

**Role of deer mice (*Peromyscus maniculatus gracilis*) on the predation  
or dispersal of *A. saccharum* and *A. rubrum* seeds in hardwood  
forested regions at UNDERC-East**

BIOS 35502: Practicum in Environmental Field Biology

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**Abstract:**

Seed predation and/or dispersal directly affect plant communities. Seed preferences of rodents can drive patterns in plant composition because seed survival and competition among species are affected by the foraging decisions of seed predators. *P. maniculatus gracilis* is known to store a variety of seeds in larder or scatter hoards. The purpose of our study was to determine the role of deer mice in the distribution or predation of *A. saccharum* and *A. rubrum* seeds in hardwood forested regions at UNDERC property by studying foraging and caching behaviour of individual mice in the laboratory. We found that in laboratory controlled conditions where both seed types were presented, *P. maniculatus* ate more *A. rubrum* than *A. saccharum* suggesting that the smaller red maple have a present value. We also found that there was no significant difference between seed type location of caches relative to the nest suggesting that mice cached both seed types without discriminating at what distance they did so. Although larger *A. saccharum* seeds were scatter hoarded more frequently, due to the seasonality effects and small sample size, there was no significant effect of seed type on the number of seeds hoarded. Our results suggest that deer mice act as seed predators of *A. rubrum* during summer months, and they predate on this seed type more than *A. saccharum*.

**Introduction:**

Granivorous small mammals depend on foraging for survival. Numerous methods of decision making have evolved in order to determine where to forage, how long to search in one area before moving on, and where to consume or store food (Goodenough *et al.* 2010). On the other hand, once food is found, handling and processing time affects decision making (Roche *et al.* 1999). Seed foraging in small rodents includes a variety of behavioral responses that may influence hoarding. Hoarding decisions are strongly influenced by the characteristics of the food items encountered (Hadj *et al.* 1996). In addition, scatter hoarding can be an important factor in seed dispersal (Van der Wall 2010). Nevertheless, seed predation by mammals destroys a significant amount of annual seed production of trees, and it has been suggested that the study of seed preference among small mammals like mice and squirrels will allow us to make predictions of how successful certain plant species will be over others (Lobo *et al.* 2009). Seed preferences of rodents can alter plant community structures because seed survival and competition among species could be affected by the foraging decisions of seed predators.

The handling cost hypothesis proposes that plants can influence an animal's likelihood of storing or preying on seeds by imposing a handling cost; physical (e.g., hard shell and large size) or chemical barriers may increase handling time (Xiao *et al.* 2005). Furthermore handling cost can have two effects on hoarding behavior; it may increase the probability of caching by a predator, and decrease the probability that the cache seeds will be retrieved and consumed (Xiao *et al.* 2005). Because seed hoarders and/or predators can promote or limit the establishment of seedlings (McCormik *et al.* 2000) it is important to understand the dynamics of these behaviors. Seed dispersal by scatter-hoarding rodents has been documented in arid environments (Beck & Vander Wall 2010). In a study performed in Nevada, the activities of scatter-hoarding antelope squirrels (*Ammospermophilus leucurus*) appeared to be crucial for the successful establishment of plants in desert patches (Beck *et al.* 2010). Our study examines the implications of seed dispersal or predation in forested hardwood regions in the midwestern United States.

Deer mice are known to store a variety of seeds in their caches in or near their nests (Van der Wall 2001). *Peromyscus maniculatus*, *Myodes gapperi*, *Microtus longicaudis* and *Microtus pennsylvanicus* have been found to eat lodge- pole pines and white spruce cones among other conifer seeds (Lobo *et al.* 2009). Seed preferences of juvenile *P. leucopus* and *P. maniculatus* included wheat (*Triticum*), bush clover (*Lespedeza*), elm (*Ulmus*), and maples (*Acer*) (Drickamer 1976). Rodent seed caches could either be larder hoards (inside central location) or scatter hoards (random caches outside the nest; Van der Wall *et al.* 2001). Understanding the behavioral patterns of granivorous small mammals is important because if preferences could be predicted, their effect on seed dispersal or predation could be determined and this could be important for conservation purposes.

