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Population Dynamics of White-Footed Mice (*Peromyscus leucopus*) from 2012-2018 in a Fragmented Landscape

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Abstract

The white-footed mouse (*Peromyscus leucopus*) is a rodent typically found in forest habitats, particularly along the edges, that contain dense understory vegetation. The primary goal of this study was to investigate the population dynamics of white-footed mice in two different habitats that include a fencerow that runs adjacent to agricultural field (Ag) and a deciduous forest (Woods). The study was conducted May through August 2012 to 2018 at Capital University's Primmer Outdoor Learning Center, which is located in Logan, OH. The data analysis showed that the densities of the mice differed between the two habitats over the course of seven years (χ^2=45.13, df=6, $p<0.001$). Specifically, the white-footed mouse population in the Ag habitat was more abundant than the one in the Woods habitat except for the years of 2014 and 2017. These results indicate that white-footed mice are extreme generalists and can achieve high densities in other habitats with dense vegetation, which they may be also utilizing as dispersal routes. This work also suggests that predation rates might be lower and food resources more abundant inside the Woods habitat. White-footed mice can thrive in a variety of habitats in a fragmented landscape.

Keywords: White-footed mice, Population Dynamics, Fragmented Landscape

1. Introduction

The white-footed mouse (*Peromyscus leucopus*) is a generalist rodent distributed throughout the eastern United States[1]. The white-footed mouse prefers forest habitats since these habitats may provide a greater vertical cover, which can provide foraging opportunities for food like berries, insects, and seeds[2]. An increase in food availability may result in the mice becoming heavier, having a female-biased sex ratio, and possessing higher densities[1]. Previous research by Anderson and Meikle[1] discovered that with a greater complexity of the understory vegetation, this then had a positive effect on the density of the white-footed mice in that area.

The white-footed mouse is not limited to the woods and the woods edge, however, as the mice can also be found in both disturbed and natural habitats, such as crop fields, barns, lawns, and ditches along the roadside[3]. Cummings and Vessey[3] live-trapped white-footed mice in disturbed habitats, but found them in significantly lower densities in the summer compared to the woods and woods edge. In contrast, Yahner[4] stated that the white-footed mouse was absent along the roadsides and oftentimes avoided grassland habitats.

Different habitat types have been shown to influence the dispersal ability of white-footed mice. Klein and Cameron affirmed that the agricultural fields act as barriers to the movement of the rodents, especially once the crops are harvested[2]. Previous research of Cummings and Vessey[3] found the opposite, stating that the crops in the adjacent agricultural field give the mice an aboveground structure and a constant food source, which assists the movements of the mice particularly in the summer.

Two habitats were analyzed for the current study, which included a fencerow between an agricultural field (Ag) and grassland, and inside a secondary-growth deciduous forest (Woods). The trapping was done at Capital University's Primmer Outdoor Learning Center in Logan, Ohio. The trapping of the mice occurred during the months of May-August because the growth of the vegetation was the highest in both habitats during this time. During these months, the growing crops could have provided a food source and aboveground structure for the white-footed mice near the Ag fencerow, or they could have acted as barriers to limit the movement of the mice. Within the Woods, the trees and shrubs could have provided vertical cover from predators including owls, hawks, and foxes [1]. This would result in a higher survivorship with a greater recapture rate (i.e., capturing the same individuals more than once). The complex vegetation could have also provided additional food sources for white-footed mice inside the woods. Between the years of 2012-2018, descriptive data was taken from each mouse along with calculating the density of each population of mice.

The purpose of this study was to test three different hypotheses'. The first hypothesis was that the white-footed mice would have a higher density in the Woods since it could be considered a higher quality habitat; as a result, there would be a lower density of the mice in the fencerow along the agricultural field. The second hypothesis was that the Woods habitat would have a higher recapture rate than the Ag habitat due to the fact that the mice would stay in the woods and survive for a longer period of time likely due to lower predation rates. The third hypothesis was that the body mass (g) of the mice would be heavier in the Woods than the Ag due to the Woods habitat having a greater availability of food.

