Resilient Forests Research Programme: An uncertain future becomes an uncertain world

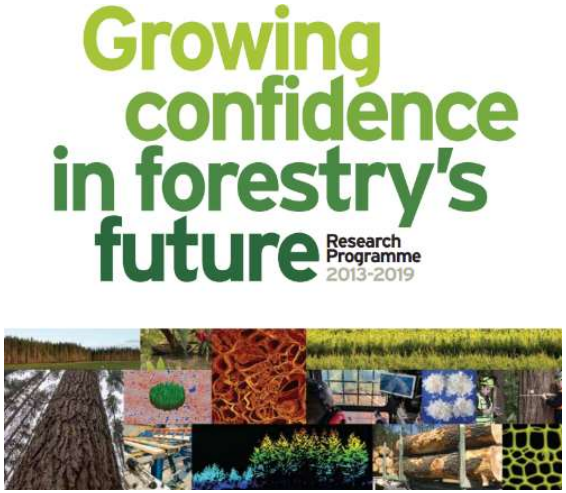
Peter Clinton, Yvette Dickinson, Grace Villamor, and Stuart Fraser

RESILIENT FORESTS scion CONFERENCE 2023

FOREST GROWERS RESEARCH

Resilient Forests Research Programme

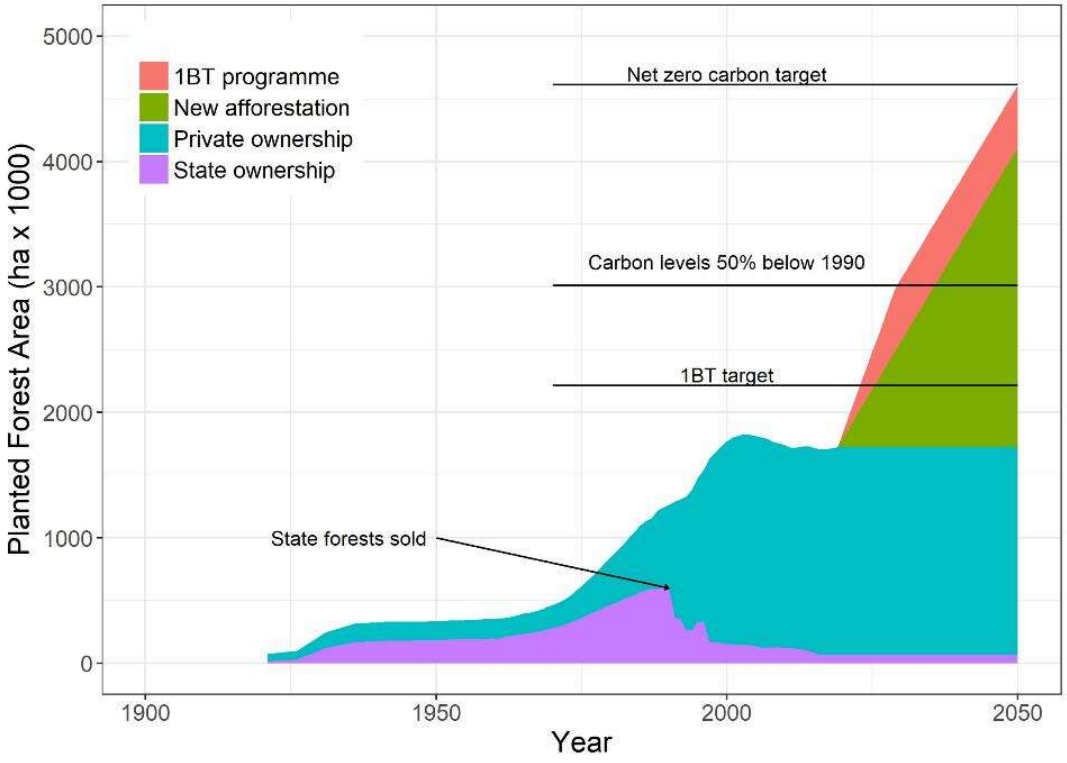
Where did the Resilient Forests Research Programme come from?



- $60 billion asset plus processing industry in the order of $13 billion, $6.6 billion exports plus domestic market in excess of 12 million cubic metres.
- The world needs more wood/fibre/biomass.
- Investors want greener investments.

Business as usual is no guarantee of success in an uncertain world

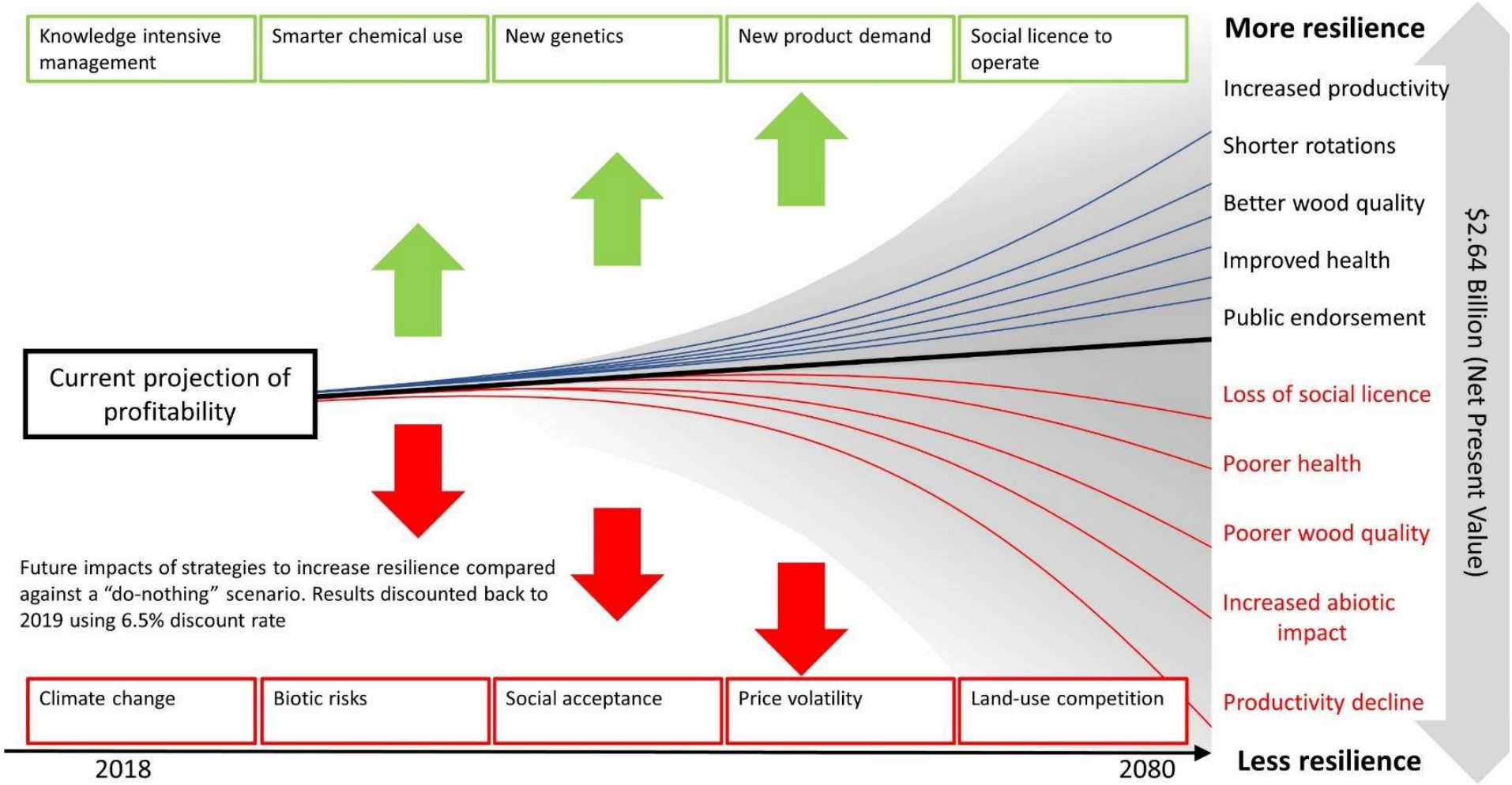
New Zealand's planted forest estate and predicted afforestation required



