Strategies for updating soil information for the Marlborough Sounds: pathways to strategic management of surface sediment loss and mass movement

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Summary

Background

Marlborough District Council (MDC) faces significant challenges in managing sedimentation, which affects water quality and marine ecosystems. Sediment enters the Sounds through two main pathways: mass movement and surface sediment loss. Mass movement, often triggered by infrequent intense rainfall, involves widespread landslides. Surface sediment loss is more common and is caused by rainfall-induced runoff, mobilising smaller amounts of soil. The two issues require different management approaches due to their distinct processes and the specific data needed for their effective management.

Objectives

This report outlines strategies for updating soil information in the Marlborough Sounds to effectively manage surface sediment loss and mass movements. It is based on workshop discussions held at a 1-day workshop on 13 August 2024 at Manaaki Whenua – Landcare Research (MWLR) in Lincoln. The discussions focused on improving legacy soil data and applying modern classification systems and techniques (such as LiDAR and S-map) to enable a better understanding of soil patterns and their role in the management of these processes.

Results

The report highlights the need for more detailed soil data to support sediment management models and improve Land Use Capability and Erosion Susceptibility Classification mapping. Digitised and updated legacy soil data and maps are a key priority, as they provide foundational information for further analysis. The integration of new technologies, such as LiDAR, can then help refine soil mapping across different terrains, enhancing the precision of soil distribution models. The report recommends prioritising the development of high-resolution landslide susceptibility models to improve sedimentation management and inform hazard assessments, land-use planning, and mitigation strategies in the Marlborough Sounds. Updating and enhancing the legacy soil data from the *Soils of the Marlborough Sounds* report is also recommended to strengthen land management systems and support sustainable practices. Additionally, securing sufficient funding, exceeding $100,000 annually, is essential to support high-quality research and ensure successful project implementation.

Conclusions

The workshop concluded that a full-scale S-map soil survey would be cost-prohibitive, but that a modified approach, focusing on high-risk areas and using lower-resolution mapping where appropriate, would provide the most efficient use of resources. Adequate funding, along with strategic partnerships, will be essential to support this effort and ensure the delivery of high-quality, peer-reviewed science.

Potential funding streams include the Envirolink Fund, direct contracts with MDC, and dual-funding partnerships with organisations such as MWLR and the Ministry for Primary Industries.

1 Introduction

This report summarises the discussions from a workshop held on 13 August 2024 aimed at addressing the challenges faced by Marlborough District Council (MDC) in managing surface sediment loss and mass movements to mitigate sedimentation and water quality degradation in the Marlborough Sounds. The workshop was attended by Kirstin Deuss, Ian Lynn, Chris Phillips, Pierre Roudier, and Linda Lilburne from Manaaki Whenua – Landcare Research (MWLR), along with Matt Oliver from MDC.

The workshop's objectives were to clarify the key issues, identify needs and challenges, outline currently available information, evaluate the opportunities and limitations of legacy data, and make recommendations on potential approaches. This report is intended to document the discussions and insights from the workshop rather than present a detailed action plan. It focuses on summarising the key points raised during the workshop to inform future decision-making by MDC.

2 Background

2.1 Sedimentation in the Marlborough Sounds

Sedimentation in the Marlborough Sounds poses a significant challenge, affecting water quality, marine ecosystems, and coastal infrastructure (Urlich 2015). It disrupts habitats, affects aquaculture, and adds to regulatory compliance requirements. Sediment enters the Sounds through mass movement (landslides) during less frequent intense rainfall, and through surface sediment loss from more frequent rainfall and runoff.

Given the steep, highly erodible terrain and the high degree of connectivity of slopes to the marine environment, managing sediment loss in the Marlborough Sounds is difficult. Forestry is often blamed for increasing sedimentation, but the issue is more complex, with contributions from feral animals, livestock, and stream bank erosion, and legacy effects from historical land clearance (Handley 2015; Handley et al. 2017).

