Methodology for GIS-based Land Use Maps for Southland

Technical Report

August 2016

Lisa Pearson, Soil and Freshwater Scientist,
and Matt Couldrey, Scientific Officer, Geospatial Specialist

Publication No 2016-10

Document Quality Control

Environment Southland Division:	Environmental Information		
Report reference:	Title: Methodology for GIS-Based Land Use Maps for Southland		No: 2016-10
Prepared by:	Dr. Lisa Pearson, Soil and Freshwater Scientist Matt Couldrey, Scientific Officer – Geospatial Specialist		
Reviewed by:	Version 1: Daniel Rutledge, Andrew Manderson, Linda Lilburne, Anne-Gaelle Asseil, Stella Belliss and Robbie Price. Landcare Research Contract Report LC2491. Version 2: Nick Ward – Marine and Freshwater Team Leader, Environment Southland Emma Moran – Senior Policy Analyst/Economist, Environment Southland		
Approved for issue by:	Graham Sevicke-Jones, Director Science and Information		
Date issued:	31 August 2016	Project Code:	4065.1452

Document History

Version: 2	**Status:** Final
Date: August 2016	**Doc ID:**

Cover photo acknowledgement: Lisa Pearson and Michael Killick

Executive Summary

Current geographical information system (GIS)-based land use maps are an essential requirement for understanding and modelling the effects of land use on water quality. The National Policy Statement for Freshwater Management (NPS-FM) Science Programme and the Southland Economic Project are building understanding to inform the setting of catchment limits for water quality in Southland. The maps and datasets behind them will have multiple roles within Environment Southland; primarily to inform catchment contaminant loss and load calculations, and regional economic impact assessments of policy options to meet policy targets. This capability includes tracing forward linkages – from water bodies up the transport pathways for contaminants to the land and its use, and through to the economy; as well as tracing backward linkages – from the economy to land use and the land, down the contaminant transport pathways to the water bodies. This technical report details the background and methodology for the development of GIS-based Land Use Maps for Southland.

Due to the varying requirements within Environment Southland, GIS layers have been produced at various scales, levels of detail, and time periods. The Southland Land Use Map provides a land use classification for each property in Southland (property scale) including hectares of land cover (pastoral, cropping, forestry and wetlands). The Southland Land Use Map has been constructed using a modified version of Agribase™ (externally collected survey information from thousands of Southland land owners) and Land Cover Database (LCDB version 4.1), Protected Areas Network (PAN-NZ 2014), Environment Southland's Resource Consent database, and input from primary industries. This layer can be used to answer "how many properties…?" or "how many hectares…?" type questions about land use in Southland.

From the Southland Land Use Map, a Technical version was developed which combines physical attributes (topography, rainfall, and soil drainage), land cover and winter forage crop areas with the land use information for the property; as well as Freshwater Management Units (FMU) and Southland's Physiographic zones. The technical map is required to answer more specific questions about hectares within a land use, slope class, rainfall zone, and soil drainage range in addition to management zones of FMU or Physiographic Unit.

In addition, Historic land use maps have been developed for the 20 year period between 1996 and 2015, which correspond to LCDB imagery dates. The land use methodology and classification has been refined to fit what is achievable through the data sources available (LCDB v4.1, Department of Conservation Estate, QEII National Trust covenants, and ES dairy layers). A 2015 version has also been created using this method for comparison with the more detailed property land use map.

An earlier version of this document was reviewed by Landcare Research and recommendations have been adopted regarding data sources and mapping methodologies. Environment Southland has the capability to update the map using the current methodology on a six-monthly basis.

Table of Contents

List of Figures

List of Tables

1. Introduction

Land use can be defined as the activity or activities for which land is used, and the same land can support multiple uses (Rutledge et al., 2009). Land use identifies the purpose for what the land is committed; which includes production of goods (such as crops, timber, animal products) and services (such as recreation, public services and natural resources protection). It differs from land cover, which describes the physical state of the land (vegetation type, soils, exposed rocks, water bodies) (Lesslie, 2004). In many classifications, land cover is treated as a *de facto* land use class. Land use statistics provide information on the function and purpose for which land is currently used and, if tracked over time, how land use changes (Young 1998).

Appropriate land use information requires consideration of three interrelated aspects or dimensions: information, space, and time (Rutledge et al., 2009). Environment Southland requires current spatial land use information, particularly for the agricultural and forestry sectors by property, at a minimum. However, as land use information is useful for general business across the council, this project develops a methodology for mapping land use, both urban and rural, in combination with land cover, to provide a resource to inform, monitor, and allow reporting on land use and change across the Southland region. Monitoring current state and trends in land use in Southland enables the Council and public to understand the extent and rate of land use change; thus providing a platform to draw linkages between the state and response of other interlinked resources, such as soils and fresh water. Furthermore, it provides a baseline with which to measure future changes against and support the management of the regions natural resources.

1.1. Environment Southland Science Programme and Southland Economic Project

The National Policy Statement for Freshwater Management (NPS-FM) Science Programme and the Southland Economic Project are developing tools to build understanding to inform the setting of catchment limits for water quality in Southland. This capability includes forward linkages – from water bodies up the transport pathways for contaminants to the land and its use, and through to the economy; as well as backward linkages – from the economy to land use and the land, down the contaminant transport pathways to the water bodies.

In Southland, policy processes to set limits for fresh water are planned to start from 2016 within 'Water and Land 2020 & Beyond'. In preparation, industry groups have been working with Environment Southland, to understand the agriculture sectors use of fresh water, particularly in terms of nutrient losses (nitrogen and phosphorus, modelled using OVERSEER® Nutrient Budgets, version 6.2) and management. Nutrient modelling and economic modelling is an essential part of the limit setting process as limits will need to be obtainable within realistic timeframes. The land use map becomes the key point of integration between the Science Programme and the Economic Project to ensure consistency of information used within Environment Southland.

1.2. Project Description and Objectives

This project has been developed following on from a detailed study of 'Land use change in the Southland region' by Ledgard (2013a). Ledgard (2013a) covered the time period 1860 to 2011, but was limited by a lack of spatial information for the region. Therefore, this project aims to develop the spatial capability to record land use information in Southland and is being developed under the 'Land Use Inputs' theme of the NPS-FM Science Programme. The project is necessary to inform the two other themes, 'Fluxes and Flows' and 'Ecosystem Response'. This project is also linked to the Southland Economic Project, which is assessing the economic impact of policy options and requires current spatial land use information.

The primary objective of this project, within the NPS-FM Science Programme, is to spatially represent land use in Southland to inform catchment nutrient loss and load calculations and assess how loads to receiving environments have changed over time and will change into the future. To achieve this objective the project will be undertaken in two stages.

Stage one is to develop a methodology for current land use mapping, which can be used to inform on the following:

- Land use of a property (activity, farm type or purpose)
- Land cover within a property (indication of intensity, range of activities occurring)
- Effective (productive) areas of a property for intensity and contaminant loss estimations
- Winter grazing areas (a critical source of contaminants)
- Bio-physical properties within land uses (topography, climate, soil drainage)
- Areas under irrigation for water quantity resource management
- Assess potential changes in policy on the region
- Assess the effectiveness of the 'Southland Water and Land Plan'

The land use map needs to have the ability to report using different units of analysis:

- number of properties
- hectares of a land use or land cover
- industry group
- activity within a land use

The land use map also has to be able to be used at different scales:

- Southland region
- Freshwater Management Unit (FMU)
- Physiographic Unit
- Lake or River catchment
- Capture zone of a monitoring site
- Property
- Activity (i.e. winter grazing)

To achieve these requirements and meet the multiple needs within Environment Southland, different versions of a land use map will be required. A land use map at the primary parcel scale will allow for the assessment of land use change over time, this layer can then be displayed at the property scale for general use around Environment Southland. Combining bio-physical

information and other spatial information (winter grazing areas, irrigation) with the property scale map produces a technical version of the land use map for more detailed land use assessments and will satisfy the requirements of the NPS-FM Science Programme and Southland Economic Project.

In addition to a current land use map, Stage one also includes the development of historical land use maps for the years 1996, 2001, 2008, and 2012, which correspond to Land Cover Database (LCDB) imagery dates, and a pre-Maori (c. 1000 AD) land cover map to inform the primary objective. For comparison between the current and the historical land use map methodology, a 2015 version is required produced using the historical method. Historical maps are necessary to inform the 'Ecosystem Health' science theme to assess how nutrient loads to the regions estuaries and lakes have changed over time.

Stage two of this project involves the distribution of farm data collected by industry representatives across the land use map to inform nutrient loss calculations. Section 2.3 contains a brief summary of Stage two methodologies. Stage two will be presented in a subsequent report.

This technical report details the background and methodology for Stage 1: the development of GIS-based Land Use Maps for Southland. An earlier version of this report was reviewed by Landcare Research and the methodology has been revised to implement their recommendations into this final version (Rutledge et al., 2016).

1.3. Abbreviations and Technical Terms

This section briefly describes some abbreviations and technical terms used throughout this report.

1.3.1. Abbreviations

GIS	Geospatial Information System (spatial mapping and analysis software)
ES	Environment Southland (brand name of Southland Regional Council)
NPS-FM	National Policy Statement for Freshwater Management
FMU	Freshwater management unit
LINZ	Land Information New Zealand
LCDB	Land Cover Database (versions 1 – 4.1)
PAN-NZ	Protected Areas Network – New Zealand
DOC	Department of Conservation
QEII	Queen Elizabeth II National Trust
N	Nitrogen
P	Phosphorus
Beef+LambNZ	Beef and Lamb New Zealand
DairyNZ	Dairy New Zealand
DINZ	Deer Industry New Zealand
FAR	Foundation of Arable Research
StatisticsNZ	Statistics New Zealand

1.3.2. GIS technical terms

ESRI ArcGIS – commercial software for creating and working with maps and geographic information.

Geodatabase – an ArcGIS geodatabase is a collection of geographic datasets of various types held in a common file system folder.

Feature – A representation of a real-world object on a map. The features used in this report are **polygons and points**.

Attribute – Non-spatial information about a geographic feature in a GIS, usually stored in the attribute table and linked to the feature by a unique identifier.

Attribute table – A database or tabular file containing information about a set of geographic features, usually arranged so that each row represents a feature and each column represents one feature attribute. In a GIS, attribute tables are joined spatial data layers, and the attribute values they contain can be used to find, query, and symbolise features or raster cells.

Field – A column in the attribute table which stores values/text for a single attribute.

Feature Class – A collection of geographic features with the same geometry type (such as point, line, or polygon), the same attributes, and the same spatial reference. Feature classes can be stored in geodatabases, shapefiles, coverages, or other data formats. Feature classes allow homogeneous features to be grouped into a single unit for data storage purposes.

Selection query – Structured Query Language (SQL) is a standard computer language for accessing and managing databases. SQL expressions are used in many parts of ArcGIS and its extensions to define a subset of data on which to perform an operation.

Definition query – A request that examines feature or tabular attributes based on user-selected criteria (SQL query) and displays only those features or records that satisfy the criteria.

Field calculator – A tool used to perform mathematical calculations to set attribute values for the selected records, within a field.

Spatial join – A type of table join operation in which fields from one layer's attribute table are appended to another layer's attribute table based on the relative **locations** of the features in the two layers.

Join – Appending the fields of one table to those of another through an attribute or field common to both tables. A join is usually used to attach more attributes to the attribute table of a geographic layer.

Intersect – A geometric integration of spatial datasets that preserves features or portions of features that fall within areas common to all input datasets.

Clip - A command that extracts features from one feature class that reside entirely within a boundary defined by features in another feature class.

Merge – A command that combines features from multiple data sources of the same data type into a single, new dataset.

Dissolve – A geo-processing command that removes boundaries between adjacent polygons that have the same value for a specified attribute, after data has been captured.

Explode – An editing process that separates a multipart feature into its component features; this process creates independent features that can be selected and edited accordingly.

Union – A topological overlay of two or more polygon spatial datasets that preserves the features that fall within the spatial extent of either input dataset; all features from both datasets are retained and extracted into a new polygon dataset.

1.3.3. Other technical terms

Parcel – The boundary polygon of a single land holding. One or more parcels form a **property**.
Agribase™ – Database of land use information compiled and maintained by AssureQuality Ltd.
Stock Units – A benchmarking system that allows the amount of feed consumed per annum by different classes of animal to be compared, and for the total feed consumed by the various stock classes to be aggregated on a whole–farm basis. SU can be used to show stocking rates on a property regardless of stock type.
Milking platform – Area of land where dairy cows are grazed during the milking season.
Support or runoff block – Area of land where dairy cows are grazed when not being milked. This land is either owned or leased by the dairy farm and may or may not be contiguous.
Winter off – When dairy cows are relocated off the milking platform for grazing over winter months.
Effective area – Productive area of a farm used for the agricultural activity.
Ineffective area – Other areas of a property that are not used for the agricultural activity or primary land use.
OVERSEER® Nutrient Budgets – OVERSEER is an agricultural management tool which can be used to examine nutrient use and movements within a farm. The computer model calculates and estimates the nutrient flows in a productive farming system and identifies risk for environmental impacts through nutrient loss, including run off and leaching, and greenhouse gas emissions.
Catchment – the area from which rainfall flows into a river, lake, or estuary.
Receiving environment – includes rivers, lakes, wetlands, estuaries, harbours and the open coastline that receive water from the above catchment.

