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ABUNDANCE OF COMMON EARTHWORMS (*LUMBRICUS TERRESTRIS*) IN VARYING SOIL ENVIRONMENTS

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ABSTRACT

Throughout time, it has been thought that common earthworms, *Lumbricus terrestris,* prefer moist, nutrient-rich soil or areas with decaying plant matter. We tested this belief. We hypothesized that worm abundance would be greater in a grassy field area with higher moisture levels than in wooded or urban areas that contain less moisture. We found that worms were most abundant at a field site with the highest moisture level. Worm abundance was also negatively correlated with soil pH.

*Keywords: abundance, common earthworms (*Lumbricus terrestris*), soil moisture and pH*

INTRODUCTION

Earthworms are important to the environment because they facilitate ecosystem functioning. They are often an indicator of ecosystem health because their actions maintain healthy soil and plant growth. Worms break up compact soil to allow air and water to penetrate deeper under the surface, improving nutrient access and reducing soil erosion. Worms are also known for recycling organic matter by breaking down dead leaves and roots into nutrient-rich castings that improve soil fertility. Through the breakdown of organic material, worms also trap carbon in the soil, which decreases greenhouse gas emissions, a major cause of climate change. Without earthworms, soil becomes sterile and lifeless due to the lack of beneficial microbes and plant growth that can only occur in healthy soil.

Earthworms have experienced a national decline in population size over the past few years (Gargiulo 2025). The decline is caused by various factors such as habitat destruction, urbanization, pesticide use, and climate change. With the growth of cities with excessive concrete and asphalt, there has been a significant decrease in the amount of green space that organisms such as worms need to survive. Natural worm habitats are continuously being turned into roads, buildings, or chemically treated lawns. Earthworms are known to support plant growth, but with increasing agriculture, farmers have turned to pesticides and other chemical fertilizers that help their plants grow but alter the chemistry of the soil in which worms live. Lastly, worms thrive in environments that are moist and have stable temperatures, so weather extremes such as long droughts, sudden downpours, and extreme heat can devastate their populations.

Not only are earthworms highly sensitive to moisture levels in soil, but there is also the aspect of pH in the soil that worms can live in. Some earthworms can thrive in more acidic soils, while others are more intolerant (Edwards and Arancon 2022). The pH is less important than moisture because, with the changes worms cause within the soil, they can change the pH through aeration and the castings they leave behind from organic matter.

Based on the vitality of worms in ecosystems, we were curious about the location where they would be most abundant. Our survey focused on three different types of locations within the same confined area behind one of the academic buildings at Juniata College, the Brumbaugh Academic Center. We collected five samples from an urban strip of land bordering the parking lot and the field, five from the center of the field, and the final five samples from along the edge of the forest located along the far side of the field. We hypothesized that worm abundance would be higher in field areas with higher moisture levels than in urban or forested areas with less soil moisture.

FIELD SITE

Our study was in the field behind Brumbaugh Academic Center and the bordering woods at Juniata College in Huntingdon, Pennsylvania. Five study sites occurred in the center of the field, 7.5 meters apart from each other. Five study sites bordered the parking lot to get a more 'urban' setting, also 7.5 meters apart. Lastly, five study sites were located on the border of the woods, again 7.5 meters apart. The distance between the study sites bordering the woods and the field study sites was 35.08 meters, and the distance between the field study sites and the 'urban' sites was also 35.08 meters.

Figure 1. Field site behind Brumbaugh Academic Center at Juniata College, Huntingdon PA, USA.

April 2nd, 2025. The field site was 50°F on the first day that we went out and conducted the experiment behind the Juniata College academic building, Brumbaugh Academic Center. The weather was slightly sunny, but there was a cool breeze that made it cold outside. This made it very tough to dig up the 3 different patches that we needed for that day, not only due to the cold, but because the soil was dry and hard.

April 16th, 2025. The field site was 47°F on the second day that we went out and conducted the experiment behind the Juniata College academic building, Brumbaugh Academic Center. The second day was a lot nicer than the first, as it was slightly sunny, and it had rained the night before, which made the dirt a lot softer. We easily dug up the six different patches that we needed to.

