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Land-Based Carbon Dioxide Removal Options for Victoria

Review Paper

Kate Dooley, Peter Christoff and Rebecca Burdon

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Authors

Dr Kate Dooley is a Research Fellow at the Australian-German Climate & Energy College, University of Melbourne. Contact kate.dooley@unimelb.edu.au

Associate Professor Peter Christoff is a political scientist, currently teaching in the School of Geography, University of Melbourne.

Rebecca Burdon is the Managing Director of the Energy Transitions Hub, University of Melbourne.

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Executive Summary

This paper considers land-based carbon dioxide removal (CDR) approaches for Australia, looking specifically at Victoria in the context of considering how the land sector can contribute to a net-zero emissions goal under the Victorian *Climate Change Act 2017*. Under the Act, the Victorian Government must legally enshrine interim targets for 2025 and 2030 by 31 March 2020. Land-based CDR is projected to play a significant role in achieving these interim targets. An understanding of the mitigation potential of all sectors is needed to ensure removals in the land sector are used to enhance rather than reduce ambition.

While emissions from agricultural land have remained relatively stable for decades, emissions from land use, land-use change, and forestry (LULUCF) activities in Australia have fluctuated dramatically, from a source in the 1990s and 2000s to a net sink today. However, this net sink is projected to decline over the next decade. For Australia's land sector overall to make a major contribution to climate mitigation through CDR, land clearing and deforestation would need to be further reduced, while the CDR potential of other activities (forest management, reforestation, farm forestry, plantations, soil management) is enhanced beyond current projections. We suggest there is potential for this to be done in Victoria, with significant economic and ecological co-benefits for biodiversity, agricultural productivity and ecosystem services.

Recent years have not seen comprehensive assessments of mitigation potential from agriculture and forestry. Many studies are site specific and do not give an overview of national or state-based mitigation potential. Research that does look at national potential has focused on carbon plantings in Australia's intensive agricultural zone, and there is a lack of research in the last decade on the mitigation potential of the extensive zone and rangelands. The narrow focus on fast-growing plantations as the key route to carbon removal undersells the full potential of abatement opportunities in Australia's land-use sector, and overlooks the considerable co-benefits that can be achieved from a broader range of options.

When looking specifically at Victoria, distinct issues emerge for public and private land. Most land area is part of the intensive agricultural zone, and so the particular challenges of competing land-uses and higher land prices present a barrier to implementation. The CDR options on freehold agricultural land are varied, and will require a mix of incentives, from carbon prices to valuing ecosystem services or good stewardship. Policy drivers need to be established to sustain changes in management practices by many dispersed landowners. Questions concern how to incentivise uptake of beneficial land management practices, through financial, awareness raising or other incentives.

Governance challenges will differ with different forms of land ownership or tenure. Claims relating to Indigenous tenure are increasingly being recognised in Victoria, resulting in joint management of public lands between Traditional Owners and government agencies. With the advancement of the Treaty process in Victoria, forms of Aboriginal land tenure cuts across the public/private land distinction, and should be seen as a significant opportunity for forms of land management that could deliver benefits across multiple areas (climate, biodiversity, social, economic and cultural). CDR activities described in this briefing for private lands are also relevant for Aboriginal and Native Title lands, with different ownership and decision-making structures.

As recent bushfires have shown, maintaining and increasing carbon storage in forests are critical challenges for sustainable forest management, alongside establishing long-term monitoring of forest conditions. However, such monitoring must address the interlinkages between carbon and biodiversity values. Strategies only aiming to expand forest reserves miss the opportunity to increase

forest connectivity and enhance forest and woodland integrity on private land – outcomes which would have benefits for biodiversity as well as for the climate.

In this report we identify four broad activities which could have a significant carbon sequestration potential in Australia and Victoria in particular, with significant economic and ecological co-benefits for biodiversity, agricultural productivity and ecosystem services. These are native forest regeneration, carbon and environmental plantings, soil carbon removal, and restoration of degraded lands. Research is now urgently needed that consolidates the knowledge base from earlier studies, identifies priorities that address carbon, environmental and social needs, and comprehensively considers the contribution of native forests to a stable climate.

Introduction

This paper aims to contribute to a discussion to clarify which land-based CDR approaches will be most likely to gain traction in Victoria, and to identify potential conflicts and synergies with other policy objectives relating to land conservation and rural development.

This enquiry is undertaken in the context of the current process to set interim targets (and sector pledges for these) under the Victorian *Climate Change Act 2017*.

Taking into account the recommendations of the Independent Expert Panel on the Interim Emissions Reductions Targets for Victoria (2021-2030)[1], this paper raises questions about the most appropriate CDR interventions that can contribute to sectoral targets for land and agriculture, and the research and policy gaps that need to be addressed to fulfil the land-based CDR potential in Victoria.

Global policy context

The Paris Agreement has highlighted the important role of the land sector in climate mitigation. Its ambitious targets include a long-term mitigation goal to be achieved through a 'balance between anthropogenic emissions by sources and removals by sinks'.[2]

The Sustainable Development Goals (SDGs) also highlight the role of land, in particular SDG 15 which sets specific targets for reversing biodiversity loss and land degradation. There are clear synergies between SDGs reliant on land, and climate mitigation.[3]

Recent major scientific publications have deepened the analysis of how the land sector can contribute to global climate mitigation. The 2018 Intergovernmental Panel on Climate Change (IPCC) Special Report on 1.5°C (SR1.5) emphasises that the Paris Agreement's objective to hold warming to 1.5°C or less is dependent on a net removal of atmospheric emissions. Further, it demonstrates the clear relationship between the speed of emissions reduction required in the coming decades and the amount of global CDR required later in the century if warming is to be held below 1.5°C.