The purpose of this study was to determine the role of *P. maniculatus gracilis* in seed predation on two common tree species (*A. saccharum* and *A. rubrum*) in hardwood forested regions at UNDERC property. A laboratory study was designed to compare the consumption of two species of *Acer*. The use of captive animal studies is ideal for quantifying diet preferences because constraints like competition and food availability can be controlled (Lobo *et al.* 2010). We expected mice to scatter-hoard seeds from *A. saccharum* more often than *A. rubrum* seeds. Most propagules stored by rodents are relatively large and nutritious, and large seeds appear to stimulate caching behavior (Van der Wall 2010). We also expected that if *A. saccharum* seeds were scatter-hoarded, these caches had a greater likelihood to be found at greater distance from the nest. Larger seeds are usually carried greater distances and cached (Van der Wall 2010). On the other hand, we expected that *A. rubrum* seeds were going to be more likely to be consumed where found and not cached. Small seeds are more often eaten or moved short distances because their food value may not be worth it to save for the future (Xiao *et al.* 2005). The answer to these hypotheses might help us understand the role of *P. maniculatus* as seed predators or seed dispersers during the summer months.

## **Materials & Methods:**

### *Trapping site:*

We studied the foraging and caching behaviour of mice in the University of Notre Dame Environmental Research Centre (UNDERC-East) Aquatic Laboratory Facility. This study is part of a larger research project which aims to determine the potential effects small mammals have on forest ecosystem dynamics through their foraging preferences and behaviour. Grids (6 x 6 with 15 m spacing) were set up in six different sites throughout property (Storage, D-Bog, Cranberry, Bono, Grasshopper Nation and Brown). The forest composition in each site consisted of mature

second-growth forest dominated by sugar and red maple and a mixture of trembling aspen and birches.

### *Capture and handling*

Mice were captured with Sherman traps baited with rolled oats, sunflower seeds, and peanut butter. Once taken in to the laboratory, individuals were housed for approximately twenty-four hours in separate plastic cages (19.05 x 21 x 12.70 cm) with pine bedding (Roche *et al.* 1999). Mouse designed igloo nests and polyfill nesting material was provided as well. Because *P. maniculatus* is a nocturnal mammal, mice were covered during the day. They were also provided with food and water before trial preparation.

### *Testing procedures*

Two trials per night were performed in a divided (180.3 x 63.5 cm) aquarium. The nest was placed in one corner of the aquarium and the feeding tray with ten grams of a mixture of *A. saccharum* (5g) and *A. rubrum* (5g) was placed on the opposite corner from the nest. We used sugar maple and red maple seeds because they are the dominant hardwood trees in most of our sampling sites. Because mice use shelter to consume seeds in the wild, a shelter of comparable size to the nest was located halfway from the nest box and the feeding tray. Trials were held overnight and each morning mice were returned to the site of capture. Cached seeds were located and the distance from the nest was measured. The remaining uneaten seeds were weighted and the quantity of each consumed seed type was also measured. Nests were searched for seeds as well. At the end of each trial, all nests, cages and equipment were cleaned with 10% bleach.

### *Statistical analysis*

To determine if seeds of the species *A. saccharum* were more likely to be scatter or larder hoarded we used a two sample t-test to compare the average number of seeds hoarded and the

seed type hoarded. In addition we also performed a Chi Square Test to determine the percentage of preferred hoarded seed type. We used a two sample t-test to determine the differences between caches of each seed type and the relative distance to the nest. We used a paired t-test determine if there was significant difference in the means of the amounts of each seed type eaten divided by the weight of each individual mouse . We also conducted a regression of body weight and total amount of seeds eaten to see if this had an effect on the amount of seeds consumed because we did not control this variable.

