Forest & Wood Products Australia

INVESTMENT PLAN

Beneficial soil microbiome-tree interactions in nursery and forest settings

October 2021

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1. EXECUTIVE SUMMARY

The soil microbiome and its complex interactions with forest trees, from seedlings to established standing trees, can have significant beneficial impacts on enhancing growth and stress tolerance. There is substantial interest from forest managers and researchers in research, development, and extension (RD&E) to improve industry's understanding of, and ability to manage, beneficial soil microbiome-tree interactions in nursery and forest settings. Investment soil microbiome-tree RD&E is a new area of focus for Forest and Wood Products Australia (FWPA).

Industry consultation and analysis identified seven priority themes for FWPA research funding in relation to this plan. Feedback from consultation with industry stakeholders generated high-level issues or research questions for each research theme area. These are outlined in the table below and discussed in further detail in the body of this Investment Plan.

Table 1: Highest priority NURSERY RD&E themes and their context

Themes	Context	Specific issues
Microbiota and seedling fertilisation	Developing complementary microbiota and fertilisation strategies.	Developing complementary microbiota and fertilisation strategies, e.g., tailored inoculum, modified fertilisation.
Seed and seedling inoculation	Improved nursery efficiency, increased survival at out-planting, and long-term tree productivity.	Better understanding of mycorrhiza and beneficial fungi management.
		Tailoring inoculants using a bespoke combination ('recipe') of microbiota for individual sites and/or species.
Microbiota and fungicide use in nurseries	Developing microbiota and fungicide strategies to provide disease treatment as well as microbiome benefits.	Developing microbiota and fungicide strategies to provide disease treatment as well as microbiome benefits.

Table 2: Highest priority FOREST RD&E themes and their context

Themes	Context	Specific issues
Soil health monitoring	Measurement and use of indicators of soil biotic health and biodiversity* .	Developing robust quantitative and qualitative measures of soil biotic health and biodiversity specific to forest soils*.
Harvest operations and residues	Managing harvest operations, soil disturbance, and residues for positive effects on soil microbiome populations, especially under multi-rotations*.	Understanding effects of harvest operations on beneficial soil microorganisms.
		Developing recommendations for slash management to maximise tree productivity through soil microbiome benefits*.
Inoculation and supplementation of standing trees	Improved growth and productivity of standing trees through inoculation and supplementation of the microbiome.	Measuring soil microbiome factors and tailoring inoculants for standing trees using a bespoke combination ('recipe') of microbiota for individual sites and/or species.
		Strategies involving fertiliser or other soil adjuvants to improve soil microbiome performance.
Climate change adaptation	Augment tolerance of standing estate through increased resilience to climate variability and extremes*.	Strategies for manipulating ACC deaminase to make trees more drought stress tolerant*.

* These priorities are of significance to native forests as well as plantation forestry.

2. INTRODUCTION

2.1 OBJECTIVE

Investment in beneficial soil microbiome-tree interactions in nursery and forest settings is a new area of focus for Forest and Wood Products Australia (FWPA).

This Investment Plan sits within FWPA's Program 4: Increasing resource availability and reducing risk and aligns with proposed activities such as building the business case for additional investment by forest growers, delivering on approved research investment plans, developing forest health systems that can minimise risk to forest owners and their customers, and ensuring that forest management and forest operation tools deliver in-field practices that are scientifically sound, safe and compatible with international best practice.

The objective of this Investment Plan is to guide the effective investment of FWPA and other funds over the five financial years from 2021/22 to 2025/26 in projects which improve industry's understanding of, and ability to manage, beneficial soil microbiome-tree interactions in nursery and forest settings which provide measurable benefits.

The focus of investment is on collaboration across research and commercial organisations to maximise the value of the FWPA funding available. Priority themes that have been rated 'low' for FWPA research funding may be more appropriately, and in some cases are being, addressed by current research activities or individual organisations.

