Low Carbon Landscape:
Discussion Paper

Final Report

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Contents

1 Summary of Main Points

1. **Australia will need substantial contributions to emissions reduction from the land sector to meet the target adopted by Victoria and all States and Territories of net zero emissions by 2050.**
    - Victoria would do well economically by going further with land-based emissions reductions and industrial use of biomass than is required by zero net emissions and could become an exporter of carbon credits and zero emissions industrial products to the rest of the world.

2. **Plants can contribute to net zero emissions by increasing the amount of carbon sequestration across the landscape; and by supplying biomass to replace fossil hydrocarbon or carbonate for construction, energy, manufacturing and transport.**
    - Biomass should be achieved without diminishing the landscape carbon stock.
    - New biomass can do everything now done by fossil fuels: including making plastics and other petrochemical manufactures.
    - Biomass will become scarce and valuable and reserved by price for those processes in which there are no low-cost alternative paths to zero emissions.
    - Forest management can create multiple values beyond storing carbon and supplying biomass for industry including biodiversity, human recreation and bushfire proofing.

~~3.~~ **Victoria could lead Australia in creating a favourable environment for bringing together the technical, financial and legal skills and capacities for large-scale reafforestation and bio-based industry.**
    - Australia's has much more woodland per capita than other developed countries, and larger still compared with most developing countries; Victoria's is not small in the global context.
    - Genetic inheritance of plant species that are adapted to a hot, dry and variable environment is another advantage specific to Australia, with much of the range in Victoria.
    - Physical infrastructure for forest-related industries is well developed and close to rich resources and potential in Gippsland and Southwest Victoria.
    - Victoria's established human capital strengths in the applied land sciences and in resource project development and management supplement its natural advantages in landscape and carbon sequestration and production of biomass, and more broadly in landscape management.

4. **It is the role of Government to correct for externalities of market exchange to deliver outcomes consistent with the public interest. This report outlines the potential role for a State entity built on the established strengths of VicForests – provisionally titled the Victorian Land Carbon Corporation (VLCC) to contribute to the commercial base from which Victoria leads the emergence of the land carbon economy. The VLCC would:**
    - Enable a biomass market: as a plantation broker linking growers and processors in and across the timber/biomass supply chain; facilitating the scaling up of processing investment across commodity types; and brokering, monetising and providing assurance on silvicultural services including for carbon markets.
    - Using the established technical expertise of VicForests the VLCC would become an expert service provider in sequestration of carbon in all parts of the landscape; including regional and landscape-scale assessment and spatial priority planning; developing premium state-based carbon products.
    - Economically efficient levels of innovation will only occur if firms generating benefits to the rest of the economy and society, beyond those that they can capture themselves, receive public fiscal support. The VLCC would lead or contribute to R&D programs for forest species, markets and resource management and also training of new skills.
    - The VLCC would correct the market failure in long term capital investments through financing arrangements such as state purchasing agreements or underwriting of plantations.

- The labour-intensive nature of capital expenditure on plantation makes the unemployment of the Pandemic Recession a good time for high levels of forestry investment.

2 Overview

2.1 The Global Carbon and Climate Challenge

Life on earth is built around a carbon cycle. Algae and plants absorb carbon dioxide from the atmosphere and in the presence of solar radiation and water produce a simple hydrocarbon while releasing oxygen. Over hundreds of millions, if not billions, of years photosynthesis converted an atmosphere in which carbon dioxide was abundant and oxygen rare, into today's atmosphere with abundant oxygen and carbon dioxide in tiny proportions. The carbon absorbed into organisms was deposited and converted in the earth's crust including as fossil hydrocarbons (coal, oil, gas) and as carbonates (limestone, chalk).

Within this carbon cycle, carbon is continually absorbed by organisms. In dynamic processes, carbon is released into the atmosphere through respiration and transpiration by animals, plants and algae. On their death carbon is partially released through decomposition of this biomass—or long after their death released back into the atmosphere through combustion of fossil hydrocarbons or reduction of carbonates. A rough balance between absorption and release was established for many millions of years, sustaining a combination of gases in the atmosphere that supports mammalian life.

Carbon dioxide is the most important of a number of heat-trapping or "greenhouse" gases in the atmosphere that play major roles in controlling temperatures on land and in the sea. After the sun's rays have landed on and warmed the earth, the greenhouse gases retard its radiation back into the atmosphere. This avoids extreme cooling at night and keeps average temperatures within a range that allows life on earth. Modest variations around the small concentrations of carbon dioxide that have been in the atmosphere over the last several million years have been associated with large changes in earth's average temperature. The relatively steady proportions of greenhouse gases over the past dozen millennia since the last ice age have kept average temperatures over the earth's surface within a fairly narrow, and for us, equable range. This period of steady and moderate temperatures is called the Holocene. The entire history of human agriculture and civilisation has been played out in the Holocene.

Modern economic development has disturbed the balance of the carbon cycle. Modern economic development at first used sources of energy and building materials in forms that retained the balance between greenhouse gases released into and withdrawn from the atmosphere. In the early decades of the industrial revolution beginning about 250 years ago, energy came mainly from renewable resources—wood to drive steam engines; animals for land transport and machines; wind for sea transport and pumping; hydro-power for mills and water pumps; fire from plant and animal residues for lighting; charcoal from wood to smelt metals. Similarly, materials used in construction did not affect the balance of gases in the atmosphere: stone and wood for buildings; chemically unaltered stone and earth for roads.

Advances of science and technology through the nineteenth and twentieth centuries uncovered and applied ways of producing much more economic value per unit of labour and capital using fossil carbon energy and industrial materials. Coal and later oil and gas became the dominant sources of energy for

industry, transport and urban life and of carbon for reducing iron ore. The manufacture of plastics and a wide range of valuable new hydrocarbon products drew heavily on coal, oil and gas. Conversion of natural carbonates into cement and related materials became a main source of building materials. All of these processes released carbon dioxide into the atmosphere much more rapidly than it was absorbed through natural processes. The gap between release and absorption increased with stronger economic growth after WWII and accelerated with the extension of modern economic development into more and more parts of the developing world later in the twentieth century.

The expansion of pastoral, agricultural and urban activities has reduced the amount of carbon in soils, soil biota and vegetation, releasing into the atmosphere carbon dioxide and, less importantly, methane. The use of fossil hydrocarbons as a source of energy and industrial feedstocks has been quantitatively even more important in increasing the rate of release of carbon dioxide into the atmosphere. Greenhouse gas concentrations have increased above anything known for millions of years. Average global temperatures have breached the upper limits of the Holocene. Average global temperatures are now about one degree Celsius higher than a century ago. Increases over land in Australia have been higher. Continuation of these trends would soon take us into a realm in which we could expect disturbance of the climate to an extent that destabilises the civilisation built during the Holocene.

These are even more immediate issues for Australians than for the people of other developed countries. We are the hottest continent, and driest except for Antarctica, in many places near the extremes of climate that support human habitation. That makes us more vulnerable than others to temperature increases. Global warming is associated with higher average precipitation across the world as a whole, but reductions in some areas and increases in others. Being at the margins of amounts of rainfall suitable for cultivation, we are more vulnerable than others to variations. Warming increases evaporation and disproportionately reduces run-off of water into streams and rivers, so multiples the effects of drying. The applied climate science tells us that in southern Australia, where most Australians live and most valuable agriculture is located, warming is likely to be associated with lower rainfall, especially in the winter months where it is most critical for crops. The early experience is confirming expectations from scientific analysis.

Australia is also more vulnerable than other developed countries because it is located close to developing countries that are likely to suffer great disruption from climate change. Developing countries are generally more vulnerable than developed, because they do not have the economic and human resources and the resilient political institutions to adapt at great cost to a changing climate. Tropical latitudes are expected to warm more than temperate. And Australia's neighbours across its northern sea borders and beyond have high proportions of their populations located on low-lying land near the sea and so are vulnerable to sea level rise and intensification of cyclonic events. The problems of our developing country neighbours will quickly become our problems as climate change disrupts human civilisation.

In December 2015, the international community through a meeting of the UNFCCC in Paris agreed to do what it takes to hold temperature increases below 2 degrees and as close as possible to 1.5 degrees. This was Australia's good fortune. It could not have been taken for granted, since some systemically important countries which signed the Paris Agreement will not be affected as quickly and severely as

Australia by climate change. Achievement of the Paris goals would not prevent substantial damage from climate change. It is too late for that. It would, however, avoid the much more damaging effects and risks from allowing temperature increases to exceed 2 degrees. Synthesis of research initiated at Paris has made it clear that the difference between the damage at 2 degrees and at 1.5 is large—large enough to provide good reason for us to strive to hold temperature increases as close as possible to 1.5 degrees.

The minimal Paris goal—having a reasonable chance of holding temperature increase below 2 degrees—requires linear reductions of global net emissions to zero by 2050. A late or slow start requires an early and fast finish. That's for the world as a whole. Realistically and ethically, that requires faster progress in developed countries. Getting as close as possible to 1.5 degrees requires a stronger start and an earlier finish.

Global average temperatures will continue to rise until we have restored balance between greenhouse gases being released into and absorbed from the atmosphere—zero net emissions. Zero net emissions by 2050 has come to be the goal of countries seeking to contribute their fair shares in the global climate mitigation effort. That is a reasonable goal for the time being. It is an achievable but challenging goal from the position in which Australians now find themselves. We will be encouraged to earlier achievement of zero net emissions once we have demonstrated that we are on a path to achieve zero by 2050 without serious short-term disruption of economic life.

Victoria along with all Australian States and Territories has adopted a target of net zero emissions by 2050. Victoria, Australia and the world as a whole will need substantial contributions to emissions reductions from the land sector to meet this target. Later, Victoria and Australia as a whole will need larger contributions from the land sector to contribute their fair shares to holding temperature increases as close as possible to 1.5 degrees.

As we will see, Australia and Victoria would do well economically by going further with land-based emissions reductions and industrial use of biomass than is required by zero net emissions. They could become exporters of carbon credits and of zero emissions industrial products to the rest of the world.

2.2 The Landscape in Climate Change Mitigation

For climate change mitigation, the central importance of absorption of carbon in the landscape, and of plants in producing industrial raw materials with zero emissions to replace fossil carbon, has been recognised more clearly in recent years. We are at an early stage of development of the policy frameworks and commercial models for utilising the potential.

The basic global carbon arithmetic provides context. The amount of carbon held in soils (about 1500GT in the top two metres and falling with modern economic development) and living things (about 500GT and falling) is two and a half times as large as that held in the atmosphere (about 820GT and rising). That means that an increase in the amount of carbon in both the soil and the biosphere all over the earth would be associated with a much larger proportionate reduction of carbon in the atmosphere.

A major study within the US National Academy of Sciences published in 2017[1] drew attention to the importance of what it calls “Natural Climate Solutions”. These can provide one third of the cost-effective climate mitigation needed between now and 2030 to stabilise temperature increases below 2 degrees, and one fifth of required reductions between now and 2050. This would be achieved at a cost of carbon of less than $US10 per tonne ($US 37 per tonne of carbon dioxide). It suggests that Natural Climate Solutions would be the lowest cost path to 37 percent of the mitigation effort to 2050, requiring a substantially higher cost of carbon.

There are two main ways in which plants can contribute to net zero emissions.

One is by increasing the amount of carbon in soils and plants. An increase in carbon in the landscape is associated with a proportionately much larger decline in atmospheric carbon.

A second is by harvesting biomass in a way that does not diminish the landscape carbon stock and using the material to replace fossil hydrocarbon or carbonate for construction, energy, industrial processes and transport. New biomass can do everything in the economy that fossil carbon and transformed carbonate do: produce heat; power electricity generators; drive cars, boats, planes and trains; provide the hydrocarbon or other carbon base for making plastics and other petrochemical manufactures; provide the material for buildings. But not all at once: new biomass cannot be grown and harvested sustainably at the rate at which the modern industrial economy is drawing down stocks of fossil carbon. We are now drawing down those fossil carbon stocks at a much faster rate than they were created by natural forces hundreds of millions of years ago. Fortunately, we now have access to relatively low-cost alternatives for many uses of fossil carbon that do not require biomass: renewable energy, replacing fossil carbon in electricity generation, land transport, and many industrial processes (including reduction of iron ore). This allows us to reserve biomass for those processes in which there are no low-cost alternative paths to zero emissions. We can expect biomass to be increasingly scarce and valuable as the world moves to zero net emissions, and for it to be reserved by its high price for those uses for which there are no low-cost alternatives.

Three variations on the second of these themes can expand the mitigation contribution of carbon in the landscape through increasing negative emissions. The first is the use of pyrolysis to convert biomass into a combination of pure carbon or char, and a liquid or gaseous hydrocarbon. Both the char and the hydrocarbon can be sources of energy and of other industrial inputs. Added to feed of ruminant animals, char can reduce methane emissions and increase productivity. It is a valuable fertiliser, supporting retention of moisture and in other ways contributing to greater farm output. If part or all of the char is returned to the soil, it can hold the carbon out of the atmosphere over a long period—thousands of

[1] Bronson W. Griscom, Justin Adams, Peter W. Ellis, Richard A. Houghton, Guy Lomax, Daniela A. Miteva, William, H. Schlesinger, David Shoch, Juha, V. Siikamäki, Pete Smith, Peter Woodbury, Chris Zganjar, Allen Blackman, João Campari, Richard T. Conant, Christopher Delgado, Patricia Elias, Trisha Gopalakrishna, Marisa R. Hamsik, Mario Herrero, Joseph Kiesecker, Emily Landis, Lars Laestadius, Sara M. Leavitt, Susan Minnemeyer, Stephen Polasky, Peter Potapov, Francis,E. Putz, Jonathan Sanderman, Marcel Silvius, Eva Wollenberg, Joseph Fargione. Proceedings of the National Academy of Sciences Oct 2017, 114 (44) 11645-11650; DOI: 10.1073/pnas.1710465114

years. While in the soil, it attracts biota that are instrumental in augmenting the soil carbon. This is potentially a large and continuing source of negative emissions.

A second variation on the second theme is through the harvesting of biomass in a sustainable way, using it in place of fossil carbon for energy and industry, and then capturing and permanently sequestering the carbon dioxide emissions from its combustion. Geological sequestration is technically feasible, but expensive in the current state of knowledge.

A third variation on the second theme is the use of timber in long-lived construction. Technological improvement is widening the range and extending the lives of timber-based alternatives to cement in construction.

In examining the potential role of sequestration in the landscape and biomass in climate change mitigation we should not lose sight of other roles of plants in life on earth and in our human lives and society. The benefits of biodiversity will not be secured by growth in forests and woodlands that only take account of carbon value. Forests and woodlands have value for humans whether or not that value is captured in market exchange through tourism and other industries. Just as failing to regulate or tax carbon externalities allows practices to develop that destabilise our climate, so valuing carbon alongside conventional commercial inputs and outputs runs the risk of depleting other sources of value. In making suggestions for the future management of the roles of plants in economic development and climate mitigation, we should take care to establish mechanisms that underwrite the contributions of the landscape in other values.

2.3 The Australian and Victorian Opportunities

Australia has a large potential for absorption of carbon in the landscape and for production of sustainable carbon from continuing photosynthesis that can replace unsustainable fossil inputs into economic activity. The size of this potential is much larger than our demographic or economic size. This is because we have a much larger per capita endowment of land, including forests and woodlands than other developed countries, and larger still compared with most developing countries.

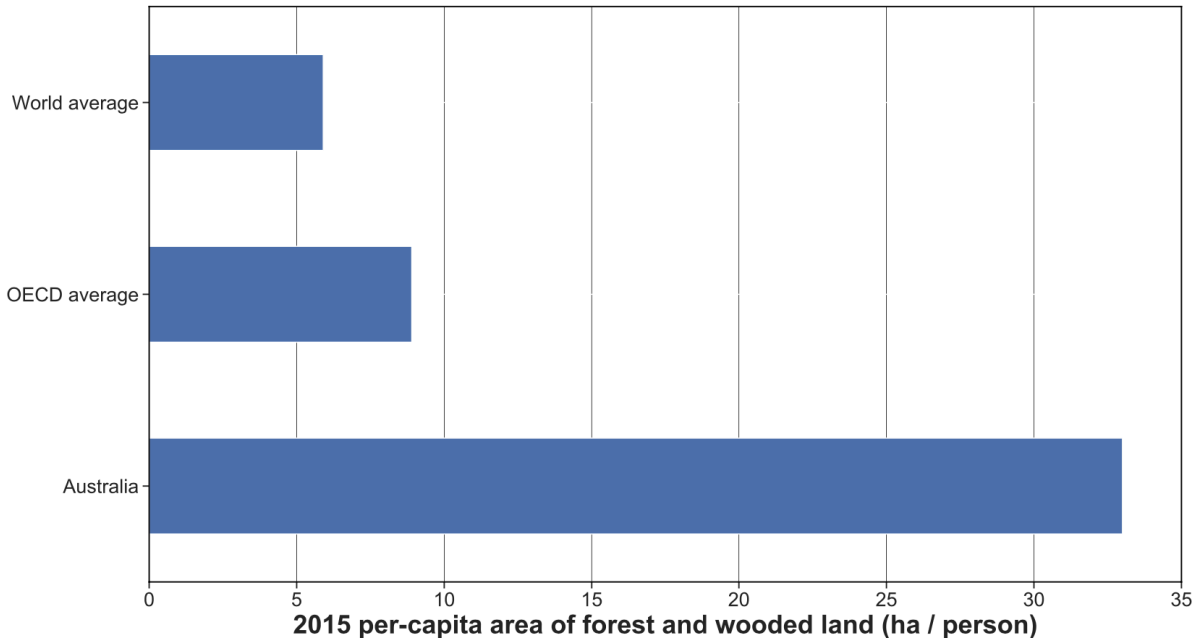

Figure 1 Per-capita area of forest and wooded land comparison of Australia, world average and OECD average for 2015[2]. Drawn from Ross Garnaut (2019), Superpower: Australia's Low Carbon opportunity, BlackInc and Latrobe University, Melbourne.

Much of our land has lower commercial value in agriculture and alternative economic uses on average than land in other developed countries, which reduces the opportunity cost of its use in absorption of carbon and production of biomass. Australian land receives much lower average precipitation than that in other inhabited continents, which slows the growth of plants and increases the cost of growing new biomass. This disadvantage of slow growth is much less important when the cost of capital is low, as it has been over the past decade, with zero sovereign real interest rates in Australia now and for as far into the future as we can see. Lower cost of capital increases the capital value of high quality land, further increasing the Australian advantage in sequestering carbon in the landscape and growing biomass.

Planting trees is amongst the most labour-intensive of capital expenditures, and so its economic costs are much lower when unemployment is high. A high proportion of Australian investment in plantations was made to create employment during the Great Depression.

These various considerations make Australia a propitious place and now a propitious time for large investments in planting trees, as part of restoration of Australia after the Pandemic Recession.

Australia's genetic inheritance of plant species that are adapted to a hot, dry and variable environment and to the frequent presence of fire, and our knowledge of those plants, is another advantage. We have not been effective in utilising that inheritance for our own economic benefit. Eucalyptus oil is a substantial product in use all over the world, but today mostly comes from trees grown and processed in

[2] FAOSTAT 2015

China. There are many larger opportunities based on the increasing value of biomass in a low emissions world economy that we can capture for our own prosperity if we are clever enough.

Australia's established human capital strengths in the applied land sciences and in resource project development and management supplement its natural advantages in landscape carbon sequestration and production of biomass, and more broadly in landscape management.

Another Australian advantage will emerge and be important to our role in the global economy as the world moves closer to zero net emissions. All countries will draw a large part of their electricity from renewable sources. Australia has the developed world's richest endowment per person of wind and solar energy resources. So long as we use our opportunity well, we should have the world's lowest cost energy. Energy is a necessary complement in many industrial processes using biomass. The combination of globally competitive biomass and energy will be powerful in creation of new industrial export industries.

It is also an advantage that many established Australian ports and industrial centres with access to thick electricity transmission networks have access to rich renewable energy resources. Victoria has a special advantage, where the industrial centres with access to low cost renewable energy are close to major concentrations of renewable biomass at Portland and in the Latrobe Valley. It is good fortune that there are geologically well known and excellent geo-sequestration sites near Portland in the Otway Basin and near the Latrobe Valley in East Gippsland and Bass Strait.

Australia and the world as a whole are in the early stages of understanding how to utilise the immense potential for land-based carbon sequestration and use of renewable biomass for zero emissions industry. This has been an area of underinvestment in research, development and commercialisation of new technologies.

We need increased investment in research, development and commercialisation relating to carbon markets, new biomass crop production and new industrial processes. This requires building on and strengthening institutions embodying Australian human resource strengths. It requires careful policy development that picks its way through constraints on good policy, and clears a path with clarity of argument and political will on issues for which it is important to do what is best.

Victoria is well placed to play a leading part in Australia's utilisation of its low carbon opportunity in the land sector. Having a Government that is unambiguously and strongly committed to building a zero net emissions economy is a necessary condition for success. That condition is met in Victoria in 2020. The concentration in a relatively small part of the Australian land mass of a significant amount and variety of opportunities and the leading role that Victoria has played over a long period in research, development and commercialisation of forest management opportunities provide a strong base upon which to build the future. Victoria's education, skill and experience base in all aspects of project management and some advanced manufacturing gives it an advantage over other parts of Australia. Victoria leads Australia and Australia makes large global contributions in the applied biological sciences. The compact geography of the state and the good transport and communications infrastructure joining its parts is an important asset. The advantages in the Latrobe Valley and in the southwest are major assets.

Utilising these opportunities can contribute a great deal to Victoria's future economic development. It can provide major new sources of employment and incomes in rural and provincial Victoria—many times larger than the timber industries ever have in the past. New plantings of trees for future industrial supply of biomass could employ thousands of people through the restoration of the Victorian economy after the Pandemic Recession.

It is a disadvantage that Australian manufacturing industry does not have a tradition of operating in open international markets in which global competitiveness is necessary for success. Overcoming the legacy of inward-looking perspectives in government, business and civil society is an important step along the way to utilising the low carbon opportunity.

Victoria could lead Australia in creating a favourable policy environment for bringing together the technical, financial and legal skills needed to finance large-scale reafforestation and build the capacity for a bio-based industrial transformation. Victorian services could be sold to support growth in the sector in other states and countries. This would underpin a large, export-oriented manufacturing and service sector. It would stand alongside strengths in innovation in zero emissions energy in establishing the State as a global centre for financing and implementing the transition to a low carbon future.

2.4 Australian and Victorian Public Sector Roles

General principles of allocation of public and private sector roles, and within the public sector allocation of roles within the Federation, can be applied in the special conditions of the forestry sector.

The private sector is the efficient locus of management decisions and ownership where there are prospects for competition amongst producers and where costs and benefits external to private firms' operations are of minor importance or can be internalised at moderate economic cost by regulation, taxes and subsidies.

Four external costs and benefits are important in the early stages of development of new industries sequestering carbon in the landscape and using biomass as an input into industrial processes. It is the role of Government to correct the effects of these externalities on the capacity of market exchange to deliver outcomes consistent with the public interest.

Carbon externalities are of large importance in growing carbon stocks in soil or biomass. These are most efficiently encouraged (absorption of emissions) or discouraged (reducing emissions) by subsidies and taxes at a rate that is governed by the social cost of carbon. The cost of carbon can be calculated as the price that would induce achievement of zero global net emissions in the required time scale—by 2050 for a 2 degrees target and earlier for 1.5 degrees. My 2008 Review calculated the relevant price for 2 degrees at about $40 per tonne carbon dioxide, rising at 4 percent per annum. US Department of Energy calculation have come up with a similar price. This is similar to the late July 2020 price in the European Trading System. Carbon prices are most effectively administered at a national level and coordinated with global carbon pricing by the national government. The rejection of general carbon pricing by the Commonwealth Government creates a problem for industries generating large positive externalities—most of all the land-based carbon sequestration industries.

The Carbon Farming Initiative within the carbon pricing arrangements in force between 2012 and 2014 allowed carbon credits certified by the Clean Energy Regulator to be offset against liabilities for carbon emissions within sectors covered by carbon pricing. Within the certification rules, there was unlimited opportunity to sell credits at the Australian carbon price—initially fixed at $23 per tonne of carbon dioxide, but to be integrated into the European carbon trading system and therefore to attract a European price from mid-2015 (later mid-2014). The Climate Solutions Fund (CSF, formerly Emissions Reduction Fund (ERF) administered by the Commonwealth's Clean Energy Regulator (CER), survives from the period of Australian carbon pricing. The most important survival is the Clean Energy Regulator, which is seen internationally as a credible agency for certifying the validity of carbon credits. The tortured political history of the CSF has left it as an unsatisfactory foundation for building large new industries that have the potential to contribute substantially to the global climate change mitigation effort, assist employment and incomes growth through post-pandemic economic recovery, and permanently expand the economic base of rural and provincial Australia.

Participation in carbon pricing is a necessary condition for large amounts of sequestration in the landscape and also for carbon capture and geological storage from industrial processes. No level of subsidy to carbon capture and storage can make it as cheap to sequester industrial emissions as to vent them into the atmosphere. We discuss expedients to allow progress in utilisation of Australia's potential for capturing carbon in the landscape pending the development of effective comprehensive carbon pricing arrangements in Section 6.

If the carbon externality is recognised but external benefits from forests' provision of other eco-system services are not, there is a danger that the other services will be neglected. It is necessary also to have an agency of Government empowered to regulate constraints on damage to biodiversity, water and other environmental services, or to provide financial incentives for their provision. The Environment Department could house such a function. Whatever its location within Government, it is important that it be given high status and is well resourced.

A second set of externalities relate to research, development and commercialisation of new technologies and commercial approaches. Economically efficient levels of innovation will only occur if firms generating benefits to the rest of the economy and society, beyond those that it can capture themselves, receive public fiscal support. The external benefits of innovation are likely to flow throughout Australia, so incentives are provided most efficiently at a Commonwealth level. The current R&D incentives are helpful. Several of the statutory rural industry Research and Development Corporations are making contributions. Movement from traditional to cash flow based corporate income taxation would help more[3].

