News

Tree root microbiome programme

SCION
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Welcome

Welcome to the first newsletter of the Tree Root Microbiome Programme.

This programme is a major five-year government and industry-funded research endeavour. It will delve deep into the 'ecological dark matter' of the millions of microbes amongst the roots of trees, not just in New Zealand, but globally.

The Tree Root Microbiome Programme involves collaborators from many parts of the world.

Jointly funded by the MBIE Endeavour Fund and the Forestry Growers Levy Trust, this research programme kicked off in October 2020.

Programme leader

The Tree Root Microbiome Programme is being led by New Zealander, Dr Steve A. Wakelin, a microbial ecologist who has worked both in New Zealand and Australia. Steve specialises in forest genomics and ecosystem functions. He has been with Scion in Christchurch since 2016.

During his career, Steve has worked on understanding the relationships between microbiomes, plants and the environment, across a range of different systems. These span agricultural land use to mine-site tailings, tussock grasslands to native shrublands. Since joining Scion, Steve's research has increasingly been within forested systems, but the focus on plants, roots, soils and the environment remains the same.

"We aim to understand the role the micro-organisms on and in plants have on influencing ecosystem outcomes", says Steve. "Whether this is plant disease, nutrition, carbon storage, biodiversity, or productivity, microbes have an important role to play. The world's demand for sustainably produced food and fibre is increasing. To meet these demands within a rapidly changing environment, we must use novel approaches. The microbiome is one of these."

Dr Steve A. Wakelin, Tree Root Microbiome Programme Leader.

> *"There is a huge information void around underground microbes and their function. The Human Microbiome Project revealed how vitally important gut microbes and function are to human health. Now where the gut has gone, soil will follow".*
>
> Dr Steve A. Wakelin

Steve's aim for the programme is to transform our understanding of how trees interact with their environment and each other, opening entirely new opportunities for protecting our productive and natural trees and forests.

What is a tree microbiome?

The tree microbiome can be defined as all the micro-organisms that live in, on, or around a tree, both above and below ground. Scientists anticipate that the tree microbiome comprises a huge genetic resource – a library of information many times greater than the genetic resource of the tree itself. It holds the potential to enhance tree health, productivity, and resilience in a changing climate.

The human microbiome project (HMP) provides a good analogue for tree microbiome research. The HMP discovered 100 trillion species living in, or on, a person and confirmed that every person has a unique microbiome akin to a fingerprint. The HMP has unlocked many possibilities – for example, in human health – that were never imagined beforehand.

Harnessing global research capability

The Tree Root Microbiome Programme is a collaboration among national and international research organisations. In New Zealand, this involves scientists at Scion, Lincoln University, and Victoria University of Wellington. Overseas partners are at the Hawkesbury Institute for the Environment at the University of Western Sydney, Wright State University in Ohio, the Woodwell Climate Research Center in Massachusetts and the University of Adelaide, South Australia.

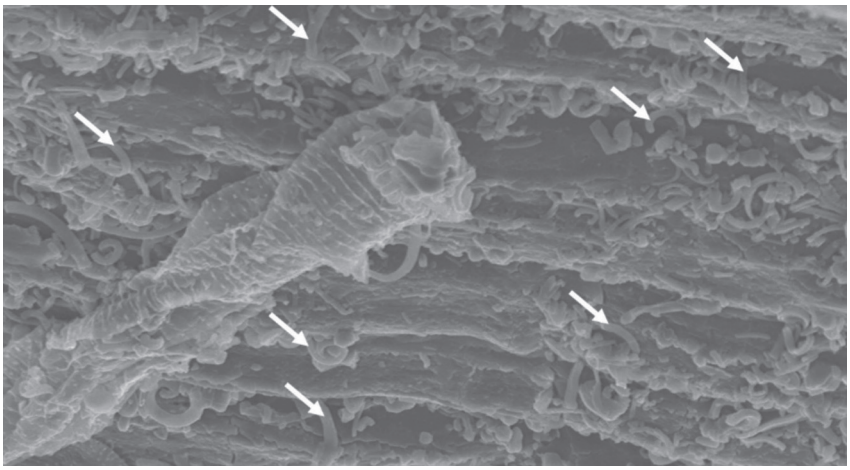
Global app for samples. Scientists globally will be engaged to collect and submit samples of radiata pine from as many different locations and environments as possible. This global science effort will be coordinated by a smartphone app. The app will provide instructions on how to sample radiata pine above and below ground. It will also collect specific information about the environment where each tree is growing.