May 1st, 2025. The field site was 71°F on the third day that we went out and conducted the experiment behind the Juniata College academic building, Brumbaugh Academic Center. The soil was very hard to dig, especially in the urban location, because it was very rocky, and the soil was extremely dry. We also encountered a lot of ants on this day.

May 2nd, 2025. The field site was 73°F on the fourth day that we went out and conducted the experiment behind the Juniata College academic building, Brumbaugh Academic Center. This day had the easiest soil to dig up out of the four days that we went out. While it was sunny when we were working, it had rained the night before, which made the soil soft and a bit muddy.

Figures 2-4. Earthworms, soil collections, and pH meter used to measure soil pH.

METHODS AND MATERIALS

Our methods are as follows:

1. The study site was behind the Juniata College Academic Building, Brumbaugh Academic Center.
2. We located spots to dig holes for worms using a shovel.

DOI

3. We measured each hole with a ruler to be about 12x12 and about 6in deep.
4. We then put the dirt in a plastic tray.
5. We placed soil samples in small, labelled measuring cups.
6. Once the dirt was on the plastic tray, we then sorted and filtered out the dirt little by little back into the hole, all the while taking out the worms that we found from that specific patch.
7. Once the dirt was all filtered out, we counted how many worms were found and marked it in our notebook.
8. We did the same procedure to collect all nine data samples.
9. We weighed the soil in each sample cup using a triple-beam balance.
10. We dried the soil samples in a conventional oven at a temperature of 55°C for three or more days.
    a. Dried soil samples were measured again to determine soil moisture, calculated as Gravimetric Water Content (%) = [(wet soil mass - dry soil mass) / dry soil mass] × 100.
11. We then created 15 slurries consisting of water and a portion of soil from each of our samples to determine the pH of the soil using a digital pH meter (model 88) from our 15 sample locations.
    a. Put around 0.75oz of each soil sample in a separate cup
    b. Filled the cup to the top with distilled water
    c. Stirred until it is a "slurry"
    d. Used the pH probe to determine pH
12. We analyzed the data using the Kruskal-Wallis test to compare worm abundance among our three sample sites. Spearman's Rank Correlation tests were used to compare worm abundance with soil moisture and pH.

RESULTS

A total of 15 observations were analyzed, including worm count as the response variable and environmental factors such as percent soil moisture, soil pH, and site location. Site location was classified based on position relative to the field and to urban or forested environments.

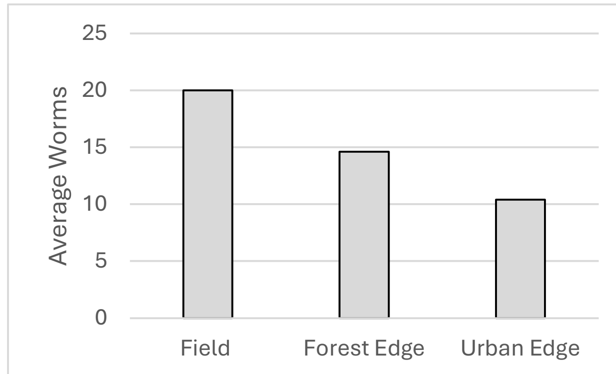

Figure 5. Bar chart of earthworm averages across three site types.

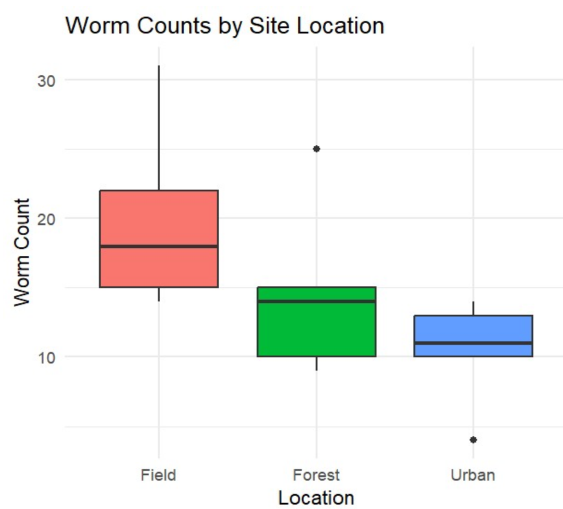

Figure 2. Boxplot of earthworm abundance across three site types: Field, Forest, and Urban.

