A revised Productive Land Classification for Tasman District

A revised Productive Land Classification for Tasman District

Prepared by:
Reece Hill and Ban Borman
Landsystems
PO Box 4348, Hamilton East 3247, New Zealand

Prepared for:
Tasman District Council

Date: August 2021
Status: Final

CITATION:
Hill, R.B. and Borman, D.W. (2021). A revised Productive Land Classification for Tasman District. Internal report for Tasman District Council. Landsystems, Hamilton.

Contents

Summary

Project and Client

Landsystems was commissioned by Tasman District Council (TDC) to revise their Productive Land Classification (PLC) based on the 1994 Agriculture New Zealand PLC report, in which land within Tasman District was classified into areas with similar productive potential. The purpose of the revision was to make use of more up to date data that has become available since the development of the original PLC in 1994 and following a review of the PLC by Landcare Research in 2011. The intention of this project was to provide a more robust and repeatable PLC for ongoing planning use in the Tasman District. Its initial use will be to assist with developing the Tasman Environment Plan (TEP) which replaces the Tasman Resource Management Plan (TRMP) which became operative in May 2016[1].

Aim and Objectives

The aim of this project is to develop a revised PLC for Tasman District based on available spatial and non-spatial data using processes that are transparent and repeatable.

The main objectives are:

- To provide a revised version of the existing PLC.
- To produce revised PLC maps for the Tasman District that are objectively based, repeatable and can guide field assessments at property scale.

Methods

A process was developed for revising the PLC. Important considerations for the revised PLC included:

- Retaining criteria if they were considered meaningful, quantitative, and well defined (both in terms of criteria values and spatial application).
- Incorporating new soil map boundaries and attribute information.
- Including National Institute of Water and Atmosphere (NIWA) climate data provided to TDC.
- Using additional or alternative criteria to improve the PLC.

Developing the revised PLC included:

- Assessing the existing PLC data, and alternative and additional data.
- Creating geospatial layers of climate and land qualities.
- Developing revised PLC options.
- Assessing the revised PLC options.

Existing data (both regionally and nationally provided or derived) and scripted geospatial processes in a Geographic Information System (GIS) were used to improve the objectivity and transparency of the revised PLC.

Results

New soil survey map and attribute information were available for part of the Tasman District, however, there was still a high reliance on older Fundamental Soil Layer (FSL) data. A blended digital elevation model (DEM), using available DEM data and TDC Light Detection and Ranging (LiDAR) data, was developed. The resulting DEM improved the delineation and spatial placement of climate and land qualities.

In general, the climate and land qualities used in the revised PLC options were based on existing

[1] https://tasman.govt.nz/my-council/key-documents/tasman-resource-management-plan/volume-1-text/part-2-land/

climate and land qualities used in the original PLC as well as those identified in a review of the PLC by Webb et al. (2011). Additional climate qualities were based on improved data from National Institute of Water and Atmospheric Research (NIWA) for the Tasman District as well as nationally available data sourced from NIWA. Revised value ranges for frost free period and growing degree days were used in some of the revised PLC options presented.

Four revised PLC options were developed using the matrix approach which sequentially allocates land to PLC classes starting from the most versatile to the least versatile (i.e. PLC classes A through to H). The four revised PLC options included:

- **PLC Option 1** matrix: based on revised criteria identified in the report by Webb et al. (2011) which included a review of the ANZ (1994) PLC (original PLC).
- **PLC Option 2** matrix: based on what are considered the most useful criteria and realistic value ranges from ANZ (1994) and Webb et al. (2011) criteria.
- **PLC Option 3** matrix: based on a mix of Land Use Capability (LUC) classes and a reduced number of climate and land criteria.
- **PLC Option 4** matrix: based on the proposed National policy Statement for Highly Productive Land (NPS-HPL) definition of “Highly Productive Land” (MPI/MfE, 2018).

An assessment of the “degree of fit” between the original PLC and land use (estimated using Landcover Database data) showed the relative distribution the original PLC classes and land use across the PLC classes for the revised PLC options. Although it was difficult to ascertain whether the degree of fit was due to misclassification or due to improved classification and spatial placement, the revised PLC Option 2 seemed to provide the best fit across all PLC classes.

Conclusions

- The currently available data is adequate to develop a revised PLC that is repeatable and is objectively based, and has improved spatial accuracy compare with the original PLC.
- The revised PLC is developed using data defined criteria, placing less reliance on the more qualitatively defined criteria associated with the original PLC.
- The revised PLC outputs include GIS accessible layers for each of the climate and land qualities used in the PLC, which were not available for the original PLC.
- Compared with the original PLC, other improvements include the use of a blended DEM to spatially place climate and land qualities more accurately, improved soil map and attribute information, the use of clearly defined climate and land qualities, and transparent and repeatable processes for constructing the PLC.
- In general, the data available is adequate for the requirements of the PLC. However, partial finer scale soil map information, a complete high resolution DEM and coarse climate data are current limitations.
- Of the four PLC options presented, the favoured option for a revised PLC is PLC Option 2. This was based on the best overall placement of land uses into appropriate PLC classes, and the distribution of the PLC classes.
- Some classification limitations remain, mainly associated with the inherent quality and scale of the available data, and the classification matrix approach. However, the revised PLC does provide guidance for identifying land areas with high productive value at a district scale.
- PLC Option 4 (based on the NPS-HPL) compared well against the original PLC classes. The main limitation of the PLC Option 4 was the lack of separation across PLC classes.
- Compared with the PLC option based on the NPS-HPL (PLC Option 4), the PLC Options 1, 2 and 3 provided greater delineation of the PLC classes, allowing for better placement of land

uses on suitable land.
- The GIS processes (including scripting) provide the metadata for process transparency and repeatability. Additionally, all components of the revised PLC can be updated or refined without the need to recreate the whole PLC.

Future revisions

Recommendations for future revisions of the PLC include:

- Replace the existing slope and contour data derived using the blended DEM with slope and contour data using a single DEM derived from the new LiDAR (once full LiDAR coverage is available for the Tasman District). This will improve the spatial placement of slope and altitude land qualities.
- Undertake a ground truthing of the revised PLC to test the validity of PLC classes relative to existing land use, and climate and land qualities and their value ranges. This information can be used to refine attribute criteria used in the PLC.
- Replace the existing mix of soil map information used in the revised PLC with Smap soil map information (once full coverage of Smap has been attained). This will improve the spatial placement of soil related attributes that inform the land qualities.
- Test the viability of replacing FSL soil attributes with Smap soil attributes.

Acknowledgements

This project was funded by TDC. Data was provided by TDC, Manaaki Whenua – Landcare Research and NIWA. The late Dr Bernard Simmons is thanked for project scoping guidance and facilitating data access. Thank you to other TDC staff including Terry O'Donnell for providing the data, Myaan Bengosi for guidance and review of the project, and Anne Wecking and Mirka Langford for reviewing the draft report. Thank you to Sam Carrick, Graeme Anderson, and other staff at Manaaki Whenua – Landcare Research for providing access to Smap attribute data. Andrew Burton is thanked for his technical review of the revised PLC.

1 Introduction

1.1 Project and Client

Landsystems was commissioned by Tasman District Council (TDC) to revise their Productive Land Classification (PLC) based on the Agriculture New Zealand 1994 report in which land within Tasman District was classified into areas with similar productive potential. The purpose for the revision was to make use of more up to date data that has become available since the development of the PLC and following a review of the PLC by Landcare Research (now Manaaki Whenua – Landcare Research) in 2011. The intention of this project was to provide a more robust and repeatable PLC for ongoing planning use in the Tasman District. Its initial use will be to assist with developing the Tasman Environment Plan (TEP) which replaces the Tasman Resource Management Plan (TRMP) which became operative in May 2016[2].

1.2 Existing PLC

The existing PLC used by TDC is based on the classification system developed by Agriculture New Zealand and outlined in the report "Classification of Productive Land in the Tasman District" (ANZ, 1994).

The classification system ranks land in terms of a "hierarchy of suitability to a range of enterprises" focusing on existing inherent characteristics of the land.

The classification system is presented as a report outlining the factors considered in giving rankings to land areas and a series of maps that show the classification given to all productive land areas in the Tasman District. Appendices in the report provide additional information for interpreting the maps (ANZ, 1994).

The series of maps have subsequently been digitised to provide a single electronic classification map for the Tasman District.

1.3 Application of the PLC

The PLC has been applied to inform land management planning decisions in the Tasman District. The revised PLC described in this report is intended to be used to inform land management decisions as part of the Tasman Resource Management Plan (TRMP).

1.4 Key principles of the revised PLC

This revised PLC follows the same principles of land evaluation as outlined in sections 1.0 and 2.0 of the ANZ 1994 report and adopted in the review by Webb et al. (2011).The key principles from the ANZ 1994 report are to develop a land evaluation system that:

- Provides a quantifiable structure that people can interpret and understand,
- focuses on information on the potential, and not the current or conservation, use
- of land,
- focuses on inherent land characteristics that may be considered permanent,
- classifies land in terms of its versatility to productive use as a proxy for land

[2] https://tasman.govt.nz/my-council/key-documents/tasman-resource-management-plan/volume-1-text/part-2-land/

- value, and
- takes account of long-term issues such as erosion that can impinge on productive land use**.**

It should be noted that the PLC's purpose is to identify land (and soils) that has high productive value and prevent its loss from production (most commonly as the result of land subdivision). In a soil ecosystem services framework, the productive value of soils is only one consideration within a broader suite of services a soil can provide. A framework for classifying and quantifying the natural capital and ecosystem services of soils has been described by Dominati et al. (2010) and a summary of soil ecosystem services is shown in **Table 1.**

Table 1. Ecosystem services provided by soils (from Dominati et al., 2010).

Service	Definition	
Provisioning services	Provision of food, wood and fibre	Agro-ecosystems' first purpose is to produce food and grow crops for a diversity of purposes. Soils physically support plants and supply them with nutrients and water.
	Provision of raw materials	Soils and vegetation can be source of raw materials, e.g. topsoil, peat, turf, sand, clay minerals, biomedical and medicinal resources, genetic resources, ornamental resources. However, the renewability of these stocks is sometimes questionable.
	Provision of support for human infrastructures and animals.	Soils represent the physical base on which human infrastructures and animals (e.g. livestock) stand.
Regulating services	Flood mitigation	Soils have the capacity to absorb and store water, thereby regulating water flows (freshwater levels) and mitigating flooding.
	Filtering of nutrients and contaminants	Soils can absorb and retain nutrients (N, P) and contaminants (E. coli, pesticides) and avoid their release in water bodies.
	Carbon storage and greenhouse gases regulation	Soils have the ability to store carbon and regulate their production of greenhouse gases such as nitrous oxide and methane.
	Detoxification and the recycling of wastes	Soils can absorb (physically) or destroy harmful compounds. Soil biota degrade and decompose dead organic matter thereby recycling wastes.
	Regulation of pests and diseases populations	By providing habitat to beneficial species, soils and vegetation of agro-ecosystems can control the proliferation of pests (crops, animals or humans) and harmful disease vectors (viruses, bacteria) and provide biological control.
Cultural services	Recreation / Ecotourism	Natural and managed landscapes can be used for pleasure and relaxation (walking, angling, mountain biking).
	Aesthetics	Appreciation of the beauty of natural and managed landscapes (wildlife viewing, scenic driving)
	Heritage values	Memories in the landscape from past cultural ties (landscape associated with an important event of regional or national significance)
	Spiritual values	Sacred places
	Cultural identity / inspiration	Natural and cultivated landscapes provide a sense of cultural identity. This establishes a strong cultural linkage between humans and their environment.

The original PLC and this revision of the PLC focus on identifying land and soil with the highest value for the provision of food, wood and fibre. However, with increasing awareness of the broader range of ecosystem services that soils provide, future classifications may consider considering other soil ecosystems services.

2 Aim and Objectives

The aim is to develop a revised PLC for the Tasman District based on objectively based spatial and non-spatial data using processes that are transparent and repeatable.

The main objectives are:

- To provide a revised version of the existing (original) PLC.
- To produce revised PLC maps for the Tasman District that are objectively based, repeatable and can guide field assessments at property scale.

3 Methods

3.1 Introduction

A geospatial based method was developed for revising the PLC. Important considerations for the revised PLC included:

- Retaining criteria if they were considered useful, quantitative, and well defined (both in terms of criteria values and spatial application).
- Incorporating revised attributes and criteria from the PLC review provided by Webb et al. (2011).
- Incorporating new soil map boundaries and attribute information.
- Including National Institute of Water and Atmospheric Research (NIWA) climate data provided to TDC.
- Using additional or alternative criteria to improve the PLC.

3.2 Assessment of the original PLC

The only source of information for each criterion is provided in ANZ (1994). A subsequent assessment of the PLC approach is provided by Webb et al. (2011). For continued use, each criterion must be clearly defined and based on available data.

Webb et al. (2011) provide recommendations for revising criteria value ranges and including new criteria. The recommendations were assessed and considered for inclusion in the revised PLC.

3.3 Assessment of available criteria data

The main new sources of soil map information (polygons and soil attribute data) data included Fundamental Soil layer data[3], soil surveys within the Tasman District[4] and Smap[5] (Licenced data provided by Manaaki Whenua-Landcare Research). Climate quality data included NIWA climate data (either provide as part of a Tasman District assessment (Pearce et al., 2019) or available through NIWA's CliFlo web system that provides access to New Zealand's National Climate Database[6].

For criteria to be included in the revised PLC they must be based on available quantitative data. Where data was not readily available for a criterion the criterion could not be included in the revised PLC.

3.4 Assessment of additional/alternative criteria

Once the available data had been identified the potential criteria (land and climate qualities could be defined. These were based on the original PLC criteria (ANZ, 1994) as well as additional literature sources including the Landcare Research review of the PLC (Webb et al., 2011), land evaluation classification manuals (Webb and Wilson, 1994; Webb and Wilson, 1995), the Land Resource Information System Spatial Data Layers Data Dictionary (Newsome et al., 2008) and

---

[3] https://lris.scinfo.org.nz/layer/48137-fsl-south-island-all-attributes/

[4] Campbell (2018); SOILS INFORMATION IN THE TASMAN DISTRICT – REPORT EP06/05/11 – Report Prepared for 10 May 2006 meeting; Waimea Plains Soil Survey" (2017); The Golden Bay area (Takaka township, East Takaka and Motupipi, Puramahoi Coastal area and Kotinga) (2016).

[5] https://smap.landcareresearch.co.nz/

[6] https://cliflo.niwa.co.nz/

Ward and Clothier (2019).

3.5 Development of PLC options

A range of PLC options were developed based on discussion with TDC staff. The options included a varied use of individual climate and land quality criteria data in combination with LUC system data. In developing the revised PLC, we considered the complexity of the PLC – that is the number of land and climate qualities to be used to provide an adequate classification for its intended use, including scale. The PLC is primarily a broad level tool to guide more detailed assessment of a land area across a range of land uses on a case by case basis – essentially a district planning tool. The PLC is not intended to provide a full suitability assessment for every land use.

Critical in the PLC are the defined value ranges of the individual land and climate qualities for defining each PLC class. Value ranges for the individual land and climate qualities were based on available literature. A scoring matrix was developed that identified more intensive land use classes first, progressively reducing the available area for lesser intensive land use class. For each PLC class the combined set of value ranges were unique to ensure the land classes were mutually exclusive and a land class could be assigned to the entire eligible PLC area.

3.6 Assessment of PLC options

A spatial comparison was used to test the PLC options against the original PLC and against existing land use in the Tasman District. These assessments were used to confirm the most appropriate revised PLC.

4 Assessment of the original PLC

The original PLC matrix is based on the climate, topography and soil attributes and land class criteria shown in **Table 2**.

Table 2. Original PLC criteria matrix climate, topography and soil attributes and land class criteria (from ANZ, 1994).

Versatility	Land class	Criteria													
		Climate					Topography		Soil						
		Altitude (m)	Length of growing season	Heat over summer	Rainfall	Wind	Slope (degrees)	North(N)/ South (S) aspect	Fertility	Water holding capacity	Rooting depth (m)	Erosion	Structure /texture	Soil Drainage /permeability
Very versatile	A	< 50	1 - 4	1 - 5	4 - 6	1 - 5	≤ 3	-	1 - 5	1 - 5	≥ 1.0	0	3 - 6	1 - 3
	B	< 50	1 - 9	1 - 7	3 - 6	1 - 5	≤ 15	N	1 - 5	1 - 5	≥ 0.8	0 - 1	2 - 6	1 - 3
	C	< 300	1 - 9	1 - 8	2 - 6	1 - 5	≤ 15	N/S	1 - 5	1 - 5	≥ 0.6	0 - 1	2 - 6	1 - 3
	D	< 300	1 - 11	1 - 8	2 - 5	1 - 5	≤ 18	N/S	1 - 4	1 - 4	≥ 0.6	0 - 1	2 - 6	1 - 3
	E	< 300	1 - 11	1 - 8	2 - 5	1 - 5	≤ 28	N	1 - 4	1 - 3	≥ 0.6	0 - 2	2 - 5	1 - 4
	F	< 1200	1 - 12	1 - 10	1 - 6	1 - 6	≤ 35	N/S	1 - 4	1 - 3	≥ 0.2	0 - 3	2 - 4	1 - 4
Not versatile	G	< 600	1 - 12	1 - 10	1 - 5	1 - 6	≤ 35	N/S	1 - 5	1 - 3	≥ 0.8	0 - 4	2 - 4	1 - 4
	H	-	1 - 12	1 - 10	1 - 6	1 - 6	-	N/S	1 - 5	1 - 5	-	0 - 6	1 - 6	1 - 5

The land classes in **Table 3** represent the range of enterprises that can be sustained on a land unit, where "A" is very versatile (supports the broadest range of enterprises, and "H" supports the narrowest range of enterprises.

Table 3. Land suitability classes and land use versatility (PLC) class for the range of enterprises represented in the original PLC (from ANZ, 1994).

Range of enterprises that can be sustained on a land unit	PLC Class									
	Very versatile					→				Not versatile
	A	B1	B2	C	D	E1	E2	F	G	H
Very Intensive horticulture										
Intensive horticulture										
Intensive horticulture poorly drained										
Intensive cropping										
Cropping										
Intensive pasture "dairy"										
Intensive pasture "other"										
Extensive pastoral										
Production forestry										
Non Productive										

Enterprises can be further delineated into land uses and aligned to PLC classes (**Table 4**), providing more specificity for applying the PLC in the Tasman District.

Table 4. A list of examples of specific land uses for each PLC class.

Range of enterprises that can be sustained on a land unit	PLC class	Nursery	Floriculture	Orchards	Vineyards	Market gardens	Cropping	Dairy	Intensive pastoral	Extensive pastoral	Production forestry	Recreation/ conservation
Very intensive horticulture	A											
Intensive horticulture	B											
Intensive cropping	C											
Cropping	D											
Intensive pastoral	E											
Extensive pastoral	G											
Production forestry	H											
Non productive	H											

The main differences shown in Table 4, are that for PLC class C, nursery and floriculture are not included as it is unlikely these could be suitable on soils that are suitable for viticulture due to soil depth limitations. Orchards and cropping of some types should still be viable on these shallower soils provided there is access to a water supply for irrigation, and dairy would likely be viable if there is access to a water supply for irrigation. It should be noted that the inclusion of viticulture in the classification is a difficult issue. This is because although viticulture is considered a high value intensive land use, it exists on soils that are not versatile (e.g. shallow stony soils).
Another change has been to reorder extensive pastoral and production forestry, so that forestry is deemed to be on land that is more versatile than extensive pastoral land. The result is that PLC classes F and G are swapped. This suggestion was based on recommendations made by Webb et al. (2011). They identified that requirements for production forestry are likely to be more restrictive than those for extensive pastoral (e.g. slope, soil depth, soil drainage).
The existing PLC is based on the report ANZ 1994. An Envirolink funded (Envirolink 921-TSDC57) report "Land versatility classification for Rural 3 Land in Tasman District" by Landcare Research in 2011 (Webb et al., 2011) included a review of the ANZ 1994 classification. Many of their conclusions provide the basis for the review considerations below.

4.1 Recommendations from Webb et al. (2011)

As part of their development of a land versatility classification of Rural 3 Land in Tasman District, Webb et al. (2011) provided a detailed review and assessment of the current PLC (ANZ, 1994). In their review they assessed the criteria used and provided recommendations for their continued use or replacement. A summary of their main findings is provided in **Table 5**.

Table 5. A summary of the PLC review in Webb et al. (2011).

Criteria	Comment	Recommendations
Versatility cf. flexibility	Suggest that the term "versatility" is a more acceptable and informative word than "flexibility".	Versatility is commonly used in land evaluation systems and appears to be appropriate to apply here.
Number of classes	Dairy farming has become a significant land use in its own right and has more restricted requirements than other intensive pastoral uses. Separately identify horticultural land on poorly drained soils. Extensive pastoral land (Class G) has less stringent soil depth and soil drainage requirements than forestry land.	Suggest the addition of a new class to subdivide class E (Intensive pastoral) into "dairying" and "intensive pastoral". Subdivide class B. Suggest that forestry land (class G) needs to be placed after extensive pastoral land (class F).
Soil data source	Does not specify their soil data source. The map unit boundaries were presumed to be taken from the New Zealand Land Resource Inventory database (NWASCO 1975 - 1979). The original PLC sometimes applied local knowledge of soil characteristics where they considered the LRI data to be inaccurate or incorrect.	No recommendation.
Altitude	Minimal justification or discussion on the use of altitude as a classifying criterion. Use of upper bounds of 1200 m for treeline and 600 m for production forest.	Use temperature parameters rather than altitude as a classifying criterion.
Length of growing season	Criterion used to estimate the frost-free period (considered to correlate with mean annual temperature). The original PLC	An objective determination of climatic factors is required.

	subdivided the district into 11 regional groups likely based on an "experience of site" basis as no maps were provided.	
Heat over summer	Criterion used to estimate the growing degree days associated with microclimate. The original PLC subdivided the district into 10 regional groups from hot to cool likely based on an "experience of site" basis as no maps were provided. The regions listed for "length of growing season" and "heat over summer" were different so it is not clear how these two lists were applied.	An objective determination of climatic factors is required.
Rainfall	Land with annual rainfall < 600 mm is recognised as requiring irrigation and is used to exclude cropping, intensive pastoral, and forestry, presumably on the basis that these uses will frequently not be irrigated and will therefore present significant droughtiness. If dairying were considered as a separate land use, availability of irrigation would need to be assumed for land with annual rainfall < 1000 mm. It is doubtful if ripening of grain is possible in most years with rainfall 1600 - 2400 mm let alone 2400 - 3200 mm as allowed in Table 2.	Suggestion to review rainfall ranges for horticultural crops and suggest class C should have an annual rainfall range of < 1600 mm and class D an annual rainfall range of 800 - 2400 mm.
Wind	Windiness is divided into six regions. In Table 2 wind is only used to separate the very windy "West Coast" and "Pakawau" districts from the remaining area. No wind-run figures were provided for this area to apply this criterion objectively. It is debatable whether intensive pasture should be excluded due to high wind run.	Windiness could be limited to criteria to specify an excessively windy class to exclude classes A to D, and class E where rainfall is < 800 mm.
Slope	Slope angle is an important criterion. We doubt that cultivation for cropping should extend beyond slope angles of 15°. Critical slope angles for key land use practices are provided. Further investigation is needed on the definition of intensive pastoral compared to extensive pastoral classes before definite classes can be made.	Critical slope angles for key land use practices are provided. Limit intensive cropping and intensive horticulture use to slopes <7° and cropping to slopes <15°.
Orientation (aspect)	Classification and discussion on orientation to be lacking in information. Part of this is due to scale limitations associated with the original PLC.	Future classifications use a DEM to map aspect and apply the soil temperature model to predict the effects of aspect on plant growth related to heat and solar radiation.
Fertility	This criterion is defined in terms of the amount of fertiliser required to maintain productivity. There are five classes. Only one class (very low natural fertility) is used to separate classes D, E and F from the rest. Fertility-related criteria need further consideration - it is unlikely that fertiliser requirement	Consider removing fertility as a criterion or retain it to separate distinctively unfertile land such as occurs on soils formed from serpentinitic or highly quartzitic rocks.

	will limit the economic production of crops (class D) or intensive pasture (class E).	
Water holding capacity	This criterion should be called available water holding capacity (AWHC) because water holding capacity is the percentage of water stored in a soil at field capacity, much of which may not be available to plants. Profile available water is a very important criterion to apply in a crop versatility classification. However, the ranges provided are questioned. Grapes can be grown successfully on land with AWHC of 25 - 50 mm but not many other horticultural crops would not. Risk of leaching loss (and consequent water pollution issues) is a further factor to consider in soils with very low profile available water but noting that it is very difficult to manage these soils under intensive land use without loss of nutrients or pesticides through leaching.	Prefer to use the term "profile available water" – the amount of water, in millimetres, available to plants within the soil profile to a nominated soil depth. Change the profile-available-water values for land classes. High versatility land for horticultural use needs soils with an AWHC in excess of 50 mm. High versatility in arable crops requires an AWHC in excess of 75 mm. Consider whether risk of leaching of contaminants to groundwater should be added as a criterion.
Rooting depth	Criterion is clearly defined and is an important factor in land use classification. There is some uncertainty over the allocation of rooting depth to separate class A land from class B. Also rooting depth by itself is of limited value; it is preferable to use root penetrability (Webb & Wilson 1994; 1995). Application of this criterion is somewhat theoretical without improved soil data.	In future classifications re-evaluate rooting depth (root penetrability) requirements for intensive horticulture, cropping and pasture.
Erosion	Defines erosion according to classes of erosion occurrence as used in the Land Use Capability Classification (LUCC) system. Six classes of erosion are defined according to the percentage of area affected by sheet and wind erosion or to severity of slip or stream-bank erosion. Important to understand that this rating for erosion is based on the severity of erosion as evident in the landscape and is not to be confused with erosion potential. The erosion criterion is not very helpful in a number of areas. Evaluation of erosion potential is dependent on many factors, including removal of vegetation and land management, and therefore needs to be carefully applied in land use classifications.	Suggest not using erosion occurrence as an index of potential erosion. Suggest either restricting proneness to erosion as a classifying criterion to arable land and forestry land on sensitive landscapes or develop a well-defined erosion potential classification with a robust set of criteria.
Structure/texture	A very confusing criterion. The descriptions include combinations of structure, organic matter, fertility, and drainage that are difficult to apply.	In future classifications do not use structure/texture criteria.

Drainage and permeability	Criterion appears to be defined according to the commonly defined soil drainage classes and requires a reference to clarify. Drainage is accepted as a relevant criterion. Forestry is also sensitive to poor drainage.	In future classifications, soil drainage could be used for greater discrimination among land uses. Recommend greater use of this criterion. Use to distinguish land suited to intensive horticulture from less intensive horticulture and dairy and cropping from intensive pastoral and intensive cropping, respectively. Forestry is also sensitive to poor drainage.
Use of climate	Classifies geographic areas according to climatic factors of importance to horticulture. A map depicting these areas is provided. These seem to be useful distinctions. There is confusion about the application used to assign the flexibility classes.	Determine critical threshold temperature factors for horticultural crops and generate temperature factors with an objective method that takes account of aspect, slope, and altitude.

