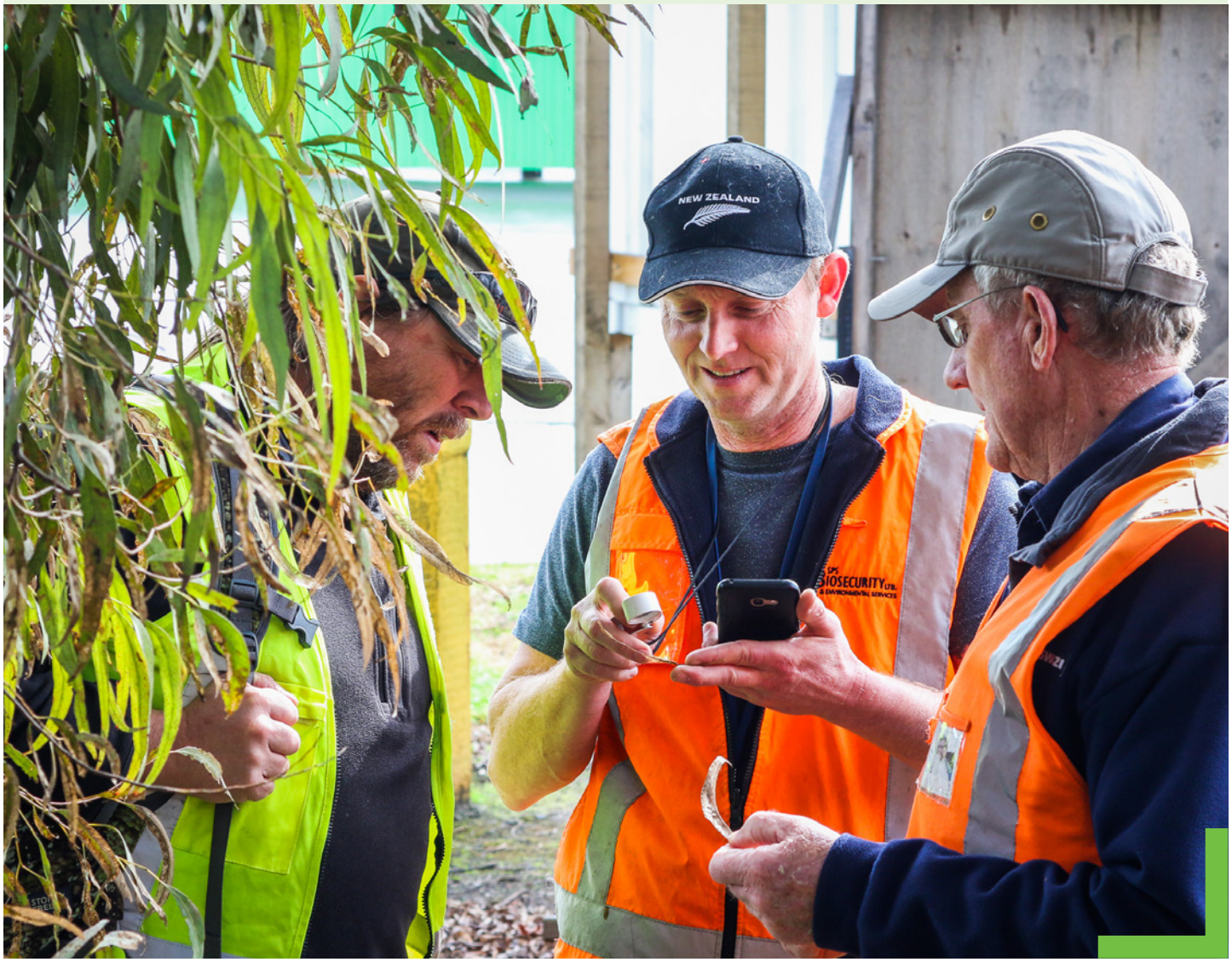
Forest Biosecurity Research Strategy 2023-2030

Protecting New Zealand's plantation forests and the export trade from biosecurity threats

FEBRUARY 2023



forestgrowers levy trust inc

New Zealand Farm Forestry Association
Oranga Rākau Aotearoa

FOREST OWNERS ASSOCIATION

Foreword

Biosecurity threats to our plantation forests and woodlots are increasing as serious pests and pathogens move closer to New Zealand.

Trade and tourism are accelerating the risk of spread of unwanted organisms, and in some cases deleterious insect pests and pathogens are blowing over from Australia (e.g., myrtle rust and fall armyworm). Changing climate is also increasing risk as some pathogens thrive in warmer and moister conditions and more insects can complete their lifecycles in regions previously too cold. Biosecurity risk also increases as pathogens mutate and become more virulent causing mortality in plantation species (e.g., *Lecanosticta acicola*).

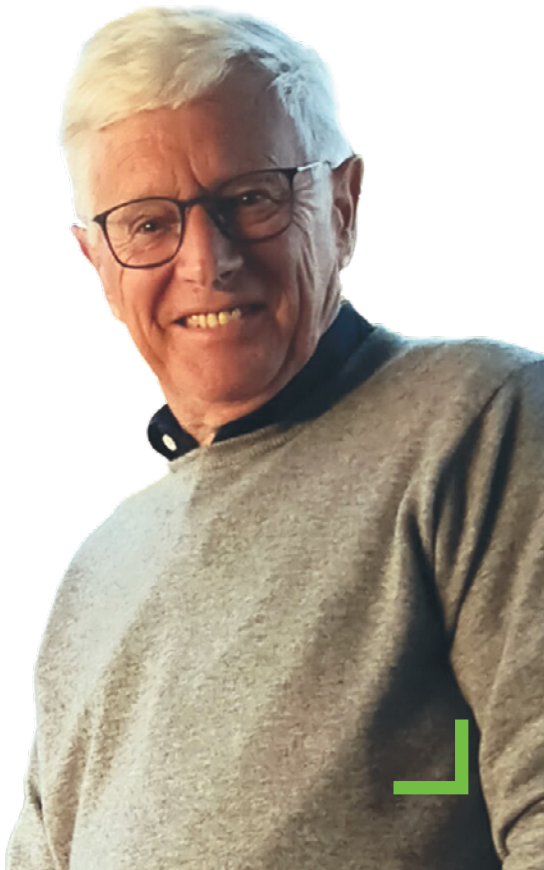
In addition to the external threats from organisms not currently present in New Zealand are less obvious risks associated with emerging plantation management regimes. Commercial plantation forests, mainly radiata pine and Douglas-fir, but other species as well, particularly in woodlots, are usually grown and managed to produce a commercial crop and are therefore healthy and vigorous through the rotation. Trees being grown for carbon and not expected to be harvested present new challenges to biosecurity. History has shown that radiata pine grown at close spacing and left un-thinned may become stressed and susceptible to pests such as the Sirex wood wasp. Similarly, radiata pine forests in Dothistroma-prone areas that are not inspected and treated with aerial copper applications as necessary, will also become sick and inoculum levels will build.

The Forest Biosecurity Committee (FBC) is charged with protecting the plantation resource and export trade from biosecurity threats. Other organisations also play a role including the Dothistroma Consultative Committee for Dothistroma surveys and spraying operations; STIMBR for log fumigation; the Radiata Pine Breeding Company for breeding resistance to pests and diseases; and Forest Growers Research (FGR) for all aspects of forest growing research, including biosecurity. These committees and organisations have their own strategies and the forest biosecurity research strategy is complementary to these.

The FBC has developed this research strategy to identify research priorities and provide direction to research providers and funders, including the plantation forestry sector and government, so as to ensure biosecurity risk to the resource and to trade is minimised as much as possible. The FBC works very closely with FGR and the Forest Research Committee to communicate research needs for the present and the next 10 or so years.

John Simmons
Chair Forest Biosecurity Committee
February 2023

“The FBC has developed this research strategy to identify research priorities and provide direction to research providers and funders



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Executive Summary

Research strategies are essential to identify strategic priorities and to provide guidance to researchers.

