The Effects of Soil Moisture and Distance from Open Water on the Species Distribution of Small Mammals

BIOS 35502: Practicum in Environmental Field Biology

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Abstract

Although there have been several studies that attempt to pinpoint the preferred habitats for many of the small mammals found on the University of Notre Dame Environmental Research Center (UNDERC) property, few have determined the transitions in species composition along a soil moisture gradient. My project aimed to determine at what point in the soil moisture gradient and at what distance from open water the wetland species are replaced by upland species. Using multiple trapping techniques, I trapped at nine sites, which included three bogs, three creeks, and three lakes. In 3240 trap nights, I captured 184 individuals of 10 different species of small mammals in three trapping weeks. Of these 10, six showed a significant preference for soil moistures either above or below 55% and only one, *Microtus pennsylvanicus*, had a significant relationship with the distance from open water. It is therefore possible that soil moistures of greater or less than 55% are an important factor in habitat preferences for these species. However, it is plausible that vegetation may also be an important factor; therefore, further studies should include more in depth research between the relationship of vegetation and soil moisture.

Introduction

Many areas of the University of Notre Dame Environmental Research Center (UNDERC) property in Vilas County, Wisconsin and Gogebic County, Michigan have been surveyed for small mammals (Dillon, 2003; Kilcline, 2003). Each of these species has an inherent preference for a particular microhabitat, which is usually determined by the predominant vegetation (Snyder and Best, 1988). For instance, the water shrew, *Sorex palustris*, has been found most often in areas near slow-moving and mucky creeks with little overhanging vegetation (Nuske, 2004). However, few studies have examined the specific microhabitats of these mammals, especially the location along the moisture gradient where wetland species decline in numbers and upland species increase.

Some previous studies have noted the significance of moisture to small mammal distributions within a species. Prairies in Minnesota were studied on both the macro- and microhabitat level for two years; the study showed a variation in habitat use due to the large variation of moisture in the area (Snyder and Best, 1988). Getz (1970) also found similar results on variations of filled and unfilled niches across microhabitats depending on the population size of meadow voles (*Microtus pennsylvanicus*) in the Madison, Wisconsin Arboretum. Getz concluded that the voles would use the optimal areas when the population was low and would only move into suboptimal habitats with lower soil moisture when the population pressure became considerable. Additionally, Vander Wall (1995) found that mice species can find seeds more efficiently in moist soil, again demonstrating the effects of habitat moisture on the lives of these animals.

A second area in need of further study is that of niche separation between species, as well as the capacity and tolerance of cohabitation. The meadow vole (*Microtus pennsylvanicus*) and montane vole (*Microtus montanus*) in the northwestern mountains of the United States showed a distinct difference in occupied niches, based largely on moisture in the area (Murie, 1969). The same trend was found for the distribution of masked shrews (*Sorex cinereus*) and northern short-tailed shrews (*Blarina brevicauda*) in southern Michigan (Getz, 1961) and northern short-tailed shrews in Pennsylvania (Zegers and Ha, 1981).

Given these trends from previous studies, the goal of my study was to further classify the microhabitat needs of small mammals by identifying the effects of soil moisture and distance from open water on the relative abundance and species composition of small mammals. In this way, I could examine the location along the soil moisture gradient where there was a change in the species composition from wetland to upland species. I hypothesize that there will be a marked change in the species composition of small mammals with movement along the soil moisture gradient based on inherent habitat preferences. In particular, I expected there would be more water shrews and southern bog lemmings (*Synaptomys cooperi)* in moister microhabitats (trap stations closer to open water) and more northern short-tailed shrews and red-backed voles (*Myodes gapperi*) as distance from water increased (i.e., in upland areas).

Methods

The University of Notre Dame Environmental Research Center (UNDERC) consisted of 7500 acres (3035ha) along the border of Vilas County, Wisconsin and Gogebic County, Michigan. Almost 20 % of the property was open water found in over 30 lakes and bogs (Kilcline, 2003). Trapping occurred for three weeks in a total of nine sites around the UNDERC property: three creeks (Tenderfoot Creek, Brown Creek, and Plum Creek), three lakes (Morris Lake, Kickapoo Lake, and Long Lake), and three bogs (Craig Bog, Hellenthal Bog, and Forest Service Bog; Table 1), adding up to 3240 trap nights. Each week, one creek, one lake, and one bog were surveyed by setting up three 90-m transect lines running perpendicular to the edge of the open water. These transects were placed in areas where there was the greatest potential to observe linear soil moisture gradients to allow for the clearest results concerning moisture gradients. Along these transects, ten trap stations were set up at 10-m intervals where soil moisture readings will be taken with a soil moisture probe (Kelway HB2 Soil and Acidity Tester, Kel

Instruments Co., Inc., Wyckoff, NJ). In order to minimize trap bias, each station had a Sherman live trap, a snap trap, and a 32-oz. pitfall trap (Francl et al, 2002); the Sherman traps were baited with peanut butter and rolled oats and the snap traps with sardines.

