



Manaaki Whenua  
Landcare Research

# Research Roadmap – Land and Soil 2018–2020

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# Research Roadmap – Land and Soil 2018–2020

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# Summary

## Project and client

- This project provides a 'refresh' of the Strategic Roadmap for Land and Water Research. It was carried out for the Land Monitoring Forum (LMF) and the Land Management Group (LMG) of the regional councils, and was supported by Envirolink 1831-HBRC231 Strategic Roadmap for Land and Soil Research – refresh.

## Objective

- To undertake a refresh of the research roadmap for LMF and LMG and produce a strategic roadmap of activities for the period 2018–2020.

## Methods

- A strategic scan of the operating environment was conducted to identify changes in drivers between 2014 and 2017 in order to formulate a set of agreed goals.
- Research priorities were reviewed and tested against these goals.
- A high-level stocktake of research completed or underway against the original Strategic Roadmap was undertaken.
- A list of critical priorities and the outputs, activities and inputs required to deliver intermediate research outcomes for each priority was developed.

## Results

- There have been many changes since the Strategic Roadmap for Land and Water Research 2014 was developed, all of which have affected the direction, emphasis and cross-over of LMF and LMG.
- A noticeable change between the 2014–2017 Roadmap and the current situation has been an increase in the number of goals and research priorities that each special interest group (SIG) is now required to focus on.
- This reflects a broadening in the remit of each SIG, as well as reflecting a widening of scope towards the more integrated and holistic approaches now being recognised as necessary to achieve the impacts required by central and regional government.
- One of the most significant shifts has been the emergence of land and soil as a focus, complementing rather than competing with the highly visible focus on freshwater in central and regional government policy. As a result, the refresh has emphasised this in the research roadmap being for land and soils.
- Twelve goals were recognised as being the key areas of focus for both groups (up from five), and of the initial set of 33 priorities 16 were deemed of high priority and 8 of those critical to the core business of the groups.
- These priorities shaped the set of activities and programmes the SIGs will focus on over the next 3 years.

## **Roadmap activities**

Roadmap activities include:

- ensuring participation in relevant cross-department discussions relating to the natural resources sector, and with relevant National Science Challenges, to enable progress in key areas (both LMG and LMF)
- supporting a collaborative work programme with the Ministry for Primary Industries (MPI) and other primary sector organisations aimed at achieving and future-proofing sustainable land management
- collaborating in pan-sector programmes to gather new data, information and knowledge of soils, erosion, sediment, etc. to support national coverage and reporting (both LMG and LMF)
- continuing to strengthen collaboration with the natural resources sector and the Ministry for the Environment (MfE) (Environmental Monitoring and Reporting and National Environmental Monitoring Standards)
- promoting cross-Crown Research Institute (CRI) collaboration on key local, regional and national issues affecting land and soil (both LMG and LMF).

## **Recommendations**

- Review and cross-reference LMG, LMF and any other relevant/related SIGs Research Science & Technology (RS&T) strategies to optimise alignment opportunities across the land, soil and water domains to ensure priorities outlined in this report are targeted.
- Assess the research roadmap activities annually to ensure they are still on target to deliver the goals.
- Undertake a further review and refresh in 2020.

## 1 Introduction

This project provides a 'refresh' of the Strategic Roadmap for Land and Water Research (1442-HBRC200). The previous roadmap, drafted in 2014, recommended a regular refresh, a review of progress, and identification of areas for further work. The refresh will support the Regional Councils' Research, Science & Technology Strategy (June 2016), as well as ensuring cross-SIG collaborative activities. The project is supported by Envirolink 1831-HBRC231 Strategic Roadmap for Land and Soil Research – refresh.

The refresh will be used in the same way as the existing Strategic Roadmap for Land and Water Research to:

- 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 CRI Strategic Science Investment Funding (SSIF) allocation; Ministry of Business, Innovation and Employment (MBIE) Endeavour investment bids; National Science Challenges; and central government's non-departmental investment streams.

## 2 Background

Most SIGs have a research strategy and a list of research priorities, and these were used to develop the most recent version of the Regional Councils' Research, Science & Technology Strategy (June 2016). This Strategy has been used to successfully influence government science strategies, the direction of several National Science Challenges, and MBIE Endeavour investments. In July 2017, the SIG strategies were brought together and re-examined collectively with a view to identifying opportunities for collaboration and as a basis for engaging with the wider research sector.

LMG and LMF had collaboratively developed a Strategic Roadmap for Land and Water Research via Envirolink 1442-HBRC200 (Collins, Weeks et al. 2014) to guide research related to their interests during the period 2014–2017. The pace of change and the energy being put into prioritising research efforts and investments – both in the regional sector<sup>1</sup> and by other agencies<sup>2</sup> – mean the timing of this current refresh will offer the LMG and LMF the opportunity to accelerate progress by working as part of the national picture and beyond business as usual.

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<sup>1</sup> For example, for Environmental Monitoring and Reporting (EMaR).

<sup>2</sup> For example, the Conservation and Environment Roadmap, the Primary Sector Science Roadmap, and the Crown Research Institute SSIF Platform proposals.

While much of the information is already available in various forms, it is held within a number of agencies, and this project brings it into one coherent body of work and applies a much-needed critical and strategic lens.

### 3 Project approach

The project provides a refresh of the 2014–2017 Strategic Roadmap for Land and Water Research. It was developed by considering the following key components (see Figure 1 and Table 1):

- a strategic scan of the operating environment to identify changes in drivers between 2014 and 2017, as well as relevant foresight work to formulate a set of agreed outcomes
- a review and test of research priorities against these outcomes
- a high-level stocktake of research completed or underway against the original Strategic Roadmap
- a list of critical priorities and the outputs, activities and inputs required to deliver intermediate research outcomes for each priority
- potential and preferred implementation and/or delivery pathways, where possible leveraging off existing or known initiatives
- indicative timelines for research investigation and implementation.



Figure 1. Logic flow in the development of the Roadmap refresh.

The project was split into several stages, which are summarised in Table 1 and expanded on below.

**Table 1. Project stages**

<b>Stage/ activity</b>	<b>Description</b>	<b>Lead</b>	<b>Involved</b>	<b>Date</b>
1	Strategic scan	Alison Collins	Alison Collins	June/July 2017
2	Critical review of progress against current roadmap	Alison Collins	Alison Collins	June/July 2017
3	Conceptual outline of goals and initiatives	Alison Collins	Alison Collins, Chris Phillips, Haydon Jones, Reece Hill, John Drewry, Nathan Heath	19 July 2017
3	Workshop with LMF	Chris Phillips	Chris Phillips, Sam Carrick and 22 LMF members	24 August 2017
3	Workshop with LMG	Chris Phillips	Chris Phillips and 12 LMG members	25 September 2017
4, 5	Analysis of feedback, prioritisation and mapping implementation pathway development	Chris Phillips	Chris Phillips	30 October 2017
4, 5, 6	Testing with select group	Chris Phillips	Chris Phillips, Sam Carrick, Reece Hill, Haydon Jones, John Drewry, Suzanne Watt, Jonathan Bengé	7 December 2017
6, 7	Present findings and solicit final feedback from combined LMF/LMG workshop	Chris Phillips	LMF and LMG members	7 March 2018
7	Report & Roadmap completion, including Envirolink reporting	Chris Phillips	As above	31 March 2018

- Activity 1: A strategic scan of the operating environment to determine a set of high-level outcomes / refresh existing outcomes.
- Activity 2: A critical review of progress against existing priorities to determine any remaining gaps and needs.
- Activity 3: Compilation and testing of a set of refreshed priorities, initially in a small-group workshop with LMG and LMF members (19 July), at the SIG meeting (July 20–21) and at a later stage with their wider membership (August 24 and September 25).

The process involved breaking into four or five groups with three to five individuals in each group. The aim was to get group consensus rather than individual feedback. The goals were assessed first in terms of being either LMF, LMG, or combined. Additional goals and modifications to wording were captured. For each goal the associated research initiatives were ranked in terms of high (H), medium (M) or low (L) and any amendments were captured. These were then brought back to the whole group and a combined rating for each was given.

- Activity 4: Research prioritisation, mapping of potential and preferred implementation pathways to identify potential opportunities to leverage, align and speed delivery.

Analyse feedback from separate LMG and LMF workshops and determine common issues, concerns and alignment. Develop an approach for prioritising research aims to meet combined needs.

- Activity 5: Development of a Draft Strategic Roadmap covering each of the elements informed by activities in Activities 1, 2, 3 and 4.

Develop the draft roadmap in association with Activity 6, along with discussion on likely implementation and potential work programmes and activities by each SIG. The discussion involved two people from Manaaki Whenua – Landcare Research, three from LMF, and two from LMG.

- Activity 6: Input from a self-selected sub-group from LMG and LMF to test, review and revise the Draft Strategic Roadmap outlined in Activity 5.

Following workshop and further collation of input, revise the draft roadmap and send to LMG and LMF for final review and comment.

- Activity 7: Consolidation of feedback and revisions into a Strategic Roadmap and accompanying report to meet Envirolink criteria.

Incorporate final feedback and changes into a Manaaki Whenua – Landcare Research contract report and complete any Envirolink project requirements.

## **4 Major shifts – scanning results**

In the 3 years since the initial roadmap was formulated several factors have changed in both the research landscape and in the natural resources sector operating environment (Figure 2). In addition, there have been several key international initiatives that have had profound impacts on what/how things are/will be done in New Zealand, and on the outcomes that were outlined in the 2014–2017 research roadmap.

One of the most significant shifts has been the emergence of land and soil as a focus area, complementing rather than competing with the highly visible focus on freshwater in central and regional government policy. The recognition that improvements in freshwater quality can be met only through improved land management activity has shifted the focus from the receiving environment to the generating environment. Further, a series of natural ‘disasters’ – floods and droughts – has brought climate change and associated adaptation and resilience to the fore as worthy areas of investigation.

The increasing need for indicators, data and standards to support national environmental policy has also been a significant driver for a stronger focus on land and soil. MfE’s Environmental Monitoring and Reporting (EMaR) Project was established in July 2014 with the launch of the EMaR initiative, a partnership between the Local Government New Zealand (LGNZ) regional sector and MfE. EMaR, together with various proposed National

Environmental Monitoring Standards (NEMS) currently being developed to establish best practice for the ongoing measurement of New Zealand's environment, is increasingly driving regional councils to assist in the development of appropriate ways to collect, share, and report on environmental issues in their regions while allowing for aggregation and national-scale interpretation of regional data. For example, a goal of the EMaR project is to have environmental data that are collected by regional councils more widely available through Land, Air, Water Aotearoa (LAWA). LMF and LMG groups and their members are heavily involved in both EMaR and NEMS projects.

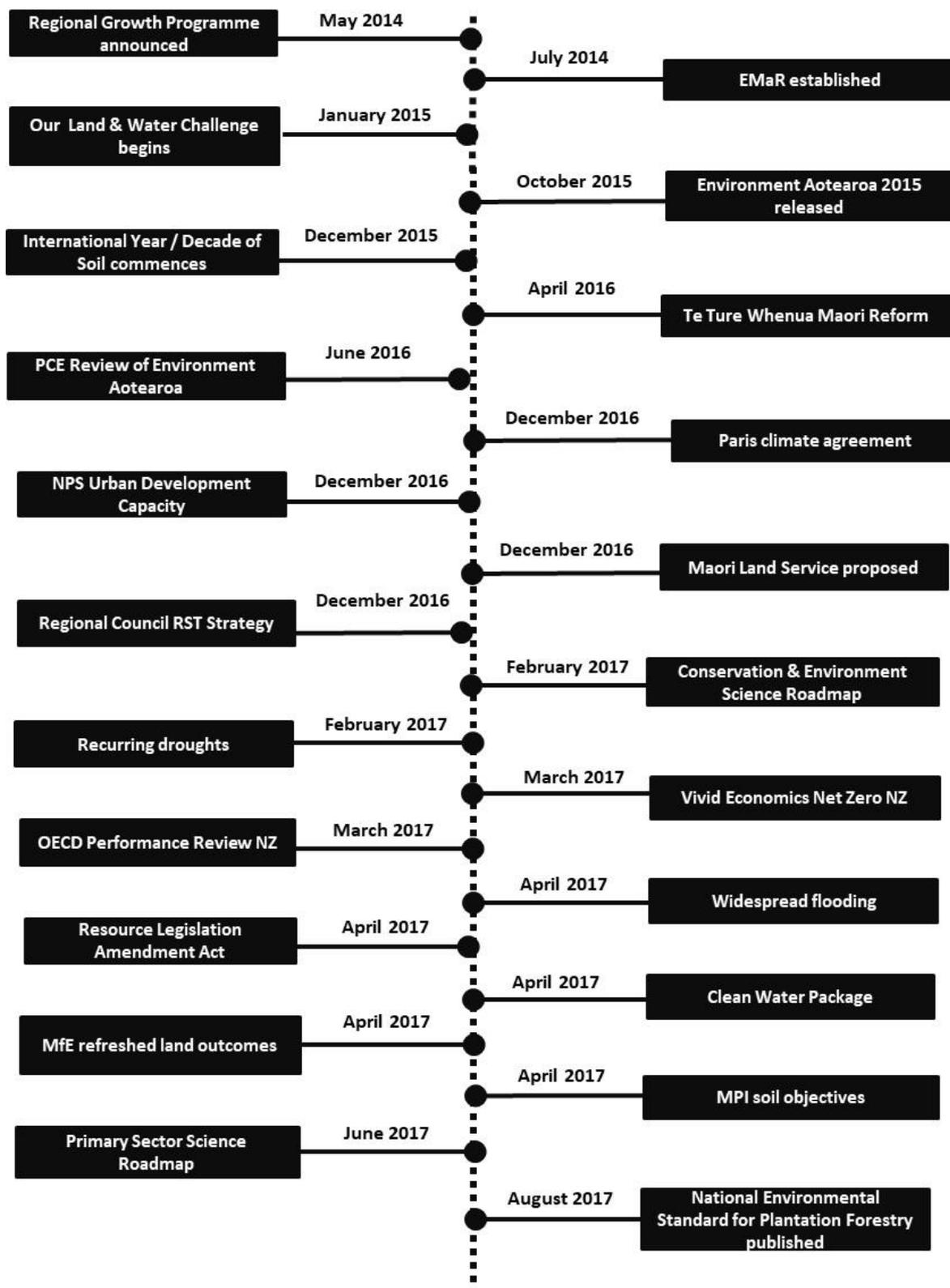


Figure 2. Timeline of some of the major impacts on 2014–2017 roadmap outcomes. Note PCE is Parliamentary Commission for the Environment; OECD is Organisation for Economic Co-operation and Development; and NPS is National Policy Statement.

