COMPARISON OF THE EARTHWORMS *Lumbricus terrestris, Lumbricus rubellus, AND Aporrectodea trapezoids* PREFERENCE FOR DIFFERENT SOIL TYPES, LEAF LITTER, AND TREE COMPOSITION

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Abstract- The purpose of this study was to determine if there is a correlation between the abundance of worms (*Lumbricus terrestris, Lumbricus rubellus*, and *Aporrectea trapezoids* combined) and a variety of factors such as leaf litter weight, soil pH, soil type (sand vs. clay), and forest type (conifer vs. hardwood). Within Colonial Point (located near Burt Lake at the University of Michigan's biological station), plots were randomly taken along a transect line within the following location types: conifer/sandy sites, conifer/clay, hardwood/sand, and hardwood/clay. Amount of worms, leaf litter weight, soil pH, soil type, and forest type were all classified and measured. The results suggested a significant correlation between soil type and worm abundance. There is also a possible trend between worm abundance and pH, however the data on forest types and leaf litter suggested that these variables did not have a significant effect on worm abundance. Worms preferred the clay soils with higher pH, yet they did not seem to have as much of a preference for forest types or leaf litter weight.

Key words- *Lumbricus terrestris, Lumbricus rubellus, Aporrectea trapezoids*, Soil type, Forest type, and Leaf litter.

INTRODUCTION

Earthworms are extremely important to the decomposition of soil and leaf litter (Bohlen et. al, 1997), play a key role in nutrient cycles, and even create assimible carbohydrates for plants (Berlin, 1988). They are important to tree regeneration and maintenance of biological diversity (Belote, 2008). For agriculture, worms have a positive effect upon soil fertility, and their burrowing open up deeper lying layers in the rain (Beddard, 1922). However in forests, earthworms often change the chemical and physical composition of the soil, and therefore change what vegetation the soil can hold (Satoko, 2003). They often deplete the O horizon, which in turn decreases nutrient, moisture, and root medium availability for trees. Because of this, invasive earthworm species can have a detrimental effect on forests (Hale et. al., 2005). Therefore, this study, which focuses on worm abundances under different conditions, would potentially help better predict and prevent where invasive earthworms may inhabit next. It may also help determine rates of decomposition and nutrient cycling within certain areas.

Colonial Point, located in the University of Michigan's Biological Station, is a forest home to an abundance of earth worms such as *Aporrectea trapezoids, Lumbricus terrestris*, and *Lumbricus rubellus.* Colonial Point has been surveyed, and conifer, northern hardwood and other stand types have been identified (Albert, 1987). Within different sections of Colonial Point, there are a multitude of different soil texture types. These include sandy and clay textures in which the earthworms live. Worms are 75-90% made of water, yet they lack the ability to maintain their own water body content. Therefore, when worms are in drier soil, they actually decrease in size. While some worms are able to tolerate dry conditions, worms generally like more mesic soil conditions, and typically clay soils are more mesic than sandy

(Bohlen et. al. 1996). Another soil condition favorable for earthworms is a circumneutral pH, while acidic soils lower than a pH of 6 are not very tolerable (Wherry 1924). Along those same lines, worm behavior is greatly dictated not only by the soil moisture content, and pH, but food content, leaf cover and even gas concentrations (Laverack, 1963). *L. terrestris* have specific leaf eating patterns, while *Aporrectodea* and *L. rubellus* are generalists (Curry et. al.,2007). With the basic understanding of what conditions earthworms thrived in, the purpose of our study was to determine if there is a difference in worm abundance in correlation with landscape features such as soil composition (sandy vs. clay), leaf liter, and tree species (primarily hardwood or conifer dominated forest stands). Conifer trees have acidic needles which create higher soil acidity. It is predicted that clay soils, with hardwood dominated leaf litter and forest stands, will have a significantly higher abundance of worms than the sandy soils and or conifer dominated leaf litter and forest stand.

