Research: Invasives

Do invasive Worms Threaten Northeast Maple Forests?

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Some maple producers have reported low sugar maple regeneration that could be related to the presence of worms. Earthworms are not native to Canada and most of the northeastern USA. While European species have been here since colonization by early settlers, Asian earthworms have only recently become established in northern hardwood forests. This second wave of invasion by *Amynthas* species is of concern to forest ecologists because of its potential disruption to the forest.

Amynthas species are commonly known as Alabama jumpers, snake worms, wrigglers or crazy worms because of their very active behavior. Earthworms have always been thought to be native organisms that enhance soil fertility. Few realize that most are actually exotic or that some species are invasive and pose a threat to sugarbush health by consuming the soil organic layer and disturbing the forest floor structure and chemistry. While the worms won't directly kill trees, the profound changes in soil fertility, biodiversity and physical soil structure that they cause may reduce maple seedling regeneration and could jeopardize future sugaring plans.

Over the past three years, scientists at the University of Vermont have gathered data in northeast maple forests to determine if these nonnative species affect forest soil structure, understory plant diversity, maple regeneration, and invasive plant species. This article highlights our findings from research conducted in sugarbushes in Vermont, New Hampshire, Massachusetts, New York, and Connecticut, covering five USDA plant cold hardiness zones: 4a, 4b, 5a, 5b and 6a.

Earthworm biology

Earthworm biology is complex, having two reproductive strategies. Some species are hermaphrodites with both female and male reproductive organs in the same individual. These reproduce sexually and are genetically diverse. Other species are parthenogenic which usually lack male organs and reproduce asexually. For these species it takes just one worm to start a new colony and invade a forest.

We estimate that one *Amynthas* worm can produce as many as 20 cocoons per season; each cocoon containing 1-3 eggs. They are an annual organism. The eggs within the cocoon hatch in the spring as temperatures warm. Adults die in November with the onset of winter. However, a 90-day growing season is sufficient for earthworms to become reproductively mature and produce the next generation. Cocoons of most earthworms are very resistant to adverse conditions and are cold hardy to -40oF, making worm management very difficult.

There are several groups of earthworms, each occupying a distinct area in the forest floor. *Amynthas* spp. and *Lumbricus rubellus* live in the litter and humus and are likely the most dam-

aging worms in sugarbushes. They deprive plants of their germination medium and the place where most of their roots intermingle with mycorrhizal fungi. In contrast, *Lumbricus terrestris*, the common night crawler, makes deep, vertical burrows, where it drags leaf litter and then feeds on fungi and bacteria that grow on it. They cap off their burrows with piles of castings (called middens) to prevent predators from entering.

In the northern hardwood forest, earthworms can contribute to a reduction in understory vegetation, including less maple seedling survival. The loss in maple seedlings has been attributed to an interaction between the effect of earthworms and deer browsing. Earthworms indirectly reduce the density of understory herbaceous vegetation, leaving only young woody vegetation on which the deer feed.

Research questions

1. Which worm species are present in sugarbushes and in what cold hardiness zones?
2. Is there a relationship between the presence of earthworms and maple regeneration?

Methodology

Over the past three years, we have sampled in 35 different sugar maple stands in five cold hardiness zones. In each stand we selected four 1 m2 plots in which we counted and identified the understory and overstory vegetation. We also examined the area within a 5-m radius, counting maple seedling and sapling, and invasive plant species. In two of the plots we used the standardized Invasive Earthworm Rapid Assessment Tool (IERAT) to rank damage to the forest floor. An IERAT score of 1 indicates no damage, while 5 indicates severe damage. The rating is based on inspecting the age of leaf litter, extent of the organic horizon, and signs of earthworms (middens and casting layers). In these two plots we also examined the earthworm community, excavating a ¼-m2 area to a depth of 4-6 inches and counting the species present.

Findings

Earthworms, including the most destructive *Amynthas* species, were found in all cold hardiness zones examined. In sites with worms, densities of 8-28 earthworms per square meter were typically found. Other minor worm species were also encountered. Over the 3-year period, more than 50% of the sites sampled were rated as heavily damaged (IERAT 4-5); whereas 31% were ranked as no- or low-damage (IERAT 1-2) (Figure 1).