The 2011 Forest Biosecurity Research Strategy[1] (updated in 2016) identified foliar diseases as the top priority for research focus. This was at a time when the industry was dealing with red needle cast (RNC), trying to better understand the pathogen causing the problem, and had several other foliar pathogens to contend with. The strategy was very useful in attracting funding from both industry and government (Ministry for Business, Innovation and Employment – MBIE) in three long-term research programmes that ran for six years and greatly improved knowledge on the foliar diseases affecting radiata pine and Douglas-fir.

This new strategy has taken a fresh look at the current situation and speculates on future conditions and issues. Climate change means that in future trees will be growing in different environments, and in some cases, this will increase stress and lead to pest and pathogen attack. A recent review[2] demonstrated that the plantation forest industry was exposed to biosecurity risk in operational practices, particularly in nurseries and stock transfer, but also from the movement of machinery and vehicles between forests. Carbon forestry, plus the Government's One Billion Trees programme, means that new plantations are not necessarily being established for the same reasons, or in the same manner, as existing plantations. New biosecurity issues may arise requiring new research.

This strategy recognises the increasing need to ensure social and cultural licence to conduct biosecurity treatments, such as aerial spraying in urban areas. It recognises that new molecular technologies might provide new solutions that replace conventional chemical and biological treatments.

The strategy groups the top 21 research issues identified by the Forest Biosecurity Committee under the following headings:

A Research to understand the potential impacts of pests and pathogens not currently present in New Zealand or the changing activity of existing ones

B Research to increase plantation and tree species' resistance and resilience to increased stress

C Research to improve operational biosecurity

D Research to develop or improve solutions to pests and diseases including social research

E Research to better understand the current situation of pests and pathogens in NZ, implications to trade, and implications of carbon forestry on the potential for increased pest and disease problems

This strategy also supports the Government's Biosecurity 2025 Direction Statement that proposes working together across five strategic directions including to develop and invest in improved biosecurity surveillance systems and distribute new tools across the system.

The intention is for research providers to respond to this strategy by working closely with the Forest Biosecurity Committee to develop and submit research proposals that target forestry sector research priorities to funding sources including FGLT, MBIE, and SFFF.

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1. 2011 Forest Biosecurity Research Strategy – https://www.nzfoa.org.nz/resources/file-libraries-resources/forest-biosecurity/research-papers/758-forest-biosecurity-research-strategy/file
2. Forest Biosecurity Committee Review – 2018 Operational Biosecurity – https://nzfoa.org.nz/resources/file-libraries-resources/forest-biosecurity/676-forest-biosecurity-review-phase-1-report-operational-biosecurity-issues/file

Introduction

The Forest Owners Association (FOA) developed and implemented a biosecurity research strategy in 2011 and updated this in 2016. Since then, some drivers for research have changed as have issues linked to key drivers.

The Forest Biosecurity Committee (FBC) commissioned a strategic review in 2019[3] which noted that there has been a strong research focus on phytophthora and fungi, and that it would be timely to consider a broader focus. It was also noted that several forest health research programmes were coming to an end and new bids were being considered or in process. The review recommended that a new biosecurity research strategy be developed.

The FBC also commissioned an operational biosecurity review, completed in 2018[4]. This review noted that further research is required to support operational biosecurity measures such as around nursery plant production and associated with hygiene practices to reduce biosecurity risk from equipment movement in forests.

Purpose of this Forest Biosecurity Research Strategy

The purpose of the Forest Biosecurity Research Strategy is:

"to identify biosecurity and forest health issues that are important to the plantation forest industry,[5] and that can be addressed through research, and other mechanisms."

and

"to determine where industry's research priorities lie and to consider what resources are needed to manage these priorities."

The intention is for research providers to respond to this strategy by working closely with the Forest Biosecurity Committee to develop and submit research proposals that target forestry sector research priorities to funding sources including FGLT, MBIE, and SFFF.

Vision

The successful implementation of the Forest Biosecurity Research Strategy will result in:

- ☑ a sufficiently comprehensive research programme to adequately protect plantation forest growing assets, particularly commercial plantation species listed in the 'Biosecurity Profile: Plantation Forestry[6]'
- ☑ research that will provide for more productive radiata pine and Douglas-fir plantations that are more resistant to pests and pathogens
- ☑ research that will provide a better understanding on how to manage the biosecurity risk from untended carbon forest plantations
- ☑ a highly viable "safe" log and wood trade where biosecurity risk has been reduced to an acceptable minimum
- ☑ more effective readiness and response initiatives, in line with Government Industry Agreement (GIA).

3. Forest Biosecurity Committee Biosecurity Strategy to 2030 – https://nzfoa.org.nz/resources/file-libraries-resources/forest-biosecurity/835-forest-biosecurity-review-phase-ii-report-strategic-biosecurity/file
4. Forest Biosecurity Committee Review – 2018 Operational Biosecurity – https://nzfoa.org.nz/resources/file-libraries-resources/forest-biosecurity/676-forest-biosecurity-review-phase-1-report-operational-biosecurity-issues/file
5. Industry includes small woodlots growing plantation trees for commercial purposes; but at this stage does not include carbon forestry as this sector is not covered by the levy on harvested wood.
6. https://www.nzfoa.org.nz/images/stories/pdfs/20160316_Biosecurity_Profile_Plantation_Forestry_Final_050716_web.pdf

Scope

The scope of the strategy reflects the Terms of Reference for FBC[7] and includes:

- ☑ forest biosecurity (including forest health – primarily radiata pine and Douglas-fir) research and delivery
- ☑ log pathway research to minimise biosecurity risk
- ☑ forest biosecurity surveillance research
- ☑ Government Industry Agreement on readiness and response and how this relates to research
- ☑ forest biosecurity research capability needs
- ☑ forest health / surveillance database needs.

Goals

The goals of the strategy are:

- ☑ protecting radiata pine, Douglas-fir, and other important commercial plantation species from pests and pathogens and achieving greater productivity with no loss in quality
- ☑ protecting the log trade and other wood exports from biosecurity threats that might lead to trade bans.

Objectives

The key objectives of the strategy include:

- ☑ developing solutions to disorders, with high priority to foliar disorders, that threaten forest health and forest products trade
- ☑ developing improved solutions for safe log trade focused on pathways and recognising STIMBR's role in log fumigation research
- ☑ developing new research in readiness and response in partnership with the Ministry for Primary Industries (MPI) as per the GIA Deed
- ☑ understanding implications of carbon forestry regimes to biosecurity risk
- ☑ developing improved operational biosecurity measures – from seed to export.

7. https://www.nzfoa.org.nz/images/Terms_of_Reference_-_FBC_Final_March_2020.pdf

Key drivers for forest biosecurity research

The protection of the plantation forest resource and the log and wood products trade from biosecurity threats are key drivers for investing in forest biosecurity research.

There are several insect pests and pathogens already present in NZ that impact the health and productivity of plantation forest species. There are also very significant biosecurity issues and market requirements that dictate log and lumber export treatments. In addition to these traditional drivers there are new drivers that should be considered in research programmes, including:

- the impact of climate change on forest health and biosecurity risks
- concern over reliance on radiata pine and Douglas-fir considering increasing biosecurity threats both in NZ and overseas
- government policies and their effects on biosecurity risk – e.g., Emissions Trading Scheme[8]
- societal shifts and pressures impacting biosecurity readiness and response
- new tools, technologies and science capability.

Implications of key drivers to forest biosecurity research

There are many biosecurity issues facing the plantation forest industry that will benefit from research. The increasing number of pests and pathogens impacting on plantation forest species are well known and have been the subject of research for decades. The 2011 version of the Forest Biosecurity R&D Strategy identified foliar diseases as the number one research priority and industry and government funding focused on this. Over the last decade considerable research has gone into improving our understanding of pathogens and the diseases they cause, however, except for copper spraying for Dothistroma control, practical and economical solutions to these remain elusive. There has also been considerable effort and resources invested in improving our biosecurity surveillance and diagnostic system.

