

Research roadmap – land and soil 2026–2036

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Summary

Project and client

- This project provides a review and update of *Research Roadmap – Land and Soil 2018–2020*.
- It was carried out for Marlborough District Council on behalf of the Land Monitoring Forum (LMF) and the Land Managers Group (LMG) of the regional councils, and was supported by Envirolink 2534-MLDC178.

Objective

- To undertake a review and update of *Research Roadmap – Land and Soil 2018–2020* for LMF and LMG, and produce a research roadmap of activities for the period 2026–2036.

Approach

Our overall approach to developing this updated research roadmap was as follows.

- We conducted an evaluation of the 2018 roadmap and current LMF and LMG plans, including extent of use of the roadmap.
- We undertook a stocktake and synthesis of the work and research completed against priority topics outlined in the previous roadmap. This stocktake included a broader scan of research undertaken through, for example, the National Science Challenges and Ministry of Business, Innovation and Employment (MBIE) Endeavour programmes that are likely to be relevant in guiding future research or implementation.
- A survey of councils was carried out to determine current regional and national priority issues. This included seeking input from other special interest groups (SIGs), with LMF and LMG convenors taking the lead in liaising with other relevant SIGs.
- We held an environmental scanning and futures workshop exercise with LMF & LMG (including the policy and regulatory environment, the themes and priorities of Te Uru Kahika – Regional and Unitary Councils Aotearoa, key drivers, and environmental trends) to determine a set of high-level outcomes.
- We compiled and tested a set of refreshed and new priorities to meet these outcomes, initially in a small group workshop with LMG and LMF members, and later with their wider membership.
- Finally, we developed a draft research roadmap, and incorporated input from and further refinement by LMF and LMG before finalising the report.

Results

- There have been significant changes in the policy and regulatory space, along with multiple severe weather events, which have influenced the direction and focus of the LMF and LMG over the last 8 years.
- Our stocktake identified the considerable amount of research undertaken through National Science Challenges, MBIE Endeavour programmes, and council-commissioned studies (including Envirolink projects) that was relevant to the 2018 roadmap, much of which remains relevant for the research priorities identified in the current project.
- Five goals and eight research priorities with 16 research sub-priorities were identified by the LMF and LMG
- Workshop discussions highlighted the opportunity to consolidate cross-council experiences for the identified research priority areas, which would help streamline actual research

requirements. Similarly, a review of the extensive amount of research related to some of the research priorities would help to better identify the specific research required.

- Paying greater attention to the connection between the research that is ‘done’ and how it is ‘used’ will help to progress the identified goals.

Activity roadmap

The following items provide an ‘activity roadmap’ that will help to meet the desired outcomes for land, soil, and catchment management.

- 1 Develop a repository of research and other information relevant to the research priorities identified (or wider work relevant to the LMF and LMG).
- 2 Develop annual action plans that allow for the most pressing activities or issues to be targeted on an annual basis, while accommodating changing pressures that are not currently foreseen (or are foreseen but whose nature is unclear; e.g. proposed regulatory reform and council mergers), and enabling tracking of progress against identified priorities.
- 3 Commission or undertake critical reviews of literature relevant to identified research priorities, and canvass cross-council experiences to identify (a) whether knowledge gaps (rather than implementation) are the key barrier to achieving the desired outcomes, and (b) the specific questions to be answered through further research.
- 4 For the identified specific research, identify intended pathways for implementation to achieve the desired outcomes (e.g. advocating/influencing council policy or plans, developing guidance, working with land managers).
- 5 Consider how existing monitoring data or the capture of information (e.g. on the extent or location of mitigation/management actions) can be used to inform relevant research, or to provide the desired information.
- 6 Maintain/increase involvement in cross-government advisory groups (e.g. S-map Advisory Group, Land Use Capability Governance Group, cross-ministry Land Monitoring Governance Group).
- 7 Develop outcome measures / key performance indicators to help measure delivery against goals and research priorities (or, at minimum, action plan items).

Recommendations

Following are the key recommendations arising from this project.

- Adopt the activity roadmap, including:
 - creating and maintaining a repository to capture relevant research that has been undertaken, both within and across councils, to ensure existing research is built upon and not duplicated
 - undertaking critical reviews of the recent research (using a stocktake developed in this project as a starting point) and council experience to further refine the specific research gaps associated with the identified research priorities
 - developing annual work plans to provide more time-relevant prioritisation of research or research implementation, and to allow tracking of progress.
- Advocate for greater coordination across council SIGs to ensure that connectivity and maximising the value of research is undertaken in areas of joint interest.
- Develop an implementation strategy that explicitly includes implementation of research and actions taken to achieve the core outcomes.
- This research roadmap should be reviewed in 2029.

1 Introduction

Regional and unitary councils throughout New Zealand are faced with increasingly complex and critical decision-making, which often requires achieving a balance between conflicting or incompatible expectations, and none more so than in relation to land and soil resources. The Land Managers Group (LMG) and Land Monitoring Forum (LMF), which are regional sector special interest groups (SIGs) of Te Uru Kahika – Regional and Unitary Councils Aotearoa, collaboratively developed a research roadmap for land and soil via Envirolink 1831-HBRC231 (Phillips et al. 2018). This provided guidance to both the councils and the science sectors by identifying key outcomes and priorities for the period 2018–2020.

The current project reviews and updates the previous roadmap, taking into consideration changes in the number and range of new drivers. These include government and council research investments, the changing policy landscape, and extensive research undertaken through the National Science Challenge Our Land and Water, and other programmes such as Manaaki Whenua – Landcare Research’s ‘Soil Health and Resilience: Oneone Ora, Tangata Ora’ and ‘Smarter Targeting of Erosion Control (STEC)’ since the completion of the previous roadmap in 2018.

The project was carried out for the LMF and the LMG to:

- inform and support planning and prioritisation of research by the LMG, the LMF, and other related regional council SIGs, where appropriate
- guide council investments and Envirolink funding strategies
- provide a statement of priorities for consideration, discussion, and inclusion within other agencies’ work, such as the Public Research Organisation Strategic Science Investment Funding (SSIF) allocation, MBIE Endeavour investment bids, and central government’s non-departmental investment streams.

It is worth noting that there is ongoing conflation between the terms *research roadmap* and *strategic roadmap*, or *strategy*, in part because of the interchangeable use of these terms in previous roadmaps (Phillips et al 2018; Collins et al 2014). A strategy should focus on all activities contributing to the achievement of outcomes, encompassing greater consideration of the extent to which existing knowledge and actions simply need to be actioned. This research roadmap focuses on research needs, identifying issues that remain unresolved due to a research gap, as opposed to other barriers affecting implementation, such as a lack of resources, capacity, or regulatory barriers. In doing so, it emphasises the importance of identifying the connection between the research that is ‘done’ and how it is ‘used’.

This project provides an updated, council-led research roadmap, comprising a set of research priorities and an activity roadmap to guide and inform research for land and soil resource management for the years 2026 to 2036.

2 Background

The LMF and LMG are two of the approximately 30 SIGs of Te Uru Kahika – Regional and Unitary Councils Aotearoa. The priority areas for Te Uru Kahika in 2025-26 (Te Uru Kahika 2025) are:

- Climate Adaptation.
- Kaupapa Māori.
- Resource Management.
- Transport.
- Bio-management (biodiversity and biosecurity).
- Science & Data.
- Business Services

This roadmap particularly aligns with the resource management, climate adaptation, and science & data priorities.

The following descriptions for the LMF and LMG are taken from the Te Uru Kahika website, being the most recent formal descriptions of the groups.

2.1 Land Monitoring Forum

The Land Monitoring Forum (LMF) is a Te Uru Kahika Special Interest Group that facilitates the interaction and collaboration of council staff whose work relates to the broad field of soil and land resources science and policy.

The purpose of the LMF is to: “Improve the management and monitoring of soil and land resources throughout New Zealand by sharing and coordinating soil and land science and policy information between regional and unitary councils, and with other organisations where appropriate (e.g. Ministry for the Environment, Stats NZ, research organisations, etc).”

The LMF is focused on the provision of robust science-based information needed to support sustainable soil and land resource management in New Zealand. Our work involves the development, improvement and reporting of the state of the environment indicators, monitoring and modelling approaches, and resource inventory information (for example) soil quality and trace elements, highly productive land, soil stability/erosion, suspended sediment, land fragmentation, land cover/use, and more.

The LMF is integrated with the Environmental and Reporting (EMaR) land project. Council representatives in the LMF are predominantly staff in soil and land science / monitoring roles, or in more applied land management roles.

2.2 Land Managers Group

The Land Managers Special Interest Group (LMG) is a network aimed at improving the sustainability of land and catchment management across Aotearoa. It consists of regional council/unitary authority managers responsible for resource management, and operates under the resource Managers Group (RMG) with Te Uru Kahika.

The Land managers Groups vision is to enhance land and management catchment through collective experience and collaboration. It aims to provide professional advice, influence policy, engage stakeholders, and deliver projects to achieve environmental outcomes.

LMG Goals:

- 1 Technical Expertise: Develop and share technical knowledge to improve land management capabilities and provide trusted advice.
- 2 Science and policy influence: work with the Chief Science Advisor to apply new scientific developments and influence policy at national and regional levels.
- 3 Stakeholder engagement: Lead behaviour change by engaging with landowners and communities to operationalise policy directions.
- 4 Project implementation: Deliver projects that achieve catchment outcomes, often in collaboration with councils and co-governance entities.
- 5 Supportive network: Maintain a network of professional to facilitate sustainable land use, improve water quality, and enhance biodiversity.

LMG aims to foster collaboration, share knowledge, and drive sustainable land management practices across New Zealand. Meetings are held regularly to discuss and coordinate efforts.

2.3 Regional councils' Research, Science & Technology Strategy

The research strategies of individual SIG groups also help to inform the regional councils' Research Science & Technology Strategy, the most recent of which was developed in 2020. This strategy identified, in no particular order, 10 key priorities:

- influencing government science direction
- incorporation of mātauranga Māori
- better science utilisation
- enhancing policy effectiveness
- integrating land and water science for enhanced sustainable production
- improving biosecurity and biodiversity
- better hazard risk management
- improving coastal management
- cross-cutting themes: adaptation to and mitigation of climate change and improving data management
- retaining and building science capability and capacity.

3 Objective

To undertake a review and update of the current research roadmap for the LMF and LMG, and produce a research roadmap for the period 2026–2036.

4 Project approach

4.1 Overview

Our overall approach to developing this updated research roadmap was to:

- evaluate the 2018 roadmap and current plans, including extent of use
- undertake a stocktake and synthesis of work and research completed against priority topics outlined in the previous roadmap, including a broader scan of research undertaken through, for example, those National Science Challenges and MBIE Endeavor Fund programmes that are likely to help guide future research or implementation
- carry out a survey of councils to determine currently identified regional and national priority issues, included seeking input from other SIGs (using LMF and LMG convenors), primarily via their research strategies
- hold an environmental scanning and futures exercise with the LMF and LMG (including the policy and regulatory environment, Te Uru Kahika themes and priorities, key drivers, environmental trends) to determine a set of high-level outcomes (via a workshop)
- compile and test a set of refreshed and new priorities to meet these outcomes, initially in a small group workshop with LMG and LMF members, and later with their wider membership
- develop a draft research roadmap, and incorporate input from the LMF and LMG and make further refinements before finalising the report.

4.2 Evaluation of the 2018 roadmap

To inform the development of the current roadmap we undertook an evaluation of the 2018 roadmap and current SIG 'Plans on a page'. This included interviews with two of the authors of the previous roadmap to better understand its intended use and the approach taken at the time of development, and to assess the use and usability of the roadmap by asking LMF and LMG members if they had read or used the document, and if so, how they had used it.

A key finding from this evaluation was that the previous roadmap had been little used by the SIG groups to inform their research activities. This largely stemmed from lack of awareness of the document, which in turn was attributed to council staff/SIG member turnover, and the absence of a systematic approach within the SIGs to routinely draw on the document, or to evaluate progress against the goals and priorities it identified. Also, since 2018, and particularly since 2020, there have been significant global and national factors affecting council operations (see also section 5).

4.3 Environmental scan and stocktake

An environmental scan of drivers and influences on the land and soil sector since 2018 was undertaken by reviewing major policy and regulatory changes over this time, and identifying key publications (e.g. Parliamentary Commissioner for the Environment reports, central government long-term insights documents). The scan was further informed by the stocktake and discussions during the research priority identification workshops.

A stocktake of material published since 2018 and relevant to the 2018 roadmap priorities was undertaken through general internet searching and targeted searching, specifically, publication lists from:

- MBIE Endeavor Fund programmes – ‘Smarter Targeting of Erosion Control (STEC)’, ‘Soil Health Oneone Ora, Tangata Ora’, and ‘Moving the Middle’
- the Our Land and Water National Science Challenge
- Envirolink advice grants and Tools projects.

A request was also made through LMF and LMG for additional reports that may have been directly commissioned by councils, although only one council responded. Collated material was also provided to Manaaki Whenua – Landcare Research experts in the specific topic areas to identify any key missing publications and provide a high-level evaluation of their likely relevance to councils.

Publications identified as relevant to multiple research priority areas were covered in each research priority area.

4.4 Identification of research priorities

The identification of research priorities involved five steps.

- 1 Gather initial information.
- 2 Hold focus group workshop I – long-term drivers (8 September 2025).
- 3 Hold focus group workshop II – short-term drivers (13 October 2025).
- 4 Identify first-cut research priorities – focus group review (21 & 24 November 2025).
- 5 Refine research priorities – individual SIG review (9 March & 7 April 2026).

To capture initial thinking on short-term and long-term issues and research needs, brainstorming sessions were held with the individual SIGs and a questionnaire was circulated among LMF and LMG members.

The two focus group workshops were held with three to four representatives from each SIG and the Chief Science Advisor from Te Uru Kahika. The first workshop on long-term thinking asked the focus group to identify key issues and associated research priorities using two IPCC¹ climate scenarios over three decades, downscaled to New Zealand, as prompts (Ministry for the Environment²; Bodeker et al. 2022). These scenarios combined characteristics of the socioeconomic (Shared Socio-economic Pathways, SSPs) and biophysical (Representative Concentration Pathways, RCPs) scenarios. The SSP scenarios range from SSP1 ‘taking the green road’, involving global transformative change towards sustainability, to SSP5 ‘taking the highway’ that maximises fossil fuel use for economic growth. RCP scenarios range from RCP2.6, with very low emissions and global warming remaining below 2°C, to RCP8.2, representing a worst-case

¹ Intergovernmental Panel on Climate Change.

² <https://environment.govt.nz/what-you-can-do/climate-scenarios-toolkit/climate-scenarios-list/ipccs-ssp-rcp-scenarios/>

scenario projected to cause 4.4°C of global warming and projected mean annual temperature increases across NZ between 0.9-1.1°C by 2031-2050 and 2.8-3.1°C by 2081-2100³.

The first focus group scenario was based on RCP4.5 (arguably the current trajectory) and somewhere between SSP2 and SSP 3. This scenario included a dramatic increase in the frequency of extreme weather events, and much more limited access to affordable energy, affecting imports, exports, and access to fertiliser, pesticides, and machinery. The second scenario was based on a more optimistic scenario: RCP 2.6 and SSP1. This scenario still had an increase in extreme weather events and reduced access to oil, but in this scenario significant national and international action on climate change has taken place earlier.

The second focus group workshop focused on the short-term drivers – including policy and regulations – of research needs, and how the information is intended to be used.

In addition, a series of issues developed from the initial information gathering and the first workshop were scored on the following questions:

How significant is this issue for your work?

- 1 = this is not affecting my work much
- 2 = this is something we are responding to
- 3 = this needs an urgent response from us.

How well is the issue understood?

- 1 = there is enough information to make decisions
- 2 = there is some information to make decisions
- 3 = there is not enough information to make decisions.

How well are solutions/mitigations/alternatives understood?

- 1 = there is enough information to make decisions
- 2 = there is some information to make decisions
- 3 = there is not enough information to make decisions.

The total score was based on relevance (1–3), with those topics scoring 2 or 3 for relevance also scored for the knowledge gap on the issue (1–3) and the knowledge gap on mitigations (1–3). High scores indicate high relevance and knowledge gaps that limit regional councils' ability to respond.

Following the scoring exercise there was further discussion to identify any missing topics, and on specific research needs associated with the identified topic areas.

From this second workshop a first-cut set of research priorities was developed (Appendix 2 provides details on the scoring of these priorities) and discussed in a review workshop with focus group representatives. The refined research priorities were then workshopped with the wider membership of each SIG.

³ <https://niwa.co.nz/climate-and-weather/climate-change/climate-change-adaptation-toolbox/projected-regional-climate-change-hazards#:~:text=RCP%208.5%20%E2%80%93%20with%20a%20range,degrees%20Celsius%20by%202081%E2%80%932100.>

5 Major shifts: scanning results

In the 8 years since the development of the previous roadmap many factors have changed in both the research landscape and the operating environment of the natural resources sector (Figure 1). There was an initial continuation of land and soil as a focus area in central government policy with the release of the Essential Freshwater package in September 2020, which focused on managing the impacts of agricultural intensification on freshwater quality, and the implementation of the National Policy Statement for Highly Productive Land in October 2022.

Alongside these policy and regulatory changes, resource management reform was announced in February 2021, with two new pieces of legislation (the Spatial Planning Act and the Natural and Built Environment Act) coming into force in August 2023. However, with a change of government in October 2023 these Acts and many of the earlier changes were repealed or paused. Resource management reform is ongoing, with the Fast-track Approvals Act coming into force in December 2024, and two new resource management bills, the Natural Environment Bill and the Planning Bill, were introduced into Parliament in December 2025. There are also ongoing wider impacts on the regional sector, with central government imposing, in April 2026, a 3-month time-frame for New Zealand councils to propose voluntary mergers into larger unitary authorities or face government-mandated amalgamation.

Outside of policy and regulatory reform, from March 2020 the Covid pandemic created unprecedented global and national disruption to all aspects of life. Ongoing natural 'disasters' – in particular extreme flooding and landslips – have given greater emphasis to investigating climate change and associated adaptation and resilience. A regional sector response was the initiation of the Climate SIG in 2022, while the Natural Hazards SIG has gained increased relevance.

From an environmental monitoring perspective, a National Environmental Monitoring Standard (NEMS) for soil quality and trace elements released in 2022 and several national reports on *Our Land* and *Our Environment*, which draw on state of the environment soil quality monitoring data, have been released since 2018. The Parliamentary Commissioner for the Environment has also published several reports since 2018 that are relevant to the environmental management of land and soil, including a critique of New Zealand's environmental monitoring system or tools (e.g. Overseer) used for environmental management. The most recent report, in December 2025, critiques the use of the Land Use Capability (LUC) system in a regulatory context, which underpins implementation of the National Policy Statement for Highly Productive Land (including the regional mapping of highly productive land).

