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Small Mammal Community Structure and Bait Preference in Missouri Prairie Patches

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SMALL MAMMAL COMMUNITY STRUCTURE AND BAIT PREFERENCE IN MISSOURI PRAIRIE PATCHES

A Master's Thesis

Presented to

The Graduate College of

Missouri State University

In Partial Fulfillment

Of the Requirements for the Degree

Master of Science, Biology

By

Sofia L. Orlando

August 2023

SMALL MAMMAL COMMUNITY STRUCTURE AND BAIT PREFERENCE IN MISSOURI PRAIRIE PATCHES

Biology

Missouri State University, August 2023

Master of Science

Sofia L. Orlando

ABSTRACT

Ecological community studies provide insights on how species interact with biotic and abiotic factors in an ecosystem. Community assembly is dynamic and often mediated by stochastic processes or deterministic properties. Establishing patterns in community composition could help to predict the suitability of a patch, which is crucial in endangered ecosystems. Small mammals are a model indicator for community change as their populations experience perplexing fluctuations. Many mechanisms have been proposed to drive small mammal species composition, but inconsistencies in past studies warrant further investigation. A previous study on prairie patches in Missouri revealed that there was an unknown catalyst for species composition. Following this study, small mammal sampling was completed across 15 prairie patches. Additionally, vegetation characteristics and other environmental data were collected to evaluate patch dynamics. Analysis of these variables, in combination with mammal data, may provide a more robust understanding of community responses to prairie attributes. Sherman live traps were used to capture 217 individuals that consisted of 7 species, with *Peromyscus maniculatus* and *Microtus ochrogaster* facilitating a two-species system. Two distinct community types were found across sites and were determined by the dominant species. Ordination plots and variation algorithms were used to quantify community structure. Heterogeneity in environmental predictors did not drive community assembly, but some patch attributes were found to explain some of the variability. Outcomes suggest that small mammal communities are forming stochastically, and this stochasticity could be driven by unknown deterministic conditions. To uncover the possible mechanism behind community makeup, a larger sample size and annual sampling must be complete. Estimates can then be made on whether deterministic variables, stochasticity, or a combination of the two are influencing community composition. Further offering applicable practices that would benefit biodiversity maintenance in one of the most imperiled ecosystems in the country.

KEYWORDS: community ecology, small mammals, prairie, habitat heterogeneity, stochasticity, species composition, vegetation characteristics, metacommunity, deterministic

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Lastly, I want to shoutout the album “Thawed” by Noah Koppel that was played on repeat during my writing process.

I dedicate this thesis to Mr. John Despain. Mr. Despain believed in me when it felt like nobody else did. He is the reason that I fell in love with academia and pursued higher education. I am eternally grateful for him and the impact he had on my life.

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OVERVIEW

Studying organisms on a community level has a long history of debate amongst ecologists. Community ecology aims to quantify patterns in species abundance, diversity, and composition. Uncovering the process driving these patterns has made it challenging for the validity of the field of study. Community ecology was revolutionized in the early 1900s with Clements (1916) suggesting that species formed communities as a unit and assembly is influenced by deterministic variables (Clements 1916). Soon after, Gleason (1926) challenged this idea and proposed that species assembled due to stochastic processes and assembly is completely random (Gleason 1926). Arguments regarding community ecology have formed on the basis of scale, deterministic variable influence, and several other community dynamics. Decades later there are still disagreements in the field of study, with old theories disappearing as new knowledge is uncovered. It was once proposed that over 120 hypotheses were explained to be the catalyst behind community dynamics (Palmer and White 1994). The contemporary community concept widely recognizes regional and evolutionary patterns of population interactions over time and space (Hanski and Gilpin 1997; Ricklefs 2008). Considering interspecific mechanisms, organizational levels, and spatial properties has given rise to metacommunity ecology that combines demography, dispersal, heterogeneity, and species co-existence to make ecological predictions (Holyoak et al. 2005; Leibold et al. 2017; Chase et al. 2020; Figure 1)

Metacommunity ecology evaluates abundance, occupancy, and beta diversity to address trends in spatial and temporal heterogeneity that can provide insights into the field of conservation biology (Socolar et al. 2016; Chase et al. 2020). One specific area of interest is

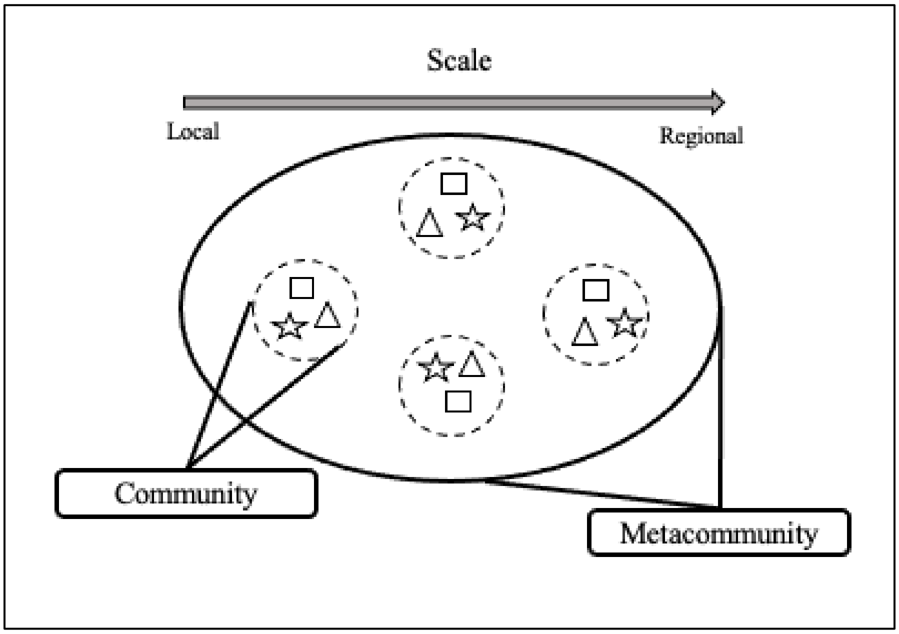


Figure 1. Theoretical figure depicting different organizational levels of community ecology across the spatial scale. On a local level, communities are made up of different populations of species co-existing in the same patch. The symbols within the community represent these different populations. On a regional scale, multiple communities across patches are embedded within a metacommunity. Figure adapted from Chase et al. (2020).

determining the role of stochastic and deterministic formation. Stochastic drivers include demographic stochasticity, environmental stochasticity, and measurement error to express variability in metacommunity composition (Shoemaker et al. 2020; Figure 2). Stochasticity is widely regarded with implementing variability in communities, but it is not always considered the main mechanism behind community dynamics (Hart et al. 2017). Stochasticity stems from the contingency of biological processes; all of which may be influenced by an underlying deterministic process (Clark 2005). Deterministic drivers cover predictable abiotic and biotic interactions including, but not limited to, anthropogenic habitat destruction, climate change, and species invasions (Stegen et al. 2012; Aguilar and Sommaruga 2020). It is clear that community assembly cannot be solely explained by just stochasticity or deterministic factors alone (Vellend

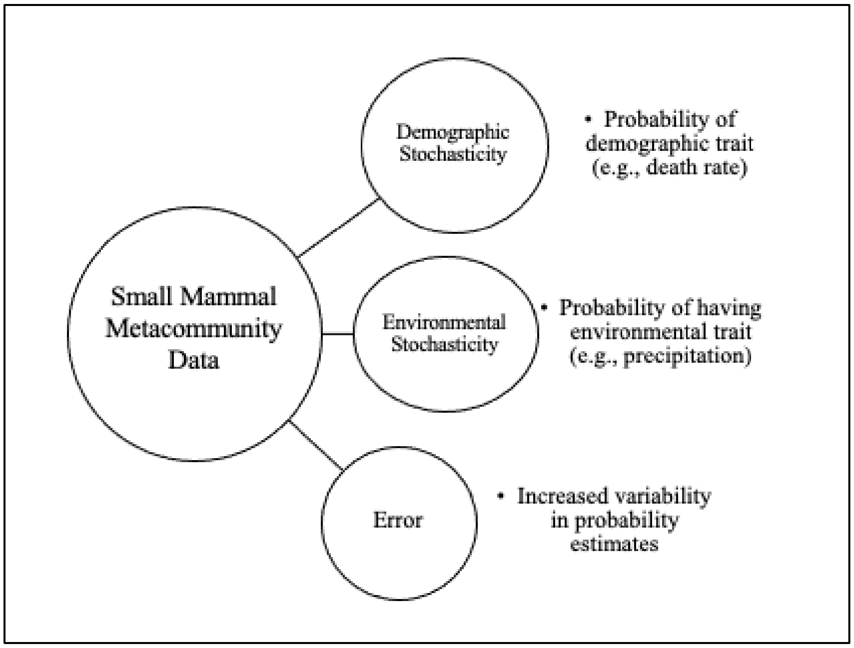


Figure 2. Conceptual diagram of the three modes of stochasticity and how they manifest into metacommunity data from a sample population. Figure adapted from Shoemaker et al. (2020).

Thus, some variability in metacommunity composition must be contributed to by bothstochastic and deterministic mechanisms (Leibold et al 2004; Vellend 2010). Observing community assemblages in a metacommunity lens may explain underlying stochastic and deterministic factors influencing species organization, which may inform conservation strategies to decrease biodiversity loss in areas undergoing ecological problems.

Biodiversity loss has become increasingly alarming in Missouri grasslands. Rising patterns of woody encroachment, habitat destruction, and fragmentation have the potential to cause prairies to experience decreases in biodiversity (Newbold et al. 2020). Since European settlement, a small fraction of native prairie is left and there is still little known about the health of the remaining landscape (Samson and Knopf 1994). The once expansive range of Missouri prairies has been fragmented into smaller, scattered patches that have undeniably lower biodiversity due to the dramatic decrease in area and increase in isolation (Samson and Knopf 1994). Prairie ecosystem sustains a wide variety of floral and faunal species that may become vulnerable due to these habitat alterations. Small mammals remain an integral part of prairie ecosystems and their presence is crucial for the habitat's survival (Kaufman and Kaufman 1997).

Many studies have used small mammals as biological indicators of patch health and for evaluations of community composition shifts (Ryszkowski 1975; Grant et al. 1982; Kaufman and Kaufman 1997). Their curious population fluctuations can be used to assess how changes in habitat structure may be affecting overall community makeup (Krebs and Myers 1974). Small mammal species are essential components of the food web. They not only act as key prey items that sustain higher trophic levels, but they facilitate micro-disturbances and seed dispersal that are thought to benefit plant life, and primary consumers (Quested and Foster 2007; Schupp et al. 2010; Gómez et al. 2019). Small mammals can have species-specific ecology regarding dietary behaviors and habitat preferences that may alter vegetation composition or be altered by vegetation composition (Matlack et al. 2008; Zwolak 2018; Hope et al. 2021). Dietary preferences can also play a part in live-trapping success within ecological surveys. Several studies suggest that choosing the preferred bait type is crucial for successful small mammal trapping (Harkins et al. 2019; Weihong et al. 1999; Hice and Velazco 2013). Observing the relationship of vegetation characteristics alongside small mammal community composition may help to further understand how the small mammal community and vegetation interactions may respond to ecological change.

Research has shown discrepancies in the overall thought on small mammal community assembly and there is a significant gap in the understanding of Missouri prairie ecosystem (Larson et al. 2018; Newbold et al. 2020). I wish to fill this gap by focusing on deterministic influences on metacommunity assemblages, while assuming that stochasticity is inevitable in a natural environment. The purpose of my study was to uncover a possible mechanism behind community composition at these sites, by testing environmental factors and evaluating species richness. I specifically wanted to examine the relationship between vegetation and small mammal communities given the proposed relationship between them. Further, I wanted to examine if different bait types impacted small mammal trapping success. In the face of anthropogenic changes, insights on small mammal metacommunities could provide useful perspectives on how to manage endangered ecosystems (Chase et al. 2020).

The first chapter includes richness calculations and ordination plots to demonstrate differences in species richness and community structure across patches, potentially yielding an idea for patches with elevated habitat suitability. Then, I used an algorithm designed to explain variation across sites by testing environmental data variability. Thus, deciding if deterministic variables are influencing individual species and metacommunity structure. The second chapter focuses on small mammal sampling methodology. Trapping procedures have become increasingly complex with trap layout, trap types, and bait types. Using Sherman live-traps to sample, I constructed Bernoulli trial experiments that tested small mammal bait preference between sunflower seeds and rolled oats. Documentation of successfully trapped individuals and their correspondent bait type was recorded and plotted using a bar graph. Binomial distribution tests then examined the degree of significance between bait type and elevated trap success. Uncovering optimal live-trapping techniques not only fine-tunes experimental design but can also lead to more accurate predictions of small mammal metacommunity structure. Due to widespread ecosystem transformations the biodiversity in Missouri prairie patches is at risk (Pimm et al. 2006). Insights from small mammal metacommunities and their responses to environmental conditions may influence conservation strategies to properly manage endangered prairie ecosystems.

SMALL MAMMAL COMMUNITY STRUCTURE IN MISSOURI PRAIRIE PATCHES

Introduction

Community ecology studies provide insights on different populations of species co-occurring in a similar spatial and temporal domain (Clements and Newman 2003). Analyzing community dynamics can illustrate patterns of species' distribution, abundance, and interactions with other species and their local environment (Leibold et al. 2004). These communities can be dynamic, with possible reliance on the individual's reaction to their surroundings (Lawton 1999). The main theory behind community assemblages is largely debated with rising concern regarding the roles of temporal and spatial range (Ricklefs and Schluter 1993); as well as the disagreement between stochastic and deterministic formations (Willig and Moulton 1989; Brown et al. 2000; Stone et al. 2000). Designing community ecology studies can be challenging with vast theories being accepted and refuted repeatedly over time. Expanding the spatial scale of community ecology has led to novel analysis of trends in a metacommunity perspective, where local communities are thought to interact through dispersal (Figure 1; Hanski and Gilpin 1991) For my research I have decided to question whether metacommunities form stochastically, deterministically, or a mix of the two (Chase and Leibold 2003; Chase et al. 2009; Chase 2010). Stochastic formations are thought to reflect ecological mechanisms that drive community composition and cannot be easily distinguished from non-random chance (Figure 2; Chase and Myers 2011). Neutral processes such as extinction, colonization, and ecological drift are frequently characterized as stochastic events (Hubbell 2001). Deterministic processes include non-random, and niche focused variables that drive assembly (Chase and Meyers 2011). Community composition that forms in relation to habitat characteristics, climate changes, and other biotic and abiotic interactions would be considered to have a deterministic influence. The scope of my research is far too narrow to be able to contextualize and test for stochastic community formations. Thus, my goal is to focus on deterministic conditions on small mammal communities, with an understanding that stochasticity may play a role as well (Stegen et al. 2012).

There is substantial information regarding the link of environmental influences and metacommunity composition, especially in small mammals (Jorgenson 2002; Benedek and Sîrbu 2018; Upendo et al. 2023). Generally, small mammals follow cyclical population fluctuations that can be highly variable (Whitford 1976; Andreassen et al. 2021). Stochastic fluctuations aside, environmental conditions are suggested to alter rodent community structure and demography (Rehmeier et al. 2005; Rowe and Terry 2015). Historically, environmental conditions within climatic zones are perceived as stable (Whittaker 1962). However, variation in environmental gradients can become apparent with climate changes and landscape alterations (Blois et al. 2013). Unstable environmental gradients may develop in grassland ecosystems as they experience habitat destruction, fragmentation, and woody encroachment (Blair et al. 2014). Specifically, in the state of Missouri less than one percent of original prairie remains (Newbold et al. 2020). Fragmentation of prairies decreases patch size, increases reliance on dispersal across the surrounding matrix, and changes patch characteristics which may lead to heightened extinction rates and loss of biodiversity (Wilcove 1986; Fuhlendorf et al. 2002). Some studies argue that small mammal responses to altered patch attributes may differ along the gradient, and across species leaving room for further investigation (Brady and Slade 2001; Morris 2005; LaFond 2022).