Issues related to the key drivers are covered below.

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1. Impact of climate change on forest health and biosecurity risks

Climate change is having direct and indirect impacts on forest health and biosecurity risks[9]. Direct effects are from changes in temperature, wind, and moisture patterns affecting both the health and resilience of plants and the biology of pests and pathogens. Indirect effects include pests and pathogens spreading globally with changing weather patterns and moving closer to New Zealand and the increasing likelihood of being transported to New Zealand with trade goods.

Changing climate will impact forest biosecurity and forest health in a number of ways. As the world warms, pests and pathogens will extend their geographic range to new regions. Pests that require warmer temperatures to reproduce and multiply to significant populations where they can cause greater damage will thrive in areas where they previously could not.

Changing climate has been predicted to cause more extreme wetting and drying cycles in some regions of New Zealand and this will increase stress on plantation forest species and may increase the impact of pests and pathogens on tree health. Pests and pathogens also evolve, and, in some cases, a changing climate may increase their virulence[10].

Issues requiring research associated with climate change and other stressors include:

- understanding the risk posed by the emergence of new insect pests and pathogens or the changing activity and potential impact of existing ones
- developing solutions to deal with the potential impacts of climate change on pests and pathogens

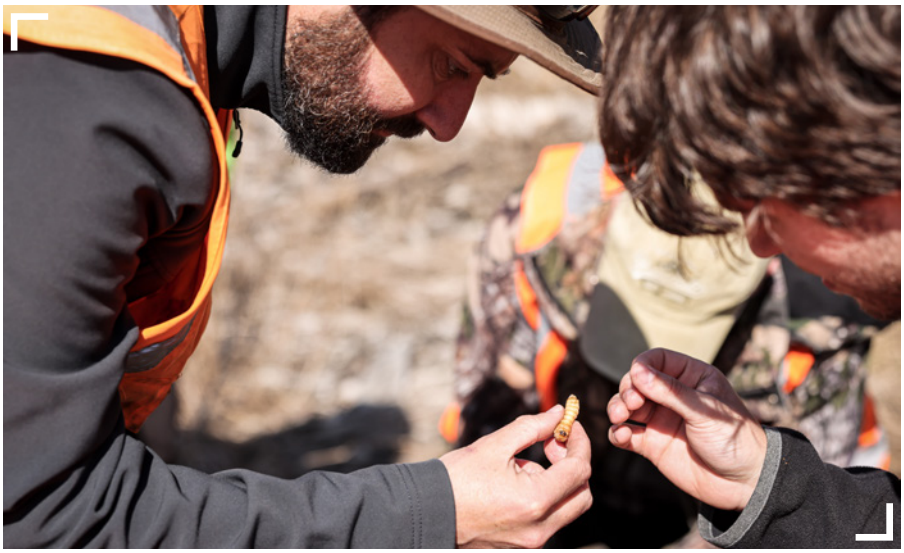
8. https://environment.govt.nz/what-government-is-doing/key-initiatives/ets/
9. https://www.fao.org/forestry/24833/en/
10. https://www.smithsonianmag.com/science-nature/new-study-shows-climate-change-may-increase-spread-plant-pathogens-180978377/

- understanding the resistance and resilience of plantations of radiata pine, Douglas-fir and other species when exposed to greater stress. This includes climatic stressors, such as increased drought, but also potentially and very likely, increased pathogen loading and disease outbreaks such as Dothistroma needle blight (DNB), red needle cast (RNC), etc
- realising the opportunity to increase plantation and tree species' resistance and resilience to increased stress. This includes genetic manipulation, through tree breeding but also genetic technologies such as gene editing, and also the manipulation of tree and plantation microbiomes[11]. It also includes researching the impacts of mixed species planting to interrupt the disruption / stress levels.

The New Zealand Government has responded to climate change by introducing legislation to help mitigate rising greenhouse gas levels

The New Zealand Government has responded to climate change by introducing legislation to help mitigate rising greenhouse gas levels[12]. The Emissions Trading Scheme is driving the planting of new 'carbon forests', and these forests will change the nature of plantation forestry for two main reasons:

- in many situations trees will not be harvested and potentially some plantations will not be thinned or otherwise tended to maintain forest health, and



- greater areas of alternative tree species will be planted to provide diversity and, in some cases, to provide longer-lived carbon sinks (e.g., redwoods). Native tree species are also being planted at a greater rate.

Biosecurity issues associated with 'carbon forests' include:

- understanding the impacts of 'plant and leave' forestry on pest and disease incidence not only on the immediate forest but also on adjacent ones
- the need to expand biosecurity research to protect plantations of alternatives to radiata pine and Douglas-fir
- the likely attraction of current and new pests to alternative species and their ability to jump host plant species
- the need for a baseline measurement of current insect and pathogen species present in NZ including on native tree species. This includes a baseline of pathogens currently in forest nurseries.

2. Concern over reliance on radiata pine and increasing biosecurity threats

New Zealand plantation forestry is primarily radiata pine and to a much lesser extent Douglas-fir. Other species are also planted but generally not as replacements for radiata pine and Douglas-fir but for alternative uses (e.g., specialty products). Both radiata pine[13] and Douglas-fir[14] productivity has been impacted by pests and pathogens, although recent calculations of growth losses have not been made and current productivity losses are not known.

Overseas, radiata pine has come under increasing pathogen pressure making it uneconomical to plant in some traditional radiata pine regions, e.g., the Basque Province of Spain (Bill Dyck – biosecurity consultant, pers comm), and parts of South Africa. In New Zealand, the pathogen and pest loading on radiata pine has significantly increased over the last 60 years, as the area grown has expanded. New pathogens, currently not

11. Biological control of emerging forest diseases: How can we move from dreams to reality? https://doi.org/10.1016/j.foreco.2021.119377
12. Climate Change Response (Zero Carbon) Amendment Act https://environment.govt.nz/acts-and-regulations/acts/climate-change-response-amendment-act-2019/
13. https://www.researchgate.net/publication/265247582_Needle_Diseases_of_Radiata_Pine_in_NZ
14. https://sncc.forestry.oregonstate.edu/sites/default/files/watt%20et%20al%20snc%20new%20zealand.pdf

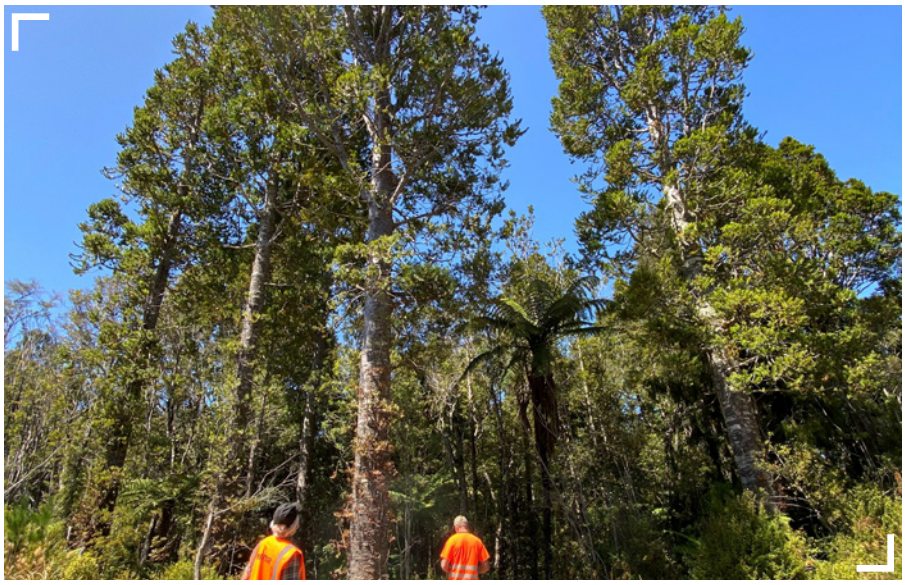
in New Zealand, such as *Phytophthora ramorum, P. pinifolia, Dothistroma pini*, and *Lecanosticta acicola* threaten radiata pine and relatively little is known about the risk posed by these pathogens to our main plantation species.