2. Background

2.1. Land Use in Southland

Over the last 150 years, the landscape of Southland has undergone major changes in land use and intensification. During the 1860's, early colonisation brought about the clearing of large areas of native bush and draining of wetlands to develop pasture across the region. Increasing wheat, meat, and dairy prices in the 1950's saw the rapid expansion of pastoral land and a large increase in sheep numbers. Areas such as the Waimea plains in Northern Southland were developed for cereal production, while large areas of native forest were cleared for agriculture on the Southland plains (Cutt, 2006; Ledgard, 2013a).

Changes in land use was commonly thought to be driven by population expansion and food availability; however it is now widely recognised that modern day land use changes are predominantly driven by economics (Moller et al. 2008). Since 1985, there has not been significant agricultural expansion into undeveloped areas; with land use transitions currently occurring with the expansion of dairy production into previously drystock and arable areas (Ledgard, 2013a).

During the 20th century sheep farming dominated in Southland peaking at over 9 million sheep in 1984. Deregulation of the agricultural sector, coupled with strengthening dairy returns and

relatively low land prices saw dairying increase from 23,000 hectares in 1992 to 184,000 hectares in 2011 (Ledgard, 2013a). Dairy cow numbers increased from 46,656 in 1990 to 731,000 in 2015 (Statistics NZ). This expansion has led to sheep numbers falling to 4,073,000 in 2015, a level not seen in Southland since the 1950s (Figure 1).

Total stock units in Southland have remained largely stable, between 10 and 11 million stock units, since the early 1980s. Data suggests that although intensification is occurring in the sheep, beef and dairy sectors, the large scale intensification seen in the 1960s and 1970s (observed through large increases in total stock units) has slowed. However nitrogen load, based on excreted N, has continued to increase despite smaller increases in total stock units in the Southland region (Figure 1; Ledgard, 2013b; StatisticsNZ).

At the same time, there is increasing evidence that water quality is declining in many areas across Southland (Environment Southland, 2000; Environment Southland and Te Ao Marama, 2010; Moreau and Hodson, 2015). Large scale loss of indigenous vegetation across the region has accelerated erosion processes, reduced biodiversity and led to the increased sedimentation in rivers and significant accumulation in estuaries. The shift to dairying and expansion of associated land management practices, such as winter cropping, which are high contaminant loss land uses, has increased pressures on the regions natural resources to the extent that there have been significant declines in soil and water quality across the region. However, this cannot solely be attributable to the expansion in dairying, as land previously considered unsuitable for intensive agriculture is developed due to new technologies and farming practices, placing further stress on resources.

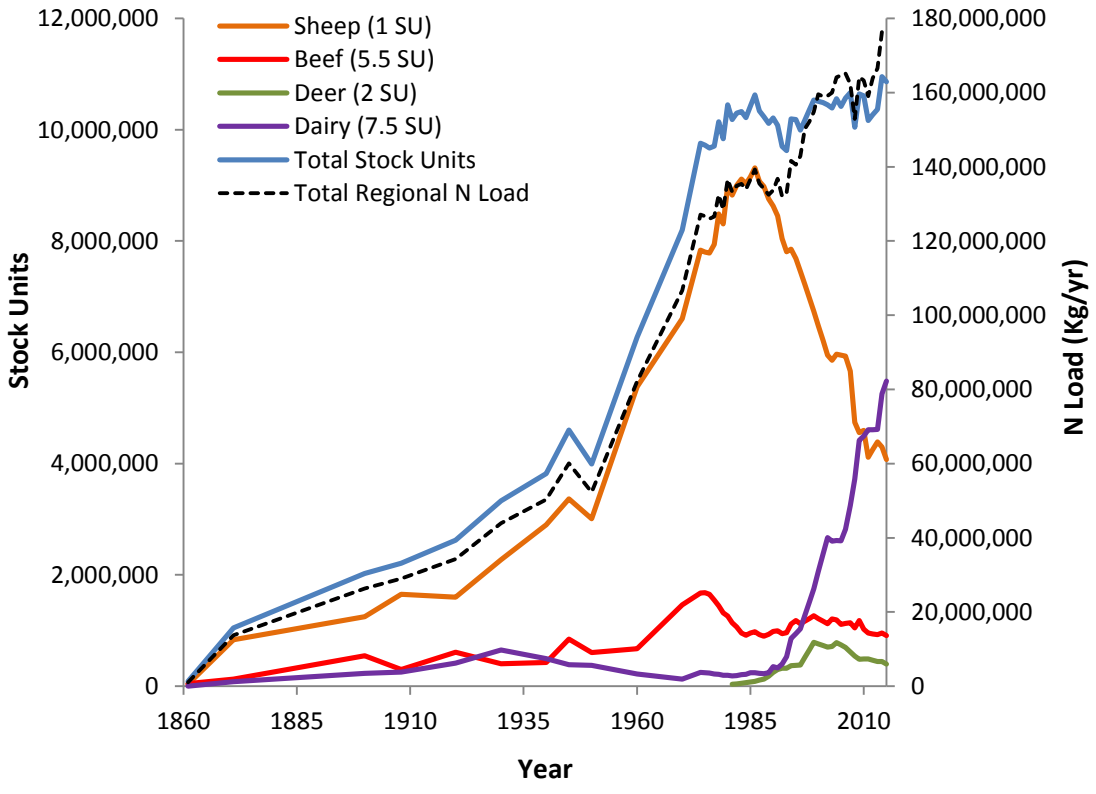


Figure 1: Stock units in the Southland region from 1860-2015 (adapted from Ledgard, 2013a and b; Statistics NZ).

2.2. Southland Water and Land Plan

The National Policy Statement for Freshwater Management (2014) sets out a framework for managing water quality and water quantity. It includes requirements to: protect the life-supporting capacity of water; maintain water quality and improve it where it is degraded; and avoid over-allocating water. The introduction of the NPS-FM has initiated the development of a new regional plan.

The NPS-FM includes a requirement to define the waterbodies to be managed, and set outcomes, limits, targets and other measures to achieve those outcomes. These waterbodies have been grouped into Freshwater Management Units (FMUs) through which the limit setting process will apply. The objectives, policies and rules will be developed for each FMU. These will be tailored to respond to the pressures faced within each particular catchment.

2.2.1. Freshwater Management Units

To implement the NPS-FM the Southland region has been separated into five Freshwater Management Units (FMUs) identified within the Regional Plan (*Water and Land 2020 & Beyond)*. These FMUs are based on the amalgamated catchments of the four main rivers (Mataura, Oreti, Aparima and Waiau) and Fiordland and Islands. The FMUs also include any surface water catchment originating from Southland but discharge in Otago, as the headwaters are within the Southland region. However, they do not include areas where water originates from the Otago region and discharges to Southland. The FMUs also contain the estuaries at the bottom of the catchments. The areas of the five FMUs are shown below in Figure 2. The FMU sub-units have been named for the receiving environment within, however the area, like the FMUs, is based on amalgamated catchments and coastal marine areas.

The Mataura FMU includes the catchments of the Mataura River (Toetoes Estuary, Fortrose), Tokanui Estuary (Toetoes Bay), Waituna Lagoon, Waikawa Harbour, The Reservoir and Haldane Estuary, Lake Vincent and Lake Brunton. The Oreti FMU includes the catchment of the Oreti River (New River Estuary) and Bluff Harbour. The Aparima FMU includes the catchments of the Aparima River (Jacobs River Estuary), Waimatuku Estuary, Lake George, Colac Bay, and Monkey Island (Te Waewae Bay).The Waiau FMU includes the catchments of the Waiau River (Waiau Lagoon), Lake Te Anau and Lake Manapouri. Fiordland and the Islands FMU includes the catchments of Lake Hauroko, Pickersgill Harbour (Dusky Sound) and Waiuna Lagoon on the mainland and Freshwater Estuary on Rakiura (Stewart Island). These catchments identified within the FMUs are those which are monitored for a range of environmental parameters by Environment Southland.

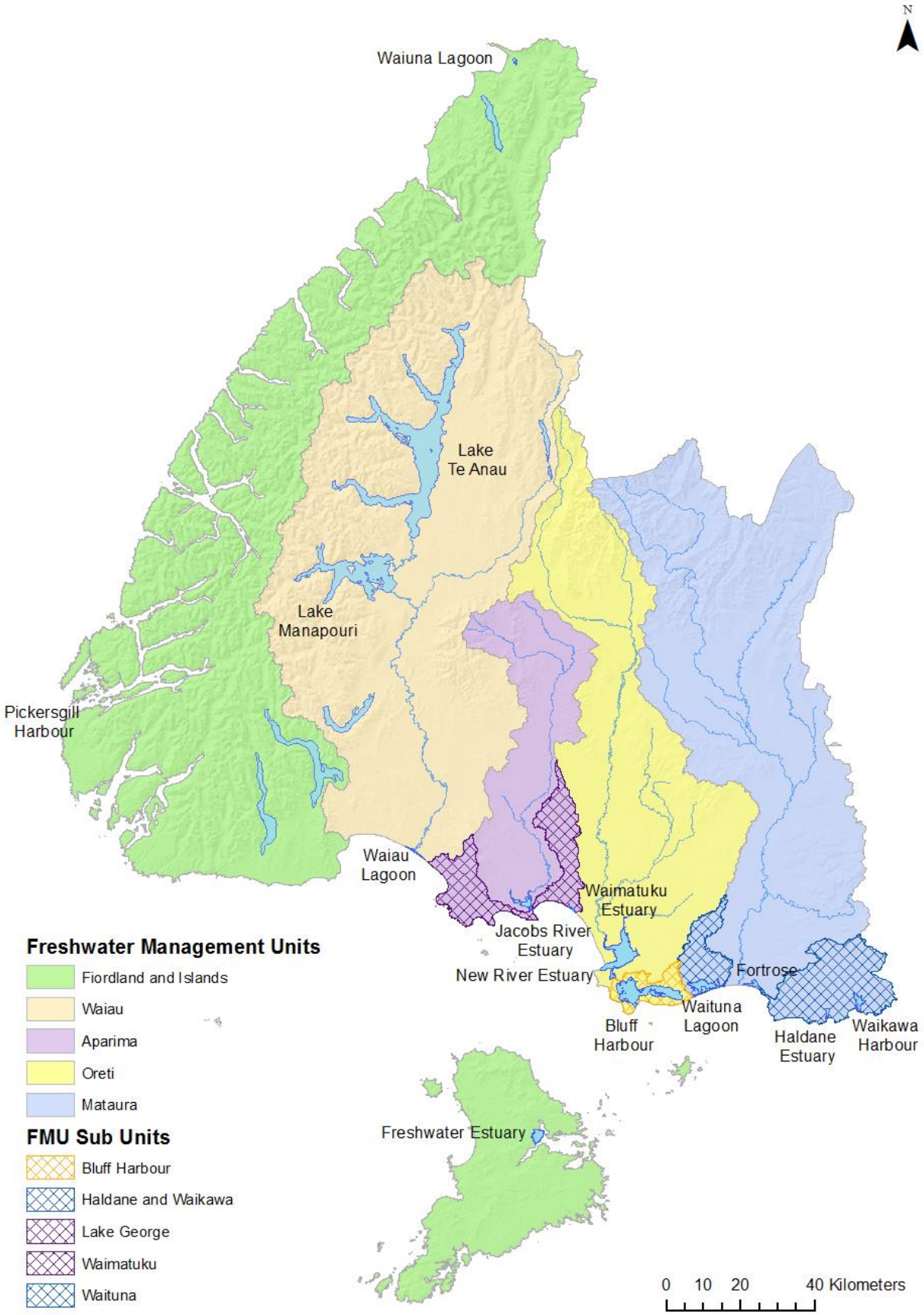


Figure 2: Fresh Water Management Units for Southland.

2.2.2. Physiographics of Southland

The 'Physiographics of Southland' project groups the Southland landscape into areas with similar inherent properties that exert a distinct influence on water quality outcomes (Figure 3). It uses a range of methodologies to distinguish regional hydrochemistry and water quality patterns (Rissmann et al., 2016). The Physiographics of Southland Part 1 report identified the following as key drivers of spatial and temporal variability in hydrochemistry and water quality across the Southland Region:

- Precipitation source (Coastal to Alpine)
- Recharge mechanism (Lowland land surface recharge, Bedrock river recharge, or Alpine river recharge)
- Geology and soil composition (Parent material type and age – Felsic (young), Mafic (old), Peat)
- Redox setting (Oxidising-low potential to Reducing -high potential)

The physiographic project identified nine units across Southland which are detailed further below (from Physiographics of Southland Part 2; Hughes et al., 2016a). Three physiographic units were identified in areas receiving rainfall or large volumes of runoff from headwater catchments, each exhibiting differing hydrochemical and water quality characteristics:

- **Alpine** - high elevation areas receiving large volumes of dilute precipitation (including seasonal snowpack accumulation) falling on steep topography;
- **Bedrock/Hill Country** - rolling to steep sub-alpine areas with carbon-rich soils receiving elevated rainfall and, in places, runoff from alpine areas.
- **Riverine** - recent alluvium along the margins of the major rivers where recharge from alpine-derived catchments provides significant dilution of local land surface recharge.

