Effects of Non-Native earthworms on the University of Michigan Biological Station soils

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Abstract

Soil is an ecosystem rich in nutrients, containing a wide variety of organisms all held within a delicate ecological balance. Earthworms a well-known detritivore, able to break down nutrients and facilitate nutrient flow throughout soil horizons. Having no earthworms native to Michigan, the purpose of this experiment was to better understand the complex interactions between earthworms and their environment, and their potential impact on native soils. Conducted on University of Michigan Biological Station (UMBS) property in the Northern Lower peninsula of Michigan, this experiment surveyed earthworm populations by replicating a procedure developed by the Great Lakes Worm Watch, as well as conducting a controlled study on earthworm facilitated nutrient flow. Results showed there to be a significant differences in worm population numbers at varying locations, as well as significant differences in soil nutrient levels when exposed to earthworms. These results could potentially inform upon soil dynamics as well as the ability of an invasive organism to have impacts on its new environment.

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Introduction

Decomposers play a critical role in nutrient cycling; a vital service for any functioning ecosystem. These organisms help to maintain the cycle of essential biological elements, such as carbon, nitrogen, and phosphorus (Alexander, 1977). The soil is an ecosystem rich in nutrients, and containing a wide variety of organisms from macrofauna, as well as microflora and microfauna. Earthworms are a well-known detritivore, able to process complex organic molecules trapped within organic matter and release them as in forms useful to other organisms (Edwards & Bohlen, 1996). This makes them particularly adept for agricultural use, able to redistribute soil nutrients and allow for improved plant growth (Sharma *et al.,* 2017).

However, within the Great Lakes Region, there are no native species of earthworm. The main decomposers in the soils of this region were beetles until earthworms native to Europe were introduced as a consequence of fishing (Shartell *et al.,* 2013). These introduced species fall into three distinct ecological groups: epigeic, leaf litter feeders, endogeic top soil feeders, and anecic, deep soil feeders (Great Lakes Worm Watch, 2011). This recent invasion has impacted forest floor characteristics, including reducing leaf litter, speeding up decomposition, and thinning organic soil layers (Bohlen *et al.* 2004; Frelich, 2006). Complex ecological systems rely on complex organismal interactions in order to function, and non-native species can upset this natural balance.

By examining the dispersion of earthworm in different soil types around the Lake Douglas area, as well as modeling their potential effects on soil nutrient flow, this experiment seeks to understand the complex interactions between earthworms and their environment. Our hypothesis is that earthworms will be more abundant in higher nutrient soils and have a clear impact on soil nutrient flow.

Materials and Methods

This experiment was conducted during July 2018 at the University of Michigan Biological Station and contained two portions, a field survey as well as a controlled lab portion. The field surveys spanned four sites across UMBS property, Pellston, MI; a moraine, an outwash plain, an outwash channel, and Colonial Point moraine. To conduct earthworm population surveys a protocol developed by the Great Lakes Worm Watch (Join the Research Team) was used. A solution of 10 g of mustard powder per 1 L of water was prepared in large portable 18 L jugs, using a total of 180 g of mustard powder per jug. Once at a site, a sampling location was chosen and cleared of leaf litter and/or brush. A center point was chosen at random and we measured one meter to the left of this point and one meter to the right. At each of these two points a transect consisting of a 60.5 cm in diameter metal bucket with the bottom sawn out, was placed. Six liters of the mustard solution was poured evenly across one transect, we waited 5 minutes, and poured another six liters. Any worms that emerged were removed and counted (to be replaced at the end of sampling). This procedure was repeated for the second transect, and across all 4 sites. Additionally at each site, soil temperature, at surface level and at 5 cm depth, was taken at center point using temperature probe and soil pH reading was taken at center point using pH testing kit.