### **Results:**

There was no significant relationship between the number of seeds hoarded and seed type (sugar maple,  $1.50 \pm 0.310$ ; red maple,  $1.25 \pm 0.164$ ;  $t_{df} = 18.57$ ;  $P=0.485$ ; Figure 1). Although sugar maple seeds were the preferred seed type cached (64%) the result was not statistically significant (red maple=8, sugar maple=14, total=22/30;  $t_{df} = 1.0$  ;  $X^2=1.63$ ;  $P=0.201$ ; Figure 2 ). There were no significant differences between caches and the distance relative to the nest (sugar maple,  $45.5 \pm 3.762$  cm; red maple,  $42.5 \pm 3.727$  cm;  $t_{df} = 20$ ;  $P=0.635$ ; Figure 3). There was a significant difference in the mean of the amounts eaten of each seed type divided by the weight of each individual mouse (sugar maple,  $0.0193 \pm 0.0055$ ; red maple,  $0.1320 \pm 0.0047$ ;  $t_{df} = 29.0$ ;  $P=0.00$ ; Figure 4). We also found a significant relationship between the total weight of seeds eaten and individual mice weight ( $P=0.023$ ,  $r^2 = 0.171$ ;  $SE=0.064$ ;  $t=2.401$ ;  $F=5.766$ ; Figure 5)

### **Discussion:**

When a mixture of both seed types (*A. saccharum* and *A. rubrum*) was presented, *P. maniculatus* showed a preference for *A. rubrum* seeds over *A. saccharum* seeds (Figure 4). This suggests that *A. rubrum* seeds have a present value, that is, mice gain more energy by eating this

seed type immediately than if they decide to store it for later (Hsia *et al.* 2009). Our results for this hypothesis are in accordance with a study that showed that rodents appear to be the most important seed predators of *A. rubrum* (Plucinski *et al.* 2001). This has also been demonstrated in other plant/rodent systems: when seeds of two species of acorn coexist, there are differences in rodent (*Apodemus*) preferences in eating, carrying and hoarding; partial preferences for small highly profitable food items which were not carried away (due to short handling time) may increase energy intake without exposure to predation (Shimada 2001). Our observations that there were differences in predation preferences among plant species (Miners and Stiles 1997) are supported by other studies that suggest that deer mice act as seed predators of maple seeds, such as *A. rubrum*, rather than seed dispersers during summer months (Hsia *et al.* 2000 and Beckage & Clark's 2005)

On the other hand, most of the cached seeds were from *A. saccharum*, but there was no significant difference between the seed type on the number of cached seeds (64%). The large amount of variation in the test for number of seeds scatter-hoarded may have masked any preference by mice. Of thirty trials, 47% of the mice did not show any hoarding behavior, and thus were not taken in to consideration for statistical tests. One possible reason for the lack of hoarding behavior is that deer mice are more likely to cache seeds during autumn (McCormick *et al.* 2000). A similar study that was conducted during summer months showed that caching during summer months was relatively rare, suggesting that *P. maniculatus* act as seed predators rather than seed dispersers during the these months (Hsia and Francl 2009). In addition an ecologically similar species (*Peromyscus leucopus*) was found that caching behavior occurred at a higher rate and at a different spatial pattern during autumn, thus the effect of season on caching is of great influence (McCormick 2009). Little information exists in the literature to make reasonable