Resilience to drought. Initial proof-of-concept work will investigate how the root microbiome influences radiata pine resilience to drought. The research will focus on radiata pine and its microbiome in dry environments in Australia and southern California. These are places with climatic conditions which represent what New Zealand will experience in the decades to come. Knowledge of the microbiome-tree associations in these environments and how they work together to enable trees to survive periods of environmental stress can be used to protect our future forests.

An early learning curve: the microbiome of radiata pine needles

Scion scientists began work several years ago on the microbiome of radiata pine needles. It has been a steep learning curve as it was entirely new research. “We needed to go right back to basics,” says Steve. "We worked out the role that factors have on microbiome variation, such as leaf age, canopy, height and sampling direction. Essentially, we had to establish field-sampling protocols before we could even start asking the big research questions.”

Back in the lab, the microbiome DNA is extracted from the plant tissue, and next-generation sequencing approaches are used to identify what micro-organisms are present.

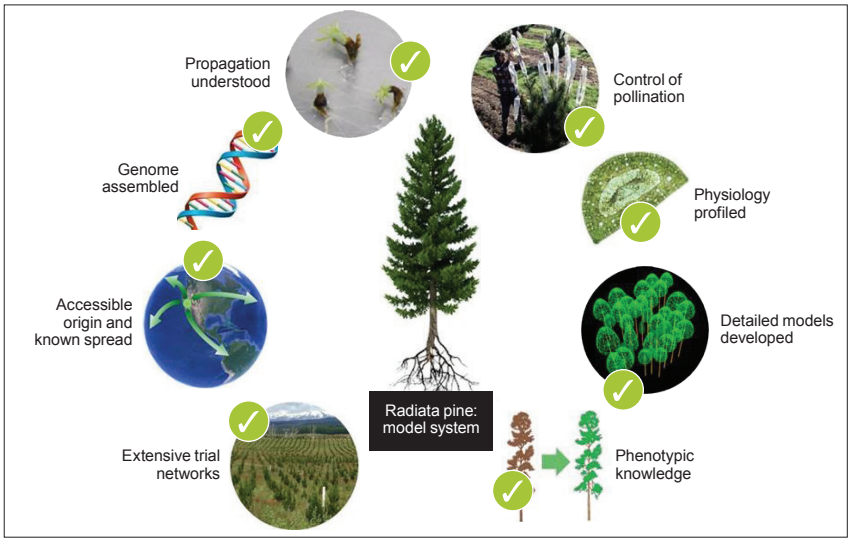


Credit: Lottie Armstrong, Scion.

Electron micrograph of many different micro-organisms on the surface of a radiata pine needle. Arrows point to example individual micro-organisms, though there are hundreds on the image.

“We are also creating unique bioinformatic approaches,” says Steve. “We want to understand the role these micro-organisms have in forest ecology.

At this stage, it’s a case of lining up our ducks in a row so we can undertake our research with rigour and be confident in our findings.”



Radiata pine makes a perfect model system.

Why radiata pine?

Radiata pine (*Pinus radiata*) has been chosen as the model tree species for microbiome research, partly, because so much is already known about it. “We already have a wealth of existing information,” says Steve. “We understand key aspects of its physiology and ecology. Its genome has been sequenced. We also have systems in place for its manipulation. It is relatively easy to grow and propagate and we have existing field trials both in New Zealand and in many places overseas.”

