Environmental Monitoring and Reporting (EMaR) land and soil indicators workshop



NATIONAL LAND RESOURCE CENTRE

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The project was delivered on time.	☐	☐	☐	☐	☐
The project met our quality standards.	☐	☐	☐	☐	☐

What impressed you most about this project?

What improvements do you suggest for future projects?

Additional comments?

Contents

1 Executive Summary

The Environmental Monitoring and Reporting (EMaR) initiative is a partnership between Local Government NZ's Regional Sector and the Ministry for the Environment (MfE).

The goal of EMaR is to achieve more consistent and integrated regional and national environmental data collection and reporting. Experts from each environmental 'domain' – for example, land, water, marine etc – will undertake a project to achieve the EMaR goal.

A workshop was convened to gather information to help scope the *EMaR Land Project*. The workshop revealed the following recommendations for each indicator area:

- *Land cover & land use* – the critical importance of ongoing development of the Land Cover Database, as well as the creation of a science-based national land use layer
- *Soil properties & processes* – the importance of the ongoing development of S-map and the National Soils Database; the platform for soil health provided for by the regional council soil quality programme; and the need to advance indicators that are biologically based and which quantify soil functional capacity
- *Soil movement & protection* – the need for national environmental standards and protocols to consistently quantify erosion (area and amount), as well as the aggregation of data to quantify the implementation and effectiveness of protection measures.

In addition, the discussions highlighted:

- The potential to develop 'next generation' environmental monitoring and reporting that is functionally focused and outcome-based; but this will require trade-offs to be made between using what we have now versus development of 'new' approaches and technologies
- The interest from a number of agencies to support EMaR and leverage related efforts; but this will require a 'whole-of-system' perspective, and clarity of roles and responsibilities, both across the system and in terms of the 'workflow' from data collection through to reporting
- The challenges of collecting, stewarding, and sharing data, given ongoing constraints relating to stable funding, ownership, licensing, and confidentiality; however, this is balanced by the potential of informatics techniques (e.g. data standards, semantics) to increase data sharing and federation.

2 Background

2.1 Environmental Monitoring and Reporting (EMaR)

The Environmental Monitoring and Reporting (EMaR) initiative is a partnership between Local Government New Zealand (LGNZ) Regional Sector and the Ministry for the Environment (MfE) that began in July 2014.

The overarching objective of EMaR is to achieve more consistent and integrated regional/national environmental data collection and reporting through widely accessible platforms (the LAWA – Land Air Water Aotearoa – website, in particular).

Projects have been established for each of the environmental 'domains' to look at the design of national data collection networks, the development of any monitoring standards needed, and the development of additional information to be reported via LAWA over the next year and beyond.

The EMaR Land project team has been reviewing current land and soil monitoring and reporting (e.g. existing information, datasets, methods, indicators, etc.) in New Zealand and will be scoping future work required for the design and development of data collection networks, datasets, and indicators for national-level reporting.

2.2 EMaR land and soil indicators workshop

The purpose of this workshop was to engage with a range of technical specialists on land and soil indicators for regional and national monitoring and reporting. The workshop aimed to gain feedback on the following key issues:

- Identification and prioritisation of land and soil indicators
- Critical gaps in, and limitations of, key supporting datasets
- Identification of future work to be undertaken

The workshop results will be used to help inform the scoping work of the *EMaR Land Project*.

3 Methods

Workshop participants (were assigned to one of three broad areas of focus:

- Land cover & land use
- Soil properties & processes
- Soil movement & protection.

Each broad area of focus encompassed several topics and considered the same questions listed below:

A. Identification & prioritisation of indicators

1. *What are the key questions to be answered through the monitoring & reporting of land & soil indicators at regional or national levels (i.e. what are we trying to find out)?*

2. *What are the indicators that could be monitored and reported on to address the questions identified above (why? – give reasons)?*

3. *What is the order of priority for development and reporting of the indicators (why? – give reasons)?*

4. *At which level could each of these indicators be monitored and reported (i.e. regional or national or both) and which level would be best (why? – give reasons)?*

B. Key supporting datasets & future work

1. *What key datasets might be available for supporting the indicators previously identified?*

2. *What are the critical gaps and limitations (including access/licensing issues) in those datasets for nationally consistent reporting?*

3. *At which level should the data be held; national (i.e. in a centralised database) or regional (i.e. by individual councils) (why? – give reasons)?*

4. *What future work is required on data collection / analysis methods, monitoring network design, and dataset improvement/ development/ maintenance?*

There were 6 groups (2 per focus area) with 3–5 people in each group. The groups had a facilitator and nominated a rapporteur to report back during plenary sessions.