2. Methods

2.1 Field Methods

The study was performed at the Primmer Outdoor Learning Center in Logan, Ohio (Figure 1). Primmer is Capital University's off-campus field research site and the location includes a fencerow, groundwater streams, grasslands, a secondary-growth deciduous forest, a great blue heron rookery, a pine plantation, and a riparian forest. The trapping sites were found in both the deciduous forest (Woods) and a fencerow that ran along an agricultural field (Ag). Live trapping of small mammals was conducted in the months of May-August over seven years (2012-2018). 24 live traps were set along the Ag while 32 traps were set within the Woods and were checked on average six times during the course of each summer. All of the traps were set 10 meters from one another, and a flag with the trap number was placed outside each trap. Each trap had oatmeal placed inside as bait during the late afternoon, and then the traps were checked in the following morning.

The white-footed mice were marked with the Monel™ ear tags to distinguish the individual mice. For each mouse, both recapture and capture, initial descriptions were written down. Some of these observations included the body and tail length (mm), body weight (g), pelage color, and gender. The mice that were recaptured were the mice that had an ear tag[5]. To determine body weight (g), the mice were placed inside a Ziploc bag and then were weighed using a Pesola spring scale. Body length, which was measured from the snout to the start of the tail, and tail length were measured using a ruler and recorded in mm. Pelage color that was recorded could have been either grey, grey to brown, brown, or reddish brown. Other observations that were recorded include the presence of ticks, and whether the nipples were visible on the mice to indicate their reproductive condition. A small tissue sample of the mice was also taken using a clean pair of dissection scissors. 5 mm or less were taken from the tip of the tail using the scissors and then placed inside a 1.5 mL autoclaved tube that contained 1.0 mL of 95% ethanol[5,6]. The tubes were labeled with the ear tag number and the date and then stored at -20˚C. If the tail started to bleed, cornstarch was applied to halt the bleeding. To protect the researchers, precautions were taken to prevent the researchers from being exposed to the Hantavirus. Gloves were worn at all times and switched between the habitats to prevent cross-contamination. The traps were also emptied into the Ziploc bags away from the researcher's faces. Capital University's Animal Care and Use Committee approved the permission to live-trap and handle the vertebrates (protocol #2014-09).

2.2 Data Analysis

Trap nights are defined as the number of traps set minus the total number of traps that were disturbed when checked the following morning during the study. Disruptions of the traps included captures of other animals, being broken open, and lying on its side. Mouse abundance was defined as the total number of different mice captured. The mouse

abundance included the number of mice tagged, but does not include the recaptures of these mice. As with other researchers, the density of mice was determined by calculating the number of different mice per 500 trap nights[1,3,5]. The recapture rate was calculated by dividing the number of mice captured more than once by the total number of mice. The descriptive data of the white-footed mice was also compared across the two different habitats and through the years of the study. The proportion of juveniles (the mice with the grey pelage) was calculated to compare the age of the mice population between the different habitats and through the seven years of research[5]. Juveniles were the mice with the grey pelage, sub-adults had a transitional phase of grey to brown pelage, and adult mice had a reddish brown to brown pelage[3,5]. Sex ratios were defined as the ratio of males to females. Average (with the standard deviation) weights (g) and body lengths (mm) were calculated for each population within each habitat.

3. Results

During the seven years of research, there were a total of 137 mice over more than 1,300 trap nights (Table 1). The densities of the mice were shown to differ between the two different habitats (X^2=45.13, df=6, p<0.001). The density of the mice was the highest in the Ag with the exception of the years 2014 and 2017 where there were more mice in the Woods (Table 2, Figure 2). The recapture rate, which was the mice that were captured more than once, was usually higher in the Woods than the Ag with the exception of 2013 (Table 2, Figure 3). Only one mouse in the Woods was found again in the same habitat during the next year. This occurred from 2017 to 2018, and none of the other mice that were captured in one of the habitats ever showed up again in the same habitat throughout the years except the one exception. Overall, the sex ratio of males to females in both habitats had more males than females throughout the years (Table 2). Adults made up most of the mouse population while the proportion of gray juvenile mice was consistently low and the proportion ranged from 0 to 0.18 (Table 2). Both the average body mass (g) and the average body length (mm) were very similar in both habitats (Table 2, Figure 4). The average body mass, however, was usually higher in the Woods with the exception of 2012 and 2017 (Table 2, Figure 4). The average body length was usually longer in the Ag than the Woods with the exception of 2016 (Table 2).