## 4.1 What has changed?

There have been many changes since the Strategic Roadmap for Land and Water Research 2014–2017 was developed, including the following (see also Appendix 1 and Appendix 2).

- The Environmental Reporting Act 2015 (the Act) was passed into law in September 2015.
- The *Future Requirements for Soil Management in New Zealand* report was launched in December 2015.
- The 2015 United Nations Climate Change Conference (COP 21) in December 2015 negotiated the Paris Agreement, a global agreement (196 parties) on the reduction of climate change. Of relevance for soil management in New Zealand was the launch of an initiative to increase carbon in the global soil stock by 4% per annum.
- The Parliamentary Commissioner for the Environment, in a review of *Environment Aotearoa*, identified the issue of erosion as a priority in the land domain.
- Progress was made, and interest generated in other agencies, on having a clearer articulation of the outcomes required from land and soil in New Zealand (e.g. MfE).
- Longer-term thinking on behalf of sectors in science and innovation was noted as part of the development of roadmaps (e.g. Conservation and Environment Roadmap; Primary Sector Science Roadmap).
- Māori landowners and entities (e.g. Te Tumu Paeroa) and services (i.e. Māori Land Service) demand to unlock the potential of Māori land.
- More than seven Regional Growth Strategies were launched as part of the Business Growth Agenda (BGA), calling for an increase in soil productivity to support the development of land-based opportunities.
- An OECD Environmental Performance Review highlighted the close coupling of environmental performance and economic growth, and the need for more integrated policy development.
- A report commissioned by an all-party group of MPs (who constitute the New Zealand chapter of GLOBE) was released by Vivid Economics of the UK. It proposes four scenarios for how New Zealand could significantly cut its greenhouse gas emissions by 2050. The intent behind the report is to find pathways that allow New Zealand to meet its international climate change commitments in ways that are economically beneficial.
- The Our Land & Water National Science Challenge came into existence.
- The National Environmental Standard for Plantation Forestry was gazetted in 2017 and will come into force in May 2018. This will provide an overarching approach to how the effects of plantation forestry are managed, and may provide more certainty for forest investment.

## **4.2 What has stayed the same?**

In tandem with the shifts pushing soil and land onto the political agenda, several drivers identified during the last strategy have remained active. These include:

- the continuing focus on implementing the National Policy Statement for Freshwater Management, including a Clean Water Package and a target that 90% of our rivers and lakes are swimmable by 2040 (although there is greater recognition that the solution to New Zealand's freshwater issues depends on tackling land-use impacts)
- recognition of the considerable pressure on the availability of land, particularly soils classified as 'versatile' (5.5% of New Zealand), and a disproportionate amount of this land being used for urban development
- the need to increase Māori engagement in discussions around soil and land, as part of making a mainstream shift from 'ownership to stewardship' and the inter-generational principles of kaitiakitanga
- the importance of presenting a systemic solution for the management of New Zealand soils that links central government intervention to regional/sector implementation, given there is no single 'owner' of outcome delivery.

## **5 Review of progress against the 2014–2017 roadmap**

An assessment was made of work completed or significantly underway for each research priority identified in the 2014–2017 roadmap (outlined in Appendix 3). This was largely based on the authors' knowledge and those who attended the select workshop from the two SIGs, rather than an exhaustive search across the whole New Zealand research community. A key early contribution was a report commissioned by MPI in which future requirements for soil management in New Zealand were reviewed and outlined (Collins, Mackay et al. 2014).

Following this search, a further assessment was made of the completeness of that research in terms of providing sufficient resolution of the problem or enough information to enable action to occur. This then informed the updated road map and any other priorities identified through subsequent workshops.

## **6 Mission goal map**

Combining the results of the scanning exercise with an assessment of progress against the 2014–2017 roadmap, a new conceptual picture emerged with 12 associated goals (Figure 3). These goals (and their associated research initiatives) formed the basis of discussion at the two independent workshops held with LMF and LMG. Eight of 12 goals were in general agreement in terms of their ownership, with four being undecided in terms of LMF, LMG or combined ownership. All goals were discussed and further refined at a workshop with selected members of each SIG (Activity 6), and agreement was reached on the final goal map to inform the draft road map.



**Figure 3. Conceptual outline and associated goals.**

## 7 Proposed goals and research needs

Following the assessment of progress against the 2014–2017 roadmap priorities and the assessment of the changes in the operating environment, a set of 33 research needs was developed to align with each goal. These (goals and initiatives) formed the basis of the workshops held with LMF and LMG.

A noticeable change between the 2014–2017 roadmap and the current situation has been an increase in the number of goals and research priorities that each SIG now focuses on. This reflects a broadening in the remit of each SIG, as well as reflecting a widening of scope towards more integrated and holistic approaches now being recognised as necessary to achieve the impacts required of central and regional government.

While this reflects the real nature of many of the problems LMF and LMG (and others) are having to deal with, it does make it more difficult to prioritise them, and so the choices on what to focus on are often hotly contested. While it would be nice to have the resources to advance all priorities, the decisions reached reflect a consensus between the groups and allow for work to progress.

Goals and research initiatives were then modified (33 initiatives refined to 16) based on feedback from the two workshops, and then further refined in a second exercise that identified eight of those deemed critical to LMG and LMF (Activity 6) (Table 2).

**Table 2. Goals (denoted by letter) and research priorities (denoted by number) with their description in left hand column and critical priorities to LMG and LMF core business in right hand column**

Goal and research priority		Critical research priority for goal		Lead SIG
	C5 Identify options for future land use to realise greater co-benefits and grow value	C5	Identify options for future land use to realise greater co-benefits and grow value	LMF
	C7 Identify options for the sustainable use of marginal land			LMG
	F16 Determine the extent to which a soil ecosystem services approach / integrated spatial modelling can inform wise use of land			LMF
	F17 Enhance the coverage, quality and inter-operability of resource soil information (S-map)	F17	Enhance the coverage, quality and interoperability of resource soil information (S-map)	LMF
JOINT Priority	H22 Develop and test better input data on erosion and sediment generation to enhance the performance of erosion/sediment modelling	H22	Develop and test better input data on erosion and sediment generation to enhance the performance of erosion/sediment modelling	LMF
	H24 Enhance the coverage, quality and interoperability of land cover and land-use data			LMF
	J27 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)	J27	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
	I25 Understand and incorporate Māori values (e.g. mahinga kai, kaitiaki) within decision-making	I25	Understand and incorporate Māori values (e.g. mahinga kai, kaitiaki) within decision-making	LMG
	I26 Determine the factors (behaviours, values, motivations) affecting decisions over land use and land management			LMG
	K30 Develop necessary tools and enable relevant research that supports community decision-making	K30	Develop necessary tools and enable relevant research that supports community decision-making	LMG
LMG	L32 Understand how many people are adopting good management practice and the real drivers behind implementation			LMG
	L33* Support development of certification and training for land management	L33	Support development of certification and training for land management	LMG
	L34 Investigate and develop ways to build capability in land management tools			LMG
LMF	E12 Develop methods to effectively characterise soil health			LMF
	E13 Characterise national state and trend of soil contamination			LMF
	D8 Assess the likelihood and impact of increasing competition for land (urban, biofuels) on the ability of soils to provide essential ecosystem services	D8	Assess the likelihood and impact of increasing competition for land (urban, biofuels) on the ability of soils to provide essential ecosystem services	LMF

\* L33 is not strictly research but a critical need.

Feedback following the final presentation to a joint meeting of LMF and LMG in March 2018 indicated general agreement with the selection of critical priorities, with the following exceptions.

- Several groups felt that the two priorities identified for Goal C (5 and 7) were now of equal importance. This change reflected emerging drivers such as the 'Billion Trees' initiative.
- L33 was recognised as not being a research priority as such, but was deemed by all to be a critical need, so it was retained.
- Comments were made that in the critical priority list there were none relating to Goal A, which many regarded as still being of high importance. The recent ex-tropical cyclones Fehi and Gita may have raised this issue in the minds of many members.

The aim was to identify critical priorities for each SIG in order to clarify what each SIG, independently and/or jointly, will focus on and:

- collectively resource (including identifying within budgets)
- target external funding opportunities, such as MPI's Sustainable Land Management and Climate Change (SLMACC) or other central government research funds and policy advice
- recommend for inclusion or involvement in National Science Challenges, particularly as Tranche 2 funding gets underway, where there are significantly more resources being managed by National Science Challenges
- guide discussions with CRIs and their SSIF investment decisions.

For both groups the refresh has provided a mix of business as usual and a shifting of priorities to meet emerging needs. As indicated earlier, the shift away from a water focus to a stronger land and soil emphasis has been the most significant change. With that shift, a need to understand and examine the human dimension in decision-making, adoption, adaptation and capability development has emerged as a critical need to be addressed and forms a foundation set of priorities for LMG.

The final set of research priorities in Table 2 was then used to create the Strategic Roadmap for Land and Soil Research (Figure 4).

## **8 Roadmap activities**

The refreshed Strategic Roadmap for Land and Soil Research suggests how effort (capability, investment, etc.) can be aligned with other stakeholders to ensure delivery of the most critical research priorities identified by LMF and LMG, and what wider systemic changes would enable an impact in the natural resources sector.

The Roadmap (Figure 4) shows some of the potential activities and programmes for the 2018–2020 period, with a focus on key establishment or ongoing activities in 2018. Key activities include:

- ensuring participation in relevant cross-department discussions relating to the natural resources sector, such as implementation of the National Policy Statement for Freshwater Management (NPS-FM), the National Environmental Standard for Plantation Forestry (NES-PF), and regional development initiatives that have an impact on sustainable land use, including impacts on versatile soils (both LMG and LMF)
- ensuring participation in research priority setting, research uptake and adoption discussion within relevant National Science Challenges to enable progress in key areas (both LMG and LMF)
- supporting a collaborative work programme with MPI and other primary sector organisations on achieving and future-proofing sustainable production – including implementation of new initiatives such as ‘Billion Trees’, the reformation of a “Ministry of Forestry”, etc. (primarily LMG)
- collaboration in pan-sector programmes to gather new data, information and knowledge of soils, erosion, sediment, etc. to support national coverage and reporting (both LMG and LMF)
- continuing to strengthen collaboration with the natural resources sector and MfE (EMaR and NEMS) in key areas such as ecosystem services, natural capital and environmental reporting (primarily LMF)
- initiating collaborative efforts with MfE, MPI and other water-focused SIGs to support further implementation of freshwater reforms (NPS-FM) (both LMG and LMF)
- promoting cross-CRI collaboration on key local, regional and national issues (both LMG and LMF)
- ensuring participation in, or influence research being undertaken in, National Science Challenges, primarily Our Land & Water.

The 2018 year could be critical for determining alignment and influence, given that many cross-sector initiatives are underway and new ones are appearing. The change of government will also have an influence on what might happen within the natural resources sector and a shifting of previous priorities as Ministers and their departments respond to changing imperatives.

