The Wood Wide Web

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In most ecosystems, plants are the keystone organisms that shape biodiversity and support entire food chains, promoting healthy competition. Trees are a common organism that determines the character and survival of life on land. In recent years, scientists have discovered another essential layer to the vegetative foundation of ecosystems that reshaped their understanding of ecosystems: the mycorrhizal fungi network.

Also known as the Wood Wide Web, the mycorrhizal fungi network is an underground network of fungi that connects trees and allows them to "communicate" with each other (Fransen, 2024). Fungi, the world's largest organism, can cover huge areas across the subterranean (*The Wood*, n.d.). Mycorrhiza refers to fungi that have a symbiotic relationship with plant roots. In this symbiotic system, trees provide about 30% of the sugar they generate through photosynthesis to the mycorrhizal network, fueling the fungi to collect phosphorus and other mineral nutrients, which they transfer to the trees. The web enhances trees' ability to obtain water, carbon, nitrogen, and other nutrients from the soil while promoting the intertree exchange of these nutrients, supporting the health of an ecosystem's entire network of trees (Fransen, 2024). Dr. Suzanne Simard and colleagues found in their research that up to 40% of carbon in a tree's fine roots—roots in charge of acquiring soil resources—could come from other trees. Dying trees have also been observed to 'dump' resources into the network of surrounding trees. More interestingly, scientists find that older and more mature trees, or mother trees, supply younger saplings with nutrients and even display kin recognition (Fransen, 2024). Mother trees have the most fungal connections, and their roots can reach deeper water sources in the soil to pass on through the network, supporting seedlings that grow in shadier regions where they cannot rely on sunlight for energy (Holewinski, n.d.). They also tend to favor saplings genetically related to them and send more carbon to their ‘kin’ as observed in a study of Douglas-fir trees at England’s University of Reading (Holewinski, n.d.). This trait perhaps contributes to the shaping of forest compositions. Beyond sharing resources, trees also send early warning signals to surrounding trees through the mycorrhizal network. A tree under attack by insects or pathogens can emit chemical signals that prompt receiving trees to set up defences (Fransen, 2024).

The Wood Wide Web is facilitated by the mycelium of fungi, the tiny ‘threads’ of a larger fungal organism with hyphae—feathery filaments—extending out, which are interwoven in the soil with tree roots (Holewinski, n.d.). While fungi remind many of mushrooms, they are simply the ‘fruit’ of the fungi while the majority of a fungal organism lies underground as a mass ‘web.’ The two main types of mycorrhizal fungi are ectomycorrhizal fungi (EM) and arbuscular mycorrhizal fungi (AM). EM reside in temperate and boreal forests with pines, firs, and oaks. They surround tree roots and do not penetrate them (Fransen, 2024). In these colder and drier climates, wood and organic matter decay slowly, and the EM network supports a slower carbon cycle by storing more carbon in the soil rather than releasing it into the atmosphere (Popkin, 2019). Currently, approximately 60% of trees are connected to EM fungi. With the accelerating threat of climate change, these fungi networks are vulnerable and predicted to decline, replaced by AM fungi. Scientists predict that if there is no reduction in carbon emissions, there could be a 10% reduction in EM fungi and their associated trees by the year 2100 (Marshall, 2019). The decline of this fungi network decreases the carbon stored in soil and promotes faster carbon cycles which could potentially accelerate climate change (Fransen, 2024). AM fungi are found in tropical and subtropical forests with hotter and wetter climates where wood and organic matter decay quickly. These fungi penetrate root cells and form smaller webs, allowing for less intertree swapping. They also promote fast carbon cycling, spewing more carbon out into the atmosphere and making this fungus network more damaging to our warming climate.

