Spotlight on Climate

Mycorrhizal Fungi - Can They Save Our Pinyon Forests?

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(700 words)

Fluorescent orange lobster mushrooms poking through the ponderosa pine needles, bright white oyster mushrooms hugging the sides of aspen logs, yellow and red Amanitas the size of dinner plates – a good monsoon season in the mountains of Arizona yields a bounty of mushrooms, both edible and poisonous. As we marvel at their ephemeral beauty and forage for delicacies available only once a year, we might not realize that mushrooms are just the little reproductive organs of a huge body of filaments that exists below the surface, in soil, decaying needles, or rotting wood. That hidden body is an integral part of the forest that many plants depend on for water and nutrients. Our research is now showing us the importance of that hidden body in helping trees survive the consequences of climate change.

Despite record snowfall this winter, the extremely hot and relatively dry summer of 2023 reminds us that we are in the midst of long-term drought brought on by climate change. A quick look at a national map of active fires this morning shows 12 fires burning in Arizona during what is normally one of the wettest times of the year. A recent NOAA study showed that climate change was the main reason for the increase in fire weather in the western United States. Ongoing drought and wildfire have devastated our forests and woodlands resulting in large scale mortality of iconic species like ponderosa and pinyon pine, one-seed juniper, and Fremont cottonwood. Forests around the world are experiencing similar stresses.

Can better knowledge about mushrooms and other fungi help us understand why our trees are sometimes slow to return following stand-replacing fire or why some trees die during drought while others survive? The roots of most plant species, including the trees that dominate much of our northern Arizona landscapes, form mutually beneficial associations with fungi, called mycorrhizas. These mycorrhizal associations involve the exchange of sugars from the plants for nutrients and water which the fungi efficiently scavenge from the soil. Our studies on pinyon pine show that some pinyons survive and grow during drought better than others. Field and greenhouse experiments have shown that these differences depend on which beneficial fungi are found on the tree's roots. The tree's genetics determine which types of fungi they associate with. The fungi on drought tolerant trees helped them acquire water from the soil during dry conditions. Matching trees with appropriate beneficial fungal partners could be key to successful restoration of pinyon pine following drought or wildfire.

Our research has also shown that, in pinyon-juniper woodlands, stand-replacing wildfires not only kill trees, but also change the species of beneficial fungi that occur in the soil. Our preliminary studies suggest that adding back the fungi lost during fire can help tree seedlings survive and grow, hopefully allowing them to re-establish in areas where pinyon and juniper have been gone for more than 20 years. We see similar benefits of adding fungi when planting cottonwoods in landscapes affected by drought and non-native tamarisk plants. Researchers in the midwestern US are using other types of mycorrhizal fungi to restore native prairies, improving not only how well the plants grow, but also increasing the number of species of plants that thrive in the area and reducing the success of non-native plants that negatively affect the ecosystem.

We are learning that different species of mycorrhizal fungi differ from one another in the ways that they can benefit plants. If we carefully observe mushrooms on the forest floor, we detect a diversity of colors, shapes, textures, tastes, and smells. Mushroom species differ in appearance in myriad ways. The more we study them the more we discover that these different species of fungi also exhibit a diversity of functions – one species of mycorrhizal fungus might be better at obtaining phosphorus from the soil for its host plant, while another is able to better access nitrogen, and a third is better at taking up water. Thus, while the use of mycorrhizal fungi in restoration holds great promise, it is not one size fits all. Instead, it requires that we carefully match the plants and fungi we replant if we hope to restore ecosystems from the effects of climate change.

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