

**Sherman Trap Survey of Small Mammal Diversity on French Creek Valley Conservancy
Managed Properties**

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Conservancy Managed Properties

Small mammals are an indispensable part of our ecosystems but are at risk for concerning population declines and biodiversity loss as a result of human interference. The French Creek Valley Conservancy (FCVC) is land trust based in Crawford County PA that's committed to maintaining ecologically healthy properties. However, they have limited resources and personnel, which has created challenges to effectively surveying the organizations properties for small mammals. To fill this gap in knowledge, live trapping was conducted using Sherman traps at three sites managed by the FCVC: Greendale Cemetery, Lew's Land, and Robert Brace Nature Reserve. Thirty traps were set each night for three consecutive nights. This three-night trapping period was performed twice at each of the three sites, once in late fall (11/10/23-11/12/23, 11/17/23-11/19/23, 12/8/23-12/10/23) and once in winter (2/7/24-2/15/24), for a total possible 180 captures per site. Captured mammals were identified, weighed, and released, and site data was recorded. There were 412 successful undisturbed trap nights across all sites and 78 captures, including white-footed mice (*Peromyscus leucopus*) and deer mice (*Peromyscus maniculatus*). This study created a better understanding of small mammal community composition in the three properties, supplementing the camera trapping conducted in the past to create a more comprehensive view of biodiversity at the sites. This information can act as an additional factor to consider in future decisions made about the properties, and the methodology used in this study can be reused for future live trapping of small mammals.

Introduction

Mammals constitute a large portion of known species, with over 6,399 living species currently identified (Burgin et al., 2018). Small mammals, a subgroup of the larger class of mammal, account for a large portion of the whole, estimated to be around 90% of all mammal species (Lidicker, 2011). Despite the wide use of the term, the parameters of what makes a small mammal are largely undefined and criteria often change based on the needs of the organization conducting a study. Sometimes the criteria are specific to the needs of the project, as with the National Ecological Observatory Network (NEON) program, a large-scale trapping operation specifically looking at tick-borne illnesses, which specifies that the mammal must be nocturnal, unable to fly, and primarily forage aboveground (NEON, 2020). Occasionally, as seen in *Micromammals and Macroparasites: From Evolutionary Ecology to Management*, the subgroup is defined by taxonomy, including orders Rodentia, Insectivora, Chiroptera, and Lagomorpha, as well as size (Morand et al., 2006). The most widely used and simple categorization comes from the International Biological Programme (IBP), which classifies any mammal less than 5 kg as a small mammal (Petrusewicz et al., 1975). However small mammals are defined, they are a critical part of every ecosystem, providing prey for higher level predators, dispersing seeds, and keeping the prevalence of invasive plants down. Because of their short lifespan and high reproductive rates, small mammals can also be an important indicator of an ecosystem's health in the early stages of decline (Santoro et al., 2016). However, they are at risk of decreased population numbers and are already showing signs of biodiversity loss around the world (Viteri & Hadly, 2022).

Small mammal populations fluctuate year to year in cyclical patterns and reproduction can be affected by a multitude of different factors, including high population density, risk of predation, stress, malnutrition, and puberty delaying hormones (Oli & Dobson, 2001). While slight warming might positively affect small mammal populations in the short term because of a predicted abundance of plants to be used as a food source (Cho, 2022), recent studies have shown that sustained warming, as well as human disturbance, may be negatively impacting population cycles (Wan et al., 2022). Exact direct and indirect factors causing differing cycles will most likely depend heavily on species and location, but all small mammals will be affected by the incoming climate crisis. While small mammals are less affected by human interference

compared to other larger mammals, habitat fragmentation and land use change does influence many small mammal species' success. The absences of large predators can help boost population numbers temporarily, but depleted resources and natural habitat loss puts increased stress on the population (Polyakov et al., 2021).

Small mammal populations can also be affected on a smaller scale by forest composition and proximity to the edge of the forest. The location of small mammals is highly dependent on the availability of food in general, as well as the presence of their preferred food. Species that produce an abundance of seeds every year are vital to small mammal populations. Trees like the American beech (*Fagus grandifolia*), produce many energy rich seeds in the fall, which small mammals will store and consume throughout the winter (Moore et al., 2022). Sugar maple (*Acer saccharum*) and red maple (*Acer rubrum*), both trees that produce an abundance of seeds, seemed to be preferred differently based on how generalized a small mammal species is (Cramer, 2014). Similarly, proximity to the edge of the forest can affect local population numbers. The edges of forests are more exposed to sunlight, which allows for greater degrees of understory growth. Low level plants and general forest debris provide a place for small mammals to hide from predators, much more so than they would be able to on an empty forest floor. Forest edges also can provide additional food sources in the form of insects for species like moles and mice (Johnson, 2017).