The Wood Wide Web has pushed scientists to understand forest ecosystems as a collection of trees assisting each other rather than a competition between individual trees. It demonstrates interspecies cooperation and the interconnectedness of all life, providing scientists with a new perspective on how life works on Earth. This new understanding has implications for forest management. Ecologists and entrepreneurs are increasingly prioritizing the integrity of the underground network, knowing that removing all the trees, especially mother trees, from an area can damage the subterranean web and hinder forest recovery and resilience (Fransen, 2024). The mycorrhizal network could also be a starting point for forest regeneration and growing species diversity; extending beyond forest ecosystems to agricultural systems, it could lead to more sustainable and resilient farming practices with reduced needs for fertilisers and pesticides (Fransen, 2024). This new understanding further underscores the value of old-growth forests which have had time to develop complex and extensive mycorrhizal networks.

The growing interest in this topic led to a mapping of the mycorrhizal fungi network by researchers from Crowther Lab at ETH Zurich, Switzerland, and Stanford University in the United States. Ecologist Thomas Crowther gathered vast amounts of data relating to tree identification, mapping the global distribution of trees in 2015 and estimating that the Earth has about 3 million trees. Inspired by his work and the association of each tree in Crowther's database with a certain type of microbe, biologist Kabir Peay at Stanford University suggested a similar mapping of a web of underground organisms. The researchers wrote a computer algorithm to investigate correlations between the fungi, their associated trees, and environmental factors in which the fungi existed (Popkin, 2019). Their mapping, completed in 2019, showed how the Wood Wide Web contributed to and was affected by climate change, revealing that losing fungal networks could increase the feedback loop of carbon emissions. It also enhanced scientists' understanding of fungal networks in tree ecosystems, such as identifying EM and AM fungi. Additionally, the mapping helped scientists understand how to restore different types of ecosystems in various regions around the world by helping to determine which trees to plant, assisting the UN's trillion tree campaign in 2021. While their data is insightful and extensive, Earth system scientist Charlie Koven pointed out that the researchers may have missed some important factors that could influence where different microbes live, such as nutrient and gas loss from the soil (Popkin, 2019).

Nonetheless, this mapping of the Wood Wide Web has great potential for future developments. Findings from Crowther and Peay's work only scratch the surface of the ancient and complex relationship between trees and their mycorrhizal networks. Scientists now understand that this symbiotic system is the foundation of many ecosystems and life on land, determining who lives where and why (Marshall, 2019). Moving forward, scientists seek to reveal more about information exchange through the Wood Wide Web, kin recognition by mother trees, and how climate change might affect these systems. For example, recent investigations have focused on developing better computer models to predict carbon sequestration—the storing and transferring of carbon through underground networks (Popkin, 2019). This initial mapping could be further developed by employing noninvasive methods to study mycorrhizal networks connected to tree ecosystems.

Research on the Wood Wide Web has introduced a new perspective on ecosystems, depicting them as intricate webs of cooperation and mutual support rather than battlegrounds of competition. As humanity tackles global warming in this new century, understanding underground networks can help develop more holistic and effective approaches to reduce the threats of climate change.

References

Fransen, B. (2024, December 7). *Understanding the Wood Wide Web*. EcoMatcher. https://www.ecomatcher.com/understanding-the-wood-wide-web/#:~:text=Discover%20the%20Wood%20Wide%20Web,even%20interspecies%20cooperation%20among%20trees.

Holewinski, B. (n.d.). *Underground Networking: The Amazing Connections Beneath Your Feet*. National Forest Foundation. Retrieved February 5, 2025, from https://www.nationalforests.org/blog/underground-mycorrhizal-network#:~:text=Mycelium%20are%20incredibly%20tiny%20%E2%80%9Cthreads,nitrogen%2C%20carbon%20and%20other%20minerals.

Marshall, C. (2019, May 15). *Wood wide web: Trees' social networks are mapped*. BBC. Retrieved February 5, 2025, from https://www.bbc.com/news/science-environment-48257315

Popkin, G. (2019, May 15). *'Wood wide web'—the underground network of microbes that connects trees—mapped for first time*. Science. Retrieved February 5, 2025, from https://www.science.org/content/article/wood-wide-web-underground-network-microbes-connects-trees-mapped-first-time

The Wood Wide Web. (n.d.). Smithsonian Gardens. Retrieved February 5, 2025, from https://gardens.si.edu/exhibitions/traveling/habitat/the-wood-wide-web/