2.2 SCOPE

This Investment Plan considers investment by FWPA in soil microbiome-tree RD&E that:

- Contributes to practical outcomes and measurable benefits for commercial forest managers.
- Is predominantly focused on softwood and hardwood plantation growing and seedling raising, however some priorities may also be appropriate for native forest management.
- Is focused on forest species of commercial relevance in Australia.
- Is focused on microbial communities associated with the root surface and adjacent soil layer (rhizosphere).

2.3 APPROACH

Development of the Investment Plan involved:

- a desktop review of key background documents, research papers and webinar contents.
- preparation of a literature review and background reading documents.
- a virtual workshop of forest growers and a key microbiome research providers.
- a prioritisation exercise of RD&E needs.
- development of a draft Investment Guide for review prior to finalisation.

The industry consultation process identified and prioritised the important themes for future soil microbiome RD&E focus.

2.4 DEFINITIONS

- **Microbiome** - The communities of fungi, bacteria, archaea, and protists colonizing plant tissues and inhabiting outer plant surfaces, collectively comprise plant microbiota.
- **Rhizosphere** - The narrow region of soil or substrate that is directly influenced by root secretions and associated soil microorganisms known as the root microbiome.

3. BACKGROUND

Forest soils are among the most species diverse systems on Earth. The soil microbiome and its complex interactions with forest trees, from seedlings to established standing trees, can have significant beneficial impacts on enhancing growth and stress tolerance. The composition and activity of the soil microbiome can affect tree growth in many positive ways, including:

- Increasing resource availability and assisting uptake of these resources by the tree, e.g., nitrogen fixing bacteria.
- Increasing stress tolerance, including drought tolerance, that protects the value of standing trees, e.g., soil bacteria breaking down ethylene precursors to enable tree productivity to be maintained for longer under stress.
- Regulating growth behaviour, e.g., plant growth promoting rhizobacteria.
- Reducing management inputs and costs, e.g., optimised use of fungicides and fertiliser to encourage beneficial mycorrhiza in the nursery, reduced water use.

There is increasing interest in understanding more about the microbiome communities found in Australian soils and how they can be better managed and utilized to increase tree growth and health, stress tolerance, and protection against future climate change impacts.

Significant microbiome research has been undertaken in agricultural production under annual cropping, (e.g., cotton) and perennial plants, (e.g., pastures, grasslands) but not as much under commercial forestry conditions.

Mycorrhizae research for Australian forests during the 1960s and 1970s focused on the effects of mycorrhizal fungi in radiata pine seedlings[2], mycorrhiza inoculation on forestry practice[3] and responses to radiata pine to different fungi[4].

More recent Australian forest microbiome research has investigated dieback and tree decline in *Eucalyptus gomphocephala* (tuart) and *Eucalyptus marginata* (jarrah). Internationally, forest microbiome research has focused on *Pinus radiata* in New Zealand and a range of eucalypt species in Brazil, China, and some African countries.

Appendix 3 lists soil microbiome-tree research in Australia and overseas since 2010 with a focus on forest species of commercial relevance to Australia. The list excludes research into non-forestry applications, e.g., mine site rehabilitation.

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[2] Lamb, R.J. and Richards, B.N. (1971) Effect of Mycorrhizal Fungi on the Growth and Nutrient Status of Slash and Radiata Pine Seedlings. Australian Forestry, 35: 1-7

[3] Bowen, G.D. (1965) Mycorrhiza inoculation in forestry practice. Australian Forestry, 29: 231–237

[4] Theodorou, C. and Bowen, G.D. (1970) Mycorrhizal Responses of Radiata Pine in Experiments with Different Fungi. Australian Forestry, 34:3, 183-191

3.1 OUTCOMES AND IMPACTS OF RD&E

Previous soil microbiome RD&E has delivered outcomes and impacts in the following areas for plantation and nursery practices:

Pinus radiata

- Initial recommendations for site manipulation to maximise benefits from microbial activity.
- Recommendations of physical soil amendments to improve nutrient availability.
- Revised specifications for nursery management for better seedling quality.
- Recommendations for reduced fungicide use in the nursery.
- Specifications for specific mycorrhizal symbionts and plant growth-promoting rhizobacteria for better seedling growth.
- Recommendations on the best symbionts for specific genotypes.
- Identification of longer-term impacts of fertilisers on bacterial and fungal communities.
- Identification of impact of weed control and fertilisers on enzymes and hormones (indole-3-acetic acid (IAA), 1-aminocyclopropane-1-carboxylate (ACC) deaminase).
- Identification of differences in genotype performance in response to nitrogen form, associated with shifts in microbiome.

