Forest Research

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Ectomycorrhizal fungal (EMF) community interlinkages and forest stability in the face of drought

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Background

Drought events are predicted to increase in frequency, intensity, spatial extent and duration[1] resulting in higher tree mortality and consequent carbon loss rates[2,3,4].

EMF provide trees with growth limiting nutrients and water in exchange for carbon[5.]. They increase the hydraulic conductivity of soils and act as conduits through which water is transported to the tree, resulting in increased oxidative resistance and photosynthesis under drought stress[6,7].

The mycorrhizal fungi colonizing two different trees can connect to form a common mycorrhizal network (CMN), as long as they are genetically similar[8,9].The function and benefits of such a connection between trees is widely debated (Figure 1).

Understanding the function of CMNs will allow for assessment of their potential to increase the resilience of host trees and forests to stress, including drought.

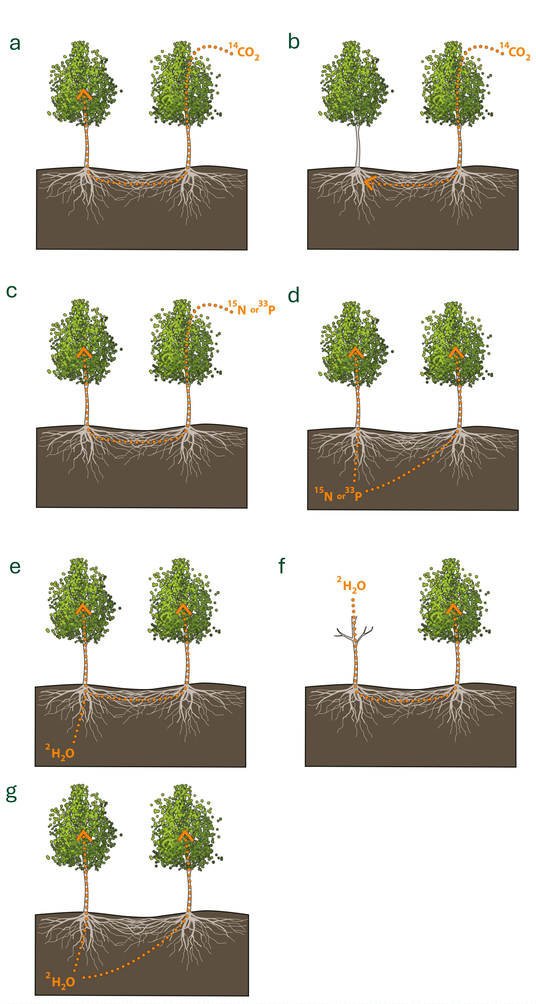

Figure 1| Theories on the function of CMNs **(a, c)** $^{14}CO_2$, ^{15}N or ^{33}P are supplied to the donor plant foliage and move through the CMN into the receiver plant tissue. This is what most research on resource transfer has focused on proving but has repeatedly failed to. **(b,d)** Rather than acting as a simple conduit for resource transfer between plants, mycorrhiza take up resources from the soil before distributing them to their plant partners. **(e,f)** Studies of water transport also tried to prove movement of water from one plant to another, suggesting the CMN facilitates hydraulic redistribution whereas a system more like **(g)** probably happens where being part of a mycorrhizal network is beneficial because it allows each plant to access resources from a greater volume of soil.

Microcosm Study

Part 1

Do CMNs form between tree species that are commonly planted in mixtures or that co-occur naturally in the UK and what ectomycorrhizal fungi (EMF) are implicated in these CMNs?

In root observation chambers, one sapling (the donor plant) will be planted and allowed to form a mycorrhizal network before an uninfected receiver plant is added. A CMN should form as the uninfected plant becomes colonized by the extra radical mycelium of the donor plant. Different combinations of seedlings (|Scots pine: Scots pine| |Scots pine: Sitka spruce| |Scots pine: birch| |birch: Scots pine| |birch: oak| |birch: birch|) will be used and the soils they are planted in will be collected from forests with the same component tree species.

Part 2

Can water be transported via a CMN to multiple partners?

- **What determines where the water is directed?**
- **Will connection to a CMN benefit drought stressed seedlings?**

For a given species combination three of the microcosms will be planted with both a donor and a receiver plant (Figure 2a,b,c) while in two of the microcosms only a receiver will be present (Figure 2d,e). Different watering regimes will be applied so that the entire microcosm will be watered (Figure 2a,d) or droughted (Figure 2c,e) or only the receiver plant will be droughted (Figure 2b,e). In the microcosms with only a receiver plant the whole microcosm and receiver only drought treatments are the same. A cup of tritium (^3H_2O) will be added to each microcosm, near to the donor plant or where the donor plant would have been. $^{13}CO_2$ will also be fed to the receiver plant in each microcosm. This will allow us to trace resource movement.