The urgency of the transition to zero net emissions warrants special support for innovation in building the low carbon economy. This are provided for renewable energy by the Australian Renewable Energy Agency (ARENA). ARENA's scope is being extended appropriately to some low-emissions industrial technologies.

[3] *Garnaut, R., Emerson, C. Finighan, R., Anthony, S.* 'Replacing Corporate Tax with a Cash Flow Tax'*, 2020*

Some big gaps have been left by the large decline in agricultural and forestry research by State Governments, the CSIRO and the Universities over recent decades. Following sections of this report discuss research and development in greater detail. One important gap is in research, development and commercialisation of simple, reliable, low cost systems for measuring carbon in soils and plants. The Commonwealth Government is expressing interest in major new support for the work. The location of this work in Victoria is a source of competitive advantage.

A third set of externalities relates to training in new skills required for new industries and processes. Victoria starts from a strong foundation of professional, technical and trades education and can extend the established system to these new activities. Education in these fields has been depleted in recent years. At advanced levels, the depletion has been increased by the decline in research effort.

The fourth set of externalities relates to the coordination challenge faced by the first investors in Victoria in new industrial activities to build the biomass-based low carbon industrial economy. Provision of information on and access to supply of infrastructure and all necessary inputs is an appropriate role of Government. This would be part of the role of the Victorian Landscape Carbon Corporation described in the last section of this Overview.

There is also an important role for Government arising out of market failure in capital markets. Investment in growing trees for sequestering carbon and to provide biomass for industry takes an unusually long time to yield its full economic benefit. It will sometimes be decades before cumulative discounted cash flows are positive. The cost of capital is crucial to investment decisions. The real cost of riskless long-term capital is now the lowest it has ever been for sovereign investors in developed countries—around zero. This reflects durable economic forces related to higher global propensities to save and lower propensities to invest. However, the cost of capital has not fallen correspondingly for private investors. This partly reflects irrational responses to the increasing abundance and falling value of capital, as investors retain high expectations for return on investment that were formed in different conditions. To some extent it reflects increased premia for risk since the Global Financial Crisis in 2008-9, especially for small and medium sized firms that are most likely to be active in innovation. Premia for risk have increased again for long term private investment in the uncertain Post Pandemic economic conditions.

If an investor is certain that Government policy will support the emergence of a low carbon national economy participating in a low carbon world economy, she will have confidence that future prices of carbon and biomass will be high and tending to rise until zero net global emissions have been achieved. A Government that is committed to playing its full part in a global climate change mitigation effort has that confidence. However, a private investor must take account of sovereign risk. Discounting of future sources of income for sovereign risk is especially high in matters related to forestry and carbon, where past changes in policy have been frequent and large.

For all of these reasons, a government will value future income from long term investment in carbon sequestration in the landscape and biomass for industry much more highly than private investors. Indeed, private firms are unlikely to invest in expanding these areas. This is the historical experience. Almost all past Australian investment in plantations has been made by Governments or directly

encouraged by large subsidies—or by anticipation of and briefly the reality of a carbon price. The differential between public and private assessment of the value of plantation investment is stronger now than ever. This makes government the logical investor in long term carbon sequestration and production of biomass.

Should the Commonwealth or State be the investor? There is a case for either or both. The Commonwealth has entered this field for renewable energy and now some low-emissions industry through the Clean Energy Finance Corporation and Snowy Hydro. It has entered the field for North Australian development through the North Australia Infrastructure Fund. The State benefits from contributions to its state carbon sequestration goals and from expansion of local industry and is justified in using its balance sheet for the purpose if the Commonwealth does not.

3 Landscape carbon potential in Victoria

1. Carbon in vegetation in Victoria has declined by an estimated 3,300 Mt CO_2e (44%) below its pre-European settlement levels. This is equivalent to 29 years of Victoria's annual emissions. There has also been large decline in carbon in soils.
2. There is an opportunity in the regrowth of native forest to sequester 65 Mt CO_2e across a 50-year rotation. This has real carbon value, although its commercial realisation depends on development of a nationally recognised methodology.
3. Planting 10% tree cover on farms could provide many co-benefits without loss of traditional farm value. If achieved state-wide this would sequester an estimated 220 Mt CO_2e in the privately-owned landscape (80% on grazing country, 20% on cropping country).

Carbon sequestration in the landscape is essential to meeting global climate change mitigation goals. The benefits of restoring landscape vegetation extend beyond storing carbon. Extensive land clearing has caused degradation of natural systems that support land productivity, healthy waterways and biodiverse habitat. Reforesting the rural landscape can also provide a renewable resource to support low carbon industries in regional communities.

Historic landscape and carbon stock change

Victoria's landscapes have been dramatically reshaped by the waves of gold mining and agricultural expansion that rapidly followed European settlement. The long-term composition of vegetation has been transformed and the carbon embodied in plants has been approximately halved compared to the preceding era of Aboriginal land management. This has led to long-term decline in soil carbon.

Public land carbon potential

Public forests have protected the natural heritage of parts of the Victorian landscape. This includes ecosystems dominated by biodiverse and carbon-rich forests. The transition from native forest harvesting using a clear-felling to an adaptive, old-growth forest management model would increase long term carbon stocks of the forest. The Victorian Government's forestry transition as outlined in the 2019 Harvesting and Regeneration Systems report could soon start to deliver carbon credits on national accounts, but at present it cannot easily be recognized in tradeable credits.

Private land carbon potential

Integrating planted forests into farmlands can provide many co-benefits. Depending on the farm, around 10-20% can be planted without reducing productive capacity while also providing additional benefits. Well-planned, commercial plantations offer some farms increased and diversified returns.

3.1 Landscape change and carbon stocks

Victoria's landscapes have been transformed since European settlement. Before this time, around 88% of what would become Victoria was covered in forests or woodlands[4]. The Victorian gold rush of the 1850s, combined with widespread and indiscriminate land clearing for mining, agriculture and settlement caused major forest loss and degradation[5,6].

As early as 1865, the Settler community took up the cause of protecting forests. Attention was drawn to the substantial benefits of timber production, avoiding the wasting of soil, conserving natural streams, avoiding adverse climate impacts and beneficially distributing storm runoff[7]. By 1873 it was estimated that there were some 1,150 steam engines in the gold mining industry, using over one million tons of firewood[8]. Firewood for heat and steam generation also powered most other industry. This caused alarm amongst early foresters and the wider community[9]. In 1890 George Samuel Perrin[10], the first Conservator of Forests, produced a report containing a number of illustrations which identified the issues and set out reforms to ensure Victoria would have a healthy, diverse and extensive forest estate for generations to come[11].

The State Forest Department (SFD) was established in 1908. Timber reserves were put aside and provision made for rehabilitation after mining and logging. The challenges facing the new organisation were formidable. Ecosystems about which little was scientifically understood had to be protected. Vast areas of rugged, remote country about which little was known had to be managed[12].

Land held in the public estate, mostly as National Parks and State Forest, now covers approximately one third of the Victorian landscape and includes 85% of Victoria's remaining native forest area. These reserves retain much of the natural heritage from and similar carbon stock levels to pre-European settlement. There is also a large dispersed public land estate that has potential for reforestation that has large sequestration and commercial timber potential. This includes infrastructure verges and easements, local government easements, and water catchments.

3.1.1 Carbon in soils

Soil carbon is a significant store and potential sink of carbon. Land use change including through deforestation, intensification of agricultural or reafforestation, causes large changes in soil carbon. This needs to be systematically measured and managed alongside carbon in the biosphere. The need to set priorities within time constraints has caused this paper to focus on the opportunity for revegetation of

[4] State of Victoria Department of Environment and Primary Industries, (2013). *Victoria's State of the Forests Report 2013.*
[5] *Legg, S M (2016). "Political Agitation for Forest Conservation: Victoria, 1860–1960". International Review of Environmental History. **2**: 28.*
[6] Forest Cover Changes in Victoria 1869-1987. Peter Woodgate and Peter Black. (1988) Conservation Forests and Lands. Remote sensing group, Lands and Forests Division. ISBN 0730615847
[7] *"Victorias Forest Heritage".*
[8] *Moulds, F. R. (1991). The Dynamic Forest – A History of Forestry and Forest Industries in Victoria. Richmond, Australia: Lynedoch Publications. pp. 232pp. ISBN 978-0646062655.*
[9] *Carron, L T (1985). A History of Forestry in Australia. Australian National University. ISBN 978-0080298740.*
[10] *"Perrin, George Samuel (1847–1900)', Obituaries Australia, National Centre of Biography, Australian National University".*
[11] *"Victorias Forest Heritage".*
[12] Carron, L T (1985). *A History of Forestry in Australia. Australian National University*. ISBN 978-0080298740.

natural and productive forests rather than soil carbon. Nevertheless, optimising carbon in soils should be seen as an integrable part of forest management.

3.1.2 Pre-European settlement vegetation cover and carbon stock

The Victorian landscape is diverse. It includes semi-arid Mallee woodlands, alpine highlands, coastal heathlands, grassy plains, open woodlands and wet rainforest. Carbon is embodied throughout this living landscape in the trees, shrubs, grasses and soils. The highland mountain ash forests are the most carbon rich of any forests anywhere[13,14]. These unique landscapes and the biodiversity within them are the product of a long history that evolved with Indigenous communities preceding European settlement. Indigenous land use was not passive. It involved transformational management of the biosphere to produce grasslands and forests that were more productive for human habitation and less vulnerable to catastrophic fires. Contemporary Australia is now coming to terms with the complex systems of landscape management that were carried by First Nation peoples long before the first books were scribed. Passed down through the rituals of life, landscape management integrated biodiversity management, food cultivation, hunting, bushfire management and cultural traditions[15,16].

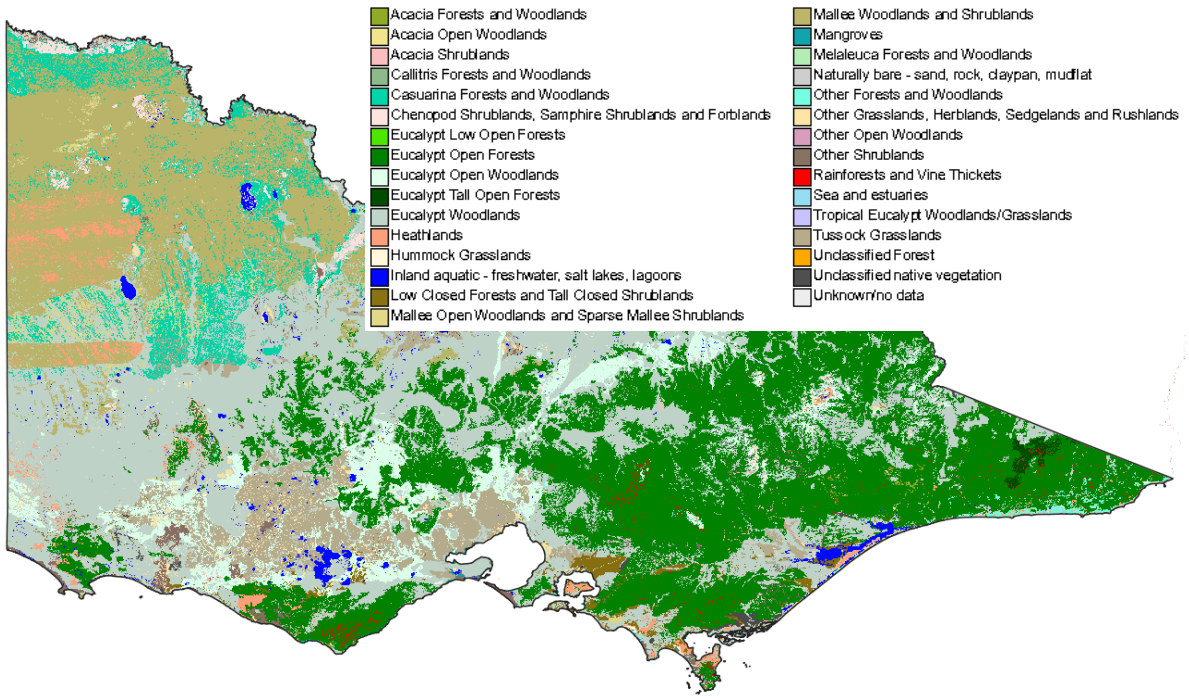

Figure 2 Estimated Pre-1750 Vegetation in Victoria: Major Vegetation Groups

[13] Keith, H., Mackey, B. G. and Lindenmayer, D. B. (2009). Re-Evaluation of Forest Biomass Carbon Stocks and Lessons from the World's Most Carbon-Dense Forests. Proceedings of the National Academy of Sciences, 106(28), pp. 11635-11640.
[14] H. Keith et al., 2009, *Re-evaluation of forest biomass carbon stocks and lessons from the world's most carbon-dense forests*, https://www.pnas.org/content/pnas/106/28/11635.full.pdf
[15] Gammage B. (2011) The Biggest Estate on Earth: How Aborigines Made Australia, Allen and Unwin
[16] Pascoe B, (2018), Dark Emu, Magabala Books

Table 1 Estimated Pre-1750 vegetation carbon stocks

Stock category	Mt C	Mt CO2e
Above ground[17]	1,800	6,600
Below ground[18]	360	1,320
Total	2,160	7,920

3.1.3 Current vegetation cover and carbon stock

For the unreserved landscape, a transformation of the carbon balance followed European settlement. Instead of the organic material that accumulated on the ground decomposing into soil or burned selectively to regenerate, vast tracts were felled, grubbed and razed for pasture and crop. Burning standing or felled timber and vegetation was the most convenient means of disposal. It transferred much landscape carbon into the atmosphere. The stock of carbon under the surface, Soil Organic Matter (SOM), is also continuing to decline. Conversion from native vegetation to agriculture typically reduces SOM by 20–70%[19,20], resulting in declining soil health and significant emissions of greenhouse gases. Agricultural production from this land is now also a major source of emissions (approximately 12% for Victoria), mainly from ruminant animals that incompletely digest pasture grass and belch methane into the atmosphere.

[17] Above ground carbon derived from Maximum Above Ground Biomass Version 2.0.
[18] Below ground carbon potential applying ratios reported by Victorian Forest Monitoring Program. Below ground carbon includes roots, not soil organic carbon.
[19] Luo Z, Wang E & Sun OJ (2010). *Soil carbon change and its responses to agricultural practices in Australian agro-ecosystems: a review and synthesis*. Geoderma 155(1–2):211–223.
[20] Sanderman J, Farquharson R & Baldock JA (2010). *Soil carbon sequestration potential: a review for Australian agriculture*, prepared for the Australian Government Department of Climate Change and Energy Efficiency, CSIRO Sustainable Agriculture Flagship, CSIRO Land and Water, South Australia.

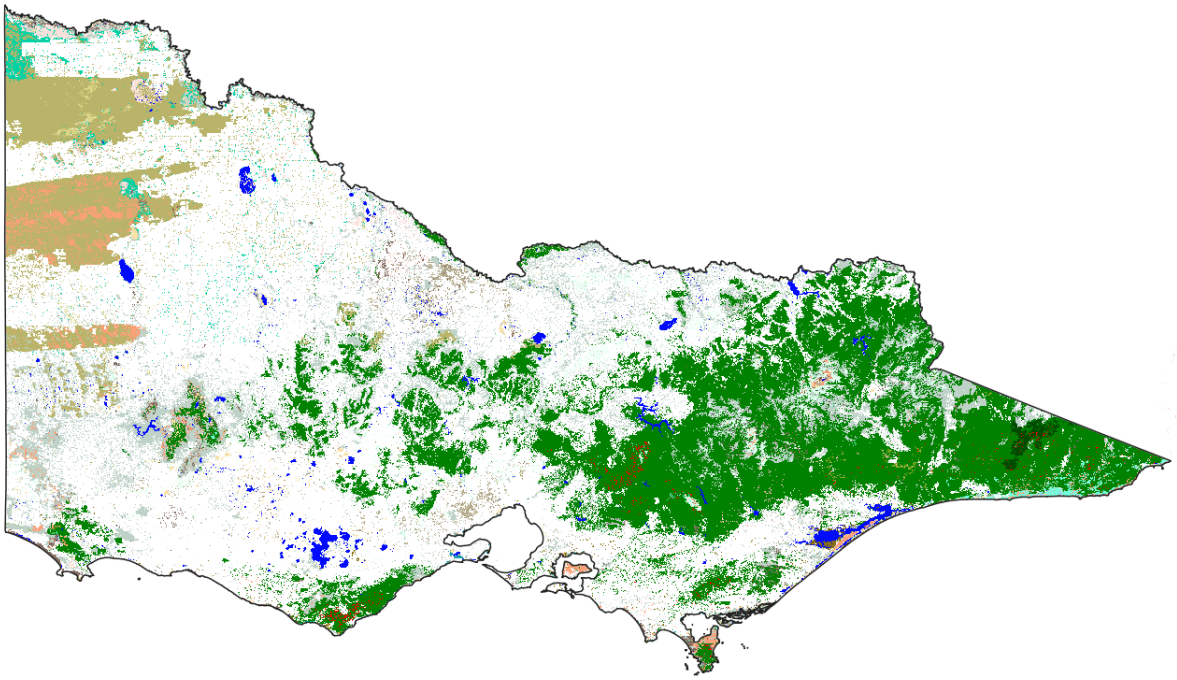

Figure 3 Current Vegetation in Victoria: Major Vegetation Groups

Table 2 Estimated current vegetation carbon stocks

Stock category	Mt C	Mt CO2e
Above ground[21]	970	3,560
Below ground[22]	240	880
Total	1,210	4,450

3.2 Victorian public forest carbon potential

Victoria's National Parks and State Forests are reported to store approximately 1,023 Mt C (3,751 Mt CO2-e)[23]. Carbon stocks and other forest attributes are continuously observed within the Victorian Forest Monitoring Program[24]. This carbon stock is unevenly distributed across the state's eleven bioregions (Figure 4)[25]. The South Eastern Highlands and Australian Alps - home to the Mountain Ash forests - and the South East Corner (Central and East Gippsland) account for two thirds of the public estate carbon stock. These high rainfall regions have supported most native forest harvesting.

[21] Above ground carbon derived from Maximum Above Ground Biomass Version 2.0. Cleared agricultural zone assumed zero.

[22] Below ground carbon potential applying ratios reported by Victorian Forest Monitoring Program. Below ground carbon includes roots, not soil organic carbon.

[23] Department of Environment and Primary Industries, (2013). *State of the Forests Report 2013*, p. 129.

[24] Victorian Forest Monitoring Program

[25] State of Victoria Department of Environment and Primary Industries, (2013). *Victoria's State of the Forests Report 2013*, p. 129.

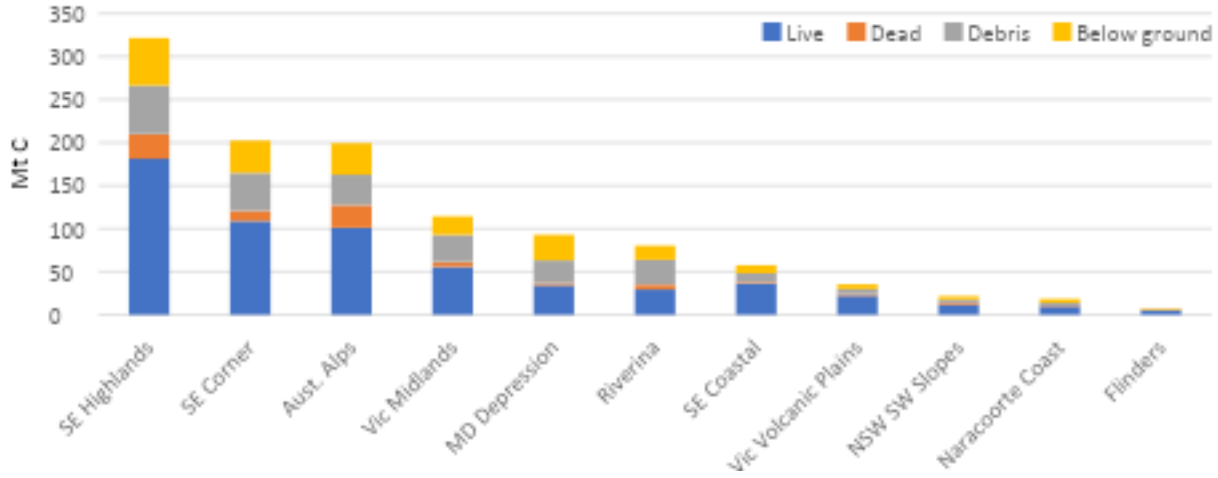

Figure 4 Contribution of public forest carbon stocks by IBRA bioregion

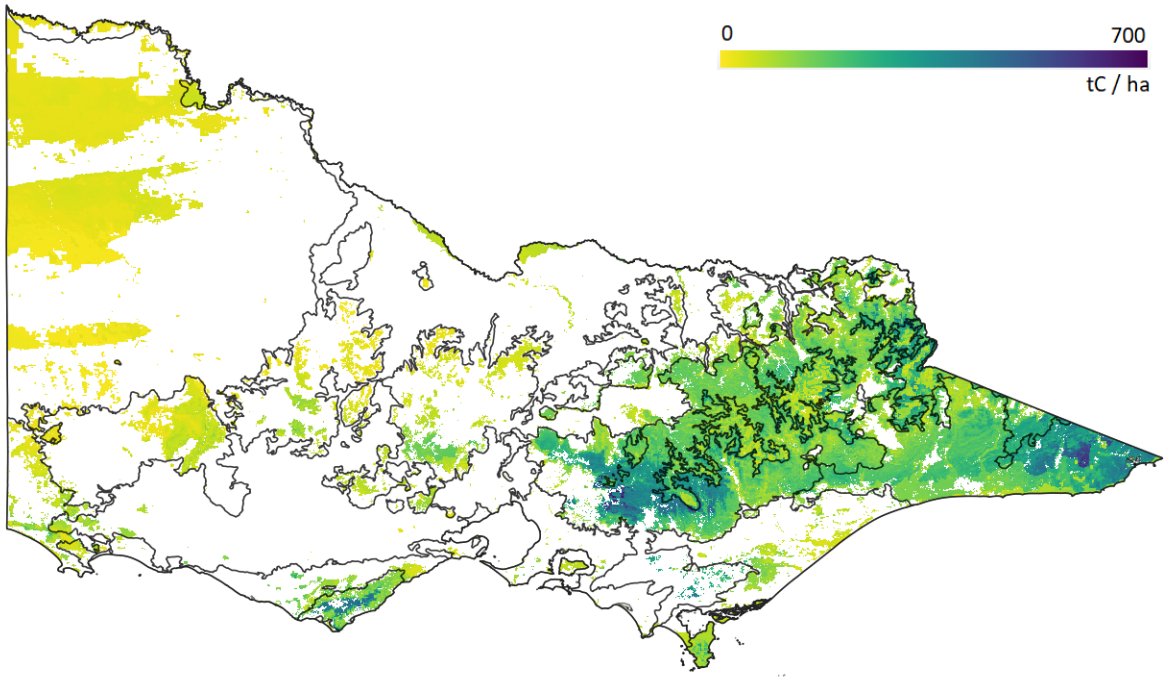

Figure 5 Victoria public forest above ground carbon potential (IBRA bioregion boundaries indicated)

3.2.1 Potential public forest carbon stock increase

A comprehensive account of the carbon flows from Victorian state forests and its downstream stores was carried out by Ximenes et al (2016), with contributions from CSIRO, VicForests and the NSW Department of Primary Industries[26]. A key delineation has been made to omit part of the calculations – that substitution effects from changes in timber sources will result in higher carbon emissions due to changes

[26] Forest and Wood Product Association, (2016), *Carbon stocks and flows in native forests and harvested wood products in SE Australia*

in national forestry practises, transportation and carbon in different tree species. As stated in the report, these figures are not included in Kyoto Protocol or national accounting practises and are therefore left out of this report. International and Australian standards for the trade of forestry products such as the Australian Forestry Standard and the Forestry Stewardship Council prevent most Australian companies from accepting unsustainable timber and the Victorian government is committed to sustainable plantation timber to replace native forest supply. Global commitments to sustainable supply of timber aim to prevent the use of unsustainable timber.

The Ximenes 2016 research project, in conjunction with FWPA, calculated the long-term carbon stocks and flows of forests and Harvested Wood Products (HWP) in Victorian and NSW forests using field surveys and measurements of native forest harvesting coupes[27]. The project demonstrated a significant (32-68%) increase-- 127 t C/ha (466 t CO2-e/ha)-- in the long-term forest carbon stocks of conservation stands compared to current harvest practices (Figure 7).

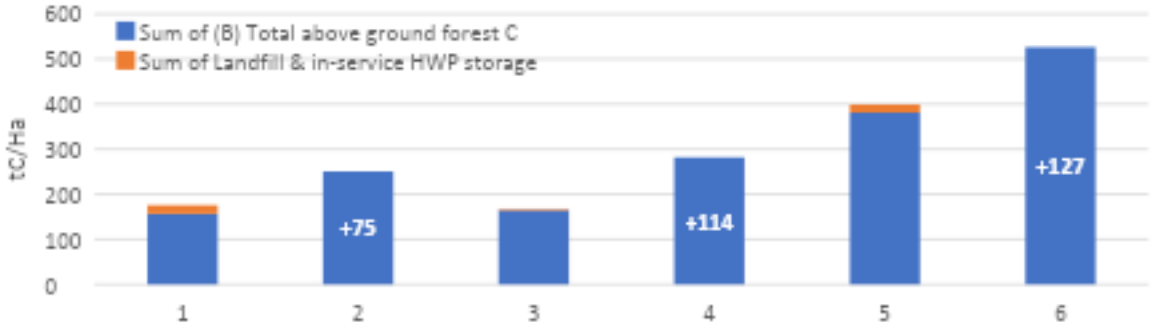

Figure 6 Long term carbon stocks and native forests and harvested wood products

It is assumed 3,000 hectares of Victorian native forest are harvested on an annual basis, with a third from Victorian Mountain Ash and 2,000 from NSW South forest types (which are a proxy for Victorian Mixed Forest species). On this basis, a change in forest management from 2030 will lead to accumulation of an additional 1.3 Mt CO2-e of carbon stocks each year. With a 50-year rotation, this translates to 65 Mt CO2e long term carbon stock increase, taking in the order of 150 years to reach 90% of the maximum carbon stock level[28]. These figures are in the assumption that all coupes are alike, and do not factor in the spatial and ecological heterogeneity of the whole state forest area.