The Intergovernmental Panel on Biodiversity and Ecosystem Services (IPBES) released its first Global Assessment in 2019 that demonstrated the trade-offs between approaches to CDR currently included in global climate models and biodiversity. The IPBES found that all modeled mitigation pathways included in the IPCC SR1.5 had a negative impact on biodiversity, due to heavy reliance on land-based mitigation for CDR.

The 2019 IPCC Special Report on Climate Change and Land found that delayed mitigation action that relies on sequestration by shifting the burden to the land sector brings higher risk of mitigation failure and of temperature overshoot.[4] Synergistic options for land-based CDR need to be found that enhance biodiversity and strengthen ecosystem resilience.

Other research has focused on the potential for large-scale removals via 'nature-based solutions' – protecting and restoring primary forests, expansion of natural forests, agroforestry and other interventions that recognise the role of biodiversity in mitigation strategies.[5,6,7] A recent *Nature* commentary makes the point that 'the current narrow focus on afforestation in climate policy runs the risk of compromising long-term carbon storage, human adaptation, and efforts to preserve biodiversity. An emphasis on diverse, intact natural ecosystems — as opposed to fast-growing tree plantations — will help nations to deliver Paris Agreement goals and much more'.[8] Rather than carbon stores, plantations can be viewed as highly efficient wood production systems which can alleviate pressures on natural forests to meet global demand for timber products, projected to double in the coming decade.[9]

The challenge now is to apply this knowledge to Australia, paying particular attention to the crossovers between biodiversity protection, restoration of degraded lands, improving long-term agricultural productivity, and climate mitigation.

Overview of land-based CDR in Australia

While emissions from Australian agriculture have remained relatively stable for decades, emissions from LULUCF have fluctuated dramatically. The LULUCF sector has been a declining source since 2007 and in 2012 switched from being a net source to a net sink. However, projections suggest Australia's LULUCF sink will weaken over the next decade, as emissions from land clearing, deforestation and forest management remain stable, while less areas are reforested.[10]

For the land sector overall to make a major contribution to Australia's climate targets, land clearing and deforestation would need to be further reduced, while the CDR potential of other activities (forest management, reforestation, farm forestry, plantations, soil management) is enhanced beyond current projections. We suggest there is significant potential for this to be done in Victoria, with significant economic and ecological co-benefits for biodiversity, agricultural productivity and ecosystem services.

While carbon forestry research in Australia has historically covered a broad sweep of potential interventions, from mulga rangelands to mallee biomass opportunities[11,12,13,14], more recent research has focused on carbon plantings in Australia's intensive agricultural zone.[15,16,17,18] The narrow focus in recent reports on fast-growing plantations as the key route to CDR in Australia[15] fails to reveal the full potential of abatement opportunities in the land-use sector. In particular for the extensive agricultural zone and semi-arid land, which has great potential for restoration.

The potential for land restoration is related to the historical extent of land-clearing, as well as current land uses. The first Australian State of the Environment report (1996) gave a land cover baseline for Australia in 1788 that included 30 per cent forest and open woodland. Comparing vegetation changes from that period to 1993 found Australian forest cover had been almost halved. Clearing of native vegetation continues to the present time, with Queensland and New South Wales appearing as global hotspots for vegetation clearing in recent years.

Studies modelling the potential for afforestation in Australia's intensive agricultural zone find very high sequestration potentials, representing a substantial proportion of Australia's mitigation commitments. Land is the second most important sector contributing to mitigation according to CSIRO's Australian National Outlook (ANO) 2019, but the estimated area of planting required to achieve this is up to 30 million hectares, an ambitious projection given this represents 40 per cent of Australia's intensive agricultural zone. Significant opportunities in forest management, on-farm forestry, and avoided deforestation are currently overlooked in national modelling studies.

Net-zero targets and carbon dioxide removal

An increasing number of countries are putting forward net-zero emissions targets for 2050 (or earlier) as part of their Paris Agreement commitments. These targets differ in scope, coverage of GHG emissions, and policy robustness. One key point of differentiation among net-zero targets is the degree to which they rely on offsetting (credits generated from emission reduction activities outside the target in question), or by relying on land-based emissions removals to compensate for higher emissions in other sectors.

The Victorian *Climate Change Act 2017* includes emission reductions within the state, and eligible offsets from outside the state. If land-based CDR is to contribute to aggregate mitigation targets, its inclusion should accompany measures ensuring appropriate mitigation action across all economic sectors. Ensuring carbon removals are not relied on to compensate for weak mitigation efforts in other sectors will be necessary if net-zero goals are to effectively contribute to meeting the Paris mitigation pathways.

Achieving the Paris Agreement, with its ambitious goals dependent on a net removal of emissions, calls for a rethink of the fungibility of terrestrial sinks with emissions from fossil fuel sources. Recent research has called for separate targets on emissions and removals to provide greater clarity over the role and timing of enhanced removals alongside accelerated emissions reductions.[19] The Parliamentary Commissioner for the Environment for New Zealand has suggested that treating fossil and biological sources and sinks separately would place climate mitigation targets in the context of impacts on other environmental challenges, risks and benefits that may flow from climate action.[20]

The differences between sources of emissions from fossil fuels, from biological sources and removal via terrestrial sinks, presents a key point of discussion in the setting of interim targets in Victoria that can contribute towards the objective of net-zero emissions by 2050.

