

Northern Woodlands

by Alexandra Kosiba [Autumn 2025](#)

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What Are Mycorrhizal Fungi and What Role Do They Have in the Forest?

Fungi are a fundamental part of forest ecosystems. They break down dead plant material, releasing nutrients for other organisms to use, and they help plants access water and nutrients needed for growth. One particularly fascinating group, mycorrhizal fungi, has drawn considerable attention in recent years, as some scientists have suggested they play a role in forming underground networks that connect trees. But what exactly are mycorrhizal fungi? What role do they play in forests? And how much do we really know about them?

What Are Mycorrhizal Fungi?

A mycorrhiza is a symbiotic relationship between a fungus and a plant's roots. In a symbiotic relationship, two different species live in a close, long-term interaction. Although "symbiosis" is often used to describe a mutualistic relationship where both organisms benefit, it more broadly encompasses all types of close interactions, including parasitism, where one organism is harmed, and competition, where both may be negatively affected.

The term *mycorrhiza* refers to the role of fungi in the rhizosphere, which is the region of soil that includes plant roots and their immediate surroundings. Mycorrhizal fungi have evolved to live on or within plant roots, obtaining their food (carbon) from the plant rather than from decomposing organic matter, as saprophytic fungi do. Mycorrhizal fungi help plants access water and nutrients from the soil. In return, the plants provide the fungi with carbon-based compounds such as sugars, proteins, and lipids.

Mycorrhizal fungi are composed of hyphae: thin, hair-like filaments that form a web called the mycelium. If you've ever pulled apart decaying wood or dug in soil, you've likely seen these white, yellow, or brown threads. Some (but not all) species of mycorrhizal fungi produce fruiting bodies (mushrooms), including porcini, chanterelles, and morels.

The mycorrhizal lifestyle has evolved independently multiple times throughout Earth's history. Scientists believe most mycorrhizal fungi evolved from saprophytic fungi, which obtain their food by decomposing dead plant and animal matter. Mycorrhizal symbioses can be categorized in several ways, with one major distinction being between *ectomycorrhizae* and *arbuscular mycorrhizae*. These types differ in how they interact with plant roots: *ectomycorrhizae* form a sheath around the roots without penetrating root cells, while *arbuscular mycorrhizae* enter the root cells and form specialized structures within them. These two forms differ in several important biological and ecological aspects.



Some – but not all – species of mycorrhizal fungi produce fruiting bodies, such as this fly agaric mushroom. Photo by Meghan McCarthy McPhaul.

Ectomycorrhizae form extensive mycelial networks in soil and leaf litter, often extending far beyond the plant's root zone. These networks enable the fungi to efficiently gather nutrients from a wide area. In contrast, arbuscular mycorrhizae have a more limited reach and function more like scavengers, assisting plants in absorbing nutrients from the root vicinity.

Ectomycorrhizae fungi produce mushrooms to release spores, but most arbuscular mycorrhizae do not produce visible fruiting bodies. Instead, they reproduce asexually via spores within the plant root system and surrounding soil.

Ectomycorrhizal fungi are more diverse than arbuscular mycorrhizae. Scientists have described about 7,750 species of ectomycorrhizae worldwide and estimate an additional 20,000 to 25,000 remain undiscovered. In contrast, only about 250 species of arbuscular mycorrhizae have been described, with scientists estimating there may be perhaps 1,000 species in total. The large difference in species diversity is rooted in their evolutionary histories. Although arbuscular mycorrhizae evolved earlier, ectomycorrhizae fungi have arisen multiple times independently across different fungal lineages, contributing to their greater species richness.

Despite the diversity within ectomycorrhizae fungi, this group associates with fewer plant species (about 10 percent globally) than arbuscular mycorrhizae do (about 78 percent). In northeastern forests, however, ectomycorrhizae play an outsized role. This is because they primarily partner with trees and other woody plants, including nearly all the conifers, such as pine, spruce, fir, and hemlock, as well as some hardwoods, including oak and birch. A single pine tree may join with more than a dozen different ectomycorrhizal species at one time.

Arbuscular mycorrhizae are also important in northeastern forests, but they partner with fewer tree species. These include ash, cherry, maple, and cedar. Interestingly, some tree species, such as white ash and bigtooth aspen, can host both types of fungi. Scientists think that trees capable of forming partnerships with both types of mycorrhizae may be better equipped to survive in harsh growing conditions because each type of mycorrhizal fungi is good at accessing and extracting different nutrients from the environment.

What Role Do Mycorrhizae Play in Forests?

Nearly all plant species form mycorrhizal relationships, and many cannot survive without them. Mycorrhizal fungi extend a plant's reach into the soil, helping it access water and nutrients that roots alone cannot. Mycorrhizal hyphae have a large surface area and can secrete compounds that break down minerals, making nutrients available to plants. This is especially critical for plants growing in nutrient-poor soils.