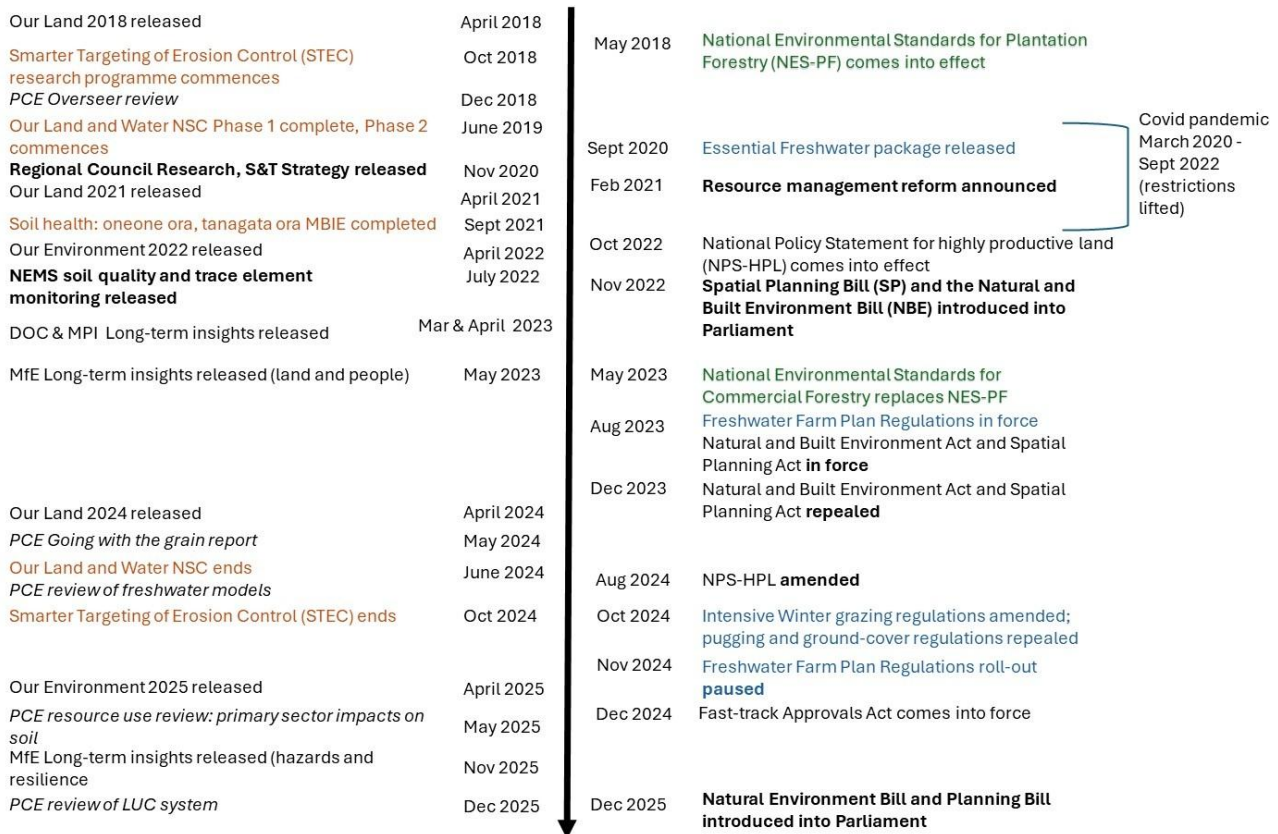


Figure 1. Timeline of some of the major impacts on the outcomes of the 2018–2020 research roadmap.

Notes: Orange colouring indicates research-related impacts, Green indicates forestry related legislation, Blue indicates freshwater related legislation, bolded text highlights particularly relevant or major impacts. Italics indicates PCE reports. NEMS = National Environmental Monitoring Standard; PCE = Parliamentary Commissioner for the Environment; NSC = National Science Challenge; DOC = Department of Conservation; MPI = Ministry for Primary Industries; MfE = Ministry for the Environment; LUC = Land Use Capability; NPS-HPL = National Policy Statement for Highly Productive Land.

5.1 Research developments

Despite the significant changes in the policy and regulatory space, a considerable amount of research has been undertaken, including through the Our land and Water National Science Challenge, MBIE Endeavour programmes (including ‘Smarter Targeting of Erosion Control’, ‘Soil Health Oneone Ora, Tangata Ora’, and ‘Moving the Middle’), and council-commissioned studies, including Envirolink projects.

Studies identified as being relevant to the 2018 research priorities are summarised in Table 1, with an extended list provided in Appendix 1. Council-commissioned reports will have direct relevance to councils; journal papers may be less directly applicable, although they may provide a robust scientific underpinning of, for example, models used by councils. This is not an exhaustive stocktake but serves to illustrate the scope of publications relevant to the identified topic areas. However, given the breadth of the identified research priorities, the number of studies identified, and the fact that there was limited evidence that the previous roadmap was used to direct or align research, a more detailed synthesis or evaluation of progress against these priorities was not undertaken.

Table 1. Summary of the number of publications, including a breakdown by sub-topic area, and a broad summary of content related to the different research priorities identified in the 2018 roadmap

Research priority from 2018 roadmap (Identified joint or lead SIG)^a	Summary (total number, subtopic, short summary)
Identify options for future land use to realise greater co-benefits and grow value (LMF/LMG)	<p>19 total: diversity/multifunctionality (7), novel land uses (6), climate-change-focused studies (2), and holistic decision-making frameworks (3) 8 reports, 10 journal articles</p> <p>These publications provide assessments of land-use options at various scales, and the assessment of their appropriateness in their social, economic, and/or environmental context.</p>
Identify options for the sustainable use of marginal land (LMG/LMF)	<p>28 total: Māori land (4), carbon sequestration (6), native afforestation (10), climate change (4), value of marginal land (3), erosion (2) 21 reports, 5 journal articles, 1 other</p> <p>This work suggests afforestation is the main option for marginal land, and predominantly explores the pros and cons of options for afforestation for carbon credits and native regeneration. Some work specifically supports options for Māori land, other works focuses on marginal (steep) land more broadly or land that may become marginal due to the impacts of climate change.</p>
Determine the extent to which a soil ecosystem services approach / integrated spatial modelling can inform wise use of land (LMF/LMG)	<p>10 total: conceptual framework (2), landscape structure (5), farm systems modelling (3) 3 reports, 7 journal articles,</p> <p>This literature shows there are examples of how ecosystems services and integrated spatial modelling can be used to make land-use decisions. Other literature under this priority describes considerations and frameworks to use when applying these approaches.</p>
Enhance the coverage, quality and interoperability of resource soil information (S-map) (LMF/LMG)	<p>15 total: climate change (2), modelling (4), soil hydrology (5), soil information (2), water quality (2) 0 reports, 13 journal articles, 2 other</p> <p>S-map coverage extended: now 44.3% of NZ, including 78.2% of 'multiple-use land'. Mapping efforts are ongoing.</p> <p>These publications cover a range of improvements to use soil information for modelling climate change impacts, soil hydrology, water quality, and soil information. Some studies are at farm scale, while others are at a regional scale.</p>
Develop and test better input data on erosion and sediment generation to enhance the performance of erosion/sediment modelling (LMF/LMG)	<p>56 total: climate change (10), land/water planning (11), economic (3), method (12), mitigation targeting (9), data acquisition (2), erosion source (2), national (2) and (process) understanding (10), model development (2), sediment budget modelling (1) 34 reports, 22 journal articles</p> <p>This literature covers progress in modelling approaches and data acquisition. Other literature improves understanding of erosion processes, attribution, with some specialising on impacts of climate change. Research done in relation to this priority also covers applications for planning, mitigation options, and economic implications.</p>
Enhance the coverage, quality and interoperability of land-cover and land-use data (LMF/LMG)	<p>18 total: wetlands (3), land-use classification (5), weblinks (e.g. Our Environment) (7), vegetation mapping (3) 8 reports, 3 journal articles, 7 other-mainly online resources.</p> <p>This research primarily covers aspects of classification and delineation of different land-use/land-cover features, and includes several online links to spatial layers.</p>
Evaluate different land management practices against major land-use effects and the policy approaches used to manage them (e.g. erosion, nutrient leakage, soil contamination) (LMG/LMF)	<p>75 total: erosion mitigation (5), erosion process (3), forestry impacts (1), irrigation management (1), management evaluation (1), management forestry slash (2), microbes (1), native (2), nutrient cycling (1), nutrient losses (3), on-farm management (17), policy approaches to manage them (13), processes (4), review (5), soil pasture (1), soil (4), soil compaction (1), trees (4), wastewater application (1), water quantity (2) 23 reports, 50 journal articles, 2 other</p>

Research priority from 2018 roadmap (Identified joint or lead SIG) ^a	Summary (total number, subtopic, short summary)
Understand and incorporate Māori values (e.g. mahinga kai, kaitiaki) within decision-making (LMG/LMF)	<p>Most of this literature is about either land management practices/interventions or a policy approach. The management practices studied span a wide range of interventions, largely looking to improve soil and water outcomes.</p> <p>154 total: te mana o te wai, takiwa,wai (23), land and soils (29), biodiversity, biosecurity, forest health, wetlands (29), climate change (20), indigenous knowledge/mātauranga Māori and science (20), decision making, te ao Māori natural resource management, indigenous knowledge (31)</p> <p>21 reports, 110 journal articles, 23 other</p> <p>This is a very broad topic and covers mātauranga in the context of environmental decision-making, ecosystems, and scenarios.</p>
Determine the factors (behaviours, values, motivations) affecting decisions over land use and land management (LMG/LMF)	<p>11 total: across land uses (3), specific (8)</p> <p>3 reports, 7 journal articles, 1 other</p> <p>This largely qualitative body of research explores what shapes decision-making by farmers and land owners. Some of it is focused on a specific land-use or practice change, while others more broadly explore factors that shape land-owner decision-making.</p>
Develop necessary tools and enable relevant research that supports community decision-making (LMG/LMF)	<p>20 total: role of catchment groups (9), catchment group operation (3), guidance (2), including online resources (6)</p> <p>6 reports, 8 journal articles, 6 online resources</p> <p>This research largely covers case studies of catchment groups and other collectives and how they are (or are not) enabled to co-manage, or have influence on the management of, their local areas. Online resources include case studies and catchment management toolkits.</p>
Understand how many people are adopting good management practice and the real drivers behind implementation LMG	<p>11 total: drivers (8), rates (3)</p> <p>0 reports, 9 journal articles, 2 other</p> <p>This work captures mostly quantitative studies that explored uptake of practices and factors that influence it.</p>
Support development of certification and training for land management (LMG) Investigate and develop ways to build capability in land management tools (LMG)	<p>Not research areas <i>per se</i>, but partially addressed through work of NZ Association of Resource Management: https://nzarm.org.nz/capability-building/capability-assessment-tool/ also https://www.mpi.govt.nz/agriculture/farm-management-the-environment-and-land-use/on-farm-support</p>
Develop methods to effectively characterise soil health (LMF)	<p>42 total: biological indicators (22), ecology (2), soil contamination (3), land use (2), review (1), SOE monitoring (2), te ao Māori (5), methods (2), well-being (1) misc. (2)</p> <p>15 reports, 27 journal articles</p>
Characterise national state and trend of soil contamination^a (LMF)	<p>32 total: cadmium (12), guideline values (3), residues (1), plastics (1), pesticides (1), silver (1), trace elements (7), misc. (2), geochemical baseline (4)</p> <p>17 reports, 14 journal articles, 1 other</p> <p>This work covers insights on specific contaminants and groups of contaminants. Most studies focus on the uptake of specific crops, understanding the contaminant in a particular area, trends over time, or the impacts of farm practices. Several studies also provide information on baseline concentrations of trace elements.</p>
Assess the likelihood and impact of increasing competition for land (urban, biofuels) on the ability of soils to provide essential ecosystem services (LMF)	<p>7 total: land fragmentation/urban (5), soil health (2)</p> <p>2 reports, 5 journal articles</p> <p>The literature covers a mix of spatial, policy, and social analysis of land-use change and competition for productive land adjacent to expanding urban centres</p>

^a The first-named SIG for joint priorities is the lead SIG.

^b This is assumed to exclude contaminated land, which falls under the remit of the Contaminated Land and Waste SIG.

6 Goals and research priorities

6.1 Goals for the roadmap

A review of the 2018 roadmap goals formed the basis for the goals developed here. Essentially, the previous goals were simplified to retain the key outcomes desired by LMF and LMG, with the overarching intent of the roadmap being to facilitate sustainable land use, improve water quality and climate resilience, and enhance biodiversity.

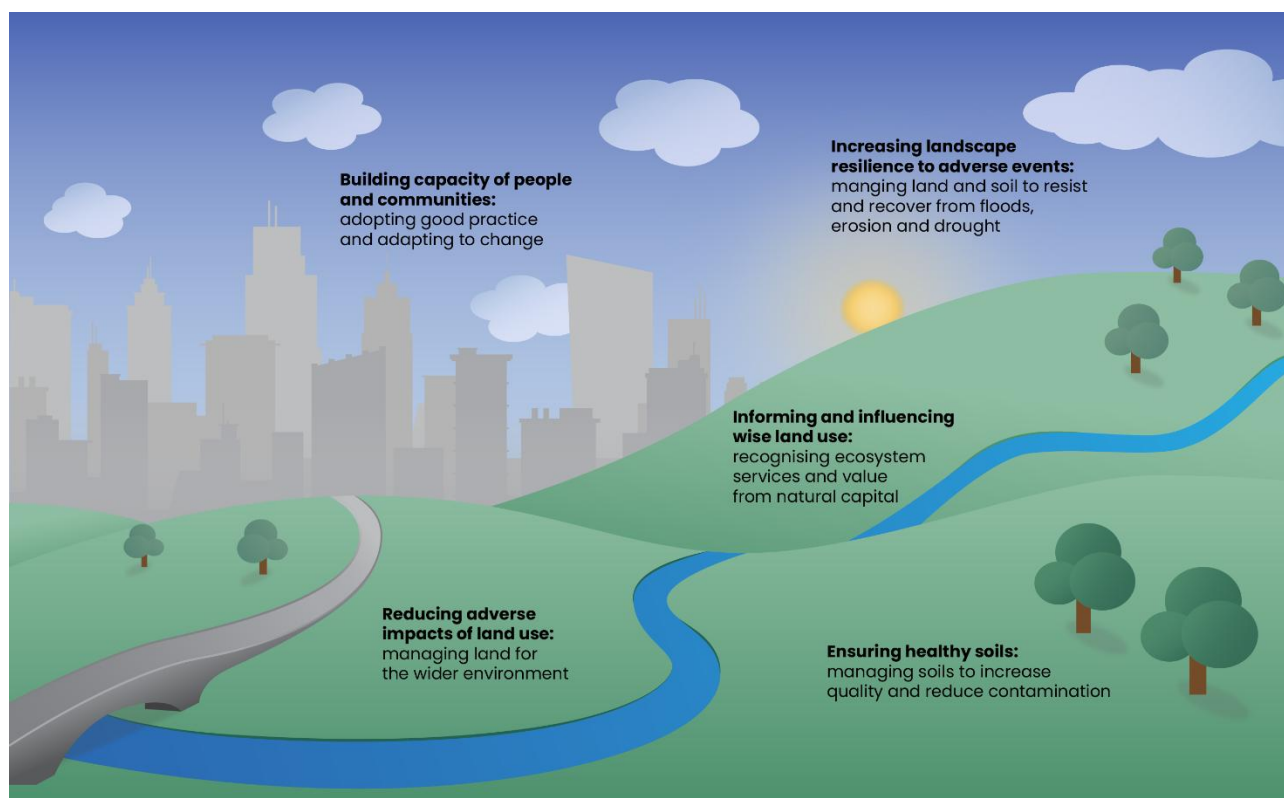


Figure 2. The 2026 roadmap goals updated from the 2018 roadmap (Phillips et al. 2018).

The previous roadmap included several ‘enabling’ goals:

- Engage meaningfully: supporting community inclusiveness
- Understanding values within decision-making: enabling effective and inclusive outcomes
- Improving monitoring and reporting: supporting effectiveness and consistency
- Enhancing data and usability: ensuring data interoperability and access
- Influencing policy effectiveness.

These enabling goals were considered to be critical mechanisms by which research can be implemented to achieve the goals identified in Figure 2. However, as discussed in section 6.2.1, more explicit consideration and focus need to be given to how research is implemented – and even whether knowledge is the key barrier to achieve the goals identified in Figure 2.

It was agreed that this research roadmap should consider research relevant over a 10-year time horizon, with a formal review undertaken every 3 years (in line with council plan review processes).

6.2 Effecting land management and land-use change, and research priorities

6.2.1 Effecting land management and land-use change

Both the LMF and LMG highlighted that achieving desired environmental outcomes as represented by the Goals in Figure 2, including through changes in land-use or land management practices, is fundamental to the purpose of the SIGs. Achieving these outcomes requires more than just the provision of knowledge and critically relies on *how* that knowledge is used to achieve the desired outcomes.

At a council level, the primary broad pathways are:

- implementing legislative requirements e.g. state of environment monitoring, farm environment plan development
- informing the development, and monitoring the effectiveness, of council policy and plans
- informing knowledge transfer, communication, and education activities undertaken by councils.

The intended purpose of undertaking the research, and the pathway for its implementation, should be clearly identified at the outset of undertaking the research. This includes the research being identified as a component of a longer-term implementation strategy to address a particular issue. Implementation also needs to be considered in the broader context of the surrounding policy and regulatory drivers, resources (people, money), and motivation of affected parties to make change. However, it is common knowledge that decisions or actions need to be taken in the absence of all desired information, and a critical question should be how will this new knowledge (research) help achieve the desired outcomes?

The 'plan-do-monitor-review' cycle described on the Quality Planning website⁴ outlines a useful approach to assessing the efficacy of implementation and progress towards outcomes – at least for outcomes or activities identified in regional plans. Monitoring can also provide useful information to deepen understanding of processes or actions; for example, tracking the location of erosion-control plantings versus simply recording the area planted could assist in the development of more refined models to assess the efficacy of mitigation measures. Monitoring can also help identify the problem or issue to be addressed.

Figure 3 outlines a simplified knowledge-to-action process that LMF and LMG could use to identify specific questions to be addressed through further research ('know'), or to identify the specific actions ('do') that might be required to achieve the desired outcomes. Determining the know/do gap probably requires identifying and evaluating approaches to implementation that are currently being utilised (e.g. which activities are driven by meeting policy and plan requirements, what non-regulatory activities are being undertaken, and how successful have the different activities been?).

⁴ <https://www.qualityplanning.org.nz/node/1049>

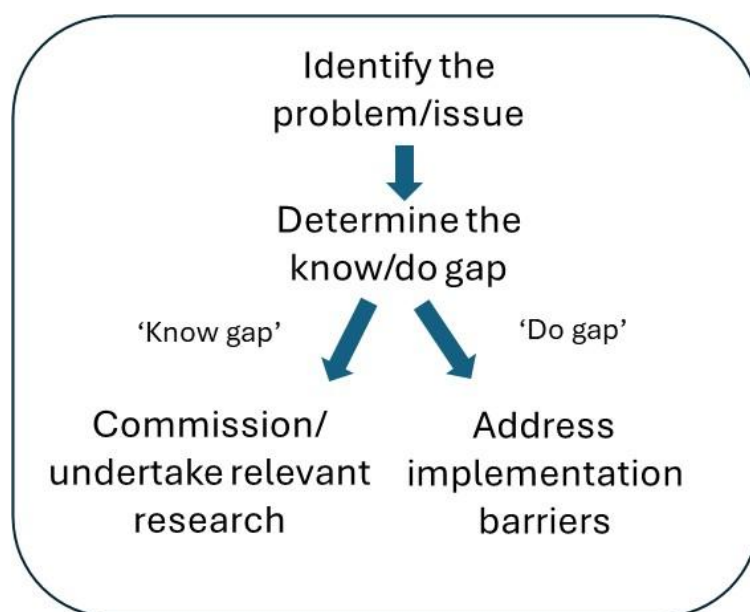


Figure 3. A simplified knowledge-to-action process for LMF and LMG to identify the specific questions to be addressed through further research ('know') or to identify the specific actions ('do') that might be required to achieve the desired outcomes.