***Eucalyptus* species**

- Identification of impact of ectomycorrhizal (ECM) fungi in immobilizing phosphorus and other nutrients.
- Identification of impact of phosphite on mycorrhizal formation in seedlings.
- Identification of impact of mixed plantations in promoting more efficient use of carbon and nitrogen by microbial communities.
- Initial recommendations for large scale inoculation of ECM fungi in commercial nurseries.
- Initial recommendations for bacteria which can be easily inoculated at transplant by using superabsorbent hydrophilic polymers (SAP).

A literature review of published journal papers for soil microbiome research of relevance to Australian commercial forest species [5], conducted in Australia and overseas since 2010, found most of the focus has been on *Pinus radiata* (conducted in New Zealand). New Zealand has 1.7 million hectares of planted forest, 90% of which is *Pinus radiata* (1.53 million hectares). Australia has 775,000 hectares of radiata pine, which equates to about 40% of plantation area. Scion, one of seven New Zealand Crown Research Institutes, is the key organisation focussing on microbiome research in *Pinus radiata* forests.

The number of journal papers for Australian microbiome research in eucalypt species is relatively small and has focused on *Eucalyptus grandis/urogranidis, E. globulus*, and other *Eucalyptus* species. Research into these species has also been conducted overseas, primarily in Brazil and China.

[5] Excluding research into non-forestry applications, e.g., mine site rehabilitation.

4. RD&E NEEDS 2021/22 to 2025/26

During the virtual workshop of forest growers and microbiome research providers, and the subsequent prioritisation exercise, key short to medium-term RD&E needs were identified.

Within nursery management, industry stakeholders nominated RD&E prospects to improve efficiency through shorter growth cycles, more robust seedlings, decreased water use, and fine tuning of fertiliser and fungicide use. The high priority areas of focus included seed and/or seedling inoculation, complementary microbiota and fertilisation strategies, and microbiota and fungicide strategies.

High priority soil microbiome RD&E opportunities to improve forest productivity and stress tolerance through forest and plantation management included soil health monitoring and harvest operations for positive effects on the soil microbiome.

On the more distant horizon, soil microbiome research and development activities could be linked with tree breeding, wood properties, and biomaterials. However, these opportunities were not strongly identified or highlighted during the investment planning process.

RD&E needs were identified based on their relevance to either nursery management or forest and plantation management. These needs were then categorised by industry stakeholders. This information is presented below in Table 3 and by key RD&E theme areas, including supporting context and specific issues, in Table 4.

Table 3: RD&E needs

PRIORITY	**Nursery management**	**Forest and plantation management**
VERY HIGH	• Developing complementary microbiota and fertilisation strategies, e.g., tailored inoculum, modified fertilisation. • Better understanding of mycorrhiza and beneficial fungi management.	• Developing robust quantitative and qualitative measures of soil biotic health and biodiversity specific to forest soils* . • Understanding effects of harvest operations on beneficial soil microorganisms.
HIGH	• Developing microbiota and fungicide strategies to provide disease treatment as well as microbiome benefits. • Tailoring inoculants using a bespoke combination (‘recipe’) of microbiota for individual sites and/or species.	• Developing recommendations for slash management to maximise tree productivity through soil microbiome benefits*. • Measuring soil microbiome factors and tailoring inoculants for standing trees using a bespoke combination (‘recipe’) of microbiota for individual sites and/or species.
MEDIUM	• Assessing effectiveness of seed treatment (as well as seedling treatments).	• Strategies involving fertiliser or other soil adjuvants to improve soil microbiome performance.