Returning to pre-European baseline levels of sediment loss is unrealistic, but MDC still has a responsibility to try to mitigate sediment losses associated with land management practices. To manage effectively at a fine scale (e.g. at a catchment or property scale), the information used in mapping must be of very high quality and resolution and should be supported by relevant and robust physical data. Currently this level of detail is lacking in the Marlborough Sounds. The best-quality soil information available is 1:50,000 S-map coverage for the main river valleys (alluvial flats only) and the 1:63,360 Fundamental Soil Layers. Mapping to an 'operational' scale would require approximately 1:10,000 scale.

2.2 Mass movement and surface sediment loss

Mass movement and surface sediment loss are two inter-related, but distinct, erosion processes affecting the Marlborough Sounds. They are related in that they both contribute to erosion and sedimentation, but they differ fundamentally in their processes and management needs. Strategies for their management differ in scope, data requirements, and regulatory approaches. As a result, a solution for one issue may not address the other.

Mass movement generally occurs during exceptional conditions and primarily involves landslides triggered by infrequent weather events. Unlike surface sediment loss, mass movement is less influenced by soil types and more by topographic, geological, and climatic factors. Improved soil information, for example, may have little impact on landslide susceptibility modelling. Information about landslide susceptibility feeds into natural hazard and risk models.

Surface sediment loss is a continual process whereby rainfall-induced surface water flow dislodges soil particles and carries them downhill into streams, rivers, lakes, or oceans. It is a natural erosion process, like mass movement, but it may be intensified by land-use practices. Soil characteristics play a critical role in surface sediment loss (Lal 2001).

2.3 Natural hazards and risk in the Marlborough Sounds

Mass movement (landslides) may present significant hazards and risk in some areas of the Marlborough Sounds. Although this was identified as a key concern for MDC, it was determined that addressing risk and hazard issues was beyond the scope of the workshop and is not covered further in this report.

3 Marlborough District Council's objectives

3.1 Rationale for MDC's need for expert guidance

MDC is concerned about the impact of both surface sediment loss and mass movement on the Marlborough Sounds' environment and infrastructure. The council aims to better regulate land-use practices, reduce sediment runoff, enhance their capacity to respond to resource consent applications, and manage areas with high susceptibility to landslides. Existing soil and landslide susceptibility data are inadequate for MDC to either make informed decisions or regulate with confidence.

The main objectives identified by MDC include:

- improving water quality in the Marlborough Sounds.
- supporting the forestry industry with better self-management practices by providing information that is suitable for use at an operational level.
- enhancing MDC's regulatory framework through better information.
- strengthening regulatory confidence by improving the accuracy and availability of data, ensuring it can withstand legal scrutiny.
- preparing for future land-use challenges, especially under climate change, by ensuring that relevant information is readily available for informed decision-making by all stakeholders.

4 Currently available information for the Marlborough Sounds

A range of information on land use, soils, landslides, and other aspects is currently available for the Marlborough Sounds (Table 1).

Table 2. Currently available information for the Marlborough Sounds.