Figure 1 Workshop participants reporting back to plenary

4 Results

A summary of the feedback from each of the focus groups is provided in Table 1. The table includes identification and prioritisation of key indicators and supporting data sets.

THEME	PRIORITY	QUESTIONS TO BE ANSWERED	INDICATORS	DATASETS	SCALE	LIMITATIONS	GAPS	FUTURE WORK
Land cover & use	1	What are the types, patterns and rates of land use and cover change across New Zealand?	Land cover, land use	LCDB (Vx)	Nationally produced	Scale, class definitions	1. Certainty on future updates and on-going maintenance of LCDB 2. Good land use map with agreed classifications 3. A steward for the fundamental data theme of land use/ cover 4. Require a land use decision support system to investigate impacts of land use changes on the environment	LCDB 5 & 6
				LUCAS		Class definitions		
				LINZ cadastre tenure		Scale		
				NZLRI/LUC		Scale, dated		National extended legend
				Protected Area Network - NZ		Limited information		
	2	What is the intensity of land use/cover change?	Stocking rates, fertilizer application, irrigation	Agribase		Licensed/commercial		Combine data sets to get a national picture of land use and intensification
				Farms Online		Private/Confidential		
				NEFD, MPI Forestry data, NAIT (MPI)		Private/Confidential		
				Agriculture Production Survey/Census Data		Private/Confidential		
				Fertilizer application layers		Private/Confidential		
	3	What impacts does land use/cover change on the environment (farm management and ecosystem services)?	Land management practices Land tenure type (conservation estate, leasehold) Fragmentation, Land availability	My Land		Lack of consistency		Identify key land management issues to monitor
				NZ-Farm		Prototype		
				Regional datasets, Farm Plans	Regional	Inconsistent		Develop new models and tools to monitor and measure land management
				Forestry Harvests, Dairy NZ		Private/Confidential		
				Resource consents		Inconsistent		
Soil properties & processes	3	What soils we have, where and what condition are they in?	Soil types and attributes by spatial distribution	S-map, National Soil Database	National level needed for consistency (NEMS) & collation but collected at regional, farm and paddock scale from variety of sources	Incomplete coverage	1. Additional indicators with relevance to impacts (e.g. radon, oestrogen, magnesium, calcium etc.) 2. Better temporal data – including more seasonally specific measurements to show risk (e.g. compaction at different times during the year) 3. More work on placing indicators within an outcome framework – i.e. starting at the end with what impacts you are trying to avoid and ensuring indicators can inform on that) 4. Priority assessment to see what is changing most and what impacts are most critical – so that future development is targeted to information that will make a difference	Complete coverage for key attributes at appropriate scale
				Fundamental Soil Layer		Generalised by polygon		
	1	How are these soils changing, and what is the magnitude and rate of change?	Soil quality	Land Monitoring Forum led soil quality monitoring (based on 500 soils); Land Management Index; Visual Soil Assessment; LUCAS plots; National Soil Database; commercial laboratories		Incomplete coverage / not all councils or land uses		Leverage wide variety of data available from different sources and combine in a single database
			Trace elements	Regional sampling (arsenic, copper, chromium, lead, mercury, nickel, zinc, cadmium and uranium) as part of soil quality		Incomplete coverage / not all councils or land uses		Increase coverage, draw on other data, and develop new indicators
			Nutrient use	Data on nutrient inputs and outputs (Overseer)		Incomplete coverage / not all nutrients		Model to aggregate Overseer inputs and outputs
			Macro-fauna and microbial health/diversity	Still in research development		Prototypes only		Further development and testing of methods, e.g. soil functional RNA and eDNA
	4	What land use and management practices are driving these changes?	Land cover, land use, stocking rates, fertiliser application, irrigation etc.	As above for land cover, use and management		As above for land cover & use		
	2	What is the impact of these changes on primary production, environmental integrity, human health and provision of cultural services?	Specified levels for: soil quality, trace elements, microbial health and diversity, nutrient use, N use efficiency	As above for soil quality, trace elements and nutrient use		Incomplete coverage / not all councils or land uses / inconsistent		Need to relate impacts with critical levels or targets

