Forest & Wood Products Australia

Climate Change

Research Investment Plan

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Declaration of interest

The author of this review declares they have no direct interest in any of the RD&E proposals put forward as part of this investment plan. The author is a current Director of Tree Breeding Australia.

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Forest & Wood Products Australia

Executive Summary

Australia is already experiencing the impacts of climate change, which vary across the country. Australia's climate is projected to continue to change into the future[1].

The Climate Change Investment Plan aggregates RD&E investment project themes and topics from existing FWPA research investment plans associated with climate change impact adaptation and resilience. Additional project themes and topics have been added where RD&E gaps were identified, including transitional projects related to emerging climate-related financial disclosure reporting requirements. The Investment Plan nominally spans from 2024 to 2029.

The scope of the investment plan focuses on climate change adaptation and resilience. It excludes emissions quantification and mitigation as well as sustainability-related projects.

The primary objective of this investment plan is to identify projects that assist forest growers and managers in understanding the physical risk elements associated with climate change impact and adapting management practices to mitigate losses in forest productivity.

In developing the investment plan, consideration has been given to previous research investments within Australia and a high-level review of international programs. Stakeholder consultations within the industry have identified potential project themes and topics.

The consequences of climate change for global forests are significant. Models predict an increased frequency of fires[2], wind throw[3] and widespread decline[4]. Elevated concentrations of atmospheric CO_2 could increase forest growth in areas where the effect is not negated by decreased rainfall. However, the cumulative effect of the expected changes in global climate is likely to be broad scale. It is crucial to continue researching and implementing forest conservation and climate change mitigation strategies.

Previous Australian research on climate-related impacts on commercial plantations and forests, and whether the industry has initiated any management response, needs to be reviewed and updated. The long timeframe associated with growing plantations and forests makes monitoring climate change impacts challenging, as does knowing when to initiate a change in management in response to impacts.

The research projects summarised in Table 1 combine existing and new themes and topics.

[1] National Climate Statement (climatechangeinaustralia.gov.au)

[2] What role does climate change play in forest fires? | World Economic Forum (weforum.org)

[3] Windthrow - Forest Research

[4] Forests are becoming less resilient because of climate change | New Scientist

Table 1: Research theme/topic – summary

Investment plan	Theme	Reference/priority	Proposed research theme/topic	Priority ranking	Comments
1. Damage agents investment plan [2022]	Adapting to heatwaves (Long established)	1.1 [DAIP-1.2.1 Medium]	Native forests: Understanding and managing the threat from heatwaves and drought to productivity decline or mortality.	1. High	
	Endemic forest pests	1.2 [DAIP-3.1.1 Medium]	a. Collate long-term forest health monitoring data to baseline historic/current distributions and damage levels of major pests affecting forests.	1. High	
		1.3 [New]	b. Use the baseline data to model relationships between pest distribution/activity and past climate. Model predicted pest distribution and damage levels under different climate scenarios.		
		1.4 [New]	c. Analyse known tree species trait data against predicted pest data to suggest (i) changes in tree species in different areas or (ii) work with tree breeders (TBA/RPBC etc) to re-focus long-term breeding aims to balance growth x drought resistance x pest resistance.		
	Exotic forest pests	1.5 [New]	a. Desktop analysis of current or emerging invasive species overseas, including what biological traits are most indicative of increased invasiveness due to climate change – use this to shortlist pests to focus on. Opportunity to align with and leveraging NZ programs (Scion and Forest Growers Research).. Include pathway analysis to Australia.,	1. High	
		1.6 [New]	b. Develop models or analytic workflows in Biosecurity Commons or similar, to predict pest distribution and damage levels under different climate scenarios.		

Investment plan	Theme	Reference/priority	Proposed research theme/topic	Priority ranking	Comments
		1.7 [New]	c. Analyse known tree species trait data against predicted invasive pest data to suggest (i) tree species to include or ii) focus on as part of future tree breeding.		
	Drought, disease and fire risk and species matching	1.8 [New]	a. Work with CSIRO, TERN, ABARES, BOM, EcoCommons or others to create long-term modelling of drought, disease and fire impacts on commercial plantation and native forests.	2. Medium	Consider use of remote sensing and AI technologies
		1.9 [New]	b. Results of (a) used to suggest new tree species to consider or introduce to tree breeding programs or seeding in the case of native forest.		
2. Fire [2023]	Effective fuel management-maximising opportunities.	2.1 [FIP-3.2.2 Moderate]	A predictive model that uses current data to show future windows of opportunity for prescribed burning and forecast potential periods of increasing fire suppression difficulty.	2. Medium	
	Fire-tolerant plantation tree species	2.2 [FIP-4.1.1 Low]	List of potential species and potential for hybrids that can fit into current/future timber resources.	2. Medium	Linkage to 1.4b
	Understanding tree fire resilience/species adaptation	2.3 [FIP-4.1.2 Low]	Answer the following questions: > Can current commercial species become more fire-resilient, > What is the driver behind post-fire tree death, > How do the following factors influence tree survival: bark thickness, depth of feeder roots, pre-fire litter/duff dryness and surface fuel burning depth, post-fire rainfall and weather - rain quantity/timing and temperature/humidity, > Would increased bark thickness result in less timber damage and lower mortality? > Can we influence ladder fuel traits?	2. Medium	

Investment plan	Theme	Reference/priority	Proposed research theme/topic	Priority ranking	Comments
3. Tree Breeding & Genetic Improvement [2020]	Understanding species adaptation under climate change scenarios	3.1 [TB&GIIP-[Priority 3, recommendation 3.3.5]	Characterising diversity within ecologically and economically important softwoods and hardwoods – having a lens on the national breeding program and natural provenance genetic resources. Identify important germplasm that would assist in the breeding of elite material suited to climate variability including new and untested plantation sites.	2. Medium	Leverage work already done. Extend to sourcing suitable germplasm and initial breeding and testing.
	Maintaining genetic diversity/pre-emptive screening	3.2 TB&GIIP-[Priority 4, recommendation 3.4.3]	Tree Breeding Australia (TBA), Radiata Pine Breeding Company (RPBC) in collaboration with Plant Health Australia (PHA) establish an 'off-shore' research program in the US (i.e. Florida), New Zealand, Chile and South Africa to evaluate the current level of susceptibility/tolerance/resistance of Australian plantation Pinus and Eucalypt spp germplasm when exposed to major plantation diseases (e.g. Pitch Canker) and pests that do not currently exist within Australia plantations.	2. Medium	Extended project to include hardwood plantations
4. Native forest silviculture [2020]	Species adaptation	4.1 [NFSIP-Project 7]	Development of climate-adapted protocols for provenances and species selection for native forests.	2. Medium	Linkage to theme/topic 2.2
			Establishing mixed tree species forests for climate resilience.		
5. Soil microbiome [2021]	Soils microbiome activity in response to climate variability and extremes	5.1 [New]	Advance understanding of the mechanisms by which the tree microbiome supports stress tolerance and how this may be compromised by climate variability		Not ranked as revised topics after review
		5.2 [New]	Understand how different climate conditions alter the function of soil microbiomes related to pathogen repression and nutrient cycling		Not ranked as revised topics after review

Investment plan	Theme	Reference/priority	Proposed research theme/topic	Priority ranking	Comments
		5.3 [New]	Identify what genetic loci in plant breeding programs associate to fostering beneficial microbiomes and profile how climate extremes may affect these		Not ranked as revised topics after review
		5.4 [New]	Develop tools to manipulate tree microbiomes in situ at both planting and mid-rotation to boost climate resilience and pathogen repression		Not ranked as revised topics after review
6. Climate change- new	Climate change adaptation- commercial native forest and plantations.	6.1	Update of the CSIRO report (Pinkard *et al* 2014) considering IPCC AR6 report climate projections. Consolidate outcomes of recent (post-2014) research into physical impacts and management framework and options for adaptation. Include nursery management, site preparation, early silviculture - fertilisation and weed control, thinning prescriptions and pest and disease impact from drought.	2. Medium	
	Monitoring change- understand spatial and temporal climate-related impacts, establishing baselines, threshold levels and response triggers.	6.2	To be considered as part of the Forest Industry Sustainability framework: >Explore options to leverage and expand the TERN project to include national commercial plantation and native forest locations. >Further understanding of water use of commercial plantations species and native forests.	2. Medium	
	Forecasting within-year climate variation to assess localised risks on commercial plantations and native forest	6.3	Prediction of likelihood and consequence of change in annual/monthly extreme weather events i.e. heat waves, drought, flooding, wind/cyclones for plantation and native forest regions.	2. Medium	Should fall under CSIRO/BoM deliverables. What is the role of the Forest Climate Risk Tool.

