

**Edge Effects of Natural and Anthropogenic Field Types on Small Mammal
Individual Condition, Population Density and Species Composition at
UNDERC-East**

BIOS 33502: Practicum in Field Biology

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Abstract

The effects of anthropogenic edges on small mammal species are not fully understood and have been shown to have negative consequences for certain species. Many studies examining these effects have been conducted on large-scale anthropogenic edges, such as highway systems. However, the majority of human disturbances are smaller, such as dirt roads and small power lines, and the possible effects of these types of edges have been generally ignored. To assess these impacts, mark-recapture trapping was conducted in northern Michigan at four different natural and anthropogenic site types, including alongside a low-traffic dirt road and a medium voltage power line. Trapping was done on a 3 x 10 grid with 10 m intervals across three replicate trapping periods. 154 individuals of seven different species were captured 314 times over 3,120 trap-nights.

ANCOVA and ANOVA analyses revealed no significant impacts of site type on condition or density of *Peromyscus maniculatus* or *Peromyscus leucopus*, with the exception of significantly higher condition levels for *P. leucopus* at the road sites over the easement sites ($p = 0.044$). No relationship was found between site type and species richness or diversity. All sites were similar in species composition. This study suggests that the presences of low-disturbance anthropogenic edges are not having a significant effect on the condition, density, or species composition of small mammal populations in northern Michigan.

However, more extensive research should be done to confirm these results and

determine other possible anthropogenic factors influencing small mammal populations.

Introduction

Over the past 150 years, there has been a significant, almost complete transformation of the deciduous forests of the Midwestern United States to highly fragmented landscapes (Wolf and Batzli 2004). This change in landscape has been expected to have significant effects on the small mammal populations that reside in these areas (Lidicker 1995). As a result, many studies have investigated the effects that fragmented forests have on vegetative and nutrient complexity of small mammal diets (Wilder and Meikle 2005), reproductive capacity of local small mammal populations (Wilder and Meikle 2006), and, most frequently, the effects on small mammal population densities at the edge of the field-forest boundary as compared to the interior forest landscapes (Moore and Swihart 2005). Some small mammal forest species, such as the eastern gray squirrel (*Sciurus carolinensis*), are negatively affected by this increasing fragmentation, mainly through decreased population density (Moore and Swihart 2005). However, other species, such as the eastern chipmunk (*Tamias striatus*) and the white-footed mouse (*Peromyscus leucopus*), may actually be positively affected and have increased density levels due to the increased edge area created by fragmentation of the forest landscapes (Nupp and Swihart 2000).

Edge effects have long been observed in naturally occurring field-forest ecotones (Baker et al. 2002); however, anthropogenic edges may create different conditions than were previously found in naturally formed edges (Chapa-Vargas and Robinson 2006). These conditions, in turn, can have substantially different effects on the resident populations (Nunes-Ramos and Maes Santos 2006). Because natural and anthropogenic edges can have significantly different effects on organisms, it is essential to consider the type of edge when analyzing differences in species density and condition in and around field-forest boundaries. Many studies have incorporated this factor by choosing their study areas based on surrounding land use, frequently locating experiments adjacent to agricultural fields (Nupp and Swihart 2000) and high-traffic road systems (Boarman and Sazaki 2006). These studies are often used for conservation and management planning purposes (Parks and Harcourt 2002). Although previous studies have shown the effects of certain types of edges on small mammal species, little attention has been paid to the effects of anthropogenic edges created for medium voltage power lines or low-traffic dirt and gravel roads, which are often categorized as low disturbance (Goosem 2000; Forman 2003; Rich et al. 1994). This is unwarranted, however, as few studies have addressed the possible effects of these types of edges on individual organisms' conditions, population densities and species composition. It has been shown that changes in vegetation structure and resource availability are a significant factor in how edges can affect species,

and these changes occur at lower disturbance edges in a manner similar to high disturbance edges (Anderson et al 2003). Additionally, a recent study by Hawbaker and Radeloff (2004) showed that with the inclusion of these low-traffic roads, estimated total edge area in Wisconsin was doubled. This means that if these types of lower disturbance anthropogenic edges are affecting small mammal species, they may be having substantial unacknowledged ecological effects on these populations.

In this study, I examined how different types of low disturbance edges, specifically low-traffic gravel roads and medium voltage power lines, may affect the population density and individual conditions of *Peromyscus maniculatus* and *Peromyscus leucopus* as compared to the effects of a natural field edge and the forest interior. I also did a survey of species composition in the four site types using species richness and Shannon Index diversity.