Based on these recommendations in **Table 5**, modified tables (based on **Table 3** and **Table 4**) can be provided (**Table 6** and **Table 7**).

Table 6. Land suitability classes and Land use versatility (PLC) class based on the Webb et al. (2011) recommendations.

Range of enterprises that can be sustained on a land unit	PLC Class									
	Very versatile				→					Not versatile
	A	B1	B2	C	D	E1	E2	F	G	H
Very Intensive horticulture										
Intensive horticulture										
Intensive horticulture poorly drained										
Intensive cropping										
Cropping										
Intensive pasture “dairy”										
Intensive pasture “other”										
Extensive pastoral										
Production forestry										
Non Productive										

Potential land use for each PLC class are provided as a guide based on the Webb et al. (2011) recommendations (**Table 7**).

Table 7. Potential land use for each PLC class based on the Webb et al. (2011) recommendations.

Range of enterprises that can be sustained on a land unit	PLC class	Nursery	Floriculture	Orchards	Vineyards	Market gardens	Cropping	Dairy	Intensive pastoral	Production forestry	Extensive pastoral	Recreation/ Conservation
Very Intensive horticulture	A											
Intensive horticulture	B											
Intensive cropping/viticulture	C											
Cropping	D											
Intensive pasture “dairy”	E											
Intensive pasture “other”	E											
Production forestry	F (G)											
Extensive pastoral	G (F)											
Non Productive	H											

4.2 Assessment of additional/alternative criteria

Potential classification criteria other than those used in the existing PLC (ANZ, 1994) were explored. There are potentially numerous alternatives or additional classification criteria that could be used for the revised PLC. However, to retain some consistency between the existing PLC and the revised PLC, where possible and logical, the existing PLC criteria were retained.

Several additional literature sources were used to identify potential classification criteria:

- Classification of Land according to its Versatility for Orchard Crop Production (Webb and Wilson, 1994).
- A manual of Land Characteristics for Evaluation of Rural Land (Webb and Wilson, 1995).
- Evaluation of selected horticultural crops for the Post-Quake Farming Project (Ward and Clothier, 2019).

Important considerations for identifying potential criteria included the availability of data, the number of criteria in the PLC classification, and the application of the PLC for its given purpose.

In the original PLC (ANZ, 1994) a lack of objective data was considered a limitation for repeating and updating the PLC. All criteria in the revised PLC require underpinning data. The revised PLC aims to include criteria that can adequately delineate the range of land uses across the area, especially for more intensive land uses such as horticulture and cropping. As previously mentioned, the PLC is not intended to provide a full suitability classification for all land uses, rather, it is intended to provide broad identification and delineation of land suitable for the range of land uses in the area. Therefore, individual criterion selected can be used to approximate other closely related qualities to minimise the complexity of the PLC and increase its functionality. The main consideration is that the range of criteria included in the PLC cover the range of climate and land qualities that will determine the general suitability of the different land uses. **Table 8** provides a summary of the potential criteria considered and data availability.

Table 8. A summary of the potential criteria considered for the revised PLC (shaded qualities were not considered due to lack of data or clarity of definition).

Qualities	PLC characteristics (ANZ, 1994)	LCR characteristics (Webb et al., 2011)	Orchard characteristics (Webb and Wilson, 1994)	Rural land characteristics (Webb and Wilson, 1995)	Criteria considered
Climate					
Crop suitability/yield	Altitude				Altitude
Crop suitability/yield	Aspect (North/South)				
Crop suitability/yield	Length of growing season, heat over summer		Growing degree days	Growing degree days, chill period, sunshine hours	Growing degree days
Crop suitability/yield	Rainfall	Rainfall			Rainfall
Crop suitability/yield		Soil temperature		Soil temperature	Soil temperature
Frost hazard		Frost free days	Frost free period	Frost free period, Frost severity	Frost free days
Wind damage	Wind (wind run)	Windiness			
Land					
Soil nutrients	Fertility			Nutrients (P, K and S), pH, CEC, phosphorus retention	Exclude soils with low inherent fertility
Soil water deficit	Water holding capacity	Profile-available water (PAW)	Profile readily available water, permeability profile, water balance, (rainfall)	Profile readily available water, soil drainage class, soil water balance	Profile readily available water
Soil constraint (workability)			Topsoil stoniness, depth to rock	Stoniness, rock outcrops, soil water content, organic matter	
Soil constraints (structural stability)	Soil structure/ texture			Topsoil clay content, salinity, pH, organic matter, phosphorus retention	
Root penetrability	Rooting depth	Rooting depth, root penetrability	Potential effective rooting depth, penetrability class or packing density	Effective rooting depth, penetration resistance, packing density, stoniness	Effective rooting depth
Soil aeration	Soil drainage/permeability	Soil drainage class	Soil wetness class (soil drainage class)	Soil drainage class, air-filled porosity	Soil drainage class
Soil waterlogging	Soil drainage/permeability		Air-filled porosity and field capacity, rainfall	Soil drainage class, air-filled porosity, permeability profile	Soil drainage class

Trafficability			Topsoil penetration resistance, soil wetness class (soil drainage class)	Rock outcrops, topsoil penetration resistance	Soil drainage class
Topography	Slope	Slope	Slope	Slope	Slope
Erosion risk	Erosion	Erosion potential	Relative erosion severity	Erosion severity	Erosion Susceptibility Classification
Salinity		Salinity	Salinity	Salinity	Salinity class
Flood risk		Flood frequency	Flood return interval	Flood return interval	Flood class
Potential leaching			Profile-available water, cation-exchange losses capacity, water balance	Permeability profile, water balance	

The criteria (climate qualities and land qualities) considered for use in the revised PLC (shown in **Table 8**) are discussed in more detail in the climate qualities and land qualities sections of this report.

5 PLC criteria data

5.1 Introduction

Since the original PLC (ANZ, 1994) was developed there have been more data become available for improving the accuracy of the classification attributes as well as new data that facilitates the replacement of map unit polygons and attributes. The available data are discussed.

For criteria to be included in the revised PLC they must be based on available quantitative data. Where data was not readily available for a criterion the criterion could not be used in the classification and was excluded. The available data was sufficient to provide for the range of climate and land qualities considered relevant for identifying land with high productive value.

Geographic Information System (GIS) processing was required to spatially update map polygons and allocate the attribute data from the various sources across the entire PLC area to provide seamless data sets for revising the PLC. This was necessary because of the different data sources used, had full or partial spatial coverage, different map unit polygons (vector data), or were grid based raster data.

5.2 Climate qualities data

Climate qualities data included NIWA climate data provided as part of a Tasman District assessment[7], NIWA CliFlo climate data[8], Manaaki Whenua - Landcare Research soil temperature data[9], and Space Shuttle Radar Topography Mission (SRTM) 30 m global digital elevation model (DEM) and TDC Light Detection and Ranging (LiDAR) data.

Table 9 provides a summary of the climate attribute data used for the revised PLC.

[7] Pearce P, Woolley J-M, Sood A. 2019. Climate change projections for Tasman and impacts on agricultural systems. Prepared for Tasman District Council/Envirolink. National Institute of Water & Atmospheric Research Ltd, Auckland.
[8] https://cliflo.niwa.co.nz/
[9] https://koordinates.com/from/lris.scinfo.org.nz/layer/48348/metadata/

Table 9. A summary of the data (and general source) used for the revised PLC climate qualities (na = not applicable).

PLC criteria	Climate qualities data source		
	SRTM and TDC LiDAR data	NIWA (accessed via Ministry for the Environment)	Manaaki Whenua - Landcare Research
Altitude	Contours derived from a blended DEM using SRTM 30m global DEM data and TDC LiDAR data. Details are provided at: http://dwtkns.com/srtm30m/; https://www2.jpl.nasa.gov/srtm/; https://catalogue.data.govt.nz/dataset/nelson-and-tasman-LiDAR-1m-dem-2008-20154.	na	na
Soil Temperature	na	na	Soil temperature surfaces for the South Island of New Zealand based on analysis of a combination of monthly mean soil temperature data from NIWA sampled at a depth of 30 cm. Details are provided at: https://lris.scinfo.org.nz/layer/48348-mean-annual-soil-temperature-south-island/metadata/
Frost free period	na	NIWA CliFlo data (https://cliflo.niwa.co.nz/) Days of occurrence: ground frost day. Splined surface of frost free days created from 72 weather station data (located in Tasman, Marlborough and Wellington regions).	na
Rainfall range	na	National Mean Annual Rainfall (30 year mean annuals for the 1972 – 2013 period). Annual rainfall estimated from the daily rainfall estimates of the Virtual Climate Station Network (NIWA). Details are provided at: https://data.mfe.govt.nz/layer/53314-average-annual-rainfall-19722013/	na
Minimum growing degree days	na	TDC supplied growing degree days data (Pearce et al., 2019).	na

5.3 Land qualities data

The main source of land qualities data included new sources of soil map information (polygons and soil attributes) data from new soil surveys within the Tasman District[10] some of which have been loaded onto Smap[11]. Older attribute data (most likely used for at least some of the original PLC) was the Fundamental Soil layer data sourced from the LRIS Portal[12].

Other land qualities data sources included the New Zealand Land Resource Inventory (NZLRI)[13], Erosion Susceptibility Classification (ESC)[14], and SRTM 30m global DEM[15] and TDC LiDAR data[16].

Table 10 provides a summary of the land attribute data used for the revised PLC.

---

[10] SOILS INFORMATION IN THE TASMAN DISTRICT – REPORT EP06/05/11 – Report Prepared for 10 May 2006 meeting; Waimea Plains Soil Survey" (2017); The Golden Bay area (Takaka township, East Takaka and Motupipi, Puramahoi Coastal area and Kotinga) (2016).

[11] https://smap.landcareresearch.co.nz/

[12] https://lris.scinfo.org.nz/layer/48137-fsl-south-island-all-attributes/

[13] https://lris.scinfo.org.nz/layer/48135-nzlri-south-island-edition-2-all-attributes/metadata/

[14] https://data-mpi.opendata.arcgis.com/datasets/dataset-1-of-4-erosion-susceptibility-classification-march-2018-1

[15] http://dwtkns.com/srtm30m/; https://www2.jpl.nasa.gov/srtm/

[16] https://catalogue.data.govt.nz/dataset/nelson-and-tasman-lidar-1m-dem-2008-20154

Table 10. A summary of the data (and general source) used for the revised PLC land qualities (na = not applicable).

PLC criteria	Land qualities data source				
	Fundamental Soil Layer attribute (Manaaki Whenua – Landcare Research)	Blended DEM (SRTM and TDC LiDAR data)	S-map attribute (Manaaki Whenua – Landcare Research)	NZLRI attribute (Manaaki Whenua – Landcare Research)	Erosion Susceptibility Classification (Ministry for Primary Industries)
LUC Sub-class	na	na		LUCCORR	na
Low fertility soil	SERIES	na	Related SERIES based on Sibling Name	na	na
Potential rooting depth	PRD_CLASS	na	SIBLING DEPTH DESCRIPTION	na	na
Profile readily available water	PRAW_CLASS	na	RAWMM90CM	na	na
Soil profile drainage	DRAIN_CLASS	na	DRAINAGE CLASS	na	na
Salinity risk	SAL_CLASS	na		na	na
Slope	na	Slope classes derived from the blended DEM using SRTM and LiDAR data.	na	na	na
Erosion risk	na	na	na	LUCCORR	The ESC identifies the erosion susceptibility of land. The ESC is based on the analysis of potential and present erosion data associated with the NZLRI and the Land Use Capability (LUC) classification.
Flood risk	FLOOD_CLASS	na	na	na	na

5.4 Slope and contour data

Slope and contour data were derived from nationally available DEM data and LiDAR data provided by Tasman District Council. At the time of this PLC revision, LiDAR data was not available for the whole Tasman region. Slope and contour data were therefore derived by fusing nationally available DEM data with higher accuracy LiDAR data provided, where available by Tasman District Council.

The LiDAR data provided the most detailed representation of the ground surface with coverage typically being available over low lying areas where most productive agricultural and horticultural activities are located.

The SRTM data, while much coarser, was selected over other options as most other freely available DEM datasets are derived using the Land Information New Zealand (LINZ) 1:50,000 20 m contours. This introduces a large amount of generalisation and smoothing into the resulting DEM dataset. By contrast, the radar derived SRTM data is believed to provide a better characterisation of the actual topography and is therefore selected over other available options.

The technique involved combining DEM data of different resolutions into a seamless mosaic. Fine scale LiDAR data downloaded from the LINZ Data Service was blended along its edges with coarser SRTM data which covers the residual areas not covered by the LiDAR extent.

Fusion of the two datasets into a seamless elevation layer was undertaken using the feather blending tool within Global Mapper GIS software. In the context of elevation data, this function works by calculating progressively modified elevation values across a user defined feathering margin specified in pixels. At the outer extents of these margins (indicated by the dashed lines in **Figure 1**, the elevation of the coarse and fine DEM data will be matched to create a seamless layer.

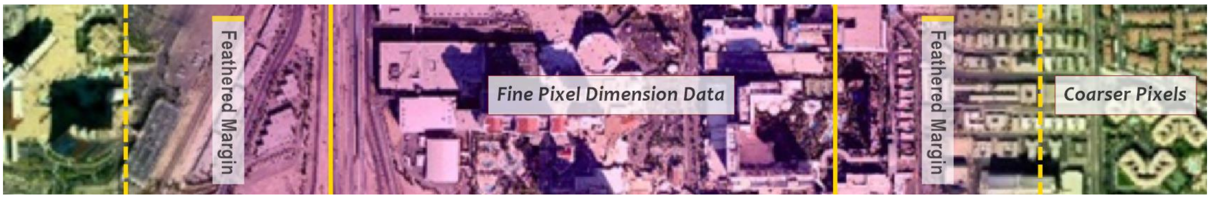


Figure 1. Illustration of feather blending (adapted from Global Mapper help[17])

As a component of the blending process, the SRTM dataset heights were globally reduced to approximate the heights of the LiDAR data where edges meet. The seams of the two datasets were then incrementally blended into one another across a user defined distance.

Once edge matched and seam blended, the resulting DEM was resampled to a nominal pixel dimension of 4 m x 4 m. This dimension was arbitrarily chosen to provide a good balance between preservation of fine scale LiDAR ground features and practical computing considerations.

As a final visual check of the resulting DEM, watercourse line work was generated using the DEM. The line work was scrutinised particularly along the blended seams to ensure that the pattern of hydrology appears natural where it flows across the DEM seams.

[17] https://www.bluemarblegeo.com/knowledgebase/global-mapper-20-1/index.htm#Feathering_Tab.htm?Highlight=feathering

5.5 Erosion susceptibility classification (ESC) data

The Erosion Susceptibility Classification (ESC) used for the National Environment Standard for Plantation Forestry 2017 (NES-PF) provides an improved dataset for erosion risk criteria in the revised PLC.

The ESC is used by the NES-PF to regulate the environmental effects of plantation forestry. The original version of the classification system was based on the potential erosion values in the NZLRI but has subsequently undergone several revisions including revisions by Basher et al., (2015) using the erosion terrain classification based on the dominant erosion process, rock type and topography to improve the High and Very High ESC classes. The ESC is now a more accepted classification for assessing erosion susceptibility (erosion risk) than the original potential erosion values in the NZLRI. The final version of the ESC is based on 1:50,000 scale (NZLRI) polygons which allows for the spatial incorporation into a revised PLC. Additionally, the ESC's national use by the NES-PF means that the erosion risk criteria in any revised PLC would align, avoiding the need for correlation of the criteria across the classifications.

6 Revision of the PLC

6.1 Introduction

This revision of the PLC utilised the existing PLC to maintain some continuity moving from the original ANZ (1994) PLC to the revised PLC. This decision was in based on discussions with TDC staff and on the review findings of Barringer et al. (2013) who stated, "*The intent of the classification to rank land in terms of a hierarchy of suitability to arange of enterprises was considered to be an appropriate system*."

The main PLC revisions were made to:

1. meet the requirements of the TRMP definition for "high productive value",
2. improve the map scale delineation using FSL, more recent soil survey and S-map soil map units,
3. include suggested criteria revisions, especially those that provide clearer, objective, and repeatable attributes and ratings, and
4. improve the quality of the input data.

Climate and land qualities were defined based on the selected attribute data by assigning range values to each of the climate and land qualities, in turn defining the PLC classes.

6.2 TRMP definition of high productive value

The Tasman Resource Management Plan (TRMP) became operative in May 2016. The TRMP provides a revised definition for identifying land that has "high productive value". The definition criteria provided is adapted from "Classification System for Productive Land in the Tasman District", Agriculture New Zealand, December 1994, and is equivalent to land under classes A, B, and C. The definition is as follows:

***High productive value** – in relation to land, means land which has a **combination of at least two** of the following features, **one of which must be** (a):*

(a) a climate with sufficient sunshine that supports sufficient soil temperature;
(b) a slope of up to 15 degrees;
(c) imperfectly-drained to well-drained soils;
(d) soil with a potential rooting depth of more than 0.8 metres and adequate available

moisture;

(e) soil with no major fertility requirements that could not be practicably remedied;

(f) water available for irrigation;

where that combination is to such a degree that it makes the land capable of producing crops at a high rate or across a wide range.

Based on this definition, only (a) a climate with sufficient sunshine that supports sufficient soil temperature has to be met, in combination with one other feature.

6.3 Description of selected climate qualities

6.3.1 Altitude

Altitude was a climate quality criteria in the original PLC (ANZ, 1994). Altitude was retained in the revised PLC for the purpose of identifying the altitude range for production forest, rather than replacing altitude with temperature parameters as suggested by Webb et al. (2011). This decision was based on an analysis of the location of existing production forest in the Tasman District using the New Zealand Landcover Database (LCDB). The original contour data was replaced with contour data derived from the blended DEM. An analysis of the amount of exotic forest (LCDB derived) against altitude indicated that an upper altitude of 600 m accounts for all but 4.4% of production forest (**Figure 2**).

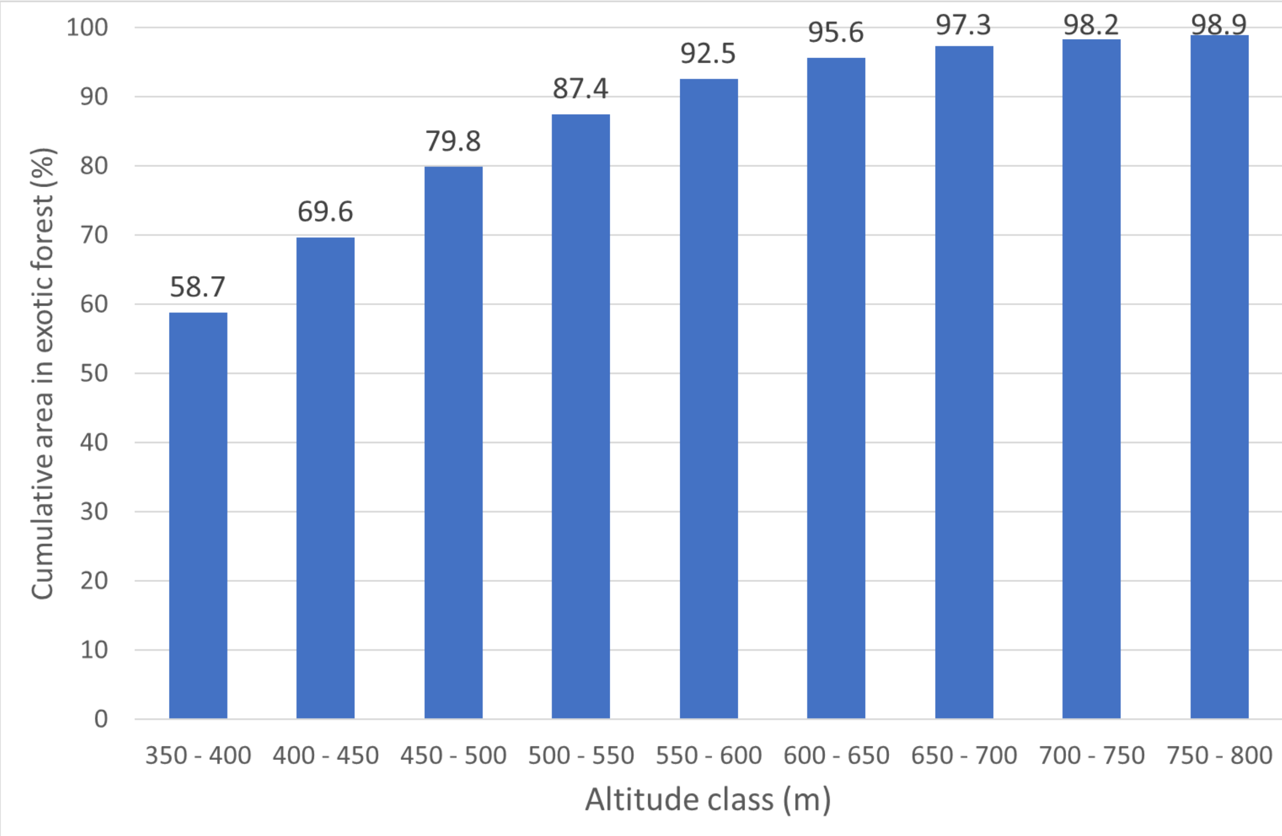


Figure 2. An estimate of cumulative area of exotic forest for altitude classes in the Tasman District.

The capture of 95.6% of exotic forest was considered appropriate given the reducing capture of exotic forest by subsequent altitude classes above 600 m. Retaining altitude was considered useful to provide an approximation of the upper limit for forest land use (600 m), as well as an upper limit for extensive pasture land use (1200 m) which is used in the original PLC.

6.3.2 Rainfall

Rainfall is a limitation for some horticultural crops. Irrigation of the land is likely a requirement where annual rainfall is < 600 mm/yr. For dairy this is likely to be < 1000 mm/yr (Webb et al., 2011). Based on the recommendations of Webb et al. (2011) rainfall is a useful criterion but requires revision of values for some classes. These include:

- Class C change to < 1600 mm/yr.
- Class D change to 800 - 2400 mm/yr.

6.3.1 Soil temperature

Mean annual soil temperature represents an index of accumulated heat in the soil and may be considered to be an approximate surrogate for growing degree days (Webb and Wilson 1995). The soil temperature regime classes relate to the soil temperature at 0.3 m depth. The classes used originate from Webb et al. (2011) and can be aligned with the classes described more fully in Webb and Wilson (1995) and Newsome et al. (2008). The classes and their corresponding characteristics are shown in **Table 11**.

Table 11. Mean soil temperature classes.

Classes from Webb et al. (2011) Mean annual soil temperature (°C at 30 cm)	Classes from Webb and Wilson (1995) TEMP_CLASS	Description			
		Soil temperature regime	Mean annual soil temperature (°C)	Period < 5 °C (days)	Period > 20 °C (days)
na	T	Thermic	15 - 22	0	na
> 14.5	WM	Warm mesic	11 - 15	0	> 5
> 12	MM	Mild mesic	11 - 15	< 60	0
> 9	CM	Cool mesic	8 - 11	< 60	0
> 8	DM	Cold mesic	8 - 11	> 60	0
< 8	C	Cryic	< 8	> 60	0

[1] Mean summer temperature <15 °C; na = not applicable.

Soil temperature values were provided by grid data[18], in place of the values provided in the FSL polygon data, as these values were likely to have improved spatial accuracy.

6.3.1 Frost free period

Frost severity limits the range of horticulture crops that can be grown successfully with frost occurrence having the potential to interfere with either flowering in spring, and harvest in late summer (Ward and Clothier, 2019). Frost tolerance varies from species to species and frost occurrence can show large variations according to micro-climatic attributes, such as slope position and aspect.

Such variations occur locally requiring data at a scale that is beyond that of the PLC. However, general frost criteria and limits can be defined and provide are useful to include in the PLC, primarily for identifying land suitable for horticulture land use in conjunction with growing degree days.

Ward and Clothier (2019) in their desktop study assessing the suitability of different horticultural

[18] https://koordinates.com/from/lris.scinfo.org.nz/layer/48348/metadata/

and plant-based foods in selected areas of North Canterbury, provide general climate requirements for horticulture. Their assessment of the general suitability for horticulture included a frost free period (FFP) of at least 200 days. The FFP of greater than 200 days has been adopted as a criteria limit for horticulture and cropping for the PLC. The FFP criteria limits roughly correspond to the moderate to very high classes of Webb and Wilson (1995).

For pasture-based land uses and exotic forest, FFP is not considered a significant limitation in this classification and no criteria limits are used.

6.3.2 Growing degree days

Growing degree-days have been widely used by growers and processors as an index of crop development (Kerr et al., 1981, cited in Webb and Wilson, 1994). Growing degree-days are assessed above a base of 10 °C (GDD10) over the July -June period. Threshold temperatures vary according to crop, and for each crop the required number of growing degree days depends on variety. For example kiwifruit require a minimum 1100 GDD10.

The Ward and Clothier (Ward and Clothier, 2019) desktop assessment was used to provide general climate requirements for horticulture for Tasman. Ward and Clothier used a growing degree day accumulation of 800 days above a base of 10 °C (800 GDD10) which was considered a minimum for horticulture. A geospatial analysis was used to spatially compare the GDD10 data provided for the Tasman District against stable LCDB land use classes (**Figure 3**).

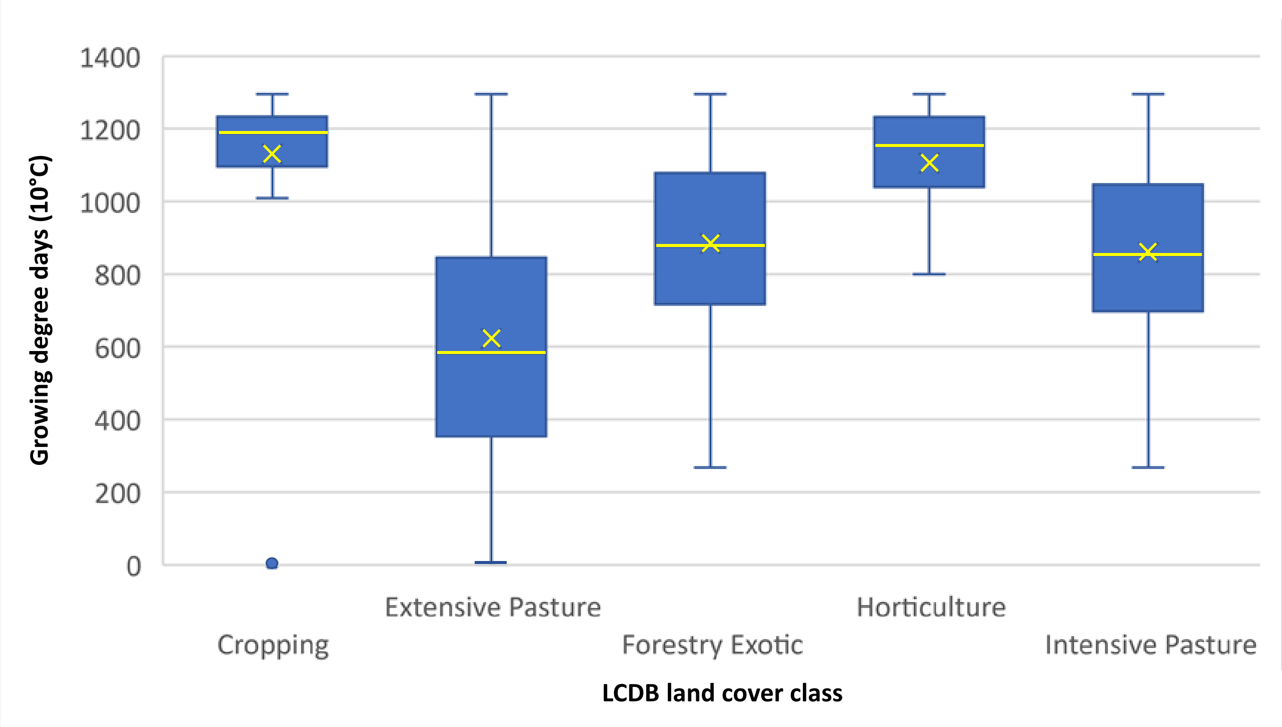


Figure 3. Estimated range of GDD10 by land use classes derived from LCDB land cover.