Table 1. Trap nights of the white-footed mice (*Peromyscus leucopus*) populations in both the Ag and the Woods habitats in each year.

	2012	2013	2014	2015	2016	2017	2018
Ag	78	43	91	71	87	66	105
Woods	139	87	123	103	132	91	91
Total	217	130	214	174	219	157	196

Table 2. Population attributes of the white-footed mice (*Peromyscus leucopus)* populations in both the Ag and the Woods habitats in each year.

	2012		2013		2014		2015		2016		2017		2018	
	Ag	Woods	Ag	Woods	Ag	Woods	Ag	Woods	Ag	Woods	Ag	Woods	Ag	Woods
Mice per 500 Trap Nights	57.7	17.9	81.4	45.9	27.5	44.7	126.7	63.1	40.23	30.3	60.61	82.42	71.43	43.96
Recapture Rate	0.44	0.8	0.29	0.13	0	0.36	0.11	0.46	0.29	0.875	0.124	0.53	0.33	0.75
Mean (SD) Body Weight (g)	21 (3)	20.2 (4)	18.4 (3.8)	21.7 (2.5)	17.8 (0.8)	19.1 (3.4)	21.1 (4.1)	21.9 (4.2)	17.86 (2.04)	18.75 (3.2)	20.5 (2.67)	19.83 (4.64)	17.8 (3.71)	18.625 (3.29)
Mean (SD) Body Length (mm)	80.9 (7.4)	75.8 (7.2)	77.4 (6.5)	74 (7.8)	78.8 (7)	77.6 (6.9)	83.7 (7)	79.6 (7.7)	71.72 (5.53)	71.75 (7.27)	84.63 (6.09)	76.2 (8.5)	79.1 (7.33)	77.13 (4.73)
Proportion of Gray Juvenile Mice	0	0	0.14	0	0	0.18	0.11	0	0	0.125	0	0	0	0
Sex Ratio (M:F)	5M:4F	3M:2F	6M:1F	5M:3F	2M:3F	7M:4F	2M:1F	9M:4F	5M:2F	3M:1F	3M:5F	4M:1F	11M:4F	1M:1F

Figure 1. Map of Primmer in Logan, Ohio. The white box indicates the fencerow and the purple box indicates the woodlot.