6.2.2 Research priorities

The evaluation of the previous roadmap identified that the research priorities were quite broad and, as a result, captured a lot of research that may not address research gaps relevant to councils. Also, the purpose of the intended priority research (i.e. to set limits, to inform advice or policies) was unclear. In response, we endeavoured to more explicitly state the specific *issue* and the *research gap* related to the issue that is currently preventing an effective *response* by a council. The research priorities developed through the workshops and subsequent discussion sessions are shown in Table 2. These are arranged roughly in order of decreasing priority (as assessed by the focus group), with Appendix 2 providing more detail on the development of the priorities.

Some priorities, particularly those related to severe weather events and erosion, were identified as being relevant to many SIGs. The following SIGs were identified as being particularly relevant to connect with to support progress in addressing the research priorities:

- Natural Hazards SIG
- River Managers SIG
- Surface Water and Integrated Management SIG
- Geospatial SIG
- Environmental Data SIG.

At a higher level, the Science Advisory Group and the Resource Managers Group were considered instrumental for ensuring coordination of research and implementation in specific topic areas across the different SIGs.

Many publications or resource links in the stocktake (Appendix 1) will also be relevant for the research priorities listed in Table 2. Additional relevant resources can be sourced from <https://www.landcareresearch.co.nz/discover-our-research/climate-change/erosion-and-sediment/smarter-targeting-of-erosion-control> (particularly relevant for priority 2A), and from the Our Land and Water National Science Challenge website (<https://ourlandandwater.nz/about-us/>) as starting points.

Table 2. Research priorities, identifying the specific *issue* and the *research gap* related to the issue that is currently preventing an effective *response* by councils. Included under the research priority is the specific roadmap goal this research will address.

Research priority	Research gap	Lead SIG ^a	Comment or specific research topics (identified in 2026)
1. Effecting land-use and management change ^b Goal: Building capacity of people and communities	A. Research is needed to <i>develop processes to help navigate tensions</i> between the context, preferences, and values of communities and land owners on the one hand, and the biophysical data on the effectiveness of mitigation options on the other, to help inform non-regulatory interventions	LMG	<ul style="list-style-type: none"> • Tree species selection for soil conservation (i.e. social, including cultural perceptions of using exotic or native species). • Better understanding of how social, economic, climate impacts and risks, and political factors shape land use. • Enabling land-use change that incorporates long-term thinking.
2. Use and effectiveness of mitigation options and techniques at farm to catchment scales Goal: Reducing adverse effects of land use	B. Further research is required to attribute changes in <i>erosion</i> to management practices and interventions to guide <i>selection of the most-effective, place-specific interventions to employ at different catchment locations</i> to reduce erosion and enhance soil conservation and water quality at farm to catchment scales	LMG/LMF	<ul style="list-style-type: none"> • Methodologies to identify the efficacy of interventions/mitigations at different scales. • Upscaling results (from measured farm/site to sub-catchment, catchment, region), and • downscaling results (typically of modelled results from region/catchment to farm scale). • Consideration of different sources (e.g. stream-bank vs erosion from high-country farms) and sediment types (e.g. coarse vs fine sediment). • Efficacy of virtual fencing. • Efficacy of other specific techniques, including riparian planting, different tree species (e.g. exotic vs native) for soil conservation, maintenance of vegetative cover, including different pasture species, constructed wetlands. • Cumulative effects of land use over time. • Differentiating between baseline and storm event sediment generation. • Sediment delivery – sources and lag times. • Evaluation under/in response to climate events. • Risk assessment.
	C. Further research is required to attribute changes in <i>contaminants</i> to management and mitigations that would enable guidance to <i>select the most effective interventions to employ in different catchment locations</i> to reduce nutrient and pathogen loss to groundwater and waterways	LMG/LMF	<ul style="list-style-type: none"> • Efficacy of specific techniques, including: <ul style="list-style-type: none"> ○ edge-of-field constructed wetlands (particularly in the South Island) ○ riparian planting, and the effects of extreme weather on riparian plantings ○ grazing management ○ virtual fencing. • Methodologies to identify the efficacy of interventions/mitigations at different scales. • Identifying critical source areas for nutrients and pathogens (e.g. <i>E.coli</i>). • The appropriateness and use of <i>E. coli</i> (or other indicators) as a measure of faecal contamination.

Research priority	Research gap	Lead SIG ^a	Comment or specific research topics (identified in 2026)
			<ul style="list-style-type: none"> • Pathogen delivery – sources and lag times. • Upscaling results (from measured farm/site to sub-catchment, catchment, region), and • downscaling results (typically of modelled results from region/catchment to farm scale). • Cumulative effects of land use over time.
	D. Evaluation of the <i>cost–benefit of the mitigation options</i> .	LMG	This research priority draws on the biophysical information generated from addressing the two preceding priorities, but has a specific focus on costs, including the cost of installation, and the value or benefits of mitigation to help prioritise the nature and location of intervention within and between catchments.
3. Land use and resource information Goal: Informing and influencing the wise use of land	A. Identify approaches to <i>assess the environmental sustainability of land use, including land-use intensity</i> , that encompasses environmental outcomes alongside classic agronomic/production outcomes <i>to inform mitigation option efficacy and non-regulatory guidance, planning, and policy</i> .	LMF/LMG	<p>This research priority is intended to explicitly assess the environmental outcomes (e.g. nutrient movement to surface- or groundwater) associated with different land uses and associated management practices, reflecting ‘traditional’ suitability from an agronomic perspective. Assessing this would provide, for example, recognition of areas where negative environmental outcomes will occur despite the use of best-management practices. This information would provide a greater ability to assess the fully accounted cost–benefit of land use (and requires consideration of commodity value alongside environmental impacts), land-use change, and land-use options under climate change. This includes:</p> <ul style="list-style-type: none"> • food production (conventional agriculture and horticulture, and urban farms and community gardens) • forestry and afforestation • urban (e.g. urban sponginess), and peri-urban environments.
	B. Land fragmentation and land-use capability	LMF	<ul style="list-style-type: none"> • Research is required to understand the impacts of increased urban expansion on food production (conventional agriculture, and urban farms and community gardens) and environmental outcomes. • Developing and undertaking cost-effective and robust approaches to undertake Land Use Capability (LUC) mapping using the LUC system or other suitable methods.
	C. <i>Underpinning data</i> : missing soil data, legacy data, and spatial layers	LMF/LMG	<p>This priority recognises the multiple advantages in having seamless national coverage at the relevant (multiple) spatial scale, and of having various spatial layers, including:</p> <ul style="list-style-type: none"> • S-map • LiDAR • LUC • land use • geology (improved on Qmap)

Research priority	Research gap	Lead SIG ^a	Comment or specific research topics (identified in 2026)
			<ul style="list-style-type: none"> • environmental sustainability of land use • land cover • various soil quality attributes • digital stream networks, surface water flow • slope & slope classes, terrain roughness • landslide susceptibility • highly erodible land. <p>These advantages include unified advocacy and planning, and greater strategic identification of priority issues within a region and at a national level.</p> <p>Advocating for sound management and the use of legacy data sets is an important part of this topic. This includes supporting research into methods to secure and reliably capture hard-copy legacy data that can support its use alongside new data sources.</p>
<p>4. Managing under change and uncertainty – building resilience</p> <p>The focus of this research priority is on temporal and spatial uncertainty, primarily associated with a changing climate, but also acknowledging the changeability of the current regulatory and economic environment.</p> <p>Goal: Increasing landscape resilience to adverse events</p>	<p>A. Research to identify options, and investigate their efficacy, to (1) <i>mitigate the impacts of severe weather events</i> and (2) <i>support recovery</i> from severe weather events</p>	<p>LMG/LMF [Natural Hazards]</p>	<p>This priority is driven by changes in the Local Government Official Information and Meetings Act (LGOIMA) to better identify natural hazards, which falls under the remit of the LMF. Specific priority topics identified for research were:</p> <ul style="list-style-type: none"> • slope destabilisation from rainfall, • attribution of cause (land-use vs climate change) and legacy land use • macro-effects such as rivers changing course, silt on land and houses, slips affecting infrastructure • land subsidence.
	<p>B. Research to explore approaches on land, including natural infrastructure⁵ that would <i>build resilience at farm and regional scale</i> to (1) reduce the impact of, and enhance the recovery from, extreme events, or (2) enable adaptation to slower climate changes</p>	<p>LMG/LMF</p>	<p>This priority relates to (for example):</p> <ul style="list-style-type: none"> • floods and the interaction of erosion/nutrient/pathogen interventions under extreme (flood) events • the opportunity to improve soil to help mitigate extreme weather events (flooding & drought) via optimal soil structure (including organic matter) in relation to soil-water movement and storage in urban and rural environments • the impacts of the intensification of on-farm land management.
	<p>C. Improve knowledge on <i>peatland management</i>. Subsidence and greenhouse gas emissions relating to drained peatlands are critical issues, alongside wetland health</p>	<p>LMF [Climate change SIG]</p>	<p>This research priority is more regionally specific, with most peatland present in Northland, Waikato, Bay of Plenty, and Southland.</p>

⁵ Aotearoa Circle. Natural Infrastructure Plan <https://www.theaotearoacircle.nz/focus-areas/natural-capital-restoration/natural-infrastructure-plan>

Research priority	Research gap	Lead SIG ^a	Comment or specific research topics (identified in 2026)
	D. Research is needed that connects climate data (long time frames and uncertainty) and risks (the urgency of) with what is required from policy and planning now, to navigate climate impacts in the (near) future.	LMF	This research priority was identified by taking a longer-term perspective on research needs.
	E. Research is needed into the viability (financial, biophysical) of land uses that build climate resilience: climate-proof crops, biofuels, agri-voltaics, diversification, continuous-cover forestry, indoor farming, paludiculture, hydroponics. An understanding is also needed of the actions required to drive these transitions, particularly those associated with providing food security alongside considerations of land-use suitability, land-use planning, and land-use change for a 'future proof NZ'.	LMF/LMG	This research priority was identified by taking a longer-term perspective on research needs. LMF and LMG are intended to be recipients of research rather than directly commissioning research, and they achieve this by actively seeking connections (e.g. to other SIGs, research organisations or consortia).
5. Incorporating te ao Māori and mātauranga Māori Goal: Building people and communities	A. Research is needed that enables incorporating knowledge from multiple knowledge systems into advice, planning, decision-making, and policy-making on soil and land.	LMF/LMG	A key focus for this priority is addressing capacity constraints to enable the effective incorporation of te ao Māori and mātauranga Māori.
6. Soil health and function Goal: Ensuring healthy soils	A. Research is needed to <i>understand and quantify the connection</i> between soil health and wider environmental (e.g. surface and ground-water quality) and production (e.g. yield) outcomes, <i>including the interaction with land management practices</i> intended to improve soil health.	LMF	This research priority area links to priority 2A (environmental sustainability of land use) and focuses on considering soils and soil health as part of the broader environment and food/fibre production system, with priority issues identified as being: <ul style="list-style-type: none"> • soil compaction and pugging • low soil carbon • soil organic matter cycling and storage • knowledge gaps in understanding the role of, and how best to monitor, soil biology and biodiversity in relation to soil health and function • the impact of large-scale soil disturbance on soil properties and ecosystem services.
	B. Research to improve and implement state of the environment soil quality monitoring and reporting.	LMF	This research priority reflects ongoing research to support improvements in soil-quality monitoring. Currently an implementation plan is being developed by LMF, drawing on recommendations in multiple reports that have been completed in recent years

Research priority	Research gap	Lead SIG ^a	Comment or specific research topics (identified in 2026)
7. Emerging contaminants Goals: Ensuring healthy soils & Reducing adverse effects of land use	A. Research to inform knowledge gaps about the <i>significance of emerging contaminants</i> in soil with respect to the spatial extent of presence and potential impact (e.g. food safety) to inform policy development to manage emerging soil contaminants.	LMF	Contaminants include: <ul style="list-style-type: none"> • microplastics • PFAS • pharmaceuticals • connections between soil contaminants, soil health, and human and animal health (e.g. One Health approaches).
8. New technologies All goals	A. Research to identify <i>new technologies</i> that may support activities being undertaken by the LMF and LMG, <i>such as more cost-effective approaches to monitoring</i> .	LMF/LMG	This research priority is included to ensure there is an ongoing scan for new technologies, with specific areas currently identified as: <ul style="list-style-type: none"> • consistent and robust methods for using AI to assess bare soil • alternatives for monitoring suspended-sediment and other contaminants (in particular <i>E. coli</i>) concentrations.

^a The lead SIG (either the LMG, LMG or both – LMF/LMG) is responsible for overseeing the direction of research and may include commissioning/directing other SIGs to undertake the work. SIGs identified in square brackets [] are anticipated to be those that may find the commissioned research useful.

^b Effecting land management and land-use change was originally scored low, but subsequent workshop discussions have elevated this topic to a research priority.

7 Activity roadmap

The process of refining the research priorities through the wider individual SIG workshops highlighted some common barriers: notably awareness of what research has previously been undertaken and how it could be used. Also, the difference in the research requirements of larger councils compared to smaller councils became more apparent, highlighting the opportunity for consolidating cross-council experiences for the identified research priority areas to help streamline actual research requirements.

We also note an ongoing conflation between the terms *research* roadmap and *strategic* roadmap, or *strategy*, in part because of the interchangeable use of these terms in previous roadmaps. A strategy should have a greater focus on all activities contributing to the achievement of outcomes (i.e. encompassing greater consideration of the extent to which existing knowledge and actions simply need to be actioned). This research roadmap focuses on research needs, although it emphasises the importance of identifying the connection between the research that is 'done' and how it is 'used'.

The following items provide an activity roadmap that will assist in meeting the desired outcomes for land, soil, and catchment management.

- 1 Develop a repository of research and other information relevant to the research priorities identified (this could also include wider work relevant for the LMF and LMG). This can be separated into three steps:
 - a scoping how this is best achieved (including ongoing maintenance)
 - b collating material (the stocktake developed in this project will be a useful starting point)
 - c updating and ongoing maintenance.
- 2 Develop annual action plans: these allow for the most pressing research priorities to be targeted on an annual basis, while accommodating changing pressures that are not currently foreseen (or are foreseen but whose nature is unclear; e.g. proposed regulatory reform and council mergers), and enabling the tracking of progress against the full set of research priorities.
- 3 Commission or undertake critical reviews of literature relevant to identified research priorities, and canvass cross-council experiences to identify (a) whether knowledge gaps (rather than implementation) are the key barrier to achieving the desired outcomes, and (b) the specific questions to be answered through further research. In determining avenues for further research:
 - consider what can be funded through individual or combined council resources (including via Envirolink) vs requiring greater resources (e.g. a large-scale research programme with alternative funding)
 - connect and coordinate with other relevant SIGs on the topic/s of interest
 - identify how addressing the knowledge gap will help to achieve the desired outcomes.
- 4 Identify intended pathways for implementing the research to achieve the desired outcomes (e.g. advocating/influencing council policy or plans, developing guidance, working with land managers).
- 5 Consider how existing monitoring data or the capture of information (e.g. on the extent or location of mitigation/management actions) can be used to inform relevant research, or to provide the desired information.

- 6 Maintain or increase involvement in cross-government advisory groups (e.g. S-map Advisory Group, Land Use Capability Governance Group, the cross-ministry Land Monitoring Governance Group).
- 7 Develop outcome measures or key performance indicators to help measure delivery against goals and research priorities (or, at minimum action, plan items).

8 Recommendations

Following are the key recommendations arising from this project.

- Adopt the activity roadmap including:
 - creating and maintaining a repository to capture relevant research that has been undertaken, both within and across councils, to ensure existing research is built upon and not duplicated
 - undertaking critical reviews of the recent research (using a stocktake developed in this project as a starting point) and council experience to further refine the specific research gaps associated with the identified research priorities
 - developing annual action plans to provide more time-relevant prioritisation of research or research implementation, and to allow tracking of progress.
- Advocate for greater coordination across council SIGs to ensure that connectivity and maximising the value of research is undertaken in areas of joint interest.
- Develop an implementation strategy that explicitly includes implementation of research and actions taken to achieve core outcomes.
- This research roadmap should be reviewed in 2029.

9 Acknowledgements

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Declaration of the use of generative AI / AI-assisted technologies

This research work did not use generative AI / AI-assisted technologies.

10 References

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<https://teurukahika.govt.nz/media/gfneobqm/2025-te-uru-kahika-bicm.pdf>.

Appendix 1 – Stocktake details

This appendix describes the literature surveyed in a stocktake of material published since 2018 and relevant to the 2018 roadmap priorities. Publications identified as relevant to multiple research priority areas were covered in each research priority area. Many publications or resource links in this stocktake are relevant to the research priorities listed in Table 2, particularly priority 2A.

Table A1. Information relevant to the 2018 research roadmap research priorities

Research priority (as in 2018 roadmap)	Subgroupings	Reference
Identify options for future land use to realise greater co-benefits and grow value	CC	Fitzgerald R 2022. Supporting land use adaption for a climate changed future. Ashburton District Council.
	CC	McDowell RW, Herzig A, van der Weerden TJ, et al. 2024. Growing for good: producing a healthy, low greenhouse gas and water quality footprint diet in Aotearoa, New Zealand. <i>Journal of the Royal Society of New Zealand</i> 54(3): 325–349.
	Diversify/multifunctionality	Macintosh KA, Doody DG, Withers PJ, et al. 2019. Transforming soil phosphorus fertility management strategies to support the delivery of multiple ecosystem services from agricultural systems. <i>Science of the Total Environment</i> 649: 90–98.
	Diversify/multifunctionality	Maseyk FJ, Dominati EJ, Mackay AD 2019. More than a 'nice to have': integrating indigenous biodiversity into agroecosystems in New Zealand. <i>New Zealand Journal of Ecology</i> 43(2): 1–12.
	Diversify/multifunctionality	Matheson L, Herzig A, Muller C, et al. 2024. Steering land use change to meet water quality targets. The Catchment Synthesis Scenarios Project. A report prepared for the Our Land and Water National Science Challenge.
	Diversify/multifunctionality	McCorquindale R, Lucci G, Smith G 2021. Creating a diverse and sustainable dairy farm and forestry landscape. LIC FarmWise Consultant, AgResearch, Miraka Farm Ltd.
	Diversify/multifunctionality	Millar H 2024. Land use diversification challenges and opportunities for three North Canterbury farmers. A report prepared for the Our Land and Water National Science Challenge.
	Diversify/multifunctionality	Tran DX, Pearson D, Palmer A, et al. 2022. A comprehensive spatially-explicit analysis of agricultural landscape multifunctionality using a New Zealand hill country farm case study. <i>Agricultural Systems</i> 203: 103494.
	Diversify/multifunctionality	Case BS, Forbes AS, Stanley MC, et al. 2023. Towards a framework for targeting national-scale, native revegetation in Aotearoa New Zealand's agroecosystems. <i>New Zealand Journal of Ecology</i> 47(1): 1–15.
	Holistic/systems decision frameworks	Harcourt N, Robson-Williams M, Tamepo R 2022. Supporting the design of useful and relevant holistic frameworks for land use opportunity assessment for indigenous people. <i>Australasian Journal of Water Resources</i> 26(1): 116–130.
	Holistic/systems decision frameworks	Higginson A, Smith PP, Glass C, et al. 2023. Systems thinking for future farm system design. <i>Agrimagic</i> .
	Holistic/systems decision frameworks	Wreford A, Bayne K, Edwards P, et al. 2019. Enabling a transformation to a bioeconomy in New Zealand. <i>Environmental Innovation and Societal Transitions</i> 31: 184–199.
	Novel land uses	Brent A 2024. Agrivoltaic systems for dairy farming in Aotearoa New Zealand: a cost-benefit analysis. Available at SSRN 5023366.
	Novel land uses	Lewis C, Hawkins S, Bryant S, et al. 2022. Pasture for humans: think piece report for Our Land and Water National Science Challenges. BakerAg.
Novel land uses	Jia R, Gretton G, Poletti S 2019. The optimal allocation of solar farms in Aotearoa New Zealand. Available at SSRN 5199416.	