Based on the spatial analysis results shown in Figure 3, the range of GDD10 values for existing cropping and horticulture are (with the exception of one very low value for cropping, indicated by the single blue data point in Figure 3) all above 800 GDD10. Therefore, the suggested minimum of 800 GDD10 suggested by Ward and Clothier (2019) seems reasonable for use.

For pasture-based land uses other than dairy (E1) and for exotic forest GGD is not considered a significant limitation in this classification and no criteria limits are used.

6.4 Description of selected land qualities

6.4.1 Soil fertility

As suggested by Webb et al. (2011), general soil fertility relating to the fertiliser requirements for different land classes was removed with the soil fertility criteria focussing on inherently low fertility soils as occurs on soils formed from serpentinitic or highly quartzitic rocks. The FSL data was used to identify soil series formed on serpentinitic rocks in the Tasman District. Only one soil series (Dun series) was identified as low fertility soil in the Tasman District.

6.4.2 Potential rooting depth

Potential rooting depth describes the minimum and maximum depths (in metres) to a layer that may impede root extension. Such a layer may be defined by penetration resistance, poor aeration, or very low available water capacity. These classes described more fully in Webb and Wilson (1995), Newsome et al. (2008) and Smap Online[19], are shown in **Table 12**.

Table 12. Potential rooting depth classes.

FSL soil depth classes (m)		Smap soil depth classes (m)	
Description	Depth (m)	Description	Depth (m)
Very deep	1.2 - 1.5	No equivalent class	
Deep	0.9 - 1.19	Deep	> 1.0
Moderately deep	0.6 - 0.89	Moderately deep	0.45 - 1.0
Slightly deep	0.45 - 0.59	No equivalent class	
Shallow	0.25 - 0.44	Shallow	0.2 - 0.45
Very shallow	0.15 - 0.24	No equivalent class	
No equivalent class		Stony	0.1 - 0.2
No equivalent class		Very stony	< 0.1

Where available, more recent (and presumably more accurate) Smap soil depth classes were used in place for FSL soil depth class data.

Soil depth criteria limits were used to delineate land suitable for horticulture, cropping, and forestry.

6.4.3 Profile readily available water

For general-purpose land evaluation, the amount of soil water available for growth is defined as the profile readily available soil water (Webb and Wilson, 1995) measured to a depth of 0.9 m, or to the potential rooting depth (whichever is the lesser). Profile readily available soil water (PRAW) is estimated from the volumetric water content difference between -10 kPa and -1500 kPa in the 0 - 0.4 m layer, and between -10 kPa and -100 kPa in lower layers.

PRAW was used in preference to profile available water (PAW) because it was considered to provide a better indication of plant available water.

[19] https://smap.landcareresearch.co.nz/

The classes originate from the work of Gradwell and Birrell (1979), Wilson and Giltrap (1982) and Griffiths (1985) and are described more fully in Webb and Wilson (1995) and Newsome et al. (2008). Profile readily available water classes, their corresponding values and their relationship to PAW are shown in **Table 13**.

Table 13. Profile readily available water (PRAW) and profile available water (PAW) classes

PRAW (mm)	PRAW_CLASS	Description	PAW (mm)	PAW_CLASS
150 - 250	1	Very high	> 250	1
100 - 149	2	High	150 - 250	2
75 - 99	3	Moderately high	90 - 150	3
50 - 74	4	Moderate	60 - 90	4
25 - 49	5	Low	30 - 60	5
≤ 24	6	Very Low	< 30	6

Also, it was noted that the value ranges provided in Webb et al. (2011) aligned with PRAW rather than PAW as stated in Table 4 of their report. These PRAW value ranges have been adopted in our revised PLC.

6.4.4 Soil drainage class

Soil drainage can determine the depth to which plant roots grow; poor soil aeration (caused by poor soil drainage) restricts roots and the range of (especially deep rooted) plants that can be grown. This is most important for horticulture, cropping and forestry. Shallower rooted plants (such as pasture) are less affected by soil drainage.

Soil drainage is described as a class. Drainage classes are assessed using criteria of soil depth and duration of water tables inferred from soil colours and mottles, as in the following table or from reference to diagnostic horizons, as described below this table. Drainage classes used here are the same as those used in the NZ Soil Classification (Hewitt, 2010), and outlined by Milne et al. (1995) and Newsome et al. (2008). The drainage classes with their descriptions are shown in **Table 14**.

Table 14. Soil drainage classes.

DRAIN_CLASS Description	Depth below A horizon (cm)	Depth from surface (cm)	Low chroma on ped or cut surfaces (%)	High Chroma Redox mottles (%)
Very poor	1	≤ 10	≥ 50	na
Poor	≤ 15	≤ 30	≥ 50	na
Imperfect	≤ 15	≤ 30	≤ 50	and/or ≥ 2
	> 15	30 - 90	≥ 50	na
Moderately well	na	30 - 90	na	≥ 2
	na	60 - 90	≥ 50	na
Well	na	< 90	na	< 2

na = not applicable

6.4.5 Salinity

High salinity can restrict plant growth by restricting rooting or by causing soil toxicity. Although limited to soil s occupying coastal margins, salinity is an important consideration especially as it occurs on flatter land that would otherwise be suitable for intensive land uses including horticulture, cropping and dairy pasture. Salinity is measured as percent soluble salts (g/100g soil). Salinity classes are described more fully in Webb and Wilson (1995), Milne et al. (1991) and are summarised in **Table 15**.

Table 15. Salinity risk classes.

Description	SAL_MIN (%)	SAL_MAX (%)
Very low	0	0.04
Low	0.05	0.14
Medium	0.15	0.29
High	0.3	0.69
Very high	0.7	1.0

6.4.6 Slope

Slope classes used in the NZLRI derived LUC classification have largely been adopted. The exception being for intensive horticultural land where a maximum slope of 5 degrees is used in place of 7 degrees. The value of 5 degrees is based on Ward and Clothier (2019). A maximum slope of 15 degrees for all cropping is used as this is generally considered the maximum slope machinery can safely traverse for cultivation and harvesting. Where a maximum slope of 20 degrees for intensive pasture is used, this is considered a threshold beyond which increased surface erosion is likely to occur. For less intensive pastoral use the assumption is that stock intensity and stock type can be adjusted to meet the lands capability. For forestry, the ESC identifies slopes >25 degrees as having increased erosion risk (Basher et al., 2016). The proposed NES-PF requires that a resource consent be obtained for harvesting and earthworks in the Very High ESC zone and for earthworks in the in the High ESC zone on slopes >25 degrees.

However, an upper slope limit of 28° for plantation forestry has more commonly been considered appropriate for conventional forest establishment, harvesting and management.

6.4.7 Erosion risk

The loss of soil through soil erosion processes can result in the loss of crop production and pollution of water bodies. Soils are rated according to potential erosion risk (erosion risk).The erosion risk criterion was based on the Erosion Susceptibility Classification (ESC) classes (Bloomberg et al., 2011; MPI, 2015; Basher et al., 2016) in conjunction with the Land Use Capability Classification sub-classes (Lynn et al., 2009). The inclusion of LUC sub-class in the erosion risk criteria to identify additional risks associated with cultivated steeper slopes under cropping and to excluded land that according to the classification was not capable of supporting any productive land use and should be retired.

The ESC has been used in place of the previously used erosion severity classes in the Land Use Capability Classification because it was considered a better representation of erosion risk associated with geology, land form and encapsulated risks associate with mass movement (erosion types). Although developed specifically for forestry, it likely provides a better estimate of erosion risk than one solely based on severity. One missing component is that of the risk associated with rainfall events. This is yet to be incorporated into erosion susceptibility in New Zealand.

The ESC classes equate to the potential erosion severity classes of Bloomberg et al. (2011) shown in **Table 16**.

Table 16. The relationship between potential erosion severity classes and ESC classes (after Bloomberg et al., 2011).

Potential erosion severity	ESC class
0 = negligible	1 = low
1 = slight	1 = low
2 = moderate	2 = moderate
3 = severe	3 = high
4 = very severe	4 = very high
5 = extreme	4 = very high

For the purposes of the erosion risk criteria no differentiation was made between the potential erosion severity classes of very severe and extreme for the ESC class 4 (very high). The justification was that the PLC is a regional classification used for guidance and any site specific assessment of erosion risk was best undertaken at property scale on a case by case basis.

For erosion risk on land when cultivated, the classes presented in Webb et al. (2011) were adopted. These classes were based on Van Berkel (1983) and shown in **Table 17**.

Table 17. Potential for erosion with and without cultivation (based on Van Berkel, 1983, cited in Webb et al., 2011).

LUC sub-class	Potential for erosion (not cultivated)	Potential for erosion (when cultivated)
1	Negligible	Negligible
2e	Slight	Slight
3e	Slight	Slight
4e	Slight	Slight to moderate
6e	Moderate	na
7e	Moderate to severe	na

na = not applicable

6.4.8 Flood risk

Flooding is the temporary covering of the land by water from waterways overflowing their banks, runoff from surrounding slopes and inflow from high tides and storm surges (Webb and Wilson (1994). The probability of flooding is an important consideration in management decisions concerning the type of land uses that may be considered. This is especially so where there is infrastructure in place (e.g. trellising for horticulture, buildings and fencing). Flood risk is expressed as a flood return interval using the class limits provided in Webb and Wilson (1995) and Newsome et al. (2008) and is shown in **Table 18**.

Table 18. Flood risk classes.

Flood interval (years)	Class	Rating
nil	Nil	1
< 1 in 60	Slight	2
1 in 20 - 1 in 60	Moderate	3
1 in 10 - 1 in 20	Moderately severe	4
1 in 5 - 1 in 10	Severe	5
> 1 in 5	Very severe	6

Where land is protected from flooding the flood return interval used in classification should adjusted to that of the flood protection design works. Additional information on flood risk was sought from TDC. TDC has flood protection and inundation area data for parts of the Tasman District. This includes the location of infrastructure such as stopbanks. However, the area protected, and the level of protection provided is not spatially determined for the whole district, nor available as a geospatial layer that could easily be incorporated into the revised PLC. As a consequence, no additional data on flood risk data (other than that provided by the Fundamental Soil Layer data) has been included in the classification of flood risk in mapping the revised PLC.

7 Developing PLC criteria layers

7.1 Soil map information attribute data

Existing map units (polygons) from three sources of soil map information (FSL, Smap and new soil surveys) each having their own soil map unit polygons and associated attribute data. The Smap and new soil survey map information (and polygons) are considered an improvement on the FSL soil map information and are included in the revised PLC. However, only the FSL soil map information covered the whole PLC area; the Smap and new soil survey map information do not cover the entire PLC area. Additionally, not all attributes were provided by the different soil map information sources. The relevant attribute data for land qualities provided by each soil map information source is shown in **Table 19**.

Table 19. Attribute data for land qualities provided by each soil map information source (FSL, Smap and new soil surveys).

Criteria	Soil map information source		
	FSL	Smap	Soil surveys
Soil series	Series name	LOCALSERIESNAME	Series name
Rooting depth	PRD_CLASS	SIBLINGDEPTHDESCRIPTION	no data
Readily available water	PRAW_CLASS	RAWMM90CM	no data
Drainage class	DRAIN_CLASS	DRAINAGECLASS	no data
Salinity class	SAL_CLASS	no data	no data
Slope	SLOPE_CLASS	no data	no data
Flood frequency	FLOOD_CLASS	no data	no data

7.2 Combining soil map information

Geospatial processes were required to spatially update map polygons and allocate the attribute data from the various sources across the entire PLC area to provide seamless data sets for revising the PLC. This was necessary because of the different data sources used, had full or partial spatial coverage, different map unit polygons (vector data), or were grid based raster data.

Linking the three sources of soil data made use of the most spatially accurate soil map unit polygons and soil attribute data for the land criteria. Only the FSL data had full coverage, with two new soil survey and Smap data providing partial coverage (**Figure 4**). Soil survey and Smap overlapped with the FSL data, and although the Smap data is derived from the new soil survey map information, soil survey and Smap do not overlap. The preference was to use new soil survey polygons and Smap polygons where available in place of FSL polygons.

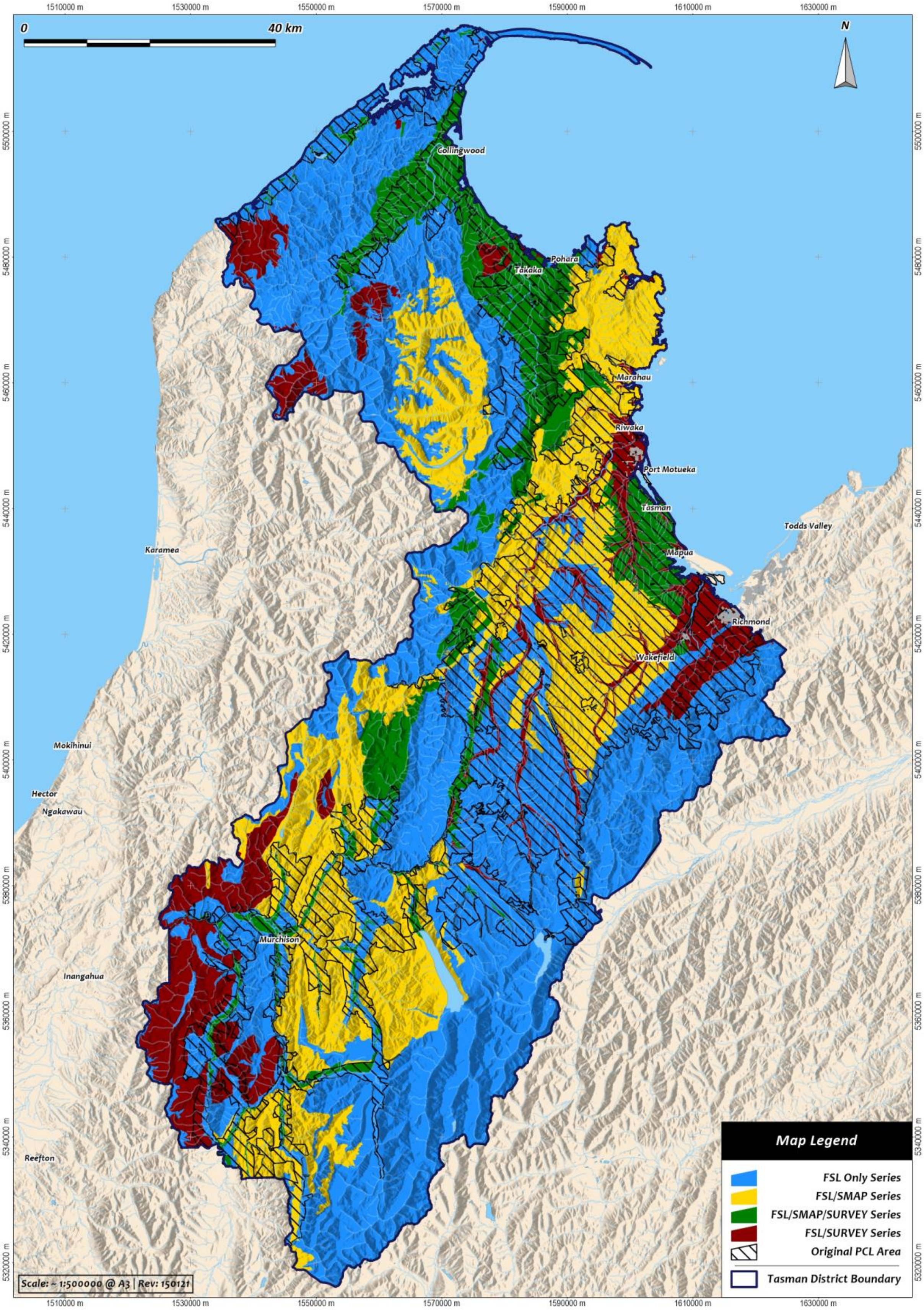


Figure 4. Soil map information coverage for the Tasman District.

There were no soil attributes provided in the soil survey data to replace FSL attributes. Therefore, FSL data was imposed on the soil survey polygons to provide the land attributes for the soil survey polygons. To join the two data a common “soil type” attribute was required. A multi-stage process was used. The soil series attribute was used where soil series was the same for both data. Where the soil series value existed in the FSL data, the FSL data for that soil series value was applied to the soil survey polygon with the same soil series value. For soil survey polygons with no corresponding FSL soil series value, the FSL New Zealand Soil Classification (NZSC) subgroup was used.

There were two soil attributes in Smap (soil profile drainage - DRAINAGECLASS and potential rooting depth – POTROOTDEPTH) that were considered an improvement, replacing FSL soil attributes. However, for all other soil attributes, FSL soil attributes were retained. Therefore, the FSL soil attributes were imposed on the Smap polygons to provide the full set of soil attributes for Smap polygons. To join the two data a common “soil type” attribute was required. The only common “soil type” attribute was NZSC subgroup. The process for linking the new soil data with the FSL land attribute data is summarised in **Table 20**.

Table 20. A summary of the process for linking the new soil data with the FSL land attribute data.

Soil data	Coverage of PLC area	Spatial overlap	New land attributes	Join attributes
New soil survey	Partial	Fundamental Soil Layer (FSL)	No land attributes, therefore, use FSL land attributes.	Join FSL by dominant soil series in preference to correlated NZSC subgroup.
Smap	Partial	Fundamental Soil Layer (FSL)	Depth class, Drainage class; for all other land attributes use FSL land attributes.	Join FSL by dominant correlated soil series or correlated NZSC subgroup.

At the scale of mapping soil map units (represented by a single GIS polygon) can contain more than one soil. This occurred in both the FSL and the Smap soil map data, creating an issue when assigning soil attributes. To assign soil attributes, the dominant soil in each soil map unit was used. This avoided the issue of trying to apportion attributes for all soils represented. To check the validity of the approach, the proportion of area occupied by the dominant soil series in each polygon was analysed for all polygons in the new soil survey and Smap soil map data (**Figure 5**).

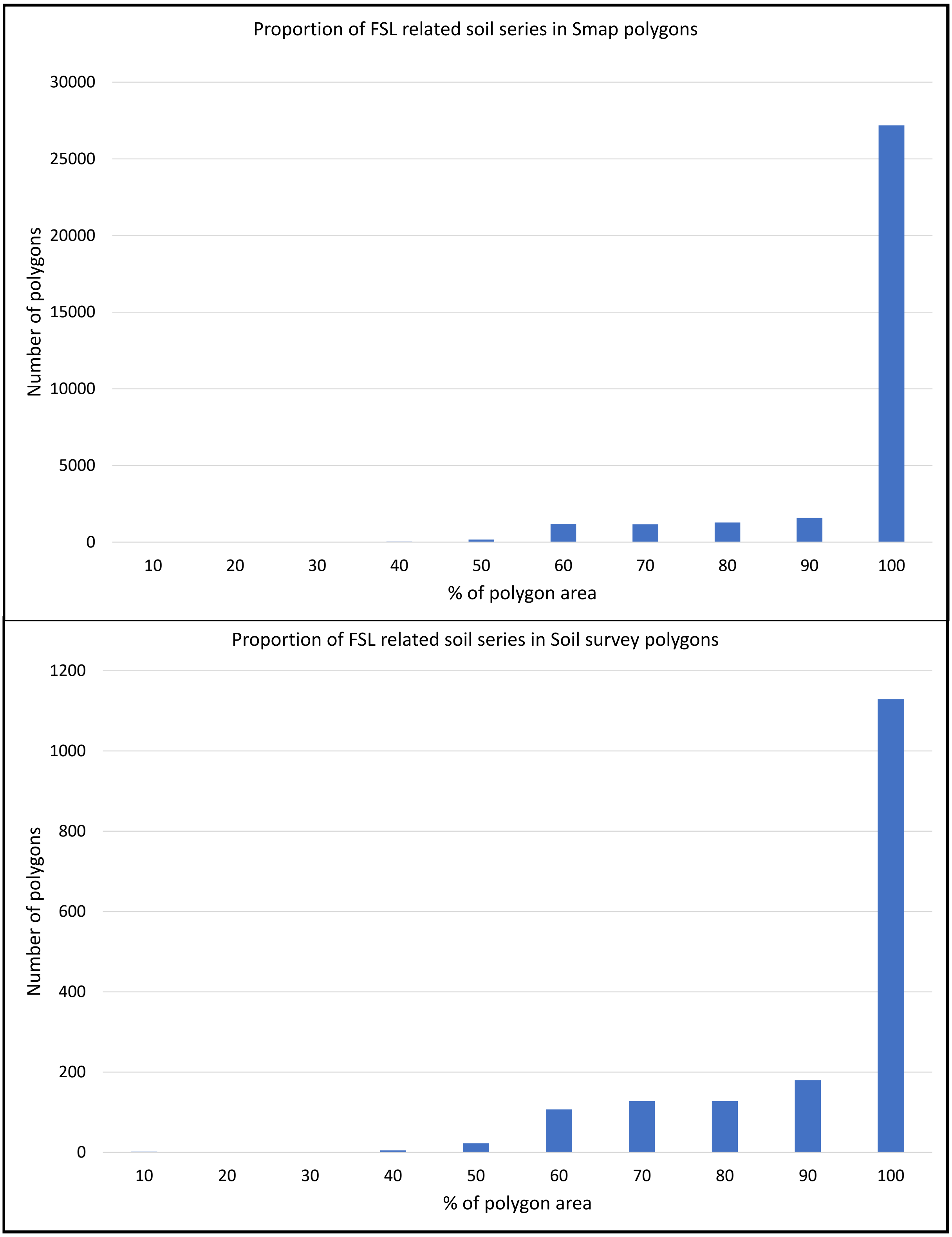


Figure 5. Proportion of FSL related soil series in new soil survey and Smap polygons.

The analysis indicated that for the new soil survey and Smap soil map data most polygons were dominated by one soil series (represent as 100% of the polygon area in **Figure 5**). This suggested that assigning the attributes associated with the dominant soil series was acceptable.
Where a common soil series name was not available, Smap and soil survey polygons were retained in preference to the older and coarser scale FSL polygons and the FSL attribute data were

intersected with the Smap and soil survey polygons. The dominant FSL attribute data were then assigned to the Smap and soil survey polygons, retaining the Smap attribute data where it was present. Preference was given to the Smap attribute data over the FSL attribute data for use in the revised PLC.

The resulting land attribute data layer used the soil and Smap polygons instead of FSL polygons (where possible) and all polygons were populated with the FSL and Smap attributes used for the revised PLC. For other non-vector data (e.g. soil temperature grid data), grid values were assigned to each polygon. If more than one grid value spanned a polygon an area weighted average of the values was assigned to the polygon. The resulting layers for Climate qualities and Land qualities used in the revised PLC are provided in Appendix 1.

8 Revised PLC options

Following discussion with TDC land science staff, a range of PLC options were developed to explore different option provided by combinations of the range of data available:

- **PLC Option 1** matrix: based on revised criteria identified in the report by Webb et al. (2011) which included a review of the ANZ (1994) PLC.
- **PLC Option 2** matrix: based on what are considered the most useful criteria and realistic value ranges from ANZ (1994) and Webb et al. (2011) criteria.
- **PLC Option 3** matrix: based on a mix of LUC classes and a reduced number of climate and land criteria.
- **PLC Option 4** matrix: based on the proposed NPS definition of "Highly Productive Land" (MPI/MfE, 2018).

In developing the revised PLC we considered the complexity of the PLC – that is the number of land and climate qualities to be used to provide an adequate classification for its intended use, including scale. The PLC is primarily a broad level tool to guide more detailed assessment of a land area across a range of land uses on a case by case basis – essentially a regional planning tool. The PLC is not intended to provide a full suitability assessment for every land use, or different crops within a land use.

Critical to the PLC are the defined *value ranges* of the individual land and climate qualities for each PLC class. Value ranges for the individual land and climate qualities were based on available literature. Where possible existing criteria and value ranges from the original PLC and criteria suggested in the review of Webb et al. (2011) were retained or adopted. Where these have been adopted the rationale for their use is provided in the original reference documents, although some additional explanation is provided in this report.

8.1 PLC class classification process

The approach used grouped together land areas (map units) with similar land versatility for sustainable production. The grouping is based on a range of criteria used to represent climate and land qualities considered important for defining land versatility, in turn classifying land use classes in the PLC. Each land versatility class is defined according to the value range for all criteria.

A scoring matrix (and an associated GIS process) was developed that identified more intensive land use classes first, progressively reducing the available area for lesser intensive land use class. For each PLC class the combined set of value ranges were unique to ensure the land classes were mutually exclusive and a land class could be assigned to the entire eligible PLC area.

Collectively, the criteria value ranges for each PLC class are unique but are not individually unique. For this reason, the classification process classifies the class with the highest versatility (PLC class

A) first and the identified land area is removed. The analysis progressively classifies and removes land areas from the PLC class with the next highest versatility in a stepwise manner until all land has been allocated to a PLC class.

8.2 Geospatial analysis, processes and data

All geospatial analysis and model development was undertaken in Manifold Release 9 GIS using structured query language (SQL) scripts. A flow diagram outlining the geospatial analysis processes for determining PLC classes in the revised PLC is shown in **Figure 6**.