Understanding deterministic influences on small mammal metacommunities would require a multi-scale study that includes data on small mammals, plants, and abiotic factors at each patch. Small mammal communities can be great indicators for patch health and offer an opportunity to determine how biodiversity reacts to environment (Avenenant 2011; Hope et al. 2021). Vegetation diversity and abundance are thought to be driven by the differences of small mammal communities and small mammals rely on vegetation for many of their life processes (Batzli and Pitelka 1970; Brown and Heske 1990). Non-volant grassland rodents rely on a variety of plants to survive. Rodents use vegetation for protection, material for nests, niche separation, and production of runways (Brown and Lieberman 1973; Hansson and Larsson 1978). Grassland rodents are mostly granivorous and herbivorous, meaning vegetation makes up a big part of their diet (Kaufman and Kaufman 1997). They display behaviors such as seed caching, foraging, and consumption that facilitate seed dispersal (Howe and Brown 2000). Different species of rodent vary in the way they display these behaviors, which may alter rates of seed dispersal (Smith and Reichman 1984; Zwolak 2018; Brehm and Mortelliti 2022). Rodents can also drive vegetational successional change by causing micro disturbances during burrow and runway construction, which alters vegetation composition (Zhang et al. 2003; Ross et al. 2007). Prairie destruction and management malpractice has resulted in an extreme loss of nutritionally rich native vegetation, limiting available resources and variety in microhabitat for small mammals (Whisenant 1990). Because vegetation diversity is related to small mammal communities, disturbance to either group may be indicated by the disturbance of the other. Having an idea of community composition with certain patch characteristics such as vegetation, could provide management directions that benefit both flora and fauna in endangered ecosystems conservation (Lark 2020).

Southwestern Missouri prairies provide a unique opportunity for research because there is an overwhelming lack of data on them (Lark 2020). A recent study by Rodery (2021) focused on small mammal occupancy and its relationship with the Equilibrium Theory of Island Biogeography (ETIB) in southwestern Missouri prairies. She hypothesized that patch size, shape and isolation would influence occupancy as suggested by Macarthur and Wilson (1963). However, ETIB predictors did not explain small mammal occupancy, and it was concluded that an unknown deterministic catalyst was responsible for differences in communities and further examination is required (Rodery 2021). In continuation of Rodery (2021), I aimed to work out differences in small mammal metacommunity composition and establish if deterministic influences were driving the variation.

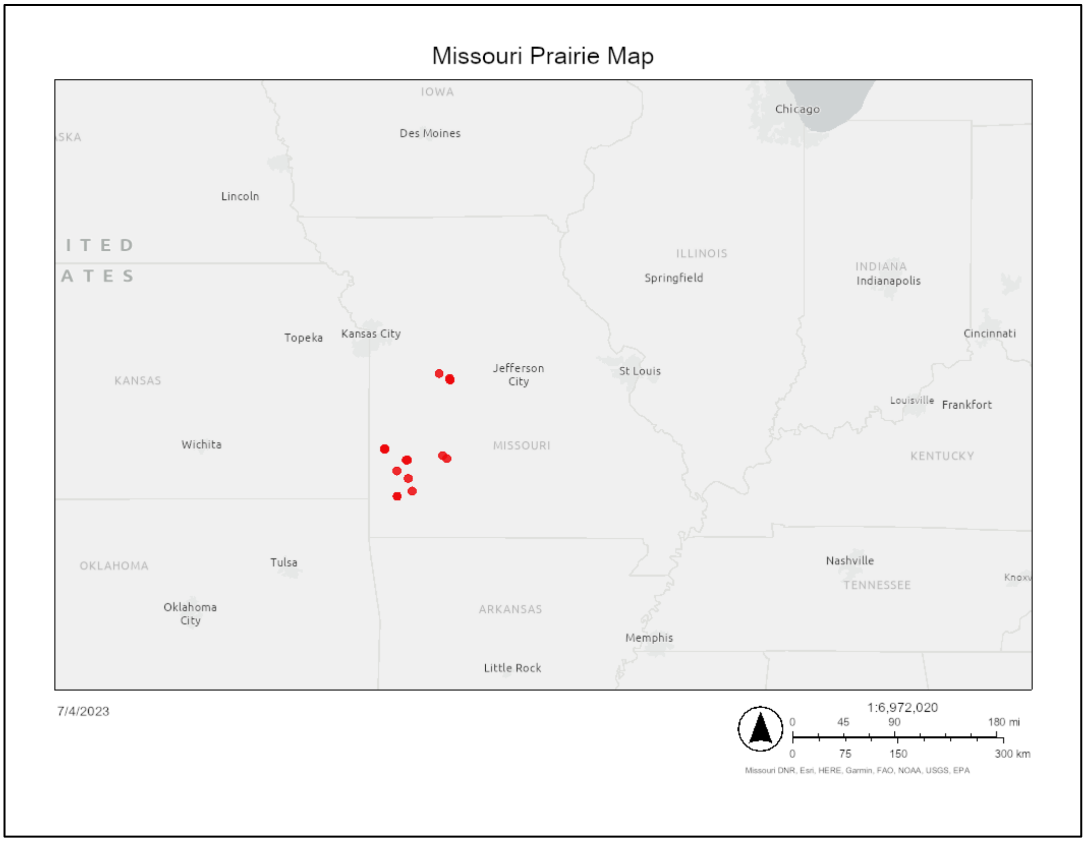
I assessed small mammal metacommunity composition in Missouri prairies to investigate patterns and test for differences using additional, micro-, and macro- patch variables to distinguish environmental influences. The first question I wished to answer was whether or not small mammal community composition differed across prairie patches. I predicted that different community structures and richness metrics would be evident and may indicate elevated habitat quality. To do so, species richness (D) was calculated and categorization of small mammal communities by species detection at each site was complete. To quantify community structure, I used a simple algorithm to compare similarities and used ordination plots to illustrate variation. Community differences were depicted by a heat map, a non-metric multi-dimensional scaling, and a canonical correspondence analysis.

The second question I address was if differences in community structure were driven by deterministic processes; specifically, vegetation characteristics. I predicted that vegetation characteristics are a main driver for the differences in small mammal community composition, as proposed from their relationship. After organizing differences in assemblies across sites, I tested richness and individual species presence alongside environmental characteristics using generalized linear models, general additive models, and AIC scores. I highlighted vegetative ground cover percentage (%), vegetation height (m), ground humidity (%RH) and temperature (C°), elevation (m), prairie type, and patch size (ha) as my predictor variables. Possible explanations of community variation across ecological conditions could be discovered with individual presence, species absence, or community reordering.

Methods

Data collection. During May–September 2022, I surveyed 15 Missouri prairies within the southwestern portion of the state (Figure 3). Eleven of these prairies were previously sampled by Rodery (2021). Sites included Linden's Prairie and NW Lawrence County Prairie in Lawrence County, Friendly Prairie, Drover's Prairie, Lordi Marker Prairie, and Brun's Tract in Pettis County, Denison Prairie, and Golden Prairie in Barton County, Lattner Prairie and Pleasant Run Creek Prairie in Vernon County, Coyne Prairie and Welsh Tract in Dade County, La Petite Gemme and Schuette Prairie in Polk County, and lastly Rae Letsinger Prairie in Newton County. A map of these sites was created using ArcGIS Online (March 2022). To sample these sites, I obtained permission from the Missouri Prairie Foundation and the Missouri Department of Conservation (Appendix A).

Small mammal surveys were conducted using procedures similar to Beasley and Maher (2019). Two ~250m linear transects were set. Each consisted of 25 trap stations that were placed ~10m apart from one another and marked with a labeled flag. Each station was made of two regular-sized Sherman traps (LFATG, dimensions 7.62×8.89×22.86 cm) baited with either rolled oats or sunflower seeds (See Chapter 2), yielding 100 total traps set each night. Coordinates



Missouri DNR, Esri, HERE, Garmin, FAO, NOAA, USGS, EPA

Figure 3. Map showing study sites. Red dots signify sites. Some sites are located closely together, so their individual dot may not be discernable from others nearby.

recorded for the start and end of each trap line, as well as each trap station that fell in intervals of 5, using a Garmin handheld GPS receiver (64s). Trapping took place over three consecutive nights when weather permitted. Each night traps were set before sundown and remained open until morning. At sunrise, traps were checked for captures and were closed for the day if found empty. Traps that had been snapped were briefly checked to see if there was an animal inside. If an animal was found, we collected it for further evaluation. If it was empty, we determined the trap was a half-trap for the night. For each site I totaled the number of trap nights as a measure of effort. Data on the species identification, sex, age, trap station, bait type, and other measurements were taken during processing. Measurements included: the mass (g), and the length of their right hind foot, ear, and tail (mm). Lastly, individuals were marked with an ear tag that contained a specialized number and then released near the trap line they were found in. All field protocols were reviewed by the Missouri State University Institutional Animal Care and Use Committee (IACUC) in July 2021 and were approved (Appendix B). Animals handling procedures were consistent with guidelines from the American Society of Mammologists (Sikes et al. 2016).

Vegetation characteristics were collected using a 1m^2 quadrat made of PVC pipes. Plant data were recorded on each of the two-trap line transects, starting at trap station 1, and then continuing at trap stations 5, 10, 15, 20, and 25, yielding 12 quadrat measurements per site. At each selected trap station, the quadrat was haphazardly tossed ~1.5m from where the station was flagged, and measurements occurred within the quadrat. I estimated the percentage of ground cover within the quadrat visually using a technique similar to Braun-Blanquet et al. (1932). To increase precision, only one person made observations (Sykes et al. 1983). Vegetation classification focused on the presence of true grasses (*Poaceae*), forb (*Aster, Apocynaceae, Fabaceae,* etc.), woody shrubs (*Rhus, Rosaceae, Onagraceae* etc.), rock, and bare ground. Forbs were distinguished from grasses with regard to Weaver and Fitzpatrick (1934). Then, I assigned an estimated percentage for each group (Swihart and Slade 1990). I measured height (m) of vegetation four times within the quadrat and determined the average. Standing within the center of the quadrat I then scanned a 3.5m perimeter around the square and identified all trees to genus (*Quercus, Acer, Juniperus,* etc.). Information on the native plant species and conservation coefficient scores (Thomas and Ladd 2015) were collected from the Missouri Prairie Foundation website (moprarie.org).

I collected data on the weather each night and morning I sampled. I determined cloud cover, temperature (C°), relative humidity (RH%), wind speed (MPH), precipitation (cm), vapor pressure, and moon phase for each sampling period. When weather information was not available, I used weather data collected from the PRISM database (PRISM.org). I used this database to collect the elevation (m) data and use it as a dummy variable. Elevation is not expected to have an influence on small mammals, so adding it to analysis will help to control for outside factors and provide ease with interpretation (Suits 1957). Using a hygrometer (PCE-555) held ~2.4cm from the ground, I recorded measurements of ground temperature and relative humidity at each station to distinguish ground conditions from the atmosphere. Further data on abiotic prairie attributes was found on moprairie.org. I chose to examine the comprehensive prairie types and prairie area. In Missouri there are 12 types of tall grass prairie that are characterized by the degree of soil substrate, soil moisture, and position. The sites chosen for this study were made up of 5 different types, including: dry-mesic chert, dry-mesic sandstone, limestone, original, and planting.

Data Analysis. I used R (Version 4.1.1 (2021-08-10)) and RStudio (Version 2021.09.0+351) to complete data analysis. First, data was formatted using "readxl" function (Wickman et al. 2019). To determine the minimum number alive for each mammal species at every site, I used function "unique" to eliminate all recaptures (Version 3.6.2). To assess species richness, the number of species per site was calculated using package "dplyr" (Version 1.1.0). Species richness per site was measured using Simpsons index (D), which evaluates community structure by measuring diversity with the additive influence of abundance (Tuomisto 2010; Leibold et al. 2017). The index ranges from 0–1, with values closer to 1 being more diverse. The values of Simpson's index increase with greater evenness (Table 1). Package vegan (Version 2.6-4) was used to plot a rarefaction curve to compare species richness across sites with unequal detections (Figure 4). If curves fail to overlap, then sites will have different species richness.

Similarity between communities was assessed using the Bray-Curtis dissimilarity of sites using the vegan function “vegdist”. Bray-Curtis dissimilarity values were plotted as a heat map, where lighter color squares indicate similar community structure between a pair, while darker squares are increasingly dissimilar, and the dendrogram represents similarity between communities (Figure 5; Gehlenborg and Wong 2012).

Community structure was compared using a Non-metric Multi-dimensional Scaling (NMDS) which condenses community data into a bivariate ordination plot (Figure 6; Clapham 2011). To illustrate the potential explanatory patterns with this ordination, I plotted the NMDS with five prairie types to assess the degree of clustering. Each site was represented by a point with a symbol that represented their prairie type. Points clustered close together would indicate that the communities have similar structure, and sites with similar prairie type should cluster if the classification explains patterns (Figure 6).

The next ordination technique was a canonical correspondence (CCA) to analyze relationships between species presence and environmental variables (Figure 7; Ter Braak and Verdonschot 1995). The CCA plot can also be used to examine habitat heterogeneity across sites. Again, I used the Bray-Curtis distance to determine levels of similarity. I included the following environmental variables: the percentage of grass (%), percentage of forb (%), average plant height (m), AM/PM ground temperature (C°), AM/PM ground humidity (%RH), elevation (m), and prairie size (ha). If the site data is oriented distantly from another, this would show a higher level of habitat heterogeneity in relation to one or more environmental variables. If sites are clustered, then the sites would have features that are homogenous to one another. Similarly, if the species data points are not clustered this indicates that one or more of these variables are influencing the presence of a species. If points are clustered, then species presence is not dependent on the environmental variables tested (Figure 7).

To further visualize environmental gradients, I made a scatterplot that illustrates the range of morning and evening ground humidity (Figure 8). Along with a scatterplot for the range of morning and evening ground temperature (Figure 9). The scatterplot may show variability in microhabitats and may also show instances of environments with a wide range of conditions.

I used general linear models (GLMs) to test if environmental conditions affected community assemblage (Guisan et al. 2002). I tested response variables individually because stepwise regression did not yield better model fit. Then, I plotted a combination of estimates based upon vegetation characteristics and richness (Figure 10). To evaluate variable importance, I used Akaike Information Criteria (AIC), where the smallest AIC value indicates the most-preferred model (Table 2). Due to the small sample sizes, I opted to use AICc values to prevent overfitting (Aho et al. 2014).

I explored individual species' responses to the six environmental conditions using GLMs. I modeled abundance GLMs for the two species that were most abundant as a function of grass percentage, forb percentage, plant height, elevation, and prairie size. Then, I plotted species' presence in relation to vegetation characteristics (Figure 11; Figure 12). Again, I used AICc values to determine which model is the best fit (Table 2).

After GLM's were fit and AICc scores were compared, I decided to deploy Generalized Additive Models (GAM's), to uncover any non-linear trends hidden within the dataset. My reason for doing this is that there could be an optimal condition for a species, which would manifest into a bell-shaped curve where the species is most abundant in-between extremes. Further, the AICc scores from the GLMs may have indicated a response to the dummy variable, elevation. Then, I calculated the AICc values for the GAM's and made a table with these values (Table 3).

Results

I captured 218 individual small mammals representing 7 species (Table 1). The North American Deer Mouse (*Peromyscus maniculatus*) was detected most frequently (n=95) and was found at 12 of the 15 sites. The Prairie vole (*Microtus ochrogaster*) was the next most frequent (n=69) and was found at 11 sites. I captured 30 hispid cotton rats (*Sigmodon hispidus*) across 2 sites, while the white-footed mouse (*Peromyscus leucopus*) was caught 17 times across 5 sites. The remaining 3 species were rarely detected. The southern bog lemming (*Synaptomys cooperi*) was detected twice at Brun's Tract, the meadow jumping mouse (*Zapus hudsonius*) was found once within Coyne prairie, and the North American least shrew (*Cryptotis parva*) was found once at Rae Letsinger. The Simpson's index ranged from values of 0-0.64 and seemed to cluster into approximately 5 groups (Table 1).

