

## Northern Research Station

# Rooted in Research

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## Earthworms, Deer, and Canopy Gaps: Understanding Disturbance Interactions in Temperate Forests

Disturbances change our forests. However, we are only just beginning to explore how disturbances can affect each other or how they might be “linked.” By understanding disturbance links, we may be able manipulate one forest disturbance to manage another.

New [research](#) published in the journal *Ecology* highlights some unexpected disturbance linkages in the North Woods of Wisconsin. The team, led by Sam Reed of the University of Minnesota; Dustin Bronson, a plant physiologist with the U.S. Department of Agriculture, Northern Research Station; and their colleagues, investigated the interactions and links between different disturbances in terrestrial ecosystems. Specifically, the research focuses on the relationship among canopy gaps, browsing by white-tailed deer (*Odocoileus virginianus*), and nonnative earthworm invasions. While the individual effects of these disturbances on vegetation are relatively well-understood, their long-term influence on each other and their combined effects are not well known.

### Deer, Canopy Gaps, and Earthworms

Deer browsing, tree removals, and invasive earthworms are relatively common disturbances in temperate forests. Deer can voraciously consume plants, which can lead to changes in the understory community and eventually alter succession and forest structure. These changes have the potential to indirectly affect forest soil properties. Group selection harvesting creates a gap in the tree canopy, increasing light availability in the understory, which can promote plant growth that may attract



A large white-tailed deer in Wisconsin's North Woods. Licensed photo by Tony Campbell/Adobe Stock Photos.

deer. Lastly, most forest soils in the Lake States do not naturally have earthworms, making their presence particularly influential. Earthworms can significantly change the chemistry and composition of forest soils, altering soil properties, nutrient cycling, and plant communities.

Despite the significance of each of these forms of forest disturbance, there has been little effort to understand their interactions. To address this knowledge gap, researchers used two different experiments in northern Wisconsin, the Managed Old-Growth Silviculture Study (MOSS) and the Flambeau Experiment (FE), to test how deer and canopy gaps influence invasive earthworms. Both experiments take place in managed forests with many large canopy gaps (22 to 24 meters in diameter) and different-sized fenced exclosures designed to keep out deer. The deer exclosures either surround the canopy gap (80 m x 80 m; FE) or are small enough to fit inside the canopy gap (5.25 m x 5.25 m; MOSS). In 2019, earthworms were sampled inside and outside of deer exclosures and in both canopy gaps and areas with closed canopy overhead. In the Flambeau Experiment, earthworms were first sampled in 2006 before exclosure fencing was constructed or group selection harvesting was implemented.

### KEY MANAGEMENT CONSIDERATIONS

- Fencing out or reducing deer populations may have benefits beyond improving forest biodiversity.
- By reducing deer populations or creating canopy gaps through targeted tree harvesting, it may be possible to control undesirable disturbances such as invasive earthworms.
- By understanding the disturbance links in temperate forests, researchers and managers may be able to develop more effective strategies for restoration and ecological management in the face of changing climates.

*“I think so many of the forest disturbances we see today can interact with one another and are going to become more influential with a changing climate. Our research highlights how we can control certain disturbances and use this as a lever to manage the negative effects of another disturbance.” – Sam Reed*

## Unexpected Research Results

Surprisingly, the results were similar in both experiments, even though the size of the deer exclosures was significantly different. Fewer invasive earthworms were found inside areas with deer exclusion fencing than in areas where deer were present. The number of earthworms was also lower in gaps with an open canopy overhead. Many of the earthworms were species in the *Aporrectodea* and *Lumbricus* genera that tend to have large impacts on soils. In the Flambeau Experiment, over the course of 13 years, earthworms increased the most in areas outside of deer exclusion fencing where deer were present and in areas far away from the center of canopy gaps.