For the lab component of this experiment, test containers were prepared by stacking three 2 liter bottles vertically, two with top and bottom cut off and one with only the top removed, and securing with duct tape. Each container was then filled with 35 cm of sand mixture (sand from UMBS campus mixed with vermiculite in a 3:1 mix), 5 cm compost (and finally 2 cm leaf litter (from UMBS campus, mixed leaf litter). Six test containers were prepared, three containers had four green worms (*Lumbricus terrestris*) an anecic species, added to each, and three containers had four red worms (*Eisenia fetida*), an endogenic species, to each. 0.5 L of water was added to each to keep moist. After a span of 11 days, during which containers were left untouched, we added 2 L of water to each container and put all in -20 C freezer. After a period of two days the containers were removed and a band saw was used to cut enclosures in half lengthwise. The cut containers were left at room temperature for two days to allow for thawing after which we removed the top layers of compost and leaf litter. Each sample container was homogenized by dumping into a bucket and mixing thoroughly. A small portion of each homogenized sample was placed in a jar and dried for 12 hours in 100 C drying oven to remove water. Dried samples were then placed into pre-weighed crucibles, along with a control sample consisting of dry sand and vermiculite mixture. All crucibles were weighed and placed into a muffle furnace at 500 C for four hours to burn off carbon. A final mass of crucibles filled with samples was taken.

A Wilcoxon t-test was run comparing worm population numbers from sites, grouped into moraine sites and outwash sites. Additionally, a t-test was run comparing carbon burn-off between red worm samples and green worm samples as well as a t-test comparing carbon burn-off between all samples containing worms and our control. Linear regressions were modeled for correlation between worm numbers and soil pH, surface soil temperature, and soil temperature at 5cm.

Results:

We found statistically significant results when comparing carbon burn-off of samples exposed to earthworms vs. our control ($p\text{-value} < 0.05$) (Table 1). Results were not significant however, when comparing carbon burn-off between red worm samples and green worm samples ($p\text{-value} > 0.05$) (Table 1). Statistically significant results were found when comparing worm numbers between moraine sites and outwash sites, with the moraine sites shown to have an average of ~12 worms while the outwash sites had an average of 0.5 worms. Results from linear regressions run comparing average worm count to soil pH (Fig. 2) and worm count to surface soil temperature (Fig. 3), were not shown to be significant (p-value>0.05). A linear regression run comparing average worm count to soil temperature at 5 cm was shown to have significant results (p-value<0.05).

Discussion

Our experiment has shown there to be both a significant difference in earthworm abundance across different habitats, as well as an impact of earthworms on soil nutrient flow. Our data show there to be a higher abundance of earthworms in moraine sites as opposed to outwash sites (Fig. 1). As our data did not show this to be due to pH levels (Fig. 2), it is quite possible this earthworm abundance is due to the higher quality soil typically associated with moraines. Other possible explanations may involve the proximity of the colonial point site to an established fishing lake, which may have led to an earlier introduction of earthworms and thus a more established population. Additionally, soil moisture was not measured in this experiment which may have affected earthworm activity. Earthworm activity has been shown to be significantly affected significantly by soil moisture (Perreault & Whalen, 2006). Additional variables that may have affected earthworm numbers include time of day. While data was generally collected in the afternoon, time of day was not held constant when visiting plots. If earthworms are more active and thus more likely to surface at one time of day, this may have affected our data collection.

As earthworms have been shown through this experiment to impact flow of organic matter through the soil horizons (Table 1), a question arises of how this may impact a relatively high nutrient system such as a moraine. Negative impacts of the increased nutrient flow caused by invasive earthworms have been shown (Frelich, 2006), but it is yet unclear how these invaders may impact native forest ecosystems. While there appeared to be no significant difference in ability of the acetic green worm species or the endogenic red worm species to facilitate flow of top soil nutrients deeper into the soil (Table 1), this may be due to skewed carbon burn-off data due to a possibility of the samples still containing water when placed into the muffle furnace.

This experiment leads us to the conclusion that non-native earthworms, regardless of their status as endogenic or acetic, to have a presence in the soils of UMBS and a likely negative effect on the soil dynamics of the region. This result helps to inform upon soil dynamics as well as shows the ability of an invasive organism to have impacts on its new environment. While earthworms are not commonly seen as invasive organisms, care should be taken when bringing a non-native species to a new area through human activity.