In addition, climate change and human interference are shifting the range of small mammals alongside the changes in population. Warming of northern latitudes has been demonstrated to promote movement in species that adapted to thrive in warmer temperatures, changing population counts of native small mammals due to increased competition and lack of space (Baltensperger & Huettmann, 2015). Mammals that have been present in Pennsylvania historically might be less common in the area due to these factors. This will especially affect species with small home ranges. Small mammals are vital for all ecosystems as an intermediate step in food webs. Decreased population numbers will but even more strain on struggling carnivorous mammal species, and plants will have less success dispersing seeds.

Despite their importance to ecosystems and their ubiquitous nature, small mammal populations are hard to study. Whereas bigger species can be reliably monitored using camera traps, most small mammal population data has historically been collected through the use of live

traps. In some instances, camera trapping is still used for small mammals, but detection of smaller species can be inconsistent and harder to quantify than with larger species, which have a higher chance of setting off the camera and can be easier to identify, even in unclear photos (McCleery et al., 2014). In studies focusing specifically on small mammals, the extra detail provided by live trapping is vital, and often worth the temporary stress of the mammal (Fletcher & Boonstra, 2006). Sherman traps are one of the most commonly used trap types for animals of this size, and also provide consistently high capture rates (Anthony et al., 2005). Their door-and-treadle design allows for painless capture, as the animal is lured to the back of the trap, away from the mechanisms that might catch its tail or fur. The collapsible nature of some models, like the model used in this study, allows for easy and quick deployment and collection, making larger research areas feasible for smaller groups of researchers (H. B. Sherman Traps, Inc., 2023).

Many components of small mammal surveying are debated within the scientific community due to a lack of generalizable results. One such issue is prebaiting of a trap location and its effect on capture rates. Prebaiting involves setting out the trapping mechanism in the location it will be for the study for a period of time before the surveying starts, baiting it, but not setting it for capture. This theoretically allows the mammals in the area to get used to the new object in their environment, and perhaps be less cautious when trapping has begun. Eldalgo & Anderson (2007) compared trap success in small mammals with or without prebaiting in Pennsylvania. The trapping was done throughout the summer with a total of 600 trapping stations. They found that prebaiting the traps didn't help with capture, instead increasing recapture rates, and recommended that prebaited be avoided in similar areas. Alternatively, there is literature that suggests that prebaiting is effective based on the time that the traps will be active (Weldy et al., 2019), or that response rates might be based on the time of year (Rodas et al., 2009), thus both methods are still commonly used for trapping, depending on the circumstances. Baiting itself, however, is vital for Sherman trapping. Typically, aromatic substances like peanut butter are used as bait. Most small mammals, particularly mice (*Peromyscus* spp.), respond strongly to the smell of bait, even if there isn't bait present in the trap at the time (Machtinger & Li, 2019).

The French Creek watershed is a watershed that is part of the Upper Allegheny Basin watershed and includes about 1,250 square miles of land, which amounts to more than 790,000

acres (French Creek Valley Conservancy, 2019). The watershed supports an abundance of biodiversity in western Pennsylvania, from freshwater mussels to migratory bird species, with many at-risk species like the Eastern Hellbender (*Cryptobranchus alleganiensis alleganiensis*) relying on its resources, but for the purposes of this project, the focus will be on the small mammals present in the area. This project expected to observe many different species native to the region, including animals like the deer mouse (*Peromyscus maniculatus*), the eastern chipmunk (*Tamias striatus*), the meadow vole (*Microtus pennsylvanicus*), the white footed mouse (*Peromyscus leucopus*), and perhaps the southern flying squirrel (*Glaucomys volans*) (K. Pearce, personal communication, 2021). The French Creek Valley Conservancy (FCVC) is a land trust that works within the region, purchasing and managing land for conservation and recreation. This allows them to protect the land from development, maintaining hectares of land that provide habitat for wildlife, including small mammals. As an organization, they are interested in having a better understanding of the conservational value of the land they already own and are looking for ways to make more informed decisions regarding land acquisition in the future. Many of their properties have been camera trapped by the Watershed Conservation Research Center (WCRC) in the past, but live trapping will add a new dimension to the biodiversity data they have accumulated, because, as stated, live trapping provides more detailed surveying of small mammals than a camera can provide.

Habitat fragmentation and degradation are major factors in mammal populations and biodiversity, and small mammals are important indicators of habitat health. The FCVC is interested in acquiring and conserving biologically and ecologically important properties, but they do not have the personnel to complete labor-intensive surveys, like live trapping, on their own. The end goal of this project was to be able to provide the FCVC with information about small mammal diversity on three of their properties, which will help prioritize conservation efforts.

