

Which of the following best describes your situation?

Research and academia

Are you responding on behalf of an organisation or industry body?

Yes

Who are you responding on behalf of?

Macdoch Ag Group

How would you like to respond?

c. Both

Upload your document here:



What are the opportunities to reduce emissions and build carbon stores in agriculture and the land? What are the main barriers to action?

Australia's farmed soils and farmer-managed vegetation can provide a significant sink for sequestration of atmospheric carbon when grazing and cropping practices are changed to promote organic carbon accrual. Barriers

to realising this capacity include limited farmer uptake of practice changes, costs of on-farm infrastructure (e.g. “wire and water”), and reactive peer pressure from “conventional” farmers and advisers. The government’s sector decarbonisation planning should include support for the various farmer extension services to make them better equipped to support farmers that are curious to try a carbon project. For example, a high priority should be given to the timely and rapid implementation and rollout of the “Carbon Outreach Officers” program (already announced). Support should also be given to those private sector “carbon project developers” who are overtly committed to helping farmers implement the lasting practice changes that will increase sequestered on-farm carbon stocks in soils and vegetation.

How can we progress emission reduction efforts whilst also building resilience and adapting to climate change?

Emissions reduction and carbon sequestration are two sides of the same management coin. ACCU creation methods recognise the need to deduct on-farm emissions from gross sequestration. Promoting sensible ACCU Scheme projects among farmers is a way to incentivise farmers to reduce emissions and generate sequestration benefits concurrently, while realising the natural increase in drought resilience that enhanced soil carbon brings.

Are there initiatives or innovative programs underway that could be applied or expanded on at a national scale?

A comprehensive, publicly-funded on-farm program that measures, monitors, and interprets data on soil and landscape health – including soil carbon baselining – would underpin scaled-up carbon sequestration and storage activity reaching many more Australian farms than is currently the case. The NSW Government is currently delivering farmer-focussed projects under its NSW High Impact Grant Partnerships program. One of these, delivered through Atlas Carbon and Wilmot Cattle Company, is helping grazing properties transition to adopt proven resilient practices through capital support for infrastructure to increase water flow to tanks, additional fencing for managed grazing, and addressing weak areas of soil type and pasture. We would propose a scaled-up version of this type of program for national application as a specific net-zero agriculture and land initiative. This should ideally involve a grant component, enabled and managed through the existing third party managed grazing advisers (such as MaiaGrazing). The program should provide specific support for direct capex investments (water, fencing, perennial species, etc.) to enable them in transitioning to resilient practices which can boost soil and vegetation carbon sequestration, with many associated productivity co-benefits.

How can the Australian Government bring together existing effort and new initiatives into one coordinated plan?

Australia already has a number of excellent agricultural support programs and policies. However, these rather disparate efforts need to be better coordinated, with deeper and stronger linkages. The sector’s decarbonisation strategy and climate outcomes could be greatly enhanced by rapidly implementing and expanding its announced “Carbon Outreach Officers” program. Also, much more government support and recognition should be given to the many demonstration activities of exemplar farmers and graziers, and leading specialist agri-tech businesses. These are providing practical leadership in climate-aware farming. Particular recognition should be given to peer-to-peer learning opportunities, such as field days and on-farm workshops that promote climate-smart farming and grazing practices. There should also be integration of the decarbonisation plan with other relevant government programs such as The Murray Darling Basin Plan, The Future Drought Fund, The National Soils Program, and the 30-by-30 biodiversity agenda. Better linkage of these policies will help leverage and multiply the effectiveness of the considerable government expenditure and resourcing across the Agriculture and Land sector.

What are the most important options to be further adopted or supported, looking in the short and the longer-term?

Stronger support for on-farm soil and vegetation sequestration activities, propelled by grazing and cropping practice change that can also deliver productivity and profitability benefits

What are the practical solutions to increase uptake?

Uptake of climate positive on-farm actions requires upskilling, training and peer-learning opportunities for farmers and other landscape managers, especially First Nations land managers.

How do you see the agriculture and land sectors contributing over the medium and longer-term? What are the opportunities to deliver emission reductions in parallel with wider goals?

Innovative farmers and land managers, armed with the right information (and some investment support) can lead in “rebuilding” the Australian landscape’s carbon stocks for both a national net zero contribution and to boost farm productivity and resilience (“... a mere 0.8% per annum increase in SOC stocks ...” – or less than an additional 1 tonne of C per hectare to 30 cm depth – across all of Australia’s landscapes could effectively mitigate Australia’s total annual greenhouse gas emissions).

How can the Australian Government better support agriculture and land sectors to:

a) drive innovation

b) build capacity

c) ensure the system enables emissions reductions

There needs to be a concerted national program of support (including training, field demonstrations, pilot studies, and farm infrastructure investment) for farmers and landscape managers in all regions to undertake CDR projects, including under the ACCU Scheme, as part of their ongoing sustainable farming and grazing activities. As well as boosting national CDR efforts, this will also help boost the profitability and resilience of the nation’s farming operations. This should include more government support and recognition for: (a) the many demonstration activities of exemplar farmers and graziers, and leading specialist agri-tech businesses, who are providing practical leadership in climate-aware farming, (b) practical peer-to-peer learning opportunities, such as field days and on-farm workshops (for example, Wilmot Field Day) that promote climate-smart farming and grazing practices, and (c) public-good research projects, such as Farming for the Future, which are adding deep knowledge about nature stewardship within productive farming contexts.

What new initiatives could the Australian Government design that would support emissions reduction and carbon storage in agriculture and land and help ensure a productive, profitable, resilient and sustainable future for the sectors?

There are many innovative farmers who are already sharing their stories via field days, Landcare Groups, and through peer learning groups facilitated by organisations like Soils For Life. Rather than developing new, duplicative, or overlapping programs, the government should be supporting these existing agricultural support programs, and perhaps modifying them so they can better support specific emissions reduction and carbon storage activities on Australian farms. Other existing government-funded programs, such as the Future Drought Fund, the ACCU Scheme (including support for project baselining costs), various Rural RDC programs (such as MLA’s CN30), and various

university research activities need better coordination and communication so they can produce additional targeted support for the sector's decarbonisation agenda.

A consistent and trusted approach for assessing and reporting emissions is often raised as a barrier to reducing emissions. Is there a role for the Australian Government in addressing this concern, and how can producers and land managers be supported?

Australia already has a world-class suite of emissions monitoring and reporting systems (e.g. NGERs, Safeguard Mechanism, MRET, ACCU Scheme, etc.).

What skills, knowledge and capabilities do you think producers and land managers need to implement change? What information and data would help them make decisions about emissions reductions and sustainable land management in the short and longer-term?

Farmer and other land managers need continuous access to upskilling, training and peer-learning opportunities to stay abreast of best science and practice. They also need access to reliable, continuously updated, real-time biophysical data on soils and other natural capital stocks and flows to inform their decision-making.

Do you have any additional views or feedback that you would like to include in your response?

See written submission.

Is your response confidential?

No

Do you agree to your response being published on our website?

Yes

I have read and understood the privacy notice and consent to the collection, use and disclosure of my personal information as outlined in the privacy notice.

Yes

Confirm that you have read and understand this declaration.

Yes

December 2023



Agriculture, land and emissions discussion paper

Response to consultation

Summary

Macdoch Ag Group's mission is to demonstrate how a resilient agricultural sector builds natural capital and contributes to global climate solutions. Its beef cattle and sheep grazing enterprises use grazing animals to build soil carbon, enhance biodiversity and promote drought resilience.

Australia's agriculture and land sector offers some of the most tangible, productive and cost-effective opportunities for governments to deliver on their climate policies, including net zero policies. However, the discussion paper significantly understates the role of land-based mitigation and abatement in helping meet Australia's decarbonisation challenge. The paper particularly depreciates the important role of carbon sequestration in on-farm soil and vegetation in our climate response.

The discussion paper also ignores recent authoritative models – such as ClimateWorks' latest scenario modelling – that highlight the Agriculture and Land sector's key role and mechanisms for achieving emissions avoidance and mitigation, particularly on-farm carbon sequestration. This contrasts with the opinions of many other government and related organisations, international agencies, and private researchers which variously attest to the importance of land-based carbon dioxide removal via nature-based sequestration as one of the main ways Australia can meet its emissions-reduction "gap" by 2050.

The discussion paper also pays insufficient attention to the role of *working farms* for sequestration opportunities. Rather, it tends to focus on carbon storage on protected and conservation lands, highlighting the need for "trade offs" with food and fibre production. There is little recognition of the mutually-beneficial role of soil organic carbon for boosting production and enhancing other on-farm performance.

In view of these shortcomings, Macdoch Ag Group offers seven recommendations for improvement in the discussion paper to enhance the sector's decarbonisation plan:

- 1) Make a more overt and emphatic acknowledgement of Agriculture and Land's role in supporting Australia's climate response
- 2) Include a deeper analysis of the potential scale and reach of carbon dioxide removal opportunities – particularly through on-farm soil and vegetation management
- 3) Provide for a greater level of integration and linkage between this sector plan and the many exemplar farmer/grazier demonstrators, as well as other government-sponsored initiatives
- 4) Quantify and promote the agricultural and landscape productivity gains achievable through positive, climate-focussed practice change
- 5) Give greater emphasis to upskilling and training of landholders (including First Nations owners/managers) for implementing on-farm nature-based solutions
- 6) Reinforce the importance of investment in baselining of data for measuring, monitoring and reporting of soil and vegetation carbon sequestration and storage
- 7) Highlight the sustainability credentials of Australian farms and landscapes that manage for food, fibre and natural capital markets (including overseas commodity trade)

This submission includes some referenced technical information on the likely scale and significance of soil and vegetation carbon sequestration within the agriculture and land sector and makes the case for much greater consideration of these crucial sinks in Australia's net zero policy and planning.

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Introduction: Who is Macdoch Ag Group and what is this submission about?

Macdoch Ag Group

Macdoch Ag Group's mission is to show how a resilient agricultural sector builds natural capital and contributes to global climate solutions. Through its farming, AgTech and advisory businesses, Macdoch Ag Group seeks to provide the tools, advice and test cases for how building natural capital can support the resilience, sustainability and profitability of farming businesses. These businesses are classified as *demonstrators* (farming businesses), *tools* (AgTech businesses) and *enablers* (advisory businesses).

Macdoch's Australian farming businesses, **Wilmot Cattle Company** and **Cavan Station**, span beef cattle and sheep grazing enterprises that embrace agro-ecological and climate-friendly principles, with a primary focus on landscape management using grazing animals to build soil carbon and encouraging biodiversity.

A key management practice is matching the grazing stocking rate with the farms' variable carrying capacity – as expressed by pasture status, soil health and the prevailing / predicted climatic conditions. This ensures ground cover is maintained, protecting the soil and enabling maximum water infiltration. In turn, farm resilience is manifested through rapid pasture growth response to rainfall around the annual cycle.

