Executive summary prepared by Jessica McQueen, October 2021.

Introduction

For many years, small mammal populations, specifically *Peromyscus maniculatus* (Deer mouse), *Microtus pennsylvanicus* (Meadow vole) and *Microtus montanus* (Montane vole) have been a subject of interest for numerous researchers. Small mammals carry significant importance within an ecosystem due to them being key prey species, and having a high seed, fungi, and berry dispersal capacity (Weldy et al, 2019). They also have the ability to alter a community through seed predation, disease transmission and herbivory (Elli & Cushman, 2018). Small mammals, such as the Deer mouse and Vole species, have been studied for many years due to their high abundance, fluctuating numbers and importance to food chains. While abiotic and biotic factors can affect small mammal populations, a productive ecosystem is expected to have natural population fluctuations, and thus, a change in factors such as increased amounts of precipitation could potentially alter Deer mice and Vole population densities. Additionally, timing of rain will influence vegetation in respect to germination, and seed ripening (Li et al, 2021) and thus could potentially affect the populations due to abundance or lack of vegetation cover and food sources.

For the past twenty-five years (1997-2021), populations of small mammals have been studied within four sampling locations of Kamloops, British Columbia with the help of students from Thompson Rivers University and community volunteers. This study is examining whether there is a relationship between site location and precipitation rates within a semi-arid dessert geographical location, and thus, their influences on the Deer mouse, Meadow vole and Montane vole population densities.

A mark-recapture model, along with conventional statistical analyses, have been in use to examine small mammal cycles and oscillations of the populations since 1997. The program MARK (Capture) was used to determine the population estimates from both the most current 2021 data, as well as historical data. Moreover, the fluctuations in both Deer mouse and Vole populations are compared with quantitative data from seven months (March-September) of average precipitation events within the past 25 years to identify any possible relationships. This study could provide further understanding of the effects of precipitation on small mammal populations and the subsequent impact on their environment.

Methods

Since 1997, the study of the small mammal populations has been at three, and since 2017, four sampling locations within Kamloops; elevations varying between 500-700m, including the Bunker (established in 2017), TRU Campus, Dufferin and Weighscale sites, displayed in Figure 1 (locations 1-4 respectively). All locations fall within the Bunchgrass Biogeoclimatic Zone, and thus will have high temperatures, low precipitation, and high evapotranspiration rates, whilst housing a variety of grasses, weeds, and forbs with a limited number of trees.

The study was broken into two parts, pre-baiting, and trapping. Pre-baiting took place over three nights, placing the traps, locked open with bait in the opening. It should be noted that traps were covered with a board and were pointed down-slope to prevent water pooling and subsequent mortality during a rainfall event. Once pre-baiting phase was completed, the traps were filled with bedding, bait (now inside the trap along with the bedding) that included a piece of apple as a water source and set open to be checked to following morning. The next morning, the traps were checked to see if a small mammal had been captured; if so, the species was recorded along with its sex, weight, and given an ear tag (if they do not already have one) and released for future capture (along with future capture of other unmarked small mammals). Once the trapping was completed, the traps were collected, removed of any bedding and bait, bleached, and carefully stored. Data from all four locations were congregated, including merging of Montane and Meadow Vole population data into *Microtus sp.* due to difficulty of distinguishing both species from one another, as seen in Table 1.

Population estimates were calculated with model estimates through MARK, and if population estimates were not available for a given species in a given year, the actual number of animals captured was used instead. Moreover, the MARK software was used only for the 2021 Deer mouse data as the number of Voles caught and/or recaptured was too low to allow a model to be fitted.

Results

As seen in Figure 2, there are high fluctuations in the average Deer mouse populations except for the years 2001-2002 and 2005-2007 when the average population densities remained steady at 35, 37 and 77, 74 and 64 respectively. While the Voles had significantly smaller average population densities, they remained more stable than those of the Deer mouse from the years 1999-2002 and 2006-2013 with 2, 5, 3, 3 and 3, 1, 1, 0, 2, 3, 1, 2 caught, respectively.

When examining the relationship between average population densities and precipitation amounts, the Ryan-Joiner (RJ) test for normality was conducted to determine if each respective month fits a normal or does not normal distribution. As seen in Table 2, the months March, May, July, and September fit a normal distribution, each having high RJ values and a p-value of >0.100. Comparatively, the months April, June and August did not fit a normal distribution, having decreased RJ values and p-values that all fell below 0.05.

To determine whether there was a correlation with precipitation levels and average population densities, a Pearson test was used for the months with normally distributed data, while a Spearman test was used for those without normally distributed data. Every month, no matter if it was normally distributed or not normally distributed, had p-values over 0.05 indicating that there was no significant correlation between population densities and precipitation.