Based on the results of previous studies (Wilder and Meikle 2006; Hadley and Wilson 2004), I hypothesized that different types of fields in each field-forest boundary would have significantly different effects on the condition of *P. maniculatus* and *P. leucopus*. I expected *P. maniculatus* would have the highest condition levels at the road sites, followed by the easement sites, the natural edge sites, and the forest interior sites, respectively, because *P. maniculatus* prefers open and disturbed habitats (Hadley and Wilson 2004). Because *P. leucopus* has been found to have increased body mass in woodlots (Nupp and Swihart 1998), I

expected to find a similar trend for *P. leucopus*, with the highest condition levels being in the road sites and the lowest condition levels at the forest interior sites. Both species have been previously demonstrated to respond to increased edge with increased density (Anderson et al. 2003; Hadley and Wilson 2004), so I expected *P. maniculatus* density to be highest at the road sites, followed by the easement sites, the natural edge sites, and the forest interior sites. I also expected *P. leucopus* to have the same trend for density as *P. maniculatus*, with the highest densities found at the road sites. Concerning species composition, I hypothesized that species richness would be significantly different between site types, with the easement sites having the highest richness, due to the increased vegetative and resource complexity associated with edges (Wilder and Meikle 2006). I expected this to be followed by the natural edge sites, road sites, and forest interior sites, respectively. For similar reasons, I expected that diversity would also be significantly different between sites and follow the same trend as species richness, indicating that species composition varies among different types of natural and anthropogenic edges.

Methods

Study Area and Plot Selection. This study was conducted at the University of Notre Dame Environmental Research Center (UNDERC) in the Upper Peninsula of Michigan (46°13'N 89°32'W). Four different site types were used to examine the effects of a field-forest edge on small mammal density, condition,

and species composition. For the purposes of this study, the edge was defined as the line along which the furthest adult trees extend into the field. Three of the site types began at the edge and extended into the forest 20 meters. These included sites along a small (approximately 10 m) gravel road, sites adjacent to a field below a medium voltage power line, and sites along a natural field. The fourth site type was a forest interior site, which began 100 m into the forest from the closest edge. Three replicates of each site type were used, and one site of each type was included in each trapping period to eliminate bias due to weather differences between trapping periods. Sites were chosen based on relative distance to other sites in each respective trapping period, as well as for similarity of vegetation composition and density across all site types.

Sampling Procedure. At each site, thirty Sherman live traps were set in a 3 x 10 grid, running parallel to the edge. The traps were spaced at 10 m intervals. This trapping interval is consistent with many previous studies (Bowman et al. 2001). Each trapping period consisted of five nights and four days of consecutive trapping, with the exception of the last trapping period. This trapping period lasted four nights and four days, due to inclement weather. The traps were all baited with a mixture of sunflower seeds, oats, and peanut butter. The traps were checked once in the morning and once in the evening, and all small mammal species were tagged in both ears, with the exception of *Blarina brevicauda*, which were noted but not used for any data analyses due to inability to individually mark

them. Tagging was done in both ears to decrease the likelihood of duplicate counting due to lost tags. Sex, mass, and reproductive condition were recorded for each individual. Body length was also recorded for *Peromyscus leucopus*, *Peromyscus maniculatus*, and *Napaeozapus insignis*.

Statistical Analysis. To determine population densities per site for *P. leucopus* and *P. maniculatus*, program MARK was used. This program estimates population sizes based on individual recapture histories. Minimum number known alive was also used as population size for certain sites due to low amounts of individuals captured at these sites. Population sizes were then converted to densities per hectare.

Program EcoStat was utilized to compare the similarity of species composition between site types. Specifically, the Horn Index was used to estimate overlap of species composition between pairs of site types. This was done for each trapping period separately, and these results were then averaged for an overall species composition comparison.

Five tests were run in program SYSTAT 12. ANCOVA tests analyzed possible differences in both *P. leucopus* and *P. maniculatus* condition due to edge type. Condition was measured as a ratio of body length to body mass (Jakob et al. 1996). An ANOVA test examined possible differences in *P. leucopus* and *P. maniculatus* densities due to edge type. Species richness was examined as a possible function of edge type using an ANOVA test, and another ANOVA test

was also run analyzing possible differences in diversity with site type. Species diversity for each site was calculated using the Shannon Index and the mean diversity was examined with ANOVA.

Results

A total of 154 individuals were captured 314 times in 3,120 trap-nights. Seven different small mammal species were captured (Table 1). These included *Glaucomys volans*, *Myodes gapperi*, *Napaeozapus insignis*, *Peromyscus leucopus*, *Peromyscus maniculatus*, *Tamiasciurus hudsonicus*, and *Tamias striatus*.