Land-based CDR potential in Victoria

Victoria's *potential* for CDR is determined, first and foremost, by its ecological features – including soil types, and existing and projected changes in temperature, rainfall, fire regime, etc.

However, social, economic and political considerations are also critical to determining its *capacities* in this domain. CDR policy must inevitably include consideration of other objectives for the land sector overall. Victoria is a major food and fibre producer among Australian states, and Australia's largest agricultural food and fibre exporting state by value. The sector provides 5.9 per cent of Gross State Product (GSP). This productive output will likely change under the influence of global warming, as food security becomes an increasing concern the value of farmland used for food production will probably increase. By contrast, timber production contributes relatively little economic value (0.5 per cent of GSP) and employment (0.5 per cent of the Victorian total) to the state's economy overall, although with regional socio-economic variations.

Victoria has 8.2 million hectares of forest, and the greatest proportion of agricultural land of any of the states. Private land holdings account for around two-thirds of the state, with agricultural land comprising about 56 per cent. Over 85 per cent of Victoria's native forests are on Crown land and managed by public entities. This is the largest proportion of any of the states and territories, other than the ACT.

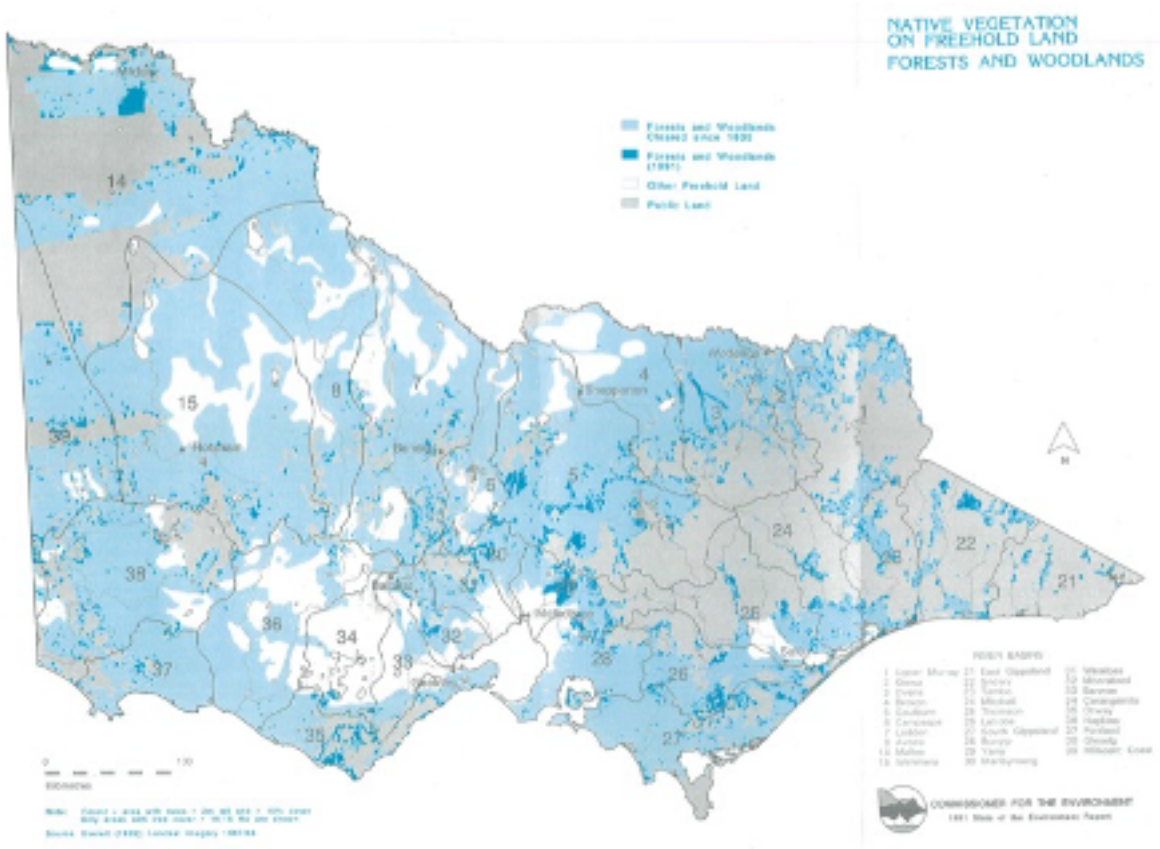

Figure 1: Victoria: Historical comparison of forest and woodland cover on freehold land, 1835 and 1991. (Source: Christoff 199221)

Estimates of the historical extent of land clearing can be used as an indicator to the potential for restoration, and therefore carbon sequestration. Historical changes in vegetation cover in Victoria (providing a broad indicator of reforestation potential) and current land use (providing an indicator of the current state of play) have been estimated and mapped (eg Figure 1), and associated broad calculations of carbon sequestration potential based on forest and woodland clearing are feasible.