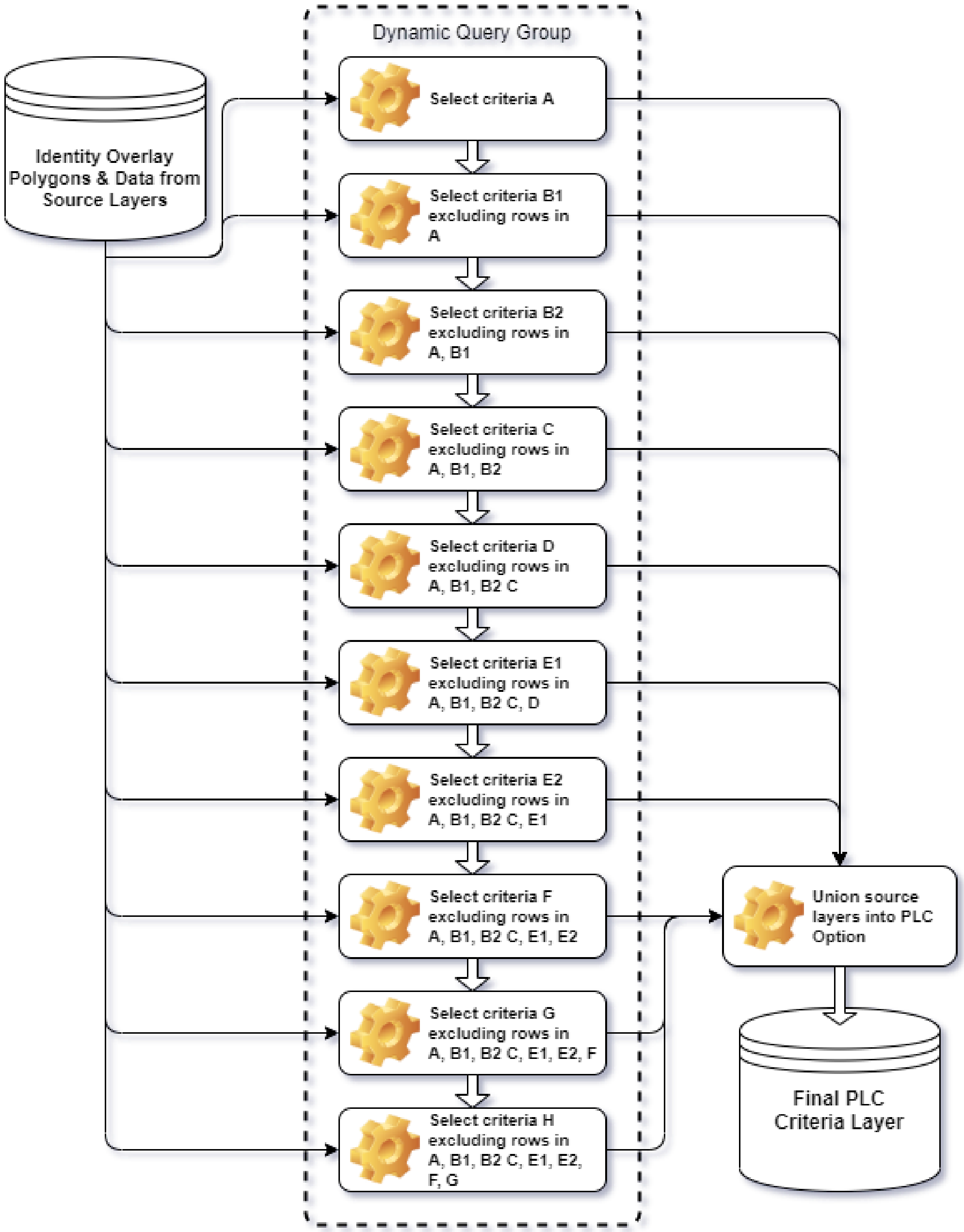


Figure 6. Flow diagram outlining the geospatial analysis processes for determining PLC classes in the revised PLC.

SQL scripting within Manifold 9 provided a robust, agile environment for model development allowing for fine tuning of model parameters irrespective of the size of the base data which contained upwards of two million polygons. Using this framework, model parameters could be modified, and the queries refreshed to facilitate rapid testing and visualization of the effect of changing one or more parameters.

The scripts additionally provide an explicit and reusable description (metadata) of the model process which can be readily extended to accommodate future model changes or additions.

Data outputs included GIS files for each of the individual criteria (climate and land qualities) used for the PLC options, and the final PLC option layers. The files are in a format compatible with a range of GIS, including ARCGIS.

8.3 Original PLC (ANZ, 1994)

For reference a map of the original PLC classes based on ANZ (1994) is provide in **Figure 7**.

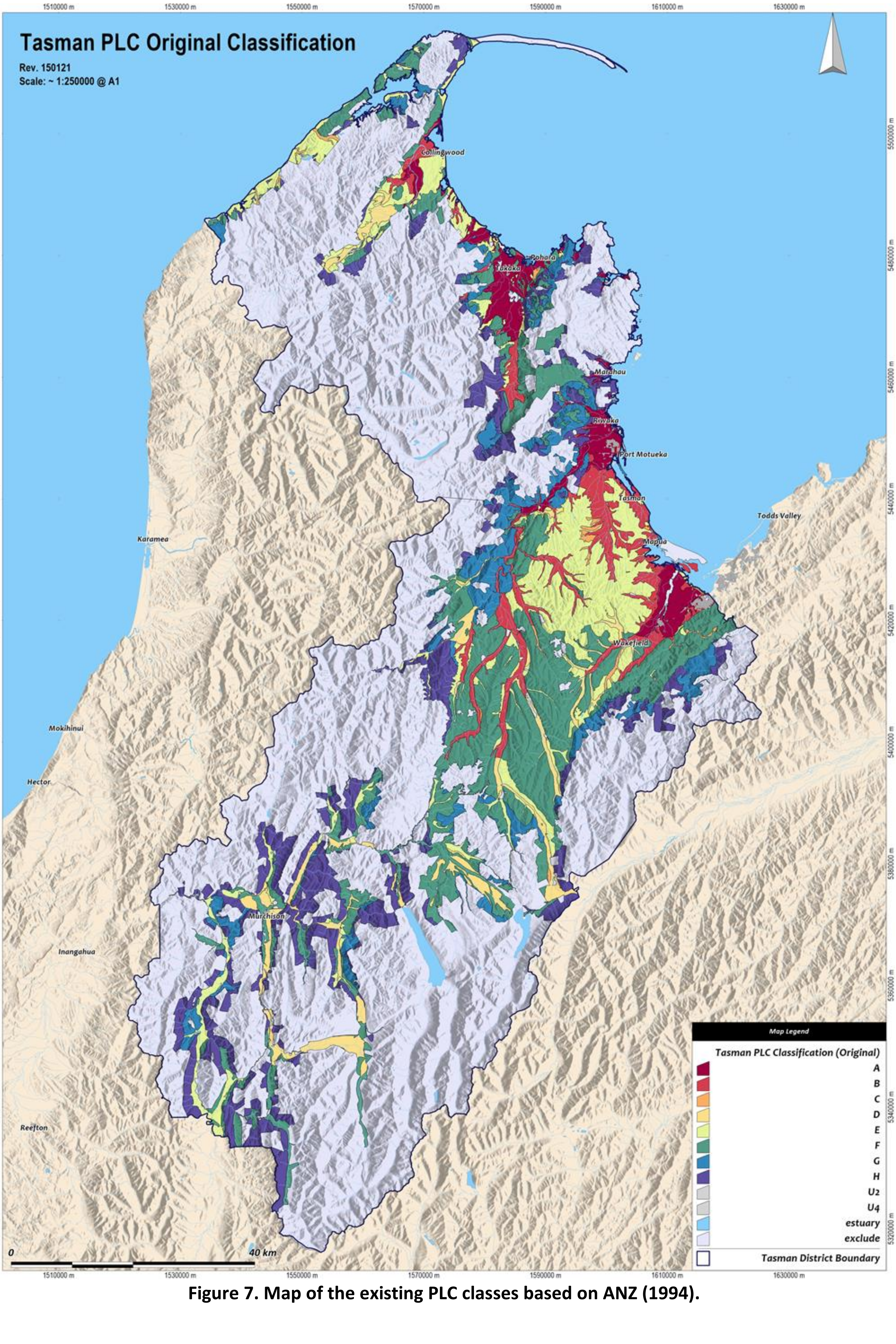


Figure 7. Map of the existing PLC classes based on ANZ (1994).

8.4 PLC Option 1

The PLC Option 1 matrix is based on revised criteria identified in the report by Webb et al. (2011) which included a review of the ANZ 1994 PLC. PLC Option 1 comprises **five climate qualities** and **eight land qualities**. Frost free period from Webb et al. (2011), GDD10 value ranges from Ward and Clothier (2019), and modified erosion criteria from Webb et al. (2011) and the Erosion Susceptibility Classification (Basher et al., 2015) are used. The frost free period value ranges from Webb et al., (2011) provide the greatest delineation across land classes of all revised PLC options. They are broadly based on Webb and Wilson (1995). The rationale for the criteria value ranges for PLC Option 1 is summarised in **Table 21**.

Table 21. The rationale for the criteria value ranges for PLC Option 1.

Climate qualities	Reference	Comment
Altitude	ANZ (1994)	600 m upper limit for forestry and 1200 m upper limit for productive use retained.
Soil temperature	Webb et al. (2011)	No change
Frost free period	Webb et al. (2011)	No change
Rainfall range	Webb et al. (2011)	No change
Growing degree days		No change
Land qualities	Reference	Comment
Low fertility soil	Webb et al. (2011)	Based on identification of soils with low inherent fertility.
Potential rooting depth	Webb et al. (2011)	No change
Profile readily available water	Webb et al. (2011)	No change
Soil profile drainage	Webb et al. (2011)	No change
Salinity class	Webb et al. (2011)	No change
Slope (degrees)	Webb et al. (2011)	No change
Erosion risk	Webb et al. (2011)	LUC classes replaced with ESC classes and recommendations for cultivated soil.
Flood frequency (years)	Webb et al. (2011)	No change

The criteria and class value ranges for PLC Option 1 are shown in **Table 22**. The mapped classes for PLC Option 1 are shown **Figure 8**.

Table 22. Criteria and class value ranges for PLC Option 1.

Land class	Criteria												
	Climate qualities					Land qualities							
	Altitude AMSL (m)	Mean annual soil temperature (°C)	Frost free period (days)	Mean annual rainfall (mm/yr)	GDD10 (days)	Low fertility soil (soil series)	Potential rooting depth (m)	Profile readily available water (mm)	Soil drainage class	Salinity class	Slope (degrees)	Erosion risk	Flood frequency in years (class)
A	na	> 14.5	> 300	na - 1200	≥ 800	Exclude "Dun"	> 0.8	≥ 50	≥ Imperfect	≤ Very low	≤7	Na	1 in 20 (≤ 3)
B1	na	> 14.5	> 250	na - 2000	≥ 800	Exclude "Dun"	> 0.8	≥ 50	≥ Imperfect	≤ Low	≤ 15	Moderate* ESC = 1; exclude LUC 4e-8e	1 in 20 (≤ 3)
B2	na	> 14.5	> 250	na - 2000	≥ 800	Exclude "Dun"	> 0.6	≥ 75	≥ Poor#	≤ Low	≤ 15	Moderate* ESC = 1; exclude LUC 4e-8e	1 in 10 (≤ 4)
C	na	> 12	> 200	na - 1600	≥ 800	Exclude "Dun"	> 0.5	≥ 75	≥ Imperfect	≤ Low	≤ 15	Slight* ESC = 1; exclude LUC 3e-8e	1 in 10 (≤ 4)
D	na	> 12	> 200	800 - 2400	≥ 800	Exclude "Dun"	> 0.5	≥ 75	≥ Poor	≤ Medium	≤ 15	Moderate* ESC = 1	1 in 10 (≤ 4)
E1	na	> 9	> 200	800 - 3200	≥ 800	Exclude "Dun"	> 0.4	≥ 75	≥ Poor	≤ Medium	≤ 15	Slight ESC = 1	1 in 5 (≤ 5)
E2	na	> 9	na	na	na	Exclude "Dun"	na	na	≥ Poor	≤ Medium	≤ 35	Moderate ESC = 1, 2	na
F (old G)	< 600	> 8	> 200	800 - na	na	Exclude "Dun"	> 0.8	≥ 75	≥ Imperfect	≤ Low	≤ 28	Very High ESC = 1, 2, 3, 4; exclude LUC 8e	na
G (old F)	< 1200	> 8	na	na	na	Exclude "Dun"	> 0.2	na	≥ Very poor	≤ High	na	High ESC = 1, 2, 3; exclude LUC 8e	na
H	na	na	na	na	na	na	na	na	na	na	na	na	na

*Assumes increased erosion risk associated with likely cultivation (Webb et al., 2011); # Assumes land can be readily drained and resulting soil drainage is equivalent to or better than imperfect (Webb et al., 2011); na = not applicable.

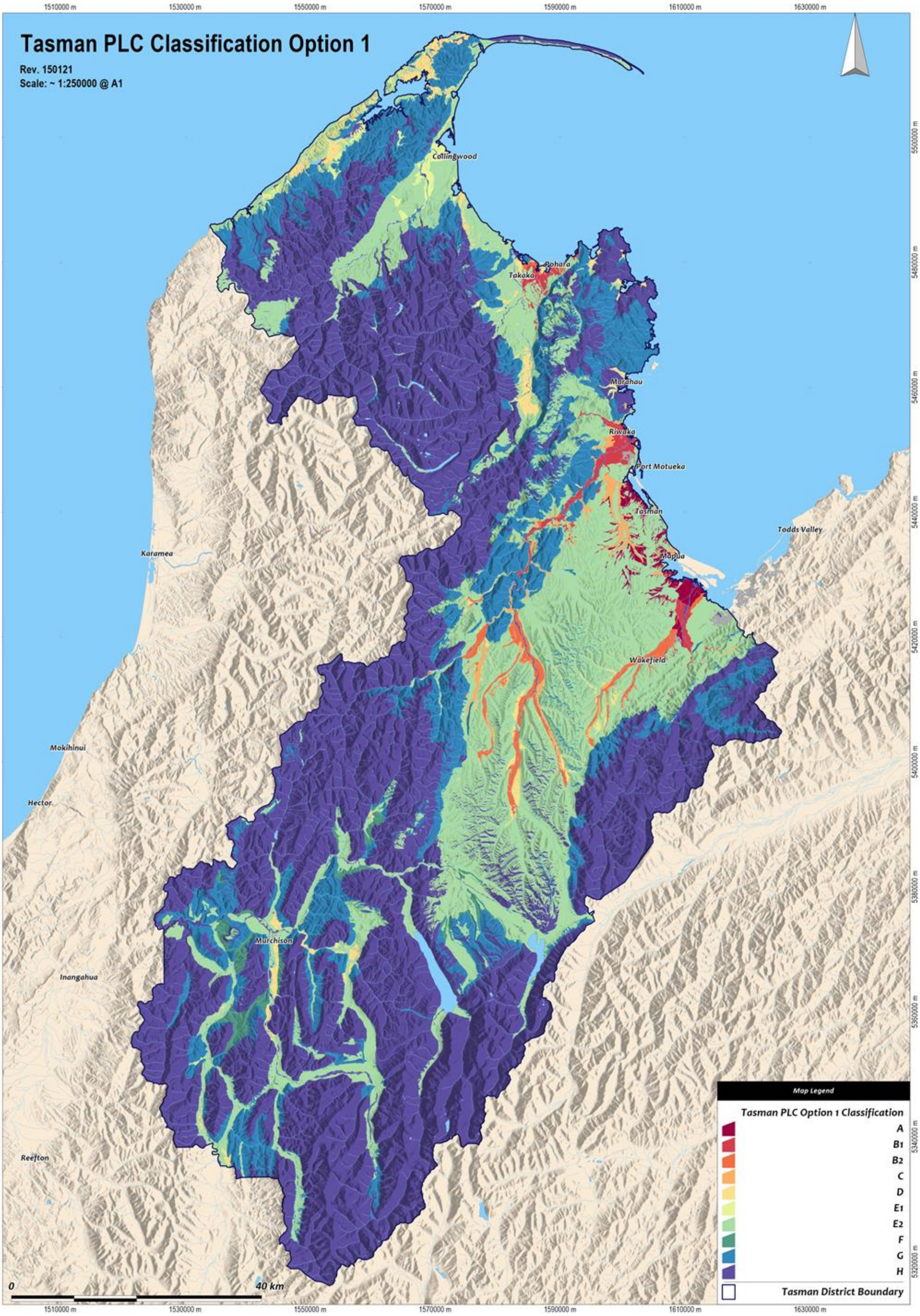


Figure 8. Map of the classes for PLC Option 1.

8.5 PLC Option 2

The PLC Option 2 matrix is based on what are considered the most useful criteria and realistic value ranges from ANZ 1994 and Webb et al. (2011) criteria. PLC Option 2 comprises **five climate qualities** and **eight land qualities**. Frost free period and GDD10 value ranges are from Ward and Clothier (2019), modified erosion criteria from Webb et al., (2011) and the ESC (Basher et al., 2015) are used. The rationale for the criteria value ranges for PLC Option 2 is summarised in **Table 23**.

Table 23. The rationale for the criteria value ranges for PLC Option 2.

Climate qualities	Reference	Comment
Altitude	ANZ (1994)	600 m upper limit for forestry and 1200 m upper limit for productive use retained.
Soil temperature	Webb et al. (2011)	Class C increased from > 12 to > 14.5 to accommodate viticulture.
Frost free period	Webb et al. (2011)	Minimum frost free period (200 days) from Ward and Clothier (2019).
Rainfall range	Webb et al. (2011)	Minimum rainfall of 600 mm add added to PLC classes A, B1, B2 and C.
Growing degree days		Minimum growing degree days (800 days) from Ward and Clothier (2019).
Land qualities	**Reference**	**Comment**
Low fertility soil	Webb et al. (2011)	Based on identification of soils with low inherent fertility
Potential rooting depth	Webb et al. (2011)	Class C reduced depth to 0.6 m 0.15 m to accommodate viticulture; classes D-F reduced from 0.5 m to 0.45 m which is more commonly used as a soil depth limit[20].
Profile readily available water	Webb et al. (2011)	Class C reduced from ≥ 50 to ≥ 25 to accommodate viticulture; class E2 reduced from ≥ 75 to ≥ 50 for non-dairy intensive pasture; no limit for remaining land in class D; lower requirement for forestry (class F).
Soil profile drainage	Webb et al. (2011)	No change
Salinity class	Webb et al. (2011)	No change
Slope (degrees)	Webb et al. (2011)	Class A slope reduced from ≤ 7° to ≤ 5° from Ward and Clothier (2019).
Erosion risk	Webb et al. (2011)	LUC classes replaced with ESC classes and recommendations for cultivated soil.
Flood frequency (years)	Webb et al. (2011)	Classes A, B and C all assigned flood frequency of < 1 in 20 years

The criteria and class value ranges for PLC Option 2 are shown in **Table 24**. The mapped classes for PLC Option 2 is shown **Figure 9**.

[20] Webb and Wilson (1994).

Table 24. Criteria and class value ranges for PLC Option 2.

PLC class	Criteria												
	Climate qualities					Land qualities							
	Altitude AMSL (m)	Mean annual soil temperature (°C)	Frost free period (days)	Mean annual rainfall (mm/yr)	GDD10 (days)	Low fertility soil (soil series)	Potential rooting depth (m)	Profile readily available water (mm)	Soil drainage class	Salinity class	Slope (degrees)	Erosion risk	Flood frequency in years (class)
A	na	> 14.5	>200	600 - 1200	≥ 800	Exclude "Dun"	> 0.9	≥ 50	≥ Imperfect	≤ Very low	≤ 5	Na	≤ 1 in 20 (≤ 3)
B1	na	> 14.5	>200	600 - 2000	≥ 800	Exclude "Dun"	> 0.6	≥ 50	≥ Imperfect	≤ Low	≤ 15	≤ Moderate* ESC = 1; exclude LUC 4e-8e	≤ 1 in 20 (≤ 3)
B2	na	> 14.5	>200	600 - 2000	≥ 800	Exclude "Dun"	> 0.6	≥50	≥ Poor#	≤ Low	≤ 15	≤ Moderate* ESC = 1; exclude LUC 4e-8e	≤ 1 in 20 (≤ 3)
C	na	> 14.5	>200	600 - 1600	≥ 800	Exclude "Dun"	> 0.15	≥25	≥ Imperfect	≤ Low	≤ 15	≤ Slight* ESC = 1; exclude LUC 3e-8e	≤ 1 in 20 (≤ 3)
D	na	> 12	>200	800 - 2400	≥ 800	Exclude "Dun"	> 0.45	na	≥ Poor	≤ Medium	≤ 15	≤ Moderate* ESC = 1	≤ 1 in 10 (≤ 4)
E1	na	> 9	>200	800 - 3200	≥ 800	Exclude "Dun"	> 0.45	≥ 75	≥ Poor	≤ Medium	≤ 15	≤ Slight ESC = 1	≤ 1 in 5 (≤ 5)
E2	na	> 9	na	na	na	Exclude "Dun"	> 0.45	≥ 50	≥ Poor	≤ Medium	≤ 20	≤ Moderate ESC = 1, 2	na
F (old G)	< 600	> 8	>200	800 - na	na	Exclude "Dun"	> 0.45	≥25	≥ Imperfect	≤ Low	≤ 28	≤ Very High ESC ≤ 3; exclude LUC 8e	na
G (old F)	< 1200	> 8	na	na	na	Exclude "Dun"	> 0.2	na	na	≤ High	≤ 35	≤ High ESC ≤ 3; exclude LUC 8e	na
H	na	na	na	na	na	na	na	na	na	na	na	na	na

*Assumes increased erosion risk associated with likely cultivation (Webb et al., 2011); # Assumes land can be readily drained and resulting soil drainage is equivalent to or better than imperfect (Webb et al., 2011); na = not applicable.

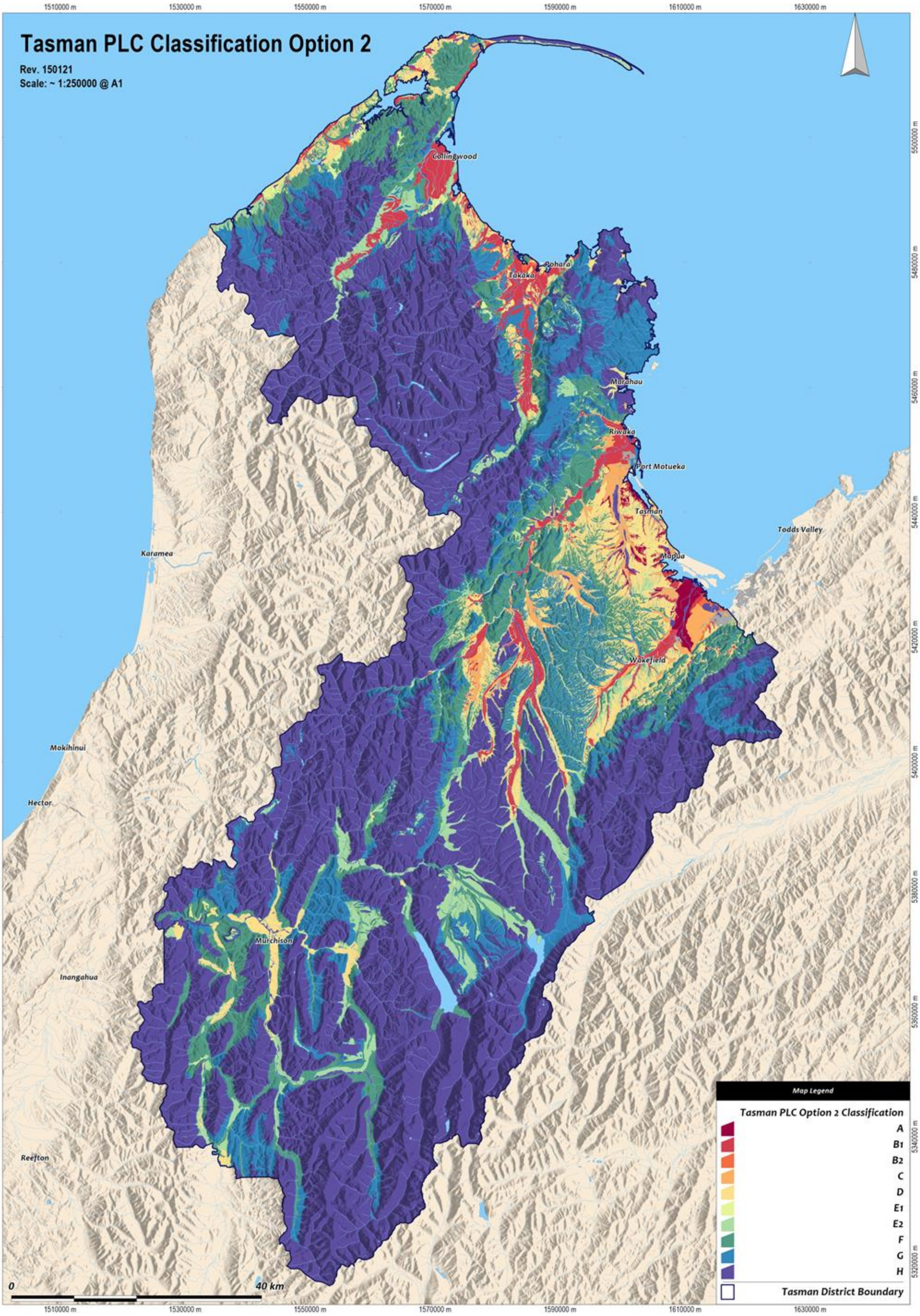


Figure 9. Map of classes for PLC Option 2.

8.6 PLC Option 3

The PLC Option 3 matrix is based on a mix of LUC classes and a reduced number of climate and land criteria. PLC Option 3 comprises **four climate qualities** and **four land qualities**. Uses Ward and Clothier (2019) criteria for frost free period and GDD10, and modified ESC erosion. Uses LUC classes to replace climate qualities and land qualities[21]. PLC Option 3 incorporates LUC in place of a broader range of individual land qualities, with Ward and Clothier (2019) criteria for Frost free period and GDD10, and modified ESC erosion. The approach uses a combination of LUC classes to replace land qualities in combination with and climate qualities to provide a less complex array of classification criteria. The rationale for the PLC criteria value ranges for Option 3 is summarised in **Table 25**.

Table 25. The rationale for the criteria value ranges for PLC Option 3.

Climate qualities	Reference	Comment
Altitude	ANZ (1994)	600 m upper limit for forestry and 1200 m upper limit for productive use retained.
Frost free period	Webb et al. (2011)	No change
Rainfall range	Webb et al. (2011)	No change
Growing degree days		No change
Land qualities	Reference	Comment
LUC class	Lynn et al. (2009)	LUC class(es) assigned based on capability to support sustainable land use.
Soil profile drainage	Webb et al. (2011)	No change
Slope (degrees)	Webb et al. (2011)	Slope limits adjusted to align with LUC classes for PLC classes D and E1.
Erosion risk	Webb et al. (2011)	LUC classes replaced with ESC classes and recommendations for cultivated soil.

The criteria and class value ranges for PLC Option 3 are shown in **Table 26**. The mapped classes for PLC Option 3 is shown **Figure 10**.

[21] Note that LUC does include a climate limitation sub-class (c).

Table 26. Criteria and class value ranges for PLC Option 3.