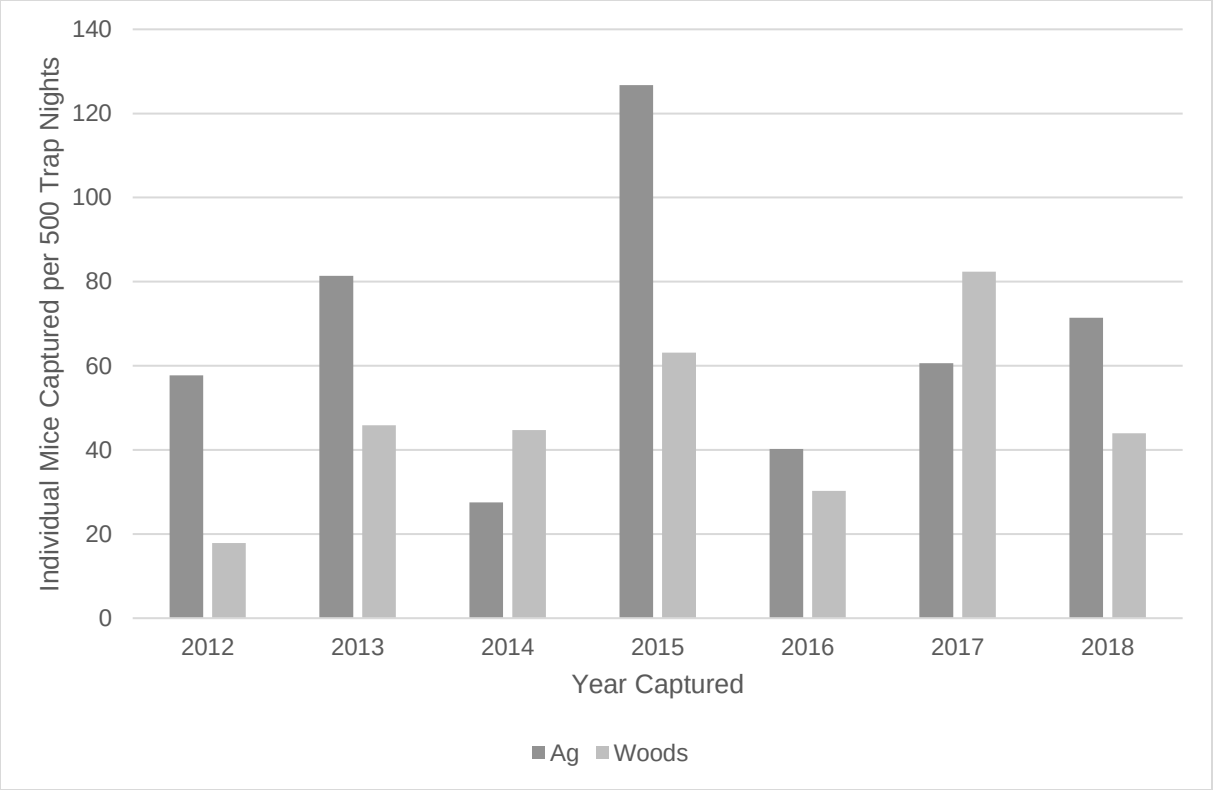

Figure 2. Density of white-footed mice (*Peromyscus leucopus*) in each habitat defined as number of individual mice caught per 500 trap nights in each year (X^2=45.13, df=6, p<0.001).

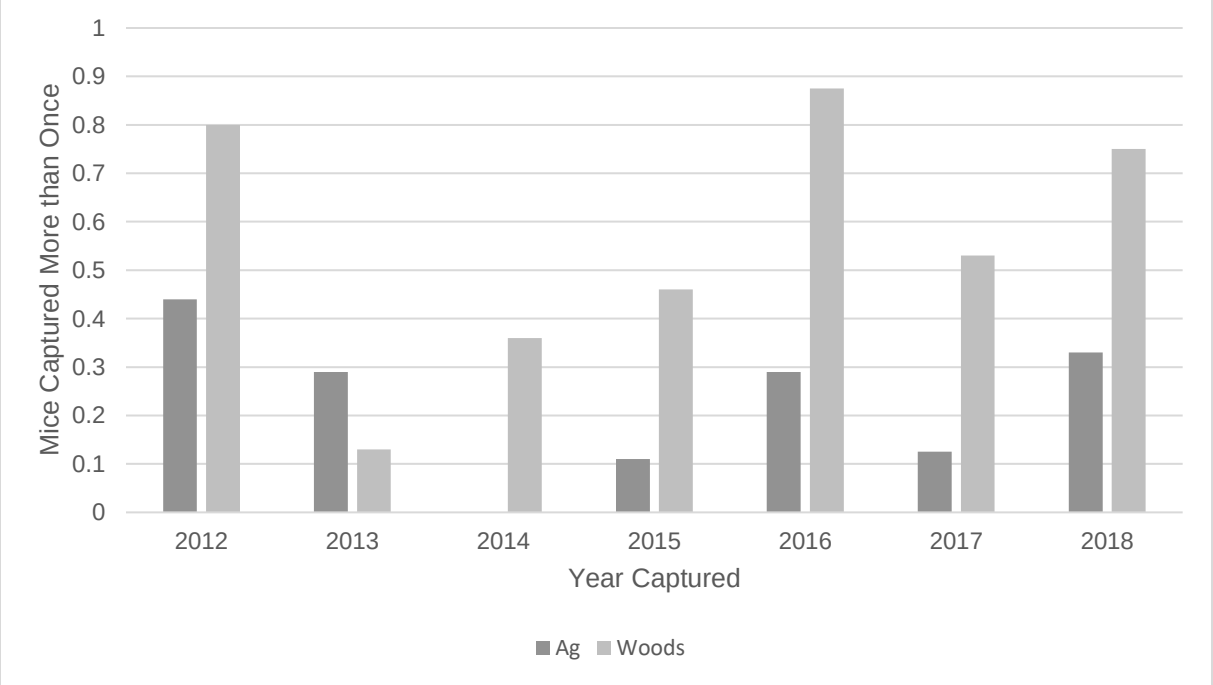

Figure 3. Recapture rate of the white-footed mice (*Peromyscus leucopus*) in each habitat and year.