Site type and Peromyscus maniculatus condition. Using body mass to estimate *Peromyscus* spp. condition in an ANCOVA with body length as a covariate, site type was found to have no significant effect on the condition of *P. maniculatus* at UNDERC ($F_{3,69} = 0.339$, $p = 0.797$; Figure 1). Pregnant females were not included in any condition analyses.

Site type and Peromyscus leucopus condition. There was no significant difference found among the four site types in their effects on *P. leucopus* condition using an ANCOVA ($F_{3,40} = 1.609$, $p = 0.203$; Figure 2); however, a Fisher's Least-Significant-Difference test showed a significant difference in *P. leucopus* condition between the easement sites and the road sites, with the road sites have mice with significantly higher condition levels ($p = 0.044$).

Site type and P. maniculatus and P. leucopus densities. Site type had no significant effect on *P. maniculatus* and *P. leucopus* densities ($F_{3,16} = 0.249$, $p = 0.861$; Figure 3). The response of each species to site was similar ($F_{3,16} = 0.319$, $p = 0.811$; Figure 3). Additionally, there were no significant differences in density between *Peromyscus* spp. ($F_{1,16} = 1.498$, $p = 0.239$; Figure 4; Table 2).

Site type and diversity. No significant differences were found between site types in relation to species richness ($F_{3,8} = 0.778$, $p = 0.539$; Figure 5; Table 3). In addition, there were no significant differences in diversity between site types ($F_{3,8} = 1.377$, $p = 0.318$; Figure 6).

Site type and species composition. Similarities in species composition between sites was determined using the Horn Index in program EcoStat, which analyzes the similarity between the composition of two sites and generates a number between 0 and 1, with 1 being perfectly alike (Horn 1966). Observed community overlaps are high enough to show that all of the site types had basically the same overall species composition (Table 4).

Discussion

In this experiment, the data failed to reject the null hypotheses, demonstrating no significant effects on small mammal individual condition, population densities, or species composition due to differing low-disturbance edge types. There was one exception, which was that *P. leucopus* showed significantly better condition levels at the road sites than the easement sites. This was not

expected, since it would seem that significant differences would occur between natural and anthropogenic edges prior to differences between different anthropogenic edge types. However, there are some possible explanations for this difference. Previous studies have shown that there are differences in road effects due to the presence or absence of canopy cover (Goosem 2000), and in this experiment the road sites tended to have nearly complete canopy cover. This is important because the lack of canopy cover at the easement sites could be associated with higher levels of avian predators, which would be a stressor and could affect mouse condition levels. In addition, open areas like easements can be thermally stressful to *P. leucopus* (Zollner and Lima 1997). Additionally, competition levels may be influencing *P. leucopus* condition levels in easement sites. Nupp and Swihart (1998) found that *P. leucopus* tend to thrive in fragments, which is related to decreased biomass of competing granivores. Roads would tend to support this decreased competition level, as the road itself does not provide a new habitat for any other granivores. Easement fields, on the other hand, provide habitat for other granivores, such as voles, which may be putting competitive stress on the mice in the easement sites. In this experiment six out of seven *M. gapperi* trapped were trapped at easement sites. It is also important to note that there were similar numbers of *P. leucopus* individuals caught during each trapping period between the two sites (Table 1), so that is probably not a source of

error. Nevertheless, the sample size was low, and a larger sample size would help to confirm that this result actually is significant.

Small sample size may have created error in other areas as well, such as some density estimates being based on minimum number known alive rather than recapture. Mark-recapture population estimates assume that there are no differences between individuals' initial likelihood to be trapped, which was noticeably violated by certain individuals that were constantly seen but never trapped. In future research on this subject, increasing the number of trapping periods or replicates could help decrease possible error. Additionally, trapping should be done for more days each trapping period to ensure that all individuals are being captured. This can be guaranteed fairly well by trapping until any new individuals caught on the last day constitute less than five percent of the total number of individuals trapped at that site (Lacher and Alho 1989). In this experiment, *P. leucopus* averaged 8.7% of the total as new captures on the last day of trapping, and *P. maniculatus* was even higher with 18.9% of the total as new captures on the last day.

Other factors may be masking the effects of these edges as well. Fragmentation is associated with increased predation levels (Nupp and Swihart 1998). These possible increased predation levels may be causing a decline in a population that may have otherwise had increased density. There has also been evidence of significant temporal differences in the effects of edges (Wilder and

Meikle 2006). This study was conducted shortly after the breeding season, and many of the mice captured were juveniles (24.2%), which may have resulted in population estimates very different from normal population levels. Additionally, it has been established that increases in small mammal density are associated with decreased competition from other granivores (Nupp and Swihart 1998), but the Horn Index showed that all of the site types have very similar species compositions, so no substantial differences in competition levels would be expected and density would be expected to be relatively stable.

