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Reviewing the use of the Land Use Capability system in a regulatory context

December 2025

Parliamentary Commissioner for the Environment
Te Kaitiaki Taiao a Te Whare Pāremata

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Key findings

- The Land Use Capability (LUC) system has been used in New Zealand since the 1950s. It is a well-recognised land classification system that was designed to support long-term sustained production on the land. The LUC system was not designed to address environmental management challenges.
- Despite not being designed for use in the contemporary regulatory environment, it is currently used in regulation, including the National Policy Statement for Highly Productive Land (NPS-HPL), as part of the Climate Change Response Act (CCRA), as well as providing the basis for the Erosion Susceptibility Classification (ESC) used in the National Environmental Standard for Commercial Forestry (NES-CF).
- This review identifies limitations to the LUC system that make it ill-suited for regulatory use. In particular:
  - the national New Zealand Land Resource Inventory (NZLRI) LUC dataset, which is the default dataset for use in the NPS-HPL and the CCRA and the basis for the ESC system used in the NES-CF, is inappropriate for use at a property level due to its coarse scale and dated nature
  - there is poor alignment between the national NZLRI LUC dataset (the default dataset in the NPS-HPL) and an alternative method of using S-map (a digital soil map) for identifying highly productive land. In the absence of validation, reconciling differences between the datasets is challenging. In the meantime, using just one method, when there is such significant disagreement between the methods, seems ill-advised
  - The ESC, a derivative of the LUC system, over and under-classifies susceptibility of land to erosion (at least) in the context of shallow landslide erosion. Under-classifying land is a risk because of the more permissive approach the NES-CF takes to management of that land.
- More broadly, PCE recommends that:
  - the current LUC system should not be used as a basis for any future regulatory controls
  - the Government should invest in progressively improving essential contemporary datasets that underpin land use regulation, and ensure they are publicly available and affordable
  - essential contemporary datasets should be used to (1) modernise the LUC and ESC systems and, (2) where suitable, create bespoke fit-for-purpose models for specific regulatory purposes, and
  - where resources are limited, improvements in environmental data and information should be focused on hotspots, i.e. those areas where better information is most urgently needed to support management of environmental issues of concern.

The purpose of this review

This review focuses on whether the Land Use Capability (LUC) classification system and the derived Erosion Susceptibility Classification (ESC) are sufficiently robust for use in a **regulatory context**.[1] The key question it addresses is: can we be confident that the LUC and ESC systems provide regulators with a robust basis for making relevant decisions in the face of growing demand for fine-grained information to support land management regulation?

This review does not set out to undermine the extraordinary effort that went into developing the LUC system. It will remain useful – as long as it is used to inform challenges that involve land productivity.

Throughout this review, the term "LUC system" refers to the entire Land Use Capability classification system. It includes the LUC classification, associated methods and the New Zealand Land Resource Inventory (NZLRI) database, which contains a national LUC dataset. The term "ESC system" refers to the Erosion Susceptibility Classification system, including the classification, associated methods and the national ESC dataset. If individual aspects of the systems are discussed, that is made clear in the text.

What is the Land Use Capability (LUC) system?

The Land Use Capability system includes the Land Use Capability classification, associated methods (the LUC Survey Handbook) and the New Zealand Land Resource Inventory (NZLRI) database.

The LUC classification

The **Land Use Capability classification** has been used in New Zealand since 1952 to help achieve sustainable land development and management on individual farms and catchments and at a national level.[2] The classification and method are focused on the capability of the land to support long-term primary production, particularly arable cropping, horticulture, pasture and forestry. The methods are described in the LUC Survey Handbook.[3] At its core, the LUC classification was designed with a productivist mindset, i.e. to support long-term sustained production on the land, as opposed to addressing environmental management challenges.

1 In this publication, regulatory context is defined as a boarder system of legislation, policies, plans and rules.

2 Lynn et al., 2021, p.7.

3 The first edition of the LUC Survey Handbook was prepared in 1969 to provide national standards for mapping. SCRCC (Soil Conservation and Rivers Control Council) 1969. The second edition described the classification and underlying methodology and was published in 1971 (and reprinted in 1974). SCRCC 1971 and SCRCC 1974. The third edition reviewed the concepts and classification components and was published in 2009 (Lynn et al., 2009). The most recent reprint of the LUC Survey Handbook (in 2021) contains minor revisions (Lynn et al., 2021).

The assessment of land for long-term sustained production, which is at the heart of the LUC classification, is based on interpreting information on five physical factors:[4]

- Rock type
- Soil unit
- Slope
- Erosion type and severity
- Vegetation cover.

The information on these factors was compiled from observations and field assessments. For the assessment of land, information on these five factors was supplemented by climate, flood risk, erosion history and the effects of past practices.[5]

The LUC classification has three components: LUC class, LUC subclass and LUC unit, with the LUC unit being the most detailed.

There are eight **LUC classes** (1–8), where LUC 1 is the most versatile land with the fewest physical limitations for productive use, and LUC 8 has the greatest limitations and is thus the least versatile land (Figure 1).

LUC 1–4 land is suitable for arable cropping (including vegetable cropping), horticultural uses (including vineyards and berry fields), pastoral grazing, and tree crop or production forestry use. LUC 5–7 land is considered unsuitable for arable cropping but suitable for pastoral grazing, tree crop or production forestry use, and in some cases, vineyards and berry fields. LUC 8 land is considered unsuitable for grazing or production forestry and is best suited to catchment protection and/or conservation or biodiversity purposes.

Increasing limitations to use

LUC class	Arable cropping suitability	Pastoral grazing suitability	Production forestry suitability	General suitability
1	High	High	High	Multiple use land
2				
3				
4	Low			
5	Unsuitable			Pastoral or forestry land
6				
7		Low	Low	
8		Unsuitable	Unsuitable	Conservation land

Decreasing versatility of use

Source: Lynn et al., 2021

Figure 1: LUC classes and related limitations on productive use and versatility of land.

4 Lynn et al., 2021, p.8.
5 Lynn et al., 2021, p.8.

According to the New Zealand Land Resource Inventory (NZLRI) database, close to 50% of land in New Zealand is classified as LUC 6 or 7 land (13.2 million hectares or 49% of land area) and 5.8 million hectares are classified as LUC 8 land (22% of New Zealand). Only 25% of New Zealand (6.6 million hectares) is classified as LUC 1–4 land, of which 5% of New Zealand (or just over 1.3 million hectares) is identified as LUC 1 and 2 land. Given urban development, rural lifestyle block expansion and other land use change since the mapping was undertaken, the area of LUC 1 and 2 land is likely to be even smaller. There is very little LUC 5 land recognised in the NZLRI.[6]

Table 1 shows the total area of each LUC class across New Zealand, as mapped in the NZLRI database.[7]

Table 1: Available land in different LUC classes, as mapped in the NZLRI database, 1975–1999. Note that only the North and South Islands were mapped.[8]

LUC class	North Island (x1,000 ha)	South Island (x1,000 ha)	Total mapped area across New Zealand (x1,000 ha)	Total mapped area (%)	Total arable and non-arable land (ha) and national %
1	152	35	187	0.7	Arable land LUC classes 1–4: 6,608,700 ha; 25%
2	696	506	1,202	4.5	
3	1,065	1,378	2,443	9.2	
4	1,300	1,477	2,777	10.5	
5	94	117	211	0.8	Non-arable land LUC classes 5–8: 19,173,300 ha; 72%
6	4,079	3,394	7,473	28.1	
7	2,774	2,915	5,689	21.4	
8	1,016	4,785	5,801	21.8	
Total	**11,176**	**14,607**	**25,783**	**97%**	The remaining 3% are lakes, rivers, etc.

Within each of the LUC classes, **subclasses** are identified based on the main or dominant limitation for productive use of the land. Note that there is a priority order of limitations, and only the dominant limitation is classified. Identification of dominant limitations only (instead of all limitations) can mask lesser but still significant characteristics, which may affect the suitability of the land for certain land uses.

6 This is due to historical classification criteria for LUC 5 land used in the NZLRI. These criteria were broadened in the 2009 LUC Survey Handbook, but the NZLRI hasn't been updated. For details, see Lynn et al. (2009, pp.62–63).

7 Lynn et al., 2009, p.147.

8 Lynn et al. 2009, p.147. The total in this table is smaller than the total land area of New Zealand because it excludes land, which was not mapped as part of the NZLRI (such as Stewart Island and the Chatham Islands). In addition, this total also excludes estuaries, lakes, quarries, rivers and towns, which account for about 3% of the area that was mapped.

The four limitations are:

1. "e" – erodibility: where susceptibility to erosion is considered the dominant limitation.
2. "w" – wetness: where a high-water table, slow internal drainage and/or flooding is identified as the dominant limitation.
3. "s" – soil: where the dominant limitation is within the rooting zone. This can be due to shallow soil profiles, subsurface pans, stoniness, rock outcrops, low soil water holding capacity, low soil fertility, salinity or toxicity.
4. "c" – climate: where the climate is the dominant limitation. This can be drought, excessive rainfall, unseasonal or frequent frost or snow, or exposure to strong winds or salt spray.[9]

The **LUC unit** is the most detailed component of the LUC classification. This is where the details of specific limitations are recorded. LUC units group together areas where similar land characteristics have been identified. These areas are considered to need similar management or conservation treatment; they are suitable for similar crops, pasture or forestry species with similar potential yields.[10]

It is worth noting that the LUC classification, including associated methods, is independent of scale. In other words, the methodology can be applied at any scale – from national to property or farm-scale (although in practice, the quality of property-scale LUC assessments has been variable and skill-dependent).[11]

The national LUC dataset

The application of the LUC classification, using associated methods laid out in the LUC Survey Handbook, has permitted a national assessment of land use capability across the North and South Islands. This national assessment is included in the New Zealand Land Resource Inventory (NZLRI) database. It is also referred to as the NZLRI LUC dataset or the national LUC dataset.[12] In addition to the national LUC dataset, the NZLRI also contains an inventory of five physical factors (rock type, soil unit, slope, erosion type and severity, and vegetation cover).

The first edition mapping for the NZLRI was undertaken largely between 1971 and 1979, resulting in a national map at a scale of 1:63,360 (one inch to one mile). The entire NZLRI was later rescaled to 1:50,000. Second edition mapping was undertaken at 1:50,000 (1 centimetre to 500 metres) in the 1980s and 1990s and included new or updated information in Northland, Gisborne-East Cape, Marlborough, Wellington and part of the Waikato region.[13]

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9 Lynn et al., 2021, p.10.

10 LUC units are identified by Arabic numerals at the end of the LUC code and are arranged within LUC subclasses in order of decreasing versatility for use and increasing limitations on use.

11 For more details, see Lynn et al. (2009, p.11).

12 To access the national LUC dataset, see LRIS portal, NZLRI Land Use Capability 2021. https://lris.scinfo.org.nz/layer/48076-nzlri-land-use-capability-2021/. Also note that the NZLRI was compiled using the methods and standards available at the time, not those in the 3rd edition of the LUC Survey Handbook.

13 The intent at the time was to undertake second edition mapping for the entire country – but this did not happen. Second edition mapping also involved the development and application of new qualitative standards and methods for assessment (e.g. new rock types) (BSI (of which the former Manaaki Whenua – Landcare Research (MLWR) is now a part of), pers. comms., 3 July 2025 and 18 August 2025).

The mapping for both editions was undertaken on paper maps and typically involved using stereo aerial photography, published and unpublished reference material, and field work. It resulted in a series of map worksheets and accompanying extended regional legends.[14] Subsequently, these worksheets were digitised and later formed the NZLRI database.[15]

Today, the NZLRI database is part of the Land Resource Information System (LRIS) database, which in turn is one of the 26 Nationally Significant Collections and Databases.[16,17] The Bioeconomy Science Institute (BSI) (of which the former Manaaki Whenua – Landcare Research (MWLR) is now a part of) is the custodian of this database.

The mapping for the NZLRI was nationally coordinated but undertaken regionally. Regional classifications and descriptions were developed, at least to a degree, by the respective mapping teams. This created some inconsistencies, the most evident of which are between the North and South Islands.[18]

Further, the LUC regions often did not coincide with current regional council and unitary authority boundaries, and several LUC regions fell within one regional authority boundary (Figure 2). Consequently, some regional councils needed to navigate different LUC legends and different descriptions of the same LUC units within their regional boundary.[19]

14 These worksheets were housed by the National Water and Soil Conservation Authority (NWASCA), which was a government body established under the Water and Soil Conservation Act 1967. It was responsible for managing and regulating the country's water and soil resources. The Authority was part of the Ministry of Works and Development, which was dissolved in 1988 with its functions distributed across several government departments.