Methods

Three FCVC sites were chosen for small mammal trapping: Greendale Cemetery, Lew's Land, and Robert Brace Nature Reserve (Figure 1). Greendale Cemetery is 75 acres with a ravine that runs through the middle, providing varied habitats and forest compositions, and its proximity to Meadville made it an interesting site (Figure 2). Lew's Land is 48 acres, with similarly uneven

terrain. It is situated slightly farther away from Meadville, but is next to a main road, I-79. A large portion of the land is composed of a grassy field, with only sporadic trees and many highly browsed saplings, while the rest is forested (Figure 3). Robert Brace nature reserve is the smallest of the sites at 21 acres, but provides a wide range of habitats in its small area. As with Lew's Land, the southwest portion of the site is composed of grasses and dense sapling growth, with active efforts by the FCVC to reforest, as planted trees are protected from deer browsing with plastic tubing. The forested area is positioned on a slope, and a stream cuts through the northern edge of the property. It's also next to a main road at the east, but the other borders are relatively residential (Figure 4). All sites were near the Allegheny College campus to allow for timely checking of the traps in the early morning.

Sherman traps (3 in x 3.5 in x 9 in) were used to conduct the live trapping at all sites. Sherman traps work through a trigger plate at the back of the trap that, when compressed, causes the entrance to close. The model used fold up to allow for easy transportation, and have holes in the siding, which can help with temperature regulation. The traps were set up in a transect pattern, approximately 10 meters from each other. For all sites, multiple transects were created to account for different microhabitats across the site, and were placed at least 10 meters apart. This was repeated until all the traps were placed. Where possible, traps were set up flushed against a fallen tree, branch, or rock, as small mammals typically run along and below these areas when moving naturally to avoid predation (Figure 5). Sites were trapped one at a time, for three consecutive nights. The traps were set as close to sunset as possible and were checked at sunrise. If a mammal was present in the trap at the time of the morning check, a zip lock bag was placed over both ends of the trap, and the mammal was encouraged to run into one of the bags, the other allowing me to reach in and guide the mammal without allowing a gap for them to escape through. Once in the bag, the mammal was identified, weighed (excess weight of bag and bait that fell in with mammal subtracted from total afterwards) and released. Mammals were handled as quickly and quietly as possible to decrease stress. Information was recorded for each trap on the first night, and additional information was recorded every morning of the trapping period (Appendix 1). For each individual trap, the nearest mature tree was identified (to account for possible inaccuracies in identifying species when leafless, this was abridged to just conifer or deciduous). If there wasn't one, it was noted as sapling, field, or barren (rocky with no plant cover). Trees were considered saplings if they had a DBH of less than 2. During daylight hours,

the traps were unarmed but left in the field, so that no mammals were trapped outside the trapping period, but the transect didn't have to be set up again every evening. Having the traps active only at night reduces non-target interactions (which typically result in traps being sprung with no mammal inside, stopping that trap from possibly catching a small mammal until next checked) and minimizes the time in the trap for the small mammals.

Traps were baited with approximately 0.25 oz of peanut butter (no added sugar/salt) and oats mixture as food and bait, 8 g of potato for moisture, and 2-3 cotton balls for both temperature regulation and nesting, to help lower stress (Machtinger & Williams, 2020). All materials were placed in the far end of the box to lure the mammal as far into the trap as possible before the door shuts to avoid the animal escaping or getting caught in the door. Food materials were placed on wax paper for easier deployment and cleanup at the end of the survey period (Figure 6). Traps and the materials inside were replaced only if the trap had a successful catch the night before, otherwise the same material was used for all three nights. Each site was surveyed using this method twice throughout the length of the study period, first in November and December, then again in February. The transects for the second survey period were in the same location as the first. The first and last traps of each transect line were marked with flags, as were traps that were harder to locate due to surrounding obstacles to expedite the surveying process. All trap locations were recorded using ArcGIS field maps and a Geode GPS receiver to help navigate in the field. At the end of the survey period, traps were emptied, and traps that contained a mammal at any point were cleaned with a Lysol wipe or bleach and water. A lot of the practical information regarding how to best carry out trapping in a timely manner in the field was adapted from the Machtinger & Williams guide to trapping mice for pathogen surveillance and the Neil blog entry of his methods for small mammal trapping with a class (2020; 2014)