Discussion

When examining the change in population densities over time in Figure 2, both the Deer mouse and the Voles appear to maintain similar patterns of change throughout the 25 years. This can be seen as both population densities decrease from the year 1997 to 1998. Additionally, both the Deer mouse and Vole populations are shown to have increased in 2005, while also both decreasing in 2021. The Deer mouse population densities appear to have regular increases and decreases year to year, while the Vole population densities are more static from the years 1999-2004 and 2001-2013 until significant fluctuations are seen beginning in 2014. Moreover, fluctuations in Deer mouse populations may be better displayed due to increased population estimates, compared to the Voles as they have overall smaller population estimates. As previously stated, in 2014 the Vole fluctuations are better seen, which may be due to the increased population estimates as it jumps from having 2 voles in 2013, to 14 in 2015 and then 5 & 31 during 2016 and 2017 respectively.

As previously mentioned, all months, no matter if they were tested with the Spearman or the Pearson correlation tests, all p-values were over 0.05; indicating there was no strong correlation between precipitation and population densities. Whilst precipitation specifically does not appear to have a significant impact on the densities of the small mammal populations, and thus their fluctuations, an extrinsic factor such as environmental variables (weather and climate fluctuations) appear to be, the most rational explanation for such large fluctuations in populations (Pinter, 1987). The lack of relationship was also seen in a study completed by Brown & Ernest, whom, also found that the influence of precipitation on rodents proved to be inadequate (2002). They, however, suggested that their model, solely examining precipitation, was too simplistic to capture the complexity of the ecosystem including aspects such as precipitation effect on plant growth and seed production (Brown & Ernest, 2002). Factors that affect survival and reproduction are often complex and multidimensional rather than being one single aspect (Previtali et al, 2010). Moreover, the interactions between different factors including temperature, amount of vegetative cover, environmental stress, and food sources (forage) could provide greater insight on their effects on population densities. Additionally, the role of territoriality in comparison to food, can hold a higher influence on a population's density even if the amount of forage is limiting (Jones, 1990).

Examining other aspects such as total cover of plant species within the grassland habitats, disturbance including habitat fragmentation and fire, and the site-respective carrying capacity based on predators, food, water, cover, etc. It is recommended that future research uses an approach such as the Dueser & Shugart multi-variate approach to quantify the microhabitat use in respect to multiple influences on population densities (1979).

Limitations of this study can include only sampling nights over three nights, using a small number of sampling locations and trap equipment malfunctions. Additionally, trapping only occurred later in the year (late September, early October) rather than multiple times within a year including spring, and early and mid-summer. Sampling more than once in a year could provide a more inclusive and insightful view of the populations and possible fluctuations in correlation to precipitation within that respective year.

Small mammals such as the Deer mouse may be small, but the impact they have on their environments is mighty. They continuously provide seed dispersal, coarse woody debris intrusion, soil aeration and increased ground water movement. Even more, they are a staple prey species for species such as predator birds (owls, hawks), larger mammals (foxes, bobcats, weasels), reptiles (snakes) and more. Further understanding of these animals may contribute to the stability of both their populations and the populations of their predator species within their natural environment, as well as stability of the environment itself.