The number of species in prairies varied from 0 to 4, with two prairies having 4 species (Coyne and Brun's Tract) and one with 0 (Golden; Table 1). La Petite Gemme, Schuette, Lordi Marker, and Pleasant Run Creek had 3 species and Welsh, Friendly, Linden's, Lattner, Drover's, and The Rae Letsinger had 2. Lastly, only 1 species was detected in NW Lawrence Co. and Denison prairie. Based upon the rarefaction curve, most sites reached maximum richness well before the maximum number of individuals captured, although Coyne and Schuette prairies are not asymptotic (Figure 4). At 9 individuals, sites with more than 1 species expect 2–3 species, with general overlap in approximate 95% confidence intervals.

The heat map distinguishes prairies as two sets of communities, determined by the

Table 1. Abundances of each species captured at each site and corresponding Simpson's Index (D). *Peromyscus maniculatus (Pm), Microtus ochrogaster (Mo), Sigmodon hispidus (Sh), Peromyscus leucopus (Pl), Synaptomys cooperi (Sc), Zapus hudsonius (Zh), Cryptotis parva (Cp).*

	Pm	*Mo*	*Sh*	*Pl*	*Sc*	*Zh*	*Cp*	(D)
Brun's	5	13	-	5	2	-	-	0.64
LPG	5	2	5	-	-	-	-	0.63
PRC	7	12	-	5	-	-	-	0.62
Coyne	7	2	-	1	-	1	-	0.55
LM	10	1	-	4	-	-	-	0.48
Friendly	4	7	-	-	-	-	-	0.46
Schuette	5	1	25	-	-	-	-	0.32
Welsh	8	-	-	2	-	-	-	0.32
Linden's	17	4	-	-	-	-	-	0.31
Drover's	15	2	-	-	-	-	-	0.21
Lattner	2	15	-	-	-	-	-	0.21
Rae Let.	10	-	-	-	-	-	1	0.17
Denison	-	11	-	-	-	-	-	0
NW L.	-	-	-	-	-	-	-	0
Golden	-	-	-	-	-	-	-	NA

dominant species in a two-species system, either *Peromyscus maniculatus* or *Microtus ochrogaster* (Figure 5). There is a clear split in the dendrogram that separates Pleasant Run Creek, Brun's Tract, Lattner, Friendly and Denison prairie with higher *Microtus ochrogaster* abundance than *Peromyscus maniculatus* (58:18). The rest of the sites, La Petite Gemme, Coyne, Lordi Marker, Schuette, Welsh, Linden's, Drover's, Rae Letsinger, NW Lawrence Co had higher *Peromyscus maniculatus* abundance and lower *Microtus ochrogaster* abundance (77:12).

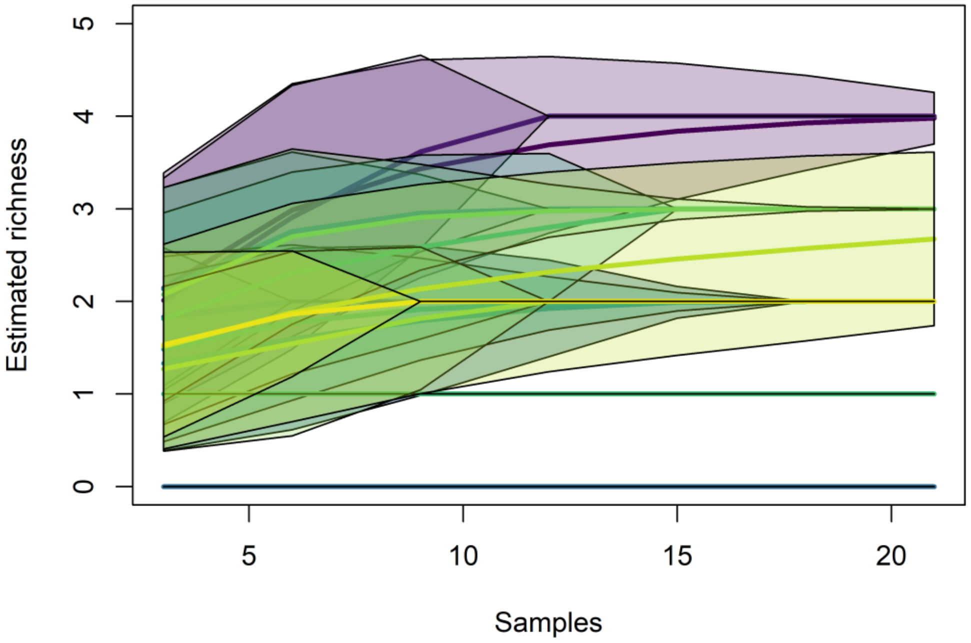


Figure 4. Rare faction curve with error bars showing relation of number of species detected based upon sampling effort. Estimated richness was similar to our observed richness.

Prairie sites did not cluster by prairie type, and instead sites of similar type were largely dissimilar (Figure 6). The NMDS shifts the prairie vole dominated sites along axis 1 towards the left, while the deer mouse dominated sites shift along axis 1 towards the middle to the right. The CCA plot highlighted 8 variables responsible for site differentiation: average percentage of grass, CCA plot highlighted 8 variables responsible for site differentiation: average percentage of grass, average percentage of forb, average vegetation height, AM/PM temperature, AM/PM humidity, elevation, and area (Figure 7). Both average percent forb, percent grass, mean humidity in the evening and elevation were associated with axis 1 and 2. AM/PM temperature, AM humidity and area were associated with axis 2. Site variability is evident with the lack of clustering of prairie points, especially along axis 2, indicating forb percentage and elevation explain the most variation of site community differences. Sites that were characterized by having the prairie vole

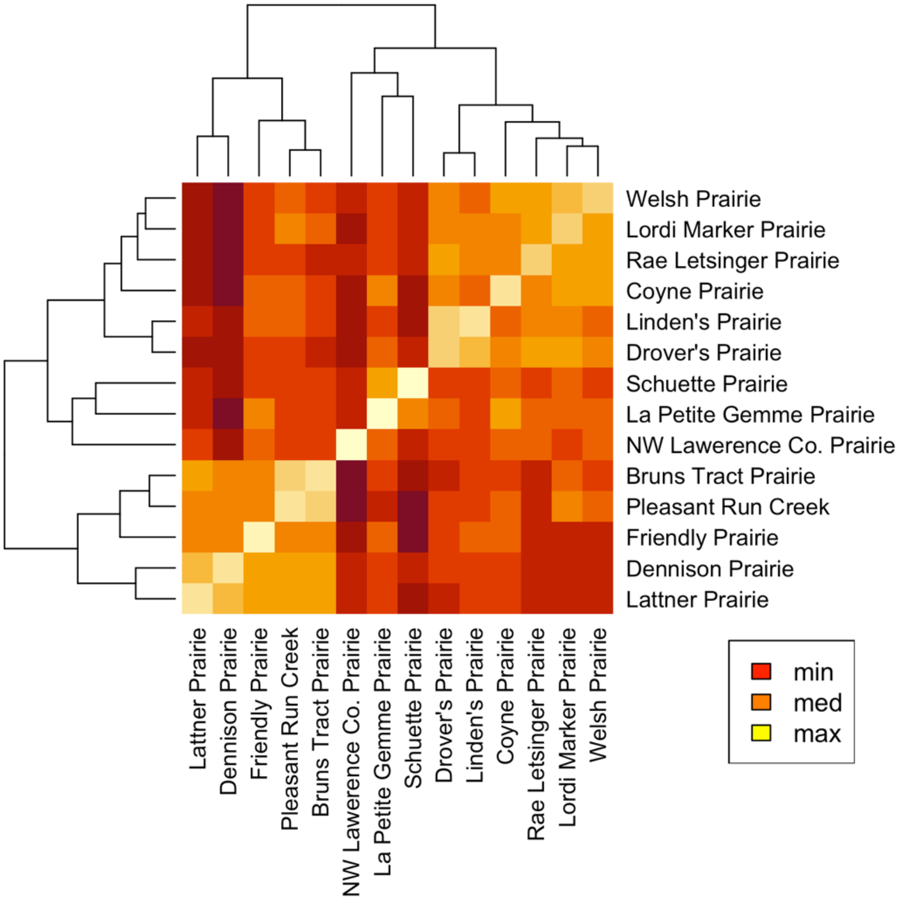


Figure 5. Heat map depicting site dissimilarities. The dendrogram clusters prairies by community assemblage. Clumps of lighter colored squares indicate increasing similarity of community assembly. Darker squares indicated decreasing similarity.

as the dominant species were all characterized with lower forb percentage and lower elevation. Despite environmental heterogeneity across sites, these variables did not show a strong influence on species presence as all species are oriented towards the middle of the plot (Figure 7).

Microhabitat variability was established further with different values and ranges of ground humidity and temperature. Scatterplots depict that some sites have a wide range between morning and evening humidity measurements (Figure 8). For example, Brun’s Tract, Golden, La

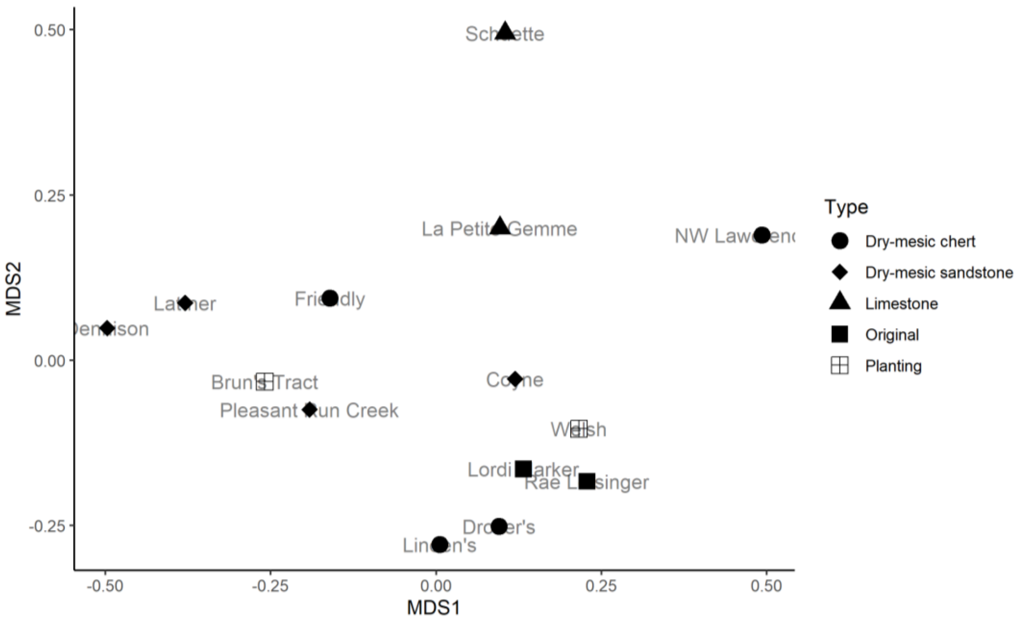


Figure 6. Non-Metric Multidimensional Scale showing community differences. Each symbol represents the prairie type assigned to that particular site.

Petite Gemme, Lattner, NW. Lawrence Co., Rae Letsinger, and Schuette prairies have a distinguishable blank space between the morning and evening plot points. These sites would be considered to have a wide environmental range throughout the day. Similarly, some sites had vast temperature differences per day. Golden, La Petite Gemme, Lattner, NW Lawrence Co., Pleasant Run Creek, Rae Letsinger, and Schuette were sites that seemed to experience a broad range of temperatures throughout the day; indicated by the blank space between measurements (Figure 9).

All the GLMs were not significant for both species' richness estimates and individual species response with these 6 variables. Species richness was tested for correlation with prairie type (AICc= 56.33), average percent grass (AICc=44.29), average percent forb (AICc= 44.54), average plant height (AICc= 44.69), elevation (AICc= 43.81), and area (AICc=45.29). Elevation

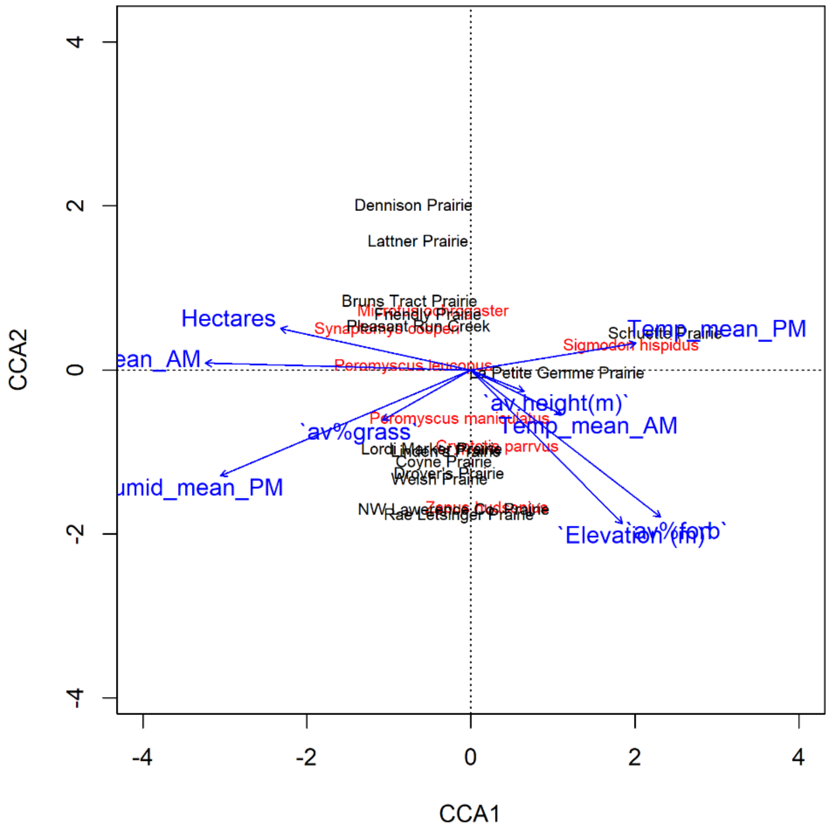


Figure 7. Canonical Correspondence plot. Sites are plotted using black text, and species are plotted using red text. Blue arrows indicate one of the environmental variables tested. The arrows position on the axis shows correlation, and length of arrows indicate the strength of influence.

had the lowest AIC score indicating that it explained the most variation of observed richness, closely followed by percent grass (Table 2). *Peromyscus maniculatus* presence was tested for correlation with prairie type (AICc= 102.00), average percent grass (AICc=90.81), average percent forb (AICc=88.91), average plant height (AICc= 91.17), elevation (AICc=91.02), and area (AICc=91.14). Forb percentage had the lowest AIC score explaining the most variation of deer mouse presence, followed by grass percentage (Table 2). *Microtus ochrogaster* presence was tested for correlation with prairie type (AICc=101.39), average percent grass (AICc=94.11), average percent forb (AICc=92.20), average plant height (AICc=94.53), elevation (AICc=90.12),

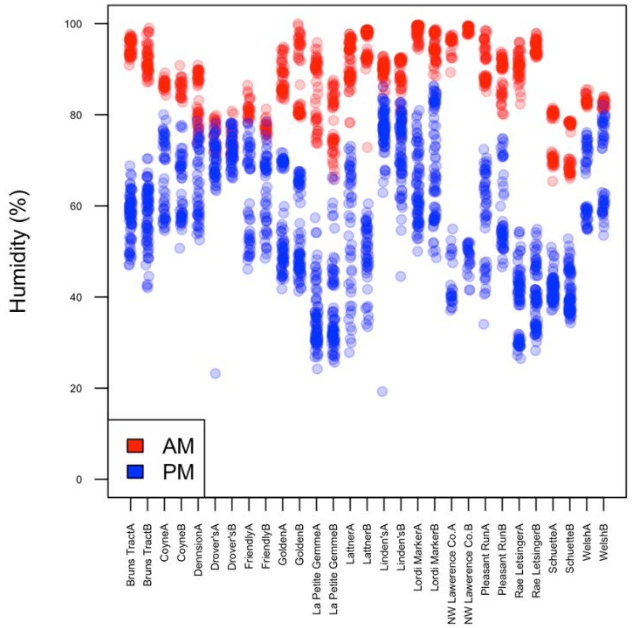


Figure 8. Scatterplot with morning and evening ground humidity (%) gradients per site. The red points signify morning measurements and the blue stands for evening measurements.