Continuous tree planting programs complement and enhance Macdoch's soil health focus, increasing functional biodiversity, building more above- and below-ground carbon, providing livestock shade and shelter. Landscape rehydration practices help buffer the soil's water storages and restore riparian zones which had been unintentionally degraded by prior high-impact farming practice. Macdoch applies farming and grazing practices featuring low or no chemical usage, plus multi species fodder cropping, to achieve its landscape goals.

Macdoch Ag Group's agtech and advisory businesses support and enable on-farm practice change and supply chain integrity in concert with emerging and rapidly evolving technology solutions for the industry. Entities include **Macdoch Ventures**, which deploys part of its capital through agrifood, climate and environment investing. **Atlas Carbon** and **MaiaGrazing** provide farmers with the tools, advice and confidence to adopt practices that prioritise natural capital, improve the ecological functioning of their landscapes, and build more resilient and sustainable businesses. This is all directed at delivering positive industry, community, environmental, and climate mitigation impacts.

Macdoch's advisory services include shareholdings in a number of specialist businesses, such as **Impact Ag Partners**, which advise farmers and landholders through identifying and structuring investment opportunities, raising capital, conducting due diligence, negotiating acquisition, and operating land-based assets on behalf of investors. Again, the focus is on value creation and financial

returns through regenerative agricultural production, the monetisation of natural capital, and participation in climate-friendly food and fibre value chains.

The Macdoch Foundation operates separately from the group's corporate and commercial businesses, providing philanthropic and impactful support for social, community and scientific initiatives. One of these initiatives is *Farming for the Future*, a world-first research project that is exploring and documenting the empirical relationship between on-farm natural capital stewardship, especially on-farm vegetation such as trees, and the economic and financial resilience of Australian farming businesses.

What is this submission about, and how is it structured?

This submission provides feedback on the Australian Government's *Agriculture, land and emissions discussion paper*¹ ("The Discussion Paper" -) which was released for public consultation on 7 November 2023. The discussion paper is directed at developing the *Agriculture and Land Sectoral Plan*. This is one of the Australian Government's six proposed sectoral plans which will together inform development of its "net zero plan". This is the plan that help the Government deliver on Australia's emission reduction goals, including reaching net zero by 2050.

Macdoch Ag Group appreciates the opportunity to participate in this consultation.

Section 1 of this submission provides a critique of the discussion paper, particularly emphasising its gaps and shortcomings. The Department has encouraged us to be candid in this process with a view to finding decarbonisation solutions for the Agriculture and Land sector that will practically address the government's net-zero mandate while also serving the best interests of landholders, primary producers and regional communities. We provide recommendations on ways to strengthen the government's approach to the Agriculture and Land sector's climate response. This is intended to assist the government to leverage the sector most effectively towards achieving Australia's legislated 2030 and 2050 emissions reduction targets, and most tangibly assist in delivering on its *Nationally Determined Contributions* (NDCs) commitments under the Paris Agreement².

Section 2 provides additional commentary, referenced opinion, and data demonstrating how Australian agriculture, and particularly our livestock grazing sector, can provide *significant positive climate solutions*. This focusses mainly on soil carbon sequestration which, through managed practice changes, can make a major contribution to *farm and landscape productivity, genuine drought resilience* and strengthening of Australia's *international trading prospects* for farm-based products. However, significant amounts of additional carbon sequestration can occur in on-farm vegetation when the landscape is managed with an eye to maintaining active tree cover, including shelter belts and including silvo-pastoral options in farm management planning. We are convinced that actions to enhance the stewardship of natural capital (including soil health, biodiversity and landscape water resources) are integral to the nation's climate response. Locating these actions *within* the farming and grazing sector's lands and operations will also enhance Australia's productive farming and grazing sector, create regional jobs and economic benefits, and help secure Australia's domestic and overseas markets for our farmers' sustainable food and fibre supplies.

Section 3 concludes the submission by briefly responding to those of the discussion paper's set consultation questions that are relevant to Macdoch Ag Group's interest and expertise.

Section 1: Comments and critique of the discussion paper's content

This Section 1 provides a critique of the discussion paper, highlighting some of its gaps and shortcomings, and making recommendations to strengthen the government's approach to the Agriculture and Land sector's climate response.

The intent here is to assist the government to better leverage agricultural landscapes towards achieving Australia's legislated 2030 and 2050 emissions reduction targets.

In fact, we believe the Agriculture and Land sector can offer some of the most tangible, productive and cost-effective opportunities for governments to deliver on their climate policies, including the current net zero policy mandate, as well as fulfil our *Nationally Determined Contributions* (NDCs) commitments under the Paris Agreement. However, the discussion paper, as currently drafted, does not adequately identify or leverage those opportunities.

Issue #1 - The discussion paper significantly understates the role of land-based abatement in meeting Australia's decarbonisation challenge

The discussion paper significantly understates and, in places tends to misconceive, the role of soil and vegetation carbon sequestration in contributing to Australia's climate response. Surprisingly, for an *agriculture sector* paper, it makes *only brief mention* of the opportunity for sequestering atmospheric CO₂ into Australia's farmed and grazed soils.

In the few places it does so, it tends to emphasise *risks and cautions* regarding, for example, potential land use conflicts and supposed "confusion" among farmers and farming communities on sequestration benefits and carbon markets.

While it is gratifying that carbon sequestration within landscapes receives some mention in the discussion paper, it nevertheless gives no substantive attention to the scale of the opportunity nor the investment models by which the required practice changes can be effectively rolled out at scale in Australia.

For example, there are only eight (8) instances of the term "sequestration" in the discussion paper, and eighteen (18) instances of "storage". In at least half of these, the context tends to be on problems and complexities rather than opportunities.

Table 1 provides an annotated content analysis of the discussion paper's consideration of carbon dioxide drawdown, storage and on-farm management.

The annotations / comments are intended to suggest where the tone and direction of the paper needs to change to give proper consideration of this crucial matter. It highlights the inadequate attention given to sequestration *opportunities* that unfortunately leaves the reader with the impression that farm and landscape soil and vegetation carbon is, at best, a "sidebar" in Australia's climate action arena.

Macdoch Ag Group's direct farming experience tells us this is definitely not the case³.

To correct this, given the discussion paper is intended as a forerunner to the government's agriculture and land sector plan to ***assist it to meet Australia's legislated emissions reduction targets***⁴, the paper ought rather to highlight, and describe in *much more detail*, the positive opportunities for farmers and land managers in helping in that task.

Table 1 – References to carbon sequestration and/or storage in the discussion paper

Reference to “sequestration” and/or “storage” (in context)	Comment
Work currently underway to update Australia’s National Biodiversity Strategy and Action Plan under the Convention on Biological Diversity may also provide future opportunities for sequestration and biodiversity including for example, through efforts to protect and conserve 30% of Australia’s landmass and marine areas by 2030 or to work towards restoring degraded ecosystems. (p.8)	There is no mention or consideration of on-farm soil or vegetation sequestration here, and the context implies this will focus mainly on protected areas.
There are opportunities for producers and private land managers to deliver carbon storage together with nature outcomes ; contributing to Australia’s commitment to address biodiversity decline, while also improving soil quality, water retention and building climate resilience. (p.8)	This is one of only three largely supportive references to carbon sequestration. Given 75% of Australia’s land base is privately owned or managed ⁵ it is surprising the paper doesn’t focus more on the role of private landholders in land-based carbon accrual and markets.
Strengthening Australia’s environmental laws to deliver better environment and heritage outcomes, supporting private landholders to invest in their natural capital, and implementing approaches that expand protected and conserved areas can support carbon storage outcomes and help to reduce pressure on the agricultural sector . (p.12)	This refers only to storing carbon in protected areas, to “help reduce pressure on the agricultural sector”, suggesting that carbon sequestration and farming/grazing cannot be co-located.
A range of established and emerging technologies and practices could help reduce emissions or increase the storage of carbon in soils and vegetation. Some of these are being implemented, but adoption of others is impeded by cost, doubt about abatement and productivity outcomes, and limited technical understanding or skills . (p.13)	While this does encourage technology uptake for carbon storage, it couches the subject in negative terms (e.g. “... doubt about abatement and productivity outcomes...”)
Sequestering carbon into vegetation and soils across all lands can reduce net emissions and provide wider co-benefits such as water and soil quality improvement , wind protection, drought resilience and more biodiverse landscapes. It can also provide new income streams for producers who choose to participate in carbon and emerging biodiversity markets. Ensuring producers have access to support and information needed to make decisions on how to optimise use of land for productive agriculture, carbon sequestration and biodiversity outcomes will be important. (p.16)	This is the second of only three mostly positive references on-farm carbon sequestration, including its productivity benefits. It does, however, imply there is necessarily a “trade off” between carbon storage / generation and farming per se.
Questions are also being raised about the extent to which sequestration offsets should be used within agriculture or sold to other sectors of the economy to offset their emissions. (p.17)	Here is another negative assertion about the role and disposition of sequestered carbon benefits in the farming context
Domestic and international opportunities and trade-offs around the use of land for carbon storage also need to be considered. (p.20)	“Trade-offs” imply competition for agricultural land when a carbon storage project is implemented.
There will also be new opportunities associated with demand for carbon sequestration and restoration of nature . An expanded vision for the industry could include more mixed farming, where producers supply larger volumes of lower emissions food and fibre into global markets, integrated with the provision of carbon and biodiversity outcomes at the farm-scale . (p.21)	This third, mostly positive reference to on-farm carbon sequestration, including its potential role in supply chain decarbonisation productivity benefits.
Delivering emissions reductions and expanding carbon storage across agriculture and the land will require more than just investment from government and industry, it will also require significant investment by private actors. (p.26)	This comment acknowledges the potential for “expanding carbon storage across agriculture”, albeit with the spectre of significant additional investment needed.

These changes should include at least consideration of information and informed opinion on matters such as:

- (a) The *quantum of potential and economically feasible carbon storage* in Australia's farmed soils and farmer-managed vegetation,
- (b) the range and *significance of additional co-benefits* that could accrue to farming and grazing enterprises from enhanced carbon stewardship actions, and
- (c) the *modelled and forecast emissions mitigation contributions* that are possible and feasible from Australia's aggregate managed agriculture land estate.

If there is doubt surrounding the extent and permanence of carbon stocks sequestered in farm soils and/or vegetation, then the Government's decarbonisation plan should include more work to support the uptake of sequestration projects by farmers and other landscape managers so that more and better data can be gathered, interpreted, and made publicly available.

Issue #2 - The discussion paper ignores authoritative models that highlight the AFOLU sector's key role and possible mechanisms of mitigation

While most climate authorities recognise that the broad land sector (as represented by the UNFCCC's "AFOLU" category⁶) can and must play a major role in the global emissions abatement task, the discussion paper pays no attention to these potential contributions.

There are two key mechanism: one is via *avoided emissions*, achieved through things like better land use (e.g. avoided clearing), reduction the use of synthetic fertilizers, minimum tillage, enteric methane reduction in livestock, etc. The other is via *biological* carbon dioxide removal (CDR) through carbon sequestration in soils and increased landscape vegetation.