In flat to rolling lowland areas, land surface recharge (via matrix[1] or bypass flow[2]) forms a larger component of the overall water balance. In these settings, water quality (in terms of nutrient concentrations and loads) is significantly influenced by the overall redox setting in the soil and underlying saturated zone. Four different physiographic units are recognised in these environments:

- **Oxidising** - well drained (oxidising) soils overlying (oxidising) alluvial deposits;
- **Gleyed** - imperfectly to poorly drained (reducing) soils overlying (oxidising) alluvial deposits;
- **Lignite/Marine Terraces** - well drained to imperfectly drained (generally oxidising) soils overlying (reducing) sediments containing elevated organic carbon;
- **Peat Wetlands** - organic (reducing) soils overlying (reducing) aquifers containing elevated organic carbon.

Although sharing similar redox characteristics to the group above, two further physiographic units are defined on the hydrochemical/water quality characteristics which reflect hydrological characteristics associated with the age and origin of soil and geological materials:

[1] Matrix flow is the movement of water and solutes through the soil pore space.
[2] Bypass flow occurs naturally through soils with large pore spaces and cracks or artificially through tile/artificial subsurface drainage. Flow is typically rapid with minimum interaction with the soil.

- **Central Plains** - areas exhibiting similar soil redox characteristics to the Gleyed unit (i.e. poorly drained, reducing soils overlying oxidising alluvial deposits) where the influence of soil redox on hydrochemistry is over-ridden by seasonal land surface recharge occurring via bypass (macropore flow) through soils exhibiting shrink-swell characteristics.
- **Old Mataura** - areas exhibiting similar redox characteristics to the Oxidising unit (i.e. oxidising soils overlying alluvial deposits) where the potential for attenuation of nitrate concentrations is limited by the highly weathered nature of soils (low organic carbon) and low to moderate permeability of underlying alluvial deposits.

Variants were also identified within the physiographic units to recognize spatial variability in flow pathways and/or hydrochemical processes (Figure 3, Hughes et al., 2016b; Pearson 2015a and b). These variants are included in the attributes which were intersected with the Southland Land Use Map. Physiographic Zone policies have been introduced into the Southland Water and Land Plan to target water quality issues specific to each unit. For the purposes of this report Physiographic Units are used as part of the policy framework, however they have a much wider use within the NPS-FM Science Programme.

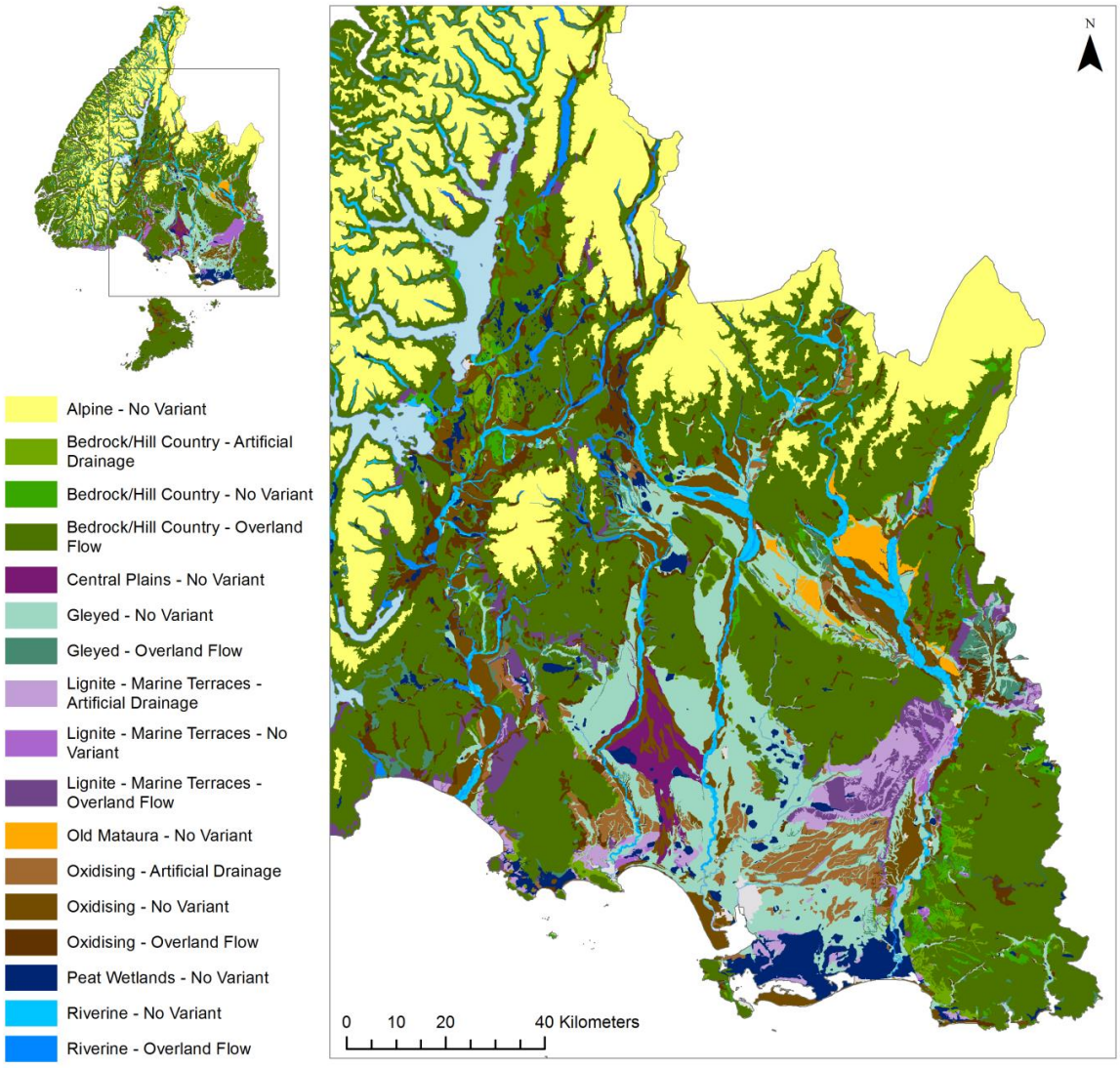


Figure 3: Southland Physiographic Units and variants.

2.3. Using the Southland Land Use Map to determine nutrient loss

How the land use map will be used in Stage 2 influences the decisions made during methodology development. This section briefly details an approach to distribute farm nutrient loss data across the Southland land use map to estimate nutrient loss from an area.

Losses of nitrogen and phosphorus from geographical areas such as FMUs or surface water catchments will be estimated using the farm data collected during the Southland Economic Project – Agricultural survey (approx. 95 farms) (Moran et al. in prep). Industry groups have surveyed farms across all of Southlands major agricultural industries and catchments. The survey farms were selected to be spatially representative across Southland and cover a wide range of activities, farm types and management systems. The industry groups have modeled the farm information in OVERSEER® Nutrient Budgets and FARMAX (financial model).

OVERSEER® is an agricultural management tool which can be used to examine nutrient use and movements within a farm[3] . The computer model calculates and estimates the nutrient flows in a productive farming system and identifies risk for environmental impacts through nutrient loss, including run off and leaching, and greenhouse gas emissions (Watkins and Selbie, 2015). Losses of N and P "to water[4]" from a property in OVERSEER® are determined by dividing the property into blocks which represent physical characteristics (climate, soil type and slope) and management activities (stock types, crops, fertilizer use, imported feed etc.) that occur on the piece of land. The losses from the individual blocks are then summed to provide an estimate of loss to water (root zone, farm boundary and the eventual receiving water body) over the whole property in kilograms of N or P per ha as an annual average.

The results of the modelling have then been weighted by how indicative they are of farming within a locality by the industry. For example, farms with irrigation are a minority in Southland and have been given a lower weighting compared to those without irrigation. Identifying features of farm location and owner is held by the industry groups that collected the information and remains anonymous to Environment Southland and other industry groups.

Once Environment Southland receives the nutrient loss data from the industry groups, the next step is to distribute the information across the Southland land use map using the key physical characteristics of slope, rainfall and soil drainage. Look-up tables will be produced which contain a loss rate (in kg/ha/yr) for all possible combinations of land use and bio-physical features which were mapped. The loss rate is informed by separating the OVERSEER farm data into blocks that represent the farm activity (land use i.e. dairy, or activity within a land use i.e. winter grazing) and physical attributes of rainfall, slope, and soil drainage on the property. All farm blocks from the Southland Economic Project available for the activity within a catchment will then be used to

[3] www.overseer.co.nz

[4] 'Loss to water' is a term used in OVERSEER to describe how N and P are lost from the property or block. It is calculated from the sum of leaching (urine patches, other), runoff, direct deposition (animals, drains, pond discharge), border dyke outwash and septic tank outflow). Leaching refers to the bottom of the root zone, which is estimated at 60cm for pastoral blocks and therefore infers a diffuse loss to shallow groundwater. Leaching is the main contaminant pathway for N, whilst P is typically lost by runoff or direct deposition.

inform the look-up table and determine a median, mean, maximum and minimum loss from that activity. The loss estimate will then be distributed to areas of similar activity and physical characteristics across the Technical Land Use Map. The range of loss information within the look-up table allows for different combinations to be tested.

This requires the Land Use Map to be at a resolution suitable for determining land use activities at the property scale and have an estimate of effective and ineffective hectares within the parcel. This will be achieved through combining the Land Use Map for farm activity/type with the Land Cover Database (LCDB version 4.1) to determine effective hectares within the property. The addition of physical characteristics for slope, rainfall and soil drainage to the map will then inform the intensity of the land use type provided by the range of farms modelled by the respective industry. This method is advantageous as specific nutrient budgets from all properties in Southland are not required to estimate nutrient loss from a catchment; however it is strongly reliant on information from industry. Mitigation scenarios and policies can be tested by implementing changes to the look-up table.

3. Land Use Categories

A list of land use categories of which information is required to satisfy the needs of the NPS-FM Science Programme and the Southland Economic Project were determined (Table 1). It was established that a combination of primary land use and additional land cover was need to achieve the objectives of the project.

In identifying land use categories, the following factors were considered:

1. The range of major land uses across Southland
2. The available land use data with information at a block or property-scale
3. The environmental drivers of contaminant losses – topography, rainfall and soil drainage
4. Knowledge gained from the collection of farm data i.e. relationships between the agricultural sectors.

Table 1: Categories, sub-categories and source of data for Southland Land Use Map.

Category	Sub-category	Description	Data Source
Conservation	Conservation	National parks, DOC Estate, Maori Trusts	PAN-NZ
	QEII	Queen Elizabeth II National Trust	LINZ
Plantation Forestry	Commercial	Pinus Radiata, Douglas Fir, Eucalyptus	Major forestry industries, Agribase
	Sustainable	Native Forest	Major forestry industries
	Farm	Farm forestry	LCDB4.1
Sheep and Beef	Sheep	Sheep only (other livestock <50 SU)	Agribase
	Beef	Beef only (other livestock <50 SU)	Agribase
	Sheep and Beef	Sheep and beef	Agribase
	Mixed Livestock	Sheep, Beef and Deer	Agribase
Dairy	Cows	Cow milking platform (>100 cows), structure details	ES Resource Consent Database
	Cows	< 100 cows	Agribase
	Sheep	Sheep milking	ES Resource Consent Database
Deer	Specialist	Deer only	DeerNZ, Johne's Management Ltd., Agribase
	Majority	Majority Deer with other livestock	Agribase
Other Animals		Horses, pigs, poultry, goats, alpacas, bees, dogs etc.	Agribase
Dairy Support		Runoff blocks - not on milking platform	Agribase, ES Resource Consent Database
Livestock Support		Graziers	Agribase
Pasture (unknown use)		Properties with no information	LCDB4.1
Arable	Specialist	Short rotation crops	FAR, Agribase, LCDB4.1
	Mixed Livestock	Arable and other livestock	FAR, Agribase, LCDB4.1
Horticulture		Vegetables	Agribase
Nurseries and Orchards		Plant Nurseries and orchards	Agribase
Flowers		Tulip bulb growers	Agribase
Lifestyle Blocks		Sized between 0.1-5 ha, non-urban	Agribase, Rates 2012
Small holdings		Sized between 5-40 ha, unknown use	Agribase, Rates 2012
Residential		Territorial authority town boundaries	Rates 2012
Commercial		Commercial properties within town boundaries	Rates 2012
Industrial and Airports		Dairy factories, Freezing works, Timber processors etc.	Rates 2012, Agribase, ES Resource Consent Database
Public use		Schools, churches, cemeteries, etc.	Rates 2012
Recreation and Tourism	Recreation	Sports grounds, camp grounds, tourism, etc.	Rates 2012, PAN-NZ
	Golf	Golf courses	Topo50
Lakes and Rivers		Waterbodies	LCDB4.1
Road		Roads	LINZ
Rail		Railways	LINZ

4. Data Sources

A number of data sources were used to create the GIS-based Land Use Map. These include Land Information New Zealand (LINZ), Agribase™, Land Cover Database (LCDB v4.1), Protected Areas Network (PAN-NZ), Topo50 and Industry information (Forestry, Foundation for Arable Research (FAR) and DeerNZ) as well as Environment Southland's Resource Consent database for dairy effluent discharges, and the Rates database (2012). It was necessary to combine information from a wide range of sources to achieve a comprehensive land use map as limited to no spatial information is held by industry for their farms.