Four broad land-use activities for significant carbon sequestration potential in Australia have been identified in the literature. These are: native forest regeneration, carbon and environmental plantings, soil carbon removal, and restoration of degraded lands.

When considering the existing land-uses and climatic conditions in Victoria, native forest regeneration on public lands and farm forestry (including plantations, regeneration and agroforestry) on private lands hold the most potential for significant CDR. The following sections consider the issues relating to the native forest estate on public lands and the potential for enhanced CDR on agricultural lands.

The Native Forest Estate

Victoria includes 7.9 million hectares of public land, where forests and soils are estimated to store 3684 million tonnes of carbon dioxide equivalent (Mt CO_2-e) – about 30 times the volume of Victoria's annual emissions.[1] Most of this land is held as National and State Parks and Reserves, and as State Forest.[22] The 2018 Victorian State of the Forests report identifies climate change (including

a changing fire regime) and biodiversity threats as major issues for long-term sustainable forest management.[22]

Consideration of activities to enhance CDR must therefore respond to biodiversity values, as well as the 'carbon value' (referring to the climate mitigation benefit of retaining carbon, avoiding emissions and increasing removals) of Victorian public native forests.

In November 2019, the Victorian Government announced an immediate ban on logging in Victorian old growth forest, and a transition plan intended to facilitate the reduction of remaining native forest logging from 2024-25 onwards, leading to its complete cessation by 2030. The major bushfires that affected much of far East Gippsland during the summer of 2020 destroyed most contractually committed forest resources in that region and have thrown into doubt the viability of the Victorian timber industry located in that region.[23]

Carbon value

Reduced emissions from deforestation have been a significant contributor to the reduction in Victoria's emissions since 1990, as they have been Australia wide. Victoria's LULUCF sector is also now a net sink for carbon and reduced Victoria's annual emissions by 11.2 Mt CO_2-e (10 per cent) in 201924, with average sequestration of about 4 Mt CO_2-e per year over the decade from 1996-2017 (primarily in Victoria's forests).[1]

Victoria's net land sink is the result of a reduction in harvest from native forests, and the rapid expansion of the for-harvest plantation estate since the late 1990s. In 2017, native forests contributed only 13 per cent of the total volume of harvested timber in Victoria, with commercial plantations delivering the remaining 87 per cent.25 This reflects a substantial change over a 10 year period, where the volume of timber harvested from Victorian native forests was 29 per cent of the total in 2007.[25]

Changes to management of public forests offers significant mitigation opportunities in Victoria, that are not reflected in national projections of sectoral abatement.[1] Native forest restoration, through further reduction in forest harvest and regeneration of previously harvested areas, needs to be viewed as an independent mitigation category in Australia and the potential fully explored. Several previous studies have considered the emissions reduction potential in Victoria from one or more forest carbon activities, but none of these provided a comprehensive state-wide assessment.[26,27,28,29] The Victorian Forest Monitoring Project reports average carbon stocks of 166 tonnes per hectare across Victoria's forest estate using standard biomass conversion factors.[22] Victoria's highland mountain ash forests contain some of the highest-known carbon density of any forests worldwide.[26] Research indicates forest carbon stocks in native forests are consistently underestimated, and hence their contribution to a stable climate is also undervalued.[26,30,31]

There is increasing evidence that for native forests, significant reduction or removal of harvest achieves the greatest mitigation benefits through increased forest carbon stocks and greater resilience to climate change and other impacts.[32,33,34]

Victoria had already achieved significant reduction in emissions through reduction in harvest of the native forest estate, where harvesting was intended to cease by 2030, prior to the major fires of early 2020. Comprehensive assessment of the ecological impacts of climate change and increased fire regimes on policy goals in Victoria is lacking. The consequence of the 2020 fires shows this area requires urgent research attention. An outstanding research question is what further mitigation potential remains through opportunities to increase sequestration in native forests by restoration of degraded areas and changes in fire management practices?[27]

Forest biodiversity values

Ecosystem integrity and connectivity are critical for the survival of many higher order forest-dependent species, for which fragmentation, disturbance, introduced species and climate change all represent major risks. Forest loss and the deterioration of forest health pose significant threats to biodiversity, and endanger the sustainability of ecological goods and services from forested land. [35,36]

Approximately 20 per cent of Victoria's threatened species are forest-dependent.[37] An assessment of forest-dependent species in areas where most commercial native-timber harvesting has taken place identified 79 forest-dependent species, of which 28 are listed as critically endangered or vulnerable in the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*, and 54 are listed as a threatened taxon under the Victorian Flora and Fauna Guarantee Act 1998.[37]

Fragmentation by roads and logging coupes create barriers to animal movement. That disturbance was intensifying in Victoria with the addition of more logging coupes under the Timber Release Plan. On average approximately 75 per cent of Victoria's forest cover in each bioregion is classed as non-fragmented forest, and around 13 per cent as 'edge area'.[22] The cessation of logging activities in areas with threatened species will help to reverse this fragmentation. Fragmentation effects are enhanced by other pressures such as inappropriate harvesting, disturbance, and over-frequent fire. In combination, these pressures make forest ecosystems more vulnerable to climate change.[38]

An expanded reserve network recognising the importance of native forests for carbon stocks and sequestration potential would contribute to climate and biodiversity goals by enhancing the existing reserve system, making it more comprehensive, adequate and representative and improving conservation efforts including fostering appropriate connectivity.[39]

Increasing carbon storage in forests and establishing long-term monitoring of key aspects of forest conditions were identified as critical challenges for sustainable forest management in the 2018 Victorian State of Forests report.[22] However, the carbon and biodiversity values are not linked in these recommendations, and conservation strategies targeting expanded reserves miss the opportunity to increase forest connectivity and intactness on private lands, which would have benefits for both biodiversity and the climate.