Insects also pose a threat to New Zealand radiata pine and Douglas-fir plantations and the recent readiness review on Lepidoptera (unpublished GIA report[15]) revealed uncertainties about our understanding of the potential impacts of several moth species (e.g., nun moth – *Lymantria monacha*). Bark beetles are another group of insects that in recent decades have caused immense damage to natural and planted pine forests in several countries and are potentially a threat to NZ plantations.

Solutions to radiata pine pathogen problems have traditionally involved breeding for increased resistance, silvicultural treatment, or spraying fungicides (e.g., copper). Breeding is an expensive long-term proposition that has had relatively few success stories, although improvements have been made to NZ's radiata pine resource over the last 50 years. Developing disease-resistant radiata pine hybrids has had limited success.

In 2021 New Zealand introduced the Plant Pass system that encourages nurseries to be certified to a plant production biosecurity standard that will decrease risk on the nursery-to-forest pathway

Copper spraying is routinely carried out to control Dothistroma needle blight and may be used to control red needle cast and other foliar diseases in future. While great gains have been made through research to reduce the amount of copper used, there are concerns about the application of copper sprays both to the environment and to human health[16, 17].



The nursery-to-forest system is recognised as a major risk pathway for the unintentional movement of pathogens and pests to forests. This pathway has spread pathogens into forests for decades with relatively minor consequences, although the spread of Dothistroma is an exception. In 2021 New Zealand introduced the Plant Pass system[18] that encourages nurseries to be certified to a plant production biosecurity standard that will decrease risk on the nursery-to-forest pathway. Adhering to this standard will reduce the movement of pathogens to forests, including new land planting. It will also provide assurances that should a new pathogen, such as *Fusarium circinatum* (the causal agent for pine pitch canker) arrive in NZ, then systems will be in place to greatly limit spread. At the time of preparing this strategy, the FBC were working toward ensuring that the Plant Pass certification scheme was practically applicable to forest nursery operations with the objective of encouraging forest nurseries to get certified.

Forest operations are another source of biosecurity risk[19] with issues around 'contaminated' equipment movement. There is no argument that soil contains pathogens but what is not known is how much of a threat the pathogen movement is to plantation forest health. A new kauri dieback pest management plan[20] is being developed that will require forestry companies operating in plantation forests with kauri to take specific measures to reduce biosecurity risk to kauri. Operational biosecurity guidelines will be required in the near future as the plan is being implemented in 2023.

STIMBR had the mandate to investigate alternative ways to reduce methyl bromide fumigant use and their focus has been on recapture, new fumigants, and alternative technology. With the Environmental Protection Authority (EPA) decisions on both methyl bromide (2021) and ethanedinitrile (2022), STIMBR is shifting its focus to more broadly enhance and maintain phytosanitary options for log exports. There are also other opportunities to provide assurances to trading partners that logs and lumber are of low risk – these include pathway management from the forest to port and applying recognised international standards such as Area Freedom, or Pest Free Place of Production[21].

15. Draft Lepidoptera Readiness stock take (GIA, unpublished report January 2022)
16. https://www.epa.govt.nz/assets/FileAPI/hsno-ar/APP203732/APP203732_Final_Grounds_Decision.pdf
17. Aerial application of copper for dothistroma control in New Zealand's planted forests—effect on stream environments. https://link.springer.com/article/10.1007/s11356-017-0020-4
18. https://www.plantpass.org.nz
19. Forest Biosecurity Committee Review – 2018 Operational Biosecurity – https://nzfoa.org.nz/resources/file-libraries-resources/forest-biosecurity/676-forest-biosecurity-review-phase-1-report-operational-biosecurity-issues/file
20. https://www.kauriprotection.co.nz/national-pest-management-plan/
21. https://www.ippc.int/static/media/files/publication/en/2017/05/ISPM_04_1995_En_2017-05-23_PostCPM12_InkAm.pdf

Considering the reliance on radiata pine as our main plantation species, a number of issues require research including:

- assessing alternatives to radiata pine and Douglas-fir including biosecurity risk of contingency species. This should include genetic and molecular technology solutions, microbiome manipulation
- assessing radiata pine and Douglas-fir productivity losses caused by needle diseases and other disorders
- understanding the potential impact on radiata pine and Douglas-fir of pathogens and insects currently not present in NZ. E.g., *Lecanosticta acicola, Lymantrid monacha; Phytophthora pinifolia, P. ramorum, Dothistroma pini*, various bark beetle species etc
- developing solutions to foliar diseases of radiata pine and Douglas-fir as alternatives to copper spraying
- applying breeding, including hybrids, molecular technology (e.g., gene editing), endophyte technology etc.
- with the Dothistroma Committee and the FOA Environment Committee, investigating reducing the need for and/or the cost of Dothistroma spraying (costs in the order of $2m/year) and fully understanding the impacts of drift spraying copper on the aquatic environment and practices to reduce or mitigate any potential impacts
- investigating nursery pathway risk to forests and the opportunity to reduce this risk by applying greater biosecurity measures including Plant Pass
- investigating operational biosecurity risk to forests and the opportunity to reduce the risk associated with equipment movement etc. Explore opportunities to work with MPI to develop guidelines to reduce biosecurity risk in kauri areas
- understanding the potential for a 'biosecurity' interruption of the log and green lumber trade because of real or perceived biosecurity threats
- developing new methods/systems to provide greater assurance of pest-free log and lumber exports outside STIMBR's mandate, e.g., research the forest-to-market pathway approach to provide trade assurances.

3. Government policies and effects on biosecurity research and science funding

Government policies are changing in response to NZ societal and also international agreements and pressures. This is particularly relevant to forest biosecurity in relation to climate change policies but also to increasing public awareness of environmental, social and cultural issues that affect government policies. There is an increasing emphasis by government on Te Tiriti Partnership. This impacts biosecurity in a number of ways including increasing recognition of Māori concerns over current practices (e.g., log fumigation), science funding (increasing need for partnerships), and research and implementation of new and existing technologies (e.g., genetic technologies) to protect plantation forests. There is also a recent move for Government departments to collaborate more in determining solutions to some of the Government's big priorities by modernising the public service[22] and this will likely include major decisions around the biosecurity system.

The introduction of a kauri dieback national pest management plan (NPMP) will require industry to develop and introduce new biosecurity guidelines. Research may be required to ensure these guidelines are sound and produce the desired results.

The plantation forestry sector partners with MPI in a Government Industry Agreement (GIA) and the future should see more biosecurity research done in partnership. Industry and government will need to agree priorities and funding arrangements. Currently there is only one 'Threat Specific Readiness Manual' (*F. circinatum*) in place[23] and industry and government are not well prepared for incursions of other organisms. The 'Lepidoptera Readiness Stock Take', currently being finalised, identified a number of issues that need to be addressed to better prepare NZ for a moth incursion. Some of these will likely involve social research.

Since the previous forest biosecurity research strategy was updated (2016), Te Uru Rākau – New Zealand Forest Service (TUR) has been created and today, as well as managing the One Billion Trees programme, TUR provides funding to forestry research through the Sustainable Food and Fibre Futures (SFFF)[24]. TUR has an important role to play in forestry biosecurity research and has had input into this strategy.