Research priority (as in 2018 roadmap)	Subgroupings	Reference
Identify options for future land use to realise greater co-benefits and grow value (cont.)	Novel land uses	Millen P, van Ballekom S, Altaner C, et al. 2018. Durable eucalypt forests – a multi-regional opportunity for investment in New Zealand drylands. <i>New Zealand Journal of Forestry</i> 63: 1.
	Novel land uses	Thomas SM, Ausseil AG, Guo J, et al. 2024. Exploring the role of high-value crops to reduce agricultural greenhouse gas emissions in New Zealand. <i>Regional Environmental Change</i> 24(3): 105.
	Novel land uses	Essien SO, Baroutian S, Dell K, et al. 2019. Value-added potential of New Zealand mānuka and kānuka products: a review. <i>Industrial Crops and Products</i> 130: 198–207.
Identify options for the sustainable use of marginal land	Māori land	Awatere S, Marden M 2018. Climate resilient Māori land. Manaaki Whenua – Landcare Research Contract Report LC3133, prepared for Deep South National Science Challenge.
	Māori land	Awatere S, Harmsworth G, Harcourt N, et al. 2023. Whakamana te tangata – ka whai oranga te taiao: indigenous led approaches for catchment health in Aotearoa-New Zealand. <i>PLoS Water</i> 2(12): e0000170.
	Climate change	Booth P, Walsh PJ, Stahlmann-Brown P 2020. Drought intensity, future expectations, and the resilience of climate beliefs. <i>Ecological Economics</i> 176: 106735
	Carbon sequestration	Burrows LE, Easdale TA, Wakelin S, et al. 2018. Carbon sequestration potential of non-ETS land on farms. Manaaki Whenua – Landcare Research Contract Report LC3161, prepared for Ministry for Primary Industries.
	Carbon sequestration	Burrows LE, Easdale TA, Carswell FE 2018. Opportunities for carbon forestry with naturally regenerating indigenous forests. Manaaki Whenua – Landcare Research Contract Report LC3095, prepared for Scion.
	Native afforestation	Easdale TA, Lavorel S, Mason NWH, et al. 2021. Environmental co-benefits of non-production vegetation on farm. Manaaki Whenua – Landcare Research Contract Report LC3917, prepared for Ministry for Primary Industries.
	Carbon sequestration	Easdale T, Burrows L, Bellingham P, et al. 2019. Rates of carbon sequestration in naturally regenerating indigenous forests. Manaaki Whenua – Landcare Research Contract Report LC3530, prepared for Scion.
	Native afforestation	Edwards P, Wegner S, Booth P, et al. 2021. Native afforestation: public perceptions survey methodology. Manaaki Whenua – Landcare Research Contract Report LC4006, prepared for Te Uru Rākau – Forestry New Zealand, Ministry for Primary Industries.
	State	Etherington T, Fergus A, Richardson S, et al. 2019. Predicting woody vegetation state at 1990 in the Marlborough Region. Manaaki Whenua – Landcare Research Contract LC3583, prepared for Te Uru Rākau – Forestry New Zealand, Ministry for Primary Industries.
	Native afforestation	Forbes AS, Richardson SJ, Carswell E, et al. 2023. Knowing when native regeneration is for you, and what you should do about it: the Aotearoa New Zealand context. <i>New Zealand Journal of Ecology</i> 47(1): 3524.
	Marginal land	Irving B 2022. Forests or fleece: the future of the North Island's marginal country. https://ruralleaders.co.nz/wp-content/uploads/2022/11/Blake-Irving_Forests-or-Fleece-The-Future-of-the-North-Islands-Marginal-Country_Kellogg-47.pdf
Native afforestation	Kirschbaum MUF, Lambie SM, Holdaway RJ, et al. 2019. Growth simulations of mānuka in the Gisborne region. Manaaki Whenua – Landcare Research Contract Report LC3585 (SLMACC 405415), prepared for Ministry for Primary Industries.	

Research priority (as in 2018 roadmap)	Subgroupings	Reference
Identify options for the sustainable use of marginal land (cont.)	Native afforestation	Lambie S, Marden M 2020. Transitioning from exotic to native forest through natural regeneration: benefits and risks. Manaaki Whenua – Landcare Research Contract Report LC3676, prepared for Hawke’s Bay Regional Council.
	Climate change	Lambie S, Awatere S, Kirschbaum MUF, et al. 2020. Best options post pine harvest in the Gisborne District under climate change. Manaaki Whenua – Landcare Research Contract Report LC3767 (SLMACC 415405) for Ministry for Primary Industries.
	Climate change	Lambie SM, Marden M, Kirschbaum MUF, et al. 2018. Best options for land use following radiata harvest in the Gisborne District under climate change literature review. Manaaki Whenua – Landcare Research Contract Report LC3190 (SLMACC 405415), prepared for Ministry for Primary Industries.
	Erosion	Lambie SM, Neverman AJ, Kirschbaum MUF, et al. 2023. Examining the effect on sediment loss by differential pricing in the ETS to encourage land use change on highly erodible land. Manaaki Whenua – Landcare Research Contract Report LC4383, prepared for Our Land and Water National Science Challenge
	Native afforestation	Marden M, Lambie S 2019. Plot-based growth performance of space-planted manuka (<i>Leptospermum scoparium</i>) on marginal land, and vulnerability to erosion: Final report. Manaaki Whenua – Landcare Research Contract Report LC3488.
	Native afforestation	Mason NWH, Jo I, Salekin S, et al. 2024. Modelling options for indigenous forest yield tables: technical report. Manaaki Whenua – Landcare Research Contract Report LC4495, prepared for Maximising Forest Carbon, Te Uru Rākau, Ministry for Primary Industries
	Carbon sequestration	Mason NWH, Jo I, Morales San Martin N, et al. 2025. Carbon stock modelling of transition forests. Manaaki Whenua – Landcare Research Contract Report LC4573, prepared for Parliamentary Commissioner for the Environment. https://pce.parliament.nz/media/3pymh420/lc4573_transition-forests-final-report.pdf
	Native afforestation	Mason NWH, Price R, Burge OR, et al. 2024. Spatial analysis of public conservation land suitable for restoration: areas available and greenhouse gas consequences of reforestation and wetland restoration. Manaaki Whenua – Landcare Research Contract Report LC4442, prepared for Department of Conservation.
	Māori Land	Mercer L 2021. Beyond the dollar: carbon farming and its alternatives for Tairāwhiti Māori landowners. Unpublished PhD thesis, Victoria University of Wellington.
	Erosion	Lambie S, Awatere S, Daigneault A, et al. 2021. Trade-offs between environmental and economic factors in conversion from exotic pine production to natural regeneration on erosion prone land. New Zealand Journal of Forestry Science 51: 14.
	Native afforestation	Pedley D, McWilliam W, Doscher C 2023. Forests from the grass: natural regeneration of woody vegetation in temperate marginal hill farmland under minimum interference management. Restoration Ecology 31(3): e13852.
	Carbon sequestration	Single-Liertz NF 2024. Determining the social costs and benefits of carbon-removal incentivised forestry models on marginal farmland in Aotearoa, New Zealand. Masters thesis in Environmental Sciences, Wageningen University and Research.
	Climate change	Soliman T, Walsh P, Manaaki Whenua – Landcare Research 2018. Best options for land use following radiata harvest in the Gisborne District under climate change: literature review. MPI Technical Paper No: 2018/46.
Native afforestation	Forbes Ecology 2021. Transitioning exotic plantations to native forest: a report on the state of knowledge. MPI Technical Paper No: 2021/22	

Research priority (as in 2018 roadmap)	Subgroupings	Reference
Identify options for the sustainable use of marginal land (cont.)	Native afforestation	Simcock R, Fergus A, Cavanagh J 2021. Improving resilience of native New Zealand woody seedlings to drought. Manaaki Whenua – Landcare Research Contract Report LC4083, prepared for Ministry for Primary Industries.
	Marginal land	Walker S, Brownstein GE, Monks A 2019. Avoiding cross-boundary effects of agricultural land use on indigenous dryland habitats. Manaaki Whenua – Landcare Research Contract Report LC3636, prepared for Canterbury Regional Council (Environment Canterbury).
	Marginal land	Walsh P, Soliman T, Daigneault A 2019. Valuing changes in New Zealand marginal land: water quality, carbon, and afforestation.
Determine the extent to which a soil ecosystem services approach / integrated spatial modelling can inform wise use of land	Conceptual frameworks	Bartkowski B, Bartke S, Helming K, et al. 2020. Potential of the economic valuation of soil-based ecosystem services to inform sustainable soil management and policy. <i>PeerJ</i> 8: e8749.
	Conceptual frameworks	Lilburne L, Eger A, Mudge P, et al. 2020. The land resource circle: supporting land-use decision making with an ecosystem-service-based framework of soil functions. <i>Geoderma</i> 363: 114134.
	Farm systems modelling	Dominati EJ, Maseyk FJ, Mackay AD, et al. 2019. Farming in a changing environment: increasing biodiversity on farm for the supply of multiple ecosystem services. <i>Science of the Total Environment</i> 662: 703–713.
	Farm systems modelling	Vannier C, Cochrane TA, Zawar-Reza P, et al. 2022. Development of a systems model for assessing pathways to resilient, sustainable, and profitable agriculture in New Zealand. <i>Land</i> 11(12): 2334.
	Landscape structure	Brandt A, Godfrey P 2023. Spatial prioritisation to inform indigenous biodiversity management in the Otago region. Manaaki Whenua – Landcare Research Contract Report LC4387, prepared for Otago Regional Council.
	Landscape structure	Herzig A, Neverman A, Price R, et al. 2021. From mountains to the sea: values and science for an informed kaitiaki/guardian-land. Manaaki Whenua – Landcare Research Contract Report LC4436.
	Landscape structure	Lavorel S, Grigulis K, Richards DR, et al. 2022. Templates for multifunctional landscape design. <i>Landscape Ecology</i> 27: 1–22.
	Landscape structure	Matheson L, Herzig A, Muller C, et al. 2024. Steering land use change to meet water quality targets. A report prepared for the Our Land and Water National Science Challenge.
	Landscape structure	Richards D, Etherington TR, Herzig A, et al. 2024. The importance of spatial configuration when restoring intensive production landscapes for biodiversity and ecosystem service multifunctionality. <i>Land</i> 13(4): 460.
Landscape structure	Tran DX, Pearson D, Palmer A, et al. 2022. Quantifying spatial non-stationarity in the relationship between landscape structure and the provision of ecosystem services: an example in the New Zealand hill country. <i>Science of the Total Environment</i> 808: 152126.	
Enhance the coverage, quality and interoperability of resource soil information (S-map)	Climate change	Lilburne L, Ausseil AG, Sood A, et al. 2024. Modelling to identify direct risks for New Zealand agriculture due to climate change. <i>Journal of the Royal Society of New Zealand</i> 55:1–18.
	Climate change	Teixeira E, Ausseil AG, Burgueño E, et al. 2020. A spatial analysis framework to assess responses of agricultural landscapes to climates and soils at regional scale. In: Mirschel, W., Terleev, V., Wenkel, KO. (eds) <i>Landscape Modelling and Decision Support</i> . Innovations in Landscape Research. Springer, Cham. pp 495–508.
	Modelling	Taylor AI 2018. Evaluating the sensitivity of the LUCI model to GIS datasets to enable robust farm management decisions in New Zealand. Unpublished PhD thesis, Victoria University of Wellington.

Research priority (as in 2018 roadmap)	Subgroupings	Reference
Enhance the coverage, quality and interoperability of resource soil information (S-map) (cont.)	Modelling	Taylor AI, Jackson BM, Metherell AK 2018. Evaluating the uncertainties in New Zealand's GIS datasets: understanding where and when frameworks such as LUCI can enable robust decisions surrounding farm management practices. Occasional Report. Fertilizer and Lime Research Centre, Massey University, Palmerston North, NZ.
	Modelling	Vogeler I, Lilburne L, Webb T, et al. 2022. S-map parameters for APSIM. <i>MethodsX</i> 9: 101632.
	Soil hydrology	Dang N, Jackson B, Tomscha S, et al. 2022. Guidelines and a supporting toolbox for parameterising key soil hydraulic properties in hydrological studies and broader integrated modelling. <i>One Ecosystem</i> 7: e76410.
	Soil hydrology	McNeill 2024. An Improved pedotransfer function for soil hydrological properties in NZ. <i>Applied Sciences</i> 14(10): 3997.
	Soil hydrology	McNeill S, Lilburne L, Carrick S, et al. 2018. Pedotransfer functions for the soil water characteristics of New Zealand soils using S-map information. <i>Geoderma</i> 326: 96–110.
	Soil hydrology	Pollacco JAP, Fernández-Gálvez J, Webb T, et al. 2024. Derivation of physically based soil hydraulic parameters in New Zealand by combining soil physics and hydropedology. <i>European Journal of Soil Science</i> 75(3): e13502.
	Soil hydrology	Vogeler I, Carrick S, Cichota R, et al. 2019. Estimation of soil subsurface hydraulic conductivity based on inverse modelling and soil morphology. <i>Journal of Hydrology</i> 574: 373–382.
	soil information	Lilburne LR, Guo J, Barringer J, et al. 2020. Comparison of S-map soil information with the older Fundamental Soil Layers: implications for modelling. In: C.L. Christensen, D.J. Horne, R. Singh eds. <i>Nutrient management in farmed landscapes</i> . Occasional Report No. 33. Farmed Landscapes Research Centre, Massey University, Palmerston North, NZ. http://flrc.massey.ac.nz/publications.html .
	Water quality	McDowell RW, Snow VO, Tamepo R, et al. 2025. A risk index tool to minimize the risk of nitrogen loss from land to water <i>Journal of Environmental Quality</i> 54(1): 233–245.
	Water quality	Snow V, Cichota R, Lilburne L, et al. 2024. A method to derive nitrogen transport factors for New Zealand's agricultural lands. <i>MethodsX</i> 13: 102814.
Soil information	Rattenbury M, Martin A, Baisden T, et al. 2018. Geochemical baseline soil surveys for understanding element and isotope variation across New Zealand. <i>New Zealand Journal of Agricultural Research</i> 61(3): 347–357.	
Develop & test better input data on erosion and sediment generation to enhance the performance of erosion/sediment modelling	Overview	Smarter Targeting of Erosion Control (STEC) » Manaaki Whenua
	CC	Neverman 2023. Climate change impacts on erosion and suspended sediment loads in NZ. <i>Geomorphology</i> 427: 108607
	CC and land/water planning	Ausseil O, Heath M, Clapcott JE, et al. 2025. Tairāwhiti water quality and ecosystem health expert panel report. Prepared for Gisborne District Council.
	CC and land/water planning	Herzig A, Neverman A, Price R, et al. 2024. Ki uta ki tai: mātāpono me te pūtaiao, ngā korero whakamahuki ma te kaitiaki – whenua : from mountains to the sea: values and science for an informed kaitiaki/guardian-land. Manaaki Whenua – Landcare Research Contract Report LC4436, prepared for Our Land and Water National Science Challenge, AgResearch.
CC and land/water planning	Neverman A, Smith H 2023. SedNetNZ modelling to assess sediment contributions from natural land cover areas and impacts of climate change in Taranaki. Manaaki Whenua – Landcare Research Contract Report LC4258, prepared for Taranaki Regional Council.	

Research priority (as in 2018 roadmap)	Subgroupings	Reference
Develop & test better input data on erosion and sediment generation to enhance the performance of erosion/sediment modelling (cont.)	CC and land/water planning	Vale S, Smith H, Robson-Williams M, et al. 2023. Effects of climate change and erosion mitigation on suspended sediment loads and visual clarity in the Wairoa catchment, Hawke's Bay. Manaaki Whenua – Landcare Research Contract Report LC4274.
	CC and land/water planning	Vale S, Smith HG 2024. Application of SedNetNZ in the Waikato Region to support NPS-FM 2020 implementation. Manaaki Whenua – Landcare Research Contract Report LC4432, prepared for Waikato Regional Council.
	CC and land/water planning	Vale S, Smith HG, Polyakov M 2025. Catchment-scale LiDAR-based SedNetNZ modelling of erosion and suspended sediment loads in Waikato CEM catchments. Manaaki Whenua – Landcare Research Contract Report 2526-0045, prepared for Waikato Regional Council.
	CC and land/water planning	Vale S, Smith HG, Neverman AJ 2025. SedNetNZ modelling and analysis of natural cover, erosion mitigation, and post-harvest scenarios in the Horizons region. Manaaki Whenua – Landcare Research Contract Report LC4618, prepared for Horizons Regional Council.
	CC and land/water planning	Vale S, Smith HG, Neverman AJ, et al. 2022. Application of SedNetNZ with SLUI erosion mitigation and climate change scenarios in the Horizons region to support NPS-FM 2020 implementation. Manaaki Whenua – Landcare Research Contract Report LC5033, prepared for Horizons Regional Council.
	CC and land/water planning	Vale SS, Smith HG 2023. Application of SedNetNZ using updated erosion mitigations with climate change scenarios in the Horizons region to support NPS-FM 2020 implementation. Manaaki Whenua – Landcare Research Contract Report LC4295, prepared for Horizons Regional Council.
	CC and land/water planning	Vale SS, Smith HG 2023. Application of SedNetNZ using updated erosion mitigations with climate change scenarios in the Horizons region to support NPS-FM 2020 implementation. Manaaki Whenua – Landcare Research Contract Report LC4295, prepared for Horizons Regional Council.
	CC and land/water planning	Vale SS, Smith HG, Neverman AJ, et al. 2021. Application of SedNetNZ with land management and climate change scenarios and temporal disaggregation in the Bay of Plenty Region. Manaaki Whenua – Landcare Research Contract Report LC4002, prepared for Bay of Plenty Regional Council.
	Economic	Polyakov M, Walsh P, Daigneault A, et al. 2024. Cost-effectiveness of erosion mitigation to meet water clarity targets in the Manawatū-Whanganui Region of New Zealand. <i>Journal of Environmental Management</i> 359: 120991. https://doi.org/10.1016/j.jenvman.2024.120991
	Economic	Walsh PJ, Soliman T, Wiercinski B 2021. The benefits and costs of erosion control in New Zealand: estimates for policy analysis. Manaaki Whenua – Landcare Research Contract Report LC3924, prepared for MBIE.
	Economic	Walsh P, Guignet D, Booth P 2023. Eliciting policy-relevant stated preference values for water quality: an application to New Zealand. <i>Agricultural and Resource Economics Review</i> 52(2):347–378.
	Land/water planning	Lambie S, Neverman A, Kirschbaum M, et al. 2024. Examining the effect on sediment loss by differential pricing in the ETS to encourage land use change on highly erodible land. Manaaki Whenua – Landcare Research Contract Report LC4383, prepared for Our Land and Water National Science Challenge, AgResearch.
	Land/water planning	Neverman AJ, Smith HG 2022. SedNetNZ modelling for freshwater planning in Otago. Manaaki Whenua – Landcare Research Contract Report LC5016, prepared for Otago Regional Council.