Additional afforestation required to meet the country's conservative and net zero 2050 emission targets.

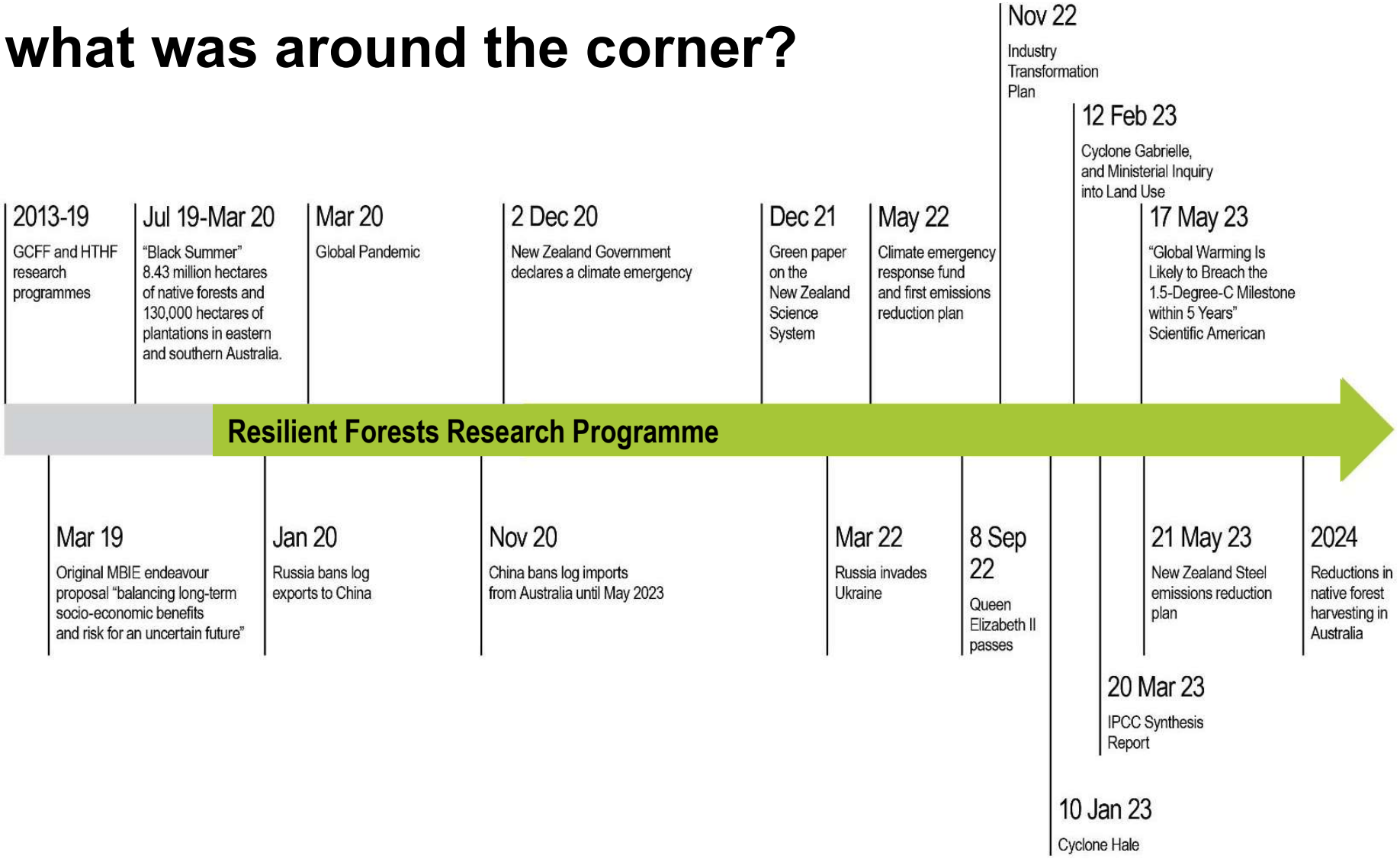
Based on 2019 prediction.

Impacts of future uncertainty on returns and their volatility



Source: Gareth Buchanan, Ngahere Resources Limited - independent forest consultant

But what was around the corner?



What does the world look like today?