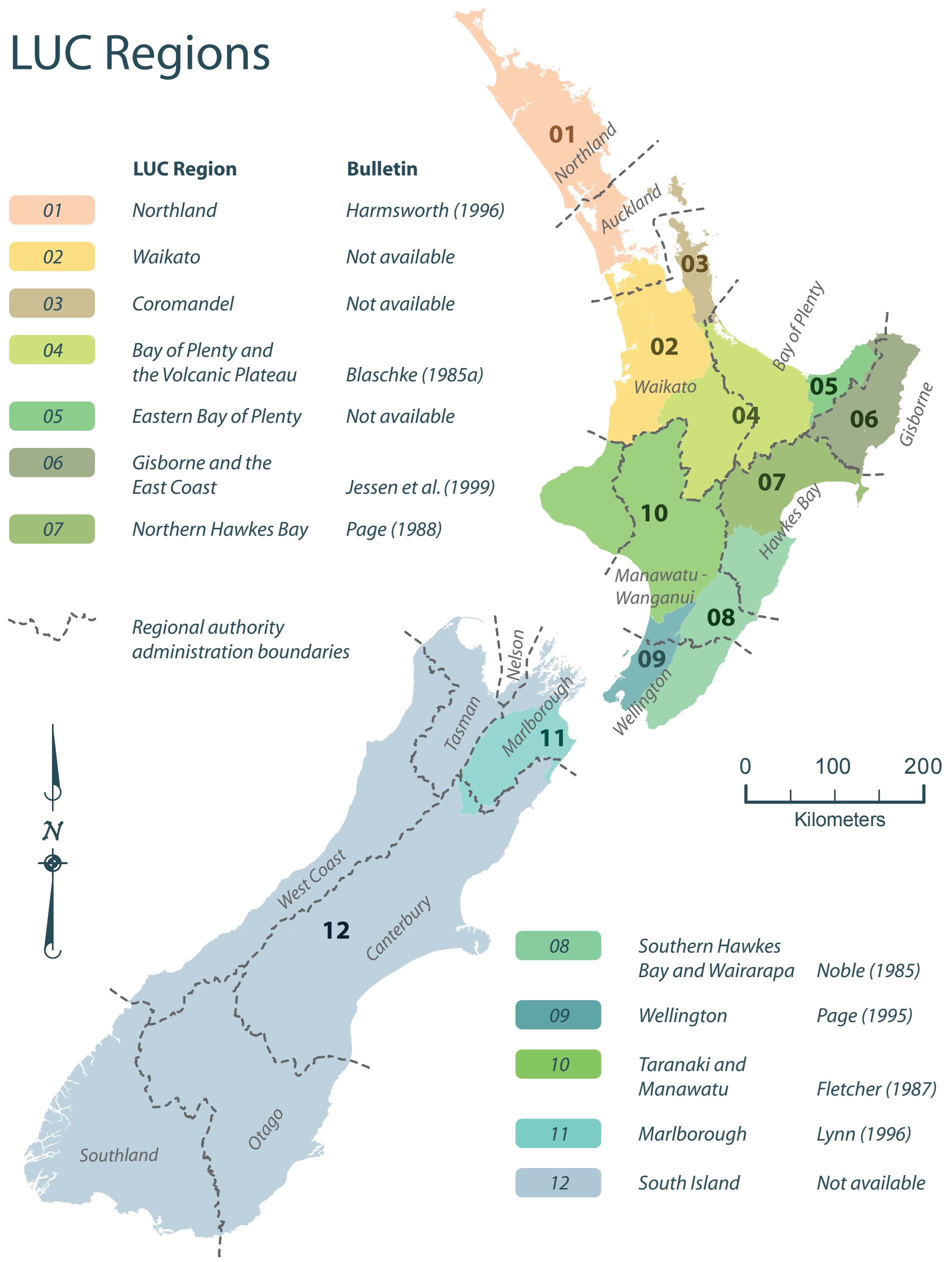
15 The forerunner to the NZLRI was considered to be New Zealand's first spatial digital database (BSI, pers. comm., 3 July 2025).

16 https://lris.scinfo.org.nz/

17 https://www.mbie.govt.nz/science-and-technology/science-and-innovation/funding-information-and-opportunities/investment-funds/strategic-science-investment-fund/funded-infrastructure/nationally-significant-collections-and-databases

18 See spreadsheets with regional LUC documentation, which are available on the Land Resources Portal. https://lrp.landcareresearch.co.nz/resources/luc-regional-data

19 For example, the Waikato Regional Council.



Source: Lynn et al., 2021

Figure 2: LUC regions (displayed in colour) are shown against current boundaries of regional and unitary councils (shown as grey dotted lines). The figure also shows the availability of published 'bulletins' or regional LUC manuals and descriptions.

A national LUC extended legend was created in 2025 to provide national consistency.[20] The 2025 report noted that "the national LUC extended legend supersedes the regional LUC classifications as it enables consistent analysis of LUC data nationally and across multiple regions."[21]

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20 844 national LUC units have been created through a combination of amalgamation, correlation and rationalisation of the original 1,200 regional LUC units. These were documented by MWLR in an April 2025 report and associated spreadsheet. See Lynn (2025) and associated spreadsheet.

21 Lynn, 2025, p.v.

However, the national legend has not technically superseded or fully replaced regional classifications, especially for LUC practitioners. So, the Land Resources Portal states:

> "When working 'regionally', i.e. within NZLRI regions, LUC regional extended legends of LUC units and inventories should be used.
>
> When working nationally, across NZLRI regions, national correlation of LUC units is helpful and can be used (but may be more generalised)." [22]

What are the strengths and limitations of the LUC system?

Strengths of the LUC system

The LUC system was a major achievement when it was originally produced. Its use as a land management tool has a number of strengths:

- The LUC classification uses a hierarchy of components with a small number of categories that are easily understood.
- Having been in place since the 1950s, the LUC system is familiar to many land management practitioners and policymakers at different levels of government.
- The method for assessing land use capability as described in the LUC Survey Handbook is independent of scale, so the methodology can be applied at any scale.
- The NZLRI database, which includes the national LUC dataset, has national coverage. This, in particular, has made it attractive to use to support the development of national regulation.

Limitations of the LUC system

While the LUC system has strengths, it also has several limitations.[23] These limitations are most evident with the NZLRI database. In addition, the LUC classification itself reflects the thinking at the time.

The NZLRI database, which includes the national LUC dataset, is dated

A significant limitation of the NZLRI database, which includes the NZLRI LUC dataset, is that it is dated. The mapping undertaken for the NZLRI database was mainly carried out in the 1970s and has remained largely unchanged since. The NZLRI mapping was paper-based using technologies of the 1970s, which are very different from the mostly digital mediums available today.[24] Mapping undertaken using manual technologies available at the time involved a high degree of expert judgement that unavoidably introduced subjectivity into mapping areas and associated boundaries.[25]

22 https://lrp.landcareresearch.co.nz/resources/luc-national-data

23 Several weaknesses of the LUC system have been documented before, for example, in the review undertaken by Ford and Hill (2020) and the NZLRI/LUC Roadmap (Barringer et al., 2013).

24 Barringer et al., 2013, pp.6–7.

25 For example, manual processing of stereo aerial photography, using a hand-held clinometer to estimate slope angles and delineating boundaries by hand on paper maps.

As noted in the NZLRI LUC roadmap:

> "Most NZLRI polygons were never physically visited, and much mapping was carried out visually, "from-a-distance", particularly in rougher terrain. In particular soils, slope, vegetation and erosion inventories rely heavily on the mapper acquiring key knowledge from on-ground observations in detailed sample areas and then using that acquired knowledge to infer what couldn't be observed directly."[26]

The land assessment, which captured landscape properties as they were when the mapping for the NZRLI was undertaken, has not evolved as the landscape has changed over the intervening half century. A case in point is anthropogenic changes to inherent soil properties – for example, land management practices, such as drainage and irrigation. These practices directly affect the subclass limitation of "wetness". The addition of permanent irrigation may change the LUC unit because potential permanent irrigation was not considered in the original assessment of the land.[27]

Further, land use and vegetation cover will have changed in some places since the mapping was undertaken.[28] While strictly speaking, neither of these should directly affect LUC because it is based on the permanent physical features of the land, how land has changed in response to its use may warrant a re-evaluation of its capability.[29] In some cases, advances in land management have significantly influenced how land is used.[30] However, the land assessment captured in the NZLRI has not evolved to account for this.

In short, while the landscape and methods for managing land have changed over the intervening half century, none of these dynamic changes are captured by the NZLRI as it stands today.[31]

By comparison, contemporary mapping methods use more up-to-date data and are more objective. This is because they are repeatable (due to automated processes and standardised methods) and minimise or eliminate human influence.[32] These contemporary methods include the widespread use of remote sensing and powerful geospatial analytics to collect and analyse the data needed to inform environmental regulation.[33] That said, these novel technologies do not negate the need for on-the-ground field surveys. These are still important, particularly at finer paddock and property scales, and are an essential part of ground-truthing modelled outputs.

26 Barringer et al., 2013, p.7.

27 Douglas et al., 2006, p.6.

28 While vegetation cover is probably not the most important factor in the LUC classification, presence of vegetation might have influenced the mapping at the time and changes in vegetation could modify current limitations. Changes in vegetation cover since the 1970s are likely to be large, given that significant changes have been observed over a more recent time period covered by the New Zealand Land Cover Database (LCDB). For example, the area of land covered by native ecosystems, including forests, decreased by about 88,000 ha between 1996 and 2018, mainly through conversion to pasture and exotic plantation forestry. During the same period, the area used for cropping and horticulture increased by 43,600 ha (MfE and Stats NZ, 2025, p.25; Stats NZ, 2021).

29 Douglas et al., 2006, p.6.

30 For example, pivot irrigation has enabled large-scale dairying in Canterbury. See Pangborn M.C. and Woodford, K.B. (2011).

31 While NZLRI may have been designed to be updated on a regular basis (BSI, pers. comm., 18 August 2025), these updates (beyond the second edition mapping) did not eventuate.

32 Although any class-based classification often involves a degree of subjectivity in the choice of class boundaries. Also, clearly specified calibration, validation and uncertainty are needed for confident use of contemporary modelling and mapping methods.

33 One of the current PCE investigations is focussed on technological advances to unlock environmental information. Specifically, this investigation aims to investigate how technological advances (including data processing, sensor technology and artificial intelligence) could make it easier and cheaper to bring together existing environmental data in the hands of disparate entities, make the data more accessible and secure, and fill the many gaps that exist.

Contemporary technologies provide the ability to map to a much higher resolution and accuracy. For example, LiDAR (which stands for Light Detection and Ranging) is a remote sensing technology that uses laser light to measure distances. The data can be used to create detailed 3D representations (called digital elevation models) of the Earth's surface and objects.[34]

Using LiDAR (where available), slope can now be mapped to a much higher resolution and accuracy than it was when the mapping for the NZLRI was undertaken (Box 1). For example, digital elevation models derived from national LiDAR have a resolution of 1 m, exceeding the spatial scale of farm-scale (1:10,000) or national (1:50,000) mapping.[35] This could have a significant impact on the LUC assessment of any given parcel of land.[36]

In Northland, a pilot study used LiDAR to update the NZLRI in a study area and confirmed that digital mapping processes were found to be more quantitative and repeatable, with the potential for reduced cost of remapping. Digital mapping also increased objectivity in the delineation and assignment of LUC map units.[37]

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34 There are two types of LiDAR: topographic and bathymetric. Topographic LiDAR typically uses a near-infrared laser to map the land, while bathymetric lidar uses water-penetrating green light to also measure seafloor and riverbed elevations. https://oceanservice.noaa.gov/facts/lidar.html

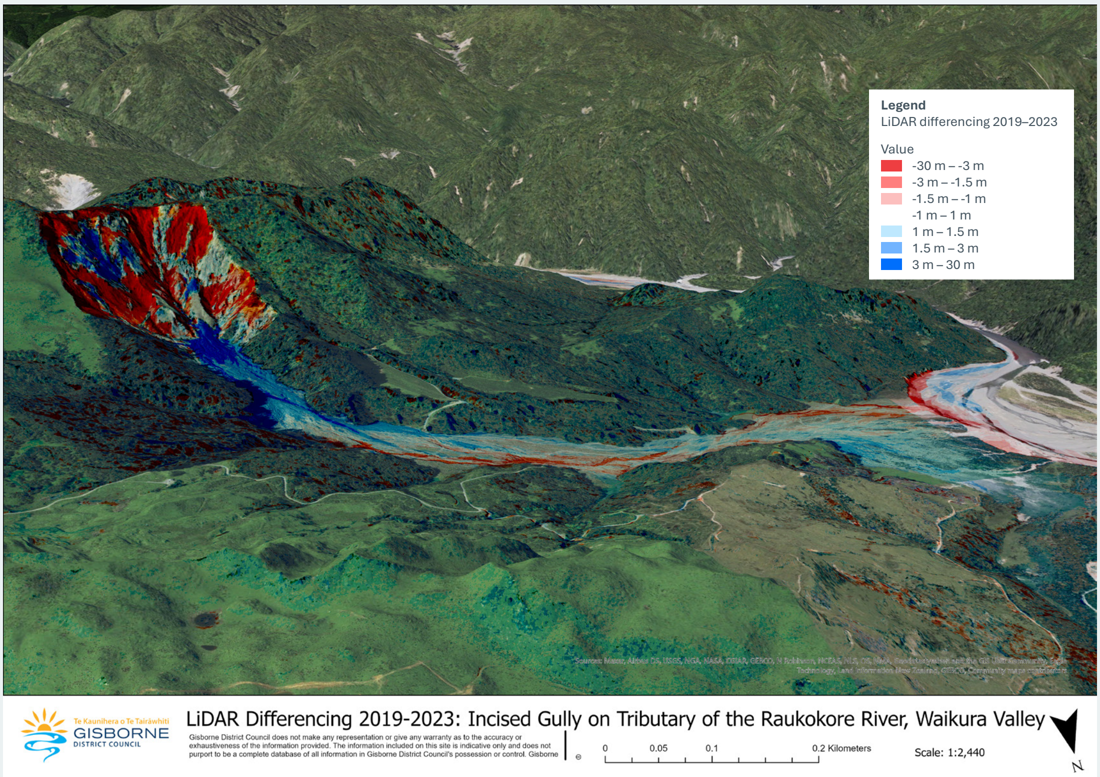
35 A 1 m resolution slope derived from the digital elevation model would be assessed at 1 million locations per km^2 (Barringer et al., 2018, p.15).

36 Barringer et al., 2013, p.14. However, to be compatible with the LUC assessment methodology, LiDAR data is required to be simplified significantly to remove surface details that far exceed that of typical manual slope mapping (Barringer et al., 2018, p.15).

37 However, the digitally derived LUC map units were constrained by the quality of the inputs, particularly the soil and rock type data in the NZLRI. For details, see Barringer et al. (2018, p.2).

Box 1: Differences between two sets of LiDAR data reveal areas of land movement.

Data derived from LiDAR provides a very useful foundation for land management, including land use and hazard management. Comparison of two (or more) sets of LiDAR data can reveal differences between two or more points in time. For example, Gisborne District Council obtained LiDAR data for the entire region for 2019 and 2023. Differences between the two sets of data have revealed areas of land movement due to Cyclone Gabrielle. In turn, this information can form the basis of targeted management, including controls on land use and hazard preparedness and management.



Source: Gisborne District Council

Figure 3: The image shows a large gully incised from the top of the ridgeline down to a tributary of the Raukokore River. Erosion is depicted in red, while aggregation (deposition) is shown in blue, highlighting patterns of earth movement across the landscape. The imagery was derived from the Tairāwhiti regional 2019 and 2023 LiDAR datasets. Differencing LiDAR in this way illustrates areas of land movement, including slips and larger-scale earthflows, within both forested and pastoral areas.

In addition, understanding land and its capability, including the underlying factors, has evolved significantly over the last half century. Boxes 2 and 3 detail the limitations of two of the five factors in the NZLRI used for the LUC classification – erosion and soil information – and outline recent advances.[38]

38 The erosion and soil factors in the NZLRI have received attention in several reports and reviews before. For example, see Barringer et al. (2013); Manderson et al. (2015); Ford and Hill (2020).