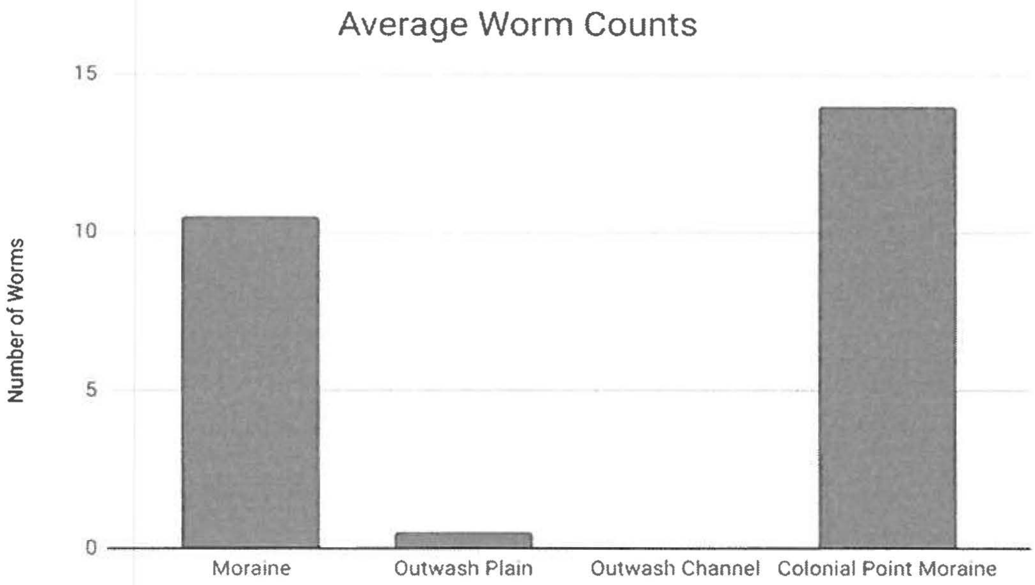

Figure 1: Displays average number of worms found between two transects at various sites across University of Michigan Biological Station property. Statistically significant results were found when comparing moraine site averages to outwash site averages (p-value<0.05)

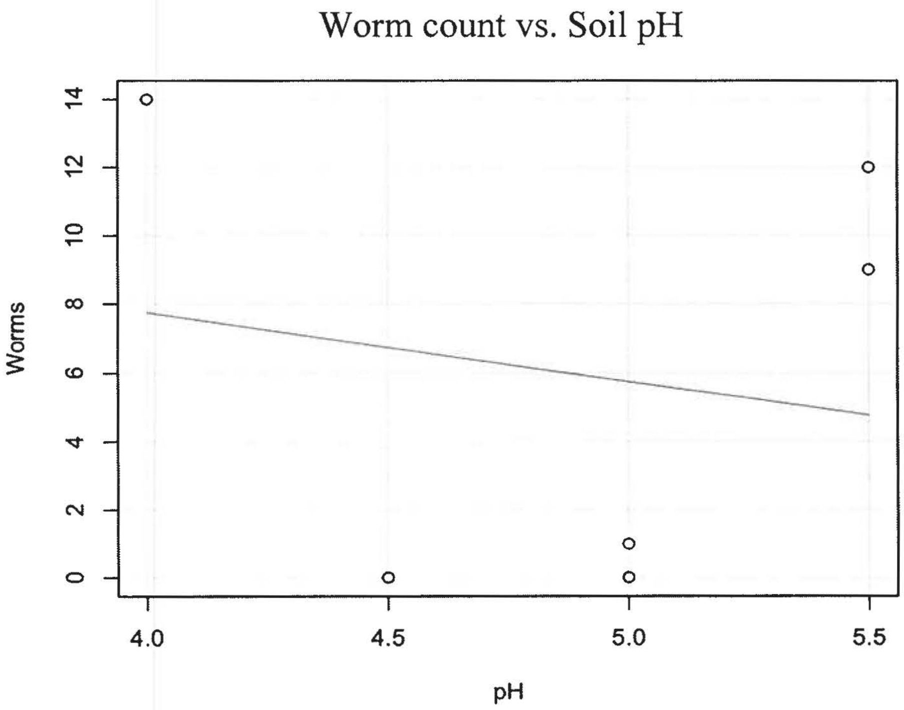

Figure 2: Displays a linear regression comparing average number of worms found and soil pH, results are shown to be insignificant (p-value > 0.05)