Current World Population

8,035,487,850

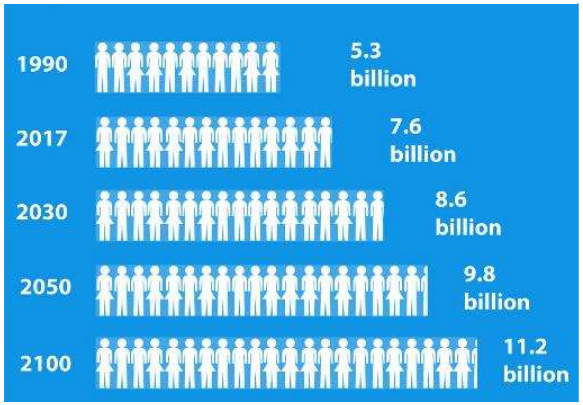
April 2023:	423.28 ppm
April 2022:	420.23 ppm

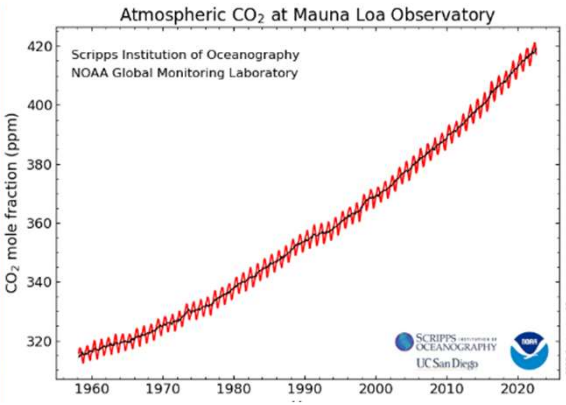
Last updated: May 09, 2023

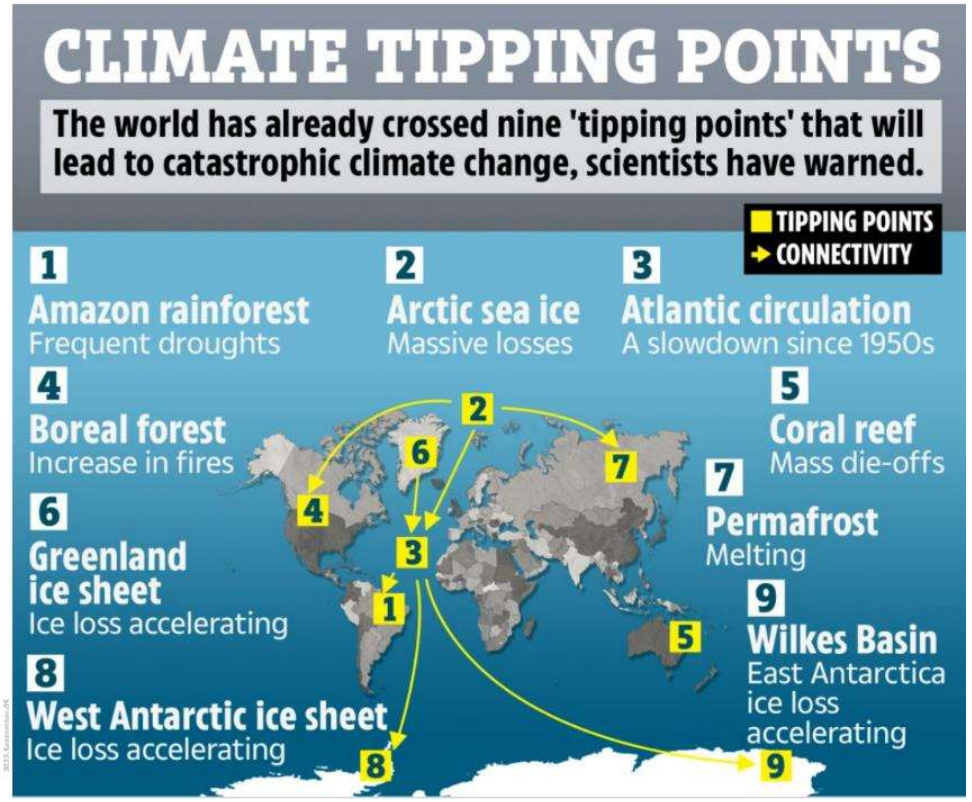
CLIMATE CHANGE

Exceeding 1.5°C global warming could trigger multiple climate tipping points

David I. Armstrong McKay*, Arie Staal, Jesse F. Abrams, Ricarda Winkelmann, Boris Sakschewski, Sina Loriani, Ingo Fetzer, Sarah E. Cornell, Johan Rockström, Timothy M. Lenton*







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Have we seen the worst yet?

This land is your land

Is this the end of forests as we've known them?

Trees lost to drought and wildfires are not returning. Climate change is taking a toll on the world's forests - and radically changing the environment before our eyes

by Alastair Gee

Camille Stevens-Rumann never used to worry about seeing dead trees. As a wildland firefighter in the American west, she encountered untold numbers killed in blazes she helped to extinguish. She knew fires are integral to forests in this part of th world; they prune out smaller trees, giving room to the rest and even help

Global warming: what will French forests look like in 2050?

Tech | March 23, 2022 | No Comments

FORESTS NEWS

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NEWS

Undisturbed forests could cease to exist in large tropical humid regions by 2050, study says

Degradation must be considered a deforestation risk factor

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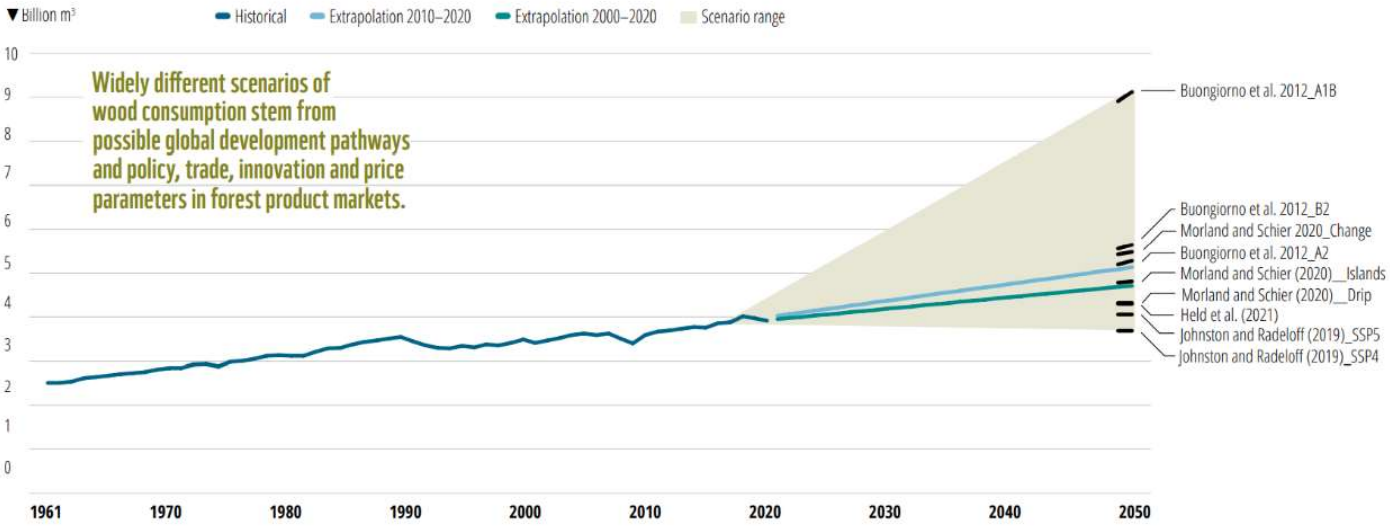
What does the world need now?