Box 2: The limitations of the erosion factor in the NZLRI and recent developments.

Several limitations of the erosion factor in the NZLRI have been documented before, for example, in the review undertaken by Ford and Hill (2020) and the 2013 NZLRI/LUC Roadmap, both recommended a rethink of the erosion data.[39] The analysis in this publication recaps and supports the weaknesses previously identified.

Erosion type and severity is one of five factors in the NZLRI that is used in the LUC classification. In the NZLRI, the erosion classification is descriptive and covers 13 erosion types and one deposition category, which are grouped into four major categories:

- Surface erosion
- Mass movement erosion
- Fluvial erosion
- Deposition.

These categories are complemented by erosion severity rankings, including assessments of present erosion and erosion potential.

However, these assessments have remained static. So 'present erosion', which described the type and severity of erosion of NZLRI polygons at the time of mapping, is no longer an accurate assessment of the situation today. The term 'potential erosion' is a subjective concept, broadly meaning the inherent predisposition of land to erode.[40] In addition, assessments today might be different due to advances in understanding of erosion processes.

Further, the assessments in the NZLRI do not reflect the risk of sediment 'delivery' to water bodies. This sediment 'delivery' to water bodies differs depending on the process (ranging from continuous but low in volume for surface erosion, to episodic but high in volume for landslides). This is important in the context of managing risk of waterway sedimentation.

Since the information on erosion was assembled in the NZLRI, understanding of erosion and an ability to map it has evolved. Newer methods of identifying, mapping and modelling erosion-prone land have been developed. These methods are based on remote sensing, modern aerial photography and modelling.[41] Some methods, such as modelling of certain types of erosion, require further development.[42] See below for additional discussion of these methods.

39 For details, see Barringer et al. (2013, p.32); Ford and Hill (2020, pp.15–16).

40 Ford and Hill, 2020, p.15.

41 These advances include, but are not limited to, identification of land movement, including slips and earthflows, by comparing changes in elevation derived from LiDAR between two points in time. Landslide susceptibility assessments by Earth Sciences New Zealand (ESNZ, of which the former GNS Science is now a part of), and BSI (of which the former Manaaki Whenua – Landcare Research is now a part of). For details, see the 2023–2028 MBIE Endeavour research project 'Sliding Lands', which is aiming to create national-scale landslide models that can forecast where landslides are likely to be triggered by earthquakes and rainfall events (https://www.gns.cri.nz/research-projects/sliding-lands/). Also, a rainfall-induced landslide susceptibility model and a landslide sediment delivery model were developed to estimate sediment production and delivery from landslides triggered by Cyclone Gabrielle. For details, see Massey et al. (2025) and Rosser et al. (2025). The 2018–2023 MBIE Endeavour research project, Smarter Targeting of Erosion Control, developed and applied shallow landslide susceptibility and connectivity models for land-use planning and erosion control. https://www.landcareresearch.co.nz/discover-our-research/climate-change/erosion-and-sediment/smarter-targeting-of-erosion-control. Further, sediment and erosion-focussed research is continuing, as two MBIE Smart Ideas projects were funded in 2024: Smart monitoring of deposited fine sediment and unlocking high-resolution sediment fingerprinting to safeguard freshwaters. Also, see Spiekermann et al. (2022) and Tsyplenkov et al. (2025).

42 It is considered that certain types of mass movement erosion will benefit from further research advances (BSI, pers. comm, 3 July 2025).

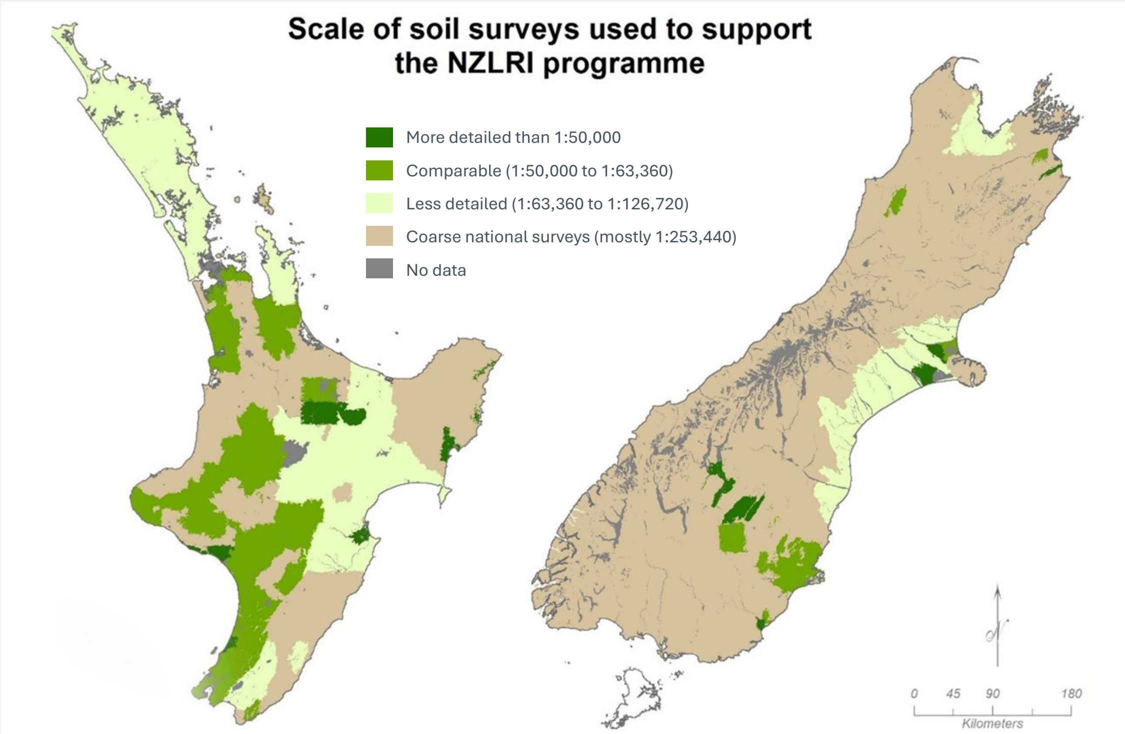
Box 3: The limitations of the soil factor in the NZLRI and recent developments.

Several limitations of the soil factor in the NZLRI have been documented in the past.[43] The analysis in this publication recaps and supports the weaknesses previously identified. The soil factor has a strong influence on the classification of more versatile LUC land (e.g. LUC 1 and 2 land) when slope and climate are similar.[44]

However, the soil factor in the NZLRI has several known limitations.[45] One is that the NZLRI units are not soil units and do not therefore represent the spatial distribution of individual soils. Another key limitation is the way in which the NZLRI soil factor was derived. As noted in the 2015 report:

> "Rather than conventional soil survey, the NZLRI was populated using soil names from already published surveys. In many areas, soil surveys at a comparable or more detailed scale did not exist, and gross interpretations of far coarser scale surveys were made. Only approximately 18% of the NZLRI has soils drawn from comparable scale surveys (1:63 360 or more detailed), while the greater extent (82%) is based on much generalised information."[46]

At the time of the NZLRI preparation available soil maps varied considerably in the scale and quality of mapping (Figure 4). High uncertainty and a lack of field work in some regions resulted in a lot of estimation to populate the information on soils.[47]



Source: Manderson et al., 2015

Figure 4: Soil surveys of varying scales were used for the NZLRI. About 70% of New Zealand only had very generalised soil information at a scale of 1:253,000. A further 20% had information at the very coarse scales ranging from 1:63,000 to 1:126,000, including most of New Zealand's key agricultural areas of Canterbury, Nelson-Tasman, Wairarapa, Hawke's Bay and Northland. Only small pockets of the country had soil surveys more detailed than the 1:50,000 scale, ranging in scales from 1:15,000 to 1:50,000.

Since the mapping for the NZLRI was undertaken, more detailed soil maps have become available in some places. The main advance has been the development of **S-map** by BSI – a soil map covering 11.8 million hectares. This equates to 44.3% of New Zealand's land area and 78.2% of the land classified as LUC 1–4 land.[48] S-map coverage varies significantly between regions. For example, there is 100% S-map coverage in Hawke's Bay and 93% coverage in Waikato, while the West Coast has only 7% S-map coverage.[49] A dedicated website allows users to explore the soil maps and associated information.[50]

In the context of LUC land assessments, this means that existing LUC assessments in the NZLRI database are likely to differ from those generated from S-map.[51] For example, this is the case for the Mangateretere area just south of Napier. According to the NZLRI database, this area is classed as LUC 1 and 2 land but, according to S-map, it is classed as LUC 4 land. The differences, in this particular case, are likely due to the noted soil salinity issues for the S-map polygons in the area.[52] As discussed further below, such differences are significant in the policy context and require validation.

While increasing, the S-map coverage remains incomplete. Another limitation is that the nominal scale of S-map ranges from 1:30,000 to 1:50,000.[53] Depending on the size of a property and the type of farm operation, it may not be useful for property and paddock-scale assessments. In areas where competition for land has markedly increased, we need higher resolution data.

The scale of the NZLRI database, including the national LUC dataset, is coarse

Another significant issue is the coarse scale of the NZLRI database, including the national NZLRI LUC dataset. The polygon boundaries were originally mapped in the 1970s at 1:63,360, and then remapped or rescaled to 1:50,000. Such broad-brush mapping is a particular challenge for the areas that were mapped as part of the first edition at 1:63,360, such as the South Island.[54]

Importantly, operational or site-based decision making requires the ability to focus on smaller areas. For farm-scale mapping, this should be between 1:5,000 and 1:15,000, depending on farm size, management intensity and surrounding landscape. Forestry surveys may be useful at a scale of up to 1:35,000, however, the National Environmental Standards for Commercial Forestry 2017 (NES-CF) require management plans to be produced at a scale of 1:10,000.

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43 For example, see Barringer et al. (2013) and Manderson et al. (2015).
44 Manderson, 2024, p.20.
45 Manderson et al., 2015, p.12.
46 Manderson et al., 2015, p.12.
47 For example, Manderson (2024) details this for the Hawke's Bay region. See Manderson (2024, pp.20–21).
48 As of the August 2025 update to S-map Online (https://soils.landcareresearch.co.nz/news/s-map-coverage-expands-again).
49 S-map coverage by region is of August 2025 (BSI, pers. comm., 6 November 2025).
50 https://smap.landcareresearch.co.nz
51 Barringer et al., 2013, p.14.
52 HBRC, pers. comm., 7 November 2025.
53 https://soils.landcareresearch.co.nz/topics/soil-survey/scale-matters
54 For example, in Marlborough, the differences between the first edition mapping at 1:63,360 in North Marlborough and the second edition mapping in South Marlborough and the Wairau Catchment at 1:50,000 were found to be quite stark. Neither mapping aligned well with on-the-ground features, leading to compliance issues for landowners in some cases. Further, the original South Island regional legend was found to have a tendency to 'lump' smaller features into bigger polygons (MDC, pers. comm, 30 October 2025).

Generally, the smaller the property and the more complex the landscape, the more detailed the maps need to be.[55] The above examples demonstrate that to make informed operational decisions, maps need to be of higher resolution and contain a greater level of detail than the NZLRI database, including the national LUC dataset can offer.

The LUC classification has broad classes and dominant limitations only

The LUC classes are intentionally broad, as they represent the highest level of a hierarchical classification. While easy to grasp, when LUC classes are used without subclasses and units (as is often done in a regulatory context), differences in land and any nuances in land management are lost. These nuances are important, particularly at the property-scale.

Even if the subclasses are used, a further shortcoming is that only four limitations have been identified – erodibility, wetness, soil and climate. Each covers a broad range, which can obscure the exact characteristics that are considered limiting.[56] For example, the wetness subclass "w" could mean that plant growth is limited by seasonal wetness, by permanently high water table of the soil or by surface flooding from nearby streams.

By contrast to the national LUC classification, with only four limitations and four LUC subclasses, a farm-scale LUC classification in Auckland identified 20 limitations and 20 specific subclasses.[57] This means that the limitations are more specific, better convey land management nuances and are likely to lead to a higher level of granularity of subclass mapping.

The LUC system and its use in the New Zealand regulatory context

The familiarity of the LUC system and its national coverage make its use in national regulation attractive. However, for something to be useful in regulation, it needs to be fit for purpose and robust, especially if its use needs to withstand judicial scrutiny.

The LUC system is currently used to inform land use restrictions to protect highly productive land through the National Policy Statement for Highly Productive Land (NPS-HPL), manage forestry on erosion prone land (NES-CF) through the use of a derivative Erosion Susceptibility Classification (ESC) system and, more recently, as the basis for restricting afforestation on agricultural land through amendments to the Climate Change Response Act (CCRA).

The LUC system's limitations outlined above, alongside recent work in Canterbury and Hawke's Bay in the context of the NPS-HPL, and Marlborough and Hawke's Bay in the context of the NES-CF, suggest it may not be the most appropriate tool in those regulatory settings. In addition, other councils are using the LUC system for different regulatory purposes in regional plans. The coarse scale of the national NZLRI LUC dataset may mean that those uses are also problematic.

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55 Hicks and Vujcich, 2017, p.21. As stated in Auckland Council's report on farm-scale LUC classification, "appropriate scales range from 1:5,000 or greater for intensively used properties, such as market gardens, orchards and vineyards, through 1:5,000–1:10,000 for dairy and drystock fattening farms or special-purpose timber wood lots, to 1:10,000–1:25,000 for extensive hill country farms and forest plantations."

56 Note that descriptions of LUC units in the regional and the national legends provide more details, although the exact nature of limitations is often not elaborated on. For example, see "wetness" limitations.

57 For details, see Hicks and Vujcich (2017).

The LUC system and the National Policy Statement for Highly Productive Land (NPS-HPL)

What is the NPS-HPL and how does it use the LUC system?

The purpose of the NPS-HPL, outlined in its solitary objective, is to protect highly productive land so that it is available for land-based primary production purposes, both now and for future generations. It recognises that highly productive land is a finite resource and that, if developed, the future use of that land for productive purposes may be lost forever.

Development of the NPS-HPL began following the release of the Ministry for the Environment's (MfE) '*Our Land 2018*' report, which rang alarm bells about the loss of New Zealand's most versatile agricultural land due to urban expansion.[58] The NPS-HPL became operative in October 2022.

