The influence of long-term agricultural management practices on seasonal red wiggler worm (*Lumbricus rubellus*) population abundance in Cormack, Newfoundland

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Introduction

Earthworms are considered fundamental bioengineers of nearly all earthly ecosystems. The bioturbation carried out by earthworms is known for contributing to improvements in crop yields (Johnston et al. 2018). Conventional agricultural practices have been designed for maximization of profit and rates of production, without much concern as to the environmental implications of such design (Gliessman 1998). After centuries of unquestioned success, the agricultural sector is failing due to the severe depletion of soil quality that conventional practices have caused on a global scale. As a result, these environmental concerns are driving food insecurity for the ever-rising human population (FAO 2000). Of importance is the universal lack of knowledge of the geographic variability in earthworm populations. Understanding this distribution may provide information that allows for the optimization of management tactics concerning the soil environment (Valckx et al. 2008).

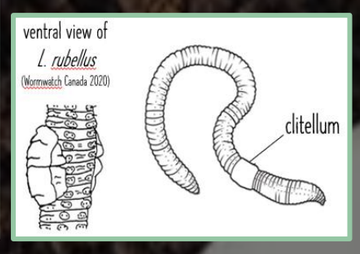
- Compile a history of long-term agricultural activities and management practices performed at this site
- Determine how such activities have altered the biological and physicochemical properties of the soil environment
- Assess how these long-term actions have impacted earthworm populations and influenced distributions seasonally at this site
- To inferentially draw conclusions based on the data collected

Methodology

SAMPLING SITE SELECTION

- 10-acre area of farmland in Cormack, NL
- In operation since 1976
- Knowledge of agricultural practices > 25 years
- 3 plots/5 sites = 15 sampling sites

1	Rotational crop with commercial fertilizer	R
2	Tilled monocrop with commercial fertilizer	M
3	Long-term forage with continuous chicken manure application	LTF
4	Burn site post-dairy manure application	B
5	Control site in undisturbed forest	F



EARTHWORM COUNTS

- Soil was hand-sorted for earthworms
- Weighed, counted, and sorted by life stage
- Mature: identified based on presence of clitellum

BULK DENSITY & GRAVIMETRIC MOISTURE CONTENT

- Sampling cores taken (105°C for 24 hours)

ORGANIC MATTER CONTENT VIA LOSS ON IGNITION

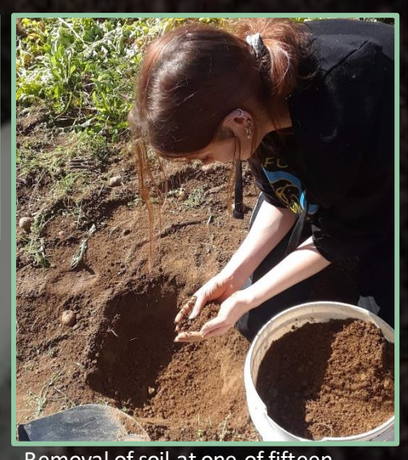
- Oven-dry soil placed in muffle furnace (500°C for 5 hours)

pH

- Oakton pH 2700 meter with 0.01 M $CaCl_2$

ELECTRICAL CONDUCTIVITY

- Oakton CON 2700 meter with deionized water and WhatmanTM 4 Qualitative filter paper



Removal of soil at one of fifteen sampling sites in Cormack, NL

Preparation of samples for organic matter content determination via loss on ignition

Results

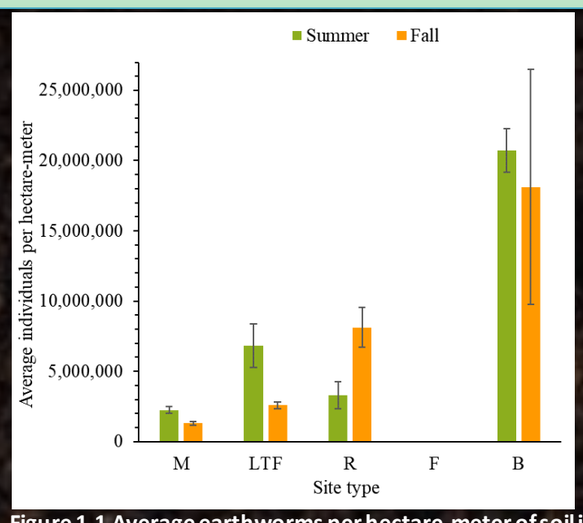


Figure 1.1 Average earthworms per hectare-meter of soil in both summer and fall at 5 sites of farmland in Cormack, NL.

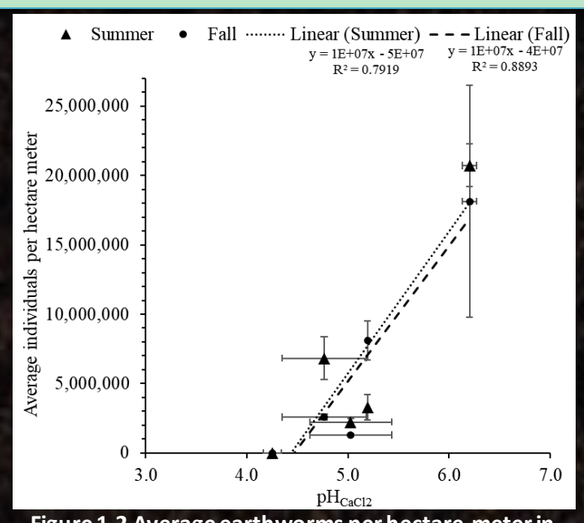


Figure 1.2 Average earthworms per hectare-meter in relation to pH_{CaCl2} at 5 sites of farmland in Cormack, NL.