More forests

- Forests are widely seen as key.
- Predictions are that the world needs 400 million hectares of plantation forests.
- 292 million ha of planted forests: 131 million ha are plantations with >50 million ha of these managed intensively.



Everything from Wood WWF 2022

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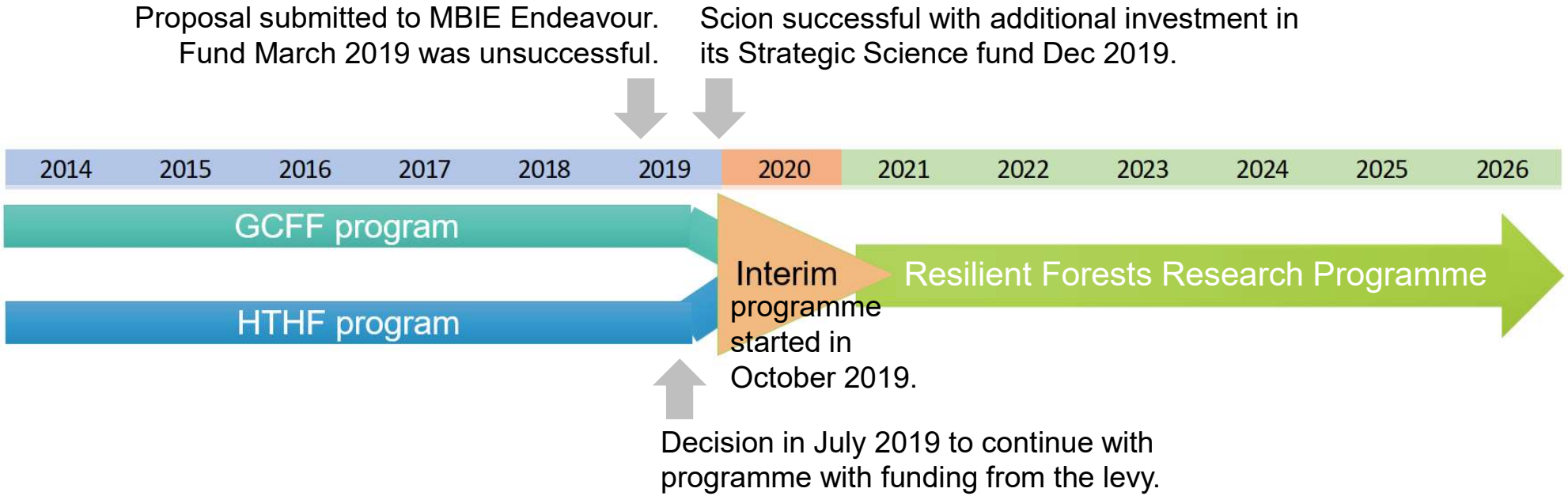
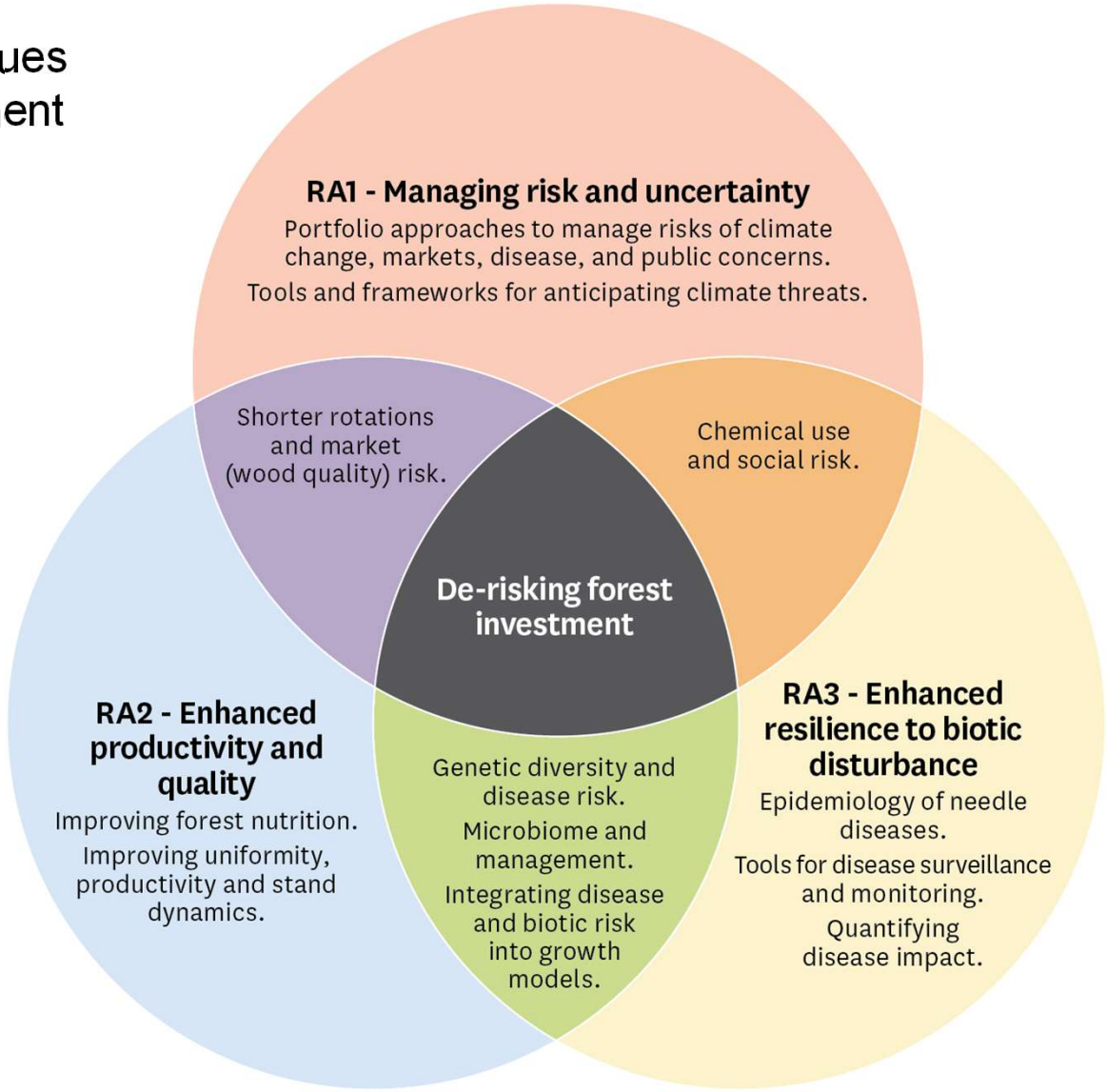
So here we are today