The path to carbon sequestration is affected by changes to forest management. Variable Retention Forestry (VRF) is a form of active forest management in which trees are retained in order to maximise other values of the forest, such as biodiversity and regeneration capacity[29]. Increased VRF is outlined in the Vicforests 2019 Harvesting and Regeneration Systems report[24]. Ongoing forest management changes until 2030 will see a proposed 75% coverage of VRF by 2030, with 25% remaining clear-fell for uniform

[27] Forest and Wood Product Association, (2016), *Carbon stocks and flows in native forests and harvested wood products in SE Australia*
[28] Roxsborough S et al., (2006), *Assessing the carbon sequestration potential of managed forests: a case study from temperate Australia*, Journal of Applied Ecology.
[29] Messier, Christian & Puettmann, Klaus & Chazdon, Robin & Andersson, Krister & Angers, Virginie & Brotons, Lluís & Filotas, Elise & Tittler, Rebecca & Parrott, L. & Levin, S.A.. (2014). From Management to Stewardship: Viewing Forests As Complex Adaptive Systems in an Uncertain World. Conservation Letters. 8. 10.1111/conl.12156.

stands. The below Figure 7 demonstrates the shift in harvesting regimes until 2030, in line with a Variable Retention Forestry regime and selective harvesting across the state forest.

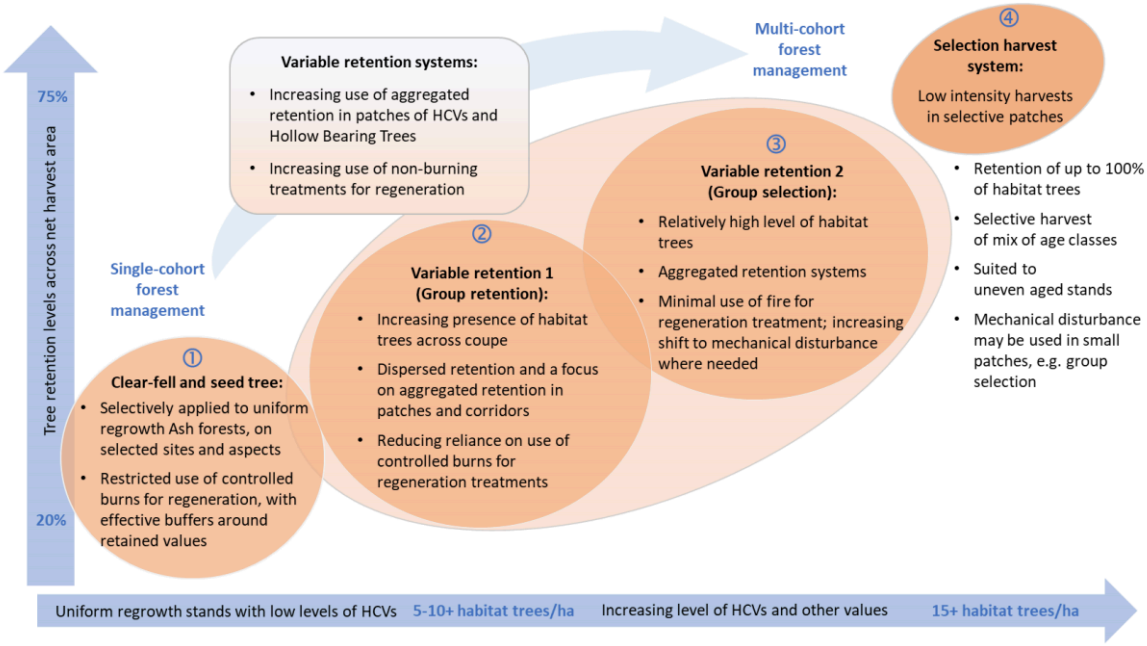

Figure 6. Overview of the upcoming Variable Retention harvesting program conducted by Vicforests until 2030[30]

The amount of carbon will increase relative to planned management practises. Due to lack of current available data for carbon sequestered through adaptive management and VRF regimes in Victoria, the annual forest carbon stock during the 2020-2030 period is difficult to forecast. Monitoring changes through satellite and field data over the 2020-2030 period will provide a record of the carbon stored through a broad mix of forest management regimes.

3.2.1.1 Carbon credits from carbon management

The Californian Cap and Trade System was one of the first carbon trading systems worldwide and has such pioneered a range of carbon offset activities since its inception in 2013. High emitting industries in California can offset 8% of their emissions annually in 2020 through a variety of techniques[31]. One of the three forestry activities covered by the Californian emissions trading system is Improved Forestry Management (IFM). For California 3 methods within IFM projects allow for credits to be rewarded; Avoided Emissions, Enhanced Sequestration and Enhanced Wood Products[32]. Enhanced sequestration

[30] VicForests 2019 Harvesting and Regeneration systems Version 1.2. 16th August 2019. Accessed at: https://www.vicforests.com.au/static/uploads/files/vicforests-harvesting-and-regeneration-systems-v1-2-wffznmahdqwe.pdf

[31] https://www.c2es.org/content/california-cap-and-trade/

[32] Forest Carbon Accounting for IFM Projects (2019). Climate Action Reserve. http://www.climateactionreserve.org/how/protocols/forest/forest-carbon-accounting-for-ifm-projects/

recognises the carbon storing potential of retention harvesting, growing older forests and improved stocking, among others[33]. To calculate the baseline, IFM methodology take the financial, legal and technical bounds of typical forest management to give a Business as Usual (BAU) scenario. Any subsequent changes in management that result in gains in carbon will result in annual carbon credits allocated from the difference between the corresponding year, see below Figure 7. Carbon credits from improved forest management benefit from incremental improvements to forest management comparative to BAU and recognise the sequestering of carbon as the trees age.

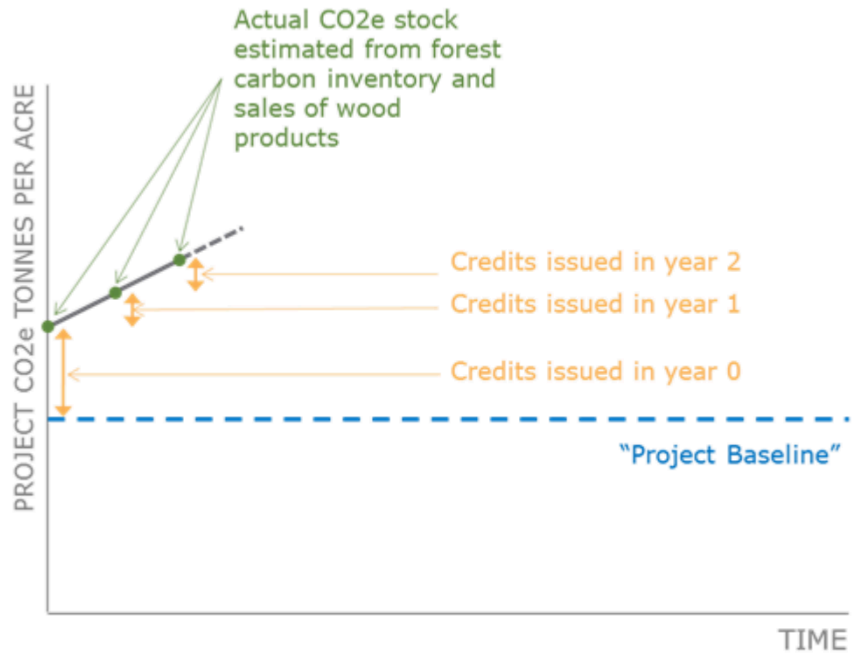

Figure 7. Methodology for carbon crediting of Improved Forest Management in the California Offset Compliance Protocol.

In 2013, the UNFCCC greenhouse inventory protocol was changed to recognise carbon stock change in Harvested Wood Products (HWP) and managed forests. Future changes in forest management that cause an increase or decrease in carbon stocks, relative to the reference level (2002-2009 average), are counted as carbon credits or debits using the international accounting methodology[34]. A 2011 Australian National University analysis, applying the methodology to calculate the carbon credit potential from transitioning from clear-fell harvesting in Australia to non-productive regimes indicated a potential 38 Mt CO2-e/y credit[35].

During the 2020-2030 period until harvesting ends in native forests, VicForests could acquire carbon credits for improved forest management within the national accounting system. The regrowth of native forest, after 2030, presents an opportunity to create a valuable carbon asset. For this to occur, it is

[33] Key Accounting Principles for Improved Forest Management Projects within the Forest Protocol (2019) Climate Action Reserve.

[34] Australian Government Department of Industry, Science, Energy and Resources, *National Inventory Report 2018: Volume 2*

[35] Macintosh A, (2011), *Potential carbon credits from reducing native forest harvesting in Australia*, ANU Centre for Climate Law and Policy.

important to ensure eligibility for ACCUs is recognised by the Australian Clean Energy Regulator for the Climate Solutions Fund or other carbon trading or offset scheme.

There is an opportunity to formally recognise these carbon credits, hold their value on a State institution's balance sheet and leverage this capital to enhance Victoria's landscape carbon and biomass industry development. This endowment will enhance management focus on the carbon stock.

The recent history of Tasmanian native forestry (see Box below) provides some guidance on the carbon crediting potential from changed forest management.

Tasmanian Native Forest Carbon

The Tasmanian Forestry Agreement Act of 2012 led to a tenure change of 356,000 hectares of forest to future reserves. In the years preceding, native timber production fell by around 1.4 million cubic meters per year (almost 50%). Reduced production has been recorded in the national greenhouse account according to the UNFCCC forest management protocol that was introduced in 2013[a]. Tasmania's native forest emissions have since declined by approximately 8.5 Mt CO2e per year since 2011 from a net source of emissions to a net sink.

At the time the TFA was signed it was unclear whether, and under what conditions, the Tasmanian Government would be eligible for carbon credits for this change. The international protocols had not yet been agreed and the Carbon Farming Initiative (now Emissions Reduction Fund) crediting methodologies had not been settled. The Rebuilding the Forestry Industry Act of 2014 reversed the tenure change, effective 2020. It is still unclear what the native timber production response, and associated carbon emissions will be.

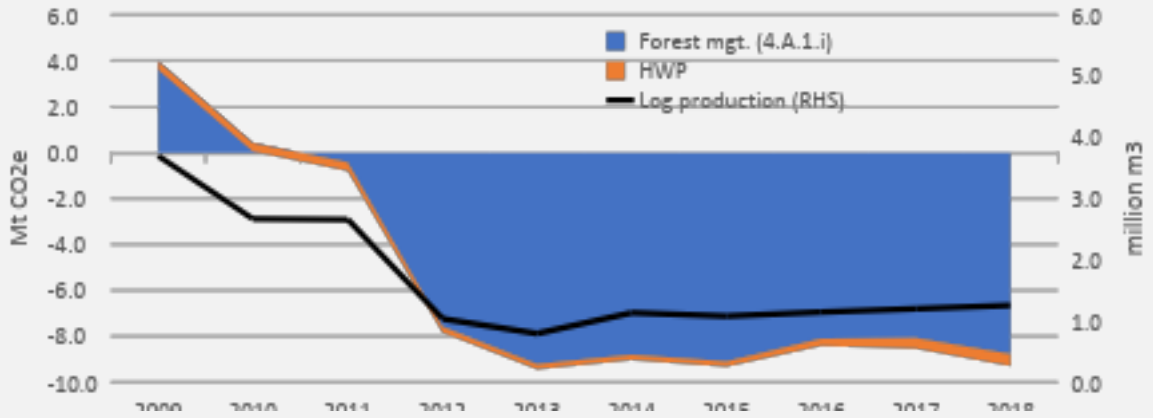

Figure 8 Tasmania native forest log production and forest management emissions following the TFA

[a] Source category 4.A.1: Forest land remaining forest land

3.3 **Private land carbon potential**

The Australian Settler community since 1788 has tended to see agricultural production as being in conflict with native biodiversity. The policy settings and motivation of most landholders led to attempts to convert every piece of land to commercial production, clearing native vegetation for pasture or crops. Clearing was often a condition of transfer of land.

Many investigations into restoring landscape carbon, including the 2019 Australian National Outlook, have embodied the presumption of land use conflict[36]. The binary "carbon or agriculture" presumption can provoke sensitivity about land use change. While the total conversion of farms to native vegetation delivers positive results from a carbon perspective, large-scale conversion can prompt community resistance and rarely maximises social value. Concerns arise about reduced population, lower employment, and threats to the fabric of local communities (see 6.4.3). Knowledge accumulated in recent decades, including from the Joint Venture Agroforestry Program[37], identifies mutual benefits from integrating trees and biodiversity into productive landscapes.

Planting trees provides complementary benefits to farming.[38]. Planting trees helps to improve farm productivity by providing shade and shelter. It can provide additional income from sale of biomass or storing carbon. It provides catchment benefits to improve water quality and quantity, and habitat to increase biodiversity[39]. Trees can occupy well-watered and highly productive zones not suitable for agriculture, building more carbon in smaller areas than would be possible in more marginal agricultural lands[40].

Carbon sequestration in Victoria's rural landscapes requires different strategies for different bioregions and agro-climatic zones. Principles for planting trees on farms are found in the JVAP[41] guidelines and more recent material generated by the Grow Landscape Carbon and NextGen Plantations research coordinated by The University of Melbourne.

3.3.1 **High rainfall pasture grazing zone carbon potential**

The well-watered southern plains and foothills, as well as areas along and north of the Great Dividing Range, provide pasture for livestock, often in small holdings. Unlike the drier Mallee plains to the north-west, the higher rainfall drains through an undulating landscape that is threaded by a dense network of waterways. Steeper slopes and drainage lines are often of low commercial value and frequently suffer from erosion. Integrated approaches that deliver co-benefits are:

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[36] Bryan B et al., (2015, *Potential for Australian land-sector sequestration and implications for land use, food, water and biodiversity: Report for the Australian National Outlook 2015*, CSIRO

[37] JVAP (Joint Venture Agroforestry Program). (2002). Achieving Environmental and Commercial Outcomes through Agroforestry – Policy and Investment Options. Rural Industries Research and Development Corporation.

[38] O'Grady P & Mitchell P, 2017, Agroforestry: realising the triple bottom line benefits of trees in the landscape, CSIRO, Australia

[39] JVAP (Joint Venture Agroforestry Program) (2000). 'Emerging Products and Services from Trees in Lower Rainfall Areas.' (Rural Industries Research and Development Corporation).

[40] JVAP (Joint Venture Agroforestry Program) (2001). 'Agroforestry and Farm Forestry JVAP Completed Projects in 2001 and Research in Progress as at June 2001.' (Rural Industries Research and Development Corporation: Canberra).

[41] JVAP (Joint Venture Agroforestry Program), 2000, Emerging Products and Services from Trees in Lower Rainfall Areas, Rural Industries Research and Development Corporation

JVAP (Joint Venture Agroforestry Program), 2000, Farm Forestry – Design Guidelines, Rural Industries Research and Development Corporation, Canberra

JVAP (Joint Venture Agroforestry Program), 2000, Trees Water and Salt: An Australian Guide to Using Trees for Healthy Catchments and Productive Farms, RIRDC

- Riparian zone planting for intercepting nutrient and sedimentary runoff, stabilising stream banks, providing wind breaks and habitat for crop pest predators and pollinators.
- Paddock shelter belts that provide protection from hot and cold temperature extremes and winds. These improve meat, dairy and wool productivity as well as survival rates of sheep and lambs.
- Steep slopes planting to stabilise soils reducing subsidence and sediment and nutrient runoff.

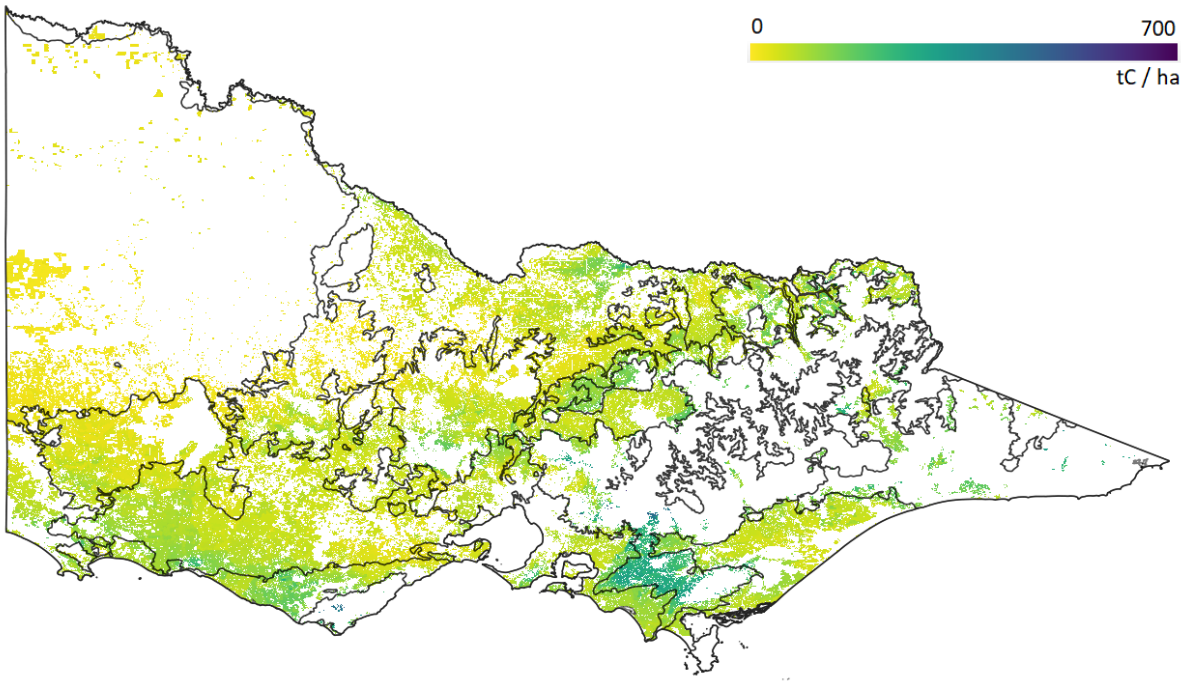

Figure 9 Victorian pasture grazing zone above ground carbon potential (IBRA bioregion boundaries indicated)

Table 3 Pasture zone estimated above ground carbon stock change and sequestration

Area	6.9 million ha	
Carbon carrying capacity	68 t C / ha	248 t CO2-e / ha
Vegetation cover increase	Increased carbon stock	Sequestered CO2-e
10%	47 Mt C	171 Mt CO2-e
20%	94 Mt C	342 Mt CO2-e

3.3.2 Low rainfall cereal and legume cropping zone carbon potential

This land use is typical of the Wimmera, Mallee and northern plains regions. Farming economics demand scale, leading to homogenous crops stretching across horizons. Farmers are sensitive to small effects on

crop yields and costs as these businesses earn small margins on large volumes. Precision farming technology allows accurate definition of the profitable areas of these cropping enterprises. Areas – like poorer soils or waterlogged areas – can be identified where removing land from annual cropping saves money. These can be planted to agroforestry. Co-benefits can be achieved:

- Riparian zones for intercepting nutrient and sedimentary runoff, also providing wind breaks and habitat for crop pest predators and pollinators.
- Fence line or crop line belts to serve as wind breaks, improving local humidity and soil moisture retention as well as reducing soil erosion from dust storms. These belts can also slow surface water and provide habitat for crop pest predators and pollinators.
- Unproductive or saline regions can cost more to cultivate than they yield. Conversion to vegetation can also help manage water table changes.

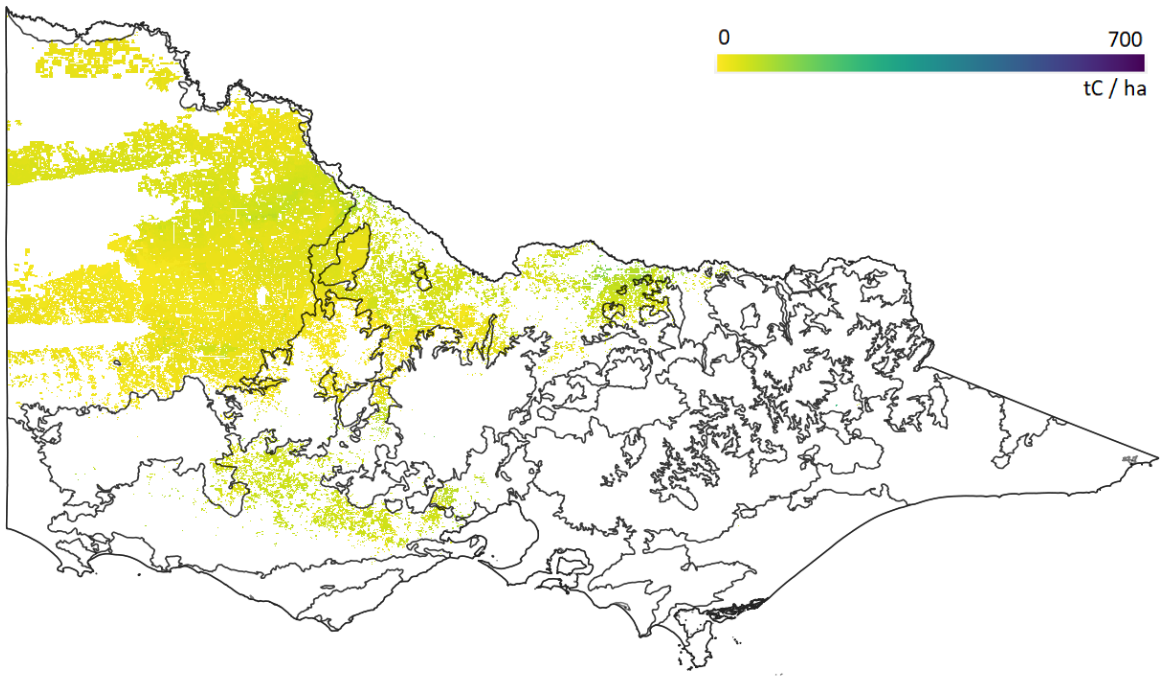

Figure 10 Victorian cropping zone above ground carbon potential (IBRA bioregion boundaries indicated)

Table 4 Pasture zone estimated above ground carbon stock change and sequestration

Area	**4.6 million ha**	
Carbon carrying capacity	28 t C / ha	101 t CO2-e / ha
Vegetation cover increase	**Increased carbon stock**	**Sequestered CO2-e**
10%	13 Mt C	47 Mt CO2-e
20%	26 Mt C	94 Mt CO2-e

4 Healthy landscapes: A look to the past and the role of knowledge and policy

1. **Restoring the landscape, building carbon stocks and expanding the renewable forest resource requires a coordinated effort with long-term commitment**
2. **Government policy will have important consequences for unlocking commercial potential from large-scale landscape change. Well-designed and stable policies and institutions are essential**
3. **Enterprises can benefit from integrating trees for production and environmental services**
4. **Decades of R&D have focused on the timber industry and some landscape remediation. Future research focus is required in species, carbon, value creation and climate change.**

The growing of trees can support regional industries. An integrated approach to agroforestry and plantation will not occur spontaneously at scale. Alignment of regulations and policies, market access facilitation, and suitable funding arrangements are required.

Australia's uniquely adapted species for landscape carbon and biomass

Many prospective native species possess a high degree of resilience to climate variability. However, new research is necessary to define the adaptive capacity of a broader range of species with commercial potential.

Suitable incentives and commercial arrangements are essential

Australia has gone through waves of plantation expansion under different policy schemes. These have delivered the sustainable and profitable timber resource underpinning the bulk of the industry today. The new opportunities require an alignment of policy and institutional settings.

4.1 An integrated approach to land use

Only 20% of native vegetation remains on private land in Victoria. There has been gradual expansion of conservation policies and practices focused on ecological restoration, revegetation and agroforestry as a response to land degradation. These actions have been impressive but remain fragmented and confined to particular districts or properties and risk not being built upon in the future[42].

The potential of agroforestry requires coherent policy and institutional settings[43]:

> *"Landscape-scale revegetation and the integration of conservation into farming landscapes have been recognised as a global imperative for decades, for which Australia has generated many innovations – in the technical, social and policy domains. Many elements of best practice exist in policy, incentives, planning,*

[42] Campbell et al 2017 Reflections on four decades of land restoration in Australia *The Rangelands Journal*
[43] Campbell et al 2017 Reflections on four decades of land restoration in Australia *The Rangelands Journal*

> *regulation and on-ground practice."* If these were integrated, *"Australia would have a world's best natural resource management framework. However, we have neither integrated these elements at multiple scales nor sustained them. Unfortunately, although we are excellent at innovating, we have been equally good at forgetting. Progress remains partial, patchy and slow. Too often, we have made gains then gone backwards, reflecting a tendency towards policy adhockery and amnesia. With Australia's continuing depreciation of institutional memory, we risk losing critical capabilities for making sound policy decisions."*

Integrating trees on farms can contribute significantly to sequestering carbon, while providing farmers with multiple on-farm benefits, including income diversification and productivity gains from improved shade and shelter for livestock, increased biodiversity, and increased soil quality. More trees on farms will add to Victoria's productive plantation sector and provide an expanded biomass resource, supporting manufacturing of essential low-carbon materials into the future (Section 4).