Soil movement & protection	1	What area of land is at risk from erosion and from what type of erosion?	Area of land affected or at risk of erosion	NZLRI/LUC		Scale, dated	1. More work needed on standard protocols for selecting indicators e.g. scale and methodology consistency 2. More sites needed to increase representativeness across indicators and coverage across regions 3. Funding to maintain national efforts and databases 4. More efforts needed on data federation to combine multiple sources of data 5. Aggregation of regional and industry farm plan and other initiative information (while conserving privacy)	
				LCDB (Vx)		Scale, class definitions		
				LiDAR		Incomplete coverage / data not interpreted		
				Regional soil stability monitoring		Incomplete coverage / not all councils or land uses covered / inconsistency in approaches used		
				Q-map				
	4	How much erosion is occurring?	Amount of topsoil lost	GNS Landslide database		Incomplete storm inventories (relies on goodwill)		Better capture procedures
				Regional soil stability monitoring		Number of sites vs. representativeness		
				Sediment yield / Total suspended solids / estuarine monitoring		Problems of attribution / lag times?		
				Regional riparian characteristics monitoring (stream-bank erosion)		Incomplete coverage / not all councils or land uses / inconsistent		
				Remote sensed data following storms		Imagery not always available or processed		
	3	How much protection is in place? What land use and practices are driving these changes?	Amount of land under vegetative cover / retired / fenced	Amount of land under regional and central government non-regulatory schemes (e.g. Afforestation Grant Scheme, Hill Country Erosion Fund, Erosion Control Fund Project, Emissions Trading Scheme, Sustainable Dairying Accord)		Inconsistent / variable / some councils don't do farm plans / gap between plan and action and effect		
				Regional riparian characteristics monitoring (riparian fencing & vegetation cover)				
				Sector initiatives such as poles planted, areas retired (e.g. Beef and Lamb LEPs, SLUI farm plans)		Access /availability of data		
	2	What are the impacts of changes in soil movement & protection on primary production, environmental integrity, human health and provision of cultural services?	Cost of erosion (including clean up)	Reviews?		Lack of available data / separating it out from flood costs / done for costs to roading not farms		More data or research needed to see what is available
			Cost of mitigation	Reviews of ECFP		Scale, dated		

4.1 Land cover & use

Understanding the types, patterns and rates of land cover/use change is critical to understanding pressure, state, and impact in the land and other domains (such as freshwater).

At present, the development of these indicators is heavily dependent on a selection of nationally produced datasets (LCDB, LUCAS, and NZLRI). Of these data sets, the Land Cover Database (LCDB) remains the most comprehensive spatial coverage and temporal record of land cover and is the most widely used. Therefore, it remains the highest priority for development and reporting of land indicators.

Measuring and monitoring of changes in the type and intensity of land management practices is increasingly important for environmental reporting and management.

One of the key indicators of land management practices is intensification. However, at present there is no comprehensive national or regional land use database or layer that can be used to adequately measure and monitor intensification (e.g. fertilizer application, irrigation, stocking intensities) or other types of land use change (e.g. urbanisation, forestry to dairy). There are a variety of data sets that could be combined to develop a land use database, including Agribase, Farms Online, NEFD, MPI Forestry data, Agriculture Production Survey/Census Data, Fertiliser application layers. However, at present, access to this information is often difficult, costly to access, and it currently sits in a variety of formats that may not be compatible.