METHODS AND MATERIALS

Within Colonial Point, East and West plots were randomly spaced 200meters apart (using a random number generator) along one north to south transect (Fig.1). These points contained: primarily coniferous trees on sandy soils, coniferous trees on clay soil, or northern hardwood trees on either sandy or clay soils. Within each location we measured variables such as tree cover, leaf litter, worm density, and soil composition. Tree cover was measured by creating four quadrants surrounding the location of each plot point (Fig. 2). Within each of those four quadrants two trees were classified by species, and measured for their DBH and distance from the end of the transect point. For our worm count, from each of our plot points, two random subplots were selected within 15 meters of the original plot point. On these two random subplots, the worms were shocked to the surface and counted within a 0.25^2 meter marker. To shock the worms, a 250V electrical generator was used for 25 minutes using 4 positive/4negative 1m electrodes. Leaf litter was gathered from within all the 0.25 meter squares in which the worms were shocked and weighed. The leaves were separated by species, and percent of each tree species present in the leaf litter was recorded. To determine soil composition, soil pits were dug at each of the plot points. Soils horizons, and length of each horizon were measured. Later the pH of the soils were recorded. *Kruskal-Wallis, Mann-Whitney U, Chi-Square*, and *Linear Regressions* were used to analyze the data where appropriate.

RESULTS

By looking at Figure 3, it is clear that there is a significant difference somewhere between the four different sets of plot types (hardwood clay, hardwood sand, conifer clay, and conifer sand). Data analysis revealed a chi-square=13.874, df=3, and a P-value=0.003. Next, tests indicate that there is a significant correlation between worm density and soil type ($p<0.001$) as seen in Figure 4. This test indicated that there are significantly more worms in clay soils than sandy soils. The findings on forest type vs. average worm abundance (Figure 5), revealed that there was not a significant correlation between forest cover type and worm abundance ($p=0.166$).

From Figure 6, one can see that there was not a significant correlation between number of worms and soil pH (R^2=0.365). However, there seems to be a trend in the data indicating a positive relationship between number of worms and pH. The next test run was to determine if there was a relationship between soil pH and soil type. A significant correlation between the two was found, as clay tended to have a higher pH than sand (Figure 7). The leaf litter weight vs. average number of worm correlation was tested for significance (Figure 8**),** however no significant difference was found between the two(R^2=0.069).

From Figure 9, the p-values indicate which plot types had significant differences in worm abundances. There is a significant difference in worm abundance between hardwood clay and hardwood sand (p-value= 0.01), conifer clay and hardwood sand (p-value= 0.021), conifer sand and hardwood clay (p-value= 0.009), and conifer clay and conifer sand (p-value= 0.018). There is no significant difference between conifer clay and hardwood clay (p-value= 0.163), or hardwood sand versus conifer sand (p-value= 0.122).

DISCUSSION

Results from the study suggest that there is a significant worm preference for clay soil, over sandy soil. While pH was not seen to have a significant correlation to worm abundance, a positive trend was seen between the two (Figure 6). Also, clay soils have been found to typically have a higher pH than the sandy soils, which may suggest that pH had an effect on worm soil choice. This makes it difficult to differentiate whether soil pH, or type were the reason for average worm abundance. There is not a significant difference in worm abundance between the different forest types, suggesting that the tree type does not have as much of an impact on the amount of worms at a given point as the soil does. It may be concluded then that the acidic needles of the conifer trees do not impact worms as much as acidic soil. Acidic needles of conifer trees typically make soils more acidic, leading to the question of how much of impact conifer tree needles have on the acidity of the soil. Also, worms like soils that hold more moisture (Bohlen et. al., 1996), and clay retains more water than sand does. Clay soil is generally more calcareous than sandy soil as well. Calcareous conditions indicate a higher soil pH (neutral to basic), which worms tend to prefer over acidic conditions. Finally, the amount of leaf liter was not shown to impact worm abundance. All in all, our results show that soil type and pH have an effect on abundance of worms, while leaf litter weight, and forest type does not. From these findings it may be beneficial in future studies to look at the effects of moisture and nutrient content in soil on earthworm abundance (clay soils are known to be more moist and nutrient rich than sandy soils). Ecologically, by knowing what conditions earthworms prefer, nutrient cycle and decomposition rates may be more easily predicted. Our conclusions may also allow new ways to predict where invasive earthworm species choose to inhabit. This may help prevent forest damage via earthworm destruction.