- Each research aim addresses strategic issues that can transform current forest management options to create resilient plantation forest industry.
- Research is geared towards supporting strategic and tactical planning.
- Applied outputs support operational management.



RA1: Managing risk and uncertainty

Strategic issues

- Forest growers need robust, socially-accepted response measures to deal with uncertainties and to de-risk the existing forestry model (climate change, markets, disease, public concerns).

Objectives

- Apply portfolio approaches to manage risk.
- Future proof forests through adaptive management.
- Tools and frameworks to anticipate climate threats and social risk.

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Highlights RA1: Managing risk and uncertainty

land

forests

Exploring the solution space for different forestry management structures in New Zealand under climate change

Anita Wreford [a,*], Andrew Dunningham [b], Alan Jones [b], Oscar Montes de Oca Munguia [b], Grace B. Villamor [b], Juan J. Monge [c]

Research article

Diversification of forestry portfolios for climate change and market risk mitigation

Thales A.P. West [a,b,c,*], Serajis Salekin [a], Nathanael Melia [d], Steve J. Wakelin [a], Richard T. Yao [a], Dean Meason [a]

Article

Credence Attributes in the Forestry Sector and the Role of Environmental, Social and Governance (ESG) Factors

Sebastian Klinger *, Karen M. Bayne, Richard T. Yao and Tim Payn

Improving the Representation of Climate Change Adaptation Behaviour in New Zealand's Forest Growing Sector

Grace B. Villamor [1,2,*], Andrew Dunningham [1], Philip Stahlmann-Brown [3] and Peter W. Clinton [1]

- Risk models that predict the distribution of future returns for a given scenario rather than simply the mean.
- A framework that enables decision makers to evaluate the mean return for a given portfolio of forest assets along with the variation in these returns.
- A new behavioural model that describes the risk preference and adaptive measures of forest owners to climate change related risks.

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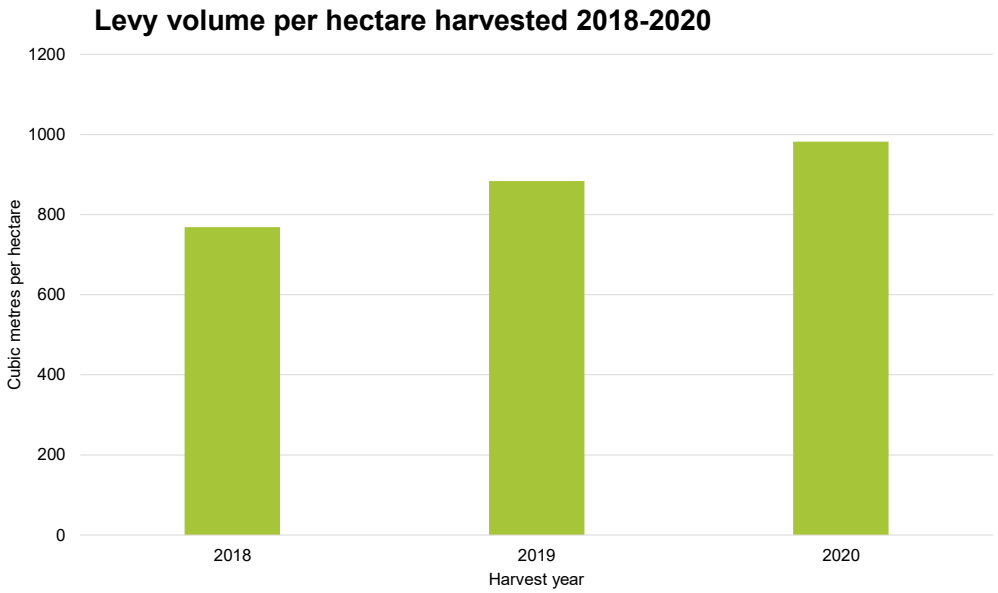
RA2: Enhancing productivity and quality

Strategic issues

- How can we realise the full potential of radiata pine?
- What is the impact of GxExS on growth and wood properties?
- What does radiata pine's microbiome look like and what role do the different organisms play?
- How do we leverage maximum benefit from previous investment in trials?
- What does resilient silviculture look like in practice?



https://www.canopy.govt.nz/forestry-data-research/total-harvesting-by-species/

Highlights RA2: Enhancing productivity and quality

Using hyperspectral plant traits linked to photosynthetic efficiency to assess N and P partition

Michael S. Watt [a,*], Henning Buddenbaum [b], Ellen Mae C. Leonardo [c], Honey Jane C. Estarija [c], Horacio E. Bown [d], Mireia Gomez-Gallego [e], Robin Hartley [c], Peter Massam [c], Liam Wright [c], Pablo J. Zarco-Tejada [f,g]

Mineralisation and nitrification of biuret and urea nitrogen in two New Zealand forest soils