What might be causing these results? It is possible that deer are fertilizing the soil with urine and feces, creating a more favorable environment for earthworms? Could deer be having an indirect effect on earthworms? When plants are browsed by deer, they may shift nutrients belowground and increase the growth of their roots, which would also favor earthworms. At the same time, tree harvesting and canopy gaps might reduce earthworms by disturbing the soil or reducing the amount of high quality, moist leaf litter that earthworms use for food and shelter.

When reflecting on this research, Sam Reed says, “I think that so many of the forest disturbances we see today can interact with one another and are going to become more influential with a changing climate. Our research highlights how we can control certain disturbances and use this as a lever to manage the negative effects of another disturbance.”

Researchers acknowledge the need for additional investigation to unravel the mechanisms behind these disturbances, as well as the need for additional research into the potential effects of deer and canopy gaps on other soil-dwelling fauna and their implications for ecosystem dynamics.

Dustin Bronson reflects that northern hardwood managers across the Great Lakes region often struggle to create healthy forests because of the effects of white-tailed deer and

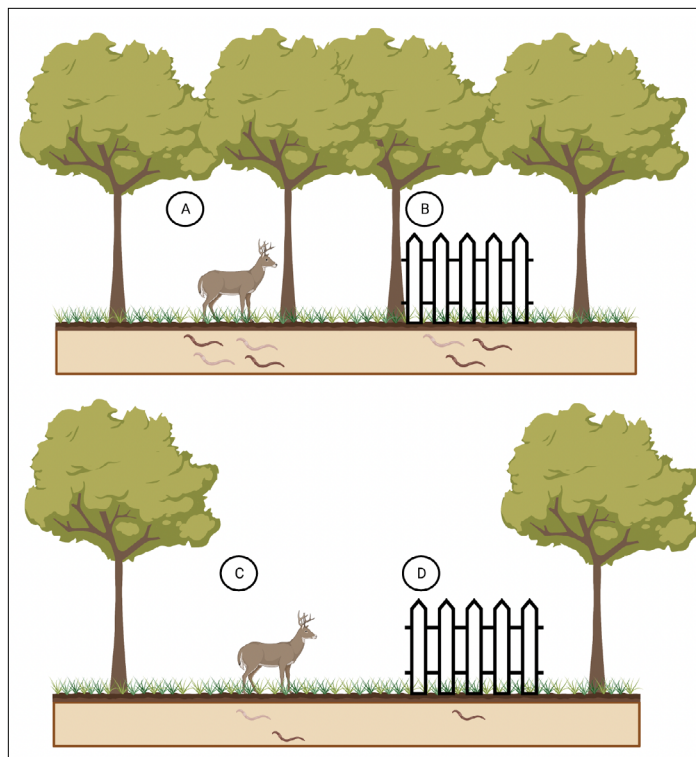


Diagram showing how earthworms are linked to disturbance treatments in this study. (A) Deer presence under a closed canopy leads to the highest earthworm biomass and density. (B) Fencing out deer decreases earthworm biomass and density. (C) Gap creation substantially decreases earthworm biomass and density. (D) Deer presence and canopy gaps cause the lowest earthworm biomass and density. Created with BioRender. (Source: Reed et al. 2023).

earthworms. He says, “Our research shows that these two biotic factors are linked together. Managers have options to consider in reducing earthworm impacts because of this research.”

## Feature Scientist

Dustin Bronson is a research plant physiologist with the Landscape Ecology and Sustainability in the Lake States Forests Unit. Learn more about Bronson’s work at: <https://www.fs.usda.gov/research/about/people/dustin.bronson>.

## FURTHER READING

Reed, Samuel P.; Bronson, Dustin R.; Forrester, Jodi A.; Prudent, Leah M.; Yang, Anna M.; Yantes, Austin M.; Reich, Peter B.; Frelich, Lee E. 2023. [Linked disturbance in the temperate forest: Earthworms, deer, and canopy gaps](https://doi.org/10.1002/ecy.4040). Ecology. 104(6): e4040. <https://doi.org/10.1002/ecy.4040>.

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