Worms: continued on page 23

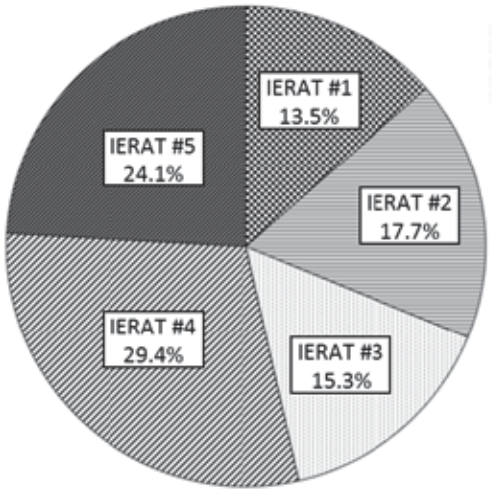

Figure 1: Percentage of sugarbushes according to IERAT damage category (1 = no damage; 5 = severe damage), averaged over the 2015-2017 study period.

Worms: continued from page 21

Maple forests with the highest damage ratings were infested with *Amynthas* spp. and *Lumbricus terrestris*. Amynthas worms voraciously devour leaf litter, leaving in their wake a thin leaf litter layer and an extensive layer of loose, granular castings. The net effect is fewer herbaceous plant species and maple seedlings. *L. terrestris* also caused extensive damage, resulting in limited leaf litter in late spring and a compacted soil surface. The presence of these species usually resulted in an IERAT damage class of 5.

There were instances where worms were not observed but forest damage was still detected. This may be because earthworms are not active year round, and can be missed depending on the sampling time. *Lumbricidae* are often inactive in the summer and burrow down for protection from heat and drought, and can escape detection under these conditions. Earthworms in the family *Megascoecidae* tend to be active in the summer, but their numbers vary greatly depending on moisture and temperature. The characteristic forest damage recorded by IERAT implies the presence of worms, even if they are not observed. For this reason, our analysis uses forest damage class rather than worm abundance as the independent variable.

We found that a higher IERAT damage rating did not reliably predict understory plant diversity, nor the occurrence of invasive plant species. However, the number of maple seedlings decreased as the IERAT damage class increased. In addition, when *Amynthas* worms were present, the number of maple seedlings was always greatly diminished. No maple seedlings were found in *Amynthas*-

Worms continued on page 26

Worms: continued from page 23

infested sites located in cold hardiness zones 4a, 4b and 5a. In zones 5b and 6 (in Connecticut), seedlings were present even when *Amynthas* worms were observed, suggesting that multiple factors affect the amount and diversity of the understory vegetation.

Solutions

There are no management solutions currently because all known vermicides (agricultural chemicals toxic to earthworms) have been banned and no new ones are certified or on the market. Therefore, when possible, prevention is the best strategy. If you don't yet have invasive earthworms in your sugarbush, make every effort to keep them out. Typical vectors include discarded fish bait (esp. night crawlers), plant exchanges by garden clubs and distribution of horticultural material (plants, soil, mulch, compost). Don't throw away used plant or soil material associated with other horticultural or agricultural activities in the vicinity of a sugarbush. Inspect nursery materials, and if they are infested with worms or their cocoons, wash off the roots before planting. Discourage fishing with live bait in or near sugarbushes. Monitor your forests for earthworm damage by looking for earthworm castings, diminished organic layers and decreases in understory plants.

If earthworms have already invaded your sugarbush, plant species with deep taproots to help stabilize the trees as the forest floor structure changes. Increase the amount of organic matter on the forest floor by leaving branches and other plant debris in your sugarbush. Work is underway to devise ecologically sound management solutions, in-

cluding naturally-occurring microbial organisms, such as entomopathogenic fungi or bacteria. Stay tuned for new developments in this sector.

References

Worm Watch: a science-based education & national volunteer monitoring program used to identify ecological changes in the environment (https://www.naturewatch.ca/wormwatch/)

Great Lakes Worm Watch: valuable resource of research, worm identification, forest ecology, resources (http://www.greatlakeswormwatch.org/)

Vermont Invasives: information about identification, biology, management, distribution, and citations for earthworms and many other species (https://vtinvasives.org/invasive/earthworms)

UVM Entomology Lab: http://www.uvm.edu/~entlab/Forest%20IPM/Worms/InvasiveWorms.html

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