This study suggests that the presences of low-traffic gravel roads and medium voltage power lines are not having significant effects on the individual conditions, population densities, or species composition of small mammal populations in northern Michigan. Future research on this subject should examine the effects different sized gravel roads may have on these populations, determine the importance of canopy cover as a variable in edge influence, and investigate how species composition and density may change as a gradient from the edge. Although more research should be done to confirm these results and further explore the relationship between anthropogenic edges and small mammal populations, these results support maintaining these low-disturbance edges as an alternative to developing these areas further into large-scale anthropogenic edges.

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Tables

Table 1. Total number of individuals of each species trapped per site. *P. leucopus* and *P. maniculatus* were the only species caught enough to calculate population estimates using program MARK. All other species were used only for species composition, richness, and diversity analyses. Mean total number of individuals trapped per site was 12.92.

Site	<i>G. volans</i>	<i>M. gapperi</i>	<i>N. insignis</i>	<i>P. leucopus</i>	<i>P. maniculatus</i>	<i>T. hudsonicus</i>	<i>T. striatus</i>	Total per Site
Easement A	0	1	0	6	5	0	0	12
Easement B	4	0	0	4	4	0	0	12
Easement C	2	2	3	1	10	0	1	19
Forest A	0	0	0	12	8	0	0	20
Forest B	0	1	1	2	4	3	0	11
Forest C	0	0	0	1	9	0	1	11
Natural A	0	0	0	7	2	0	0	9
Natural B	0	0	2	0	6	0	4	12
Natural C	0	0	0	0	9	0	1	10
Road A	0	0	0	5	2	0	1	8
Road B	0	0	1	5	10	0	1	17
Road C	1	0	2	3	5	1	2	14
Total per Species	7	4	9	46	74	4	11	155

Table 2. Densities per site with mean density per site type, including standard error, and overall mean density per species with standard error for *P. maniculatus* and *P. leucopus*.

Site	<i>P. maniculatus</i> densities	<i>P. leucopus</i> densities
Easement A	25.000	30.897
Easement B	27.350	20.816
Easement C	51.711	5.000
Easement Mean	<i>34.687±8.539</i>	<i>18.904±7.537</i>
Forest A	54.095	86.054
Forest B	17.071	10.000
Forest C	61.723	5.000
Forest Mean	<i>44.296±13.790</i>	<i>33.685±26.225</i>
Natural A	10.000	37.021
Natural B	34.033	0.000
Natural C	47.102	0.000
Natural Mean	<i>30.378±10.865</i>	<i>12.340±12.340</i>
Road A	10.000	20.000
Road B	51.336	16.944
Road C	30.202	10.000
Road Mean	<i>30.513±11.934</i>	<i>15.648±2.959</i>
Overall Mean	<i>34.969±11.282</i>	<i>20.144±12.265</i>

Table 3. Species richness per site with mean richness per site type, including standard error, and overall mean richness with standard error. Species diversity per site with mean diversity per site type, including standard error, and overall mean diversity per site type with standard error as calculated by the Shannon Index.

Site	<i>Species Richness</i>	<i>Species Diversity (H')</i>
Easement A	3	0.399
Easement B	6	0.477
Easement C	2	0.614
Easement Mean	<i>4.000±1.000</i>	<i>0.497±0.0628</i>
Forest A	2	0.292
Forest B	5	0.638
Forest C	3	0.261
Forest Mean	<i>3.333±0.882</i>	<i>0.397±0.121</i>
Natural A	2	0.230
Natural B	3	0.439
Natural C	2	0.141
Natural Mean	<i>2.333±0.333</i>	<i>0.270±0.088</i>
Road A	3	0.391
Road B	4	0.437
Road C	6	0.708
Road Mean	<i>4.333±0.882</i>	<i>0.512±0.0989</i>
Overall Mean	<i>3.500±0.774</i>	<i>0.419±0.0927</i>

Table 4. Site type by site type comparison of species composition using the Horn Index. This index, in program EcoStat, analyzes the composition of all sites per type and compares it to the overall composition of another site type. A value between 0 and 1 is then assigned, with 1 indicating that the two site types have perfect similarity in composition. All of the Horn Index values below are high enough to indicate that all of the site types have the same basic composition.