MBIE is currently undertaking a major review of Research and Science Investment (RSI)[25] 'Te Ara Paerangi – Future Pathways Green Paper' and it is likely that the outcome of the review will lead to further changes in the way biosecurity research is funded and resourced in New Zealand. The focus of the review is on Crown Research Institute (CRI) science. The plantation forestry industry has benefited from government-funded research at Scion, the Lincoln University Bioprotection Centre, and other research institutes. However, the outcome of the Green Paper could mean significant changes to the way biosecurity science is funded.

Issues around government policies that should be considered and possibly prepared for include:

- the implications of the Green Paper and the likely greater emphasis on Te Tiriti Partnership and recognition of mātauranga Māori in the science system to the point that government research funds may not be available outside of a partnership; greater focus on determining and funding national science priorities; potentially new science structures (CRIs) and processes.
- GIA agreement to co-fund biosecurity readiness research
- implications of National Pest Management Plans, e.g., kauri dieback.
- implications of the Emissions Trading Scheme and potential insect and disease problems that may arise from carbon forestry.

22. https://legislation.govt.nz/act/public/2020/0040/latest/LMS106159.html
23. Threat specific readiness manual for Fusarium circinatum https://www.nzfoa.org.nz/resources/file-libraries-resources/forest-biosecurity
24. https://www.mpi.govt.nz/funding-rural-support/sustainable-food-fibre-futures/
25. https://www.mbie.govt.nz/have-your-say/future-pathways/

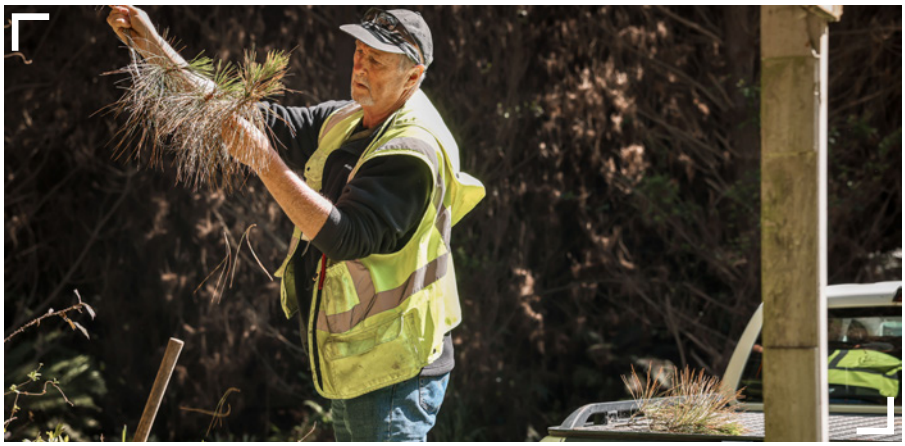
4. Societal shifts and pressures impacting biosecurity readiness and response

Society is rapidly changing, and new social pressures are in play with the advent and increasing power of social media leading to greater and more rapid communication, but also the insidious influence of algorithms that can perpetuate conspiracy theories[26]. New Zealand's biosecurity system is under-prepared to deal with this phenomena and will struggle to implement some response practices that have been used in the past (e.g., broadcast spraying of pesticides in or near urban areas). The Lepidoptera Readiness Stock Take identified public and Māori acceptance of aerial spraying of Btk (or other insecticides) as issues that need to be addressed in advance of an incursion.

> **What can we learn from these experiences that can be applied to plantation forestry biosecurity, particularly where potentially controversial practices are required...?**

There are also increasing social, cultural, and environmental concerns over the use of chemicals in the environment and a push to more environmentally friendly alternatives. While many genetic technologies offer environmentally friendly alternatives, they too face challenges from social pressures often driven by social media rather than by science. There is an urgent need to front-foot some of these issues.

Log fumigation with methyl bromide is being phased out because of the effect of the release of the gas on stratospheric ozone and international agreements to reduce the output of chlorofluorocarbons released to the atmosphere. Recapture or alternatives to methyl bromide are being investigated as a matter of urgency. However, the problem with fumigants is much more than just the impacts on the environment and the ozone layer, and in the case of methyl bromide there are strong social issues as well because of concerns over human health. The solution to continued use or replacement of methyl bromide with another fumigant will require more than technical research[27].



Aerial copper spraying is also under threat as society becomes more concerned about the application of toxic chemicals in the environment[28]. Forestry is not alone on the issue of copper spraying but does stand out in the delivery methodology. New Zealand research has shown that copper does not significantly increase in streamwater following aerial application[29] but there has not been any research on the effects on stream ecology. Alternatives to copper are currently not readily available.

To a large extent many of the barriers to implementation of biosecurity technologies are social and cultural and require non-technical solutions. NZ has demonstrated through the Covid experience that it is possible to get 'the Team of Five Million' on board to help respond to a biosecurity crisis. Similarly, Predator Free 2050 has encouraged and linked many grassroots organisations to reduce and/or eradicate possums, stoats and rats. How can this 'excitement' be leveraged for a biosecurity incursion? What can we learn from these experiences that can be applied to plantation forestry biosecurity, particularly where potentially controversial practices are required, such as aerial spraying in an urban area to control a moth incursion?

NZ plantation forestry includes many iwi landowners and Māori-owned and operated companies. It is in the best interests of all stakeholders to better understand differing priorities and how biosecurity systems can be developed and adapted to meet diverse needs.

Some social issues related to forestry biosecurity that require research include:

- understanding increasing social, cultural, environmental concerns – chemicals, aerial spraying
- preparing for new/changing regulations – e.g., methyl bromide log fumigation restrictions, kauri dieback and NPMP development etc.
- understanding societal attitudes around the application of molecular technologies and other new technologies
- pathways to ensure trading to markets as fumigants come under increasing pressure
- understanding market drivers including social responsibility of suppliers and customers
- understanding how to harness the Team of Five Million to support biosecurity efforts
- social media impact and particularly dealing with conspiracy theories amplified on social media.

26. https://medium.com/thewashingtonpost/algorithms-are-one-reason-a-conspiracy-theory-goes-viral-another-reason-might-be-you-9ead5822e3e0
27. https://www.stuff.co.nz/national/103690904/its-banned-in-other-countries-but-new-zealand-is-using-more-toxic-methyl-bromide-than-ever
28. Wightwick, A.; Walters, R.; Allinson, G.; Reichman, S.; Menzies,N. 2010. Environmental Risks of Fungicides Used in Horticultural Production Systems, Fungicides, Odile Carisse (Ed.), ISBN: 978-953-307-266-1,
29. Baillie, B. R., Evanson, A. W., Unsworth, D., & Jeram, S. 2017. Aerial application of copper for dothistroma control in New Zealand's planted forests-effect on stream environments. Environmental science and pollution research international, 24(31), 24494

5. New technologies and science capability

Technology is constantly advancing, bringing new opportunities to deal with biosecurity issues and to enhance forest protection. Advances in remote sensing technology using satellites, aircraft, and UAVs are opening new possibilities for monitoring forest health and potentially for early detection of biosecurity incursions. UAVs can now apply chemicals with great precision. However, there are potentially social issues, as well as technical ones, regarding using UAVs to apply chemicals in urban areas and elsewhere. There are also non-technical issues securing supplies of insect control products such as Btk and regulatory issues in their use. These have been identified by a GIA team working on Lepidoptera readiness.

In addition to enhanced remote sensing technologies there have also been advances in the application of molecular technologies to improve biosecurity surveillance. The use of eDNA shows considerable progress towards making surveillance more cost effective and research is currently underway that should lead to enhanced operational capability. The tools and technology used for biosecurity surveillance can also be used to find unique and rare native species. A parallel smaller programme can run alongside the surveillance network to look for and identify these species – also making sure there is a media-release protocol so that this information gets out and raises excitement.

The Government's Biosecurity 2025 Direction Statement[30] identifies a need for greater efficiency in biosecurity surveillance to keep up with increasing threats. The forest industry has a long history of biosecurity surveillance and continuous improvement of detection and diagnostic technology. We strongly support a national drive to improve biosecurity surveillance, including new diagnostic capabilities, for the benefit of all sectors. It may be that tomorrow's biosecurity surveillance system is based on enhanced technologies such as eDNA, AI, and remote sensing. The FBC encourages collaborative research in this area.