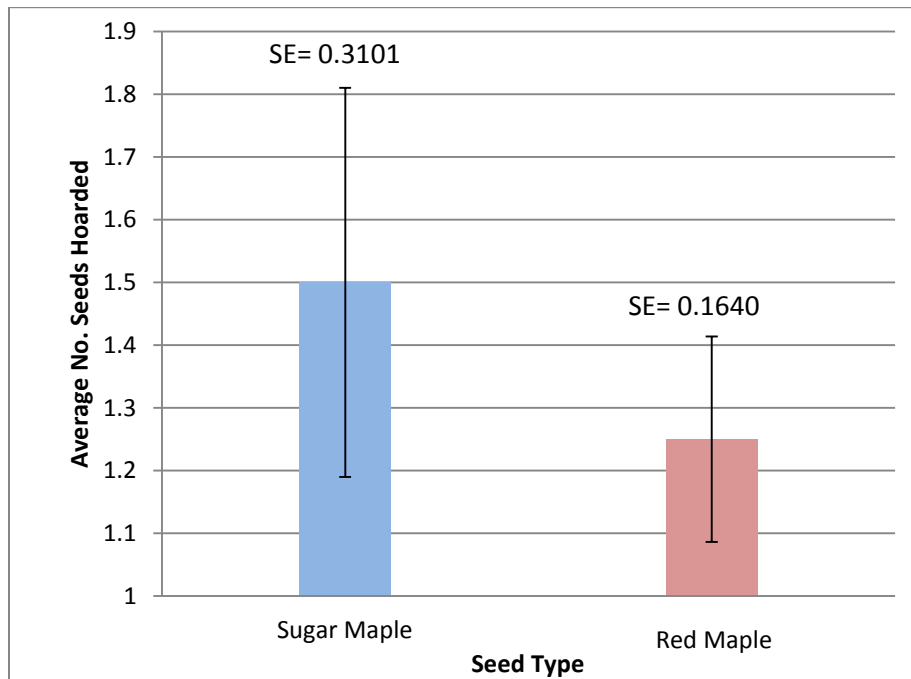
comparisons. Even though some mice hoarded *A. saccharum* seeds, we cannot confirm hoarding preferences without larger sample sizes. Furthermore, future study in different seasons could aid in the confirmation of our hoarding hypothesis.

There was no difference between seed type cached and the relative distance from the nest. Mice cached both seed types without discriminating at what distance they did so. Although 53% of the thirty mice tested cached seeds, our sample size was too small to establish differences. Future studies with greater sample sizes may confirm the observations for our first two hypotheses. Our results for the third hypothesis determined that deer mice are an important factor affecting the fate of *A. rubrum* seeds during the summer. We suggest that deer mice act as seed predators of *A. rubrum* during summer months, and they predate on this seed type more than *A. saccharum*. In addition we suggest that handling and processing time differences between the two seed types may affect the decisions of *P. maniculatus* in whether to eat seeds immediately or save them for later (Roche *et al.* 2009) and we confirmed that foraging and hoarding decisions are strongly influenced by the characteristics of the food items (Hadj *et al.* 1996).

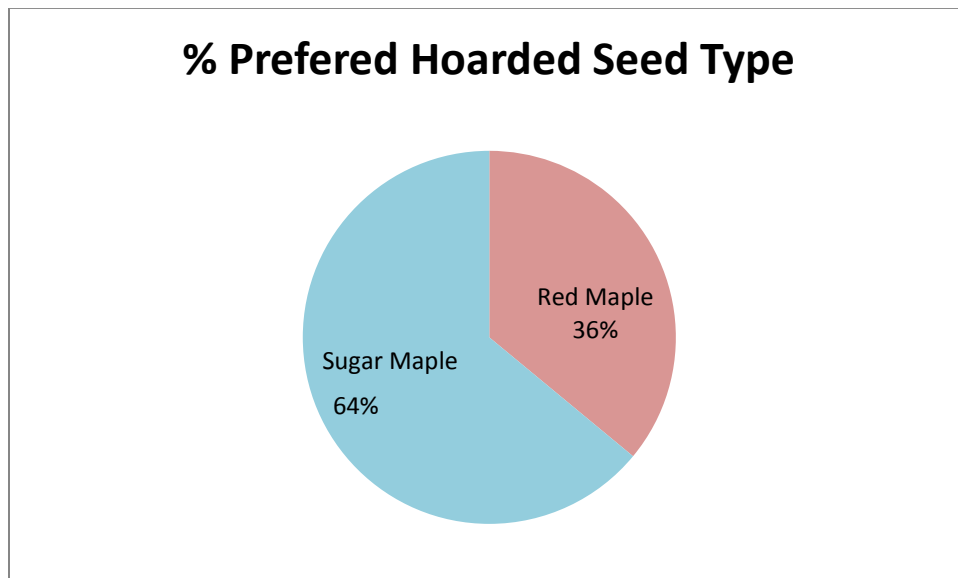
In conclusion, *P. maniculatus* is an important seed predator that may influence the structure of plant communities (Meiners and Stiles 1997). By selectively feeding on seeds of woody plants, predators can have the potential to alter succession dynamics within a site (Siepielski and Benkman 2008). Our results suggest that the role of *P. maniculatus* in UNDERC property during the summer is predation on *A. rubrum* more than *A. saccharum*. Future studies in different seasons with bigger sample sizes, and other seed preferences are needed to understand more clearly the bigger ecological role of *P. maniculatus* in northern hardwood succession forests.