Agricultural land

While the majority of Victoria's agriculture emissions are methane emissions from livestock[1], enhancing the CDR potential of agricultural land can help to offset emissions within this sector.

There has been significant focus in policy circles on the potential for increased soil carbon sequestration in farmland.[40,41,42] However, in Victoria, where climate change is projected to cause rainfall to decrease, maintaining existing levels of soil carbon will be a challenge.[43,44] To enhance CDR, appropriate integration of tree-plantings into agricultural landscapes holds the greatest potential.[45]

Accordingly, this section discusses the 'carbon value' and biodiversity values of Victorian farmland by considering four activities to enhance CDR on farmland: tree planting outside of native forest areas through commercial plantations, carbon and environmental plantings, farm-forestry, and changes in agricultural practices to enhance soil carbon. These terms are defined in Table 1.

Plantations

Plantations refers to tree plantings established for the purpose of timber and wood product production. Victoria has the largest total area of plantations for any state in Australia, accounting for approximately one-fifth of Australia's total commercial plantations.[22] Victoria's plantations are almost

all privately owned (99 per cent), and are currently providing a carbon sink of about -7 Mt CO_2-e.[25] In 2016–17, there were 421 700 hectares of industrial hardwood and softwood plantations in Victoria.[22] While the area of commercial softwood plantation has been stable since 2000 (at between 212 000 and 226 000 hectares), commercial hardwood plantation areas doubled since 1990 (from 101 500 to 203 000 hectares) mainly due to managed investment schemes in the early 2000s.[22]

Plantations	Commercially harvested for timber and wood products. Established for commercial harvest, as distinct from native forest harvest.
Carbon plantings	Carbon-focused permanent plantings that are established to maximise carbon sequestration.
Environmental plantings	Planted primarily for biodiversity and other natural resource management benefits.
Farm forestry	Farm forestry refers to plantings integrated into farms as shelter belts or blocks, and can be a combination of any of the above options in terms of carbon forestry (smaller scale for-harvest or permanent carbon plantings).

Table 1. Proposed terminology for carbon forestry options (drawn from Mitchel et al47)

The collapse of several high profile agri-business managed investment schemes saw substantial losses for many investors – and a decrease in the rate of new plantation establishments since 2000, with no new plantation areas established in Victoria since 2013.[22] As mature trees are harvested without being replaced, the area of forest plantation has been decreasing by about 3 per cent since 2013 and this trend is likely to continue if unchecked.[1]

The Independent Review Panel suggested that if plantations are converted to long-rotation, replaced, or if new plantations are established, the carbon sink can be preserved and increased, but achieving this will require new policy initiatives to overcome financial and other barriers.[1] Establishing new plantations on cleared non-marginal agricultural land is not viable without additional financial support, given establishment and land costs in Victoria compared to returns for wood products.[1] The State Government pledged $110 million in the 2017–18 budget[48] to support the long-term sustainability of Victoria's timber-harvesting industry through assisting plantation establishment in the Latrobe Valley.[22]

Policy discussions need to consider whether for-harvest plantations are the best way of creating and maintaining a long-term carbon sink, as well as the economic, social and environmental impacts of plantations. Benefits that can motivate the establishment of new plantations include harvest income, carbon income, and on farm benefits (including ecosystem services payments) where appropriately designed plantations are integrated into an agricultural landscape.

Carbon and environmental plantings

Carbon and environmental plantings are often treated separately in research and modelling studies, with carbon plantings referring to fast-growing monocultures with higher carbon sequestration rates, while environmental plantings refers to mixed-species plantings such as reforestation and land remediation that promote biodiversity, watershed protection, reduced erosion and other ecosystem services.[15]

Broad-scale carbon plantings can take a range of forms and have not generally been planted in areas with high sequestration rates due to high land costs. Modelling of carbon plantings in Australia's intensive agricultural zone find very high sequestration potentials with a sufficiently high carbon price to offset land values, representing the second largest sector contributing to Australia's abatement according to CSIRO's ANO 2019.[15] The estimated area of planting required to achieve this (sequestering between 400 and 700 Mt CO_2-e by 2060) is up to 30 mega hectares Australia-wide, which the models project could occur at a carbon price of $153/t CO_2-e in 2050 and $274/t CO_2-e in 2060.[15] The ANO modelling assumes the carbon plantings require land-use change, rather than being integrated into continuing agricultural land.

Carbon and environmental plantings on the scale modelled would represent a significant land-use shift, requiring careful planning, consultation and engagement with the community, particularly regional communities, and ensuring protection of prime agricultural land for food and fibre production and avoiding adverse effects on water supplies.[15] Such a large area of planting would come at the expense of land for cattle and sheep and, to a lesser degree, food crops.