	Easement	Forest	Natural	Road
Easement	1	0.781950	0.699998	0.819420
Forest		1	0.823783	0.810573
Natural			1	0.789561
Road				1

Figures

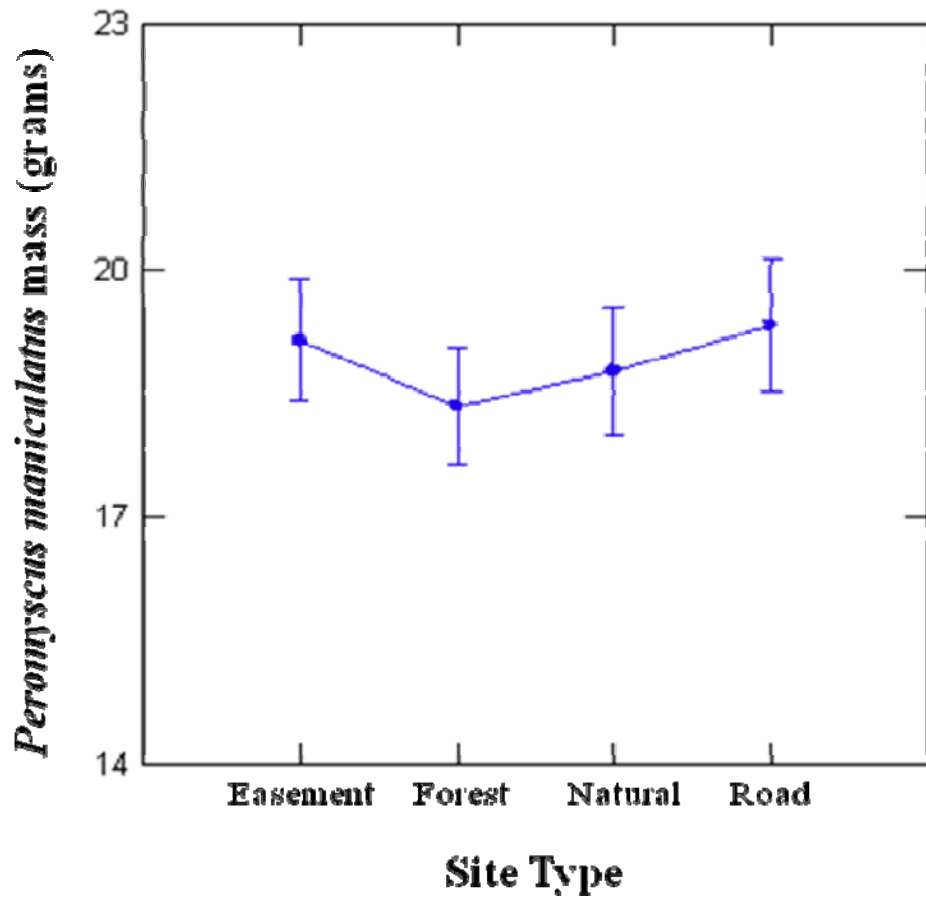


Figure 1. Condition of *Peromyscus maniculatus* for different site types determined by an ANCOVA ($F_{3,69} = 0.339$, $p = 0.797$).