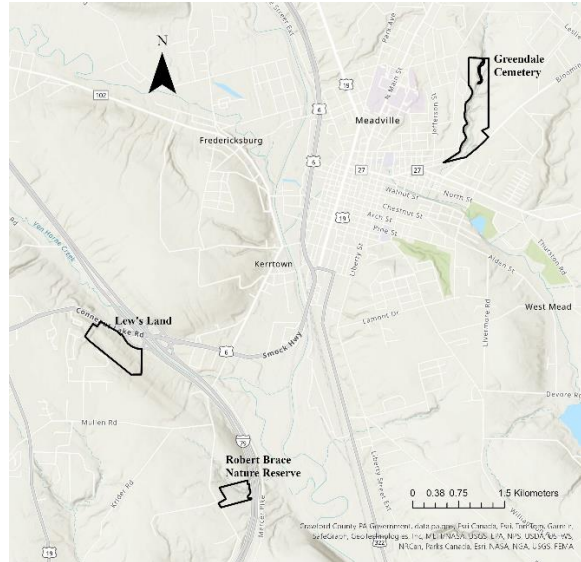


Figure 1. Location of the three French Creek Valley Conservancy sites surveyed in this study. Greendale Cemetery (top right) is closest to the city of Meadville and Allegheny College visualized in pink. Lew's Land (bottom left) is against I-79 and Smock Highway. Robert Brace Nature Reserve (bottom middle) is near I-79 but is surrounded by largely residential areas. Imagery sourced from Esri.



Figure 2. Boundary of Greendale Cemetery, a French Creek Valley Conservancy managed property, in Crawford County, PA. visualizing the land cover in and surrounding the property. Imagery sourced from Esri.



Figure 3. Boundary of Lew's Land, a French Creek Valley Conservancy managed property, in Crawford County, PA. visualizing the land cover in and surrounding the property. Imagery sourced from Esri.



Figure 4. Boundary of Robert Brace Nature Reserve, a French Creek Valley Conservancy managed property, in Crawford County, PA. visualizing the land cover in and surrounding the property. Imagery sourced from Esri.



Figure 5. Example of trap set up. Sherman traps were positioned against obstacles like fallen trees or rocks to increase the likelihood of mammals entering the trap. Picture taken at Robert Brace Nature Reserve on 2/6.



Figure 6. Materials inside the Sherman trap. Heavier materials (peanut butter and oats mixture, potato) were placed back far enough in the trap to not sit on the pressure plate.

Results

There was a total of 412 successful undisturbed trap nights across all sites throughout the study period. A trap night was considered successful and undisturbed if the trap had remained open all night and the bait was intact at the time of the morning check, or if a mammal was present inside the trap at the morning check. This distinction was made because there were many instances of traps being disturbed but not closed, and this definition of a successful trap night takes that into account (Table 1). Across all sites there were 78 mammals trapped: 37 deer mice (*Peromyscus maniculatus*), 34 white-footed mice (*Peromyscus leucopus*), and 7 unidentified mice species (Table 2). Inability to identify was due to either injury to the mammal's tail sustained before being trapped, or mammals escaping before I was able to identify them, as I was still figuring out the best way to get the mammals reliably from the trap into the bag (Figure 7).

Greendale Cemetery was first surveyed from 11/10/23 to 11/12/23, then again from 2/13/24 to 2/15/24. Fifteen of the traps were set near the stream in the ravine, and fifteen were set out of the ravine in a flat wooded area in two lines of eight and seven (Figure 8). There was snow on the ground for most of the second trapping period, which caused some frost to build up on the traps, but it didn't affect the closing mechanism. Lew's Land was first surveyed from 11/17/23 to 11/19/23, then again from 2/10/24 to 2/12/24. Twenty traps were set in the field, in lines of ten,

and the remaining ten were set in the wooded area to the southeast of the site (Figure 9). During the first trapping period, there was quite a bit of rain, and portions of the field ended up being flooded, especially the areas that had been driven through in the past and had residual tire marks. It rained during the second sampling period on 2/13, which caused flooding in the field again, though not as severe as during the first sampling period. Robert Brace Nature Reserve was first surveyed from 12/8/23 to 12/10/23 and again from 2/7/24 to 2/9/24. Twenty-four traps were set in the wooded area of the site and six were set in the grassy field that FCVC is attempting to reforest (Figure 10).

Greendale Cemetery had a mostly even split between conifer and deciduous nearest trees, and very few traps not near a mature tree. Lew's Land had more instances of traps with no mature trees around, and many of the deciduous mature trees were individual large trees amongst saplings that had taken advantage of the ample sunlight available at the site. Robert Brace was similar to Greendale, save for the open area to the south, where traps were placed in grassy fields or against the base of a sapling (Table 3).