PLC class	Criteria							
	Land and climate qualities							
	LUC class	Altitude AMSL (m)	Frost free period (days)	Mean annual rainfall (mm/yr)	GDD10 (days)	Soil drainage class	Slope (degrees)	Erosion risk
A	1, 2	na	> 200	600 - 1200	≥ 800	≥ Imperfect	≤ 7	na
B1	1, 2	na	> 200	600 - 2000	≥ 800	≥ Imperfect	≤ 15	Moderate* ESC = 1 but exclude LUC 4e-8e
B2	1, 2	na	> 200	600 - 2000	≥ 800	≥ Poor#	≤ 15	Moderate* ESC = 1 but exclude LUC 4e-8e
C	1, 2, 3, 4s – 7s	na	> 200	600 - 1600	≥ 800	≥ Imperfect	≤ 15	Slight* ESC = 1 but exclude LUC 3e-8e
D	1, 2, 3, 4	na	> 200	800 - 2400	≥ 800	≥ Poor	≤ 20	Moderate* ESC = 1
E1	1, 2, 3, 4	na	> 200	800 - 3200	≥ 800	≥ Poor	≤ 20	Slight ESC = 1
E2	1, 2, 3, 4, 5	na	na	na	na	≥ Poor	≤ 25	Moderate ESC = 1, 2
F (old G)	1, 2, 3, 4, 5, 6, 7	< 600	>200	800 - na	na	≥ Imperfect	≤ 35	Very High ESC = 1, 2, 3 but exclude LUC 8e
G (old F)	1, 2, 3, 4, 5, 6, 7	< 1200	na	na	na	≥ Very poor	≤ 35	High ESC = 1, 2, 3 but exclude LUC 8e
H	na	na	na	na	na	na	na	na

*Assumes increased erosion risk associated with likely cultivation (Webb et al., 2011); # Assumes land can be readily drained and resulting soil drainage is equivalent to or better than imperfect (Webb et al., 2011); na = not applicable.

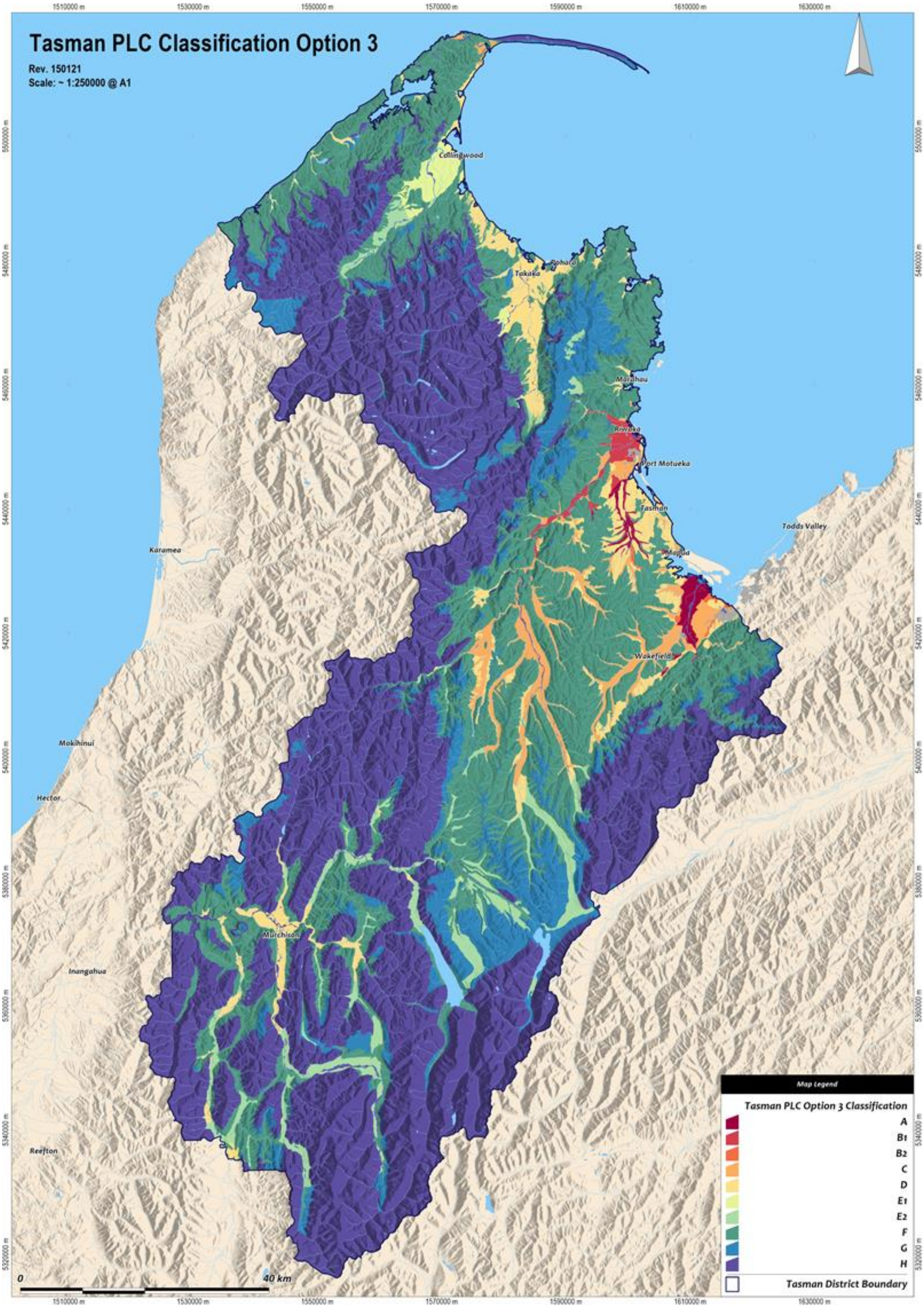


Figure 10. Map of PLC classes for Option 3.

8.7 PLC Option 4

The PLC Option 4 matrix is based on the definition of highly productive land provided in the proposed National Policy Statement for Highly Productive Land (NPS-HPL - MPI/MfE, 2018). The definition uses LUC classes 1, 2 and 3 to identify highly productive land. The rationale was to apply this combination of LUC classes to provide an indication of what the PLC would look like if based on the NPS-HPL. It should be noted that the use of LUC 1, 2 and 3 by the NPS-HPL is an interim measure until individual regions have developed their own region/district specific definition of highly productive land.

The NPS-HPL only focusses on highly productive land definition and does not separate productive land into classes. Highly productive land includes land that has a LUC class of 1, 2 or 3. The remaining land is by default not highly productive land and includes LUC classes 4, 5, 6, 7 and 8. A map of highly productive land based on the NPS-HPL definition is provided in Appendix 3. However, for the purposes of the PLC, the land that is not highly productive land can be delineated using LUC class into two land classes. **Three land classes** defined by LUC classes replace all climate qualities and land qualities. The rationale for the criteria for PLC Option 4 is summarised in **Table 27**.

Table 27. The rationale for the criteria value ranges for PLC Option 4.

Land Qualities	Reference	Comment
Highly productive land LUC classes 1, 2 and 3 (undifferentiated A, B and C PLC classes)	Lynn et al. (2009)	Highly productive land is defined by the NPS-HPL as LUC classes 1, 2 and 3.
Not highly productive land LUC class 4 (undifferentiated D and E PLC classes)	Lynn et al. (2009)	Land that is not Highly productive land is by default LUC class 4.
Not highly productive land LUC classes 5, 6, 7 and 8 (undifferentiated F and G PLC classes)	Lynn et al. (2009)	Land that is not Highly productive land is by default LUC classes 5, 6, 7 and 8.

The criteria and PLC class value ranges for Option 4 are shown in **Table 28**. The mapped classes for PLC Option 4 is shown **Figure 11**.

Table 28. Criteria and class value ranges for PLC Option 4.

PLC class	PLC classes identified	NPS-HPL class	Land Use Capability (LUC) Classification		Most productive land use suitability class
			LUC class	LUC general suitability	
A	Undifferentiated A, B and C	Highly productive land	1	Multiple use land	Horticulture
B1			1, 2		
B2			1, 2		
C			1,2 , 3		
D	Undifferentiated D and E	NOT highly productive land	1, 2, 3, 4		Cropping
E1			1, 2, 3, 4		
E2			1, 2, 3, 4		
F	Undifferentiated F and G		1, 2, 3, 4, 5, 6, 7	Pastoral grazing or forestry land	Extensive pastoral or production forestry
G			1, 2, 3, 4, 5, 6, 7		
H	H		1, 2, 3, 4, 5, 6, 7, 8	Conservation land	Non productive

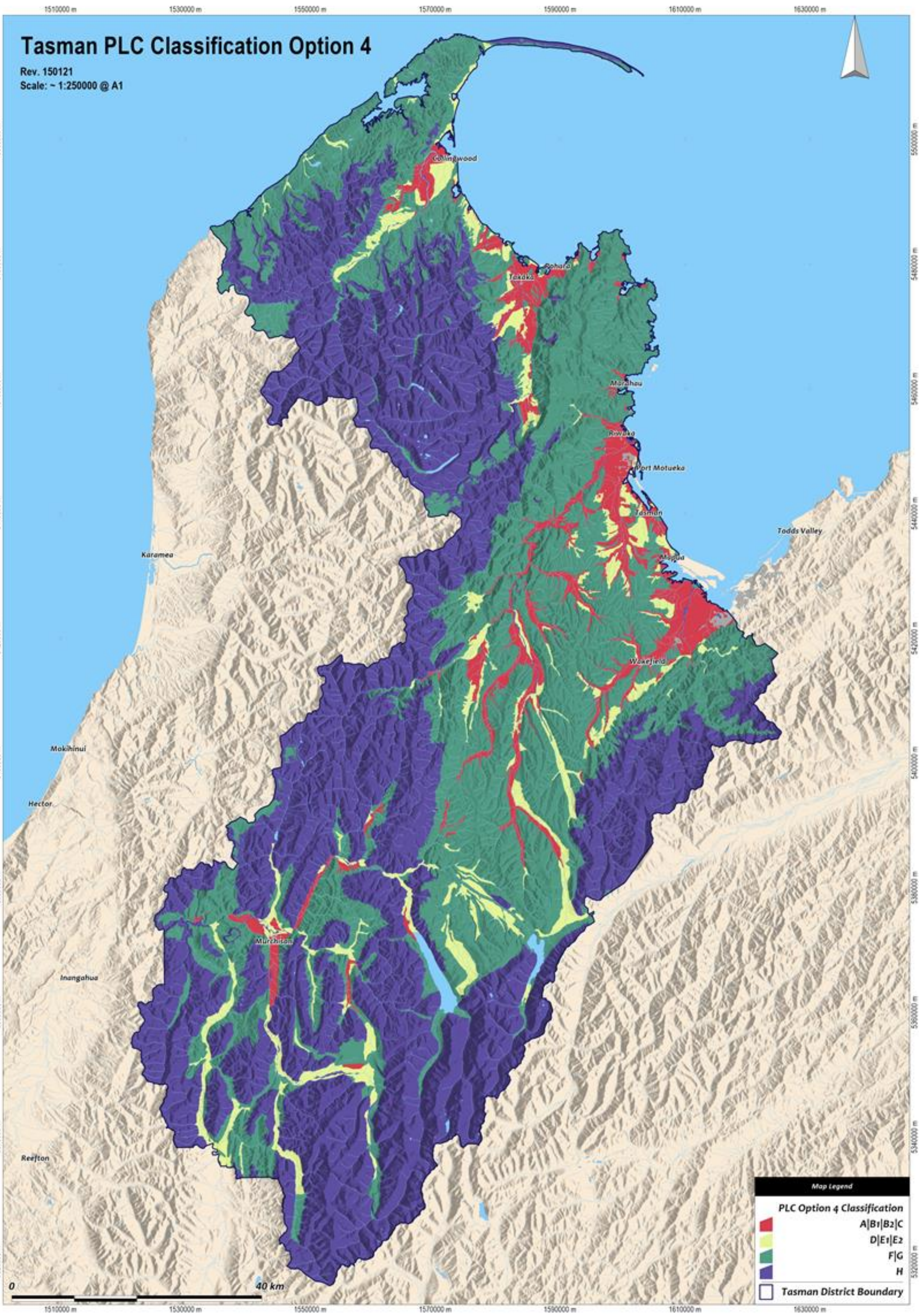


Figure 11. Map of classes for PLC Option 4.

9 Assessment of the revised PLC options

9.1 Introduction

This revision of the PLC was a desktop analysis and did not include in its scope the opportunity for fieldwork to confirm or validate if the land classes identified matched current land use on the ground or potential land use of the land.

To determine the most appropriate revised PLC option, two desktop techniques were used. These included testing the spatial alignment with the original PLC (ANZ, 1994) and with LCDB based land use class.

9.2 Comparison of the revised PLC and original PLC

A comparison of the spatial overlap of classes for each of the revised PLC options was compared against the original PLC classes. For each PLC option, the area percentage of each original PLC class (A to H) is presented for each of the productive revised PLC classes (**Figure 12**). This provides an indication of the spread of original PLC classes across the classes for each of the revised PLC options, as well as the proportion of original PLC classes within each class. The comparison can be used to assess the degree of fit of the PLC options with the original PLC, but (as with the original PLC classes) does not indicate whether the PLC classes are a correct representation of the actual PLC classes on the ground.

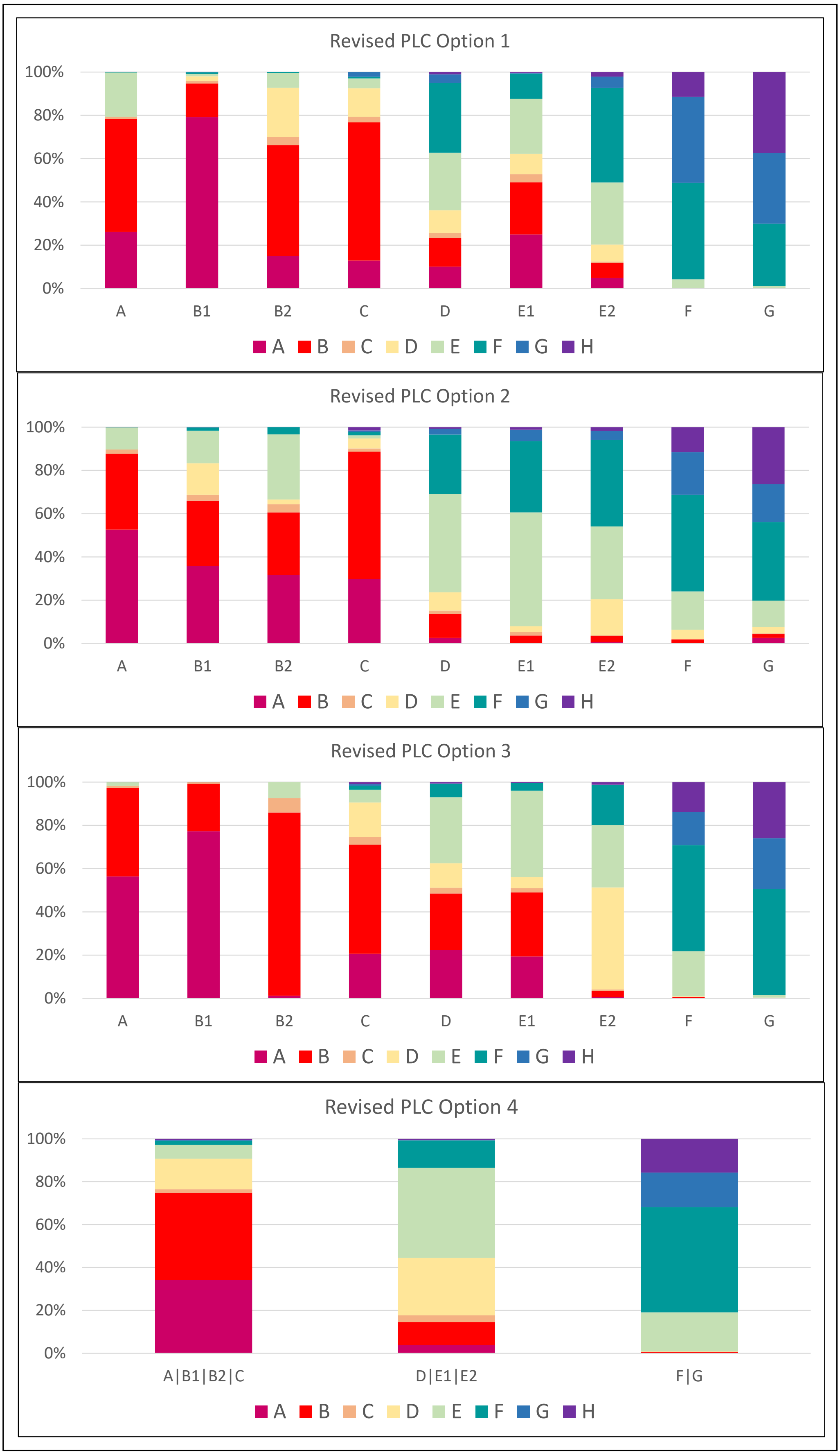


Figure 12. PLC class distribution for the revised PLC options compared against the original PLC classes. Note that the PLC class colours are as used for the PLC maps.

PLC Option 2 provided the best overall comparative fit with the original PLC classes, with the greatest overlap of PLC classes A, B and C. The next best fit was Option 3. Option 1 seemed to provide the least fit with the original PLC classes. Option 4 was difficult to interpret given the grouping of the revised PLC classes. However, the separation of the original classes seemed to be well represented. Some areas originally classed as A and B were classified as classes C, D and E using the revised PLC classes. This was less so for Option 2. Without ground truthing, it is difficult to assess whether this is misclassification (i.e. the revised PLC class incorrectly differs from the original (1994) PLC class and actual PLC class on the ground), or spatially improved criteria resulting from the refinement of slope using the blended DEM (i.e. the original (1994) PLC class was incorrect, and the revised PLC class correctly represents the PLC class on the ground).

9.3 Comparison of PLC classes and land use

To assess the best fit PLC option, the PLC classes for each option were spatially compared with the general estimated long term or "stable" land use classes (horticulture, cropping, intensive pasture, extensive pasture and production forestry) provided by Landcover Database version 5.0 (LCDB v5.0). For a land use class to be considered stable, the land area was required to remain in the same land cover class for at least two LCDB time steps; LCDB v5.0 provides corrections to all time steps 1997/97, 2001/02, 2008/09, 2012/13 and 2018/19. For each PLC option, the area percentage of land use for the productive PLC classes (A to G) is presented (**Figure 13**). This provides an indication of the spread of land uses across classes, as well as the proportion of each land use within a class.

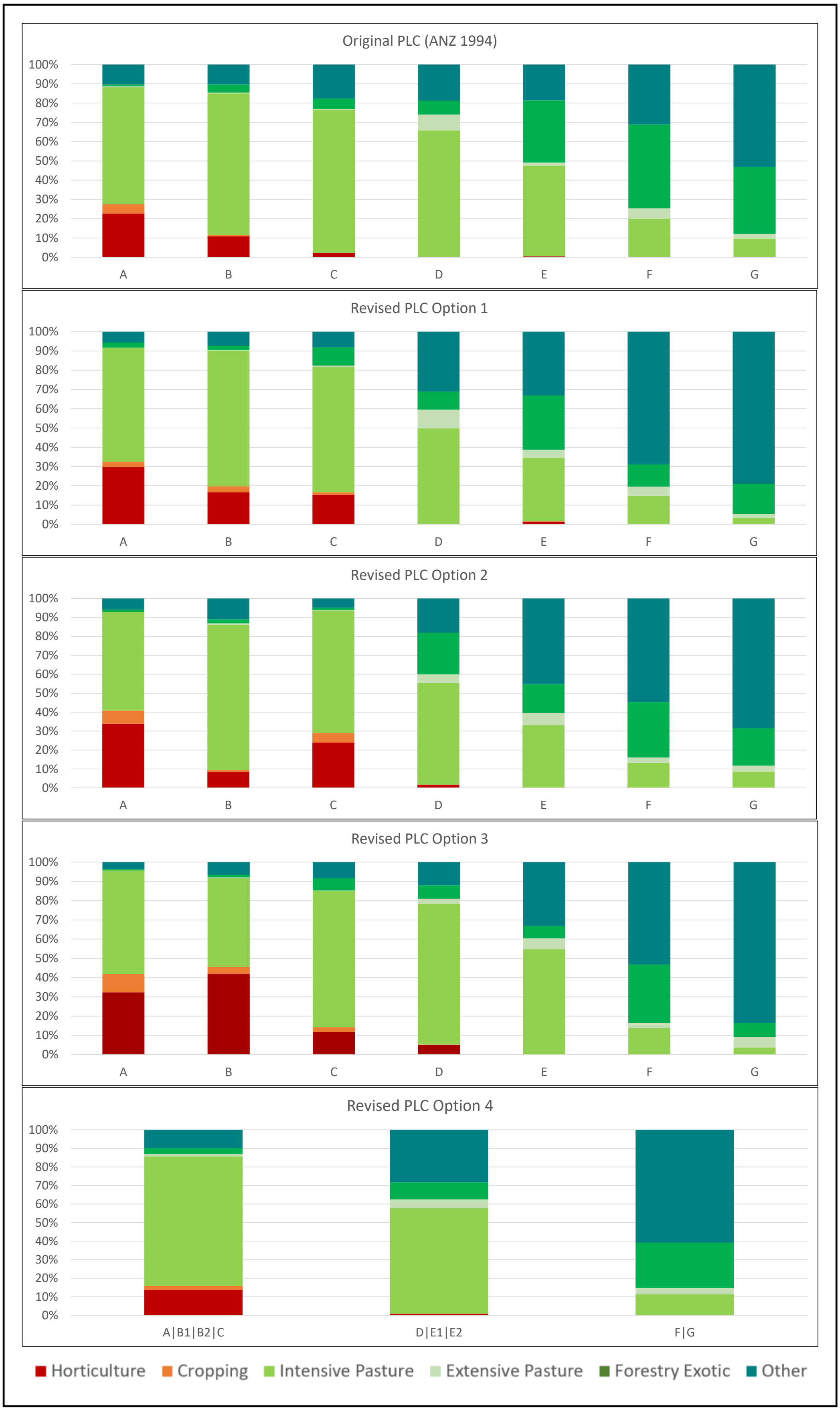


Figure 13. Productive PLC class distribution for the revised PLC options compared against LCDB derived land use classes.

PLC Option 2 provided the best overall comparative fit with the LCDB derived land uses, with PLC classes A, B and C capturing most of the horticulture and cropping land, and providing the best capture compared to other PLC options. The next best fit was Option 3, which also captured all horticulture and cropping land across PLC classes A to D. Option 1 had some horticulture in PLC class D and had the greatest capture of extensive pasture in PLC class D. PLC Option 4 (based on the NPS-HPL) provided good capture of horticulture and cropping land in its PLC class A|B1|B2|C, and other land uses were distributed logically across the other two PLC class.

9.4 A preferred option for the revised PLC

The factors considered for determining a preferred option for the revised PLC included:

1. Alignment with the ANZ (1994) PLC classes (Figure 12),
2. the degree of spatial alignment of PLC classes with the LCDB derived land use (Figure 13), and
3. the overall balance and distribution of the resulting PLC classes for each option (PLC maps).

Of the three factors, The greatest emphasis is placed on factors 2 and 3, with less emphasis on factor 1. The reason for this is that although alignment with the ANZ (1994) PLC classes does assist with a transition from the original PLC to the revised PLC, there is an underlying assumption that the original PLC classes are correct, which may not always be true given the broader scale of the data used and qualitative nature of the criteria for the original PLC. Emphasis should also be on the representation of PLC classes A. B and C, as these represent the land with the highest productive value.

Overall, Option 2 provided the most balanced representation of the PLC classes. The comparison with the original PLC classes (see Figure 12) indicated that Option 2 PLC classes A, B and C captured the greatest proportion of classes a, B and C in the original PLC, when compared to the other PLC options. The comparison with LCDB derived land use (see Figure 13), indicated that PLC Option 2 classes A, B and C captured most of the horticulture and cropping land, with a small proportion in PLC class D. A visual assessment of the revised PLC option maps indicated that Option 2 provided the most balanced distribution of the classes. In comparison, PLC Option 1 looked to over represent PLC class E2, and PLC Option 3 looked to over represent PLC class F. PLC Option 4 (based on the NPS-HPL) compared well against the original PLC classes, and proved good capture of horticulture and cropping land uses in the PLC class A|B1|B2|C. The main limitation of this PLC option is the lack of separation across PLC classes.

10 Limitations and advantages

10.1 PLC options

PLC Option 2 seemed to provide the best overall option for a revised PLC. In general, PLC classes aligned well with land uses and the original PLC. It is difficult to assess if any misalignment was a factor of misclassification or improved data and spatial resolution of climate and land qualities based on the blended DEM. The capture of viticulture land presents a challenge given this land does not necessarily need to have characteristics that are “highly productive” when compared with other horticulture and intensive cropping. However, separation and capture of this land in PLC Class C does at least clearly identify potential land for viticulture.

10.2 Data quality and availability

The range of climate and land qualities was generally well served by the data available. The available data allowed the inclusion of a sufficient range of climate and land qualities for revising the PLC, possibly with the exception of wind data. An obvious improvement was that data were not “locally” modified or adjusted, which improved classification transparency and repeatability. However, the inability to locally improve the data also meant that the PLC was limited by the accuracy (quality) and scale of the available data. Even for a regional scale classification, some data was still only available at a scale that was coarser than required for a regional classification such as the revised PLC (≤ 1:50,000 scale). The increasing availability of finer resolution DEM related data is seen as an important component of the revised PLC, primarily with regard to improving the spatial placement of both climate and land qualities. There is an opportunity to improve the DEM further once full LiDAR coverage is available for the Tasman District. New, finer scale soil map information also likely improved the placement of land qualities, especially for soil related qualities such as soil profile drainage, potential rooting depth and profile readily available water. The greatest limitation was in bringing together the multiple sources of data, especially the soil map information which has a high reliance on the FSL attributes and map units (polygons).

10.3 PLC matrix approach

The matrix approach used for the revised PLC was as used for the original PLC, in that land areas were assigned a PLC class based on meeting all of the climate and land quality criteria for that class. For the ten PLC classes (A to H, including two sub-classes for B and E) the value ranges for at least one climate or land quality had to differ to ensure land could be classified in the subsequent PLC class. This meant that for the revised PLC, a sufficient number of climate and land qualities needed to be used to ensure that PLC classes could be differentiated. This difficulty was increased where the separation between classes was reliant on coarse scale data, or value ranges were broad and poorly defined.

10.4 Repeatability and revision

All data used in the revised PLC has been used in its original form, or there are clear processes for deriving the data layers (captured in the GIS SQL scripts).

The majority of climate and land qualities used in the revised PLC align with those that could clearly be interpreted in the original PLC or the review provided by Webb et al. (2011). This serves two main purposes. Firstly, it provides continuity transitioning from the original PLC to a revised PLC. Secondly, there is some robustness and objectivity provided to justify the selected climate and land qualities and the value ranges selected.

