Human traffic and fire effects on invasive earthworm abundance in the Boundary Waters Canoe Area Wilderness of northern Minnesota

Melissa Seidel, Matthew Rothaus and Todd Wellnitz
University of Wisconsin- Eau Claire, Eau Claire, WI, USA.

Introduction

Exotic earthworm invasion of temperate North American forests may be an important driver of ecosystem change (1). Earthworms can alter soil structure, nutrient cycles, and the diversity and abundance of plants (2). However, the extent of earthworm invasion and their impact on northern forests is incompletely understood (3).

To study the role of humans in spreading exotic earthworms and their response to fire, we examined the distribution and abundance of earthworms in the Boundary Waters Canoe Area (BWCA) Wilderness in Minnesota, USA. We hypothesized that worms would be more abundant near BWCA campsites and less abundant in areas burned by the Pagami Creek Fire of 2011. We assessed earthworm abundance across four landscape categories: campsites, non-campsites, burned forest, and unburned forest. Earthworm impacts were assessed by measuring soil nitrogen, pH and percent organic matter, and surface litter accumulation.

Methods

• BWCA campsites were located using the F4 Fisher (4) map and burn areas were identified using US Forest Service fire maps delineating the Pagami Creek Fire. All sites were recorded using GPS (see map).
• Non-campsite sampling areas were selected to be at least 300 m away from established campsites.
• Sampling was conducted approximately 60 m from lake shorelines.
• Worms were extracted within two, 0.25 x 0.25 m plots using mustard water and were preserved in 5% formalin. In the lab worms were identified and counted.
• Four soil samples (500 ml total) collected at each site were assayed for N, pH, and organic matter. Litter depth was measured 6 points/plot.

Results

• There were striking differences between burned and unburned plots, so we ran a hierarchical structural equation model to examine each in turn. Noteworthy results were:
  - 80% of the relationships examined in the burned forest ecosystem had greater effect sizes than those in the unburned forest ecosystem.
  - Litter had a significant effect on worm biomass and worm density in burned areas; however, it had close to no effect in unburned areas.
  - In both ecosystems, worm biomass had a strong positive effect on pH and a strong negative effect on percent organic matter, whereas worm density had a strong negative effect on pH and a positive effect on percent organic material.

Figure 1. Worm density did not differ between burned and unburned sites, but was greater near campsites ($F = 4.31, P = 0.04$)

Figure 2. Worm density decreases away from the BWCA entry point, but this trend is driven by the pattern in the burned area ($F = 6.4, P = 0.02$).

Figure 3. There were striking differences between burned and unburned plots, so we ran a hierarchical structural equation model to examine each in turn.

Implications

Research suggests that exotic earthworm invasion is a widespread phenomenon with ecosystem-level implications (1, 2). By altering soils and plant communities, earthworms affect the way northern forests look, act and function (2, 5). Understanding of how anthropogenic activities spread earthworms is necessary for developing policy and management strategies to lessen their impact and minimize future invasions.

In the next 100 years, the BWCA will undergo drastic change (1, 4). If the rate of climate change continues as predicted, the Boundary Waters’ boreal forests will disappear and be replaced by oak savannas. As this transition occurs, it is important that we understand how these dynamics of change will affect the forests, plants and animals living in the BWCA, and how continued human activity will impact this remarkable ecosystem.

By studying invasive earthworms, we can learn about the role they play in influencing the boreal forest-oak savanna transition. We hope that studies such as ours will aid conservation efforts to preserve one of North America’s amazing wilderness areas.

Acknowledgments

Thanks to everyone in the Fall 2014 Collaborative Research in Biology class (Biol 423) and to all the UW-Eau Claire Biology faculty who let them miss class to conduct this research. Special thanks goes to Ryan Huesmann, Great Lakes WormWatch director, for his expert advice, and to the outstanding staff at Williams & Hall Outfitters.

Literature Cited