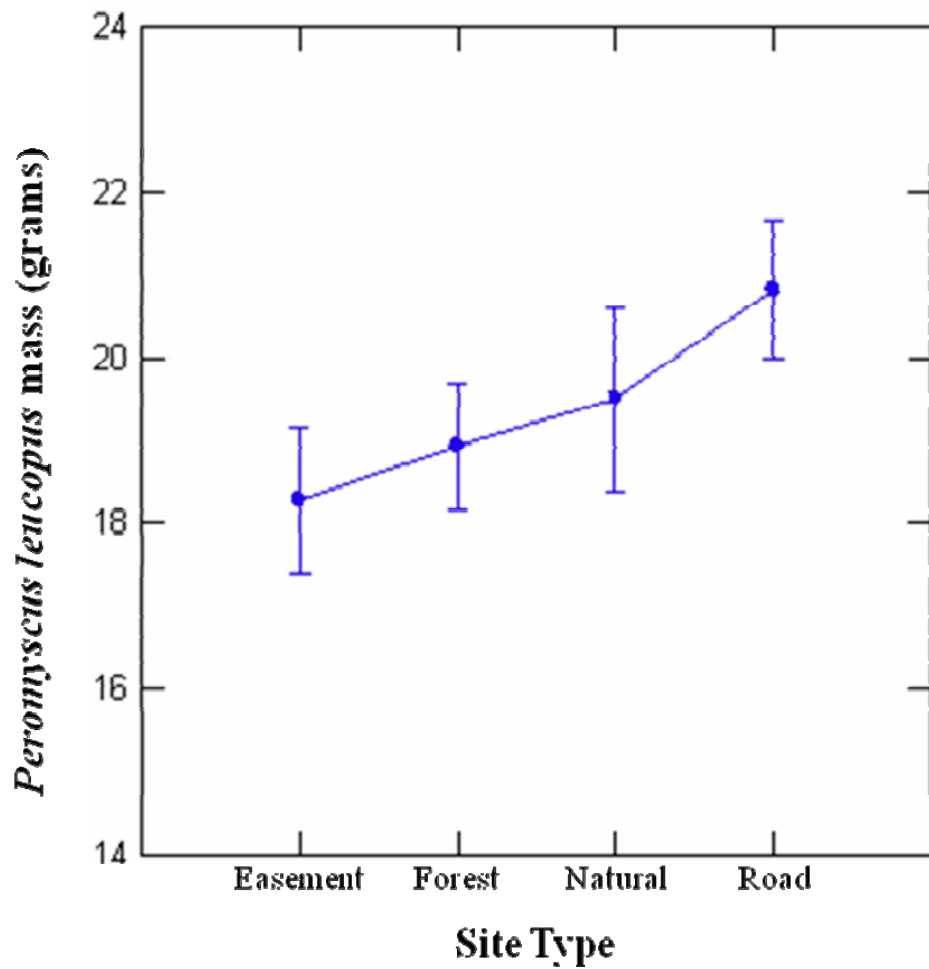


Figure 2. Condition of *Peromyscus leucopus* for different site types determined by an ANCOVA ($F_{3,40} = 1.609$, $p = 0.203$). Fisher's Least-Significant-Differences also run for road sites and easement sites ($p = 0.044$).

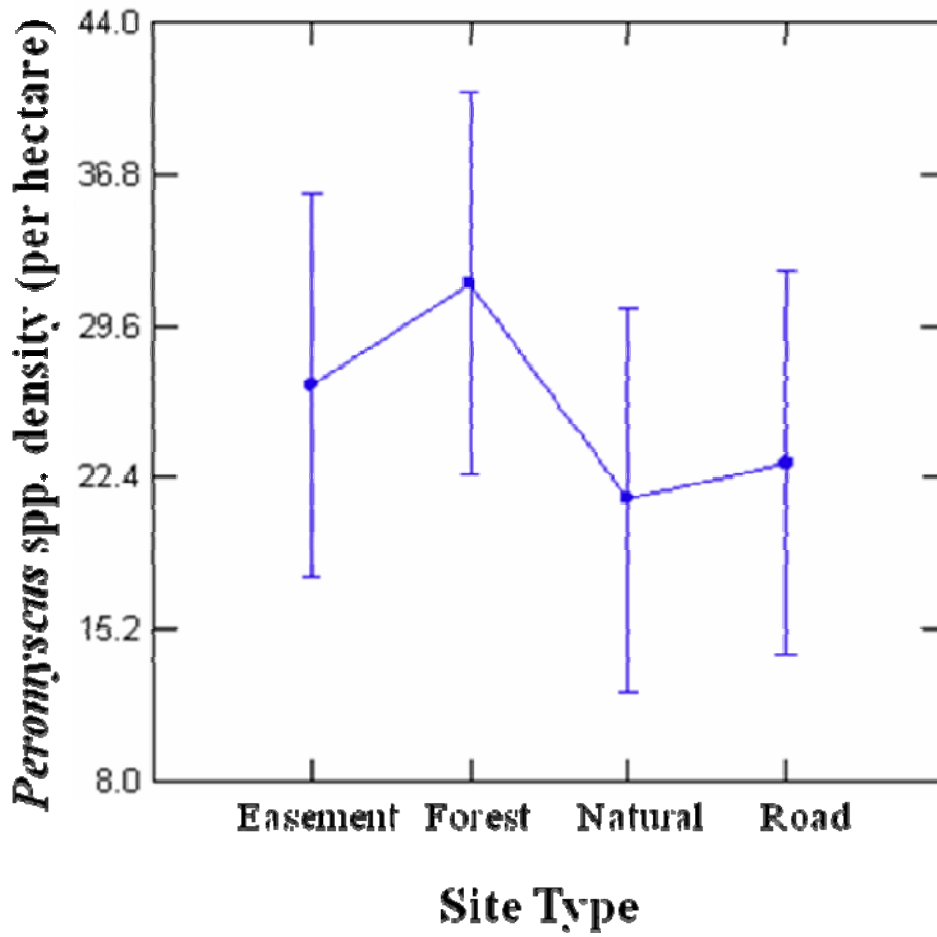


Figure 3. Density of *Peromyscus* spp. for different site types determined by an ANOVA ($F_{3,16} = 0.249$, $p = 0.861$). The response of each species to site was similar ($F_{3,16} = 0.319$, $p = 0.811$).