The basic characteristics of these datasets are explained below. The process for amending the data source and for determining which data source was used to assign a land use classification is described in Section 6.

4.1. Land Information New Zealand

Land Information New Zealand (LINZ) was used to obtain data on the locations of:

- Primary parcels[5]
- Topo50 Map Series[6] - Road centrelines
- Topo50 Map Series - Rail centrelines
- Topo50 Map Series - Golf courses

4.1.1. Primary Parcels

The primary parcels layer provides the current parcel polygons and some associated descriptive data that details the legal description, purpose, size and a list of titles that have an interest in the parcel. Primary parcels can be thought of as the 'base level' of the 'jigsaw puzzle' of all land making up New Zealand. The primary parcel layer has a nominal accuracy of 0.1-1m in urban areas and 1-100m in rural areas.

A primary parcel is a portion of land that is intended to be:

- Owned by the Crown, except moveable marginal strips
- Held in fee simple ((predominately private ownership)
- Maori freehold land or Maori customary land
- Public foreshore and seabed
- The bed of a lake or river
- Road or Railway
- Vested in a local authority

The primary parcels layer provides a framework to populate with land use information from multiple data sources. As the primary parcels represent the legal parcel boundaries, their shape will not be manually altered during land use mapping. An exception to this will be Queen Elizabeth II National Trust areas, which will be separated from the primary parcel polygons to

[5] https://data.linz.govt.nz/layer/772-nz-primary-parcels/ (downloaded 20/01/2016)
[6] http://www.linz.govt.nz/land/maps/topographic-maps/topo50-maps (downloaded 21/01/2016)

spatially identify the area but will be identifiable with the primary parcel by the 'Parcel ID' which remains unaltered.

The advantage of using the Primary parcel layer as a framework is that it contains no overlapping or duplicate information, has a unique identifier for each polygon and provides legal boundaries to properties. It contains polygons for all of Southland, including off-shore islands. This layer also contains some land use information via both the "Parcel Intent" and "Statutory Actions" fields. These attribute fields can be used to help map roads, railways, water via hydro parcels, and recreational areas.

A major limitation of the primary parcel layer is the date of regional surveying (c. 1860). Since then, river channels have been altered, either by natural river meandering or by intentional catchment management; and therefore no longer represent the current position of the river. Updates to this layer occur on a regular basis to adjust for newly resurveyed areas; however these updates do not extend to the entire reach of a river. Parcels bordering hydro parcels remain in error and would require resurveying adjacent to all rivers across the entire region to correct it.

4.1.2. Topo50 Map Series

The Topo50 map series provides topographic mapping for the New Zealand mainland and Chatham Islands, at 1:50,000 scale, and identifies a wide range of geographical information. Geographical information for a specific feature is downloadable from the LINZ website. Layers downloaded from the Topo50 map series were NZ road centrelines, NZ railway centrelines and NZ golf course polygons.

The "Road" parcel intent in the primary parcel layer includes all surveyed roads, whether they are actual formed roads or paper roads. The road centrelines layer[7], Topo50 Map series, was used to identify any formed roads, while the reclassification of paper roads can be done as farm boundary information is utilised from other data sources, such as Agribase™. This greatly reduces the error associated with identifying features of interest by parcel intent. Similar is true for railway lines using the NZ railway centrelines layer[8].

Topo50 was also used to provide information on the location of golf courses in Southland[9]. Golf is a recreational land use that was considered separately from other recreational land uses due to the potential for high inputs of N and P from fertilizer application.

4.2. Agribase™

AsureQuality Ltd. compiles and maintains land use information for all types of rural properties by voluntary survey and farm visits. These property types include farms, horticulture, forests and small holdings. The database, known commercially as Agribase™, has coverage of 97% of Southland (Pat Turton, pers. com. April, 2015). The definition of a farm in Agribase™ is "One or

[7] https://data.linz.govt.nz/layer/329-nz-road-centerlines-topo-150k/ (downloaded 21/01/2016)
[8] https://data.linz.govt.nz/layer/221-nz-railway-centrelines-topo-1500k/ (downloaded 21/01/2016)
[9] https://data.linz.govt.nz/layer/281-nz-golf-course-polygons-topo-150k/ (downloaded 21/01/2016)

more blocks of land owned by a single farming business, typically within 20 km of each other, where there is a single identifiable individual with day-to-day responsibility (termed the "key decision maker"), personnel and equipment resources are shared, and in the case where livestock are farmed, there is relatively frequent interchange of livestock between the blocks" (AssureQuality, 2015). For the purposes of land use mapping in Southland this definition will be used to define a 'property' where Agribase™ has been used to identify the land use.

Updates to the Agribase™ data set will be provided to Environment Southland on a six monthly basis. AssureQuality estimate farms in Southland are visited on a 12-36 month basis to gather farm information (Pat Turton, pers. com. April, 2015). This provides Environment Southland with the capability to utilize land use information for the region that has been verified by an independent source.

For Tier 1 national statistics, records must be less than 5 years old. The Agribase™ data received in April 2015 contains records for 6230 properties. Prior to analysis, records were checked to ensure polygons were within the Southland boundary, which resulted in the removal of 25 records. Table 2 shows the source date for the dataset, in which 71% are at Tier 1 level. An assessment of data provenance is described in more detail in Section 11.

Table 2: Source date and number of records in Agribase (April 2015) as provided by AsureQuality.

Date	No. of Records	Percentage (%)
1995 - 1999	9	0.15
2000 - 2005	149	2.40
2006 - 2010	1604	25.85
2011-2015	4443	71.60
Total	**6205**	**100**

Agribase™ was deemed to be the most accurate source of available information and an essential source of rural land information for producing a land use map for Southland. It does, however, have the following limitations:

Definition of land use from the questionnaire – as most information is provided by a voluntary survey, the interpretation of survey questions strongly influences the land use classification, especially where there are multiple land uses. The criteria to determine land use, whether it be land area, economic return or what the farmer wants the land classified as requires refinement. However, AsureQuality are moving away from postal surveys with the aim to data capture through their staff visits to farms for AssureQuality programmes or corporate customer databases.

Data gaps around grazing stock – Agribase™ reports own stock numbers as at 30th June, however this may not give a good indication of actual stock numbers on the property. This is especially important as wintering off the dairy platform to support farms is a common practice in Southland. Information about dairy support farms, which receive dairy cows for the winter, needs to be captured within a land use map to accurately assess seasonal effects of stock location.

Varying level of detail – various levels of detail is provided by the person completing the Agribase™ survey. For confidentiality some people have selected not to disclose some information, especially around stock numbers. The classification of the farm type is not always consistent with the stock numbers identified on the property.

Information overlaps - These exist where spatial property boundaries contain duplicate land use information. Overlapping polygons are an issue, as the area of overlap is double accounted in the land use map resulting in more than what is present in the region. Information overlaps are a legitimate result of two or more farming enterprises (i.e. multiple Farm_Id's) occurring on a land parcel. For example, a landowner farming most of his/her property might also lease out a small section of the property to another farmer. A small operator owning a property larger than they can use might lease out the larger portion of the property as grazing to another farmer. Also, farm boundaries may not accurately reflect the actual location of the farm. There are some records where farm boundaries occur within urban areas, and therefore are likely to indicate the property where the owner lives, rather than or included in the farm.

New farms - Farms that are new to the Agribase™ database, which have not been validated by AsureQuality, are entered as land use NEW and contain no further information other than the farm boundary. Land use is unable to be determined for these properties.

Property area - Enterprise area (reported Farm Size by the person who completed the survey) and geographic areas (the Shape-area field in a GIS layer) often disagree, sometimes substantially. This is likely an unintended error when creating a farm in Agribase™ if quality control checks are not undertaken.

To minimise the effect of the above limitations, Environment Southland undertook a reclassification of Agribase™. Systematic 'rules' were developed to ensure that the reclassification process was undertaken in a consistent and logical manner. These rules were developed into a methodology defined in Section 7.1.3. As Agribase is the primary data source for sheep, beef and deer properties in the Southland Land Use Map, it was necessary to insure consistency of land use classification.

4.3. Protected Areas Network (PAN-NZ)

Spatial data for conservation and protected areas was provided by the Protected Areas Network – New Zealand (PAN-NZ) database, which contains information on legally protected areas for the three main islands of New Zealand (North, South, and Stewart) and all the inshore islands. This database includes Crown Conservation Estate (managed by the Department of Conservation (DOC)), regional parks, and a range of covenant schemes: Queen Elizabeth II National Trust (QEII), Ngā Whenua Rāhui, Nature Heritage Fund, and local council reserves via the Reserves Act. The database is managed and maintained by Landcare Research and obtained on request. The database received for this project was dated 2014.

PAN-NZ was produced by Landcare Research by combining the data sources listed above, in which there can be multiple or overlapping polygons if the land parcel is identified in multiple data sources. Crown Conservation Estate (managed by the Department of Conservation, DOC)

and LINZ are the most common cause of spatial overlap. Duplicate information was a limitation when using this data source and required a hierarchical approach to selecting data sources where overlaps occur. Another limitation identified was the inability to attribute some data to a primary parcel. Most polygons in the dataset can be attributed to a LINZ parcel; however QEII covenants are often not the primary land use within a parcel and will need to be considered differently to other PAN-NZ records (See Section 6.3.1).

Identified as part of DOC Conservation Estate, is Stewardship land. However, Stewardship land is not always used for conservation or protected. It is a category of land that can be sold or swapped for areas of private land and only needs to be managed so that its "natural and historic resources are protected", whereas other categories of conservation land have more specific management criteria. Therefore, there is potential that these areas are used for agriculture rather than as a conservation estate. However, on comparison with aerial photography areas under pasture are minimal.

4.3.1. Queen Elizabeth II National Trust

To obtain the most up-to-date information on Queen Elizabeth II National Trust (QEII), data was sourced separately from the PAN-NZ database, directly from the QEII National Trust[10]. Some QEII Trust areas may require manipulation of the primary parcel layer to allow for spatial representation separate from that of the primary parcel. The method used is detailed in Section 7.2.3. The resulting QEII areas are still associated with the original property through the unaltered parcel ID.

4.4. Land Cover Database

LCDB (version 4.1) is a national land use classification provided by the Ministry for the Environment for public use. It was mapped by Landcare Research from satellite imagery taken over summer 2012/13 and contains 33 land cover classes split within the broad categories of artificial surfaces, bare or lightly vegetated surfaces, water bodies, cropland, grassland, sedge and saltmarsh, scrub and shrubland, and forest[11].

The main limitation of using LCDB v4.1 for a land use classification is that the land cover category classes are coarse and do not distinguish between agricultural land uses. For example, the "high producing exotic grassland" in LCDB v4.1 could be any of the pastoral farming land uses resulting in limited ability to use land cover as a proxy for land use.

However, land cover is an essential piece of information to use in combination with land use. LCDB provides the ability to determine effective hectares on a property. Effective area or the productive area for the land use, will improve contaminant loss estimates for Stage two of this project. For a pastoral land use, the area of grassland (high producing, low producing, tussocks etc.) and cropping are determined to be the effective area, while tree blocks (native, exotic), wetlands, ponds are estimated as ineffective area. For plantation forestry, the effective area is

[10] Environment Southland has a data sharing agreement with QEII National Trust and receives updates approximately every four months.
[11] https://lris.scinfo.org.nz/layer/423-lcdb-v41-land-cover-database-version-41-mainland-new-zealand/

that covered by exotic forest, while all other land cover classifications are estimated to be ineffective area.

Land cover also provides the ability to determine relative intensity of an activity with high producing exotic grassland more intensive than low producing grassland > depleted grassland > tall tussock grassland > alpine grass/herbfield within a pastoral land use.

The scale of LCDB v4.1 is mapped to the nominal minimum mapping unit of 1 hectare, and is more accurate with spatially larger areas than those that occupy a small area i.e. a pasture surface of a farm is better represented than a small wood lot/forested area. LCDB also includes polygons with sizes smaller than 1 ha, particularly polygons that indicate areas of change in land cover, which will be an advantage when mapping historic land change.

4.5. Environment Southland Resources

4.5.1. Environment Southland Rates Database 2012

Environment Southland collected land use information with rate payments, with the latest record available from December 2012. In 2013, ES changed the computer programme used to record rates information, which resulted in an inability to extract land use information. The Rates 2012 layer is the latest record Environment Southland holds regarding land use for the region.

The layer was used as an additional data source to identify residential, commercial, industrial, public use (schools, churches etc.) and recreational areas (parks and sports grounds etc.) within an urban area. It was also used to identify small holding forestry blocks, which were not identified in the forestry layer (section 5.6.1). The land use categories identified in the Rates database were difficult to align with those land use categories identified in Table 1 for this project. However, in combination with other data sources, such as Argibase™, more in-depth detail can be ascertained as to the farming type. For example, livestock farms are classified in the Rates database as either finishing breeding or intensive finishing rather than a classification based on the identification of stock type as used for the Southland Land Use Map.