Jianming Xue[A,*], Peter W. Clinton[A], Roger Sands[B] and Tim W. Payn[C]

Article

An Assessment of High-Density UAV Point Clouds for the Measurement of Young Forestry Trials

Robin J. L. Hartley [1,*], Ellen Mae Leonardo [1], Peter Massam [1], Michael S. Watt [2], Honey Jane Estarija [1], Liam Wright [1], Nathanael Melia [1,3] and Grant D. Pearse [1]

remote sensing

frontiers in Plant Science

Mid-infrared spectroscopy for planted forest soil and foliage nutrition predictions, New Zealand case study

Loretta G. Garrett [a,*], Jonathan Sanderman [b], David J. Palmer [c], Fiona Dean [a], Sunita Patel [a], James H. Bridson [a], Thomas Carlin [c]

Spatial Models With Inter-Tree Competition From Airborne Laser Scanning Improve Estimates of Genetic Variance

David Pont[1], Heidi S. Dungey[2], Mari Suontama[2,3] and Grahame T. Stovold[2]*

- The development of methods to delineate and characterise key attributes of individual trees from LiDAR data.
- The development of a methodology for spatially characterizing foliage nutrition from aerial imagery.
- New management recommendations for managing forest nutrition.

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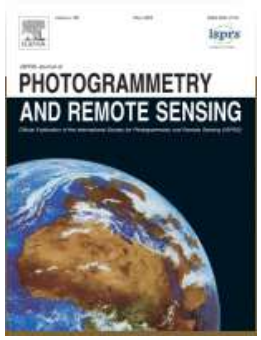
Highlights RA2: Enhancing productivity and quality



Detecting and mapping tree seedlings in UAV imagery using convolutional neural networks and field-verified data

Grant D. Pearse [a,*], Alan Y.S. Tan [a], Michael S. Watt [b], Matthias O. Franz [c], Jonathan P. Dash [a]

Genome Sequence of *Dermacoccus* Strain Tok2021, a Soil Actinobacterium Isolated from a *Pinus radiata* Forest

C. Armstrong,[a] D. Sen,[b] K. Walker,[b] L. Garrett,[b] A. Byers,[b] S. Wakelin[a]

Article

An Assessment of High-Density UAV Point Clouds for the Measurement of Young Forestry Trials

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remote sensing

- Entirely new opportunities to manage forest productivity and resilience to abiotic and biotic threats through management of the microbiome.
- Long term research infrastructure assets maintained and Puruki research catchments re-established to provide insights into next generation plantations.

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Highlights RA2: Enhancing productivity and quality

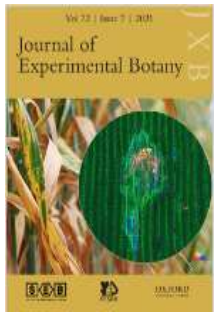
Radial growth anisotropy and temporality in fast-growing temperate conifers

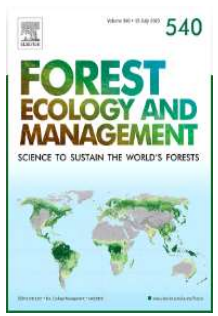
Damien Sellier[1] · Raphaël Ségura[2]

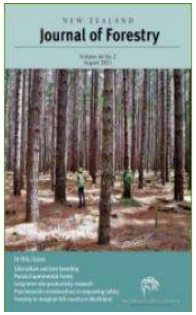
Globally relevant lessons from a long-term trial series testing universal hypothesis of the impacts of increasing biomass removal on site productivity and nutrient pools

L.G. Garrett[a,*], S.J. Smaill[b], S.L. Addison[a], P.W. Clinton[b]

Annals of Forest Science







Long-term site productivity research – 30 plus years in the making

Peter Clinton, Loretta Garrett and Simeon Smaill

Puruki Experimental Forest – half a century of forestry research

Loretta Garrett, Steve A. Wakelin, Stephen Pearce, Steve J. Wakelin and Tim Barnard

RESEARCH PAPER

Interclonal variation, coordination, and trade-offs between hydraulic conductance and gas exchange in *Pinus radiata*: consequences on plant growth and wood density

Juan Rodríguez-Gamir[1,2,*,†], Jianming Xue[2], Dean F. Meason[3], Michael Clearwater[4], Peter W. Clinton[2] and Jean-Christophe Domec[5,6]

- Quantitative information on the patterns of variation in wood properties within radiata pine and the implications of these patterns for end-product performance.
- New strategies to manage wood properties variation to improve outcomes for plantation grown timber.
- Long term research infrastructure assets maintained, Puruki research catchments re-established to provide insights into next generation plantations.

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RA3: Enhancing the resilience of radiata pine forests to biotic impacts

Strategic issues

- Needle diseases cause significant growth losses.
- No control recommendations for RNC.
- Climate change.
- Biosecurity threats.
- Environmental, Social, and Governance pressures.

Foresters need a suite of tools and systems that build resilience now and into the future.

Highlights RA3: Enhancing the resilience of radiata pine forests to biotic impacts

plants

Infection periods of *Phytophthora pluvialis* and *Phytophthora kernoviae* in relation to weather variables and season in *Pinus radiata* forests in New Zealand

Ian A. Hood*, Sean Husheer, Judy F. Gardner, Tony W. Evanson, Gordon Tleman, Catherine Banham, Liam A.H. Wright and Stuart Fraser*

Efficacy and optimal timing of low-volume aerial applications of copper fungicides for the control of red needle cast of pine

Stuart Fraser[1]*, Mike Baker[2], Grant Pearse[1], Christine L. Todoroki[1], Honey Jane Estarija[1], Ian A. Hood[1], Lindsay S. Bulman[1], Chanatda Somchit[1] and Carol A. Rolando[1]

Article

Targeted Gene Mutations in the Forest Pathogen *Dothistroma septosporum* Using CRISPR/Cas9

Hannah M. McCarthy [1,*], Mariana Tarallo [1], Carl H. Mesarich [2], Rebecca L. McDougal [3] and Rosie E. Bradshaw [1]

- Epidemiological models for the four main needle diseases of radiata pine that quantitatively describe the spatial and temporal patterns of infection and can be used by forest managers to predict disease outbreaks.
- Quantitative information on the growth losses at a stand level resulting from different intensities and severities of infection by pathogens.
- New management recommendations for managing pathogens.

