

SOIL CARBON SCIENCE STRATEGY

2022 - 2025



**NEW ZEALAND
AGRICULTURAL GREENHOUSE GAS
Research Centre**

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NOTE: This document is in final draft form while internal NZAGRC processes are completed.

PURPOSE OF THIS DOCUMENT

This document sets out the Science Strategy for soil carbon management for the New Zealand Agricultural Greenhouse Gas Research Centre (NZAGRC). It has been developed by the NZAGRC, with input from a wide range of stakeholders during September to December 2022. The Strategy was developed to guide and update the NZAGRC's prioritisation of future investment decisions in soil carbon research. It should be read alongside the Research & Development (R&D) Plan for soil carbon management, which will be finalised in early 2023.

This Science Strategy and associated R&D Plan are focused on soil carbon management. Achieving the strategic goal relies on continuing investment in comprehensive long-term soil carbon monitoring programmes. These programmes provide essential evidence to underpin management practices, and to monitor, verify and potentially account for long-term changes. These underpinning long-term monitoring programmes are not currently included in this strategy as these programmes require dedicated funding that goes beyond the length of the MPI-NZAGRC contract. However, it is essential that they receive dedicated attention by relevant funders (including the NZAGRC) and stakeholders.

CONTEXT

Science

Globally and in New Zealand, there is considerable interest in the capacity of soils to sequester carbon and thereby reduce the amount of carbon dioxide in the atmosphere. It is also essential that losses of soil carbon, and hence the release of carbon dioxide to the atmosphere are minimised.

Available data indicates that carbon stocks in New Zealand's agricultural topsoils are high (almost 100 tonnes per hectare in the top 30cm) when compared to the global average (around 62 tonnes per hectare in the top 30cm). This is largely due to New Zealand's moist temperate climate, land cover dominated by perennial vegetation, and our specific mix of soil types that can hold high amounts of organic matter.

Research in New Zealand has shown that changes in land use (e.g., from forest to pasture) lead to changes in soil carbon stocks. Perennial pastures typically have the highest soil carbon stocks, annual cropland the lowest and forests have intermediate values. Less is known about the impact on soil carbon stocks from changes in specific management practices within a land use, e.g., grazing and cropland management or changes in fertilizer use.

While uncertainties are high for the consequences of many management practices on agricultural soils, available data indicate that soil carbon content in flat pastureland is mostly stable, but some specific soil groups have been shown to have lost carbon up to 2010. In hill country, soil carbon content appears to have increased during the two to three decades before about 2010, but uncertainties are large and the reasons for this increase are not well understood. Whether these localized carbon losses on flat land and gains in hill country have continued is not known. However, there are large carbon losses (again with high uncertainties) occurring from drained peat/organic soils used predominantly for grazing.

Overall, there are limited data from direct measurements of soil organic carbon change through time. Those data that do exist have often been collected for purposes other than soil organic carbon monitoring and so may not be fully representative of soil carbon changes in New Zealand's agricultural land. As a result, a comprehensive understanding at the national scale is still lacking on whether New Zealand soil carbon is accumulating or being lost and where changes might be occurring. Increased monitoring and research are therefore vital to improve understanding and identify actions to help New Zealand protect and manage its soil carbon.

In 2019, the NZAGRC initiated a new long-term national soil organic carbon benchmarking and monitoring system (2019-2030) to better understand how New Zealand's agricultural soil carbon stocks are changing over time within different land uses and environmental conditions. The future of this programme beyond the current contract of the NZAGRC (30 June 2025) is under discussion.

Reporting and accounting

Every year, under the United Nations Framework Convention on Climate Change and from 2023 onwards under the Paris Agreement, New Zealand is obliged to report its national human-produced (anthropogenic) greenhouse gas emissions and removals. Currently, only the effects of land-use change on soil carbon stocks are included in New Zealand's national greenhouse gas inventory and are modelled using the national soil carbon monitoring system (SoilCMS).

National-scale changes of soil organic stocks in mineral soils are currently predicted based on transitions of land use (e.g., forest to pasture) using a statistical model calibrated with historical data. The model assumes that soil organic carbon doesn't change if there isn't a change in land use (e.g., if an area remains in long-term pasture). Between 1990 and 2016, around 92 percent of the total land area of New Zealand remained within the same land-use, and hence soil organic carbon is assumed to be constant for this area.

New Zealand's domestic and international emission targets, and accounting towards those targets, are based on a narrower set of emissions and removals. This target-based accounting does not consider soil carbon changes between different land-uses except for land going into and out of forestry. For example, the majority of soil carbon losses from drained peatland that are reported as part of our emissions inventory are not accounted for under our emission targets.