Adoption of agroforestry at scale has been constrained by inadequate institutional arrangements. There are few examples of commercial investment. The few include oil mallee plantings to generate multiple products in Western Australia and industrial scale Eucalyptus plantations in higher rainfall areas.

Yan Yan Gurt Creek, Victoria

The Yan Yan Gurt Creek Story demonstrates that trees do not have to be at the expense of on-farm production. Between 1990 and 2002 forest cover in the Yan Yan Gurt Creek catchment increased from 6% to 21% of the total area. More than 20 families have planted trees on cleared farmland with at least 10 managing their trees for sawlogs production.

The catchment's diversity reflects the diversity of aspirations and interests amongst the landholders, industry players and their supporters. Tree plantings owned by farmers, and dispersed through the farming landscape, are acceptable to this rural community.

Family and farm forestry contributes to future wood supply while ensuring that commercial tree growing has local community support, underpins sustainable agricultural production and delivers real environmental benefits.

In 1990, 6 per cent of the Yan Yan Gurt Creek Catchment, incorporating Deans Marsh near Colac, had forest cover. By the turn of the century forest cover was up to 21 per cent. Part of the story documented by the Otway Agroforestry Network is reproduced below.

Figure 11 Yan Yan Gurt creek catchment showing what's possible with agroforestry.

"The narrow Yan Yan Gurt Creek Catchment runs through farmland from the Otway Ridge to the Barwon River. As it passes through the foothills it becomes saline, rendering once fertile flats unproductive.

By 1990, native forest cover had been reduced to just 5% of the total area. An additional 1% of the catchment had been planted to trees. The unprotected creek banks were easily eroded, adding sediment and nutrients to the flow. More than 80% of the landscape was devoid of any useful wildlife habitat or stock shelter. It was about this time that local farmers formed the local East Otway Land Protection Group and the regionally focused Otway Agroforestry Network. The emphasis of both groups has since been on assisting landholders in the design, establishment and management of multipurpose revegetation projects on their farms. These reflect individual landholder aspirations, and also the interests of the wider community. Soon after, Midway Pty Ltd, and later other plantation companies, began establishing eucalypt plantations for pulpwood in the area.

By 2002, 281ha of forest had been established on cleared farmland increasing the forest cover from 6% to 21% of the total catchment area. Ninety hectares of this was conventional eucalypt pulpwood plantation on company owned land and a further 15ha was owned by a forestry company but planted on farmers' land. The remaining 175ha of new forest is owned by a minimum of 20 families.

Forest design and management indicates that at least 10 families are actively pursuing commercial timber production. Together they now own 147ha of commercial trees that represents 8% of the total catchment area. These plantings commonly include more than one species and are generally designed to provide land protection, shelter and habitat as well as timber.

This catchment, and the surrounding East Otway region, has become a show piece for family and farm forestry contributing to significant landscape change supported by the local community, local government, timber industry and Corangamite Catchment Management Authority."

4.2 Next Generation Plantations

One option for integrated planting involves belts or blocks of plantation timber interspersed with conventional farming. Access to land for dedicated plantation estates has become challenging following the surge in property prices over the past two decades and the inflow of tree changers moving from urban areas. Incorporating forestry plantations, in various spatial patterns, into existing farming operations provides an opportunity to expand plantation tree resources in Victoria. The fall in the cost of capital reflected in historically low long-term interest rates has increased the present value of long-term investments like plantations. Private markets have yet to adjust fully to the reduction in the cost of capital, leaving larger roles for public investment.

The University of Melbourne has undertaken extensive research on integrated timber plantations and carbon plantings in Victoria as part of its Next Generation Forest Plantation Investment (NextGen)[44] and associated Growing Landscape Carbon projects[45]. In the past the Joint Venture Agroforestry Program[46] investigated the many opportunities for integrating diverse native and exotic species into productive farm operations for commercial and conservation purposes. While the NextGen project focused on large scale commodity timber and processing industries that gravitate to high productivity zones, the JVAP R&D program explored a wide variety of species, products and values the can be employed throughout rural landscapes, including in the lower rainfall cereal cropping districts.

Biomass and timber will be increasingly valuable resources in the low carbon economy. Well-managed, forests provide a renewable resource that can support large and complex regional industries. Expanding the plantation estate through farm forestry or dedicated plantations expands this renewable resource.

Plantations must be well planned and managed. Land selection is important. Species must be suited to the growing conditions. Markets must be available within an economic transport range. Access and planting geometries affect the harvesting efficiency (Section 6).

Three existing plantation zones were identified by the NextGen project to be prospective for new models of plantation investment. These are centred on the Latrobe Valley, Colac-Otways and the Green Triangle between Portland and Mt Gambier.

[44] Next Generation Forest Plantation Investment
[45] Growing Landscape Carbon
[46] Powell J, (2009), *Fifteen years of the Joint Venture Agroforestry Program – Foundation research for Australia's tree crop revolution*, Rural Industries Research and Development Corporation, ISBN 1741518652

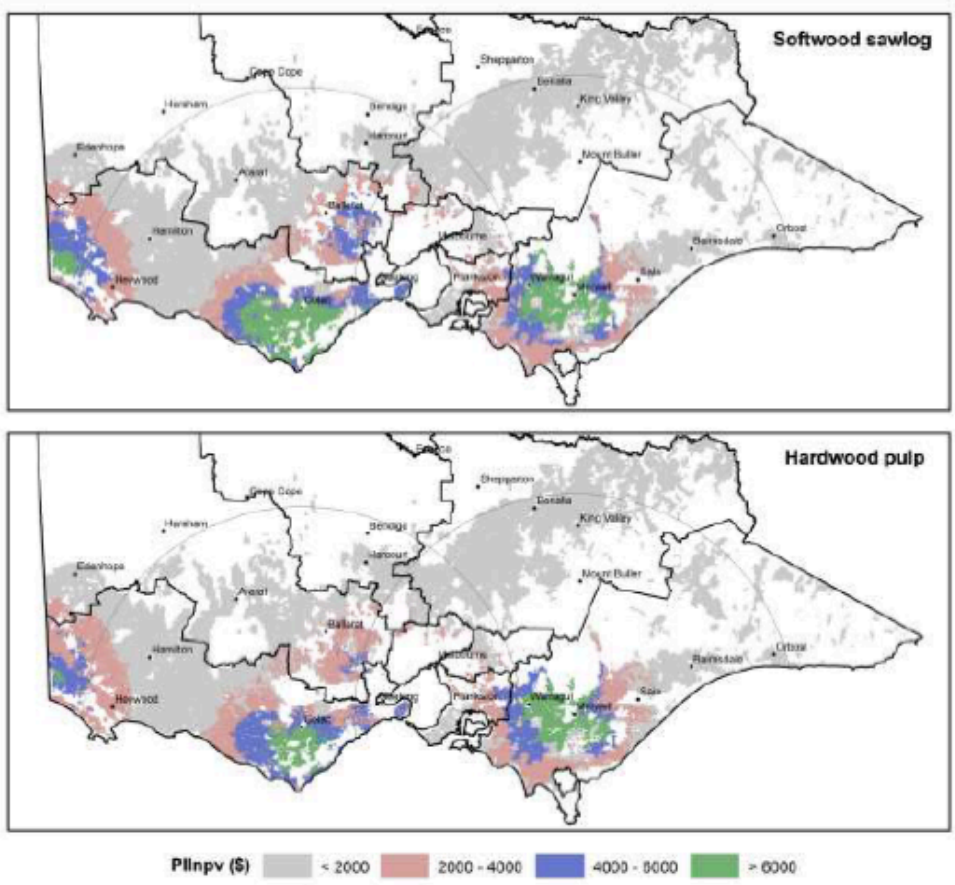

Figure 12 NextGen spatial Plantation Investment Index. Represented in colour classifications for $/ha.

Victoria's agroforestry strategy launched in 1989 identified the potential for integrated plantations to supply forestry products on an equivalent scale to native forest harvests. While the strategy has languished, the potential it identified has been demonstrated on some individual farms and in some neighbourhoods. In just over a decade the area of planted trees increased from just 6% to 21% of the total area of Yan Yan Gurt Creek catchment (see box text above).

4.2.1 Forestry and biomass supply

4.2.1.1 Constraints and opportunities to integrated plantings

Expanding the timber and biomaterials industry represents a significant opportunity for Victoria. These opportunities are based on large areas of relatively well-watered fertile land suited to plantations and carbon reafforestation and established processing capacity.

Constraints to expanding the plantation timber and farm forestry sector have been identified by research dating back several decades[47]. They include smaller land titles, higher cost land (compared with other states), significant fire risks and a history of opposition to plantations transforming farmland.

On the positive side, Victoria has good infrastructure and a long-standing, productive and internationally competitive plantation sector that generates substantive wealth and employment.

Agroforestry networks active in Gippsland and the Otways have pioneered and promoted integrated agroforestry production systems. They have explored different species and silvicultural strategies, demonstrating the potential of community driven innovations[48,49,50]. With limited support from governments, these groups have been able to provide innovative extension and education services promoting multi uses of trees in the rural landscape.

Figure 13 On-farm biomass production provides multiple ecosystem services, including habitat provision and sequestering carbon.

[47] Alexandra J. and Hall M. (1998) *Creating a viable farm forestry industry in Australia—what will it take?* Final Report of the project 'Policy Reforms for Farm Forestry' RIRDC Canberra
Schirmer, J, Bull L 2014 Assessing the likelihood of widespread landholder adoption of afforestation and reforestation projects - Global environmental change, 2014
University of Melbourne 2020 Grow Landscape Carbon Growing Landscape Carbon | Online Brokerage Platform Final Project Report https://growcarbon.science.unimelb.edu.au/
[48] https://www.gippslandagroforestry.com.au
[49] http://agroforestry.org.au
[50] http://www.oan.org.au/

For over thirty years, the primary approach to promoting agroforestry has been information provision. Other constraints are more significant in impeding afforestation in general and integrated commercial and environmental tree growing in particular. These impediments include policy instability (especially after the MIS schemes), lack of suitable finance models, desire for flexible land use options and uncertainty about carbon policies and harvesting rights[51].

Stop-start agroforestry policy settings have constrained realisation of the potential of integrated plantings. The Victorian Agroforestry Strategy launched by the Minister (later Premier) Joan Kirner in 1989 has been largely ignored and therefore tacitly abandoned. Proposed Government support mechanisms mostly evaporated without trace or justification. The restructuring of departments and the downscaling of staff levels resulted in loss of corporate memory. The strategy's aspirational 30-year target of generating the majority of Victoria timber from farm forests by 2019 failed dismally. The Next Gen plantation reports show that potential exists to reach the targets later[52].

The failure of the Managed Investment Schemes tarnished the reputation of plantation investments. Lessons from their rapid expansion and demise are outlined below.

The Managed Investment Scheme experiment

Generous tax treatment underpinned the rapid expansion of the plantation estate via the Managed Investment Schemes (MIS) in the early twenty first century.

In the 1990s, debates about harvesting native forests in Australia were heated. Protests included log trucks blockading the nation's parliament. There were national inquiries and reform plans, eventually resulting in the Regional Forest Agreements which focused on native forests. Industry and governments adopted the target of tripling the area of plantations. The new policies supported rapid expansion with specialist investment companies raising substantial capital from small investors. The area of eucalyptus plantations grew from almost nothing in 1998 to about 1 million hectares by 2008.

The Managed Investments Act (1998) enabled investors whom the ATO deemed to be primary investors to substantially lower their taxable income in the year of their purchase of a small fraction of a planned plantation project.

The absence of careful analysis prior to legislation of taxation incentives in the MIS led to adverse financial, economic, environmental and rural community impacts.

Three factors led to the demise of most of the Managed Investment Scheme (MIS) companies involved in plantation establishment and management. Firstly, the global financial crisis increased the cost of borrowing for long-term investments, especially those deemed to be exposed to sovereign risk like forestry. Secondly, a change in one new tax rule resulted in significant cash flow problems for the MIS

[51] Alexandra J. and Hall M. (1998) *Creating a viable farm forestry industry in Australia—what will it take?* Final Report of the project 'Policy Reforms for Farm Forestry' RIRDC Canberra

[52] University of Melbourne 2020 Grow Landscape Carbon Growing Landscape Carbon | Online Brokerage Platform Final Project Report https://growcarbon.science.unimelb.edu.au/

companies. The 13-month rule had allowed companies to take investments and develop the plantations over two financial years. This was changed to limit tax deductions for capital expenditures occurring only in the year of the investment. Thirdly, there had been strong expectations that the MIS companies would benefit from Australia establishing an Emissions Trading Scheme, which would have generated large value from the sequestering of carbon. An Emissions Trading Scheme was not legislated when expected in 2009. The abandonment of the planned carbon market downgraded the value of plantation companies.

Timbercorp, Forest Enterprises Australia, Great Southern Plantations and other companies went into liquidation. Although investors lost much capital, the plantations continued to grow. Extended court cases resolved questions of ownership and liability. The intricate ownership patterns, land-leasing and legal structures took marathon court cases and years to unwind.

The restructuring and liquidation of the companies' assets provided an opportunity for institutional investors to consolidate the ownership of the plantations. New Forests Pty Ltd acquired over 700,000 hectares, and Global Forest Partners over 150,000 hectares. Private investors bought many smaller lots. Of the 700,000 hectares of land under ownership of New Forests Pty Ltd, there was a mix of agricultural land, native forest and plantations.

Many MIS plantations were poorly sited for climate and soils, used inappropriate species, or suffered from drought, pest or disease. Some have been written-off, bulldozed and returned to pasture. Others are likely to be. Current estimates suggest that up to a third of the eucalyptus plantations are uneconomic in the absence of a carbon price, with harvesting unlikely. Another third will probably be harvested but unlikely to be replanted to the same species. The rest will form Australia's future hardwood plantation estate.

4.2.1.2 Lessons from the MIS experiment

The absence of clear economic principles from design of taxation incentives allowed distorting schemes to be promoted by financial advisers.

The focus on financial engineering led to inadequate attention being given to the siting, markets and productivity of the plantations.

The MIS expansion generated political opposition to plantations. Concerns about impacts on stream flows may account for the 600ml rule excluding high rainfall plantation from the ERF.

Policies designed to increase plantings for biomass or carbon in the future need to heed the lessons from the MIS. These include the fragility of plantation investments based on special rather than general tax incentives; the importance of stable policy settings and the cost of changes to rules; and the need for long-term perspectives.

4.2.2 A coordinated agenda

Sound policy and institutions are necessary for success of forestry, landscape carbon and plantations. Some policy settings and institutions encourage short-term exploitation of natural resources (including

the soil and landscape carbon), simple technologies and transactions and low-value commodity or raw material exports. Others encourage longer-term perspectives, greater investor confidence and utilisation of more valuable complex value chains and adding of value[53].

Establishing and enforcing market rules is a primary state function. Global timber and wood fibre markets are well-established. Carbon markets are emerging with rapidly evolving rules, and their evolution has been distorted in Australia by the absence of shared perspectives on climate change and decarbonisation. High levels of political leadership and skilful policy design are required for this market to function well in Victoria.

The state determines the features, dynamics and characteristics of all markets. This is particularly clear in land use for carbon sequestration and biomass production, which depend on clear specifications of access and property rights, and where sovereign risk and investment confidence in policy stability shape outcomes over generational time scales.

The Victorian plantation industry is based largely on resources established either directly by the State (the bulk of the softwood estate), or in the case of the recently established hardwood plantations, the tax incentives provided via the managed investment schemes supported later by expectations of an Emissions Trading Scheme[54].

4.2.3 Clarity of policy instrument selection

Public sector agencies have promoted the expansion of plantations through regulation, investment facilitation and investment as an owner-operator. The latter role (owner-operator) typified the development of the softwood plantation estate in Australia from the 1930s to the 1980s. However, most State-owned plantations were privatised in the late twentieth and early twenty first centuries.

Historically, financial incentives for investment in plantations included loan schemes and grants; tax concessions; and provision of infrastructure, R&D, extension and information[55]. Softwood plantations were established by direct involvement of state-owned enterprises.

In contemporary Australian public policy, governments rarely take on roles that can be provided efficiently by the market. The overview described a number of areas in which the presence of costs and benefits external to the firms in the plantation timber, carbon and biomass industry require interventions by government for efficient outcomes.

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[53] West, J, "The Mystery of Innovation: Aligning the Triangle of Technology, Institutions and Organisation", Australian Journal of Management, 26 (Special Issue) pp. 21-43. ISSN 1327-2020 (2001)

[54] Alexandra, J., & Campbell, A. (2003). Plantations and sustainability science: the environmental and political settings. Australian Forestry, 66(1), 12-19 https://www.researchgate.net/publication/239745558_Plantations_and_sustainability_science_The_environmental_and_political_settings

[55] Tree plantation investment and partnerships in Australia: an analysis of past experiences Braden Jenkin, Rodney J Keenan and Lyndall Bull Report 1 Next Gen Plantations https://cpb-ap-se2.wpmucdn.com/blogs.unimelb.edu.au/dist/d/279/files/2019/03/MELBUNI-Treeplantations-A4x16p-FINART-revised5-002-1wq2ef1.pdf

Recent research by The University of Melbourne[56] identifies a range of reforms across the local, state and national government that are required to realise the potential and overcome the constraints to expanding Victoria plantations. For example, it identified the need for state coordination of aspects of plantation development, such as regional brokerage services that facilitate market linkages. Private Forest Tasmania provides an example of a public agency established to fulfil this and other coordination roles.

There is an extensive literature on the choice and selection of policy instruments targeted to achieving specific societal outcomes. In this case the need for rapid decarbonisation of the economy provides the macro settings[57],[58],[59].

It is essential that policy interventions are directed at clearly defined public good outcomes. Further, it is important that public sector involvement does not crowd out the private sector in areas where competition allows it to provide efficient outcomes. It is important, too, that intervention does not stifle innovation through anti-competitive use of State powers[60].

Land prices, forest growth rates, rainfall and proximity to infrastructure, including ports for exports or major mills determine the competitiveness of plantations in most locations[61]. If plantations are integrated into agricultural and pastoral systems, the opportunity cost of land use for planting trees is lower and sometimes zero or negative. The statutory planning system constrains land use and has been problematic for plantations in many areas.

A detailed study of the Goulburn Broken catchment[62] has illuminated barriers to successful land use change. Victoria's multi-functional rural landscape needs to be recognised. False binaries about competing uses of land need to be contested.

4.2.4 Multipurpose rural landscapes

After four decades of land restoration programs there is an extensive literature on engaging landholders in reafforestation[63]. There are many determinants of their willingness to engage in and undertake

[56] University of Melbourne 2020 Grow Landscape Carbon Growing Landscape Carbon | Online Brokerage Platform Final Project Report https://growcarbon.science.unimelb.edu.au/

[57] Enters T, Durst PB and Brown C 2003 What Does it Take? The Role of Incentives in Forest Plantation Development in the Asia-Pacific Region UNFF Intersessional Experts Meeting on the Role of Planted Forests in Sustainable Forest Management, 24-30 March 2003, New Zealand

[58] Alexandra J., Bonacci M., and Riddington C., (2007), *Public-private partnerships for regional reforestation* The Rural Industries Research and Development Corporation www.rirdc.gov.au https://www.academia.edu/7921571/Public-private_Partnerships_for_Reforestation_Potential_frameworks_for_investment

[59] Alexandra & Associates Pty Ltd, (2002) *Landscape Change in the Goulburn Broken Catchment Final Report*, Goulburn Broken Catchment Management Authority, Shepparton

[60] Alexandra J. and Hall M. (1998) *Creating a viable farm forestry industry in Australia—what will it take?* Final Report of the project 'Policy Reforms for Farm Forestry' RIRDC Canberra

[61] University of Melbourne 2020 Grow Landscape Carbon Growing Landscape Carbon | Online Brokerage Platform Final Project Report https://growcarbon.science.unimelb.edu.au/

[62] Alexandra & Associates Pty Ltd, (2002) *Landscape Change in the Goulburn Broken Catchment Final Report*, Goulburn Broken Catchment Management Authority, Shepparton

[63] Campbell A., Alexandra J., and Curtis D., (2017) Reflections on four decades of land restoration in Australia *The Rangeland Journal* - https://doi.org/10.1071/RJ17056 https://www.academia.edu/35405868/Reflections_on_four_decades_of_land_restoration_in_Australia

afforestation.[64], [65]. Program goals that recognise the human and economic dimensions of multipurpose plantings in multi-functional landscapes are required.

It would help to engage landowners in reafforestation if monetary rewards were developed for contributions to environmental services beyond carbon. These would include water catchment protection, salinity and erosion control and habitat enhancement (corridors, buffers etc). For example, an urban water authority could offer payments for landscape services to improve water quality.

The history of introducing then failing to follow through with programs to encourage landholder investment in afforestation has increased perceptions of risk. A period of stability in policy settings is necessary for success[66],[67].

4.2.5 Concerns about land use change

Concerns about plantations driving land-use change have been important for several decades[68]. These focus on loss of employment and changes to landscape character and 'rurality'[69]. Perceptions of socio-economic impacts differ markedly from actual impacts, especially on employment[70]. Williams and Schirmer (2012) note that regional land-use change results from,

> *"decisions made at an individual or property scale influenced by regional, national and global norms, environmental change, policy and market forces. As such, the extent and impacts of change may be highly variable across even relatively small areas. A shift in what is grown on the land is accompanied by flow-on changes in socio-economic production systems, such as a shift to new forms of land ownership (for example, from the family farm to corporate management), or in the supply chain, for example through intensification of production."*

A review of several studies[71] found between 1.3 and 1.9 jobs are generated for every 100 hectares of softwood planation in mature softwood plantation regions with the majority in harvesting and processing. Therefore, the regional employment impact is dependent on the location of processing facilities.

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[64] Schirmer, J, Bull L 2014 Assessing the likelihood of widespread landholder adoption of afforestation and reforestation projects - Global environmental change, 2014

[65] Ross M, Emily S, Bernhardt, Doyle M, Heffernan J (2015) Designer Ecosystems: Incorporating Design Approaches Into Applied Ecology Annual Review of Environment and Resources 40 (1). Annual Reviews: 419–43. doi:10.1146/annurev-environ-121012-100957.

[66] Schirmer, J, Bull L 2014 Assessing the likelihood of widespread landholder adoption of afforestation and reforestation projects - Global environmental change, 2014

[67] University of Melbourne 2020 Grow Landscape Carbon Growing Landscape Carbon | Online Brokerage Platform Final Project Report https://growcarbon.science.unimelb.edu.au/

[68] Alexandra, J., & Campbell, A. (2003). Plantations and sustainability science: the environmental and political settings. *Australian Forestry*, *66*(1), 12-19 https://www.researchgate.net/publication/239745558_Plantations_and_sustainability_science_The_environmental_and_political_settings Campbell A., Alexandra J., and Curtis D., (2017) Reflections on four decades of land restoration in Australia *The Rangeland Journal* - https://doi.org/10.1071/RJ17056 https://www.academia.edu/35405868/Reflections_on_four_decades_of_land_restoration_in_Australia

[69] Barlow K, Cocklin C, 2003 Reconstructing rurality and community: plantation forestry in Victoria, Australia, Journal of Rural Studies, Volume 19, Issue 4, 2003, Pages 503-519, https://doi.org/10.1016/S0743-0167(03)00029-9

[70] Williams KJH, Schirmer J, 2012 Understanding the relationship between social change and its impacts: The experience of rural land use change in south-eastern Australia, Journal of Rural Studies, Volume 28, Issue 4, 2012, 538-548, https://doi.org/10.1016/j.jrurstud.2012.05.002.

[71] Schirmer, J, 2006 Socio-Economic Impacts of Land Use Change to **Plantation** Forestry: A Review of Current Knowledge and Case Studies of **Australian** Experience Proceedings of the 2006 IUFRO Forest **Plantations**

Likewise, CSIRO's analysis[72] demonstrated that:

> *"employment in industrial plantations was found to be comparable to alternative land uses, suggesting forestry does not result in a net loss of regional jobs."*

This study also concluded that realising the considerable potential for carbon sequestration through industrial plantation management depends on the carbon price. Limiting institutional factors, such as policies restricting plantation expansions on agricultural land, are less important. Obviously, the effects on rural employment and incomes are more favourable when plantings occupy parts of established farms rather than completely replacing farming in some areas.

4.3 R&D for Industry Development

The presence of externalities in R&D warrants government support. R&D can range from genetic improvement to processing and marketing innovations. The current plantation estate is dependent on a few species (mostly *Pinus radiata* and eucalyptus from the blue gum family *E. globulus* and E. *nitens*). These species have been selected and bred so that more productive strains are available. Many other potential plantation species show enormous potential.

Many prospective native species possess a high degree of resilience to climate variability[73]. However, research is limited and more work is necessary to capitalise on the adaptive capacity of a broader range of potential commercial species[74]. Economic research is required to increase understanding of the role of slow-growing timbers of higher quality, the economic value of which has been increased by the fall in long-term interest rates. More research is required on opportunities to generate value from forestry from lands with demonstrated low value in agricultural and pastoral activities.