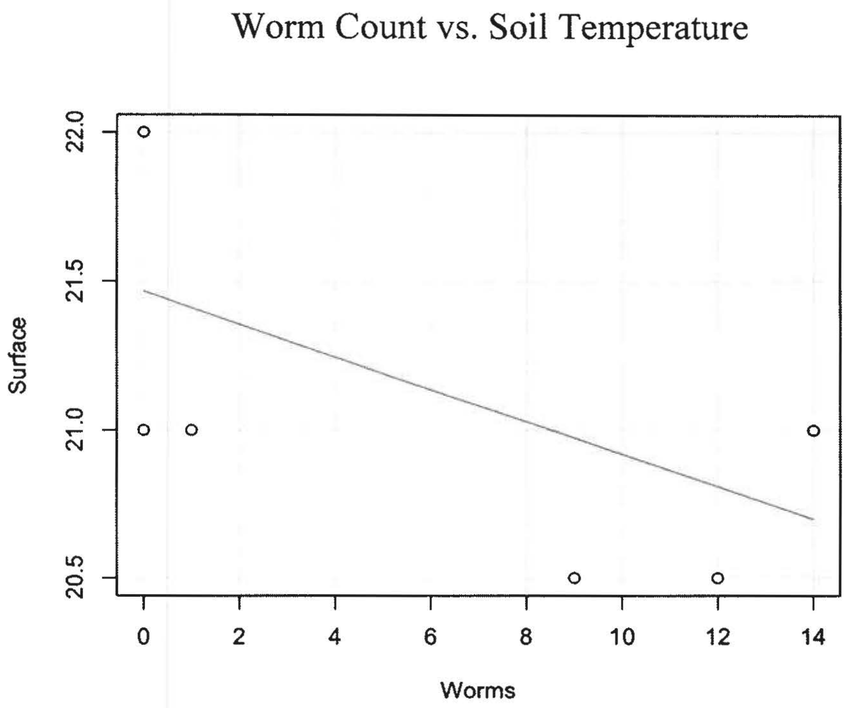

Figure 3: Displays a linear regression comparing average number of worms found and surface soil temperature, results are shown to be insignificant (p-value > 0.05).

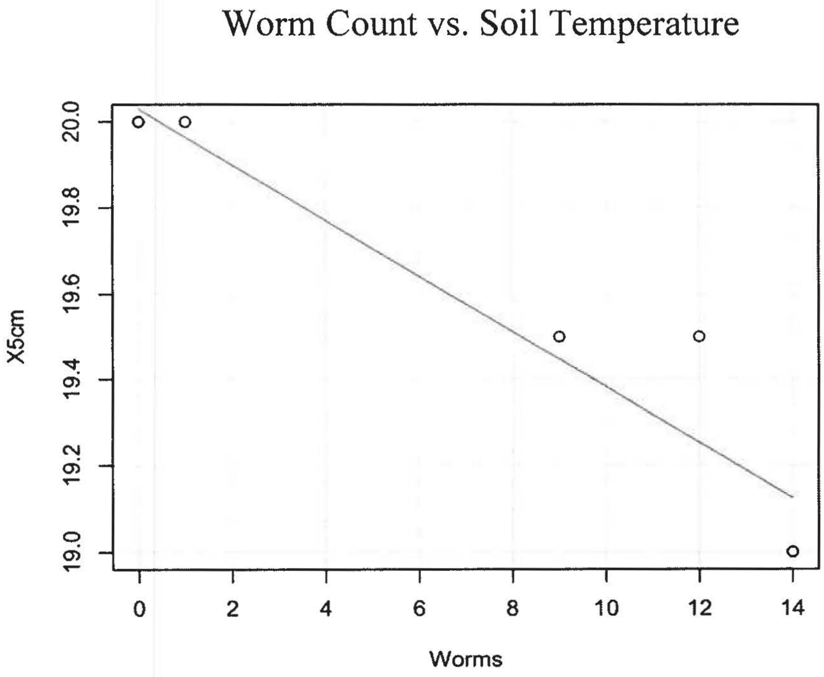

Figure 4: Displays a linear regression comparing average number of worms found and soil temperature at 5cm, results are shown to be significant (p-value < 0.05).

Percent Carbon Lost from Each Sample:

Green Worm #1:	7.41%
Green Worm #2:	5.48%
Red Worm #1:	8.27%
Red Worm #2:	6.12%
Control:	0.68%

Table 1: Displays percent of organic matter burned off from each sample, results are significant when comparing samples with worms to our control ($p\text{-value} < 0.05$).

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Join the Research Team. Retrieved from http://greatlakeswormwatch.org/team/conduct.html