* These priorities are of significance to native forests as well as plantation forestry

	• Better understanding of interactions of fungicides with mycorrhiza. • Quantifying effects of *Trichoderma* on growth and disease suppression in nurseries.	• Strategies for manipulating ACC deaminase to make trees more drought stress tolerant*. • Comparison of the effect of burning versus mechanical fuel reduction strategies on the functionality of the soil microbiome*
LOW	• Assessing effectiveness of mycorrhizae and other microbiota inoculants, e.g., field-collected versus commercial. • Understanding impacts of beneficial endophytes in seed germination.	• Manipulating soil microbiome in response to changes in behaviour and/or prevalence of pathogens (due to climate change)*. • Understanding the impacts of fallow crops and woody weeds, e.g., acacia, on soil microbiome populations. • Improving nitrogen fixation and reduce need to use remedial fertilisers. • Quantifying effects and delivering *Trichoderma* applications to established forests to increase growth and/or disease suppression in plantations. • Modifying the rhizobiome to improve rooting in apical mini-cuttings.

Whilst the prioritisation process provided clear guidance on the relative rankings of RD&E needs, there was diversity in the importance of topics areas across forest managers and between forest managers and researchers. For example, for each of the RD&E needs rated overall as 'low' there was often one or two forest manager participants who rated the need as 'high' or 'very high'. In these cases, research activities may be undertaken by the individual organisations to meet these needs.

Additional RD&E themes that were identified by individual contributors during the process were:

- Impact of fire on the microbial community and microbial benefits to plantations.
- Understanding the influence of mycorrhizae by rhizobacterial inoculation interactions on seedling quality and out-planting performance.
- Understanding the influence of inorganic versus organic potting mix fertilisers on the effectiveness of inoculants.
- Investigating the time taken for soil communities and the services they provide to recover to a pre-harvest level if the soil microbiome is drastically altered by harvesting.
- Harnessing the soil-plant microbiome for resilience against biotic and abiotic stresses, using a system-based approach.

The prioritisation process did not distinguish RD&E needs by hardwood (e.g., eucalypts) vs softwoods (e.g., radiata), or plantation versus native forests, but future RD&E should align with forest species of commercial relevance to Australia, e.g., Radiata pine, Tasmanian blue gum, etc.

Table 4: Summary of key RD&E themes – theme, context, specific issues, and priority

Theme	Context	Specific issues	Priority
Microbiota and seedling fertilisation	Developing complementary microbiota and fertilisation strategies.	Developing complementary microbiota and fertilisation strategies, e.g., tailored inoculum, modified fertilisation.	**VERY HIGH**
Soil health monitoring	Measurement and use of indicators of soil biotic health and biodiversity.	Developing robust quantitative and qualitative measures of soil biotic health and biodiversity specific to forest soils* .	**VERY HIGH**
Seed and seedling inoculation	Improved nursery efficiency, increased survival at out-planting, and long-term tree productivity.	Better understanding of mycorrhiza and beneficial fungi management.	**VERY HIGH**
		Tailoring inoculants using a bespoke combination ('recipe') of microbiota for individual sites and/or species.	**HIGH**
		Assessing effectiveness of seed treatment (as well as seedling treatments).	**MEDIUM**
		Quantifying effects of *Trichoderma* on growth and disease suppression in nurseries.	**MEDIUM**
		Assessing effectiveness of mycorrhizae and other microbiota inoculants, e.g., field-collected versus commercial.	**LOW**
		Understanding impacts of beneficial endophytes in seed germination.	**LOW**

*These priorities are of significance to native forests as well as plantation forestry

