Along the way, the fungi drew off and metabolized some of the photo-synthesized resources that were moving along their hyphae; this was their benefit from the mutualism.

Here was proof that trees could move resources around between one another using the mycorrhizal network. The isotope tracking also demonstrated the unexpected intricacy of the interrelations. In a research plot thirty metres square, every single tree was connected to the fungal system, and some trees – the oldest – were connected to as many as forty-seven others. The results also solved the puzzle of the fir–birch mutualism: the Douglas firs were receiving more photosynthetic carbon from paper birches than they were transmitting. When paper birches were weeded out, the nutrient intake of the fir saplings was thus – counter-intuitively – reduced rather than increased, and so the firs weakened and died.

The fungi and the trees had 'forged their duality into a oneness, thereby making a forest', wrote Simard in a bold summary of her findings.[Fn2] Instead of seeing trees as individual agents competing for resources, she proposed the forest as a 'co-operative system', in which trees 'talk' to one another, producing a collaborative intelligence she described as 'forest wisdom'. Some older trees even 'nurture' smaller trees that they recognize as their 'kin', acting as 'mothers'.[Fn3] Seen in the light of Simard's research, the whole vision of a forest ecology shimmered and shifted – from a fierce free market to something more like a community with a socialist system of resource redistribution.

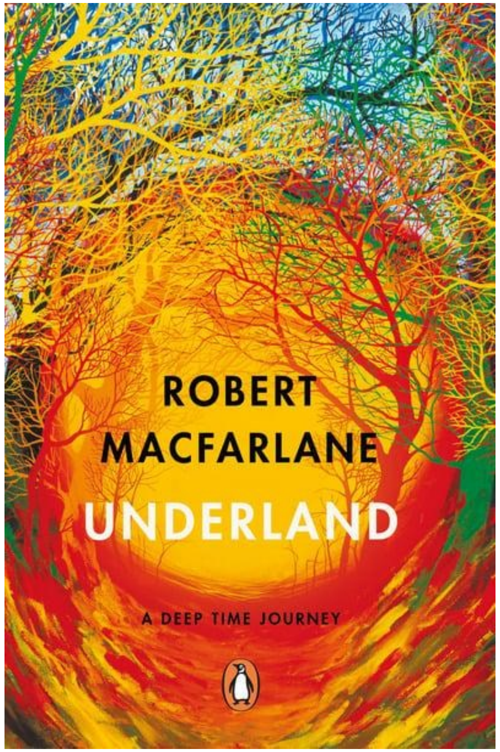
Simard's first major paper on the subject was published in Nature in 1997, and it was from there that the subterranean network of tree–fungus mutualism gained its durable nickname of 'the wood wide web'.[Fn4] Her Nature paper was a ground-breaking publication, the implications of which were so significant that an entire research field subsequently formed to pursue them. Since then the scientific study of below-ground ecology has boomed. New technologies of detection and mapping have illuminated fresh details of this 'social network' of trees and plants. 'The wood wide web has been mapped, traced, monitored and coaxed,' as Simard puts it, 'to reveal the beautiful structures and finely adapted languages of the forest network.' [Fn5]

Macfarlane, Robert. **Underland** (p. 86-91). Penguin Books Ltd. Kindle Edition.

Footnotes:

1. 'underground social network … fungal species': Suzanne Simard, 'Notes from a Forest Scientist', afterword to Peter Wohlleben, The Hidden Life of Trees, trans. Jane Billinghurst (Vancouver/Berkeley: Greystone Press, 2016), p. 247.
2. 'forged their duality … making a forest': Simard, in Wohlleben, Hidden Life of Trees, p. 249.
3. 'co-operative system … forest wisdom … mothers': Suzanne Simard, 'Exploring How and Why Trees "Talk" to Each Other', Yale Environment 360, 1 September 2016
4. 'the wood wide web': see Suzanne Simard et al., 'Net Transfer of Carbon between Ectomycorrhizal Tree Species in the Field', Nature 388:6642 (1997), 579–82.
5. 'The wood wide web … languages of the forest network': Simard, in Wohlleben, Hidden Life of Trees, p. 249.

NAMBUCCAVALLEYANGLICANS SUNDAY PAPERS 05.09.2021



When I read this section of **Underland** by Robert Macfarlane in a bookshop I was completely blown away. I was so excited I shared it with one of the people working there. I'm sure she was impressed!

The idea of inter-connectedness in this section ties in very well with our opening prayer for this Sunday, as we start the Season of Creation:

> This we know, all things are connected;
> like the blood which unites one family.