R&D is also needed on adaptation to climate change. A range of adaptation options for forestry remains under-explored or unimplemented within Victoria including:

> *"gene management programs and off-site gene banks, ex-situ conservation and increasing cooperation in species management, increasing stand and regional species diversity, identification and deployment of more drought or disturbance-tolerant species or genotypes, planning to reduce diseases losses through monitoring and sanitation harvests, managing stand structure to reduce impacts on water availability, and implementing silvicultural techniques to promote stand vigour[75]".*

Historically, governments have played active roles in investigation and commercial trials of timber species and provision of R&D infrastructure for industry development. However, public investment in

[72] Paul, K.I., A. Reeson A, Polglase P, Ritson P., 2013 Economic and employment implications of a carbon market for industrial plantation forestry, Land Use Policy, Volume 30, Issue 1, 2013, Pages 528-540, https://doi.org/10.1016/j.landusepol.2012.04.015.
[73] Booth, TH, Broadhurst, LM, Pinkard, E, Prober, SM, Dillon, SK, Bush, D, Pinyopusarerk, K, Doran, JC, Ivkovich, M & Young, AG 2015, 'Native forests and climate change: Lessons from eucalypts', *Forest Ecology and Management*, vol. 347, pp. 18-29.
[74] Keenan, R., 2015: Climate change impacts and adaptation in forest management: a review. *Official journal of the Institut National de la Recherche Agronomique (INRA),* 72, 145-167
[75] Keenan RJ and Nitschke C (2016) Forest management options for adaptation to climate change: a case study of tall, wet eucalypt forests in Victoria's Central Highlands region. *Australian Forestry* 79(2): 96–107 https://doi.org/10.1080/00049158.2015.1130095

forestry and timber processing research and education has declined. More R&D is required on sequestering carbon, and expansion of supply of biomass for bio-economy and industrial transformation[76,77].

R&D should guide innovation in the processing and marketing of timber and biomass production. Some innovations will be technical, some economic and some social. For example, there is growing international acceptance and interest in the forest stewardship certification system. This interest can be found in retail timber sales of FSC certified and sustainably harvested timbers due to consumer concerns about illegal and unsustainable harvesting, including in tropical rainforests.

R&D on forestry and related subjects suffers from being too small for the task, fragmented, and lacking strategic focus and strong institutional backing. These weaknesses can be corrected by focus on the low carbon transition including its industrial dimensions, and support from a major state corporation with this focus. With this focus, projects should be funded for periods that allow fruition of investments (at least two by five years), with collaboration across government agencies, universities and the private sector.

Priorities for R&D include:

1. Synthesising existing knowledge and practices in growing and processing, including documenting and analysing generation of trials on-farm and in experimental plots.

2. Improving carbon measurement methodologies that lower transaction costs.

3. Selection and genetic improvement of highly prospective species and improving site and species selection for production and processing. Further development in species suited to high-grade solid wood products such as spotted gum (Corymbia maculata), Yellow Stringybark (E. mullerana), flooded gum (E. grandis) and durable species such as Sugar Gum (E.cladocalyx), river red gum (E. camaldulensis), rainforest and exotic species that have not been seriously investigated.

4. Understanding value generation from multiple sources at farm, landscape and catchment levels.

5. Processing technologies suited to the bio-materials sector.

6. Integrated production and land management regimes for ecosystem services including fuel load management and reducing bushfire impacts in peri-urban landscapes.

[76] Bryan, Brett & Meyer, Wayne & Campbell, Andrew & Harris, Graham & Lefroy, Edward & Lyle, Greg & Martin, Paul & Mclean, Josie & Montagu, Kelvin & Rickards, Lauren & Summers, David & Thackway, Richard & Wells, Sam & Young, Mike. (2013). The second industrial transformation of Australian landscapes *Current Opinion in Environmental Sustainability* 2013. 1-10. 10.1016/j.cosust.2013.05.011.
[77] Alexandra J., (2017) Water And Coal – Transforming and Redefining 'Natural' Resources in Australia's Latrobe Region *Australasian Journal of Regional Studies*

7. Research into species that are resilient to climate change. More work is needed to utilise the adaptive capacity of a broader range of species and their growth rates in relation to increased drought and bushfire.

Perspectives from a wide range of disciplines from the natural and social sciences need to be brought together. R&D needs to be integrated across agriculture, water and regional development.

Landscape carbon and planted forests R&D

The Victorian State Government has a long and proud tradition of forestry R&D and education. It founded the Victorian School of Forestry (VSF) at Creswick in 1910. This is one of the oldest forestry schools in the English-speaking world. Since inception it has focussed on improved land and forests management and overcoming degradation.

The creation of VSF was one of the many recommendations of a Royal Commission between 1897 and 1901 into forest degradation. The first tertiary forestry school in Australia, VSF was administered by the Forests Commission Victoria (FCV) until 1980, when VSF amalgamated with the University of Melbourne to become that institution's School of Ecosystem and Forest Sciences.

Forestry R&D and education are critical to the emerging opportunities arising from growing landscape carbon and the new biomass industries. However, both have declined in recent decades. There is concern that the University of Melbourne may abandon education at Creswick. Historically, the Victorian State Government has played significant roles in forestry innovation, funding research institutes and programs. However, public sector investment has shrivelled.

Forestry and related R&D and education is an essential component of a broader strategy to mobilise the skills and capabilities needed to develop carbon sinks and biomaterials feedstock for the transition to a low carbon economy.

The wood fibre processors pay a levy to Forest and Wood Products Australia (FWPA) – the forestry R&D Corporation established under the PEIRD Act in the late 1980s, funded by the Commonwealth and processor levies. FWPA deliver programs designed to expand the market for forest and wood products, increase productivity and profitability across the value chain, and ensure positive environmental and social outcomes. FWPA focuses mostly on commercial processing. Other R&D is undertaken within the universities and CSIRO. In broad terms, the Commonwealth has historically funded more of the pure research through the ARC and CSIRO. The States are focused more on the applied end, and industry on commercial prospects.

5 Renewable resources sustaining low carbon regional industries

1. **It is estimated that 8 million tonnes of biomass residues are available annually across Victoria. Expansion and utilisation of this resource can underpin high value regional industries.**
2. **Innovation and commercialisation in the biomaterials sector is proceeding internationally due to the prospect of low carbon materials, chemicals and energy.**
3. **Major processing hubs for large scale processing of biomass are identified in the Latrobe Valley and Green Triangle. Smaller scale processing hubs also have potential in the upper Murray Valley, Barwon, and the Mallee/Wimmera (Mildura or Horsham).**

Timber and wood biomass will play a significant role in the low carbon economy. Victoria has substantial natural and human resource advantages in nurturing the production and use in manufacturing of biomass. Embracing this opportunity and supporting long term evolution of this industry will provide a regional industrial base not dependent on a finite resource, as are industries based on fossil carbon.

Renewable resource of the low carbon economy

Biomass is a renewable hydrocarbon. Just as fossil hydrocarbons have been an indispensable part of the 20th century economy, biomass will be a pillar of the low carbon economy. Biomass can be converted into a wide variety of biomaterials and bio-chemicals. Building a renewable biomass resource base will be essential to developing high value processing industries that invest and reinvest for the long term. Regional economies built around renewable resources and industries drawing inputs from them will be sustainable.

Regional biomass processing hubs

Biomass processing refineries (biorefineries) convert primary resources into high value combinations of goods and energy. The residues of one process is the feedstock or energy of another. Biorefineries will evolve over time as new products are developed and the economics of the low carbon economy change. Having a secure resource is essential for attracting investment and responsible stewardship certification an advantage.

Logistic efficiency is essential for competitive production. For this reason, biomass processing hubs will be close to resource growing regions. The Latrobe Valley and the Green Triangle are the standout prospects for this industry, with other possibilities in the Geelong-Colac region and the North East. The drier West (Mallee-Wimmera) has important prospects for growing and harvesting mallee, combined with decentralised processing and transport of processed industrial inputs with higher rations of value to volume to centralised processing facilities.

Small scale and distributed processing

Timber and biomass from farm forests and agricultural residues can supply smaller scale processing facilities producing specialty products or converting local waste to useful inputs, long-lived carbon stores and energy.

5.1 Renewable resources for the low carbon economy

Unlike the depleting reserves of 20th century industry, the low carbon economy will be linked to renewable resources that are part of the natural flows and cycles of the planet: water, sunlight and atmospheric carbon coming together to produce hydrocarbons through photosynthesis. Carefully stewarded, renewable resources never deplete. Infrastructure built around renewable resources need never be stranded. Renewable resource boomtowns need never bust.

Regional communities across Australia are contending with the closing days of industries that have defined and supported them for as long as most can remember. Coal mining towns today, like the gold mining towns of the 19th century, will run their course. While Australia is accustomed to 'boom and bust', few Australians are comfortable with the reality. Economic insecurity and decline stigma leads to social decay and a negative outlook. This reality is faced by many communities in the adjustment away from industries that deplete their resource base or create unacceptable pollution.

Trees are a renewable resource and forestry biomass will be a pillar of the low carbon economy. Victoria has competitive advantage in forestry with productive growing conditions and access to a competent and established industry. This industry value chain is long and rich in employment- all the way from seed raising, through harvesting, milling, manufacture and utilisation as construction timber, paper or furniture. A commitment to managing these resources responsibly for the long term will attract the investment of industries that continue and evolve.

The availability of globally competitive zero emissions electricity is a natural complement to industrial production and will be another source of sustained competitive advantage in Australia.

Over the years, the potential of biomass for high and low value chemicals and fuels has been extensively explored. Brazil and the U.S. have at various times mandated biofuel blends across different state and federal levels. Biorefineries for bio-chemicals have been developed in the European Union, U.K., Japan, Scandinavia and the U.S. The availability of low-cost renewable electricity means that electrification rather than biofuels will be the route to zero emissions in land transport. Hydrogen-based thermal energy, probably with ammonia as a hydrogen carrier, may be cost-effective for sea transport. Biofuels will have a strong and valuable place in zero emissions civil aviation for a long period into the future.

Benefits external to the investing firm provide strong economic justification for fiscal support for commercialisation of new technologies. The absence of economically rational carbon pricing increases the external benefits generated by innovation in zero emissions investment in new industrial activities.

This biomass resource has been investigated a number of times by the CSIRO as the basis for an energy or material substitute for fossil hydrocarbons. A 2016 analysis[78] provides an estimate of biomass potential according to type and location (Table 5).

[78] Crawford D et al., (2016), *A spatial assessment of potential biomass for bioenergy in Australia in 2010, and possible expansion by 2030 and 2050*, Global Change Biology

Table 5 2010 biomass potential in Victorian regions

Region	Stubble Kt/y	Plantation forest Kt/y	Waste Kt/y	Total Kt/y
Melbourne	11	0[79]	1046	1057
Barwon	130	151	75	356
Western District	188	1120	28	1336
Central Highlands	272	155	41	468
Wimmera	1488	191	13	1692
Mallee	1065	0	25	1090
Loddon	318	13	48	379
Goulburn	374	177	56	607
Ovens-Murray	34	264	26	324
East Gippsland	4	367	23	394
Gippsland	1	233	46	280
Totals	3885	2671	1427	7983

This analysis went further to include the potential of Short Rotation Trees (SRT) that grow tenaciously and are able to be coppiced at ground level on a rotation of around 5 years. Mallee coppice farming is a small but established enterprise in WA. It was initially introduced to contend with dryland salinity and climate change. It was encouraged in anticipation of, and then in response to, carbon pricing. The end of the Emissions Trading Scheme in July 2014 led to a slump in the WA industry, but past plantings have established a resource that can be utilised when value is again given to removing carbon from the atmosphere.

The CSIRO study assumed progressively reaching a 5% cover of available agricultural land. This is consistent with past research programs investigating the co-benefits of trees on farms. This would provide a resource twice the size of estimates of biomass from residues.

[79] While greater Melbourne has few plantation forest resources the entire metropolitan area is a large urban forest that generates an estimate 500,000m^3 of green waste (biomass) per year most of which currently goes to landfill.

Figure 14 Victorian biomass potential including future short rotation tree cropping

The integration of trees into the landscape is an opportunity to restore landscape function, carbon stocks and biodiversity habitat, as emphasised in Section 3 of this report. Many new plantings will not be intensively harvested. Mixed species vegetation can provide these co-benefits whether or not it is harvested.

Sourcing biomass from multiple waste pools, and from dedicated crops will build a larger base for the biorefinery industry in Australia. Government support and large-scale deployment of Energy from Waste systems is a significant opportunity. Victoria has large quantities of waste currently going to landfill that can become part of the bio-industrial resource based[80,81].

5.1.1 State-wide biofuel and biochar potential

Table 6 Indicative biomass conversion yields

Biomass conversion yield (per tonne)	Unit	Qty
Bio-ethanol	L	227
Bio-jet fuel	L	309
Biochar	t	0.34
CO2 sequestered/avoided	t	1.0
Syngas	GJ	4.86

Victoria has been estimated to have a lignocellulosic biomass residue potential in 2030 of 11Mt, when expansion of SRT crops is included and waste is omitted (Figure 14). It is recognised that petroleum fuels for intercontinental civil aviation will be the most difficult of all transport energy sources to replace with zero emissions energy sources. This will be a niche for biofuels, when most land transport will be driven

[80] Victoria State Government. 2020. "Department of Environment, Land, Water & Planning." Recycling Victoria, a New Economy. Accessed July 1st, 2020. https://www.vic.gov.au/transforming-recycling-victoria.
[81] Sustainability Victoria. (2018). Statewide waste and resource recovery infrastructure plan. Melbourne: Sustainability Victoria. Retrieved from http://www.sustainability.vic.gov.au/About-Us/What-we-do/Strategy-and-planning/Statewide-Waste-and-Resource-Recovery-Infrastructure-Plan

by renewable battery electric or hydrogen electric motors. Zero emissions long distance civil aviation will depend for the foreseeable future on biofuels. The Victorian lignocellulosic resource could produce 3,000ML per annum of jet fuel, one third of Australia's total current aviation consumption (international and domestic)[82]. This estimate is based on use of a jet fuel process using woody biomass, called BioChemCat. This is a result of Gevo-Washington State University collaboration.[83] The first flight using jet fuel from lignocellulosic residues was in 2016[84].

Studies predict maximum available lignocellulosic biomass Australia-wide could supply 34% of current gasoline use nationally. In total, first and second generation biofuels could mitigate 38% of road transport fuels and 5% of national emissions[85]. Calculations of total lignocellulosic waste in Victoria from 2010 would translate to 2 billion litres of ethanol fuel. Global production of bioethanol in 2016 was 100 billion litres. Comparatively, biofuel production in Australia in 2019 was an estimated 250 million litres, therefore Victorian bioethanol could provide 8 times the current national amount[86]. Fuel for electricity generation and road transport would be a wasteful use of a scarce and valuable resource, when renewable electricity can perform these tasks at lower cost. Nevertheless, these quantities illustrate the scale of the biomass potential for Victoria and Australia.

Biochar is co-produced with syngas and bio-oil from biomass via a process called pyrolysis. It consists of concentrated carbon that is stable for long periods (100-100,000 years) and so is an effective pathway to bio-sequestration. Hydrocarbon syngas is a versatile feedstock or energy source that can be used for heat, power or chemical synthesis. Processing the total 12.8Mt Victorian 2030 biomass residue (Figure 14) would produce 4.4Mt C/y in biochar. This carbon, extracted from the atmosphere by growing plants and locking it in biochar, would effectively sequester 12Mt CO2e/y. This is a potential ongoing sink that is around 10% of Victoria's current annual emissions. Biochar has other sources of value. Added to soils it improves soil quality, assists moisture retention, and leads to further accumulation of soil carbon through the support it provides for biota that increase carbon stocks. As an additive to feed for ruminant animals it leads to more complete digestion of hydrocarbon foodstuffs, lower methane emissions, and higher conversion of food into meat. It can replace fossil carbon in many industrial processes. Pyrolysis produces bioenergy as well as char—a gaseous or liquid hydrocarbon, that can be burnt for energy or used as an industrial raw material in place of fossil hydro-carbons.

Biochar is discussed further in Section 4.3.

5.1.1.1 Maximising biomass use and value with biorefineries

The low carbon economy in Victoria has opportunities to supply biomass products to domestic and international markets. Current biomass markets are oversupplied and generating low prices. This would change with restoration of global economic growth after the Pandemic recession and global progress towards removing emissions from industrial use of fossil carbon.

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[82] https://www.bitre.gov.au/statistics/aviation/av_fuel_sales

[83] https://nararenewables.org/documents/2017/06/production-of-jet-fuel-using-biochemcat.pdf/

[84] https://news.wsu.edu/2016/11/14/forest-powered-biofuel-flight/

[85] Farine et al., 2012, An assessment of biomass for bioelectricity and biofuel, and for greenhouse gas emission reduction in Australia. Global Change Biology Bioenergy. 4, 2, Pp 148-175

[86] https://apps.fas.usda.gov/newgainapi/api/report/downloadreportbyfilename?filename=Biofuels%20Annual_Canberra_Australia_11-7-2018.pdf

Different value pathways are constantly being developed to create new bioproducts. A typical pathway requires the breakdown and subsequent aggregation of biomass polymers, either through chemical or enzymatic processes. Other pathways require the use of microorganisms to reassemble molecules into useful polymers or chemical compounds. Presented below are some bioproducts that have high emitting fossil fuel counterparts they could replace. At the core of the bio-economy concept is the replacement of a non-renewable resource for a renewable lower emission substitute.

Table 7 Bioeconomy products, their environmental impacts and fossil fuel substitutes

Value stream	Products	Fossil carbon substitute
Sawn timber	Engineered structural products	Concrete or steel
Bio-aromatics	Platform chemicals and solvents	Oil or gas feedstocks
Bio-chemicals	Specialty chemicals, pharmaceuticals, adhesives, cosmetics, fertilizer	Oil or gas feedstocks
Bio-packaging	Polymers, textile fabrics, mouldable/stretchable paper	Oil or gas feedstock based polyester, PET & single use plastics
Bio-fibres	Rayon, carbon fibre	Metals and fossil feedstock plastics
Bio-char	Char, syngas, soil amendment	Coke, gas feedstocks
Bio-fuel	Diesel, jet fuel, gasoline	Oil
Bio-energy	Electricity, heat	Coal, gas

Shifting biomass in manufacturing, fuel and fibre from added-value products to in-demand products in a growing bio-economy is under development. The bio-economy will evolve as technology advances and the economics of carbon shift market demand. The Finnish Science and Innovation Institute (VTT) has developed a roadmap, that anticipates the path of evolution[87]. On this path the industry will grow from the bottom, at first utilising cheaper feedstocks such as woody residues for bioenergy and lower value products and diversifying into higher value products. Bioenergy production (as seen) largely prompts the blossoming of biorefinery systems due to low-cost energy production and approved technologies. Investment in R&D is required for higher value bio-products and has been seen to rely on bioenergy development and existing bioprocessing infrastructure such as paper and pulp mills.

Recent investment in Latrobe's Maryvale mill signals confidence in biomass-based industrial activity. Other countries have gone much further than Australia in developing forestry and biomass processing capabilities to take part in the economic transition.

Finland has an economically important biomass resource base and forestry industry. Producing large amounts of timber and pulp products, wood also provides 27% of the country's total energy consumption[88]. Finland has invested in a coordinated research, innovation and industry development

[87] Ahlqvist et al, (2013) : https://www.vttresearch.com/sites/default/files/julkaisut/muut/2013/VTT-CR-04761-13.pdf
[88] https://www.stat.fi/til/ehk/2018/04/ehk_2018_04_2019-03-28_tie_001_en.html

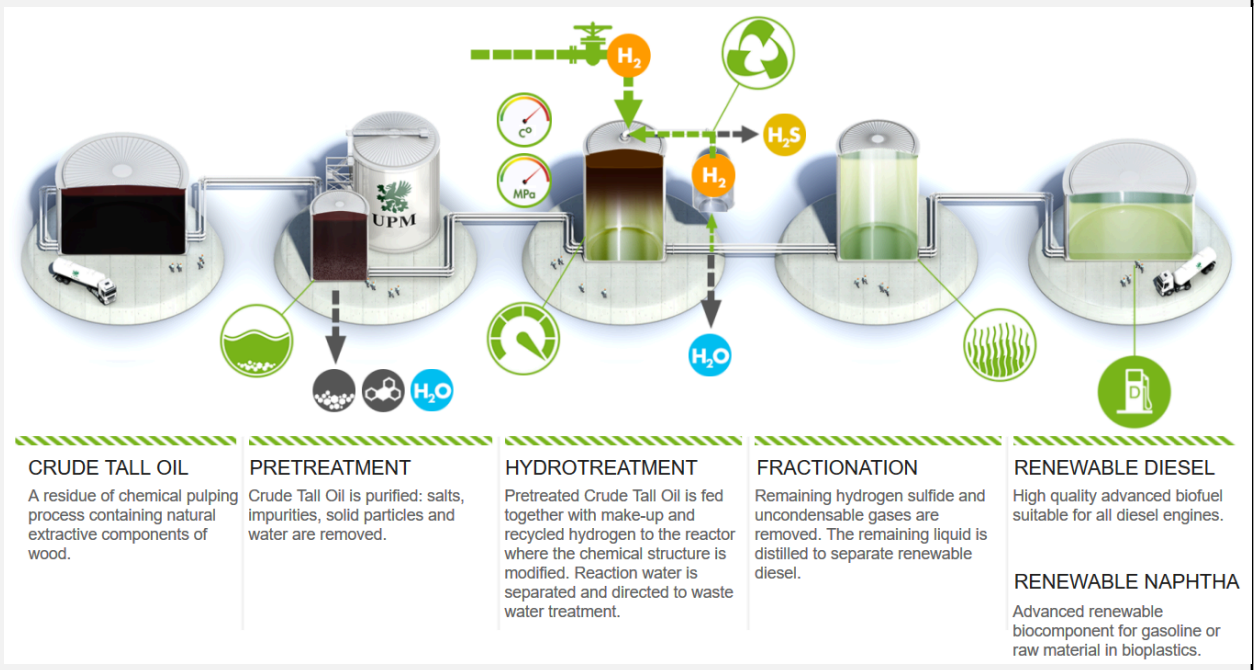
program led by Finnish Science and Innovation Institute (VTT). This program was designed to establish world-class competence in biomass conversion and to maximise the value of this resource to benefit their economy and carbon footprint.

The program has led to a series of investments in Finland extending wood pulping facilities and establishing facilities to produce a range of new high value products. As with fossil hydrocarbon refineries, these biorefineries produce a range of products that maximise resource use and value.

UPM Lappeenranta Biorefinery - Finland

The first commercial-scale biorefinery to produce renewable wood-based diesel and naphtha is located beside the UPM Kaukas pulp and paper mill, is helping to meet growing demand for biofuel in the European Union.

Renewable UPM BioVerno is made from wood-based tall oil by a hydro-treatment process developed at the UPM Research Centre in Lappeenranta, Southeast Finland. UPM is pioneering a transformation of the forest industry, seeking to use wood with optimal efficiency. It wants to maximise the lifecycle of wood-based raw materials replacing fossils.



Crude tall oil is a natural wood extract of mainly softwood origin. This renewable raw material comes from sustainably managed forests - extracted as a residue when separating wood fibre for pulp production. The renewable raw material for UPM BioVerno naphtha is crude tall oil. A residue of pulp making process, it does not increase wood usage.

UPM BioVerno naphtha is 100% bio-based and has identical physical properties to fossil-based naphtha. In the polymer industry, intermediate products such as naphtha are supplied in bulk and mixed during polymer production. It is ideal for replacing fossil raw materials in various innovative products such as plastics, glues or films. Every ton of wood-based UPM BioVerno used saves 3 tons of carbon dioxide emissions compared to fossil raw material.

Wood-based turpentine, a residue of UPM´s renewable diesel production, is a sustainable, non-fossil feedstock for aroma chemicals used in the fragrance industry. Aroma chemicals are used in many products from perfume, flavours and cosmetics to cleaning products and detergents. In fact, a large proportion of all aromatic molecules used in today’s fragrance industry are based on turpentine obtained from natural, renewable resources, such as wood biomass.

5.2 Regional industrial development potential

5.2.1 Current industry profile

Victoria has 8.2 million ha of forested land (34 % of the State's land area) of which 75% is publicly owned, and 25 % is private freehold tenure. Of the public forest estate, approximately 0.9 million ha is used to produce timber. Victorian forestry produced an estimated 9.5 million m^3 of logs in 2016-2017. Of this, 1.3 million m^3 were sourced from native forests and 8.2 million m^3 from plantations, with a total gross value of $731 million, ($108 million from native forests and $623 million from plantations)[89].

The total value added from this harvested round wood through elaborate value chains is significant. The forest industry value chain includes specialist plantation managers, harvesting and logging contractors, sawmills and specialist transport services. Eighty per cent of the Victorian commercial wood supply comes from 0.44 million ha of intensively managed plantations. Supplies are split roughly 50-50 split between softwood (pine) and hardwood (mostly Eucalypt) plantations. Currently, the majority of hardwood plantations are used for wood chip production. The majority of this is exported. However, some specialist plantation companies and many individual growers focus on solid wood production.

5.2.1.1 Regional capacity in the timber industry

Victoria's forest industries directly employ approximately 1,800 people, with the majority in rural and regional Victoria. An additional 14,500 people are employed in wood products processing and manufacturing, such as furniture and cabinet making, and 7,500 in paper production and distribution. However, these downstream processors are not entirely dependent on locally produced raw materials, as there are significant imports. Jobs and skills within forestry are increasingly technology, capital and information system-oriented[90]. Between 2011 and 2016, the total number of jobs within Victorian forestry decreased by 25% through consolidation of processing facilities, and efficiency gains.

Plantations are the major source of raw materials for Victoria's forest industries. Volumes harvested from native forest have declined steadily since the early 2000s due to shrinking log allocations from state governments.

The Victorian government transition plan to end native forest logging provides a $120m transition package for redundancies, retraining and financial support for affected businesses. The phase-out will result in greater reliance on plantation timber. Plantation stocks are a legacy of government initiative in previous eras. These include the Depression-era job creation planting schemes, the Commonwealth softwood loan schemes to the states and the MIS expansion of hardwoods.

[89] Karanja, F 2019, An Overview of Victoria's Agriculture Factsheet, Agriculture Victoria.
[90] DAWR (Department of Agriculture and Water Resources) 2018, Australia's State of the Forests Report: Executive summary, Australian Government.