While both mechanisms are clearly important for Australia's Agriculture and Land sector, the CDR aspect has a particularly crucial role in the context of Australia's net zero trajectory.

This has been highlighted, for example, by ClimateWorks' most recent (2023) scenario modelling, which have been published since the discussion paper was released. The ClimateWorks 2023 model

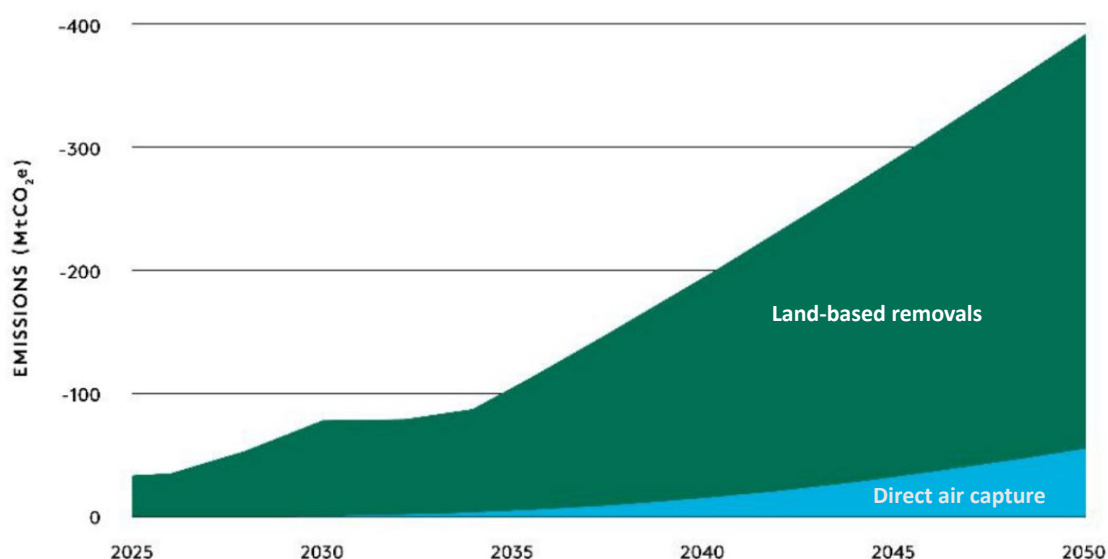


Figure 1 – ClimateWorks' 2023 scenario for CO₂ removals (Mt/yr) for 1.5°C

tracks Australia's alignment with the Paris Agreement's warming limiting targets (as distinct from achieving the Australian Government emissions reduction targets *per se*).

This approach applies carbon budgets which define a "fair share" of the total emissions that Australia can emit between now and 2050, to have the best chance of limiting global temperature rise.

Importantly, these assume and document a *major role* for land-based CO₂ removal between now and 2050 (see Figure 17).

For example, it considers:

"... Removing carbon from the atmosphere is critical, so practicalities need to be resolved. Land management practices such as tree planting – and *emerging soil carbon technologies* – can absorb carbon dioxide from the atmosphere.

"...an unprecedented scale of effort to absorb carbon dioxide is needed to stay within the Paris Agreement temperature limits ... from 1.4 gigatonnes of CDR in the 'well-under-2°C' scenario to 4.6 gigatonnes in the '1.5°C scenario'.

"... *Most* would come from increased uptake of established land-based practices, such as planting trees and ecosystem restoration.

"... CDR in the 1.5°C scenario in 2050 is around 17 times what Australian land currently sequesters each year..."

It's also important to point out that **landscape-based** CO₂ removals dominate ClimateWorks' best-case response, which does not see a material role for the other emerging technology, direct air capture (DAC) until the 2040s. Even then, DAC has a maximum uptake rate of 0.25 MtCO₂e removal per year, and increasing to just 5 MtCO₂e per year from new plants *by 2050*.

Hence, in ClimateWorks' opinion, soil and vegetation sequestration will remain the dominant CDR mechanism until Australia reaches its 2050 net zero target.

ClimateWorks' modelled *quantum* of CDR required essentially represents the "gap" between emissions reductions and target national emissions reductions achievements to meet the Paris warming limit goals under two scenarios: achieving the Paris Agreement's preferred 1.5°C warming limit by 2050, and a "well below 2°C" limit (but assumed to be a 1.8°C warming limit).

The required CDR levels by type of removal for Australia, under each warming scenario, are summarised in Table 2.

Table 2 Modelled CO₂ removals required to meet the two Paris warming limits (Mt CO₂e/yr)

Warming limit ↓	... by 2035		... by 2050	
	Nature-based	Direct air capture	Nature-based	Direct air capture
1.5°C	190	10	224	31
< 2°C (1.8°C)	29	1	141	19

The scale and implications of the 2023 ClimateWorks analysis for Australia's Agriculture and Land sector's future highlights the discussion paper's failure to adequately consider sequestration – particularly on-farm sequestration – as a major opportunity for Australian agriculture and the government as it pursues its net-zero ambitions.

Issue #3 – There is a major disconnect between the discussion paper’s priorities for Carbon Dioxide Removal and that of other agencies and climate authorities

As noted earlier, the discussion paper is deficient in that it grossly underappreciates the positive role of agriculture and land in providing carbon dioxide drawdown services, thus contributing to Australia’s net emissions reduction goals.

In contrast with this tone and approach, many other government and related organisations, international agencies, and private researchers attest to the fact that ***land-based carbon dioxide removal via nature-based sequestration is one of the main ways Australia is going to be able to meet its emissions-reduction “gap” by 2050.***

This is a surprising shortcoming of the discussion paper, given its stated intention is to canvass “... opportunities for agriculture and land to *contribute to the whole-of-economy goals*, in a way that supports industry growth, productivity, sustainability and resilience ...”.

Organisations and authorities which recognise and endorse the key role of Agriculture and Land in climate policy, particularly in CO₂ drawdown, storage and credit generation, include:

- Australia’s Climate Change Authority (CCA)
“The land sector, which accounts for changes in the amount of carbon stored in trees, vegetation, soils and harvested wood products, removed more carbon dioxide from the atmosphere than it released in the year to June 2023”
- The Department of Climate Change, Energy, the Environment and Water (DCCEEW)
“... Improving soil carbon storage can help reduce Australia’s greenhouse gas emissions. Farmers can increase the carbon stored in soil by changing land management practices.”
- Professor Ian Chubb (Australia’s former Chief Scientist)
“... removing significant amounts of CO₂ already emitted into the atmosphere is essential if global heating is to be controlled ... to start at scale well before 2050, the land sector will have to carry much of the immediate load, starting now ...”
- Australia’s Agriculture Ministerial Council
“... Participating in a growing carbon market presents an opportunity for the agricultural sector ... producers can be paid for storing carbon in vegetation and soils, and for avoiding emissions in line with approved methodologies set out by the ACCU scheme...”
- The Clean Energy Finance Corporation (CEFC)
“... soil organic carbon has a vital role to play in reducing carbon emissions in Australia’s agricultural sector...”
- United Nations Framework Convention on Climate Change (UNFCCC)
“... Nature Based Solutions (NbS), including regenerative agriculture, have a central role in countries’ NDCs and national adaptation plans ... (and) ... regenerative agriculture and NbS have a critical role to play in food and agricultural systems, able to sequester 10Gt CO₂eq per year, make land use net zero by 2030, and a 10Gt CO₂eq carbon sink by 2030, with benefits for biodiversity and livelihoods...”

- The UNFCCC's Independent Panel on Climate Change (IPCC)

*"... Agriculture provides the **second largest share of the mitigation potential** ... from cropland and grassland soil carbon management, agroforestry, use of biochar, improved rice cultivation, and livestock and nutrient management..."*

These organisations' views on the important role agriculture has in meeting climate targets are elaborated in Table 5 in Appendix 1, which includes sources / references.

The IPCC's estimates of AFOLU mitigation contributions – especially where soil carbon fits as a feasible, low-cost, multi-benefit CO₂ removal opportunity – are worth further comment in the context of the Australian government's climate policies and approaches to achieving net zero.

Moreover, these IPCC data confirm **soil carbon sequestration** as the second largest mitigation opportunity, with a mid-range potential of 5 billion tonnes of CO₂-e removal globally each year.

A recent FAO-sponsored study on that global grassland soils⁸ notes "... the adoption of improved management practices offers the opportunity to sequester *significant amounts of carbon in the near term*, and potentially to make an important contribution to global mitigation efforts ...". It estimates that global *grassland soils* have the feasible potential to sequester some 2.2 billion tonnes of CO₂-e per year in the 0-30 cm layer alone. This corroborates the IPCC's overall global SOC sequestration estimate, given that grasslands make up only part of the available farming and grazing land estate.

The data in Table 3⁹ provide a summary of the IPCC's assessments, showing the overall mitigation potential of agriculture as part of the AFOLU sector.

Table 3 - IPCC AFOLU removals potential (2022)

CDR option	Mitigation potential range (Gt CO ₂ e / yr)		
	<i>Lower</i>	<i>Mid</i>	<i>Upper</i>
Afforestation / reforestation	0.5	5.3	10.0
Soil carbon sequestration	0.6	5.0	9.3
Peatland and wetland restoration	0.5	1.3	2.1
Agroforestry	0.3	4.9	9.4
Improved forest management	0.1	1.1	2.1
Biochar	0.3	3.5	6.6
Enhanced weathering	2.0	3.0	4.0
Totals (excluding blue carbon & oceans)	4.3	24.1	43.5

This assessment indicates that the combination of cropland and grassland **soil carbon management**, agroforestry, use of biochar, improved rice cultivation, and livestock and nutrient management could together deliver an average of 4.1 (range 1.7–6.7) GtCO₂-eq /yr of abatement at a cost of less than USD100 /tCO₂-eq¹⁰.

The IPCC also identifies and endorses a suite of practical, reasonable-cost actions that can be taken within the AFOLU sector to bring that sectors *own* global emissions contribution down to meet its share of the Paris 1.5C target. It groups these into three mitigation categories, viz: "Prevent", "Reduce" and "Remove".

The global potentials for these actions are illustrated in the waterfall chart in Figure 2, which provides a stepwise scheme for agriculture and AFOLU mitigation. Soil and vegetation CDR (that is, *sequestration*) together feature as a very material 18% of that global effort.

The burden of informed opinion summarised in the above list of authorities (elaborated in Table 5) underlines Macdoch Ag Group's concern that the discussion paper significantly *understates* the significance and role of land-based abatement, and the associated role of offsets, needed to meet Australia's decarbonisation challenge.