Mycorrhizal fungi play a key role in helping plants obtain nitrogen and phosphorus – two essential elements for growth and photosynthesis. In many forests, including those in the Northeast, these nutrients are scarce or are locked in organic matter, making them inaccessible to plants. Mycorrhizal fungi help release and deliver these nutrients in exchange for carbohydrates and other organic compounds the plants produce through photosynthesis.

In some cases, mycorrhizal fungi connect the roots of multiple plants, even of different species, into what scientists call *common mycorrhizal networks* (CMNs). These underground networks may allow the transfer of water, carbon, and nutrients between plants.

In August 1997, editors at the journal *Nature* coined the term *wood-wide web* to describe this phenomenon, referencing a paper titled *Net transfer of carbon between ectomycorrhizal tree species in the field*, by mycologist and University of British Columbia professor Suzanne Simard and her colleagues. The term likened underground fungal networks to the internet, with fungi serving as conduits for communication and resource sharing among trees. This concept led Simard to propose the *mother tree hypothesis*: the idea that older trees recognize and support their offspring by sharing resources or sending chemical warnings throughout the fungal network.

These ideas captured public imagination, appearing in books, documentaries, and popular media – including the television show *Ted Lasso*. Many of these narratives depicted trees as cooperative, communicating organisms connected by underground fungal networks. As these concepts spread, some scientists began to question whether the science had been overstated and whether the public narrative had become too simplified.

In 2023, mycorrhizal ecologist and University of Alberta associate professor Justine Karst and her colleagues reviewed the research on mycorrhizal networks. They concluded that much of the literature showed a citation bias, with studies that reported positive effects of common mycorrhizal networks being cited more frequently than those with neutral or negative results. They also pointed to a shortage of forest-based studies. Much of the existing research has been conducted in pots in greenhouses, which does not reflect the complexity of conditions in forests. Factors such as soil freeze-thaw cycles, root turnover, and earthworm activity can disrupt or sever fungal connections, suggesting these networks may be more fragile and transient than once believed.

Karst and her team also found that while fungal networks can connect trees and seedlings, the benefits of these connections for survival and growth remain uncertain. Only about 18 percent of the studies they reviewed showed positive effects on seedling survival or growth. Some studies found negative effects, and most showed no measurable impact. Outcomes varied by species, soil type, planting distance, and environmental conditions.

Even for those studies that observed carbon transfer between trees, researchers noted that alternative explanations, such as movement of carbon through the soil, could not be ruled out because carbon compounds can move freely through the soil without needing to travel through fungal mycelia.

Also in 2023, another group of scientists led by Nils Henriksson, a researcher at Swedish University of Agricultural Sciences, evaluated the evidence for the mother tree hypothesis. They concluded that existing research on forest ecosystems does not provide sufficient support for the hypothesis. In fact, some studies suggested the opposite – that seedlings growing near parent trees performed worse than those near unrelated trees. This reduced performance could be the result of several factors, with one of the most significant being the higher concentration of pests and pathogens near parent trees, which can negatively affect seedling survival and growth.

Although scientists agree that fungal networks exist, many fundamental questions remain unanswered: How large are these networks? How long do they last? Which trees are connected, and by which fungal species? Do these connections meaningfully influence forest dynamics? Studying these mycorrhizal networks is difficult because they exist underground, requiring indirect methods. So far, scientists have mapped common mycorrhizal networks in only three forests worldwide, including two in the same forest type (a pine forest in Japan and two Douglas-fir forests in British Columbia, Canada). Given the immense diversity of tree and fungal species globally, we still know too little to make broad generalizations.

Where Do We Go from Here?

The importance of mycorrhizal fungi to forests is undisputed. Even if the wood-wide web metaphor needs refining, it has helped bring fungi into the public spotlight – a major shift for a group of organisms historically overlooked.

This growing awareness offers an opportunity to better integrate fungi into forest stewardship. Mycorrhizal fungi highlight the complexity and interconnectedness of forest ecosystems. We can support fungal conservation by promoting tree diversity and age-class variation, retaining legacy trees during harvest, minimizing soil disturbance, leaving deadwood to preserve moisture and microhabitats, and protecting forests from conversion to other land uses.

Research shows that fungal communities can recover from soil disturbances, including fire. In northeastern forests, small mammals such as mice, voles, and chipmunks play an important role in dispersing fungal spores to new locations after disturbances such as timber harvests. Creating and maintaining a range of microhabitats can help support this biodiversity. The more we understand fungi, the better we can steward the forests they help sustain.

by Alexandra Kosiba

Alexandra Kosiba, PhD, is a forest ecophysiologicalist and assistant professor at University of Vermont Extension.

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Discussion *

Oct 17, 2025

Thank you for this informative article. When I visited Germany a couple decades ago, the State and Community Forest were restricting skid trails to around 8-10% of the managed forest. It was hand felling and then winched to the skid trails. Considering the impacts of current logging machines this seems like a sensible approach but no one seems to be doing this type of work. This would seem to reduce the impact on fungi. Do you know of any logging systems that are designed to reduce the impact on fungi? Sincerely, Bruce

Bruce A. Spencer

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