A Kruskal-Wallis test revealed a significant difference in worm abundance between the three site types. (Kruskal-Wallis $\chi^2 = 6.25$, df = 2, p = 0.0439). Post-hoc analysis using Dunn's test with Bonferroni correction identified a significant difference between Field and Urban sites (p = 0.0385), but not between Field–Forest or Forest–Urban comparisons.

We used Spearman's rank correlation coefficient to test relationships between environmental variables- moisture and pH- and worm abundance. Soil moisture was positively but not significantly correlated with worm abundance (Spearman's ρ =

0.21, p = 0.46). However, Soil pH was negatively correlated with worm abundance (Spearman's ρ = -0.65, p = 0.0092). This indicates that higher pH values were associated with a decrease in worm abundance.

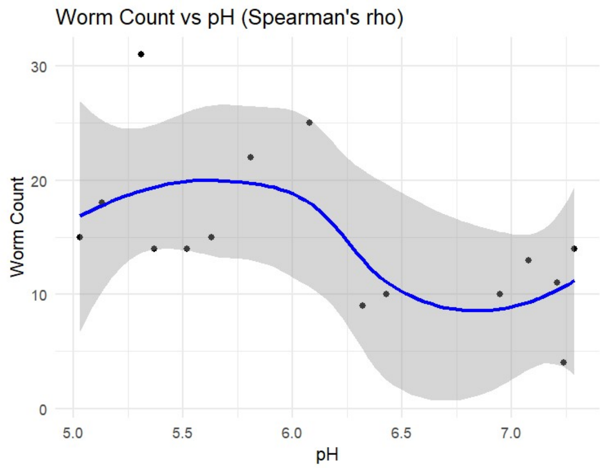

Figure 3. Scatterplot showing the relationship between soil pH and earthworm abundance.

DISCUSSION

Our hypothesis that worm abundance would be higher in field areas with higher moisture levels than in urban or forested areas with less soil moisture was partially supported by the data. Field sites demonstrated significantly more worms than urban sites, and this was confirmed by a Kruskal-Wallis test and Dunn's post-hoc comparison. However, soil moisture alone was not significantly correlated with worm counts, and forested areas did not differ significantly from urban or field sites. This suggests that other factors are likely important.

During the study, we also measured soil pH as a possible factor affecting worm abundance. Interestingly, soil pH showed a strong and statistically significant negative correlation with worm abundance. This indicates that worms may prefer less alkaline soil. Prior research suggests that even though common earthworms can influence soil pH, they also show a sensitivity to it (Edwards and Aracon 2022). However, it is interesting because although earthworms are generally known to be more sensitive to moisture than pH, our data suggest that pH may play a more critical role than expected.

One limitation of this study is the small sample size (n=15) and a relatively small geographic range. Future studies could include more diverse sites in a larger geographic range. Additionally, while soil moisture and pH were measured, variables such as soil composition, organic matter content, and soil compaction were not assessed but could play a role in worm abundance.

These results suggest that habitat and soil chemistry, particularly pH, play an important role in influencing the abundance of common earthworms in the environment. Further research is needed to explore these relationships in depth and identify additional environmental factors that influence earthworm distribution.

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LITERATURE CITED

Blalock, J. 2024. How to measure soil moisture. Cropler website accessed 11 May 2025. www.cropler.io/blog-posts/how-to-measure-soil-moisture.

Edwards, C.A., and N.Q. Arancon. 2022. The influence of environmental factors on earthworms. Pages 191-232 in C.A. Edwards and N.Q. Arancon, editors. Biology and ecology of earthworms, 4th edition. Springer, New York, USA.

Gargiulo, M. 2025. Where have all the earthworms gone? Blog website accessed 11 May 2025. www.michelegargiulo.com/blog/where-have-the-worms-gone.