To protect land for land-based primary production purposes, the NPS-HPL requires regional councils to map highly productive land and incorporate these maps into their regional policy statements within three years of the NPS-HPL becoming operative. At the time of writing, notification of any new plan or regional policy statement reviews, changes or variations is on hold until 31 December 2027, by which time the new resource management system is expected to be in place.[59]

Under the NPS-HPL, the national NZLRI LUC dataset is the default dataset for identifying whether land is considered highly productive land. While the NPS-HPL requires councils to undertake more detailed mapping to identify highly productive land, there is a general presumption that rural zoned land identified as LUC 1, 2 or 3 in the NZLRI LUC dataset will be considered highly productive land, and therefore subject to the restrictions of the NPS-HPL, unless a landowner can demonstrate that the land in question is subject to permanent or long-term constraints that mean it should not be identified as highly productive land.[60]

Recognising that it would take some time to map highly productive land, the NPS-HPL includes a transitional definition of highly productive land that applies while councils progress their more detailed mapping.[61] This was seen as a pragmatic solution to start protecting highly productive land. However, it also raises some uncertainties for landowners that have land classed at the boundaries between LUC 1, 2 or 3 land and other land due to the coarseness of the NZLRI database. Consequently, all general rural and rural production zone land that is classed LUC 1, 2 or 3 in the NZLRI is considered highly productive land. This may include isolated pockets of land surrounded by other LUC classes. The transitional definition also does not account for size, shape or natural boundaries of LUC classified land, and therefore, some land parcels may also only partially be identified as highly productive land, which may pose further challenges for landowners (e.g. reverse sensitivity).

To complicate matters, a 2024 Environment Court decision clarified that in the transition period – until regional councils notify changes to their regional policy statements to include

58 One of the key findings of that report was that significant shifts in land use took place in the past two decades. These included "expansion in urban areas (a 10 percent increase between 1996 and 2012) and accompanying loss of some of our most versatile land" (MfE, 2018, p.6).

59 For details, see s80P of the RMA 1991 and MfE (2025b).

60 Clause 3.10 of the NPS-HPL.

61 Clause 3.5(7) of the NPS-HPL.

maps of highly productive land – applicants in consenting processes could not challenge the LUC classes of their land as mapped in the NZLRI database, even if more detailed individual site investigations conclude that land is not considered LUC 1, 2 or 3.[62] In other words, "land zoned rural that is mapped as LUC 1, 2 or 3 in the NZLRI is 'stuck' as highly productive land until regional councils introduce changes to their regional policy statements."[63]

Does the LUC system provide a robust foundation for identifying highly productive land and achieving the objective of the NPS-HPL?

Fulfilling the objective of the NPS–HPL relies on the effective identification of highly productive land. This is reliant on the robustness of the LUC system including its components. The implementation of the NPS-HPL falls to regional councils and unitary authorities across the country.

How do councils view the appropriateness of the LUC system in the NPS-HPL?

The council-initiated mapping of highly productive land that will be included in the regional policy statements is meant to address some of the limitations of relying solely on the NZLRI for the identification of highly productive land. MfE states that the council mapping needs to be completed at a scale that leaves "landowners with no doubt as to whether their land is considered to be highly productive land or not."[64] When working with the NZLRI as a main data source, this will require some translation of that data, including the national NZLRI LUC dataset, to the scale of land parcels, including site-specific decisions on where to place highly productive land boundaries.

In February 2025, PCE staff surveyed councils to inform this publication.[65] Councils were asked about their progress in mapping highly productive land:

- 2 councils – Environment Canterbury and Bay of Plenty Regional Council – had completed (but not formally notified) their mapping.
- 12 were in the early stages of mapping. Of these, 10 were still assessing methodologies, 1 council had assigned staff/engaged consultants, and 1 was in the process of mapping highly productive land.
- 1 council had not formally started.[66]

As part of the survey, councils were also asked whether they had enough information to identify highly productive land in their regions. Close to half agreed that they had sufficient information while a quarter disagreed. Further, to address some of the known limitations of the NZLRI LUC dataset, nine councils were exploring complementing the NZLRI LUC dataset with other data to identify highly productive land.

Regional councils have also indicated that the NZLRI LUC dataset and the LUC classification are not suitable for assessing modern land-based production that is heavily dependent on

62 *Blue Grass Limited v Dunedin City Council* [2024], NZEnvC 83.

63 https://hobec.co.nz/news-resources/2024/05/stuck-in-the-highly-productive-mud/

64 MfE, 2023, p.62.

65 In February 2025, PCE sent an online survey to all 16 regional councils to understand how they use LUC and ESC to implement the NPS-HPL and the NES-CF. 15 out of 16 regional councils filled out the survey.

66 Note that the Government has recently completed consultation on changes to the NPS-HPL, which may, *inter alia*, include removing LUC 3 land from the definition of highly productive land and establishing special agricultural areas (SAAs), as well as extending the October 2025 deadline. As a result, several changes to the NPS-HPL are on the cards. Councils may be apprehensive about mapping highly productive land, given these anticipated changes.

the addition of inputs, like water and nutrients. As the focus of the LUC classification is on more traditional primary sector land use, it does not capture emerging land uses, for example, greenhouses with concrete floors, that do not depend on the biophysical characteristics of the land, yet may be allowed on highly productive land.

The councils surveyed indicated that while the national NZLRI LUC dataset is a good starting point to identify highly productive land, its coarse scale poses challenges with leaving "landowners with no doubt as to whether their land is considered to be highly productive land or not."[67]

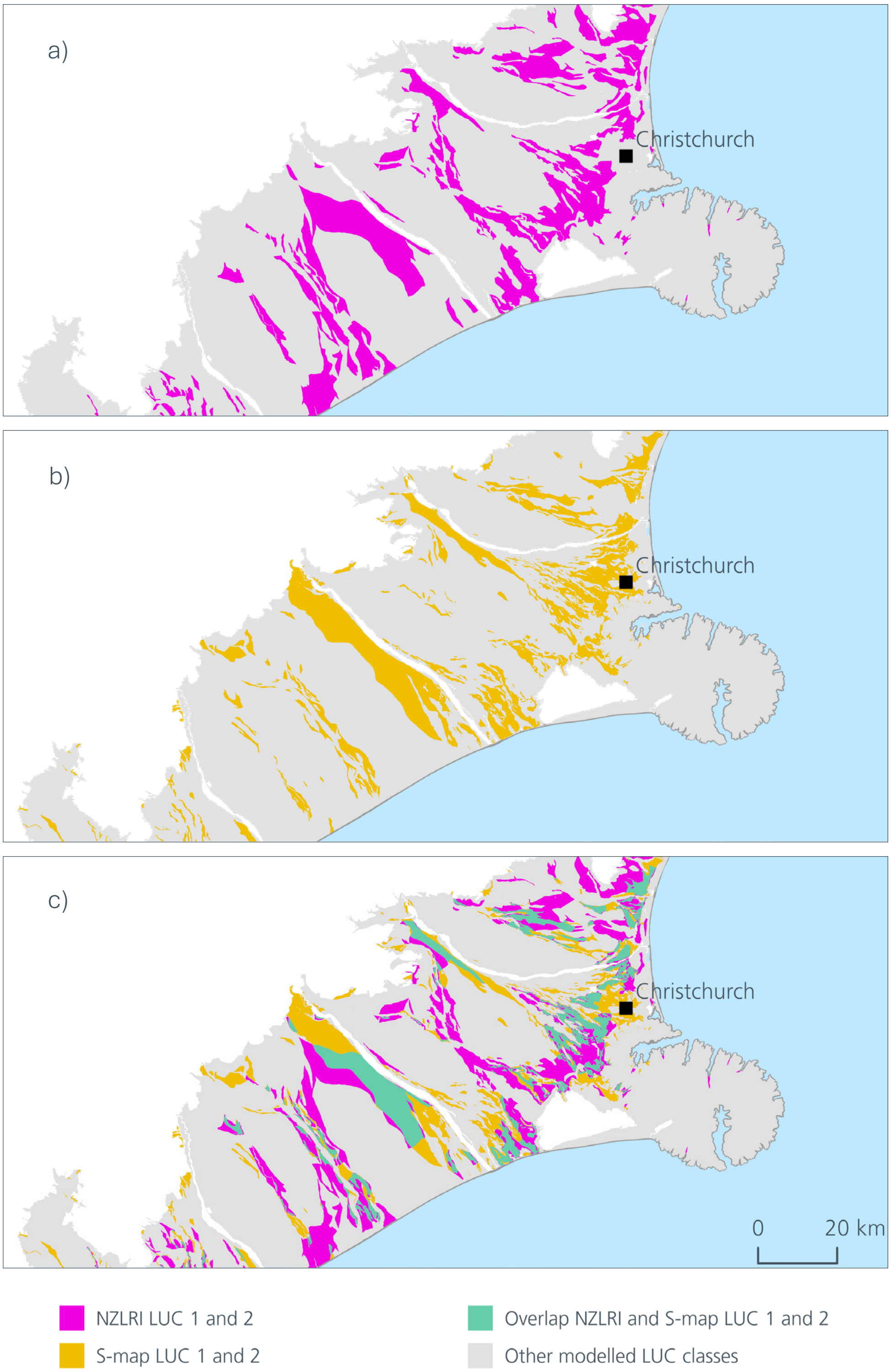
How suitable is the LUC system to support identification of highly productive land by regional councils?

Hawke's Bay Regional Council and Environment Canterbury have explored different methods to inform identification of highly productive land. Employing different methods allows the LUC system's suitability for identifying highly productive land to be tested.

In the Canterbury study, areas of LUC 1 and 2 land, as identified in the NZLRI LUC dataset, were compared with areas of LUC 1 and 2 land, identified through S-map.[68] The different methods produced significantly different results. Comparisons of the areas based on the NZRLI dataset and S-map are shown in Figure 5.

67 MfE, 2023, p.62.

68 For details, see Lilburne et al. (2020).



Source: adapted from Lilburne et al., 2020, using the data supplied by Lilburne, L., BSI.[69]

Figure 5: Comparison of the areas of LUC 1 and 2 land in Canterbury mapped using (a) the NZLRI LUC dataset, (b) S-map and (c) the overlaps and discrepancies between the two datasets. Only 97,877 ha or 24% of the areas overlap. The areas that were not analysed are shown in white.

69 Figure 5 has been created following methodology described in Lilburne et al. (2020) using updated S-map data for 2025 instead of 2020, reflecting the extended S-map coverage.

The Canterbury study demonstrated very poor alignment between the two datasets when working to identify highly productive land. For the area analysed, the NZLRI LUC dataset identified 290,958 hectares of LUC 1 and 2 land, while S-map identified 208,560 ha. Of the areas identified as LUC 1 or 2 land, by either dataset, only 24% of the areas overlap (97,877 ha). In other words, if LUC 1 and 2 land is considered highly productive land, S-map identified 110,683 ha of land, which the NZLRI LUC dataset did not, and the NZLRI LUC dataset identified 193,081 ha of land, which S-map did not.

Note that the extent of this Canterbury study was limited by the fact only 50% of the Canterbury region is covered by S-map.[70] This incomplete coverage resulted in areas that were not analysed, shown in white on the maps above. While highly productive land is more likely to exist in the lowland areas (LUC1–4 land), incomplete coverage is likely to lead to some highly productive land being missed.

With such significant disagreement between the two methods, it would be ill-advised to rely on either without further work to validate them and reconcile the differences.

Hawke's Bay Regional Council also explored different methods to inform the identification of highly productive land in the region. In a commissioned BSI study, areas of LUC 1–3 land in the NZLRI LUC dataset were compared with the LUC 1–3 land identified by combining the S-map data with other data.[71,72] Again, different methods produced different results (see Figure 6).

For the Hawke's Bay region, the total area of LUC 1–3 land identified using the S-map data (186,272 ha) was some 11,000 hectares larger than the area estimated using the NZLRI LUC dataset (175,240 ha). Even larger differences were observed between each of the three classes.[73] These differences – especially the differences between the datasets in identifying LUC 3 land – are likely to come to the fore in the context of recent consultation to remove LUC 3 land from the definition of highly productive land in the NPS-HPL. To reconcile these differences, the BSI report recommended field validation.[74]

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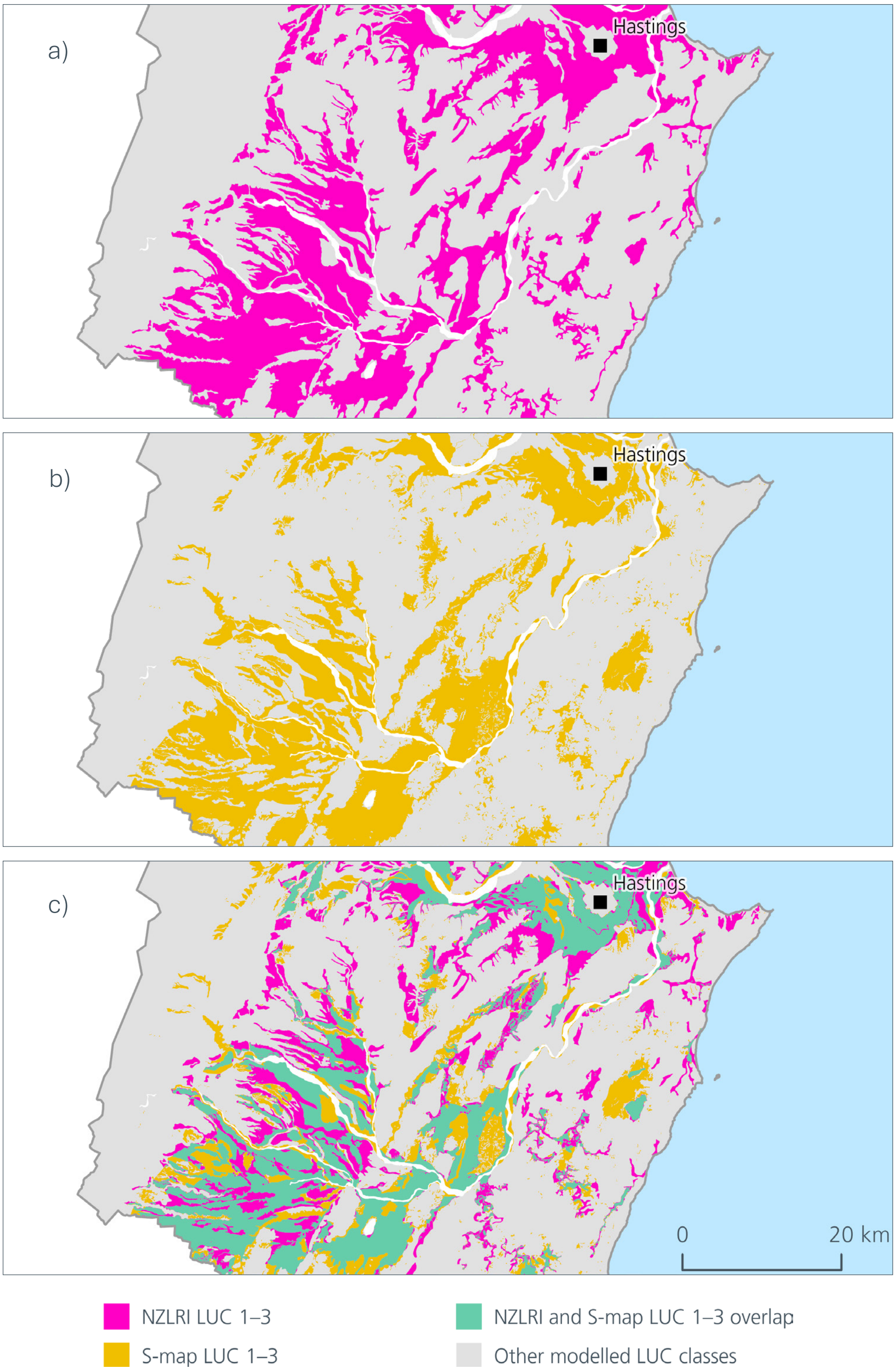
70 BSI, pers. comm., 6 November 2025

71 For details, see Manderson (2024).

72 Other data that was combined with S-map data included LiDAR elevation, LiDAR-derived slope and ESNZ (formerly NIWA) rainfall data. Note that report authors considered that combining the S-map data with other data represented a better method of identifying highly productive land, so this output was used in the subsequent analysis (Manderson, 2024, p.13).