4.5.2. Resource Consent Database – Dairy (Cows and Sheep)

Environment Southland's resource consent database holds spatial information for dairy farming (both cows and sheep) as effluent discharge to land from this activity is a consented activity in Southland. The area of dairying represented in Figure 4 is termed the milking platform, which is the area where stock is grazed during the milking season. As the information is obtained directly from the resource consent application, there is a high level of certainty with the dataset.

A limitation of this data is that it locates the milking platform only and does not contain areas where stock, especially dairy cows, are grazed outside of the milking season. These areas, typically termed runoff or support blocks, are a key part of the farm business and will need to be identified spatially. Dairy farms without runoff areas or infrastructure, typically winter stock off farm using a grazier (support farm). To spatially map the total area of dairying, a combination of data sources was used to identify both milking platform and runoff/support areas through

Agribase™ providing polygons for the total farm area while ES resource consent dairy layer provides milking platform. The difference between these two areas on a property was deemed to be the runoff/support block. Dairy will be the exception to mapping at property scale as these two areas have been mapped seperatly. The number of dairy farms in Southland can be determined by the number of milking platforms identified in the land use map. This differs to how DairyNZ present number of farms, which is by number of herds.

In Southland, dairy farms with less than 100 cows are a permitted activity, which does not require resource consent; therefore these farms are not included in the resource consent dataset. This information gap was filled by using the Agribase™ classification for dairy (DAI) and where dairy cow numbers were less than 100 cows, we can identify the farms not located by the ES consent layer.

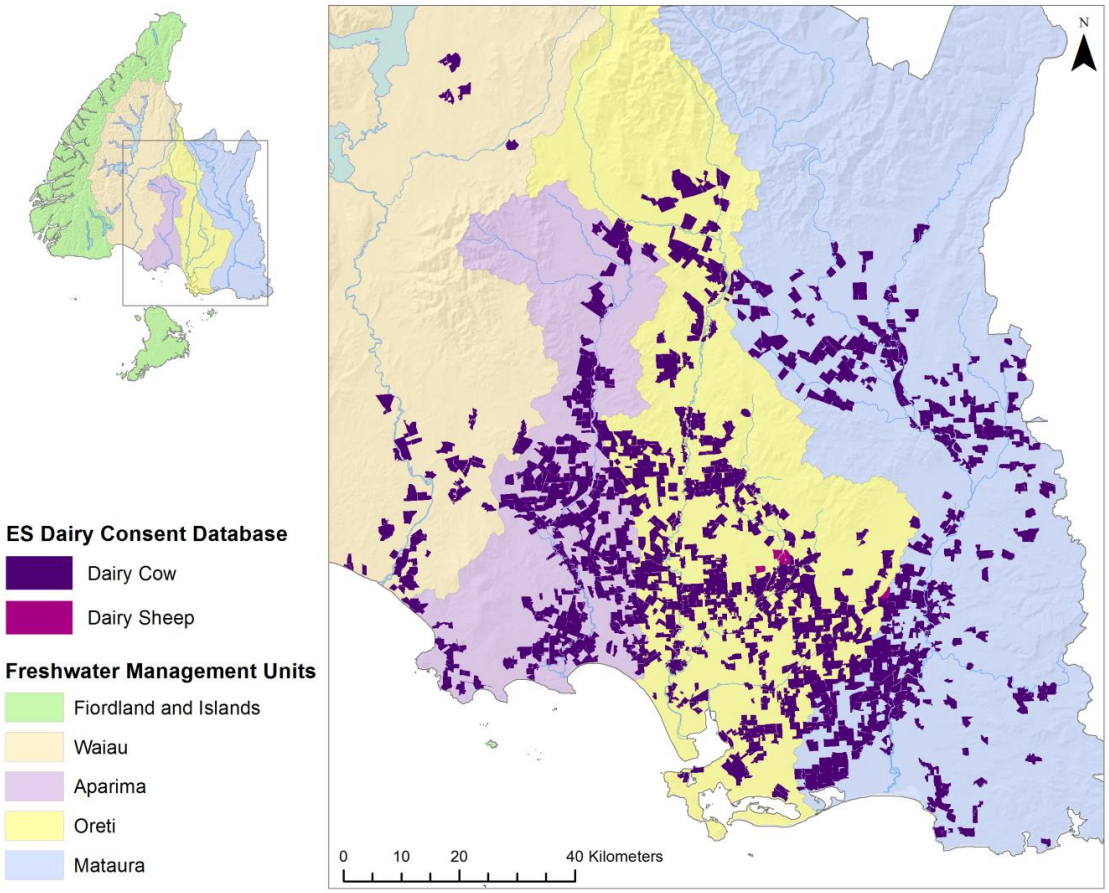


Figure 4: Dairy locations in Southland as of April 2015 (area represented by milking platform only).

4.5.3. Resource Consent Database - Major Industry

Environment Southland holds information on major industries through the resource consent database for point source discharges to air, land and water. The database includes polygon locations of major industries such as meat works, milk factories, and mines etc. This data source is updated on a regular basis when new information is obtained by the council.

4.5.4. Science Investigations – Winter grazing survey 2014

During winter in Southland when there is little pasture growth, cattle, sheep and deer are often strip-grazed on specially–grown forage crops. This activity is recognised as a key source area for losses of contaminants from agricultural areas. To obtain spatial information on winter grazing, Environment Southland contracted Landcare Research to construct a map of livestock forage locations throughout winter of 2014 for the entire Southland region (North and Belliss, 2015). The winter forage image produced by Landcare Research, had a high degree of uncertainty with some classifications. To improve on the level of uncertainty and spectral errors, Pearson and Couldrey (in prep) refined the map using LCDBv4.1, a Digital Elevation Model (DEM, 8m), Southland Physiographic Units and an earlier version of the Southland Land Use Map. LCDB was used to remove winter cropping areas coinciding with areas of scrub and shrubland. The Physiographic Units were used to remove cropping areas within the 'Alpine' Physiographic Unit to eliminate areas with unsuitable growing conditions. The 8m Digital Elevation Model (DEM) was also used to remove crop on steep slopes (> 26 degrees) as all forage crops identified within these areas are likely erroneous. Version 1 of the Southland Land Use Map was used to remove areas unlikely to be used for forage (i.e. residential, industry, lifestyle and airports) or those that are likely to have been mapped in error due to similar spectral signatures to that of winter crops (i.e. horticulture, tulip bulb growers and plant nurseries). The extent of winter forage crops in Southland is shown in Figure 5a as the total hectares of forage grown on a property, which identifies properties with large amounts of forage crops, and by Figure 5b which displays the amount of forage crop as a percentage of suitable land on a property to identify smaller scale intensive growers (Pearson and Couldrey, in prep).

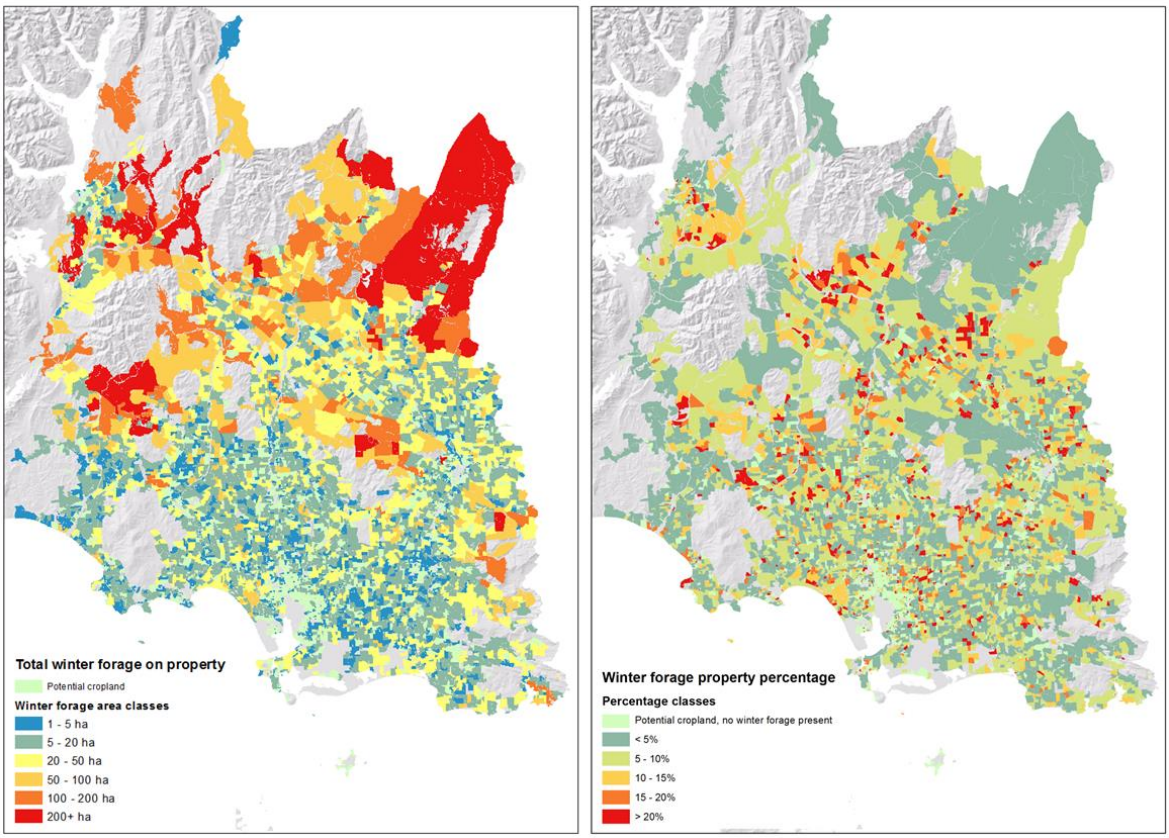


Figure 5: a) Total hectares of forage grown by property and b) as a percentage of available land on the property (Pearson and Couldrey, in prep).

4.6. Contributions from Industry Groups

Industry groups have provided information about their relevant sectors to aid in land use mapping. These contributions range from spatial details to detailed information and map validation. Deer, forestry and arable land uses have been mapped with industry input and support.

4.6.1. Deer farms

Deer farm identification was aided in by the provision of farm point locations by Johne's Management Ltd. Farm points can be matched against the Agribase record of deer farms and properties with deer. Of the 289 farm points, 95% success rate (274 of 289 farm points). Unknown pastoral areas without Agribase records are then able to be classified as deer. The limitation of this information is that farms are identified from a point location and farm area is inferred from LINZ property parcels.

4.6.2. Plantation Forestry

A Forestry layer was created in GIS by ES in consultation with major forestry owners/managers in Southland to be used as an input into the Southland Land Use Map (Figure 6). This layer is limited to the major forestry companies only and does not include smaller privately owned forestry blocks occurring on land identified by other land uses.

For the base map no separation of tree species was included. However, the major producers of pinus radiata in Southland are Rayonier/Matariki Forest and Craig Pine, with Ernslaw One and Southwood minor producers of this species. Douglas fir is the main species produced by Ernslaw One, with minor production by Rayonier/Matariki Forest. Eucalyptus is the main species grown in Southland by Southwood. Other smaller forestry owners, such as Southland District Council, were identified using the Rates 2012 information (section 5.5.3) and grouped together as other plantation forestry in Figure 6. The forestry owner/manager of a forestry block was recorded in the attribute table of this GIS layer.

Indigenous forestry is undertaken in the Longwood and Rowallan forests by Lindsay & Dixon and comprises a total area of 11,582 hectares. These forests are predominantly maple beech (Nothofagus Menziesii) with small areas of mixed podocarps, such as Rimu and Totara. From the total estimated indigenous forest stock of 1.32 million cubic metres, Lindsay & Dixon's annual permissible harvest volume is 23,628m^3 inclusive of all log grades and species[12]. This amount represents a sustainable yield extraction volume of 1.8%, which is very conservative by international standards (typically average 10%).