Investment plan	Theme	Reference/priority	Proposed research theme/topic	Priority ranking	Comments
	Forecasting infrastructure damage	6.4	Using climate forecast models explore the potential to identify forested (native and plantation) areas that will be most impacted from extreme weather events driven by climate change that would impact on forest grower infrastructure (roads, bridges) and supply chains.	2. Medium	
	Stand management-thinning options to reduce stand mortality due to drought/limited water availability.	6.5	Investigate the effectiveness of i) managing initial stocking rates and thinning in commercial plantations in response to limited water availability, ii) thinning as a management tool in commercial native forests in response to limited water availability.	1. High	
	Transitional impacts- the implementation of climate-related financial disclosure standards by the Australian Accounting Standards Board (AASB).	6.6	A pilot study to develop an industry framework and guidelines to address reporting of climate-related financial disclosure.	1. High	
	Transitional impacts- Forest Valuation Standards- climate-related financial disclosure requirements.	6.7	Engage forest valuers and accountants to understand the impact of climate-related financial disclosure requirements and how they are to be implemented in forest valuation and standards. Includes information and data requirements and assumptions.	1. High	
	Modelling productivity impacts of climate change scenarios	6.8	Proposal #1 Integrating APSIM into resource management systems for estate wood flows and valuations that account for climate change.	1. High	
		6.9	Proposal #7 Transforming future softwood productivity through optimal site-specific silviculture.	1. High	

Further scoping for each project theme or topic will be required before seeking any research funding provision to ensure sufficient detail is captured, deliverables are clearly defined, impacts assessed, and any complimentary work being undertaken either recently or concurrently can be adequately considered.

Forest & Wood Products Australia

Contents

1 Background

The vision of the Forest and Wood Products Australia (FWPA) Grower Research Advisory Committee (GRAC)[5] is to "double the value of Australia's commercial forests by 2040, by fostering an innovation culture in our enterprises, applying world's best practices, collaborating and investing into research and development as appropriate".

In support of the GRAC vision, FWPA commissioned a suite of investment plans that provided technical reviews and business cases to guide industry investment in RD&E for the Australian commercial forestry sector from 2019 to 2023, with an outlook to 2028 and beyond to 2040.

Following the development of the current suite of nine investment plans, FWPA identified the need for a Climate Change Investment Plan. Whilst existing investment plans may identify research priorities in response to climate change, there is a need to consolidate the projects into one document to bring focus to climate change projects as part of a program that can be progressively addressed. The investment plan also identifies gaps in existing priorities and proposes new project themes and topics.

[5] An advisory committee to Forest and Wood Products Australia.

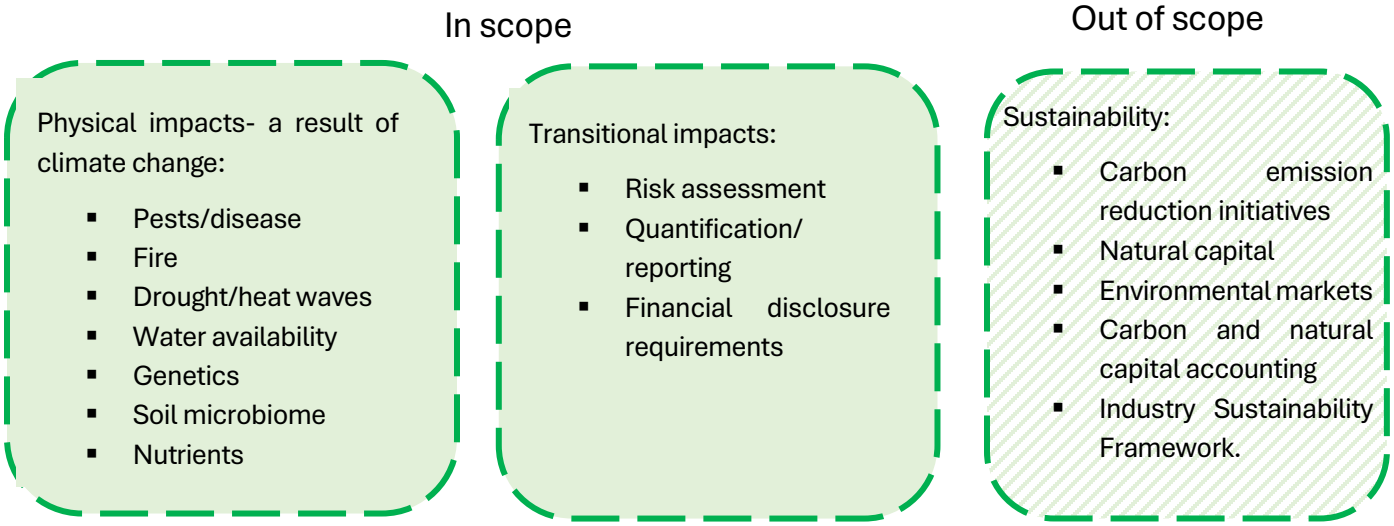
2 Objectives and scope

The Climate Change Investment Plan aggregates RD&E investment projects from existing FWPA research investment plans associated with climate change impact adaptation[6] and resilience[7]. Additional project themes and topics have been added where RD&E gaps were identified including transitional projects relating to emerging climate-related financial disclosure reporting requirements. The Investment Plan spans from 2024 to 2029.

The primary objective of this investment plan is to identify projects that assist forest growers and managers in understanding the physical risk elements associated with climate change impact and potential adaptation practices to mitigate production losses and make the forests and plantations more resilient.

The scope of the investment plan focuses on climate change adaptation and resilience. It excludes emissions quantification and mitigation, as well as sustainability-related projects, as shown in Figure 2.1.

Figure 2.1: Investment plan scope



In developing the investment plan, consideration has been given to previous research investments within Australia and a high-level review of international programs. Consultation with industry stakeholders has identified potential project themes and topics.

[6] Adaptation is defined as 'adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities' (Innes *et al*., 2009).

[7] Resilience is the capacity of a system (such as forest) to deal with change and continue to develop.

3 Method

The investment plan was developed by;

- Initial engagement with FWPA to compile a key contact list of stakeholders to engage with to understand the main climate change-related issues for grower members;
- One-on-one conversations with grower members, key industry and research personnel;
- Aggregation of climate-related projects from existing investment plans and capturing additional themes and topics;
- A high-level review of current and recent research programs and available reports;
- Consolidation of research themes and topics based on engagement feedback;
- Preparation of a draft investment plan for review;
- Review of the draft Investment plan and ranking of projects by a selection of stakeholders;
- Presentation of the investment plan to GRAC; and
- Finalisation of the investment plan based on feedback from FWPA/GRAC.

It should be noted that the investment plan does not try to present research topics in their final form but rather gives an indication of the priority areas to be explored. It is expected that additional scoping and problem definition, as well as consideration of other complementary research programs, would be required before research proposals are submitted to FWPA for evaluation.

4 Climate change - context

4.1 Australia's changing climate

In general, climate change will affect the forest conditions (area, health, vitality, and biodiversity), allowing increases in growth rates in some areas while endangering the survival of species and forest communities in others. Temperature, availability of water and changes in seasonality may all become limiting factors, depending on geographic area, original climatic conditions, species diversity and human activities. Most commonly, these changes will affect the frequency and intensity of fires and insect pests and diseases, as well as damage done by extreme weather conditions, such as droughts, torrential rains and severe winds.

Australia is currently feeling the effects of climate change, with various impacts across regions. The country's climate is anticipated to undergo further changes in the future, according to the 2022 State of the Climate Report[8] prepared by CSIRO and Bureau of Meteorology. The report predicts that the ongoing increase in global temperatures will likely cause shifts in rainfall patterns, more frequent and severe storms, and heightened climate variability.

In Australia, the impacts of climate change are already evident. There have been changes in the growth and distribution of plants, animals, and insects; shifts in the distribution of marine species and increases in coral bleaching on the Great Barrier Reef and Western Australian reefs. Southwest Western Australia has experienced a reduction in rainfall since the 1970s, attributed in part to enhanced greenhouse warming.[9]

The Copernicus Climate Change Service reported that 2023 was the warmest year on record[10]. If global trends extend to Australia, then 2023 eclipses the previous records set in 2019 - confirming a long-term trend of global warming.

The number of extreme fire risk days has grown over the past four decades, particularly in southeast Australia and away from the coast. Future hotter and drier conditions, especially in southern Australia, are likely to cause further increases in the number of high fire-risk days and in the length of the fire season (Australian Academy of Science, 2024).

The Black Summer of fires in 2019-2020 destroyed 140,000 hectares of commercial plantations (Geddes 2020) and greater than 8.3 million hectares of forest (ABARES, 2020). The fires were

[8] State of the Climate 2022: Bureau of Meteorology (bom.gov.au)

[9] 7. What are the impacts of climate change? | Australian Academy of Science

[10] Copernicus: November 2023 – Remarkable year continues, with warmest boreal autumn. 2023 will be the warmest year on record | Copernicus.

associated with a record drought before the season, low rainfall during the season and multiple high-temperature records (Bushfire Hub, 2020).

The State of the Climate 2022 report offers an authoritative perspective on national and international climate change research, observations, and analysis. It presents future projections to illustrate year-on-year variability and long-term changes in Australia's climate. The report also incorporates new information from the 2021 Sixth Assessment Report by the Intergovernmental Panel on Climate Change (IPCC).