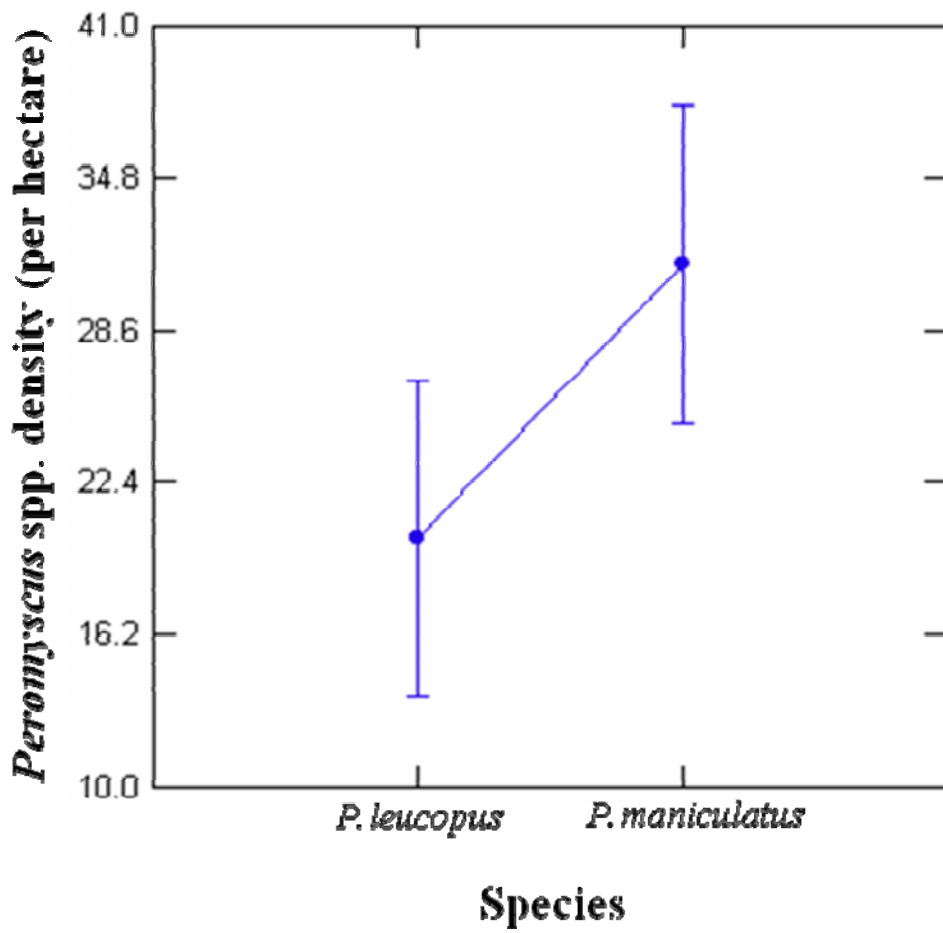


Figure 4. Overall densities of *Peromyscus* spp. determined by an ANOVA ($F_{1,16} = 1.498$, $p = 0.239$).