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Outlook and impact on wider research activities

- Original proposal was for $36 million over 5 years 2019 -2024.
- To date: Scion Strategic Science investment $12.7 million, FGR levy investment $6.0 million.
- Seeded Tree Root Microbiome Program $15 million five years 2020-2025.
- Transforming Tree Phenotyping $9.63 Million 2021-2026.
- Biomechanical responses to climate change: designing adapted forests from new trees and silviculture.
- Micronutrient homeostasis in the tree holobiont for more resilient forestry and durable wood.
- Future-proofing of NZ timber in a tele-coupled and globalized timber world: managing effects of global timber trade flows.

Five year roadmap

RESILIENT FORESTS

Vision: Sustainably protect and add value to the existing radiata pine forest estate in perpetuity

Updated: 1 September 2021

Critical issues

What are the current issues (or opportunities) that this project will address?

The full potential of the current radiata pine model has yet to be realized. There is a necessity in a fast-moving world to keep increasing productivity, improving wood quality and uniformity, and resilience to biotic threats through precision forestry

Greater public and investor scrutiny of forest management practices will limit management opportunities in the future. New environmentally sustainable, financially viable and socially acceptable management practices are needed. Industry requires robust evidence and tools to engage with the public and government to continue to sustainably manage forests

Greater governance, and climate change & sustainability reporting requirements require more rigorous evidence to sustain shareholder confidence

The negative perceptions of radiata pine forestry are limiting the expansion of the forest estate and the contribution of plantation forestry as an effective means for mitigating future climate change

The long time frames and concentration risk in forestry creates unique uncertainty, risk, and opportunity compared to other sectors. Research is needed to understand uncertainty and increase the industry's agility to respond.

Climate change impacts on the existing radiata pine forest are not well understood and mitigation/**adaptation** strategies have not been developed

The research opportunity and the Resilient Forests response

Opportunity: To increase productivity, wood quality, uniformity and resilience to biotic threats through precision forestry.

Response: Resilient Forests will use excellent science to increase the economic return, adaptation, and resilience of current and future *Pinus radiata* forest production. It will do this by taking an integrated approach to de-risk forest management decisions and future proofs the investment of what we already have 'in the ground'

Critical Inputs: Capability, TST, new and existing , research infrastructure, long term field trials, greenhouses, biological collections, remote sensing equipment, data and software, other sources of funding, including Scion Capex. International and domestic collaborations

Integrated research portfolio
Co-innovation approach to support uptake by policy and industry

Outputs

What will we produce in this project?

A clear and actionable roadmap that describes what the next-generation of forestry management looks like

Models and frameworks that better account for risk and uncertainty to support good quality (and more confident) decision-making

Development of protocols and approaches that make smarter use of technology and data that support and inform good quality decision-making (including the supporting models and frameworks)

New low-cost methods that can gather data needed to support the decision-making models, frameworks and protocols

Outcomes

Short-term

Improved confidence by forestry managers to invest in forestry

Improved **ability to manage socioeconomic and biotic risk** and uncertainty

Reduced reliance on chemicals through smarter forest management

Prototypes of **advanced tools and techniques** used to increase productivity and control disease and manage biosecurity

Public have embraced the radiata forestry system as a way to address climate change challenges

Industry is informed by Long-term trials delivering clear **demonstration** of what can be achieved to make trees fatter, stronger, faster

Long-term research infrastructure is enhanced via industry and Scion co-investment

Mid-term

Foresters understand the economic impact of important pests and diseases across a range of sites, and know how, where and when to intervene using appropriate treatments (e.g. genetics, silviculture, chemicals) and application methods (e.g. precision tools) that have minimal environmental impact

Foresters have greater confidence to invest in forestry through their choice of rotation options, a diverse choice of more valuable products including carbon, enhanced environmental performance that enhances the reputation of radiata pine forestry

Capacity building in the sector has accelerated the industry's ability to rapidly respond to change

Long-term

Trees can be planted in any setting with confidence that they will survive and remain productive

Critical forest management decisions are supported by fit-for-purpose tools

Forestry-based land use is optimised

Forest disease is effectively managed and mitigated

The public advocates for plantation forests because the non-commercial benefits of forests are clear and understood

Overall delivers on

Fit for a Better World
Accelerating our economic potential

Forestry has an increased contribution to NZ's Economic recovery post Covid-19 and wellbeing through next generation diverse, healthier, more productive radiata pine forests integrated into the landscape, supporting the Industry Transformation Plan and enhancing environmental benefits and industry reputation.
The Government is achieving zero-carbon emissions and meet its international obligations

Assumptions:
- A more informed and efficient research programme due to integrated forestry research across the value chain.
- Biosecurity research is covered elsewhere.
- Outputs reflect a five-year work programme.
- The resilient forests programme is well connected to other research activities in Scion's impact area 2.1 plus broader FGR funded research activities

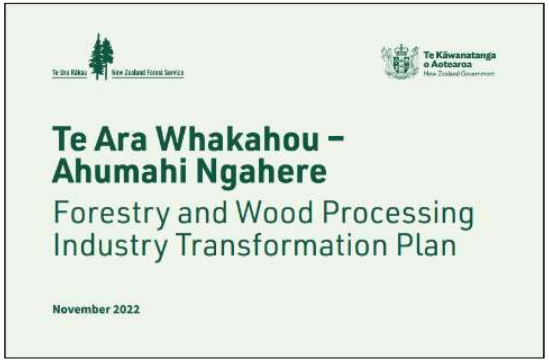
Scope: *Pinus radiata* inside the forest estate

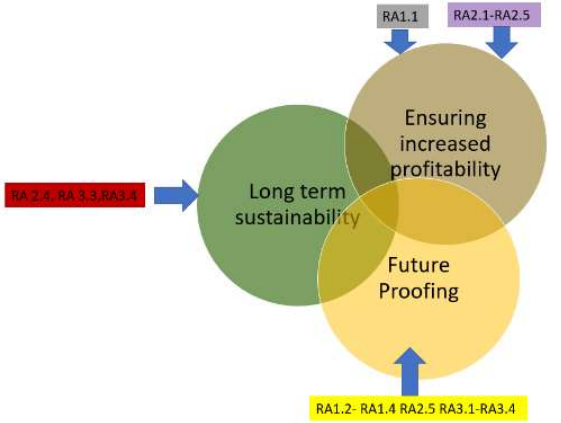
Out of Scope: Other tree species, tree breeding, pre-border and border biosecurity, environmental impacts of management practices such as clearcutting and riparian setbacks

Programmatic Linkages and interrelationships: Linked to several other Scion research programmes, including Tree Root microbiome, Forest Flows, Tree breeding, Biosecurity, and new MBIE proposals (phenotyping & biosecurity) and MBIE legacy programmes GCFF & HTHF.