Key points from The State of the Climate 2022 report include:

- Australia's climate has warmed by an average of 1.47 ± 0.24 °C since national records began in 1910;
- Sea surface temperatures have increased by an average of 1.05 °C since 1900. This has led to an increase in the frequency of extreme heat events over land and sea;
- There has been a decline of around 15 per cent in April to October rainfall in the southwest of Australia since 1970. Across the same region, May to July rainfall has seen the largest decrease, by around 19 per cent since 1970;
- In the south-east of Australia, there has been a decrease of around 10 per cent in April to October rainfall since the late 1990s;
- There has been a decrease in streamflow at most gauges across Australia since 1975;
- Rainfall and streamflow have increased across parts of northern Australia since the 1970s; and
- There has been an increase in extreme fire weather, and a longer fire season, across large parts of the country since the 1950s.

4.2 Australia's climate change forecasts

The State of the Climate 2022 report states trends described above are expected to persist. In coming decades Australia is projected to experience:

- Continued increase in air temperatures, more heat extremes and fewer cold extremes;
- Continued decrease, on average, in cool season rainfall across many regions of southern and eastern Australia, which will likely lead to more time in drought, but with ongoing climate variability that will give rise to short-duration, heavy-rainfall events at a range of timescales;
- Continued increase in the number of dangerous fire weather days and a longer fire season for southern and eastern Australia;

- Further sea level rise and continued warming and acidification of the oceans around Australia;
- Increased and longer-lasting marine heatwaves that will affect marine environments, such as kelp forests, and increase the likelihood of more frequent and severe bleaching events in coral reefs around Australia, including the Great Barrier Reef and Ningaloo Reef;
- Fewer tropical cyclones, but a greater proportion is projected to be of high intensity, with large variations from year to year; and
- Reduced average snow depth in alpine regions, but with variations from year to year.

4.3 Climate change impacts on forest productivity in Australia

Climate change poses significant risks and opportunities for forests in Australia, depending on the location, species, management, and adaptation strategies.

The ABARES 'Potential effects of climate change in forests and forestry in Australia' report (2011) provides a summary of some of the potential impacts of climate change on forest productivity in Australia, as follows:

- Changes in temperature, rainfall, evaporation, and CO_2 concentration will affect the growth, yield, and quality of trees. For example, higher temperatures and lower rainfall may reduce the water availability and increase the drought stress for some forests, especially in southern and western Australia. On the other hand, higher CO_2 concentration may enhance the photosynthesis and water use efficiency of some plantations, especially in northern and eastern Australia;
- Changes in the frequency and intensity of extreme weather events, such as heatwaves, frosts, storms, floods, and fires, will affect the health, survival, and resilience of forests. For example, heatwaves and frosts may damage the tissues and organs of trees, reducing their growth and quality. Storms, floods, and fires may cause physical damage and mortality to trees, reducing their yield and increasing the costs of recovery; and
- Changes in the pest and disease pressure will affect the susceptibility and resistance of forests and plantation trees. For example, higher temperatures and lower rainfall may increase the risk of insect outbreaks and fungal infections for some plantations, especially in southern and western Australia. On the other hand, higher CO_2 concentration may increase the defence mechanisms and tolerance of some plantations, especially in northern and eastern Australia.

Further, the report advises that to manage the impacts of climate change, plantation managers and owners need to adopt appropriate adaptation strategies, such as:

- Selecting and breeding suitable tree species and genotypes that can cope with the projected climate conditions and meet the market demand;

- Adjusting the planting density, spacing, thinning, pruning, fertilisation, irrigation, and harvesting regimes to optimise the growth, yield, and quality of plantation trees under changing climate;

- Implementing integrated pest and disease management practices to reduce the vulnerability and enhance the resistance of plantation trees;

- Enhancing the diversity and resilience of plantation forests by mixing different species, genotypes, and age classes, and by creating buffer zones, corridors, and refuges for native flora and fauna; and

- Monitoring and evaluating the performance and impacts of plantation forests under changing climate and adjusting the management practices accordingly.

4.4 Australia's climate change forecasts – Representative Concentration Pathways

Representative concentration pathways (RCPs) are forecast of greenhouse gas (GHG) concentrations used for climate modelling simulations and to assess potential climate change impacts and mitigation options. They describe possible climate change scenarios depending on the amount of GHG emitted.

The four key RCPs are:

- RCP2.6[11]: Limit warming to 2^{o}C. Moderate scenario leading to a warming at the end of the 21st century of less than 2^{o}C relative to pre-industrial period. This is the most ambitious mitigation scenario, with emissions peaking early in the century (around 2020), then rapidly declining. Such a pathway would require early participation from all emitters, including developing countries, as well as the application of technologies for actively removing carbon dioxide from the atmosphere;

- RCP4.5: Intermediate scenario. Leads to a warming of more than 2^{0}C but limited to 3^{o}C relative to the pre-industrial period;

- RCP6.0: Intermediate scenario. This scenario represents lower emissions achieved by the application of some mitigation strategies and technologies to control CO_2 concentration and other greenhouse gases; and

- RCP8.5: High scenario. Exceeds warming of 4^{o}C. The most severe scenario leading to a warming at the end of the 21st century of probably more than 4^{o}C relative to the pre-industrial period. This

[11] Radiative forcing (W m^{-2}). Change in radiative flux (downward – upward) at the top of atmosphere due to climate change drivers ie change in concentration of CO_2.

represents a future with little curbing of emissions, with a CO_2 concentration continuing to rapidly rise.

The IPCC (2022) suggests that the current trajectory is consistent with RCP4.5 but is dependent on global efforts to reduce GHG emissions. Under the current trajectory the IPCC forecasts we are likely to hit 1.5°C of warming around 2030.

In Australia, the Bureau of Meteorology and the Commonwealth Scientific and Industrial Research Organisation (CSIRO) use RCPs to investigate plausible future scenarios for greenhouse gas emissions. These climate prediction models can aid in forecasting the effects on forests, thereby helping to devise strategies for mitigation.

5 Current state of RD&E

5.1 Review of existing investment plans

In 2019, a set of eight investment plans was created. These plans were then evaluated together to allocate funding to each plan from a pool of funds. This information was used to propose an increase in compulsory levies contributed by growers, which is now in effect and has significantly boosted the RD&E budget.

This process was followed by the development of a Soil Microbiome Investment Plan in 2021. Several investment plans are planned to be reviewed or have been reviewed since 2019. These include:

- Damage agents (reviewed September 2022);
- Forestry operation and supply chain (Mayday Hill Consulting, Damien O'Reilly) for release in April 2024;
- Fire (Waroo Consulting, Ruth Ryan) finalised October 2023; and
- Plantation silviculture & nutrition (review in progress as of April 2024).

5.2 International and national scan of forestry related climate change research

A desktop review of recent and relevant research projects was conducted to help with the consultation process and prioritisation of potential new areas of focus.

There is comprehensive and ongoing research into the impacts of climate change, specifically focusing on impacts on forest ecosystems and the productivity of commercial forests. This reflects the role forests play in mitigating climate change impacts, as well as the need to understand the forecasted impact of climate change on commercial forests and plantations.

5.2.1 International research

Intergovernmental Panel on Climate Change (IPCC)

A significant amount of research is compiled and cited in the 6th Assessment Report by the IPCC (2022). Of particular interest is the report of Working Group II titled 'Climate Change 2022: Impacts, Adaptation and Vulnerability'[12]. This report assesses the impacts of climate change from a world-wide to a regional perspective, covering ecosystems and biodiversity and the impact on humans, societies, cultures and settlements. The report cites numerous research projects undertaken in each region, including Australia, that support the impact assessment and adaptation strategies.

[12] Climate Change 2022: Impacts, Adaptation and Vulnerability | Climate Change 2022: Impacts, Adaptation and Vulnerability (ipcc.ch)

Food and Agriculture Organisation (FAO)

The Food and Agriculture Organisation of the United Nations (FAO) forest and climate change program 'works to enhance national and international action on forests and climate change adaptation and mitigation' (FAO, 2012). The programs publication[13] provides a holistic view of forest-based adaptation. Numerous studies are cited that underpin the role forests can play in climate adaptation as well as evidence of the impact climate change has already had on forests.

Both the IPCC and FAO studies often emphasise the impact of climate change on forests, particularly in relation to pest infestations, diseases, and fires. They stress the importance of implementing sustainable forest management practices.

European Forestry Institute

The European Forestry Institute comprises 30 European States and conducts research and provides policy support on issues related to forests. Its Resilience Programme investigates all questions relating to the resilience of forests and livelihoods connected to them, namely, global change adaptation, biodiversity and integrated forest management, and resilience at the urban-rural interface.

US Department of Agriculture- US Forest Service

Climate Adaptation Plan

The US Forest Service Climate Adaptation Plan[14] provides a detailed strategy for incorporating climate change adaptation into the Forest Service's functions and objectives. This plan identifies significant climate threats to the agency's operations and essential adaptation measures to mitigate these threats, thereby ensuring that the Forest Service can continue to serve current and future generations. The plan leverages the robust groundwork laid by years of Forest Service research on the effects of climate change and adaptation, as well as more than ten years of work in climate adaptation decision support, planning implementation, and practical actions.