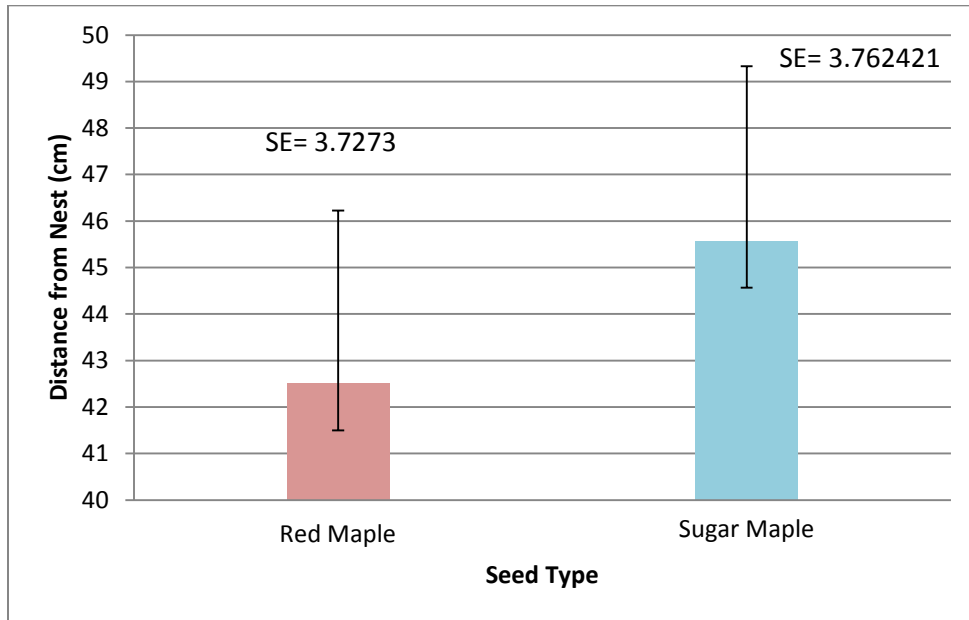
**Figures:**



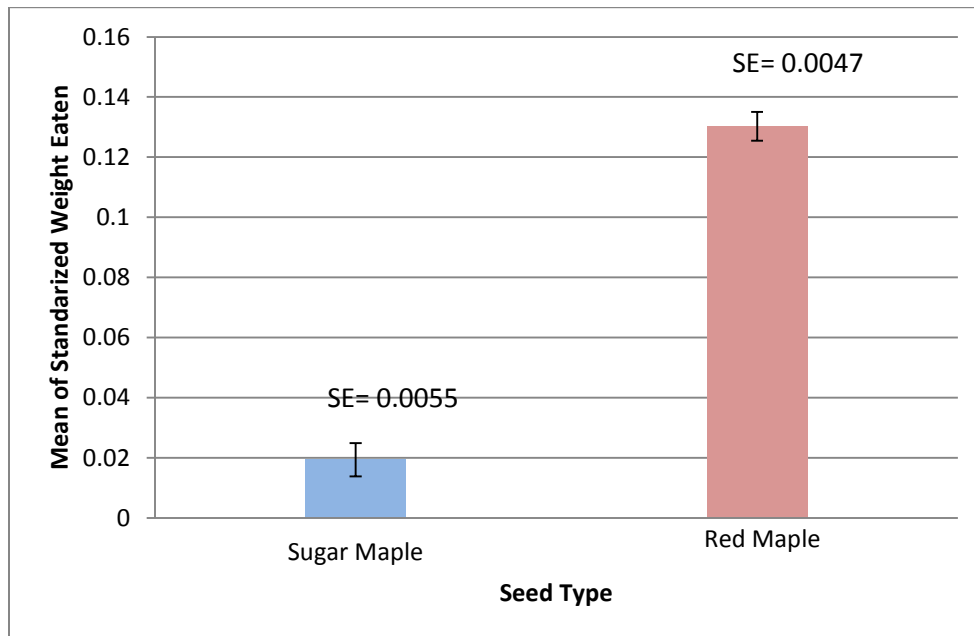
**Figure 1.** Two sample t-test between the average number of seeds hoarded and seed type. There was no significant (sugar maple,  $1.50 \pm 0.310$ ; red maple,  $1.25 \pm 0.164$ ;  $t_{df} = 18.57$ ;  $P=0.485$ ) effect of seed type on the number of seeds hoarded.



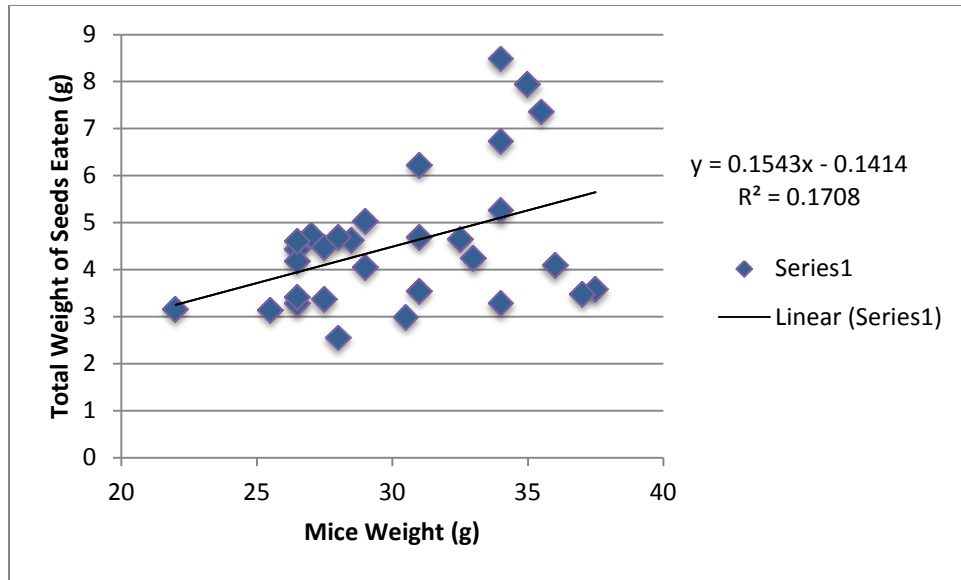
**Figure 2.** Proportion of each type of maple cached. Sugar maple seeds were the preferred seed type cached (64%). This preference was not statistically significant (red maple=8, sugar maple=14, total=22/30;  $t_{df} = 1.0$ ;  $X^2=1.63$ ;  $P=0.201$ )



**Figure 3.** Two sample t-test for cache type and distance relative to nest (sugar maple,  $45.5 \pm 3.762\text{cm}$ ; red maple,  $42.5 \pm 3.727\text{cm}$ ;  $t_{df} = 20$ ;  $P=0.635$ ). There was no significant difference between the locations of caches relative to the nest.