Table 1

	<u>Greendale Cemetery (fall)</u>			<u>Greendale Cemetery (winter)</u>			<u>Lew's Land (fall)</u>			<u>Lew's Land (winter)</u>			<u>Robert Brace (fall)</u>			<u>Robert Brace (winter)</u>		
<i>Night of Session</i>	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Total Traps (including traps that were open in the morning)	28	29	27	22	29	29	29	28	30	29	30	30	24	20	14	28	23	24
Total Traps (including only traps that were open <u>and</u> still contained bait)	28	29	23	22	28	28	27	28	28	28	29	25	21	7	2	22	20	17

Table 1. Number of total traps active for each night of sampling the three French Creek Valley Conservancy sites, located in Crawford County PA. Each night, 30 traps were set out, and at the time of the morning check, their status was reported. For the purposes of this study, the total successful traps for each night of sampling excluded both closed traps and traps that had been disrupted enough that the bait was no longer present at the time of the morning check. This is the most accurate account of the number of active traps, as mammals would have no incentive to enter a Sherman trap with no bait, but it does result in a big difference in total successful traps, as seen on Robert Brace (fall) night 2 and 3.

Table 2.

	Date	Average Temperature (C°)	Cloud Cover	Total Active Traps	Total Mammals Trapped	<i>P. maniculatus</i>	<i>P. leucopus</i>
<i>Greendale Cemetery (fall)</i>	11/10/23	9.4	full	28	2	2	0
	11/11/23	8.9	full	29	3	1	1
	11/12/23	4.2	partial	23	1	0	1
<i>Lew's Land (fall)</i>	11/17/23	12.9	full	27	1	1	0
	11/18/23	5.2	none	28	4	2	2
	11/19/23	6.6	none	28	3	1	1
<i>Robert Brace (fall)</i>	12/8/23	7.3	none	21	2	1	0
	12/9/23	13.1	partial	7	1	1	0
	12/10/23	7.4	full	2	1	0	0
<i>Greendale Cemetery (winter)</i>	2/13/24	-0.2	partial	22	8	6	2
	2/14/24	-0.1	partial	28	7	2	4
	2/15/24	-0.6	partial	28	5	4	1
<i>Lew's Land (winter)</i>	2/10/24	13.3	full	28	5	2	3
	2/11/24	3.7	full	29	10	3	7
	2/12/24	2.5	full	25	5	1	4
<i>Robert Brace (winter)</i>	2/7/24	0.8	partial	22	5	4	1
	2/8/24	7.0	partial	20	9	4	3
	2/9/24	11.6	full	17	6	2	4

Table 2. Site information for fall and winter trapping sessions of three FCVC properties, located in Crawford County PA. Information was recorded in the morning of the date listed. There were 78 mammals trapped total: 37 deer mice (*Peromyscus maniculatus*), 34 white-footed mice (*Peromyscus leucopus*), and 7 unidentified mice species.



Figure 7. Example of a deer mouse (*Peromyscus maniculatus*) caught at Lew's Land on 11/19/2023. The first picture depicts the gray color of the base of the throat hair, as well as the length of the tail, which is typically about the length of the body. The second picture shows the indistinct line between the bottom and top of the tail. The white-footed mouse, conversely, has only white hair on the throat, a tail shorter than their body, and a starker line between brown and white on the tail.

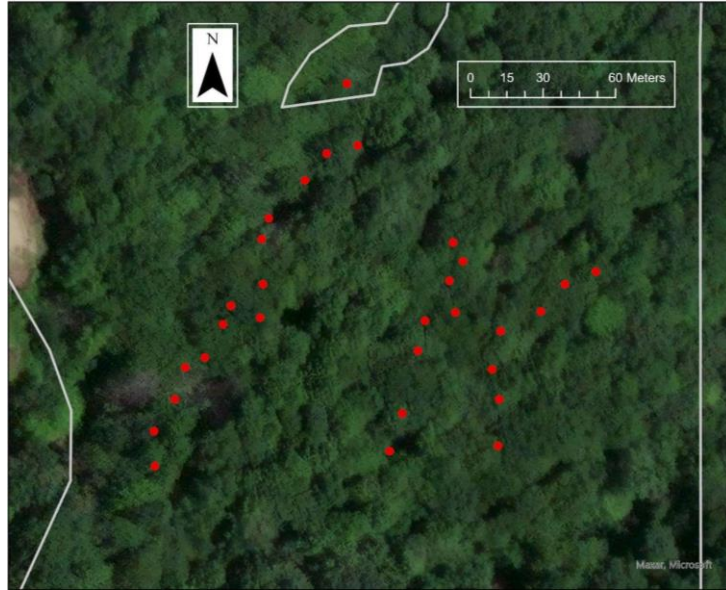


Figure 8. Locations of Sherman traps at the French Creek Valley Conservancy property Greendale Cemetery, recorded at the time of the first survey period (11/10/23-11/12/23)