Information type	*Description*	*References*
Land Use Capability	**NZ Land Use Capability (LUC) classification system** Built on the New Zealand Land Resource Inventory (NZLRI), the LUC incorporates rock types, soil characteristics, slope gradients, erosion types and severity, vegetation cover, climate, flood risks, erosion history, and past land-use impacts. The first LUC map for the entire Marlborough region (NZLRI Legend 00) was produced in the 1970s at a scale of 1:63,360 (an inch to the mile). Remapping at 1:50,000 in the early 1990s involved the development of an extended legend for the Marlborough Region (NZLRI Legend 11), which included the Marlborough Sounds. Due to funding constraints, only the productive lands south of the Marlborough Sounds were remapped, leaving the Sounds reliant on the first edition map (I. Lynn, MWLR, pers. comm., 2024). A key missing component needed to make the LUC a reliable data layer in the Sounds is accurate and comprehensive soil information.	NZLRI Legend 00; van Berkel 1983 NZLRI Legend 11; Lynn 1996
	Partial mapping of LUC at a scale of 1:25,000 This work was undertaken by Ron Sutherland in the 1980s for MDC (M. Oliver, MDC, pers. comm., 2024). Although a map was completed the soil legend was not, resulting in an incomplete product that is also inconsistent with both the NZLRI Legend 11 (Lynn 1996) and the Laffan et al. (1987) soil map. MDC has since digitised the map polygons. Notably, even the author no longer recalls the rationale behind certain mapping decisions, but the polygons themselves may still hold valuable information.	M. Oliver, MDC, pers. comm., 2024
	An updated 'LUC' map at a scale of 1:10,000 Mark Bloomberg and David Palmer used the NZLRI Legend 11 rules with LiDAR data to create a higher-resolution 'LUC' map. The new units are based on the LUC legend, but the authors primarily correlated LUC class with slope. Because it lacks the finer-scale soil, climate, and other data needed to accurately identify LUC units, it cannot be described as a true LUC map. However, it did demonstrate that a digital mapping of LUC would be possible with a combination of refined slope classes and the use of fine-scale soil data.	Bloomberg and Palmer 2022
Soil	***Soils of the Marlborough Sounds*** In this document soils are described and mapped at 1:100,000 (see section 4.1 for more detail).	Laffan et al. 1987
	The Fundamental Soil Layers (FSL) The FSL consists of 16 soil properties, each described using around 5 predefined intervals or classes. The FSL map relies on the 1:63,360 NZLRI polygons for its structure. Considered outdated and inaccurate by soil scientists, it is still used in areas where S-map is unavailable. Only 4 soil units are identified by the FSL in the Marlborough Sounds area. The clay content data in the FSL are notably poor, offering only a general 'clay class'. While soil depth data are somewhat better, they are still limited to 5 or 6 broad classes.	Manaaki Whenua – Landcare Research 2023

Information type	Description	References
Landslide susceptibility	**Erosion Susceptibility Classification (ESC)** This is a tool developed by the Ministry for Primary Industries (MPI) to support councils and foresters in decisions on the level of erosion risk under the National Environmental Standards for Commercial Forestry (NES-CF). Built from the LUC maps, the ESC is used to determine activity status for consenting. It was never intended to provide operational guidance to foresters or councils, and its practical application in this context is limited by its low resolution and lack of detail. Although the ESC outlines the general framework for regulations, the council can adopt more stringent measures if they provide the necessary supporting information (e.g. an updated, finer-scale LUC map).	MPI 2017
	Landslide Inventory This is a comprehensive landslide inventory for the Marlborough region, mapping over 7,500 landslides triggered by the July 2021 and August 2022 storms. Using remote imagery and field investigations, it highlights factors influencing landslide distribution, including rainfall, geology, and land cover, and recommends detailed analyses for risk assessment and mitigation in vulnerable areas.	Rosser et al. 2023; Wolter et al. 2022
Other	**Gamma radiometrics and LiDAR data** These covariate data sets cover the Marlborough Sounds and have the potential to enhance soil mapping by improving spatial delineation. Pearson and Rissmann (2024) and Rissmann et al. (2019) use these data sets to attempt to identify weathering patterns and geological boundaries. However, they would require further calibration and validation to ensure their accuracy and reliability.	New Zealand Petroleum & Minerals 2015; Land Information New Zealand 2018
	Various legacy studies, theses, and engineering reports A range of studies and reports have examined soils, vegetation, and geological features in the Marlborough Sounds, addressing soil classification, landform relationships, forestry impacts, and engineering geology. More recent updates have focused on soil properties and land management challenges.	Atkinson and Webb 1982; Basher 2016; Begg and Johnston 2000; Campbell and Rait 2014; Gray 2012, 2013; Horrey 1989; Johnston 1996; Kingsbury 1987; Laffan 1980; Laffan 1987a, 1987b; Laffan and Daly 1981; Laffan et al. 1985; Laffan et al. 1986; Laffan et al. 1989; McManus 1996; Walls and Laffan 1986; Ward 1961; Whitton et al. 1985

4.1 Soils of the Marlborough Sounds

The *Soils of the Marlborough Sounds* (Laffan et al. 1987) report summarises soil surveying efforts in the Marlborough Sounds, including detailed mapping at a scale of 1:75,000 and reconnaissance surveys from the 1960s to the 1980s. Until recently the location of the foundational data underlying the report and map were unknown, preventing verification of the map's accuracy, reliability, or updates. However, the original soil observation data underpinning Laffan's map were recently discovered in hard copy at MWLR's physical archive. This discovery presents significant opportunities and became a key focus of the workshop.

