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**Small Mammal Populations: A Comprehensive Study
of the Surrounding Plant Life**

BIOS 35502: Practicum in Environmental Field Biology

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Abstract:

As we watch our planet slowly change, it is becoming increasingly more important to solidify our understanding of the ecosystems around us to be able to predict, and explain, local and wide-scale phenomena. As such, much of the literature is still inconclusive about small mammal richness and its relation to surrounding vegetation. This study takes a comprehensive look at small mammal communities and the canopy, understory, and vegetation cover around them. While there was no significant relationship found in either tree canopy or understory richness when compared to small mammal community richness, predictable trends are seen which support the idea that increases in tree species richness increase small mammal richness. A significant positive relationship was found between immediate cover and number of small mammals caught over a three day trapping period. Capture rate increased further when the surrounding vegetation contained coarse woody debris. In all, this study suggests that there is a significant relationship in direct cover and success in small mammal captures. This can be used to increase small mammal trapping efficiency. Similarly, if changes in vegetation, such as sudden loss of coverage, are seen in an area due to anthropogenic changes, small mammal populations can be managed before population crashes are seen.

Introduction:

With changing climates and species loss globally, it is becoming increasingly important to understand the key factors to species richness and diversity across all habitats. With high focus in the rapidly disappearing ecosystems, such as the arctic or the coral reefs, forests can be forgotten. With many models predicting their imminent change, it is crucial that we begin to understand how small mammal populations will change as the forest composition around them changes (Scheller & Mladenoff, 2005). These small mammals can be crucial for attracting and maintaining predator populations, as well as eating certain overabundant plants and insects. They are also crucial in seed dispersal, as many small mammals cache seeds, especially in areas with seed shadows, where seeds would not naturally reach the soil due to thick vegetation (Stoner et al, 2007). This helps with forest renewal and improves overall ecosystem stability.

However, due to climate change, ecosystems across the world are being impacted, and northern forests are no different. Studies have shown that as land masses in the northern hemisphere heat up, there is less available habitat for sugar maple (*Acer saccharum*), aspen

(*Populus*), birch (*Betula*), spruce (*Picea*), and cedar (*Cedrus*) trees (Ravenscroft, 2010). At least two climate models have predicted complete loss of certain trees species such as, balsam fir (*Abies balsamea*), red pine (*Pinus resinosa*), jack pine (*Pinus banksiana*), paper birch (*Betula papyrifera*), and white spruce, (*Picea glauca*) in northern Wisconsin (Scheller & Mladenoff, 2005). This change in tree types could lead to a change in small mammal populations and an entire ecosystem shift. Previous studies have found that sugar maples are retreating north at a faster pace than originally predicted (Brown, 2015). Knowledge about how tree composition affects small mammal communities located in the Great Lakes' forests may allow ecologists to predict how these communities will change as the forests are impacted.

There are many different small mammal populations that play an important role in the ecosystems of the Great Lakes region. In the area of study, the generalist, *Peromyscus maniculatus* (woodland deer mice), is one of the most abundant small mammal species. (Hakon et al, 2012). *Peromyscus leucopus* (white footed mouse), another commonly found species, is larger and consumes more seeds than the *P. maniculatus* (Cramer, 2014). Other common small mammals in the area are *Blarina brevicauda* (northern short-tailed shrew), *Sorex cinereus* (masked shrew), *Myodes gapperi* (southern red-backed vole), and *Tamias striatus* (eastern chipmunk). *Zapus hudsonius* (meadow jumping mouse), *Napaeozapus insignis* (woodland jumping mouse), *Glaucomys sabrinus* (northern flying squirrel), *Glaucomys volans* (southern flying squirrel), and *Tamiasciurus hudsonicus* (American red squirrel) are occasionally caught as well. These small mammals aid in seed dispersal by caching seeds. The more small mammals present will increase the number of seeds cached, and the type of seed cached may depend on their seed preferences (Smith & Reichman, 1984).

Seed preferences of *P. maniculatus* and *P. leucopus* in the study area were tested previously. The researchers found that both *Peromyscus* species tend to prefer the red maple (*Acer rubrum*) to the sugar maple seeds, although the preference is stronger in the *P. maniculatus* (Cramer, 2014). Other common small mammals, such as, *M. gapperi*, *Microtus pennsylvanicus*, and *P. maniculatus* tested in Alberta showed high seed preference in conifer trees as well (Lobo et al, 2009). As these species hold different seed preferences, a rich forest composition is necessary to support a diverse small mammal community. We predict that small mammals that hold strong preferences would favor certain forest compositions to others and could relocate depending on the availability of their preferred food availability. Further, if the current tree community composition significantly impacts the richness of the small mammal populations, sapling community composition may be used to predict the future tree composition, and therefore, future small mammal populations. This information would allow ecologists to determine future ecosystem health in regards to small mammals.

Beyond showing a preference for seeds of certain canopy trees, small mammals may also respond in a predictable way to understory composition. While saplings and pollinating plants do not produce edible seeds, they do provide habitat and cover for small mammals and can affect their food sources, such as insects. A higher richness of understory plant communities has been shown to increase diversity in insect communities due to more plant resources and more vegetation structure (Haddad et al, 2001). A more diverse insect community may, in turn, support larger populations of insectivorous mammals, such as shrews and moles (Soricomorpha). Not only may it influence food sources, but it also may provide much needed protection as well.

Birds of prey, such as the Swainson's Hawk, are able to capture and eat smaller amounts of small mammals as vegetation cover increases. In cases of high vegetation cover, higher

densities of small mammals are found as well (Bechard, 1982). Likewise, small mammals have higher rates of seed predation when immediately covered by vegetation (Meiss et al, 2010). Standing crops are foraged at higher rates than bare soil, as forest floor may be foraged at higher rates when ferns and vegetation cover more of the ground.

As such, there are known links between increases in small mammal population richness and increases in surrounding vegetation richness. (Lindemann et al, 2015). Even when testing areas in close proximity, the surrounding vegetation type has a strong influence on the types of small mammals supported in the area (Lacher & Cleber, 2001). As a positive relationship between vegetation richness and mammal richness is found in Massachusetts and Brazil, it stands to reason that same relationship will be found in Michigan forests as well.