Harvest operations and residues	Managing harvest operations, soil disturbance, and residues for positive effects on soil microbiome populations, especially under multi-rotations.	Understanding effects of harvest operations, e.g., slash management, stump removal on beneficial soil microorganisms.	**VERY HIGH**
		Developing recommendations for slash management to maximise tree productivity through soil microbiome benefits*.	**HIGH**
		Comparison of the effect of burning versus mechanical fuel reduction strategies on the functionality of the soil microbiome*.	**MEDIUM**
		Understanding the impacts of fallow crops and woody weeds, e.g., acacia, on soil microbiome populations.	**LOW**
Microbiota and fungicide use in nurseries	Developing microbiota and fungicide strategies to provide disease treatment as well as microbiome benefits.	Developing microbiota and fungicide strategies to provide disease treatment as well as microbiome benefits.	**HIGH**
		Better understanding of interactions of fungicides with mycorrhiza.	**MEDIUM**
Inoculation and supplementation of standing trees	Improved growth and productivity of standing trees through inoculation and supplementation of the microbiome.	Measuring soil microbiome factors and tailoring inoculants for standing trees using a bespoke combination (‘recipe’) of microbiota for individual sites and/or species.	**HIGH**
		Strategies involving fertiliser or other soil adjuvants to improve soil microbiome performance.	**MEDIUM**
		Improving nitrogen fixation and reduce need to use remedial fertilisers.	**LOW**
		Quantifying effects and delivering *Trichoderma* applications to established forests to increase growth and/or disease suppression in plantations.	**LOW**
Climate change adaptation		Strategies for manipulating ACC deaminase to make trees more drought stress tolerant*.	**MEDIUM**

	Augment tolerance of standing estate through increased resilience to climate variability and extremes.	Manipulating soil microbiome in response to changes in behaviour and/or prevalence of pathogens (due to climate change)*.	**LOW**
Rooting promotion	Use of soil microbiota, such as rhizobacteria, for improving rooting in clonal propagation systems.	Modifying the rhizobiome to improve rooting in apical mini-cuttings.	**LOW**

4.1 FUNDING ALLOCATIONS

Funding allocations should be based on the ranked importance of the themes and the commercial relevance of different forest species in terms of their contribution to the industry. This is intended to ensure that soil microbiome-tree RD&E investment is aligned with FWPA levy payers' priorities.

Research projects should focus on working collaboratively across research and commercial organisations to maximise the value of the FWPA funding available.

APPENDIX 1: WORKSHOP PARTICIPANTS

Participants in the virtual workshop of forest managers and a key microbiome research providers, held on 28th May 2021, were:

NAME	ROLE	ORGANISATION
Allie Muneri	Research Manager	PF Olsen
Andrew Jacobs	Chief Technical Officer	Forico
Angus Carnegie	Senior Research Scientist	Forest Health & Biosecurity, Forest Science, NSW DPI
Ben Bradshaw	R&D Manager	Australian Bluegum Plantations
Brajesh Singh	Director	Global Centre for Land-Based Innovation, Western Sydney University
Chanyarat Paungfoo-Lonhienne	Research Fellow	School of Agriculture and Food Sciences, University of Queensland
Chris Murphy	Consultant	Chris Murphy Advisory
Christopher Oliver	Operations Manager	African Mahogany Australia
Craig Torney	Nursery Manager	OneFortyOne
Daniel Revie		VicForests
Darryn Crook	Technical Manager	Reliance Forest Fibre
Dean Williams	Forest Management Services Manager	Sustainable Timber Tasmania
Gerald Harvey	Harvest and Procurement Manager	SFM Environmental Solutions
Glen Rivers	Chief Forester	OneFortyOne
Helen Whelan	Research Officer	Bio-Protection Research Centre, Lincoln University
Ian Last	Manager, Plantation Development & Innovation	HQPlantations
James Williams	Silviculture Manager	Reliance Forest Fibre
Janette Newport	Business Development Manager	VicForests
Jeffrey Cook	Nursery and Seed Centre Manager	Forest Products Commission
Jodie Mason	Forest Research Manager	Forest & Wood Products Australia
John Senior	Science Forester	HQPlantations
Jonathon Plett	Senior Lecturer/Assistant Professor	Hawkesbury Institute for the Environment, Western Sydney University