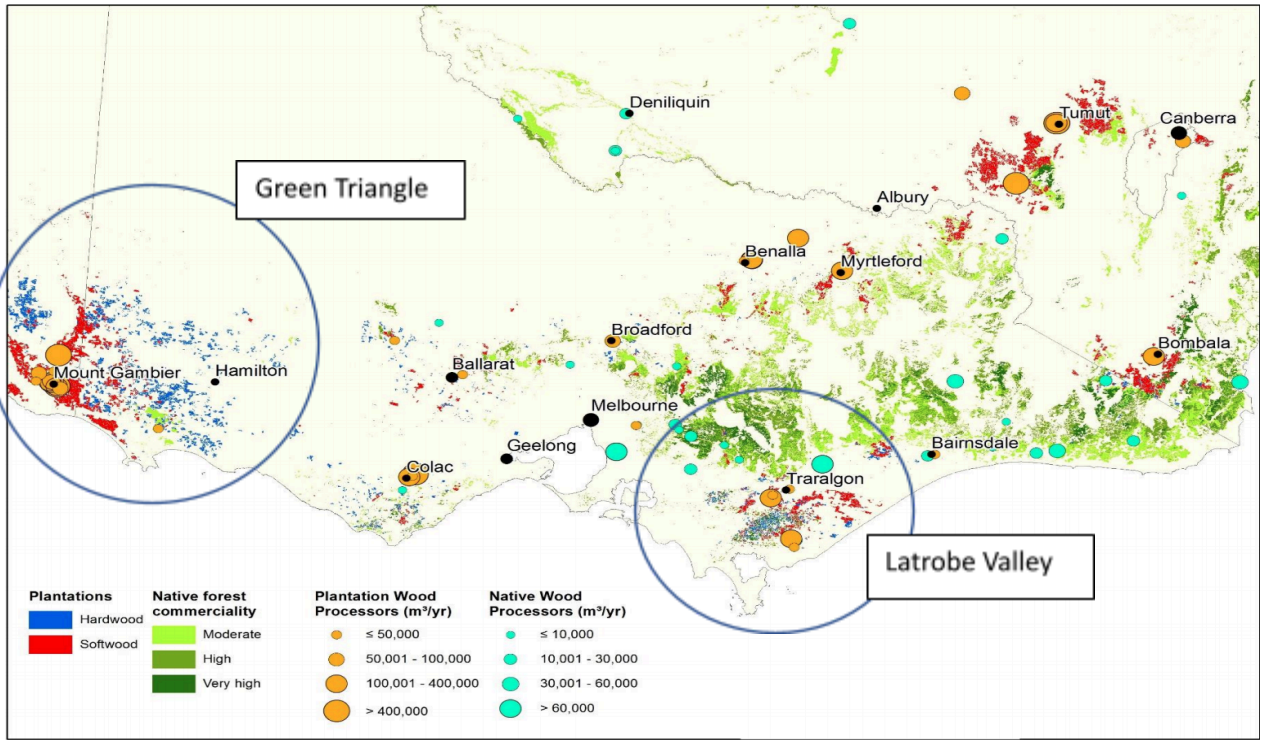


Figure 15 Distribution of forestry and wood processing in Victoria and surrounds

Timber production in the state is now concentrated around plantation estates in the Latrobe Valley, the Green Triangle, Otway-Colac, and the upper Murray Valley. These account for 80% of the state's timber supply with the balance coming from native forest logging.

The Green Triangle hub around Portland has 355,000 hectares of plantations. All is currently privately managed. Half is softwood (mainly in SA). The remainder, mostly hardwood, is from Victoria. The region has over 150 businesses that rely on the forestry industry, including in Portland, the world's largest hardwood chip export port. There are six globally significant plantation companies in the GT region. A significant volume is exported as logs or chips adding very little value to the primary product.

The Latrobe Valley hub is supplied by a mix of native hardwood forests and softwood and hardwood plantations. Around 70% of the Gippsland region is state-owned forests and national parks[91]. Most of the plantations are managed by Opal (owned by Nippon Paper) and Hancock Victorian Plantations (HVP).

91 https://www.agriculture.gov.au/sites/default/files/sitecollectiondocuments/forestry/australias-forest-policies/fiac/submissions/latrobe-city-council.pdf

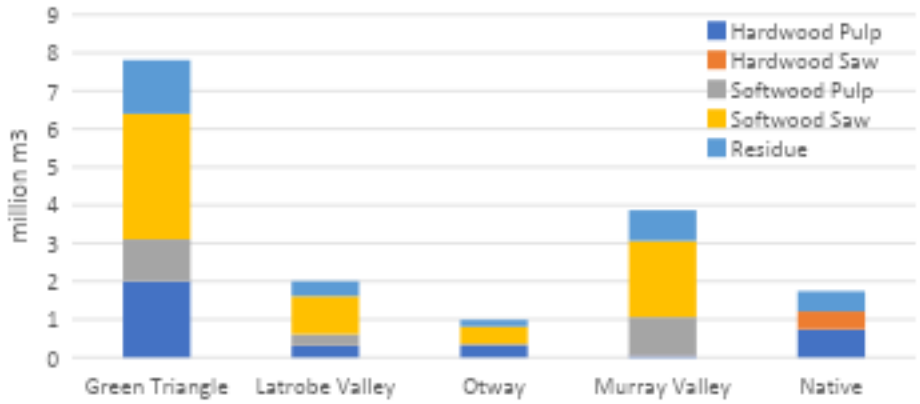


Figure 16 Plantation zone forestry production and primary outputs

These plantation hubs produce sawn and engineered timber products, as well as pulp and paper. Demand for wood for construction is steady. New products such as Cross Laminated Timber (CLT) and Glulam have boosted the demand for timber products in large construction projects. Because of the relatively low cost and flexibility of timber in construction, it can be valuable in a range of constructions from individual housing projects to apartment buildings[92] to skyscrapers[93]. Companies including VicBeam and Australian Sustainable Hardwoods provide timber beams and trusses for domestic markets. Pulp and paper mills are adjusting to increased recycling rates, declining newsprint demand (from the rise of electronic screens) and increasing demand for paperboard and packaging products (replacing single use plastics). The Maryvale pulp and paper mill is in a region that is adjusting to the phasing out of lignite-fired electricity generation -the foundation of the Latrobe Valley's industry and employment since 1920[94].

While the wood through-put of the Green Triangle Region is greater, the Latrobe Valley supports much more high-value processing. Six Gippsland sawmills add considerable value [95]. In the 1990s, an industry cluster was created that took 10% of the highest-grade timber from mills in the area[96]. TERRA Timbers was formed by the Victorian Eastern Development Association and has continued to promote value-added processing within the region.

Paper Mills are often centres for high value biomass conversion due to their centralised resource and capital. The Maryvale mill has been in operation for almost 85 years, with almost $1 billion worth of annual sales revenue across Australia. Its market position gives it the opportunity to expand its range of biomass-based products.

[92] https://www.forum-holzbau.com/pdf/41_IHF_2015_Abrahamsen.pdf
[93] https://www.cam.ac.uk/research/news/sowing-seeds-for-timber-skyscrapers-can-rewind-the-carbon-footprint-of-the-concrete-industry
[94] Weller S (2017) The Geographical Political Economy Of Regional Transformation In The Latrobe Valley *Australasian Journal of Regional Studies*, Vol. 23, No. 3, 2017
[95] Latrobe City MFMD submission Australia's forest products and forestry industry https://www.agriculture.gov.au/sites/default/files/sitecollectiondocuments/forestry/australias-forest-policies/fiac/submissions/latrobe-city-council.pdf
[96] Latrobe City MFMD submission Australia's forest products and forestry industry https://www.agriculture.gov.au/sites/default/files/sitecollectiondocuments/forestry/australias-forest-policies/fiac/submissions/latrobe-city-council.pdf pp 20.

5.2.1.2 Commitment to a vibrant future

Expanding the plantation estate to support existing and future industries will again require government initiative. Establishing timber plantations requires confidence that the industry will remain when harvest time comes around, perhaps 20-30 years later. Processing industries will invest in world-class facilities only if they are confident of an adequate supply of resources.

Current disputation about the rationale for forestry and the timber industries and uncertainty about policy is a barrier to investment in using biomass in the low carbon economy. This stalemate can only be resolved by a government with a long-term vision and policy commitments that lead to the sharing of that vision across industry, growers and the public.

Employment growth depends on the sector moving away from low value commodity exports, towards more complex value chains with elaborately transformed manufactures from an innovative sector[97].

Investment in biomass processing requires secure access to a defined quantity of fibre resources available on a sustained basis. Likewise, investment in plantations requires secure access to carbon and biomass markets on the necessary scale for a long period. Governments have historically played roles as market enablers through direct investment in plantations, or by providing incentives for the private sector to develop a critical mass of plantations and related processing capacities.

Government policies play significant roles in processing investment due to its long lead times, capital-intensive nature, dependency on large-scale and long-term access to the resource and the need for transport infrastructure.

Biomass from near a port can be exported as a low-value, bulk commodity – either chips or round wood. A processing capability provides substantial increases in employment and value generation. Advanced biomaterials production systems are being developed with support strategies as part of the transition to the bio- economy in the EU and other developed countries[98].

Victoria could accelerate the establishment of an internationally competitive bio-based industry[99,100].

State agencies need to contribute through the following roles:

- Develop and coordinate the delivery of the state-wide bio-industry transformation strategy
- Providing infrastructure and expanding resource supply in prospective regions – e.g. Latrobe Valley and the Green Triangle
- Major programs of applied R&D on new crops and crop production technologies and industrial processes.
- Education and training in relevant skills.

[97] West, J, An innovation strategy for Tasmania: A new vision for economic development, Tasmanian State Government, Hobart, October (2009) West, J, "The Mystery of Innovation: Aligning the Triangle of Technology, Institutions and Organisation", Australian Journal of Management, **26** (Special Issue) pp. 21-43. ISSN 1327-2020 (2001)

[98] Scarlat, N., Dallemand, J. F., Monforti-Ferrario, F. and Nita, V. (2015) The Role of Biomass and Bioenergy in a Future Bioeconomy: Policies and Facts. *Environmental Development,* 15, pp. 3-34. d Policy 32(4) pp.587–602. DOI: 10.1016/j.envdev.2015.03.006

[99] West, J, An innovation strategy for Tasmania: A new vision for economic development, Tasmanian State Government, Hobart, October (2009)

[100] West, J, "The Mystery of Innovation: Aligning the Triangle of Technology, Institutions and Organisation", Australian Journal of Management, **26** (Special Issue) pp. 21-43. ISSN 1327-2020 (2001)

- Support for the first commercialisation of technologies in Australia.

A public agency can play a number of important roles to accelerate development of markets for biomass. These include provision of market information (prices, volumes over time); structured timber off-take contracts; stable opportunities for sale of carbon credits; support for R&D and skills development; supply of resource management and forestry/silviculture contractor clearing house services; and lowering the transaction cost of small growers' participation in carbon markets. A public agency can also play important roles in lowering finance costs for long-term investments.

5.2.2 Regional economic impact

Development of sophisticated biorefineries will provide additional employment over a wide variety of roles including plant maintenance, logistics, engineers, scientists and corporate staff. Metsa Fibre in Finland currently employs 1,300 people, with company sales totalling US$2.2 billion. The biorefinery embodies processing wood for pulp, bioproducts such as tall-oil, turpentine and product gas, as well as a research centre dedicated to creating biofibres from wood residues. Demand from Asia is driving growth of the pulp sector in Finland by 1-1.5% annually[101].

In Australia, Queensland sugarcane has the potential to underpin a high value tropical biorefinery industry. A Queensland state-wide initiative would contribute $1.8 billion per year to gross state product and provide over 6,600 new jobs by 2035[102]

The existing human resource capacities and infrastructure of both the Latrobe Valley and the Green Triangle region would assist the development of bio-processing hubs. The established forestry sector has developed knowledge and skills in forest growing, logging and downstream processing. The development of product-specific knowledge to support new processing will assist the adjustment to the decline and closing of coalmines and coal generators in the Latrobe Valley[103].

In the Latrobe Valley, the Maryvale mill directly employs 857 Victorians[104]. The upcoming waste to energy project at the Maryvale processing plant will supply 1,600 FTE jobs during construction with 440 permanent positions, and additional benefits to the Victorian community[105]. This is an example of the way industry can evolve around the use of forest biomass.

Forestry in the Green Triangle region currently contributes $1.6 billion from sales of primary wood products[106]. 2,594 people were directly employed, in either primary or secondary processing of wood

[101] Metsa Groups innovative bioproduct mill is world first Konecranes 2017
https://www.konecranes.com/resources/metsa-groups-innovative-bioproduct-mill-is-world-first

[102] Deloitte Access Economics, 2014. Economic impact of a future tropical biorefinery industry in Queensland. [Accessed at:
https://cms.qut.edu.au/__data/assets/pdf_file/0004/482728/ife-biorefinery-report.pdf]

[103] Weller S (2017) The Geographical Political Economy Of Regional Transformation In The Latrobe Valley *Australasian Journal of Regional Studies*, Vol. 23, No. 3, 2017

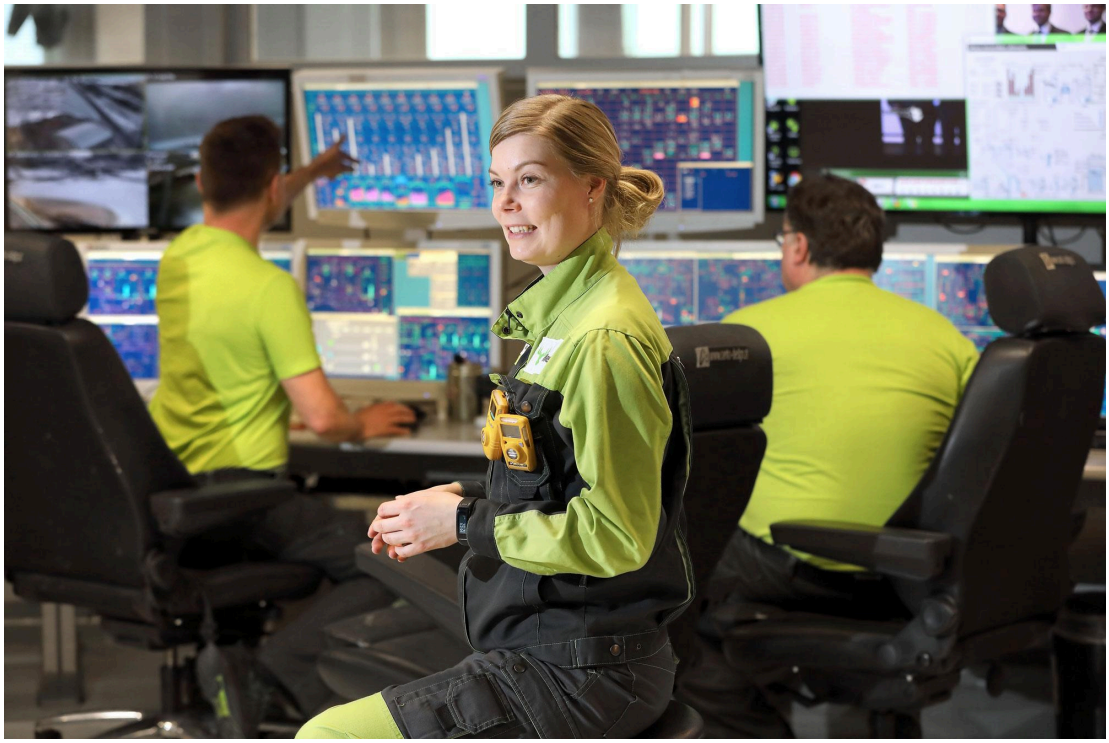
[104] Australian Paper Sustainability Report 2018
https://www.australianpaper.com.au/wp-content/uploads/Australian_Paper_SustainReport-2018_Final.pdf

[105] Australian National Pulp and Paper Processing Report 2018
https://ausfpa.com.au/wp-content/uploads/2018/12/2018-National-Pulp-and-Paper-Sustainability-Report.pdf
https://www.agriculture.gov.au/sites/default/files/sitecollectiondocuments/abares/publications/NationalWoodProcessingSurvey2016-17_20190613_v1.0.0.pdf

[106] FWPA Socio-economic impacts of the forest industry Green Triangle November 2017
https://www.fwpa.com.au/images/Green_Triangle_Report_8Dec2017_published.pdf

products in the region in 2016. The majority of this activity occurs over the border in Mt Gambier, which is home to most of the timber processing businesses. The majority of hardwood timber grown in the state is shipped offshore from Portland as logs or chips at very low value. This is a prime candidate for an integrated biorefinery, feeding a local industrial cluster.

Realising the bio-based industry opportunities requires a State agency to develop and coordinate the delivery of a state bio-industry transformation strategy, including major programs of R&D and commercialisation and technical skills and capacity building.



5.3 Flexible distributed processing

Biomass residues and waste are generated across the rural and urban landscape as agricultural residues, forestry and timber processing residues and municipal waste. Currently this potential resource is underutilised. In some cases this “waste” is converted into a valuable alternative in place of costly treatment or disposal – such as bioenergy from sewerage. The local and regional supply varies with circumstances. Some is large and concentrated, some small and diffused. Broad-acre croplands generate vast amounts of crop stubble. Horticulture generates pruning and processing wastes. Forestry produces residues and sawdust. Municipal green waste can be a significant source. The management of fuel loads varies across regions but may supply material from short rotation tree cropping.

A range of technologies are capable of converting biomass, of different varieties, into useful goods. Some are amenable to decentralised as well as centralised processing of biomass. One of these options –

pyrolysis – is considered here in further detail due to its flexibility, scalability and significant potential for atmospheric carbon dioxide removal.

5.3.1 Pyrolysis: Net-negative emissions energy and materials

Pyrolysis is the heating of biomass without combustion in the absence of oxygen. The water and volatile constituents are separated from a carbon rich solid. The production of charcoal from wood burned in earthen kilns is an ancient craft.

The smelting and blacksmithing of the iron age created a huge demand for charcoal. It was a major cause of deforestation in Europe. At its peak, hundreds of thousands were employed in felling trees in Europe to produce it. In England, many forests were managed as coppices, which were cut and regrown cyclically, so that a steady supply of charcoal was available. This environmental and resource management legacy provides an important lesson for future renewable biomass industries. The increasing scarcity of easily harvested wood and expanding industrial demand from the steam driven industrial revolution was a major factor behind the switch to fossil coal from the 18th century.

Modern pyrolysis uses both the volatiles and the solid carbon. It captures the volatiles for use as energy or industrial raw materials and char solids are used for other purposes. The temperature and duration of combustion influence the properties of finished products and can be easily tuned. The concept is illustrated in Figure 18.

The water and volatiles present in biomass form synthesis gas – or syngas. This comprises a mixture of methane hydrogen, ethylene, carbon monoxide and carbon dioxide. It can be burned directly for heat or energy, processed into chemicals and polymers or converted to liquid hydrocarbon fuels and lubricants. Components such as hydrogen or carbon dioxide have valuable separate applications in their pure form.

Char, around a third of biomass input, is a versatile and valuable substance. It is three quarters and up to nearly 100 percent pure carbon depending on the process. Char is thermodynamically stable for long periods, forming an effective long-term storage of carbon removed from the atmosphere. Each tonne of carbon in char represents sequestration of 3.7 tonnes CO2. This sequestration technique is currently not recognised or eligible for carbon credits in the national scheme but is eligible for international voluntary credits.

Char can contribute in other ways while continuing to store carbon. The solid maintains much of the cellular structure on the original material. Woody feedstocks can produce highly porous char with exceptional surface area to volume ratio which makes it an effective medium for filtering or reactive exchange. Char is being used increasingly as a soil amendment that is able to carry and disperse nutrients in an efficient and targeted way as well as accommodating soil microbes and improving water retention. Other uses include as a substitute for a proportion of bitumen in road building. It can be used as a zero emissions substitute for fossil carbon in many industrial processes, including reduction of iron ore. In these applications, it replaces a source of emissions, but does not continue to store carbon itself.

Agricultural applications are of particular interest due to the multifaceted benefits of soil remediation, reduced use of costly and degrading farm inputs and potential to inhibit the enteric fermentation emissions of ruminant animals.

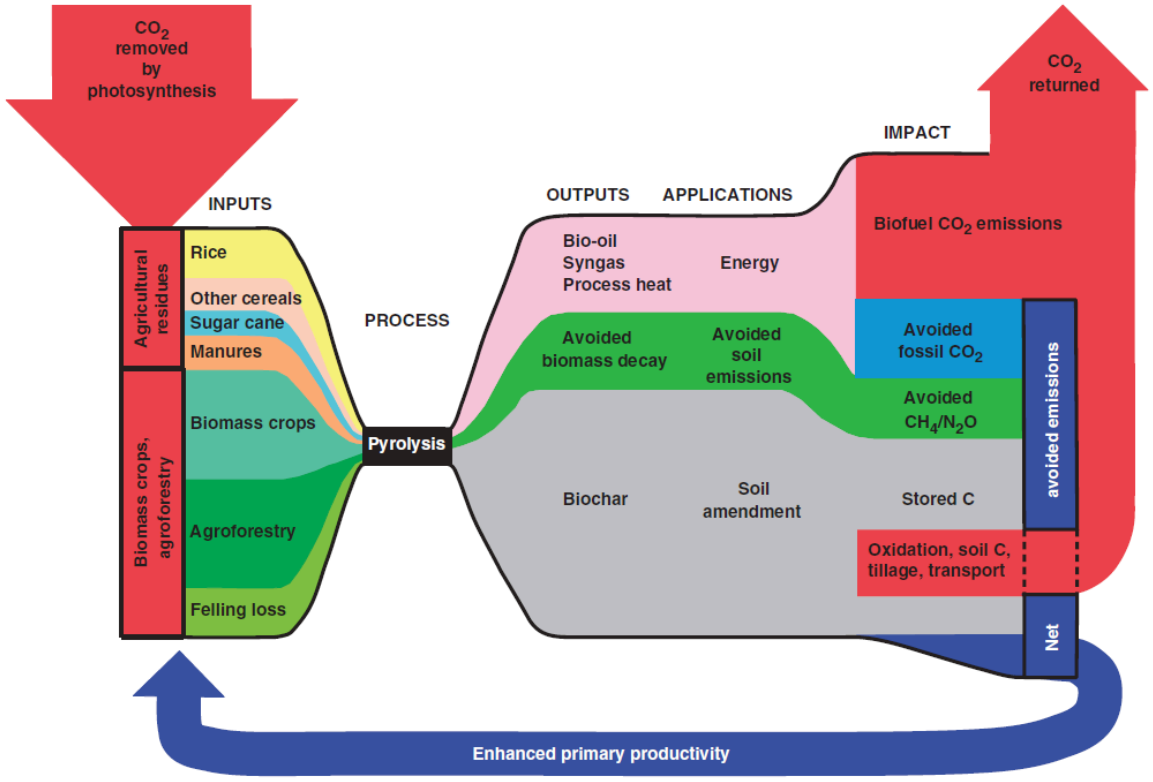


Figure 17 Biochar system concept[107]

The case below, pioneered by Rainbow Bee Eater in Mount Gambier, demonstrates how use of char in agricultural application can be combined with energy and carbon emission reductions with pyrolysis combustion. This example can be an enabling path to converting biomass waste into useful products at scales from very small to very large.

[107] Woolf D et al., (2010), *Sustainable biochar to mitigate global climate change*, Nature Communications

Industry symbiosis: Pyrolysis turning wood waste into organic food and energy

Rainbow Bee Eater delivers modular or integrated pyrolysis conversion technology that can be configured to suit particular feedstocks and downstream opportunities. An early commercial project demonstrating the possibilities has been operating in Mt Gambier utilising scrap timber – a municipal waste liability – and forest residues. These are supplied by a local producer of soil amendments and fertiliser **Bio-Grow**, to be converted to biochar for inclusion in their organic products. The pyrolysis unit is affixed to a local horticulture greenhouse operated by **Holla-Fresh**, providing the facility with greenhouse heat, CO2 enrichment for plant growth and supplementing electricity supply. The material flow and benefits are represented in Figure 19.

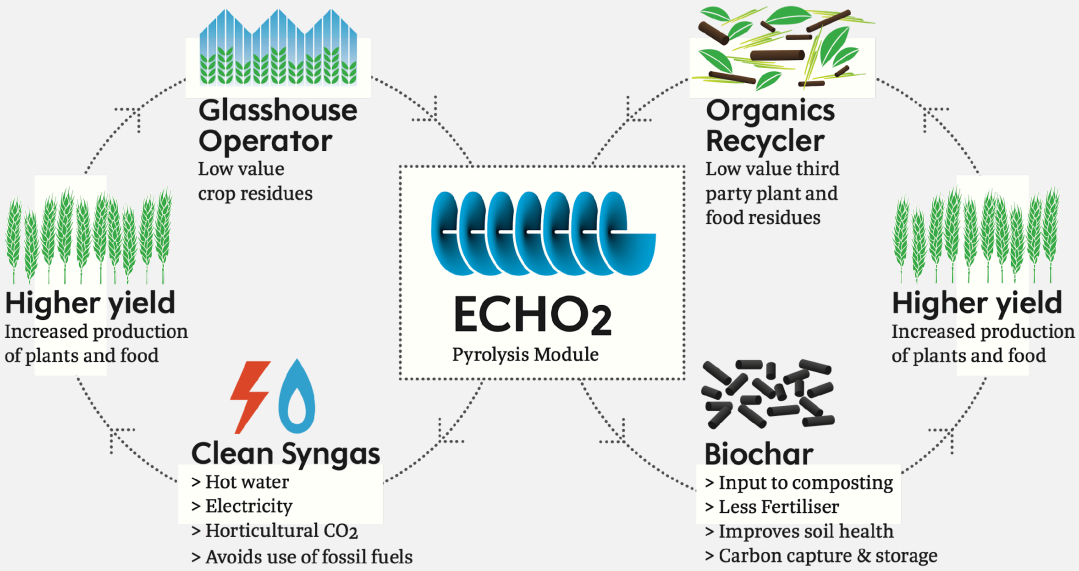


Figure 18. The demonstrated flow of products and benefits from Rainbow Bee Eater pyrolysis project

6 Resilient forests supporting biodiversity, recreation and tourism

1. **Forests support, provide and create a growing number of services. Forest health, climate change and access to forests are key areas of concern for Victorians.**
2. **New and existing forest management practices such as fuel load management, ecological thinning and fostering of older trees are essential to resilient forests.**
3. **Growing visitor numbers and an increasing population require management. A public land manager would maintain human resource capacity and apply community-based decision-making.**

Victoria's National Parks and State Forests have been reserved to protect their unique character and the services they provide to surrounding ecosystems and productive activity. A lot has been learned about these forests and the threats that a warming and drying climate pose to them into the future. A lot has been learned about effective management activities that protect against threats and support the biodiversity that depends on them.

