



Invasive Species Assessment in the Boundary Waters Canoe Area Wilderness: Earthworms

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Introduction

- Invasive species are known to be major contributors to extinction events and alter ecological systems^{6,7}
- Earthworms (worms) initially invaded North America via European colonists¹
- Worms are major drivers of ecological change and are considered ecological engineers^{2,4,5,6}
- There has been no quantification of earthworm abundance, community composition, or ecological impacts for the BWCAW³
- We investigated whether species composition and biomass of earthworm populations change with increasing distance from campsites, which are hypothetically epicenters of earthworm invasion

Methods

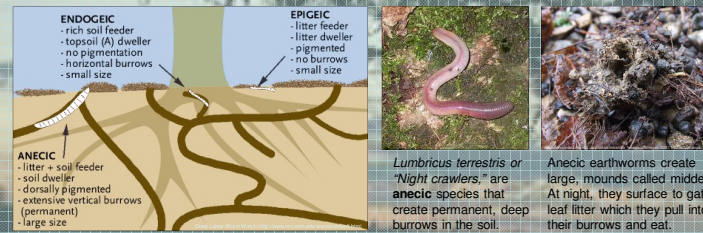
- The study was conducted in the Minnesota's Boundary Waters Canoe Area Wilderness in September 2013
- Worms were sampled using the mustard liquid extraction technique to drive worms to the surface
- Campsite study sites were randomly selected using ArcGIS based on a preplanned route
- Transects were 150-m in length and consisted of 3 plots, each with randomly selected distances
- 10 transects were sampled (30 plots) and 146 worms were collected for analysis
- Worms were sent to the Great Lakes Worm Watch laboratory for identification and biomass analysis
- Data were analyzed using R.2.14.1 and with ESRI ArcGIS 10.2

References

- Callahan Jr. M., González G., Hale C., Heneghan L., Lachnicht S., Zou X. 2006. Policy and management responses to earthworm invasions in North America. *Biological Invasions* 8:1317-1329
- Bohlen P., Goffman P., Fahey T., Fisk M., Suarez E., Pelletier D., Fahy R. 2004. Ecosystem consequences of exotic earthworm invasion of north temperate forests. *Ecosystems* 7:1-12
- Halter B. USA. US Forest Service. Superior National Forest. Record of Decision: BWCAW Non-native Invasive Plant Management Project.
- Hendrix P., Bohlen P. 2002. Exotic earthworm invasions in North America: ecological and policy implications. *BioScience* 52: 801-811.
- Scheu S., Parkinson D. 1994. Effects of an invasion of an aspen forest (Alberta, Canada) by *Dendrobaena octodeca* (Lumbricidae) on plant growth. *Ecology* 75: 2348-2361.
- Didham R., Tylianakis J., Hutchinson M., Ewers R., Gemmill N. (2005). Are invasive species the drivers of ecological change? *Trends in Ecology & Evolution* 19: 470-474.
- Pimm S., Russell G., Gittleman J., Brooks T. 1995. The future of biodiversity. *Science* 269: 347-350.

Worm Ecotypes

There are three different ecological groups of earthworms that are based on their vertical distribution in soil and the resources they feed on. The three groups are **epigeic**, **endogeic** and **aneic**.



Discussion

- Assessing the extent of earthworm invasion is an important step in making educated management decisions, policies, and worm management plan for the BWCAW^{1,3}
- All three ecological types of earthworms were found in our study and worms were found at every transect, suggesting heavy invasion at the survey sites
- Lumbricus terrestris* and *L. rubellus* constituted the majority of worm density, suggesting that humans are playing a role in their transportation as these are the two most common bait species
- Distance from campsite did not account for variations in worm number but elevation did, suggesting that worms have naturally colonized beyond 150-m and are being limited by environmental barriers

