THE EFFECTS OF DOMINANT OVERSTORY AND SOIL ON THE DENSITIES OF WORM POPULATIONS IN THE FORESTS OF COLONIAL POINT

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Abstract - The purpose of this study was to determine the factors that affect worm distribution in northern Michigan forests, specifically within Colonial Point. The variables in consideration are dominant tree species, comparing hardwood and conifer, soil composition, comparing clay and sand, soil Ph, and leaf litter mass. The densities of worms in clay soil were significantly higher than in sandy soil. The densities were also consistently higher in the hardwood areas than in the conifer areas, however, there was no significant difference. There was no correlation between mass of the leaf litter and worm densities. Soil texture was found to be the primary determinant for worm densities.

Key Words- Worms, worm densities, conifer stands, hardwood stands, leaf litter mass, soil pH.

INTRODUCTION

Earthworms play an important role in the development of soils, and are a crucial part of the agriculture and grazing areas. The worms serve to cycle nutrients and help aerate the soil and increase moisture (Lavelle, 1988). In the Great Lakes Region, however, they are an invasive animal with many harmful effects on the forests that they invade. One theory states that native worms went locally extinct during the last glacial advance and any worms present today that did not return by their own migration are exotic species (Reynolds et al 1974). This theory, however, is hard to support as worms do not fossilize well and it is difficult to determine what species were present before (Kalisz 1991). Given that the average rate that a worm can travel is about 10 meters a year, and the last retreat was about 12,00-25,000 years ago worms would not be expected more than 155 miles north of the line of maximum glaciations (Proulx 1974, Hoogerkamp et al 1983). Worms are currently seen above this point and were therefore introduced by a method beyond their own means. An increase in worm biomass in northern hardwood forests have been associated with a decrease in available soil nutrients including ammonium, phosphate, and nitrates (Hale et al., 2005). In addition, it has been observed that an increase in worm densities lead to a decrease in sapling densities, native understory diversity, and the thickness of the O layer. Nutrient availability in the soils of sugar maple forests also decrease (Hale and Host, 2005). The leaf litter on the forest floor has plays an important role in the ecosystem function for energy cycling, tree regeneration, and the maintenance of biological diversity (Belote 2008). Different earthworm species play different roles in the forest degradation as they have different eating habits *L.*

terrestris being very specific and *L. rubellus* generalist feeders (Curry and Schmidt 2007). Two of the most common species in the forests of Colonial Point are *Lumbricus rubellus* and *Lumbricus terrestris. Lumbricus rubellus* generally accounts for the least amount of biomass in the forests however it is the species largely responsible for the decrease in species diversity and density in the understory and herbaceous groundcover. *Lumbricus terrestris* accounts for the majority of the earthworm biomass and is associated with a decrease in species richness in the forests where it dominates (Hale 2004). It has been suggested that differences in vegetation, soil nutrients, pH, and texture all seem to affect the presence of worms in an area (Lavelle, 1988). This paper will look at the soil texture, soil pH, dominant vegetation, and leaf litter composition in a local area to determine which of these factors demonstrate the greatest affect on the presence of worms in the forests of northern Michigan, specifically within Colonial Point. If worms prefer mesic conditions and nutrient rich leaf litter, they will prevail in rich clay soils and hardwood dominated areas. If none of these factors affect the density of the worms then there will be no difference in worm densities between the various plots.

METHODS AND MATERIALS

Plot Selection. To conduct this study a transect was placed along the road at the 2000E line as indicated by Dennis Albert's grid of Colonial Point (Albert and Minc, 1987). At 200 meter intervals along this transect, beginning at 1200N and working northwards, points were randomly selected on both the east and west side of the road using a random number chart to determine both the angle from north and the distance from the 2000E line that our plot was to be located. In order to avoid any data discrepancies which might be associated with contact with the road, the random angles were restrained within a range of 45-135 degrees on the east side of the road and 225-315 degrees along the west side of the road and the distances were between 50 and 100 meters.

Tree Sampling. In order to determine the dominant trees in the area of our sample, the area was divided around the random point into quadrants according to the cardinal directions and the two overstory trees in each quadrant nearest to the point were measured, taking note of tree species, DBH, and distance from the center point.

Soil Sampling. In order to look at the effects of soil type on worm density the depth of each horizon was measured. A sample from each horizon was taken pH recorded.

Leaf Litter Sampling. To determine the possible effect of leaf litter composition on worm density, the leaf litter within the two half meter squares was collected. The percent of the total made up by each species and the weight of the entire sample was measured.

Worm Density Measurement. To measure the worm density in the area, two half meter plots were placed randomly within 15 meters of the point. These half meter plots were then shocked using an electrical generator with a charge of 250 V for 25 minutes and the worms that came to the surface were counted.