The introduction to *Soils of the Marlborough Sounds* states that the report presents an interim map at 1:100,000, pending final map checking and soil unit correlation. However, the map was never progressed or finalised. Draft documents from a 1997 review (K. Vincent, pers. comm., 15 March 1997) that was never formally published noted gaps and inconsistencies between the soil series and the mapping units provided in the taxonomic legend. The reviewer noted in a letter that Laffan et al. (1987) was only just beginning to write the soil survey report for the Marlborough Sounds when he was made redundant in 1988: 'I fear that we have therefore lost most of the detail which would be required to adequately summarise his findings'. This suggests that to fully utilise the decades of work captured in *Soils of the Marlborough Sounds* it may be necessary to re-evaluate and re-interpret the raw soil data.

4.1.1 Current limitations of the soil data for modern applications

The soil information provided by Soils of the Marlborough Sounds, as well as the data underlying it, have several limitations that reduce their effectiveness for modern land management and decision-making, as outlined below.

- The soil pattern in *Soils of the Marlborough Sounds* is presented through a classification of soils into 19 soil-physiographic units based on topography, climate, parent materials and soil drainage class. While this provides a broad overview, it does not capture the important finer-scale spatial variability of soils within these units, limiting its applicability in land management decision-making.
- Soil information is provided only for the dominant soil within each soil-physiographic unit. This focus limits representation of the full range of soils in the Marlborough Sounds.
- The dominant soil within each soil-physiographic unit is classified according to the now-outdated New Zealand Genetic Soil Classification, restricting interoperability with contemporary data.
- The map scale of 1:100,000 is too coarse for applications sought by the MDC.
- Published in 1987, the report relies on surveys and classifications from that period, which may no longer reflect current soil properties due to decades of land-use changes, climate variations, and human activities.
- The report data are not readily digitised or compatible with modern geospatial platforms, requiring manual integration for digital tools such as GIS.

4.1.2 Data opportunities

The rediscovered hard-copy records include detailed soil profile descriptions and data for over 600 georeferenced points across the Marlborough Sounds (Figure 1). Currently stored on paper, these data require digitisation, accurate georeferencing, and reclassification using the NZ Soil Classification System before they can be integrated into modern soil information systems.

This discovery offers a rare and valuable opportunity to revisit soil mapping in the Marlborough Sounds. Once updated, we will have a comprehensive understanding of both the areas covered by existing data and those lacking coverage, allowing us to revisit the soil map with modern technologies. Collecting this number of detailed data points today would probably be prohibitively expensive.