Scion New Zealand

Of relevance to the Australian forests, specifically the commercial plantation estate, is the work undertaken by Scion in New Zealand. It has a specific program titled 'Managing forestry risk and climate

[13] Forest-based adaptation: transformational adaptation through forests and trees

[14] Adaptation | US Forest Service (usda.gov)

change'[15]. Work under the program is carried out under the Ministry for Primary Industries Sustainable Land Management & Climate Change (SLMACC) program.

Sub-programs that are relevant to this Investment Plan are:

- Protecting our forests from pests and diseases;
- Preparing for climate change;
- Rural fire research; and
- Reducing wind damage.

The sub-program 'Preparing for climate change' provides useful links to Scions publications[16] .

Australia and New Zealand have common concerns about the impact of climate change, including wind damage, pests, diseases, weeds, and fire risk. Any new research undertaken by Australian growers should aim to collaborate with Scion if it is relevant to the Australian context.

NZ Forest Owners Association- Forest Growers Research

The New Zealand Forest Owners Associated (FOA) Forest Growers Research (FGR[17]) annual works program (2023) allocates NZD$5.4M to research science and technology. The program includes continuing and new projects. There is a strong representation of biosecurity-related and productivity enhancing projects.

Through a climate change lens there are number of projects that should be of interest to Australian growers such as the pre-emptive biosecurity testing and components of the Resilient Forests program (RA1). Collaboration with FGR researchers through FWPA should be fostered.

5.2.2 National research

The Australian government, along with state and territory governments, is proactively engaged in comprehending and evaluating the risks associated with climate change and formulating strategies for adaptation at a national level.

A scan of research papers lists numerous climate and forests related publications. Keenan *et al.*,[i](2015) reviewed literature on climate change impacts of forests and adaptation options for forest management. Using the Web of Science database to focus on papers published between 1945-2013, 1172 papers

[15] Scion - Managing forestry risk & climate change (scionresearch.com)

[16] Scion - Preparing for climate change (scionresearch.com).

[17] fgr.nz

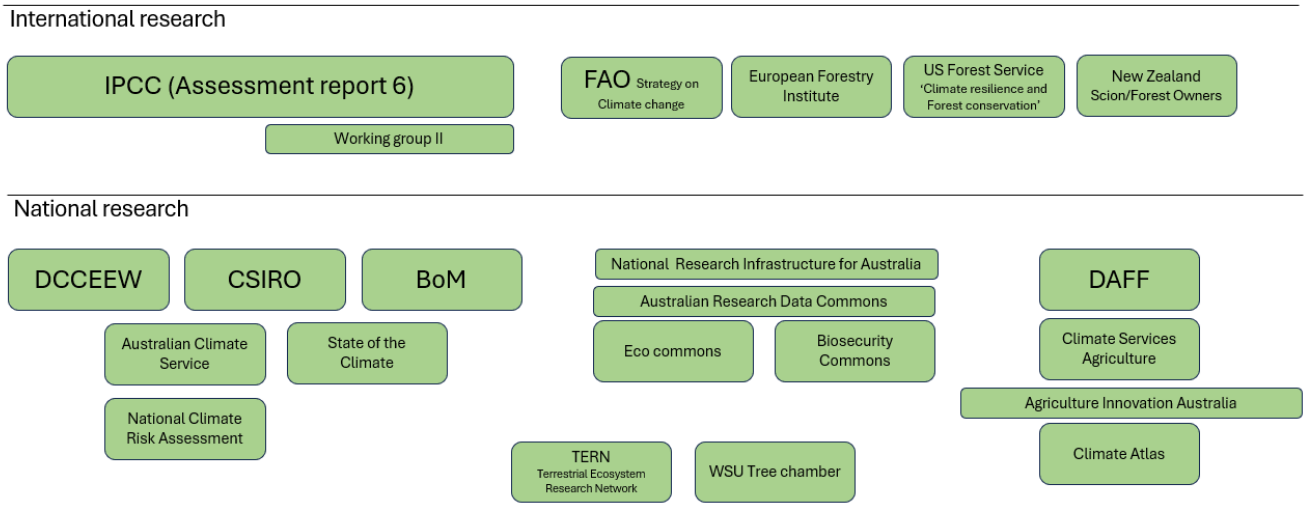
were identified. Most papers were focused on assessing impacts and vulnerability with few considering adaptation.

The research papers explore impacts of elevated CO_2 concentrations, reduced precipitation, elevated temperatures, and more extreme weather events leading to losses in productivity or mortality. Research on physical impacts caused by pests and disease, fire, and wind is also extensive (Keenan, 2015).

Studies of climate change adaptation associated with Australian commercial plantations and forests after 2015 are sporadic. A more comprehensive and structured approach is warranted.

The relationship between various national climate-related initiatives and the responsibility of specific government departments at the national level seems unclear. Figure 6.1 provides a visual representation of several national programs and initiatives currently in operation that are pertinent to the Climate Change investment plan.

Figure 6.1 Climate change research constructs



Commonwealth Scientific and Industrial Research Organisation-CSIRO

The CSIRO has a long history of providing research services to the forest industry. However, its capacity has reduced considerably over the last decade, with remaining forest expertise now spread across several divisions and programs.

There are numerous research papers relating to climate change produced by the CSIRO. The most relevant and definitive works for the Climate Change Investment plan include 'Climate Change and Australia's plantation estate: Analysis of vulnerability and preliminary investigation of adaptation options' (Battaglia *et al*., 2009), 'Adaptation strategies to manage risk in Australia's plantations' (Pinkard *et al*., 2014) and 'Implications of climate change for Australia's plantations forests: weeds, insects and fungal pests' (Pinkard *et al*., 2010).

This research informs the IPCC AR6 Working Group II Impacts, Adaptation and Vulnerability report, Chapter 11, which covers Australasia. The chapter includes sections on Forestry (11.3.4.3) and a subsection on Adaptation (11.3.4.3.3)[18].

The CSIRO developed the 'Forest Climate Risk Tool' in 2018 with funding from FWPA. This interactive online tool provides information on climatic factors such as the likely periods of drought, rainfall, number of heatwave days, temperatures, and the risk of fire down to a 5km x 5km grid of almost all forested and plantation areas of Australia.

When developed (2018), the tool used the best available scientific models for climate change and enables users to see both the "most likely" result and a range of other possible results for 2030, 2050, and 2070.

Growers' use of the tool's functionality appears to have been limited across the industry. The tool is no longer available to download. Updating the tool's functionality and providing access to the latest climate forecasts has been considered part of ongoing CSIRO work with other national initiatives, such as Climate Services Australia (see below).

The CSIRO is also supporting national climate change initiatives through the Australian Climate Service and The Department of Climate Change, Energy, the Environment and Water (DCCEEW).

Department of Climate Change, Energy, the Environment and Water- DCCEEW

The DCCEEW is currently working on several initiatives as part of its Climate Change policy program. One of the key projects is the development of Australia's first National Climate Risk Assessment. This assessment aims to identify and prioritise aspects that are important to Australia. Some of the aspects that may be included are:

- environment
- agriculture
- biodiversity
- health
- our social and cultural way of life
- infrastructure, and
- the economy.

[18] Chapter 11: Australasia | Climate Change 2022: Impacts, Adaptation and Vulnerability (ipcc.ch)

To be delivered in two stages and scheduled to be completed in late 2023, the first risk assessment will focus on physical climate risk, that is, the direct impact of climate change. Transition risks from climate policy could be included in future iterations.

As part of this assessment "The Australian Climate Service will build, maintain and make available datasets and indicators. Information provided to governments, businesses and communities will help them understand their climate risks and plan. This will provide a direct benefit to those without a dedicated climate science capability. It will increase the capacity and capabilities of those that do."[19]

Department of Agriculture, Fisheries and Forestry- DAFF

The Climate Services for Agriculture (CSA) program, launched in June 2021 and funded under Australian government DAFF- Future Drought Fund is an online platform that provides climate risk information tailored for Australian agriculture. CSA has developed the Climate Atlas, a digital tool providing long range information tailored to specific locations, enterprises, commodities, and agricultural sectors.

A series of workshops were held by Agriculture Innovation Australia (AIA) with each of the 15 RDCs, including FWPA. The purpose was to gain a better understanding of the needs of the Climate Atlas initiatives and to assess whether existing CSA climate projection products could meet the needs of the forest industries. As of the time of writing this plan, there is uncertainty about the future of AIA as its operations have been reduced.

The forest industry, through FWPA, should engage with CSIRO, DCCEEW and DAFF to better understand how climate information relevant to the industry is to be generated and delivered.

Other programs and initiatives

There are also other national initiatives that can potentially be leveraged for climate-related forestry research projects. These include:

- Terrestrial Ecosystem Research Network (TERN);
- Western Sydney University Whole tree chambers;
- EcoCommons; and
- Biosecurity Commons.

