Influences of Land Use and Habitat Heterogenetiy on Rodent Diversity in Savanna Ecosystems of Swaziland

Nicole Jennings
University of Florida
International Research Experience for Students

INTRODUCTION

Conversion of land to grow crops, raise animals, harvest timber, and build cities is the main factor contributing to the reduction of the world's biodiversity (DeFries et al. 2004). This land degradation affects biological responses and has long-term and short-term negative effects on biological diversity (Luo 2012). Land-use changes often create heterogeneity in landscapes. According to the habitat-heterogeneity hypothesis, an increase in habitat heterogeneity of an area will lead to an increase in the species diversity (Luo 2012). Therefore, habitat heterogeneity is an important factor for influencing biodiversity (Moro et al. 2007).

There are many indices that can be used to quantify spatial heterogeneity, all of which fall into two general categories - composition and configuration (Gustafson 1998). Composition describes the proportion of each land-use class within an area. To measure composition, it is important to combine both the component of land-use richness, which refers to the number of land-uses present, and to evenness, which refers to the distribution of area among classes (Fahring 2003). On the other hand, configuration focuses on describing spatial characteristics of individual patches and spatial relationships among multiple patches (Gustafson 1998). Studies have found that broad-scale spatial patterns of species and functional richness persist across agriculturally mixed landscapes and protected area mixed landscapes (e.g. Child et al. 2009).

Since vegetative structure is such an important factor in determining small mammal abundance and diversity, we believed focusing on fine scale heterogeneity would help explain patterns in rodent diversity (Monadjem 1997). Previous studies have shown that a reduction in standing biomass can have negative effects on small mammal survival and reproduction (Peles and Barrett 1996). Savannahs worldwide and in Africa have had grasses replaced by an increase in woody biomass, known as shrub encroachment. With low levels of ground cover from grasses and shrubs, we predicted that small mammal diversity would likely decrease as well (Yarnell et al. 2007).

Rodents are a useful taxa for studying the effects of habitat heterogeneity on species diversity because they are functionally diverse and highly mobile. Since rodents have short generation times, it is easy to observe how populations respond to the environment and landscapes around them (Hurst et al. 2013). They also serve important ecological roles as seed dispersers, habitat modifyiers and as a key prey base for many mesocarnivores and birds of prey. Many are also considered pest species (e.g *Mastomys natalensis*).To understand rodent species diversity and configuration, we must accept that the complexity of habitat is a key factor influencing richness and diversity of rodent communities (Yang *et al.* 2014).

Objectives and Predictions
The purpose of this study is to evaluate changes in rodent species diversity in response to fine and broad scale land-use heterogeneity in savanna systems. We predicted that a greater diversity of habitat types will lead to greater diversity of rodent species. With the results from this project, we hope to gain insight into whether or not fine-scale vegetative structures are influential to rodent species diversity. In addition, we hope to find whether configuration or composition of a landscape help to predict rodent diversity.

STUDY POPULATION AND METHODS

Species of Study

There are four functional groups into which the small mammal species of Swaziland can be categorized: Omnivore, Insectivore, Granivore, and Herbivore. Although there are many species of small mammals in our area of study, these are a few that we are likely to sample,. Omivores: *Mastomys natalensis, Mus minutoides, Gerbilliscus leucogaster, Elephantulus branchyrhynchus* and *Dendromus mystacalis*. Insectivore: *Crocidura hirta, Crocidura fuscomurina, Suncus lixus* and *Crocidura silacea*. Granviore: *Aethomys inceptus, Steatomys pratensis* and *Saccostomus campestris*. Herbivore: *Lemniscomys rosalia* (Hurst *et al.* 2014).