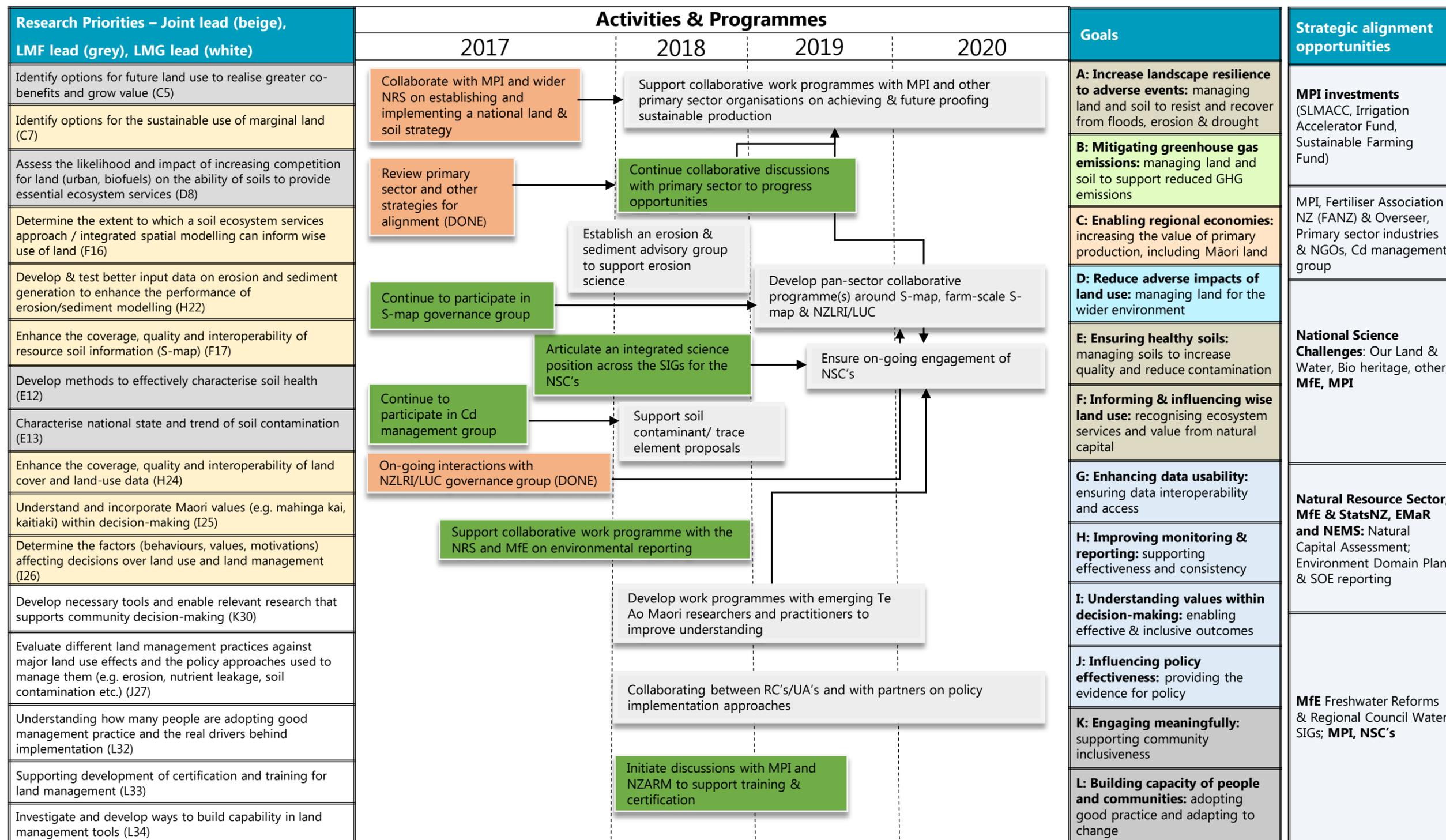


Figure 4. Strategic Roadmap of alignment activities and programmes for land and soil research. Orange boxes = complete; green boxes = underway and following on from previous roadmap; light grey = to be actioned.

## 9 Recommendations and conclusions

Recommendations for further work are provided below to ensure the intent of the refresh project is realised and the Strategic Roadmap becomes a resource for the LMG and LMF.

### Strategic roadmap

- 1 Key activities within the Strategic Roadmap are endorsed and resourced, and leaders or 'owners' from within the LMG and LMF are appointed to drive them.
- 2 Recommended activities (such as discussion with key government agencies and the primary sector) are endorsed at a senior level within regional councils, and are targeted and well facilitated to ensure adequate progress.
- 3 Recommended activities are discussed with other SIGs to ensure appropriate synergies and opportunities are realised.
- 4 Strategic scans are periodically undertaken to ensure the Strategic Roadmap and associated research priorities remain relevant to the changing environment.
- 5 A further review and refresh will be undertaken in 2020.

### Research priorities

- 1 LMG, LMF and any other relevant/related SIGs RS&T strategies are reviewed and cross-referenced to optimise alignment opportunities across land, soil and water domains to ensure priorities outlined in this report are targeted.
- 2 A coordinated and strategic programme of work is sought to give effect to the highest research priorities identified as critical to the LMG and LMF, either through collective resourcing, a more coordinated and proactive input into Envirolink decision-making, or targeting of external funding opportunities.
- 3 A light review of priorities is conducted annually to ensure they are relevant to any changes in the wider operating environment.
- 4 Given the dependence on behaviour change and uptake to achieve research priorities I25, I26, K30, J27, and L32–34 (particularly for LMG), discussions are held to determine the shape of a collaborative effort with MPI, the primary sector, and Our Land & Water National Science Challenge.

### Systemic changes

- 1 The LMG and LMF support and/or contribute to relevant activities that emerge in the wider environment (e.g. MPI requests for proposals related to climate change effects on land, soil and water; planting a 'Billion Trees'). This should include connecting where relevant to the Our Land & Water National Science Challenge and continued involvement with MfE and Statistics NZ in relation to a national reporting framework and indicator development (NEMS and EMaR).
- 2 Support is provided for over-arching enabling programmes of work (as described in Table 3, following the initial 2014–2017 roadmap recommendations). The future of the

National Land Resource Centre is being considered as part of Manaaki Whenua – Landcare Research’s strategy refresh and as such may limit any future coordination of such programmes.

- 3 This project, the relationships that underpinned it, the partnership approach and the strategic outputs are widely communicated at relevant forums (e.g. New Zealand Association of Resource Management (NZARM) and New Zealand Society of Soil Science (NZSSS) conferences) and to key stakeholders (e.g. through the SIG strategy refresh, to chief executives, central government partners and the Land and Water Forum (LAWF)) as an exemplar of working within the innovation system.

**Table 3. Enabling programmes and activities – from the previous 2014–2017 roadmap**

<b>Programme of work</b>	<b>Recommended activity</b>	<b>Purpose – key systemic change</b>	<b>Still relevant 2018–2020</b>
Human capital	Develop a pan-sector knowledge transfer strategy	To increase uptake and adoption of science information and tools, thereby increasing the value and impact of research	Yes
	Identify and address regional council needs for capability development to use science tools and information		
Information capital	Explore opportunities for shared data infrastructure and services between CRIs, National Science Challenges, regional councils and other agencies	To maximise the utility of data and information from research	Yes
	Develop principles and technologies to bring together and analyse heterogeneous data		
Organisational capital	Initiate a cross-agency stocktake of research in land and soil, including analysis of implementation pathways and possible additionality gains, and critical gaps identified	To ensure the right science is being done and additionality gains are maximised	Yes
	Facilitate discussions and progress in each of the alignment opportunities outlined in the Strategic Roadmap	To ensure the most effective implementation pathways are being used and alignment opportunities are being utilised	Yes

## 10 Acknowledgements

We acknowledge work carried out by Alison Collins when on secondment from Manaaki Whenua – Landcare Research to MPI that contributed to identifying many of the issues affecting soil and land from a meta-analysis of global megatrends. Nathan Heath (Hawke’s Bay Regional Council), Jonathan Benge (Auckland Council) and Sam Carrick (Manaaki Whenua – Landcare Research) are thanked for contributing at small workshop sessions. LMG and LMF members who attended workshops over the last 9 months are also thanked for their contributions to refining the goals and research priorities, and for making useful suggestions for activities and programmes to deliver on those priorities. Jo Cavanagh reviewed this report and Ray Prebble edited it. Funding via Envirolink enabled this project to be carried out.

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## Appendix 1 – Drivers and changes that have the potential to affect research priorities

Initiative	NZ owner	Goals relevant to soil and land	Research themes / areas
<b>Regional Growth Programme</b>	MBIE and MPI	<p><i>Tai Tokerau – Northland</i></p> <p>Potential for irrigation, given a study found an additional 92,000 ha of irrigated land could contribute \$247 million</p> <p>Investment in the detailed mapping of Northland’s land and resources using light detection and ranging data (LiDAR)</p> <p>Lifting on-farm performance through knowledge sharing, UMF mānuka planting on under-utilised land, and Te Tai Tokerau Māori Forestry Collective training and planting programme</p> <p><i>Waikato</i></p> <p>Completing a regional Māori Agenda and Action Plan for economic development in the region</p> <p><i>Bay of Plenty</i></p> <p>A Mānuka Action Group is established comprising Māori land owners, bee keepers, research organisations, key processors, exporters and local government</p> <p>Unlocking Māori land for the use and expansion of kiwifruit production</p> <p>Regionally coordinated Māori Development Strategy, Cluster Projects for the Eastern Bay Dairy Cluster and Te Puke Horticulture Cluster, which aim to improve the productivity of Māori land</p> <p>Water strategy for the region to ensure this resource is responsibly managed</p> <p><i>Tairāwhiti – Gisborne</i></p> <p>Adding value and increasing production in sectors such as wood processing and mānuka honey, and through irrigation</p> <p><i>Hawke’s Bay</i></p> <p>Provision of resilient physical, community and business infrastructure – including managing climate change impacts</p> <p><i>Taranaki</i></p> <p>To be developed, but six action teams focusing of Future Foods, Energy Futures, Tourism,</p>	<p>Uptake and adoption</p> <p>Mānuka honey</p> <p>Irrigation</p> <p>Māori-led economic development</p> <p>Māori land-use options</p> <p>Value-added primary production</p> <p>Kaitiakitanga</p> <p>Informed land-use planning</p> <p>Pathways to net-zero emissions</p> <p>Increased resilience to adverse events</p> <p>Land-use potential</p> <p>Land and soil information</p>

Initiative	NZ owner	Goals relevant to soil and land	Research themes / areas
		<p>Liveability/Lifestyle, Māori Economy and Talent, and Skills and Innovation</p> <p><i>Manawatū-Whanganui</i></p> <p>Land-use optimisation – better assessment and utilisation of land</p> <p>Mānuka honey – create a resilient and scaled mānuka sector in the region</p> <p>Realise Māori potential under a number of opportunities (e.g. connecting with Te Pae Tawhiti, the Māori Economic Development Strategy for the region)</p> <p><i>Canterbury</i></p> <p>Managing freshwater and irrigation infrastructure by implementing the Canterbury Water Management Strategy – a collaborative solution to sustainable freshwater management.</p> <p>Improving value-added production by embracing opportunities in agri-technology, sustainable food production, value-added food processing</p>	
<b>Environmental Monitoring and Reporting (EMaR) Land</b>	Local Government New Zealand (LGNZ) regional sector and MfE	Achieve nationally consistent and integrated regional-level land and soil monitoring and reporting across New Zealand, including the monitoring and reporting of regional and national indicators associated with the use and management of land and soil resources (including the pressures and impacts of change).	Soil health Land & soil information Monitoring tools and technologies Data analysis, storage and quality assurance Transparency of data workflows
<b>Te Ture Whenua Māori Bill</b>	Te Puni Kōkiri	<p>Provide a clearer more empowering decision-making framework</p> <p>Sets out the core functions of the proposed Māori Land Service</p> <p>Maintain and update a register of Māori landowner decisions, ownership and governance information</p>	Māori-led economic development Māori land-use options
<b>Review of Environment Aotearoa</b>	Parliamentary Commissioner for the Environment	<p>Erosion as a change in the state of the land and a pressure on freshwater and coastal habitats</p> <p>Climate change is projected to lead to more intense and frequent heavy downpours, exacerbating the problem</p> <p>Purpose of state of the environment reporting to inform the public and decision-makers of the current state and long-term trends in the environment</p> <p>Reports contain conclusions on the relative significance of different environmental issues</p>	Erosion and sedimentation Land-use impacts on freshwater