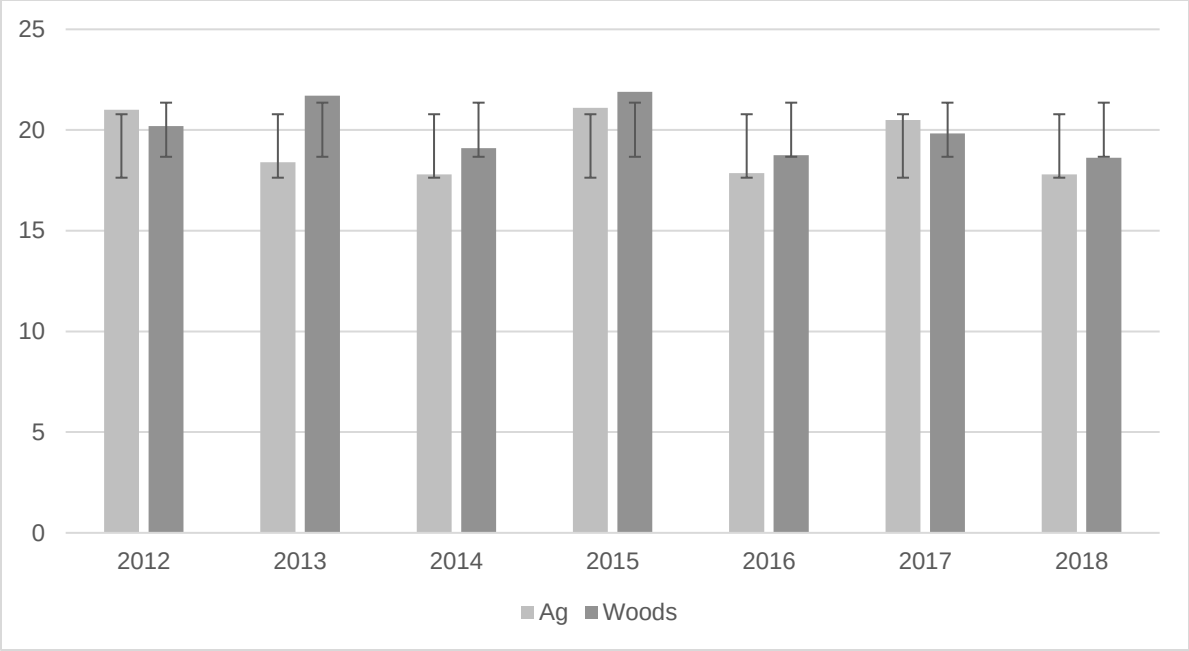

Figure 4. Mean of body mass (g) of the white-footed mice (*Peromyscus leucopus*) in each habitat and year.

4. Discussion

The first hypothesis that the white-footed mice would have a higher density in the forested areas instead of the fencerow that separated an agricultural field from a grassland was rejected during the course of this experiment. The white-footed mice had a greater density inside of the Ag rather than the Woods with the exception of the years 2014 and 2017. These results were contrary to past research in Ohio that stated that the white-footed mice typically achieved extremely high densities inside forests and the forest edges[1,3]. Cummings and Vessey did trap mice in ditches, fields, and farms, but with significantly lower trap success compared to the woods in the summer[3].

There are several possible factors to explain why densities tended to be higher along the Ag fencerow compared to the Woods over the course of this study. The most likely factor may be that the fencerow is serving as a dispersal route in the fragmented landscape. Hence, the Ag fencerow habitat could be experiencing higher immigration rates resulting in higher densities there. According to a study done by Zollner, the range of white-footed mice across an agricultural field at dusk was around 90 m and this suggests that the mice follow a strategy of 'look now and move later'. This then suggests that the white-footed mice use the agricultural field as a place to look out of predators and when the predators are nearby, the mice will move away later[7]. A study done by Keaka also suggests that the migration of the white-footed mice between the Ag habitat and the Woods habitat was bidirectional[8].The white-footed mice may have also preferred the Ag habitat because of the mortality rates being low due to the Ag having lower predation, the Ag contained lower emigration rates, and the Ag had less competition along with a higher resource availability[9].