Study Area and Design

We sampled 20 grids (size 550m^2 x 550m^2) over a region approximately 30 km x 100 km in NE Swaziland (Figure 3). The grid locations were randomly selected within savanna and are at least 1 km from the nearest intensive agriculture site. Each grid consists of 5 plots (one in the center and one in each corner) with 20 sherman live traps in each plot (Figure 1 and Figure 2). The study area includes five cover types: open savannah, closed savannah, communal areas, riparian/ forest areas, and intensive agriculture (Figure 3). To account for variability in landscapes, we split up the study area into three regions latitudally: north, middle, and south, each containing five different landscape treatments which meausure the levels of composition and configuration in that area. The five treatments are: low composition and low configuration (LL), high composition and high configuration (HH), medium composition and medium configuration (MM), low composition and low configuration (LH) and high composition and low configuration (HL). We compared these treatments to understand thier effects on small mammal diversity across different gradients of landuse.

Methods

We trapped small mammals in May - July 2016 over the study site, for 15 sites. Each site contained five plots spaced 250 m apart, and each plot contained a 4 x 5 trapping grid with Sherman live traps spaced 10 m apart (Figure 2). We trapped each site for four consecutive nights, resulting in a total of 7,200 trap-nights. We baited traps with dried oats and peanut butter and checked them at sunrise each morning. We recorded the species, sex, weight, tail length, body length, hind foot length, and approximate age of captured animals. We also took body measurements and gave each individual a metal ear tag stamped with unique numbers. For pygmy mice (*Mus minutoides*), we felt that the metal ear tags would represent too large of a percentage of the total body weight of the mice, and would thus place unneeded stress on the animals (Aldridge and Brigham 1988).

Vegetation Surveys

In order to quantify small mammals' selection of habitat structures, we measured five components of vegetative structure and composition at our sites. Surveys included measurements of grass biomass, shrub cover, canopy cover, canopy layer diversity, and canopy height. Within each plot, we ran two 50 meter tapes east and west, 20 meters apart from one another. Grass biomass was measured using a disc pasture meter every 5 meters along each line. Shrub cover was measured by counting the percentage of the tape that was intercepted by woody vegetation between 0 meters and 1 meter in height. Canopy cover was measured using a concave spherical densitometer with which we took measurements every 5 meters in no specific direction. We measured canopy layer diversity every ten meters by looking at the canopy in a 2 meter cube from 0-2m, 2-4m,4-6m, 6-8m, 8-10m, 10-12m, 12-14m, and 14-16m. Finally, we measured canopy height every 5 meters on the line with a meter stick.