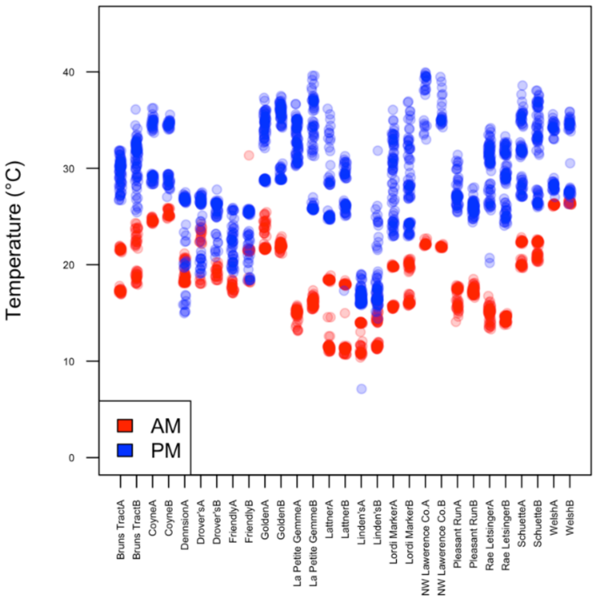


Figure 9. Scatterplot of morning and evening ground temperature (C°) gradients per site. Red points are morning measurements and blue points are evening measurements.

and area (AICc=93.41). Elevation had the lowest AIC value accounting for the most variation on prairie vole presence, followed by forb percentage (Table 2). Plots showing richness, deer mouse, and prairie voles' relation to grass percentage, forb percentage, and vegetation height were found to be insignificant (Figure 10; Figure 11; Figure 12).

Generalized additive models were fitted due to the peculiar AICc score for richness and the prairie vole and elevation (Table 2). As stated before, elevation was used as a dummy variable and was not expected to yield a supported model. AICc scores were calculated for the GAMs (Table 3). The model that was most supported for species richness was that for elevation (AICc= 43.81), followed by percent forb (AICc=44.45). Deer mice were most explained by forbs (AICc=90.81), then prairie size (AICc=91.14). The prairie vole model explaining the most variability is prairie size (AICc=89.14), followed by elevation (AICc=90.12; Table 3). GAMs were then plotted but resulted with insignificance with these relationships, except that of prairie voles and prairie size (Figure 15). The plot shows a hump shaped pattern that may represent prairie voles prefer patches that are medium sized.

Discussion

I hypothesized that Missouri prairie patches would have differences in their small mammal communities that coincided with deterministic variables, such as vegetation characteristics. Ultimately, community assemblages were found to be different across sites and some environmental conditions were found to explain a scattering of the variation. I expected richness measurements that would indicate elevated habitat suitability at certain sites. However, community richness measurements showed little discrepancies across sites that would explain heightened suitability (Table 1). Despite having some high and low richness values, overlapped error bars within the rare faction curve show uncertainty with our expected richness values (Figure

4). Several studies have similarly found changes in species composition, with richness estimates

Table 2. AICc scores and AIC weight for Richness (D), PM (*Peromyscus maniculatus*), and MO (*Microtus ochrogaster*) general linear models (GLMs).

	Richness		PM		MO	
	AICc	AICcWt	AICc	AICcWt	AICc	AICcWt
~Prairie type	56.33	0.00	102.00	0.00	101.39	0.00
~Grass	44.29	0.22	90.81	0.16	94.11	0.08
~Forb	44.54	0.19	88.91	0.42	92.20	0.20
~Height	44.69	0.18	91.17	0.14	94.53	0.06
~Elevation	43.81	0.28	91.02	0.15	90.12	0.56
~Area	45.29	0.13	91.14	0.14	93.41	0.11

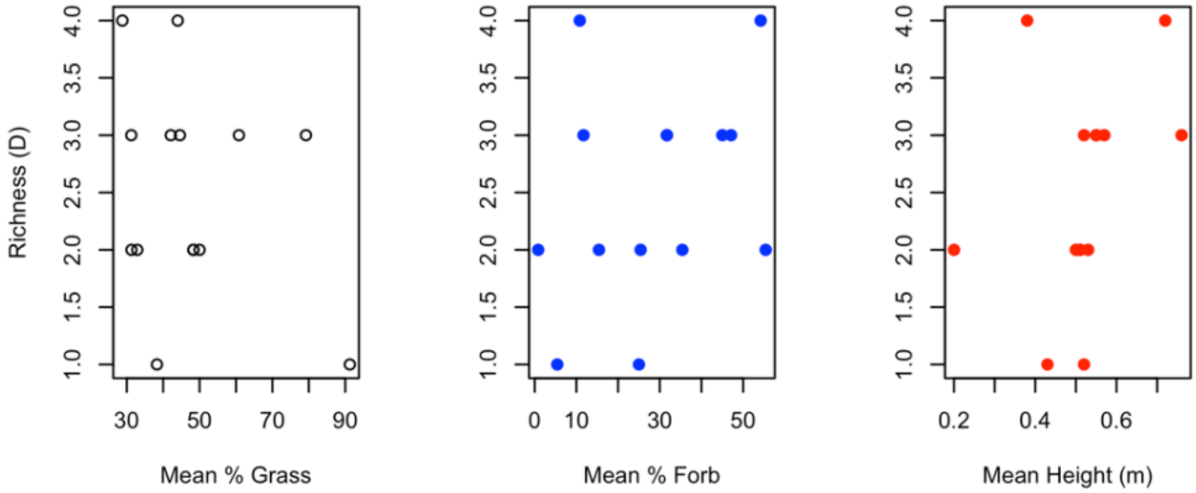


Figure 10. General linear model (GLM) comparing vegetation characteristics with species richness (D). Mean percent grass is plotted with a clear circle, a blue circle is used for mean percent forb, and a red circle is used for mean height.

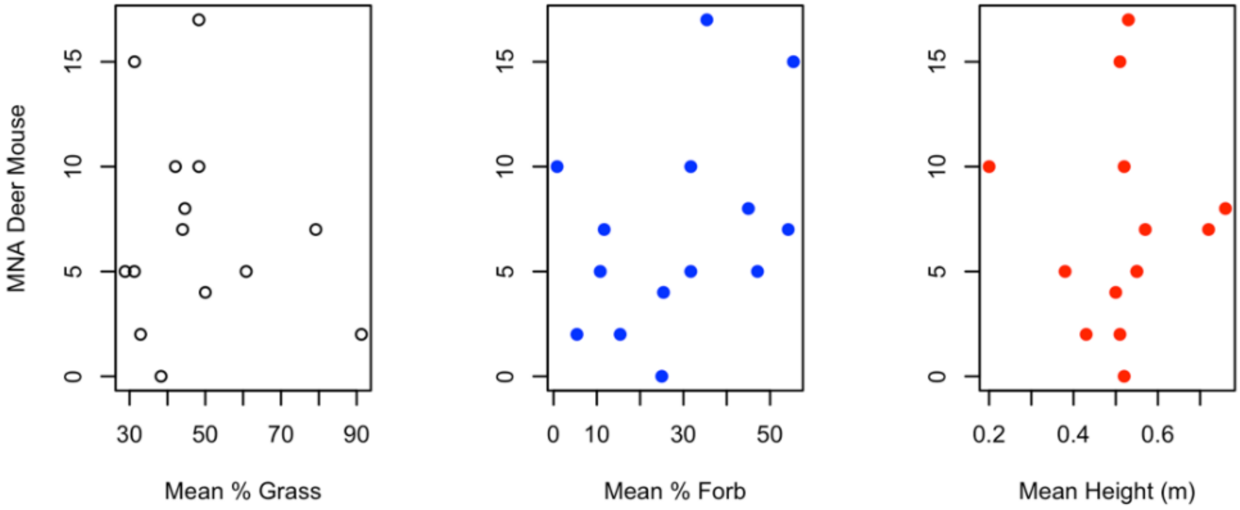


Figure 11. General linear model comparing the minimum number alive (MNA) of deer mouse with vegetation characteristics. Mean percent grass is plotted with a clear circle, a blue circle is used for mean percent forb, and a red circle is used for mean height.

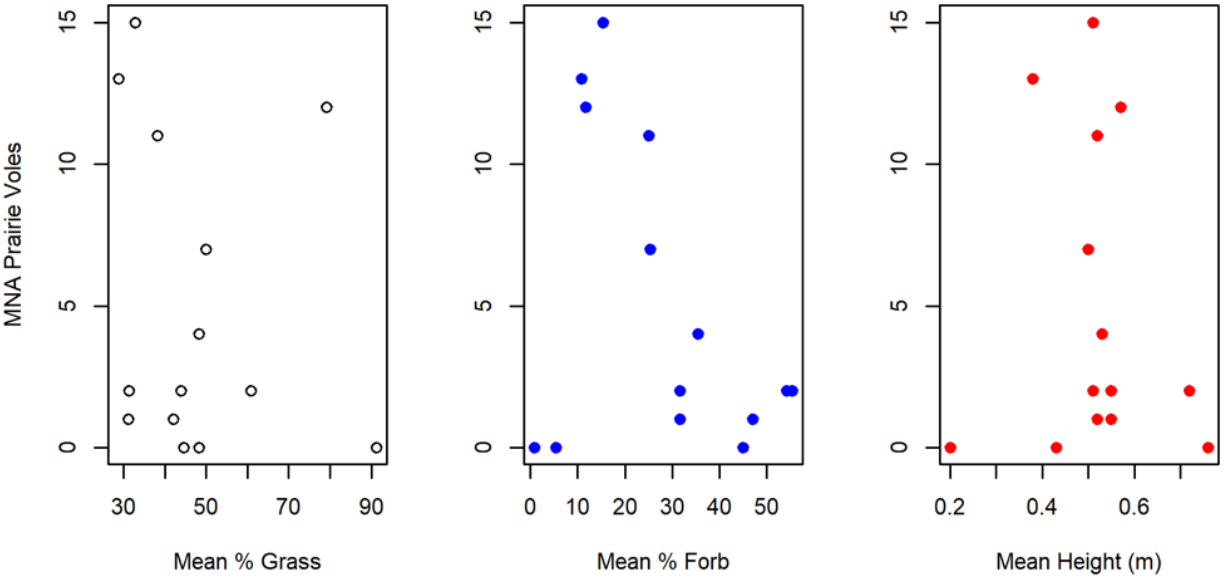


Figure 12. General linear model (GLM) comparing vegetation characteristics with the minimum number of Prairie voles. Mean percent grass is plotted with a clear circle, a blue circle is used for mean percent forb, and a red circle is used for mean height.

Table 3. AICc scores and AIC weight for Richness (D), PM (*Peromyscus maniculatus*), and MO (*Microtus ochrogaster*) general additive models (GAMs)

	Richness AICc	PM AICc	MO AICc
~Grass	67.79	90.81	94.20
~Forb	44.45	125.26	119.35
~Height	57.51	91.17	94.80
~Elevation	43.81	91.30	90.12
~Area	45.29	91.14	89.14

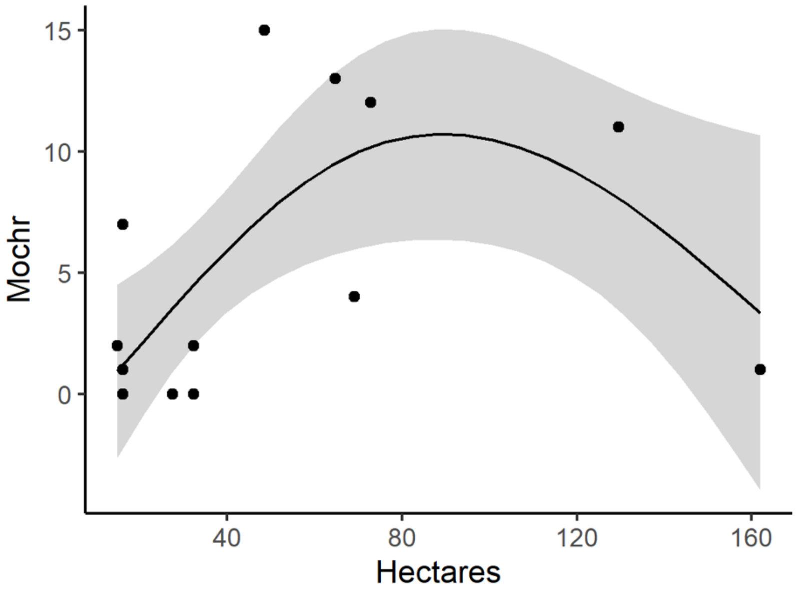


Figure 13. Generalized additive model depicting the bell-shaped curve relationship between *Microtus ochrogaster* and hectares.

remaining constant (Vellend et al. 2013; Dornelas 2014; Jones et al. 2017). Richness measurements may exclude temporal and spatial elements that could dilute community understanding (Cleland et al. 2013; Hillebrand et al. 2017). The communities that I sampled are a fraction of a regional species pool and richness may be locally confined due to patch isolation. Alpha diversity measurements may also leave out important processes such as turnover (Cleland et al. 2013). Additionally, sampling effects are common in richness analysis, as detection of common species is frequent and disproportionate compared to rare species detection (Gu and Swihart 2004). Therefore, local site richness estimates may not accurately represent the totality of species richness. Instead, assessing changes in organizational levels may be a better indicator for community responses to environmental conditions (Jones et al. 2017). Smith et al. (2009) found that using a Hierarchical-Response Framework (HRF) that combines individual, community reordering, and species loss will elevate prediction accuracy on community response to altered ecosystem suitability.

Evidence of dominant species reordering was found in my study, which has the potential to uncover community response to deterministic factors (Jones et al. 2017). Prairie sites were driven by a dominant two-species system, with additional species fluctuating in appearance. Some prairies had up to four species present and others had as little as zero, but trends lean towards two species with an occasional third and fourth (Table 1; Figure 4). The dominant two-species system that was found is seen frequently in other studies on small mammal communities (Schröpfer 1999; Heroldová et al. 2007; Melo et al. 2011). The two-species trend corresponds with Grant and Birney (1979) who found that small mammal communities are frequently associated with lower diversity, as they are often structured with 1-2 dominant species (Grant and Birney 1979).

This studies community system was based on the dominant presence of *Peromyscus maniculatus* (North American deer mouse) and *Microtus ochrogaster* (prairie vole), which was consistent with the findings of Rodery (2021) and Hope et al. (2021). Both of these species specialize in prairie ecosystems, so their dominance can be expected (King 1968; Stalling 1990; Schwartz et al. 2001). They were often found coexisting with one another at the same site but exhibited minor shifts in dominance (Table 1). Further, deer mice and prairie voles have slightly different grassland niches and diets that propose low competition between them (Hope et al. 2021). Shifts in dominance could be attributed to differences in population cycles, or potentially increases in resource competition due to decreased patch size from fragmentation (Abramsky et al. 1979; Hope et al. 2021).