<b>Initiative</b>	<b>NZ owner</b>	<b>Goals relevant to soil and land</b>	<b>Research themes / areas</b>
		and are done transparently	
<b>National Policy Statement for Urban Development Capacity</b>	MfE	<p>Enable urban environments to grow and change in response to the changing needs of the community and future generations</p> <p>Provide enough space for populations to happily live and work by allowing development to go 'up' by intensifying existing urban areas</p>	<p>Values and trade-offs</p> <p>Land use potential</p> <p>Integrated land-use modelling</p> <p>Informed land-use planning</p>
<b>Paris Climate Agreement</b>	MfE	<p>Keep the increase in global average temperature to well below 2°C above pre-industrial levels, while pursuing efforts to limit the temperature increase to 1.5° C, with an aim to reach peaking of global greenhouse gas emissions as soon as possible and to reach net-zero emissions by the second half of the century</p> <p>Enhance the ability of countries to adapt and reduce vulnerability to the adverse impacts of climate change</p> <p>Make sure financial flows support the development of low-carbon and climate-resilient economies</p>	<p>Pathways to net-zero emissions</p> <p>Increased resilience to adverse events</p> <p>Land-use potential</p>
<b>Māori Land Service proposal</b>	Te Puni Kōkiri	<p>Information on whenua including (e.g. location, size and ownership)</p> <p>Advice on how to look after whenua (e.g. governance arrangements or options)</p> <p>Providing practical support and advice on options for using your whenua</p>	<p>Land and soil information</p> <p>Uptake and adoption</p>
<b>OECD</b>	Natural resources sector	<p>Long-term vision for the transition towards a low-carbon, greener economy</p> <p>Effective implementation of the national freshwater policy reform</p> <p>More efficient use of resources and land, and containing urban sprawl</p> <p>Ensure coherence of regional and territorial land-use plans, including assessing cumulative environmental impacts and integrating biodiversity into land-use planning</p>	<p>Policy effectiveness</p> <p>Integrated land-use modelling</p> <p>Informed land-use planning</p> <p>Pathways to net-zero emissions</p> <p>Land-use impacts on freshwater</p>
<b>Vivid Economics Report</b>	GLOBE-NZ	<p>Holistic approach to policy-making, including both economic and cultural interests.</p> <p>Meaningful consultation with iwi and hapū, as per the Treaty of Waitangi's principle of partnership, to acknowledge their interests and aspirations.</p> <p>Upgrade of the evidence base to support New Zealand's low-emissions pathway planning, including land-system modelling tool(s) that generate bottom-up estimates of abatement opportunities and costs, and that take account of the interactions between sectors</p>	<p>Pathways to net-zero emissions</p> <p>Integrated land-use modelling</p> <p>Meaningful engagement with iwi and hapū</p> <p>Uptake and adoption</p>

<b>Initiative</b>	<b>NZ owner</b>	<b>Goals relevant to soil and land</b>	<b>Research themes / areas</b>
<b>Resource Legislation Amendment Bill</b>	MfE	Stronger national direction and consistency in natural resource management A more responsive planning process, and a streamlined resource consent process Better alignment with other legislation	Policy effectiveness Integrated land-use modelling
<b>Refreshed Land Outcomes Framework</b>	MfE	Soil functional capacity is maintained and enhanced Threats to the environment from accelerated erosion actively are managed Chronic impacts of land use on ecosystem health and biodiversity are actively managed Land use and management take account of the capability of the land and the vulnerability of receiving environments (optimal or wise use) Systems are in place to identify and manage risks from contaminated land, hazardous substances and new organisms Risks from natural hazards (weather, earthquakes) are effectively identified and responses are in place for their management Land managers have the tools, skills and knowledge to make, implement and report on land management decisions Communities take into account the full range of short- and long-term impacts and opportunities when making land management decisions	Soil health Pathways to net-zero emissions Increased resilience to adverse events Soil contamination Land-use potential Meaningful engagement with iwi and hapū Values and trade-offs Monitoring tools and technologies Data analysis, storage, and quality assurance Transparency of data workflows Kaitiakitanga Informed land-use planning Uptake and adoption Land-use impacts on freshwater
<b>Clean Water Package</b>	MfE	A target of 90% of rivers and lakes swimmable by 2040 New maps and information on the current water quality for swimming Exclusion stock from waterways	Land & soil information Informed land-use planning Values and trade-offs Monitoring tools and technologies Land-use impacts on freshwater
<b>Soil objectives to support smarter soil management</b>	MPI	Soil ability to provide ecosystem services is maintained and enhanced Greenhouse gas emissions from soils are reduced Soil ability to provide food and fibre maintained and enhanced Freshwater quality enhanced through improved soil management	Soil health Value-added primary production Pathways to net-zero emissions Increased resilience to adverse events

<b>Initiative</b>	<b>NZ owner</b>	<b>Goals relevant to soil and land</b>	<b>Research themes / areas</b>
		Soils are more resilient to erosion and degradation Soil contamination reduced Soils are more resilient to adverse events (including flood and drought) Soils are more able to recover from natural hazards Soils are valued and optimally used	Soil contamination Land-use potential Land-use impacts on freshwater Meaningful engagement with iwi and hapū Values and trade-offs Monitoring tools and technologies Data analysis, storage, and quality assurance Transparency of data workflows Kaitiakitanga Informed land-use planning Uptake and adoption

## Appendix 2 – Global megatrends and implications for land and soil research

	GLOBAL MEGATREND	TRANPOSED TO NZ CONTEXT	RELEVANCE TO LAND / SOIL ISSUES
POLICY (& PHILOSOPHY)	<ul style="list-style-type: none"> <li>• Devolution of governance</li> <li>• Technology expanding range and power of decision-makers</li> </ul>	<ul style="list-style-type: none"> <li>• Growing importance of regional development and growth?</li> <li>• Building role of local government?</li> <li>• Policy reform – RMA evolution?</li> </ul>	<p><i>Bigger focus on location-specific options for soil use and management. Regional councils and sectors likely to become even more critical as frontline decision-makers</i></p>
	<ul style="list-style-type: none"> <li>• Ideas, identities and paranoia driving a wave of exclusion</li> <li>• Populism at far right and far left threatening liberalism</li> <li>• Strengthening of nationalistic/religious and ethnic movements</li> </ul>	<ul style="list-style-type: none"> <li>• Impact of protectionism elsewhere (e.g. UK and US) and the effect on our exports</li> <li>• Potential change in trade focus</li> <li>• Increase in view of national protectionism reducing palatability of overseas investment in favour of NZ ownership</li> </ul>	<p><i>A shift to other markets (such as China) may manifest as increased demand for good soil management and increased verification and provenance.</i></p> <p><i>Reduction in farm size and a returning focus on NZ ownership? Local owners more familiar with local soils? Or less willing to consider new approaches?</i></p>
ENVIRONMENT (CLIMATE & ENERGY)	<ul style="list-style-type: none"> <li>• Climate change</li> <li>• Increased storminess and volatility</li> <li>• Sea-level rise</li> </ul>	<ul style="list-style-type: none"> <li>• Land degradation</li> <li>• Potential for environmental refugees for Pacific Island territories</li> <li>• Climate shock?</li> <li>• NZ's agricultural emissions (increasing cows/acre and fertiliser use) increasingly unacceptable in a world facing climate crisis – social licence?</li> <li>• Increase in drought, fire?</li> </ul>	<p><i>Increased pressures resulting from climate shocks such as erosion, changing soil temperatures (may affect soil processes such as buffering and filtering) and the need for soil management to better account for extremes of drought and fire.</i></p> <p><i>Greater pressure to stabilise soil organic matter and increase soil carbon sequestration.</i></p> <p><i>As before, increased demand for good soil management that can be verified – important for securing domestic social licence to operate and overseas trade</i></p>
	<ul style="list-style-type: none"> <li>• Growing tensions over water use – water/food/energy nexus</li> <li>• Peak resources and global fertiliser regulation</li> <li>• Pressure to feed a growing population – 70% increase in food production needed by 2050 but as approaching peak resources</li> </ul>	<ul style="list-style-type: none"> <li>• Increased competition for water supply (domestic and overseas?)</li> <li>• Peak phosphorus</li> <li>• Policy shock leading to rapid increase in carbon price?</li> <li>• Tension between sustainability and intensification – trying to do more with less</li> <li>• Questions over sustainability of ongoing fertiliser and irrigation use</li> </ul>	<p><i>Greater demand for targeted and precision agriculture (irrigation, fertigation etc.) and a 'more for less'/low-input, high-output approach</i></p> <p><i>Greater need to match land use and management to soil/land capacity</i></p>

	GLOBAL MEGATREND	TRANPOSED TO NZ CONTEXT	RELEVANCE TO LAND / SOIL ISSUES
ENVIRONMENT (CLIMATE & ENERGY), con't	<ul style="list-style-type: none"> <li>• Demand for biofuel crops displacing food crops</li> <li>• OECD International Energy Agency goals of ¼ of all transportation fuel to come from biofuels by 2050</li> <li>• Growth of disease-resistant, high-nutritional quality and high-yield crops as a result of biotechnology</li> <li>• Smart cities/farms - farm system automation</li> <li>• Alternative options for agriculture – ‘soil-less farming’ and hydroponics</li> </ul>	<ul style="list-style-type: none"> <li>• Shift from geological to biological fuel production in New Zealand will change landscapes and land use</li> <li>• Potential for new crop and agricultural systems – and opening up of areas previously not considered suitable for agriculture</li> <li>• Potential for new crop and agricultural systems. Pressures on New Zealand cities less likely to see growth in agriculturally based cities</li> </ul>	<p><i>Increased pressures on land and water to support biofuel production. Likely increase in erosion as a result of deforestation, land-use change and at harvesting time</i></p> <p><i>Reduced pressures on land and water as crops are bred to be more drought-tolerant, require less input and agriculture thrives in areas previously not considered suitable for agriculture</i></p>
SOCIAL (AND HEALTH)	<ul style="list-style-type: none"> <li>• Population growth, rapid urbanisation, increase in refugees and immigrants</li> <li>• Rise in obesity, cardiovascular diseases and cancer, transmissible diseases penetrating borders, moving beyond ‘sick care’ to health management</li> <li>• Social inequality increasing with growth in the top 10% and bottom 10%</li> </ul>	<ul style="list-style-type: none"> <li>• Urban expansion and increased housing demand as a result of population growth and (environmental refugees – see above)</li> <li>• Increased imbalance between urban and rural communities</li> <li>• Increasing demand for ‘healthy’ and whole foods, produced organically and with few inputs (e.g. pesticides and fertilisers)</li> <li>• Clear and evidence-based product traceability and provenance</li> <li>• Dual pressures for affordable and premium products</li> </ul>	<p><i>Land-use change, loss of versatile soils, as well as increase in pressures/intensification in other areas to meet demand</i></p> <p><i>As before, increased demand for good soil management that can be verified – important for securing domestic social licence to operate and overseas trade</i></p> <p><i>Greater demand for targeted and precision agriculture (irrigation, fertigation etc.), a ‘more for less’ approach and local food production</i></p>
TECHNOLOGIES	<ul style="list-style-type: none"> <li>• Increased automation, artificial intelligence and disruptive technologies</li> <li>• Social media</li> <li>• Internet of things/hyper-connectivity</li> <li>• Technological literacy</li> </ul>	<ul style="list-style-type: none"> <li>• Potential for new crop and agricultural systems</li> <li>• Reputation/ social licence implications for primary industries (social media activists, e.g. bobby calf tapes, vegan blogger on <i>InterIslander</i>)</li> </ul>	<p><i>Reduced pressures on land and water as crops require less input and agriculture thrives in areas previously not considered suitable for agriculture</i></p> <p><i>As before, increased demand for good soil management that can be verified – important for securing domestic social licence to operate and overseas trade</i></p>

	GLOBAL MEGATREND	TRANPOSED TO NZ CONTEXT	RELEVANCE TO LAND / SOIL ISSUES
TECHNOLOGIES con't	<ul style="list-style-type: none"> <li>• Cloud-based and super-computing</li> <li>• Data-driven innovation</li> <li>• Increased piracy</li> <li>• Transparency, privacy and cybersecurity concerns</li> </ul>	<ul style="list-style-type: none"> <li>• Vast amount of data allows new insights into behaviour and response of environment</li> <li>• Individuals and agencies become concerned about who can access their data and what they will use it for</li> </ul>	<p><i>Potential to use data to drive improvements in soil management and verify the step-change (to secure domestic social licence to operate and overseas trade)</i></p> <p><i>Counter to leveraging data opportunities, which could shut-down new approaches for soil management</i></p>
ECONOMICS	<ul style="list-style-type: none"> <li>• Global financial collapse, interdependent economies/global marketplace, trade liberalisation/Free trade agreements (FTAs)</li> <li>• Shutting down of markets, trade/currency protectionism, sanctions</li> <li>• Economic imbalances/volatility in market prices</li> <li>• New tier of emerging nations driven by their growing middle classes</li> <li>• Shift in global economic/state power to the East</li> <li>• Rise of entrepreneurship</li> </ul>	<ul style="list-style-type: none"> <li>• Local economic growth</li> <li>• Resilience of primary industries to global recession?</li> <li>• Diversification away from dairy?</li> <li>• Specific production requirements (limits on amount/type of fertiliser use, etc.) under FTAs?</li> <li>• China, India etc. will be leading import/food demand; NZ set to benefit from a closer proximity and strengthening relationship with China</li> <li>• Increase in demand for premium products (vs. commodities) with good environmental credentials</li> </ul>	<p><i>As before, increased demand for good soil management that can be verified – important for securing domestic social licence to operate and overseas trade</i></p> <p><i>Greater demand for targeted and precision agriculture (irrigation, fertigation etc.) and a 'more for less approach'</i></p>
LEGAL	<ul style="list-style-type: none"> <li>• Employment regulations</li> <li>• Competitive regulations</li> <li>• Health and safety regulations</li> <li>• Product regulations</li> <li>• Anti-trust laws</li> <li>• Patent infringement</li> </ul>	<ul style="list-style-type: none"> <li>• High-compliance, low-trust environment reduces opportunity for innovation, practice change or data sharing</li> </ul>	<p><i>Shuts down new approaches for soil management in favour of sticking to 'what we know' and 'protecting what we own'</i></p>

### Appendix 3 – Review of progress on research priorities and actions for the earlier 2014–2017 Roadmap

This table outlines the research priority from the 2014–2017 Roadmap, indicates which SIG ranked it as a high-ranking priority (shaded cell in light blue for LMF and light green for LMG). The actions taken to address the priorities are listed together with a statement of progress and examples or evidence of what has been completed (bulleted citations). To the right-hand side of the table, comments on what still needs to be done to address that priority are listed together with an assessment of the completeness of that research (shaded cell far right – red indicates large gaps still need to be addressed and orange indicates that progress towards addressing the priority is well underway though not complete).