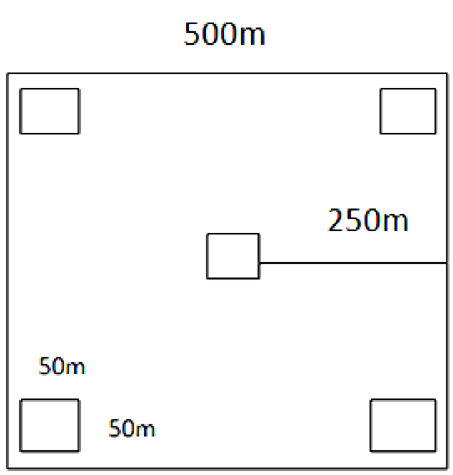

Figure 1. Example Grid

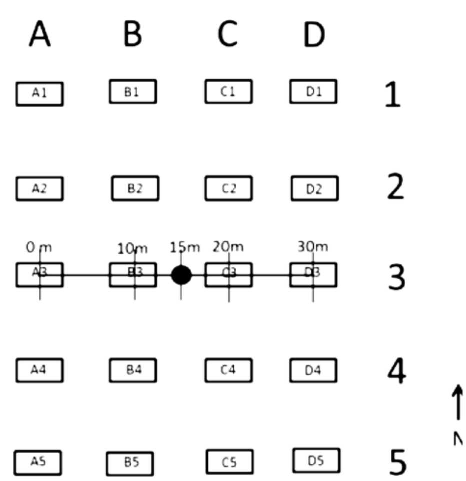

Figure 2. Example plot with Sherman trap set up

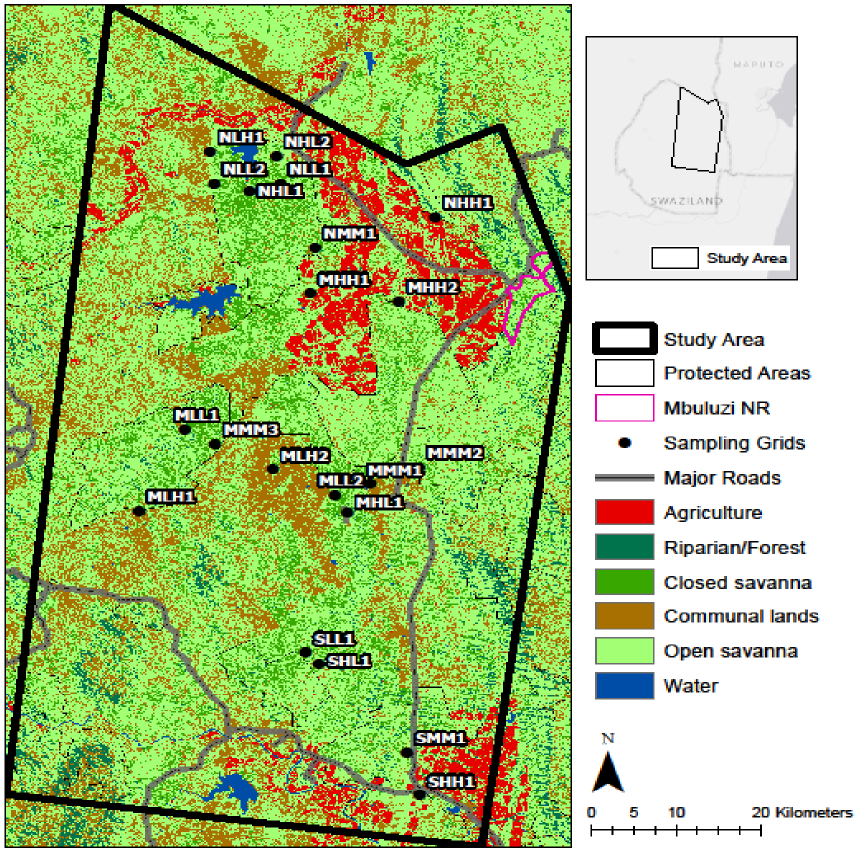

Figure 3. *This map represents the 30km^2 x 100km^2 study area within the NE region of Swaziland, Africa. Each black dot represents one grid -- in total there are 20 grids.*

Data Analysis

We analyzed our data all at once, comparing the capture, recapture, data from the two months of the project. We used R Studio and packages, 'vegan', 'plyr', 'bbmle', and 'lme4' to run multiple models and select the best fit and lowest AIC. This helped us determine what most greatly affected rodent species diversity at the plot, grid and landscape level.

Results

After a total of 7,200 trap nights we caught a total of 52 individuals, recapturing 33 of them. From running multiple models we discovered that canopy cover variance was the most influential to rodent species diversity across the sites, at both the plot and grid level. Species diversity was not affected at the landscape level. This result may be explained by the habitat heterogeneity hypothesis. As the land becomes more heterogeneous, in this case the canopy cover, the rodent species diversity increases as well (Fig 4). Canopy cover variance may be influential to rodent diversity because the preferences of every species varies. While some rodent species prefer more open habitat, others prefer to live in more dense shrubby habitat (Monodjem 1997). For this reason, a landscape with more heterogeneity is more able to support a variety of small mammal species.