Linkages to other programmes and strategies

- Specialty Wood Products Partnership.
- Radiata Pine Breeding Company.
- Precision Silviculture Programme.
- Tree Root Microbiome.
- Next Generation Tree Phenotyping.





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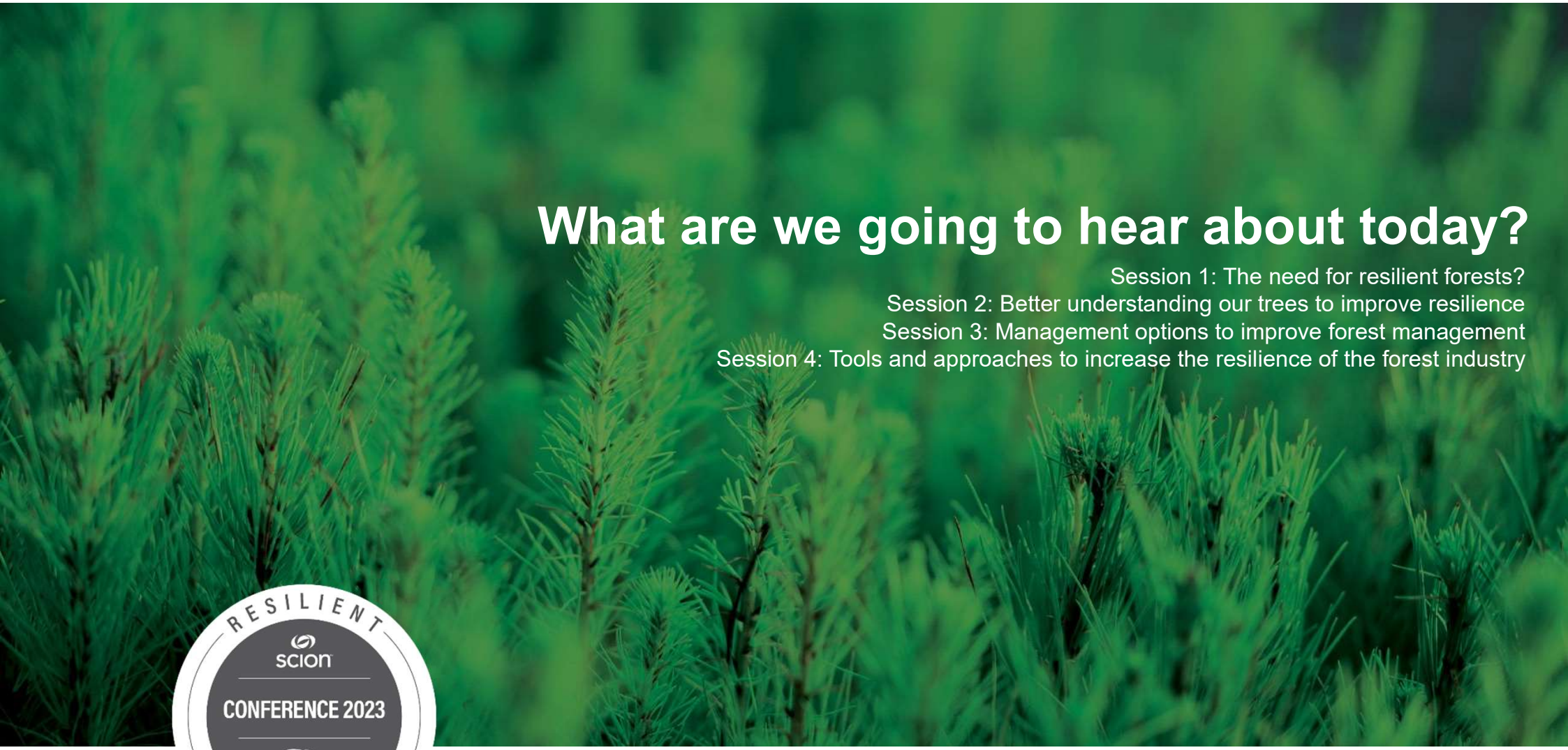

What are we going to hear about today?

Session 1: The need for resilient forests?
Session 2: Better understanding our trees to improve resilience
Session 3: Management options to improve forest management
Session 4: Tools and approaches to increase the resilience of the forest industry

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FOREST GROWERS RESEARCH

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Session 1: The need for resilient forests?

Paul Adams
Research and development investment via the Forest Growers Levy – an update

Peter Clinton
An uncertain future becomes an uncertain world

Grace Villamor
Towards a responsible forestry sector - an initial review of the sustainability activities of New Zealand forest companies

Session 2: Better understanding our trees to improve resilience

Jonathan Harrington
Predicting product performance: recent progress

Robin Hartley
Backpack mobile laser scanning – progress towards autonomous mensuration and phenotyping

Kathryn Walker
Uncovering the *Pinus radiata* microbiome: a key to resilient forests?

David Lane
Impact of red needle cast on tree growth

Session 3: Management options to improve forest management

Emily McLay
Red needle cast epidemiology

Stuart Fraser
Control options for pine needle diseases

Yvette Dickinson
Advancing forest simulation through individual tree models

Simeon Smaill
The Accelerator trials: what have we learnt over the last eight years?

Session 4: Tools and approaches to increase the resilience of the forest industry

Grant Pearse
Autonomous forest health monitoring

Nicolo Camarretta
Automatic mapping of red needle cast using satellite imagery

Don White
Application of a process based model to support management for ‘resilience’ under rapid change

Andrew Clarke
Developing strategy in uncertainty

Andrew Cridge
From uncertainty to action: building resilient forests in a fast-changing world

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Guest speaker

Ryan Cavanagh – Timberlands Chief Executive Officer
Resilience and crystal ball gazing in forestry

Acknowledgements

- Forest Growers Levy Trust
- Scion Strategic Science Investment fund
- All the programme contributors and industry collaborators for forest access and their time

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Resilient Forests Research Programme

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