Statistical Analysis. A *Kruskal-Wallis Test* was used to compare the combined forest cover types and soil texture to worm densities. *Mann-Whitney U* tests were used to determine if there were significant relationships between the number of worms and soil type, the number of worms and forest cover type, and the relationship between soil type and soil pH. Regressions were used to determine the relationship between the number of worms and soil pH and the number of worms and leaf litter weight.

RESULTS

The combined forest cover and soil type had a significant effect on worm counts for each of the four test site types indicating a significant difference between either the soil types or the forest cover ($P=.003$) (Figure 1). While there was a trend for more worms in hardwood plots than in conifer plots, no significant difference was seen between the two forest cover types ($P=.166$) (Figure 2). Similarly, there was no significance between the gross leaf litter weight and worm abundance (Figure 3). The next test showed a significant correlation between the type of soil present and the worm abundance ($P < 0.001$) (Figure 4). While there was no significant correlation between the pH of the soils and the densities of the worms, there was a general trend for the more basic areas to have a higher worm density ($R^2=.365$) (Figure 5). There was also a significant difference between the pH of clay soil and sandy soil ($P =.007$) (Figure 6) which supports the correlation between pH and worm abundance.

DISCUSSION

The significant differences in worm density between the four different site combinations indicate that soil has an effect on the worm population density. The lack of a significant difference between the hardwood and conifer sites focusing on tree type alone indicates that the dominant overstory is not influential in worm densities. It could be assumed, then, that the soil type is the major determinant in this analysis. This is supported by the significant values associated with soil type and worm densities. While there is a significant relationship between the soil pH and worm densities, the relationship is very weak in comparison to the soil texture. It can therefore be suggested that, of the variables studied, soil texture is the primary determinant of worm density in the area. More tests would be necessary to support this claim. Control sites with high pH and sandy soil and low pH and clay soil would help to determine which variable is more significant in worm densities. Knowing more about what factors play a significant role in the distribution of worms can lead to predictions of where the earthworm invasion will head in the future and which forest types should be observed for signs of worm infestation.

REFRENCES

ALBERT, D. A. and MINC, L.D. 1987. The natural ecology and cultural history of the Colonial Point red oak stands. Technical report, University of Michigan Biological Station no. 14

Belote, R. T. and R. H. Jones. 2008. Tree leaf litter composition and nonnative earthworms influence plant invasion in experimental forest floor mesocosms. Biological Invasions 11:1045-1052.

Curry, J. P. and O. Schmidt. 2007. The feeding ecology of earthworms - A review. Pedobiologia 50:463-477.

Hale, C. M., Frelich, L. E., and Reich, P. B. 2005. Exotic European Earthworm Invasion Dynamics in Northern Hardwood Forests of Minnesota, USA. Ecological Applications, 15:3:848-860 < http://www.jstor.org/stable/4543400>

HALE, C.M. and HOST, G. E. 2005. Assessing the impacts of European earthworm invasions in beechmaple hardwood and aspen-fir boreal forests of the western Great Lakes region. National Park Service Great Lakes Inventory and Monitoring Network Report GLKN/2005/11.

HALE, C. M. 2004. Ecological consequesces of exotic invaders: interactions involving European earthworms and native plant communities in hardwood forests. PhD dissertation. Universidy of Minnesota.

Hoogerkamp M., Rogaar, H., and Eijsackers. H.J.P. 1983. Effect of earthworms on grassland on recently reclaimed polder soils in the Netherlands. pp. 85-103. In: Satchell, J.E. (ed.) Earthworm Ecology from Darwin to Vermiculture, Institute of Terrestrial Ecology Cumbria, UK.

Lavelle, P. 1988. Earthworm activities and the soil system. Biology and Fertility of Soils, 6:3:37-251. <http://www.springerlink.com/content/l34271u0x83k8070/> DOI: 10.1007/BF00260820.

PROULX, N. 2003. Ecological risk assessment of non-indigenous earthworm species. Minnesota Department of Natural Resources. Saint Paul, MN.

RENYOLDS, J. W., CLEBSCH, E.E.C., RENYOLDS, W.M. 1974. Contributions to North American earthworms. The earthworms of Tennessee (Oligochaeta). I. Lumbricidae. *Bulletin of Tall Timbers Research Station.* 17: 1-133.