To gain a more comprehensive understanding of small mammal community surroundings, there will be four specific hypotheses tested. One, as tree richness increases, small mammal richness will increase. This is due to the increased availability of different food types, opening up a greater chance of small mammals finding their preferred seed. Two, as understory richness increases, small mammal richness will also increase. This is due to increased habitat and insect populations. Three, traps surrounded by higher vegetation and fern cover will yield higher capture rates, as small mammals will be drawn to the cover and protection from predators. Finally, areas with higher tree diversity will also yield higher small mammal diversity because as richness and evenness increase in the food availability, they will also increase in the mammals drawn to the area.

Methods and Materials:

Study Site:

To test relationships between small mammal populations and surrounding plant life, a 10-week study, from May 22nd to July 28th 2017, was conducted at the University of Notre Dame Environmental Research Center (UNDERC) in Michigan's Upper Peninsula. In this study, eight 60 m x 60 m grids were used that were located all around the property (Figure 1). Historical data of small mammal population estimates on those eight grids was also obtained. Topography and proximity to water varied from site to site, but each grid was located in sugar maple (*Acer saccharum*) dominated forest.

Data collection:

In each site small mammal traps were set, tree composition data was collected, understory composition was collected, and fern and vegetation coverage over traps was calculated.

Small Mammals:

An ongoing study, done by Michael J Cramer, has been capturing small mammals at ten different grids since 2008. In the last six years small mammal trapping was done consistently at eight of those grids for three consecutive days either in August or September. All mammals were captured alive using Sherman traps (7.62cm by 8.89cm by 22.86cm) and then released. These traps were chosen because they are designed to capture a wide variety of small mammals varying in size from *Sorex cinereus* to *Tamiasciurus hudsonicus*. On each of the eight grids, 25 traps were baited using a mixture of black oil sunflower seeds and other seeds depending on the year. Each trap was placed 15 meters away from the surrounding traps (Figure 2). Traps were baited in the evening and checked around 12 hours later in the morning. Each trap was labeled and small

mammals were identified, weighed, and measured. For the purpose of this study, only the species and capture numbers were used.

Trees:

We inventoried canopy tree species along five transect lines within each trapping grid. One researcher would hold a 5 m rope at the beginning of each transect line while I would walk in a circle counting and identifying each tree with a diameter at breast height (DBH) greater than 10 cm, as that is when most trees are reproductive and seed producing (Tubbs, 1968). At the end of the first 5-meter half circle, a flag was placed and another circle transect began. I did this until I reached the end of the grid transect line (Figure 3). All identification was done to species. These transects accounted for 52% of the grid's total area.

Understory:

To determine the understory composition, each grid was broken up into 16 subplots (15 by 15 meters each) and numbered based on the nearest road (Figure 4). 10 plots were sampled, giving us a 57% coverage, which is considered a valid indicator of a grid's overall composition (Kurten and Carson, 2015). I began by walking back and forth from side to side of each subplot creating a list of all the understory plants. I then walked through a second time counting the number of each species. In some cases, the exact species could not be identified, so they would be labeled, catalogued and compared among sites.

Vegetation around Traps:

To examine the plant community presence immediately around traps, a 1 by 1 meter PVC square was placed over each of the 25 traps (Figure 5) and percent coverage was estimated. I

separately estimated fern, woody debris, and total vegetation coverage. If the one meter by one meter subplot also encompassed a tree, that tree was noted and identified as well.

Data analysis:

To test whether small mammal species richness increased with tree species richness I used a linear regression. Likewise, linear regression was also used to compare small mammal community richness with the understory richness.

Next, average capture success was calculated for each of the 200 traps (8 grids by 25 traps) and compared with its fern and vegetation coverage. Only 2017 June trapping data was used, as that was when the ferns and vegetation were sampled. Since capture success data could not be normalized via transformation, two separate Kendall Tau Rank Correlation Coefficient tests were then performed- one for vegetation and one for fern coverage. The Kendall Tau Rank Correlation was run again to compare small mammal capture rates with total coverage, including all vegetation and coarse woody debris. A Tau-B was used to adjust for ties in the data.

Finally, the Shannon-Wiener Diversity Index (H) was calculated for trees and small mammals at each site. Those two diversity indexes, or H values, were then compared for each site by running a linear regression. All linear regressions were done in SYSTAT, while the Kendall Tau was done in R Studio.

Results:

In total, 11 different species of small mammals were caught, and 11 different tree species were identified across the property. Across all sites, the average richness in mammal species (mean=8.375, sd= 1.598, n=8) was larger than average richness in tree species (mean=4.75, sd=1.282, n=8), with the average richness of the understory being the highest (mean=26.5,

sd=15, n=80). Average percent vegetation coverage across property (mean=34.5, sd=14.4, n=200) and average percent fern coverage (mean=6.28, sd=5.58, n=200) were also calculated.

There was no significant relationship between fern coverage alone and trap success (Kendall rank correlation, $\tau = -0.675$, $p = 0.27$ Figure 6). However, there was a significant positive relationship between total vegetation coverage and trap success (Kendall rank correlation, $\tau = 0.156$, $p = .0048$; Figure 7). When coarse woody debris coverage was combined with total vegetation coverage, the positive relationship was also significant (Kendall rank correlation, $\tau = 0.264$, $p = 3.03 \times 10^{-5}$, Figure 8).

While small mammal richness per grid tended to increase with tree richness, the relationship between the two was not significant (Linear regression, $R^2 = 0.372$, $p = 0.108$, Figure 9). The relationship between understory species richness and small mammal richness was not significant (Linear regression, $R^2 = 0.067$, $p = 0.535$, Figure 10).

The mean H value of small mammals at each grid (n=8) was 1.025 ± 0.235 and that of trees was 0.469 ± 0.198 (Table 1). There was no significant relationship between small mammal diversity and tree diversity (Linear regression, $R^2 = 0.252$, $p = 0.205$; Figure 11).