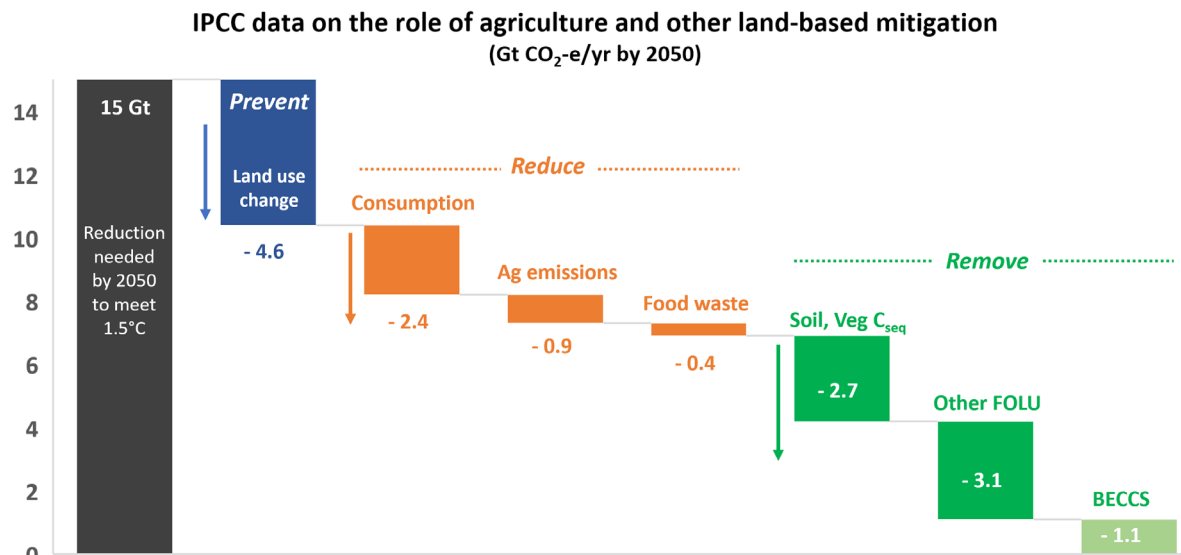


Figure 2 – Mitigation chart reconstructed from IPCC data (2022-23) and Roe et. al. (2019)

Issue #4 - The discussion paper pays insufficient attention to the role of working farms for sequestration opportunities

The discussion paper pays only scant attention to the opportunities afforded by well-managed farming and grazing to boost carbon sequestration in soil and vegetation *on working farms*. This shortcoming hinders the proper promotion of scaled-up carbon sequestration and storage in our farmed and grazed landscapes as part of the sector's decarbonisation plan.

Further, while some attention is given to storage on protected and conservation lands, and to the need for "trade offs" with food and fibre production, there is virtually no recognition of the mutually-beneficial role of soil organic carbon for boosting production and enhancing other on-farm performance.

In contrast with the discussion paper's approach, an increasing number of farmers and landscape managers are undertaking CDR projects, including under the ACCU Scheme, *in concert with ongoing sustainable farming and grazing activities*. They routinely give first-hand reports of the significance of increased carbon sequestration in their soils *and* vegetation for the ongoing profitability and resilience of their farming operations, for example:

*"... properties sequestering soil carbon are better equipped to handle droughts ... they increase the water holding capacity as carbon is added to the soil, for example Rexton can now hold an additional 200,000t of water, slowing entry into drought and speeding up recovery. That water holding capacity has allowed carrying capacity to increase by two-and-a-half times ..."*¹¹.

Examples of published case studies include the following:

- The government's own **Clean Energy Regulator** has published a number of case studies that demonstrate that "... more carbon in soil can increase productivity and drought tolerance while reducing farm input costs ..." ¹²;
- Non-government organisations such as **Soils for Life** have published many examples of the multiple benefits of regenerative agriculture, including on-farm soil carbon sequestration actions, to demonstrate the productivity uplift possible for our food and fibre commodities ¹³.

To truly reflect the interests and opportunities offered by the Agriculture and Land sector to address Australia's climate challenges, the discussion paper (and its following sector plan) should definitely include examples of practical, on-farm management practice changes that can assist cost-effective decarbonisation while delivering other on-farm sustainability and profitability benefits.

Indeed, the Government's decarbonisation planning should more properly comprehend the essential nexus between on-farm stewardship of natural capital – such as soil and vegetation carbon stocks – and farm productivity and profitability.

In this respect, the Government's attention is drawn to the major sponsorship by **The Macdoch Foundation** – the philanthropic arm of the wider Macdoch Group – of a significant, world-first public-good research initiative titled *Farming for the Future* ¹⁴.

This project is deeply investigating the relationship between natural capital status and stewardship and financial outcomes within working Australian farming businesses. The outputs of this important multi-stakeholder project will, subject to appropriate privacy protocols, be in the public domain. This will assist the development of complementary natural capital innovations, for example, by providing a ground-truth reference data set to support and improve the remote sensing and A.I. products being developed by Ag-Tech companies. It will also minimise the need for duplicate data collection processes, ensuring efficient investment that will accelerate Australian agriculture towards climate- and market- readiness.

Recommendations for change and inclusion in the sector plan

Flowing from the above analysis, Macdoch Ag Group offers seven recommendations for additions and improvements to the discussion paper which we believe will greatly enhance the development of effective and practical decarbonisation plan for the sector.

1. Make a more overt and emphatic acknowledgement of Agriculture and Land's role in supporting Australia's climate response

The discussion paper should highlight and describe in *much more detail* the positive contribution that farmers and land managers can make in helping Australia meet its net emission reduction goals through on-farm carbon sequestration.

2. Include a deeper analysis of the potential scale and reach of carbon dioxide removal opportunities – particularly through on-farm soil and vegetation management

The discussion paper could usefully include detailed information on the *quantum* of potential and economically feasible carbon storage across Australia's managed agriculture land estate and align this with the various modelled and forecast emissions mitigation requirements to meet our national net zero and Paris Agreement targets.

3. Provide for a greater level of integration and linkage between this sector plan and the many exemplar farmer/grazier demonstrators, as well as other government-sponsored initiatives

The discussion paper should provide deeper and stronger linkages between the Agriculture and Land sector's decarbonisation imperatives with the many demonstration activities of exemplar farmers and graziers, and leading specialist agri-tech businesses.

These are providing practical leadership in climate-aware farming. In particular, recognition should be given to peer-to-peer learning opportunities, such as field days and on-farm workshops (such as, for example, the annual **Wilmot Field Day**¹⁵). There should also be greater acknowledgement and support for public-good, farmer-focussed research projects, such as *Farming for the Future*, which are adding deep knowledge about nature stewardship within productive farming contexts.

There also needs to be a higher degree of integration of policies and planning across other rural / regional government-supported program. These include, for example, The Murray Darling Basin Plan, The ACCU Scheme, The Future Drought Fund, The National Soils Program, the 30-by-30 biodiversity agenda, and the various Rural Research & Development Corporation programs.

Better linkage of these policies will help leverage and multiply the effectiveness of the considerable government expenditure and resourcing across the Agriculture and Land sector.

4. Quantify and promote the agricultural and landscape productivity gains achievable through positive, climate-focussed practice change

The discussion paper should include (more) examples of practical, on-farm management practice changes that can assist cost-effective decarbonisation while also delivering other on-farm sustainability and wider environmental benefits. This will provide an important reorientation of the paper (and subsequent plan) toward multiple *opportunities*, rather than just focusing on risks and barriers.

5. Give greater emphasis to upskilling and training of landholders (including First Nations owners/managers) for implementing on-farm nature-based solutions

The discussion paper should include greater consideration of the "human element" in addressing ways for the sector to support Australia's net zero trajectory. In particular, it should consider ways to upskill and train farmers and other landscape managers, especially First Nations land managers, to implementation practice changes that support national climate policy objectives.

6. Reinforce the importance of investment in baselining of data for measuring, monitoring and reporting of soil and vegetation carbon sequestration and storage

There is a dearth of systematic public data available to properly and reliably assess the potential for carbon sequestration and storage in the Australian farming context. This is possibly a reason for the discussion paper's lack of attention to is important issue.

The discussion paper therefore should give greater emphasis to the need for, and mechanisms for, the roll-out of a comprehensive, publicly funded on-farm soil and vegetation carbon baselining program.

The recent commitment of the Northern Ireland government to a national program of soil health baselining is a model worthy of adopting¹⁶. Access to reliable data will greatly assist the government to assess the sector's true carbon stocks and flows, inform its emissions reduction policies and programs, and reliably evaluate the impacts of grazing practice change and other on-farm climate-smart innovations.

7. Highlight the sustainability credentials of Australian farms and landscapes that manage for food, fibre and natural capital markets (including overseas commodity trade)

The discussion paper needs to take a much more positive and “farming-friendly” posture toward the contribution that is already being made, and can be accelerated with the right incentives, by some of Australia’s leading farmers and land managers.

This is particularly important to support the task of integrating sustainable agriculture principles in our international trade, free trade agreements and the upsurge in Australia’s engagement in international for a such as the UNFCCC’s COP agenda.

Section 2: The role of on-farm carbon sequestration as a positive climate solution

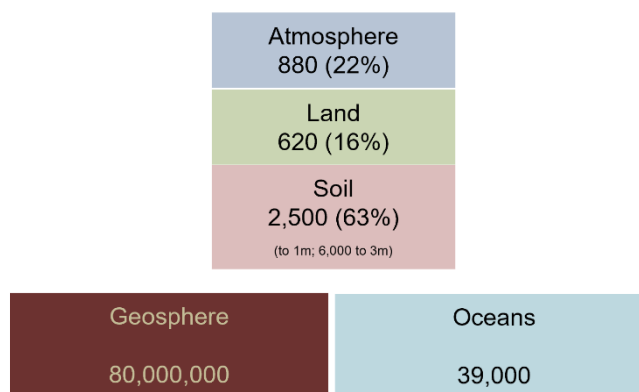
This Section 2 provides important technical information, lacking in the discussion paper, on the science, role and importance of on-farm carbon sequestration as a fundamental contributor to the Agriculture and Land sector’s climate response. Our focus here is mainly on soil carbon sequestration which, through managed practice changes, can make a major contribution to *farm and landscape productivity, genuine drought resilience* and strengthening of Australia’s *international trading prospects* for farm-based products.

The significance of soil carbon for global climate management

Globally, the stock of carbon in the soil is much larger than the combined land and atmospheric carbon stocks (Figure 3). When measured to 1 metre depth, the world’s soils hold four times the carbon stocks of the “above-soil” biomass/land pool, and ten times at 3 metres depth¹⁷. And because many soils are much deeper than 1m (or even 3m), these are conservative estimates of the significance of the soil as a global carbon storage pool.

Despite this significance, international climate change mitigation discussions have to date tended to ignore or sideline soil as a potential carbon sink. However, with the world searching for urgent, practical ways to draw down excess atmospheric carbon, nature-based solutions including soil carbon are emerging as strong candidates for action.

Figure 3 – Global stocks of carbon in billion tonnes of C
(% allocation - excluding oceans & geosphere)



The scale of the soil carbon sequestration opportunity in Australia

Since Europeans began farming in Australia there have been large increases in carbon emissions from our landscapes. It’s widely believed that Australia’s farmed and grazed soils have lost *up to 70%* of the stored carbon in their top 10 cm since the beginning of the 18th Century¹⁸.