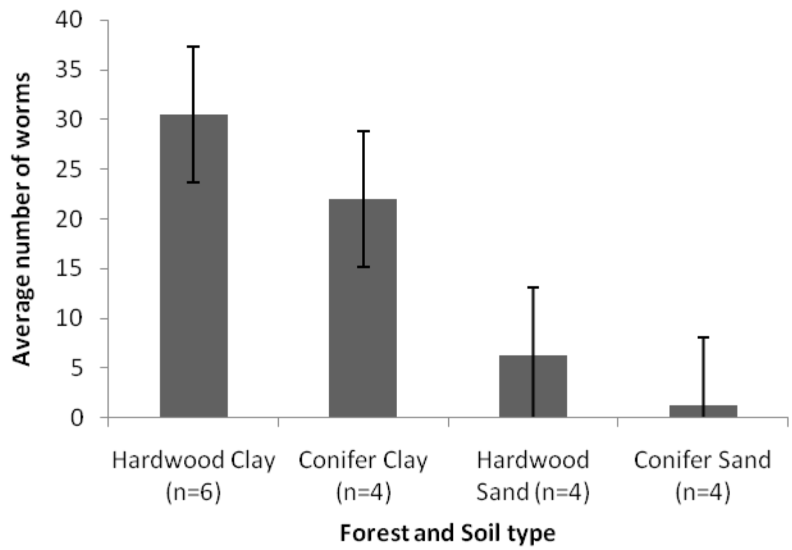

Figure 1. AVERAGE NUMBER OF WORMS IN EACH PLOT TYPE
Kruskal-Wallis p=.003

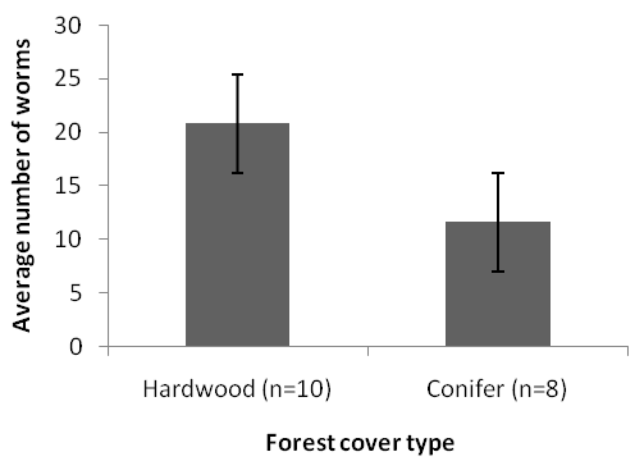

Figure 2. AVERAGE NUMBER OF WORMS FOUND IN THE DIFFERENT OVERSTORY TYPES *Mann-Whitney U* test shows no significant difference between the the two (*p=.166*).

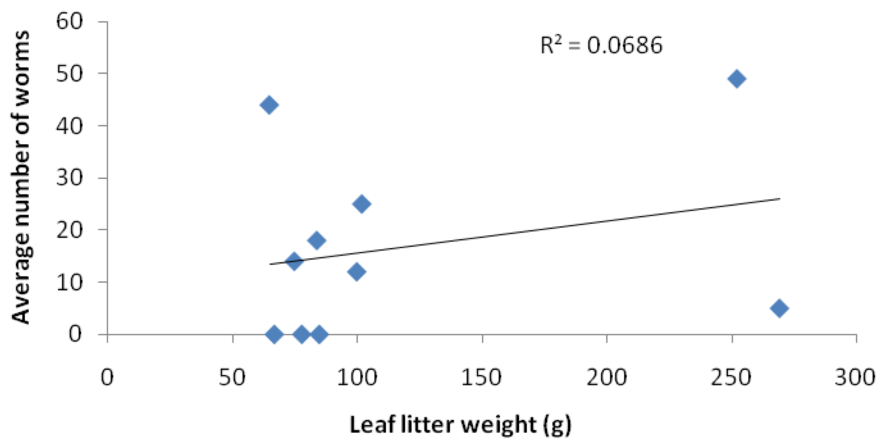

Figure 3. RELATIONSHIP BETWEEN LEAF LITTER WEIGHT AND THE NUMBER OF WORMS No significant realtionship is seen.