Fast-growing single-species plantations focused solely on carbon values risk severely altering local hydrology and reducing water availability, although good planning and careful site selection can avoid negative impacts.[49] Research shows that carbon plantings will only have real biodiversity value if they comprise appropriate native tree species and provide suitable habitats and resources for valued fauna.[8,50] CSIRO's ANO 2019 suggests a landscape level solution of diverse plantings to satisfy the multiple criteria of maximising carbon sequestration for immediate income and prioritising ecosystem restoration through environmental plantings in the right river catchments and corridors to restore the ecosystem health upon which Australia's agricultural productivity and biodiversity depend.[1]

Farm forestry

Farm forestry refers to tree plantings integrated into farms as shelter belts or blocks. Farm forestry presents an opportunity both to increase sequestration on private land and deliver co-benefits to Victoria's agricultural sector. It can comprise both for-harvest and permanent environmental plantings.

Farm forestry has been ranked as the simplest and most cost-effective form of land-based abatement to implement in several studies in Australia and other countries.[51] The incorporation of trees on farms has been shown to provide significant co-benefits to farm productivity, through enhanced biodiversity, ecosystem services, wind breaks, and erosion protection.[52,53] There is also some evidence that native vegetation can increase farm sale value, relative to similar properties with no native vegetation.[54]

Farm forestry should not be valued on financial returns alone, an important consideration is that integration of trees into the agricultural landscape can potentially increase both the total productive value of the land (tree crops plus agricultural crops) and the resilience of agricultural land.[15] Developing and valuing methods to increase carbon stores without changing land-use to non-agricultural uses will create better opportunities for land-sector engagment in climate mitigation. Farm forestry activities such as shelterbelts, or increasing woodland density on pastoral areas and practices to increase soil carbon in managed landscapes support existing production while creating emissions abatement.

The 2018 Victorian *State of the Forests* report shows that only one-third of forests on private land are intact, compared to a larger proportion of intact forests on public lands.[22] This underscores the significant potential for the restoration and reconnection of forests on private land which would provide climate and biodiversity benefits, along with potential productivity benefits for farms. Farm forestry has perhaps the largest potential for achieving land-based CDR in Victoria while providing co-benefits to agricultural productivity, ecosystem services and rural communities.

Soil carbon sequestration

With predictions for a drying climate, the challenge facing Victorian farmers is to maintain existing soil carbon. Increasing soil carbon stocks in the face of increased heat and drying that will be experienced in southeastern Australia is particularly challenging.[44]

The long-recognised declining health of Victorian agricultural soils, including erosion, acidification, soil compaction and soil nutrient decline is a clear threat to productivity.[55] Ongoing poor ecosystem and land management practices continue to drive the deterioration of soil health. Previously large estimates of the technical potential of soil carbon sequestration in Australian agriculture may still be relevant.[56] However, updated Australia-wide studies do not exist. Moreover, the barriers to realising that estimated potential have been more fully understood in recent research (including monitoring cost, and climate impacts such as reduced rainfall increasing soil carbon loss[57,58]).

The CSIRO's ANO 2019 suggests that encompassing a broader set of environmental outcomes that include the underpinning drivers of farm production (such as soil health), and monetising these outcomes, could sustain farm production and income in the longer term by acknowledging the need for ecosystem restoration.[15]

Stakeholders, rights holders and other actors

Key stakeholders in the fate of agricultural and forested land in Victoria include farmers, often represented by various state-based and national industry bodies, domestic timber and paper producers and their representative organisations, relevant unions, regional and rural communities impacted by land-management decisions and land-use change, scientific bodies, and community-based organisations (especially environmental ones). Key representatives of Traditional Owners in Victoria include the Victorian Aboriginal Heritage Council and Aboriginal Victoria. Other actors include government agencies, from the national through to local level. Many of these groups made submissions to the Independent Review Panel, who noted the range of views in the Victorian community and the need to balance different demands and values such as employment, recreation and biodiversity preservation.1

This section identifies and discusses the key agendas of some of the relevant non-government stakeholder groups when considering land-based CDR.

Traditional Owners

The Independent Review Panel notes that Victoria's Traditional Owners have a strong interest in and can support and benefit from actions to reduce Victoria's emissions. Traditional Owner groups are already undertaking activities that sequester carbon, for example by protecting, restoring or regenerating native vegetation. The Victorian *Advancing the Treaty Process with Aboriginal Victorians Bill 2018* begins a state level treaty process which will give greater flexibility and funding to Aboriginal communities, including more autonomy in land management decisions, especially in joint management operations involving the State Government.

In Victoria, Aboriginal land tenure occurs under freehold, Aboriginal Title and Native Title, with most occupancy occurring in the west and south-west of the state. This land is generally native forest or farmland which is suitable for land remediation and offers significant carbon and biodiversity benefits.[59]

Australia continues to lead and raise standards on the development of Aboriginal carbon farming, with the Aboriginal Carbon Foundation recently producing a 'core benefits' verification framework, to provide guidance on implementing and verifying the environmental, social and cultural values of Aboriginal carbon farming.[60]

While carbon farming projects currently only exist in the northern regions of Australia (eg Western Arnhem Land Fire Abatement Scheme), carbon farming on Aboriginal land in Victoria has received attention from peak bodies such as the Federation of Victorian Traditional Owner Corporations, who have produced a handbook to assist member corporations to understand how carbon farming works and how Traditional Owners and native title holders in Victoria may benefit.[59] The handbook describes four existing Aboriginal Carbon Fund case studies in Victoria.