Some of evidence for this comes from Paul Edmund de Strzelecki’s 1845 account of the biogeography of Eastern Australia, which included physical soil analysis data from a range of Eastern Australian sites¹⁹. They showed soil organic matter levels (typically described as “vegetable and animal matter”) ranging from 7.30% to 37.75%, with a mean of 14.7% (Figure 4).

This, when interpolated to soil organic carbon (SOC), would indicate a soil carbon range of between about 4.23% and 21.90%, with a mean of 8.53% SOC. Similarly, historic records for the Inverell district suggest typical levels of 11% SOC existed prior to the start of “European” farming. By comparison, soil tests in 2007 on native grass country in the same Inverell area showed SOC levels of 1.0% to 1.5%!²⁰

Despite this tragic historic legacy, these data demonstrate that there is a tangible opportunity to apply regenerative farming and grazing practices which could demonstrate the opportunity to *re-sequester* large quantities of carbon through these more climate-appropriate approaches soil and landscape management.

This potential for “rebuilding” the landscape’s carbon stocks is so great that some experts believe that “... a mere 0.8% per annum increase in SOC stocks ...” (or less than an additional 1 tonne of C per hectare to 30 cm depth) across all of Australia’s landscapes could effectively mitigate Australia’s total annual greenhouse gas emissions²¹.

Number to which the Soil refers.	PHYSICAL CHARACTER.				CHEMICAL CHARACTER OF THE SOILS.													
	Absorption of Solar Rays.	Emission of Heat.	Capacity for Moisture.	Specific Gravity.	Soluble Portion of 100 Parts.	Proximate Constituents in 100 Parts.												
						Vegetable and Animal Matter.	Water.	Silica.	Alumina.	Peroxide of Iron.	LIME.		Potash and Soda.	Chlorides.	Magnesia.	Metallic Sulphurets and Oxides.	Loss.	
											Carbo-nate.	Sul-phate.						
No. 1	+ 14.0	— 1.0	+ 6.0	1.9	19.74	18.44	6.53	56.63	10.15	4.00	2.70	1.20	—	—	Traces.	—	0.35	
No. 2	+ 11.0	— 2.5	+ 7.0	2.2	33.07	15.60	5.50	59.80	9.00	1.90	2.00	4.70	1.50	—	Traces.	—	—	
No. 3	+ 7.0	— 2.0	+ 8.0	2.0	26.51	7.30	4.00	65.73	12.42	3.75	6.20	0.60	Traces.	—	—	—	—	
No. 4	Subsoil not taken.				23.26	8.10	3.00	65.40	8.90	4.50	6.50	2.25	Traces.	—	1.10	—	—	
No. 5	+ 12.0	— 4.0	+ 5.0	3.0	25.75	9.00	4.00	63.00	15.00	4.00	3.20	0.80	—	—	1.00	—	—	
No. 6	+ 11.7	— 3.0	+ 7.0	2.2	30.30	10.00	5.20	53.70	19.20	3.20	2.50	4.20	0.80	—	1.20	—	—	
No. 8	+ 14.0	— 2.5	+ 6.0	1.8	25.30	7.50	3.00	72.30	10.00	3.50	1.20	2.50	Traces.	—	Traces.	—	—	
No. 10	+ 12.6	— 2.0	+ 18.0	1.1	40.30	37.75	24.40	14.86	2.75	Traces.	10.30	5.70	2.00	Traces.	Traces.	—	2.19	
No. 14	+ 14.2	— 0.5	+ 17.0	1.0	38.10	34.05	22.80	19.54	8.32	3.50	1.50	2.80	Traces.	Traces.	Traces.	5.70	1.79	
No. 15	+ 12.0	— 3.0	+ 4.0	2.0	32.80	11.00	6.00	56.50	10.10	4.50	2.10	4.80	1.50	Traces.	1.50	Traces.	2.00	
No. 18	+ 14.0	— 3.5	+ 9.0	1.9	35.10	9.28	10.00	51.52	9.00	5.10	5.40	5.50	1.10	Traces.	2.00	—	1.10	
No. 21	+ 24.7	— 7.0	+ 13.0	2.7	30.00	18.93	8.50	49.17	5.90	3.10	4.20	2.80	1.80	Traces.	3.10	Traces.	2.50	
No. 22	+ 21.0	— 6.0	+ 3.0	2.2	25.20	8.50	6.60	54.50	15.10	3.10	8.10	1.40	—	—	1.50	1.20	—	
No. 24	+ 10.5	— 0.4	+ 6.1	1.7	26.50	10.60	5.50	61.80	10.20	2.50	5.50	1.50	—	—	1.30	—	1.10	
No. 27	+ 14.0	— 1.5	+ 6.0	1.9	22.00	11.50	5.20	66.65	5.30	3.20	3.80	0.80	Traces.	—	Traces.	2.80	0.75	
No. 31	+ 19.0	— 2.0	+ 8.0	2.0	25.40	9.50	4.00	70.90	6.90	2.10	2.90	2.50	Traces.	Traces.	Traces.	1.20	—	
No. 32	+ 15.0	— 3.0	+ 12.0	1.0	38.50	20.10	10.10	37.00	6.50	3.30	6.20	Traces.	1.90	Traces.	1.50	1.20	2.20	
No. 39	+ 16.0	— 2.0	+ 9.0	1.3	41.20	18.00	7.50	52.60	10.00	2.10	7.10	Traces.	1.20	Traces.	1.50	Traces.	—	
No. 40	+ 13.0	— 3.0	+ 10.0	1.6	37.50	15.00	8.00	50.50	12.00	3.20	8.00	Traces.	2.30	Traces.	Traces.	Traces.	1.00	
Mean.	+ 13.4	— 2.5	+ 8.0	1.8	30.23	14.70	7.88	54.32	9.82	3.18	4.74	2.33	0.74	—	0.82	0.63	0.84	

Figure 4 – Facsimile of Strzelecki's 1845 "Table of Australian soils of the highest productive power"

At a more realistic scale, recent data suggests that if just the best 10% of Australia’s current *grazing* land was harnessed for active net soil carbon sequestration through managed grazing, achieving an annual average of 0.8 tonnes of soil carbon per hectare, this alone would deliver over 100 million tonnes of net CO₂e of abatement *per year*²², or around 20% of Australia’s current total national emissions.

This estimated “average” SOC sequestration rate is consistent with conclusions from recent meta-data compilation studies, for example:

“... Rates for soil carbon sequestration vary considerably, depending on the climate, soil type, land use history, and management practices employed ... as a rough approximation, best practices on land growing annual crops (such as barley and corn) can yield annual carbon sequestration rates up to 0.6 t C/ha/yr (around 2.2 tCO₂/ha/yr), whereas conversion of tilled annual cropland to pastures, conservation buffers, or grassland set-asides can yield increases of 1 t C/ha/yr or more (that is, 3.67 t CO₂/ha/yr or more) ...”²³.

These results from meta-data studies have been confirmed (or even eclipsed) by the most recent ACCU creation event under the Carbon Farming Initiative's *Soil Carbon* method, for two properties in Central Queensland. This rigorously-audited project showed that, over that 5 year period, between 10.6 and 12 tonnes of CO₂-e was sequestered for every tonne of livestock grazed on the two properties, respectively. This was after accounting for all operational emissions, including enteric methane²⁴.

Soil carbon sequestration rates from data from most Australian on-farm projects are broadly consistent with the findings of a CSIRO assessment²⁵ that estimates the *technical* potential for soil carbon sequestration, with the application of different management practices, could generate 115 Mt of CO₂e per year across Australia's landscapes. Lower estimates for *economic* potential depend upon the up-front costs of practice change, and costs of sampling and reporting under various schemes.

There is thus a compelling case for an active and urgent program of building soil organic matter in the world's agricultural landscapes, with managed livestock grazing one of the best-known low cost, profitable ways of achieving it.

Of all the countries in the world, Australia may be unique with its combination of a well-developed, well-managed livestock grazing sector and a vast area of available rangelands to accommodate enlightened grazing practices. Hence Australia is an ideal place to demonstrate the opportunity to *re-sequester* large quantities of agriculture's historical carbon losses through managed grazing.

A realistic scale of the opportunity, and with an eye to key issues such as *continuity of practice change*, and *appropriate protections against reversal risks*, there would be major national advantages in promoting soil carbon sequestration as a practical climate response tool. Accordingly, rather than demonising grazing and beef cattle production as a threat to the climate, the government can be supporting ways to *harness and promote the climate-moderating features of grazing*, making it part of Australian climate solution.

Examples of on-farm soil carbon sequestration success

In the Australian context, while several forms of "regenerative" agriculture have positive climate impacts, ***changing from intensive cropping to managed grazing*** appears to offer the greatest potential for material, sustained increases in soil carbon stocks over at least a medium (10-20 years) timeframe. For example, global surveys of SOC accrual on hundreds of sites following conversion from cropland to grassland indicate soil carbon increases of between 0.33 and 1.1 tonnes of soil carbon per hectare per year²⁶.

Table 4 includes data from on-farm studies in Australia and New Zealand which highlights the potential for soil carbon sequestration due to practice change to rotational / managed livestock grazing.

Table 4 – Examples of soil organic carbon sequestration rates from Australasian managed grazing

Landscape / biome / practice	Av. soil carbon gain (t C / ha / yr)	Reference
Pasture grazing (NSW)	0.35	Chan <i>et. al.</i> (2010) ²⁷
Annual & perennial pasture grazing (NSW)	0.50	Orgill and Murphy (2021) ²⁸
Hill country grazing (NZ)	0.90	Schipper <i>et. al.</i> (2014) ²⁹
Arid rangelands – rotational grazing (Qld)	1.30	McCosker, T. (2023) ³⁰
Semi-arid pasturelands (Qld)	2.01	Atlas Carbon (2023) ³¹

These examples from a range of biomes and grazing practices, and which are consistent with the global meta-data cited above, indicate it's operationally feasible to achieve annual carbon sequestration rates in soil equating to between 1.3 tonnes and 7.3 tonnes of CO₂-e per hectare through managed grazing in permanent pastures.

Maintaining soil carbon stocks requires committed long term practice change

The significance of soil organic carbon as an atmospheric carbon dioxide sequestration option has been challenged on assumptions of lack of "permanence". Some of such critiques are justified in circumstances where project proponents seek short-term monetisation *without* a commitment to long-term agricultural practice change.

This highlights the need for *bona fide* soil carbon projects to commit to at least two actions: (1) continuation of the specified management practice(s) over the long term, and (2) making allowance for potential carbon stock reversals due to occasional extrinsic perturbations such as drought and bushfire. These are briefly elaborated below.

Continuing management practices: The degree to which newly-sequestered soil carbon stocks can be accumulated and maintained over time is highly contingent upon continuing to practice enlightened grazing management. A landholder's commitment to observe and actively manage carbon-friendly on-farm practices is an essential pre-requisite to maintaining soil carbon stock accrual.