Live animals caught in the Sherman and pitfall traps were removed and placed in a garment bag for identification of species, reproductive status, and gender. Captured animals were be marked by an approximately ca. 1-cm clip or hole punch in the ear so that recaptured animals may be distinguished from new catches. Animals caught in snap traps were removed and measurements taken of total length, tail length, length of the rear foot, and ear length, as well as weight, gender, and reproductive status. The specimens were then placed in small plastic bags and returned to the lab for future museum specimen preparation.

To analyze the data, I ran ANOVAs and t-tests in Systat 11.0 (Systat, Inc., Point Richmond, CA). I first determined if the data could be grouped to produce the most powerful statistics. To do this, I used ANOVA to establish if there were any relationships between soil moisture and habitat type across all distances as well as between soil moisture and distance within each habitat type. I then ran ANOVA to test for relationships between distance from open water and the number of individuals caught for each species. Based on the outcome of theses preliminary tests, I was able to run t-tests to determine if there were relationships between soil moisture and the number caught of each species.

Results

Over three research weeks (June 7-10, June 27-30, and July 16-19), I trapped 184 small mammals of 10 species (Table 1). Because only one least chipmunk (*Tamias* *minimus*) was captured throughout the survey, no statistical analyses were performed for this species.

Using an ANOVA, I found that lakes had a significantly lower mean soil moisture than either bogs or creeks (F=21.181, df=2, p<0.001); creeks and bogs were not significantly different (Figure 1). When examining general trends within habitat types, the soil moisture readings of bogs decreased fairly gradually as distance from open water decreased, the moisture of lakes decreased sharply within the first 10m, and creeks had soil moistures that showed no clear pattern (Figure 2). Because there was no interaction between distance and habitat, I grouped the species data by habitat.

When examining trends across each transect within the different habitats, I discovered a significant difference in soil moisture for the first 10m from the water's edge (trap stations 1 and 2; F=8.166, df =9, p<0.001) when compared to the next 80 m (trap stations 3 – 10; Figure 2); the turning point in the soil moisture gradient was 55%. No other points across the transect were statistically different from one another. Because of this trend, I ran all soil moisture analyses by grouping captures per unit effort in trap stations 1 and 2 and compared them to captures per unit effort for trap stations 3 – 10.

Once the small mammal captures were grouped according to the soil moisture gradient (0-10m and 20-90m), I used a paired t-tests comparing capture success per unit effort and obtained significant differences between the two moisture groups (p<0.10) for six of the species (Table 2): northern short-tailed shrew (t=2.718, p=0.015), southern red-backed vole (t=1.761, p=0.096), meadow vole (t=5.132, p<0.001), arctic shrew (*Sorex arcticus;* t=1.826, p=0.085), masked shrew (t=2.672, p=0.016), and eastern chipmunk (*Tamias striatus* (t=9.953, p<0.001). Meadow voles preferred areas with higher soil moisture values (>55%), while the other five species preferred areas with lower (<55%) moisture values

When examining distance from open water and capture success for each species, I found that meadow voles were the only species that showed a significant difference in number caught—there was a greater number of meadow voles caught in the first 10m than at any other distance (F=2.802, df=9, p=0.007; Table 2).

Discussion

I expected to find a difference in soil moisture gradients across the three habitat types. Anecdotally, all three bogs had fairly even soil moistures across the *sphagnum* mat until the transects reached the upland forest, where it decreased more rapidly. On the other hand, the lake habitat typically reached upland forest within the first 20m, after which the soil moistures leveled out. The creeks showed no clear pattern, most likely due to their different physical characteristics. Tenderfoot Creek's shoreline has little elevation gradient, which allows the entire area in which I trapped to be somewhat flooded when the water levels of the creek are high. Both Brown Creek and Plum Creek had much smaller flood plains—half way through the transects, I encountered substantial hills that were not as wet. This implies that the elevation of an area is related to soil moistures and may be another factor in habitat use for small mammals