Discussion:

Contrary to the expected results, only the third hypothesis stating that more small mammals would be captured in areas with higher vegetation coverage was supported. The fern coverage on its own could not predict small mammal captures; however, when combined with vegetation as a whole, results were significant. As total vegetation surrounding a trap increased, the number of small mammals caught also increased on average. This increase in captures is most likely due to the fact that small mammals feel safer foraging while under cover and would be more likely to go after the seeds found in the traps (Hughes & Ward, 1993). Likewise, this

suggests that as vegetation cover lessens, small mammals will face increased danger from predators. Similarly, when total percent vegetation was combined with percent coarse woody debris (CWD) found around the trap, the mean capture success rate increased significantly. Small mammals were more often drawn to not only traps with higher vegetation, but also traps with higher vegetation and CWD cover. Since the tau value increased once the CWD was added, the correlation between coverage and capture became stronger. This finding could suggest that small mammals not only prefer foraging in areas with high vegetation cover, but also high levels of CWD such as fallen trees and logs. Small mammals have also been observed to run along certain premade highways, such as fallen logs, as it can be a faster, more direct path (Hamilton, 1937). This could explain why more small mammals were captured in traps with high vegetation in combination with CWD.

While no significant relationship between small mammal and tree species richness was found, examination of the graphed data suggests that small mammal richness does increase as tree species richness increases (Figure 9). The insignificant relationship may be explained by the time of the trapping. Of the 11 small mammals caught, seven were primarily nocturnal, with two being active at all times. Only two of the small mammals caught were considered diurnal, and with all the trapping completed at night, this could be a limiting factor for species richness. Other small mammals, such as the *Tamias minimus* (least chipmunk) and the *Sciurus carolinensis* (gray squirrel), have been observed in the study area and may have been caught during daytime trapping, increasing species richness, but were not caught over past the six years of trapping (University of Notre Dame).

Those same issues may have influenced the outcome of the statistical analysis between small mammal and understory richness. The relationship between the two was found

insignificant, with no strong trend (Figure 10). This lack of significance can possibly be explained by looking at the types of small mammals caught. Small mammal community richness was expected to increase with understory plant community richness because of the corresponding rise in insect community diversity, but contrary to my hypothesis, mammal richness actually seemed to decrease or stay the same with increases in understory richness. Possible explanations include the fact that most of the mammals caught were primarily seed predators like *Peromyscus* instead of insectivores like those in the order Soricomorpha. Thus, the effects of a larger insect population on small mammal diversity were not necessarily reflected in the data. Furthermore, studies have found that stratification of plants actually has a bigger effect on consumers than actually plant composition, even in microhabitats (Tews et al, 2003). Although, it is also possible that populations of *Sorex* (shrews) are higher than the data suggests, but due to their smaller body size, did not set off the traps as much as *Peromyscus* were observed to.

Also in the case of understory richness, richness may have decreased due to overabundance of sugar maple saplings. On that note, all 8 of the grids were placed in patches of sugar maple dominated forest instead of in a variety of different tree dominated areas. This could have not only effected the understory composition, as sugar maple dominated sites tend to have less understory richness, but also the tree diversity index as well (Rogers et al, 2008).

The same problems surrounding the small mammal and tree species richness can also be applied to the results of the tree and small mammal diversity index. The relationship between the two was insignificant, but if more grids were trapped and surveyed, I predict that the noticeable upward trend would continue to grow (Figure 11). As the diversity in tree species goes up, so does the food diversity, and therefore the small mammal population's diversity as well in local-scale habitats (Williams, 2002). Had the experiment been run in a variety of tree species

dominated forests, with both day and night trapping, I would expect the significance and the correlation to increase, as the species abundances would become more even.

It is also possible that the small mammal diversity was smaller than it could have been due to the timing of trapping. The trapping data used to calculate diversity was collected in September and August. Due to the reproductive patterns of *Peromyscus*, the abundance of the two species tends to increase through the summer. *Peromyscus* have short gestation periods and will have multiple litters as the summer progresses, increasing populations as favorable weather holds (Svihla, 1932). Traps are also more likely to go off as small mammals, especially *Peromyscus*, begin to bulk up as food sources increase. This could have inflated the *P. maniculatus* and *P. leucopus* captures, lowered the evenness, and decreased the diversity index for each site. Leastwise, abundance of sugar maple, the most abundant tree species, did not significantly increase either *Peromyscus* species, the most abundant small mammals. This suggests that the two most abundant species of each variable were not related (Linear Regression, $R^2 = 0.007$, $p = 0.848$).

Had daytime trapping been done along with night time trapping, small mammal richness and diversity index most likely would have increased (Hamilton, 1937). If trapping had also been done in varying forest types, tree diversity and richness would have also increased. (Dueser & Shuggart, 1979). While many of the expected trends were still seen in the data collected, in most cases they were not significant. To confirm the visible trends, further data should be collected, with less biased sampling techniques. With the forests changing on a daily basis due to climate change, it is imperative that current relationships between small mammals and their surroundings are understood to help predict future changes. Due to this study, it can be concluded that small mammals frequent areas of high cover more than areas of low cover, however much is still

unknown. Without a confirmed baseline understanding, anthropogenic and natural changes will be increasingly hard to differentiate whether it includes small mammal communities and forests, or entire ecosystems.

Acknowledgments:

I would like to thank the University of Notre Dame for allowing me to do this project at the University of Notre Dame Environmental Research Center (UNDERC). This study was also made possible by generous funding from Bernard J. Hank Family Endowment Fund. It also would not have been possible without my mentor, Patrick Larson. I would like to thank him for providing support throughout the entire process, from the creation and experimental design, to the data analysis and conclusions. Another crucial part of this project was the yearly trapping data. I would like to thank Dr. Michael J Cramer for providing me the historical data and for trapping consistently over the past six years. This study would have no basis without it. I am also extremely grateful to our class teaching assistants and past students, Hannah Legatzke and Claire Goodfellow; without them, the organization and data analysis would be severely lacking. Finally, I would like to thank the UNDERC 2017 class. The endless hours in the field surveying grids and identifying plants could only be completed with their help.