"Together we will accelerate innovation to drive smarter, better and more efficient ways of detecting and managing biosecurity risk throughout the system. We will proactively identify and invest in new tools and technology, seek out and adopt innovations from other sectors, and enable the distribution of these new tools across the system." (Biosecurity 2025 Direction Statement)

There are opportunities to realise increased plantation and tree species' resistance and resilience to increased stress including pathogen load. While there is research underway at Scion in resistance scanning and breeding to match the 'right tree to the right place' there is relatively little research on the application of gene technologies, such as gene editing or gene silencing (RNAi) or in science to modify the microbiome of plantation tree species to enhance resistance. Molecular technologies have made rapid advancements and offer opportunities to select for greater disease-resistant germplasm and for modifying germplasm by altering genetics in other countries and in other sectors (e.g., endophyte application in NZ pasture grass). Less invasive, and not considered GMO, RNA technology offers exciting opportunities to deal with incursions and existing biosecurity issues such as foliar diseases. For example, double-strand RNA (dsRNA) technology is being trialled in Australia to combat myrtle rust[31], and the varoa bee mite in New Zealand[32].

NZ and other countries are producing significant numbers of highly trained molecular biologists and engineers, but there is a shortage of more traditionally trained scientists for example in taxonomy and those who have a solid understanding of plants, and productive and natural ecosystems[33]. These skills are needed to ensure we understand the consequences of altering components of the productive ecosystem, which in the past we have failed to comprehend in our tree breeding programmes. Such generalist skills are also invaluable to provide practical guidance and leadership in the event of an incursion.

Scion has lost a considerable number of skilled scientists in the last few years who have moved to other organisations or retired. Does Scion, or NZ, have all the skills needed to deal with future

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research questions? Closed borders due to Covid made it very difficult to recruit internationally and NZ does not generally train forestry biosecurity specialists. The current funding system makes it difficult to maintain scientists in biosecurity as it is largely applied rather than the favoured 'step-change' science that funding models require. DOC as well as MPI have similar requirements to plantation forestry in biosecurity skills and there are opportunities to work together to fill gaps and develop improved systems.

Some specific issues around new technologies and science capability to consider include:

- accelerating research into the application of molecular technologies for enhancing tree species' resistance and resilience to combat biosecurity threats, and in areas of diagnostics and surveillance
- researching and/or adapting remote sensing and chemical delivery technologies (e.g., UAVs etc.)
- ensuring adequate funding and training or recruitment in taxonomy
- addressing perceived issues of declining biosecurity science capability and capacity issues within Scion and challenges sourcing skills nationally and internationally
- ensuring strong linkages with international scientists and technology suppliers as resources, and in some cases technology availability, remain limited in New Zealand

30. https://www.mpi.govt.nz/dmsdocument/14857-Biosecurity-2025-Direction-Statement-for-New-Zealands-biosecurity-system
31. http://www.apbsf.org.au/exploration-of-rnai-vaccines-as-a-novel-control-for-myrtle-rust-in-critically-endangered-australian-taxa-pbsf034/
32. https://www.epa.govt.nz/assets/FileAPI/hsno-ar/APP204363/APP204363_Final_Application_Form.pdf
33. https://www.landcareresearch.co.nz/uploads/public/Publications/Working-papers-and-reports/Report-Plant-Biosecurity-Science-in-New-Zealand.pdf

Research priorities

This strategy has identified key issues that limit our biosecurity efforts to protect the plantation forestry sector and associated trade. Many can be addressed by research, science and technology; others are more fundamental and relate to industry, government, and the New Zealand research system and in some cases social and cultural aspects.

Members of the Forest Biosecurity Committee were surveyed to determine what they identified as the key biosecurity issues that needed to be researched. Thirty-four issues were initially ranked and later reduced to 21 based on further input. These are discussed below and listed in Appendix 1 and in a separate spreadsheet[34]. There was a high degree of agreement for the rankings.

The 21 priorities have been grouped and summarised below with an explanation. The main value in the prioritised list of research topics is to be able to communicate research priorities to the FGLT, FGR, MPI, MBIE and to research providers. The strategy provides emphasis to funding organisations that research proposals addressing priorities are important to commercial plantation forestry.

Groups of research priorities and FBC ranking

A Research to understand the potential impacts of pests and pathogens not currently present in New Zealand or the changing activity of existing ones

Priority ranking	Research topic
1	Understanding the potential impact on radiata pine and Douglas-fir of pathogens and insects not yet present in NZ.
3	Understanding the risk posed by the emergence of new insect pests and pathogens or the changing activity and potential impact of existing ones. This includes advances in surveillance and diagnostic technology.
19	Ensuring strong linkages with international scientists and technology suppliers as resources, and in some cases technology, remain limited in New Zealand.
20	Changes to science structure and greater emphasis on Te Tiriti – implications to government research funding for forest biosecurity; addressing declining forestry biosecurity science capability.
21	Ensuring adequate funding and training or recruitment in taxonomy.

Explanation: There are a number of new threats to radiata pine internationally such as *Lecanosticta acicola* in the Basque Country and North America[35], and new insect pests have emerged in Australia (giant pine aphid)[36]. Other pests and pathogens that require research effort include Nun moth; pine processionary moth; *Phytophthora pinifolia*, and *P. ramorum*. Greater research effort is needed to ensure the plantation forest industry, including the log trade, is not caught by surprise. There are opportunities to better understand the epidemiology of these organisms in other countries and to investigate measures to minimise the likelihood of arrival and to develop effective treatments should they arrive. There is also a need to take a systematic approach to objectively determine which organisms pose the biggest threat to NZ plantation forestry based on their traits and potential economic impact. Further advances in surveillance and diagnostic technology are required to keep up with increasing global biosecurity threats.

Serious pine pathogens overseas, such as *L. acicola*, are exhibiting increased virulence to pines. Changing climatic patterns, e.g., longer wetting periods, may cause existing pathogens and possibly insects to cause greater problems. Both *P. cinnamomi* and *P. pluvialis* could become more of a problem with climate change.

Strong linkages with international researchers are paramount. Also important is that NZ forestry biosecurity science capability is maintained and enhanced where possible. There are particular concerns about declining national capability in taxonomy[37], which is vital to diagnostics and early detection.

34. https://www.nzfoa.org.nz/committees/forest-biosecurity-committee
35. https://pubmed.ncbi.nlm.nih.gov/31309681/
36. https://www.dpi.nsw.gov.au/biosecurity/plant/insect-pests-and-plant-diseases/giant-pine-scale
37. https://www.landcareresearch.co.nz/uploads/public/Publications/Working-papers-and-reports/Report-Plant-Biosecurity-Science-in-New-Zealand.pdf

B Research to increase plantation and tree species' resistance and resilience to increased stress

Priority ranking	Research topic
2	Increasing plantation and tree species' resistance and resilience to increased stress.
7	Assessing alternatives to radiata pine and Douglas-fir including biosecurity risk of contingency species. This should include genetic and molecular technology solutions, microbiome manipulation.
14	Attraction of current and new pests to new species and their ability to jump host plant species to radiata pine.

Explanation: Stressors include climate stressors but also increased pathogen and insect loading. Research to realise the opportunity to increase plantation and tree species' resistance and resilience to increased stress includes genetic manipulation, through tree breeding but also genetic technologies such as gene editing for enhancing tree species' resistance and resilience to combat biosecurity threats. Research also includes the manipulation of tree and plantation microbiomes. The potential biosecurity risk of growing alternative species on a larger scale also needs to be investigated.