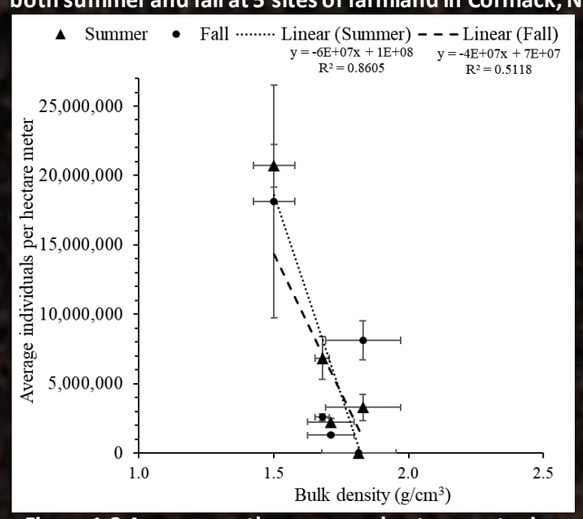


Figure 1.3 Average earthworms per hectare-meter in relation to bulk density of soil at 5 sites of farmland in Cormack, NL.

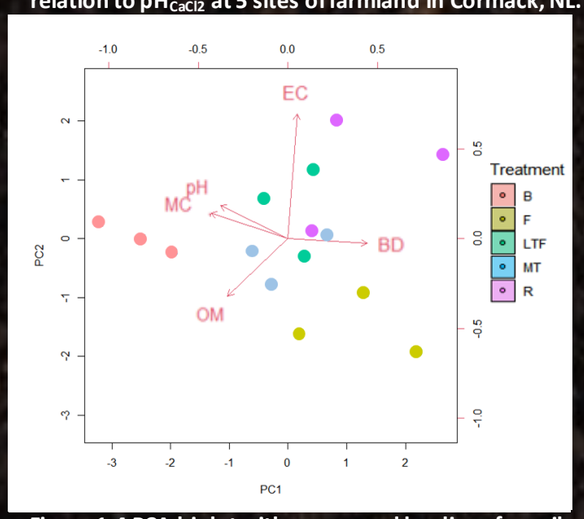


Figure 1.4 PCA biplot with scores and loadings for soil characteristics at 5 sites of farmland in Cormack, NL.

Preliminary Results & Discussion

- Abundance increased with pH (summer: R^2 = 0.7919; fall: R^2 = 0.8893) and moisture content (summer: R^2 = 0.7667; fall: R^2 = 0.4420) but decreased with increasing bulk density (summer: R^2 = 0.8605; fall: R^2 = 0.5118).
- Proportion of juveniles increased in the fall (due to reproductive season) but no significant difference in overall abundance between seasons.

ANOVA TWO-FACTOR WITH REPLICATION

- Statistically significant difference between the means of site counts (P = 7.75 x 10-6, α = 0.05) and biomass (P = 4.65 x 10-8, α = 0.05).

POSSIBLE CAUSES - LOW ABUNDANCE IN MONOCROP

- Most "unhealthy" soil site. Acidic pH and long-term tillage render soil lacking in OM, regular physical disturbance (all of which earthworms are sensitive to). Rotational had same treatments applied, but was not tilled, indicating that traditional tillage and lack of rotation in crops contribute to soil degradation.

POSSIBLE CAUSES - LACK OF INDIVIDUALS IN FORESTED AREA

- Lowest pH (4.25 ± 0.09; uninhabitable range). 80-95% canopy cover, limiting moisture reaching topsoil. Earthworms typically do not inhabit dense forest of North America.

POSSIBLE CAUSES - HIGH ABUNDANCE AT BURN SITE

- High organic matter content = ample food resources. Burn raises pH within favorable range. Low-intensity practices and relatively undisturbed soil.

TUKEY'S HSD POST-HOC

Variable	Means compared	*Ptukeys*
pH	B & F	0.003
	B & LTF	0.022
MC	B & F	0.004
	B & R	0.01
OM	B & LTF	0.014
	B & M	0.038
	B & R	<0.001
	F & R	0.03
Summer Biomass	B & F	<0.001
	B & LTF	0.006
	B & M	<0.001
	B & R	<0.001
	F & LTF	0.012
Fall Biomass	B & F	0.006
	F & LTF	0.017
	F & R	<0.001

References

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Johnston, A. S. A., R. M. Sibly, and P. Thorbek. 2018. Forecasting tillage and soil warming effects on earthworm populations. *Journal of Applied Ecology* **55**(3): 1498-1509. doi: 10.1111/1365-2664.13096.

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Conclusions

- Traditional agriculture leads to diminished soil health and negative effects on biota. Soil biota, particularly earthworms, are fundamental to amelioration of the soil environment. The absence of such organisms coupled with intensive practices leads to a degradation vortex, whereby soil can no longer support crop growth, contributing to food insecurity concerns.
- Future research should aim to assess impacts of modern sustainable farming on soil and how this compares to traditional farming, to find solutions for land reclamation in areas degraded by long-term agriculture, and to investigate the absence of earthworms in NL forests.