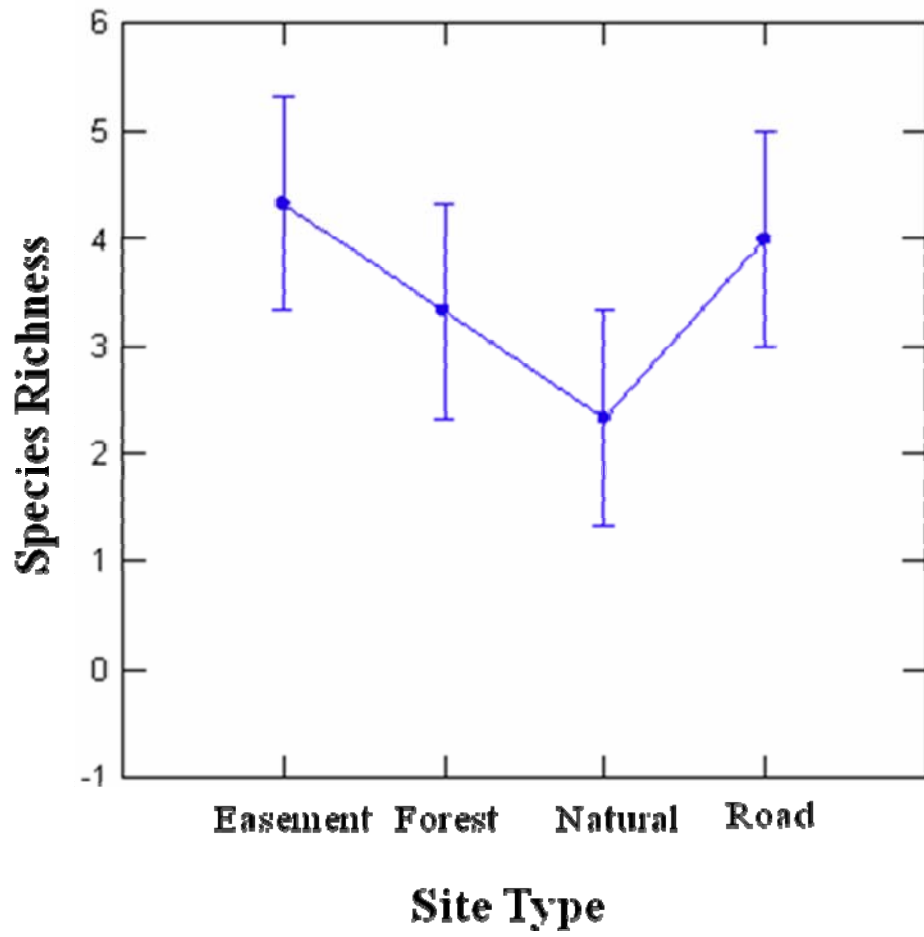


Figure 5. Species richness for different site types determined by an ANOVA ($F_{3,8} = 0.778, p = 0.539$).

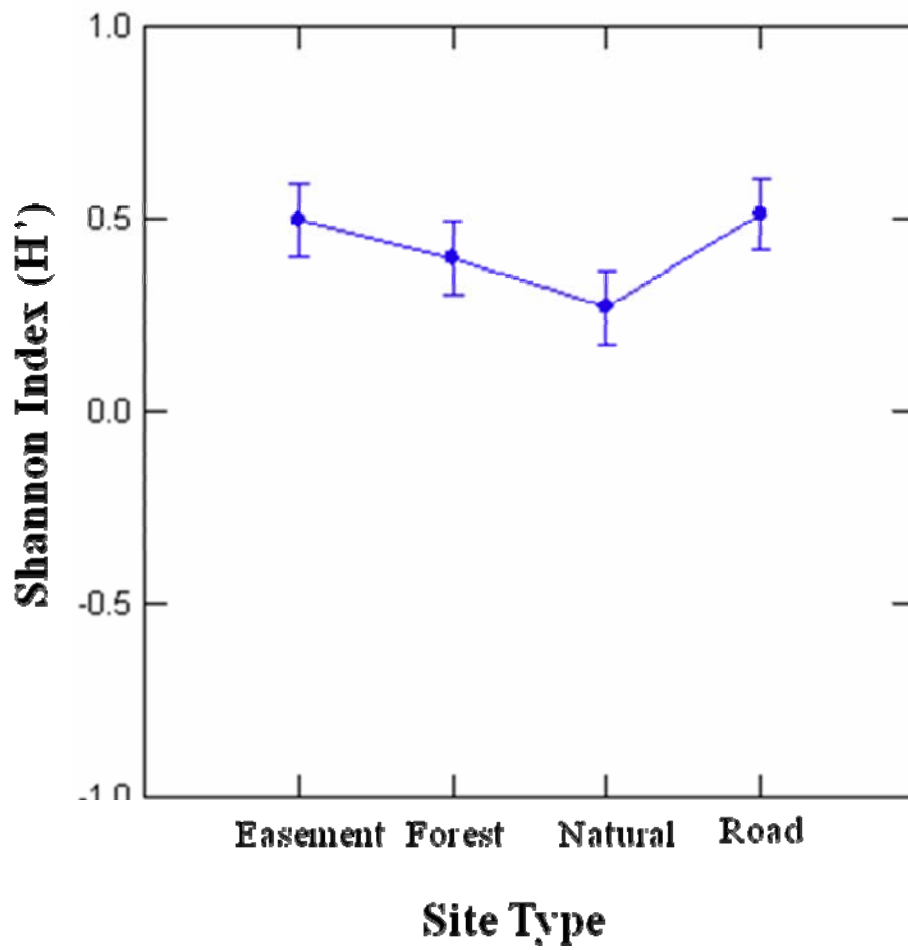


Figure 6. Shannon Index diversity values for different site types determined by an ANOVA ($F_{3,8} = 1.377$, $p = 0.318$).