[12] http://www.lindix.co.nz/Environment.html

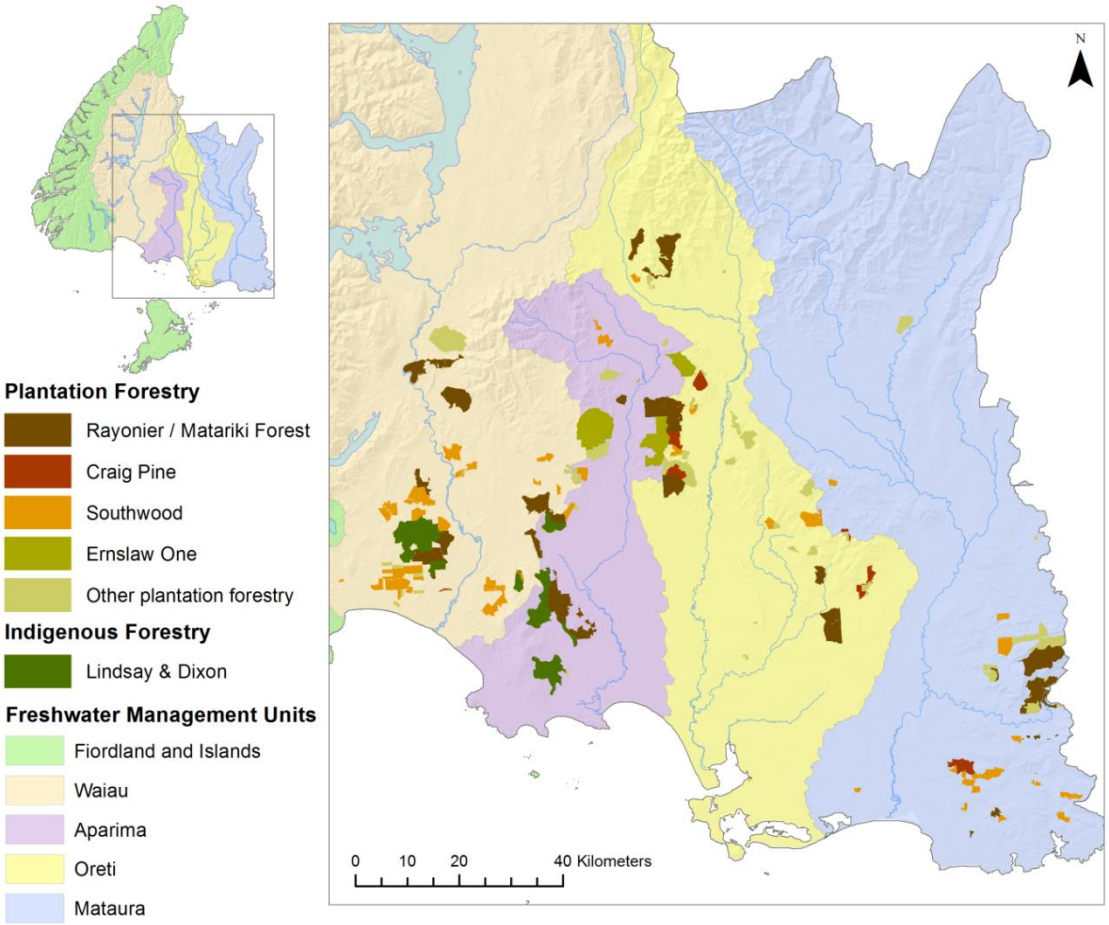


Figure 6: Southland forestry plantations by company. Plantation forestry species are Pinus radiata, Douglas fir and Eucalyptus and ingenuous forestry of beech.

4.6.3. Arable

Arable cropping areas were identified in a GIS-layer with the support of the Foundation of Arable Research (FAR, Figure 7). Identifying arable farms is difficult as a 100% arable land use is uncommon in Southland and is often part of a larger enterprise, typically sheep and beef farming (Diana Mathers, FAR, pers. com). Therefore, a layer was produced which combined the information received by FAR and that produced by Ledgard (2013a) from 2010 data.

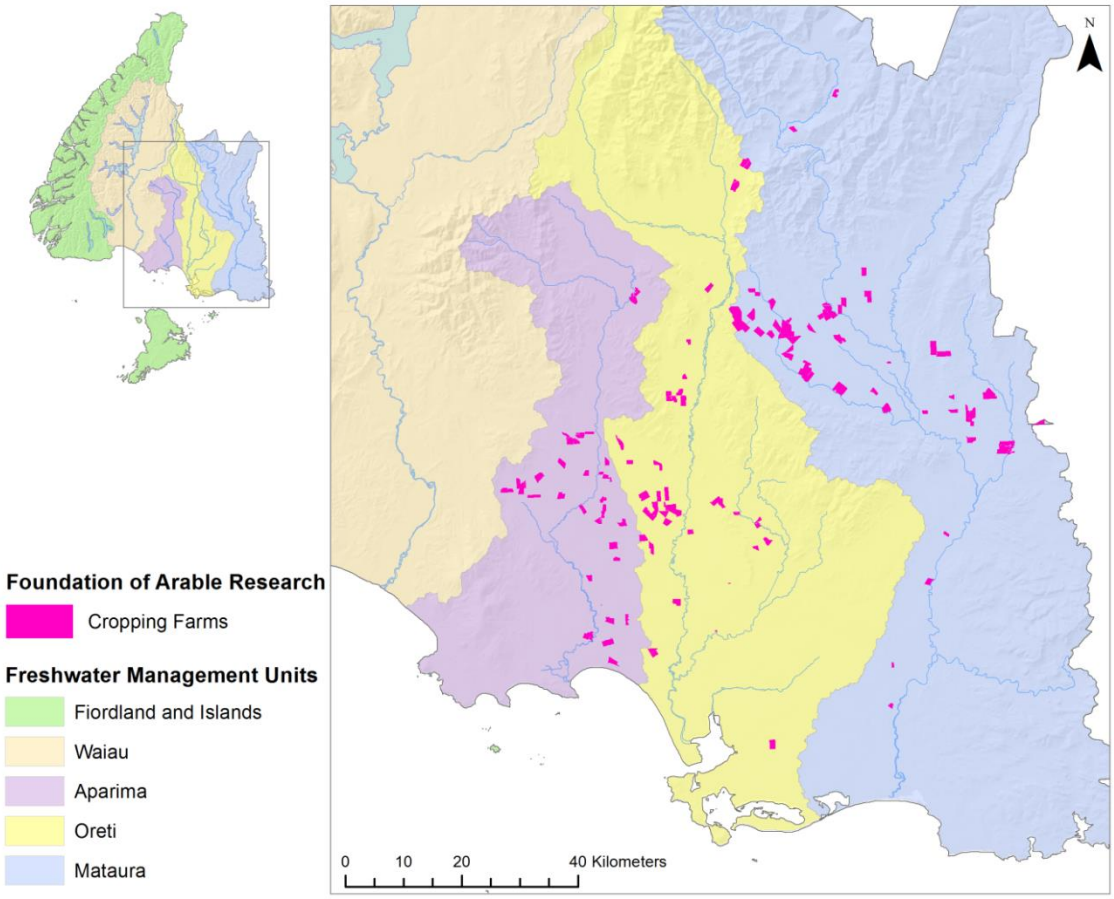


Figure 7: Arable cropping farms in Southland as identified by FAR.

5. Data Storage – ArcGIS Geodatabase

A geodatabase was created to house the Land Use Map GIS files. Within the geodatabase, a feature class was created for each data source. The geodatabase allows for multiple users of the files, with only one person allowed to edit a record at any time. Changes to the file can be recorded by enabling file tracking. File tracking in ArcGIS, automatically populates the name of the user who edited it and the date and time the record was last edited to provide transparency of data transformation.

All files sourced for, or created during, this project are stored in the geodatabase for transparency around what data sources were used, where they were sourced from, and the transformations and methodology used in developing the land use map. Detailed documentation of all methods, processes and decisions made during this project are included in this report and subsequent appendices to allow for repeatability given the same data sources. Future updates will also follow this methodology for consistency of mapping techniques. Additional data sources may be incorporated when they become available.

6. Methodology for building the GIS-based Southland Land Use Map

This section details the modification of any dataset identified in Section 4 and the process by which it was incorporated into the Southland Land Use Map. Modifications to some datasets were necessary to remove information overlaps and insure consistency in land use classification. This section also documents the data hierarchy and methodology used to import the land use information into the primary parcels framework, which forms the base of the Southland Land Use Map.

6.1. Modification of Data Sources

Detail of any modifications made to the original source data are detailed in Structured Query Language (SQL) format in Appendix 1: Modification of Data Sources.

6.1.1. LINZ Primary Parcel Layer

The primary parcel layer was used to provide a framework to populate with land use information. Prior to the addition of information to this layer, GIS file tracking attributes of 'Last edited user' and 'Last edited date' were added to the attribute table as file tracking was enabled. This feature allows for any polygon which is altered from the original layer to be tracked.

To record metadata of source information, attribute text fields for 'Source', 'Source_Data', 'Source_Class', 'Source_Date', 'ES Code', 'ES Code 2' and 'Details' were added to the attribute table, to be manually populated when data sources are added. 'Source' is the data source of the original record, 'Source_Data' is the secondary source, 'Source_Class' is the classification given to the polygon by the Source or Source data, 'Source_Date' is the date the record was obtained, 'ES Code' is Environment Southlands land use code, 'ES Code 2' is for secondary land uses and 'Details' is for any other comments. For example, the metadata added for the PAN-NZ data source was as follows:

- Source: PAN-NZ
- Source_Data: DOC public conservation areas
- Source_Class: National Park, Source_Date: 2014
- ES_Code: CON
- ES_Code2: <Null>

All records must have a minimum of Source, Source_Date and ES_code recorded.

The primary parcel layer was checked for overlapping polygons by intersecting the layer with itself. One polygon was identified as being overlapping during this process and was removed (Appendix 1a). This layer should not have had overlapping polygons, and is an error in the primary parcel layer.

6.1.2. ES Rates Information 2012

The ES Rates data was modified by simplifying the numerous classes into 16 different codes representing the land uses identified within Southland (Table 3, Appendix 1b). Some of these

categories and Rates codes created will directly correlate to the new GIS-based Southland Land Use Map classifications, while others were used to inform decisions on new classifications.

Table 3: Land use categories and respective rates code determined from the land use classifications in the Rates database December 2012.

Category	Rates Code	Rates Classification
Residential Use	RES	Residential, Residential Multi-Unit, Residential Single Unit excluding Bach, Vacant Residential, Single Unit, Special Accommodation, Multil-Use within Residential, Multi-Unit, Communal Residence Dependent on Other Use, Bach, Communal Residence Dependent on Other Use
Commercial Use	COM	Carparking, Commercial, Communications, Defense, Electricity, Entertainment, Multi-Use within Commercial, Multi-Use within Utility Services, Offices, Other Utility Services, Parking, Personal and Property Protection, Public Communal - Licensed, Public Communal - Unlicensed, Retail, Services, Utility Services, Vacant Commercial, Vacant Utility Services, Water, Wholesale
Public Use	PUB	Cemeteries and Crematoria, Community Services, Educational, Halls, Medical and Allied Hospitals, Multi-Use within Community Services, Religious, Sanitary, Vacant Community Services, Water Supply
Industrial Use	IND	Building Materials other than Timber, Chemicals, Plastics, Rubber and Paper, Depots, Yards, Engineering, Metal Working, Appliances &, Industrial, Industrial Food, Drink and Tobacco, Gas, Industrial Textiles, Leather and Fur, Industrial Timber Products and Furniture, Mineral Extraction, Multi-Use within Industrial, Other Industries, Vacant Industrial
Recreational Use	REC	Active Indoor, Active Outdoor, Multi-Use within Recreational, Passive Indoor, Passive Outdoor, Recreational, Vacant Recreational
Unknown Use – Urban	URBUNK	NULL, Vacant, Vacant/Indeterminate (within RPMS area)
Unknown Use – Rural	UNK AGRI	NULL, Vacant, Vacant/Indeterminate (outside RPMS area) Multi-Use within Rural Industry, Rural Industry, Vacant or Idle - Primary Industry
Dairy	DAI	Dairying
Arable	ARA	Arable Farming
Mixed Livestock	FINLIV SPLLIV STORELIV	Stock Finishing Specialist livestock Store livestock
Forestry	FOR	Forestry
Horticulture	HORT	Market Gardens and Orchards
Lifestyle	LIF	Lifestyle, Multi-Use within Lifestyle, Single Unit
Transport	TRANS	Air Transport, Multi-Use within Transport, Rail Transport, Road Transport, Transport, Water Transport

6.1.3. PAN-NZ

The PAN-NZ layer required reclassification of some data sources within the PAN-NZ database to separate conservation areas from that of public use, recreational use, hydro (lakes and rivers) and coastal marine areas. Definition queries in ArcGIS were used for 'LINZ parcels with statutory actions' to identify polygons which under the ES classification (Table 1) would not be considered conservation (see Appendix 1c). These areas were assigned a PAN-NZ code as shown in Table 4.

Table 4: Land use categories and respective PAN-NZ code determined from the status phrase classifications in the PAN-NZ database.

