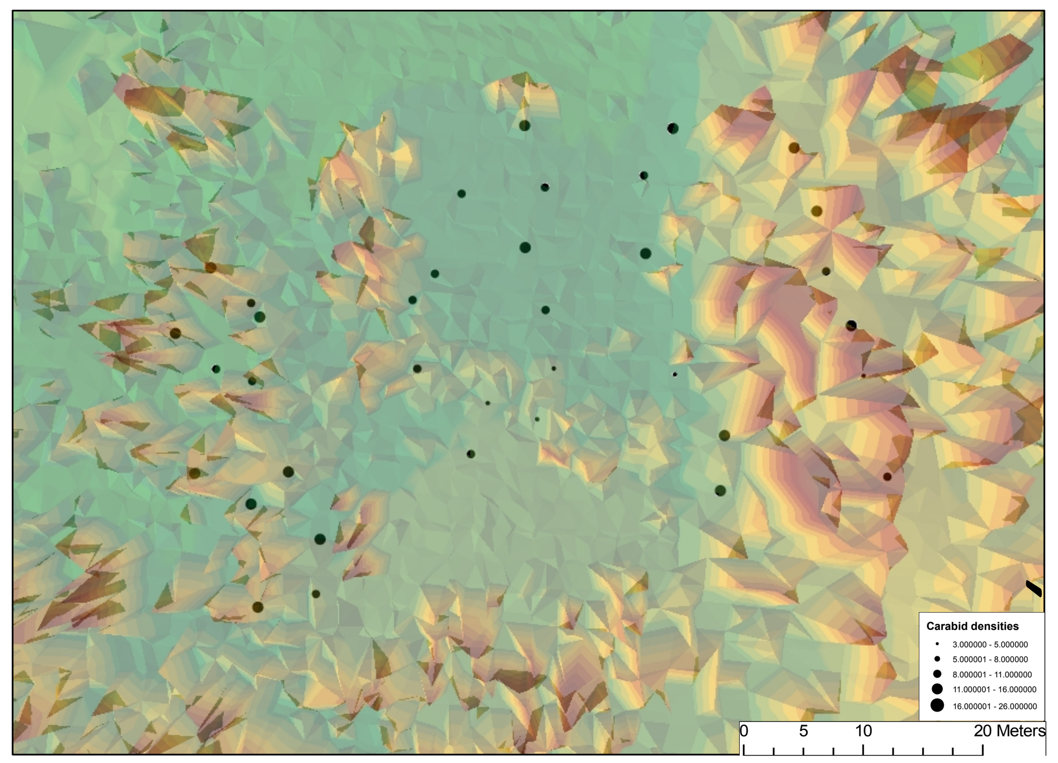

Figure 3. Lidar DSM representation of vegetative cover height and total Carabidae abundance within the field site.

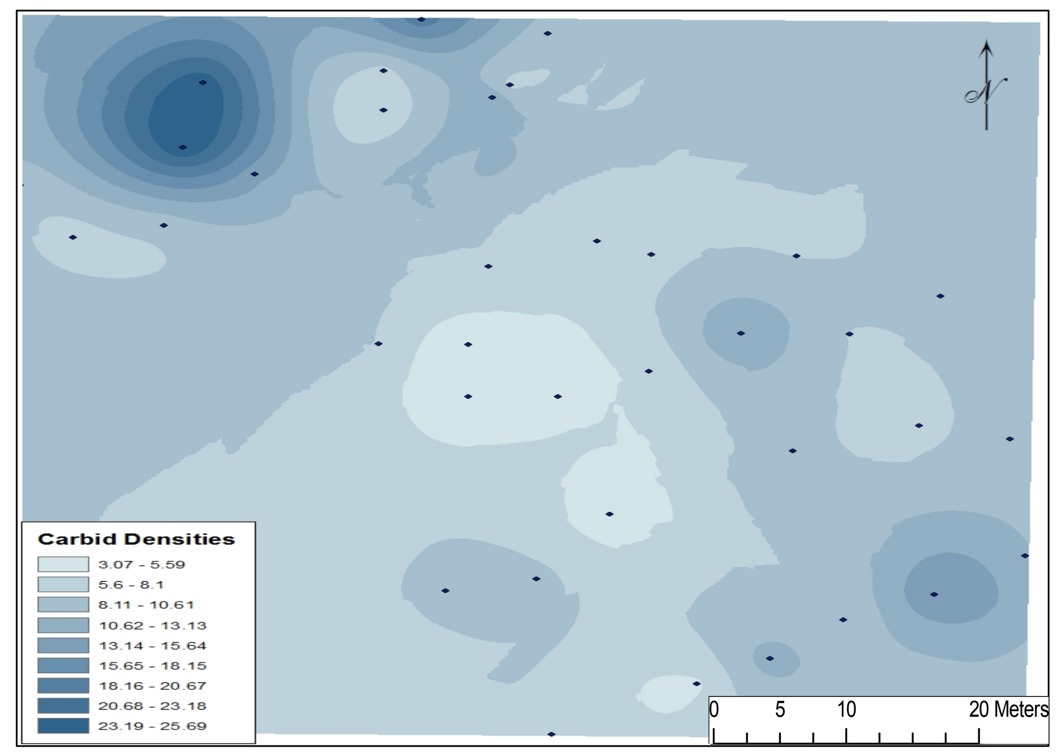

Figure 4. Kriging density of total carabid species abundance with sampling plot locations within the field site as determined by weekly collection.