Characterising the soil environment

Soil samples from beneath radiata pine trees globally will help scientists understand the role of soil properties, chemical and physical, in shaping tree root microbiome associations.

Scion's 'Characterising the Soil Environment' Research Area Lead, Senior Scientist Loretta Garrett says there is a target to test 5,000 samples that will come from Europe, Africa, the Americas, Australia, New Zealand and tropical Fiji.

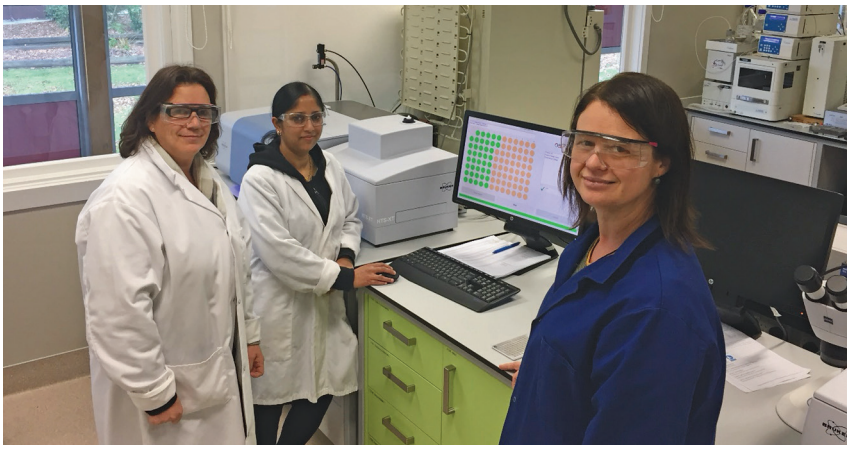
Each sampling site (beneath a single radiata pine tree) will be identified by GPS coordinates. The climate, slope, aspect and soil classification will be characterised using global data layers. Root and needle samples will also be taken at each site and all samples will be DNA-tested, so eventually a global picture is developed of the composition of the needle and root microbiomes associated with radiata pine.

"We will discover soil microbes that have never been described before, and it will be fascinating to look for similarities and differences in soil microbes from different environments. We will begin to understand the functions of different microbes in the pine root microbiome, which will be a huge step forward."

Working with Dr Jonathan Sandman at the Woodwell Climate Research Center in the USA, Loretta and her colleagues have recently developed a new low cost/high throughput soil analysis service for New Zealand planted forest soils. This is based on mid-infrared (MIR) spectroscopy. Internationally, MIR is widely used to characterise soils.

However, its application in New Zealand is relatively new, especially for forest soils. To get this testing method working, Loretta, Jonathan and their team have had to build large libraries of forest soil information against which computer algorithms can 'learn' to interpret and understand what the MIR signals are saying.

The collection and data produced from global soil samples will become available as findings of the Tree Root Microbiome Programme are peer-reviewed and published.



Senior Scientist Loretta Garrett (front) with Sunita Jeram (middle) and Catherine Banham (left) from Scion's MIR spectroscopy team.

Four research areas of the 'Tree Root Microbiome Programme'

1. **Environmental drivers**
   Aims to understand the critical associations between radiata pine plants, the microbiome and the environment. Do these associations differ around the world and vary with extreme climates?

2. **Host drivers**
   Aims to understand and quantify how genetic differences between radiata pine trees shape the tree root microbiome.

3. **Characterising the soil environment**
   Understanding the role of soil properties in shaping tree root microbiome associations.

4. **Altering the phenotype**
   The microbiome helps the trees interact with and respond to its environment. This research explores ways to help radiata pine adapt to stressful environments. These results may then be translated to other species.

The Tree Root Microbiome Programme is jointly funded by the MBIE Endeavour Fund and the Forest Growers Levy Trust.

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