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Appendix

Figures

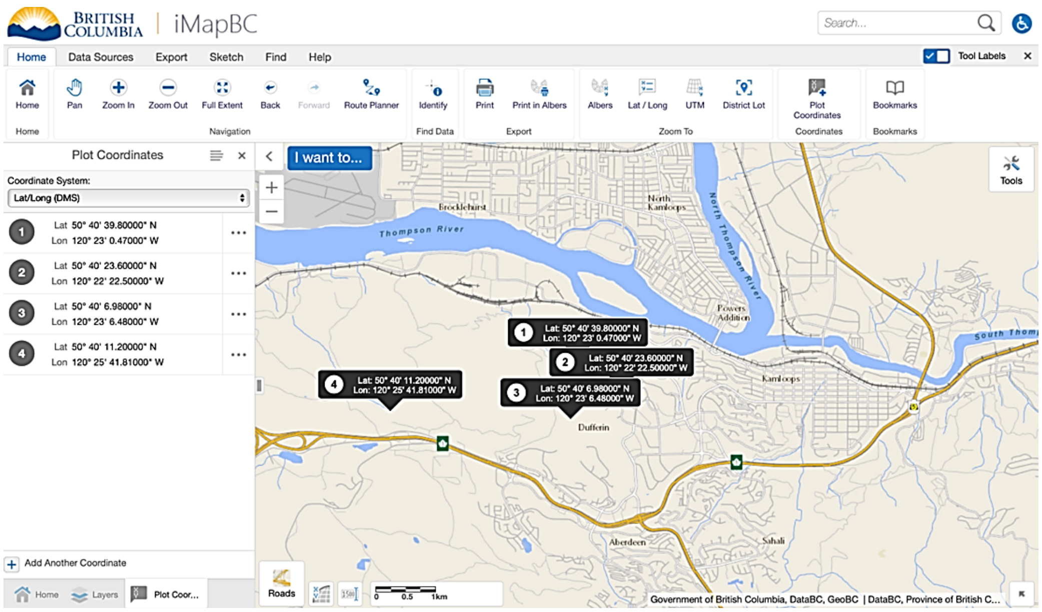

Figure 1. Coordinates of the four sampling grid locations including the TRU Campus, Dufferin, Weighscale and Bunker sites (location 1-4 respectively) displayed via iMap.

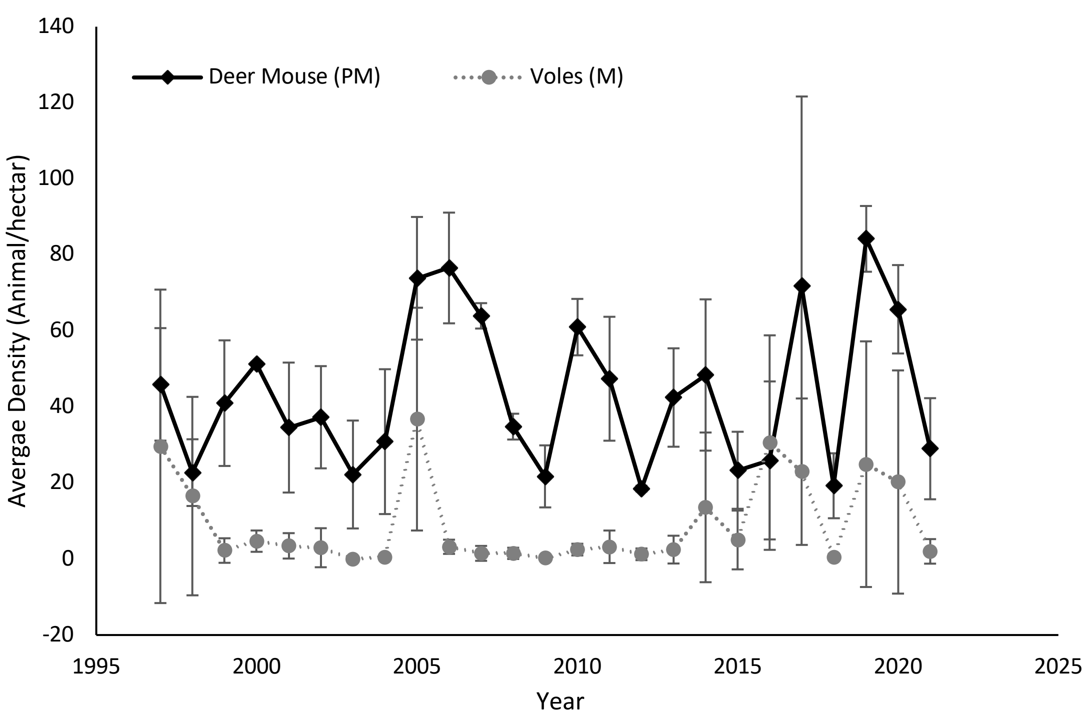

Figure 2. Average Deer Mouse and Vole population change in density (animal/hectare) over 25 years (1997-2021 inclusive). Error bars represent +/-1 standard deviation.

Tables

Table 1 Number of Deer Mouse and Voles caputured at each location of the 2021 sampling year.

	TRU Campus	Bunker	Dufferin	Weighscale
Number of Deer Mouse (Pm) Captured	20	53	28	55
Number of Voles (M) Captured	0	0	1	8

Table 2. Normality test using Ryan-Joiner test to determine normality and subsequent correlation test needed, including both respective normality and correlation test p-values, 1997-2021 inclusive.

	RJ Value	P-value	Correlation Test Type	Correlation Value	P-value
Average Deer Mice Density	0.969	>0.100			
March	0.980	>0.100	Pearson	-0.039	0.853
April	0.908	<0.010	Spearman	-0.248	0.232
May	0.967	>0.100	Pearson	0.101	0.632
June	0.953	0.040	Spearman	-0.100	0.642
July	0.979	>0.100	Pearson	-0.147	0.493
August	0.897	<0.010	Spearman	0.062	0.770
September	0.973	>0.100	Pearson	0.150	0.474