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Tables:

Table 1: The results of the Shannon-Wiener Diversity Index (H) for small mammals and for trees from each of the 8 grids.

Grid Name	Tree Diversity (H)	Small Mammal Diversity (H)
Bono	0.36	0.82
Storage	0.06	0.76
Plum	0.57	1.29
North	0.69	0.96
Grasshopper	0.57	0.93
DBOG	0.41	0.88
Brown	0.61	1.14
Cranberry	0.48	1.42

Figures:

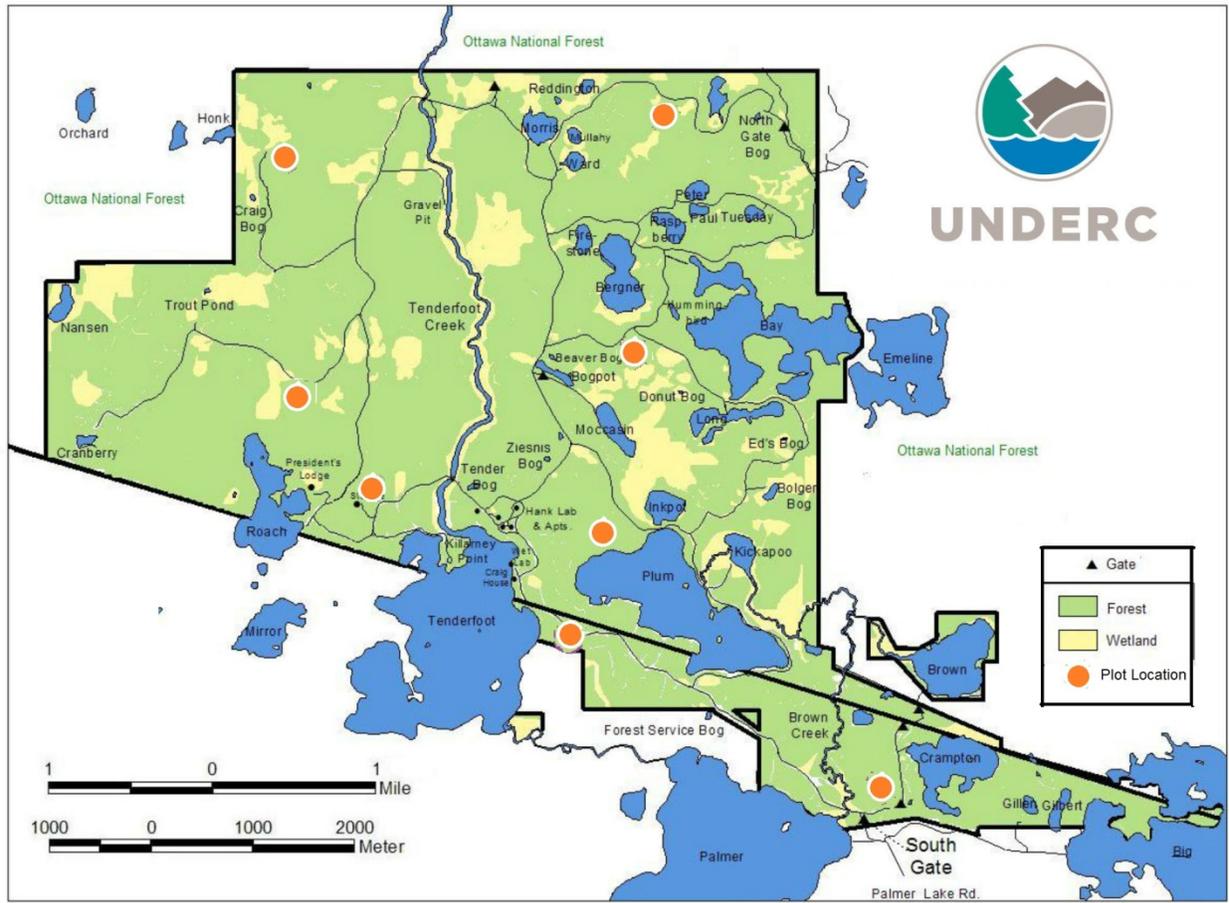


Figure 1: Map of sampling locations. Each grid is represented by the orange circles above.