4.2 Soil properties & processes

To report on the quality and state of soils requires understanding what soils we have, where they occur, and what condition they are in. Data on soil type are available in the *Fundamental Soil Layer* (*FSL*) within the *NZ Land Resource Inventory*. While the *FSL* provides a national approximation of key soil attributes, it is limited by scale and generalised to a polygon.

S-map – New Zealand's national soil mapping programme - has been superseding *FSL* and provides the best available data on soil variation at a range of scales, but is currently limited by coverage: 26% of New Zealand is covered (while S-map covers 55% of multiple use land, less than one fifth of the other land classes are recovered). Further coverage is limited only by resources (time and funding).

To gauge both how soils are changing (in condition), and the magnitude and rate of that change requires temporal indicators. The regional council *soil*

quality monitoring programme provides a good platform to establish spatial and temporal variation in soil chemical, physical, and biological properties (Olsen P, pH, mineralisable N, Total C, Total N, bulk density, and macroporosity). However, further work is needed to ensure a wider range of sites and land uses is included in the analysis, particularly those in the conservation estate. An opportunity to include a wider range of data (e.g. from LUCAS plot sampling the National Soil Database and commercial laboratories) was also highlighted. Method development is proceeding to improve indicators such as hot water carbon and dissolved organic nitrogen. Research is also underway to better characterise the biological components of soil health and quality (e.g. method development in soil RNA[1] and DNA[2]).

Data on trace elements within soils are collected, with a set of Land Monitoring Forum guidelines; however, not all councils routinely collect data. Other perceived gaps include radon, a breakdown product of uranium; a range of compounds that may impact on human health, such as persistent organic pollutants (POPs) and oestrogens; and elements that may impact on animal health, such as magnesium and calcium.

Monitoring has progressed significantly in the soil properties and processes component of the land domain. However, a key gap remains in the impact of changes in soil quality on primary production, environmental integrity, human health, and provision of cultural services. An outcome-based monitoring framework that links agreed outcomes to thresholds of change would be a significant advancement. This would also help prioritise future development, such as increasing the coverage of existing indicators versus developing new indicators.

4.3 Soil movement & protection

To understand what area of land is at risk from erosion and from what type of erosion requires estimation through mapping and modelling. This relies on a variety of data from a range of sources, and at present there is no national environmental monitoring standard used to guide efforts, although the guidelines developed by the Land Monitoring Forum provide a foundation.

The same issues apply to the questions of how much erosion is occurring and how much protection is in place to address the erosion. While there is a variety of data available to answer these questions, they are distributed

[1] Auckland University, Landcare Research, and Auckland Council work to test the usefulness of soil functional RNA as proxy indicators for key soil processes underpinning soil / water "health"

[2] Landcare Research project looking at assessing soil biodiversity and community structure using DNA. It includes quantifying changes in community structure along a land use gradient for microbial groups (fungi, bacteria, archaea) as well as other soil organisms such as mites, nematodes, and macro-invertebrates.

across a number of agencies, are inconsistent between regions, lack a standardised approach, and in some cases lack complete national coverage.

Gauging the impact of erosion and the value of protection is the biggest gap in this topic. There is little or no data available on the cost of erosion beyond a few local or specific scheme studies (such as the East Coast Forestry Project review), or where the effects of erosion are separated from flood costs. Furthermore, there is a paucity of information on the effectiveness or value of mitigation measures. Both these gaps (cost of erosion and value of mitigation) are critical to increase public awareness of the issue and provide opportunities to address it.

4.4 Overarching issues and enabling activities

Discussions extended to a number of overarching issues or enabling activities necessary to support further development of the integrated monitoring and reporting for the land domain. These enabling activities are linked within a *'workflow'* and are represented in Figure 2 below.