Research priority (as in 2018 roadmap)	Subgroupings	Reference
Develop & test better input data on erosion and sediment generation to enhance the performance of erosion/sediment modelling (cont.)	Land/water planning	Neverman AJ, Smith HG, Herzig A 2021. Planning soil conservation for sediment load reduction in Taranaki. Manaaki Whenua – Landcare Research Contract Report LC3942, prepared for Taranaki Regional Council.
	Land/water planning	Neverman AJ, Smith HG, Herzig A, et al. 2021. Modelling baseline suspended sediment loads and load reductions required to achieve Draft Freshwater Objectives for Southland. Manaaki Whenua – Landcare Research Contract Report LC3749, prepared for Environment Southland.
	Land/water planning	Smith H, Spiekermann R, Herzig A, et al. 2020. Application of a revised bank erosion model to update SedNetNZ results for Hawke's Bay. Manaaki Whenua – Landcare Research Contract Report LC3740.
	Land/water planning	Vale S, Smith H, Polyakov M 2025. Catchment-scale LiDAR-based SedNetNZ modelling in Waikato CEM catchments. Manaaki Whenua – Landcare Research Contract Report LC4588, prepared for Waikato Regional Council.
	Land/water planning	Vale SS, Smith HG, Marden M 2021. Upper Mōtū catchment sediment sources study. Manaaki Whenua – Landcare Research Contract Report LC393, prepared for Gisborne District Council.
	Method	Tsyplenkov A, Neverman AJ 2025. Analysis of sediment yields for the Auckland region (2009–2024). Manaaki Whenua – Landcare Research Contract Report LC4605, prepared for Auckland Council.
	Method – erosion source	Neverman AJ, Smith HG 2025. Sediment load scenario modelling in Tairāwhiti Gisborne. Manaaki Whenua – Landcare Research Contract Report LC4587, prepared for Gisborne District Council.
	Method – erosion source	Vale S, Swales A, Smith HG, et al. 2022. Impacts of tracer type, tracer selection, and source dominance on source apportionment with sediment fingerprinting. <i>Science of the Total Environment</i> 831: 154832. https://doi.org/10.1016/j.scitotenv.2022.154832
	Methods	Dymond JR, Vale SS 2018. An event-based model of soil erosion and sediment transport at the catchment scale. <i>Geomorphology</i> 318: 240–249.
	Methods	Pooladsaz K, Hölbling D, Brus J 2023. Monitoring the evolution of the Kaiwhata Landslide in NZ using object based image analysis and sentinel 2 time series. <i>GI_Forum</i> 11(2): 88–101.
	Methods	Rosser BJ, Jones KE 2022. Application of LiDAR differencing to assess sediment load in upper Waipaoa river 2005 to 2019. GNS 2021/102. Prepared for Gisborne District Council.
	Methods	Rosser BJ, Ashraf S, Dellow S 2019. Assessment of the use of differencing satellite imagery as a tool for quantifying landslide impacts from significant storms – a case study in the Uawa catchment, Tolaga Bay. Consultancy Report 2019/93. Lower Hutt, NZ, GNS Science.
	Methods	Smith H, Neverman A, Betts H, et al. 2024. Improving understanding and management of erosion with LiDAR. Manaaki Whenua – Landcare Research Contract Report LC4466, prepared for Hawke's Bay Regional Council.
Methods – data acquisition	Betts H, Smith HG, Neverman AJ, et al. 2023. Wairoa shallow landslide and debris deposit mapping following storm events in March 2022. Landcare Research Contract Report LC4331, prepared for Hawke's Bay Regional Council.	
Methods – data acquisition, mitigation targeting	Smith H, Spiekermann R, Betts H et al 2021. Comparing methods of landslide data acquisition and susceptibility modelling. Examples from New Zealand. <i>Geomorphology</i> 381: 107660.	
Methods – mitigation targeting	Smith H 2020. A region-wide assessment of shallow landslide susceptibility in Hawke's Bay. Manaaki Whenua – Landcare Research Contract Report LC3720, prepared for Hawkes's Bay Regional Council.	

Research priority (as in 2018 roadmap)	Subgroupings	Reference
Develop & test better input data on erosion and sediment generation to enhance the performance of erosion/sediment modelling (cont.)	Methods – mitigation targeting	Spiekermann RI, McColl S, Fuller I, et al. 2021. Quantifying the influence of individual trees on slope stability at landscape scale. <i>Journal of Environmental Management</i> 286: 112194.
	Methods – mitigation targeting	Spiekermann RI, Smith HG, McColl S, et al. 2022. Development of a morphometric connectivity model to mitigate sediment derived from storm-driven shallow landslides. <i>Ecological Engineering</i> 180: 106676
	Methods – mitigation targeting	Spiekermann RI, Zadelhoff FJ, Schindler J, et al. 2023. Comparing physical and statistical landslide susceptibility models at the scale of individual trees. <i>Geomorphology</i> 440: 108870.
	Methods – mitigation targeting	Tsyplenkov A, Smith H 2024. Assessing the effectiveness of trees for landslide mitigation in Hawke's Bay. Manaaki Whenua – Landcare Research Contract Report LC4479, prepared for Hawke's Bay Regional Council.
	Methods – mitigation targeting	Tsyplenkov A, Smith HG, Betts H, et al. 2025. Data-driven analysis of shallow landslide-to-stream connectivity. <i>Global and Earth Surface Processes Change</i> 2: 100002.
	Methods – mitigation targeting	Vale S, Smith H, Matthews A, et al. 2020. Determining sediment source contributions to overbank deposits within stopbanks in the Oroua River, New Zealand, using sediment fingerprinting. <i>Journal of Hydrology (New Zealand)</i> 59(2): 147–172.
	Methods – mitigation targeting	van Zadelhoff FB, Albaba A, Cohen D, et al. 2021. Introducing SlideforMAP: a probabilistic finite slope approach for modelling shallow-landslide probability in forested situations, <i>Natural Hazards Earth System Science</i> 22: 2611–2635
	Methods – model development	Smith HG, Spiekermann R, Dymond J, et al. 2019. Predicting spatial patterns in riverbank erosion for catchment sediment budgets. <i>New Zealand Journal of Marine and Freshwater Research</i> 53(3): 338–362.
	Methods – model development	Donovan M 2022. Modelling soil loss from surface erosion at high-resolution to better understand sources and drivers across land uses and catchments: a national-scale assessment of Aotearoa, New Zealand. <i>Environmental Modelling & Software</i> 147: 105228.
	Model review	Robson-Williams M, Phillips C, Oliver M 2025. Guidance for councils on choice and use of erosion and sediment models in regulation. Envirolink Grant: 2445MLDC173. Bioeconomy Science Institute Contract Report registration number 2526-0030.
	Methods – sediment budget modelling	Smith HG, Herzig A, Dymond J, et al. 2019 Application of revised Sednetz model in Oreti and Aparima catchment in Southland. Manaaki Whenua – Landcare Research Contract Report LC3507.
	National	Donovan M 2022. Modelling soil loss from surface erosion at high-resolution to better understand sources and drivers across land uses and catchments: a national-scale assessment of Aotearoa, New Zealand. <i>Environmental Modelling & Software</i> 147: 105228.
	National	Dymond J, Shephard J 2023. Update to Highly Erodible Land and Estimated Long-term Soil Erosion data sets for environmental reporting. Manaaki Whenua – Landcare Research Contract Report LC4365, prepared for Ministry for the Environment.
	Process understanding	Phillips C, Betts H, Smith HG, et al. 2024. Exploring the post-harvest 'window of vulnerability' to landslides in New Zealand steepland plantation forests. <i>Ecological Engineering</i> 206: 107300.
	Process understanding	Smith HG, Neverman AJ, Betts H, et al. 2023 The influence of spatial patterns in rainfall on shallow landslides. <i>Geomorphology</i> 437: 108795
Process understanding	Vale SS, Smith HG, Davies-Colley RJ, et al. 2023. The influence of erosion sources on sediment-related water quality attributes. <i>Science of the Total Environment</i> 860: 160452.	
Process understanding	Vale SS, Dymond JR 2020. Interpreting nested storm event suspended sediment-discharge hysteresis relationships at large catchment scales. <i>Hydrological Processes</i> 34(2): 420–440.	

Research priority (as in 2018 roadmap)	Subgroupings	Reference
Develop & test better input data on erosion and sediment generation to enhance the performance of erosion/sediment modelling (cont.)	Process understanding	Williams F, McColl S, Fuller I, et al. 2021. Intersection of fluvial incision and weak geologic structures cause divergence from a universal threshold slope model of landslide occurrence. <i>Geomorphology</i> 389: 107795.
	Understanding	Drewry J, Phillips C, Graham S 2023. Sediment reduction and mitigation principles – a review of New Zealand literature. Manaaki Whenua – Landcare Research Contract Report LC4380, prepared for: Waikato Regional Council.
	Understanding	Schwarz M, Poesen J, Rey F, et al. 2020. Bio-physical performance of erosion and sediment control/mitigation techniques – an international comparison to common practices in New Zealand. Manaaki Whenua – Landcare Research Contract Report LC3891, prepared for MBIE.
	Understanding	Phillips C, Basher L, Spiekermann R 2020. Biophysical performance of erosion and sediment control techniques in New Zealand: a review. Manaaki Whenua – Landcare Research Contract Report LC3761.
	Understanding	Phillips C, Bloomberg M, Marden M, et al. 2023. Tree root research in New Zealand: a retrospective ‘review’ with emphasis on soil reinforcement for soil conservation and wind firmness. <i>New Zealand Journal of Forestry Science</i> 53:6.
	Understanding	Phillips C, Hales T, Smith H, et al. 2021. Shallow landslides and vegetation at the catchment scale: a perspective. <i>Ecological Engineering</i> 173: 106436.
Enhance the coverage, quality and interoperability of land cover and land-use data	Wetlands	Burge OR, Price R, Wilmhurst JM, et al. 2023. LiDAR reveals drains risk to wetlands have been underestimated. <i>New Zealand Journal of Ecology</i> 47(1): 3523.
	Wetlands	Dymond JR, Sabetizade M, Newsome PF, et al. 2021. Revised extent of wetlands in New Zealand. <i>New Zealand Journal of Ecology</i> 45(2): 3444
	Wetlands	Clarkson B 2018. Wetland delineation protocols. Manaaki Whenua – Landcare Research Contract Report LC3354, prepared for Tasman District Council.
	Methods	De Gouw S, Morgenroth J, Xu C 2020. An updated survey on the use of geospatial technologies in New Zealand’s plantation forestry sector. <i>New Zealand Journal of Forestry Science</i> 50.
	LiDAR	Haotian Z 2018. Monitoring land cover change with LiDAR and aerial imagery in Christchurch, New Zealand. Unpublished MSc thesis, University of Canterbury, Christchurch.
	Online resource	https://lrp.landcareresearch.co.nz/
	Online resource	https://ourenvironment.scinfo.org.nz/
	Online resource	https://smap.landcareresearch.co.nz/
	Online resource	https://soils.landcareresearch.co.nz/
	Online resource	https://soils.landcareresearch.co.nz/topics/soil-classification/nzsc/
	Online resource	https://landuseopportunities.nz/
	LiDAR	Barringer J, Lynn I, Basher L, et al. 2018. Use of modern technology including LiDAR to update the New Zealand Land Resource Inventory. MPI Technical Paper No: 2018/51..
	Land use	Law R, Whitehead B, Cavanagh J, et al. 2024. Deliverable 8: Land Use Information System – Land Use. Manaaki Whenua – Landcare Research Contract Report LC4488, prepared for Ministry for the Environment.
Land use	Cavanagh J, Whitehead B 2023. Enabling flexibility and connectivity in land-use classification for state of the environment soil quality monitoring. Manaaki Whenua – Landcare Research Contract Report LC4309, prepared for Land Monitoring Forum under Envirolink Tools Grant C09X2205	

Research priority (as in 2018 roadmap)	Subgroupings	Reference
Enhance the coverage, quality and interoperability of land cover and land-use data (cont.)	Land use	Cavanagh J, Whitehead B 2022. Land-use classification for state of the environment soil quality monitoring and reporting. Manaaki Whenua – Landcare Research Contract Report LC4146, prepared for Gisborne District Council for Envirolink Advice Grant 2222-GSDC170.
	Land use	Planzer S, Harris L, van Noppen F, et al. 2023. Protected Areas Network New Zealand methodology review and report. Manaaki Whenua – Landcare Research Contract Report LC4299.
	Land use	Harris L, Shephard J, Pairman J, et al. 2020. Establishing New Zealand's LUCAS 2023 Land Use Map. Manaaki Whenua – Landcare Research Contract Report LC4445, prepared for: Ministry for the Environment.
	Vegetation	Schindler J 2024. LiDAR-derived vegetation layers in Hawke's Bay. Manaaki Whenua – Landcare Research Contract Report LC4470, prepared for Hawke's Bay Regional Council.
Evaluate different land management practices against major land-use effects and the policy approaches used to manage them (e.g. erosion, nutrient leakage, soil contamination etc.)	Erosion mitigation	Dymond JR, Davies-Colley RJ, Hughes AO, et al. 2017. Predicting improved optical water quality in rivers resulting from soil conservation actions on land. <i>Science of the Total Environment</i> 603: 584–592.
	On-farm management	Fitzgerald M, McDowell R, Bailey S, et al. 2024 Strip-till fodder beet to improve land and water outcomes. Report for Our Land and Water National Science Challenge
	On-farm management	Gray CW, Ghimire CP, McDowell RW, et al. 2022. The impact of cattle grazing and treading on soil properties and the transport of phosphorus, sediment and <i>E. coli</i> in surface runoff from grazed pasture. <i>New Zealand Journal of Agricultural Research</i> 65(6): 445–462.
	Broadscale modelling	McDowell RW 2021. Land use and water quality. <i>New Zealand Journal of Agricultural Research</i> 64(3): 269–270. https://doi.org/10.1080/00288233.2021.1933093
	On-farm management	McDowell RW, Macintosh KA, Depree C 2023. Linking the uptake of best management practices on dairy farms to catchment water quality improvement over a 20-year period. <i>Science of the Total Environment</i> 895: 164963.
	On-farm management	O'Connell S, Lucock D, Scobie S, et al. 2022. Dispersed forage feeding to minimise negative impacts on soil and water quality. Report for Our Land and Water National Science Challenge.
	Broadscale modelling	Snelder TH, Fraser C, Larned ST, et al. 2021. Attribution of river water-quality trends to agricultural land use and climate variability in New Zealand. <i>Marine and Freshwater Research</i> 73(1): 1–19.
	Processes	Cichota R, Kelliher FM, Thomas SM, et al. 2016. Effects of irrigation intensity on preferential solute transport in a stony soil. <i>New Zealand Journal of Agricultural Research</i> 59: 141–155.
	On-farm management	Monaghan R, Manderson A, Basher L, et al. 2021 Quantifying contaminant losses to water from pastoral land uses in New Zealand II. The effects of some farm mitigation actions over the past two decade. <i>New Zealand Journal of Agricultural Research</i> 64(3): 365–389.
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	Management forestry slash	Visser R, Campbell Harvey 2020. Design of debris slash traps: considerations for NZ plantation forestry operating. School of Forestry, University of Canterbury, prepared for Gisborne District Council.
	Microbes	Humphries B, Weaver L, Devane M, et al. 2020. Quantification of source loading inputs for a microbial risk assessment tool. Prepared for Horizons Regional Council, Environment Canterbury, and Hawke's Bay Regional Council. ESR CSC20010.
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Evaluate different land management practices against major land-use effects and the policy approaches used to manage them (e.g. erosion, nutrient leakage, soil contamination etc.) (cont.)	Afforestation	Cavanagh JE, Simcock R, Smaill S, et al. 2021. Feasibility of using nutrient-rich wastes in nurseries and for managing sites with exotic and native plantings. Report prepared for One Billion Trees project 1BT-01972, Ministry for Primary Industries.
	Native	Lambie SM, Marden M 2020. Transitioning from exotic to native forest through natural regeneration: benefits and risks. Manaaki Whenua – Landcare Research Contract Report LC3676, prepared for Hawke's Bay Regional Council.
	Native	Norton D 2024. Native biodiversity and regenerative agriculture in New Zealand. Manaaki Whenua – Landcare Research Contract Report LC3954-17, prepared for Our Land and Water National Science Challenge & The NEXT Foundation.
	Erosion mitigation	Phillips CJ, Hales T, Basher L, et al. 2021. Shallow landslides and vegetation at the catchment scale: a perspective. <i>Ecological Engineering</i> 173: 106436.
	On-farm management	Beukes PC, Gregorini P, Cameron K, et al. 2020. Farm-scale carbon and nitrogen fluxes in pastoral dairy production systems using different nitrogen fertilizer regimes. <i>Nutrient Cycling in Agroecosystems</i> 117: 1–12.
	On-farm management	Bloomer D 2020. Collaborative research towards best practice nitrogen management in asparagus cropping. Report for Our Land and Water National Science Challenge.
	On-farm management	Boitt G, Black A, Wakelin S, et al. 2017. Impacts of long-term biomass management on soil phosphorus under temperate grassland. <i>Plant Soil</i> 427: 163–174
	Processes	Chapman DF, Dalley DE, Edwards GR, et al. 2021. Production, profit and nitrogen flows in irrigated dairy systems representing different industry development pathways: the Pastoral 21 experience in Canterbury. <i>New Zealand Journal of Agricultural Research</i> 64(1): 3–35
	On-farm management	Drewry JJ, Hedley CB, McNeill SJ, et al. 2024. Nitrogen and phosphorus leaching losses under cropping and zone-specific variable-rate irrigation. <i>Soil Research</i> 62. SR23136. https://doi.org/10.1071/SR23136
	Broadscale modelling	Fenemor A, Green S, Price R 2023. Modelling of nitrate losses and impacts from Waimea Plains rural land uses. Manaaki Whenua – Landcare Research Contract Report LC4215, prepared for Tasman District Council.
	On-farm management	Journeaux P, Glass C, Beatson C 2023. Optimising on-farm nitrogen management in the face of regulated fertiliser input. A report for Our Land and Water National Science Challenge.
	Wastewater application	Lizarralde CA, McDowell RW, Condrón LM, et al. 2021. Potential phosphorus losses from grassland soils irrigated with dairy factory wastewater. <i>Nutrient Cycling in Agroecosystems</i> 121: 69–84.
	Wastewater application	Lizarralde CA, McDowell R, Condrón L, et al. 2023. The potential for phosphorus loss to groundwater from soils irrigated with dairy factory wastewater. <i>New Zealand Journal of Agricultural Research</i> 66(3): 189–207.
Wastewater application	Lizarralde CA, McDowell RW, Condrón LM, et al. 2022. Amending soils of different pH to decrease phosphorus losses. <i>Soil Research</i> 60: 114–123.	
On-farm management	Macintosh KA, Mayer BK, McDowell RW, et al. 2018. Managing diffuse phosphorus at the source versus at the sink. <i>Environmental Science & Technology</i> 52(21): 11995–12009.	
Nutrient losses	McDowell RW, Monaghan RM, Dougherty W, et al. 2017. Balancing water-quality threats from nutrients and production in Australian and New Zealand dairy farms under low profit margins. <i>Animal Production Science</i> 57: 1419–1430.	