Research priority from June 2014	High ranking priority?		Recommended actions from Roadmap	General progress against actions	Examples of research underway or completed that have been <u>funded</u> or <u>supported</u> by SIGs or relevant to research priorities (since development of Strategic Roadmap, many are Envirolinks)	Research gaps remaining in each priority	Research completeness
	LMF	LMG					
Framework to explore future land-use options and its uptake (E19)			Collaborate with MPI and the wider natural resources sector (NRS) to establish a national land / soil strategy	Both SIGs co-authored the MPI-commissioned Future Soils suite of reports that identified pressures on the soil and land resource and opportunities to address them.	<ul style="list-style-type: none"> <li>Collins A, Mackay A, Basher L, Schipper L, Carrick S, Manderson A, Cavanagh J, Clothier B, Weeks E, Newton P 2014. Phase 1: Looking Back: future requirements for soil management in New Zealand. <a href="https://www.mpi.govt.nz/document-vault/10397">https://www.mpi.govt.nz/document-vault/10397</a></li> <li>Envirolink Tools starting July 2017: interoperable modelling systems for integrated land and water management</li> <li>Spiekermann R, Jolly B, Herzig A, Medyckyj-Scott D 2017. Innovative data analysis for land resources – the role of provenance. Landcare Research Contract Report LC2838 for the MBIE-funded Innovative Data Analysis Programme.</li> <li>Cavanagh JE, Munir K 2016. Development of soil guideline values for the protection of ecological receptors (Eco-SGVs): technical document. Envirolink Tools Grant: C09X1402. Landcare Research Contract Report LC2605 for Regional Waste and Contaminated Land Forum, Land Monitoring Forum and Land Managers Group.</li> <li>Collins A, Lynch B 2016. Strategic guidance for land science. Landcare Research Contract Report LC2509 for Hawke's Bay Regional Council.</li> <li>Simcock R, Samarasinghe O 2015. Establishment of mānuka for honey production at Northland College Farm: feasibility study: Draft report. Landcare Research Contract Report LC2407 for Ministry for Primary Industries.</li> <li>Cradock-Henry N 2017. SLMACC Mind the Gaps: synthesis and systematic review of climate change adaptation in New Zealand's primary industries.' Job number 683120-0170 (in progress).</li> <li>Rutledge DT, Baisden WT, Cradock-Henry N, Keller E, Mason N, Mullen B, Overton J McC, Palmer D, Sood A, Stuart S, Tait A, Timar L, Vetrova V, Zammit C 2017. Climate change impacts and implications for New Zealand to 2100. Synthesis report: RA2 Uplands case study. Upper Waitaki Catchment.</li> <li>Kirk N 2017. Systems thinking to improve planning. Envirolink 1834-ESRC173.</li> <li>Fenemor A 2016. Peer review of 'Climate change impacts on agricultural water resources and flooding'. Landcare Research Contract Report LC2708 for NIWA.</li> <li>Eppink F, Wright W 2016. Scan of long-term environmental issues: land and biodiversity domains. Landcare Research Contract Report LC2647 for The Treasury.</li> <li>Climate change and variability: Horizons region. Envirolink 1619-HZLC126 (NIWA).</li> <li>Manawatū–Wanganui estuaries habitat mapping vulnerability assessment and monitoring recommendations related to issues of eutrophication and sedimentation. Envirolink 1624-HZLC127 (Wriggle Ltd).</li> <li>Pollacco J 2015. Assessing soil vulnerability to ponding using the physically based HyWat model. Landcare Research Contract Report LC2411 for Landcare Research.</li> <li>Rutledge D, Price R, Hart G 2015. National guidelines for monitoring and reporting effects of land fragmentation. Landcare Research Contract Report LC2144.</li> <li>Ross C, Sutherland A 2016. Manawatū District Council's District Plan – Rural Zone review: investigation of versatile soils and high-class land in the Manawatū District. Landcare Research Contract Report LC2617 for Manawatu District Council.</li> <li>Collins A, Mackay A, Basher L, Schipper L, Carrick S, Manderson A, Cavanagh J, Clothier B, Weeks E, Newton P 2014. Phase 1: Looking Back: future requirements for soil management in New Zealand. <a href="https://www.mpi.govt.nz/document-vault/10397">https://www.mpi.govt.nz/document-vault/10397</a></li> </ul>	Work underway in Our Land & Water (OLW), which is relevant. However, a wide variety of models with the capacity to explore options and trade-offs exists, but an agreed approach and validation are lacking	Still large gaps
Potential risk scenarios for land use and management (E20)							
Rate and impact of high-class soil/ versatile land loss (A3)	Yes					Have measures of urban expansion in larger cities but not across regions. Considerable debate still on what constitutes optimal land use.	Still large gaps

Research priority from June 2014	High ranking priority?		Recommended actions from Roadmap	General progress against actions	Examples of research underway or completed that have been <u>funded</u> or <u>supported</u> by SIGs or relevant to research priorities (since development of Strategic Roadmap, many are Envirolinks)	Research gaps remaining in each priority	Research completeness
	LMF	LMG					
Cost benefit of best management practices including whole-farm planning (A1)		Yes	Review primary sector strategies for alignment and additionality opportunities moving towards a collaborative programme of work with MPI and primary sector	<p><i>Good relationship developed with MPI and several primary sector organisations (Dairy NZ, Beef &amp; Lamb) attending LMG meetings. Specific focus has been on farm plans, riparian management and stock exclusion, including with the MfE/MPI Water Directorate</i></p>	<ul style="list-style-type: none"> <li>Marden M, Phillips C 2015. A review of research on the erosion control effectiveness of naturally reverting mānuka and kānuka implications for erosion mitigation of space-planted mānuka on marginal hill country. Landcare Research Contract Report LC2280.</li> <li>Manderson A 2017. Final completion report for Large Advice grant 1753-HZLC138, Soil conservation FEP riparian. Landcare Research contract Report LC3008.</li> <li>Buxton R 2017. Final completion report for Medium Advice grant 1766-WCRC162, Sphagnum moss harvesting impacts. Landcare Research contract Report LC3009.</li> <li>Walsh P, Soliman T, Greenhalgh S, Mason N, Palmer D 2017. Valuing the benefits of permanent forests: final report. Landcare Research Contract Report LC2788 for Ministry for Primary Industries.</li> </ul>	<p><i>Despite relationship-building with the primary sector and MPI, there still remains a gap around our knowledge of the effectiveness as well as the costs and benefits of different good management practices. More information on cost-benefits may help to increase the rate of adoption and uptake.</i></p>	Still large gaps
Develop farm-scale S-map coverage and interoperability (A2)			Participate in establishment of S-map governance group and develop collaborative programme of funding for S-map	<p><i>Collaborative work underway (funded through Envirolink Tools and LR SSIF) to identify methods and standards for the preparation of (farm-scale) soil maps, and to assess the quality of a prepared (farm) soil map and supporting data</i></p>	<ul style="list-style-type: none"> <li>Carrick S, Hainsworth S, Lilburne L, Fraser S 2014. S-map @ the farm-scale: towards a national protocol for soil mapping for farm nutrient budgets. In: Currie LD, Christensen CL eds. <i>Nutrient management for the farm, catchment and community</i>. Occasional Report No. 27. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand.</li> <li>Grealish G 2017. Nutrient management for the farm, catchment and community: farm soil mapping protocols and guidelines. Landcare Research Report LC3050. Envirolink C09X1606 New Zealand soil mapping protocols and guidelines. <a href="http://www.envirolink.govt.nz/assets/Envirolink/Tools/R12-4-New-Zealand-soil-mapping-protocols-and-guidelines.pdf">http://www.envirolink.govt.nz/assets/Envirolink/Tools/R12-4-New-Zealand-soil-mapping-protocols-and-guidelines.pdf</a></li> <li>Ritchie A 2015. S-map WFS for Overseer. Landcare Research Contract Report LC2368.</li> <li>Belliss S, Lilburne L, Carrick S 2016. Results of online survey of soil factsheets. Landcare Research Contract Report LC2465.</li> <li>Envirolink NLRC180. Communicating soil management.</li> <li>Envirolink MLDC102. Marlborough soil data to S-Map.</li> <li>Envirolink 1580. S-map for two Gisborne stations.</li> <li>Envirolink HBRC221. S-map training workshops. Aislabie J, Collins A, McLeod M, Sutherland A, Grant D 2017. S-map training workshop: what it is, what it can do and how to operate it. Landcare Research Contract Report LC2890 for Hawke's Bay Regional Council.</li> <li>Envirolink NLRC195. Soil map and farm planning Northland. Envirolink Medium Advice Grant 1724-NLRC195, Soil map and farm planning. May 2017.</li> <li>Envirolink MLDC118. Cost-effective soil mapping Marlborough Sounds – workshop. Final report to MBIE for Envirolink Advice Grant C09X1602, 1704-MLDC118, Cost-effective soil mapping Marlborough Sounds (workshop). October 2016.</li> <li>Envirolink MLDC135. Evaluation of S-map water retention predictions, by comparison with Wairau Valley soil samples. Landcare Research Contract Report LC3088.</li> <li>Envirolink MLDC133. S-map fact sheets Wairau Valley. Landcare Research Contract Report number LC3084.</li> <li>Odgers NP, Roudier P 2017. Potential sources of scorpan covariates for digital soil mapping in New Zealand. Landcare Research Contract Report LC2894.</li> <li>Manderson A, Hainsworth S, Grealish G 2017. S-map options for the Horizons Region. Landcare Research Contract Report LC2892 for Horizons Regional Council.</li> <li>Pollacco JAP 2017. Deriving Green-Ampt parameters from S-map data. Landcare Research Contract Report LC2825 for NIWA.</li> <li>Pollacco JAP 2017. An unsaturated hydraulic conductivity pedotransfer function computed from bimodal soil-water characteristic curves. Landcare Research Contract Report LC2726.</li> <li>Pollacco J 2016. Literature review of hydrological processes of soils with rock fragments. Landcare Research Contract Report LC27688 for Landcare Research.</li> <li>Pollacco JAP, Hedley C 2016. Linking field measurements of soil moisture to S-map information. Landcare Research Contract Report LC 2652 for Landcare Research.</li> <li>Palmer D, Malone B, Carrick S, Fraser S, Eger A 2016. Digital soil modelling and mapping across</li> </ul>	<p><i>Excellent progress has been made through the LMF and the Funders Group. Attention still required to complete (accelerate) coverage and ensure a sustainable funding pathway for the underpinning infrastructure (e.g. through SSIF infrastructure review, licensing).</i></p>	Proceeding
Enhance coverage, quality & interoperability of S-map (B5)	Yes			<p><i>LMF was fundamental to the establishment of the S-map Funders Group and they have supported new membership from councils. The funders were critical to securing MIBE Endeavour to support research advancement, continue to fund coverage (particularly Waikato, Hawke's Bay, Canterbury and Greater Wellington) and contribute to SSIF proposals and allocation decisions.</i></p>			