One reason that there was a decline in the population abundance inside the Ag habitat in 2014 and 2017 may be due to the captures of competitors inside of the traps during those years. In 2014, there were 20 captures of short-tailed shrews (*Blarina brevicauda*) and other competitors, while in 2017, there was a capture of 13 shrews, meadow voles, and various other competitors. It is also possible, according to a previous study, that the mice avoided traps that had previously held a shrew[10]. During this study, there was a higher abundance of the white-footed mice inside the Ag habitat during most years, which suggests that the mice can thrive and survive in a variety of habitats[11]. Previous studies also propose that the mice populations can even be enhanced by agricultural use along with forest fragmentation[6].

Recapture rates were often slightly higher inside the Woods than the Ag with the exception of the year 2013, which suggests that the Woods could be considered a higher quality habitat. Hence, the evidence supported the second hypothesis, which stated that the Woods would have a higher recapture rate. The white-footed mice might survive longer in the Woods because the Woods population had a lower emigration rate, better resources, or lower predation

rates. The Woods also had more tree coverage that could have protected the mice from aerial predators. The higher vertical density along with the understory vegetation may have led to cover from predators or an increase in food availability[12,13,14,15]. According to a previous study done at the Primmer Outdoor Learning Center, the Woods habitat may be a higher quality habitat throughout the entire year because the recapture rate of individual mice was higher in the Woods habitat[16].

Along with higher recapture rates, the average weight of the mice in each habitat was also estimated in this experiment. According to a previous study, forests have diverse tree species, which provide food, such as acorns, that the rodents can store over the winter months[17]. The hypothesis made in this study was that the average weight of the mice would be heavier inside the Woods than the Ag because the Woods had a greater diversity and availability of food. The average weight of the mice was generally higher in the Woods across the seven years, but overall, the average weights were quite similar. For the white-footed mice, food resources are presumably a limiting factor since the breeding of the mice occurs during the spring, summer, and early autumn months[5]. One reason why the average weight of the mice was similar in both habitats could be that while the Woods may have had a greater diversity and availability of food (such as arthropods, green vegetation, and fungi), but the Ag field and grassland also provided plenty of food (including lepidopteran larve, adults, and corn and soybeans) for the mice along the fencerow. A study done by Wolff suggested that both the white-footed mouse along with the cloudland deermouse most often eat nuts, arthropods, and fruit along with a smaller amount of fungi and green vegetation[18].

The proportion of gray juvenile mice were also estimated in this study. In 2014, the Woods had the highest proportion of gray juvenile mice between the years of 2012 to 2018. These results suggest that reproduction is occurring in the Woods. A previous study, however, affirmed that the appearance of young animals in any type of habitat could occur from their dispersal from source habitats[3]. Overall, in the case of this study, dispersal is one of the main reasons why there are higher densities inside the Ag habitat because the Ag may serve as a habitat for transient individuals moving through the landscape. Food availability is also an important factor, which influenced densities inside the Woods since recapture rates were higher and the average weight of the mice was slightly higher in the Woods.

Future research needs to be done to determine the predation rates between the two difference habitats and to also quantify the amount and types of food resources. To determine if there is a difference in the densities of the white-footed mice during the winter season, further research on this topic could be conducted using mouse nest boxes. The metal Sherman live traps cannot be used during the winter months as the mice would get too cold to survive, but the mouse nest boxes can keep the mice warm and alive during the winter season[3]. Future research can also be used to determine if there is a significant difference in the abundance of male and female mice in the two different habitats as the evidence in this study shows no significance between the two genders in either the Ag or the Woods.