Dominant species have the tendency to affect community structure and species reordering can change community structure and function (Whitaker 1965; Wohlgemuth et al. 2016). Two distinguished community types formed upon which species was dominant (Figure 5). When comparing the (2021) study to the current, it is evident that abundances of small mammals fluctuate over time (Brady and Slade 2004). Abundance fluctuations are especially notable in habitats that are experiencing other landscape disturbances (Schweiger et al. 1999; Scott et al. 2006). In 2021, 111 deer mice and 27 prairie voles were detected, suggesting a weighted dominance towards the deer mouse (Rodery 2021). In 2022, abundances were more even with 75 deer mice and 55 prairie voles being detected, proposing a rise in the prairie vole's role in the community and species reordering. Brady and Slade (2004) found that heightened prairie vole abundance can alter community structure, which may explain species reordering in some sites. I found that deer mice were found in 12 of the 15 sampled sites and prairie voles were detected at 11 of the 15 sites. Deer mice and prairie voles were essentially found everywhere (Table 1).

To achieve a thorough idea of community reordering, sampling should encapsulate cyclical rodent fluctuations. Typically, deer mice have a population cycle that climaxes around 3-5 years and prairie voles experience population peak around 4 years (Schwartz et al. 2001;

Getz et al. 2003). Microtine rodents such as the prairie vole are notorious for having populations that experience annual or even irregular fluctuations (Krebs 1966a; Krebs 1996b). Deer mice data from 2021 could emulate a population peak and data from 2022 could show the beginning of a population dip. Similarly, data from 2021 could have been taken from a decreased prairie vole population and 2022 data could show the prairie vole population moving towards a peak (Rodery 2021).

Another interesting observation was the loss and gain of species from 2021 to 2022. In 2022 there was a curious absence of *Sigmodon hispidus* (Hispid cotton rat) at sites that they have been present at previously. In 2021, the hispid cotton rat was detected at five sites, and was found at only two sites in 2022 (Table 1; Rodery 2021). Patterns like this have been previously detected and interspecific competition was described as the main catalyst (Brown and Heske 1990). A study by Swihart and Slade (1990) found a negative relationship between hispid cotton rats and prairie voles. Often, these species were not found to coexist due to factors such as habitat heterogeneity, space limitations, seasonal peaks, and differing habitat tolerances (Fleharty and Olson 1969; Glass and Slade 1980; Swihart and Slade 1990). Interspecific competition aside, cotton rats frequently experience local extinctions that can cause unprecedented absence from a site (Sauer and Slade 1985). Sampling completed in 2021 could have taken place during a phase of high hispid cotton rat population and sampling in 2022 could have been during a period of local extinction of the cotton rat population. The cause of the population oscillations in Missouri small mammals is unknown, but with the data presented I conclude that this trend may be due to chance variation and that demographic stochasticity drives some extent of boom-and-bust rodent fluctuations (Figure 2; Shoemaker et al. 2020).

Rare species were also found to fluctuate in appearance between the two studies. In 2021, *Reithrodontomys megalotis* (Western harvest mouse) was detected at two sites (Rodery 2021). I did not detect any western harvest mice, but I detected other rare species that were not present in the 2021 sampling period (Table 1). In 2022, our communities included three rare species that have not been detected in these sites prior. *Zapus hudsonius* (Meadow jumping mouse), *Synaptomys cooperi* (Southern bog lemming), and *Cryptotis parva* (North American least shrew) were detected in 2022. Inevitable detection effects could explain variations in the species captured between sampling years, but other unknown factors could be responsible as well. It is seldom in ecological surveys that a false presence is recorded. However, it is common to fail to detect a species that is actually present in a habitat patch (Gu and Swihart 2004). Detecting species relies on population density, experimental design, and trapping effort. Rare species can be considered cryptic with insufficient effort and low probabilities of detection (Gu and Swihart 2004). Rare species presence fluctuations could be due to demographic stochasticity as well (Figure 2). The loss and gain of species was made evident in this study, despite the reasoning behind it being unclear. Regardless, losing species can be detrimental to patch health by inducing or deducing species turnover and limiting the ability for ecosystems to respond to altering conditions (Gu and Swihart 2004; Hillebrand et al. 2018). From the data collected, further examination of this species loss and gain is warranted.

I tested environmental variables to analyze macro- and micro- patch attribute differences and found heterogenous conditions across sites. Firstly, I found that underlying prairie type did not change small mammal community composition (Figure 6). This contrasts Snyder and Best (1988) who captured similar species but discovered habitat type preferences that drove variation in their communities (Snyder and Best 1988). Outcomes as such may differ from my study because even though prairie sites had different underlying geology, they were all considered tall grass prairie habitat. Current tall grass prairie can contain a mosaic of grassland, woodland, and shrubland all of which different small mammal assemblages rely on (Matlack et al. 2008). Shifts in species composition could be due to contemporary prairie patches including other vegetation types (Clark et al. 1989, Jones et al. 2017). Hope et al. (2021) did a study involving the large, tall grass Kanza prairie which showed different assemblages congregating by vegetation delineated habitat type. It seems like delineating prairie type does not provide evidence for shifting community composition, because the prairie type may not encompass substantial differences, as they are still considered the same ecosystem type. Instead, the habitat focus should be looked through the lens of vegetation type, which I briefly address.

After testing patch area with rodent richness, I can further accept the findings of Rodery (2021) that species-area trends were not consistent with ETIB in prairie ecosystems (Table 2; Figure 7). An interesting observation can be made about the relationship between prairie voles and prairie size (Table 3; Figure 13). It seems that prairie voles were most abundant in patches that were not too big or too small (Figure 13). The trend mirrors optimality models where intermediate variables are favored (Parker and Smith 1990). This finding does not follow ETIB, so the reason behind it is unknown. Again, unexpected outcomes may be attributed to ecological background noise or another force that has yet to be discovered. Small mammal studies of species-area relationships have often shown similar inconsistencies. Lomolino (1984) did a study on small mammals inhabiting archipelagoes and found that degrees of isolation and area impacted small mammal communities (Lomolino 1984). Lomolino and Perault (2001b) completed a similar study and could not conclude the same as he did only years ago (Lomolino and Perault 2001b). Recently, ETIB has expanded its focus beyond patch area. It has been suggested that the area surrounding the patches may have properties that drive species richness

(Lomolino and Smith 2003). Many of the sites that I sampled are surrounded by agriculture and studies have shown that patches surrounded and affected by agriculture have the tendency to alter species richness (Witt and Huntly 2001; Silva et al. 2005; Shilereyo et al. 2021). Currently, there is no evidence that explains how the surrounding landscape affects small mammal communities in these patches. To continue understanding of ETIB we could begin to focus on including the surrounding habitat mosaic, rather than the patch area itself.

To attune to species-specific diet and caching behaviors, I expected vegetation characteristics to relate to differences in small mammal composition. The average percentage of ground cover varied, with each patch having a unique combination of grasses and forbs (Figure 7). Ultimately, I found that certain vegetation characteristics explained some variation in small mammal community structure (Figure 7; Table 2). Even with some of the variation explained, I cannot confidently conclude that small mammal communities are determined by vegetation without more data. Some variation is explained with the tendency for richness and prairie vole dominated sites to be characterized by lower elevation (Figure 7; Table 2) Elevation acted as our dummy variable and I did not expect that it would have any significance in community composition. Elevation can have impacts on species composition, but in the context of extreme elevation ranges, which is often found on mountain ranges (Janzen 1967). Variation of elevation gradients on mountains facilitate drastic environmental changes, that separate species in terms of their tolerances (Janzen 1967). Elevation across my sites ranged from 372m-248m, which is not a large discrepancy of altitudinal differences that would cause stark environmental gradients. Local studies may only acknowledge noise in community assembly, which may be the reason that elevation explained model variation (Nee and stone 2003; McGill 2003).

Another trend was that of prairie vole dominated sites being characterized with low forb percentage (Figure 7) Historically, prairie voles inhabited grass dominated sites and true grasses made up the majority of their diet (Getz et al. 1987). Habitat disturbances have introduced more broad-leaf forb vegetation, that contains higher nutritional content, which has become a staple in the diet of prairie voles (Cole and Batzli 1979). The finding that prairie voles inhabited sites with less forbs is intriguing considering that prairie voles do not thrive on a diet that only consists of prairie grasses. Deer mice model variation was found to be most explained by forb percentage which supports the idea that forb plants are most sought after due to higher nutritional value (Table 2; Cole and Batzli 1979). With the current data, I am unable to accept that small mammal community composition relies on vegetation composition, but there is interesting information that suggests underlying relationships may become clear with more data.

Broadening vegetation analysis to identify species of herbaceous plants and expanding to the inclusion of woody plant influence is recommended to test these hypotheses further. For this study, I emphasized grass and forb estimates which ignores the influence of woody plant presence. A study by Bruckerhoff et al. (2020) explained that changes in habitat structure from elevated woody plant invasion was more predictive of small mammal community dynamics than herbaceous plant diversity (Bruckerhoff et al. 2020). Vegetation data could have also been collected in the microhabitat perspective, as small mammals in habitat patches on macro- and microhabitat levels (Reichman and Price 1993). Unfortunately, the vegetation data collected for my study did not fully depict the entirety of the patch, visual observations may have been inaccurate, and microhabitat vegetation was not assessed (Sykes et al. 1983).

Interestingly, heterogeneity in microhabitats was evident in this study. Some sites varied in ground humidity and temperature ranges from morning to evening (Figure 8; Figure 9). With such a broad range in environmental conditions it was surprising that small mammal species were not affected. A study by Stephens and Anderson (2014) provided evidence that small mammal communities were altered by microhabitat conditions. Notably, temperature and humidity gradients were observed to create species-specific tolerance thresholds (Stephen and Anderson 2014). The species that inhabited my study sites do not seem to be sensitive to conditions that could be deemed stressful. While the scatter plot depicts a vast range between morning and evening conditions, the species that we frequently detected may be acclimated, or perhaps the condition range may not be as extreme as it is perceived on the figure (Figure 8; Figure 9). Additionally, the stark contrast of early summer and late summer weather conditions during sampling could have influenced the variation seen.

Climate trends and habitat destruction concerns have increased interest in how environmental factors are affecting ecosystem biodiversity and community assemblages. It is widely believed that environmental factors can influence small mammal community composition (Carmignotto et al. 2022). A review by Batzli (1992) summarized small mammal population studies and found little agreement between them. In fact, twelve different conclusions were made on which environmental attribute was responsible for species composition (Batzli 1992). With such a dynamic concept, I am unable to confirm what mechanism or mechanisms are behind species composition in Missouri prairie patches. Reed and Slade (2007) suggested that small mammal communities are unchanged by individual environmental variables but respond to a stochastic environment (Reed and Slade 2007). With the data presented, I believe community composition can be mostly explained by stochastic variation, as habitat attributes did not influence species presence (Figure 5; Smith et al. 2009). I cannot ignore that some variation was explained by deterministic environmental variables, so underlying drivers could still be influencing community flux, they have just not been made apparent yet (Shoemaker et al. 2020).

My explanations do not represent the evidence required to conclude that metacommunities are formed by deterministic predictors or stochasticity alone. Studies with the idea that stochastic and deterministic determents are intertwined have become increasingly prevalent (Chase and Myers 2011; Matthews and Whittaker 2014; Renner et al. 2014). Renner et al. (2014) closely matches this assumption as they believe that stochastic change is an apparent function of deterministic environmental factors (Renner et al. 2014)

As daunting as it seems, a multifactorial study is needed to encompass such a dynamic research question. A larger sample pool is needed to decipher communities in flux across time and space (Doka et al. 2005). These sites do not vary greatly across geographic space, so the heterogeneity in environmental variables do not accurately represent the range of conditions that the small mammal metacommunity experiences. As stated before, rudimentary spatial sampling can leave out important information that can be gathered from the regional species pool. With little accumulated spatial data, it is apparent that further evaluation of the small mammal communities is required to understand how biodiversity may change as ecosystems do. My study was also limited by temporal data restraints. I had conducted two field sessions, all within the spring and summer months. To conceptualize rodent population cycles, multiple year and interannual small mammal surveys are advised. Surveys spanned across several years are suggested to understand how small- and large-scale fluctuations influence community dynamics (Brady and Slade 2004). Expanding the temporal range would also encompass stages of vegetation succession, as vegetation composition can also be altered by deterministic and stochastic processes (Måren et al. 2018).

Accumulation of data on deterministic prairie patch attributes, as well as stochastic demographic traits may help to form proper management decisions. Regardless of the constraints, this study has introduced possible deterministic influences that can be studied more in depth. It has demonstrated that small mammal communities in Missouri prairie patches are in flux, and the drivers of this change are widely misunderstood. As of now, this study provides another year of data, that when continued, could bring about powerful insights on prairie ecosystem and how it supports small mammal metacommunities.

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SMALL MAMMAL BAIT PREFERENCE

Introduction

For accurate estimates of community dynamics in an ecosystem, accounting for imperfect species detection in field data is imperative. Detection can be influenced by several factors; including smaller sample sizes, restricted sampling effort, and studying cryptic species (Nupp and Swihart 1996; Kerr et al. 2000; Gu and Swihart 2004)). Further, detection probabilities can change with chosen field survey techniques (Thompson and Thompson 2007). Enhancing species detection often involves altering trapping procedures attuned to the preferences of different faunas (Thomas et al. 2020). In addition to trap layout and trap effort, trap type efficiency may be examined in relation to detection success (Bovendorp 2017).

For small mammals, there are various types of traps, and there are many studies comparing the efficacy of models (Woodman et al. 1996; Slade et al. 2013; Stephens and Anderson 2014). Small mammals are often active at distinct intervals of time and are rather cryptic, and because of their small size (<100g), choosing an effective trap type is imperative (Woodman 1996). Direct catch traps are often constructed to appeal to a specific target species or group. Snap traps can be extremely effective, but result in the fatality of the study subject, potentially limiting inference on population dynamics and temporal structure. As an alternative to snap traps, field studies can implement pitfall and live traps, such as Sherman, Longworth, Fitch, and Tomahawk traps (Kirkland 1998). These live traps are vastly unique from one another and vary with capture success, mortality rates, and species biases (Stephens and Anderson 2014). Pitfall traps have a strong bias towards shrew and vole species and due to the concave structure of pitfall traps, and mortality rate is high (Briese and Smith 1974). Comparatively, Sherman traps capture more species of mice and have a lower mortality rate with increased protection from the environment (Stephens and Anderson 2014). Tomahawk traps are most often successful in catching larger small mammals such as individuals in the *Sciuridae* family, that otherwise would be challenging to capture in the smaller Sherman and Longworth traps. Combining trap types in a survey may yield a more accurate characterization of the small mammal community. However, deploying multiple trap types per sampling period may be labor intensive. Therefore, it is crucial to pick the trap type that is configured to increase capture rates for a diverse array of target species. In America, Sherman traps are used most frequently to evaluate small mammal communities (Slade et al. 1993). The low mortality rates make Sherman traps a popular choice amongst ecologists concerned with survivorship, mortality, and other demographic factors. Using traps with low fatality is especially critical for surveys in imperiled habitats and sensitive species (Stephens and Anderson 2014).

In addition to trap type, bait selection may be a major component in detecting a species and, thus, determining community composition (Patric 1970; Wilson et al. 1996). However, most bait preference studies do not include community dynamics such as species richness and diversity in their analysis (Kok 2013). Instead, studies have shown that bait influenced capture rates (Fitch 1954, Beer 1964, Patric 1970; Wilson et al. 1996, Harkins et al 2019, Weihong et al. 1999, Hice and Velazco 2013), and others concluded the type of bait had no control over trap success (Woodman 1996, Jorgenson 2002; Keiter 2013). Other studies found that bait type was influential, but only in months where resources were scarce (Fitch 1954). Ultimately, there are differing opinions on the bait preferences of specific species and entire small mammal communities (Oswald and Flake 1994, Stickel 1948). Most often, the bait chosen for surveys was oats, peanut butter, or a mix of the two (Beer 1964, Harkins et al. 2019). However, Harkins et al.

(2019) revealed that using oats and peanut butter as bait may introduce a negative bias towards elusive species. Despite findings, many of the studies suggest one bait type, followed by urging trappers to continue to use a variety of bait.