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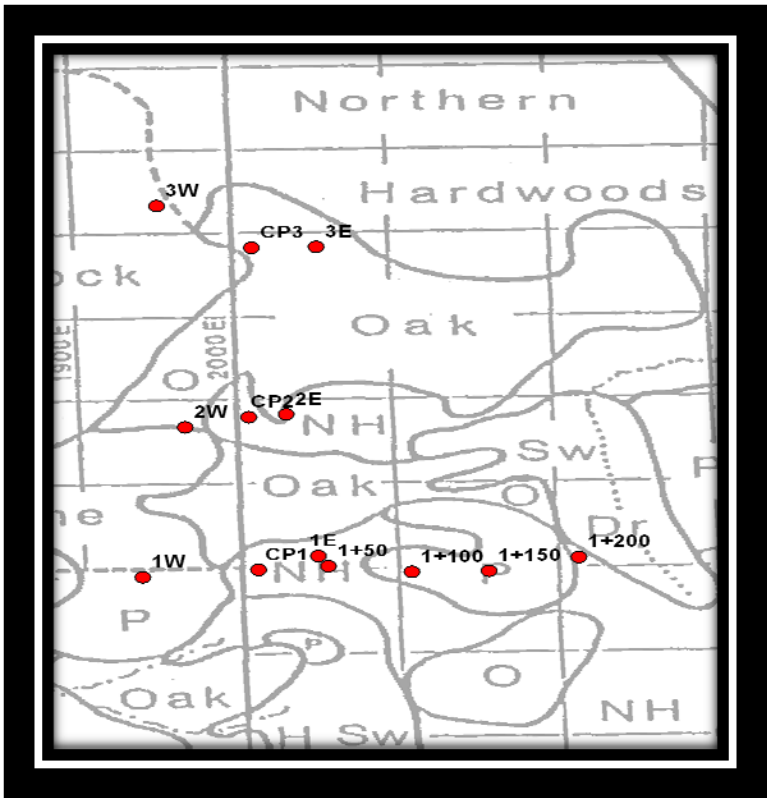


Figure 1. NORTH TO SOUTH TRANSECT WITH RANDOM PLOT POINTS. Red dots contain plot samples used with different soil and tree types within Colonial Point.

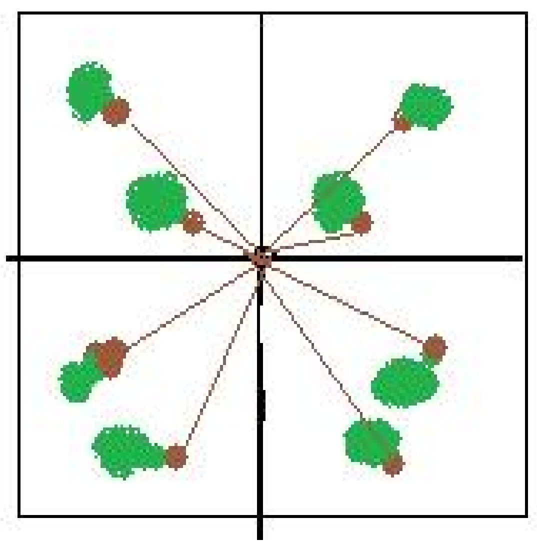


Figure 2. TREE QUADRANTS USED FOR MEASUREMENTS. Center is plots point, with four quadrants surrounding the point (two trees per quadrant were measured for DBH, species, and distance from center).