Terrestrial Ecosystem Research Network (TERN[20]) – is an Australian Government National Collaborative Research Infrastructure Strategy (NCRIS) enabled project. It is centred around 'field-based ecological research and land observatory using sensors, surveys and tools to produce data and analytics'. The land observatory is structured around three aspects of observation - **landscape observation**, **ecosystem observation**, and **ecosystem processes**. TERN measures key terrestrial

[19] National Climate Risk Assessment - DCCEEW

[20] Ecological Research & Environmental Monitoring and Assessment | About Us (tern.org.au)

ecosystem attributes over time from continental scale to field sites at hundreds of representative locations and openly provides model-ready data that enable researchers to detect and interpret changes in ecosystems.

There is potential to expand or supplement the project to include commercial plantations and forests regions and species acknowledging that there are current projects undertaken in native forests in Southern Tasmania.

Western Sydney University is researching physiological responses of trees to changes in air temperature, soil moisture, CO_2 levels and humidity to predict the effects of climate change[21]. This is done using whole tree chambers- 9-metre-tall structures that fully enclose the trees in field-soil conditions. Air temperature and humidity is controlled, and the chambers allow monitoring of carbon uptake and water loss. The forest industry should investigate if this research can be leveraged for commercial forest and plantation species to fill a gap in current forest research into the physiological responses to climate change.

EcoCommons is a partnership between the Australian Research Data Commons (ARDC) and nine organisations including CSIRO and several universities[22]. It is a 'platform providing enhanced computing and analytical capabilities for earth and environmental researchers. It will be a common place for multiple disciplines across the environmental science domain, such as:

- Biodiversity;
- Biosecurity;
- Hydrology; and
- Agriculture'.

'EcoCommons will contain highly sought-after data, community-driven methods and computational resources, while enabling better collaborations beyond discipline, institutional and jurisdictional boundaries'. Australian Research Data Commons is enabled by the National Research Infrastructure for Australia.

Biosecurity Commons is a new (2023) biosecurity project under a joint initiative between Australian and Queensland governments, the ARDC and partners [23]. It will deliver a cloud-based decision support platform for modelling and analysing biosecurity risk and response. It aims to play a transformative role in protecting Australia from the arrival of invasive species that threaten the economy and the environment.

[21] HIE | Whole Tree Chambers (westernsydney.edu.au)

[22] EcoCommons | ARDC

[23] About us | Biosecurity Commons.

Forest growers should leverage the capacity of both the EcoCommons and Biosecurity Commons initiatives specifically for climate-related pest and disease projects.

The FWPA[24], the National Institute Forest Products Innovation[25] (NFIPI), Regional forestry hubs[26] and other research providers have initiated and funded research projects in which climate-related themes are inherent.

Research topics and themes include:

- Plantation water use estimation and measurement for plantation forests. NS091 NIFPI Mt Gambier
- Developing more productive plantation trees better adapted to changing environments. NS096 NIFPI Mt Gambier.
- Water security and sustainable water use in forestry management, sustainable management. GT Forestry hub.
- Climate change and carbon policy assessment (Keenan *et al*., 2020). North-North West Tasmania Regional Forestry Hub.
- Explore plantation areas likely to be significantly impacted by anticipated climate change, such as: increased surface temperatures, drought, rainfall and potentially bushfire. Climate Data. (Spatial Vision, 2021). South West Slopes Forestry Hub.

[24] FWPA Research Reports | Access & Download Reports

[25] NIFPI – National Institute for Forest Products Innovation

[26] Regional Forestry Hubs - DAFF (agriculture.gov.au)

6 Outcomes

In this section of the investment plan, proposed research themes and topics that are climate change related are presented under the heading of the relevant investment plan. The last sub-section introduces additional project themes and topics for consideration under the heading 'Climate Change Investment Plan'.

6.1 Damage Agents Investment Plan

The Damage Agents Investment Plan was reviewed in September 2022. The updated portfolio of RD&E projects and priorities followed a review of past and existing projects and identified new ones.

Several new initiatives have been included in this Climate Change Investment Plan. These were developed in collaboration with Paco Tovar, the National Forest Biosecurity Manager at AFPA. As outlined in Table 6.1, the focus of these new projects is to identify and comprehend the threats that both endemic and exotic pests pose to forests and plantations due to climate change. They also aim to understand the effects of drought, disease and fire and how these impacts may influence the selection of species in the future.

Table 6.1: RD&E projects- Damage Agents Investment Plan.

Investment plan	Theme	Reference/priority	Proposed research theme/topic
1. Damage agents investment plan [2022]	Adapting to heatwaves (Long established)	1.1 [DAIP-1.2.1 Medium]	Native forests: Understanding and managing the threat from heatwaves and drought to productivity decline or mortality.
	Endemic forest pests	1.2 [DAIP-3.1.1 Medium]	a. Collate long-term forest health monitoring data to baseline historic/current distributions and damage levels of major pests affecting forests.
		1.3 [New]	b. Use the baseline data to model relationships between pest distribution/activity and past climate. Model predicted pest distribution and damage levels under different climate scenarios.
		1.4 [New]	c. Analyse known tree species trait data against predicted pest data to suggest (i) changes in tree species in different areas or (ii) work with tree breeders (TBA/RPBC etc) to re-focus long-term breeding aims to balance growth x drought resistance x pest resistance.
	Exotic forest pests	1.5 [New]	a. Desktop analysis of current or emerging invasive species overseas, including what biological traits are most indicative of increased invasiveness due to climate change – use this to shortlist pests to focus on. Opportunity to align with and leveraging NZ programs (Scion and Forest Growers Research).. Include pathway analysis to Australia.,
		1.6 [New]	b. Develop models or analytic workflows in Biosecurity Commons or similar, to predict pest distribution and damage levels under different climate scenarios.

Investment plan	Theme	Reference/priority	Proposed research theme/topic
		1.7 [New]	c. Analyse known tree species trait data against predicted invasive pest data to suggest (i) tree species to include or ii) focus on as part of future tree breeding.
	Drought, disease and fire risk and species matching	1.8 [New]	a. Work with CSIRO, TERN, ABARES, BOM, EcoCommons or others to create long-term modelling of drought, disease and fire impacts on commercial plantation and native forests.
		1.9 [New]	b. Results of (a) used to suggest new tree species to consider or introduce to tree breeding programs or seeding in the case of native forest.

6.2 Fire Investment Plan

The Fire Investment Plan was reviewed in September 2023. The review incorporated an evaluation of the impact of the recent developments on commercial forestry including the 2019-2020 Black Summer bushfires and closure of State native forest harvesting in Victoria and WA.

Projects shown in Table 6.2 focus on fuel management/prescribed burning and fire resilience and adaptation.

Table 6.2: RD&E projects within the Fire Investment Plan.

Investment plan	Theme	Reference/priority	Proposed research theme/topic
2. Fire [2023]	Effective fuel management-maximising opportunities.	2.1 [FIP-3.2.2 Moderate]	A predictive model that uses current data to show future windows of opportunity for prescribed burning and forecast potential periods of increasing fire suppression difficulty.
	Fire-tolerant plantation tree species	2.2 [FIP-4.1.1 Low]	List of potential species and potential for hybrids that can fit into current/future timber resources.
	Understanding tree fire resilience/species adaptation	2.3 [FIP-4.1.2 Low]	Answer the following questions: > Can current commercial species become more fire-resilient, > What is the driver behind post-fire tree death, > How do the following factors influence tree survival: bark thickness, depth of feeder roots, pre-fire litter/duff dryness and surface fuel burning depth, post-fire rainfall and weather - rain quantity/timing and temperature/humidity, > Would increased bark thickness result in less timber damage and lower mortality? > Can we influence ladder fuel traits?

6.3 Genetics Investment Plan

Since the development of the Genetics Investment Plan, GRAC has funded numerous genetics projects.

Through the funded projects, progress is being made in exploring the adaptation of *Pinus* species to drier climates though FWPA and NIFPI related projects researched by Tree Breeding Australia. Table 6.3 shows climate change related projects within the current plan.

Testing of softwood hybrids should be considered as well as pre-emptive screening of germplasm that evaluates the impacts of major disease found outside of Australia. This work should be collaborative and leverage linkages already established with international partners. This work should aim to cover commercial softwood and hardwood plantation species.

A review of the Genetics Investment Plan is scheduled for the 2024/25 period.

Table 6.3: RD&E projects within Genetics Investment Plan.

Investment plan	Theme	Reference/priority	Proposed research theme/topic
3. Tree Breeding & Genetic Improvement [2020]	Understanding species adaptation under climate change scenarios	3.1 [TB&GIIP-[Priority 3, recommendation 3.3.5]	Characterising diversity within ecologically and economically important softwoods and hardwoods – having a lens on the national breeding program and natural provenance genetic resources. Identify important germplasm that would assist in the breeding of elite material suited to climate variability including new and untested plantation sites.
	Maintaining genetic diversity/pre-emptive screening	3.2 TB&GIIP-[Priority 4, recommendation 3.4.3]	Tree Breeding Australia (TBA), Radiata Pine Breeding Company (RPBC) in collaboration with Plant Health Australia (PHA) establish an 'off-shore' research program in the US (i.e. Florida), New Zealand, Chile and South Africa to evaluate the current level of susceptibility/tolerance/resistance of Australian plantation Pinus and Eucalypt sp germplasm when exposed to major plantation diseases (e.g. Pitch Canker) and pests that do not currently exist within Australia plantations.