Including a wider set of soil carbon emissions and removals, including those arising from management practices, could increase or decrease reported net emissions and future trends. This would then require a review and potential revision of existing emission targets.

Policy

Agricultural greenhouse gas emissions are part of New Zealand's domestic and international climate change targets and will be priced in New Zealand from 2025 as part of the Government's Emissions Reduction Plan.

Soil carbon is not planned to be included in the agricultural pricing scheme in the near term. It was recognised as an issue by both the He Waka Eke Noa partnership and the Climate Change Commission in their respective recommendations to Government on the proposed pricing scheme. However, both concluded that more research was needed to understand, quantify and manage changes in soil carbon for New Zealand.

The 2022 Government budget allocated \$338.7m in funding from 1 July 2022 to 30 June 2026 to strengthen research and development in new tools and technologies to reduce on-farm emissions. This includes the establishment of a new Centre for Climate Action on Agricultural Emissions (CCAEE), within which will sit an enhanced NZAGRC and a joint venture with industry. There is also an increased commitment to ongoing baseline agricultural greenhouse gas R&D funding that will be around \$120m per annum.

At this point it is not known what portion of the overall budget might be allocated to soil carbon research and management. However, this soil carbon research strategy will play a key part in giving direction to future funding, and the strategy therefore takes a flexible and scalable approach to inform future investment decisions. Much of the research needed to achieve the strategy's goal will take longer than three years. While the core focus of the strategy is to provide direction for research capacity and investments up to 2026, its strategic goal, objectives and R&D plan take a longer time horizon of 10 years to ensure an enduring pathway to success.

NZAGRC STRATEGIC AND SCIENCE PLANS (2019–2025)

The NZAGRC is a core component of the Government's approach to understanding, managing, and reducing greenhouse gases in agriculture. The NZAGRC maintains an ongoing open, transparent, and inclusive process for identifying and prioritizing research investments, and has invested in a soil carbon research programme since 2010.

The NZAGRC has Strategic and Science Plans covering the period 2019-2025 that are relevant to this new strategic plan for soil carbon management. Those Plans were co-developed with leading international and New Zealand scientists, senior representatives from primary sector organizations, government departments, farmers, and other key individuals.

The goal of the NZAGRC is stated in the [Strategic Plan](#) and is to: *Discover, develop, and make available to New Zealand farmers and growers, products, tools, and knowledge that enable the practical and cost-effective reduction of agricultural greenhouse gas emissions.*

The goal is achieved through eight objectives, one of which directly relates to soil carbon research: *Quantify and increase the understanding of how management practices, climate and their interactions, influence soil carbon sequestration in New Zealand's agricultural soils.*

The [NZAGRC Science Plan 2019-2025](#) has been developed to align with the funders' expectations and the NZAGRC's goal and objectives. In the Science Plan, the focus of the soil carbon research was prioritized towards a systematic long-term study designed to quantify to a given degree of accuracy the change in soil carbon stocks under different agricultural land uses and land management practices over time. Alongside this, the Plan prioritized the examination of modified management practices to influence the quantity of carbon stored by New Zealand soils. The NZAGRC's current portfolio of soil carbon research totals \$4.3m over three years. It began in July 2020 and will end on 30 June 2023.

To prepare for any future investment in soil carbon research beyond June 2023, the NZAGRC has undertaken a comprehensive process to refresh and develop a specific science strategy and R&D plan for soil carbon management. This NZAGRC strategy does not include investments to support specific policy needs or underpinning long-term monitoring programmes.

STRATEGIC GOAL AND OBJECTIVES FOR SOIL CARBON

Goal

The NZAGRC's strategic goal for its soil carbon research programme is:

To develop and support practical and science-based approaches for farmers and growers to protect and where possible enhance soil carbon stocks, while also meeting other land stewardship objectives.

Objectives

The soil carbon goal will be achieved through the following four objectives:¹

1. **Knowledge:** Increase process-based understanding and models of the drivers and determinants of soil carbon stocks in New Zealand, including regulation by nutrient cycling, location specific factors, climate change impacts and sensitivity to different land uses, soil, crop and animal management practices, and farm systems.
2. **Measurement:** Develop or improve cost-effective approaches for measurement, monitoring and/or verifying soil carbon at national, regional and farm levels and across a range of time scales, and integration of measurements with models.
3. **Management:** Identify and validate practical management approaches and technologies that protect and/or enhance soil carbon stocks and that build on a diversity of existing and potential future farm and land management systems, practices, experiences and objectives.
4. **Decision-making:** Provide relevant information to farmers, landowners and policy makers to help them:
 - a. understand potential opportunities and risks, costs and benefits of different management practices as well as land-use change for soil carbon, and
 - b. any co-benefits or trade-offs with other land stewardship and te taiao outcomes and diverse sets of values.