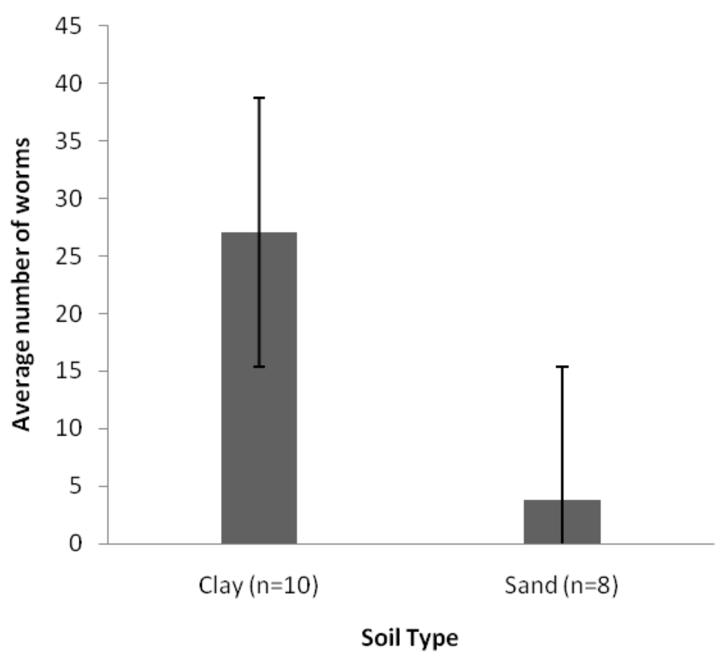

Figure 4. AVERAGE NUMBER OF WORMS FOUND IN PLOTS WITH DIFFERENT SOILS *Mann-Whitney* test indicates a significant difference between the two ($p< 0.001$).

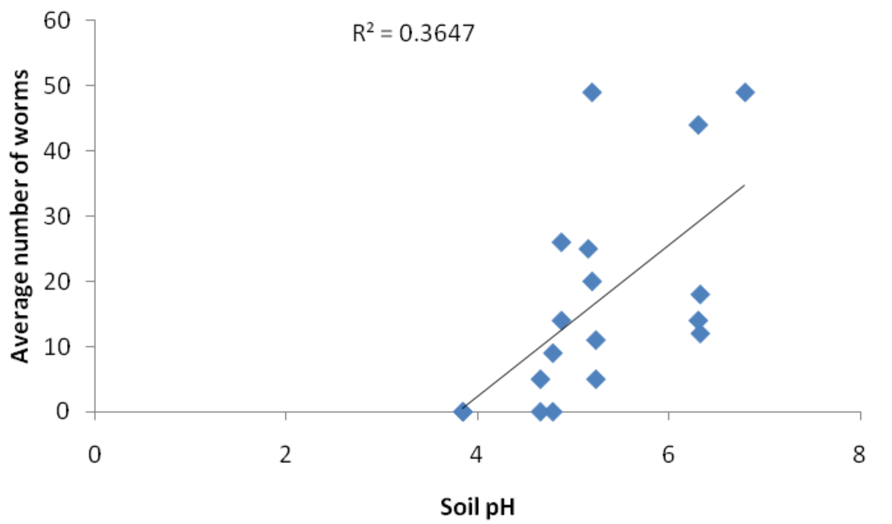

Figure 5. AVERAGE NUMBER OF WORMS AS RELATED TO Ph Relationship between the pH of the soil and the numberof worms in the measured half meter plot. The relationship is not significant.

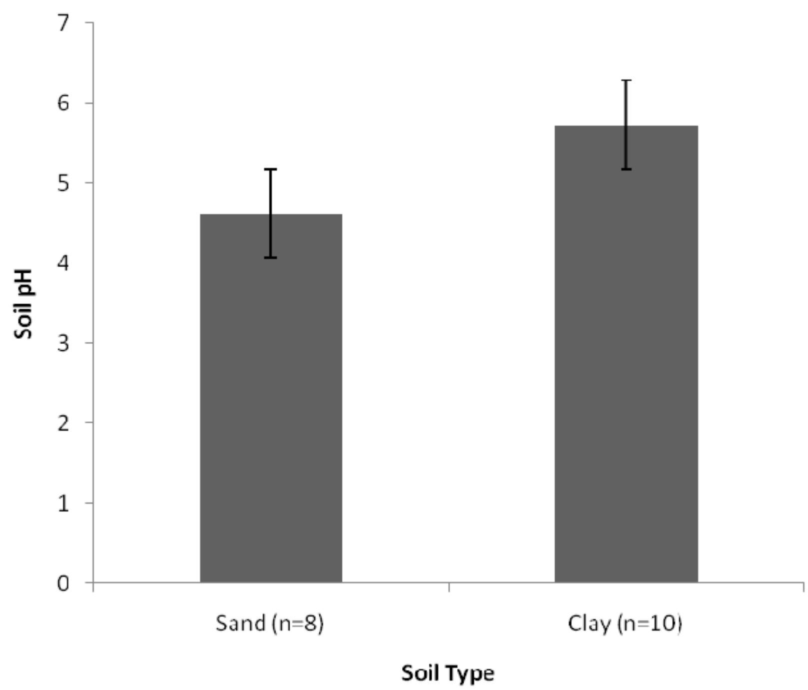

Figure 6. AVERAGE PH OF THE SOIL COMPARED TO THE SOIT TYPE Average clay pH is significantly higher than sand pH. *p= .0007*.