Category	PANNZ Code	PAN-NZ Status Phrase
Conservation	CON	Local Purpose Reserve (Environment and Landscape Protection), Local Purpose Reserve (Conservation), Government Purpose Reserve (Wildlife Management), Wildlife Management Reserve, Wilderness Area, Stewardship Area, Scientific Reserve (Private Land), Scientific Reserve, Scenic Reserve (Private Land), Scenic Reserve, Nature Reserve, National Park
Public Use	PUB	Government Purpose Reserve (Lighthouse), Government Purpose Reserve (Police), Government Purpose Reserve (Purpose Not Specified), Historic Reserve, Local Purpose Reserve (Access and Car Park), Local Purpose Reserve (Accessway), Local Purpose Reserve (Afforestation), Local Purpose Reserve (Beautification), Local Purpose Reserve (Car Park), Local Purpose Reserve (Cemetery), Local Purpose Reserve (Childcare Centre), Local Purpose Reserve (Community Buildings), Local Purpose Reserve (Community Centre), Local Purpose Reserve (Community Hall and Education), Local Purpose Reserve (Drainage), Ferry Reserve, Esplanade Strip, Crown Land (Water Race), Crown Land (Cemetery Reserve), Burial Ground (Private Land), Burial Ground, Amenity Area, Conservation Park, Ecological Area, Local Purpose Reserve (Esplanade), Local Purpose Reserve (Fire Station), Local Purpose Reserve (Floodway), Local Purpose Reserve (Gravel), Local Purpose Reserve (Hall), Local Purpose Reserve (Kindergarten), Local Purpose Reserve (Landscape), Local Purpose Reserve (Library), Local Purpose Reserve (Municipal), Local Purpose Reserve (Museum), Local Purpose Reserve (Plantation), Local Purpose Reserve (Playcentre), Local Purpose Reserve (Plunket), Local Purpose Reserve (Public Convenience), Local Purpose Reserve (Public Hall), Local Purpose Reserve (Public Utility), Local Purpose Reserve (Purpose Not Specified), Local Purpose Reserve (Quarry), Local Purpose Reserve (Refuse Disposal), Local Purpose Reserve (River Control), Local Purpose Reserve (Road), Local Purpose Reserve (Segregation Strip), Local Purpose Reserve (Service Lane), Local Purpose Reserve (Soil Conservation and River Control), Local Purpose Reserve (Utility), Local Purpose Reserve (War Memorial), Local Purpose Reserve (Water Supply), Maori Reservation (Marae), Marginal Strip (Fixed), River Protection, Road Reserve, Soil Conservation and River Control, Water Conservation Reserve, Water Race Reserve, Water Reservoir, Water Supply Purposes, Waterworks
Recreational Use	REC	Local Purpose Reserve (Recreation), Recreation Reserve, Local Purpose Reserve (Recreation, Cultural Buildings and Associated Activities) , Local Purpose Reserve (Recreation)
Lakes and Rivers	HYDRO	River Bed
Coastal Marine Area	MARINE	Marine Reserve, Sea Bed
Unknown	UNK	Areas without a status phrase

6.1.4. Environment Southland Resource Consent Database

The Dairy Consent layer was exported from the ES database on 17th April 2015. A definition query was applied to the 'Status' field to select for only 'Active' and 'Expired - Section 124 Protection' consents.

The layer was modified to remove duplicate polygons, which exist due to multiple resource consents for the same piece of land. Duplicate polygons were identified by intersecting the GIS layer with itself. This creates an output layer which shows spatially where duplicates occur. Once identified the duplicate was deleted, retaining the record with the 'active' status. Polygons with the same IRIS_ID were dissolved to form one polygon for the property. These polygons could be contiguous or non-contiguous. ES codes of DAICOW and DAISHP were applied to the respective dairy cow and dairy sheep polygons.

The Dairy consent layer contains additional details about the consent in a text field, which was deemed useful information to incorporate into the land use map. To allow for this information to be quickly accessed, additional attribute fields were added to the layer for maximum cow numbers ('Max_consen'), structures present ('DAI_Struct') and maximum number of cows wintering on ('MaxWintOn'). These fields were populated manually with information from the 'Details' text field within the dairy consent layer.

6.1.5. Agribase

To overcome some of the limitations identified in Section 4.2, a set of rules were developed to classify land use in Agribase™ before its use in the Southland Land Use Map. This reclassification ensures consistency in land use categories and removes duplicate or overlapping records within the dataset. These rules are intended to be followed in sequential order to allow for a reproducible and consistent land use classification.

The starting layer is titled 'Agribase_April_2015'. This layer contains a number of attribute fields that were not necessary for ES purposes and were turned off. The fields that were retained are as follows with the field name identified in brackets:

- Unique farm identifier assigned by AsureQuality Ltd. ('Farm ID')
- Property type ('Farm Type')
- Total area of property in hectares as reported by farmer/occupier, rounded to one decimal place ('Size ha')
- Date record was added to Agribase™ ('Source date')
- Land area devoted to livestock ('aaa_ha')
- Arable land ('ara_ha')
- Beef numbers ('bef_no')
- Sheep numbers ('shp_no')
- Dairy cattle numbers ('dai_no')
- Deer numbers ('dee_no')
- Flowers ('flow_ha')
- Fodder (' fodd_ha')
- Forestry ('for_ha')
- Grazing other peoples stock ('graz_ha')
- Native bush ('nat_ha')

In ‘Agribase_April_2015’, text fields were added to record the changes made to the Agribase dataset. Two fields were added, called ‘Agri_Code’ and ‘Agri_Code2’ to record the new ES land use classification of the polygon. A two code system was implemented to allow for multiple land uses. Additional text fields were added for each rule (Rule 1 to 10) to record which rules were applied to each polygon where changes were made. These fields were populated manually using the field calculator after each rule is queried. The rules are intended to be performed in a sequential order as ‘Agri_Code’ or ‘Agri_Code 2’ may be reclassified again as the rules are implemented. Table 5 shows the Farm Type code as described by the Agribase™ database and the new ES assigned Agri code. New codes developed as part of the reclassification process do not have a farm type code from Agribase™. Where Agribase™ Farm Types exist, the description is obtained from AsureQuality.

Table 5: Farm type as identified in Agribase and respective Agri code used by ES.

Farm Type Code	Description	Agri Code
ALA	Alpaca and or lama breeding	OAN
API	Beekeeping and hives	OAN
ARA	Arable cropping or seed production	ARA
BEF	Beef cattle farming	BEF
DAI	Dairy cattle farming	DAICOW
-	Dairy sheep farming	DAISHP
DEE	Deer farming	DEE
-	Majority deer farming - minor sheep stock	DEESHP
-	Majority deer farming - minor beef stock	DEEBEF
-	Majority deer farming - minor sheep and beef	DEESNB
DOG	Dogs	OAN
DRY	Dairy dry stock	DAISUP
FLO	Flowers	FLO
FRU	Fruit growing	FRU
GOA	Goat farming	OAN
GRA	Grazing other peoples stock	LIVSUP
HOR	Horse farming and breeding	OAN
LIF	Lifestyle block	LIF
-	Small land holding	SMH
-	Temporary code to indicate presence for reclassification	LIVESTOCK
NAT	Native bush	CON2
NEW	New Record- Unconfirmed farm type	UNK
NOF	Not farmed (i.e. idle land or non-farm use)	UNK
NUR	Plant nurseries	NUR
MTW	Meat works	IND
OAN	Other livestock (not covered by other types)	OAN
OST	Ostrich bird farming	OAN
OTH	Enterprises not covered by other classifications	UNK
PIG	Pig farming	OAN
POU	Poultry farming	OAN
SHP	Sheep farming	SHP
SNB	Mixed sheep and beef farming	SNB
-	Mixed sheep and deer farming	SND
-	Mixed beef and deer farming	BND
-	Mixed sheep, beef and deer farming	SBD
TOU	Tourism (i.e. camping ground, motel)	TOU
UNS	Unspecified (farmer did not give indication)	UNK
ZOO	Zoological gardens	OAN

The reclassification rules developed by ES to ensure a consistent classification are listed below and rules and sub-rules explained further in this section.

- Rule 1: Remove duplicate and overlapping land parcels
- Rule 2: Retain speciality land types
- Rule 3: Identify support properties
- Rule 4: Identify Dairy
- Rule 5: Identify other livestock (sheep, beef, deer)
- Rule 6: Identify arable and mixed livestock
- Rule 7: Identify lifestyle and small holdings
- Rule 8: Identify native properties
- Rule 9: Classify remaining Agribse dairy, sheep , beef and deer farm types
- Rule 10: Classify other farm types

'Source date' in 'Agribase_April_2015' specifies the month, day, year, and time a record was created. In this format, these records are not able to be sorted by chronological order in ArcMap, as the sort feature is limited to month and day only. A 'Year' text field was added to the attribute table and populated using 'select by attributes' ('SOURCE_DAT' LIKE '%2015%') and the field calculator (Year = 2015). This process was undertaken for each year records existed (from 1995 to 2015), to allow for records to be easily sorted chronologically and provenance of data to be ascertained.

See Appendix 1d for detail of all GIS commands and queries used to reclassify Agribase™.

RULE 1: Duplicate and overlapping land parcels

For some properties there are duplicate polygons caused by a number of reasons. These are either:

- Legitimate overlaps produced from the landowner providing information for the whole property and a land occupier/manager providing information on the leased section of land
- Properties that have been subdivided
- Properties that have been amalgamated
- Erroneous duplicates caused by updates added as new records in Agribase creating a new Farm_ID for the same property.

The native classification in Agribase (NAT) is one large multipart polygon and caused 16 overlaps with other farm polygons. To correct for this error NAT was removed by applying a definition query, excluding NAT in the Agribase layer and native areas were addressed by Rule 8 in the classification.

Duplicate and overlapping records were identified by intersecting the Agribase_April_2015 layer with itself, which produced an output (Agribase_Duplicate) of 313 polygons where duplicate information existed (excluding NAT). The affected polygons in Agribase_April_2015 were identified by 'Select by Location' using Agribase_Duplicate as the source layer and 'contain the source layer feature' as the spatial selection method. The resulting selection returned 275

polygons where duplicate/overlapping polygons exist. The reduction in the number of polygons selected is a result of two or more overlaps occurring with the same polygon. The data was exported as 'Agribase _Rule1'.

Manual corrections were made on a farm by farm basis to ensure all records were adjusted in the intended manner and the Rule 1 field populated with either a, b, or c to identify specific situations. Rule 1a identifies duplicate polygons that are identical and the record with the most recent date is retained (Figure 8). Rule 1b and 1c identifies overlapping polygons where a part of a property has a shared record with another property (Figure 8). To correct for this overlap the polygon with the most recent date is retained (1b). The other polygon is amended to not include the overlapping area (1c). Rule 1c polygons now have an area different to that of the original record and the original Agribase™ classification is retained. The definition query on NAT was removed and Rule c applied with the Agribase™ record retained and the overlapping areas removed from Agribase™.

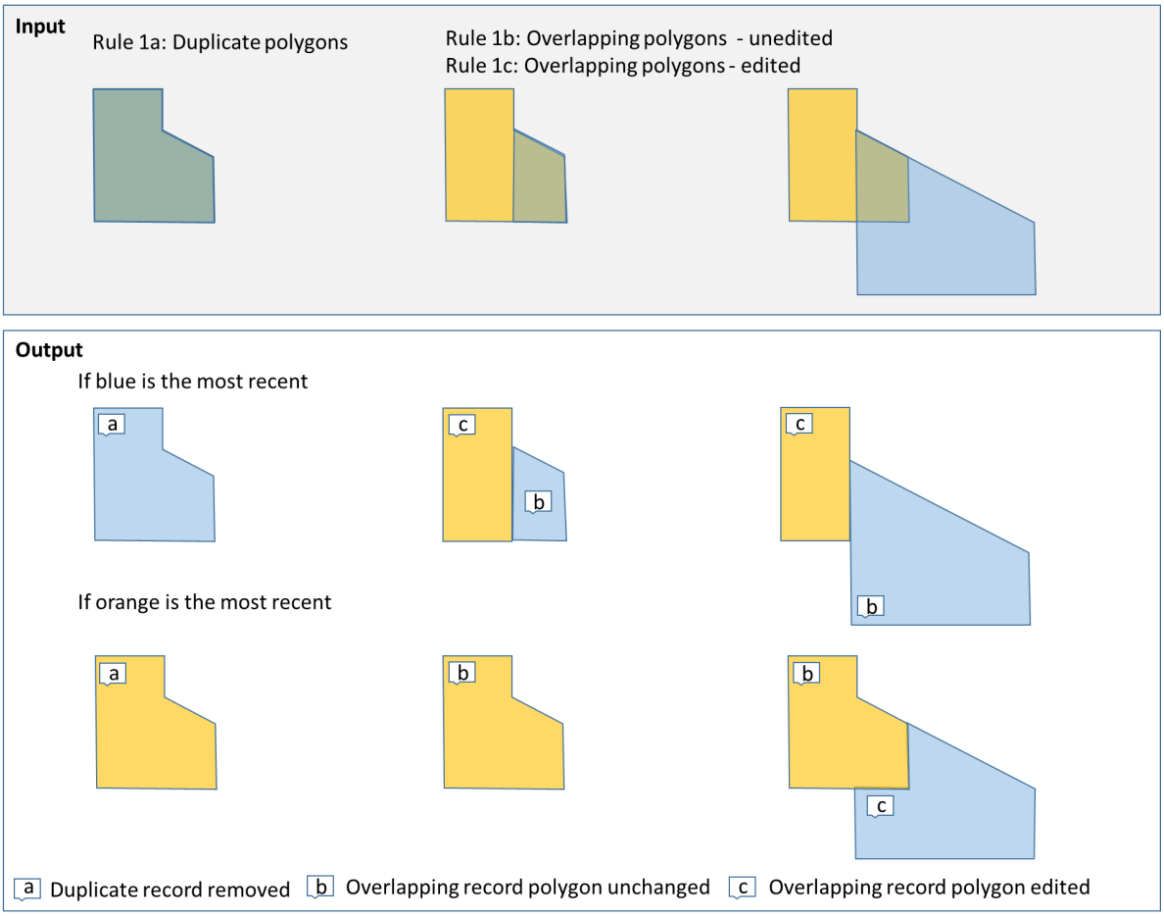


Figure 8: Changes to Agribase™ polygons from Rule 1.