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Evaluate different land management practices against major land-use effects and the policy approaches used to manage them (e.g. erosion, nutrient leakage, soil contamination etc.) (cont.)	Management evaluation	McDowell RW 2017. Does variable rate irrigation decrease nutrient leaching losses from grazed dairy farming? <i>Soil Use and Management</i> 33(4): 530–537.
	On-farm management	McDowell RW, Smith LC 2023. The longevity of cultivation in decreasing the potential for phosphorus loss in runoff. <i>Soil and Tillage Research</i> 227: 105618.
	On-farm management	McDowell RW, Gray CW, Cameron KC, et al. 2019. The efficacy of good practice to prevent long-term leaching losses of phosphorus from an irrigated dairy farm. <i>Agriculture, Ecosystems & Environment</i> 273: 86–94.
	On-farm management	McDowell RW, Rotz CA, Oenema J, et al. 2022. Limiting grazing periods combined with proper housing can reduce nutrient losses from dairy systems. <i>Nat Food</i> 3: 1065–1074.
	On-farm management	Merfield CN 2024. Strategies to improve the efficiency and decrease the negative environmental impacts from phosphorous fertiliser use. Report for Our Land and Water National Science Challenge.
	Broadscale modelling	Monaghan R, Manderson A, Basher L, et al. 2020. Quantifying contaminant losses to water from pastoral landuses in New Zealand II. The effects of some farm mitigation actions over the past two decades. <i>New Zealand Journal of Agricultural Research</i> 64: 365–389.
	Broadscale modelling	McDowell RW, Monaghan RM, Smith C, et al. 2021. Quantifying contaminant losses to water from pastoral land uses in New Zealand III. What could be achieved by 2035? <i>New Zealand Journal of Agricultural Research</i> 64(3): 390–410.
	Broadscale modelling	Monaghan R, Manderson A, Basher L, et al. 2021. Quantifying contaminant losses to water from pastoral land uses in NZ I: Development of a spatial framework for assessing losses at a farm scale. <i>New Zealand Journal of Agricultural Research</i> 64: 344–364.
	Nutrient losses	Singh R, Horne DJ 2019. Water-quality issues facing dairy farming: potential natural and built attenuation of nitrate losses in sensitive agricultural catchments. <i>Animal Production Science</i> 60(1): 67–77.
	Broadscale modelling	Snelder TH, Larned ST, McDowell RW 2018. Anthropogenic increases of catchment nitrogen and phosphorus loads in New Zealand. <i>New Zealand Journal of Marine and Freshwater Research</i> 52(3): 336–361.
	Review	Thompson-Morrison H, Cavanagh J 2024. Mitigating the leaching of nitrate from stony soils on the Waimea Plains: literature review. Manaaki Whenua – Landcare Research Contract Report LC4557, prepared for Tasman District Council.
	Nutrient cycling	Touhami D, McDowell RW, Condron LM, et al. 2022. Nitrogen fertilization effects on soil phosphorus dynamics under a grass-pasture system. <i>Nutrient Cycling in Agroecosystems</i> 124(2): 227–246.
	On-farm management	Vogeler I, Thomas S, van der Weerden T 2019. Effect of irrigation management on pasture yield and nitrogen losses. <i>Agricultural Water Management</i> 216: 60–69.
	Broadscale modelling	Donovan M 2022. National contaminant mapping of soil losses from surficial erosion: an analysis of livestock grazing pressures on soil losses across Aotearoa, New Zealand. Report prepared for Our Land and Water National Science Challenge.
	Erosion	Drewry J, Phillips C, Graham S 2024 Sediment reduction and mitigation principles – a review of New Zealand literature. Manaaki Whenua – Landcare Research Contract Report LC4380, prepared for Waikato Regional Council. TR 2023/28.
Soil	Drewry JJ, Carrick S, Penny V, et al. 2021. Effects of irrigation on soil physical properties in predominantly pastoral farming systems: a review. <i>New Zealand Journal of Agricultural Research</i> 64: 483–507. https://doi.org/10.1080/00288233.2020.1742745	

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Evaluate different land management practices against major land-use effects and the policy approaches used to manage them (e.g. erosion, nutrient leakage, soil contamination etc.) (cont.)	Soil	Drewry JJ, McNeill SJ, Carrick S, et al. 2019. Temporal trends in soil physical properties under cropping with intensive tillage and no-till management. <i>New Zealand Journal of Agricultural Research</i> . https://doi.org/10.1080/00288233.2019.1684323
	Soil	Drewry JJ, Thompson-Morrison H, Cavanagh J 2024. Impact of primary sector activities on soil resources. Manaaki Whenua – Landcare Research Contract Report LC4484, prepared for Parliamentary Commissioner for the Environment.
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	Erosion control	Phillips C, Basher L, Spiekerman R 2020. Biophysical performance of erosion and sediment control techniques in New Zealand – a review. Manaaki Whenua – Landcare Research Contract Report LC3761.
	Erosion control	Smith LC, Muirhead R 2024. A review of the effectiveness of sediment traps for New Zealand agriculture. <i>New Zealand Journal of Agricultural Research</i> 67(5): 547–564
	Soil compaction	Wallace D, Almond P, Carrick S, et al. 2020. Targeting changes in soil porosity through modification of compost size and application rate. <i>Soil Research</i> (Published online early: 18 December 2019). https://doi.org/10.1071/SR19170
	Forestry impacts	Bright CE 2021. Impacts on marine and freshwater environments from plantation forestry. Landpro, prepared for Marlborough District Council and Tasman District Council.
	Trees	Fellowes C 2022. The impact of exotic carbon forestry on rural Aotearoa New Zealand. Kellogg Rural Leadership Programme Report.
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	Erosion	Phillips C, Bloomberg M, Marden M, et al. 2023. Tree root research in New Zealand: a retrospective ‘review’ with emphasis on soil reinforcement for soil conservation and wind firmness. <i>New Zealand Journal of Forestry Science</i> 53:6.
	Erosion process	Phillips C, Betts H, Smith HG, et al. 2024 Exploring the post-harvest ‘window of vulnerability’ to landslides in New Zealand steepland plantation forests. <i>Ecological Engineering</i> 206: 107300.
	Erosion mitigation	Spiekermann R, Smith H, McColl S et al. 2022 Quantifying effectiveness of trees for landslide erosion control. <i>Geomorphology</i> 396: 107993.
	Silvo pasture	Velarde-Pajares S, Wills K, Hajdu I, et al. 2024. Silvopastoral agroforestry systems for dryland corners in Canterbury farms. <i>Journal of New Zealand Grasslands</i> 86: 223–235.
	Irrigation management	https://www.landcareresearch.co.nz/news/maximising-value-from-irrigation/
	Water quantity	Srinivasan MS, Measures R, Muller C, et al. 2021. Comparing the water use metrics of just-in-case, just-in-time and justified irrigation strategies using a scenario-based tool. <i>Agricultural Water Management</i> 258: 107221
Water quantity	The future of irrigation is here Connolly JD, Robson-Williams M, Kirk N 2024. Wider than freshwater: how non-freshwater-related activity can indirectly influence and have an impact on freshwater outcomes. Manaaki Whenua – Landcare Research Contract Report LC4413	

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Evaluate different land management practices against major land-use effects and the policy approaches used to manage them (e.g. erosion, nutrient leakage, soil contamination etc.) (cont.)	Review	Whitehead D, Schipper LA, Pronger J, et al. 2018. Management practices to reduce losses or increase soil carbon stocks in temperate grazed grasslands: New Zealand as a case study. <i>Agriculture, Ecosystems & Environment</i> 265: 432–443.
	Policy approaches	Dorner Z 2024. How behavioural and experimental economics can contribute to agricultural policy with an application to agri-emissions pricing. <i>New Zealand Economic Papers</i> 57(2): 191–197.
	Policy approaches	Drewry JJ, Stahlmann-Brown P 2024. Influences affecting adoption of management to mitigate impacts of intensive winter grazing of forage crops. <i>New Zealand Journal of Agricultural Research</i> 68(7): 1683-1695.
	Policy approaches	Kirk N, Robson-Williams M, Fenemor A, et al. 2020. Exploring the barriers to freshwater policy implementation in New Zealand. <i>Australasian Journal of Water Resources</i> 24(2): 91–104.
	Policy approaches	Leining C, Kerr S, Bruce-Brand B 2020. The New Zealand Emissions Trading Scheme: critical review and future outlook for three design innovations. <i>Climate Policy</i> 20(2): 246–264.
	Policy approaches	Macintosh KA, McDowell RW, Thiange CX 2025. A 10-year evaluation of management practices and nutrient losses from dairy farms in New Zealand: trends and drivers. <i>Agriculture, Ecosystems & Environment</i> 377: 109261.
	Policy approaches	McDowell RW, Pletnyakov P, Lim A, et al. 2021. Implications of water quality policy on land use: a case study of the approach in New Zealand. <i>Marine and Freshwater Research</i> 72: 451–455.
	Policy approaches	Meyer V 2022. Soil conservation legislation development in New Zealand: implications for environmental policy and planning. <i>New Zealand Journal of Environmental Law</i> 26: 245–254.
	Policy approaches	Pannell D, Rogers A 2022. Agriculture and the environment: policy approaches in Australia and New Zealand. <i>Review of Environmental Economics and Policy</i> 16(1): 126–145.
	Policy approaches	Percy E, Bailey A, Wreford A, et al. 2025. The effect of freshwater regulation on farmland values in New Zealand—'Dairy farming in Selwyn Waihora, Canterbury'. <i>Land Use Policy</i> 153: 107516.
	Policy approaches	Polyakov M, Walsh P, Daigneault A, et al. 2024. Cost-effectiveness of erosion mitigation to meet water clarity targets in the Manawatū-Whanganui Region of New Zealand. <i>Journal of Environmental Management</i> 359: 120991
	Policy approaches	Polyakov M, Edwards P, Kaine G, et al. 2024. Evaluating incentives to encourage native afforestation on private lands in Aotearoa–New Zealand. <i>Landscape and Urban Planning</i> 244: 104979.
	Policy approaches	Stevens D, Canton M, Harpham S 2021. Farming with reduced winter cropping in southern New Zealand: the risks and practicalities. <i>Journal of New Zealand Grasslands</i> 83: 123–134.
Policy approaches	Stokes S, Macintosh KA, McDowell RW 2021. Reflecting on the journey of environmental farm planning in New Zealand. <i>New Zealand Journal of Agricultural Research</i> 64(3): 463–470.	
Understand and incorporate Māori values (e.g. mahinga kai, kaitiaki) within decision-making	Te Mana o te Wai, Takiwa, Wai	Ataria J, Mark-Shadbolt M, Te Pareake-Mead A, et al. 2018. Whakamanahia te mātauranga o te Māori: empowering Māori knowledge to support Aotearoa's aquatic biological heritage. <i>New Zealand Journal of Marine and Freshwater Research</i> 52(4): 467–486.
		Awatere S, Harmsworth G, Harcourt N, et al. 2023. Whakamana te tangata – ka whai oranga te taiao: indigenous led approaches for catchment health in Aotearoa-New Zealand. <i>PLOS Water</i> 2(12): e0000170. https://journals.plos.org/water/article?id=10.1371/journal.pwat.0000170

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Understand and incorporate Māori values (e.g. mahinga kai, kaitiaki) within decision-making (cont.)		Bishop C 2018. A review of indicators used for 'Cultural-health' monitoring of freshwater and wetland ecosystems in New Zealand. PRP2018/27. Discussion Paper. Research and Evaluation Unit. Auckland Council Report.
		Callaghan P, Paraone R, Murray M, et al. 2018. Tuākana/Teina Water Warriors Project: a collaborative learning model integrating mātauranga Māori and science. <i>New Zealand Journal of Marine and Freshwater Research</i> 52(4): 667–674.
		Clapcott J, Hoani-Waaka A, Kitson J, et al. 2025. Out of sync: transforming environmental monitoring through indigenous perspectives of time. <i>Earth Stewardship</i> . https://doi.org/10.1002/eas2.70021 .
		Clapcott J, Williams E, Jackson A-M, et al. eds 2018. Mātauranga Māori shaping marine and freshwater futures. Special Issue: <i>New Zealand Journal of Marine and Freshwater Research</i> 52(4): 457–466.
		Cribb M, MacPherson E, Borchgrevink A 2024. Beyond legal personhood for the Whanganui River: collaboration and pluralism in implementing the Te Awa Tupua Act. <i>The International Journal of Human Rights</i> . https://doi.org/10.1080/13642987.2024.2314532
		Crow SK, Tipa GT, Booker DJ, et al. 2018. Relationships between Māori values and streamflow: tools for incorporating cultural values into freshwater management decisions. <i>New Zealand Journal of Marine and Freshwater Research</i> 52(4): 626–642.
		Harmsworth G, Taura Y 2022. Mātauranga Māori o ngā repo – Māori knowledge of wetlands. In: Denyer K, Peters M eds. <i>Life in the shallows: the wetlands of Aotearoa New Zealand</i> . Auckland, NZ, Massey University Press. Pp. 26–53.
		Henwood W, Brockbank T, Moewaka-Barnes H, et al. 2019. Enhancing drinking water quality in remote Māori communities: climate change, microbes and mātauranga Māori. <i>MAI Journal</i> 8(2): 97–109.
		Hikuroa D, Salmond A, Brierley G, et al. 2025. Listening to rivers: sharing river stories from Aotearoa New Zealand in a European context. <i>Shima</i> 19(1): 170–193. https://doi.org/10.21463/shima.251
		Hikuroa D, Nikitine J, Burkhardt H, et al. 2025. Aotearoa New Zealand: a laboratory for future marine conservation. <i>Marine Policy</i> 178: 106711.
		Kitson JC, Cain AM, Johnstone MNTH, et al. 2018. Murihiku cultural water classification system: enduring partnerships between people, disciplines and knowledge systems. <i>New Zealand Journal of Marine and Freshwater Research</i> 52(4): 511–525.
		Kusabs IA, Hicks BJ, Quinn JM, et al. 2018. Evaluation of a traditional Māori harvesting method for sampling kōura (freshwater crayfish, <i>Paranephrops planifrons</i>) and toi toi (bully, <i>Gobiomorphus</i> spp.) populations in two New Zealand streams. <i>New Zealand Journal of Marine and Freshwater Research</i> 52(4): 603–625.
		Hopkins A 2018. Classifying the mauri of wai in the Matahuru Awa in North Waikato. <i>New Zealand Journal of Marine and Freshwater Research</i> 52(4): 657–666.
		Rainforth H, Harmsworth G 2019. Kaupapa Māori freshwater assessments: a summary of iwi and hapū-based tools, frameworks, and methods for assessing freshwater environments. Perception Planning. https://www.trc.govt.nz/assets/Documents/Research-reviews/Freshwater/KaupapaMaoriFreshwaterAssessments-web.pdf
		Rayne A, Beaven K, Clapcott JE, et al. 2025. Rethinking freshwater translocation policy and practice in Aotearoa New Zealand. <i>New Zealand Journal of Ecology</i> 49(1): 3602.
	Reihana K 2024, March. Cultural monitoring tools: a mana whenua narrative. Taiao Ora Consultants.	

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Understand and incorporate Māori values (e.g. mahinga kai, kaitiaki) within decision-making (cont.)		Ruru J 2018. Listening to Papatūānuku: a call to reform water law. <i>Journal of the Royal Society of New Zealand</i> 48: 2–3, 215–224.
		SWIM SIG strategy. Beyond 2020, Surface water integrated management – Te Rōpū Tiaki I Te Kahu o Te Wai.
		Tadaki M, Astwood J-R, Ataria J, et al. 2022. Decolonising cultural environmental monitoring in Aotearoa New Zealand: emerging risks with institutionalisation and how to navigate them. <i>New Zealand Geographer</i> 78(1): 37–50.
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	Land and soils (whenua, oneone, whenua haumanu)	Ataria J, Baker V, Goven J, et al. 2019. From tapu to noa: Māori cultural views on biowastes management: a focus on biosolids. Institute of Environmental Science and Research. https://auckland.figshare.com/articles/book/From_Tapu_to_Noa_-_Māori_cultural_views_on_biowastes_management_a_focus_on_biosolids/9037676
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		Harcourt N, Awatere S, Hyslop J, et al. 2022. Kia manawaroa kia puawai: enduring Māori livelihoods. <i>Sustainability Science</i> 17(2): 391–402.
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Understand and incorporate Māori values (e.g. mahinga kai, kaitiaki) within decision-making (cont.)		<p>Harmsworth G 2022. Exploring indigenous Māori soil health concepts in Aotearoa-New Zealand. Discussion paper. MBIE project 'Soil health and resilience: oneone ora, tangata ora' (C09X1613). https://www.researchgate.net/publication/367380710_Exploring_indigenous_Maori_soil_health_concepts_in_Aotearoa-New_Zealand (accessed 2025).</p>
		<p>Harmsworth G 2022. Soil security: an indigenous Māori perspective from Aotearoa-New Zealand. Discussion paper. MBIE project 'Soil health and resilience: oneone ora, tangata ora' (C09X1613). https://www.researchgate.net/publication/367381014_Soil_security_An_indigenous_Maori_perspective_from_Aotearoa-New_Zealand (accessed 2025).</p>
		<p>Hutchings J, Smith J 2020. Te mahi oneone hua parakore: a Māori soil sovereignty and wellbeing handbook. Christchurch, NZ, Free Range Press. https://shop.projectfreerange.com/item/pre-order-te-mahi-oneone-hua-parakore-a-mori-soil-sovereignty-and-wellbeing-handbook</p>
		<p>Hutchings J 2020. Chapter 3. Māori soil sovereignty: advocating for the rights of our ancestral soils. In: Hutchings J, Smith J eds. Te mahi oneone hua parakore: a Māori soil sovereignty and wellbeing handbook. Christchurch, NZ, Free Range Press. Pp. 45–59.</p>
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		<p>Hutchings J, Smith J, Harmsworth G 2018. Elevating the mana of soil through the hua parakore framework. MAI Journal 7(1): 92–102. doi: 10.20507 / MAIJournal. www.journal.mai.ac.nz/content/elevating-mana-soil-through-hua-parakore-framework</p>
		<p>Hutchings J, Smith J, Roskrige N, et al. 2017. Enhancing Māori agribusiness through kaitiakitanga tools: a report for the Our Land and Water National Science Challenge. Wellington, NZ, Landcare Research NZ Ltd. https://www.researchgate.net/publication/323227912_Enhancing_Maori_agribusiness_through_kaitiakitanga_tools</p>
		<p>Kohuratia: Kohuratia. An on-line decision support tool to enable best practice farm sustainability assessment for Māori trusts, rūnanga and incorporations. Developed by Ngāi Tahu in partnership with the NZ Sustainability Dashboard Programme, Ngāi Tahu farms, and the University of Canterbury. Lincoln, NZ.</p>
		<p>Lucock XKS, Moir JL, Ruwhiu D 2023. Māori cultural values and soil fertility management: an exploratory study. Journal of New Zealand Grasslands 85: 135–141. https://doi.org/10.33584/jnzg.2023.85.3640</p>
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	<p>Percy H, Kingi T, Allen W, et al. 2024. Pohewa pae tawhiti (visualising horizons): a Māori holistic approach to the co-design of land-use systems. Journal of the Royal Society of New Zealand. https://doi.org/10.1080/03036758.2024.2427824</p>	
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Research priority (as in 2018 roadmap)	Subgroupings	Reference
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	Contaminants (paihana, takakino, tukinotanga)	