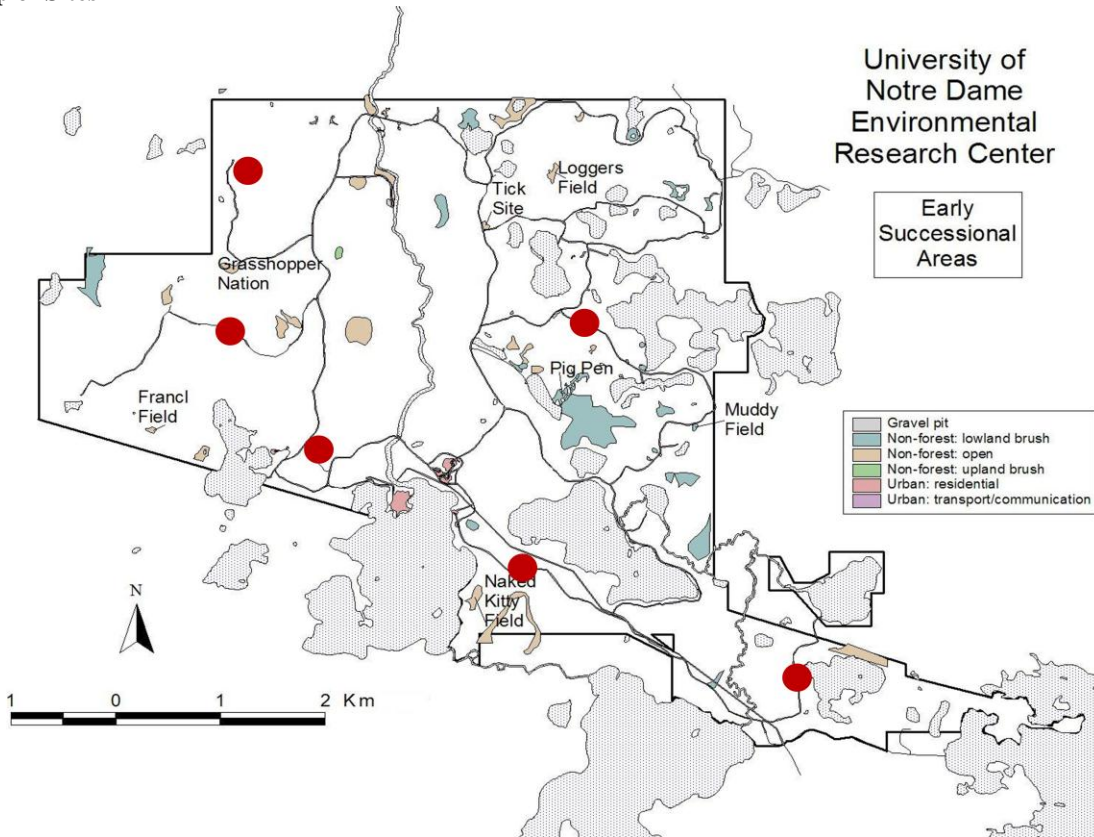


**Figure 4.** Paired t-test comparing means of the amount eaten of each seed type divided by the weight of each individual mouse. The results were statistically significant (sugar maple,  $0.0193 \pm 0.0055$ ; red maple,  $0.1302 \pm 0.0047$ ;  $t_{df} = 29.0$ ;  $P=0.00$ ) meaning that for *P. maniculatus* red maple seeds have a present value and are more likely to be eaten on site, rather than stored.



**Figure 5.** Regression of amount eaten and mouse weight ( $P=0.023, r^2 = 0.171$ ;  $SE=0.064$ ;  $t=2.401$ ;  $F=5.766$ ). Larger mice ate more seeds. This

**Map of Sites**



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