Building and maintaining the capacity of New Zealand's community of researchers and practitioners on soil organic carbon, and approaches that integrate soil, plant and animal science as well as localised knowledge and mātauranga Māori, underpin these objectives as a critical cross-cutting need.

Other considerations

Achieving reductions in net emissions related to soil carbon will also rely on effective communication and change leadership, national alignment and coordination of efforts, and recognition of social, behavioural and economic aspects of change. These aspects are outside of what this NZAGRC strategy can deliver on its own but are recognised as important next steps in the path to implementation.

¹ Objectives are numbered for referencing purposes only, this does not represent a sequence or priority. Different areas of research may place emphasis on specific objectives, with an expectation that the overall portfolio of research under this strategy will be balanced across all objectives.

SCOPE

The following core areas are considered within scope for the NZAGRC's soil carbon management programme:

- Understanding, modelling and monitoring of changes in soil carbon stocks in agricultural land that result in emissions or removals of carbon dioxide to and from the atmosphere
- Practices that reduce emissions or enhance the removal of carbon dioxide from the atmosphere through deliberate changes in soil carbon stocks
- Co-benefits and trade-offs of changes in soil carbon stocks with efforts to reduce emissions of other greenhouse gases on agricultural land, including supply chains, and within systems approaches that consider other environmental outcomes and pressures
- Research and development to the point where it can be directly applied by farmers and growers or passed on to agribusinesses for commercialisation and delivery

The NZAGRC, where relevant, will partner with others to undertake or advance work in areas that are in the margins of scope, provided there is a clear link with the strategic goal of protecting and where possible enhancing soil carbon stocks:

- Adaptation to climate change
- Soil function/fertility
- Agricultural productivity
- Land-use change management
- Regenerative agriculture.

Issues considered out of scope for this strategy include non-agricultural land uses, commercial research, and practices that promote soil stabilization (e.g. erosion control) but do not result in demonstrable net sequestration of CO₂ from or avoid net CO₂ emissions to the atmosphere.

PARTNERING WITH MĀORI

This soil carbon management strategy is closely aligned with the NZAGRC's Māori Research Strategy, which was developed by the [NZAGRC's Toihau](#) with input from experts from the Māori agribusiness and research communities during 2021/22.

The Māori Research Strategy upholds a vision for a lower emissions, sustainable food system built on a deep relationship of respect and reciprocity with te taiao and where the full diversity of Māori landowners, agribusiness, and their iwi, hapū and whanau can thrive. In working towards this vision, the NZAGRC seeks to be a trusted advocate, connector and research partner for Māori landowners and agribusiness to achieve their aspirations relating to agricultural greenhouse gas emissions. The NZAGRC also seeks to enhance Māori access to and participation in research that is seen as directly beneficial.

The Māori Research Strategy makes specific mention to soil carbon in its identified high-level priority work areas:

- *Research on soil carbon sequestration options for Māori land, that:*

- *Uses taonga species and mātauranga Māori/kaupapa Māori-based carbon recycling*
- *Contributes to diversification of land use*

The vision and values expressed in the Māori Research Strategy hold true for the soil carbon strategy more generally, and efforts will be made to ensure the two programmes of work are well aligned.

INVESTMENT APPROACH AND DECISION MAKING

Design Principles

In line with the design principles expressed in the NZAGRC's 2019-2025 Strategic Plan and the Māori Research Strategy, the NZAGRC will deliver a soil carbon work programme that:

- Involves co-design with farmers and landowners and provides opportunities for engagement and participation
- Enhances understanding of the co-benefits of soil carbon protection and enhancement for achieving other te taiao and land management objectives
- Enables actions to manage soil carbon in areas where the risk of losses is high
- Grows capability and skills within New Zealand's science and practitioner community
- Partners both domestically and internationally to have the greatest positive impact on New Zealand farming systems and, where possible, broader global applicability
- Supports national alignment and coordination of research efforts
- Recognises and addresses the specific challenges and diversity of aspirations and needs of Māori landowners

Prioritisation framework

The NZAGRC has developed a set of criteria that will be used to identify and prioritize key components of an R&D Plan for soil carbon management consistent with the strategic goal, objectives and design principles set out above.

This prioritization framework builds on the existing prioritisation framework set out in the NZAGRC Science Strategy and a set of draft prioritization criteria developed as part of the BERSA process². These have been adapted to the specific context of soil carbon management, drawing also on insights from a stakeholder workshop held in September 2022.