Research priority (as in 2018 roadmap)	Subgroupings	Reference
Understand and incorporate Māori values (e.g. mahinga kai, kaitiaki) within decision-making (cont.)	Biodiversity, biosecurity, forest health, wetlands (rerenga rauropi, pūnaha hauropi, ngahere ora, repo)	Ataria J, Baker V, Goven J, et al. 2016. From tapu to noa – Māori cultural views on human biowastes management: a focus on biosolids. Centre for Integrated Biowaste Research, Scion, Christchurch, NZ. https://doi.org/10.26091/ESRNZ.9037676.v1
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Research priority (as in 2018 roadmap)	Subgroupings	Reference
Understand and incorporate Māori values (e.g. mahinga kai, kaitiaki) within decision-making (cont.)		Lyver PO'B, Ruru J, Scott N, et al. 2018. Building biocultural approaches into Aotearoa – New Zealand's conservation future. <i>Journal of the Royal Society of New Zealand</i> 49(3): 394–411.
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Research priority (as in 2018 roadmap)	Subgroupings	Reference
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Research priority (as in 2018 roadmap)	Subgroupings	Reference
Understand and incorporate Māori values (e.g. mahinga kai, kaitiaki) within decision-making (cont.)	Indigenous knowledge/ mātauranga Māori and science	Reid J, Challies E, Tau T, et al. 2024. Adapting to climate change through nature-based solutions and indigenous knowledge: the case for landscape-scale ecosystem regeneration in the Rokohouia Delta. Kotuitui. https://doi.org/10.1080/1177083X.2023.2299364
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Research priority (as in 2018 roadmap)	Subgroupings	Reference
Understand and incorporate Māori values (e.g. mahinga kai, kaitiaki) within decision-making (cont.)		Parsons M 2025. Indigenous knowledge and politics of recognition in the Colonialcene. In: Machin A, Wissenburg M eds. Handbook of environmental political theory in the Anthropocene. Pp. 330–339.
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Research priority (as in 2018 roadmap)	Subgroupings	Reference
Understand and incorporate Māori values (e.g. mahinga kai, kaitiaki) within decision-making (cont.)		Jones J, Hikuroa D, Gregory E, et al. 2020. Weaving mātauranga into environmental decision-making. <i>New Zealand Science Review</i> 76(1–2). Special Issue – Mātauranga Māori and Science – Part 2: 49–53.
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Research priority (as in 2018 roadmap)	Subgroupings	Reference
Understand and incorporate Māori values (e.g. mahinga kai, kaitiaki) within decision-making (cont.)		Taute N, Morgan TKB, Ingram J, et al. 2023. Cultural sustainability thresholds to measure the mauri of indigenous Māori values impacted by geothermal engineering projects. <i>Environmental and Sustainability Indicators</i> 20. https://doi.org/10.1016/j.indic.2023.100303
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Determine the factors (behaviours, values, motivations) affecting decisions over land use and land management	Across	Brown P, Daigneault A, Dawson J 2019. Age, values, farming objectives, past management decisions, and future intentions in New Zealand agriculture. <i>Journal of Environmental Management</i> 231: 110–120.
	Across	Gray D, Butler C, Majala T, et al. 2023. Understanding signals influencing on-farm change. <i>Rural Extension and Innovation Systems Journal</i> 19(2): 35–46.
	Across	Kirk N, van Noppen F, Robson-Williams M 2022. Understanding drivers of on-farm change: a literature summary. Christchurch, NZ, Environment Canterbury.
	Across	Kirk N, van Noppen F, Robson-Williams M 2023. Drivers of on-farm decision-making and change in Canterbury. Christchurch, NZ, Environment Canterbury.
	Specific	Alföldi T, Guichaoua A, Marchand F, et al. 2020. Action groups to foster peer to peer learning – example of Red Meat Profit Partnership, New Zealand. Research Institute of Organic Agriculture FiBL.
	Specific	Doehring K, Longnecker N, Cole C, et al. 2022. A missing piece of the puzzle of on-farm freshwater restoration: what motivates land managers to record and report land management actions?. <i>Ecology and Society</i> 27(4).
	Specific	Guthrie G 2024. Farm debt and the over-exploitation of natural capital. <i>Resource and Energy Economics</i> 77: 101439.
	Specific	Kaine G, Wright V 2024. Determinants of the management of native vegetation on farms. <i>Conservation</i> 4: 163–175.
	Specific	Kaine G, Wright V 2024. Social desirability bias and the prevalence of self-reported conservation behaviour among farmers. <i>Sustainability</i> 16(22): 9658.
	Specific	Kirk N, Robson-Williams M, van Noppen F, et al. 2022. Freshwater regulations and their impacts on on-farm innovation and investment. Christchurch, NZ, Environment Canterbury.
Specific	Pinxterhuis I, Dirks S, Bewsell D, et al. 2019. Co-innovation to improve profit and environmental performance of dairy farm systems in New Zealand. <i>Rural Extension and Innovation Systems Journal</i> 14(2): 23–33.	

Research priority (as in 2018 roadmap)	Subgroupings	Reference
Develop necessary tools and enable relevant research that supports community decision-making		<p>Boone S, Fragaszy S 2018. Emerging scarcity and emerging commons: water management groups and groundwater governance in Aotearoa New Zealand. <i>Water Alternatives</i> 11(3): 795.</p> <p>Challies E, Tadaki M, Sinner J, et al. 2025. In pursuit of water policy nirvana: examining the role of catchment groups in Aotearoa New Zealand. <i>Water Alternatives</i> 18(2): 440–461.</p> <p>Duncan R, Diprose G 2020. Collaboration and practice change in resource management: collective action case studies from Central Otago. Prepared for Manaaki Whenua – Landcare Research.</p> <p>Fenemor A, Deans N, Davie T, et al. 2008. Collaboration and modelling: tools for integration in the Motueka catchment, New Zealand. <i>Water SA</i> 34(4): 448–445.</p> <p>Hepburn CD, Jackson AM, Pritchard DW, et al. 2019. Challenges to traditional management of connected ecosystems within a fractured regulatory landscape: a case study from southern New Zealand. <i>Aquatic Conservation: Marine and Freshwater Ecosystems</i> 29(9): 1535–1546.</p> <p>Hoani-Waaka A, Vaka P 2024. Enabling Te Mana o Te Wai with cultural health assessment tools. Report for Our Land and Water National Science Challenge.</p> <p>https://ourlandandwater.nz/outputs/the-catchment-group-toolkit/</p> <p>https://www.catchmenttoolkit.co.nz/</p> <p>Wai Connection: Tataki ki te wai project. https://www.waiconnection.nz/pages/about</p> <p>McMurtie S, Dewson Z, Gay B, et al. 2023. Transforming lowland waterway networks: summary of the catchment management plan & implementation guide for reimagining the Ararira/LII. EOS Ecology Report no. AQU02-21015-02 and website https://www.livingwater.net.nz/im:62bbfee5-df04-4c39-a9bf-f679925bbe9d/</p> <p>Kirk N, Robson-Williams M, Fenemor A, et al. 2022. Employing intermediaries to achieve freshwater quality improvements: lessons from catchment groups in Aotearoa New Zealand. <i>Australasian Journal of Water Resources</i> 26(1): 104–115.</p> <p>Kirk N, Edwards S, Booth P 2025. Catchment groups in Aotearoa New Zealand: understanding why farmers participate and how it influences their farming practices. Policy Brief No.33.</p> <p>Landcare Trust 2025. Catchment groups: an essential guide. <i>Catchment-Groups-An-essential-guide.pdf</i></p> <p>Lyver POB, Ruru J, Scott N, et al. 2019. Building biocultural approaches into Aotearoa – New Zealand’s conservation future. <i>Journal of the Royal Society of New Zealand</i> 49(3): 394–411.</p> <p>McIntyre J, Mager S, Connelly S 2022. Can catchment groups fill the democratic deficit? Catchment groups as a hydrosocial phenomenon in Waikaka, Southland. <i>New Zealand Geographer</i> 78: 76–86.</p> <p>Our Land and Water National Science Challenge 2023. New models of collective responsibility. <i>Our Land & Water – Toitū te Whenua, Toiora te Wai</i></p> <p>McFarlane K, Wallace K, Shanahan D 2021. Collective approaches to ecosystem regeneration in Aotearoa New Zealand. Report prepared for New Zealand’s Biological Heritage National Science Challenge.</p> <p>Robson-Williams M, Painter D, Kirk N 2022. From pride and prejudice towards sense and sensibility in Canterbury water management. <i>Australasian Journal of Water Resources</i> 26(1): 84–103.</p>

Research priority (as in 2018 roadmap)	Subgroupings	Reference
Develop necessary tools and enable relevant research that supports community decision-making (cont.)		Sinner J, Tadaki M, Mccarthy A, et al. 2018. Catchment and community environment groups in Aotearoa New Zealand: goals, activities and needs. Cawthron Institute Report no. 3733, prepared for the Ministry for the Environment.
		Srinivasan MS, Measures R, Fear A, et al. 2022. Making the invisible visible: co-learning guided development of an operational tool for irrigation management Agricultural Water Management 264C.
Understanding how many people are adopting good management practice and the real drivers behind implementation	Both	https://www.landcareresearch.co.nz/discover-our-research/environment/sustainable-society-and-policy/survey-of-rural-decision-makers/
	Drivers	Dorner Z, Knook J, Yang W, et al. 2022. Busy road frontage influences on-farm adoption of visible good management practices. Journal of Rural Studies 99: 45–52.
	Drivers	Drewry JJ, Stahlmann Brown P 2024. Influences affecting adoption of management to mitigate impacts of intensive winter grazing of forage crops. New Zealand Journal of Agricultural Research 68(7): 1683-1695.
	Drivers	Kaine G, Edwards P, Polyakov M, et al. 2023. Who knew afforestation was such a challenge? Motivations and impediments to afforestation policy in New Zealand. Forest Policy and Economics 154: 103031.
	Drivers	Montes de Oca Munguia O, Pannell DJ, Llewellyn R, et al. 2021. Adoption pathway analysis: representing the dynamics and diversity of adoption for agricultural practices. Agricultural Systems 191: 103173.
	Drivers	Moving the Middle » Manaaki Whenua
	Drivers	Villamor GB, Dunningham A, Stahlmann-Brown P, et al. 2022. Improving the representation of climate change adaptation behaviour in New Zealand's forest growing sector. Land 11(3): 364.
	Drivers	Yletyinen J, Perry GLW, Stahlmann-Brown P, et al. 2021. Multiple social network influences can generate unexpected environmental outcomes. Scientific Reports 11: 9768.
	Drivers	Yletyinen J, Perry GLW, Burge OR, et al. 2021. Invasion landscapes as social-ecological systems: role of social factors in invasive plant species control. People and Nature 3: 795–810.
	Rates	Doehring K, Young RG, Robb C 2020. Demonstrating efficacy of rural land management actions to improve water quality: how can we quantify what actions have been done?. Journal of Environmental Management 270: 110475.
	Rates	Kaine G, Wright V 2022. Relative advantage and complexity: predicting the rate of adoption of agricultural innovations. Frontiers in Agronomy 4: 967605. https://doi.org/10.3389/fagro.2022.967605
Supporting development of certification and training for land management		https://www.mpi.govt.nz/agriculture/farm-management-the-environment-and-land-use/on-farm-support/about-on-farm-support-a-service-for-farmers-and-growers/
Investigate and develop ways to build capability in land management tools		https://nzarm.org.nz/capability-building/upcoming-events https://nzarm.org.nz/capability-building/capability-assessment-tool
Develop methods to effectively characterise soil health	Biological indicators	Burge OR, Clarkson BR, Eger A, et al. 2021. Wetland plant foliage nutrients as indicators of soil nutrients. Manaaki Whenua – Landcare Research Contract Report LC3955, prepared for Hawke's Bay Regional Council.
	Biological indicators	Hsu PC, Schon N, Hill R 2023. Biological test of soil health using molecular techniques. Report for Our Land and Water National Science Challenge.

Research priority (as in 2018 roadmap)	Subgroupings	Reference
Develop methods to effectively characterise soil health (cont.)	Biological indicators	Thompson-Morrison H, Cavanagh J 2023. Assessing biological indicator options for soil quality monitoring. Manaaki Whenua – Landcare Research Contract Report LC4382, prepared for Environment Canterbury.
	Biological indicators	Schon NL, Fraser PM, Mackay AD 2022. Earthworms for inclusion as an indicator of soil biological health in New Zealand pastures. <i>New Zealand Journal of Agricultural Research</i> . doi: 10.1080/00288233.2022.2041676.
	Biological indicators	Louisson Z, Hermans SM, Buckley HL, et al. 2023. Land use modification causes slow, but predictable, change in soil microbial community composition and functional potential. <i>Environmental Microbiome</i> 18: 30.
	Biological indicators	Hermans SM, Buckley HL, Case BS, et al. 2017. Bacteria as emerging indicators of soil condition. <i>Applied and Environmental Microbiology</i> 83. doi: 10.1128/aem.02826-02816.
	Biological indicators	Hermans SM, Buckley HL, Case BS, et al. 2020. Using soil bacterial communities to predict physico-chemical variables and soil quality. <i>Microbiome</i> 8: 79.
	Biological indicators	Hermans SM, Buckley HL, Curran-Cournane F, et al. 2020. Temporal variation in soil bacterial communities can be confounded with spatial variation. <i>FEMS Microbiology Ecology</i> 96(12): fiae192.
	Biological indicators	Hermans SM, Lear G, Buckley T, et al. 2022. Environmental DNA sampling detects between-habitat variation in soil arthropod communities, but is a poor indicator of fine-scale spatial and seasonal variation. <i>Ecological Indicators</i> 140: 109040.
	Biological indicators	Hermans S, Lear G, Case B, et al. 2023. The soil microbiome: an essential, but neglected, component of regenerative agroecosystems. <i>iScience</i> 26(2): 106028.
	Biological indicators	Hermans S, Gautam A, Lewis GD, et al. 2024. Exploring freshwater stream bacterial communities as indicators of land use intensity. <i>Environmental Microbiome</i> 19: 45.
	Biological indicators	Louisson Z, Gutiérrez-Ginés M, Taylor M, et al. 2024. Soil conditions are a more important determinant of microbial community composition and functional potential than neighboring plant diversity. <i>iScience</i> 27.
	Biological indicators	Dopheide A, Tooman LK, Grosser S, et al. 2019. Estimating the biodiversity of terrestrial invertebrates on a forested island using DNA barcodes and metabarcoding data. <i>Ecological Applications</i> 29(4). WOS:000474122100010
	Biological indicators	Watts C, Dopheide A, Holdaway R, et al. 2019. DNA metabarcoding as a tool for invertebrate community monitoring: a case study comparison with conventional techniques. <i>Austral Entomology</i> 58(3): 675–686.
	Biological indicators	Dopheide A, Xie D, Buckley TR, et al. 2019. Impacts of DNA extraction and PCR on DNA metabarcoding estimates of soil biodiversity. <i>Methods in Ecology and Evolution</i> 10(1): 120–133.
	Biological indicators	Lear G, Dickie I, Banks J, et al. 2018. Methods for the extraction, storage, amplification and sequencing of DNA from environmental samples. <i>New Zealand Journal of Ecology</i> 42(1): 10.
	Biological indicators	Holdaway RJ, Wood JR, Dickie IA, et al. 2017. Using DNA metabarcoding to assess New Zealand’s terrestrial biodiversity. <i>New Zealand Journal of Ecology</i> 41(2): 251–262.
Biological indicators	Hermans SM, Buckley HL, Lear G 2019. Perspectives on the impact of sampling design and intensity on soil microbial diversity estimates. <i>Frontiers in Microbiology</i> 10: 1820.	
Biological indicators	Dickie IA, Boyer S, Buckley HL, et al. 2018. Towards robust and repeatable sampling methods in eDNA-based studies. <i>Molecular Ecology Resources</i> 18: 940–952.	

Research priority (as in 2018 roadmap)	Subgroupings	Reference
Develop methods to effectively characterise soil health (cont.)	Biological indicators	Astudillo-García C, Hermans SM, Stevenson B, et al. 2019. Microbial assemblages and bioindicators as proxies for ecosystem health status: potential and limitations. <i>Applied Microbiology and Biotechnology</i> 103: 6407–6421.
	Biological indicators	Wu J, Buckley HL, Curry L, et al. 2021. Livestock exclusion reduces the spillover effects of pastoral agriculture on soil bacterial communities in adjacent forest fragments. <i>Environmental Microbiology</i> 23: 2919–2936.
	Biological indicators	Mathieu C, Hermans SM, Lear G, et al. 2020. A systematic review of sources of variability and uncertainty in eDNA data for environmental monitoring. <i>Frontiers in Ecology and Evolution</i> 8: 135.
	Indicators	Lohrer D, Alder A, Bellingham Pet al. 2024. Information stocktakes of fifty-five environmental attributes across air, soil, terrestrial, freshwater, estuaries and coastal waters domains. Prepared by NIWA, Manaaki Whenua – Landcare Research, Cawthron Institute, and Environet Limited for the Ministry for the Environment. NIWA report no. 2024216HN (project MFE24203).
	Indicators	Berthelsen A, Cavanagh J, Campos C, et al. 2022. Review of priority attributes for ecological integrity. Cawthron Institute Report No. 3860, prepared for Ministry for the Environment.
	Indicators	Berthelsen A, Cavanagh J, Clapcott J, et al. 2023. Developing a national framework for attributes of ecological integrity. Cawthron Report No. 3909, prepared for Ministry for the Environment.
	Soil contamination – env	Cavanagh JE 2019. [Updated.] User guide background soil concentrations and soil guideline values for the protection of ecological receptors (Eco-SGVs) – consultation draft. Manaaki Whenua – Landcare Research Contract Report LC2595, prepared for Envirolink Tools Grant C09X1402.
	Soil contamination – env	Cavanagh JE 2019. Updating the ecological soil guideline values (Eco-SGVs). Envirolink Grant: 1935-GSDC156.
	Soil contamination – env	Cavanagh JE, Harmsworth G 2023. An implementation framework for ecological soil guideline values. Manaaki Whenua – Landcare Research Contract Report LC4311, prepared for Envirolink Tools Grant: C09X2206.
	Land use	Schon A, Roberts A 2020. Farm soil health: assessment across a forestry to pasture chronosequence. AgResearch and Ravensdown, prepared for Ngai Tahu.
	Review	Schon N, Fraser T, Masters N, et al. 2021. Soil health in the context of regenerative agriculture. Manaaki Whenua – Landcare Research Contract Report LC3954-13, prepared for Our Land and Water National Science Challenge & The NEXT Foundation.
	Land use	Schon NL, Roberts A, Narbey R 2023. Assessing soil health following conversion from forestry to pasture in Canterbury. <i>Journal of New Zealand Grasslands</i> 84: 123–130.
	SOE monitoring	Cavanagh J, Thompson-Morrison H, Drewry J 2023. Review of methods and data used to develop target values for soil quality indicators. Manaaki Whenua – Landcare Research Contract Report LC4305, prepared for Otago Regional Council, Envirolink Advice Grant 2333-ORC005.
	SOE monitoring	Cavanagh J, Drewry J, Thompson-Morrison H, et al. 2025. Revision of soil quality target values. Manaaki Whenua – Landcare Research Contract Report LC4614, prepared for: Ministry for the Environment.
SOE monitoring	Drewry JJ, Stevenson BA, McNeill SJ, et al. 2022. Impact of volumetric versus gravimetric assessment on Olsen P concentrations. <i>New Zealand Journal of Agricultural Research</i> 65(6): 463–483.	