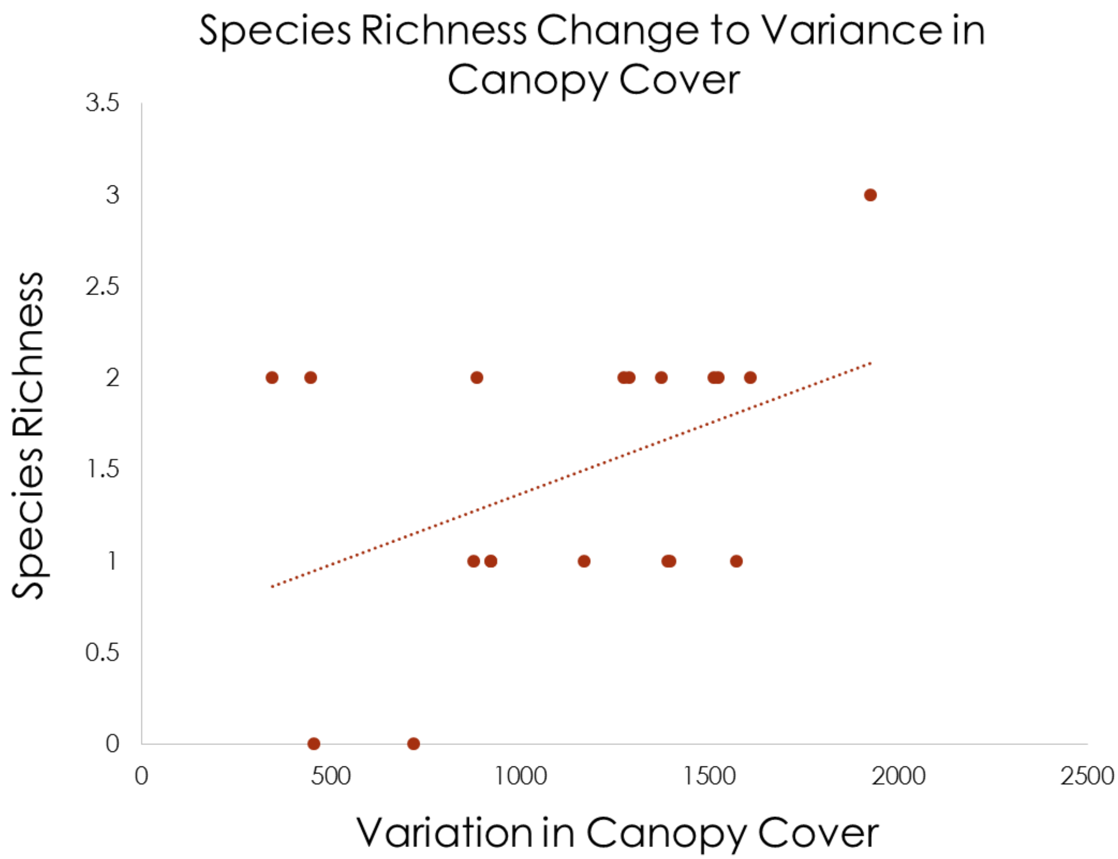

Figure 4: Graph showing increase in species richness with inceasing varaiton in canopy cover

Discussion

This study contributes to improving our understanding of the main drivers of small mammal diversity in the lowveld of Swaziland. We know that savannahs are dynamic and constantly changing due to abiotic and biotic factors and that our data were influenced by those factors. Our study was done during a major drought period in the lowveld savannah of Swaziland. Compared to other studies done in the same area, and for a similar period of time, our sample size of small mammals was very low (see Hurst et al. 2013, Hurst et al. 2014). To maintain small mammal diversity in savanna ecosystems, the combined effects of the drought, grazing pressure from herbivores and effects from fire need to be considered. The extremely low levels of rain that we experienced during this study may have caused increased grazing pressure by cattle and higher risks of wildfires in natural areas (Yarnell et al. 2007). These factors most likely caused a large decrease in ground cover from grasses and low shrubs, leading to a decrease in small mammal populations and species diversity. While conducting our research, we saw that there was almost no grass to influence rodent diversity. Therefore, it makes sense that canopy cover variance is what best explains the species-level diversity at the plot and grid level. Therefore, our results support the hypothesis that rodent species diversity is strongly correlated with the habitat and vegetative heterogeneity at the fine-scale level.

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