Krista Plett	Visiting Fellow	Hawkesbury Institute for the Environment, Western Sydney University
Matt Giles	Plantations and Nursery Manager	WA Plantation Resources
Rhiana Archie	Marketing, Communications and Administration Assistant	Forest & Wood Products Australia
Simeon Smaill	Senior Scientist	Forest System Group, Scion
Stephen Elms	Manager Research	HVP Plantations
Tony O’Hara	General Manager Forest Resources	HVP Plantations

APPENDIX 2: GLOSSARY

ACRONYM	DESCRIPTION
ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
ACC	1-aminocyclopropane-1-carboxylate
AM	Arbuscular mycorrhizas
ECM	Ectomycorrhizal
IAA	indole-3-acetic acid
SAP	Superabsorbent hydrophilic polymers

APPENDIX 3: Soil microbiome-tree research

Paper	Authors	Institution	Journal	Year
Pinus radiata				
Reduced fungicide use in the nursery improves post-planting productivity of *Pinus radiata* for at least six years.	Simeon J. Smaill, Katrin Walbert, Rodrigo Osorio	Scion	Forest Ecology and Management 475:118416	2020
Effects of forest harvest and fertiliser amendment on soil biodiversity and function can persist for decades.	SL Addison, Simeon J. Smaill, LG Garrett, SA Wakelin	Scion	Soil Biology and Biochemistry 135, 194-205	2019
Edaphic properties related with changes in diversity and composition of fungal communities associated with *Pinus radiata.*	SL Addison, Katrin Walbert, Simeon J. Smaill, A Menkis	Scion	Pedobiologia 66, 43-51	2018
Host Genotype and Nitrogen Form Shape the Root Microbiome of Pinus radiata.	Marta Gallard, Karen L. Adair, Jonathan Love, Dean F Meason, Peter W. Clinton, Jianming Xue, Matthew H. Turnbull	Scion; University of Canterbury	Microbial Ecology 75(8)	2018
Genotypic variation in *Pinus radiata* responses to nitrogen source are related to changes in the root microbiome.	Marta Gallard, Karen L. Adair, Jonathan Love, Dean F Meason, Peter W. Clinton, Jianming Xue, Matthew H. Turnbull	Scion; University of Canterbury	FEMS Microbiology Ecology 94(6)	2018
Fertilizer and fungicide use increases the abundance of less beneficial ectomycorrhizal species in a seedling nursery.	Simeon J. Smaill, Katrin Walbert	Scion	Applied Soil Ecology 65, 60–64.	2013
Influence of inoculation with a Trichoderma bio-inoculant on ectomycorrhizal colonisation of *Pinus radiata* seedlings.	R. Edward Minchin, Hayley J Ridgway, LM Condron, E E Jones	Plant & Food Research; Lincoln University	Annals of Applied Biology 161(1):57-67	2012
Investigation of organic anions in tree root exudates and rhizosphere microbial communities using in situ and destructive sampling techniques.	Shengjing Shi, Maureen O'Callaghan, E E Jones, AE Richardson, C Walter, A Stewart, LM Condron	AgResearch; Lincoln University	Plant and Soil 359, 149–163.	2012
A nutrient balance model (NuBalM) to predict biomass and nitrogen pools in Pinus radiata forests	Simeon J. Smaill, Peter W. Clinton, BK Höck	Scion	Forest ecology and management 262 (2), 270-277	2011
Plantation management induces long-term alterations to bacterial phytohormone production and activity in bulk soil.	Simeon J. Smaill, AC Leckie, Peter W. Clinton, AC Hickson	Scion	Applied Soil Ecology 45 (3), 310-314	2010
Legacies of organic matter removal: decreased microbial biomass nitrogen and net N mineralization in New Zealand *Pinus radiata* plantations.	Simeon J. Smaill, Peter W. Clinton, LG Greenfield	Scion	Biology and fertility of soils 46 (4), 309-316	2010