Land-sector projects under Australia's Climate Solutions Fund (previously Emissions Reduction Fund [ERF]) have proven challenging to establish in Victoria for a number of reasons to do with additionality and pricing levels. It is important that support and incentives are provided to enable initiatives on Aboriginal lands for restoration and regeneration that are not reliant only on carbon market financing.

Due to barriers to establishing viable ERF land restoration projects in Victoria, engagement and incentives for enhancing carbon sequestration on Aboriginal lands should be considered within a broad policy approach, across all policy levels available and land titling considerations, and not sidelined to only the specific consideration of carbon funding projects under the ERF or an equivalent project mechanism. This is consistent with the Independent Review Panel recommendation that emissions reduction policies in Victoria should include early engagement from, and seek to support and overcome barriers to, Traditional Owner involvement.[1]

Industry organisations

The National Farmers' Federation (NFF), the peak national body representing farmers, is calling for a $1 billion eco-systems services fund[61], following on from a $30 million biodiversity stewardship fund announced in the 2019 federal election that would develop a framework to pay farmers to improve landscape and capture carbon. The NFF likened the concept to a new Landcare system, as a system that will recognise, reward, and put a value on the systems and land management processes that farmers undertake.

In line with the NFF's stewardship approach, the Victorian Farmers Federation (VFF) considers an agro-ecological approach to restoring native vegetation as a more effective strategy than the current Victorian Native Vegetation Removal Regulations. The VFF believes planting new trees on farms would be a more effective long-term strategy for biodiversity protection than protecting existing paddock trees.

Farmers for Climate Action, a national body that started in Queensland, calls for a national long-term action plan for farming and climate change to protect food production.

There are also various farm forestry groups and other regional initiatives. Farm Forestry Growers Victoria is a voluntary organisation of about 30 tree farm growers across Victoria that represents growers' interests and liaises with industry to promote small-scale plantations of mixed species.

Environment groups

Environmental organisations at the state and national level have been engaged with forest policy since the late 1970s. Of note are Environment Victoria and the Victorian National Parks Association, the Australian Conservation Foundation, the Wilderness Society, and Greening Australia. While some of these groups have also campaigned for the retention of forests to preserve carbon, their engagement with the issue of CDR has to date been slight.

Policy recommendations

The sections below first consider a whole of landscape policy overview and relevant questions for determining a land sector pledge. Second, we consider promising policy options relevant to enhancing CDR under different land management arrangements and activities.

Victorian land sector pledge

The most important issue to consider is how a whole-of-state 'land sector' pledge could accommodate the kinds of landscape scale, place-based, social network enabled, approach to implementation that will be required to reverse the decline in terrestrial sink strength in Victoria. Government policy tends to focus on one thing at a time: waterways, biodiversity, carbon, etc. Farmers, on the other hand, need to deal with everything at once. The land sector pledge is a chance to bring these opportunities together in one place, and deal with it at a landscape scale.

As a first step, it is useful to clarify the priority areas for intervention to enhance Victorian CDR beyond current expectations. There is currently no public comprehensive state-based assessment of mitigation potentials. Constraints in national assessments lead to these overlooking the mitigation potential of the land sector for Victoria. CDR potential in Victoria needs to be understood first from a technical perspective to then determine social and economic levers or constraints.

It is also important to be clear about the timeframe in which actions to promote land-based CDR are required, and how their role may change over time. The short-term nature of the interim targets is critical for a continual revision of ambition levels, but also for thinking about how economic sectors, and therefore emissions profiles, may change over different periods of time. As emissions decline, agriculture will become a bigger proportion of overall emissions. If Victoria allows land-based CDR to be used to offset energy sector emissions rather than pursuing a rapid transition to low emissions energy, the task for the agriculture sector will be much more difficult: there will be fewer terrestrial sinks available within the state to offset harder to reduce agricultural emissions. Sector pledges in Victoria need to ensure CDR in the land sector is strongly incentivised, without undermining incentives to invest in emissions reductions in other sectors.

Another example of the importance of timeframes is an earlier phase-out of native forest harvest, which might only represent a small mitigation benefit in terms of a reduced source, but over several decades can result in a significant increase in forest carbon stocks.

Promising policy areas

Following a Melbourne-based workshop in 2019 among key industry, government, farming and academic communities, we suggest six priority areas for further research and action:

1. Determining which are the least cost/biggest CDR opportunities in Victoria

Restoration of riparian vegetation

Water access in riparian zones or floodplains, results in higher carbon sequestration than the landscape median. Degraded riparian zones require interventions such as off-stream watering points and fencing, but policies such as subsidies for fencing off riparian zones can result in large carbon benefits. Extension of existing policies such as the Regional Riparian Action Plan in Victoria would be essential to protect and remediate degraded Crown lands along riparian zones.

Trees on farms

Integrating trees into farming for commercial and other farm benefits is likely to be the single biggest policy intervention that could increase land-based CDR in Victoria. A stewardship scheme for provision of ecosystem services that recognises on-farm benefits from incorporating trees could incentivise farm forestry. Ongoing Research and Development and extension services are needed to understand the provision of ecosystem services in agricultural lands. This includes understanding and quantifying the value proposition of trees on farms, which goes beyond carbon or direct commercial gain, to include benefits of shade, shelter, etc. Shifts in commodity price, and tying up land with tree plantings, reduce on-farm flexibility, making it critical to emphasise and demonstrate productivity benefits for farmers.