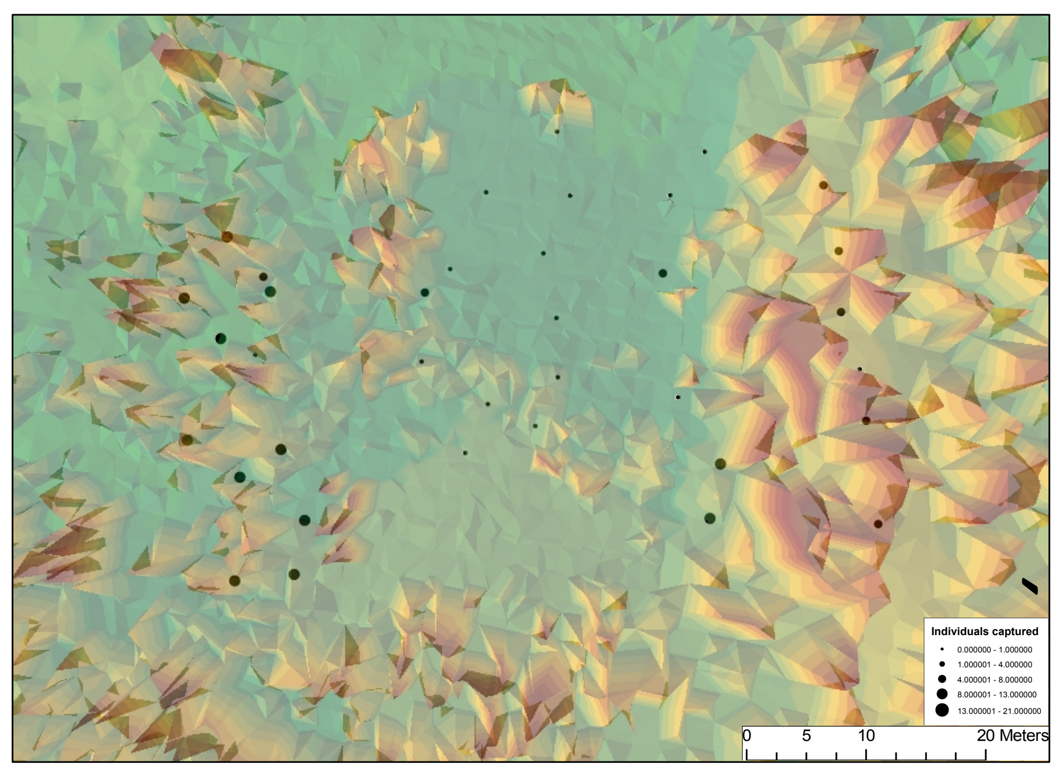

Figure 5. Lidar DMS representation of vegetative cover height and *Cyclotrachelus sigillatus* capture data by sampling plot.