73 Manderson, 2024, pp.19–20.

74 Manderson, 2024, p.vi.



Source: adapted from Manderson, 2024 using the data supplied by HBRC.

Figure 6: Comparison of the areas of LUC 1–3 land in Hawke's Bay as identified by (a) NZLRI LUC, (b) S-map and (c) the overlaps and discrepancies between the two datasets. Only 107,161 ha or 41% of the areas overlap. While only part of the Hawke's Bay region is shown here, the analysis was undertaken for the entire region.

Again, the Hawke's Bay study showed poor alignment between the two datasets when working to identify highly productive land. The entire Hawke's Bay region was analysed using both the national NZLRI LUC dataset and S-map. Only 41% (107,161 ha) of the areas overlap. Based on this work, if LUC 1–3 land is considered highly productive land, S-map identified 79,220 ha of land, which the NZLRI LUC dataset did not; while the NZLRI LUC dataset identified 74,573 ha of land, which S-map did not. In this example, the degree of overlap is better than that observed in Canterbury, yet the disagreement is still significant. Similarly, it would be ill-advised to rely on either without further work to validate them and reconcile the differences.

As of August 2025, S-map covers 78.2% of LUC 1–4 land. This means that in these areas S-map could provide an alternative to the national NZLRI LUC dataset (the default dataset in the NPS-HPL) to inform identification of highly productive land.

For this purpose, MfE currently has a work programme underway to identify LUC 1–4 land from S-map data (where there is coverage). This is intended to aid and inform councils' regional mapping of highly productive land based on improved soil information over time.[75]

However, S-map coverage decreases to 51.5% for LUC 5 and 6 land and 20.4% for LUC 7 and 8 land. If we look at the entire country, only 44.3% of Aotearoa is covered by S-map.

Another limitation of S-map is that its nominal scale ranges from 1:30,000 to 1:50,000.[76] Depending on the size of a property and the type of farm operation, it may have similar limitations to the NZLRI LUC dataset and may not be fit for purpose for use at the property scale in all situations.

In summary

In summary, fulfilling the objective of the NPS–HPL relies on effective identification of highly productive land, which in turn is reliant on the robustness of the LUC system.

The NZLRI LUC dataset is the default dataset for the NPS-HPL and provides a starting point, however, its limitations pose challenges to the successful identification of highly productive land at a scale that leaves "landowners with no doubt as to whether their land is considered to be HPL or not."[77]

While alternative methods for identifying highly productive land exist and can be used in parts of the country (e.g. S-map), different methods and datasets produce different results, as demonstrated above. In the absence of ground truthing and validation, reconciling differences is very challenging and could provide a fertile ground for debates and disputes during a plan making process. At the time of writing, no councils have formally notified maps of highly productive land in their regional policy statements. Further, the Government has put notification of any new plan or regional policy statement reviews, changes or variations on hold until 31 December 2027.[78]

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75 The method for this MfE investment area will include rule-based modelling that will be applied to available S-map and LiDAR data to produce an initial draft LUC 1–4 classification. This will be followed by verification from BSI through qualified appraisal, comparison with other LUC datasets and surveys, and assessment against maps of expected LUC 1–4 determined from high value land uses and covers. Depending on the quality of legacy soil surveys, BSI will attempt to identify S-map siblings that are known to associate with LUC 1–4. This will generate a national S-map LUC 1–4 layer that will be publicly available. This work is due to be delivered by 30 June 2026 (MfE, pers. comm., 13 Nov. 2025).

76 https://soils.landcareresearch.co.nz/topics/soil-survey/scale-matters

77 MfE, 2023, p.62.

78 Section 80P of the RMA 1991.

Given that the issues come to the fore due to urban expansion and fragmentation of peri-urban holdings, effort might be better spent on undertaking granular mapping in hotspot areas. In short, more effective identification of highly productive land will better support achievement of the NPS–HPL objective.

The Erosion Susceptibility Classification (ESC) system and the National Environmental Standards for Commercial Forestry (NES-CF)

What is the NES-CF?

The NES-CF (previously called National Environmental Standards for Plantation Forestry, NES-PF) provides nationally consistent regulations to manage the environmental effects of eight core commercial forestry activities.

The NES-CF has two objectives:

- maintain or improve the environmental outcomes associated with commercial forestry activities, and
- increase the efficiency and certainty of managing commercial forestry activities.[79]

One of the key environmental issues the NES-CF is meant to manage is erosion risk from forestry activities. The vulnerability of land to erosion is higher during and after harvesting, with maximum vulnerability 2–4 years post-harvest.[80] This so-called 'window of vulnerability' lasts until a closed canopy and protective root system have reestablished. Under extreme conditions, such as very high rainfall on highly erodible soils and steep slopes, land can remain vulnerable to landslides for longer periods.

The environmental impacts of erosion from forestry blocks include adverse effects on water quality as a result of increased sedimentation from different types of erosion. Deposition of sediment and woody debris, which constrains or diverts water flows, can impact on catchment hydrology and natural processes ,and damage roads, dwellings and other infrastructure. The aftermath of Cyclone Gabrielle in the Gisborne area illustrated how damaging these effects can be.

Use of the LUC system in the NES-CF

The NES-CF uses the Erosion Susceptibility Classification (ESC) – a derivative of the LUC system. The NES-CF incorporates the ESC by reference.

What is ESC and how was it developed?

The Erosion Susceptibility Classification (ESC) is a classification with a focus on erosion susceptibility for forestry activities, derived from the LUC system.

The ESC system was developed specifically for use in the NES-PF (now NES-CF) as a nationwide dataset that could be embedded in regulations to provide a consistent initial national assessment of erosion susceptibility for plantation forestry activities.

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79 https://www.mpi.govt.nz/forestry/national-environmental-standards-commercial-forestry/

80 It was previously thought that maximum vulnerability to landslides occurred 2–8 years post-harvest, e.g. Phillips et al. (2012), but recent research by BSI suggests the window is narrower (MWLR, 2024).

The ESC system was developed using information in the NZLRI database and the LUC classification regional extended legends. At the time, this was considered the preferred approach for generating nationally consistent spatial assessments of erosion susceptibility. Although other tools existed, including spatial datasets and models, they were considered to have drawbacks, including incomplete spatial coverage, variable quality of spatial data or cumulative modelling errors.[81]

The ESC was originally developed in 2011 using the data on erosion type and severity in the NZLRI database. Specifically, potential erosion severity data for each LUC unit were used to classify land into four categories of erosion susceptibility: low, moderate, high and very high (green, yellow, orange and red zones, respectively). Given that the erosion profile of the LUC system was developed for pastoral land use, potential erosion had to be reevaluated under plantation cover, focusing on the window of vulnerability. Using this system, a national spatial dataset was produced by overlaying ESC zones onto LUC units.[82]

The original method was further refined between 2015 and 2017, although the fundamental approach largely remained the same.[83] Following concerns that some LUC units in the high and very high (orange and red) ESC zones were misclassified or conservatively classified, the Ministry for Primary Industries (MPI) commissioned an update to assess erosion susceptibility associated with plantation forestry activities in the high and very high zones with more accuracy.[84]

As a result, several refinements were made. This included reassessing LUC units in the South Island, for which, in the NZLRI database only a single erosion severity category was listed for multiple erosion types. It also included developing a terrain classification based on dominant erosion process, rock type and topography from the data in the NZLRI and updating the high and very high (orange and red) ESC zones based on erosion terrains.[85]

Additional refinements included improving the mapping precision along river margins, lakes and the coastline, and testing and further refining ESC zones with experts in both LUC and plantation forestry across the country.[86] All of the refinements resulted in changes of classification for some of the LUC units.

The final ESC retained the original four zones – low (green), medium (yellow), high (orange) and very high (red). Recognising that application of the ESC in the context of the NES-PF “may bring about local issues that require adjustment to the ESC to improve its accuracy”, in 2018, MPI developed a process to enable reassessments and adjustments to ESC.[87] Some landowners had their land remapped, although there is no publicly available database that records these changes.[88] The ESC itself has remained unchanged since it was developed. The 2018 versions of the ESC and associated national dataset remain current and are available on MPI’s website.[89]

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81 Bloomberg et al., 2011, p.13.
82 Bloomberg et al., 2011.
83 See Basher et al. (2015); Basher et al. (2016); Basher and Barringer (2017).
84 MPI, 2017, p.4.
85 For details of the ESC development, see MPI (2017) and technical reports therein.
86 See Basher et al. (2016); Basher and Barringer (2017).
87 MPI (Te Uru Rakau), 2019a, p.1.
88 MPI, pers. comm., 30 October 2025.
89 For more details, see MPI’s website. https://www.mpi.govt.nz/forestry/national-environmental-standards-commercial-forestry/erosion-susceptibility-classification/

Limitations of the ESC

Given that the ESC was derived from the NZLRI database, it also has significant limitations, despite several refinements during development stages.

The limitations of the ESC were acknowledged by the original developers who emphasised that ESC, based on 1:50,000 scale mapping, was only the first step in the management of erosion risks from plantation forests; and that, to account for important variation in erosion susceptibility at a site level, planning and regulation at a scale of 1:5,000 to 1:10,000 would be required.[90] As noted in MPI's guidance:

> "After consulting the ESC, an essential second step in risk assessment to guide decision is detailed planning at an operational scale. Additional site-specific information, such as the likely effects of topography, soils, drainage and risks of high intensity rainfall events provide for the ESC outputs to be refined to a larger scale. It is not credible to apply (e.g. simply blow up/ expand to a larger scale) the ESC at this scale without interpretation and/or adjustment to the operational management plans scale."[91]

While the method for deriving ESC zones underwent several refinements during its development, fundamentally it uses data from the NZLRI database, the mapping for which was largely undertaken in the 1970s. Given the degree of expert judgement involved at the time, the mapping for the NZLRI was undertaken, there is a degree of inherent subjectivity in the ESC classification which potentially results in compound errors.[92] As noted by the developers of ESC, potential erosion severity is based on expert opinion.

> "As such, it can be "wrong"– assessments by NZLRI surveyors of potential erosion severity can change with experience and observation over a working lifetime."[93]

An additional important limitation of ESC is that the classification is focused on the susceptibility of land to erosion, not the risks of or from erosion.[94] While this may have been clear at the time ESC was developed, MPI's 2019 guidance and website say that ESC is used to identify the erosion risk of land as a basis for determining where a plantation forestry activity is permitted, subject to certain conditions being met, or requires resource consent on higher-risk land.[95] Erosion risk is a more encompassing concept than susceptibility of land to erosion.

Erosion susceptibility is an inherent property of the land, which is based on potential erosion severity, erosion type and dominant erosion processes, rock types and topography.[96] Erosion susceptibility can be either increased or decreased by human activities, such as roading or forest harvesting.

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90 Bloomberg et al., 2011, p.43.
91 MPI (Te Uru Rakau), 2019b, p.1.
92 MPI, 2017, pp.3–4.
93 Bloomberg et al., 2011, p.14.
94 For details, see Bloomberg et al. (2011); Bloomberg et al. (2015).
95 See MPI (2019b, p.1) and https://www.mpi.govt.nz/forestry/national-environmental-standards-commercial-forestry/erosion-susceptibility-classification/
96 For details, see the four MPI technical reports (2017) that were contracted as part of the ESC development.

The ESC focuses on the susceptibility of land to erosion, it does not consider connectivity to water bodies and associated sediment delivery. One implication of this is that the downhill and downstream effects of forestry activities are likely to be more severe in areas that are highly connected to waterways compared with those areas that are not. This is particularly important when considering the impacts of forestry when developing regulation in the context of freshwater management under the National Policy Statement for Freshwater Management. In short, susceptibility of land to erosion does not provide a full picture, as it is just one piece of the puzzle.

By contrast, **risk** is a more encompassing concept, which in simple terms can be described as the likelihood and consequences of a hazard. Erosion risk depends on the intersection of erosion susceptibility, the probability of triggering events (e.g. heavy or persistent rainfall) and the consequences of erosion (e.g. impacts on human life, property assets, high-value ecosystems). The identification of downslope or downstream consequences (e.g. housing located on fans directly in the path of debris flows) is as critical to risk management as mapping erosion susceptibility or assessing the probability of triggering events (e.g. rainfall or earthquakes).[97]

How is the ESC intended to be used in the NES-CF?