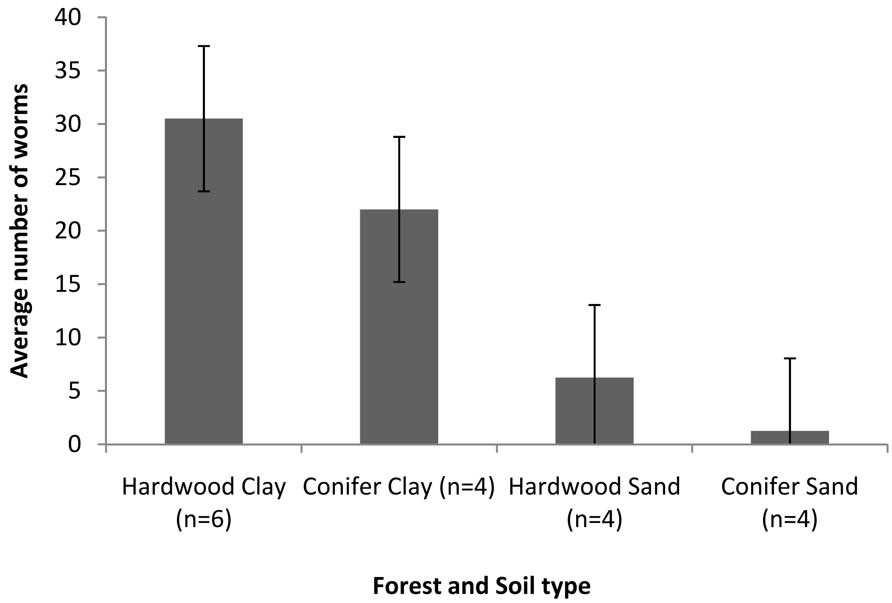


Figure 3. AVERAGE NUMBER OF WORMS IN THE HALF METER PLOTS FOR THE DIFFERENT FOREST AND SOIL COMBINATIONS. N = 6 for Hardwood clay. N = 4 for Conifer Clay, Hardwood Sand, and Conifer Sand. *Kruskal-WallIS* test used

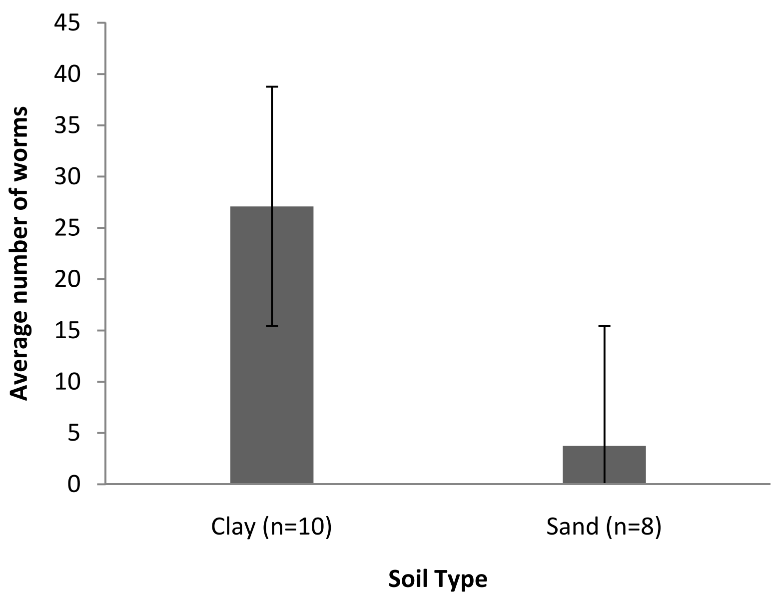


Figure 4. THE AVERAGE NUMBER OF WORMS FOUND IN HALF METER PLOTS WITH CLAY SOIL (N=10) AND SANDY SOIL(N=8). *Mann-Whitney U* test indicates a significant difference between the two ($p < 0.000$). SEM bars