The following four criteria are considered key for any area of research to be supported under this strategy. The R&D plan will seek to take calculated risks, but proposals that score very low on any one of those four criteria are unlikely to be included in the R&D plan.

1) Scale and impact

- Reach: what is the percentage of farms or land area that could be reached?

² The Biological Emissions Reduction Science Accelerator (BERSA) was set up by MPI in 2021/22 to develop a national R&D plan for prioritising and accelerating the development of mitigation options for reducing methane and nitrous oxide emissions from agriculture.

- Impact: what is the maximum technical mitigation potential (change in net CO₂ emissions related to soils) at farm scale that could be achieved?
- Is underpinning work (e.g., model development/validation, monitoring programmes, infrastructure) adequately embedded in mitigation approaches?
- Confidence: what is the evidence that this approach could work in principle, based on evidence overseas and in New Zealand?

2) Fit for purpose

- System fit, feasibility and ease of implementation under current farm systems and regulatory constraints, or a plausible pathway towards future farm systems
- Interactions with other on-farm greenhouse gas emissions and likely impact on net greenhouse gas emissions across the farm system including supply chains
- Synergies/lack of significant trade-offs across freshwater quality, biodiversity, other taonga, and resilience and adaptation practices to climate change impacts

3) Economic considerations

- Indicative net costs/benefits for adoption on-farm
- Potential costs associated with commercialisation and on-farm demonstration
- If costs might exceed direct benefits, are there sound other reasons why this approach would be in the national interest?

4) Sound scientific approach

- Sound scientific hypothesis, adequate methodology to test the hypothesis
- New Zealand has the core capacity and capability to deliver this work and, where necessary, to attract additional capacity and capability

The four criteria below will be used to ensure a balanced portfolio of research. This means not every area of work is expected or required to score high on each of those criteria. However, proposals that score high in aggregate are more likely to be included in the R&D plan.

5) Inclusion of te Ao Māori perspectives and Te Tiriti principles

- Alignment with Māori Research Strategy, its design principles and priority work areas, and specifically the soil carbon priority work areas

6) Reflective of end-user needs

- Supports policy development and goal setting, with outcomes able to be monitored, reported and verified at national, regional, catchment or farm-level
- Credible and verifiable data/tools to assure decision-makers and regulators
- Absence of prohibitive market barriers, standards or regulatory requirements
- Includes beneficiaries in development of research, farmer co-development
- Allows integration in e.g., integrated farm management plans

7) Capability, capacity, engagement and collaboration

- Further builds research capability, capacity and diversity
- Provides opportunities for active participation by farmers and practitioners
- Collaborates in New Zealand and internationally to achieve maximum impact
- Co-investment (particularly where high risk of commercial pressures)

8) Timescale for delivery

- Provides realistic timescale of the approach becoming available and adoptable
- For long-term programmes of work, identifies suitable measures of progress

Decision making

The Strategy's goal, objectives, design principles and prioritisation framework will be used to develop an R&D plan that sets out key research areas and core investments in infrastructure and capability. The NZAGRC will maintain an open, transparent and co-development process for identifying and prioritising research investments.

As the overall amount of investment in soil carbon research under this strategy is not yet known, funding levels for key research areas identified in the R&D plan will be indicative and expressed relative to this overall amount. The R&D plan will be developed based on submission of proposals and ideas by New Zealand's research and practitioner community and prioritised by a dedicated science advisory panel set up for this purpose. This panel will comprise expertise from research, government, Māori and the primary sector.

Achieving the Strategy's goal and objectives will depend on the capacity of the New Zealand research community, including its ability to connect with farmers and growers, practitioners, agribusinesses and other end-users, and the provision of adequate research infrastructure. Building and maintaining New Zealand soil carbon capabilities and capacity are therefore important aspects of the overall strategy. This will require a mix of investment types and time horizons, including competitive funding as well as negotiated longer term investments.

Given the multiple functions of soil and benefits of improved soil management, investments under this strategy will seek to align and where relevant partner with other organisations and initiatives to enable holistic and integrated approaches to farm management.

This Strategy and R&D plan will then be used to guide investment decisions about individual research projects, following established NZAGRC mechanisms and principles and subject to funding allocated and any relevant requirements for this work by MPI.

KEY RELATIONSHIPS

Strong relationships are critical to the success of this Strategy and associated R&D Plan. This includes science organisations and related entities such as the National Science Challenges, central government agencies (including MPI, MfE and DOC), regional councils, Māori landowning entities and agribusinesses, farmers and growers, and primary sector organisations and companies.