Environmental Effects

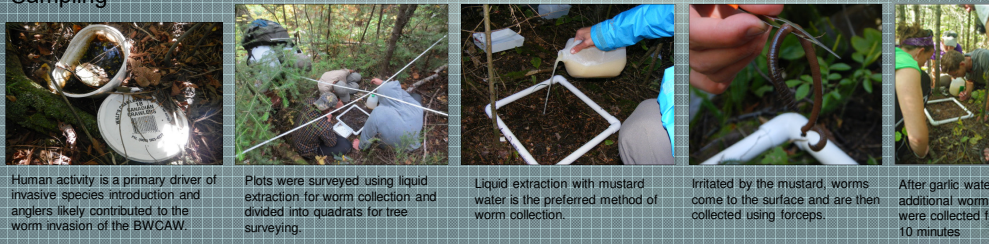
Earthworms rapidly strip the forest floor of organic material. This has a dramatic effect on the ecology of the forest, altering soil structure, the hydrologic cycle, nutrient cycling, and seedbed conditions.

Changes in these fundamental processes can have dramatic impacts including drier soils, lower nutrient availability, plant mortality, lower native plant richness, facilitation of invasive plant species, and reductions in invertebrate as well as microbial diversity.



A typical forest before (left) and after (right) earthworm invasion (15 years). Note the lack of understorey plants, the few tree saplings and the extensive patches of bare soil.

Sampling



Human activity is a primary driver of invasive species introduction and anglers likely contributed to the worm invasion of the BWCAW.

Plots were surveyed using liquid extraction for worm collection and divided into quadrats for tree surveying.

Liquid extraction with mustard water is the preferred method of worm collection.

Irritated by the mustard, worms come to the surface and are then collected using forceps.

After garlic water, additional worms were collected for 10 minutes.

Results

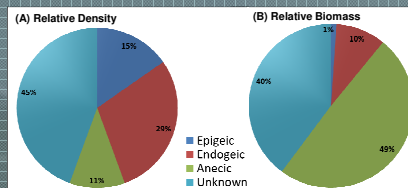


Figure 1. Percent relative abundance of worm ecotypes sampled by density (A) and biomass (B) for the entire data set (n=144). Worms in the "Unknown" group were juveniles and their ecotype could not be determined.

Results. All three worm ecotypes are present in the Boundary Waters. Endogeic worms were the most abundant numerically. Anecic worms were the most abundant group in terms of biomass. *Lumbricus* worms, the most ecologically harmful, were found in all transects. The prevalence of all worm-ecotypes suggests that the BWCAW is heavily invaded.

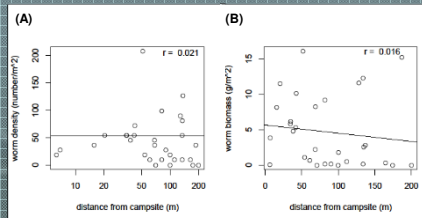


Figure 2. Scatterplots with best fit linear regression for distance from campsite (m) versus worm density (number/m²) (A) and worm biomass (g/m²) (B). Each point represents one sample plot. R² values indicate the amount of variation in respective worm metrics explained by distance from campsite.

Results. Distance from campsite did not explain a significant amount of variation in worm density or worm biomass, largely refuting our hypothesis.

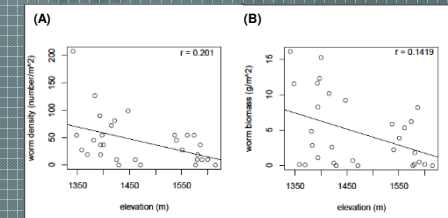


Figure 3. Scatterplots with best fit linear regression for elevation (m) versus worm density (number/m²) (A) and worm biomass (g/m²) (B). Each point represents one sample plot. R² values indicate the amount of variation explained by elevation.

Results. Elevation was the best predictor of both worm density and biomass for all the variables measured, and was negatively correlated with both metrics. However, the amount of variation captured was still relatively low, suggesting that worm presence is a complex pattern explained by more than one variable.