The geospatial processes used for the revised PLC were all scripted which provides the “metadata” for repeating the classification, updating input data as it becomes, or refining value ranges for climate and land qualities. Examples of revision include incorporating improved LiDAR derived DEM slope and contour layers, incorporating new soil attributes and map information from Smap, and revising climate data based as future climate records and predictions become available. These are seen as important improvements compared with the original PLC.

11 Conclusions

- The currently available data is adequate to develop a revised PLC that is repeatable and is objectively based, and has improved spatial accuracy compare with the original PLC.
- The revised PLC is developed using data defined criteria, placing less reliance on the more

qualitatively defined criteria associated with the original PLC.

- The revised PLC outputs include GIS accessible layers for each of the climate and land qualities used in the PLC, which were not available for the original PLC.
- Compared with the original PLC, other improvements include the use of a blended DEM to spatially place climate and land qualities more accurately, improved soil map and attribute information, the use of clearly defined climate and land qualities, and transparent and repeatable processes for constructing the PLC.
- In general, the data available is adequate for the requirements of the PLC. However, partial finer scale soil map information, a complete high resolution DEM and coarse climate data are current limitations.
- Of the four PLC options presented, the favoured option for a revised PLC is PLC Option 2. This was based on the best overall placement of land uses into appropriate PLC classes, and the distribution of the PLC classes.
- Some classification limitations remain, mainly associated with the inherent quality and scale of the available data, and the classification matrix approach. However, the revised PLC does provide guidance for identifying land areas with high productive value at a district scale.
- PLC Option 4 (based on the NPS-HPL) compared well against the original PLC classes. The main limitation of the PLC Option 4 was the lack of separation across PLC classes.
- Compared with the PLC option based on the NPS-HPL (PLC Option 4), the PLC Options 1, 2 and 3 provided greater delineation of the PLC classes, allowing for better placement of land uses on suitable land.
- The GIS processes (including scripting) provide the metadata for process transparency and repeatability. Additionally, all components of the revised PLC can be updated or refined without the need to recreate the whole PLC.

12 Future revisions

Recommendations for future revisions of the PLC include:

- Replace the existing slope and contour data derived using the blended DEM with slope and contour data using a single DEM derived from the new LiDAR (once full LiDAR coverage is available for the Tasman District). This will improve the spatial placement of slope and altitude land qualities.
- Undertake a ground truthing of the revised PLC to test the validity of PLC classes relative to existing land use, and climate and land qualities and their value ranges. This information can be used to refine attribute criteria used in the PLC.
- Replace the existing mix of soil map information used in the revised PLC with Smap soil map information (once full coverage of Smap has been attained). This will improve the spatial placement of soil related attributes that inform the land qualities.
- Test the viability of replacing FSL soil attributes with Smap soil attributes.

13 References

Agriculture New Zealand. 1994. Classification system of productive land in Tasman District. Contract report prepared for Tasman District Council by Agriculture New Zealand, MAF, Richmond, Nelson.

Barringer JRF, Lynn IH, Basher LR, Medyckyj-Scott D. 2013. LUCCS Roadmap. Unpublished Landcare Research Internal Report.

Basher L, Barringer J, Lynn I. 2015. Update of the Erosion Susceptibility Classification (ESC) for the proposed NES for Plantation Forestry: Managing changes to the ESC and incorporating detailed mapping. MPI Technical Paper No: 2015/12. Prepared for the Ministry Primary Industries by Landcare Research. Ministry Primary Industries, Wellington.

Campbell IB. 2018. Soils of the Tasman District – Rural 3 and Coastal Tasman. Report prepared for Tasman District Council by Land & Soil Consultancy Services. Nelson. 13p.

Dominati EJ, Patterson MG, Mackay AD 2010. A framework for classifying and quantifying the natural capital and ecosystem services of soils. Ecological Economics 69: 1858–1868.

Kerr JP, Bussell W, Burnard S, Sale P, Todd J, Wilton J, Wood R. 1981. Matching horticultural crops and the climates of the lower North Island. DSIR Plant Physiology Division technical report 11. 52 p.

Lynn I, Manderson A, Page, M, Harmsworth G, Eyles G, Douglas G, Mackay A, Newsome P. 2009. Land Use Capability Survey Handbook – a New Zealand Handbook for the classification of land. 3rd edition. AgResearch, Landcare Research, GNS Science.

MPI/MfE. 2019. Valuing Highly Productive Land: a discussion document on a proposed national policy statement for highly productive land. Wellington, Ministry for Primary Industries & Ministry for the Environment.

Newsome PFJ, Wilde RH, Willoughby EJ. 2008. Land Resource Information System Spatial Data Layers Data Dictionary. Landcare Research New Zealand Ltd, Palmerston North.

Pearce P, Woolley J-M, Sood A. 2019. Climate change projections for Tasman and impacts on agricultural systems. Prepared for Tasman District Council/Envirolink. National Institute of Water & Atmospheric Research Ltd, Auckland.

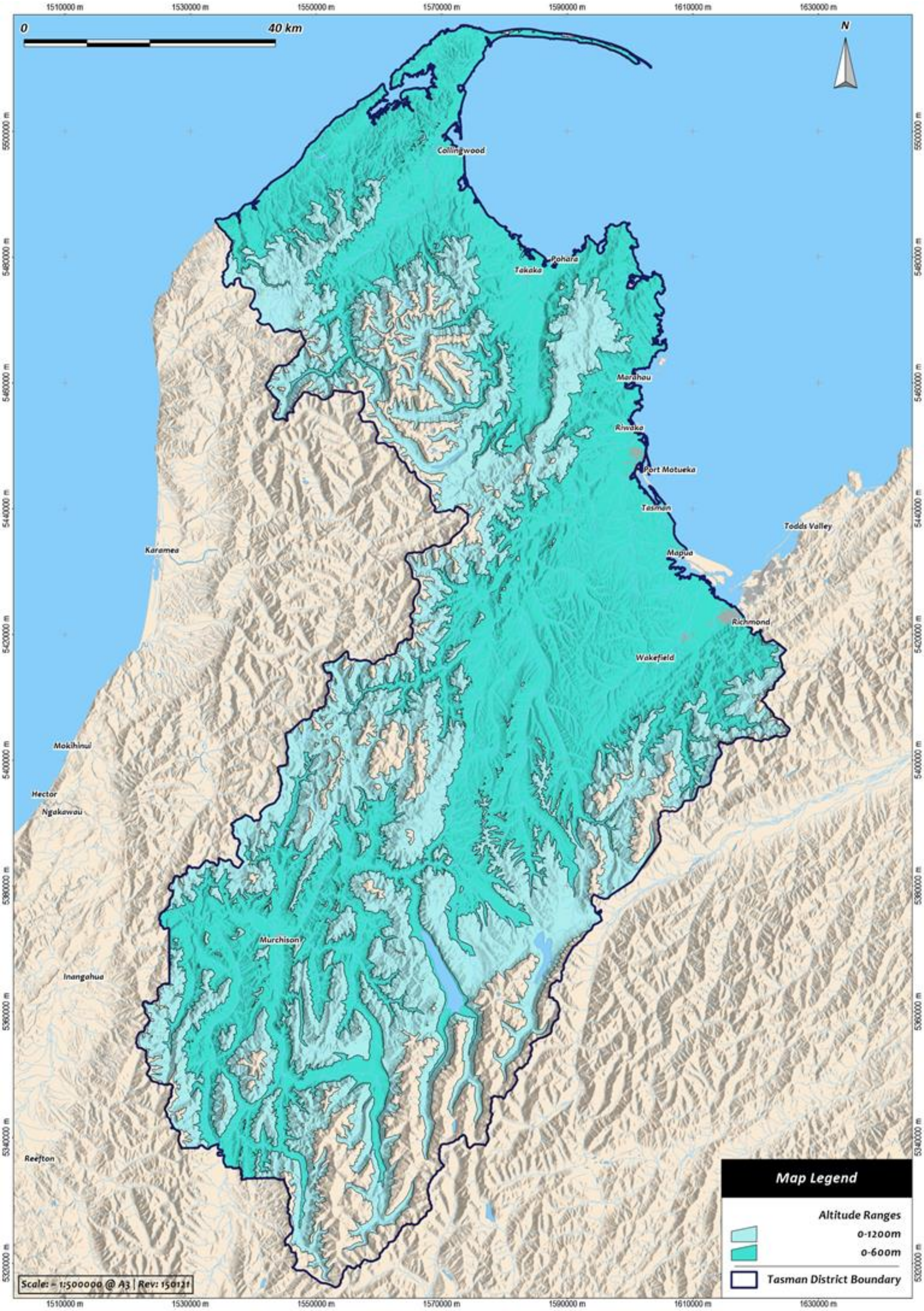
Van Berkel P. 1983. The South Island capability extended legend for the New Zealand Land Inventory. 2nd edn. Produced by Water and Soil Division, MWD for NWASCO.

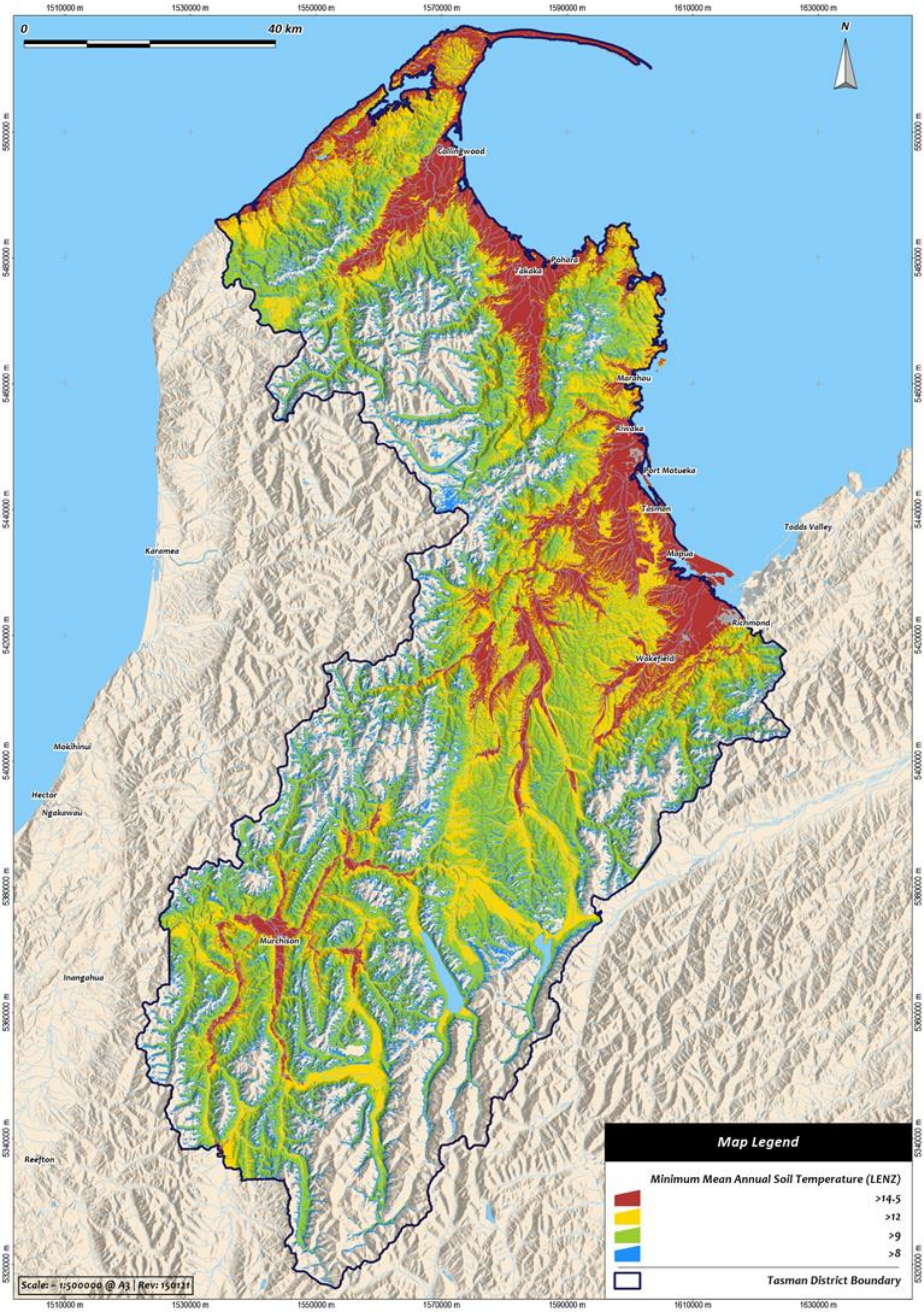
Webb TH, Wilson AD. 1994. Classification of land according to its versatility for orchard crop production. Manaaki Whenua Press. 31p.

Webb TH, Wilson AD. 1995: A manual of land characteristics for evaluation of rural land. Landcare Research Science Series 10. Lincoln, New Zealand, Manaaki Whenua Press. 32p.

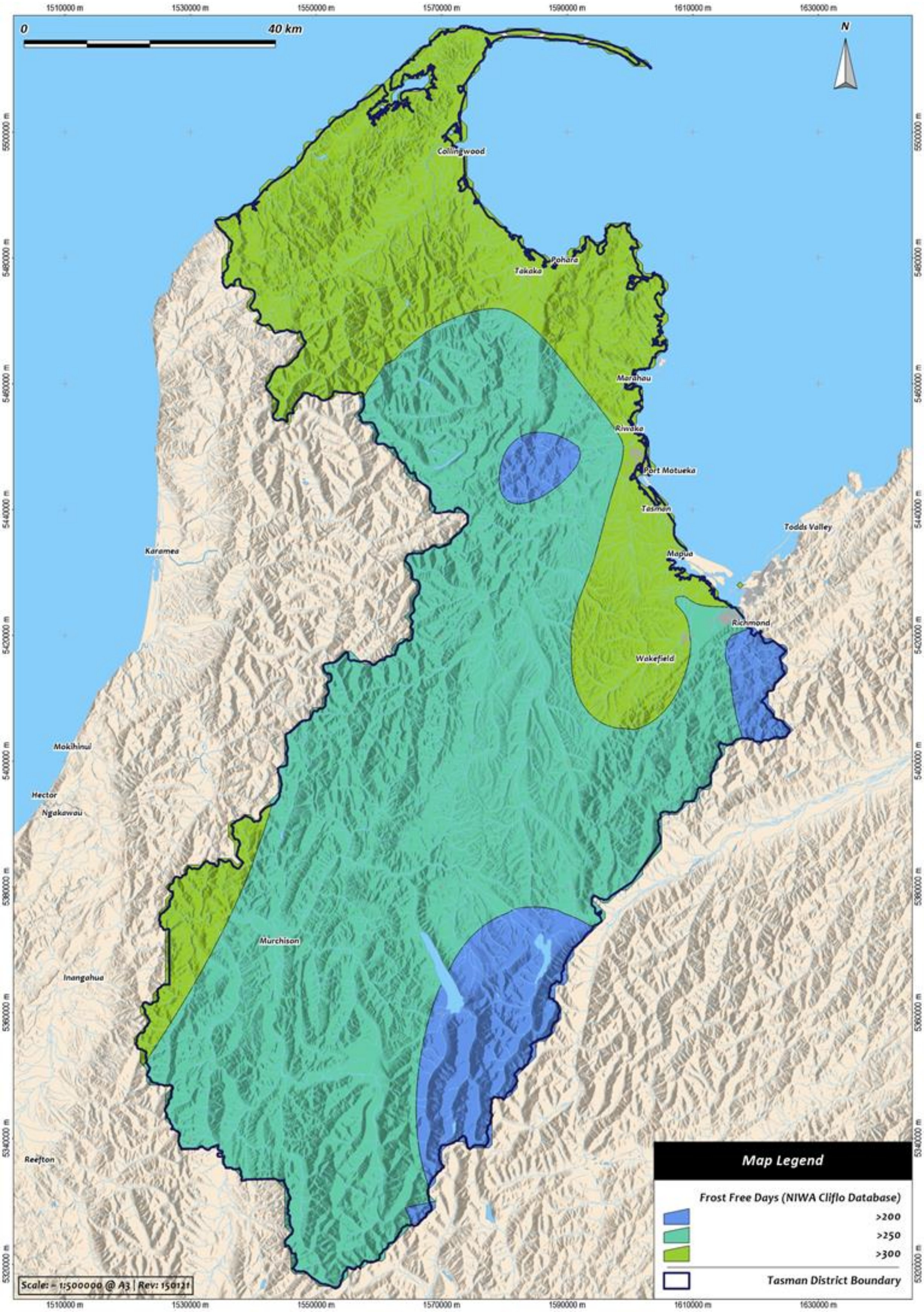
Webb TH, Barringer J, Basher L. 2011. Land versatility classification for Rural 3 Land in Tasman District. Envirolink 921-TSDC57. Landcare Research, Lincoln. 24p.

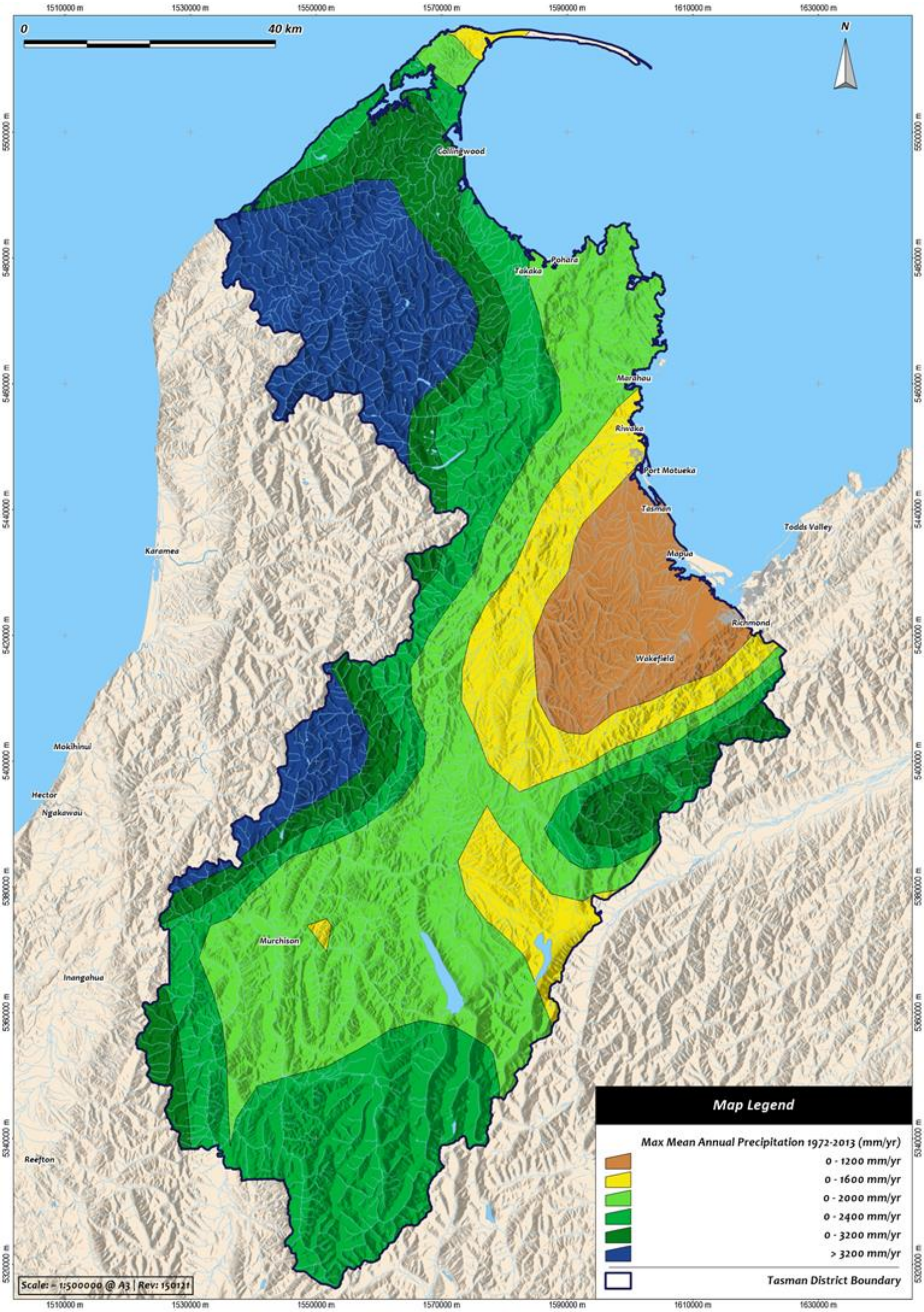
Appendix 1: Maps of the revised PLC Climate and Land qualities.

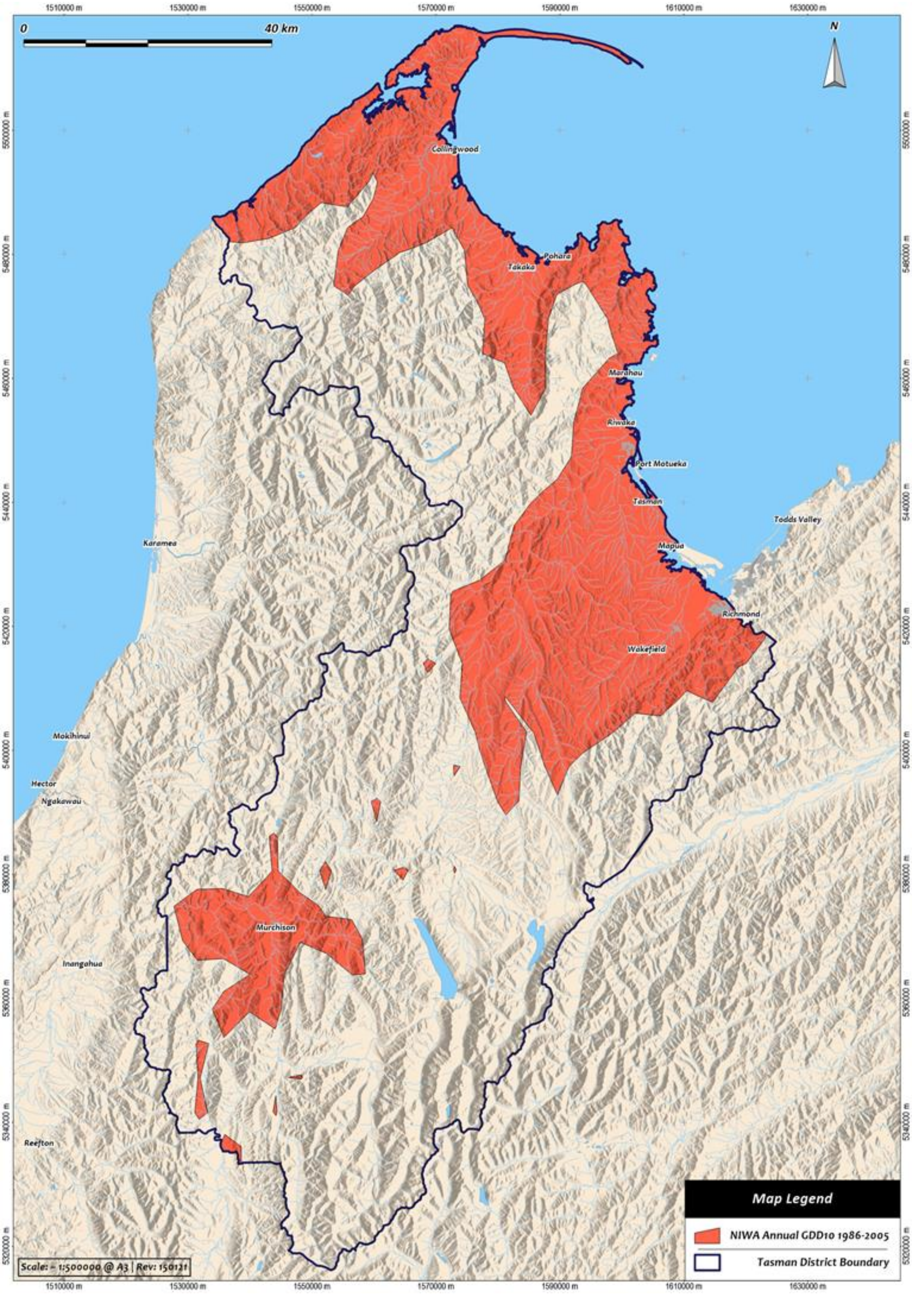




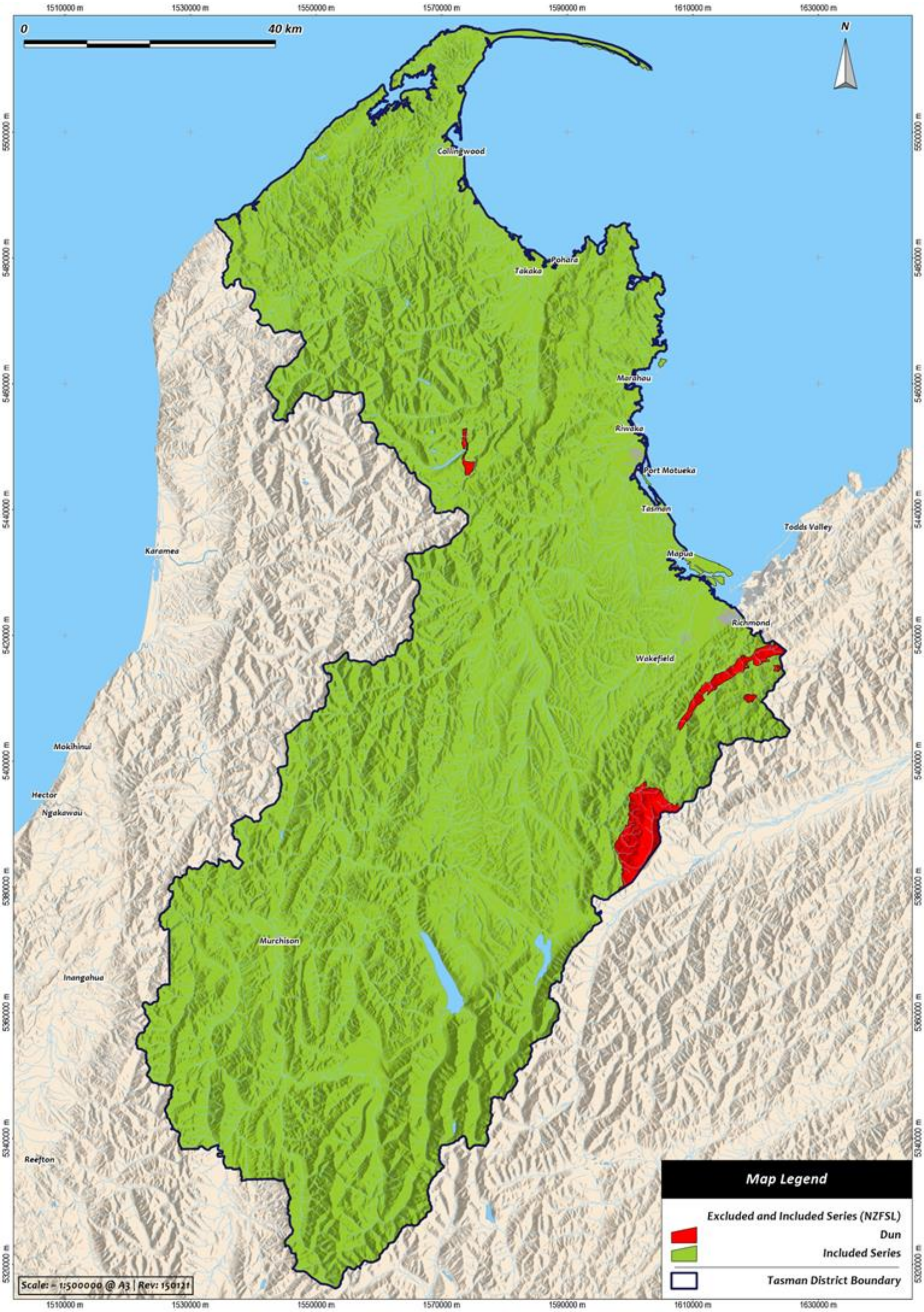
0
40 km
N
Collingwood
Takaka
Pohara
Marahau
Riwaka
Port Motueka
Tasman
Mapua
Richmond
Wakefield
Todds Valley
Karamea
Mokihinui
Hector
Ngakawau
Murchison
Inangahua
Reefton
Map Legend
Minimum Mean Annual Soil Temperature (LENZ)
>14.5
>12
>9
>8
Tasman District Boundary
Scale: ~ 1:500000 @ A3 | Rev: 150121