Ectomycorrhiza of *Pinus radiata* (D. Don 1836) in New Zealand – an above- and below-ground assessment.	Katrin Walbert, Tod D. Ramsfield, Hayley J Ridgway, E E Jones	Scion; Plant & Food Research; Lincoln University	Australasian Mycologist 29, 7–16	2010
Ectomycorrhizal species associated with *Pinus radiata* in New Zealand including novel associations determined by molecular analysis.	Katrin Walbert, Tod D. Ramsfield, Hayley J Ridgway, E E Jones	Scion; Plant & Food Research; Lincoln University	Mycorrhiza 20(3):209-15	2010
Eucalyptus globulus				
Nitrogen-fixing bacteria in *Eucalyptus globulus* plantations.	da Silva MC, Paula TA, Moreira BC, Carolino M, Cruz C, Bazzolli DM, Silva CC, Kasuya MC	Universidade Federal de Viçosa (UFV)	PLoS One 9, e111313	2014
Eucalyptus grandis / Eucalyptus urograndis				
Mycorrhizal effector PaMiSSP10b alters polyamine biosynthesis in Eucalyptus root cells and promotes root colonization	Plett JM, Plett KL, Wong-Bajracharya J, Pereira MD, Costa MD, Kohler A, Martin F, Anderson IC,	Western Sydney University	New Phytologist, vol.228, no.2, 712-727	2020
Comparative metabolomics implicates threitol as a fungal signal supporting colonization of Armillaria luteobubalina on eucalypt roots'	Wong JW-H, Plett KL, Natera SHA, Roessner U, Anderson IC, Plett JM	Western Sydney University	Plant Cell and Environment, vol.43, no.2, pp 374-386	2020
Inorganic nitrogen availability alters *Eucalyptus grandis* receptivity to the ectomycorrhizal fungus *Pisolithus albus* but not symbiotic nitrogen transfer.	Krista L. Plett, Vasanth R. Singan, Mei Wang, Vivian Ng, Igor V. Grigoriev, Francis Martin, Jonathon M. Plett, Ian C. Anderson	Western Sydney University	New Phytologist 226, 221-231	2019
The Influence of Contrasting Microbial Lifestyles on the Pre-symbiotic Metabolite Responses of Eucalyptus grandis Roots	Wong JWH, Lutz A, Natera S, Wang M, Ng V, Grigoriev I, Martin F, Roessner U, Anderson IC, Plett JM,	Western Sydney University	Frontiers in Ecology and Evolution, vol.7, Article no.10	2019
The effect of elevated carbon dioxide on the interaction between *Eucalyptus grandis* and diverse isolates of *Pisolithus sp.* is associated with a complex shift in the root transcriptome.	Jonathan M. Plett, Kerry Keniry, Annegret Kohler, Amit Khachane	Western Sydney University	New Phytologist 206(4)	2015
Growth promotion and protection from drought in *Eucalyptus grandis* seedlings inoculated with beneficial bacteria embedded in a superabsorbent polymer.	Chaín, J.M., Tubert, E., Graciano, C. et al.	Universidad de Buenos Aires	Scientific Reports 10, 18221	2020
Differences in bacterial community structure and potential functions among Eucalyptus plantations with different ages and species of trees.	Zhaolei Qu, Bing Liu, Yang Ma, Hui Sun,	Nanjing Forestry University	Applied Soil Ecology 149, 103515	2020
Interactions between mesofauna, microbiological and chemical soil attributes in pure and intercropped *Eucalyptus grandis* and *Acacia mangium* plantations.	Maurício Rumenos Guidetti Zagatto, Arthur Prudêncio de Araujo Pereira, Adijailton José de Souza, Rafael Fabri Pereira, Luis Fernando Baldesin, Caroline Medrado	University of São Paulo	Forest Ecology and Management 433, 240-247	2019