Such discrepancies about preferred bait type leaves room for further research to determine how bait type impacts estimates of entire communities. To begin to address this issue, I compared two bait types, sunflower seeds and rolled oats, and their potential influence on the trapping success of individual species and the entire community in Missouri prairies. These bait types were chosen because the bait types are cost effective, easy to work with, and have different nutritional values while similarly attracting mammals with granivorous diet habits (the target species in this study). Considering both the complex opinions of past literature and the natural history of targeted species, I predict that bait type would not influence capture success for individual species, and therefore, not impact estimates of entire community.

Methods

Data collection. During the spring and summer months of 2022, I sampled small mammals in prairies located in central and southwestern Missouri. These prairies were owned and managed by the Missouri Prairie Foundation, with help from the Missouri Department of Conservation. Fifteen prairies were chosen based off past studies, relative locations, and prairie attributes (Chapter 1). The prairies chosen were considered part of a fragmented landscape, occurring within a matrix of agriculture and forest. Eleven of these 15 sites previously were surveyed during the summer of 2020 (Rodery 2021). I included 4 additional sites to increase the range of my sample sites and to achieve a better understanding of the regions' small mammal communities. The additional sites added were centrally located or near other prairies and were easily accessible.

To capture small mammals, I used the LFATDG Sherman live-traps (7.62×8.89×22.86 cm) employed a method similar to Rodery (2021) in prairie patches and Beasley and Maher (2019) in Ozark glade habitat. At each site I set two ~250m linear transects. Each transect was split into 25 numbered trapping stations that were ~10m apart and placed two traps in the general vicinity (~2m) of the station. Latitude and longitude coordinates were recorded for the start and end of the trap line and every fifth trap station using a Garmin handheld GPS unit (64s).

To ensure proper accessibility for small mammals, traps were placed on flat ground with paved soil leading to the entrance of the trap. At each station, one trap was baited with black oil sunflower seeds, while the other was baited with rolled oats. Traps were set during the evening and were open throughout the night to optimize trapping of nocturnal and crepuscular small mammals (Kirkland 1998; Sikes et al. 2016). Each morning traps were checked for captures and closed for the day if found empty. Upon finding a trapped individual, I recorded the transect, trap station number, and transported the trap with animal to a central location. Species identification and several characteristics of the individual were recorded. To assess capture rates in relation to bait type, documentation of the bait type for every successful catch was required. The 'choice' of sunflower seeds or oats was determined at the time of processing. Upon opening the trap, the bait type was often visible and easily identified. If bait type was not initially discernable, we identified bait type from the remains found in the cloth processing bag after the individual was removed. After data collection, the individual received an ear tag marked with a unique numeric and was then released back into the prairie for possible evaluations of recapture. Following each trapping session, traps and processing bags were emptied and washed to remove leftover bait and scent. The animal procedures followed the American Society of Mammologists (Sikes et al. 2016) and were approved by the Missouri State University Institutional Animal Care and Use Committee (Appendix B).

Data Analysis. To compare small mammal community bait preferences, I summed the total amount of catches and their given bait type. I assumed that individual captures would follow a Bernoulli trial, in which animals could choose between either bait type, and the total captures would then follow a binomial distribution. Ultimately, I used sunflower seeds as the measure of success (1) and oats as the measure of failure (0) and tested whether the probability was different than random chance ($p = 0.5$) under a two-sided test. I used a similar method to test individual species' bait preferences. I determined bait type choice for captures of each of the four species with the greatest abundance. Again, using sunflower seeds as success and oats as failure, I used the binomial test for each species. This data analysis was completed using R (Version 4.1.1 (2021-08-10)) and RStudio (Version 2021.09.0+351) the package “tidyverse” (Wickham et al. 2019). Then, I plotted the results using a simple bar graph that depicted the bait preference for the entire community, and for each individual species that has more than ten captures.

Results

During our sampling period 218 individual small mammals were caught, made up of 7 different species (See Chapter 1; Table 1). I identified a bait choice for every catch except for two; in the first case, the individual was not included in further analysis and in the second I could not determine species. After removing individuals caught at the same station during the same night,

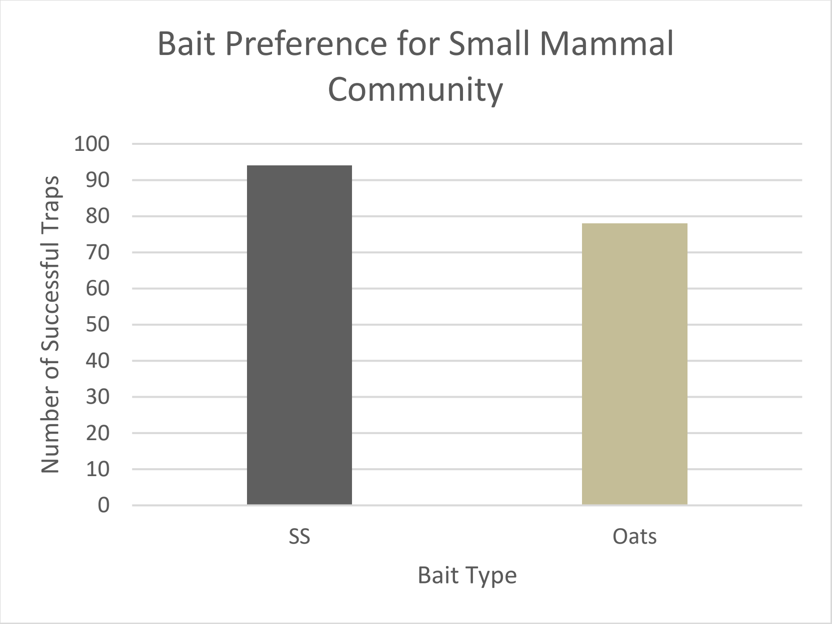

Figure 14. Bar chart depicting the bait choice for each individual in the small mammal metacommunity. Dark shaded bar signifies the number of individuals trapped with sunflower seeds (SS). Light shaded bars indicate the number of individuals trapped with rolled oats (Oats).

there were 172 individuals to use at trials in the binomial test. Ninety-four individuals (55%) chose the trap with sunflower seeds and 78 (45%) were caught using rolled oats (Figure 14; *P=0.3074*). The four dominant species that I caught were deer mouse (*Peromyscus maniculatus*), prairie vole (*Microtus ochrogaster*), hispid cotton rat (*Sigmodon hispidus),* and the white-footed mouse (*Peromyscus leucopus)*. In total I caught 95 deer mice but ended up evaluating only 83 to maintain the integrity of the Bernoulli trials. Fifty (60%) deer mice chose sunflower seeds, and 33 (40%) chose oats (Figure 15; *P=0.1002*). I caught 70 prairie voles but 54 capture qualified as a Bernoulli trial, of which 29 (53%) chose sunflower seeds and 25 (46%) chose oats (Figure 16; *P=0.7202*). I caught 30 hispid cotton rats and 20 were used for analysis; 6 chose sunflower seeds (30%) and 14 (70%) chose oats (Figure 17; *P=0.2005*). Finally, I trapped 17 white-footed mice and tested 14; 8 chose sunflower seeds (57%) and 6 chose oats 43% (Figure 18; *P=1*).

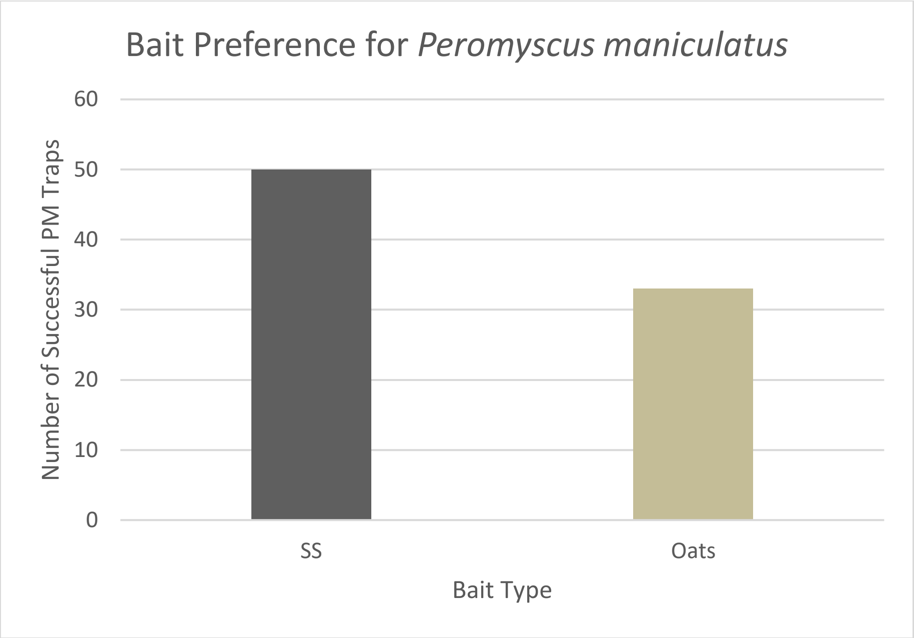

Figure 15. Bar chart depicting the bait choice for each individual *Peromyscus maniculatus* (PM) trapped. Dark shaded bar signifies the number of individuals trapped with sunflower seeds (SS). Light shaded bars indicate the number of individuals trapped with rolled oats (Oats).

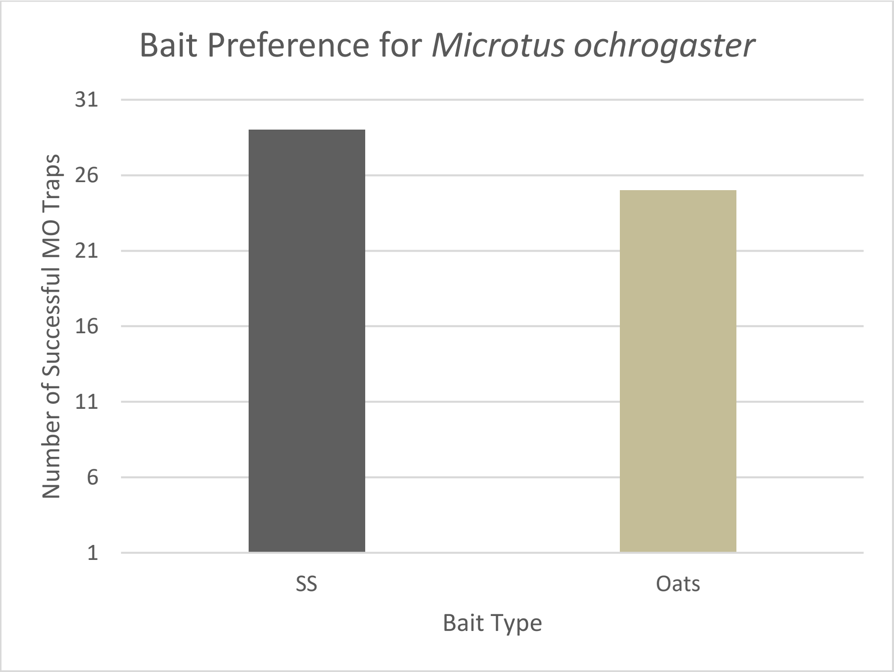

Figure 16. Bar chart depicting the bait choice for each individual *Microtus ochrogaster* (MO) trapped. Dark shaded bar signifies the number of individuals trapped with sunflower seeds (SS). Light shaded bars indicate the number of individuals trapped with rolled oats (Oats).

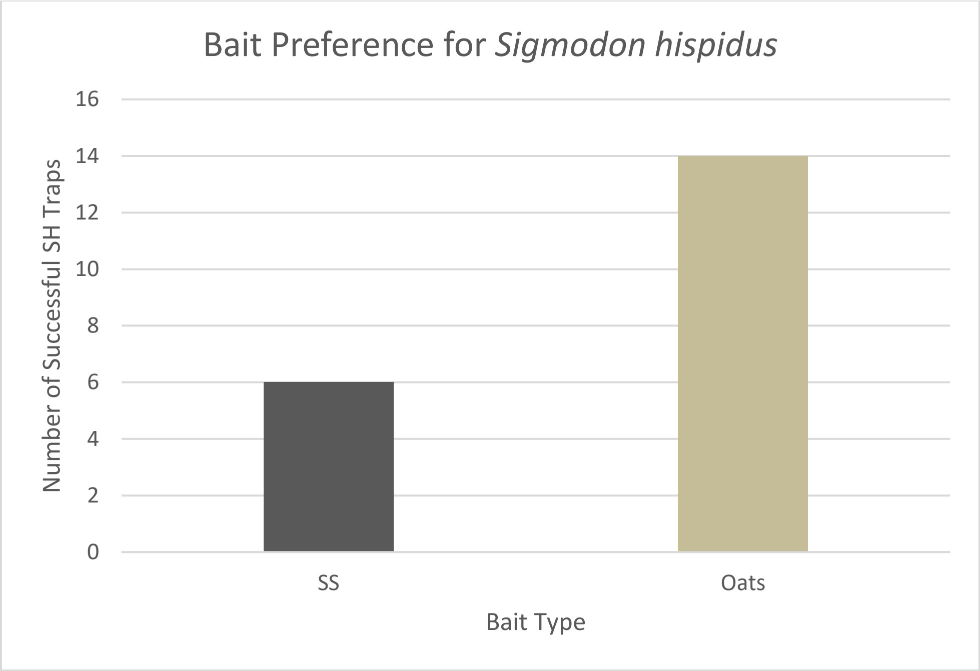

Figure 17. Bar chart depicting the bait choice for each individual *Sigmodon hispidus* (SH) trapped. Dark shaded bar signifies the number of individuals trapped with sunflower seeds (SS). Light shaded bars indicate the number of individuals trapped with rolled oats (Oats).

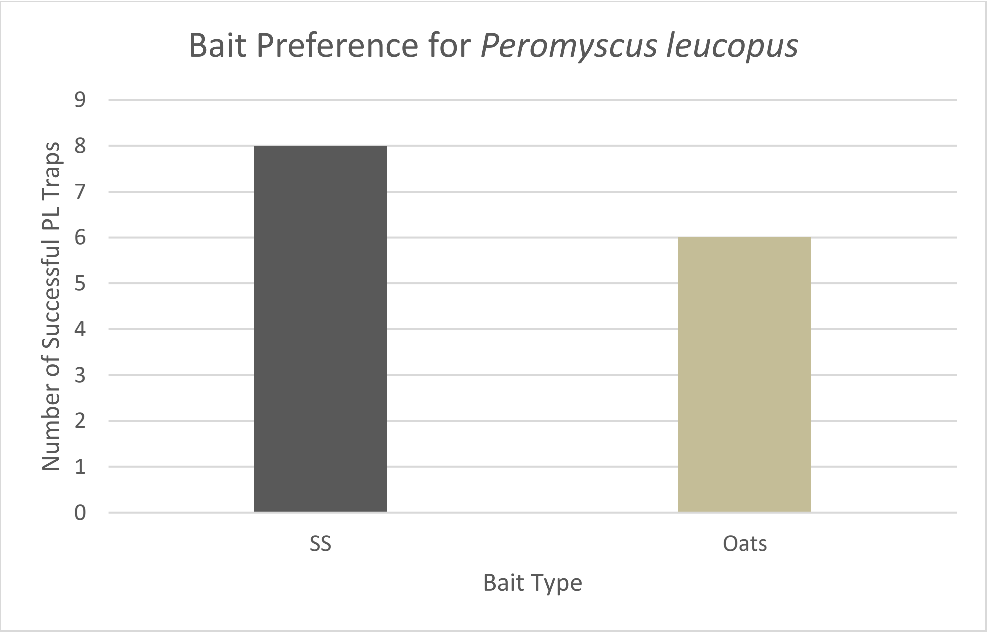

Figure 18. Bar chart depicting the bait choice for each individual *Peromyscus leucopus* (PL). Dark shaded bar signifies the number of individuals trapped with sunflower seeds (SS). Light shaded bars indicate the number of individuals trapped with rolled oats (Oats).