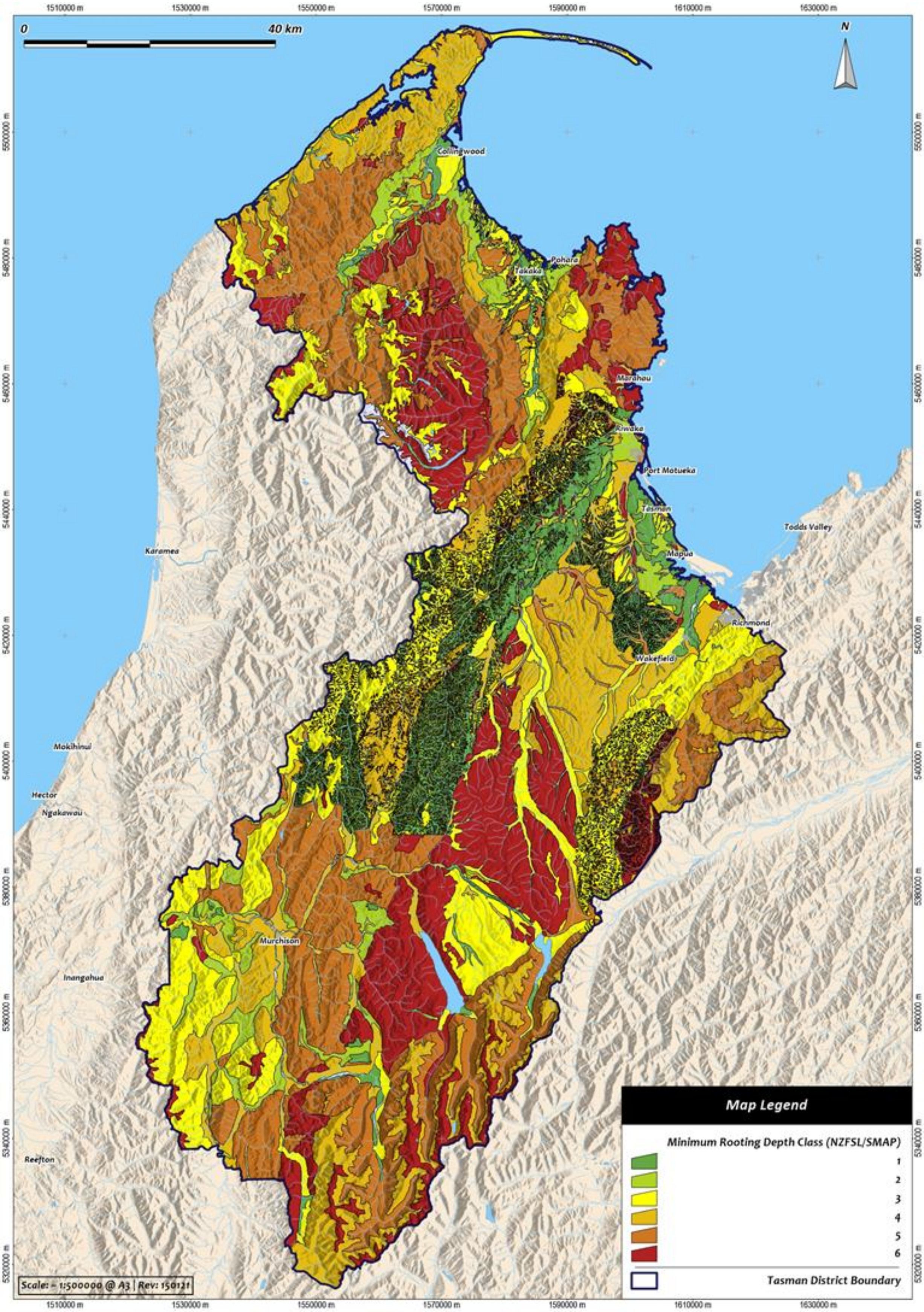

0
40 km
N
Collingwood
Pohara
Takaka
Marahau
Riwaka
Port Motueka
Tasman
Todds Valley
Karamea
Mapua
Richmond
Wakefield
Mokihinui
Hector
Ngakawau
Murchison
Inangahua
Reefton
Map Legend
Frost Free Days (NIWA Cliflo Database)
>200
>250
>300
Tasman District Boundary
Scale: ~ 1:500000 @ A3 | Rev: 150121

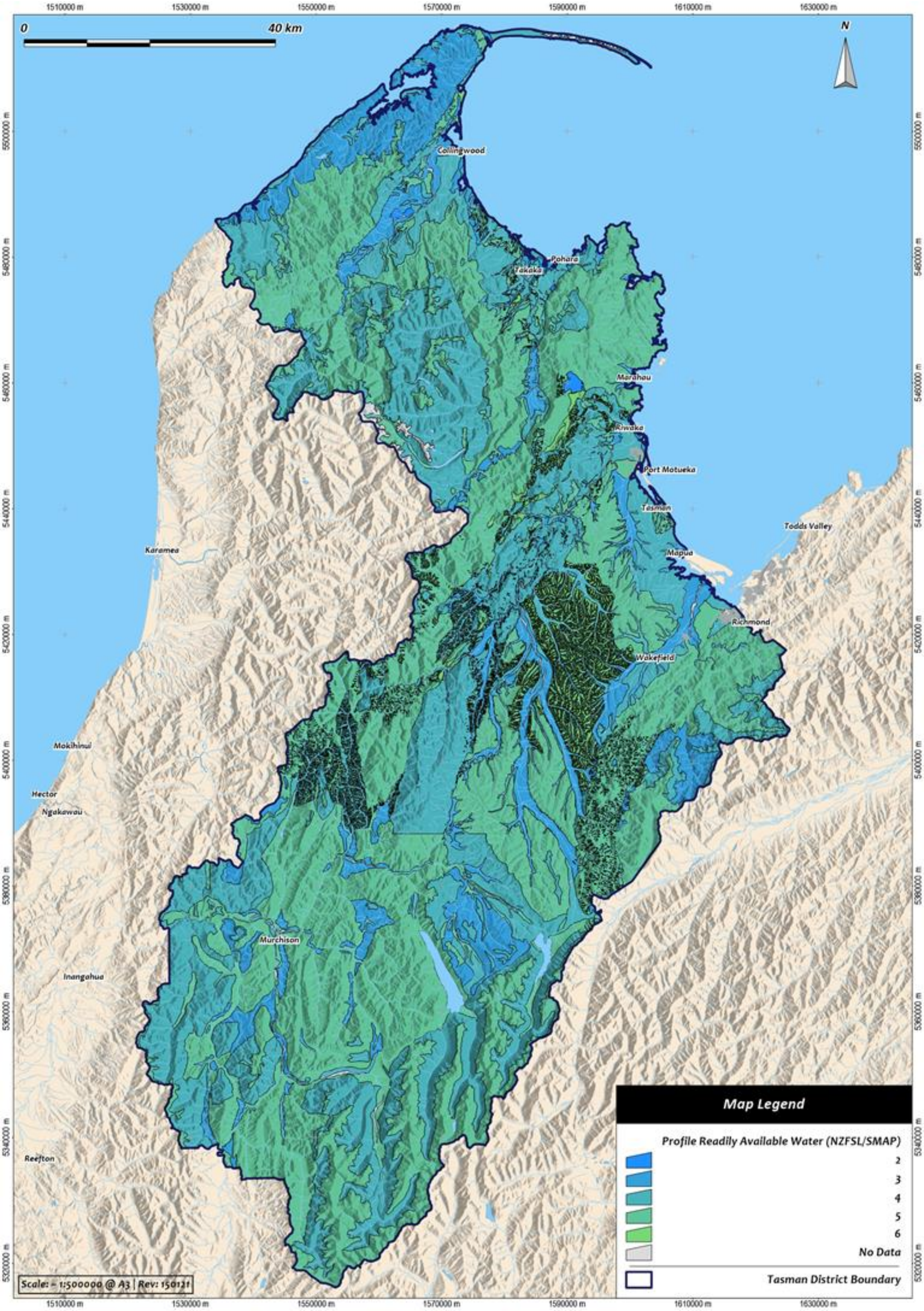

40 km
N
Collingwood
Pohara
Takaka
Marahau
Riwaka
Port Motueka
Tasman
Todds Valley
Mapua
Karamea
Richmond
Wakefield
Mokihinui
Hector
Ngakawau
Murchison
Inangahua
Reefton
Map Legend
Max Mean Annual Precipitation 1972-2013 (mm/yr)
0 - 1200 mm/yr
0 - 1600 mm/yr
0 - 2000 mm/yr
0 - 2400 mm/yr
0 - 3200 mm/yr
> 3200 mm/yr
Tasman District Boundary
Scale: ~ 1:500000 @ A3 | Rev: 150121



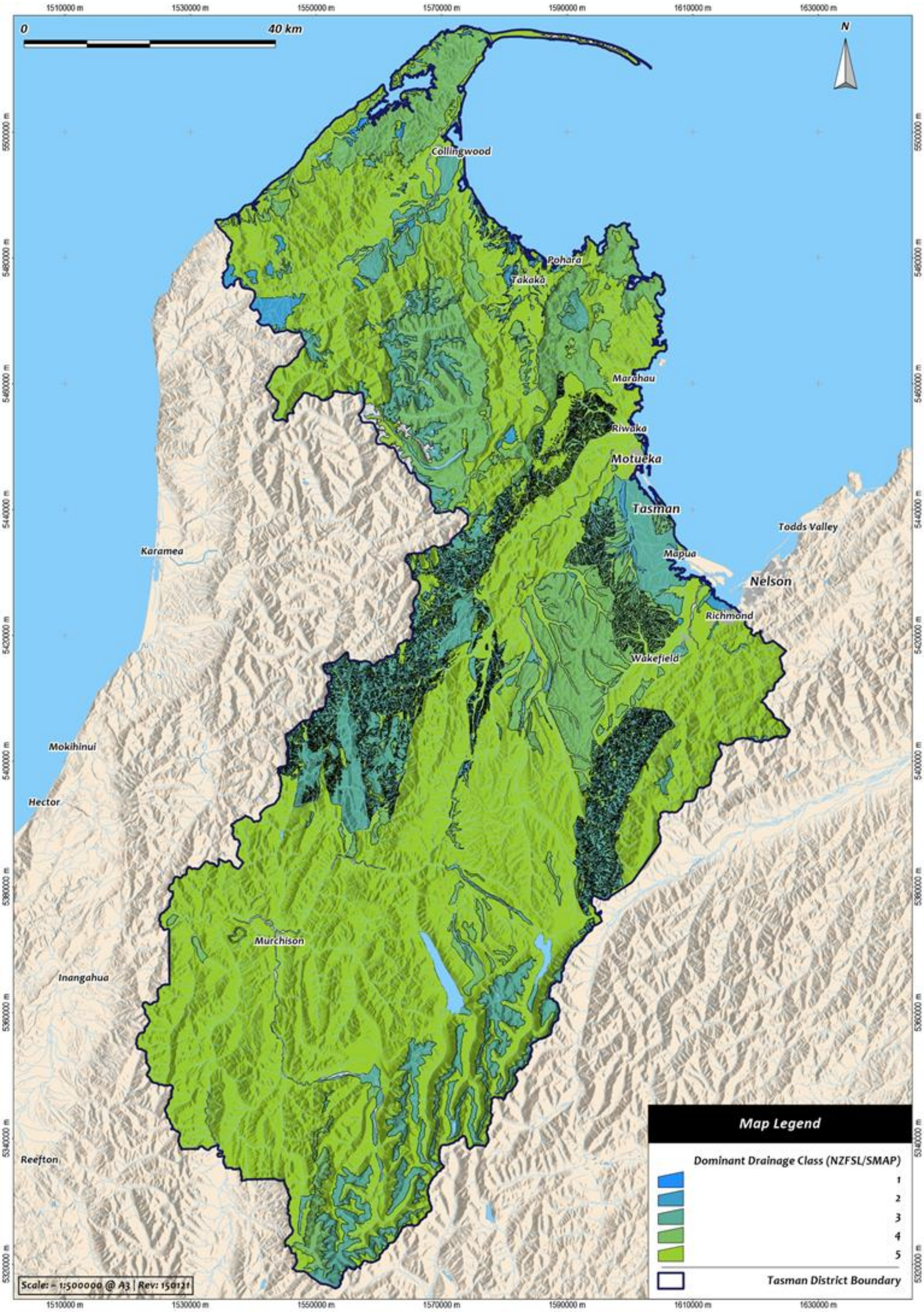
0
40 km
N
Collingwood
Takaka
Pohara
Marahau
Riwaka
Port Motueka
Tasman
Mapua
Richmond
Wakefield
Todds Valley
Karamea
Mokihinui
Hector
Ngakawau
Murchison
Inangahua
Reefton
Map Legend
NIWA Annual GDD10 1986-2005
Tasman District Boundary
Scale: ~ 1:500000 @ A3 | Rev: 150121


1510000 m
1530000 m
1550000 m
1570000 m
1590000 m
1610000 m
1630000 m
0
40 km
N
Collingwood
Takaka
Pohara
Marahau
Riwaka
Port Motueka
Tasman
Todds Valley
Karamea
Mapua
Richmond
Wakefield
Mokihinui
Hector
Ngakawau
Murchison
Inangahua
Reefton
Map Legend
Excluded and Included Series (NZFSL)
Dun
Included Series
Tasman District Boundary
Scale: ~ 1:500000 @ A3 | Rev: 150121

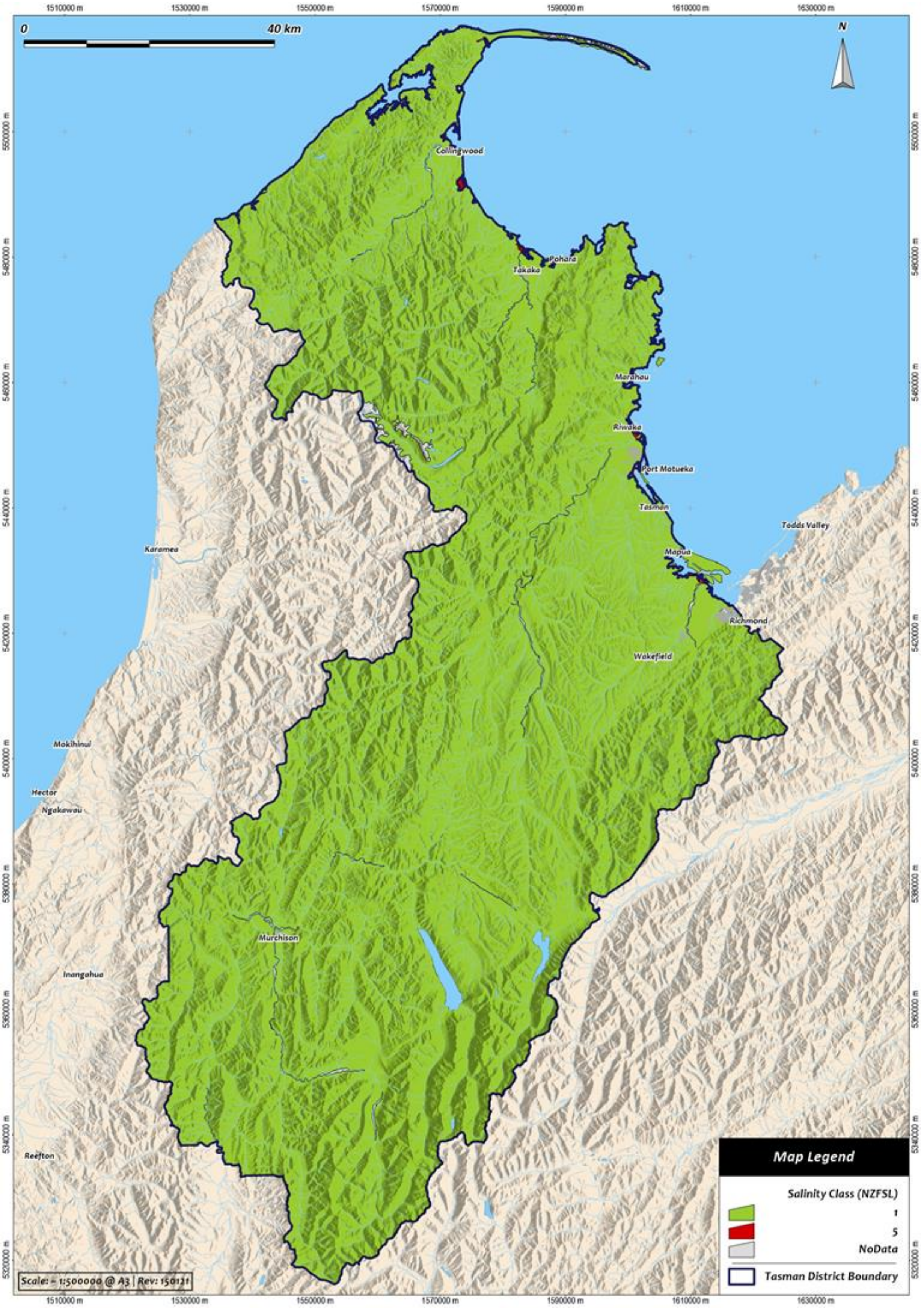

0
40 km
N
Collingwood
Takaka
Pohara
Marahau
Riwaka
Port Motueka
Tasman
Mapua
Richmond
Wakefield
Todds Valley
Karamea
Mokihinui
Hector
Ngakawau
Murchison
Inangahua
Reefton
Scale: ~ 1:500000 @ A3 | Rev: 150121
Map Legend
Minimum Rooting Depth Class (NZFSL/SMAP)
1
2
3
4
5
6
Tasman District Boundary



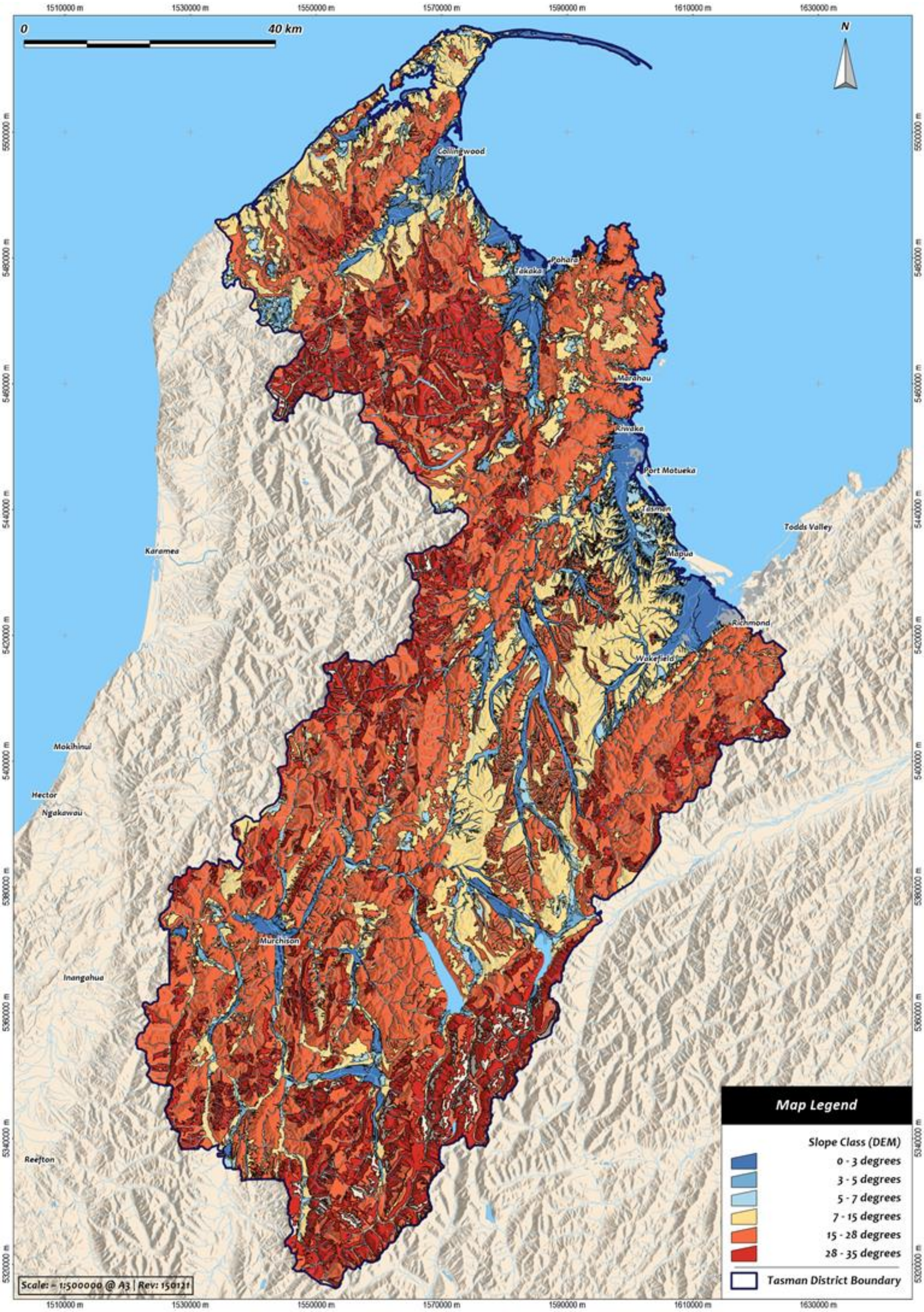
0
40 km
N
Collingwood
Pohara
Takaka
Marahau
Riwaka
Port Motueka
Tasman
Todds Valley
Karamea
Mapua
Richmond
Wakefield
Mokihinui
Hector
Ngakawau
Murchison
Inangahua
Reefton
Map Legend
Profile Readily Available Water (NZFSL/SMAP)
2
3
4
5
6
No Data
Tasman District Boundary
Scale: ~ 1:500000 @ A3 | Rev: 150121



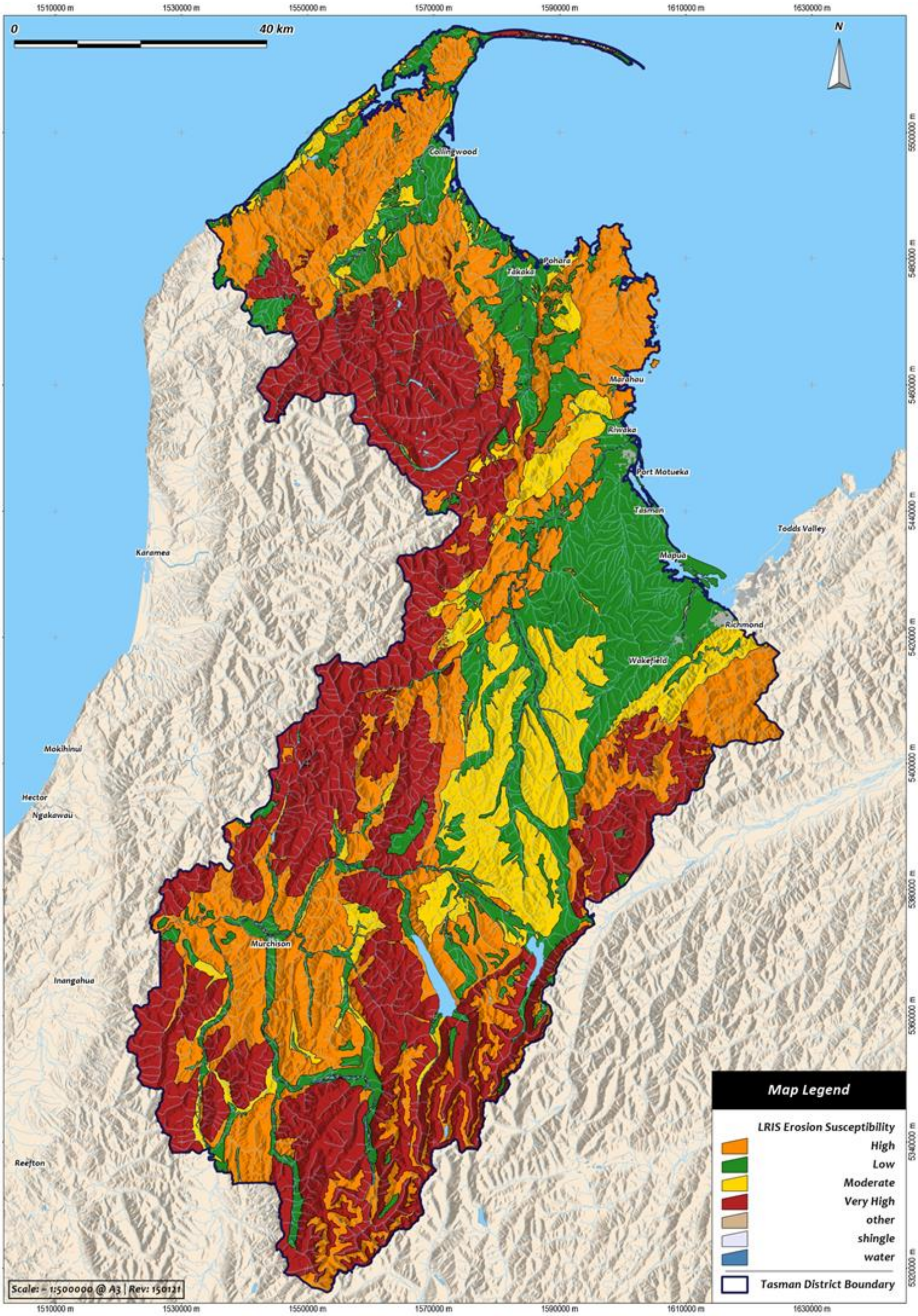
0
40 km
N
Collingwood
Pohara
Takaka
Marahau
Riwaka
Motueka
Tasman
Todds Valley
Karamea
Mapua
Nelson
Richmond
Wakefield
Mokihinui
Hector
Murchison
Inangahua
Reefton
Map Legend
Dominant Drainage Class (NZFSL/SMAP)
1
2
3
4
5
Tasman District Boundary
Scale: ~ 1:500000 @ A3 | Rev: 150121