	Pereira, Renan Viccino Lopes, Elke Jurandy Bran Nogueira Cardoso			
Mixed Eucalyptus plantations induce changes in microbial communities and increase biological functions in the soil and litter layers.	Arthur P.A. Pereira, Ademir Durrer, Thiago Gumiere, José L.M. Gonçalves, Agnès Robin, Jean-Pierre Bouillet, Juntao Wang, Jay P. Verma, Brajesh K. Singh, Elke J.B.N. Cardoso,	University of São Paulo	Forest Ecology and Management 433, 332-342	2019
Changes in fungal diversity and composition along a chronosequence of *Eucalyptus grandis* plantations in Ethiopia.	Carles Castaño, Tatek Dejene, Olaya Mediavilla, József Geml, Juan Andrés Oria-de-Rueda, Pablo Martín-Pinto,	University of Valladolid, Spain	Fungal Ecology 39, 328-335	2019
The microbiome related to carbon and nitrogen cycling in pure and mixed *Eucalyptus grandis* and *Acacia mangium* plantations.	Pereira, Arthur & Cardoso, Elke	Universidade Federal do Ceará; University of São Paulo	PhD in Soil and Plant Nutrition DOI: 10.13140/RG.2.2.17989.91363	2018
The Microbiome of Eucalyptus Roots under Different Management Conditions and Its Potential for Biological Nitrogen Fixation.	Fonseca, Eduardo & Peixoto, Raquel & Rosado, Alexandre & Balieiro, Fabiano & Tiedje, James & Rachid, Caio	Federal University of Rio de Janeiro	Microbial Ecology 75(1)	2018
Digging deeper to study the distribution of mycorrhizal arbuscular fungi along the soil profile in pure and mixed *Eucalyptus grandis* and *Acacia mangium* plantations.	Arthur Prudêncio de Araujo Pereira, Maiele Cintra Santana, Joice Andrade Bonfim, Denise de Lourdes Mescolotti, Elke Jurandy Bran Nogueira Cardoso,	University of São Paulo	Applied Soil Ecology 128, 1-11	2018
Ectomycorrhizal fungi associated with the roots of planted *Eucalyptus grandis* in northeastern Brazil	Coelho, Isadora & Nelsen, Donald & Ben Hassine Ben Ali, Mourad & Stephenson, Steven	University of Arkansas	Current Research in Environmental & Applied Mycology. 8. 455-467	2018
Illumina DNA metabarcoding of Eucalyptus plantation soil reveals the presence of mycorrhizal and pathogenic fungi.	Luke Jimu, Martin Kemler, Lizzie Mujuru, Eddie Mwenje	Bindura University of Science Education	Forestry 91, 238–245	2018
Fungal diversity and succession under *Eucalyptus grandis* plantations in Ethiopia.	Dejene T, Oria-de-Rueda JA, Martín-Pinto P.	Ethiopian Environment and Forestry Research Institute (EEFRI)	Forest Ecology and Management 405, 179–187	2017
Diversity and distribution of the endophytic bacterial community at different stages of Eucalyptus growth.	Miguel, Paulo & Oliveira, Marcelo & Delvaux, Julio & Jesus, Guilherme & Borges, Arnaldo & Totola, Marcos & César, Júlio & Costa, Maurício	Universidade Federal de Viçosa (UFV)	Antonie van Leeuwenhoek 109(6)	2016
Eucalyptus marginata / Eucalyptus gomphocephala				
Diversity of fungi associated with roots of *Eucalyptus gomphocephala* seedlings grown in soil from healthy and declining sites.	Lily Ishaq, Paul A. Barber, Giles E. St. J. Hardy, Bernard Dell	Murdoch University	Australasian Plant Pathology. 47. 10.1007/s13313-018-0548-x.	2018

Sensitivity of jarrah (*Eucalyptus marginata*) to phosphate, phosphite, and arsenate pulses as influenced by fungal symbiotic associations.	Ricarda Jost, Patrick M. Finnegan, Mark Tibbett	University of Western Australia	Mycorrhiza 26, 401–415	2016
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