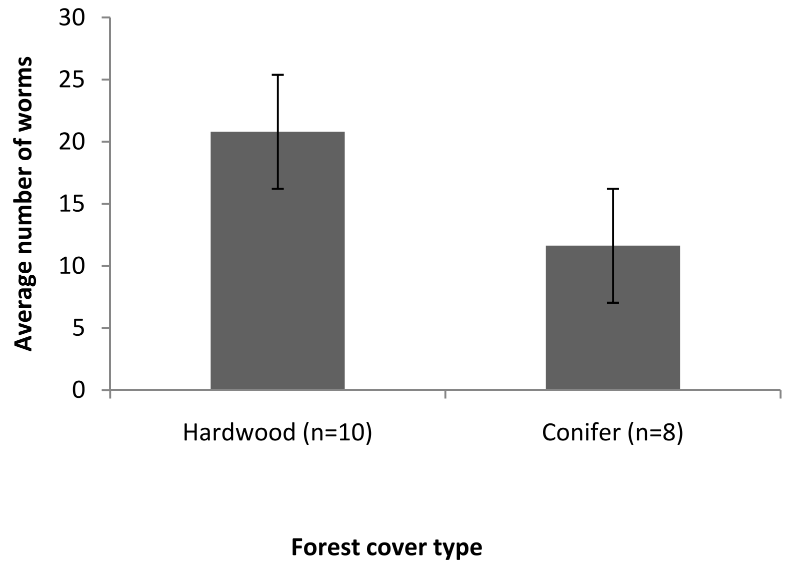


Figure 5. THE AVERAGE NUMBER OF WORMS IN CONIFER VERSUS HARDWOOD FORESTS. the average number of worms founds in half meter plots in hardwood dominated areas and conifer dominated areas. *Mann-Whitney U* test show no significant difference between the two.SEM bars present.

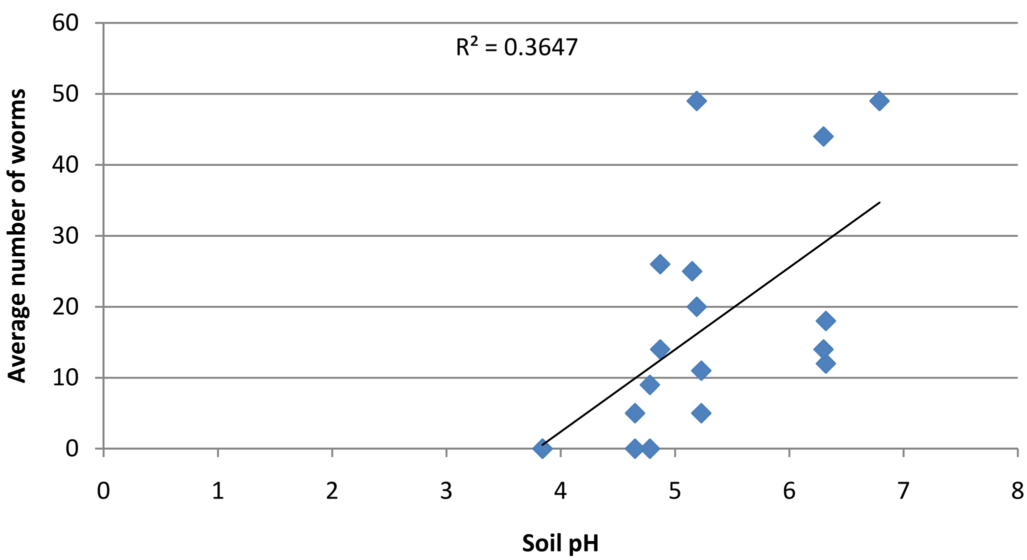
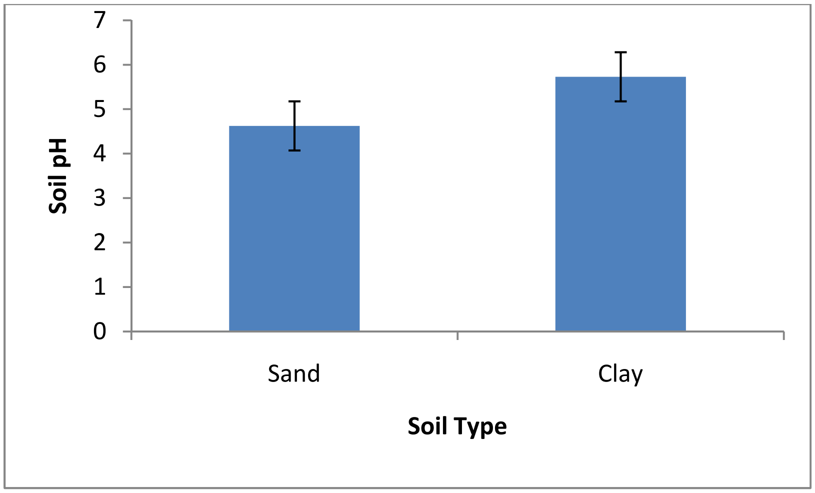