Forest values

Within a forest there are modern, traditional and ancient indigenous values. These have been thoroughly explored by the RFA process which found diverse public interest in Victoria's forests including; protection of unique flora and fauna, recreational use, as well as sustainable forest management and employment.

Public forest management

Protection and management to sustain these public values needs support from specialist managers. This, in turn, requires careful definition and funding of essential roles.

Adaptive management

Ongoing research and accumulated experience have identified the sensitivity of forests to disruptive events like fire, drought and harvesting. Much has also been learned about the ecological function of forests and the dependency of threatened species. Research into management and silvicultural practices has defined options to boost the resilience of forests and resident biodiverse communities.

The anticipated warming and drying will push some species and ecosystems outside of their limits. The collection, banking and nursing of seeds will be important to protect the ecological heritage of forest genealogy. They will be important in adaptation, by adding species that complement threatened ecosystems and extend the time available for evolutionary adaptation.

Access to forested areas will continue to be important for infrastructure maintenance, bushfire relief and the many activities valued by the community for recreation and by the tourism industry.

6.1 The many values of Victoria's forests

In order to define the value of forests to the surrounding population, DEWLP has conducted an economic assessment of ecosystem services, under the United Nations System of Economic-Environmental Accounting (SEEA). These services are split into provisioning, regulating and cultural services from forests in Victoria (Table 8).

Ecosystem services include preventing flooding by filtering water through forests. Natural systems absorb water and debris, providing a barrier to harsher weather, storms and the flow of water downstream.

Provisioning services such as water, firewood and honey provide immediate and measurable benefits.

Table 8 presents data from economic valuation of ecosystem services—including only a subset of the value contributed by forests.

Table 8 Economic assessment of ecosystem services[108]

Provisioning services	Regulating services	Cultural services
Water yields $800-1,300m	Preventing soil erosion $3,100-8,000m/yr	Tourism and recreation $905m/yr
Firewood collection $3-7m/yr	Flood mitigation $97m/yr	
Honey production $3-4.5m/yr	Carbon stocks $3,000m	
	Pollination services Not calculated	

6.1.1 Interests of Traditional Owners

A number of different land tenures are held under Traditional Ownership or management with 15.9 million hectares under leasehold/co-management land through Registered Aboriginal Parties. Private forest management consists of 4,430 hectares across Victoria.

Inclusion of indigenous consultation in forest strategy contributes values and insights that support productive management of landscapes. Cultural burning methods have been incorporated into state fire management strategies in recent years in collaboration with state government authorities. The Cultural Landscapes Strategy will provide the parks and forests management strategies across the state, in conjunction with the State Forest Management strategy and Park's Victoria Land Management Strategy. Mapping out networks between human and the land, include animals, plants, ancestors, Songlines, physical structures and trade routes that are of importance to Aboriginal groups in Victoria. Important values for Traditional Owners include the heritage and history of the land and forests, as well as the "use values" for food, shelter and medicine.

[108]Ecosystem services from forests in Victoria: Assessment of Regional Forest Agreement regions, Fact Sheet – December 2019. Accessible at: https://www.environment.vic.gov.au/__data/assets/pdf_file/0033/459573/Fact-sheet-Ecosystem-services-from-forests-in-Victoria.pdf

Diverse Forest Values

Biodiversity: Victoria's forests provide rich and complex ecosystems supporting unique biodiversity.

Old Growth Forests: These ecologically mature forests provide a wide range of habitats for plants, insects and animals and are a vital part of the water and carbon cycles. Old growth forests hold cultural significance for Traditional Owners and for non-Indigenous people.

Endangered species: Victoria's forests provide habitat to a number of threatened species including the Glossy Black Cockatoo, the Long-footed Potoroo, the Giant Burrowing Frog and the Leadbeater's Possum.

Heritage values: Victoria's forests are home to treasured natural wonders and cultural legacies of both Traditional owners and European settlers.

Water: Victoria's forests are a major catchment and provide quality drinking water to the state. They are vital to the regulation of flow into aquifers, streams and rivers that support downstream habitats and agriculture.

Traditional Owners: The land is an inseparable feature of the culture and identity of Indigenous peoples.

Social values: Communities value the natural heritage and access to the forest for recreational activities such as walks, four-wheel driving, sightseeing, hiking, biking, fishing, hunting and camping.

Economic and industry values: The main forest industry value is native timber harvesting in state forests. Forests also support sales from seeds, mining, prospecting and quarrying.

6.1.2 Community values

To understand the variety of interests and perspectives on the states forests a series of surveys was conducted in the process of modernising Victoria's Regional Forest Agreements. Figure 19 presents data on the evaluation of the greatest opportunities for Regional Forest Agreement modernisation by respondents to a Community Survey on forests[109].

[109] DELWP Modernisation of the Victorian Regional Forest Agreements Independent Report on the Joint Victorian and Australian Government Consultation December 2019

Figure 19 Community Survey responses for improvements to Regional Forest Areas[110]

6.2 Forest management practises

Management of Victorian native forest areas is carried out by a range of actors that ensure these values are protected. VicForests' concern is not only for successful harvesting of timber but also the study and monitoring of forests including growth rates, general health, disturbance history and changes establish forests through ecological restoration and replanting trees. These activities require landscape management planning, including manual and satellite mapping (including LiDAR surveying technology), aerial photo interpretation (with drones) and field measurements. Success of forest management requires continued assessment and maintenance as well as pre-emptive planning and knowledge-acquisition.

6.2.1 Forest management

Forestry management has evolved globally over the last 50 years. The US, Canada, Japan and Europe lead practical and research management evolution to capture multiple forest values, solving issues from past mistakes including lack of ecosystem diversity, inefficient production returns and large-scale pest outbreaks. New and existing problems facing forestry include climate change-induced damage, habitat destruction, fragmentation and globalised and uncertain markets.

Forest management can secure widely shared objectives. A lack of management can impede forest structure and function and result in dominance of successful single species. To take forest management out of the Australian context, North America and Europe participate in a range of forest management regimes with consequences for biomass, biodiversity, aesthetics, carbon and fireproofing. Sweden holds just 1% of the world's forests but provides 10% of global tradeable wood products[111]. Thinning improves the productivity of Sweden's forests through multiple harvests. The practise of thinning removes trees

[110]

[111] Forests and forestry in Sweden, 2015 https://www.skogsstyrelsen.se/globalassets/in-english/forests-and-forestry-in-sweden_2015.pdf

from overgrown stands, to make way for new species and to improve the growth of existing trees. Thinning increases the average age of stands by removing limiting factors such as light through the canopy and competition for water. Large old trees contribute disproportionately to carbon and other ecosystem services.

For Sweden, this provides a solid medium-age forest. Native forest management could provide something different for Victoria. For example, thinning can contribute to factor growth of older and larger trees following cessation of clear-fell harvesting. Older trees are more fire-resistant and store a larger amount of carbon due to their size. A study in 2014[112] found that ~72% of carbon was stored in the largest 10% of the trees. Due to the legacy of timber harvesting and frequent bushfires in native forests in Victoria, there are less larger trees and therefore less carbon.

Forests can require management to reconstruct natural processes. Sometimes legacies from previous land use have altered nutrition cycling and fire regimes. Effective forest management involves bringing resilience to forests through our understanding of forest dynamics and disturbance. The legacy of production forest in Victoria has resulted in young stands, that increase the chances of forest fires. After fires, many more seedlings establish than can ultimately survive. They grow unimpeded for a number of years and then from year 10-30 growth can be severely slowed by competition creating a congested forest of young, thin, vulnerable stand – effectively a match box. This slows the maturation of the forest and is a prolonged fire threat.

Figure 20 below shows a process model, suggesting a range of impacts from disturbances and the effect of thinning on Red Gums in NSW. Ecological thinning in this example speeds the growth and number of large old trees in a forest. Inaction on thinning results in stands 'locking up'--a term foresters use to define the intense competition from closely spaced trees. A comparison is shown between a mature mountain ash stand and a dense production forest stand.

[112] Fedrigo, M., Kasel, S., Bennett, L., Roxburgh, S. and Nitschke, C., 2014. Carbon stocks in temperate forests of south-eastern Australia reflect large tree distribution and edaphic conditions. Forest Ecology and Management, 334, pp.129-143.

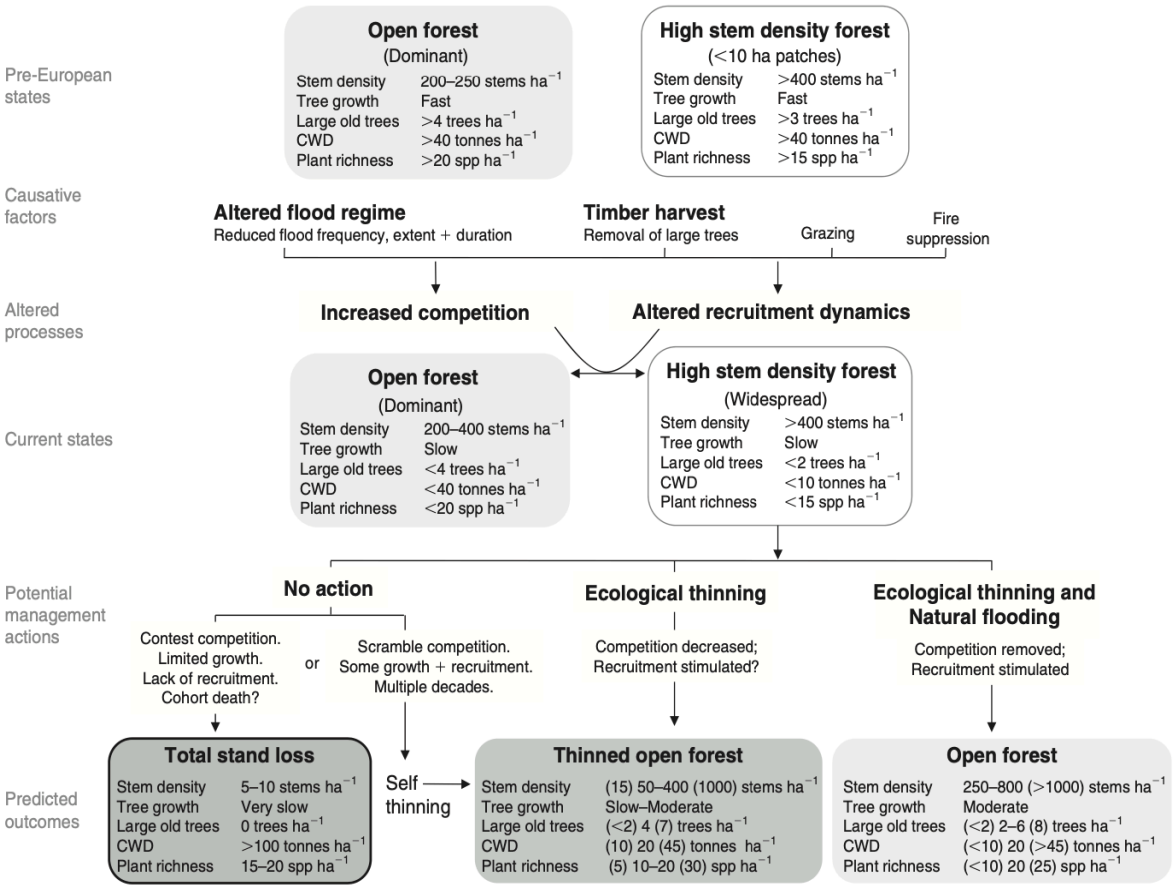


Figure 20 Process model to understand past and current states of river red gum forest in NSW. CWD – Coarse Woody Debris.

Figure 21 Comparison of mountain ash conservation forest[113] and production forest[114] stands.

A very important issue in Australian forests is resilience to bushfires. Larger trees are more resilient to fire due to thicker layers of protective bark. The stand structure of production forests inhibits growth and causes some forests to remain vulnerable to fire for longer. Accelerated growth from thinning can also increase species diversity and the formation of tree hollows much sooner than would be the case under passive management[115].

6.2.1.1 Forest management in a changing climate

Climatic conditions in South East Australia are already being affected by a national 1-degree temperature increase, more extreme regional cyclic events such as La Niña and lower rainfall during the winter and

[113] Forest and Wood Product Association, (2016), *Carbon stocks and flows in native forests and harvested wood products in SE Australia*, Fig 1.18
[114] Forest and Wood Product Association, (2016), *Carbon stocks and flows in native forests and harvested wood products in SE Australia*, Fig 1.20
[115] Overview of Victorias Forest Management system March 2019 DEWLP
https://www2.delwp.vic.gov.au/__data/assets/pdf_file/0027/458640/Forest-Management-System-Overview-2019-1.pdf

autumn months[116]. These climatic changes make it likely that bushfires will be more intense and frequent.

The carbon stored in Victoria's forests is equivalent to around 30 years of the total greenhouse emissions of the state. The bushfires of the 2020 summer have reminded us that it can't be taken for granted. Almost 19 million hectares burned across the country, with about 1.4 million hectares in Victoria. The carbon emissions from these wildfires has been estimated to be 940 Mt CO2-e[117], equal to more than one and a half years of Australia's total emissions.

Australian forests are adapted to episodic drought and bushfire and are renowned for their recovery after disturbances. Bushfire is treated as having minimal impacts on long term forest carbon stocks[118]. Because of this resilience, the restoration of carbon from the 2020 fires is assumed to be complete within 10-15 years.

While adapted to fire, the frequency and intensity of fires can inhibit the adaptive capacity of some forest types. This is true for mountain and alpine ash species. Their long-term persistence is vulnerable to multiple fires within short intervals. Additionally, they are obligate seeders. This means that fire usually causes tree mortality and the release of seeds (if the tree is mature enough) that can germinate in the ash bed. If fire frequency exceeds the time it takes for the tree to reach maturity for seed production, fire-adapted species such as silver wattle take over. Fires in short successions (e.g. less than 20 years) can cause failure to regenerate, requiring management to recover dominance of ash species[119]. Parts of north east and central Victoria experienced major fires in the summers of 2002, 2006, 2009 and 2020. There is currently over 20,000 ha of twice burned forest as well as a backlog of 7,000ha of production forests that have not regenerated[120].

Anticipated changes to the future of Victorian climate include higher average temperatures, more heatwaves, lower rainfall and more frequent droughts. These factors can lead to more frequent and intense bushfires. The natural ability of forests to regenerate after disturbances is threatened by the increasing frequency of bushfires as well as changed local climates. Dryer and warmer conditions inhibit regeneration of some species[121]. Short-interval bushfires in the temperate forests of Australia have been found to exhibit re-sprouting failure and reduced seedling recruitment. The increased drought of a BAU high emissions RCP8.5 scenario may have a strong debilitating effect on seed regeneration of *E.regnans,*

[116] Rodney J. Keenan & Craig Nitschke (2016) Forest management options for adaptation to climate change: a case study of tall, wet eucalypt forests in Victoria's Central Highlands region, Australian Forestry, 79:2, 96-107, DOI: 10.1080/00049158.2015.1130095
[117] Australian Government Department of Industry, Science, Energy and Resources, (2020), *Estimating greenhouse gas emissions from bushfires in Australia's temperate forests: focus on 2019-20.*
[118] Australian Government Department of Industry, Science, Energy and Resources, (2020), *Estimating greenhouse gas emissions from bushfires in Australia's temperate forests: focus on 2019-20.*
[119] Griffith T. 2001 Forests of Ash- An Environmental History Cambridge University Press Melbourne
[120] URS Australia, (2011), *Implications of Kyoto Protocol Commitment Period 2 and current national climate change policies for Victoria's native forestry sector*, prepared for Department of Primary Industries.
[121] Mok H et al., (2011), *Modelling the potential impact of climate variability and change on species regeneration potential in the temperate forests of South-Eastern Australia*, Global Change Biology

as demonstrated in Wang et al, 2017[122]. All of these effects into the future must be managed for a healthy forest.

Adaptive management involves preparing for climate change through adaptation.

Jandl et al (2015)[123] outline the main pillars of adaptive management under a changing climate:

- Managing disturbance exposure (for example pest outbreaks and forest fire increases)
- Increasing heterogeneity (through selecting species adapted to climate change and development of tree breeding programs to improve adaptive alleles and genotypes)

Adaptation to changes include understanding ecosystem adaptation, climate risk, balancing tree species diversity and redundancy, understanding modularity and landscape scale connectivity and understanding uncertainty through scenario analysis. The Complex Adaptive System (CAS)[23] builds upon an ecosystem-based approach to better understand the adaptive qualities and abilities of forests and where to focus management practises. Principles of CAS are found across the world from Belgium to Canada.

Table 9. Below demonstrates more adaptive management practises.

Table 9. Proposed management options for climate change impacts on threat areas in the forest

Threat areas	Management options
Biodiversity conservation	● Gene management programs and gene banks ● Protecting highly threatened or rare species ex-situ
Productive capacity	● Identifying drought and disturbance tolerant species ● Establishing long-term seed lot trials ● In-situ studies and monitoring of reproduction and regeneration ● Retention harvesting and thinning
Forest health	● Implementing techniques to improve stand vigour ● Sanitation harvests ● Thinning to improve drought stress and disease impacts in *E.regnans*
Soil and water	● Thinning to increase water yield
Socio-economic benefits	● Strategic planning for climate risks to society ● Improved Integrated assessments of system vulnerabilities ● Documenting Indigenous and local community forest knowledge

Continued sowing and planting of seedlings, and identification of young stands of trees that require assistance to regeneration due to their age, are important adaptive responses to climate change[124]. This

[122] Wang, G., Wang, T., Kang, H. et al. Adaptation of Asia-Pacific forests to climate change. J. For. Res. 27, 469–488 (2017). https://doi.org/10.1007/s11676-016-0218-1

[123] Jandl, R., Bauhus, J., Bolte, A. et al. Effect of Climate-Adapted Forest Management on Carbon Pools and Greenhouse Gas Emissions. Curr Forestry Rep 1, 1–7 (2015). https://doi.org/10.1007/s40725-015-0006-8

[124] VicForests press release Bushfire Response https://www.vicforests.com.au/fire-management-1/vicforests-bushfire-response

enables the forests to recover better from bushfires as a genetically diverse population for a more resilient future.

The development of a nursery to sell seeds and genetically distinct varieties to research facilities would have high value. Seeds could be stored in VicForests' extensive seed bank. Working with organisations such as the Australian Seed Bank Partnership, can ensure the seeds collected before and after bushfires are assessed for their genetic diversity, while supporting the maintenance of the unique plant heritage of Australia. These seed collections are important in case of pest outbreaks, as seen with Ash dieback in Northern Europe[125]. Recovery from pest outbreaks is aided by genetic diversity studies and seed stores. Pest outbreaks are increasing due to rising temperatures and trade in wood products[126] with weeds in dry fragmented forests[127] a particular concern. The practical knowledge and expertise of VicForests is important for this type of forest management. Forest management equipment and machinery will continue to be an essential element of emergency response during and after bushfires[128].

Without skilful and adaptive forest management the climate changes anticipated may permanently change the character of Victoria's forests and require large effort to re-instate a resilient forest. The release of carbon in a non-resilient forest is a greenhouse gas feedback risk, which may accelerate climate change.

The formal recognition of carbon credits attributable to the Victorian Forest Plan, and the holding of these on a balance sheet will motivate more careful management of forest carbon stocks. Management will need to be well resourced, adaptive and accountable. This framework will ultimately need to ensure that the public lands capacity to generate ecosystem services beyond carbon, including habitat and watershed protection, are sustained over the long term.

6.2.1.2 Infrastructure and access in State forests.

Many forest values require access. Road building and maintenance has been part of the regular activity of foresters for many decades. This activity has provided ease of access to remote and infrequently visited places. Many take it for granted that here will be a road to where they need to go – even deep into mountainous forested places.

Large, heavy and wide vehicles are used to transport people and equipment into the forests. Activities involve tour operators, event staff and guests, farmers and prospectors. Forests are also being used for professional photography and filming[129]. Although the native forest will no longer be logged, roads are in place and new roads will need to be built. There is a duty of care to anyone that uses the roads in emergency or contractual conditions. Bushfire relief requires access to roads.

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[125] Elizabeth S. A. Sollars, Andrea L. Harper, Richard J. A. Buggs, (2017)*Genome sequence and genetic diversity of European ash trees* Nature, 541, pages212–216

[126] Seidl et al (2017) Forest disturbances under climate change. Nature Climate Change. 7. pages395–402

[127] Dry forests and woodlands Parks Victoria https://www.parks.vic.gov.au/get-into-nature/conservation-and-science/our-amazing-diversity/dry-forests-and-woodlands

[128] Indufor VicForests Strategic Marketing Plan Part B Report 14 February 2017

[129] https://www.forestsandreserves.vic.gov.au/land-management/crown-land-leases-licences-and-permits. https://pmav.org.au/wp-content/uploads/2019/11/prospecting-guide.pdf.

VicForests plays an important role in building and maintaining roads[130] to provide access and enable the enjoyment of many of the values identified in community surveys. Access is required to carry out surveys and monitoring programs such as in the Victorian Forest Monitoring Program. Ad-hoc and planned surveys will need to be carried out after 2030, to monitor many endangered and vulnerable species. Maintenance of roads is imperative to successful monitoring of the forests, including removing debris, fixing holes and grading of the road network.

During bushfires, road closures need to be maintained by many different actors,[131]. The safety of these roads depends upon the work of VicForests with the Forest Fire Management team to prevent residents from getting close to the fires by blocking roads. Climate change will require construction of new and the re-design of old roads[132].

Forest recreation and tourism

According to the 2017–18 Parks Victoria Annual Report, 14 million people took part in at least one nature-based activity. Victorian State forests provide for a wide range of activities and are typically free-of-charge to the public. RFA regions provide for a broad range of recreation and tourism activities. Some of the most common across the state include walking, mountain-bike riding, camping, fishing, picnicking and four-wheel driving. Facilities that cater for these recreational activities include campgrounds, day visitor areas, walking tracks, mountain-bike trails, visitor information infrastructure, roads and parking.

Victoria's forests are home to a range of ecosystems, bio-types, endemic species and native flora and fauna that bring tourists from all over the world. Attractive regions include the Great Ocean Road, Otways, Australian Alps and Coastal East Gippsland. International and National visitors for bushwalking in the Australian Alps reached 637,000 over 2012–16.

In 2017, annual visitor numbers grew by 12.7% for the Australian Alps, 3.7% for the Great Ocean Road and 16.6% for the Australian Coastal Wilderness region. The Great Ocean Road receives 5.7 million domestic day visitors annually. Increased nature-based day trips and activities raises visitor numbers on the forest roads in and around these tourist areas and campsites. The 2017 Unlocking our Great Outdoors report by Tourism and Transport Forum Australia, asserts the importance of road and infrastructure maintenance for growing numbers of tourists to Australia's natural assets.

[130] Indufor VicForests Strategic Marketing Plan Part B Report 14 February 2017
[131] http://emergency.vic.gov.au/relief-and-recovery/948.
[132] Rodney J. Keenan & Craig Nitschke (2016) Forest management options for adaptation to climate change: a case study of tall, wet eucalypt forests in Victoria's Central Highlands region, Australian Forestry, 79:2, 96-107, DOI: 10.1080/00049158.2015.1130095

7 A Victorian Land Carbon Corporation

1. **There are critical roles for government agencies in achieving planned societal outcomes - involving employment generation, industry development, natural resources management and low carbon transitions**
2. **Socially desirable landscape scale outcomes require institutional arrangements to facilitate large scale investment; an unstructured market or environmentally focused programs will not achieve scale.**
3. **This section maps out the potential roles for a State entity built on the established strengths of VicForests in forestry and land management. It lays out a redefined purpose and range of expanded functions for this entity – provisionally titled the Victorian Land Carbon Corporation as a statutory agency that contributes to the transition to a low carbon economy.**

Currently, VicForests is a State-owned business responsible for the harvesting, regrowing and commercial sale of timber from public forests on behalf of the Victorian Government.

Under the Victorian Forestry Plan native forest harvesting of timber will be phased out by 2030. This restructuring provides an impetus for a strategic assessment of the future opportunities in the forestry and biomass sectors in Victoria, and to assess prospective roles for a specialist State entity involved commercially and in other ways in forest management.

Throughout this report we have mapped out the potential roles for a State entity - Victorian Land Carbon Corporation (VLCC) - with expertise and experience in forestry and land management. These lay out a redefined purpose and range of expanded functions for VFCC as a statutory entity that contributes to the transition to a low carbon economy.

In assessing the future of VicForests we have had to determine what is an appropriate role for VicForests, how this interacts with industry participants and what sits more broadly as the Government's responsibility, within a Victorian Government biomass industry development agenda.

The Victorian Land Carbon Corporation's primary role would be to create commercial value from trees and the biomass harvested from them. It would:

- Create value from carbon sequestration across both public and private land
- Increase the supply of harvestable biomass and
- Enable the development of high value processing industries and selling biomass to them

In this report we have argued that the Land Corporation would be a statutory authority with a mandate to apply forestry expertise and experience to the transition of Victoria to a low carbon economy. The analysis is premised on the Victorian Government adopting:

- A transition strategy to meet its CO_2 reduction targets.
- Separation of regulatory and operating roles into different agencies.
- A broader, statutory role for a new forest and carbon commercial entity.