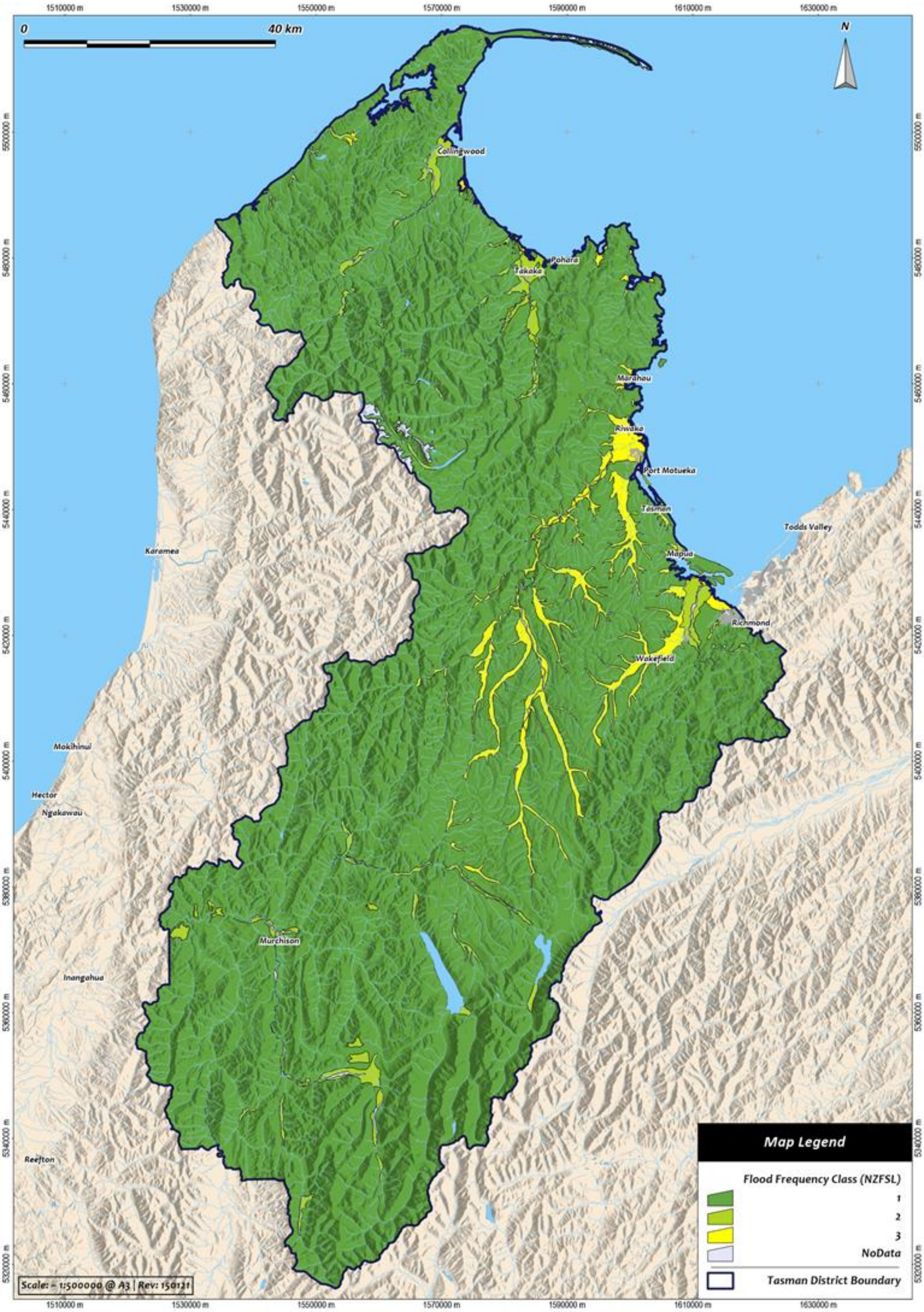


0
40 km
N
1510000 m
1530000 m
1550000 m
1570000 m
1590000 m
1610000 m
1630000 m
5500000 m
5480000 m
5460000 m
5440000 m
5420000 m
5400000 m
5380000 m
5360000 m
5340000 m
5320000 m
Collingwood
Takaka
Pohara
Marahau
Riwaka
Port Motueka
Tasman
Todds Valley
Mapua
Karamea
Richmond
Wakefield
Mokihinui
Hector
Ngakawau
Murchison
Inangahua
Reefton
Map Legend
Salinity Class (NZFSL)
1
5
NoData
Tasman District Boundary
Scale: ~ 1:500000 @ A3 | Rev: 150121

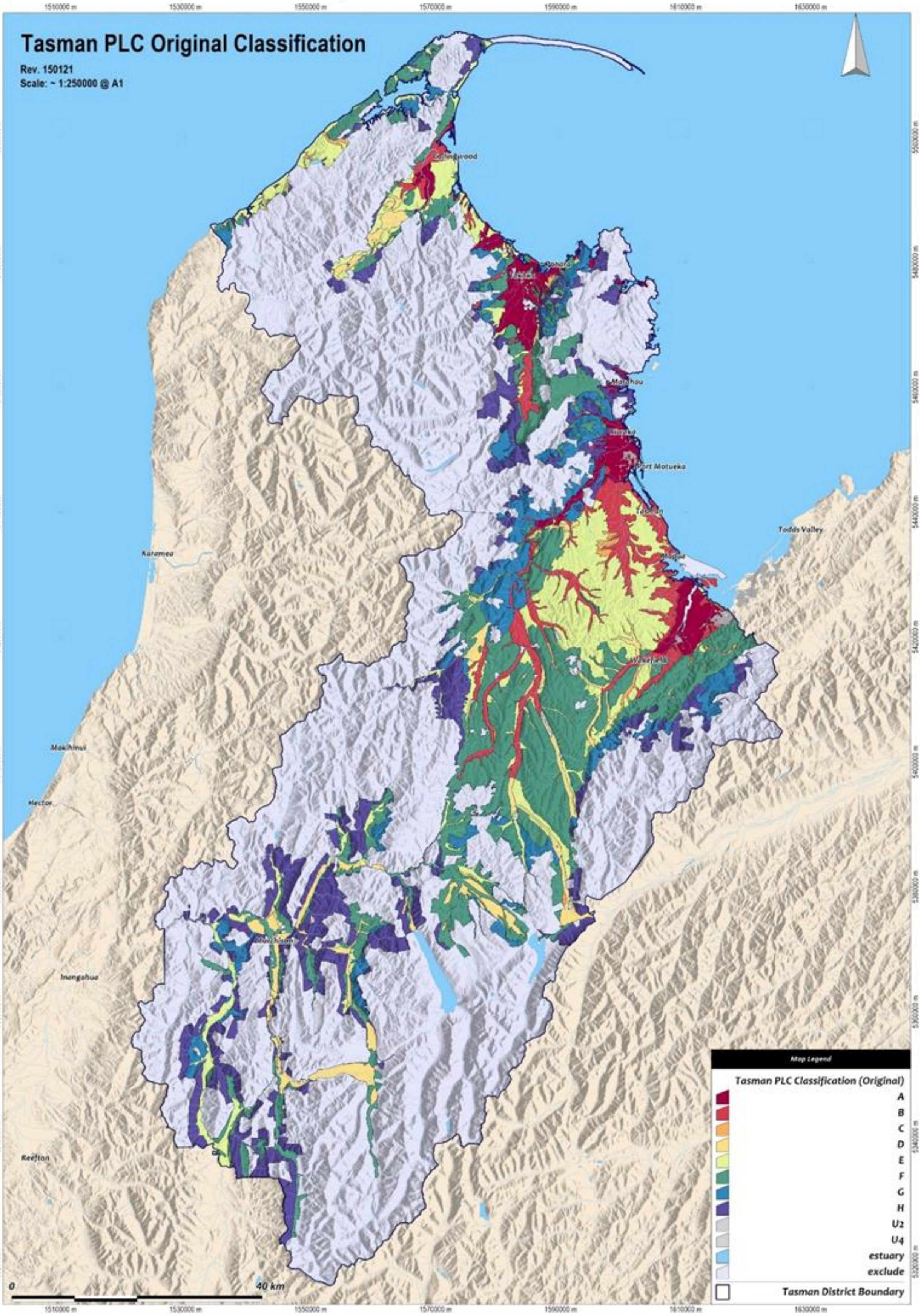


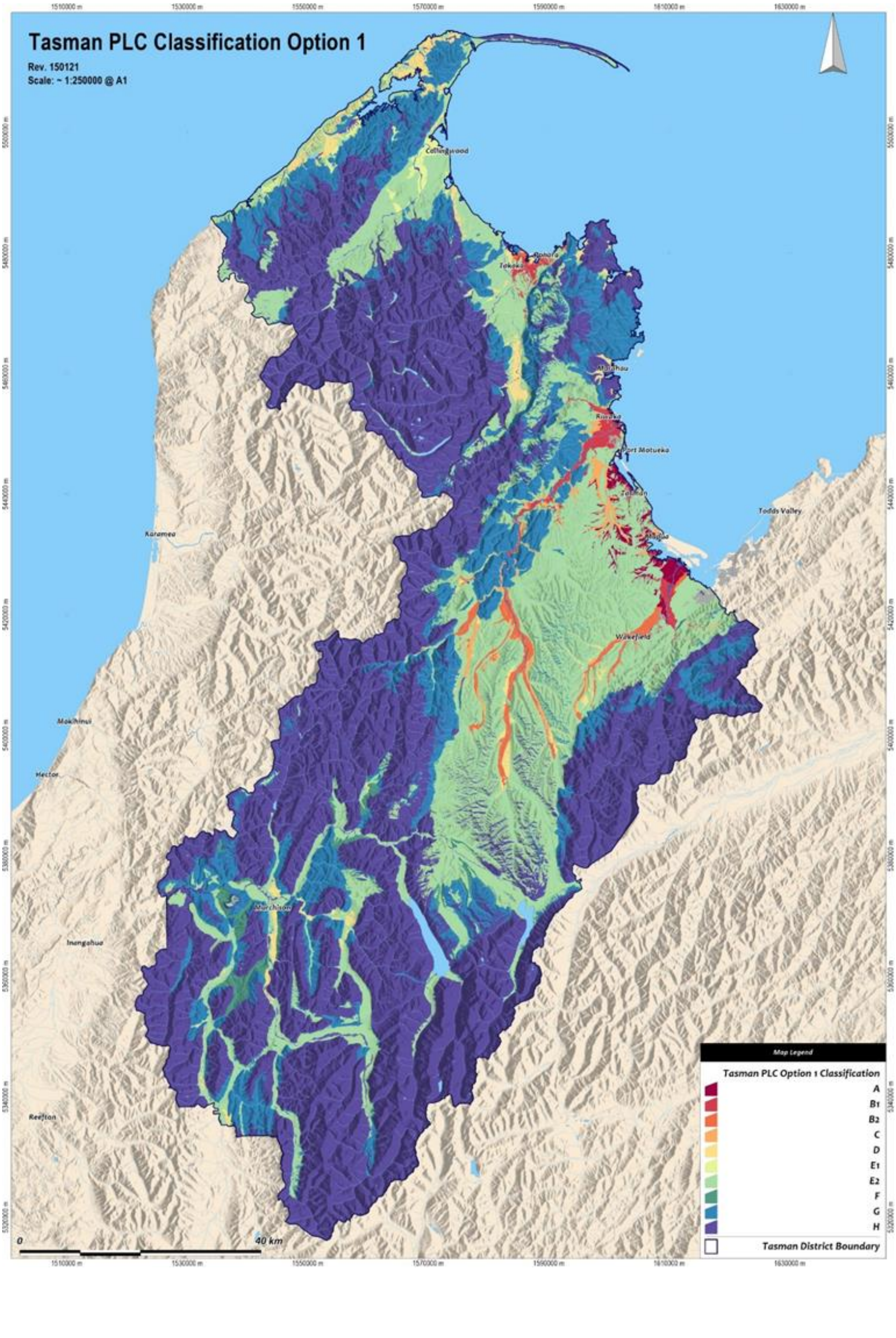
1510000 m
1530000 m
1550000 m
1570000 m
1590000 m
1610000 m
1630000 m
0
40 km
N
Collingwood
Pohara
Takaka
Marahau
Riwaka
Port Motueka
Tasman
Todds Valley
Karamea
Mapua
Richmond
Wakefield
Mokihinui
Hector
Ngakawau
Murchison
Inangahua
Reefton
Scale: ~ 1:500000 @ A3 | Rev: 150121
Map Legend
Slope Class (DEM)
0 - 3 degrees
3 - 5 degrees
5 - 7 degrees
7 - 15 degrees
15 - 28 degrees
28 - 35 degrees
Tasman District Boundary


1510000 m
1530000 m
1550000 m
1570000 m
1590000 m
1610000 m
1630000 m
0
40 km
N
Collingwood
Takaka
Pohara
Marahau
Riwaka
Port Motueka
Tasman
Mapua
Richmond
Wakefield
Todds Valley
Karamea
Mokihinui
Hector
Ngakawau
Murchison
Inangahua
Reefton
Map Legend
LRIS Erosion Susceptibility
High
Low
Moderate
Very High
other
shingle
water
Tasman District Boundary
Scale: ~ 1:500000 @ A3 | Rev: 150121

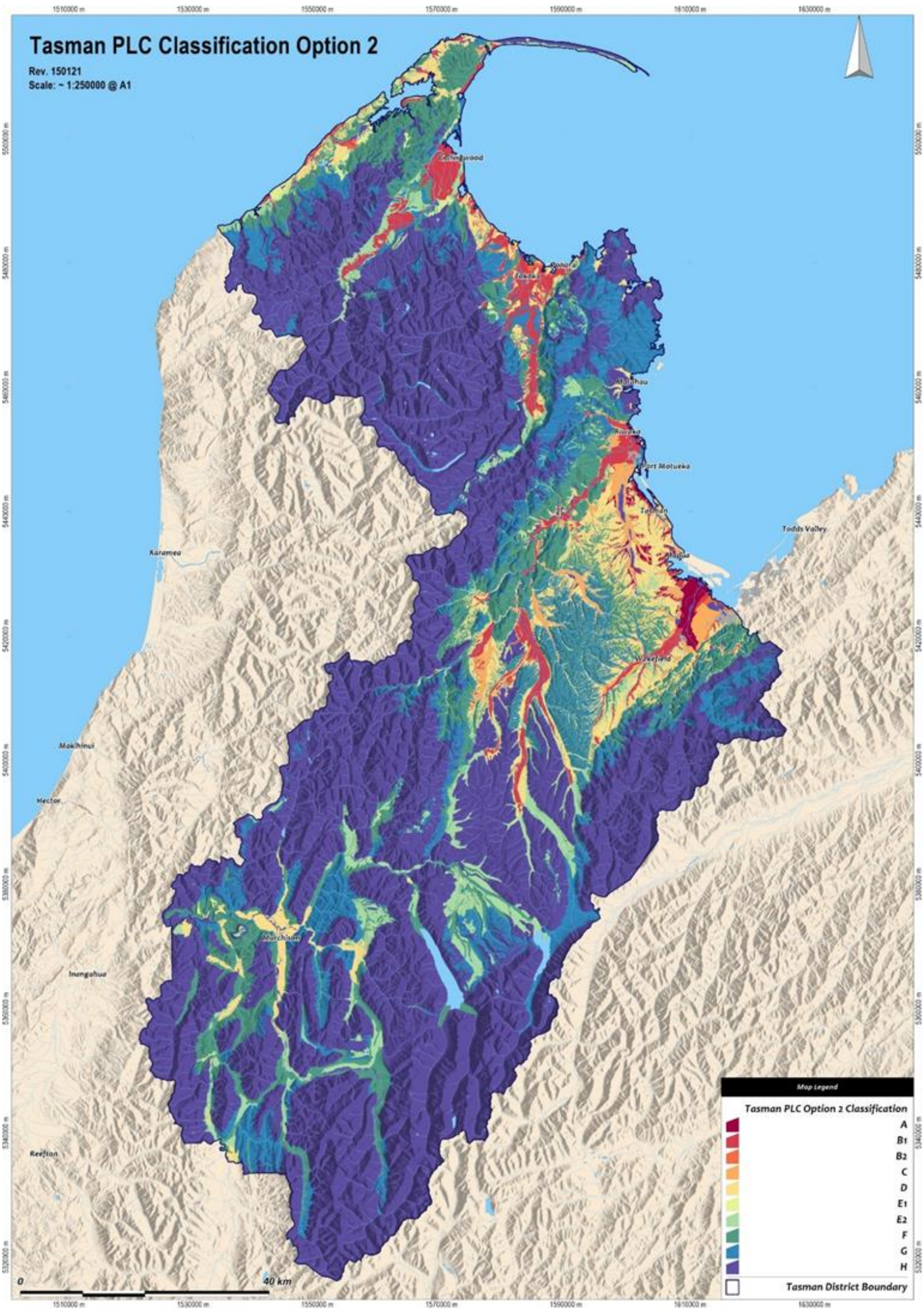

0
40 km
N
Collingwood
Takaka
Pohara
Marahau
Riwaka
Port Motueka
Tasman
Mapua
Richmond
Wakefield
Todds Valley
Karamea
Mokihinui
Hector
Ngakawau
Murchison
Inangahua
Reefton
Map Legend
Flood Frequency Class (NZFSL)
1
2
3
NoData
Tasman District Boundary
Scale: ~ 1:500000 @ A3 | Rev: 150121

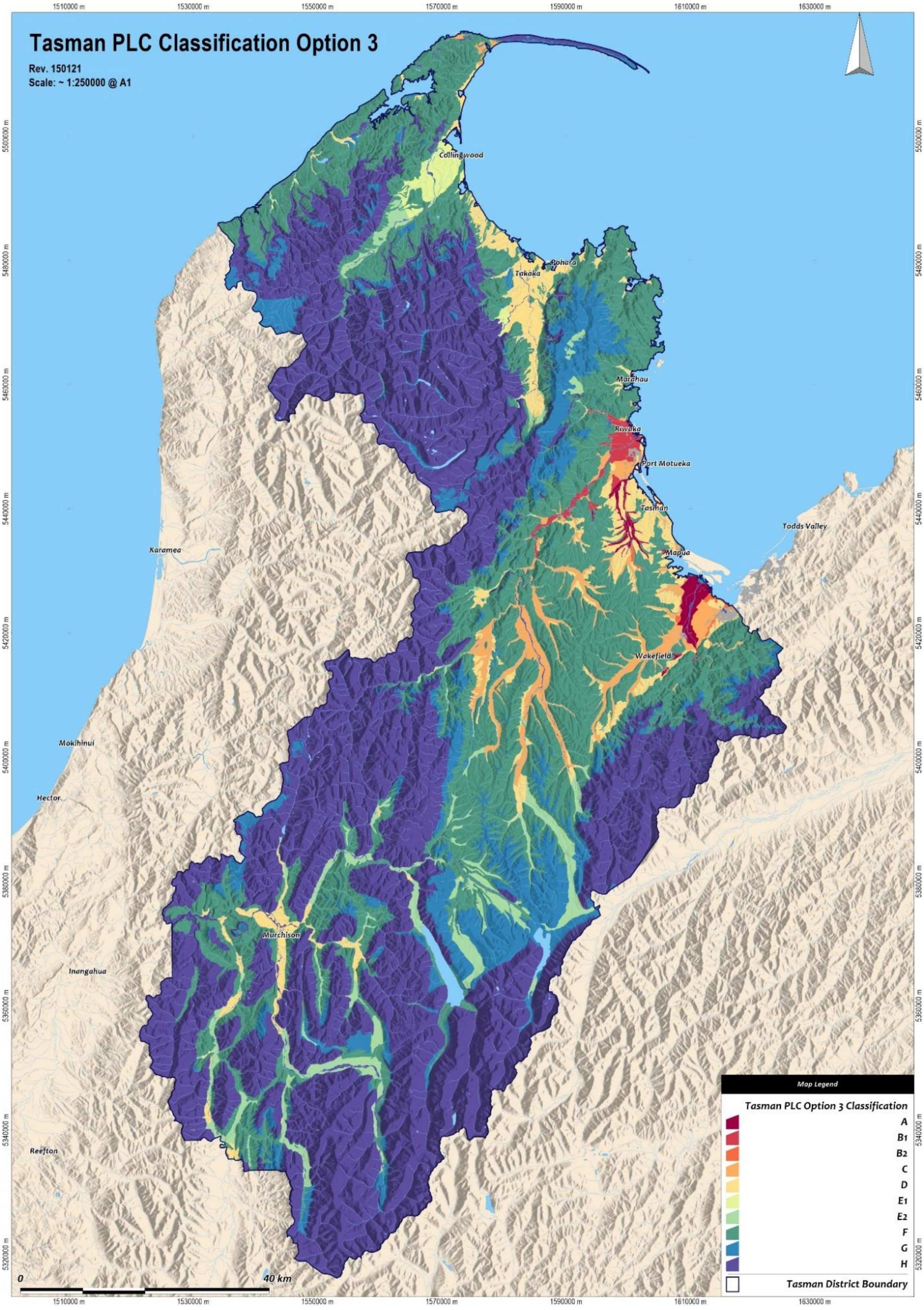
Appendix 2: Maps of the original PLC and revised PLC options.



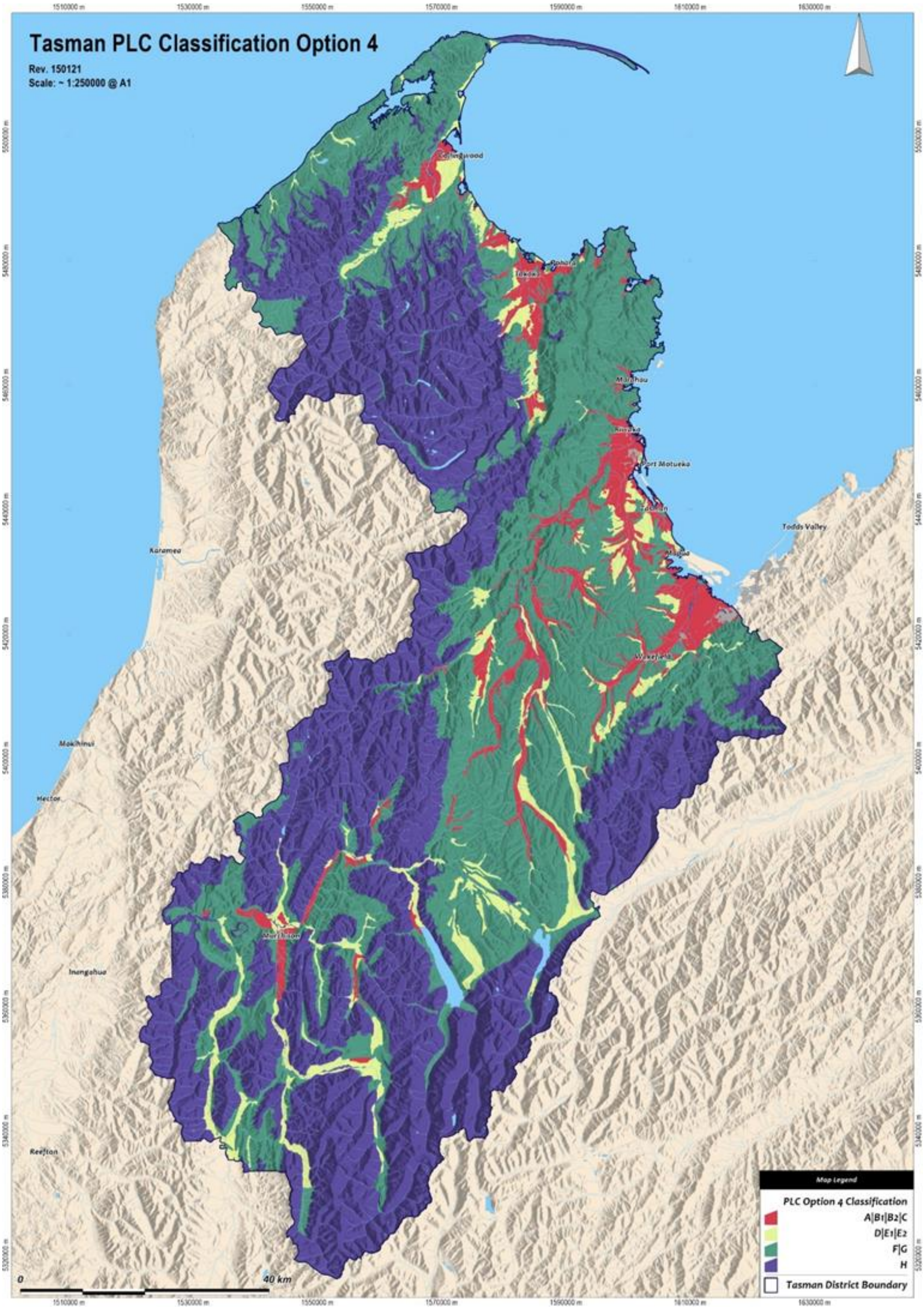


Tasman PLC Classification Option 1
Rev. 150121
Scale: ~ 1:250000 @ A1
Collingwood
Takaka
Port Motueka
Todds Valley
Karamea
Wakefield
Mokihinui
Hector
Murchison
Inangahua
Reefton
0
40 km
Map Legend
Tasman PLC Option 1 Classification
A
B1
B2
C
D
E1
E2
F
G
H
Tasman District Boundary


Tasman PLC Classification Option 2
Rev. 150121
Scale: ~ 1:250000 @ A1
1510000 m
1530000 m
1550000 m
1570000 m
1590000 m
1610000 m
1630000 m
Collingwood
Takaka
Pohara
Port Motueka
Wakefield
Karamea
Todds Valley
Mokihinui
Hector
Murchison
Inangahua
Reefton
0
40 km
Map Legend
Tasman PLC Option 2 Classification
A
B1
B2
C
D
E1
E2
F
G
H
Tasman District Boundary



Tasman PLC Classification Option 3
Rev. 150121
Scale: ~ 1:250000 @ A1
Collingwood
Pohara
Takaka
Marahau
Riwaka
Port Motueka
Tasman
Todds Valley
Mapua
Karamea
Wakefield
Mokihinui
Hector
Murchison
Inangahua
Reefton
0
40 km
Map Legend
Tasman PLC Option 3 Classification
A
B1
B2
C
D
E1
E2
F
G
H
Tasman District Boundary


Tasman PLC Classification Option 4
Rev. 150121
Scale: ~ 1:250000 @ A1
Karamea
Todds Valley
Mokihinui
Hector
Inangahua
Reefton
Map Legend
PLC Option 4 Classification
A|B1|B2|C
D|E1|E2
F|G
H
Tasman District Boundary
0
40 km

Appendix 3: Map of Highly Productive Land based on NPS-HPL criteria