In conclusion, the hypothesis that the white-footed mice would be found in higher densities in forest areas as compared to fencerows near agricultural fields was not supported. This study found that the white-footed mice were found in higher densities along the Ag fencerow instead of the Woods. The fencerow habitat could have had higher dispersal rates from the nearby agricultural field, which made densities higher in the Ag compared to the Woods. The hypothesis that the white-footed mice would tend to stay in the Woods and survive longer, which would make the Woods have a greater recapture rate than the Ag, was supported in this study. One reason why the Woods could have had a greater recapture rate was that the Woods habitat had more food resources with better quality. Mortality rates may have also lowered in the Woods due to aerial coverage from birds of prey. The average weight of the mice in both the Ag and the Woods were extremely similar, but they were, on average, slightly higher in the Woods. This study showed that the white-footed mice live in a variety of disturbed and natural habitats with moderate densities.

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6. References Cited

1. Anderson, C. S., & Meikle, D. B. (2006). Annual changes in structural complexity of understory vegetation and relative abundance of *Peromyscus leucopus* in fragmented habitats. Acta Theriologica, 51(1): 43-51.

2. Klein, G. P., & Cameron, G. N. (2012). Effect of habitat gradients on space used by white-footed mice (*Peromyscus leucopus*). Journal of Mammalogy, 93 (3): 706-715.

3. Cummings, J. R. & Vessey, S. H. (1994). Argicultural influences on movement patterns of white-footed mice (*Peromyscus leucopus*). The American Midland Naturalist, 132 (2): 209-218.

4. Yahner, R. H. (1983). Small mammals in farmstead shelterbelts: habitat correlates of seasonal abundance and community structure. The Journal of Wildlife Management, 47 (1): 74-84

5. Bope, A. (2014). Population Dynamics of *Peromyscus leucopus* at Clear Creek Metro Park. Epistimi, 53-63.

6. Anderson, C. S., & Meikle, D. B. (2010). Genetic estimates of immigration and emigration rates in relation to population density and forest patch are in *Peromyscus leucopus*. Conservation Genetics, 11 (5): 1593-1605.

7. Zollner, P. A., and Steven L. L. Illumination and the perception of remote habitat patches by white footed mice. (1999). Animal Behavior, 58 (3): 489-500.

8. Farleigh, K. (2018). Genetic estimates of migration for white-footed mice (*Peromyscus leucopus*) at the Primmer Outdoor Learning Center. Proceeding of The National Conference On Undergraduate Research (NCUR) 2018, 690-699.

9. Nupp, T. E., & Swihart, R. K. (1996). Effect of forest patch area on population attributes of white-footed mice (*Peromyscus leucopus*) in fragmented landscapes. Canadian Journal of Zoology, 74 (3): 467-472.

10. Wolf, M & Batzli, G. O. (2002). Relationship of previous trap occupancy to capture of white-footed mice (*Peromyscus leucopus*). Journal of Mammalogy, 83 (3): 728-733.

11. Anderson, C. S. (2004). Effects of forest fragmentation on the abundance, distribution, and population genetic structure of white-footed mice (*Peromyscus leucopus*). Ph.D. Dissertation, Miami University, Oxford, OH, USA, 1-144.

12. M'Closkey, R. T. (1975). Habitat dimension of white footed mice, *Peromyscus leucopus*. The American Midland Naturalist 93: 158-167.

13. Drickamer, L. C. (1990). Microhabitat preferences of two species of deermice (*Peromyscus*) in a northeastern United States deciduous hardwood forest. Acta Theriologica 35: 241–252.

14. Schmid-Holmes, S. & Drickamer, L. C. (2001). Impact of forest patch characteristics on small mammal communities: a multivariate approach. Biological Conservation 99 (3): 293–305.

15. Anderson, C. S., Cady, A. B. & Meikle, D. B. (2003). Effects of vegetation structure and edge habitat on the density and distribution of white-footed mice (*Peromyscus leucopus*) in small and large forest patches. Canadian Journal of Zoology 81 (5): 897–904.

16. Hanlin, T. (2016). Prevalence of White-footed Mice in an Outdoor Learning Center. Epistimi 9: 113-128.

17. Burt, W. H., & Grossenheider, R. P. (1980). Peterson Field Guide Series: A Field Guide to the Mammals. Houghton Mifflin Co., New York.

18. Wolff, J., Dueser, R., & Berry, K. Food Habits of Sympatric *Peromyscus leucopus* and *Peromyscus Maniculatus*. (1985). Journal of Mammology, 66(4): 795-798.