Although both water shrews and southern bog lemmings have been found on property (Kilcline, 2003; Nuske, 2004), I did not capture any of either species. Spencer (1966) had very low success in capturing water shrews; he suggested that the shrews were large enough to climb out of traps that were dry and were only caught when they traps were partially full of water. Brown (1967) also had low success in capturing the shrews; those that were caught were within 100 feet (30m) of a stream or pond. The effort in this project to capture water shrews was very low with only three trap stations at the water's edge per site, severely reducing the chances of capturing an already-elusive mammal. In addition, the pitfall traps at these shoreline stations were almost completely filled with water, perhaps allowing the shrews a chance to escape. As a result, I did not capture any water shrews, despite previous success at Plum Creek and Morris Lake (Nuske, 2004)

The bog lemming has been reported in strictly grassy areas (Wetzel, 1958), strictly forested areas (Iverson et al, 1967), and in both areas (Swihart and Slade, 1990). Krupa and Haskins (1996) propose that the reason for these variances in habitats is due to competition, particularly with meadow vole. Although I did not capture many meadow voles (n = 5), it is possible that this competition was occurring at the sites I surveyed.

Out of the six species that had a significant relationship with soil moisture, meadow voles were the only species that was found more often in wetter areas (which occurred within the first 10m). This species was also the only species to show a significant preference for living closer to open water—again, within 10m. Because of the overlap, it is possible that the soil moisture and distance to open water are equally-important influences in the vole's living habitat; however, both may simply be a reflection of vegetative cover type. Meadow voles tend to prefer early-successional areas with large amounts of grass cover (Iverson et al, 1967; Grant, 1971; Krupa and Haskins, 1996); although I performed no extensive vegetation studies, anecdotal evidence suggests that more grassy areas occurred near the water in this study.

The other five species (northern short-tailed shrew, red-backed vole, arctic shrew, masked shrew, and eastern chipmunk) all showed significant preferences for drier areas but did not show a preference for certain distances from water. For the most part, these findings coincide with other small mammal surveys. Feldhamer et al (1993) found that northern short-tailed shrews prefer areas of upland hardwood forests, which corresponds with lower soil moistures. Iverson et al. (1967) found that the shrews were more widespread than strictly upland forests but that they still avoided areas with standing water and riparian woodlands. Iverson et al. (1967) also discovered that southern red-backed voles were found in highest abundance in upland forested areas of all types. The article also mentioned that the voles are occasionally found in riparian forests, but periodic flooding of the river basin can be a limiting factor in the resident population (Iverson et al., 1967).

Brown (1967) and Iverson et al. (1967) both found the masked shrew in almost all habitats. Brown was successful in capturing the masked shrew in relatively high abundance in bogs as well as forest and grasslands, corresponding to all of the areas in which I caught the species; however, although Brown mentions these boggy areas as moist, he does not list specific moisture percentages with which to compare. My results for the arctic shrew varied from Wrigley et al. (1979); they obsereved that the arctic shrew was most commonly found in areas near watercourses and moist depressions that had plenty of grass and alder, whereas I found no significant relationship between number of individuals captured and the distance from open water. Again, no specific soil moistures were mentioned, making it difficult to compare my trapping data with their findings.

Finally, my results for the eastern chipmunk match closely with previous surveys. Iverson et al (1967) found that the chipmunk resided in highly-developed forests, particularly deciduous forests. Although the sites at which I caught chipmunks were not strictly deciduous, an anecdotal survey of the sites concluded the forests were primarily mixed.

Because only one species had a significant relationship between capture success and distance from water, soil moisture appears more influential than distance for the other five species; however, it is likely that vegetation composition is the driving influence in habitat use. In order to determine if either soil moisture or vegetation is a more important factor, trap sites should be selected based on general vegetation type and then tested for variations in soil moistures between sites of similar cover. If the vegetation component is removed, then it can be strongly stated soil moisture is a determining factor in habitat selection and not simply a consequence of vegetation.

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Table 1. Trap site description and location for sites surveyed in summer 2006. Listed are habitat types and UTM (NAD27, Zone 16N) readings, as well as dates trapped.

