The surprising link between deer, invasive earthworms and tree harvesting

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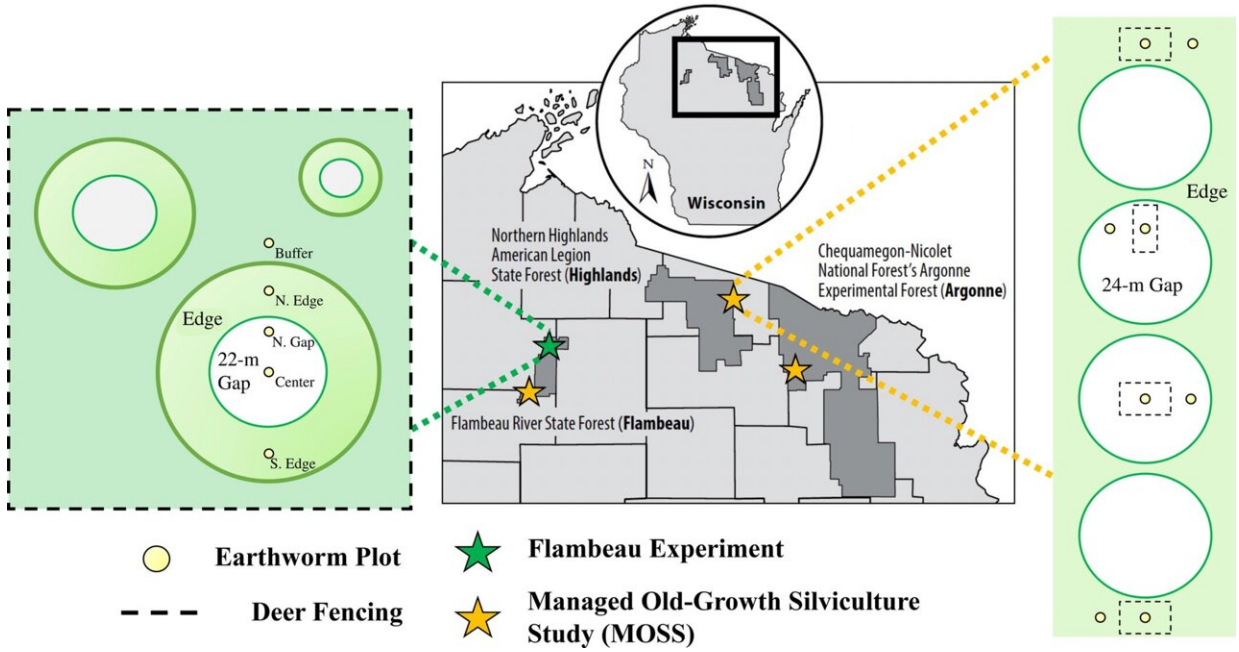

Map of Northern Wisconsin, USA with depictions of canopy gap and earthworm sampling design. Gold stars represent the Managed Old-growth Silviculture Study (MOSS) experiment, where earthworms were sampled inside and outside of small fences underneath a canopy gap (n = 47). The green star represents the Flambeau Experiment, where earthworms were sampled along a north–south transect across a fenced (n = 5) or unfenced gap (n = 5) in both 2006 and 2019. Sampling points along this transect extended from the northern buffer (25 m from gap center), to the northern transitional edge (16 m from gap center), to the northern gap (7 m from gap center), to the gap center, to the southern transitional edge (16 m from gap center). Credit: *Ecology* (2023). DOI: 10.1002/ecy.4040

There's a surprising and highly influential link between invasive earthworms, white-tailed deer and tree harvesting in northern forests, according to new research from the University of Minnesota.

The findings, recently published open access in the journal *Ecology*, show invasive earthworm populations increase with deer presence and decrease with tree harvesting. Increased earthworm invasion is cause for concern because the species is known to harm soil and regenerating trees.

"Invasive earthworms are ecosystem engineers which negatively impact fundamental ecosystem properties such as nutrient retention and the diversity of native plant species. Deer exacerbate these negative impacts by increasing earthworm populations," said Lee Frelich, an adjunct professor in the Department of Forest Resources and Director of the Center for Forest Ecology.

The team of U of M researchers, in collaboration with the U.S. Forest Service, the Wisconsin Department of Natural Resources and others, sampled earthworms in two long-term experiments in northern Wisconsin. Both experiment sites were established in the mid-2000s and simulated deer exclosures and tree harvesting—which leaves behind a large canopy gap in the overstory.

Nearly 13 years after each experiment started, the team tested how the deer exclosures and the tree canopy gaps impacted earthworm populations. The researchers also used earthworm data collected prior to the experiment's establishment to test how earthworms changed over 13 years. Earthworms were sampled by pouring a slurry of mustard powder and water on the ground, which causes earthworms to come shooting to the surface—a method anyone can use at home.

The researchers found:

- In both experiments, invasive earthworms were lowest in areas where there were no deer and with a canopy gap overhead.
- In addition, earthworms increased the most over 13 years in areas outside of deer fencing and far away from the center of canopy gaps.
- The largest and most influential earthworm species were increased by deer and decreased by canopy gaps.

These findings suggest reducing deer populations may be one management strategy to slow earthworm invasion. In situations where it is not possible to reduce deer populations, creating mid-sized canopy gaps might be another strategy to slow the invasion.

"Capitalizing on the links between disturbances may be a real solution to safeguard ecosystems, as controlling one disturbance can indirectly reduce the severity of another. However, we have to figure out which disturbances are linked in the first place, highlighting the need for more multi-disturbance research," said lead author Sam Reed, a Ph.D. student in the College of Food, Agricultural and Natural Resource Sciences.

The research team has several theories as to how these disturbances might be linked. First, deer could be changing the soil in a way that is favorable for earthworms, through fecal and urinary waste. Another theory is that since deer voraciously consume and kill flora, plants could be reallocating nutrients below ground to their root systems to avoid being eaten, which could indirectly favor earthworms. When it comes to tree harvesting and canopy gaps, researchers theorize canopy gaps could decrease earthworm populations because there is less moist, high-nutrient leaf litter underneath a canopy gap, which earthworms use for food and shelter.

Future research is needed to focus on the mechanisms behind how deer and tree harvesting might change invasive earthworm populations. In

addition, disturbance ecology as a whole should be broadly testing how disturbances might be influencing one another and how ecosystems respond to multiple, overlapping disturbances.

More information: Samuel P. Reed et al, Linked disturbance in the temperate forest: Earthworms, deer, and canopy gaps, *Ecology* (2023). DOI: 10.1002/ecy.4040

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