Figure 6. RELATIONSHIP BETWEEN PH OF THE SOIL AND THE NUMBER OF WORMS IN THE MEASURED HALF METER PLOT. The correlation is not significant, although there appears to be a trend occuring. *Linear Regression* used for analysis.



-**Figure 7**. COMPARISON OF SOIL TYPE VS. SOIL PH. *Mann-Whitney U* test used for analysis. SEM bars present.

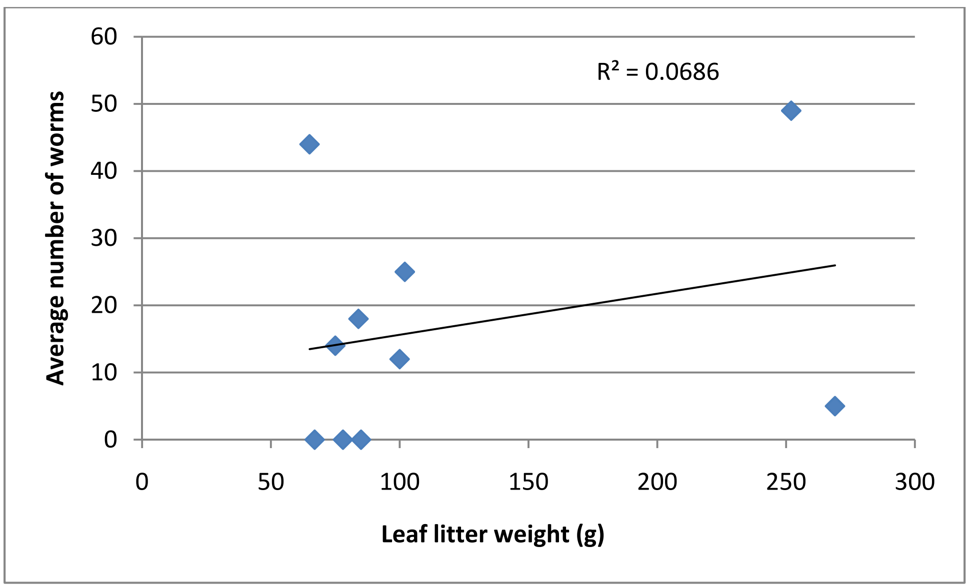


Figure 8. LEAF LITTER WEIGHT VS. NUMBER OF WORMS. The relationship between the weight of the leaf litter to the number of worms in each half meter plot is shown. No significant relationship is seen (R^2= 0.0686). *Linear regression* used for analysis.

	Hardwood Clay	Hardwood Sand	Conifer Clay
Hardwood Sand	**0.01**		
Conifer Clay	0.163	**0.021**	
Conifer Sand	**0.009**	0.122	**0.018**

Figure 9. P-VALUE TABLE WITH DIFFERENT SITE TYPES. Table of p-values indicating whether there is a significant difference between the three different site types. The bolded p-values indicate a significant different in worm abundance.