Figure 9. Locations of Sherman traps at the French Creek Valley Conservancy property Lew's Land, recorded at the time of the first survey period (11/17/23-11/19/23)



Figure 10. Locations of Sherman traps at the French Creek Valley Conservancy property Robert Brace Nature Reserve, recorded at the time of the first survey period (12/8/23-12/10/23)

Table 3

	Greendale Cemetery	Lew's Land	Robert Brace
Conifer	44.12%	3.33%	35.48%
Deciduous	52.94%	53.33%	45.16%
Sapling (DBH < 2)	2.94%	30%	6.45%
Grassy Field	—	10%	12.90%
Barren	—	3.33%	—

Table 3. Microhabitats around each individual trap location at all three FCVC sites in Crawford County PA. The nearest mature tree was reported for each trap location, and if there wasn't one, the surroundings were described as sapling, grassy field or barren. Data was calculated as percentages for each property.

Statistical analysis

Catch rate was calculated by dividing the total mammals caught by the total successful undisturbed traps for that night of trapping, resulting in 6 catch rates for each site (Table 4). One-way ANOVAs were conducted to analyze if there was a significant difference in catch rate between sites. The tests were first run with the seasons as separated datasets, which resulted in

no significant difference ($p = 0.294$, $F = 1.512$ between fall sites, $p = 0.461$, $F = 0.883$ between winter sites). Then I conducted an ANOVA in which the seasons were collapsed, and compared only sites, as the two sampling periods acted as replicates. There was again no significant difference between sites ($p = 0.198$, $F = 1.806$).

I compared the catch rate between seasons, with all sites combined, resulting in a significant difference between the fall trapping sessions and the winter trapping sessions ($p = 0.022$, $F = 6.426$).

For the sake of future endeavors, I ran an ANOVA to see if there was a difference in capture rates between trap nights, testing if how long the traps had been out affected how many mammals were captured, but the difference wasn't statistically significant ($p = 0.606$, $F = 0.518$). The number of disturbances was also compared between trap nights, and also proved to be not significant ($p = 0.649$, $F = 0.445$).

The relationship between morning temperature and catch rate was analyzed using a linear regression. There was no significant relationship between the two, with an R^2 value of 0.012 for the fall data and an R^2 of 0.023 for the winter data (Figure 11).

Table 4

	Greendale Cemetery	Lew's Land	Robert Brace
<i>Fall (night one)</i>	0.071	0.037	0.095
<i>Fall (night two)</i>	0.103	0.143	0.143
<i>Fall (night three)</i>	0.044	0.107	0.5
<i>Winter (night one)</i>	0.364	0.179	0.227
<i>Winter (night two)</i>	0.25	0.345	0.45
<i>Winter (night three)</i>	0.179	0.20	0.353

Table 4. Catch rates, calculated as number of mammals caught/active traps, for each of the three FCVC sites located in Crawford County PA. Some rates, like Robert Brace fall night three seem extremely high due to a small number of viable traps due to nontarget interactions.

Small Mammal Catch Rate vs the Average Temperature at the Time of the Morning Check Between Fall and Winter Trapping Sessions