Improved forest and fire management practices

Wildfires in the last 20 years have had a profound effect on carbon stocks within the native forest estate in Victoria. Human-induced regeneration of forests provides a low cost and potentially large opportunity to preserve and increase carbon sequestered in the state, with big benefits for biodiversity.

Supporting natural regeneration

In Victoria, most fragmented native forest areas are on private land, with only about one-third of forests on private land intact. Restoration incentives for private landholders could therefore yield high carbon and biodiversity benefits. On lands owned or managed by indigenous peoples, support for ecological restoration may provide more effective results than development of projects to strict methodologies such as those under Climate Solutions Fund.

Substituting carbon intensive building products with wood

The mitigation potential of Harvested Wood Products (HWP) has been highlighted by the timber industry, but achieving this potential comes down to how long-lived are HWP. Given the longevity of forest carbon stocks can be hundreds of years, better data is needed on the end-use of forest harvest to understand where mitigation opportunities lie.

2. Determining policy synergies

Linking land-based CDR to other policy objectives such as water quantity and quality management, and biodiversity management, will be critical for effective outcomes and is often overlooked in government policies and management strategies. Scientific research is unambiguous in its statement of the importance of biodiversity for the resilience and longevity of terrestrial carbon stocks. Yet current policy frameworks do not directly address enhancing the protection and management of forests and plantings on private land with attributes important to both ecological conservation and carbon storage. Increasing synergies between biodiversity and carbon goals will be critical to the objective of achieving increased CDR in Victoria. Policies should encourage farming communities to bundle the benefits to water, soil, biodiversity, and carbon sequestration and do this at the catchment level.

While carbon is one of many factors in deciding to plant trees, it is not generally the definitive one, and so policy incentives need to target benefits beyond a carbon payment. Permanent carbon plantings (monoculture species) have few co-benefits beyond carbon sequestration and may have negative environmental impacts resulting in opposition from rural communities.

It is important to consider how to ensure Victorian CDR contributes to delivering the Paris Agreement objectives. Using CDR merely to compensate for emissions in other sectors within Victoria, within Australia, or internationally may squander this limited resource and contribute to a moral hazard that undermines the ambition level needed to achieve the Paris Agreement. An understanding of the mitigation potential of all sectors is needed to ensure removals are used appropriately.

3. Quantifying the integrated value-proposition for farmers, landowners and other stakeholders

Around half of the land in Victoria is freehold agricultural land, according to the Victorian Land Use Information System. The CDR options on this land are varied, and require a mix of incentives, from carbon price to valuing ecosystem services and good stewardship. Policy drivers would need to be established to sustain changes in management practices by many dispersed landowners. When these policy drivers are targeted at local (catchment scale) initiatives, there are local benefits and local ownership. Working with farmers to develop a farm plan that helps them account for emissions in line with the Victorian interim targets (2025 and 2030) could be achieved through an incentive package that quantifies all the benefits of planting trees in the right place and makes this accessible to farmers. An integrated approach to on-farm benefits that is locally driven is needed, with a long-term commitment to consistent policy.

Tools such as bridging finance, rollover funds, etc, could be included to support landholders to reduce on farm emissions and support regenerative agriculture and increased trees on farms. Rabobank, through its Rural Bank and Agribusiness Farm Finance arm, provides an example of an effort to encourage best environmental practice and animal welfare, through the way it configures loans. A sustainability dashboard for farms that provides a way for farmers to capture and input data on key sustainably indicators (eg tree diversity, lamb survival, riparian revegetation) could be monetised via favorable lending or government subsidies.

4. Developing Networks

The policy and outreach instruments that can be utilised will be key, as delivering on ambitious land sector pledges for Victoria is about working with farmers. Mapping of physical and social network analysis is critical to better understand where farmers get their information and how to articulate programs that mesh with their needs.

Characterising and rebuilding social landscapes is needed. The capacity to adopt extension services and the prioritisation of extension services now needs to be targeted to climate outcomes. Many farmers see the solution to agricultural emissions is to manage the broad range of emissions sources and potential sinks, including plantings, on their own farms. Policy initiatives could tap into the existing desire to plant trees – such as funding Landcare, fencing, biodiversity links, riparian zones and building the service sector. These are on the ground activities that are largely untapped by current federal policy initiatives, such as the Climate Solutions Fund, but deliver significant local benefits. Stakeholders emphasised the need to identify initiatives to support the sector to facilitate agricultural regeneration (eg plant nurseries, planting contractors, knowledge outreach to guide species and form of plantings), all of which could be done now based on existing knowledge.

5. Reviewing inventory accounting

Reviewing the links between the national inventory and property and project level accounting in land-based emissions and sequestration to determine how robust they are, and what is and is not being covered at present is a critical next step for national level emissions accounting. Measurement and accounting issues linking to the national inventory relates to agricultural and forest emissions as well as sequestration.

6. Evaluating existing policies and gap analysis

Evaluate existing policies and the practices used by government, landowners and stakeholders, to ascertain the impacts of different measures and which are most appropriate and effective now, and determine where gaps might exist. Now is an important time to learn from the past 30 years of policy implementation in the agriculture sector and to review and assess the existing and potential impacts of relevant existing governance and legal frameworks on land-based CDR activity.

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www.sustainable.unimelb.edu.au

Melbourne Sustainable Society Institute
Glyn Davis Building, Masson Rd
The University of Melbourne
Parkville VIC 3010, Australia

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