Research priority from June 2014	High ranking priority?		Recommended actions from Roadmap	General progress against actions	Examples of research underway or completed that have been <u>funded</u> or <u>supported</u> by SIGs or relevant to research priorities (since development of Strategic Roadmap, many are Envirolinks)	Research gaps remaining in each priority	Research completeness
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Fitness of New Zealand Land Resources Inventory (NZLRI) and Land Use Capability (LUC) for contemporary use (A4)	Yes	Yes	Participate in establishment of Land Use Capability Classification System (LUCCS) governance group and develop collaborative programme of funding	<i>Both SIGs were critical to the establishment of the pan-sector LUCCS governance group. Both LMG and LMF led the development of a 'strategy on a page' and have sought support from their members. More work is needed to establish investment mechanisms and links to Our Land &amp; Water (OLW).</i>	<ul style="list-style-type: none"> <li>Kaihiku-Hokonui region, Southland. Landcare Research Contract Report LC2473.</li> <li>Ritchie A 2015. S-map WFS for Overseer (Envirolink Tools project C09X1301). Landcare Research Contract Report LC2368 for Marlborough District and Hawke's Bay Regional Councils.</li> <li>Grey Valley legacy data has been converted to an S-map compatible format for upload. This was a test case and the S-map Funders Group are currently looking at sources of funding to enable the conversion and upload of a much greater volume of legacy data held by MWLR. Next meeting 15 March 2018. Grey Valley job 682204-0136</li> <li>Barringer J 2015. Land use capability information recovery: a Gisborne example. Landcare Research Contract Report LC2212. Envirolink contract 152-GSDC120.</li> <li>Envirolink GSDC136. LUC Legend.</li> <li>Summary notes from meeting and field trip on land resource data and forestry issues in the Marlborough Sounds. Envirolink 1704-MLDC118 (Landcare).</li> <li>Barringer J, Lynn I, Basher L, Fraser S, McLeod M, Price R, Shepherd J, Spiekermann R, Grant L 2018. Use of modern technology including LiDAR to update the New Zealand Land Resource Inventory. Landcare Research Contract Report LC3091 for Ministry for Primary Industries.</li> <li>Ausseil A-GE, Manderson A, Rutledge D, Wyman T, Osborne T 2015. Land use mapping review for Ministry for the Environment. Landcare Research Contract Report LC2356 for the Ministry for the Environment.</li> <li>McKergow L 2015. FOCUS: Maximising the effectiveness of farm plans. NIWA Client Report No. HAM2015-026. Prepared for Envirolink</li> <li>Brown P 2015. Survey of rural decision makers. Landcare Research NZ Ltd. www.landcareresearch.co.nz/srdm2015 (accessed 8 June 2017).</li> <li>Envirolink Tools starting July 2017: improving uptake of decision support system (DSS) tools.</li> <li>Kalaugher E, Kaine G, Hyslop J, Kirk N, Wagner CH, Harmsworth G 2017. Exploring the role of values and place in perceptions of natural resource policy: the case of Lake Taupō. Landcare Research Contract Report LC3006.</li> <li>Manderson A, Lilburne L, Hedley C 2016. Options and implications for implementing nutrient rules using soil data according to OVERSEER best practice. Landcare Research Contract Report LC2653 for Horizons Regional Council.</li> <li>McIvor I, McKergow L, Reid L 2016. Evaluation of the effectiveness of conservation planting and farm plans: a discussion document. Landcare Research Contract Report LC2546 for Greater Wellington Regional Council.</li> <li>Collins K 2016. NZ Sustainability Dashboard: building a community of practice. Landcare Research Contract Report LC2518. Prepared for the Agribusiness Group.</li> <li>Manderson A 2015. Nitrogen leaching estimates for sheep and beef farming in the Mangatainoka catchment. Landcare Research Contract Report 2015/EXT/1450.</li> <li>Fenemor A, Price R, Green S 2016. Modelling the source and fate of nitrate-nitrogen losses from Waimea Plains land uses. Landcare Research Contract Report LC2459. Envirolink 1592-TSDC116.</li> <li>Envirolink TSDC116. SPASMO extension modelling work.</li> <li>High resolution monitoring of nitrate in agricultural catchments – a case study on the Manawatu River, New Zealand. Envirolink 1720-HZLC135 (FLRC).</li> <li>Saggar S, Giltrap D 2016. Development of a framework for estimating nitrous oxide emissions from fertiliser use on different slope pasture classes. Final Report. Landcare Research Contract Report LC 2502 for Ministry for Primary Industries.</li> <li>M McLeod 2015. N-leaching under lucerne: final report. Landcare Research Contract Report LC2398 for Taupō Lake Care Inc.</li> <li>McLeod M 2015. N-leaching under lucerne: data for Winter-Spring 2014. Landcare Research Contract Report LC2394 for Taupō Lake Care Inc.</li> </ul>	<i>More work is required to modernise the LUCCS to enable use of new data; engage key agencies/stakeholders to support the maintenance, modernisation and funding of LUCCS; ensure the LUCCS use is based on a nationally consistent framework, capable of being used at many scales, and is used appropriately in a regulatory setting, and user capability is developed.</i>	Proceeding
Farmer motivation and behaviour for improved uptake (D15)		Yes	Workshop with Our Land & Water (OLW) development team to identify opportunities for collaboration and ensure on-going role in technical advisory or governance of OLW	<i>At governance level regional councils represented by Mike McCartney. Roles in programmes or technical advisory capacity.</i>	<ul style="list-style-type: none"> <li>McIvor I, McKergow L, Reid L 2016. Evaluation of the effectiveness of conservation planting and farm plans: a discussion document. Landcare Research Contract Report LC2546 for Greater Wellington Regional Council.</li> <li>Collins K 2016. NZ Sustainability Dashboard: building a community of practice. Landcare Research Contract Report LC2518. Prepared for the Agribusiness Group.</li> <li>Manderson A 2015. Nitrogen leaching estimates for sheep and beef farming in the Mangatainoka catchment. Landcare Research Contract Report 2015/EXT/1450.</li> <li>Fenemor A, Price R, Green S 2016. Modelling the source and fate of nitrate-nitrogen losses from Waimea Plains land uses. Landcare Research Contract Report LC2459. Envirolink 1592-TSDC116.</li> <li>Envirolink TSDC116. SPASMO extension modelling work.</li> <li>High resolution monitoring of nitrate in agricultural catchments – a case study on the Manawatu River, New Zealand. Envirolink 1720-HZLC135 (FLRC).</li> <li>Saggar S, Giltrap D 2016. Development of a framework for estimating nitrous oxide emissions from fertiliser use on different slope pasture classes. Final Report. Landcare Research Contract Report LC 2502 for Ministry for Primary Industries.</li> <li>M McLeod 2015. N-leaching under lucerne: final report. Landcare Research Contract Report LC2398 for Taupō Lake Care Inc.</li> <li>McLeod M 2015. N-leaching under lucerne: data for Winter-Spring 2014. Landcare Research Contract Report LC2394 for Taupō Lake Care Inc.</li> </ul>	<i>Remains a significant research gap for many agencies including the Water Directorate. Underpins effective delivery of many of the research priorities</i>	Still large gaps
Better incorporation of Nitrogen (N) & Phosphorus (P) data within models (C13)					<ul style="list-style-type: none"> <li>High resolution monitoring of nitrate in agricultural catchments – a case study on the Manawatu River, New Zealand. Envirolink 1720-HZLC135 (FLRC).</li> <li>Saggar S, Giltrap D 2016. Development of a framework for estimating nitrous oxide emissions from fertiliser use on different slope pasture classes. Final Report. Landcare Research Contract Report LC 2502 for Ministry for Primary Industries.</li> <li>M McLeod 2015. N-leaching under lucerne: final report. Landcare Research Contract Report LC2398 for Taupō Lake Care Inc.</li> <li>McLeod M 2015. N-leaching under lucerne: data for Winter-Spring 2014. Landcare Research Contract Report LC2394 for Taupō Lake Care Inc.</li> </ul>	<i>Significant amount of work underway in OLW, which would be relevant.</i>	Proceeding

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	LMF	LMG					
Impact of cumulative effects for ecosystems of on- and off-site activities (B7)					<ul style="list-style-type: none"> <li>Manderson A, Dymond J, Ausseil A-G 2015. Climate change impacts on water quality outcomes from the Sustainable Land Use Initiative (SLUI). Horizons Regional Council. <a href="http://www.envirolink.govt.nz/Envirolink-reports/1-NLCC1/1522-HZLC116/">http://www.envirolink.govt.nz/Envirolink-reports/1-NLCC1/1522-HZLC116/</a> (Report, 2015)</li> <li>Lambie S, Lear G, Müller K, Wakelin S, Smaill S, Orwin K 2017. Microbial function and adaptation in response to climate change driven drought and the resulting effects on plant production and nutrient cycling: final report. Landcare Research Contract Report LC3054.</li> <li>Greenaway A 2016. CP1.1 Ecosystem based management (EBM) within New Zealand's existing legislative framework: the Sustainable Seas Challenge (in progress). Job 224313-1001.</li> <li>Rutledge DT, Ausseil A-GE, Baisden T, Bodeker G, Booker D, Cameron MP, Collins DBG, Daigneault A, Fernandez M, Frame B, Keller E, Kirschbaum MUF, Lewis J, Mullan B, Reisinger A, Sood A, Stuart S, Tait A, Teixeira E, Timar L, Zammit C 2016. Identifying feedbacks, understanding cumulative impacts and recognising limits: an integrated assessment. Climate change impacts and implications project synthesis. Report RA3. MBIE contract C01X1225. Landcare Research Contract Report LC2785 for NIWA.</li> <li>Barron M, Pech R, Christie J, Rait A, Byrom A, Elliott G 2017. Climate change impacts and implications for New Zealand to 2100: synthesis report XXX. An integrated assessment in the alpine case study. Landcare Research Contract Report LC2735 for NIWA.</li> <li>Ausseil AGE, Bodmin K, Daigneault A, Teixeira E, Keller ED, Taisden T, Kirschbaum MUF, Timar L, Dunningham A, Zammit C, Stephens S, Bell R, Cameron M, Blackett P, Harmsworth G, Frame B, Reisinger A, TaitA, Rutledge D 2016. Climate change impacts and implications for New Zealand to 2100: synthesis report RA2: lowland case study. Landcare Research Contract Report LC2714 for NIWA.</li> <li>Assessing condition of frostflat heathland at Waipunga, a critically threatened rare ecosystem in Hawkes Bay. Envirolink contract 1553-HBRC209 (Landcare).</li> <li>Whitehead D, Kirschbaum M 2015. Milestone report 7.1.1: modelling scenarios of the effects of management and environmental changes on productivity and carbon stocks, December 2015. Landcare Research Contract Report LC2443 for NZAGRC/MPI.</li> <li>Weeks E, Collins A 2015. Environmental Monitoring and Reporting (EMaR) land and soil indicators workshop report. Palmerston North, National Land Resource Centre.</li> <li>Jones H, Drewry J, Burton A, Burgess D, Wyatt J 2015. Knowing Our Land: a review of land and soil state of the environment monitoring and reporting in New Zealand. Scoping report of the Environmental Monitoring and Reporting (EMaR) Land project.</li> <li>Daigneault A, Dymond J, Tanner C, Burge O, Carswell F 2017. An ecosystem services assessment for the Living Water Partnership – Upper Wairua Catchment. Landcare Research Contract Report LC2811 for Living Water Partnership.</li> <li>Ecosystem Services – Ecosystems Services – Identifying Priorities for Fonterra. Landcare Research Contract Report LC2799 for Fonterra Research Centre Ltd.</li> <li>Medyckyj-Scott D, Stock K, Gibb R, Gahegan M, Dzierzon H, Schmidt J 2016. Our Land and Water National Science Challenge: a data ecosystem for land and water data to achieve the Challenge mission. Landcare Research Contract Report LC2664 for Our Land &amp; Water National Science Challenge.</li> <li>Ecosystem health in highly modified lowland catchments – Karamu catchment, Hawkes Bay. Envirolink 1733-HBRC223.</li> <li>North H, Pairman D, Belliss S 2015. Agricultural land use in Mid-Canterbury, 2012-14. Landcare Research Contract Report LC2278 for Ministry for the Environment.</li> <li>North H, Belliss S, Pairman D 2015. Waimakariri district agricultural land use map. Landcare Research Report LC2227.</li> <li>North H, Belliss S, Pairman D 2016. Temuka district agricultural land use map. Landcare Research Contract Report LC2529 for Environment Canterbury.</li> <li>Pairman D, Belliss S, McNeill 2016. Land cover, crop type and land use mapping in Hawkes Bay.</li> </ul>		
Value of soil natural capital stocks and ecosystem services (B6)	Yes		Secure regional council role on Land Domain Technical Advisory Group (TAG).	<p><i>LMF have representation on the Land TAG and have also worked closely with MfE and StatsNZ as part of the Environmental Monitoring and Reporting (EMaR) programme.</i></p> <p><i>More could be done to progress a collaborative work programme with the NRS, and MfE and MPI in particular, around soil and land ecosystem services.</i></p>	<ul style="list-style-type: none"> <li>Weeks E, Collins A 2015. Environmental Monitoring and Reporting (EMaR) land and soil indicators workshop report. Palmerston North, National Land Resource Centre.</li> <li>Jones H, Drewry J, Burton A, Burgess D, Wyatt J 2015. Knowing Our Land: a review of land and soil state of the environment monitoring and reporting in New Zealand. Scoping report of the Environmental Monitoring and Reporting (EMaR) Land project.</li> <li>Daigneault A, Dymond J, Tanner C, Burge O, Carswell F 2017. An ecosystem services assessment for the Living Water Partnership – Upper Wairua Catchment. Landcare Research Contract Report LC2811 for Living Water Partnership.</li> <li>Ecosystem Services – Ecosystems Services – Identifying Priorities for Fonterra. Landcare Research Contract Report LC2799 for Fonterra Research Centre Ltd.</li> <li>Medyckyj-Scott D, Stock K, Gibb R, Gahegan M, Dzierzon H, Schmidt J 2016. Our Land and Water National Science Challenge: a data ecosystem for land and water data to achieve the Challenge mission. Landcare Research Contract Report LC2664 for Our Land &amp; Water National Science Challenge.</li> <li>Ecosystem health in highly modified lowland catchments – Karamu catchment, Hawkes Bay. Envirolink 1733-HBRC223.</li> </ul>	<p><i>Good progress on environmental reporting and EMaR</i></p> <p><i>Further potential to collaborate, characterise and implement natural capital approaches within regional councils. Also opportunity to bring together thinking with work on land-use capability and land-use suitability (see Research Priority 3)</i></p>	
Enhance coverage, quality & inter-operability of land cover and land-use data (B5a)	Yes		Participate in pan-sector governance group and develop collaborative programme of funding for land cover and land use	<p><i>LMF was a critical partner in a proposal for MBIE Endeavour funding for remote sensing research and continuation of Land Cover Database (LCDB).</i></p> <p><i>LMF supported securing MBIE Endeavour funding for Innovative</i></p>	<ul style="list-style-type: none"> <li>North H, Pairman D, Belliss S 2015. Agricultural land use in Mid-Canterbury, 2012-14. Landcare Research Contract Report LC2278 for Ministry for the Environment.</li> <li>North H, Belliss S, Pairman D 2015. Waimakariri district agricultural land use map. Landcare Research Report LC2227.</li> <li>North H, Belliss S, Pairman D 2016. Temuka district agricultural land use map. Landcare Research Contract Report LC2529 for Environment Canterbury.</li> <li>Pairman D, Belliss S, McNeill 2016. Land cover, crop type and land use mapping in Hawkes Bay.</li> </ul>	<p><i>Land cover data is urgently required for a number of EMaR land indicators. There is significant interest in the NRS to ensure continuation of the LCDB and underpinning research</i></p> <p><i>Land use remains one of the biggest information gaps and needs addressing to</i></p>	Still large gaps