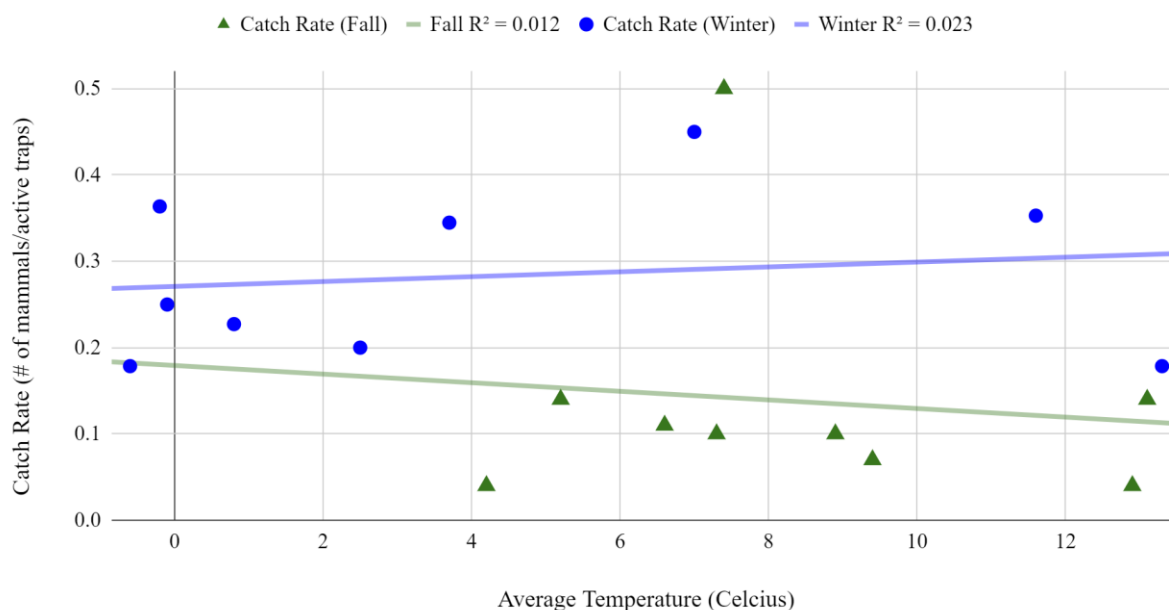


Figure 11. Linear regression analysis of the catch rates between seasons and the average temperature at the time of the morning check for each day. There is no significant relationship between temperature and catch rate in fall or winter ($R^2 = 0.012$ and $R^2 = 0.023$ respectively).

Discussion

Despite large differences in catch rates across the three FCVC properties at a glance, those differences turned out to be not significant. This is interesting considering the differing habitats across the three sites. Greendale consists of entirely older forests with full canopy cover during the growing period, Robert Brace also has a lot of fully forested area that is largely unmaintained, resulting in many fallen branches and downed trees, with only a portion being unforested areas, and Lew's Landing is largely deforested, with grassy fields and exposed soil. The lack of significant difference in small mammal captures suggests that deer mice and white-footed mice can thrive in all these environments.

The lack of other species is notable as well. The fact that this study didn't observe any chipmunks is most likely a result of the size of the traps. Chipmunks could fit in the 3 in x 3.5 in x 9 in traps technically but would probably not feel comfortable trying to squeeze into a foreign box. While it's possible the meadow vole is also too big to comfortably venture into the Sherman traps, their missing presence in this study also probably has to do with their behaviors and

habitats. They are commonly found in Pennsylvania but may be less likely to be caught in a transect due to their underground burrowing, and their reluctance to travel very far from their burrows (UCIPM, n.d.). They are also less likely to be found on plots that are entirely forested, as low-level vegetation is unable to thrive under the canopy and the root structure of grasses supports their shallow borrows (Reich & Tamarin, 1984). Lew's Land is grassy in places, but it's possible that vegetation coverage is not thick enough to hold the structure of these burrows. Future studies should conduct trapping at different FCVC sites to see if these trends continue.

Robert's Brace Nature Reserve appears to have a much higher catch rate than the other sites, but the catch rate wasn't significantly higher than Greendale Cemetery and Lew's Land after analysis. This is also complicated by the fact of sample size. After some consideration, I decided to exclude traps that were closed in the morning and traps that had been disturbed (flipped or moved in some way) and no longer contained bait, as the trap had lost its appeal to small mammals. Many traps were technically open all night but were disqualified because of outside interaction of some kind. This especially affected Robert Brace Nature Reserve in the first round of trapping. As the session went on, the problem of outside interference got worse, to the point that on the last morning (12/10/23), there were only two traps that hadn't been disturbed in any way, resulting in a catch rate of 0.50. This small sample size and consecutive high catch rate have the potential to skew the data. While there was still some disturbance in the second round of trapping at Robert Brace, it wasn't nearly as much, and there were similar disturbances across the three properties. When analyzed farther, there was no significant difference between the night in the session and the amount of disturbance, because this pattern was not seen at any of the other sites as dramatically (Table 1). In the literature, there are many examples of modifications to Sherman traps to stop these non-target interactions, from the more expensive Havahart trap option, to fashioning a drainage piping to encase the trap (Rodén-Reynolds et al., 2018), to something as simple as placing the trap in a milk carton (Hoffmann et al., 2010). Stopping interactions would be ideal, but it's hard to say if the extra effort is worth it in this circumstance, as only one trapping session was majorly affected. Any of these options require more materials, more resources, and maybe most importantly, more space. In individual cases, this might not be a problem, but for studies like this one, 30 milk cartons are not easily transported when considering the materials already required for set up. Further trapping and more careful analysis of the kinds of interactions that cause traps to fail at these sites would shed

light on if exclusion devices would be beneficial in this area.