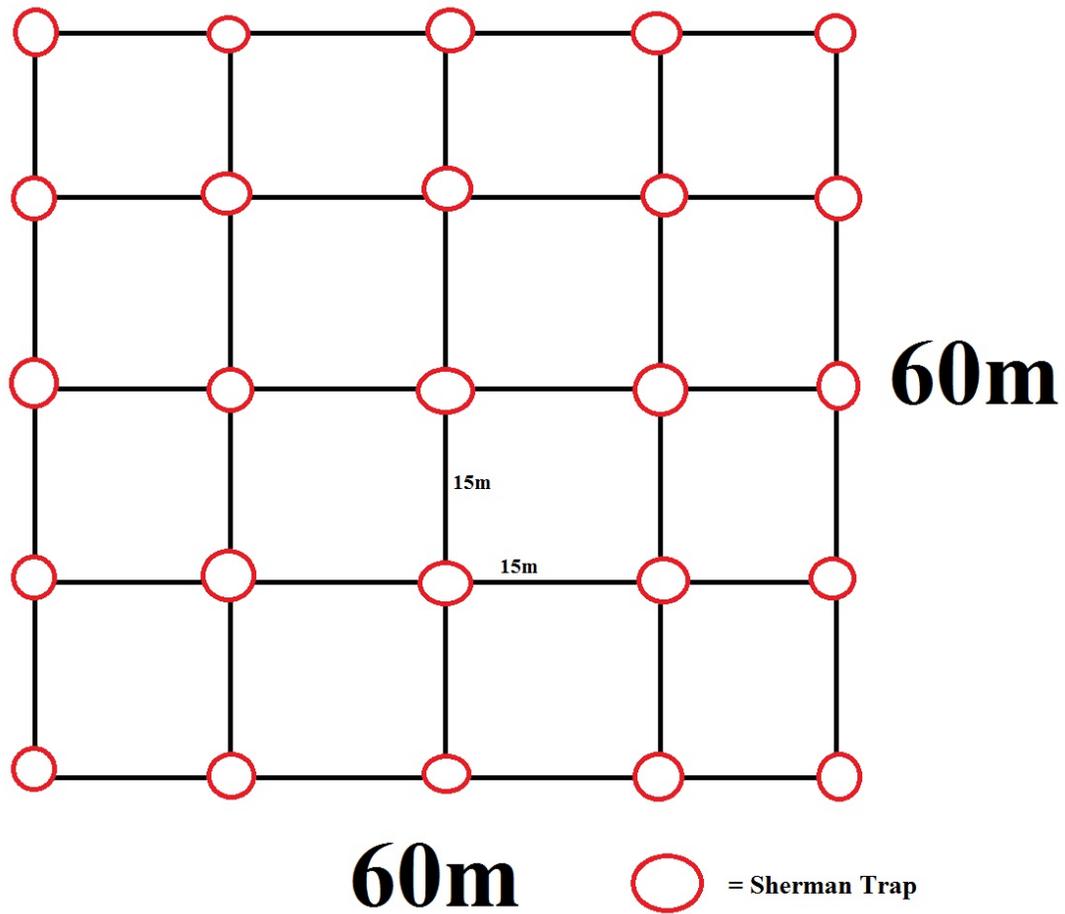


Figure 2: This figure above shows the locations of the Sherman traps on each of the 8 grids. Each red circle is one of the 25 traps.

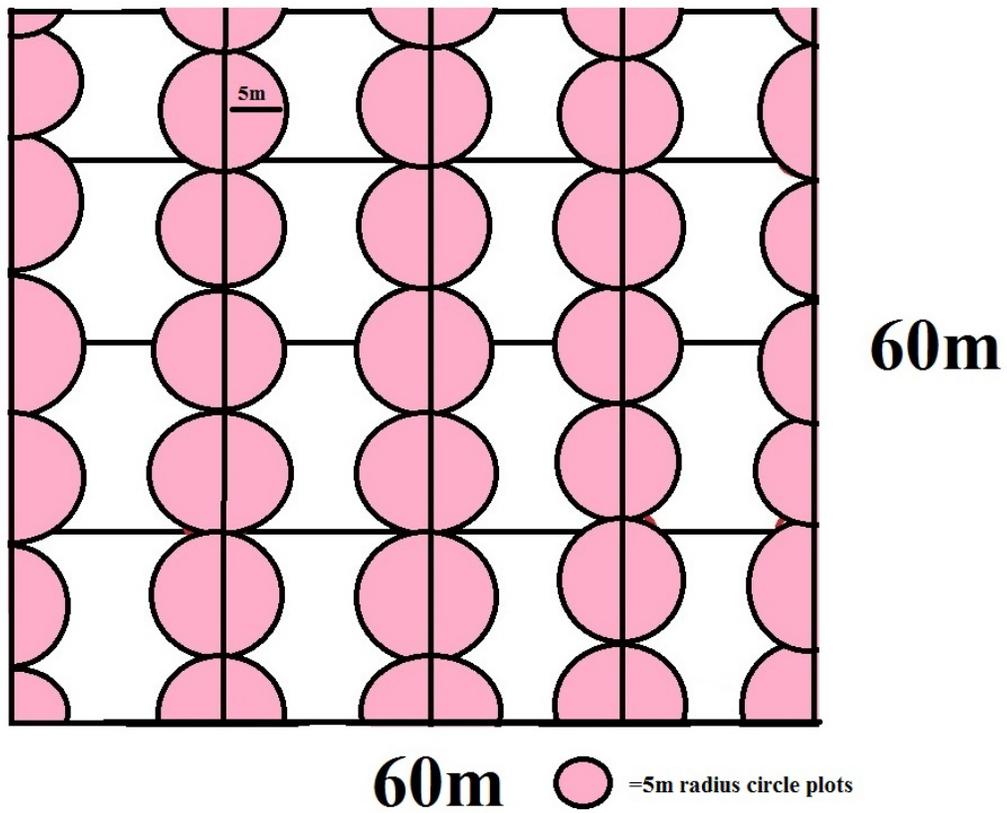
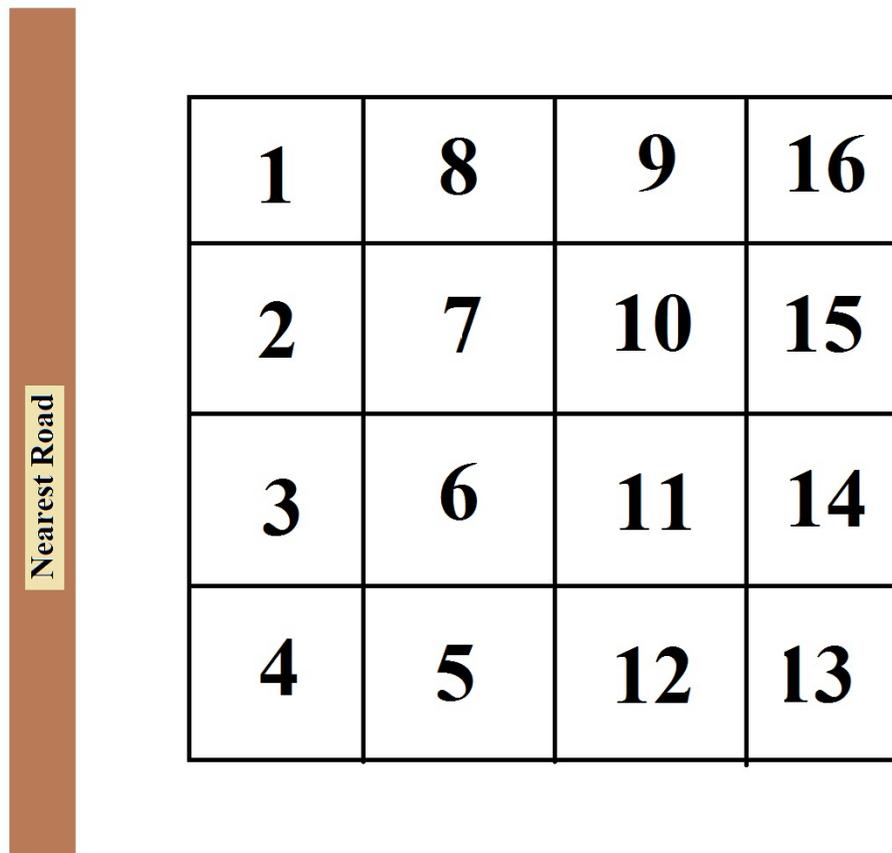