Just remember: All things are connected.

The Understorey
Epping Forest, London

Occasionally – once or twice in a lifetime if you are lucky – you encounter an idea so powerful in its implications that it unsettles the ground you walk on.

The first time I heard anyone speak of the 'wood wide web', more than a decade ago now, I was trying not to cry. A beloved friend was dying too young and too quickly. I had gone to see him for what I took to be the last time. He was tired by pain and drugs. We sat together, talked. My friend was a woodsman. Trees grew through his life and thought. His grandfather's surname was Wood, he lived in a timber-framed house that he had built himself, and he had planted thousands of trees by hand over the years. 'I have sap in my veins,' he wrote once.

That day I read aloud a poem that was important to us both, 'Birches' by Robert Frost, in which climbing the snow-white trunks of birches becomes both a readying for death and a declaration of life. Then he told me about new research he had recently read concerning the interrelations of trees: how, when one of their number was sickening or under stress, they could share nutrients by means of an underground system that conjoined their roots beneath the soil, thereby sometimes nursing the sick tree back to health. It was a measure of my friend's generosity of spirit that – so close to death himself – he could speak unjealously of this phenomenon of healing.

He did not have the strength then to tell me the details of how this below-ground sharing operated – how tree might invisibly reach out to tree within the soil. But I could not forget the image of that mysterious buried network, joining single trees into forest communities. It was planted in my mind, and there took root. Over the years I would encounter other mentions of the same extraordinary idea, and gradually these isolated fragments began to connect together into something like understanding.

In the early 1990s a young Canadian forest ecologist called Suzanne Simard, studying the understorey of logged temperate forests in north-west British Columbia, observed a curious correlation. When paper birch saplings were weeded out from clear-cut and reseeded plantations, their disappearance coincided with first the deterioration and then premature deaths of the planted Douglas fir saplings among which they grew.

Foresters had long assumed that such weeding was necessary to prevent the young birches (the 'weeds') depriving the young firs (the 'crop') of valuable soil resources. But Simard began to wonder whether this simple model of competition was correct. It seemed to her plausible that the paper birches were somehow helping rather than hindering the firs: when they were removed, the health of the firs suffered. If this interspecies aid-giving did exist between trees, though, what was its nature – and how could individual trees extend help to one another across the spaces of the forest?

Simard decided to investigate the puzzle. Her first task was to establish some kind of structural basis for possible connections between the trees. Using microscopic and genetic tools, she and her colleagues peeled back the forest floor and peered below the understorey, into the 'black box' of the soil – a notoriously challenging realm of study for biologists. What they saw down there were the pale, super-fine threads known as 'hyphae' that fungi send out through the soil. These hyphae interconnected to create a network of astonishing complexity and extent. Every cubic metre of forest soil that Simard examined held dozens of miles of hyphae.

For centuries, fungi had generally been considered harmful to plants: parasites that caused disease and dysfunction. As Simard began her research, however, it was increasingly thought that certain kinds of common fungi might exist in subtle mutualism with plants. The hyphae of these so-called 'mycorrhizal' fungi were understood not only to infiltrate the soil, but also to weave into the tips of plant roots at a cellular level – thereby creating an interface through which molecular transmission might occur. By means of this weaving, too, the roots of individual plants or trees were joined to one another by a magnificently intricate subterranean system.

Simard's enquiries confirmed that beneath her forest floor there did indeed exist what she called an 'underground social network', a 'bustling community of mycorrhizal fungal species' that linked sapling to sapling. [Fn1] She also discovered that the hyphae made connections between species: joining not only paper birch to paper birch and Douglas fir to Douglas fir, but also fir to birch and far beyond – forming a non-hierarchical network between numerous kinds of plants.

Simard had established a structure of connection between the saplings. But the hyphae provided only the means of mutualism. Its existence did not explain why the fir saplings faltered when the birch saplings were weeded out, or details as to what – if anything – might be transmitted via this collaborative system. So Simard and her team devised an experiment that could let them track possible biochemical movements along this invisible buried lattice. They decided to inject fir trees with radioactive carbon isotopes. Using mass spectrometers and scintillation counters, they were then able to track the flow of carbon isotopes from tree to tree.

What this tracking revealed was astonishing. The carbon isotopes did not stay confined to the individual trees into which they were injected. Instead, they moved down the trees' vascular systems to their root tips, where they passed into the fungal hyphae that wove with those tips. Once in the hyphae they travelled along the network to the root tips of another tree, where they entered the vascular system of that new tree.