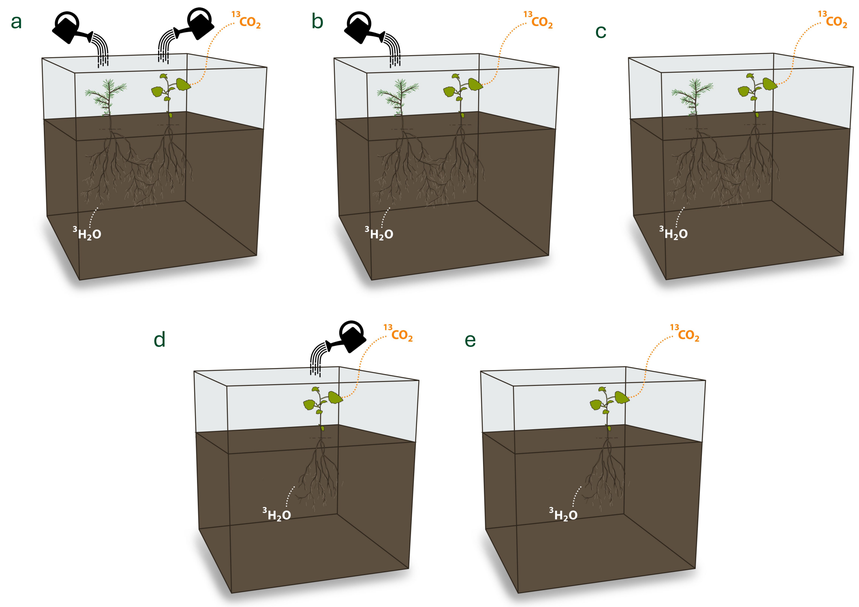

Figure 2| Experimental microcosm supplied with ^3H_2O and $^{13}CO_2$ to trace resource movement. **(a)** Both donor and receiver plant are watered. **(b)** Donor and receiver plant but the receiver plant is droughted and should contribute less carbon to it's mycorrhizal partner. **(c)** Both receiver and donor plants are droughted and both will contribute less carbon to their partners. **(d)** Only a receiver is present but it is well watered. **(e)** Only a receiver is present but droughted. Differences between connected and unconnected microcosms should inform us of the benefits/ detriments of a CMN while differences between drought treatments should illuminate whether CMNs operate by principles of biological market or source-sink theory.

Fieldwork

Little is known about how drought affects mycorrhiza, and consequently CMNs themselves. Shi *et al.*[10] found through a water exclusion experiment that drought did not significantly influence root colonization or the number of species colonizing birch trees, but it did influence the composition of the ectomycorrhizal community. **This research needs to be extended to the field to identify which species of mycorrhizal fungi are more commonly found in drought prone conditions in a range of forests of different component tree species.**

Sites will be selected which have the same species combinations that I am using in my microcosm experiments. For each species combination five sites will be selected that have been droughted and five will be selected which have not experienced drought resulting in 50 sites. Ectomycorrhizal community data will be collected using environmental DNA (eDNA) metabarcoding at these same sites[11] (Figure 3).

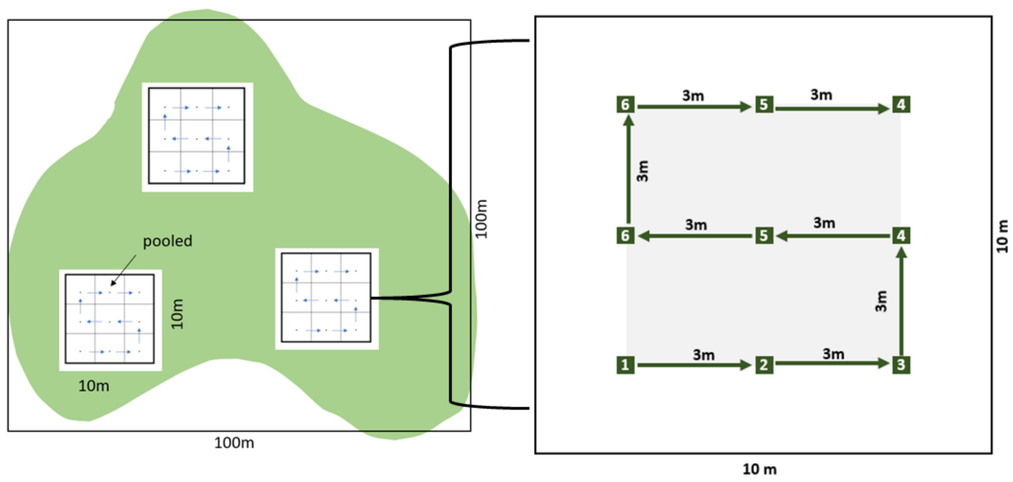

Figure 3| Overview of the draft sampling protocol per site; (right) Soil sampling protocol per quadrat (three per site).

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