Discussion

As predicted, the small mammal community in southwestern Missouri prairies did not show evidence of bait type preference. There was no difference in trapping success between Sherman traps baited with sunflower seeds or traps baited with rolled oats. Overall, small mammals were caught with sunflower seeds more than traps baited with oats, but the success rate between the two differed by only 10% (Figure 14). The trap success for individual species was similarly uninfluenced by bait type. The dominant species found within the community all belong to Order Rodentia and consume foods similar to the baits used in the experiment (Anderson and Jones 1967; Landry 1970; Schwartz et al. 2001). Animals in Rodentia can have specialized diets, but the ones we observed during sampling are typically characterized by having a generalist diet (Hope et al. 2021). Deer mice, prairie voles, and white-footed mice all chose sunflower seeds slightly more than rolled oats (Figure 15; Figure 16; Figure 18). Again, the sunflower seed choice was consistently under 10% higher than oat choice and was deemed insignificant. The cotton rats diverged from the rest of the species and chose oats over sunflower seeds (Figure 17). In terms of the cotton rat, oats were chosen 20% more frequently than sunflower seeds. However, this trend was not significant.

According to natural history findings, Peromyscus species are mainly omnivorous, while prairie voles and cotton rats are dominantly herbivorous (King 1968; Cameron and Spencer 1981; Lackey et al. 1985; Stalling 1990). Despite this difference, they all are familiar with including seeds in their diet which may explain the relatively even distribution between sunflower seeds and oat trap success. The seeming lack of preference could also be due to the mild odors omitted from both baits. Sunflower seeds and oats are both characterized by not having an overwhelming scent which may make them equally attractive to rodents. Bait attraction may have been different if we supplemented bait with a stronger, more enticing scent (Harkins et al. 2019). However, this could also lead to trapping disturbances, as an increasing number of faunas could be lured into, or around the trap (Kumar et al. 2013). Additionally, it could be hypothesized that natural diet preferences had little relation to bait type choice (Hice and Velazco 2013).

Outcomes in which bait does not influence trap success may also be interpreted as completely random. As in, the small mammals caught were acting in a purely opportunistic manner and were caught in the trap that they came across first. One thing to consider with field surveys is the bait types and their reaction to the moisture in the environment. It was frequently observed that the oats were accumulating mold over each trap night. Rodents can experience positive and negative reactions to ingesting mold (Rebar and Reichmann 1983). There is a limit to the benefits gained from ingesting mold and during our experiment we were not able to examine whether or not we passed that limit into toxicity. Further, we are not able to tell if moldy oats may have deterred or attracted some individuals. Traps with oat bait were also difficult to clean in between trapping occasions. The moisture in the environment softened them to a paste, which took an increasingly long time to remove.

Our results did not show bait type preference which contrasts the majority of past literature. Our findings match those of Woodman et al. (1996) and Keiter (2013). Unlike many studies, Woodman et al. (1996) and I compared only two bait types at once within our experiments. Comparing two bait types seems to prioritize simplicity in experimental design; making it time, labor, and resource conscious. This design allows for flexibility in experiments and when using a linear transect we were able to ensure pseudo-independence. Simplicity in design subsequently produces more straight-forward results. Testing more than two bait types introduces complexity into the design of the experiment. Trap layout must be organized in a manner that eliminates potential bias, increasing effort exerted into the study. When using a variety of bait options per sampling occasion, it increases the odds that preferences would show up. Research that included multiple bait types had the advantage of increasing the probability that each species would prefer at least one of the options.

Simplifying baiting procedures can still yield valuable information about small mammal communities, as seen in this experiment. Our main goal of this study was to gain insights on the community and their reactions to environmental. Considering this, most resources were emphasized on this component rather than on the baiting procedures. Studies that aim to catch a diversity of species would ideally use the bait that would be most desired by the entire community (Patric 1970) but appealing to every species in a community may be a task. Thus, suggesting that to be efficient with experimental resources using a basic bait would suffice. Overcomplication of bait methodology could have limited our data collection abilities and the proposed trap optimization may not have manifested or changed our results.

Ultimately, bait type did not matter to the community and to individual species in southwestern Missouri prairies. Optimizing trap success is important for increasing detection and understanding community members, however, overcomplicated trapping methodology is unnecessary and may take precious effort away from other goals in ecological studies. When designing an experiment, it is important to weigh your resources with your main goals and delegate your effort carefully. I suggest that using a simple bait type, like a seed, is sufficient in catching small mammals in prairie habitat.

To conclude, a lot of variables go into bait type preferences. Habitat quality, region, climate, resources, and target species should all be considered when choosing trapping procedures (Hice and Velazco 2013). If resources and time are not an issue, using an abundance of bait and trap types may increase the chances of having a bait type available for other small mammals with different lifestyles (Hice and Velazco 2013). Further examination of Missouri prairies could include changing out the two bait types for other popular choices; but the slew of options becomes daunting when we expect to see no changes in our observations regardless. Simplifying trapping methods should not be counted out, and in some cases will not influence research results. Future studies should consider the use of seed bait first to ease trapping procedures and evaluate then if bait type should be modified to optimize trap success.

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SUMMARY

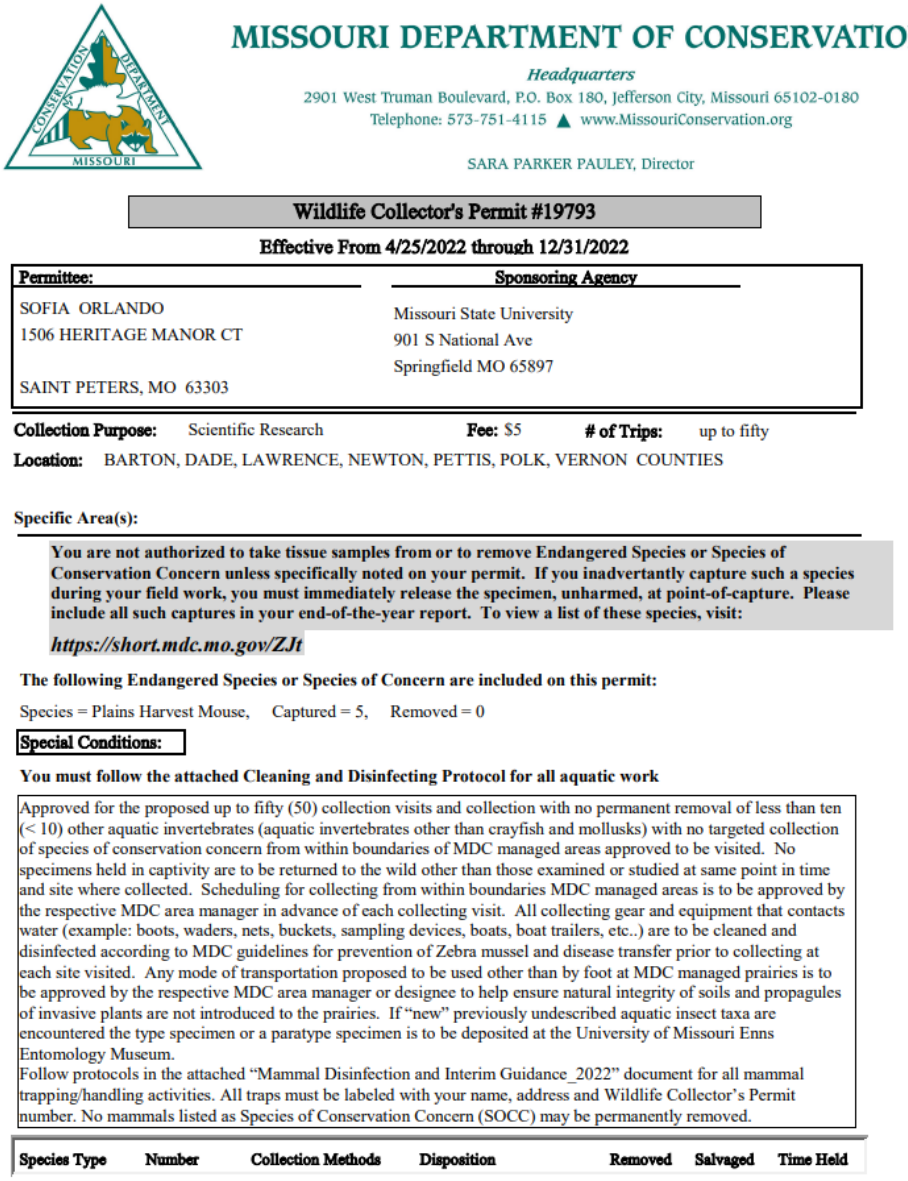
Studying metacommunities can provide useful information for evaluating patch dynamics and fluctuations in community composition. There are several sampling biases that manifest during community studies that affect overall conclusions. However, examining species composition can be insightful regardless of some limitations. In the first chapter I found that small mammal communities in Missouri prairies are consistent with a two-species system, where two species are completely dominant over others. Common species are frequently found, and rare species remain elusive, resulting in a lower diversity value. This finding is consistent with other studies that suggest that lower diversity is common in grassland habitats. I found that our sites were organized by two community types that were dependent on the dominant species. Five sites consisted of community assemblages that were dominated by the prairie vole. Nine sites had a community assembly dominated by the deer mouse. This information is crucial for the accumulation of data needed to accurately evaluate community dynamics. Combining these insights with those of the future will manifest into the understanding of small mammal metacommunity flux.

With this, I found a few patterns that suggest that there may be an environmental mechanism behind this. One pattern was established with the prairie vole dominant sites were found frequently with lower forb percentage and lower elevations. This finding could be due to the dietary and movement behaviors of the prairie vole. Other environmental influences were not found, but this could be due to limited spatial and temporal community understanding and lack luster sampling. Current studies on community ecology encompass data that expands along the community's range and includes data that spans across time. For my study, I am unable to make concrete conclusions on the drivers of small mammal community dynamics due to labor, spatial, and time constraints. An adequate community study would be extremely difficult to complete. Despite this, I believe that there is still information we can learn from examining species composition. Importantly, completing small mammal surveys in endangered ecosystems can be crucial for implementing proper management techniques.

In the second chapter, I examined small mammal trapping techniques with emphasis on bait type preference. I found that bait type did not matter for trapping on a community and individualistic level. This finding contrasts with several others that conclude that bait type does increase trapping success. With this conclusion, simplified trapping procedures may be used and effort can be distributed in other parts of the experiment. Enhancing trapping success leads to more accurate population and community estimates. Future studies can develop other methods to increase trap success, but I believe bait type can be simple.

APPENDICES

Appendix A: Wildlife collectors permit



MISSOURI DEPARTMENT OF CONSERVATION

Headquarters
2901 West Truman Boulevard, P.O. Box 180, Jefferson City, Missouri 65102-0180
Telephone: 573-751-4115 ▲ www.MissouriConservation.org

SARA PARKER PAULEY, Director

Wildlife Collector's Permit #19793

Effective From 4/25/2022 through 12/31/2022

Permittee:
SOFIA ORLANDO
1506 HERITAGE MANOR CT

SAINT PETERS, MO 63303

Sponsoring Agency
Missouri State University
901 S National Ave
Springfield MO 65897

Collection Purpose: Scientific Research **Fee:** $5 **# of Trips:** up to fifty

Location: BARTON, DADE, LAWRENCE, NEWTON, PETTIS, POLK, VERNON COUNTIES

Specific Area(s):

You are not authorized to take tissue samples from or to remove Endangered Species or Species of Conservation Concern unless specifically noted on your permit. If you inadvertantly capture such a species during your field work, you must immediately release the specimen, unharmed, at point-of-capture. Please include all such captures in your end-of-the-year report. To view a list of these species, visit:

https://short.mdc.mo.gov/ZJt

The following Endangered Species or Species of Concern are included on this permit:

Species = Plains Harvest Mouse, Captured = 5, Removed = 0

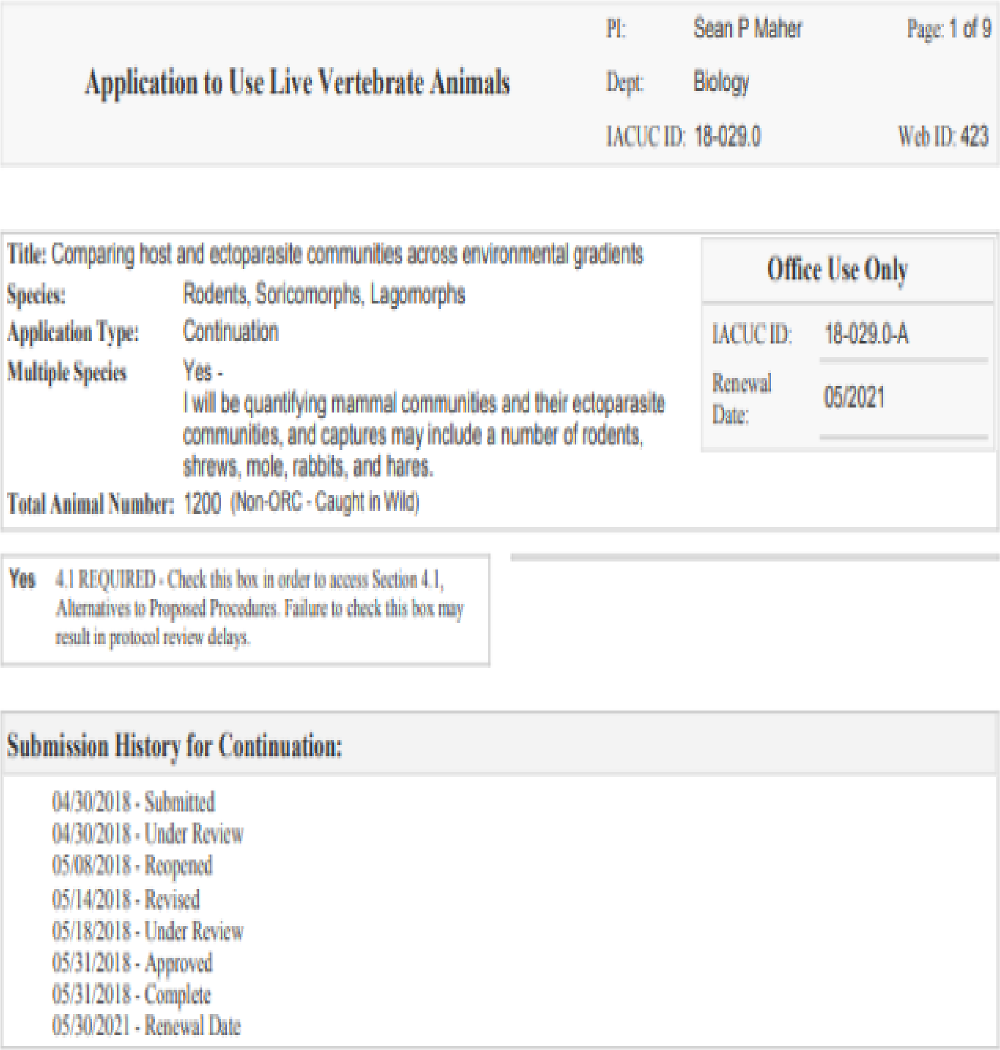
Special Conditions:

You must follow the attached Cleaning and Disinfecting Protocol for all aquatic work

Approved for the proposed up to fifty (50) collection visits and collection with no permanent removal of less than ten (< 10) other aquatic invertebrates (aquatic invertebrates other than crayfish and mollusks) with no targeted collection of species of conservation concern from within boundaries of MDC managed areas approved to be visited. No specimens held in captivity are to be returned to the wild other than those examined or studied at same point in time and site where collected. Scheduling for collecting from within boundaries MDC managed areas is to be approved by the respective MDC area manager in advance of each collecting visit. All collecting gear and equipment that contacts water (example: boots, waders, nets, buckets, sampling devices, boats, boat trailers, etc..) are to be cleaned and disinfected according to MDC guidelines for prevention of Zebra mussel and disease transfer prior to collecting at each site visited. Any mode of transportation proposed to be used other than by foot at MDC managed prairies is to be approved by the respective MDC area manager or designee to help ensure natural integrity of soils and propagules of invasive plants are not introduced to the prairies. If "new" previously undescribed aquatic insect taxa are encountered the type specimen or a paratype specimen is to be deposited at the University of Missouri Enns Entomology Museum.
Follow protocols in the attached "Mammal Disinfection and Interim Guidance_2022" document for all mammal trapping/handling activities. All traps must be labeled with your name, address and Wildlife Collector's Permit number. No mammals listed as Species of Conservation Concern (SOCC) may be permanently removed.