Figure 3: The figure above shows the 30 circular plots that were sampled. All trees over 10 DBH were identified in the circles and used to describe the total tree composition.



The diagram consists of a vertical brown bar on the left and a 4x4 grid of subplot numbers on the right. The bar is labeled "Nearest Road" in a yellow box. The grid contains the following numbers:

1	8	9	16
2	7	10	15
3	6	11	14
4	5	12	13

Figure 4: The above figure demonstrates the system used for numbering subplots for sapling composition study.

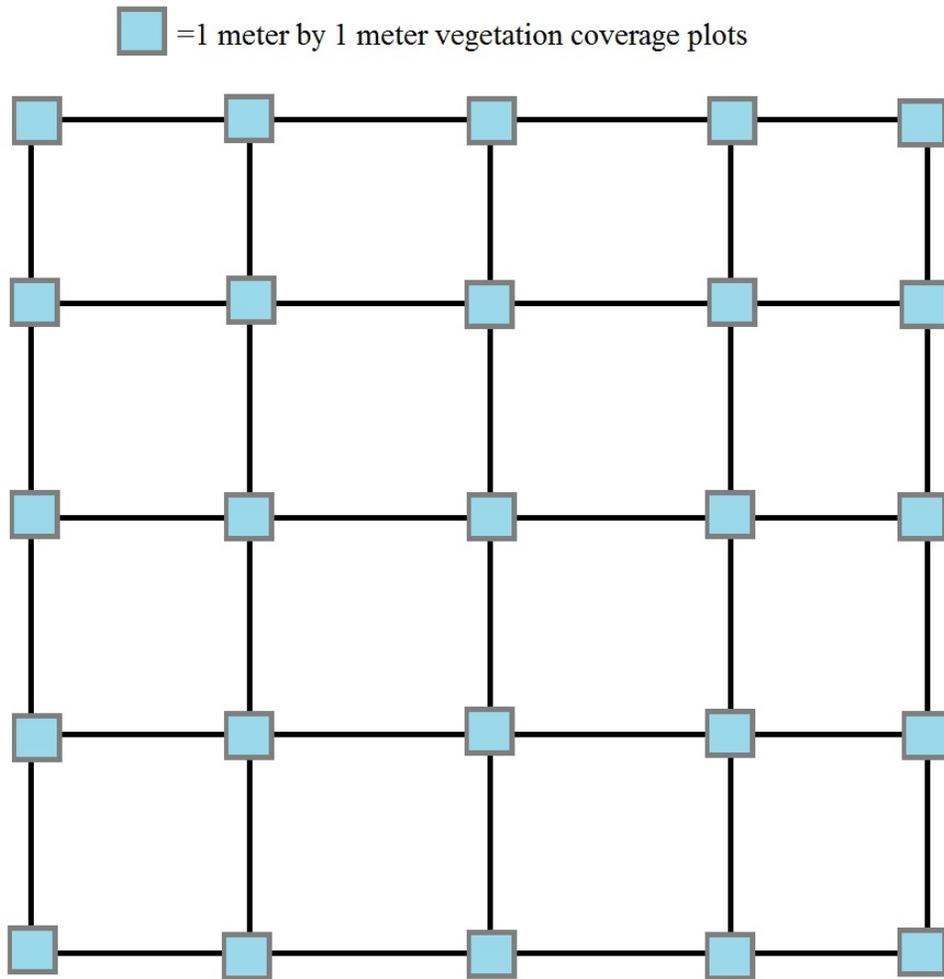


Figure 5: The figure above shows the 1 by 1 meter fern and vegetation coverage plots, the blue squares above, that were placed over each of the 25 traps on each 60 by 60 meter grid.