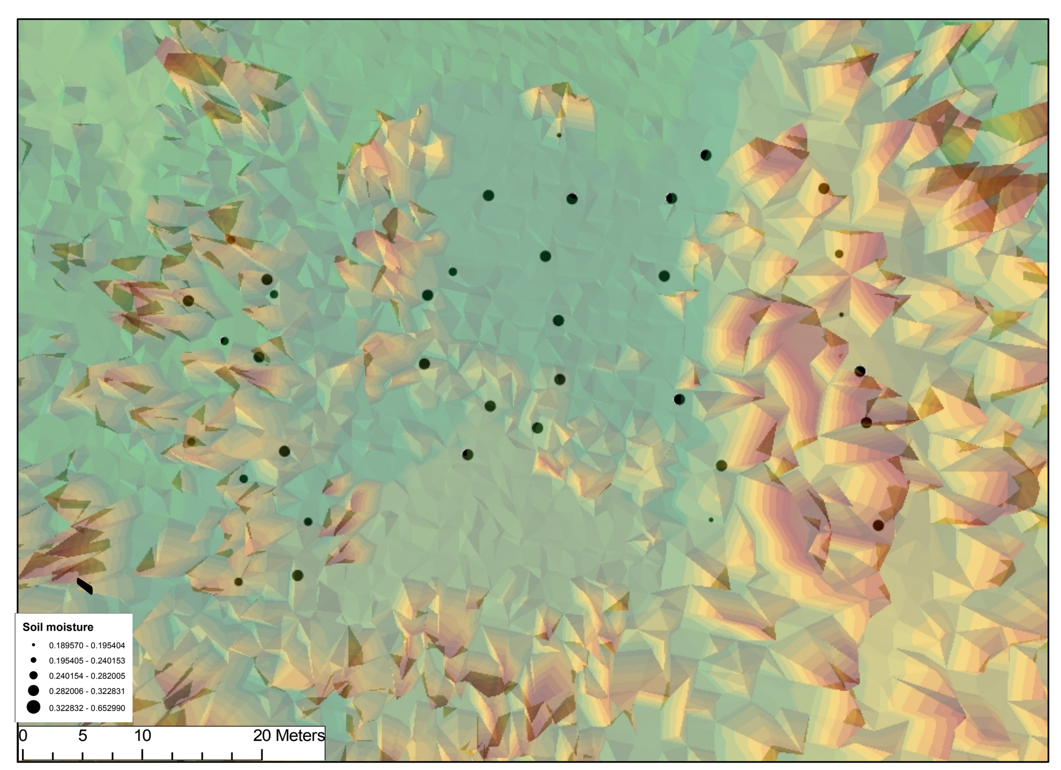

Figure 6. Lidar DSM representation of vegetative cover height and soil moisture by sampling plot, measured in percent water by mass.

Results and Discussion

Total abundance between habitats was found to be significantly different (F= 3.264; df=5; p=0.18). A Nested ANOVA ensured differences between transects of the same habitat type were considered. Differences in total abundance were obscured by same-habitat transect differences, particularly the difference in catch between the wooded transects A (n=96) and F (n=60). This difference appears to have been driven by the significant difference in *Cyclotrachelus sigitallus* catch (76 in A and 14 in F) determined by chi-square analysis. There was also a startling difference in *Carabus* sp. Catch (0 in A and 13 in F); however, the sample size was too small to perform statistics.

No species richness differences were observed between the transects. However, Simpson's Diversity test showed that the mean diversity (Mean±SD) of the wooded (3.077±1.901), field (2.986±1.377), and ecotone (2.810±1.112) habitats were significantly different (F=3.705; df=5; p=0.10). The high beetle abundance in the wooded habitat corresponded with traditional knowledge that beetle abundance is positively correlated with leaf-litter density. The limited abundance in the ecotone could be due to the edge effect, implying the beetles do exhibit a degree of specialization.

A non-parametric Spearman-Rank Correlation revealed a weak negative correlation between soil moisture and total beetle abundance (r=-0.324; p=0.054). This contradicted traditional findings that soil moisture and beetle abundance are positively correlated. This dichotomy could have been due to our limited sampling of soil moisture. Soil moisture differences were examined between transects A and F to explain the differences in the captures. A Wilcoxon test revealed a significant difference (mean ±SEM) in soil moisture between transects A (0.239±0.008) and F (0.299±0.047) (p=0.38).

These results suggest that the majority of Carabid beetles prefer drier, wooded habitats. Of these wooded regions, *C. sigitallus* prefer drier habitats, while the *Carbus* genus prefers wetter habitats. *Harpalus protractus* dominated the field transects. The distribution of *C. sigitallus* across the three habitat types suggests it is a habitat generalist, unlike *H. protractus* and *Pterostichus* sp., which appear to be a grassland-associated species and forest specialists respectively.

Conclusion

In conclusion, this study utilized pitfall traps to examine Carabid beetle distribution in a field site at the Blue Wall Preserve. The site included three habitat types: wooded, ecotone, and field. The dominant species at each plot through out the summer was determined and compared with vegetative cover and soil moisture. The results of this study showed that the majority of the beetles prefer wooded habitats. This could be explained by the fact that the invertebrate prey of the beetle feeds on leaf litter, which is denser in the forest. Moisture findings were inconsistent with previous studies, likely due to insufficient sampling. The greatest limitation of this study was its brevity and small land area.

Future Research

Future endeavors should extend the duration of the study to address seasonality effects. It should also integrate a combination of trap and hand collection. The addition of manual beetle gathering would permit the inclusion of a greater variety of species by targeting niches potentially excluded by trap collection. Extending the study site would provide a greater variety of microhabitats from which to sample. Leaf-litter density should also be examined to further explain the environmental differences in the wooded transects A and F.

Figure 7. From left to right, these beetles are *Cyclotrachelus sigillatus, Carabus sylvosus, Pasimachus depressus, and Harpalus protractus.*

Acknowledgements

We sincerely thank Dr. Wade Worthen and Mike Winiski for their continual support in our completion of this project. We would also like to thank The Nature Conservancy, particularly Colette DeGaredy, for permitting us use of the Blue Wall Preserve. Finally, we would like to thank Furman Advantage for funding this research project.

References

Magura, T., Tothmeresz B., Molnar, T., 2001, Forest edge and diversity: carabids along forest-grassland transects: Biodiversity and Conservation, v. 10(2), p. 287-300.

Niemela, J., Hajla, Y., Halme, E., Pajunen, T., and Punttila, P. (1992). Small-scale heterogeneity in the spatial distribution of carabid beetles in the southern Finnish Taiga. Journal of Biogeography, 19(2): 173-181.

Refseth, Dagfinn. (1980), Ecological analyses of carabid communities---potential use in biological classification for nature conservation. Biological Conservation, 17(3): 131-141.

Worthen, W. and Merriman, D., 2013, Relationships between Carabid beetle communities and forest stand parameters: Taxon congruence of habitat association?. Southeastern Naturalist, 12(2):379-386.