6.4 Native Forest Silviculture Investment Plan

Under the theme of species adaptation, the selection of provenance and species within native forests is the sole climate-related project from the Native Forest Silviculture Investment Plan (2020), as shown in Table 6.4. Thinning of commercial native forests as a management option is considered in Section 6.6 of this plan.

Table 6.4: RD&E projects within Native Forest Silviculture Investment Plan.

Investment plan	Theme	Reference/priority	Proposed research theme/topic
4. Native forest silviculture [2020]	Species adaptation	4.1 [NFSIP-Project 7]	Development of climate-adapted protocols for provenances and species selection for native forests.
			Establishing mixed tree species forests for climate resilience.

6.5 Soil Microbiome Investment Plan

Developed in 2021 the Soil Microbiome Investment Plan specifically addresses climate change variability and proposes two projects shown in Table 6.5.

Table 6.5: RD&E projects within Soils microbiome Investment Plan.

Investment plan	Research theme	Reference/priority	Research project theme/topic
5. Soil microbiome [2021]	Soils microbiome activity in response to climate variability and extremes	Medium	Strategies for manipulating ACC deaminase to make trees more drought stress tolerant.
		Low	Manipulating soil microbiome in response to changes in behaviour and/or prevalence of pathogens (due to climate change).

Feedback from the review of the draft of this investment plan has resulted in the two topics being replaced by four new ones shown in Table 6.6. The new topics were developed after engagement with Associate Professor Jonathan Plett of Western Sydney University who is leading two soil microbiome research projects for NFPI/FWPA. These themes aim to broaden the understanding of microbiome processes and responses to climate variability, and pathogen activity and impact. They leverage initial findings from research currently being undertaken.

Table 6.6: New projects related to soil microbiome.

Investment plan	Research theme	Reference/priority	Research project theme/topic
5. Soil microbiome	Soils microbiome activity in response to climate variability and extremes	5.1 [New]	Advance understanding of the mechanisms by which the tree microbiome supports stress tolerance and how this may be compromised by climate variability
		5.2 [New]	Understand how different climate conditions alter the function of soil microbiomes related to pathogen repression and nutrient cycling

Investment plan	Research theme	Reference/priority	Research project theme/topic
		5.3 [New]	Identify what genetic loci in plant breeding programs associate to fostering beneficial microbiomes and profile how climate extremes may affect these
		5.4 [New]	Develop tools to manipulate tree microbiomes in situ at both planting and mid-rotation to boost climate resilience and pathogen repression

6.6 Climate Change Investment Plan

This sub-section encompasses new themes and topics, as detailed in Table 6.6. They can be classified into two categories: physical impacts and transitional impacts.

6.6.1 Adaptation and resilience - physical impacts

In the comprehensive reports by Pinkard *et al*., in the mid-2010s, commissioned by the FWPA and the Federal Government, the authors expanded upon the foundational climate change research previously conducted by Battaglia *et al.*, spanning 1996 -2011, to develop a variety of tools to evaluate the risks and impacts of climate variability on productivity and wood properties. These tools also aid in making decisions about cost-effective management strategies to mitigate the effects of climate variability and change.

However, more recent work by Keenan *et al*., (2020) lists three barriers to climate change and impacts:

- Lack of knowledge of future climate change, potential climate impacts and options for adapting to climate change is a barrier to avoiding future impacts. Current knowledge is not easily accessible, or in a useful form for making decisions, for forest managers and farm foresters;

- Limited capacity to monitor and assess changes in forest condition and potential risks is a barrier to effectively responding to climate change impacts in a timely way. Improved forest monitoring can facilitate decisions of alternative management options to address key risks; and

- Lack of knowledge is limiting capacity to develop alternative species that are likely to be more suited to different sites in future climates.

This investment plan contributes to addressing the first two barriers through projects 6.1 and 6.2. Research aimed at addressing the third barrier, alternative species, is supported by FWPA and NIFPI, with projects being carried out by Tree Breeding Australia[27] and the University of Tasmania[28].

The first of the projects (6.1) is to review and update the Pinkard *et al.*, reports (2014) to identify climate-related risks and mitigation strategies that may have been developed and implemented since 2014. Importantly, engagement with forest growers would be included to document and evaluate any management strategies practiced, or in-house research undertaken where formal research papers were not produced. The review should be based on the latest climate forecasts contained in the IPCC AR6 report.

Feedback from consultation with stakeholders identified that an important outcome of these projects is to increase confidence in the modelling of climate-related impacts so that it may instigate a change to current practices. Understanding the threshold and trigger points that initiate changing practices is critical.

Project 6.2 seeks to ensure that there is focus on monitoring, particularly long-term trends, to assist in understanding threshold levels that triggers a management response. Whilst not directly associated with physical adaptation or resilience these activities are critical and should form part of a sustainability monitoring framework. The scope should consider grower, regional and national level programs.

Project 6.3 aims to create climate forecasts within-year, grounded on RCP scenarios. This detailed information will aid in modelling, for instance through process-based models like 3PG or APSIM, variations within-year of impacts such as drought and heatwaves. The joint efforts of CSIRO and DCCEEW, as part of the Australian Climate Service forecasts, may result in developing these within-year predictions. Revaluation of the use of the Forest Climate Risk Tool for this purpose should be considered. Communicating with the CSIRO/DCCEEW team is encouraged to monitor recent progress on climate modelling. This should include engagement with AIA.

These forecasts may also be used to model likelihood and consequence of extreme events on infrastructure such as roads, culverts and bridges and wind throw of forests - Project 6.4.

[27] NIFPI Mt Gambier NS096 Developing more productive plantation trees better adapted to changing environments.

[28] FWPA VNC584-2122 Project 6: Improved provenance choice for native forest silviculture and management in the face of climate change.

Table 6.6: RD&E new projects proposed for the Climate Change Investment Plan.

Investment plan	Research theme	Reference/priority	Research project theme/topic
6. Climate change-new	Climate change adaptation-commercial native forest and plantations.	6.1	Update of the CSIRO report (Pinkard *et al* 2014) considering IPCC AR6 report climate projections. Consolidate outcomes of recent (post-2014) research into physical impacts and management framework and options for adaptation. Include nursery management, site preparation, early silviculture -fertilisation and weed control, thinning prescriptions and pest and disease impact from drought.
	Monitoring change-understand spatial and temporal climate-related impacts, establishing baselines, threshold levels and response triggers.	6.2	To be considered as part of the Forest Industry Sustainability framework: >Explore options to leverage and expand the TERN project to include national commercial plantation and native forest locations. >Further understanding of water use of commercial plantations species and native forests.
	Forecasting within-year climate variation to assess localised risks on commercial plantations and native forest	6.3	Prediction of likelihood and consequence of change in annual/monthly extreme weather events ie heat waves, drought, flooding, wind/cyclones for plantation and native forest regions.
	Forecasting infrastructure damage	6.4	Using climate forecast models explore the potential to identify forested (native and plantation) areas that will be most impacted from extreme weather events driven by climate change that would impact on forest grower infrastructure (roads, bridges) and supply chains.
	Stand management-thinning options to reduce stand mortality due to drought/limited water availability.	6.5	Investigate the effectiveness of i) managing initial stocking rates and thinning in commercial plantations in response to limited water availability, ii) thinning as a management tool in commercial native forests in response to limited water availability.
	Transitional impacts-the implementation of climate-related financial disclosure standards by the Australian Accounting Standards Board (AASB).	6.6	A pilot study to develop an industry framework and guidelines to address reporting of climate-related financial disclosure.

Investment plan	Research theme	Reference/priority	Research project theme/topic
	Transitional impacts- Forest Valuation Standards- climate-related financial disclosure requirements.	6.7	Engage forest valuers and accountants to understand the impact of climate-related financial disclosure requirements and how they are to be implemented in forest valuation and standards. Includes information and data requirements and assumptions.
	Modelling productivity impacts of climate change scenarios	6.8	Proposal #1 Integrating APSIM into resource management systems for estate wood flows and valuations that account for climate change.
		6.9	Proposal #7 Transforming future softwood productivity through optimal site-specific silviculture.

Projects 6.5 focuses on silvicultural options to mitigate the impact of drought and limited water availability for commercial plantations and native forests. A recent proposal submitted to FPWA to research ecological thinning in Western Australia to address limited water availability confirms the need for such research. There is potential for a project to expand beyond Western Australia to other states as they face similar issues.

6.6.2 Transitional impacts

Emerging financial disclosure reporting requirements.

Projects 6.6 and 6.7 relate to reporting the financial impacts of climate change. Inherent in this reporting is an assumption that climate change impacts can be modelled physically and financially. It is the physical modelling that interacts with projects in this plan that has led to the transitional impacts being included in this plan.