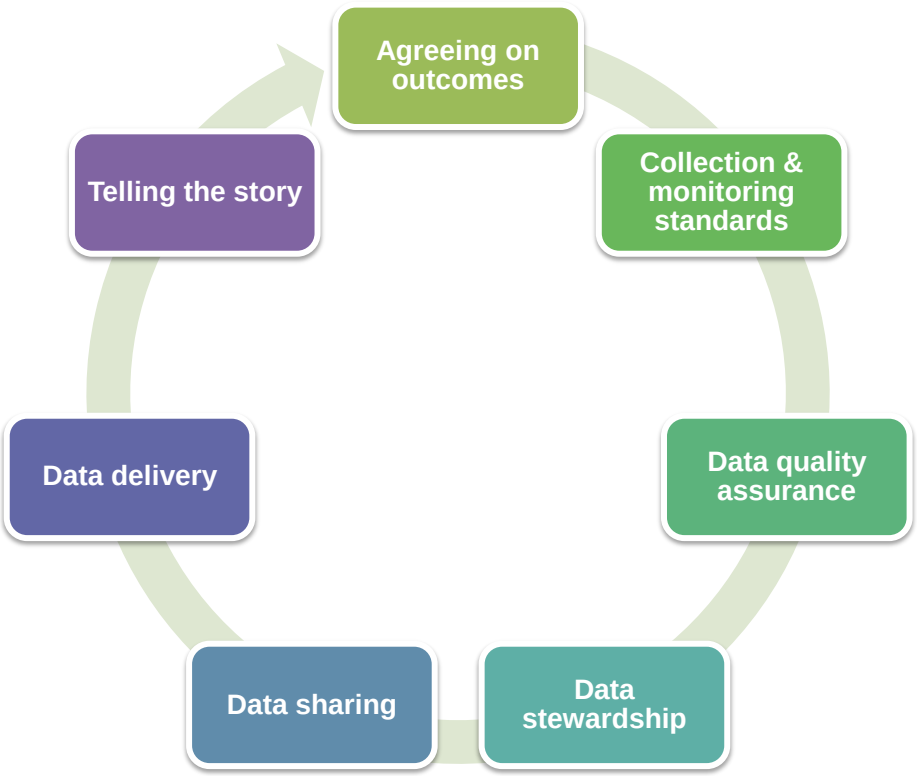

Figure 2 Enabling workflow for high-quality regional and national environmental data collection and reporting

Without a specific focus on describing the enabling workflow, a number of specific recommendations and ideas were raised during the meeting:

A. **Agreeing on outcomes***:* Most participants felt there was much to gain from using an outcome-based approach in the establishment of EMaR. This requires agreeing at the outset the key outcomes to be achieved or impacts to be addressed and ensuring appropriate indicators are selected to quantify risks and evaluate performance. Given the relationship between land and water quality, this should encompass outcomes for rivers, groundwater, and estuaries.

   It was also acknowledged that understanding the complex functioning of the land and soil system was a major challenge and that an ecosystem services approach could offer promise. In this regard 'services' could potentially be used to represent the environmental, cultural and economic outcomes desired(e.g. ability of soils to filter nutrients) and would be of greater value to users than measures of soil properties. The idea that next-generation indicators should be '*functionally focused and outcome based'* was raised on several occasions.

B. **Collection and monitoring standards**: Many in the group felt that significant gains had already been made in standardising monitoring such as those driven by the Land Monitoring Forum (e.g. soil quality, land fragmentation, etc.). For some topics or questions there was more to do either in the design or the implementation of monitoring guidelines (for example, developing/implementing a national standard protocol for soil erosion measurement/estimation). Another gain point was identified around the potential coordination of sampling/collection across topics and domains through the use of a national sampling framework or grid. A national grid with agreed sampling points and standardised labelling, which could be used for a variety of different parameters, was seen to offer a cost-effective way of collecting a wide range of data.

C. **Data quality assurance**: The quality and integrity of datasets were also questioned. Since the indicators developed in EMaR will be available to the wider public, it is important to have clear metadata, and transparent and auditable workflows as well as uncertainty descriptions of the underpinning data. This is a role Statistics New Zealand plays for the national environmental reporting framework.

D. **Data stewardship**: This was seen as a critical activity, but with the data described in sections 4.1 to 4.3 sitting across a number of different agencies, with very few having dedicated funds, it remains a challenge. The group felt more national leadership and governance could help prioritise and elevate nationally significant datasets and ensure their curation was appropriately funded.

Resourcing for the development and on-going maintenance of data sets was raised a number of times as a significant national issue.