Name	Habitat Type	UTM E	UTM N	Dates Trapped
Brown	Creek	308263	5119767	6/27-6/30
Craig	Bog	303230	5124919	7/16-7/19
Forest Service	Bog	307141	5120542	6/27-6/31
Hellenthal	Bog	307937	5121125	6/7-6/10
Kickapoo	Lake	307358	5121812	6/7-6/10
Long	Lake	307276	5123093	6/27-6/30
Morris	Lake	305537	5125545	7/16-7/19
Plum	Creek	307722	5121287	6/7-6/10
Tenderfoot	Creek	304295	5122586	7/16-7/19

Table 2. Individuals of each species caught at nine trap sites (360 trap-nights per site) in summer 2006. Locality data available in Table 1. See Appendix 1 for full names of species, listed as codes.

Site	BLBR	MYGA	MIPE	PELE	PEMA	SOAR	SOCI	TAMI	TAST	ZAHU
Brown Creek	3	0	2	1	4	7	8	0	10	1
Craig Bog	3	1	1	0	0	0	7	0	0	1
Forest Service Bog	0	0	0	11	12	0	1	0	0	0
Hellenthal Bog	0	0	0	1	5	0	4	0	1	0
Kickapoo Lake	0	2	0	1	2	3	7	0	2	1
Long Lake	2	0	0	0	9	0	6	0	0	0
Morris Lake	4	0	0	0	1	1	0	0	0	1
Plum Creek	0	4	1	1	3	2	14	0	3	2
Tenderfoot Creek	7	3	1	3	9	0	4	1	0	0

Table 3. Trends in capture success for nine species of small mammals, examining trends according to distance from water (ANOVA) and between two distinct soil moisture classes (t-test). Results in bold indicate a significant biological trend (p<0.10).

	Distance (df = 9)			Moisture		
Species	F-ratio	p	Preference	t	p	Preference
Blarina brevicauda	0.726	0.684		**2.718**	**0.015**	**< 55%**
Myodes gapperi	1.633	0.120		**1.761**	**0.096**	**< 55%**
Microtus pennsylvanicus	**2.802**	**0.007**	**0-10m**	**5.132**	**<0.001**	**> 55%**
Peromyscus leucopus	0.641	0.758		0.872	0.395	
Peromyscus maniculatus	0.619	0.777		0.703	0.492	
Sorex arcticus	1.075	0.390		**1.826**	**0.085**	**< 55%**
Sorex cinereus	1.190	0.313		**2.672**	**0.016**	**< 55%**
Tamias striatus	0.343	0.958		**9.953**	**<0.001**	**< 55%**
Zapus hudsonius	1.293	0.254		0.676	0.508	

Appendix 1. List of species captured, with four-letter codes referenced in Table 2.

Family	**Scientific name**	**Common name**	**Code**
Muridae	*Myodes gapperi*	Southern red-backed vole	MYGA
Muridae	*Microtus pennsylvanicus*	Meadow vole	MIPE
Muridae	*Peromyscus leucopus*	White-footed mouse	PELE
Muridae	*Peromyscus maniculatus*	Deer mouse	PEMA
Sciuridae	*Tamias minimus*	Least chipmunk	TAMI
Sciuridae	*Tamias striatus*	Eastern chipmunk	TAST
Soricidae	*Blarina brevicauda*	Northern short-tailed shrew	BLBR
Soricidae	*Sorex arcticus*	Arctic shrew	SOAR
Soricidae	*Sorex cinereus*	Masked shrew	SOCI
Zapodidae	*Zapus hudsonius*	Meadow jumping mouse	ZAHU

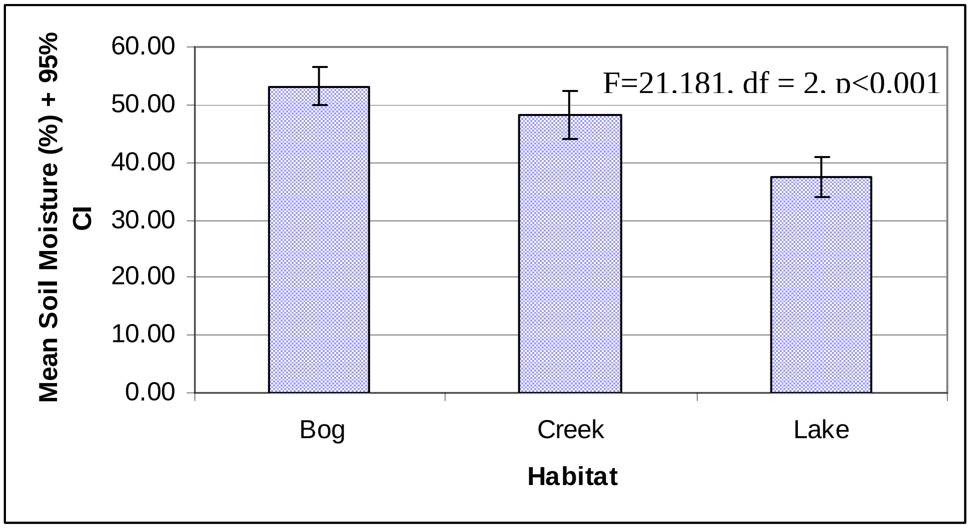

Figure 1. Mean soil moistures (95% CI) for the three different habitats. An ANOVA indicated that, on average, lakes were significantly drier than either the bogs or creeks.