C Research to improve operational biosecurity

Priority ranking	Research topic
4	Investigating nursery pathway risk to forests and the opportunity to reduce this risk.
9	Investigating operational biosecurity risk to forests and the opportunity to reduce the risk associated with equipment movement etc. Explore opportunities to work with MPI to develop guidelines to reduce biosecurity risk in kauri areas.

Explanation: The 2018 review on operational biosecurity identified gaps that need to be addressed to reduce biosecurity risk in the forest industry[38]. Priorities were nursery stock pathways and improving knowledge on the biosecurity risk associated with machinery and truck movement. Since that review a small project demonstrated that equipment and logging trucks do move pathogens contained in soil. It is not known how much of a risk this poses and it will likely depend on the situation. Effort will need to go into understanding risk in 'kauri areas'.

> **Changing climatic patterns, e.g., longer wetting periods, may cause existing pathogens and possibly insects to cause greater problems**

38. https://www.nzfoa.org.nz/resources/file-libraries-resources/forest-biosecurity/676-forest-biosecurity-review-phase-1-report-operational-biosecurity-issues/file

D Research to develop or improve solutions to pests and diseases including social research

Priority ranking	Research topic
5	Developing alternative solutions to copper to combat foliar diseases of radiata pine and Douglas-fir.
8	Researching and/or adapting remote sensing and chemical delivery technologies (e.g., UAVs etc).
12	Understanding increasing social, cultural, environmental concerns – chemicals, aerial spraying.
15	With the Dothistroma Committee and the FOA Environment Committee investigate reducing the need for and/or the cost of Dothistroma spraying (costs in the order of $2m/year) and fully understanding the impacts of drift spraying copper on the aquatic environment.
17	Understanding societal attitudes around the application of molecular technologies and other new technologies.
18	Developing new methods/systems to provide greater assurance of pest-free log and lumber exports outside STIMBR's mandate, e.g., research the forest-to-market pathway approach.

Explanation: Since the 1960s when *Dothistroma septosporum* was found to be a serious problem to radiata pine (and other pines) in NZ there has been considerable research effort to develop and implement a cost-effective copper spraying regime. Research has successfully reduced the cost of this operation and only very small amounts of copper need to be applied (approx. 1g per tree). Some people are concerned about the use of copper particularly when used in drift spraying. Copper has been shown to rapidly dissipate on entering forest streams, but there has not been conclusive research on the potential impact on aquatic organisms.

Aerial spraying of chemical and biological solutions to deal with a forest insect incursion is a socially and culturally sensitive issue and one that has been very evident since the painted apple moth incursion more than 20 years ago. Social research has been conducted to understand the problem, but solutions have not been found, at least not in NZ. Parts of Canada and the USA regularly launch moth eradication or control programmes using aerial application of Btk. It is possible to develop a solution that gets public support and Tim Ebata presented what the government of BC developed at an NZFOA/MPI Biosecurity conference in 2018[39]. It is not just chemicals that cause concern and Scion is currently conducting research into the use of UAVs in urban areas[40].

Recent international developments have proven the opportunity to use molecular technologies, such as RNAi, to combat pests and pathogens. This is another area requiring social and cultural research, as well as technical research, to develop acceptable solutions. The NZ Government recently announced funding for an RNA technology platform[41] which could conceivably benefit research for the application of RNA technologies in forestry and other sectors.

Log fumigation is also under pressure and there is a need for further research to investigate a forest-to-market pathway approach to determine the possibility of providing greater market assurances that forests and trade are pest free.

> **Aerial spraying of chemical and biological solutions to deal with a forest insect incursion is a socially and culturally sensitive issue**

> **Recent international developments have proven the opportunity to use molecular technologies, such as RNAi, to combat pests and pathogens**

39. https://www.nzfoa.org.nz/resources/file-libraries-resources/foa-workshop-conference-reports/forest-biosecurity-conferences/previous-biosecurity-conferences-2009-to-2018/2018-14-and-15-march-rotorua/641-gm-bc-presentation-2018/file
40. https://www.b3nz.org.nz/projects/improving-uav-effectiveness-for-spot-application-of-btk-during-incursion-responses/
41. https://www.beehive.govt.nz/release/booster-rna-research-and-development

E Research to better understand the current situation of pests and pathogens in NZ, implications to trade, and implications of carbon forestry on the potential for increased pest and disease problems

Priority ranking	Research topic
6	Baseline of current insect and pathogen species present in NZ including on native tree species.
10	The impact of non-forestry 'pests' on forest operations and trade.
11	Potential insect and disease problems that may arise from plant-and-leave forestry.
13	Assessing radiata pine and Douglas-fir productivity losses caused by needle diseases and other disorders.
16	Understanding the potential for a 'biosecurity interruption' of the log and green lumber trade because of real or perceived biosecurity threats.

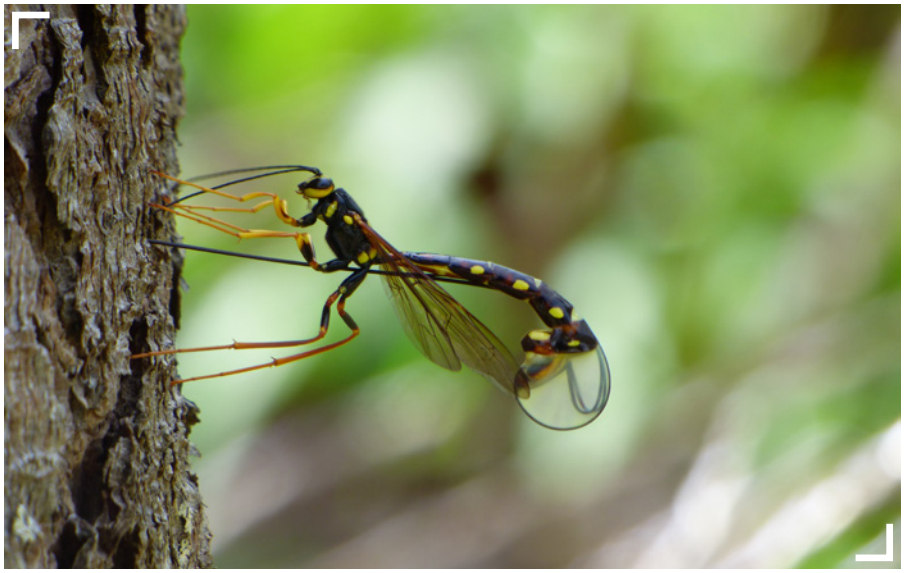
Explanation: NZ has incomplete knowledge of the insect species present in the country, and even poorer knowledge of the pathogen species present. This is particularly true for the natural estate and less for the radiata pine estate. This creates issues for plantation forestry as plants are moved around the country, planted in new areas, and pathogens have an opportunity to infect new hosts, including radiata pine. A key priority is to understand the populations of pathogens living in plantation forest nurseries and native plant nurseries that get transported to planting sites. The introduction of the Plant Pass[42] system will reduce the biosecurity risk, but data are needed to convince nursery managers that there is a problem to address.

Plant-and-leave forestry will introduce exotic trees to new areas and transport pathogens. Very little tending will occur in these regimes as there is no intention to harvest the trees for a commercial crop but instead just grow them to absorb carbon. This will potentially cause significant and predictable problems – e.g., Sirex wood wasp[43] thrives in over-stocked pine stands; if Dothistroma is not controlled by copper spraying the inoculum load will build up to high levels and infect adjacent forests.

Resourcing required to address key issues

Scion has been the main research institute involved in addressing most biosecurity research issues with some involvement from the University of Canterbury, the BioProtection Centre at Lincoln University, Manaaki Whenua Landcare Research, and Plant and Food Research.

There are additional skills in other research organisations and universities. This strategy does not commit to Scion, but the FBC believes it is in the industry's interest to have a strong biosecurity science team focused on our main plantation species.