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Improved knowledge of the spatial and temporal distribution and accumulation of contaminants (B8)			Secure regional council role on Land Domain Technical Advisory Group	<p><i>Data Analysis, which is already producing workflows for land-use characterisation. Several councils have invested in research to characterise paddock-scale land use and land-use change.</i></p> <p><i>LMF have representation on the Land TAG and have also worked closely with MfE and StatsNZ as part of EMaR.</i></p> <p><i>LMF support for the MBIE Endeavour programme represents a major success.</i></p>	<ul style="list-style-type: none"> <li>Landcare Research Contract Report LC2737.</li> <li>North H, Belliss S, Pairman D 2017. Winter livestock forage map: Canterbury region 2016. Landcare Research Contract Report LC2742.</li> <li>Envirolink ESRC274. Environment Southland Land Use Mapping Methodology Review. Final completion report for Envirolink Medium Advice Grant 1645-ESRC274, Environment Southland Land Use Mapping Methodology Review. April 2016.</li> <li>Envirolink HZLC137. National protocol for site numbering and naming. National environmental monitoring site identification. Envirolink 1729-HZLC137 (Landcare).</li> <li>Barringer J, Lynn I, Basher L, Fraser S, McLeod M, Price R, Shepherd J, Spiekermann R, Grant L 2018. Use of modern technology including LiDAR to update the New Zealand Land Resource Inventory. Landcare Research Contract Report LC3091.</li> <li>Pairman D, Newsome P 2017. LCDB and LUM integration experiment extension and national trial. Landcare Research Contract Report LC2998.</li> <li>Shepherd J, Pairman D, Jolly B 2016. Forestry change detection with Sentinel-2A imagery. Landcare Research Contract Report LC2769 for Ministry for the Environment.</li> <li>Wiser SK 2106. Guiding future vegetation mapping efforts: results of 2016 workshop. Landcare Research Contract Report LC2679 for Department of Conservation.</li> <li>Holdaway RJ 2016. Design of New Zealand's 8-km grid-based plot network: Static master data. Landcare Research Contract Report LC2527 for the Ministry for the Environment.</li> <li>Rutledge D, Manderson A, Lilburne L, Ausseil A-G, Belliss S, Price R 2016. Methodology for a GIS-based land-use map for Southland: a review. Landcare Research Contract Report LC2491 for Environment Southland.</li> <li>Cavanagh J, Munir K 2016. Development of soil guideline values for the protection of ecological receptors (Eco-SGVs): Landcare Research Contract Report LC2605.</li> <li>Cavanagh J, McNeill S, Arienti C, Rattenbury M 2015. Background soil concentrations of selected trace elements and organic contaminants in NZ. Landcare Research Contract Report LC2440.</li> <li>Envirolink GSDC128. Awapuni drain contaminant monitoring.</li> <li>Cavanagh J-A E, Munir K 2018. Assessing cadmium uptake in New Zealand agricultural systems II. Landcare Research Contract Report LC3088.</li> <li>Cavanagh J 2017. Developing a sampling plan for soil fluorine in New Zealand agricultural soils. Landcare Research Contract Report LC3063.</li> <li>Eger A 2017. Capability fund project on reactive transport modelling with CrunchFlow: application to soil lysimeters and other future opportunities. Landcare Research Contract Report LC3018.</li> <li>Ross C 2016. 2016 peer review report No. 30 – Land Rehabilitation, Martha Mine, Waihi. Landcare Research Contract Report LC2980 for OceanaGold NZ Ltd.</li> <li>Cavanagh J 2016. Assessment of herbicide residues in a mid-Canterbury farm. Landcare Research Contract Report LC2975 for Geoff Brown.</li> <li>Cavanagh J 2017. Ecotoxicity of fluoride in soil. Landcare Research Contract Report LC2740 for Fertiliser Association of New Zealand.</li> <li>Cavanagh J, Munir K, McNeill S, Stevenson B 2017. Review of soil quality, including trace elements, State of the Environment monitoring programme. Lincoln, Landcare Research.</li> <li>Weeks E, Collins A 2015. Environmental Monitoring and Reporting (EMaR) land and soil indicators workshop report. Palmerston North, National Land Resource Centre.</li> <li>Envirolink HBRC226. Soil quality trace element SOE monitoring review.</li> <li>Hedley C, McNeill S, Roudier P, Mudge P, Schipper L 2017. A balanced sampling framework for monitoring soil organic carbon stocks in New Zealand's managed grasslands. Landcare Research Contract Report LC2845 for MPI.</li> <li>Cavanagh J 2017. Soil quality trace element SOE monitoring review. Completion report for Envirolink large advice grant 1757-HBRC226.</li> </ul>	<p><i>support decision-making and environmental reporting in regional councils (e.g. EMaR) and across the NRS.</i></p> <p><i>Still no national-scale research programme in this area, with much of the research funded through the councils.</i></p>	<p>Still large gaps</p>
Cost-effective indicator of soil health for national reporting (B9)	Yes					<p><i>Progressing as part of EMaR and environmental reporting. Securing MBE Endeavour funding will advance the research frontier significantly.</i></p>	<p>Proceeding</p>

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Scientific basis for setting of water quality impacts (C10)	Yes				<ul style="list-style-type: none"> <li>Stevenson BA, Mudge OL 2017. A review of the Total N soil quality indicator for Waikato Regional Council. Landcare Research Contract Report LC2820 for Waikato Regional Council.</li> <li>Final progress report for GRA Project 'An innovative solution for accurate and affordable estimates of soil organic carbon' (Project No. SOW04-FTRG-LCR-CH2) in collaboration with CSIRO (Raphael Viscarra Rossel). New Zealand's Contribution to the Filling the Research Gap Funding Round 1. Landcare Research Contract Report LC2734 for MPI.</li> <li>Final progress report for GRA Project 'Farm scale assessment of SOC from disaggregated national/regional scale models' (Project no. SOW04-FTRG1-LCR-CH) in collaboration with University of Sydney (Alex McBratney, Budiman Minasny, Brendan Malone).</li> <li>Final Report. Landcare Research Contract Report LC2701 for Alice Ryan, Senior Policy Analyst, MPI.</li> <li>Price R 2016. Review of MfE R code for soil health and land use indicators. Landcare Research Contract Report LC2663 for MfE.</li> <li>Hedley C. Quarterly Progress Report (10): October-December 2015: an innovative solution for accurate and affordable estimates of soil carbon. Landcare Research Contract Report LC2438 for MPI (via NZAGRC).</li> <li>Envirolink HZLC131. Implementing nutrient management rules.</li> <li>Envirolink MAG 1808-MLDC135. Soil water holding capacity data to improve water quality policy decision making (LC4003).</li> <li>Monks A, Burrows L 2017. Effects on terrestrial vegetation of enhanced southern lakes hydrology scenarios. Landcare Research Contract Report LC2779 for Meridian Energy New Zealand Ltd.</li> <li>Wairau River-Wairau Aquifer interaction report. Envirolink contract 1514-MLDC96 (Lincoln Agritech).</li> <li>Climate change impacts on water quality outcomes from the Sustainable Land Use Initiative (SLUI). Envirolink 15200-HZLC116 (Landcare).</li> <li>Envirolink Tools starting July 2017: interoperable modelling systems for integrated land and water management.</li> <li>Singers, N, Rogers G 2014. A classification of New Zealand's terrestrial ecosystems. DOC report.</li> <li>Walker S, Cieraad E, Barringer J 2015. The Threatened Environment Classification for New Zealand 2012: a guide for users. Landcare Research Contract Report LC2184.</li> <li>Collins A, Mackay A, Basher L, Schipper L, Carrick S, Manderson A, Cavanagh J, Clothier B, Weeks E, Newton P 2014. Phase 1: Looking Back: future requirements for soil management in New Zealand. <a href="https://www.mpi.govt.nz/document-vault/10397">https://www.mpi.govt.nz/document-vault/10397</a></li> <li>Dymond JR, Herzig A, Basher L, Betts HD, Marden M, Phillips CJ, Ausseil A-GE, Palmer DJ, Clark M, Roygard J 2016. Development of a New Zealand SedNet model for assessment of catchment-wide soil-conservation works. <i>Geomorphology</i> 257: 85-93. <a href="http://doi.org/10.1016/j.geomorph.2015.12.022">http://doi.org/10.1016/j.geomorph.2015.12.022</a></li> <li>Betts H, Marden M 2015. Preliminary report on ground reconnaissance and aerial survey of bank/cliff erosion in the TANK catchments, Hawke's Bay. Landcare Research Contract Report LC2517 for Hawke's Bay Regional Council.</li> <li>Betts H, Marden M 2016. Preliminary report on ground reconnaissance and aerial survey of bank/cliff erosion in the Porangahau and coastal catchments, Hawke's Bay. Landcare Research Contract Report LC2511 for Hawke's Bay Regional Council.</li> <li>Phillips C, Marden M, Betts H, Basher L 2017. Effectiveness of riparian buffers for trapping sediment in steepland plantation forests. Landcare Research Contract Report LC3039.</li> <li>Lambie SM 2017. Monitoring of Lake Ruatuna silt trap system. Landcare Research Contract Report LC3014 for Department of Conservation.</li> <li>Daigneault A, Dymond J, Basher L 2017. Kaipara Harbour sediment mitigation study: catchment economic modelling. Landcare Research Contract Report LC2905 for Streamlined Environmental Ltd.</li> <li>Betts H, Spiekermann R, Dymond J 2017. SedNetNZ modelling of sediment sources and loads from</li> </ul>	Significant amount of work underway in OL&W, which would be relevant.	
Classify NZ catchment according to pressure, state and impact (C14)			<p>Convene a land and water SIG alignment workshop</p> <p>Work with MfE on a shared approach to setting research priorities</p> <p>Cross-reference SIG RS&amp;T strategies to identify priorities that fall within a common framework</p> <p>Set in place a collaborative work programme to support implementation of freshwater reforms across SIGs and with MfE</p>	<p><i>A cross-SIG workshop was held during the development of the Roadmap.</i></p> <p><i>Useful discussions were held with both MfE and MPI on land-use effects, good management practice and research needs, but not yet considered a joint programme of work.</i></p> <p><i>LMF again, supported MBIE Endeavour bids in this area.</i></p>	<ul style="list-style-type: none"> <li>Collins A, Mackay A, Basher L, Schipper L, Carrick S, Manderson A, Cavanagh J, Clothier B, Weeks E, Newton P 2014. Phase 1: Looking Back: future requirements for soil management in New Zealand. <a href="https://www.mpi.govt.nz/document-vault/10397">https://www.mpi.govt.nz/document-vault/10397</a></li> <li>Dymond JR, Herzig A, Basher L, Betts HD, Marden M, Phillips CJ, Ausseil A-GE, Palmer DJ, Clark M, Roygard J 2016. Development of a New Zealand SedNet model for assessment of catchment-wide soil-conservation works. <i>Geomorphology</i> 257: 85-93. <a href="http://doi.org/10.1016/j.geomorph.2015.12.022">http://doi.org/10.1016/j.geomorph.2015.12.022</a></li> </ul>		
Input data on erosion and sediment generation for modelling (C11)	Yes	Yes			<ul style="list-style-type: none"> <li>Betts H, Marden M 2015. Preliminary report on ground reconnaissance and aerial survey of bank/cliff erosion in the TANK catchments, Hawke's Bay. Landcare Research Contract Report LC2517 for Hawke's Bay Regional Council.</li> <li>Betts H, Marden M 2016. Preliminary report on ground reconnaissance and aerial survey of bank/cliff erosion in the Porangahau and coastal catchments, Hawke's Bay. Landcare Research Contract Report LC2511 for Hawke's Bay Regional Council.</li> <li>Phillips C, Marden M, Betts H, Basher L 2017. Effectiveness of riparian buffers for trapping sediment in steepland plantation forests. Landcare Research Contract Report LC3039.</li> <li>Lambie SM 2017. Monitoring of Lake Ruatuna silt trap system. Landcare Research Contract Report LC3014 for Department of Conservation.</li> <li>Daigneault A, Dymond J, Basher L 2017. Kaipara Harbour sediment mitigation study: catchment economic modelling. Landcare Research Contract Report LC2905 for Streamlined Environmental Ltd.</li> <li>Betts H, Spiekermann R, Dymond J 2017. SedNetNZ modelling of sediment sources and loads from</li> </ul>	New funding under OL&W Tranche 2 and potential MBIE Endeavour funding will ensure more focus on this research gap.	Proceeding