Assessing and quantifying climate-related risks emerged as a recurring theme in initial discussions with stakeholders. Efforts are underway at both international and national levels to establish risk assessment frameworks and financial disclosure standards related to climate impacts. Concurrently, standards related to sustainability are also being developed. A more detailed discussion of these standards can be found in Appendix B.

Treasury and the Australian Accounting Standards Board (AASB) commenced consultation on implementing financial disclosure for climate-related risks for Australian businesses in December 2022. The AASB released an Exposure Draft ED SR1 Australian Sustainability Reporting Standards-Disclosure of Climate-related Financial Information on October 2023. A staged implementation of the Australian Sustainability Reporting Standards (ASRS) will begin from 1 January 2025 (Group 1). The Treasury Laws and Amendment (Financial Market Infrastructure and Other Measures) Bill 2024 was

introduced into Parliament in March 2024 and must be passed by December 2024 for the ASRS to take effect.

The ASRS requires entities to disclose information about their exposure to climate-related risks and opportunities (CRRO) that could reasonably be expected to affect the entity's prospects. Entities shall provide disclosure about governance processes and controls, strategy to manage CRRO, risk management processes and metrics and targets.

There was consensus from stakeholders that Growers would benefit from a collaborative industry approach to interpret and transition to these standards (Project 6.6). As Treasury's proposed disclosure timelines is short, early understanding and preparation is required to meet the requirements.

Forest valuation

The methodology for forest valuation in Australia is guided by the Forest Valuation Standards (Exposure draft November 2020). This is a collaborative publication by the Institute of Foresters Australia (formerly the Institute of Foresters, IFA) and the New Zealand Institute of Forestry (NZIF). It provides a set of standards and guidelines for the physical and financial characterisation of commercial plantations and natural forests in Australia and New Zealand.

The standard defines 'what is value' and cites various accounting organisations and standards that contribute to these definitions. It also refers to the IFRS 13-fair value measurement 2012, which incorporates risk assumptions.

Some forest valuers are incorporating a risk adjustment to forest valuations based on guidance note 'Climate-related and other emerging risk disclosures: assessing financial statement materiality using AASB/ISAB Practice Statement 2 (2019)'[29]. The value adjustment considers the significant risk posed by climate change impacts on losses from plantation fires. The adjustment is quantified based on historical data, including those from the Black Summer fires of 2019-2020, and predictions from climate science that suggest an increase in fire frequency due to a progressively hotter and drier climate.

It is important to consider the introduction of the ASRS in the Forest Valuation Standards (Project 6.7). Additionally, the criteria and methodologies for quantifying the risk adjustment consistently in the Forest Valuation Standards should be considered. A key question is whether this information should be supplied by the forest growers to the valuer, or whether it should be independently developed by the forest valuer.

The IFA (now Forestry Australia) Forest Valuation Subcommittee and Working Group, and NZIF Forest Valuation Working Party will need to convene to discuss the implementation of the ASRS.

Creating a standard evidence base would strengthen the industry's position with investors, banks and insurance companies when assessing, quantifying, and disclosing risk.

[29] AASB_AUASB_Joint_Bulletin_Finished.pdf

6.6.3 Proposal under GRAC evaluation

Two project proposals have been evaluated (April 2024) by the GRAC executive for recommendation to FWPA for funding support- projects #1 and #7. These integrated projects aim to develop the capacity to forecast productivity variation due to climate change using process-based modelling (APSIM) and to explore if APSIM modelling can integrate into current forest resource systems. Outputs from these projects could be used to quantify metrics used in climate-related financial disclosure statements.

Project #1

Title- Integrating APSIM into resource management systems for estate wood flows and valuations that account for climate change.

The following is an extract from the executive summary of the proposal.

This project aims to address the following needs of industry partners:

- Explore the use of APSIM for use in resource assessment systems, with a focus on generating climate change scenarios.
- Outputs from APSIM should be suitable for input to standard and operational industry software such as YTGen (or similar), to enable use for a wide range of purposes, e.g.:
    - Predicting long term wood flows to support investment decisions and valuation to support bank loans.
    - Green fields site modelling for land acquisition decision making and valuation.
- Input of plot level inventory data to define size class distributions and product out turn.
- Options for using stocking and height data from LiDAR (for example) to establish and simulate wood yields from virtual plots.

This project aims to address these needs by (a) building and embedding APSIM expertise for on-going use by the industry, and (b) for developing functionality in APSIM that provides input to YTGen for generating yield tables suitable for input to Woodstock or alternative optimisation systems. Alternatives to the YTGen-Woodstock combination can also be considered. This will allow consistent wood flow and forest valuation modelling under alternative climate scenarios that can be operationally rerun as new climate forecasts are provided, e.g. for annual reporting.

Project #7

Title- Transforming future softwood productivity through optimal site-specific silviculture.

The following is an extract from the executive summary of the proposal.

For much of Australia's plantation resource, potential yield will be limited by water, and understanding the interactions between water availability, competition, nutrient availability, will be critical in developing the knowledge required to define potential productivity and hence estimate the yield gap.

Soundly calibrated process-based growth modelling underpinned by spatial climatic and edaphic data provides a consistent analytical approach to determining the factors affecting yield, including climate change.

Based on industry input and interactions with the co-design working group the project will:

1. Estimate potential productivity by synthesising measurements of plantation yield from published and unpublished research, accessing productivity measurements from softwood growers, and utilizing outputs from empirical and process-based growth modelling.
2. Estimate Yield Gaps for key plantation regions by comparing operational timber yields with potential yield from both empirical data and process-based modelled productivity.
3. Estimate plantation yields under future climates, and for areas where plantations have not previously been established including non-traditional areas. Modelling will be necessary to predict the impact of climate change and productivity in non-traditional areas.
4. Adapt and calibrate the APSIM model to explore genetic, climate, soil and management inter-relationships.
5. Adapt the ProFert model to use outputs from APSIM to model the growth of unfertilised stands in situations where empirical data may be lacking and calibrate to reflect measured fertilizer responses.
6. Continue the measurements for recently established Southern Pine trials and establish new trials to overcome the current lack of data in this area. Without this data APSIM cannot be parameterised and the productivity of softwood yield in this major growing region cannot be modelled.

The modelling capability of both APSIM and ProFert will be developed for industry's use to inform region- and site-specific management strategies and practice across regions. This will allow underlying potential growth to be predicted for sites or scenarios where existing empirical data may be inadequate (e.g. under future climates) and the potential increases in both productivity and product yield from specific changes to stand management to be estimated.

7 Discussion

The scope of the investment plan focuses on climate change adaptation and resilience.

Consultation with stakeholders identified the physical impacts of climate change on commercial plantations and native forests. Common themes around adaptation quickly emerged amongst stakeholders and are consistent with adaptation options identified in the IPCC Working Group II report[30] and the work of Pinkard *et al*., (2014) and Keenan *et al*., (2017, 2020).

These options include:

- increased investment in monitoring forest condition and functioning leading to understanding of critical processes;
- ongoing establishment of trials with a range of feasible silvicultural treatments in anticipation of future information and modelling needs;
- early detection and management of insect pests, diseases and invasive species;
- improved selection of land with appropriate growing conditions for plantation timber production under current and future conditions;
- trialling new species and genetic varieties;
- changing the timing and frequency of planned fuel reduction fires;
- maintaining access and emergency response capacity
- introducing more fire-tolerant tree species where appropriate;
- facilitate opportunities for knowledge sharing internationally and nationally between forest managers and researchers on their experiences of the implications of climate change on forest management practices and actual or potential responses;
- improved awareness of forestry staff of the latest science relating to climate impacts within the management areas in which they operate;
- improved understanding of forestry staff of the importance of accurately implementing adaptive management practices; and
- bringing researchers with appropriate climate and ecological skill sets into the forest industry.

Keenan *et al*., (2020) note that adapting to climate change impacts will require forest managers to plan at multiple spatial and temporal scales and adopt more adaptive and collaborative management approaches to meet future challenges. Whilst growers are accustomed to managing over long periods and factoring in uncertainty into management decisions, many are responding to much shorter-term social or economic imperatives.

[30] Climate Change 2022: Impacts, Adaptation and Vulnerability | Climate Change 2022: Impacts, Adaptation and Vulnerability (ipcc.ch)

Stakeholder engagement identified the challenges associated with understanding what threshold levels would trigger a management response to climate-related impacts, for example, a change in silvicultural practice- initial stocking rates or thinning regimes. In this context, the adoption of sustainable management practices that monitors change can assist in identifying threshold limits to mitigate the negative impacts and take advantage of potential benefits.

Keenan *et al*., (2020) further expand on this concept 'For the next 10 years or so, when extreme climate events remain within the bounds of those experienced historically, past practice can be used as a basis for future management. Once climatic conditions move outside that range, new practices are likely to be required. Past strategies used by the forest industry involve locally based, autonomous decisions. Preparing for, and adapting to, more extreme climatic changes will require policy and infrastructure support and greater planning at regional and national levels'.