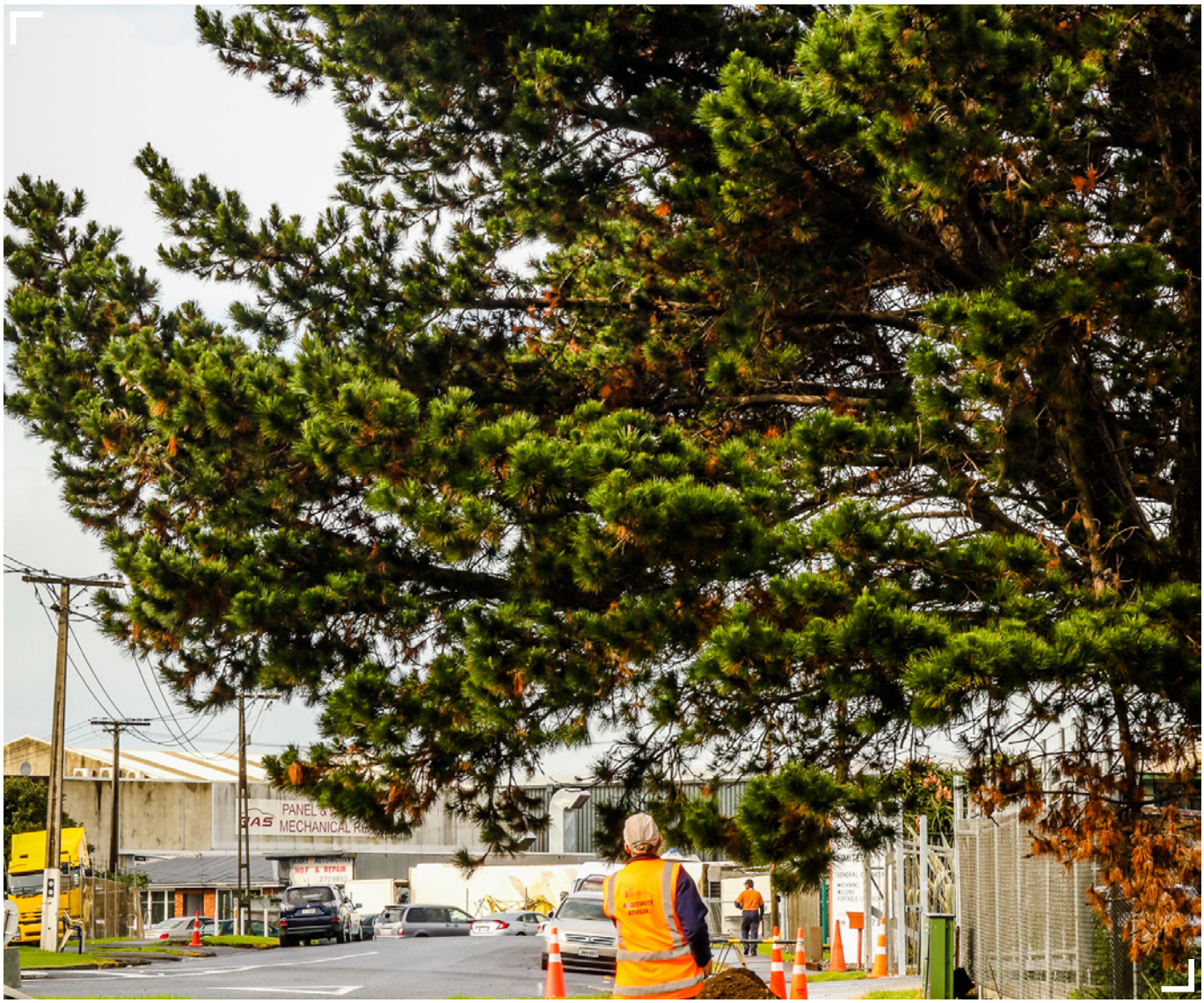


42. https://www.plantpass.org.nz
43. https://www.nzffa.org.nz/farm-forestry-model/the-essentials/forest-health-pests-and-diseases/Pests/Sirex-noctilio/Sirex-noctilioEnt20/

Implementation plan

This research strategy has been endorsed by the FBC and a near-final version was communicated to research providers and others to provide direction for research proposal development in 2022.

The FBC will work with the FGR Research Committee to communicate priority research projects and to influence funding allocation of both forestry sector and government funding. The research strategy will also be discussed with MPI (BNZ and TUR), forestry companies (through the FOA Executive), farm foresters (through FFA), and carbon foresters to both raise awareness of the issues and to gain buy-in for funding.



Appendix 1

Prioritised list of research topics

Rank	Research Priority
1	Understanding the potential impact on radiata pine and Douglas-fir of pathogens and insects currently not present in NZ. E.g., *Lecanosticta acicola, Lymantrid monacha; Phytophthora pinifolia, P. ramorum, Dothistroma pin*i, various bark beetle species etc.
2	Realising the opportunity to increase plantation and tree species' resistance and resilience to increased stress. This includes tree breeding, genetic technologies such as gene editing, microbiomes manipulation, and silvicultural treatments, e.g., mixed species planting.
3	Understanding the risk posed by the emergence of new insect pests and pathogens or the changing activity and potential impact of existing ones. This includes advances in surveillance and diagnostic technology.
4	Investigating nursery pathway risk to forests and the opportunity to reduce this risk by applying greater biosecurity measures including Plant Pass.
5	Developing solutions to foliar diseases of radiata pine and Douglas-fir as alternatives to copper spraying.
6	Need for baseline of current insect and pathogen species present in NZ including on native tree species. This includes a baseline of pathogens currently in forest nurseries.
7	Assessing alternatives to radiata pine and Douglas-fir including biosecurity risk of contingency species and carbon forestry species.
8	Researching and or adapting remote sensing and chemical delivery technologies (e.g., UAVs etc).
9	Investigating operational biosecurity risk to forests and the opportunity to reduce the risk associated with equipment movement etc. Investigating guidelines to reduce biosecurity risk, e.g., KDB guidelines.
10	The impact of non-forestry "pests" on forest operations and trade.
11	Potential insect and disease problems that may arise from plant-and-leave forestry.
12	Understanding increasing social, cultural, environmental concerns – chemicals, aerial spraying.
13	Assessing radiata pine and Douglas-fir productivity losses caused by needle diseases and other disorders.
14	Attraction of current/new pests to new species and their ability to jump host plant species to radiata pine.
15	Reduce the need for and/or the cost of Dothistroma spraying. Also fully understanding the impacts of drift spraying copper on the aquatic environment.
16	Understanding the potential for a "biosecurity" interruption of the log and green lumber trade because of real or perceived biosecurity threats.
17	Understanding societal attitudes around the application of molecular technologies and other new technologies.
18	Developing new methods/systems to provide greater assurance of pest-free log and lumber exports outside STIMBR's mandate, e.g., research the forest-to-market pathway approach.
19	Ensuring strong linkages with international scientists and technology suppliers as resources, and in some cases technology availability remain limited in New Zealand.
20	Changes to science structure and greater emphasis on Te Tiriti – implications to forest biosecurity govt research funding; addressing declining forestry biosecurity science capability.
21	Ensuring adequate funding and training or recruitment in taxonomy.

There is some research currently underway in some of these areas but not in others. See the FOA website for more detailed information[44]. FBC members were asked to consider the criteria in the table below when making their rankings.

Criteria	Meaning	Score (4 high)
Importance to the short-term economics of the industry	Is the issue likely to have a major impact to immediate industry value?	1-4
Importance to the longer-term economics of the industry	Is the issue likely to have a major impact to longer-term industry value?	
Science/technology to solve the issue	Or is the solution more political or other?	
Likelihood of S&T success	Based on science & technology, including cost, but also social and political risk.	
Addresses urgent government policy	Research is required to address policy in order to reduce impact on industry.	
Addresses future government policy	Research initiated now would provide answers to expected government policy.	
Total		

44. https://www.nzfoa.org.nz/committees/forest-biosecurity-committee