The ESC, as used in the NES-CF, operates as a screening tool ('threshold test') to identify erosion susceptibility of the land used (and proposed to be used) for forestry. This threshold test is then used to determine where a forestry activity is permitted, subject to certain conditions being met, or requires a resource consent.[98] Land in green and yellow zones is considered less likely to erode and forestry activities in these zones are permitted (subject to permitted activity conditions being met). Land in orange and red zones is considered more likely to erode and is subject to further restrictions. It is worth noting that ESC covers all types of erosion, but different erosion types require different management during forestry operations. For example, some coastal areas are zoned red in the ESC to account for their significant risk from wind erosion but they have no risk of landslides.

As a screening tool, the ESC is used to determine what conditions landowners must comply with as susceptibility to erosion increases. For example, earthworks in orange zones come with increased requirements while some earthworks may still operate as permitted activities. If they cannot meet additional requirements that do not apply to land in green or yellow zones (e.g. slope, volume of material), then these activities will require resource consents.[99]

Most activities in red zones require a resource consent.[100] Requiring consents on red-zoned land is enshrined in the regulations due to the elevated risk of adverse environmental effects related to erosion. For example, the land may experience greater risk of landslides and slips during establishment of the forest, particularly if vegetation clearance is required prior to planting. Due to the steeper slopes, there is also increased susceptibility to surface

97 Bloomberg et al., 2011; Bloomberg et al., 2015.

98 A 'threshold test' is also sometimes referred to as a 'drafting gate'. For details, see the MPI website. https://www.mpi.govt.nz/forestry/national-environmental-standards-commercial-forestry/erosion-susceptibility-classification/

99 NES-CF, regulations 24–35.

100 While low intensity harvesting of exotic-continuous cover forestry (permanent or carbon forestry) can be undertaken as a permitted activity in all zones, generally, forestry activities require a resource consent in red zones.

and landslide erosion risks during the growing phase and the window of vulnerability post-harvest. Sediment, slash and woody debris mobilised during significant weather events can negatively affect waterways, private land, infrastructure and beaches downstream. The resource consent process is the mechanism in place to manage these effects.

In addition to the four ESC zones, the NES-CF also explicitly mentions LUC 8e land (LUC 8 land where susceptibility to erosion is considered the dominant limitation) defined as land with severe to extreme erosion limitations or hazards that make it unsuitable for arable, pastoral or commercial forestry use.[101] Harvesting is a restricted discretionary activity in red zones that are on LUC 8e land, meaning that councils are able to decline resource consent applications.[102]

In addition to evaluating erosion risk on land at the coarse ESC scale, the NES-CF requires more detailed information about management of commercial forestry activity and environmental risk to be presented in management plans.[103] To meet permitted activity regulations, foresters or landowners must provide a notification that forestry activity is planned,and councils may request a copy of the management plan.[104] If a notification is not received, a management plan does not satisfy the requirements of the NES-CF or is not provided upon request, the activity requires a resource consent.

However, in practice, given capacity and capability constraints, the ESC is used as somewhat of a risk matrix for regulatory purposes. Some councils use the ESC zones to decide whether a review of a management plan is required or, alternatively, prioritise management plan reviews based on the ESC zones. For example, councils may always request and review management plans in orange ESC zones but only sometimes in green or yellow ESC zones. As discussed below, green and yellow zones can contain areas at high risk of landslide erosion that are not identified due to the coarse resolution of the ESC dataset.

While the national ESC dataset has a scale of 1:50,000, the NES-CF requires management plans with mapping at a scale not less than 1:10,000. While the NES-CF itself is silent on the required mapping tools, a 2025 MPI technical paper outlines several spatial data tools that could be used to refine scale and improve interpretation.[105] As long as the regulations are complied with, landowners (or their advisors) are free to use any tool they see fit.

While the NES-CF has quite prescriptive information requirements, in practice, council expectations around the level of detail, and therefore the effectiveness of the management plan process, vary from region to region. In short, the level of detail provided in a management plan is only as effective as compliance and enforcement of the requirements of the NES-CF by councils.

101 NES-CF 2017, regulation 3.

102 NES-CF 2017, regulation 71. Note that there is land in the red zone that is not LUC 8e land.

103 For example, the requirements for more detailed information include a map and description of the ESC zones that apply, as well as a map (or maps) that are at a scale not less than 1:10,000, that refer to afforestation and replanting plans, forestry earthworks management plans, quarry erosion and sediment management plans, and harvest plans (Schedules 3–6 of the NES-CF).

104 In practice, most councils have an online platform where foresters/landowners are required to attach relevant management plans to their notifications.

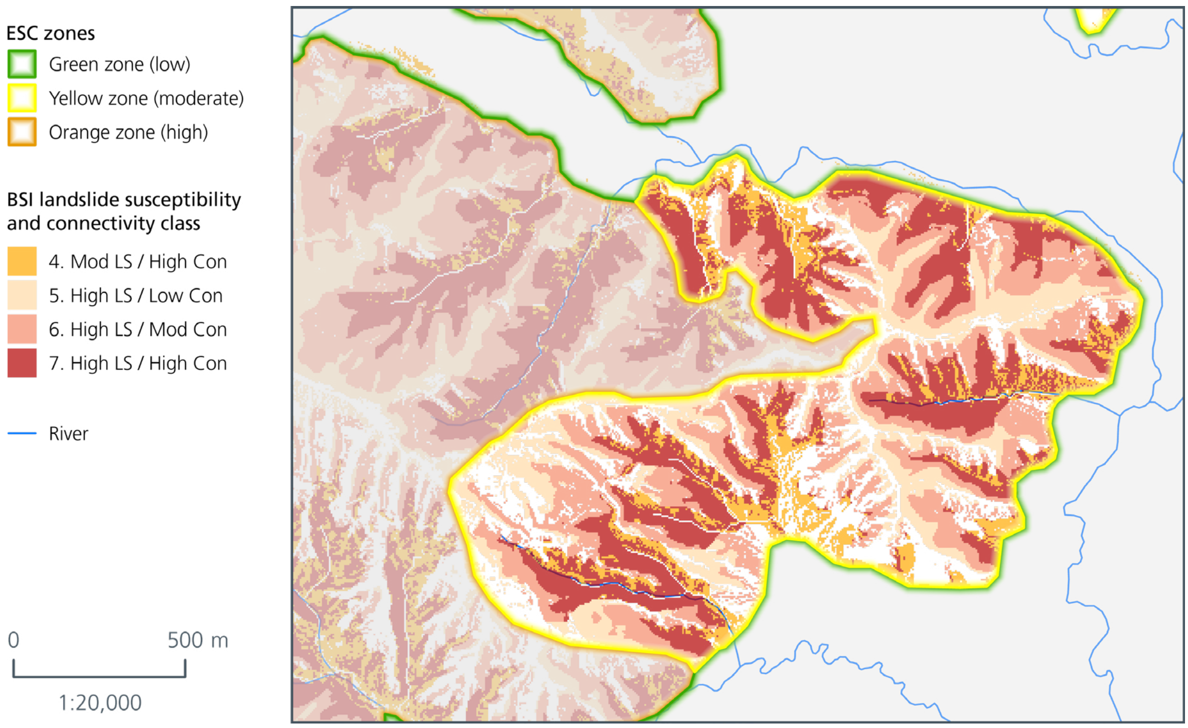
105 MPI (Te Uru Rakau), 2025.

Does the ESC provide a robust foundation for making regulatory decisions and achieving the objectives of the NES-CF?

The ESC was specifically developed to manage erosion risk from forestry and could be expected to provide a more robust basis for regulatory decisions than 'raw' LUC classifications. However, the coarseness of the ESC national dataset means there will likely be areas where erosion risk is both over and under-classified. Analysis undertaken in Marlborough and Hawke's Bay demonstrates this.

Marlborough District Council has recently commissioned research by BSI, which identified and prioritised areas of landslide susceptibility and landslide connectivity to waterways.[106] Connectivity to waterways helps estimate the effects of sedimentation, which are likely greater in areas that are highly connected to waterways compared with areas that are not. Areas identified by BSI include areas of low, moderate and high susceptibility and connectivity.

The research focusses on erosion associated with shallow landslides only and produces a higher-resolution output compared with the ESC zones. As Figure 7 shows, BSI research outputs are higher resolution, showing greater variability compared with the ESC zones. The map demonstrates how certain areas are estimated to have moderate erosion susceptibility according to ESC (and thus fall in the yellow ESC zone) but are estimated to have high landslide susceptibility and high connectivity to waterways according to the research by BSI (shown in red and pink).



Source: Data provided by Marlborough District Council

Figure 7: The map shows ESC zones for a location in Marlborough overlaid with the outputs from BSI landslide susceptibility and waterway connectivity research.

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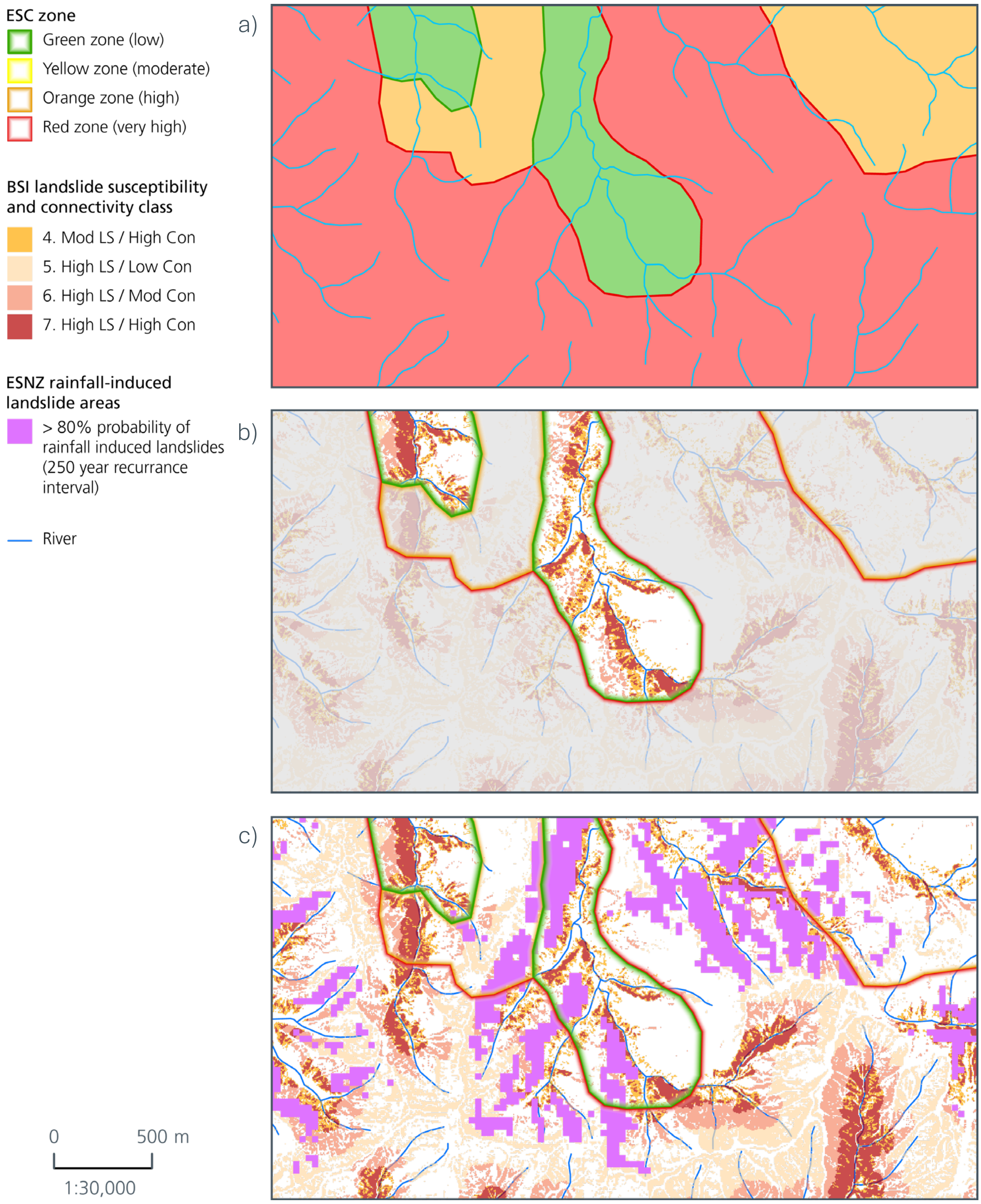
106 Smith and Tsyplenkov, 2025. Note that this research by BSI only covered approximately 33% (343,000 ha) of the Marlborough region (1,047,000 ha).

Similarly, the **Hawke's Bay Regional Council** makes use of the geospatial layers from BSI together with recent research by Earth Sciences New Zealand (ESNZ), which identifies areas of different probabilities of rainfall-induced landslides.[107,108]



Source: Data provided by Hawke's Bay Regional Council

Figure 8: Maps show a location in the Hawke's Bay. Map (a) shows the ESC zones. Map (b) shows the ESC zones overlaid with the outputs from BSI landslide susceptibility and waterway connectivity research. Map (c) is identical to map (b) overlaid with outputs from the ESNZ research on rainfall-induced landslide areas.

107 Note that the research covered the entire Hawke's Bay region (https://experience.arcgis.com/experience/8fc839a4a41b4271b2e519c617a2f7a0). See also Smith et al. (2024); Tsyplenkov and Smith (2024).

108 This includes rainfall-induced landslide susceptibility models developed following Cyclone Gabrielle, which were mentioned above. For details, see Massey et al. (2025).

Figure 8 demonstrates that BSI and ESNZ research outputs are higher resolution, showing greater variability compared with the ESC zones. The coarseness of ESC zones is particularly evident when comparing Figure 8(a) with Figures 8(b) and 8(c). While the ESC zones identify uniform susceptibility of land to erosion, higher resolution and more detailed mapping reveals more heterogeneity and is better suited for informing targeted management.

In addition, Figures 8(b) and 8(c) demonstrate that certain areas are estimated to have low erosion susceptibility according to ESC (and thus fall in the green ESC zone). However, some of these areas are estimated to have high landslide susceptibility and high connectivity to waterways (shown in red and pink) according to the research by BSI, and/or have an 80% or greater probability of a landslide occurring under modelled rainfall amounts (shown in purple) according to the research by ESNZ. More effort is needed to enable reconciliation of the differences in the various outputs, to make them useful for decision-making.