The investment plan's scope has been expanded to incorporate the reporting of climate-related impacts in financial disclosures. This change was prompted by several stakeholders who recognise the necessity for a unified industry strategy considering the forthcoming reporting mandates from the Treasury and the AASB.

Prioritisation of projects into High, Medium and Low was derived from ranking of projects by a selection of stakeholders shown in Appendix 1. The ranking is relative for projects in this investment plan and not intended to be comparable with ranking within other investment plans. Funding allocation to the investment plan has not been undertaken at this time and should be considered by the GRAC.

Appendix 1 – Consultation

Stakeholders engaged

Name	Organisation	Review of draft/ranking
Paco Tovar	AFPA	☑
Auro Almeida	CSIRO	
Libby Pinkard	CSIRO	☑
Patrick Mitchell	CSIRO	
Andrew Jacobs	FORICO	
Andrew Moore	GFP	
David West	HQPlantations	
Ian Last	HQPlantations	☑
Michelle McAndrew	HQPlantations	
Sharon Occhipinti	HVP Plantations	☑
Andrew Morton	Indufor	
Damien O'Reilly	Mayday Hill Consulting	
John McGrath	McGrath Forestry Services	
Matt Crapp	New Forests	
Angus Carnegie	NSW DPI	☑
Jessica Douglas	OneFortyOne	☑
Phil Lacey	PF Olsen	
Brian Rawley	Silmetra	
Jim O'Hehir	UniSA	☑
Jonathan Plett	Western Sydney University	

Appendix 2 – IFRS Financial Reporting Standards

Background

International Financial Reporting Standards (IFRS) is a unique set of rules and regulations followed worldwide for recording the financial transactions of a business entity. Its purpose is effective, efficient, and accurate reporting of financial statements using standard accounting principles to ensure transparency, consistency, growth, and interest of public services. It was designed by the International Accounting Standards Board (IASB). At present, it is adopted by 167 jurisdictions (Investopedia, 2022).

In 2021 the IFRS Foundation established the International Sustainability Standards Board (ISSB) responsible for the development of global baseline sustainability disclosures to inform economic and investment decisions.

In March 2022 the ISSB published exposure drafts IFRS S1 and S2 which set out requirements for disclosing information about an entity's sustainability (S1) and climate-related (S2) risks and opportunities.

In June 2023 the ISSB issued IFRS S1 General requirements for Disclosure of Sustainability-related Financial Information and IFRS S2 Climate-related Disclosures.

'Climate-related financial disclosures are a way of reporting how companies are managing the risks and opportunities associated with climate change. They can help investors, regulators, customers, and other stakeholders make informed decisions about the companies they engage with.

The Australian Government has committed to introduce mandatory climate-related financial disclosure requirements for **large, listed companies, banks, insurers, and superannuation funds** by **2025**. The requirements will be based on the recommendations of the **Task Force on Climate-related Financial Disclosures (TCFD)**, which is a global framework for voluntary and consistent climate-related financial risk disclosures[31].

The TCFD framework covers four areas: **governance, strategy, risk management, and metrics and targets**. Companies are expected to disclose how they oversee and assess climate-related risks and opportunities, how they incorporate them into their business strategy and financial planning, how they identify, measure, and manage them, and how they track and report their performance and progress.

Some of the benefits of climate-related financial disclosures for companies include:

- Enhancing their reputation and credibility with stakeholders
- Improving their access to capital and reducing their cost of capital
- Increasing their resilience and competitiveness in a low-carbon economy
- Identifying new opportunities and innovations for growth and value creation

[31] Climate-related financial disclosure - consultation paper (treasury.gov.au)

- Strengthening their risk management and governance practices

Some of the challenges of climate-related financial disclosures for companies include[32]:

- Lack of data and standards for measuring and reporting climate-related impacts
- Uncertainty and complexity of climate scenarios and projections
- Diversity and inconsistency of stakeholder expectations and preferences
- Legal and regulatory risks and liabilities
- Potential trade-offs

IFRS S2

The objective of IFRS S2 is to require an entity to disclose information about its climate-related risks and opportunities that is useful to users of general-purpose financial reports in making decisions relating to providing resources to the entity.

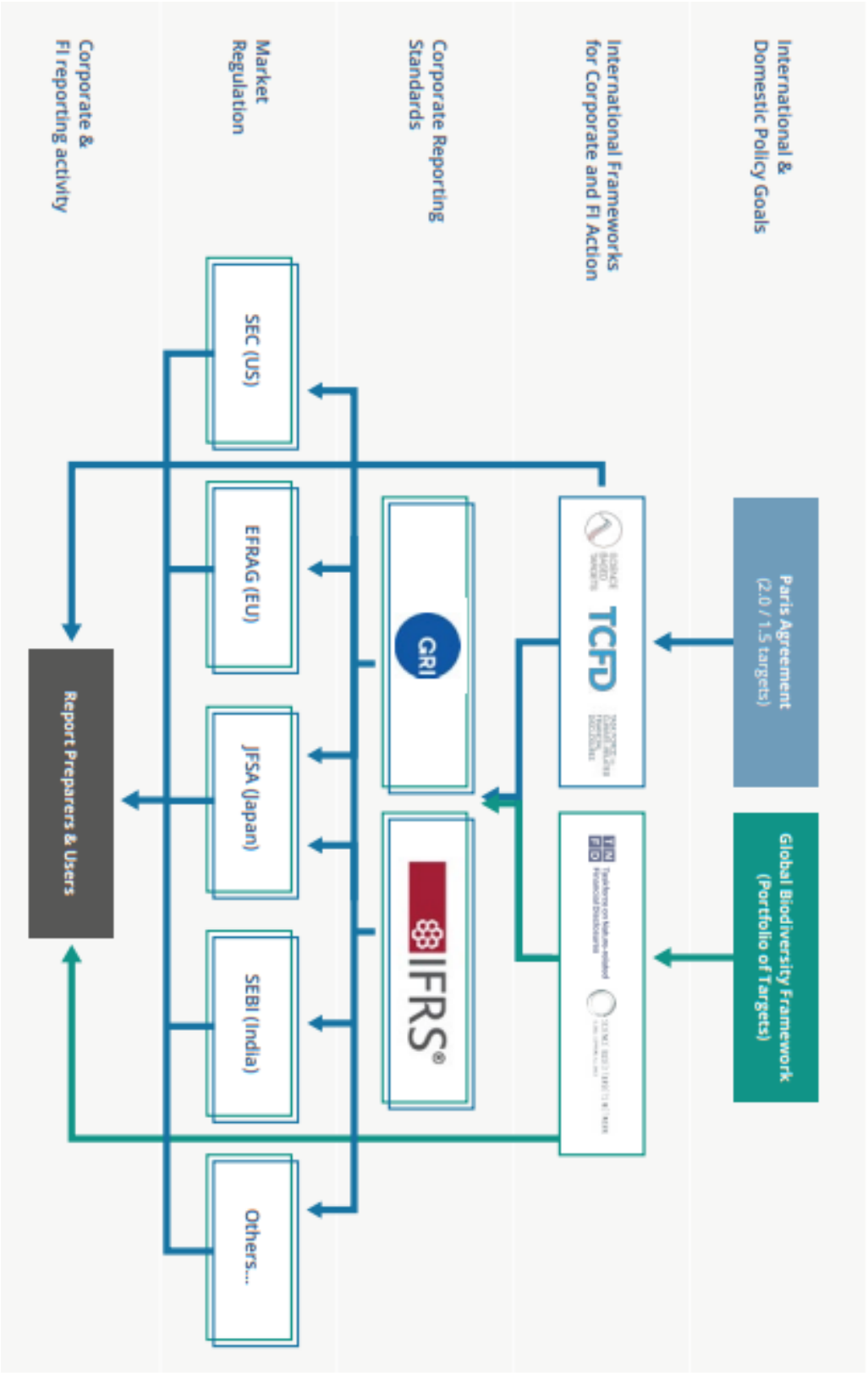
IFRS S2 requires an entity to disclose information about climate-related risks and opportunities that could reasonably be expected to affect the entity's cash flows, its access to finance or cost of capital over the short, medium or long term (collectively referred to as 'climate-related risks and opportunities that could reasonably be expected to affect the entity's prospects').

IFRS S2 applies to:

a. climate-related risks to which the entity is exposed, which are:
    i. climate-related physical risks; and
    ii. climate-related transition risks; and
b. climate-related opportunities available to the entity.

The standard builds on the recommendations of the Task Force on Climate related Financial Disclosures (TCFD). The relationship between the climate-related and nature- related financial disclosures policy goals and reporting standards is shown in the following diagram.

[32] Climate-related financial disclosure - consultation paper (treasury.gov.au)


International & Domestic Policy Goals
International Frameworks for Corporate and FI Action
Corporate Reporting Standards
Market Regulation
Corporate & FI reporting activity
Paris Agreement (2.0 / 1.5 targets)
Global Biodiversity Framework (Portfolio of Targets)
TCFD
GRI
IFRS®
SEC (US)
EFRAG (EU)
JFSA (Japan)
SEBI (India)
Others...
Report Preparers & Users

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