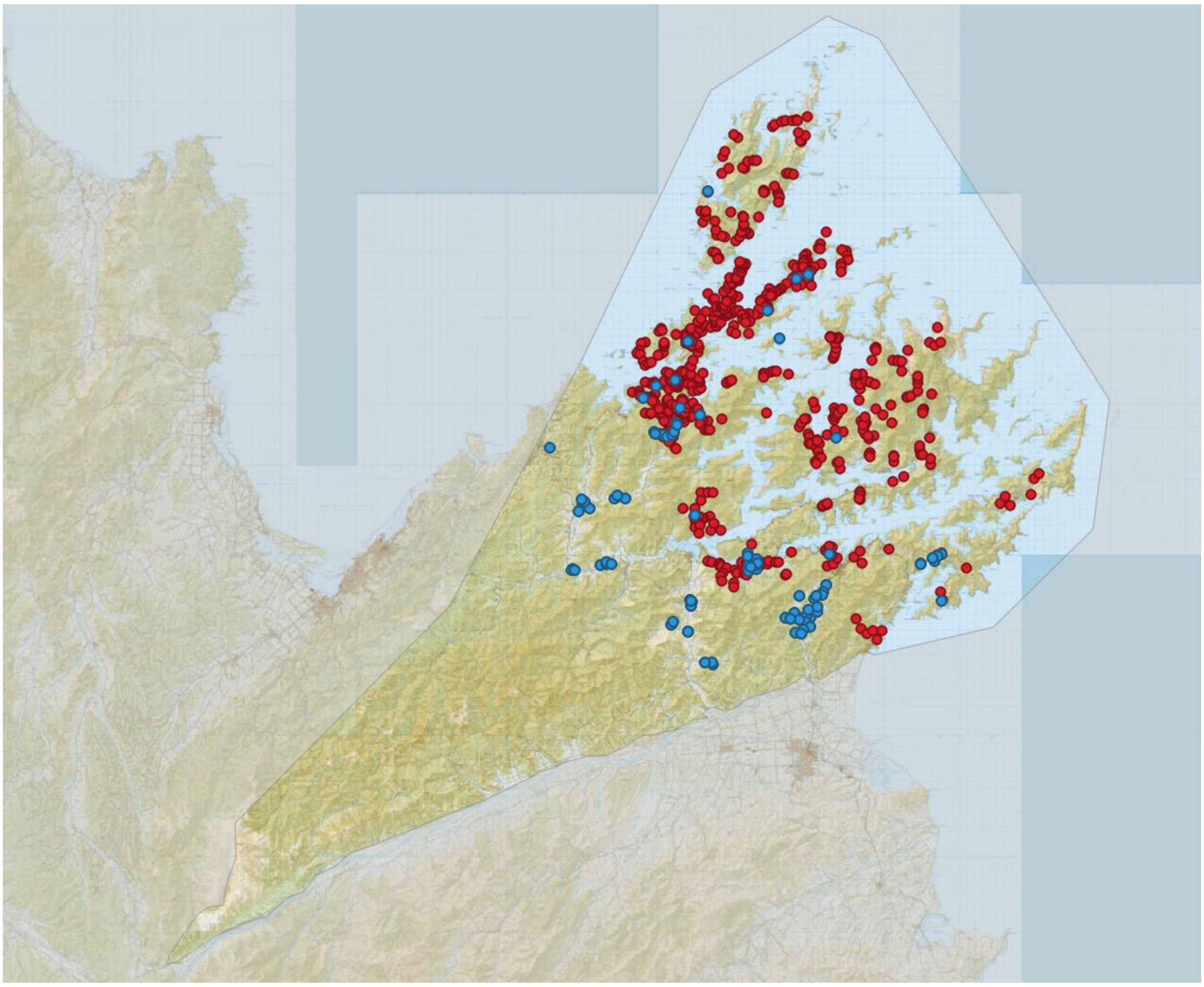

Figure 1. The Marlborough Sounds, shown within the region of interest identified by MDC. Notes: The blue points represent the current data stored within New Zealand's National Soil Data Repository. The red points represent the recently discovered hard-copy data collated by Laffan et al. in the 1980s. Note that the georeferencing is approximate (hand-drawn); for proper restoration, accurate georeferencing will be needed, and more reliable geolocation data may be available.

A very brief examination of the spread of the data revealed that present-day grassland is significantly over-represented in terms of the number of observations (Table 3). In contrast, based on the observed land use distribution in the region of interest, exotic forest and native forest appear under-represented. This is probably because less forestry existed at the time and grasslands were more accessible during the surveys, much of which will have reverted to scrub today.

Table 4. Land cover (based on Land Cover Database v5.1) area of the Marlborough Sounds region of interest shown on Figure 2, and observations per class

Land cover	*Approx. area (ha)*	*Approx. area (%)*	*No. of observations*	*% of observations*
Exotic Forest	45,294	16	79	12.97
Grassland	34,161	12	185	30.38
Native Forest	197,898	70	336	55.17
Other	4,111	1.5	9	1.48

5 Recommendations

5.1 Mass movement

Recommendation 1

Prioritise the development or application of high-resolution landslide susceptibility models for the Marlborough Sounds to improve sedimentation management, and to inform hazard and risk assessments, land-use planning, and mitigation strategies, by identifying areas prone to landslide-driven sediment transport and deposition.

Approach

Refine existing MWLR models used in other regions of New Zealand, ensuring local applicability. As a result of this workshop this work has been initiated and contracted, and is scheduled to commence in 2025.