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	LMF	LMG					
					<p>the Western Waikato, Coromandel, Waihou-Piako and Taupo Water Management Zones, Waikato Region. Landcare Research Contract Report LC2835 for Waikato Regional Council.</p> <ul style="list-style-type: none"> <li>• Basher L 2017. Erosion measurements on croplands at Levin: progress report, June 2017. Landcare Research Contract Report LC2823 for Horticulture New Zealand.</li> <li>• Spiekermann R, Dymond J, Betts H, Marden M 2017. SedNetNZ modelling of sediment sources and loads in the Northern Hawke's Bay Region. Landcare Research Contract Report LC2815 for Hawke's Bay Regional Council.</li> <li>• Dymond J 2017. Cascade of Soil Erosion to River Sediment Project: progress report 1.1.1: Quarterly Report, March 2017. Prepared for the OLW NSC. Job 682201-0128.</li> <li>• Basher L, Barringer J 2017. Erosion susceptibility classification for the NES for Plantation Forestry. Landcare Research Contract Report LC2744 for Ministry for Primary Industries.</li> <li>• Phillips C, Basher L, Marden M 2016. A risk matrix for storm-initiated forestry-related landslides and debris flows in the Gisborne region. Landcare Research Report LC2711 for Gisborne District Council.</li> <li>• Betts H 2016. Deriving landslide scar-slope relationships for SedNetNZ model development. Landcare Research Contract Report LC2689 for AgResearch and Ministry of Business Innovation and Employment.</li> <li>• Cavanagh JE, Fenemor A 2016. Developing a sediment and biota monitoring programme for Awapuni-Moana. Landcare Research Contract Report LC2671 for Gisborne District Council.</li> <li>• Spiekermann R, Basher L, Betts H 2016. Volumetric measurement of river bank erosion from sequential historical aerial photography in the Kaipara Catchment. Landcare Research Contract Report LC2660 for AgResearch.</li> <li>• A review of research on the erosion control effectiveness of naturally reverting manuka and kanuka. Envirolink 1562-HBRC210 (Landcare).</li> <li>• Mitigating fine sediment from forestry in coastal waters of the Marlborough Sounds. Envirolink 1626-MLDC110 (Marlborough DC).</li> <li>• Research and sampling strategy for evaluation the effectiveness of sediment erosion mitigation options for plantation forestry in the Marlborough Sounds. Envirolink 1736-MLDC128.</li> <li>• Basher L, Moores J, McLean G 2016. Erosion and sediment control in New Zealand: information gaps. Landcare Research Contract Report LC2629 for Tasman District Council.</li> <li>• Basher L 2016. Erosion mitigation on cropland. Landcare Research Contract Report LC2612 for Horticulture New Zealand.</li> <li>• Phillips C, Marden M, Basher L, Spencer N 2016. Storm-initiated debris flows and plantation forestry: protocols for monitoring &amp; post-storm data capture. Landcare Research Contract Report LC2607 for Gisborne District Council.</li> <li>• Palmer D, Dymond J, Mueller M, Herzig A 2016. SedNetNZ modelling to estimate sediment sources from the TANK, Porangahau, and coastal Hawke's Bay watersheds. Landcare Research Contract Report LC2599 for Hawke's Bay Regional Council.</li> <li>• Betts H, Dymond J 2016. Setting up and running the SedNetNZ sediment generation and transport model. Internal report LC2594 for Landcare Research.</li> <li>• Basher L, Moores J, McLean G 2016. Scientific basis for erosion and sediment control practices in New Zealand. Landcare Research Contract Report LC2562 for Tasman District Council.</li> <li>• Marden M, Lambie S 2016. Plot-based, growth performance of space-planted mānuka (<i>Leptospermum scoparium</i>) on marginal land, and vulnerability to erosion: final report. Landcare Research Contract Report LC2559 for Ministry for Primary Industries</li> <li>• Basher L, Barringer J, Lynn I 2016. Update of the Erosion Susceptibility Classification (ESC) for the proposed NES for Plantation Forestry – subdividing the High and Very High ESC classes. Final report. Landcare Research Contract Report LC2472 for MPI.</li> <li>• Palmer D, Dymond J, Herzig A, Betts H, Marden M, Basher L 2015. SedNetNZ modelling of the Waikato catchment. Landcare Research Contract Report LC2428 for Waikato Regional Council.</li> <li>• Mueller MU, Dymond JR 2015. SedNetNZ modelling of soil erosion in Northland. Landcare Research</li> </ul>		

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	LMF	LMG					
Input data on faecal microbes and hormones (C12)					<ul style="list-style-type: none"> <li>Contract Report LC2424 for Northland Regional Council.</li> <li>Marden M, Phillips C 2013. Review for Marlborough District Council report 'Mitigating fine sediment from forestry in coastal waters of the Marlborough Sounds: options for determining plan rules'. Landcare Research Contract report LC2414 for Marlborough District Council.</li> <li>Dymond JR 2015. Temporal disaggregation of sediment loads in the Whangarei Harbour Catchment and response to soil conservation. Landcare Research Contract Report LC2413 for AgResearch.</li> <li>Faecal source tracking in the Taruheru River, Gisborne. Envirolink 1767-SDC142 (ESR).</li> <li>Wai Ora Wai Māori – a kaupapa Māori assessment tool.</li> <li>Taylor L, Te Whenua T, Hatami B 2018. Discussion paper: how current legislative frameworks enable tikanga-based management &amp; ecosystem-based management in Aotearoa New Zealand: the contemporary practice of rāhui. Landcare Research Contract Report LC4005 for Sustainable Seas National Science Challenge: CP 1.1 Enabling EBM in the current legislative framework.</li> <li>Awatere S 2017. Deep South quarterly progress report 'Climate Resilient Māori Land'.</li> <li>Boffa Miskell (Loiuse Saunders) 2017. The mānuka &amp; kānuka plantation guide. Report produced by Boffa Miskell.</li> <li>Wehi P 2017. Indigenous ecological knowledge, introduced species, and the new New Zealand environment. Annual report for Rutherford Discovery Fellowship LC2997.</li> <li>Reihana K 2017. Appendix 5 of the UCM Tuhonhono Final Report. Report by the Maniapoto Maori Trust Board. Prepared for MBIE (Unlocking Curious Minds. LC2984</li> <li>Newsome P, Lynn I, Scheele S, Fenemor A, Vale S, Bellingham P, Arnst E, Sutherland A, Newton M, Young R 2016. Te Awa Tupua scoping study. Landcare Research Contract Report LC 2721 prepared for Ngā Tāngata Tiaki o Whanganui.</li> <li>Robb M, Harmsworth G 2016. Collaborative modelling project and mātauranga Māori: review of cross-cultural collaboration. Landcare Research Contract Report LC2621 for Greater Wellington Regional Council.</li> <li>Taura Y 2016. Raakau preservation technique scoping report: cultural indicator for wetland health. Milestone 10. Landcare Research Contract Report LC2616 for MBIE – Vision Matauranga.</li> <li>Scheele S, Carswell F, Harmsworth G, Lyver P, Awatere S, Robb M, Taura Y, Wilson T 2016. Reporting environmental impacts on te ao Māori. Landcare Research Contract Report LC2600 for Ministry for the Environment.</li> <li>Harmsworth G, Awatere S, Procter J 2016. Māori research findings (2013–2016) for the Clean Water Productive Land Science Programme (C10X1006). Landcare Research Contract Report LC2560 for Agresearch Ltd.</li> <li>van Schravendijk-Goodman C, Clarkson B, Kalaugher E, Taura Y 2016. Wetland wānanga with Manaaki Whenua, Hamilton. Manaaki Whenua Internal Report.</li> <li>Robb M, Barton J, Harris W 2015. Living Water: iwi engagement and vision at Lake Areare. Landcare Research Contract Report LC2430 for Department of Conservation.</li> <li>Awatere S, Hudson M, Pauling C, Lambert S, Mika J, Reid J 2015. Whakatipu Rawa ma ngā Uri Whakatipu: optimising the 'Māori' in Māori economic development. Landcare Research Contract Report LC2425 for Nga Pae o te Maramatanga.</li> <li>Daigneault A, Wright W, Samarasinghe O 2015. Economic analysis of land use opportunities in Maniapoto Rohe. Landcare Research Contract Report LC2415 for Maniapoto Māori Trust Board.</li> <li>Awatere S 2016. Deep south 'climate resilient Maori land'. Job number 229002-0015 (in progress).</li> <li>Envirolink TSDC118. Innovative communication with the community to improve water quality.</li> <li>Simcock R 2017. Activating water sensitive urban design for healthy, resilient communities. Progress Report to 10 December 2017. Landcare Research Contract Report LC3075.</li> <li>Completion report submitted for Envirolink Medium Advice Grant 1769-NLCC96. Plants for sensitive</li> </ul>		
Māori values and land development options (D16)							Still large gaps
Community values to support implementation of the FW reforms (D17)							

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Science and tools to support increased policy effectiveness (D18)					<p>water design. Robyn Simcock, June 2017.</p> <ul style="list-style-type: none"> <li>• Simcock R, Heijs J 2016. Applying low impact (water sensitive) design – in Nelson Tasman. Landcare Research Contract Report LC2606 for Tasman District Council and Nelson City Council.</li> <li>• Final completion report for Envirolink small advice grant C09X1504 1611-TSDC118. Innovative communication with the community to improve water quality. January 2016.</li> <li>• Envirolink Tools project C09X1701. 'Improving uptake of DSS'. Job number 682003-0024 (in progress).</li> <li>• Envirolink C09X1702. Wetland Delineation Soil Tool Development 223001-0040.</li> <li>• Clarkson BR 2017. Horizons wetlands monitoring protocols and processes: review. Landcare Research Contract Report LC3021.</li> <li>• Lambie S. Mangawara Stream Wetland and Riparian Project WRA: WRA 13-012. 682202-0189.</li> <li>• Lambie SM 2017. Monitoring of Lake Areare floating wetland. Landcare Research Contract Report LC3007 for Department of Conservation.</li> <li>• Ekanayake J, Hunt J, Hedley C 2107. Remote data communication for Ashley Dene. Landcare Research Contract Report LC3005.</li> <li>• Newsome P 2017. Considering a future spatial framework for wetland mapping and monitoring in New Zealand. Landcare Research Contract Report LC3000.</li> <li>• Envirolink Large Advice Grant 1732-GSDC137, Wetland soils tool. June 2017. Bev Clarkson. Job 223001-0035</li> <li>• Mudge P, May 2017. Progress report detailing milestones 6-7 for MPI contract 405379 'Impact of irrigation on soil carbon'. LC2826. Job 682002-0043</li> <li>• Ritchie A, Osorio-Jaramillo J 2017. National Environmental Monitoring Site Identification System. Landcare Research Contract Report LC2814 for Horizons Regional Council.</li> <li>• Belliss S, Shepherd JD, Newsome P, Dymond J 2017. An analysis of wetland loss between 2001-2002 and 2015-2016. Landcare Research Contract Report LC2798 for Ministry for the Environment.</li> <li>• Easdale T, Marden M, Richardson SJ 2017. Review of forest below-ground biomass and implications for carbon accounting in New Zealand's temperate forests. Landcare Research Contract Report LC2761 for Ministry for the Environment.</li> <li>• Final completion report for Envirolink Small Advice Grant 1707-MLDC119, Wetland Restoration Methodology. February 2017.</li> <li>• Meurk C 2017. Wetland restoration methodology support/advice. Landcare Research Contract Report LC2729 for Marlborough District Council.</li> <li>• Clarkson BR, Bartlam S 2016. State of the Environment monitoring of Hawke's Bay wetlands: Tukituki Catchment. Landcare Research Contract Report LC2709 for Hawke's Bay Regional Council.</li> <li>• National rapid habitat assessment protocol for streams and rivers. Envirolink contract 1519-NLRC174 (Cawthron).</li> <li>• A tool to estimate ground water recharge from hillslopes to shallow foothill aquifers. Envirolink 1546-TSDC107 (Landcare).</li> <li>• Daigneault A, Elliott S, Greenhalgh S, Kerr S, Lou E, Murphy L, Timar L, Wadhwa S 2016. Modelling the potential impact of New Zealand's freshwater reforms on land-based greenhouse gas emissions. Landcare Research Contract Report LC2630 for MPI SLMACC.</li> <li>• Holdaway RJ 2016. Design of New Zealand's 8-km grid-based plot network: Static master data. Landcare Research Contract Report LC2527 for the Ministry for the Environment.</li> <li>• Collins A, Lynch B 2016. Strategic guidance for land science. Landcare Research Contract Report LC2509 for Hawke's Bay Regional Council.</li> <li>• Price R, Rutledge D, Kalaugher E 2016. Spatial models and decision support systems review: phases 2 and 3. Landcare Research Contract Report LC2501 for Waikato Regional Council.</li> </ul>		