As can be seen on the maps above, the ESC both over and under-classifies susceptibility of land to erosion in Marlborough and Hawke's Bay, at least in the context of shallow landslide erosion. For example, in the area modelled in Marlborough, 10% of the areas classified using the ESC as green and yellow (low and moderate susceptibility, respectively) contain areas of high landslide susceptibility and high connectivity to waterways. In addition, only 1% of the land has been classified as both red ESC zone land (land with very high erosion susceptibility) and land with high landslide susceptibility and high connectivity to waterways. This raises questions about alignment between the classifications. A similar situation emerges in Hawke's Bay.

The ESC may over-classify erosion susceptibility for some land resulting in less permissive rules than are warranted. This is not a significant environmental issue as the NES-CF requires more detailed information (via management plans) for most forestry activities and landowners have an incentive to provide this to minimise the restrictions they may be subject to. But over-classification places higher than necessary costs on the foresters and landowners having to provide this information.

Under-classifying land is an environmental risk because of the more permissive approach the NES-CF takes to management (via rules and standards) for that land. There is no incentive for a landowner to alert the council to an erosion risk that is higher than the ESC assessment, and it may be beyond the resources or capability of local government to challenge the classification of the land.[109] If that erosion risk is not appropriately managed, there is a much higher chance of sedimentation and debris affecting local waterways, and damaging land and infrastructure downstream.

In the absence of additional regulation that goes beyond the requirements of the NES-CF, misclassification may result in councils being left without the necessary levers to ensure effective management of the forestry activity and the land. This could have devastating consequences, particularly in the face of extreme weather events.

While this risk may be mitigated to an extent by the management plan requirements, this mitigation only applies where a management plan is requested. As described above, councils may not request (or may not undertake detailed review) of management plans on land that is classified as being lower risk.[110]

109 While mechanisms exist by which the ESC classification can be challenged by councils, it is likely to be a costly exercise, the funding of which will fall on ratepayers. See MPI website, https://www.mpi.govt.nz/dmsdocument/28542-Process-to-update-the-NES-PF-ESC-on-a-case-by-case-basis

110 While foresters/landowners are required to prepare notifications and management plans for most forestry activities, whether or not councils are reviewing the management plans submitted or using receipt of the notifications as a trigger for site-inspections and compliance checks is another matter.

It also must be acknowledged that, while helpful, the recent research in Marlborough and Hawke's Bay has its limitations. The higher resolution geospatial layers by BSI and ESNZ provide more detailed information to enable more meaningful property-scale decisions regarding the best ways to manage risks associated with landslide erosion.

However, there are also drawbacks. The geospatial data from BSI and ESNZ is currently limited in coverage and focuses on a specific erosion category (landslide erosion). These, and other alternative datasets and broader tools used by councils focus on individual and separate erosion types, for example, focussing on mass-movement (landslides) only. By comparison, the ESC covers all types of erosion.

In addition, a variety of erosion tools generate different types of outputs, making comparisons difficult. Greater effort is needed to enable reconciliation of the differences in the various outputs, to make them useful for decision-making.

How do councils view the appropriateness of the ESC?

"As part of this review, PCE staff surveyed councils across the country who are using the ESC and implementing the NES-CF. Councils were asked to indicate their confidence in the ESC to support erosion management in their regions. One council was fairly confident, three councils were somewhat confident, five councils were slightly confident, and four councils were not confident at all. None of the councils were completely confident.

Councils reported the use of several alternative tools to better identify erodible land in their regions and/or provide advice on targeted management in those areas, including but not limited to:

- modelling using SedNetNZ, RUSLE, eSource, physiographic models
- the BSI landslide susceptibility and stream connectivity model and associated geospatial layers
- the ESNZ rainfall-induced landslide probability model and associated geospatial layers
- Bay of Plenty Regional Council's geospatial layers showing biophysical risk (inherent vulnerability)
- Environment Canterbury's high soil erosion risk geospatial layers
- elevation data derived from LiDAR
- radiometric surveys data
- buffer zones and setbacks from streams
- farm-scale LUC mapping.

Engagement undertaken during the preparation of this report identified that the ESC is useful as a preliminary screening tool to identify where more consideration of the potential impacts of forestry activities is required. However, there is consensus that the ESC is not well suited to the more detailed assessments needed to support operational decision-making. To make informed operational decisions, tools and systems that contain more detail and go beyond the coarse scale of the ESC are required.

Overall, councils' reliance on a variety of erosion tools is similar to their reliance on various freshwater models used to support the regulation and management of water in New Zealand. A 2024 PCE review found a large number of (often overlapping) models used in a regulatory context.[111] These models were not systematically evaluated and were used variably, often not to their full potential.[112]

In summary

In summary, while useful as a screening tool for identifying and managing risks associated with commercial forestry activities on erodible land, the limitations of ESC pose challenges.

Limitations include:

- a degree of inherent subjectivity in the classification
- coarse scale
- a focus on susceptibility to erosion instead of risks of or from erosion.

In many cases, councils use a variety of additional tools to better identify and manage erodible land. These are not without their own drawbacks.

Given the NES-CF settings and their focus on ESC zones to identify the level of risk, there may be instances where forestry activities are currently carried out without a resource consent and with less regulatory scrutiny than may otherwise be warranted. If the ESC zones were more accurate, the same forestry activity on the same land could require a resource consent (which may also include the option of refusing consent because the activity is inherently too risky) and a greater focus on monitoring and compliance from the relevant council.

A requirement to obtain a resource consent does not manage erosion risk in and of itself, and permitted activity conditions are legal requirements designed to manage effect. Greater awareness of erosion risk factors combined with appropriate management of effects can decrease that risk. Importantly, the more accurate the underlying data, the more robust the foundation for making any regulatory decisions.

The LUC system and the Climate Change Response Act (CCRA)

What is the CCRA?

The Climate Change Response Act (CCRA) 2002 provides a framework for the development and implementation of clear and stable climate change policies. Among other things, it provides for the operation of a greenhouse gas emissions trading scheme (NZ ETS).

The unlimited use of forestry in the New Zealand Emissions Trading Scheme (NZ ETS) has driven significant land use change from pastoral farming to forestry, including so called 'permanent' carbon forestry. In response to vocal concerns by some rural communities, the Government introduced the Climate Change Response (Emissions Trading Scheme – Forestry Conversion) Amendment Act to regulate ETS-driven land conversions. The Act uses the LUC classification and the accompanying NZLRI LUC dataset to restrict the number of exotic forestry conversions that can be registered in the NZ ETS.[113]

111 Among other things, that review found that 13 different models were used to assess sediment in rivers and streams. For details, see PCE (2024a, pp.35–37).

112 PCE, 2024a.

113 The Climate Change Response (Emissions Trading Scheme – Forestry Conversion) Amendment Act 2025.

Does the LUC system provide a robust foundation for making regulatory decisions in the context of the CCRA?

As the amendment legislation has only recently been enacted, it is too early to provide any evidential analysis about the suitability or otherwise of LUC for restricting forestry conversions. However, a few general observations can be made.

The restrictions are intended to determine which properties and parts of properties can or cannot be converted to forestry. As noted above, a key limitation of the national NZLRI LUC dataset is its coarseness, making it ill-suited to supporting property level decisions. The use of the coarse and dated NZLRI LUC dataset as the default is likely to lead to debates when it comes to identifying precise boundaries of land parcels that can or cannot be afforested. Consideration of land at the boundaries of LUC 6 and 7 may be difficult as there are restrictions on whole-farm conversions on LUC 1–6 land but no limits on LUC 7 and 8 land.

Landowners who disagree with how the land is classified in the NZLRI LUC dataset and wish to use the land contrary to the regulation (including registering exotic forestry in the ETS), must, at their own cost, correct the classification of their land through a property-scale assessment using approved mapping standards. Passing the costs onto landowners may be considered appropriate when they have vested interest and the most to gain in the short-term, either from developing land that may be highly productive or changing land use to a potentially more profitable one. However, imposing regulations that limit access to a key potential revenue stream and passing the cost of remedying any inadequacies to landowners erodes property rights, potentially impacting the value of the land. It seems perverse that government knows that the information base used to identify the restrictions is not fit for purpose, yet it requires landowners to pay to prove their land is suitable.

The LUC system and the regional regulatory plans

In addition to the three legislative instruments mentioned above, the LUC system has been used by two regional councils as part of water quality management – specifically, as part of allocating nitrogen discharge allowances in the Manawatū-Whanganui region (through the One Plan) and in the Tukituki Catchment in the Hawke's Bay region (through Plan Change 6 to Hawke's Bay Regional Resource Management Plan for the Tukituki River Catchment).[114]

Regional plan rules and methodologies are intended to be used to manage environmental impacts at the property scale. As noted above, the national NZLRI LUC dataset is generally ill-suited to property scale management.

In these regional plans, LUC classification has been used as a proxy measure for the natural capital of the land – a proxy for the goods and services to humans and ecosystems that land can provide. Nitrogen allowances have been assigned according to the inherent pastoral productivity of the land. For example, LUC 1 and 2 land has been allocated a higher nitrogen leaching rate allowance than LUC 8 land.

114 See Table 12 of the One Plan (Horizons Regional Council, 2025, pp.3–83). See also Table 5.9.1D in the Plan Change 6 to Hawke's Bay Regional Resource Management Plan for the Tukituki River Catchment (Hawke's Bay Regional Council, 2015, p.13).

This application of the LUC system was not envisaged at the time of its development. The LUC system was designed to support long-term sustained production on the land, not address environmental management challenges. The system was found to have limitations for setting nitrogen leaching limits. This was due to poor correlation between the LUC classes and nitrogen loss rates, and the classification itself being a poor proxy for natural capital of the land.[115]

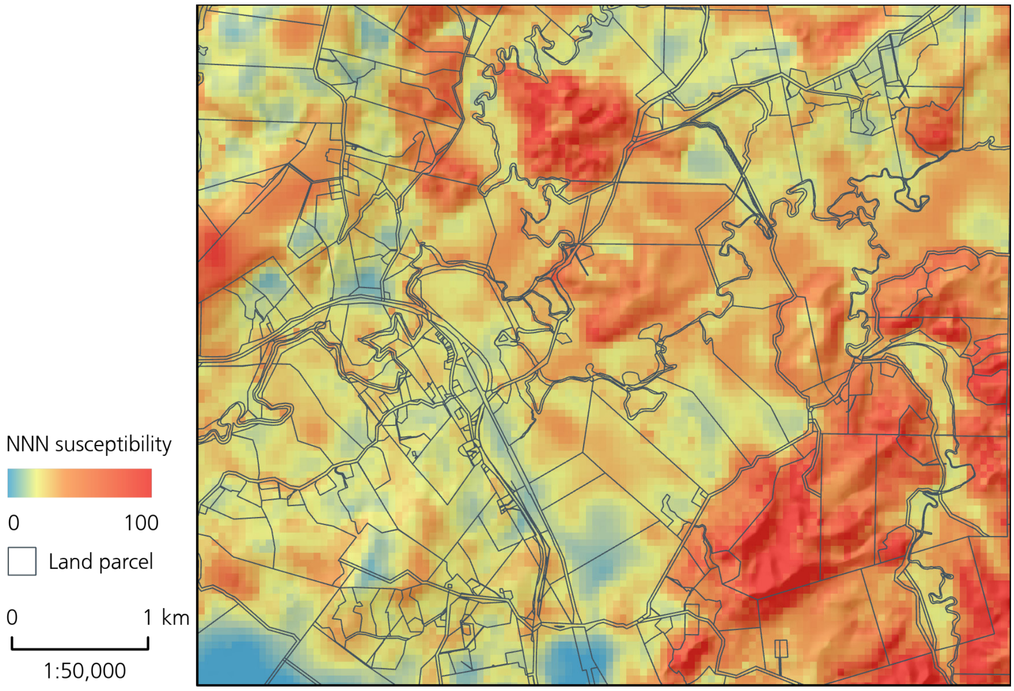
Additional issues with using the LUC system as part of water quality management arose due to coupling the LUC system with the Overseer model, and assigning absolute numbers generated by Overseer to LUC classes without accounting for uncertainty.[116] Previous PCE work and the review by the independent Science Advisory Panel identified several shortcomings with Overseer, which make it ill-suited for regulatory use.[117] Coupling shortcomings of Overseer with the limitations of the LUC system creates the potential for errors to compound.

Figure 9 illustrates just how hard it is to use generalised classifications such as the LUC classification to manage nutrient (and other) pollutants using regulation targeted at individual properties. There is simply too much variation within and across properties for there to be an accurate proxy. The figure shows susceptibility of the land to loss of nitrate-nitrite-nitrogen. This information needs to be combined with land use information to understand the likely environmental impact. This type of information can help identify hotspots for particular contaminants and guide land use decisions accordingly. Consequently, a suite of different management and regulatory tools, including input controls, might be needed.

115 For details, see Lilburne et al. (2016).

116 Note that the currently proposed Plan Change 2 (Existing Intensive Farming Land Uses) to the One Plan in the Manawatu-Whanganui region is envisaged to update the nutrient management framework. For details, see https://www.horizons.govt.nz/publications-feedback/one-plan-reviews-changes/plan-change-2/pc2appealandimplementation

117 See PCE (2018), PCE (2021) and MPI (2021).



Source: Adapted from data provided by Land & Water Science

Figure 9: Relative susceptibility to loss of nitrate-nitrite nitrogen (NNN) in the Wairoa catchment in Northland. Susceptibility was derived by Land & Water Science by mapping controlling landscape characteristics, such as topography, climate, geology, hydrology, weathering, and other physical and chemical processes, compared against direct measurements from the water quality monitoring networks in each catchment. Susceptibility to NNN loss is represented on a 0-to-100-point scale, with 100 indicating the highest susceptibility (red) and zero indicating no susceptibility (blue). Black lines show or land parcel boundaries.

Ways forward

The LUC system has been used in New Zealand since the 1950s. It is a well-recognised land classification system that conveys information about the capability and versatility of land for primary production. The NZLRI LUC dataset, as part of the wider LUC system, has national coverage and can generate high-level screening insights, which are useful in the context of challenges that involve land productivity.

The LUC classification was designed to support long-term sustained production on the land. It was not focussed on addressing environmental management challenges. While the classification identifies some environmental management challenges (e.g. wetness), these are approached through a productivist lens and not for the inherent value of the environmental services they provide.