Another interesting aspect of this study was the seasonal difference in the number of small mammals caught. When conducting preliminary research into small mammal trapping, I made note of the time of year when small mammal trapping is typically done in the literature, and while I didn't find any sources that said explicitly that researchers shouldn't trap in the fall months, it didn't seem to happen often. Instead, in areas with similar climate restrictions as Crawford County, trapping seemed to be done most commonly in the spring and summer. Due to time constraints regarding the senior project, I decided to go forward with the trapping in November and December, then again in February. The stark difference in capture rates between the fall sessions and the winter sessions ($p = 0.022$) explains why trapping is not done in the fall. I believe this difference is for a few reasons. In the fall months, there is much more food available on the forest floor, from low level vegetation to seeds dropped by trees, like beech, red and white oak, sugar maple, and black walnut (Osborne, 2023). This may affect the capture rates of small mammals as they stock up on food for the winter, as they would be less likely to engage with an unknown when there are readily available alternatives. Additionally, the unusual conditions for the winter trapping period might also be relevant. The cold weather this winter did not last as long or get as intense as it normally does, and there was little snow accumulation. The warm winter was helpful for me at the time, as I was able to fit in another round of trapping without having to provide more intensive insulation of the traps or risking harm to the mice, but it also introduces some uncertainty. Would the catch rate have been as high as it was if Crawford County would have had a normal winter, with considerable snow on the ground in February? The species present in this study don't hibernate but have been noted to undergo brief periods of torpor when temperatures get cold enough (Ambler et al., 2022). They're less active in the winter as deer mice and white-footed mice (as well as meadow voles) are known to huddle in groups during the winter to conserve heat (ICWDM, n.d.; Ondrasek et al., 2015). It's possible that the warmer temperatures resulted in less huddling and less torpor, meaning that there was an increased demand for food, as energy isn't conserved as well outside of torpor. Future studies could trap these sites again during the winter months to get a better sample of typical winter weather so that capture rates could be compared.

Of course, time was a constraint, as it would have been helpful to sample a few more nights at each location, especially to Robert Brace to account for all of the disrupted traps. It would also be interesting to sample in bigger groups, as more trap locations at each site would result in a better understanding of the habitats present at each site. While I tried to account for all the differing habitats at each site, a bigger sample size would make that more accurate. Another limitation was the lack of mark/recapture data. At the start of this project, I tried to mark the stomachs of the mice I caught with a marker, but I was largely unsuccessful and decided to stop trying because of stress to the mammals and trapping sessions that would not have that data due to failures. My inability to mark the mice I think largely comes down to a lack of experience handling these animals. Future studies using the Sherman traps should invest more time in handling mice before going out in the field, perhaps with mice already present on campus in other departments (e.g. the neuroscience labs). Being able to calculate Lincoln–Petersen Index results would be a good next step for future sampling, as well as the more detailed information that can be gleaned about a mammal on closer hands-on examination, like sex, tail length, hind leg length, etc. Another oversight of this project has to do with the level of detail recorded about the surroundings of the traps. I collected data about low level vegetation one meter around each trap, but failed to consider that that isn't as applicable to the late fall and winter months that this study was conducted in, as almost every trap ended up having 0-10% vegetative coverage outside of the few areas in open grassy fields. While I still think this information could be useful, especially when trapping in the spring or the summer, for future studies I would modify the datasheet to include a report of woody debris around one meter around the trap, as that cover also plays a role in where small mammals venture and is much more applicable for winter sampling.

This study didn't find a significant difference between the three sites surveyed, but it did further enhance the understanding of community composition at the sites, and it developed a methodology for small mammal live trapping that works consistently for the future use on FCVC properties. It also proved a significant difference between trapping rates in fall and winter, which is important information for any trapping research done in the future.

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Appendix 1:

Small mammal trapping datasheet

Initials: _____

Site: _____ Trap Number: _____

Closest mature tree: _____

Low level vegetation 1 m around trap (circle): 0-10% 10-25% 25-50% 50-75% 75-100%

Day One (morning):

Date: _____ Time set previous night: _____ Time checked: _____

Temperature (C): _____ Cloud cover (circle): none partial full

Mammal species (circle): chipmunk white-footed mouse deer mouse meadow vole

Other: _____

Weight (grams): _____

Day Two (morning):

Date: _____ Time set previous night: _____ Time checked: _____

Temperature (C): _____ Cloud cover (circle): none partial full

Mammal species (circle): chipmunk white-footed mouse deer mouse meadow vole

Other: _____

Weight (grams): _____

Day Three (morning):

Date: _____ Time set previous night: _____ Time checked: _____

Temperature (C): _____ Cloud cover (circle): none partial full

Mammal species (circle): chipmunk white-footed mouse deer mouse meadow vole

Other: _____

Weight (grams): _____

Notes: _____