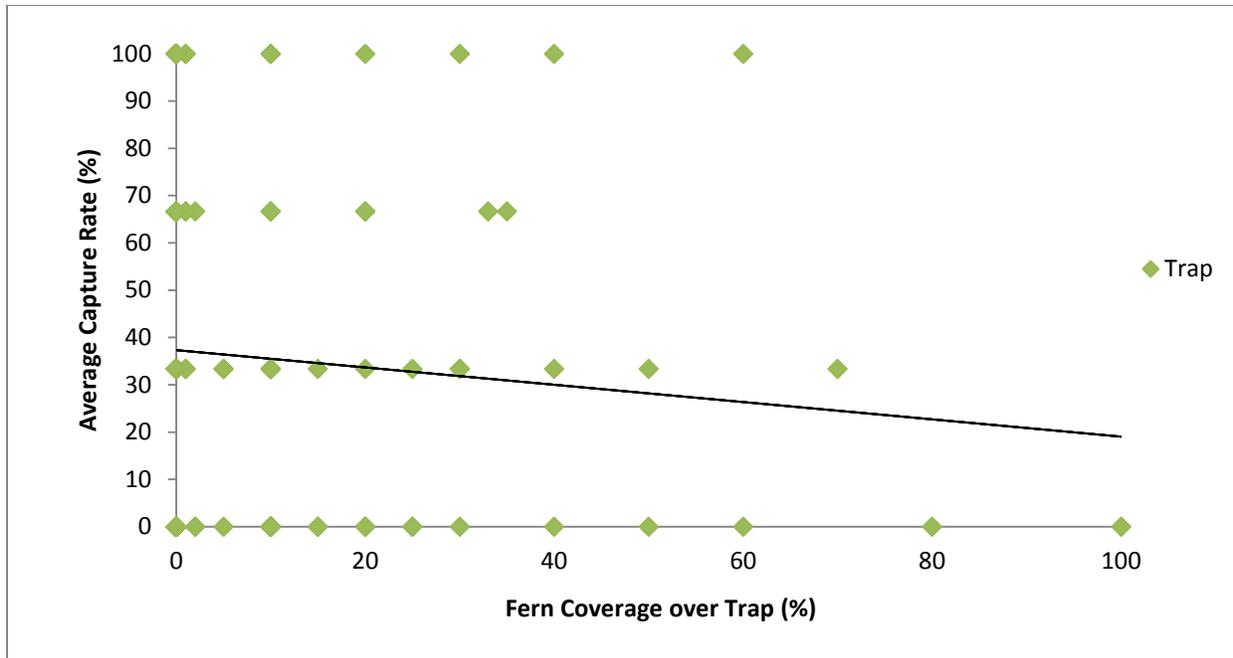


Figure 6: The average percent of small mammals caught after three days of trapping compared to the fern coverage at that same trap. Each green diamond is one of the 200 traps over eight grids. (Kendall rank correlation, $\tau = -0.675$, $p = 0.27$)

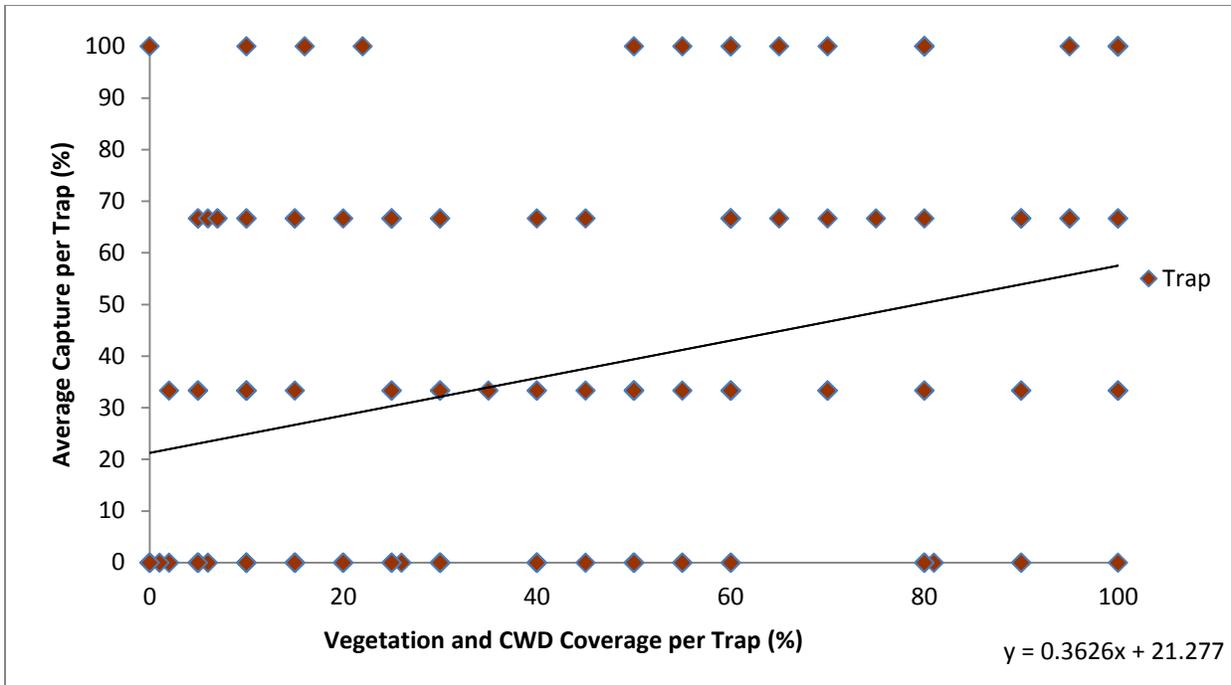


Figure 8: A comparison of the average capture per trap with percent vegetation and CWD at all 200 traps in June of 2017 (Kendall rank correlation, $\tau=0.264$, $p=3.03 \times 10^{-5}$).