The success of the corporation, and a major part of its rationale, depends on the presence of institutional arrangements that give commercial value to accretion of carbon stocks. Australia does not have that now. It is possible to make a start with makeshift adjustments to current carbon pricing arrangements. These will need to be followed by more far-reaching arrangements.

Private Forests Tasmania[133] provides another example of a State statutory business whose structure, operations and operations could be examined for insights into the development of the Landscape Corporation (see Appendix).

7.1 Expansion of the Victorian Land Carbon Corporation role

Built on established strengths of VicForests, the Land Carbon Corporation would contain a concentration of scientific, technological and commercial knowledge of photosynthesis and its contribution to sequestration of carbon in the landscape and growing biomass for industrial use.

The VLCC would have responsibility for managing the carbon and biomass value of the state forest estate. With the phasing out of logging in native forests, it would operate within constraints established by an external agency to ensure that environmental and wider human values beyond carbon were fully taken into account. The broader framework will need to ensure that the public lands' capacity to generate ecosystem services – like habitat, watershed protection and sequestration - are sustained. It would respect these wider values, as any business has to take account of the wider social and environmental implications of its activities. But it would be clear that in relation to wider values, it was subject to the regulatory supervision of another agency, possibly in the Environment Department.

Managing for carbon and other environmental and human values is not passive management. This point is made by reference to Indigenous Australian management of land and ecosystems. Indigenous management on this hot, dry, climatically variable and fire-prone continent required continuing intervention to shape the growth of vegetation.

Without skilful and adaptive forest management, climate change will change and damage Victoria's forests and their long-term carbon stocks more than is necessary. This is a potential greenhouse account liability. The formal recognition of the carbon credits attributable to the Victorian Forest Plan, and the holding of these on a balance sheet will encourage more focussed management of these forests for carbon value. A continued forest management regime as stated in Section 5, prioritising resilience and the capture of all forest values will extend the carbon potential of the forest. This requires the collaboration of a range of experts to get right.

The Land Carbon Corporation's commercial role would be built on three pillars:

- expertise in all matters related to the carbon cycle and production of biomass for industrial use
- a balance sheet incorporating increments in carbon stocks to which it has rights
- within clear Treasury rules, its access to capital at a cost that reflects its status as a sovereign borrower.

[133] https://www.pft.tas.gov.au/about-pft/overview

While this paper focusses mainly on the value of carbon in vegetation, the value of carbon in soils on land under its management would also be brought to account.

The Land Carbon Corporation's balance sheet would contain the capital value of the growing carbon stock within the State forest estate. The value would derive from the potential for sale in carbon markets. This will require further development of carbon markets—including qualification for ACCUs certified by the Australian Clean Energy Regulator. The Land Corporation would be able to borrow on reasonable terms with this asset on its balance sheet. The Overview noted the crucial role that public balance sheets can play in lowering the cost of capital in forestry investments with their long lives, tendency towards and recent history of policy instability[134].

The Land Carbon Corporation's own investments using the State balance sheet would be confined to Victoria. However, it would be able to make commercial investments in other States off its own balance sheet and from its own accumulated earnings under rules specified by the Treasury.

The Victorian Land Carbon Corporation would have responsibility for directly developing, or facilitating the development, of trees on public and private land throughout the State. It would also sell services related to such activities throughout Australia. Victoria's plantation estate is currently privately owned (or leased), and it is not proposed that this should change in relation to established plantations. The VLCC would invest where there was a commercial case based on the State's cost of capital. This would include long term investments in the plantation sector which would not qualify for private sector's investment because of firms' perceptions of sovereign risk.

It would develop expertise in innovative arrangements to bring others' ownership of land and management of appropriate parts of a biomass-growing business into productive interaction with its own access to long term capital and specialist knowledge. It could, for example, enter into a long-term arrangement with a farmer to fund the planting of trees for their carbon and sustainable biomass value on 20 percent of a property, while the farm owner was responsible under contract for continuing management. The landowner and the Landscape Corporation could share revenues above recoupment of capital in agreed proportions. With rising carbon and biomass value as we move towards zero net emissions, the landowner would have the right to substantial present value from future expected revenues.

Potential roles in enabling a biomass market:

- Acting as a regional "biomass market deal maker" or plantation broker linking growers and processors in and across the timber/biomass industry supply chain
- Provision of transparent and trusted information about market rates, harvest costs, potential growth rates, risks and returns
- Provision of regional brokerage services that enable ease of participation for diffuse land holders/growers, and third-party timber growing investors and businesses

[134] Alexandra & Associates Pty Ltd, (2002) *Landscape Change in the Goulburn Broken Catchment Final Report*, Goulburn Broken Catchment Management Authority, Shepparton

- Facilitating the scaling up of processing investment, including through assessing the total consolidated value potential across commodity types (e.g. solid wood, chip, biomass energy stock etc.), within a viable regional woodshed
- Brokering, monetising and providing assurance on environmental services including carbon markets

The Land Carbon Corporation would be expert in the alternative uses of biomass and active in promotion of industrial activities that would make use of its product. It would guarantee supply of timber for industries seeking long term access to it. It would not itself be an investor in the industrial use of biomass. That is an activity which is suitable for private investment because of the potential for effective competition, the moderate gestation period of investments, and the normal level of sovereign risk.

Enabling of investment could include:

- Structure financing arrangements to lower the cost of finance over the life of the project – including through state purchasing agreements or underwriting
- Enable investors, including registered superannuation funds, to pre-purchase the CO2 sequestered in a reafforestation project, with payments structured over years 3 to 5 to lower the time cost of money invested
- Broker progress payments for projects that achieve other priority environmental services, like catchment or habitat benefits
- Invest directly in, or provide incentives to first movers in the bio-energy or bio-materials sector
- Administration of financial incentives for carbon plantings that achieve priority environmental outcomes

The Land Carbon Corporation would be expert in sequestration of carbon in all parts of the landscape including soils, in use in biomass and in capture and geological sequestration for negative emissions from industrial use of biomass. Due to the technical expertise of Vicforests, development of some of the following services would be achievable within the next couple of years:

- Regional and landscape-scale assessment and spatial priority planning (for biomass, carbon, biodiversity and catchment outcomes)
- Value assessments and aggregating agent for carbon sequestration projects and other environmental outcomes
- Integrating landscape carbon plantings into the work of other land management organisations (water, parks, agriculture, conservation agencies and local government)
- Developing a premium state-based carbon product, including recognising the carbon sequestered in native forests, plantations, natural regeneration and mixed plantings that meet specific standards
- Leading or contributing to R&D programs for forest species, markets and resource management.

The Corporation would help develop commercial partnerships and innovative programmes for promotion of a bioeconomy. A proposed decade long R&D program with the objective of accelerating landscape carbon sequestration and the transition to bio-economy consists of:

- R&D focused on new crops and crop production technologies, and processing innovations ($35 million over 10 years);
- While contributing to the tertiary education sector's capacity to advance the technical and professional skills and capacity building required.

The Land Carbon Corporation would be expert in official and voluntary carbon markets. It would sell its own carbon credits at highest value. It would act commercially as an aggregator of credits generated on private land. It would work with Commonwealth and State Governments and international bodies on market design to maximise their effectiveness in providing efficient incentives to reducing emissions. In particular, it would be active in discussion of the evolution of the Commonwealth's Climate Solutions Fund methodologies to encourage recognition of value from forest management change, and guide discussion on comprehensive accounting for carbon in soils and plants.

Summary

Core activities of the Land Carbon Corporation would include:

- Monitoring, accounting for, and optimising the value of Victoria's landscape carbon stocks.
- Leveraging the State's balance sheet to invest directly, underwrite or otherwise provide access to capital for the growing of biomass in Victoria.
- Mediating between individual growers and the national carbon accounts.
- Supporting the development of high-value and innovative biomass processing industries.
- Working with others to accelerate the growth of the bio-economy in the Southwest, the Latrobe Valley, the Northeast and the Green Triangle.
- Being an industry participant in research, development and commercialisation of technologies relevant to growing and enhancing the value of carbon in the landscape and biomass.
- Participate as an industry partner in the strengthening of relevant education and training.
- Selling services throughout Australia and internationally from its expertise in carbon and biomass production and sale.
- Under regulatory arrangements defined by the State, managing the State's landscapes for their provision of ecosystem goods and services.
- Generating high levels of investment and employment in the early 2020s as part of the State's post-pandemic economic policies.

8 Carbon markets for landscape change

1. **Lack of carbon credit markets and a checkered history limits development of sequestration of carbon in the land to lower Australia's national and state emissions**
2. **International arrangements and markets can provide richer carbon pricing and increase carbon investment for low-emission goods and manufacturing**
3. **Recognition of co-benefits to carbon sequestration may need distinct policy to avoid weakening of other values. Current value is found in voluntary 'gold standard' markets**

Carbon value is not reflected in established market processes. This means that there will be less than the socially desirable investment in reduction of carbon emissions in the absence of carbon pricing, or regulation requiring it as a condition for doing other things. There will also be underinvestment in low emissions industrial processes if they are not encouraged by subsidy or if high-carbon alternatives aren't taxed or penalised by regulation.

Australia has neither carbon pricing nor, in relation to the land-based zero- and negative-emissions industries and processes, regulatory support and subsidy that provide comprehensive encouragement. There will be less sequestration of carbon and less industrial economic commitment. For some industries there will be none at all. The land-based industries will be more adversely affected by the absence of carbon pricing than renewable energy, where falls in costs are now driving investment and expansion of supply.

As we do not have comprehensive carbon pricing now and will not have it for the foreseeable future, what can we do pending its arrival, or in its absence?

The objections to carbon pricing that led to its abolition in 2014 after two years of effective operation did not include opposition to absorption of carbon in the landscape. The blockage of major new sources of employment and incomes in regional Australia was collateral damage in other battles. One could say that the new industries in regional Australia were wounded by friendly fire.

Can anything be done to introduce incentives to carbon sequestration in the landscape and industrial use of biomass that is commensurate with their potential contributions to Australian climate and economic goals?

We can make a good start, realising that new economic activities would do better if economically more efficient policies were introduced. Here we focus on supporting policies that are not inconsistent with electoral commitments of either major Australian political party at Federal or State levels.

8.1 The Emissions Reduction Fund (ERF) and Climate Solutions Fund (CSF)

The Federal Government's Clean Energy Future package which introduced carbon pricing from 1 July 2012 also established the Carbon Farming Initiative. This allowed certified carbon credits from the accumulation of carbon in the landscape to be offset against the liabilities of companies covered by carbon pricing. A market was created for unlimited sale of credits at a fixed price of about $23 per tonne,

rising at 4 percent per annum for three years. After the third year, the Australian Emissions Trading Scheme was to be integrated into the European, so that the Australian carbon price would come to be set by supply and demand for carbon credits in a combined Australian-European market in which prices would be determined mainly by the larger European economy.

The Carbon Farming Initiative, like the emissions trading scheme and the older Renewable Energy Target was administered by the Federal Government's Clean Energy Regulator. The Regulator set to work developing a range of "methodologies" which defined acceptable approaches to carbon sequestration which could be awarded carbon credits—or Australian Carbon Credit Units (ACCUs). These are accepted as credible methodologies and carbon credits in countries in which these matters are taken seriously. This is an important asset upon which we can build.

The main market for ACCUs has been the Emissions Reduction Fund, introduced by the Commonwealth Government with effect after the abolition of carbon pricing. This was funded through the Commonwealth budget, with an initial allocation of $2.5 billion. The Clean Energy Regulator periodically runs auctions to purchase ACCUs from the lowest bidder. The Regulator entered into contracts to purchase credits as they became available for specified periods up to 10 years. A secondary market in ACCUs developed around the periodic auctions. Ten years is less than half of the period over which carbon stocks will be accumulating.

The initial budgetary allocation is close to exhaustion. The Government announced in early 2019 that it would be augmented by an additional allocation of $2.5 billion over 10 years. The Emissions Reduction Fund was to be renamed the Climate Solutions Fund. Its scope has been extended to cover a wider range of activities.

The ERF/CSF contains provision for major emitters of greenhouse gases to hold emissions below a defined baseline. Emissions above this baseline are to be acquitted by surrender of ACCUs. This adds a small amount to demand for Australian carbon credits. It would have been larger—and may yet be much larger—were it not for undemanding baselines and a loose approach to enforcement of obligations. The Review of the ERF in 2020 by Grant King for the Commonwealth Government recommended changes that could have the effect of increasing demand for ACCUs—although possibly increasing supply by allowing sale of credits by companies reducing emissions below their baselines. It is open to the Commonwealth government to interpret these recommendations in ways that unambiguously increase demand for ACCUs.

In addition to supply into auctions conducted by the Clean Energy Regulator, ACCUs are also sold into Australian and international voluntary carbon markets. The voluntary markets are becoming more active as increasing numbers of major corporations are entering commitments on carbon neutrality that can be met in part by purchase of offsets.

The ERF/CSF has several big weaknesses. First, it depends on subventions from the Commonwealth Budget for purchase of carbon credits (Australian Carbon Credit Units, or ACCUs). That limits the purchase of carbon to a small proportion of the potential.

The second weakness is that projects that meet the CER's criteria cannot simply sell their credits into the market but must be successful at auction. This introduces uncertainty and transactions costs. Secondary markets have not yet emerged with the depth to cover this weakness.

A third weakness is the absence of a general opportunity for owners of land to register into a carbon pricing scheme and be rewarded for all accretion and penalised for all depletion of carbon. Rather, accretion of carbon is rewarded only if it can be demonstrated to have occurred within one of a range of specified ways ("methodologies"). There is no mechanism for continuing calculation, and reward of accretion and penalisation of depletion.

A fourth weakness is the high cost of measurement, which is prohibitive for producers seeking to sell small amounts of carbon sequestration.

Some voluntary carbon markets in Australia and abroad provide opportunities for Australian producers to sell carbon credits. Access to these is facilitated by official certification, which is also often costly. In Australia this is a role of the Commonwealth's Clean Energy Regulator.

8.2 Comprehensive Carbon Accounting in the Land Sector

Two developments are crucial to large expansion of carbon sequestration in Australian plants and soils.

One is low-cost, credible measurement of carbon in plants and soils. Contemporary research and development based on remote sensing and other technologies applied from satellites or closer to the earth from drones is revealing opportunities for reliable measurement at much lower costs than established terrestrial approaches. The University of Melbourne and connected networks of scholars lead this work. Funding to accelerate application of new approaches is an important area for research and development effort in the period immediately ahead.

The second is the development of a methodology that allows comprehensive reward or penalty for all changes, positive and negative, in carbon above and below the ground on a defined piece of land. Owners of land could choose to opt into the arrangements. They would earn ACCUs for increases in carbon stock and be required to surrender them for reductions. A decision to opt in would be irrevocable, with contingent revenues and liabilities being attached legally to the land title. Participants would be able to deliver an unlimited number of ACCUs to the market at an announced price. Later, the price could be set in a market, through the interaction of supply and demand.

8.3 Expanding the Market for Land-Based ACCUs.

Current demand for ACCUs can absorb only a small proportion of the ACCUs that would be supplied from the land sector at a price anywhere near an economic price of carbon.

First, businesses owning ACCUs could do everything they can to gain access to the growing Australian and global voluntary markets. A number of international voluntary markets have open access. These include the Verified Carbon Standard (VCS), the Clean Development Mechanism (CER), Gold Standard (GS) and PURO (CORC). Each of these markets has its own eligibility and verification standards. Some products are valued more highly by credit purchasers for the co-benefits they deliver. The ability to track

performance in the digital era allows this project distinction to be recorded, observed and transacted with relative ease.

Second, the Commonwealth Government could expand the budgetary allocation to this activity. The $2.5 billion committed by 2030 could be made available immediately and used to purchase ACCUs as they were presented for sale. This would be a useful counter-recessionary measure, encouraging highly labour-intensive activities.

Third, the Commonwealth could tighten the baselines of large emitters and require rigorous enforcement of requirements to buy and surrender ACCUs on exceeding baselines.

Fourth, as suggested by Ross Garnaut in Superpower (Garnaut 2019), the Commonwealth could require that all fossil carbon mining companies generating fugitive emissions—by far the largest source of Australian emissions growth over recent years, now accounting for one sixth of total emissions— to offset them by purchase of ACCUs. If phased in over a decade, this would provide a major boost to demand for ACCUs and underwrite strong expansion of land-based sequestration. These arrangements could be implemented at a State level if the Commonwealth were not inclined to implement them—either individual state or states acting alone or all or some states acting together.

Fifth, Victoria alone or with other States could seek to join a sub-national trading system elsewhere. Sub-national schemes elsewhere – such as the California Cap and Trade Program – have been effective where a national policy was not available. The Californian CaT has brought in other US states and Canadian provinces including Quebec. Within such an international trading arrangement, Victoria would likely be a substantial net exporter of credits and an exporter of zero emissions manufactures in the longer term, so long as there are coherent and sustained policies that support biomass-based industrial exports as well as credits from sequestering carbon in the landscape.

8.4 Access to Markets for Low-Emissions Goods.

The building of low-emissions manufacturing industries based on biomass raises similar issues to land-based sequestration. However, they are more challenging, as emissions reduction interacts with trade policies. Australia's own carbon pricing affects export potential mainly through its effects on access to other countries' markets. In the Australian market, grant support for innovation can assist early investments in new biomass-based manufacturing industries. Similarly, a Clean Energy Finance Corporation with a wider mandate that allows lending for investment in low-emissions manufacturing can help.

The most important question is whether low-emissions Australian manufactured products will have access to international markets that favour low-emissions over traditional products. The European Union is likely through the first half of the 2020s to introduce a border carbon tax against imported products that are more carbon-intensive than European products subject to the European Emissions Trading System. It would not be an issue if the European tax were not applied to zero emissions Australian products; goods made with zero emissions from Australian biomass would qualify. But there is a risk that the new arrangements will not be applied with great subtlety, and that Australian products will be excluded on the basis of general judgements about Australia's progress on reducing emissions. It is likely

that UK emissions reduction policies will remain closely aligned with Europe after formal withdrawal from the European Union. If Joe Biden is elected president of the United States in November, as seems likely, the US will probably follow a similar path to Europe on ambitious emissions reductions and border taxes. This path will be followed more quickly and strongly if Biden's Democratic Party secures a majority in both the House of Representatives and the Senate.

8.5 The Right Price of Carbon.

What is the appropriate price for carbon?

It is the price which, if applied as a global carbon tax, would achieve agreed climate outcomes at the lowest possible cost.

The credible estimates are more than twice as high as the $A20-25 CO2-equivalent that professional carbon project developers and timber enterprises see leading to large increases in areas of timber plantations and environmental planting.

The Garnaut Climate Change Review in 2008[135] estimated that for a 2°C warming objective, the appropriate carbon price was about $A40, rising at 4% per annum. The Obama Administration required Government agencies, coordinated by the Department of Energy and the Environmental Protection Agency, to calculate the social cost of carbon for incorporation into regulatory decisions relating to carbon emissions. The most recent estimates under the methodologies developed for the Obama Administration was around $US 50 (in 2018 prices) in 2020 (applying a 3 percent discount rate) and rising over time. Applying different methodology provided by the Trump Administration (seeking to withdraw from international cooperation on climate change), more recent estimates have been much lower. The European Emissions Trading System, based on emissions reduction targets broadly consistent with the Paris goals, was generating a carbon price of about 25€ in late July 2020, the price having fallen with the Covid pandemic.

Outside of the ERF/CSF purchasing options there is a spot market for trading ACCUs. This is Australia's carbon market. Voluntary and safeguard compliance credits are exchanged as well as ERF contract shortfalls. The volumes traded are small. Because the ERF/CSF is the main destination of ACCUs and most of those traded on the spot market are to balance ERF/CSF contract supply shortfalls, the spot price reflects the prevailing ERF/CSF contract price. The average price secured by auction in mid-2020 was $16.14 / tCO2e. The spot market traded ACCUs between $15.80 and $17.50 / tCO2e in the first seven months of 2020.

The ACCU price can be compared to international compliance market credits. Figure 23 shows that the established markets in the Euro Zone, New Zealand, South Korea and California have been generating steadily increasing prices. These prices were trading in the range $25-40 / tCO2e until the trend was temporarily disrupted by the pandemic recession. In July 2020, European prices lifted to all-time highs.

[135] Garnaut, Ross. (2008). The Garnaut Climate Change Review. Cambridge, UKCambridge University Press

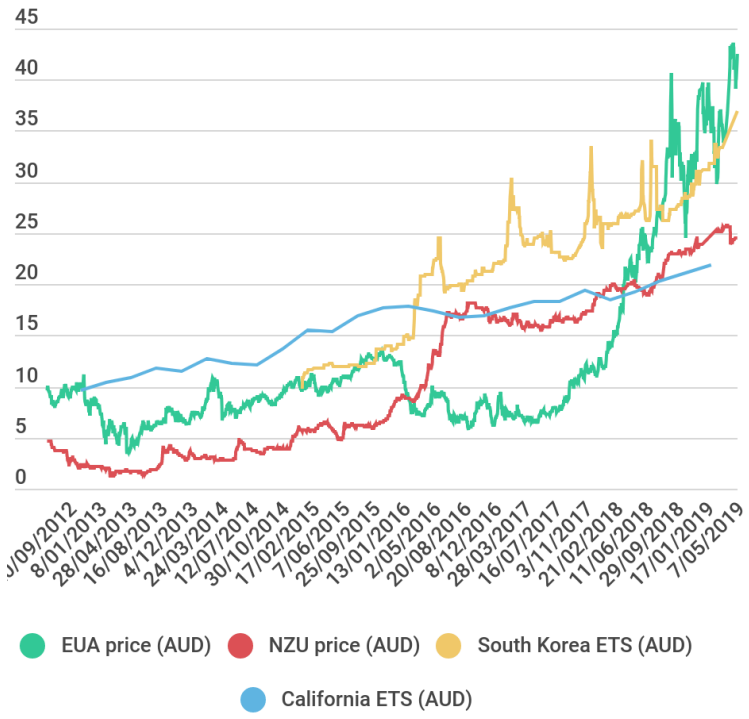

Figure 22 Comparison of international carbon credit prices AU$/t CO2

8.6 Recognising co-benefits

Some voluntary markets place a higher value on carbon credits if they are accompanied by certification of positive contributions to biodiversity and other environmental values beyond carbon. Such certification is a role for the state agency (or delegated authority) with responsibility for protecting environmental services beyond carbon.

Carbon markets will encourage planting of trees but will not drive provision of other valuable ecosystem services. Other mechanisms, including active government planning and delivery of ecosystems markets is required for multiple benefits. An agency is needed to define, regulate delivery of or monetise the establishment of a basis for market exchange of ecosystem services (like biodiversity and catchment protection).

A Commonwealth agency, or in its absence a State agency, could specify conditions that establish Victorian landscape carbon as a premium product, differentiating it from a unit of carbon sequestration traded alone. A carbon product could be linked to contributions to other environmental objectives, including biodiversity, water catchment management, drinking water protection or habitat corridors.

The Queensland Land Restoration Fund (LRF) provides one model where co-benefits are characterised and rewarded with premiums on top of underlying commodity carbon. Certification of contributions to multiple environmental objectives, may allow carbon sequestration units to qualify for access to premium international markets for environmental services, which may be a source of additional value. A state government offtake of ACCUs pays a premium in recognition of co-benefits.

Global voluntary markets including the “Gold Standard” for carbon sequestration trade at a premium to standard carbon units.

Pursuing multiple environmental objectives with a single instrument would generally be economically inefficient. An alternative is to credit separately co-benefits that align with other Natural Resource Management, environmental or socio-economic objectives. This would align strongly with the Victorian Government land use and natural environment pledge actions[136]. Credits from carbon value, a biodiversity fund for habitat enhancement and other sources can be brought together so that the landowner can access cumulative sources of value.

[136] Alexandra & Associates Pty Ltd, (2002) *Landscape Change in the Goulburn Broken Catchment Final Report*, Goulburn Broken Catchment Management Authority, Shepparton

9 Appendix

Private Forests Tasmania

Private Forests Tasmania (PFT) was established in 1994 as a statutory authority under the Private Forests Act (1994). Private Forests Tasmania has a Board consisting of Directors who are appointed for their practical knowledge, industry, commercial and technical expertise in forestry and reports to the Minister for Energy and Resources. The Board oversees strategic direction, and a staff of permanent and fixed-term officers undertakes the functions of the authority. Staff are located in Burnie, Hobart and Launceston.

PFT is a government authority with a legislated role to facilitate and expand the development of the private forest resource in a manner which is consistent with sound forest and land management practices.

PFT is at this time the only government-funded authority established in Australia to promote, foster and assist the private forestry sector on forestry matters. It does this mainly through providing information and advice to private growers and their markets, through research, innovation and planning tools, and by providing practical policy advice to Tasmanian and Australian governments on matters affecting the interests of private forest growers.

PFT Purpose

To support sustainable growth and development of Tasmania's private forest resource.

Goal 1: Work creatively with stakeholders to expand private forestry on a commercial basis.

Goal 2: Effectively communicate the benefits of wood and the benefits of private forestry in the primary production landscape.

Goal 3: Work with Government policy makers and regulators at local, state and national levels to improve regulatory efficiency and practical policy settings for private forestry.

Goal 4: Continuously improve management and business systems to ensure staff and contractors work in a safe, productive and healthy environment.

PFT Funding

The functions of Private Forests Tasmania are partially supported through a levy paid by private forest growers based on the net area of a forest operation permitted pursuant to the certification of a forest practices plan by the Forest Practices Authority. PFT supports private forest owners by responding to their enquiries, organising field days and market forums, development of planning tools and information services, and behind the scenes, through forest practices advice, practical policy input to the Tasmanian and Australian Governments, and supporting research and innovation