Recommendation 2

Generate a map of rock weathering or weathered rock type. Incorporating this as an input covariate could add considerable value to future landslide susceptibility models, which generally do not use this information. In the Marlborough Sounds this could be especially relevant given the specific environment and the established relationship between elevation, weathering, and the production of fine sediment.

Approach

While likely to be useful, this recommendation faces significant challenges in producing the necessary information at the required scale and was therefore not explored in detail.

5.2 Surface sediment loss

Recommendation 3

Update and enhance the legacy soil information underpinning *Soils of the Marlborough Sounds* (Laffan et al. 1987) so that it is fit for purpose. This will support the refinement of existing land management systems, such as Land Use Capability (LUC) and Erosion Susceptibility Classifications (ESC). Improved soil data will provide landowners with a stronger foundation for adopting sustainable practices and enable central and local governments to develop more targeted and effective regulations. Also, by creating a robust legacy soil data set now, we can ensure it has value for future and unforeseen applications, such as enhanced sedimentation and erosion modelling.

Approach

1 Safeguard and preserve legacy hard-copy soil survey data

The original data underpinning *Soils of the Marlborough Sounds* is currently in a fragile and vulnerable state, as it remains the only known copy and has not yet been scanned. Scanning and archiving are essential to ensure its preservation and accessibility for future use. Also, supplementary physical documents stored with the raw soil data (which lack sufficient backup) may contain valuable insights and should be considered in any re-analysis of the data.

2 Digitise and georeference the legacy soil data

Converting the analogue data (e.g. hard-copy documents) into a digital format compatible with modern data storage and geospatial systems is essential. This process will ensure the information can be efficiently stored, processed, and accessed using computer systems.

3 Update the legacy soil data

Given the availability of detailed soil description cards and sample data it would be logical to review and reclassify each point using the New Zealand Soil Classification. This would enable integration of the data into New Zealand's National Soils Data Repository, ensuring it can be used alongside more recent soil information. It would also allow for more accurate interpretation of the primary data, offering a clearer understanding of the soil patterns than the high-level physiographic summary by Laffan et al. (1987).

4 Evaluate existing information and identify gaps

Examine how Laffan et al. (1987) group the soil information by physiographic region and review the original soil descriptions for each group. This will allow analysis of their distribution and determine which parts of the landscape (topography, land cover, etc.) were sampled and what areas are lacking data, and identify any patterns that have emerged over the 40 years since the original work was completed (e.g. through changes in land use). It will also help determine the reliability of the observations and assess whether the authors' descriptions and statements are adequately supported by the data.

It is also important to evaluate whether the data show meaningful differences in key soil properties; if not, further investigation may not be justified. However, if significant variations are observed, further study could prove valuable. Key soil properties essential for understanding sediment generation and quality, which should be included in any refined soil map, are:

- depth of soil
- regolith characteristics (particle size, stone content, etc.)
- mineralogy (degree of weathering)
- texture/clay content
- drainage class
- permeability
- structure.

During this process it would be prudent to identify areas within the region of interest that can be divided for modelling and mapping purposes. This approach could allow a future mapping exercise to be conducted in stages, focusing on the most relevant subdivisions, such as geology, climatic zones, altitude, and land use.

5 Identify areas requiring high-confidence soil data

Areas where accurate soil data are most critical should be identified, with the required level of detail varying based on specific objectives such as sediment management or other applications. High-priority areas may require additional data collection to supplement existing information, while low-priority areas could be mapped at a coarser scale using legacy data.

For example, when considering the management of surface sediment loss, sites with significant human land use should be prioritised. Key areas of interest include pastoral and exotic forest land uses, which should be mapped at a 1:50,000 scale, with sufficient observations to meet minimum confidence criteria. Exotic forest areas may require finer-scale mapping (c. 1:10,000) to enable operational-scale refinement of Land Use Capability and Erosion Susceptibility Classification. Land under virgin or regenerating native forest may be a lower priority, except where investigations are needed to confirm soil–landscape relationships.