When ongoing practice change is applied to soils historically depleted of carbon, progressive SOC gains are often observed for up to several decades. After this there is typically an observed plateauing in net SOC stock. The typical time period between the adoption of regenerative farming practice and the soil reaching some sort of SOC equilibrium or "saturation" is 25-50 years for arable systems and 30-50 years for grazing systems³², and the IPCC uses a default SOC saturation time of 20 years. Notwithstanding this assumed multi-decadal plateau in net SOC accretion, the IPCC considers SOC sequestration to be a significant avenue for global CO₂ drawdown in the few decades remaining for the world to achieve its committed climate change mitigation targets³³.

Potential for carbon stock reversals: Soil carbon stock reversals can occur due to extrinsic extremes of climate, drought and other impacts such as fire. While we still don't have the benefit of large amounts of data on such carbon losses, we do know that maintaining managed grazing principles, including taking timely destocking decisions, are really important.

Understanding the *mechanisms* of possible SOC retention and / or loss is crucial. Researchers note that "... because of the complex interplay between soil moisture, biomass production and soil microbial responses to water content, the precise impacts of drought on farm soil SOC are difficult to elucidate ...", but that "... a key question to answer regarding the long-term impacts of drought is whether, under continued operation of appropriate farming practice change, the trajectory of SOC stocks over time is generally upward..."³⁴. On this particular point, the most recent SOC data from five years of managed grazing in Queensland (from Carbon Link projects) indicate that the trajectory during drought is still positive³⁵.

Australian researchers also note that the effects of drought on carbon storage and sequestration depends on how different plants respond to disturbance, and "... for resprouting species, mortality may be delayed compared to non-resprouting species (and) ... ecosystem recovery is likely to be more rapid following release from drought, due to the rapid recovery of foliage in resprouting plants. Thus, *the impacts of drought on carbon stores are likely to be lower in vegetation dominated by*

*resprouting species ...*³⁶. There is thus a strong biophysical rationale for promoting pasture species that can exhibit these particular phenotypic characteristics.

The degree to which bushfires deplete SOC stocks depends upon the balance between the fire's effect on the soil's microbial decomposer community and on the physical removal or suppression of new biomass sources. So, "... while fire is generally treated as a liability to long-term C storage, [there are] a number of ways that fire could enhance the soil organic matter (SOM) stability. Prescribed burns could potentially lead to more stable SOM stocks via two mechanisms: limiting the fuel amount to reduce the wildfire severity and thus the combustion-based losses of SOM during high-intensity wildfires; and/or by increasing the C stability in soil by impacting the accessibility, interactions, recalcitrance and decomposer communities. The relative importance of these different processes differs across environments, requiring the implementation of management strategies that depend on the ecological context..."³⁷.

Soil carbon persistence is a dynamic process

Recent soil micro-biophysical research has yielded new understandings of the way organic matter and its carbon are cycled and stored in soils. This shift has important implications for defining and characterising *permanence*.

Whereas classical soil science teaches that long-lived humic substances impart most of a soil's carbon recalcitrance (that is, long-lived resistance to decay), evidence is emerging of a more dynamic interplay between SOC stocks, microbial populations and clay-carbon interchange. This new evidence is shifting the rather static idea of *permanence* toward the more dynamic concept of *persistence*.

In this sense, persistence more properly describes the longevity of the entire stock and flow of soil carbon, irrespective of particular forms at particular points in time. Hence: "... rapid cycling can still result in long-term SOM persistence, with mineral interactions temporarily slowing the flow of SOM rather than conferring permanent protection ...", and "... SOM persistence is driven by its flow throughout the heterogeneous soil environment and its interactions with both soil microbes and the physical soil matrix..."³⁸.

On-farm carbon sequestration and storage in vegetation

As well as soil carbon, which has been the main focus of this section, significant amounts of additional carbon sequestration can occur in on-farm vegetation when the landscape is managed with an eye to maintaining and strategically increasing active tree cover. Practical measures include retention of existing native vegetation belts and patches, planting of new shelter belts, and incorporating agroforestry and / or various silvopastoral options in farm management planning.

The opportunities for strategic carbon sequestration in on-farm trees and other permanent vegetation is now being assessed by governments and other land management groups as key contributors to net-zero planning.

In Australia, for example, the NSW Government applied the Full Carbon Accounting Model (FullCAM) to calculate that over 50 million tonnes of additional CO₂-e could be sequestered in on-farm vegetation in the decade to 2030 in that State alone. Incentivised measures include "avoided clearing", natural regeneration management, reforestation for on-farm timber production and other environmental plantings³⁹.

At the global level, the IPCC's latest technical assessment has "high confidence in agroforestry's mitigation potential at the field scale ... with countless options for farmers and land managers to implement agroforestry". Indeed, such "field scale agroforestry" could accumulate at annual rates of

between 0.59 and 6.24 tonnes per hectare for *above-ground carbon*, whilst its below-ground carbon component makes up an additional 25% or more of the total potential vegetation carbon sequestration gains. When expressed on a global basis, the IPCC believes agroforestry has a technical sequestration potential of 4.1 billion tonnes of CO₂-e per year for the period 2020–2050, with 800 million tonnes per year of this available at costs below USD100 per tonne⁴⁰.

Section 3: Responses to the discussion papers set consultation questions

- 1) What are the opportunities to reduce emissions and build carbon stores in agriculture and the land? What are the main barriers to action?

Australia's farmed soils and farmer-managed vegetation can provide a significant sink for sequestration of atmospheric carbon when grazing and cropping practices are changed to promote organic carbon accrual. Barriers to realising this capacity include limited farmer uptake of practice changes, costs of on-farm infrastructure (e.g. "wire and water"), and reactive peer pressure from "conventional" farmers and advisers.

The government's sector decarbonisation planning should include support for the various farmer extension services to make them better equipped to support farmers that are curious to try a carbon project. For example, a high priority should be given to the timely and rapid implementation and rollout of the "Carbon Outreach Officers" program (already announced). Support should also be given to those private sector "carbon project developers" who are overtly committed to helping farmers implement the lasting practice changes that will increase sequestered on-farm carbon stocks in soils and vegetation.

- 2) How can we progress emission reduction efforts whilst also building resilience and adapting to climate change? What stakeholder group do you identify as?

Emissions reduction and carbon sequestration are two sides of the same management coin. ACCU creation methods recognise the need to deduct on-farm emissions from gross sequestration. Promoting sensible ACCU Scheme projects among farmers is a way to incentivise farmers to reduce emissions and generate sequestration benefits concurrently, while realising the natural increase in drought resilience that enhanced soil carbon brings.

- 3) Are there initiatives or innovative programs underway that could be applied or expanded on at a national scale?

A comprehensive, publicly-funded on-farm program that measures, monitors, and interprets data on soil and landscape health – including soil carbon baselining – would underpin scaled-up carbon sequestration and storage activity reaching many more Australian farms than is currently the case.

*The NSW Government is currently delivering farmer-focussed projects under its **NSW High Impact Grant Partnerships** program. One of these, delivered through **Atlas Carbon** and **Wilmot Cattle Company**, is helping grazing properties transition to adopt proven resilient practices through capital support for infrastructure to increase water flow to tanks, additional fencing for managed grazing, and addressing weak areas of soil type and pasture. We would propose a scaled-up version of this type of program for national application as a specific net-zero agriculture and land initiative. This should ideally involve a grant component, enabled and managed through the existing third party managed grazing advisers (such as **MaiaGrazing**). The program should provide specific support for direct capex investments (water, fencing, perennial species, etc.) to enable them in transitioning to resilient practices which can boost soil and vegetation carbon sequestration, with many associated productivity co-benefits.*

- 4) How can the Australian Government bring together existing effort and new initiatives into one coordinated plan?

Australia already has a number of excellent agricultural support programs and policies. However, these rather disparate efforts need to be better coordinated, with deeper and stronger linkages. The sector's decarbonisation strategy and climate outcomes could be greatly enhanced by rapidly implementing and expanding its announced "Carbon Outreach Officers" program.

Also, much more government support and recognition should be given to the many demonstration activities of exemplar farmers and graziers, and leading specialist agri-tech businesses. These are providing practical leadership in climate-aware farming. Particular recognition should be given to peer-to-peer learning opportunities, such as field days and on-farm workshops that promote climate-smart farming and grazing practices.

There should also be integration of the decarbonisation plan with other relevant government programs such as The Murray Darling Basin Plan, The Future Drought Fund, The National Soils Program, and the 30-by-30 biodiversity agenda. Better linkage of these policies will help leverage and multiply the effectiveness of the considerable government expenditure and resourcing across the Agriculture and Land sector.

- 5) What are the most important options to be further adopted or supported, looking in the short and the longer-term?

Stronger support for on-farm soil and vegetation sequestration activities, propelled by grazing and cropping practice change that can also deliver productivity and profitability benefits.

- 6) What are the practical solutions to increase uptake?

Uptake of climate positive on-farm actions requires upskilling, training and peer-learning opportunities for farmers and other landscape managers, especially First Nations land managers.

- 7) How do you see the agriculture and land sectors contributing over the medium and longer-term? What are the opportunities to deliver emission reductions in parallel with wider goals?

Innovative farmers and land managers, armed with the right information (and some investment support) can lead in "rebuilding" the Australian landscape's carbon stocks for both a national net zero contribution and to boost farm productivity and resilience ("... a mere 0.8% per annum increase in SOC stocks ..." – or less than an additional 1 tonne of C per hectare to 30 cm depth – across all of Australia's landscapes could effectively mitigate Australia's total annual greenhouse gas emissions).

- 8) How can the Australian Government better support agriculture and land sectors to:

- drive innovation,
- build capacity,
- ensure the system enables emissions reductions?

There needs to be a concerted national program of support (including training, field demonstrations, pilot studies, and farm infrastructure investment) for farmers and landscape managers in all regions to undertake CDR projects, including under the ACCU Scheme, as part of their ongoing sustainable farming and grazing activities. As well as boosting national CDR efforts, this will also help boost the profitability and resilience of the nation's farming operations.

This should include more government support and recognition for: (a) the many demonstration activities of exemplar farmers and graziers, and leading specialist agri-tech

businesses, who are providing practical leadership in climate-aware farming, (b) practical peer-to-peer learning opportunities, such as field days and on-farm workshops (for example, Wilmot Field Day) that promote climate-smart farming and grazing practices, and (c) public-good research projects, such as Farming for the Future, which are adding deep knowledge about nature stewardship within productive farming contexts.

- 9) What new initiatives could the Australian Government design that would support emissions reduction and carbon storage in agriculture and land and help ensure a productive, profitable, resilient and sustainable future for the sectors?

There are many innovative farmers who are already sharing their stories via field days, Landcare Groups, and through peer learning groups facilitated by organisations like Soils For Life. Rather than developing new, duplicative, or overlapping programs, the government should be supporting these existing agricultural support programs, and perhaps modifying them so they can better support specific emissions reduction and carbon storage activities on Australian farms.

Other existing government-funded programs, such as the Future Drought Fund, the ACCU Scheme (including support for project baselining costs), various Rural RDC programs (such as MLA's CN30), and various university research activities need better coordination and communication so they can produce additional targeted support for the sector's decarbonisation agenda.