Research priority (as in 2018 roadmap)	Subgroupings	Reference
Develop methods to effectively characterise soil health (cont.)	SOE monitoring	Stevenson B, Drewry J 2023. Review of approaches to setting target values for evaluating soil quality indicators for state of the environment reporting. Manaaki Whenua – Landcare Research Contract Report LC4148, prepared for Environment Southland and Horizons Regional Council.
	Methods	El-Naggar AG, Hedley CB, Roudier P, et al. 2021. Imaging the electrical conductivity of the soil profile and its relationships to soil water patterns and drainage characteristics. <i>Precision Agriculture</i> 22: 1045–1066. https://doi.org/10.1007/s11119-020-09763-x
	Methods	Smith GJ, McDowell RW, Daly K, et al. 2021. Estimating and modelling the risk of redox-sensitive phosphorus loss from saturated soils using different soil tests. <i>Geoderma</i> 398: 115094.
	Te ao Māori	Harmsworth G 2022. Exploring indigenous Māori soil health concepts in Aotearoa-New Zealand. Discussion paper. MBIE project 'Soil health and resilience: oneone ora, tangata ora' (C09X1613).
	Te ao Māori	Harmsworth G 2022. Soil security: an indigenous Māori perspective from Aotearoa-New Zealand. Discussion paper. MBIE project 'Soil health and resilience: oneone ora, tangata ora' (C09X1613).
	Te ao Māori	Hutchings J, Smith J, Harmsworth G 2018. Elevating the mana of soil through the Hua Parakore Framework. <i>MAI Journal: A New Zealand Journal of Indigenous Scholarship</i> 7(1): 92–102.
	Te ao Māori	Stronge DC, Kannemeyer RL, Harmsworth G, et al. 2023. Achieving soil health in Aotearoa New Zealand through a pluralistic values-based framework: mauri ora ki te whenua, mauri ora ki te tangata. <i>Sustainability Science</i> . https://doi.org/10.1007/s11625-022-01269-x
	te ao Māori	Bruce-Iri P, Murupaenga-Ikenn C, Kepa M, et al. 2020. Whakaora ngā whenua whāma: utilising mātauranga Māori and Western science to protect and restore the soil on rural farms in Te Tai Tokerau. Final Report to UNESCO NZ.
Well-being	Stronge D, Stevenson B, Harmsworth G, et al. 2020. Taking a wellbeing approach to soil health. <i>Sustainability</i> 12(18): 7719	
Characterise national state and trend of soil contamination	Cadmium	Gray CW, Cavanagh JE 2023. The state of knowledge of cadmium in New Zealand agricultural systems: 2021. <i>New Zealand Journal of Agricultural Research</i> 66(4): 285–335.
	Cadmium	Al Mamun S, Lehto NJ, Cavanagh J, et al. 2023. Temporal changes in Cd sorption and plant bioavailability in compost-amended soils. <i>Soil Systems</i> 7(4): 107.
	Cadmium	Cavanagh JE, Yi Z, Munir K, et al. 2019. Cadmium uptake by onions, lettuce and spinach in New Zealand: implications for management. <i>Science of the Total Environment</i> 668: 780-789.
	Cadmium	Gray CW, Cavanagh JE 2021. Prediction of soil solution concentrations and leaching losses of cadmium in agricultural soils. <i>Journal of Environmental Quality</i> 50(6): 1464–1475.
	Cadmium	Gray CW, Lucci G, Cavanagh JE 2021. Can the application of farm dairy effluent enhance cadmium leaching from soil? <i>Environmental Science and Pollution Research</i> 28(36): 50919–50929.
	Cadmium	Gray CW, McDowell RW, Noble AD 2022. Total soil cadmium concentrations in the Winchmore long-term phosphorus fertiliser trial are still increasing. <i>New Zealand Journal of Agricultural Research</i> 65(1): 103–110.
	Cadmium	Manaaki Whenua – Landcare Research 2020. Managing cadmium in food crops in New Zealand. Guide produced by Manaaki Whenua – Landcare Research for the Cadmium Management Group.
	Cadmium	McDowell RW 2019. The potential for potassium chloride fertiliser applications to leach cadmium from a grazed pasture soil. <i>Geoderma</i> 353: 293–296.

Research priority (as in 2018 roadmap)	Subgroupings	Reference
Characterise national state and trend of soil contamination (cont.)	Cadmium	McDowell RW 2022. Assessing the leaching of cadmium in an irrigated and grazed pasture soil. <i>Environmental Pollution</i> 292: 118430.
	Cadmium	McDowell RW, Gray CW 2022. Do soil cadmium concentrations decline after phosphate fertiliser application is stopped: a comparison of long-term pasture trials in New Zealand? <i>Science of the Total Environment</i> 804: 150047.
	Cadmium	Yi Z, Lehto NJ, Robinson BH, et al. 2020. Environmental and edaphic factors affecting soil cadmium uptake by spinach, potatoes, onion and wheat. <i>Science of the Total Environment</i> 713: 136694.
	Guideline values	Cavanagh JE, Harmsworth G 2022. Exploring the implementation of ecological soil guideline values for soil contaminants. Manaaki Whenua – Landcare Research Contract Report LC4128. Envirolink Grant: 2214-MLDC162.
	Guideline values	Cavanagh JE, Harmsworth G 2023. An implementation framework for ecological soil guideline values. Manaaki Whenua – Landcare Research Contract Report LC4311. Envirolink Tools Grant: C09X2206.
	Microplastics	Tremblay LA, Pochon X, Baker V, et al. 2019. A review of microplastics risk: implications for Environment Southland. Cawthron Report No. 3350, prepared for Environment Southland.
	Urbanisation	Martin AP, Lim C, Kah M, et al. 2023. Soil pollution driven by duration of urbanisation and dwelling quality in urban areas: an example from Auckland, New Zealand. <i>Applied Geochemistry</i> 148: 105518.
	Pesticides	Thompson-Morrison H, Cavanagh J 2024. Analysis of pesticide residues in soils from the Greater Wellington region. Manaaki Whenua – Landcare Research Contract Report LC4516, prepared for Greater Wellington Regional Council.
	Pesticides	Cavanagh JE, Gordon D 2020. Results from a pilot pesticide monitoring programme in the Wellington region. Manaaki Whenua – Landcare Research Report LC3745, prepared for Greater Wellington Regional Council.
	Silver	Saleeb N, Gooneratne R, Cavanagh J, et al. 2019. The mobility of silver nanoparticles and silver ions in the soil-plant system. <i>Journal of Environmental Quality</i> 48(6): 1835–1841.
	Baseline	Martin AP, Turnbull RE, Rattenbury MS, et al. 2015. Geochemical atlas of southern New Zealand. GNS Science Report 2015/26.
	Baseline	Martin AP, Turnbull RE, Rattenbury MS, et al. 2017. Otago-northern Southland Geochemical Surveys Analyses. GNS Science consultancy report 2017/124). Lower Hutt, NZ, GNS Science.
	Baseline	Morgenstern R, Martin AP, Turnbull RE, et al. 2024. Urban geochemical atlas of Wellington. GNS Science consultancy report 2024/01. Lower Hutt, NZ, GNS Science.
	Baseline	Martin AP, Turnbull RE, Roudier P, et al. 2023. Geochemical atlas of Aotearoa New Zealand. GNS Science report 2023/23. Lower Hutt, NZ, GNS Science.
	Trace elements	Curran-Cournane F 2020. Differences in soil quality and trace elements across land uses in Auckland and changes in soil parameters from 1995-2017. Auckland Council Technical Report No. TR2020/001. Auckland Council.
Trace elements	Cavanagh J, Thompson-Morrison H, McNeill S, et al. 2025. Determination and use of background concentrations in Otago and Southland. BSI Contract Report 2526-0042, for Otago Regional Council & Environment Southland.	
Trace elements	Cavanagh J, McNeill S, Roudier P, et al. 2023. Determining background soil concentrations of trace elements across New Zealand. Manaaki Whenua – Landcare Research Contract Report LC4324 for Hawkes Bay Regional Council under Envirolink Medium Advice Grant 2321-HBRC267.	

Research priority (as in 2018 roadmap)	Subgroupings	Reference
Characterise national state and trend of soil contamination (cont.)	Trace elements	Cavanagh JE, Whitehead B, Vickers S, et al. 2021. Collating soil quality and trace element State of Environment monitoring data. Manaaki Whenua – Landcare Research Report LC 3803 for Envirolink Advice Grant 2050-HBRC254.
	Trace elements	Kim ND, Taylor MD, Caldwell J, et al. 2020 Development and deployment of a framework to prioritize environmental contamination issues. Sustainability 12: 9393; doi:10.3390/su12229393
	Trace elements	Stevenson B, Cavanagh J, Price R, et al. 2021. Soil quality and trace element data for Land 2021. Manaaki Whenua – Landcare Research Report LC3857, prepared for Ministry for the Environment.
	Trace elements	Stevenson BA, McNeill S 2020. Soil quality and trace element dataset trend analysis. Manaaki Whenua – Landcare Research Contract Report LC3887, prepared for Ministry for the Environment.
	Trace elements	Drewry JJ, Stevenson BA, McNeill SJ, et al. 2022. Impact of volumetric versus gravimetric assessment on Olsen P concentrations. New Zealand Journal of Agricultural Research 65(6): 463–483.
	SOE monitoring	Ministry for the Environment & Stats NZ 2024. New Zealand's Environmental Reporting Series: Our land 2024. Available from environment.govt.nz and www.stats.govt.nz.
	SOE monitoring	Ministry for the Environment & Stats NZ 2021. New Zealand's Environmental Reporting Series: Our land 2021. Available from environment.govt.nz and www.stats.govt.nz.
Assess the likelihood and impact of increasing competition for land (urban, biofuels) on the ability of soils to provide essential ecosystem services	Land fragmentation	Carrick S, Drewry J, Barnes M, et al. 2020. Land fragmentation environmental reporting indicator – technical methods for analysis from 2002 to 2019. Manaaki Whenua – Landcare Research Contract Report LC3846, prepared for Ministry for the Environment & Statistics New Zealand.
	Land fragmentation	Curran-Cournane F, Carrick S, Barnes MG, et al. 2023. Cumulative effects of fragmentation and development on highly productive land in New Zealand. New Zealand Journal of Agricultural Research 66(1): 1–24.
	Land fragmentation	Curran-Cournane F, Golubiewski N, Buckthought L 2018. The odds appear stacked against versatile land: can we change them? New Zealand Journal of Agricultural Research 61(3): 315–326.
	Land-use intensity	Drewry JJ, McNeill SJ, McDowell RW, et al. 2024. Linking land value to indicators of soil quality and land use pressure. Geoderma 450: 117054.
	Land-use intensity	McDowell RW, McNeill SJ, Drewry JJ, et al. 2024. Difficulties in using land-use pressure and soil quality indicators to predict water quality. Science of the Total Environment 935: 173445.
	Urban	Grinlinton D 2019. Sustainable management of urban soils: the New Zealand approach. International Yearbook of Soil Law and Policy 2018. Pp. 55–82.
	Urban	Silva C 2018. Auckland's urban sprawl, policy ambiguities and the peri-urbanisation to Pukekohe. Urban Science 3(1): 1.

Appendix 2 – Research priority scoring

The raw scores from workshop 2, ordered by identified issues, are shown in Table A2. The respondents column is a count of how many participants scored >1 for relevance, indicating how many participants this is an issue they are addressing through their role in the council. In general, topics that had relevance for more people scored higher. Issues not relevant to all reflected both regional variation and focus of participants.

The final column shows scores normalised to the number of respondents who rated the topic >1 for relevance. The higher ranking of erosion and flooding associated with extreme events, and emerging contaminants for the normalised responses, suggests a greater knowledge gap exists for these topics; this elevated the priority of these topics.

Table A2. Total score for issues, grouped by topic area, number of respondents scoring the relevance of the issue as 2 or 3, with score normalised to the number of respondents. Yellow = the highest total or normalised scores, orange = the next highest total scores, and teal = the lowest scoring issues.

Grouped topic	Specific issue	TOTAL	respondants	normalised
Erosion	Assessing erosion risk, impact and mitigation	53	9	5.9
	Erosion mitigation – techniques and efficacy	56	9	6.2
	Water quality impacts from erosion – sedimentation	52	9	5.8
Extreme events	Erosion associated with extreme events (including wet weather destabilisation)	47	6	7.8
	Flooding associated with extreme events – hazard assessment, mitigations	30	4	7.5
	Sediment deposition on land	24	4	6.0
Managing at catchment/landscape scale	Land use optimization	40	7	5.7
	Pest control and impacts	23	4	5.8
	Land fragmentation & urban encroachment – inc LUC 3, fragmentation and reverse sensitivity	41	7	5.9
	Land use capability mapping/assessment	41	7	5.9
	Suitability of land use, and interaction with management practices	52	9	5.8
	Land use and land use change	49	8	6.1
	Missing soil and land spatial information	48	8	6.0
	Effecting change on the land (e.g. communications, extension activities)	28	5	5.6
	Nutrient and sediment loss to waterways	52	9	5.8
Water quality impacts & mitigations	Nutrient leaching to groundwater	48	8	6.0
	Salt water intrusion to groundwater	31	5	6.2
	Riparian plantings	47	9	5.2
	Wastewater application to land	29	5	5.8
Soil health and function	Soil organic matter (Low OM/C in cropping systems, OM loss, Carbon stabilization and sequestration)	41	7	5.9
	Soil biology – biodiversity and function	39	6	6.5
	pugging /compaction pastoral land	41	8	5.1
	Compaction in orchards/vineyards)	42	7	6.0
	Soil structural degradation in cropping soils	38	7	5.4
	Known contaminants (metals, pesticides)	24	5	4.8
	Emerging contaminants	32	4	8.0
	Incorporating te ao Maori, Matauranga Maori	48	8	6.0
	Managing in change and uncertainty	50	8	6.3

Issues added during the workshop were:

- *E. coli*/bacteria/swimmability, as per National Policy Statement for Freshwater Management (this was added to nutrient and sediment loss)
- construction of edge-of-paddock tools, such as constructed wetlands (this was added into mitigation efficacy priorities)
- use, uptake, and impacts of land management technologies (e.g. virtual fencing)
- sustainable peatlands (subsidence and greenhouse gas emissions relating to drained peatlands) – unique issue)
- knowledge transfer, communication, and education (this was incorporated into effecting change on the land)
- extreme events – drought.

Some of these issues were incorporated into other identified issues (as shown above), and are included in the further discussion below.

Table A3 shows the scored topics ranked by their total scores. Topics with a score of <38 were considered low-ranking and are in general not discussed further. The exceptions are ‘Emerging contaminants’ and ‘Flooding associated with extreme events’, both of which had high normalised scores. ‘Knowledge transfer, communication, and education’ was added as a missing topic during the workshop; this was intended to be covered in the ‘Effecting change on the land’ topic.

It was surprising to see ‘Effecting change on the land’ scoring so low when so much other emphasis is given to interventions to mitigate land-use effects, and because ‘Knowledge transfer, communication, and education’ was added as a missing issue during the workshop.

Table A3. Ranked issues, the two top-scoring normalised scores are highlighted in bold

Issue and state of knowledge	Score	N of respondents identifying issue as being responded to or urgent	Normalised score
Erosion mitigation – techniques and efficacy	56	9	6.2
Assessing erosion risk, impact and mitigation	53	9	5.9
Water quality impacts from erosion – sedimentation	52	9	5.8
Suitability of land use, and interaction with management practices	52	9	5.8
Nutrient and sediment loss to waterways	52	9	5.8
Managing under change and uncertainty	50	8	6.3
Land use and land-use change	49	8	6.1
Missing soil and land spatial information	48	8	6.0
Nutrient leaching to groundwater	48	8	6.0
Incorporating te ao Māori, mātauranga Māori	48	8	6.0
Erosion associated with extreme events (including wet weather destabilisation)	47	6	7.8
Riparian plantings	47	9	5.2
Compaction in orchards/vineyards	42	7	6.0
Land fragmentation & urban encroachment – incl. LUC 3, fragmentation and reverse sensitivity	41	7	5.9
Land-use capability mapping/assessment	41	7	5.9

Issue and state of knowledge	Score	N of respondents identifying issue as being responded to or urgent	Normalised score
Soil organic matter (low OM/C in cropping systems, OM loss, carbon stabilisation and sequestration)	41	7	5.9
Pugging /compaction pastoral land	41	8	5.1
Land use optimisation	40	7	5.7
Soil biology – biodiversity and function	39	6	6.5
Soil structural degradation in cropping soils	38	7	5.4
Emerging contaminants	32	4	8.0
Salt water intrusion to groundwater	31	5	6.2
Flooding associated with extreme events – hazard assessment, mitigations	30	4	7.5
Wastewater application to land	29	5	5.8
Effecting change on the land (e.g. communications, extension activities)	28	5	5.6
Sediment deposition on land	24	4	6.0
Known contaminants (metals, pesticides)	24	5	4.8
Pest control and impacts	23	4	5.8

Responses received during the brainstorm events and the two workshops were considered in grouping the different scored research priorities, and to provide additional insight into specific issues that should be addressed. The overview is provided in Table A4. These were further refined through workshop discussions to yield the research priorities listed in Table 2 of the main document.

Table A4. Grouping of identified research priorities

Grouped category	Specific issues	Score	N	Normalised score
Use and effectiveness of mitigation options and techniques – erosion	Erosion mitigation – techniques and efficacy	56	9	6.2
	Assessing erosion risk, impact and mitigation	53	9	5.9
	Water quality impacts from erosion – sedimentation	52	9	5.8
Use and effectiveness of mitigation options and techniques – contaminants	Nutrient, pathogen and sediment loss to waterways – impact and mitigation	52	9	5.8
	Nutrient leaching to groundwater – impact and mitigation	48	8	6.0
Use and effectiveness of mitigation options and techniques	Riparian plantings – extent and mitigation efficacy	47	9	5.2
Land-use suitability	Suitability of land use, and interaction with management practices	52	9	5.8
	Land use and land-use change	49	8	6.1
	Land use optimisation	40	7	5.7
Managing under change and uncertainty	Managing under change and uncertainty	50	8	6.3
	Erosion associated with extreme events (including wet weather destabilisation)	47	6	7.8
	Flooding associated with extreme events – hazard assessment, mitigations	30	4	7.5

Grouped category	Specific issues	Score	N	Normalised score
	Climate-related changes from workshop 1 – land-use change, food/biofuel security	Not scored		
<i>Cross-topic issue</i>	<i>Missing soil and land spatial information</i>	48	8	6.0
Incorporating te ao Māori, mātauranga Māori	Incorporating te ao Māori, mātauranga Māori	48	8	6.0
Land fragmentation and land-use capability	Land fragmentation & urban encroachment – incl. LUC 3, fragmentation and reverse sensitivity	41	7	5.9
	Land-use capability mapping/assessment	41	7	5.9
Soil health and function	Compaction in orchards/vineyards)	42	7	6.0
	Soil organic matter (low OM/C in cropping systems, OM loss, carbon stabilisation and sequestration)	41	7	5.9
	Pugging /compaction pastoral land	41	8	5.1
	Soil biology – biodiversity and function	39	6	6.5
	Soil structural degradation in cropping soils	38	7	5.4
Emerging contaminants	Emerging contaminants	32	4	8.0
Excluded from further consideration	Salt-water intrusion to groundwater	31	5	6.2
	Wastewater application to land	29	5	5.8
	Effecting change on the land (e.g. communications, extension activities)	28	5	5.6
	Sediment deposition on land	24	4	6.0
	Known contaminants (metals, pesticides)	24	5	4.8
	Pest control and impacts	23	4	5.8