Despite this, in recent years the LUC system has been used in a regulatory context under the RMA (NPS-HPL and NES-CF) and most recently under the CCRA to manage forestry conversions. The limitations identified in this review suggest that the LUC system is ill-suited for regulatory use. In particular:

- there is poor alignment with the national NZLRI LUC dataset (the default NPS-HPL dataset) and the S-map dataset to identify highly productive land. In the absence of validation, reconciling differences between the datasets is challenging. In the meantime, using just one method when there is such significant disagreement between the methods seems ill-advised
- the ESC – a derivative of the LUC system – over and under-classifies susceptibility of land to erosion, (at least) in the context of shallow landslide erosion. Under-classifying land is a risk because of the more permissive approach the NES-CF takes to management for that land. If not appropriately managed, there is a higher chance of sedimentation and debris affecting local waterways and damaging land and infrastructure downstream
- the national NZLRI LUC dataset, which is the default dataset in the legislative instruments and the basis for the ESC system, is inappropriate for use at a property scale on account of its coarse scale and dated nature.

Recommendation 1: Do not use the current LUC system as the basis for any future regulatory control

As a result of its outlined shortcomings for regulatory use, PCE recommends that the current LUC system should not be used as a basis for any future regulatory controls.

This recommendation applies both to national and regional regulation (through RMA plans). The use of the national LUC dataset for property scale regulation, used regularly in RMA plans, is particularly problematic.

This places the Government in a difficult position as it will need to invest in the development of some suitable tools for regulatory use. The three interrelated recommendations presented below should be progressed in tandem.

Recommendation 2: Invest in essential contemporary datasets that underpin land use regulation and ensure they are publicly available and affordable

PCE recommends that the Government invests in progressively improving essential contemporary datasets that underpin land use regulation and ensures they are publicly available and affordable.

Since the LUC system was initially developed, important advances have been made in terms of modern technologies to gather, model and analyse environmental data. These advances need to be leveraged to improve the robustness with which regulatory decisions are made.

For this purpose, the Government needs to identify essential contemporary datasets that underpin land use regulation, prioritise them and invest to fill gaps and address known limitations. This in turn would optimise their use in regulation. The list below provides a starting point with a focus on land use but is by no means a full prioritisation exercise:

- **LiDAR** provides accurate information on elevation as well as slope, which is used for multiple applications in natural hazard management, forestry, engineering and flood management.[118] While LiDAR-based data is available for most of the country, some important gaps remain, notably in areas in the Manawatū-Whanganui and Otago regions, as well as Fiordland and Stewart Island.[119] These gaps need to be filled.

  In addition, capture dates for LiDAR vary across the country, with data for some regions being over a decade old.[120] As demonstrated by the Gisborne example above, there is value in repeat LiDAR capture, particularly in areas that are susceptible to erosion. More broadly, advances in remote sensing, including different sensors and platforms, coupled with automated processing, offer additional avenues for collecting data that could be leveraged.
- **S-map** provides soil maps and associated information about soil properties. S-map presents an advance in the quality and granularity of soil information compared to the soil information in the NZLRI database (see Box 3). However, there are significant gaps in S-map coverage and investment needs to be made to extend this coverage to provide better soil information across the country to support improved land use management.[121] S-map has been produced at a scale ranging from 1:30,000 to 1:50,000, and this can, depending on the size of a property, present challenges for use at a property scale.[122] Thus, high-quality property-scale soil maps (at a scale of 1:10,000), where available, contain additional valuable information and could be leveraged

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118 For details, see https://storymaps.arcgis.com/stories/59af2967e2c64664aebce8ca154c5c49

119 Note that at the time of writing surveys are being planned or are in progress in some areas already. For details, see https://www.linz.govt.nz/products-services/data/types-linzdata/elevation-data

120 The age of LiDAR data across different regions of the country can be viewed at the NZ National Elevation Programme website. https://experience.arcgis.com/experience/45262b6f24ab463d856191a9728ab0f6/page/NZ-Elevation---LiDAR-age-view

121 MfE is currently undertaking a work programme to identify LUC 1–4 land from S-map to aid and inform councils' regional mapping of highly productive land using improved soil information relative to what was used in the original NZLRI compilation with the purpose of ultimately creating a national S-map LUC 1–4 layer, which can be improved upon as S-map coverage extends (MfE, pers. comm., 13 November 2025).

122 https://soils.landcareresearch.co.nz/topics/soil-survey/scale-matters

- **Land Cover Database (LCDB)** currently provides national data on land cover, which includes forests, grasslands, wetlands, urban areas, bare soil, water bodies and other details at the nominal scale of 1:50,000. LCDB6, which shows land cover in 2023/24 summer, was released in October 2025. However, the update frequency (average frequency about 5.5 years) and coarse scale provide some challenges. Technological advances could be leveraged to increase frequency and resolution.
- **Comprehensive land use mapping** can support spatial planning decisions at the national and local level. Such a map needs to be developed (and once developed, regularly updated), leveraging technology, including remote sensing, as well as information gathered on land use through surveys and other tools. There is an opportunity to build on the progress to date in establishing a land use classification framework and develop a comprehensive land use map as part of the spatial planning component of the upcoming resource management reforms.
- **Erosion mapping:** several recent methods represent advances that should be evaluated with a preferred suite chosen, extended nationally and leveraged for improved land management (see recommendations below for more detail).

Recommendation 3: Modernise the LUC and ESC systems and create bespoke fit-for-purpose models

PCE recommends that essential contemporary datasets (1) be used to modernise the LUC and ESC systems, and (2) where suitable, be used to create bespoke fit-for-purpose models for specific regulatory purposes.

Given the national coverage of the NZLRI database, the LUC system is likely to remain a tempting tool to use for national regulation. However, the limitations identified in this review suggest that the LUC system is ill-suited for regulatory use, especially for regulating environmental challenges.

With improvements, the usefulness of the LUC system could be increased, especially for informing challenges that involve land productivity. This would involve significant investment in improving its data around soil, slope angle, erosion type and severity, and vegetation cover.

Modernisation should include the LUC and ESC systems and extend to the NZLRI database and the NZLRI LUC dataset. If viewed in the context of a national dataset informing legislative instruments, there is considerable scope for improvement. Modernising the system that underpins the NZLRI LUC dataset would reduce subjectivity. This means creating an objective classification that is quantitative, automated, validated and repeatable to reduce subjective bias. This could be achieved by using new datasets and modern technology to both gather and process up-to-date data.

Modernising the ESC should build on and leverage any refinements to the LUC system. This should include refinements to the ESC zones based on advances in LiDAR, GIS and remotely sensed vegetation data at a more detailed scale.[123] In addition, in areas where landslide erosion is the main type of erosion, ESC could be linked with models to provide

123 For example, MDC commissioned a study to investigate upgrading the first edition mapping for North Marlborough using high-resolution DEMs and other geospatial datasets, to achieve a resolution suitable for mapping LUC and erosion susceptibility at an operational scale for modern-day land use planning (1:10,000). For details, see Bloomberg and Palmer (2022).

a more detailed picture of the areas where landslide erosion and resulting impacts on waterways are expected to be significant.[124] However, landslide susceptibility and connectivity mapping will need to be completed nationally to a consistent standard using up-to-date data first. There may also be a case for more significant refinements to the ESC, which could include incorporation of a landslide risk management framework.[125]

The shift to objective classifications and up-to-date data would lead to increased confidence in the LUC and ESC systems, which are needed to provide a robust basis for making regulatory decisions.

Importantly, **there is a range of other tools** (models and datasets) already available or currently being developed that could effectively support regulatory instruments. These could be used alongside or instead of the LUC and ESC systems. Further development of a preferred suite of fit-for-purpose models based on robust evaluation needs to be considered for specific regulation use cases.

The datasets and models listed in the recommendation above, which could refine the NZLRI database, including the national NZLRI LUC dataset, also have value in their own right. While these datasets and models are more modern and less dependent on expert judgement, they are not perfect. Two particular areas need improvement:

- **Coverage:** As noted above, none of the alternative and complementary tools have national coverage, which is critical for supporting and implementing nationally consistent policy and regulation. It would be beneficial for New Zealand to extend coverage of S-map and LiDAR in particular, to ensure the whole country is covered.
- **Evaluation and development:** The range of erosion tools used by councils generate different types of outputs, making comparisons difficult. Overall, councils' reliance on a variety of erosion tools is not too dissimilar from the reliance on a range of freshwater modelling tools used to support the regulation and management of water in New Zealand.[126] Given the similarities, it makes sense to evaluate the tools to clearly identify their strengths, weaknesses and suitability for their intended purposes. Following evaluation of these different tools, the Government should settle on a preferred suite of tools that can be developed to provide national coverage. A preferred suite of fit-for-purpose models that can be used and reused in the regulatory context would make model application across councils more comparable and consistent. It would streamline processes associated with the use of models in a regulatory context. It would also avoid councils' resources being wasted building customised models that reinvent the wheel.

Ultimately, in a future world where New Zealand has a developed and well-functioning **federated environmental information system**, insights from models, datasets and environmental information held by a variety of actors could be pulled together depending on the policy need. This could permit the cost-effective creation of purpose-built tools, which could be leveraged for environmental policy and regulation. It would also be

124 Such as the BSI landslide susceptibility and connectivity mapping and the ESNZ rainfall-induced landslide database.

125 For details about the landslide risk management framework, see the Landslide Planning Guidance released by ESNZ (de Vilder et al. 2024).

126 The 2024 review of freshwater models found that at least 75 biophysical freshwater models were used by regional councils and unitary authorities in a regulatory context to assist with a variety of tasks, including managing contaminant discharges and water takes. Of the 75 models, 13 models were used to assess sediment in rivers and streams. For details, see PCE (2024a).

valuable to resource users. PCE has previously written a note on the benefits of federating the huge amount of environmental information that is currently held – disparately – in New Zealand.[127]

Recommendation 4: Focus limited resources for improving data on hotspots

Where resources are limited, PCE recommends that improvements in environmental data and information should be focused on hotspots – areas where better information is most urgently needed to support management of environmental issues of concern.

National instruments have tried to standardise regulation across New Zealand in the belief that regulatory consistency across regions supports efficiency and compliance. However, if one-size-fits-all national regulation is to work, more detailed high-quality and high-resolution data needs to be available nationwide. This is expensive. Simultaneously, funding improvements in data for environmental regulation across domains would be difficult.

Therefore, if the resources needed to provide high-quality granular information are limited, the pragmatic way forward is to focus on hotspots first. Hotspots will vary depending on the stressor and the context. Many of the challenges the NPS-HPL, the CCRA, and the NES-CF are aiming to address are highly context-dependent and complex. The risks from erosion or the pressures from urban expansion on highly productive land will be different in different parts of Aotearoa New Zealand.

Hotspots in the context of the NPS-HPL, for example, could be highly productive land in areas under pressure from urban expansion. Auckland, Tauranga, Hamilton, Napier-Hastings and Christchurch are all growing urban centres surrounded by mostly LUC class 1–3 land. In the winter of 2025, the Government consulted on changes to the NPS-HPL, including the removal of LUC 3 from the definition of highly productive land and instead introducing Special Agricultural Areas (SAA).[128] The process for identifying such SAAs could be considered akin to the process of identifying hotspots where resources to improve data and information are focused.

In the PCE's submission on the proposed changes to RMA national direction, the Commissioner emphasised that the definition of highly productive land should be based on detailed high-quality and high-resolution mapping. This mapping should reveal a range of environmental data, including soil types and soil properties, climate, land use and its current productivity, resulting in high quality information potentially able to defuse some of the debates about the boundaries of highly productive land. If the Government is to press ahead with the establishment of SAAs, then these areas should be based on standards that are collaboratively developed across the country by central government with councils and respective industries based on several criteria, including the inherent properties of the land, current land use and proximity to infrastructure.

In the context of the NES-CF and the ESC, hotspots could be areas where not only the susceptibility to erosion is high but also where there is a higher connectivity to waterways or sensitive environments. In areas like Tairāwhiti and Wairoa, work is already underway to provide more detailed and high-resolution information for more targeted local management. This has been driven by the experience of Cyclone Gabrielle.

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127 See PCE (2025b).
128 See MfE (2025a); PCE (2025a).

The identification of hotspots is also required in other regions of Aotearoa New Zealand to address known risk from erosion, including areas that have seen a surge in permanent carbon forestry (vs. production forestry). While permanent carbon forests may never be intentionally harvested, they are still exposed to risks from fire, which can create similar erosion hotspots to those revealed through harvesting.[129] As a result, more detailed and higher-resolution risk assessments where erosion risk is assessed to be higher would become standard across the entire commercial forestry estate.[130]

In areas where information of that resolution and detail is absent, instead of reducing the ability of councils to manage forestry risks (by narrowing the use of the 'stringency tests', as proposed by the Government), a better approach would be to retain and broaden provisions in regulation 6 of the NES-CF to allow councils to tailor relevant rules to the landscape, based on the best available information.[131]

In the context of the CCRA, hotspots are likely to be areas of land used for extensive farming and forestry in the hill country. Particular focus is likely to be at the boundaries of LUC 6 and 7 classes because restrictions on whole-farm conversions apply to LUC 1–6 land but do not extend to LUC 7 and 8 land. In these situations, it makes sense to have detailed, high-resolution data to inform debates about boundaries of land that can be used for registering exotic forestry in the ETS (or not). Landowners should not be required to pay for this data. Arguably, this is the Government's responsibility because it introduced the restriction using unsuitable information.

Central government plays an irreplaceable role as a generator of data and a supporter of the development of new techniques and tools to gather data. In addition, national direction and national regulation can help standardise policy approaches and streamline implementation. Yet, some areas need more focused attention. For these areas, incremental regulatory tweaks do not work well, and decisions may need to be made closer to the communities involved. In these contexts, providing granular high-quality information is critical, and it must be done alongside community involvement and with a wider catchment-based lens on land use and development dynamics.[132]

Finally, as part of the proposed resource management reform, the Government has signalled a shift to relying on permitted activities subject to standard conditions rather than managing risks upfront. Such a regime will require:

- investment in the information needed to impose standardised conditions in different landscapes
- an increase in monitoring and compliance of activities to ensure standards for permitted activities are met, and
- a corresponding increase in environmental monitoring, including compliance monitoring, to ensure environmental limits are not breached.

This switch in approach considerably increases the risk of cumulative effects, which will need to be an important focus for increased monitoring.

129 See PCE (2025c).
130 See also PCE (2025a).
131 These provisions provide for rules to be more stringent than national regulations. See NES-CF 2017, regulation 6.
132 See also PCE (2024b).

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