- 10) A consistent and trusted approach for assessing and reporting emissions is often raised as a barrier to reducing emissions. Is there a role for the Australian Government in addressing this concern, and how can producers and land managers be supported?

Australia already has a world-class suite of emissions monitoring and reporting systems (e.g. NGRS, Safeguard Mechanism, MRET, ACCU Scheme, etc.).

- 11) What skills, knowledge and capabilities do you think producers and land managers need to implement change? What information and data would help them make decisions about emissions reductions and sustainable land management in the short and longer-term?

Farmer and other land managers need continuous access to upskilling, training and peer-learning opportunities to stay abreast of best science and practice. They also need access to reliable, continuously updated, real-time biophysical data on soils and other natural capital stocks and flows to inform their decision-making.

Contact information

The contents of this submission can be discussed, in the first instance, with [REDACTED]

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Appendix 1 – Authoritative opinions on the role of agriculture in climate action

Table 5 – Summary of some authoritative opinions on the positive role of agriculture in climate action

Agency / organisation	Views and actions supporting the positive role of Agriculture and Land sector in achieving net zero emissions
The Climate Change Authority	<p>The Australian Climate Change Authority (CCA), the Government’s official adviser on climate policy, considers⁴¹ that, while meeting the targets will require achieving steep reductions in direct emissions, some of the abatement required will “... take place elsewhere in the economy, mainly in the land, agriculture and waste sectors under the ACCU Scheme...”. That is, there will be a continuing role for <i>offsets</i> whose purchase by SGM emitters will effectively <i>finance</i> the practices farm and other land-based activities required to generate the ACCUs under various legislated methods.</p> <p>The CCA further highlights the significance of the land sector in providing atmospheric carbon sequestration opportunities: “... 154 million ACCUs have been issued to projects that store carbon in the land. The land sector, which accounts for changes in the amount of carbon stored in trees, vegetation, soils and harvested wood products, removed more carbon dioxide from the atmosphere than it released <i>in the year to June 2023</i>. It contributed net negative emissions of 64 Mt CO₂-e. Much of the activity in the land sector occurred on agricultural land, with emissions coming from land clearing and forest harvesting, but more carbon dioxide was removed by forests regrowing on previously cleared land...”⁴².</p>
Department of Climate Change, Energy, the Environment and Water	<p>The Department of Climate Change, Energy, the Environment and Water (DCCEEW) highlights the importance of soil carbon for role in Australia’s emission reduction task, and for its agricultural and landscape co-benefits, viz: “... Improving soil carbon storage can help reduce Australia’s greenhouse gas emissions. Farmers can increase the carbon stored in soil by changing land management practices. These practices increase the living and decomposing organic matter in soil. Increasing the amount of carbon in soil can also support: improved agricultural productivity; protection against drought and erosion; improved water quality and biodiversity...”⁴³</p>
Professor Ian Chubb (Australia’s former Chief Scientist)	<p>Australia’s former Chief Scientist, Professor Ian Chubb, concluded in his ACCU Scheme review “... it is clear that removing significant amounts of CO₂ already emitted into the atmosphere is essential if global heating is to be controlled ... (and) ... the only pathway known to science that has the immediate capacity to remove GHG (CO₂) from the atmosphere at scale is photosynthesis: the mechanism by which plants and some other organisms use light, CO₂ and water to create energy (stored as sugars) to fuel cellular activity and growth ...” and “... science and technology may well develop effective and scalable options to meet the twin challenges of GHG removal and secure long-term (millennial) storage. But to start at scale well before 2050, the land sector will have to carry much of the immediate load, starting now ...”⁴⁴.</p>

Agency / organisation	Views and actions supporting the positive role of Agriculture and Land sector in achieving net zero emissions
Agriculture Ministerial Council	Australia's agriculture ministers have committed to the 2023 National Statement on Climate Change and Agriculture , which commits all governments to enhancing Australia's climate-smart sustainable agriculture sector, notes: "... Participating in a growing carbon market presents an opportunity for the agricultural sector ... producers can be paid for storing carbon in vegetation and soils, and for avoiding emissions in line with approved methodologies set out by the ACCU scheme. These methodologies include practices relating to waste management and feed additives for livestock. Producers also have the option to use carbon to reduce the net emissions from their businesses. Well-managed carbon projects can also benefit regional communities by providing alternative income streams and supporting improved land management as part of a farming business..." ⁴⁵ .
Clean Energy Finance Corporation	The Clean Energy Finance Corporation has stated that "... soil organic carbon has a vital role to play in reducing carbon emissions in Australia's agricultural sector – with the potential for an estimated 541 million tonnes of carbon to be sequestered in Australia's soil, equivalent to 18 years of annual CO ₂ emissions from the agricultural sector..." ⁴⁶ .
United Nations Framework Convention on Climate Change	The UNFCCC has endorsed and emphasised that regenerative agriculture offers some of the most obvious, direct, low cost and beneficial ways to draw down atmospheric carbon into farm soils and vegetation. For example, at COP-27 it was declared that "... Nature Based Solutions (NbS), including regenerative agriculture, have a central role in countries' NDCs and national adaptation plans ... (and) ... regenerative agriculture and NbS have a critical role to play in food and agricultural systems, able to sequester 10Gt CO ₂ eq per year, make land use net zero by 2030, and a 10Gt CO ₂ eq carbon sink by 2030, with benefits for biodiversity and livelihoods..." ⁴⁷ . Similarly, COP-28 has seen the launch of the <i>Action Agenda on Regenerative Agriculture</i> , which will include "... leading food and agriculture organizations join(ing) forces to scale regenerative agriculture, transitioning 160 million hectares to regenerative agriculture by 2030..." ⁴⁸ .
Independent Panel on Climate Change (IPCC)	The Independent Panel on Climate Change (IPCC) notes: "...Agriculture provides the second largest share of the mitigation potential ... from cropland and grassland soil carbon management, agroforestry, use of biochar, improved rice cultivation, and livestock and nutrient management..." ⁴⁹ ; "... Achieving global net zero GHG emissions requires all remaining CO ₂ and metric-weighted non-CO ₂ GHG emissions to be counterbalanced by durably stored CO ₂ removals ..." ⁵⁰ . "... The AFOLU sector offers significant near-term mitigation potential at relatively low cost and can provide 20-30% of the 2050 emissions reduction described in scenarios that likely limit warming to 2°C or lower ..." ⁵¹
Professor Ross Garnaut	Professor Ross Garnaut has noted: "...The realisation of a substantial part of the biosequestration potential of rural Australia would greatly reduce the costs of mitigation in Australia. It would favourably transform the economic prospects of large parts of remote rural Australia. Full utilisation of biosequestration could play a significant role in the global mitigation effort. This is an area where Australia has much to contribute to the international system...". He has suggested there is a potential sequestration quantum on Australia's grazing lands of 286 Mt CO ₂ e per year for 20–50 years ⁵² .

Agency / organisation	Views and actions supporting the positive role of Agriculture and Land sector in achieving net zero emissions
Professor Alex McBratney	For croplands, Professor Alex McBratney believes the <i>aggregate</i> potential is around 2,000 Mt CO ₂ e, equivalent to a full 4 years' worth of Australia's total national CO ₂ e emissions. He also notes: "... Increasing the carbon in our agricultural soils has the potential to provide social, environmental and economic benefits. Soils will be able to absorb and store a larger proportion of rainfall, reduce runoff and erosion, and lead to more stable and less polluted water systems. With more moisture going into our soils, yields will become more consistent and predictable. In the face of an uncertain climatic future with sporadic and heavy rainfalls; predictability will go a long way to securing our national food supply and export markets ..." ⁵³ .
Emissions-reduction Roadmap	The former Government's Emissions-reduction Roadmap cited CDR from land-based management activities as a key climate mitigation measure, stating "... improving land management practices on <i>a quarter</i> of Australia's crop and grazing lands could draw between 35 and 90 Mt of CO ₂ per annum from the atmosphere while improving agricultural productivity and soil resilience..." ⁵⁴

... / Notes and references

Notes and references

- ¹ DAFF 2023. *Agriculture, land and emissions: discussion paper*, Department of Agriculture, Fisheries and Forestry, Canberra, October ([Ref](#))
- ² See Australian Government. 2022. *Australia's Nationally Determined Contribution Communication 2022*, Department of Industry, Science, Energy and Resources ([Ref](#))
- ³ See, for example, the *Soils for Life* case study on Wilmot Cattle Co. ([Ref](#)), and *Impact Ag Partners' Cavan Station* case study ([Ref](#)).
- ⁴ As mandated in §10 of the *Climate Change Act 2022*. Those targets are: (a) reducing Australia's net greenhouse gas emissions to 43% below 2005 levels by 2030 – implemented as a point target and as an emissions budget covering the period 2021-2030 –, and (b) reducing Australia's net greenhouse gas emissions to zero by 2050 ([Ref](#)).
- ⁵ Source: ABARES ([Ref](#))
- ⁶ The UNFCCC conceives "AFOLU" as the sum of the greenhouse gas inventory sectors Agriculture and Land Use, Land-Use Change and Forestry (LULUCF). "FOLU" (Forestry and Other Land Use, also referred to as LULUCF) is the subset of AFOLU emissions and removals of greenhouse gases resulting from direct human-induced land use, land-use change, and forestry activities excluding agricultural emissions ([Ref](#)).
- ⁷ ClimateWorks Centre. 2023. *Op. cit.* p.20 ([Ref](#)).
- ⁸ Dondini, M., et. al. 2023. *Global assessment of soil carbon in grasslands – From current stock estimates to sequestration potential*. FAO Animal Production and Health Paper No. 187. Rome, FAO. [Ref](#). This study compares its calculations with the 4p 1000 initiative's 3.5 Pg C/year goal, and notes: "... Our estimates suggest that 17 percent of this (4p 1000) target could be reached in the top 30 cm of grasslands and continue over at least 20 years after adoption of SOC enhancing management, such as the incorporation of animal manures, agroforestry and rotational grazing. This requires that grasslands increase SOC storage between 0.18–0.41 tonnes C/ha every year..." (p. 44f).
- ⁹ Developed from IPCC *Op. cit.* (Table TS.7, p.TS-96)
- ¹⁰ IPCC's Working Group III Report. 2022, p.TS-86
- ¹¹ See, for example, Baker, E. 2023. Carbon gamechanger with govt to make first large-scale issuance of soil credits. *Beef Central* news report ([Ref](#))
- ¹² Clean Energy Regulator. 2023. *Emissions reduction case studies* ([Ref](#)).
- ¹³ See: *Soils for Life* 2023. *Case Studies* ([Ref](#)).
- ¹⁴ See: *Farming for the Future* ([Ref](#)).
- ¹⁵ See: Wilmot Field Day 2024 - "Accelerating the Change: Food, Fibre & Nature" ([Ref](#)).
- ¹⁶ Note: Australia could usefully learn from the current program being rolled out in Northern Ireland. There, a pilot study from 7 farms has included soil vegetation carbon stocks, practice change measures and impacts. The program has also addressed other outcomes of practice change, such as biodiversity measurement (finding a dramatic improvement of biodiversity scores on grazed grasslands versus non-grazed areas), water and nutrient flow impacts, and the production of "runoff risk" maps (highlighting critical hydrological zones for soil/nutrient loss). The Northern Ireland pilot study provided the impetus for that government to commit £45 million (\$85 million) to baseline *every farm* in Northern Ireland for soil organic carbon vegetation carbon stock. This program is providing the data required to understand how the Northern Ireland farming sector could achieve carbon neutrality through practice change and innovation, with flow-on benefits to achieving the country's wider climate goals. See: DAERA 2023. Agriculture Minister opens £45million Soil Nutrient Health Scheme investment over four years. *Northern Ireland Environment Link* ([Ref](#)) – and see SNHS FAQs [here](#).
- ¹⁷ Lal, R., Monger, C., Nave, L. and Smith, P. 2021 The role of soil in regulation of climate. *Phil. Trans. R. Soc. B* 376: 20210084
- ¹⁸ Estimates vary regarding Australia's SOC loss in the 230 years since European farming was commenced. See, for example, Jones, C., 2008. Our Soils, Our Future. In: *Amazing Carbon* ([Ref](#)); various citations in Orgill, S.E. and Murphy, B.W., 2021. Opportunities to build Soil Organic Carbon in a challenging environment; climate change and shifting paradigms. In: *Proceedings of the Grassland Society of NSW Conference* 20-21 July ([Ref](#)).
- ¹⁹ Strzelecki, P.E. 1845. Physical Description of New South Wales and Van Diemen's Land: Accompanied by a Geological Map, Sections and Diagrams, and Figures of the Organic Remains. Longman, Brown, Green, and Longmans, Paternoster-Row. London. 462pp ([Ref](#))
- ²⁰ Source: *The Land* newspaper (*Diversity for Drought Surety*) – 24 March 2022.
- ²¹ Source: Sanderman, J, Farquharson, R and Baldock, J. 2010. *Soil Carbon Sequestration Potential: A review for Australian agriculture*. CSIRO Report for Department of Climate Change and Energy Efficiency, Australian Government.
- ²² There are ~400m hectares of grazing land in Australia. 10% of this is 40m hectares x 0.8t = 32m tonnes of carbon; times 3.7 = 118m tonnes of CO₂e. The potential of Australia's soils to sequester significant amounts of atmospheric carbon has also been attested by the Australian Government's Clean Energy Finance Corporation, viz: "... Soil organic carbon has a vital role to play in reducing carbon emissions in Australia's agricultural sector – with the potential for an estimated 541 million