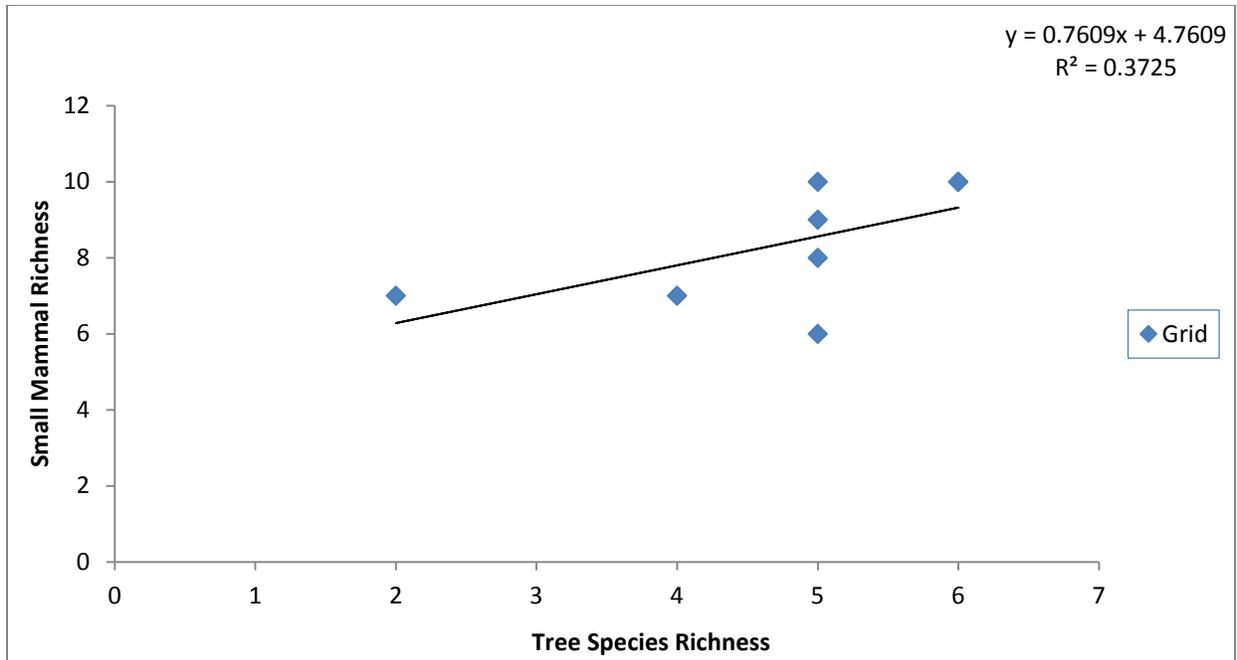


Figure 9: A comparison of small mammal and tree species richness. Each blue diamond represents one of the eight grids used. The black line shows the positive trend of the data (Linear regression, $R^2=0.372$, $p=0.108$).

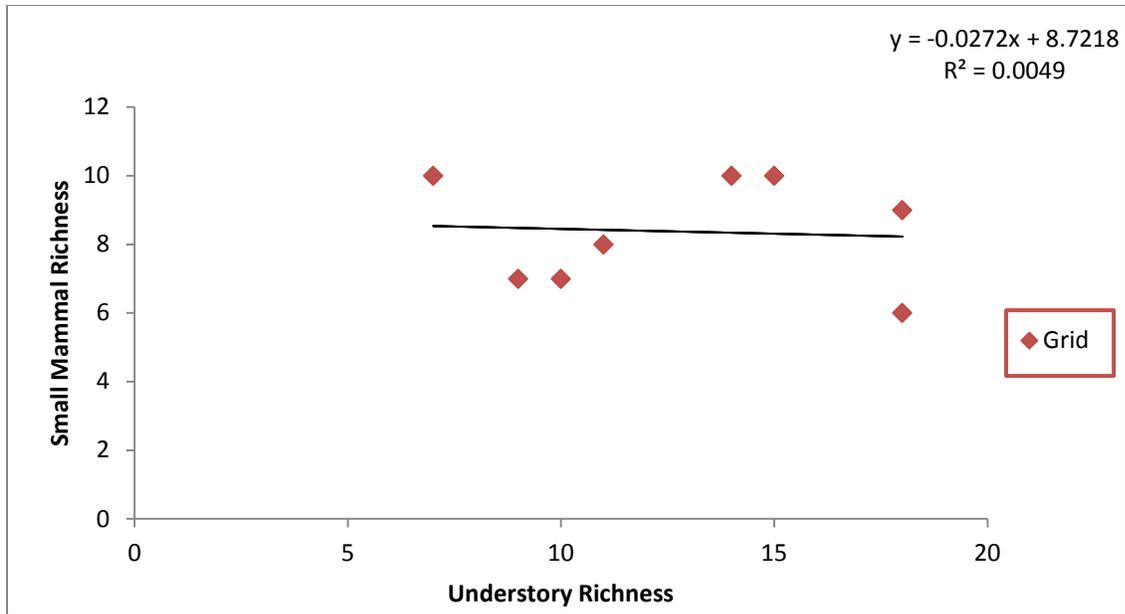


Figure 10: A comparison of the small mammal richness with the understory richness at each of the 8 grids across property. The line shows the negative trend of the data (Linear regression, $R^2 = 0.005$, $p=0.535$).

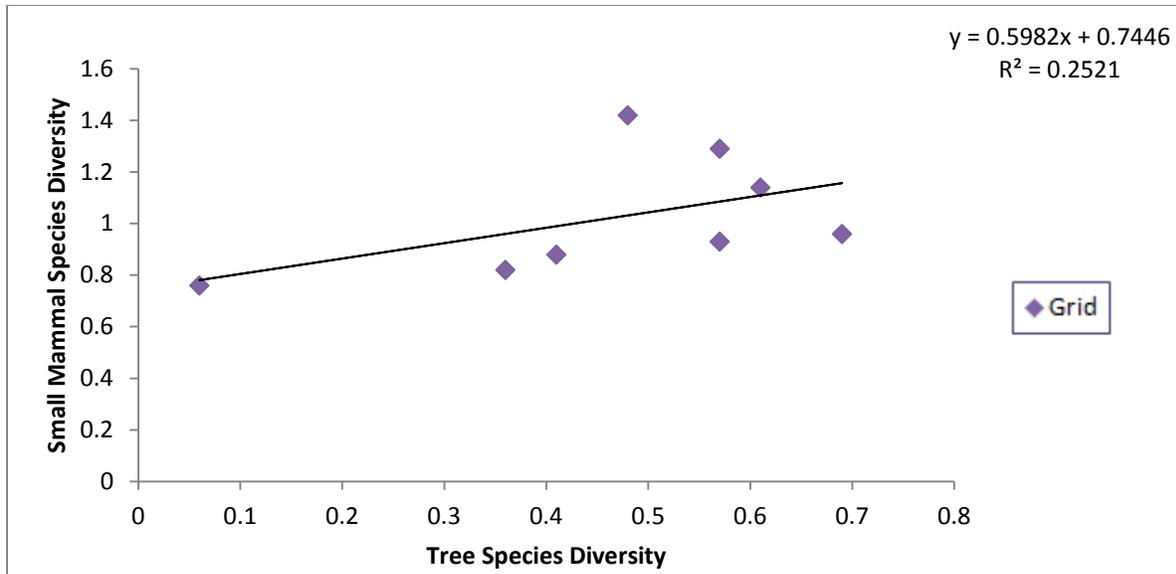


Figure 11: The figure above expresses the relationship between small mammal species diversity (H value) and tree species diversity (H value). The black line shows the overall positive trend of the data. Each purple diamond represents one of the eight grids (Linear regression, $R^2=0.252$, $p=0.205$).