6 Improve data utility with modern technologies

Use modern technologies, such as LiDAR, to enhance understanding of soil distribution across different landform components (such as ridges, backslopes, and footslopes) that were not detailed in the Laffan et al. (1987) report. Within each of Laffan's mapped zones there may be significant differences in soil patterns in some terrains, while others may show more uniformity. The available data will allow us to confirm these patterns with evidence-based analysis.

7 Develop a calibration data set

Develop a calibration data set by revisiting areas where data are missing or outdated. Ideally, if resources were not a limitation, sending a team to collect new soil samples across these gaps would allow for a more comprehensive update of the soil information.

To optimise resource allocation and extrapolate from known data sources it would be more efficient to focus on areas with existing access and tracks and avoid navigating through dense bush. Using exposures in accessible areas (such as track cuttings), while not without its limitations, can save time and reduce the need for digging many holes. The information gathered from these accessible sites can then be used to extrapolate soil patterns across less accessible areas, such as native bush or plantation forests.

8 Use S-map to present the soil information

S-map is New Zealand's national soil database, providing digital soil maps and detailed soil information to support land management and decision-making (Manaaki Whenua – Landcare Research 2024). Conducting a full-scale soil survey, similar to other recently conducted S-map surveys, would be excessive and prohibitively expensive in the Marlborough Sounds. The region presents significant physical challenges, including dense vegetation, difficult terrain, and limited access. Also, there will probably be less demand for certain types of soil information that are more relevant to regions with, for example, economically-significant intensive livestock production. However, by adopting a modified approach to minimise fieldwork costs, this would enable the integration of new data into the existing S-map system while creating a permanent, valuable data resource for future use.

S-map utilises a mix of scales, allowing for higher detail in high-interest areas and lower resolution or coarser detail in less critical areas, even within the same region. A fully modelled, low-confidence map can be produced for low-consequence areas, while more detailed work can be carried out where higher precision is justified. This targeted approach ensures that resources are focused where they will have the most impact. In areas where greater impact is expected, scaling down to higher-resolution mapping can be more easily justified. The key priority is to ensure that high-quality data and covariates are provided. These data will enhance the effectiveness of any statistical approach that depends on it.

While a fully traditional soil survey approach is clearly costly, relying solely on a statistical approach is also not ideal. The best solution lies in finding a balance between the two. A practical starting point would be to use a statistical approach to fill gaps in less significant areas, followed by a refinement incorporating targeted field observations. The raw observations by Laffan et al. (1987) should serve as the fundamental building blocks for any future work. The key is determining whether the existing data can be effectively interpreted and utilised to enhance the overall mapping process.

An alternative approach to S-map could involve focusing on mapping just two or three relevant soil attributes; however, this is not ideal because it would operate separately from S-map and fail to leverage the benefits of an already established and functional database.

5.3 Funding sources

Recommendation 4

Investigate sources of funding. A brief discussion on costs indicated that a budget below $100,000 per year would not be sufficient to achieve significant progress. Adequate funding is necessary to ensure the production of high-quality, peer-reviewed science and to elevate the overall standard of work. Securing sufficient funding allows for more dedicated research time, enabling better planning and execution. Smaller, fragmented contributions are unlikely to support the level of work required.

Approach

- *Envirolink Fund:* This could be used to support initial work in discrete areas but will not cover the full scope of what is required. Envirolink could also be used to develop digital soil modelling processes and practices where they might be useful nationally. Envirolink Tools is a separate source of funding but needs to benefit all councils.
- *Direct contract by MDC to MWLR:* MDC holds a soil mapping budget, which could be used for this work. The scale of a possible Marlborough Sounds project would utilise the full budget for several years, so a staged approach would be required.
- *Dual-funding partnerships:* Explore collaborations with MPI, regional councils, and MWLR to pool resources for a more comprehensive approach.
- *Endeavour Fund:* Although competitive, the Endeavour Fund could provide significant resources for scientific innovation in this area, particularly if integrated with ongoing national erosion and hazard management programmes. However, the proposal would need to be nationally significant, and several criteria such as science excellence, novelty, and impact would need to be satisfied.
- *Alternative funding:* Investigate alternative funding, such as MPI's Sustainable Food and Fibre Futures, depending on criteria.

A combination of the above is likely to be the most effective way forward.

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