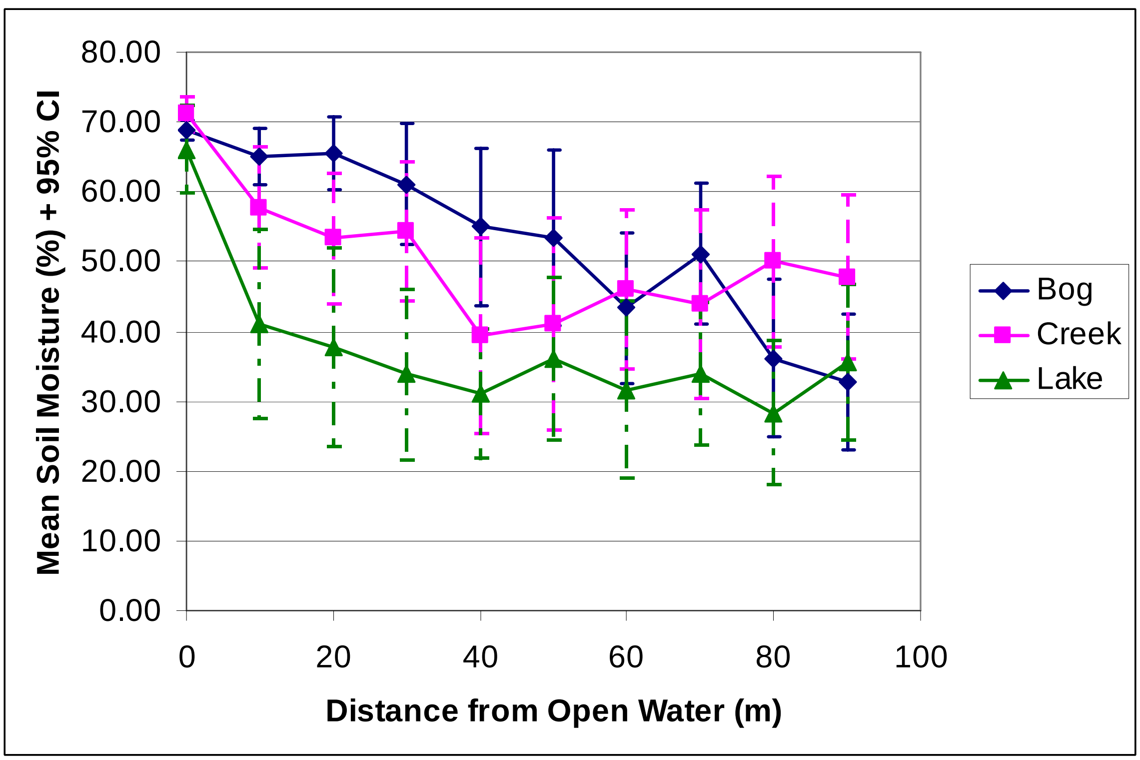

Figure 2. Mean soil moisture readings across distances for the three habitat types. Across all habitat types, the only significant difference in soil moisture was between 0-10m and 20-90m from the water's edge.

Appendix 2. List of species captured, with four-letter codes referenced in Table 2.

Family	**Scientific name**	**Common name**	**Code**
Muridae	*Myodes gapperi*	Southern red-backed vole	MYGA
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Muridae	*Peromyscus leucopus*	White-footed mouse	PELE
Muridae	*Peromyscus maniculatus*	Deer mouse	PEMA
Sciuridae	*Tamias minimus*	Least chipmunk	TAMI
Sciuridae	*Tamias striatus*	Eastern chipmunk	TAST
Soricidae	*Blarina brevicauda*	Northern short-tailed shrew	BLBR
Soricidae	*Sorex arcticus*	Arctic shrew	SOAR
Soricidae	*Sorex cinereus*	Masked shrew	SOCI
Zapodidae	*Zapus hudsonius*	Meadow jumping mouse	ZAHU