tonnes of carbon to be sequestered in Australia's soil, equivalent to 18 years of annual CO₂ emissions from the agricultural sector..." (Ref).

²³ Paustian, K., Smith, P., Jacobson, R. and Torn, M. 2022. Soil Carbon Sequestration. In Chapter 2 "The building blocks of CDR systems", in: *CDR Primer*, edited by J Wilcox, B Kolosz, J Freeman (Ref). Similar findings have been reported in livestock grazing systems in other places - sometimes with much higher soil carbon sequestration rates than found in Australia. For example, researchers in the USA have observed a steady increase in soil carbon stocks averaging 2.3 tonnes of C per hectare per year across a 20-year farming chronosequence where managed rotational grazing was the key driving variable (See Rowntree JE, Stanley PL, Maciel ICF, Thorbecke M, Rosenzweig ST, Hancock DW, Guzman A and Raven MR. 2020. Ecosystem Impacts and Productive Capacity of a Multi-Species Pastured Livestock System. *Frontiers in Sustainable Food Systems* Vol. 4, Article 544984 (Ref)

²⁴ Source: Carbon Link media release (Ref).

²⁵ Fitch P, Battaglia M, Lenton A, Feron P, Gao L, Mei Y, Hortle A, Macdonald L, Pearce M, Occhipinti S, Roxburgh S, Steven A. 2022. *Australia's sequestration potential - A stocktake and analysis of sequestration technologies*. CSIRO (Ref)

²⁶ Paustian, K., et. al. 2022. Soil Carbon Sequestration. In Chapter 2 "The building blocks of CDR systems", in: *CDR Primer*, edited by J Wilcox, B Kolosz, J Freeman (Ref).

²⁷ Chan, K.Y. et. al. 2010. Soil carbon stocks under different pastures and pasture management in the higher rainfall areas of south-eastern Australia. *Australian Journal of Soil Research* 48(1):7–15 (Ref)

²⁸ Orgill, S.E. and Murphy, B.W. 2021. Opportunities to build Soil Organic Carbon in a challenging environment; climate change and shifting paradigms. *Proceedings of the Grassland Society of NSW Conference* 20-21 July (Ref).

²⁹ L.A. Schipper, R.L. Parfitt, S. Fraser, R.A. Littler, W.T. Baisden, C. Ross, 2014. Soil order and grazing management effects on changes in soil C and N in New Zealand pastures. *Agriculture, Ecosystems & Environment* 184:67-75 (Ref)

³⁰ Data sourced from McCosker, T. 2023. *personal communications*. The data were collected on Qld property *Bonnie Doone* where a shift to rotational grazing (which included "... reducing paddock sizes, shortening how long the cattle were in them, lifting the number of water points to reduce cattle walking and soil compaction, and some technology ...") led to sequestration of 126,222 tonnes of CO₂-e over 5,275 hectares over 5 years (see media report [here](#)). This represents an average annual sequestration rate of 1.3 tonnes of soil carbon per hectare (or 4.79 tonnes of CO₂-e per hectare). The soil carbon gains were achieved "... despite three very dry years, bushfires and disease attacking their pasture...", and the project included a commitment to continue the grazing practice change for at least 25 years.

³¹ Data compiled by Atlas Carbon utilising data sourced from Carbon Link and the Clean Energy Regulator (see [Rexton data](#) and [Moora Plains data](#)). These data were collected on two Queensland grazing properties, *Rexton* and *Moora Plains*, which produced 202,000 tonnes of soil carbon over 5,488 hectares over 5 years, equating to an average annual sequestration rate of 2.01 tonnes of soil carbon per hectare (or 7.37 tonnes of CO₂-e per hectare).

³² Lal, R. et. al. 2018. The carbon sequestration potential of terrestrial ecosystems. *Journal of Soil and Water Conservation*. 73(6):145A-152A (Ref)

³³ So, Bossio et. al. note: "...For most improved carbon management practices, the rate at which soils will store additional carbon ... begins to decline after some decades, and eventually will reach a new steady state when a higher carbon stock is achieved. The time before a new steady state is reached will vary greatly depending on soil type, management intervention, climate regime and pre-existing SOC depletion, but is generally on the order of decades. *This timing aligns with the need to reduce peak atmospheric CO₂ levels and mitigate peak warming ...*". Bossio, A.D, Cook-Patton, S.C, Ellis, P.W, Fargione, J, Sanderman, J, Smith, P, Wood, S, Zomer, R.J., von Unger, M, Emmer, I.M and Griscrom, B W. 2020. The role of soil carbon in natural climate solutions. *Nature Sustainability* 3:391-398. (Ref)

³⁴ Nolan, R.H., Sinclair, J., Eldridge, D.J. and Ramp, D. 2018. Biophysical risks to carbon sequestration and storage in Australian drylands. *Journal of Environmental Management*. 208:102-111 (Ref)

³⁵ McCosker, T. 2023. *personal communications* (see Op. cit.)

³⁶ Nolan et. al. 2018. *Op.cit.*

³⁷ Pellegrini, A.F.A., Harden, J., Georgiou, K., Hemes, K.S., Malhotra, A., Nolan, C.J. and Jackson, R.B. 2022. Fire effects on the persistence of soil organic matter and long-term carbon storage. *Nature Geoscience* 15, January: 5–13 – pp10f. (Ref)

³⁸ Dynarski, K.A., Bossio, D.A. and Scow, K.M. 2020. Dynamic Stability of Soil Carbon: Reassessing the "Permanence" of Soil Carbon Sequestration. *Frontiers in Environmental Science* 8:514701 (Ref)

³⁹ Waters C., et. al. 2020. *Abatement opportunities from the agricultural sector in New South Wales: Modelling to support the development of the Primary Industries Productivity and Abatement Program*. NSW Department of Primary Industries. ISBN: 978-1-76058-415-3 (Ref)

⁴⁰ Nabuurs, G.-J., et. al. 2022. *Agriculture, Forestry and Other Land Uses (AFOLU)*. In IPCC, 2022. *Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Shukla, P.R. et. al. (eds.). Cambridge University Press (Ref) Section 7.4.3.3 (page 791)

⁴¹ Climate Change Authority. 2023. *2023 Annual Progress Report*, October (Ref). The CCA notes the Government "intends" that this will mainly be achieved via the power generation sector – through the 82% renewable energy target, and via the

large-emitting industrial sector – through the Safeguard Mechanism, with these together aiming to achieve ~74 million tonnes of CO₂-e savings in 2030 (p. 5).

⁴² Climate Change Authority. 2023. *Op. cit.* page 9.

⁴³ DCCEEW 2023. *Improving soil carbon storage and measurement* ([Ref](#))

⁴⁴ Chubb, I., Bennet, A., Gorrington, A., Hafield-Dodds, S., 2022, *Independent Review of ACCUs*, Department of Climate Change, Energy, the Environment and Water, Canberra, December ([Ref](#)).

⁴⁵ Commonwealth of Australia 2023, *National Statement on Climate Change and Agriculture*, Department of Agriculture, Fisheries and Forestry, Canberra ([Ref](#)).

⁴⁶ Clean Energy Finance Corporation. 2022. Downforce brings hi-tech soil solution to Australia: Enhanced monitoring to improve soil carbon. *CEFC Case Study* ([Ref](#))

⁴⁷ COP-27. 2022. *Agriculture & COP27*. Climate Champions news release ([Ref](#)).

⁴⁸ COP-28 UAE. 2023. COP28 Presidency puts food systems transformation on global climate agenda as more than 130 world leaders endorse Food and Agriculture Declaration. Media statement ([Ref](#))

⁴⁹ IPCC. 2022. *Climate Change 2022: Mitigation of climate change*. Working Group III contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. UNFCCC, WMO, UNEP ([Ref](#)) – page TS-86.

⁵⁰ IPCC, 2022: *Op. Cit.* p. 26. and IPCC AR6 Synthesis Report 2023.

⁵¹ IPCC, 2022: *Op. Cit.* (WGIII 2022), page TS-85

⁵² Garnaut, R. 2008. *Climate Change Review Report*. [Chapter 22 *Transforming rural land use*], p.543 ([Ref](#))

⁵³ McBratney, A. *et. al.* 2020. The untapped potential of soil carbon. *University of Sydney News* 20 November ([Ref](#))

⁵⁴ Australian Government. 2020. *Technology Investment Roadmap: First Low Emissions Technology Statement – 2020* p.23 ([Ref](#))