Species Type	Number	Collection Methods	Disposition	Removed	Salvaged	Time Held

Appendix B-1: IACUC Approval



Application to Use Live Vertebrate Animals

PI: Sean P Maher
Page: 1 of 9
Dept: Biology
IACUC ID: 18-029.0
Web ID: 423

Title: Comparing host and ectoparasite communities across environmental gradients

Species:	Rodents, Soricomorphs, Lagomorphs
Application Type:	Continuation
Multiple Species	Yes - I will be quantifying mammal communities and their ectoparasite communities, and captures may include a number of rodents, shrews, mole, rabbits, and hares.
Total Animal Number:	1200 (Non-ORC - Caught in Wild)

Office Use Only

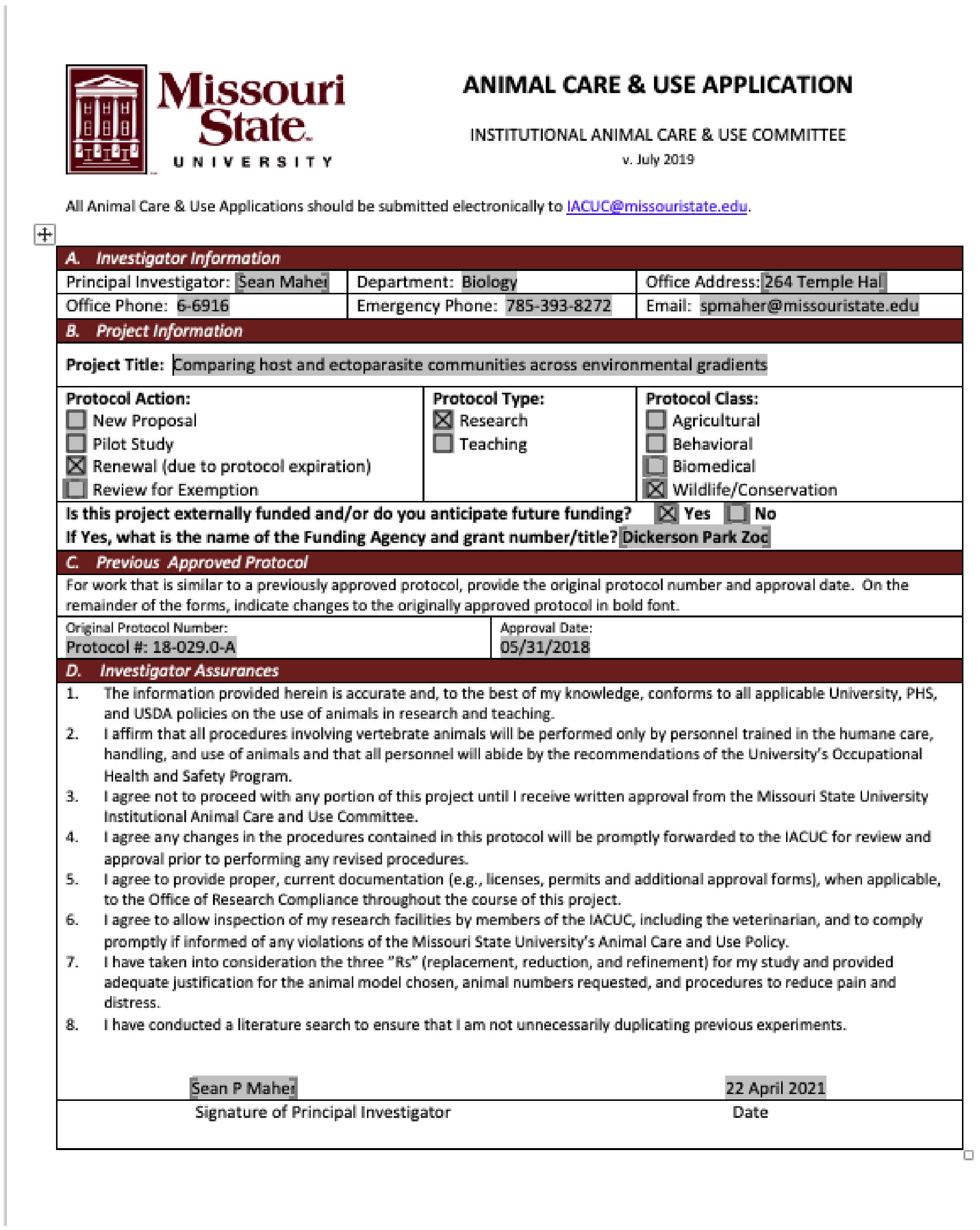
IACUC ID:	18-029.0-A
Renewal Date:	05/2021

Yes 4.1 REQUIRED - Check this box in order to access Section 4.1, Alternatives to Proposed Procedures. Failure to check this box may result in protocol review delays.

Submission History for Continuation:

04/30/2018 - Submitted
04/30/2018 - Under Review
05/08/2018 - Reopened
05/14/2018 - Revised
05/18/2018 - Under Review
05/31/2018 - Approved
05/31/2018 - Complete
05/30/2021 - Renewal Date

Appendix B-2: IACUC approval



Missouri State UNIVERSITY

ANIMAL CARE & USE APPLICATION

INSTITUTIONAL ANIMAL CARE & USE COMMITTEE
v. July 2019

All Animal Care & Use Applications should be submitted electronically to IACUC@missouristate.edu.

A. Investigator Information

Principal Investigator: Sean Maher	Department: Biology	Office Address: 264 Temple Hal
Office Phone: 6-6916	Emergency Phone: 785-393-8272	Email: spmaher@missouristate.edu

B. Project Information

Project Title: Comparing host and ectoparasite communities across environmental gradients

Protocol Action:	**Protocol Type:**	**Protocol Class:**
☐ New Proposal	☒ Research	☐ Agricultural
☐ Pilot Study	☐ Teaching	☐ Behavioral
☒ Renewal (due to protocol expiration)		☐ Biomedical
☐ Review for Exemption		☒ Wildlife/Conservation

Is this project externally funded and/or do you anticipate future funding? ☒ **Yes** ☐ **No**

If Yes, what is the name of the Funding Agency and grant number/title? Dickerson Park Zoo

C. Previous Approved Protocol

For work that is similar to a previously approved protocol, provide the original protocol number and approval date. On the remainder of the forms, indicate changes to the originally approved protocol in bold font.

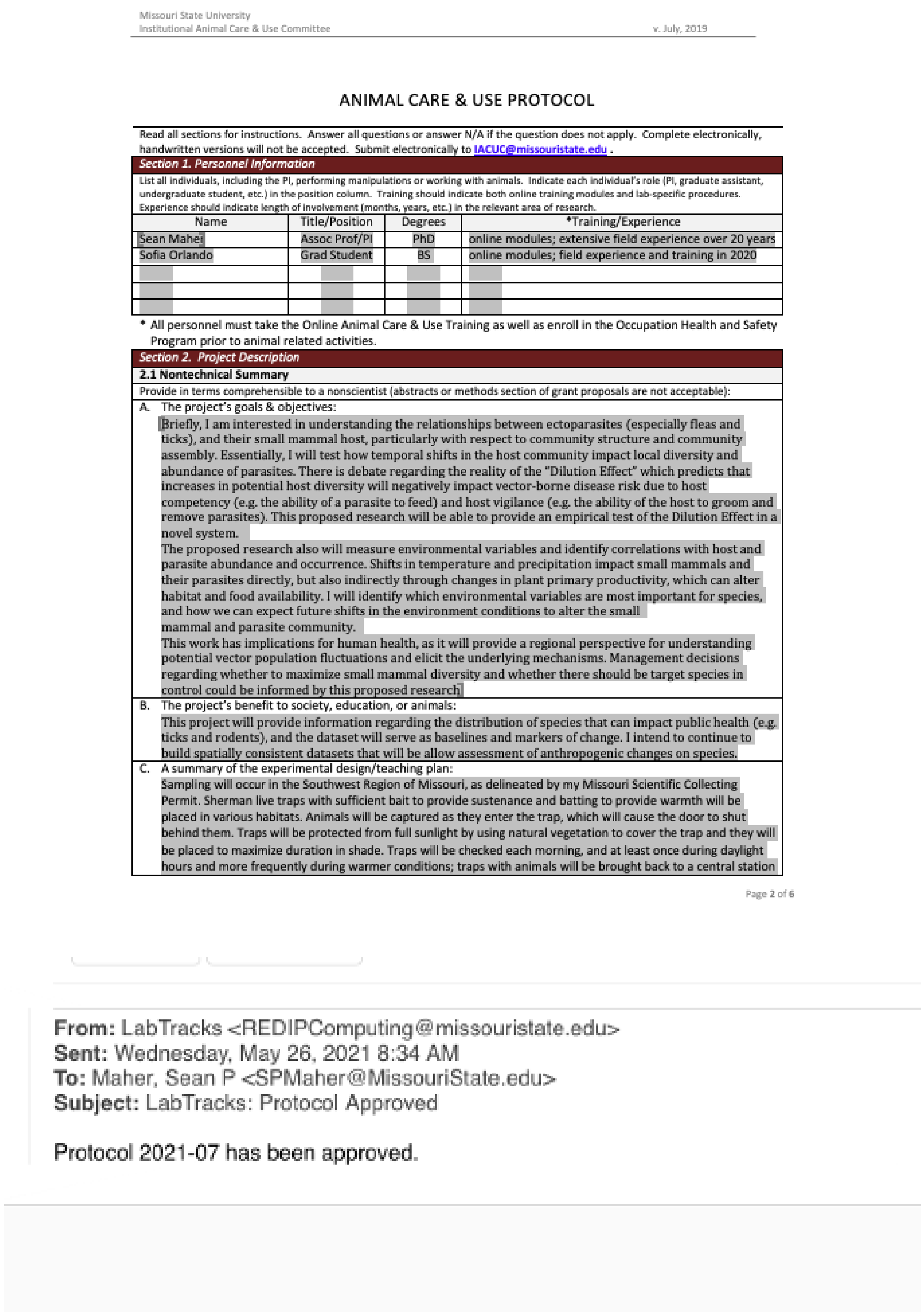
Original Protocol Number: Protocol #: 18-029.0-A	Approval Date: 05/31/2018

D. Investigator Assurances

1. The information provided herein is accurate and, to the best of my knowledge, conforms to all applicable University, PHS, and USDA policies on the use of animals in research and teaching.
2. I affirm that all procedures involving vertebrate animals will be performed only by personnel trained in the humane care, handling, and use of animals and that all personnel will abide by the recommendations of the University's Occupational Health and Safety Program.
3. I agree not to proceed with any portion of this project until I receive written approval from the Missouri State University Institutional Animal Care and Use Committee.
4. I agree any changes in the procedures contained in this protocol will be promptly forwarded to the IACUC for review and approval prior to performing any revised procedures.
5. I agree to provide proper, current documentation (e.g., licenses, permits and additional approval forms), when applicable, to the Office of Research Compliance throughout the course of this project.
6. I agree to allow inspection of my research facilities by members of the IACUC, including the veterinarian, and to comply promptly if informed of any violations of the Missouri State University's Animal Care and Use Policy.
7. I have taken into consideration the three "Rs" (replacement, reduction, and refinement) for my study and provided adequate justification for the animal model chosen, animal numbers requested, and procedures to reduce pain and distress.
8. I have conducted a literature search to ensure that I am not unnecessarily duplicating previous experiments.

Sean P Maher	22 April 2021
Signature of Principal Investigator	Date

Appendix B-3: IACUC approval



Missouri State University
Institutional Animal Care & Use Committee v. July, 2019

ANIMAL CARE & USE PROTOCOL

Read all sections for instructions. Answer all questions or answer N/A if the question does not apply. Complete electronically, handwritten versions will not be accepted. Submit electronically to IACUC@missouristate.edu .

Section 1. Personnel Information

List all individuals, including the PI, performing manipulations or working with animals. Indicate each individual's role (PI, graduate assistant, undergraduate student, etc.) in the position column. Training should indicate both online training modules and lab-specific procedures. Experience should indicate length of involvement (months, years, etc.) in the relevant area of research.

Name	Title/Position	Degrees	*Training/Experience
Sean Maher	Assoc Prof/PI	PhD	online modules; extensive field experience over 20 years
Sofia Orlando	Grad Student	BS	online modules; field experience and training in 2020

* All personnel must take the Online Animal Care & Use Training as well as enroll in the Occupation Health and Safety Program prior to animal related activities.

Section 2. Project Description

2.1 Nontechnical Summary

Provide in terms comprehensible to a nonscientist (abstracts or methods section of grant proposals are not acceptable):

A. The project's goals & objectives:

Briefly, I am interested in understanding the relationships between ectoparasites (especially fleas and ticks), and their small mammal host, particularly with respect to community structure and community assembly. Essentially, I will test how temporal shifts in the host community impact local diversity and abundance of parasites. There is debate regarding the reality of the "Dilution Effect" which predicts that increases in potential host diversity will negatively impact vector-borne disease risk due to host competency (e.g. the ability of a parasite to feed) and host vigilance (e.g. the ability of the host to groom and remove parasites). This proposed research will be able to provide an empirical test of the Dilution Effect in a novel system.

The proposed research also will measure environmental variables and identify correlations with host and parasite abundance and occurrence. Shifts in temperature and precipitation impact small mammals and their parasites directly, but also indirectly through changes in plant primary productivity, which can alter habitat and food availability. I will identify which environmental variables are most important for species, and how we can expect future shifts in the environment conditions to alter the small mammal and parasite community.

This work has implications for human health, as it will provide a regional perspective for understanding potential vector population fluctuations and elicit the underlying mechanisms. Management decisions regarding whether to maximize small mammal diversity and whether there should be target species in control could be informed by this proposed research.

B. The project's benefit to society, education, or animals:

This project will provide information regarding the distribution of species that can impact public health (e.g. ticks and rodents), and the dataset will serve as baselines and markers of change. I intend to continue to build spatially consistent datasets that will be allow assessment of anthropogenic changes on species.

C. A summary of the experimental design/teaching plan:

Sampling will occur in the Southwest Region of Missouri, as delineated by my Missouri Scientific Collecting Permit. Sherman live traps with sufficient bait to provide sustenance and batting to provide warmth will be placed in various habitats. Animals will be captured as they enter the trap, which will cause the door to shut behind them. Traps will be protected from full sunlight by using natural vegetation to cover the trap and they will be placed to maximize duration in shade. Traps will be checked each morning, and at least once during daylight hours and more frequently during warmer conditions; traps with animals will be brought back to a central station

Page 2 of 6

From: LabTracks <REDIPComputing@missouristate.edu>
Sent: Wednesday, May 26, 2021 8:34 AM
To: Maher, Sean P <SPMaher@MissouriState.edu>
Subject: LabTracks: Protocol Approved

Protocol 2021-07 has been approved.

Appendix B-4: IACUC Citi Training

Completion Date 24-Jan-2021
Expiration Date 24-Jan-2024
Record ID 40511479

This is to certify that:

Sofia Orlando

Not valid for renewal of certification through CME.

Has completed the following CITI Program course:

Animal Care and Use
(Curriculum Group)
Researcher - Wildlife
(Course Learner Group)
1 - Basic Course
(Stage)

Under requirements set by:

Missouri State University