E. **Data sharing**: As most supporting data are distributed across agencies, a significant challenge is to find ways (and resources) in which to aggregate and integrate them. The potential for building a national land use layer is a good example of the opportunity to integrate heterogeneous data from a variety of different sources (other examples include land use practice from various sector plans; soil quality from existing monitoring; the National Soil Database; and LUCAS plot data). However, this raises issues over ownership, confidentiality, licensing, and access – and who should be responsible for the stewardship of the aggregated products.

   The opportunity to share data and ensure they are interoperable is becoming increasingly possible, however, through informatics techniques such as data standards, semantics, and web feature services.

F. **Data delivery**: The main delivery platform for reporting agreed indicators for EMaR is the Land Air Water Aotearoa (LAWA) website. It is important that LAWA and other delivery platforms are capable of dealing with the characteristics of largely spatial data associated with the land domain (as opposed to point data with good temporal richness in the freshwater domain).

G. **Telling the story**: This is both the starting point and end-point of the workflow. A number of participants identified the need to understand what stories need to be articulated as a way of guiding the development of the EMaR land framework (see the item on 'agreeing on outcomes'). Another important consideration is the way indicator data are synthesised and visualised to engage the wider public.

Finally, a number of generic recommendations were raised by the group, including developing more national-level leadership and governance so that the ongoing development of priority datasets was ensured. This includes clarifying the roles and responsibilities of the regional sector, MfE, and the research providers (mainly Crown Research Institutes) as well as agencies such as Statistics New Zealand and the Parliamentary Commissioner for the Environment, as they relate to individual components of the workflow to ensure effective operation of EMaR.

5 Conclusion

The workshop was a useful forum to convene technical experts to help inform the scoping work of the *EMaR Land Project*. The workshop discussions revealed:

- The potential to develop 'next generation' environmental monitoring and reporting that is functionally focused and outcome-based; but this will require trade-offs to be made between using what we have now versus development of 'new' approaches and technologies
- The interest from a number of agencies to support EMaR and leverage related efforts; but this will require a 'whole-of-system' perspective, and clarity of roles and responsibilities, both across the system and in terms of the 'workflow' from data collection through to reporting
- The challenges of collecting, stewarding, and sharing data, given ongoing constraints relating to stable funding, ownership, licensing, and confidentiality; however, this is balanced by the potential of informatics techniques (e.g. data standards, semantics) to increase data sharing and federation
- The importance of secure and stable funding for data collection, interpretation, curation and delivery for both the regional sector and science providers to ensure the EMaR aspirations are met.

6 Acknowledgements

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Appendix 1 – Workshop attendees and assigned focus groups

Attendee	Focus Group	Organisation
Deb Burgess	Land cover & use	MfE (Project Team)
Bronwyn Newton	Land cover & use	Stats NZ
Jim Payne	Land cover & use	LCR
David Pairman	Land cover & use	LCR
Barbara Hock	Land cover & use	Scion
Anne-Gaelle Ausseil	Land cover & use	LCR
James Barringer	Land cover & use	LCR
Reece Hill	Land cover & use	WRC
Emily Weeks	Land cover & use	NLRC/LCR
James Lambie	Land cover & use	Horizons RC/EMaR Biodiversity
John Drewry	Soil properties & processes	GWRC (Project Team)
Roger Uys	Soil properties & processes	MfE
Bryan Stevenson	Soil properties & processes	LCR
Alec Mackay	Soil properties & processes	AgR
Matthew Taylor	Soil properties & processes	WRC
Gerald Rys	Soil properties & processes	MPI
Alison Collins	Soil properties & processes	NLRC/LCR
Haydon Jones	Soil movement & protection	WRC (Project Team)
Andrew Burton	Soil movement & protection	TDC (Project Team)
Mike Page	Soil movement & protection	GNS
Estelle Dominati	Soil movement & protection	AgR
Chris Phillips	Soil movement & protection	LCR
Kerry Hudson	Soil movement & protection	GDC
David Medyckyj-Scott	Soil movement & protection	NLCR/LCR
Brenda Rosser	Soil movement & protection	GNS