RULE 1a: Duplicate record - If the polygon is identical to the source layer feature remove duplicate polygon by keeping that with most recent date.

RULE 1b: Overlapping record - If the polygon is contained within the source layer feature and has the most recent date.

RULE 1c: Overlapping record - If the polygon is contained within the source layer feature and does not have the most recent date, amend polygon to remove overlap. 'Agri_Code' is classified as Agribase FARM_TYPE.

RULE 2: Speciality land types

For some land uses, Agribase™ was determined to be the most reliable source of information. These land uses listed below were retained by RULE 2:

- Forestry (FOR)
- Arable (ARA)
- Flowers (FLO)
- Fruit (FRU)
- Nursery (NUR)
- Tourism (TOU)
- Vegetables (VEG)
- Meat works (MTW)
- Zoological garden (ZOO)
- Bee keeping (API)
- Alpacas (ALA)
- Dogs (DOG)
- Goats (GOA)
- Horses (HOR)
- Other animals (OAN)
- Ostrich birds (OST)
- Pigs (PIG)
- Poultry (POU)

These farm types are separated by Rule 2 into the land use categories identified in Table 1. Rule 2a retains the classification provided by Agribase™, Rule 2b combines all animal types that are not sheep, beef, deer or dairy cows into a classification for other animals, and Rule c classifies meat works as industry.

A recommendation by Rutledge et al. (2016), which was not implemented, was that to map pigs as a separate land use category. The decision not to follow this recommendation was that pigs are such a minor land use in Southland, with only two farm types classified as PIG in Agribase™. However, as this classification allows for a farm type to be retained as a speciality land type under Rule 2a, it is possible to separate out any farm type as in individual classification in future classifications.

RULE 2a: Where Agribase classifies farms as FOR, ARA, FLO, FRU, NUR, TOU, and VEG, 'Agri_Code' is the same.
RULE 2b: Where Agribase classifies farms as API, ALA, DOG, GOA, HOR, OAN, OST, PIG, POU, and ZOO, 'Agri_Code' classification is OAN for Other Animals.
RULE 2c: Where Agribase classifies farms as MTW, 'Agri_Code' is IND for industry.

RULE 3: Support properties

Properties which are used for grazing of other peoples stock or are used to raise young stock are often considered support areas for other industries. There are three classifications in the Agribase™ database which could be used to identify support properties and form Rule 3a-c. Table 1 identifies two classifications for support properties, dairy support and other livestock. It is likely that both these categories are used primarily for dairy support; however the properties which are identified as livestock support (LIVSUP) contain none or limited stock type

information. Those that are identified as dairy support (DAISUP) are either runoff blocks (classified further in Rule 4) or specifically identified as dairy grazing.

In the Agribase™ dataset, the farm type for identifying dairy dry stock is DRY. This category was classified as Dairy Support (DAISUP) by RULE3a. Agribase Grazing (GRA) category, defined as grazing other peoples stock, will be classified as Livestock Support (Rule 6b). Other planted types (OPL) with fodder crops (fodd_ha) identified as greater than 50 % of the farm area, are classified as Livestock Support (LIVSUP) (RULE 6c).

RULE 3a: Where Agribase classifies farms as DRY, 'Agri_Code' is classified as DAISUP for dairy support.
RULE 3b: Where Agribase classifies farms as GRA, 'Agri_Code' is classified as LIVSUP for livestock support.
RULE 3c: Where Agribase classifies farms as OPL with Fodd_ha > 50% of farm area, 'Agri_Code' is classified as LIVSUP for livestock support.

RULE 4: Dairy

Properties that are identified as Dairy (DAI) in Agribase™ are classified in a way which will supplement the ES Dairy Resource Consent data in classifying this land use in the Southland Land Use Map. This rule would require modification if supplementary information was unavailable.

While the ES Dairy Resource Consent layer was used to identify the position of the milking platform, Agribase™ data was used to determine runoff blocks (DAISUP) and small holdings with less than 100 dairy cows (DAI), which are not captured by resource consent. A minimum of 10 dairy cow numbers will be used to define a dairy property. Sheep milking properties are also identified in the ES Dairy Resource Consent layer and are given the Agri Code of DAISHP.

Other livestock present on a dairy property needs to be accounted for as some properties have both dairy and have other livestock on hill country blocks. On these farms, the farm type recorded in Agribase™ is DAI. Therefore, other livestock are considered in Rule 4 based on number and type of stock calculated from Table 6. Stock units are those used at the national level by the Ministry for Primary Industries (MPI), which ES has simplified to stock type, as only total numbers are provided in Agribase™. Stock units are used in this classification to identify the main stock type on a property.

Attribute fields were added for stock factor ('Stock_Fact') to calculate the total stock units on a property, and stock factor per hectare ('SF_ha'), which was calculated from the stock unit field divided by the 'SIZE_HA' field. The 'SIZE_HA' field was deemed to provide the most accurate description of area as recorded by the landholder. Attribute fields for each stock type ('DairyStockF', 'BeefStockF', 'DeerStockF', 'SheepStockF') were also added and calculated using the stock number multiplied by the stock unit identified in Table 6.

Table 6: Averaged stock unit (adapted from Beef & Lamb benchmarking tool).

Stock type	Stock unit*
Sheep	1.0
Beef cow	5.5
Deer	2.0
Dairy cow	7.5
Grazing dairy cow	5.5
Horse	5.0
Pig	1.0
Goat	0.8

*NOTE: The resulting stock units identified in this table have been modified for use to approximate stock units based from a total stock number.

RULE 4a Non-Consented Dairy Farms: Where 'cow no's' are between 10 and 100, and other livestock contribute less than 50 stock units;

a1: If Agri Code is NULL, classify as 'DAICOW'

a2: If Agri Code is NOT NULL, classify Agri Code2 as 'DAICOW'

RULE 4b Consented Dairy Farms: Where 'cow_no's' are greater than 100, and other livestock contribute less than 50 stock units;

b1: If Agri Code is NULL, classify as 'DAI'

b2: If Agri Code is NOT NULL, classify Agri Code2 as 'DAI'

RULE 4c Non-Consented Dairy Farms with Other Livestock: Where 'cow_no's' are between 10 - 100, and other livestock contribute more than 50 stock units;

c1: If dairy has the higher stock factor Agri Code is DAICOW and Agri Code 2 is LIVESTOCK (to be reclassified by RULE 5)

c2: Agri Code is LIVESTOCK (to be reclassified by RULE 5) if other livestock have a higher combined stock factor and Agri Code2 is DAICOW

RULE 4d Consented Dairy Farms with Other Livestock: Where 'cow_no's' are greater than 100, and other livestock contribute more than 50 stock units;

d1: If Agri Code is NULL classify as 'DAICOW' and Agri Code2 as 'LIVESTOCK'

d2: If Agri Code is NOT NULL classify Agri Code2 as 'LIVESTOCK' (to be reclassified by RULE 5)

RULE 5: Other Livestock (Sheep, Beef, Deer)

Drystock is a general classification given to Sheep, Beef and Deer farms in OVERSEER® and is the terminology used to describe this farm type in the Land Use Map for consistency with the OVERSEER® model in Stage 2.

Drystock farm classifications varied greatly in Agribase depending on how the person completing the survey assessed the land use. To minimise this variation in farm classification, a set of rules were developed based on stock units to assess land use (Table 6). Based on the ES classification, 50 sheep is approximately equal to 25 deer or 9 beef cows.

A minimum stock factor of 50 (50 sheep/25 deer/9 beef) was applied to this land use type. Using this classification system, the main stock type was identified for each property by the Agri Code used. An indication of intensity of the land use was also given by the stock factor/ha field ('SF_ha'). See Appendix 1d for more information.

If properties have an existing Agri Code of ARA the code for other livestock is entered in Agri Code2.

Speciality farm type – One stock type

RULE 5a Sheep Farms: Where the sheep stock factor is greater than 50 and the combined beef and deer stock factor is less than 50;

a1: If Agri Code is NULL classify as 'SHP'

a2: If Agri Code is NOT NULL classify Agri Code2 as 'SHP'

RULE 5b Beef Farms: Where the beef stock factor is greater than 50 and the combined sheep and deer stock factor is less than 50;

b1: If Agri Code is NULL classify as 'BEF'

b2: If Agri Code is NOT NULL classify Agri Code2 as 'BEF'

RULE 5c Deer Farms: Where the deer stock factor is greater than 50 and the combined sheep and beef stock factor is less than 50;

c1: If Agri Code is NULL classify as 'DEE'

c2: If Agri Code is NOT NULL classify Agri Code2 as 'DEE'

Mixed farm types – Two or more stock types

RULE 5d Sheep and Beef Farms: Where both sheep and beef stock factors are greater than 50, with deer stock factor is less than 50;

d1: If Agri Code is NULL classify as 'SNB'

d2: If Agri Code is NOT NULL classify Agri Code2 as 'SNB'

RULE 5e Sheep and Deer Farms: Where both sheep and deer stock factors are greater than 50, with beef stock factor is less than 50;

e1: If Agri Code is NULL classify as 'SND'

e2: If Agri Code is NOT NULL classify Agri Code2 as 'SND'

RULE 5f Beef and Deer Farms: Where both beef and deer stock factors are greater than 50, with sheep stock factor is less than 50;

f1: If Agri Code is NULL classify as 'BND'

f2: If Agri Code is NOT NULL classify Agri Code2 as 'BND'

RULE 5g Mixed Livestock Farms: Where beef, deer and sheep stock factors are greater than 50;

g1: If Agri Code is NULL classify as 'SBD'

g2: If Agri Code is NOT NULL classify Agri Code2 as 'SBD'

Mixed farm types – Majority deer farms with other livestock (reclassification of RULES 5e-g)

RULE 5h Majority Deer Farms with other livestock: Where the deer stock factor is greater than the other stock factor/s:

h1: If Agri Code is SND reclassify as 'DEESHP'

h2: If Agri Code2 is SND reclassify Agri Code2 as 'DEESHP'

h3: If Agri Code is BND reclassify as 'DEEBEF'
h4: If Agri Code2 is BND reclassify Agri Code2 as 'DEEBEF'
h5: If Agri Code is SNB reclassify as 'DEESNB'
h6: If Agri Code2 is SNB reclassify Agri Code2 as 'DEESNB'

RULE 6: Arable and Mixed Livestock

Arable farms were previously classified by Rule 2a when Agribase™ classified the farm type as ARA. Rule 5, subsequently classified ARA farms which had additional livestock numbers. However, farms classified by Rule 4 and 5, with arable as a secondary land use would not have been identified in this classification. Therefore, Rule 6 identifies properties which have a large amount of arable hectares.

If arable hectares (ara_ha) are greater than 20% of a property area, a secondary code (Agri Code2) of ARA is applied. If properties already have an 'Agri Code2' they have been previously classified as dairy support or livestock support and arable crops are deemed to be grown for the support of livestock under that land use. The 20% threshold was determined with consultation with FAR and Beef+LambNZ Ltd.

RULE 5a: Properties classified in Rule 4 and 5, with greater than 20% of the farm area recorded as arable hectares, are classified as 'Agri Code2' ARA.

RULE 7: Lifestyle blocks and Small holdings

For the purposes of the land use map a lifestyle (LIF) block is defined by RULE 7a as a rural property between 0.1 and 5 ha. This size limit was selected to include the typical lifestyle block of 4 ha (10 acre) plus one hectare to include slightly larger lifestyle properties. Small holdings are classified as properties between 5 and 40 hectares as defined by Rule 7b. Properties which had been previously classified by Rules 2-6 remain unchanged.

RULE 7a: Lifestyle blocks are defined as rural properties between 0.1 and 5 ha and are classified as LIF.
RULE 7b: Small Holdings are properties between 5 ha and 40 ha and are classified as SMH.

RULE 8: Native properties

Properties that are classified as NAT in Agribase™, that have not been previously classified by the above rules, are classified as CON2. These areas are native cover but may not be under any conservation protection status. As PAN-NZ data will be used to identify conservation areas over Agribase™, these areas will be classified as Unknown land use - Indigenous cover.

RULE 8: Agribase classification of NAT is classified to CON_2.

RULE 9: Remaining Agribase Dairy, Sheep, Beef and Deer farm types

The properties remaining without classification in Agribase either do not have stock numbers for the property or were unable to be classified by RULEs 4-5 as their combined stock factors were less than the 50 stock unit thresholds. In RULE 7 properties less than 40 ha were given an 'Agri Code' of LIF or SMH.

RULE 9a: Properties with an 'Agri_Code' of LIF or SMH that have an Agribase farm type classification of DAI, SHP, BEF, SNB or DEE the 'Agri_Code2' field is classified the same as the Agribase farm type (DAI, SHP, BEF, SNB or DEE).

RULE 9b: Properties with an Agribase farm type classification of DAI, SHP, BEF, SNB or DEE that remain unclassified, the 'AgriCode' field is classified the same as the Agribase farm type (DAI, SHP, BEF, SNB or DEE).

RULE 9c: Properties with an 'Agri_Code' of LIF or SMH with the sum of DAI, SHP, BEF, or DEE stock factors >50 are classified by the combination of stock present on the property.

RULE 10: Other farm types

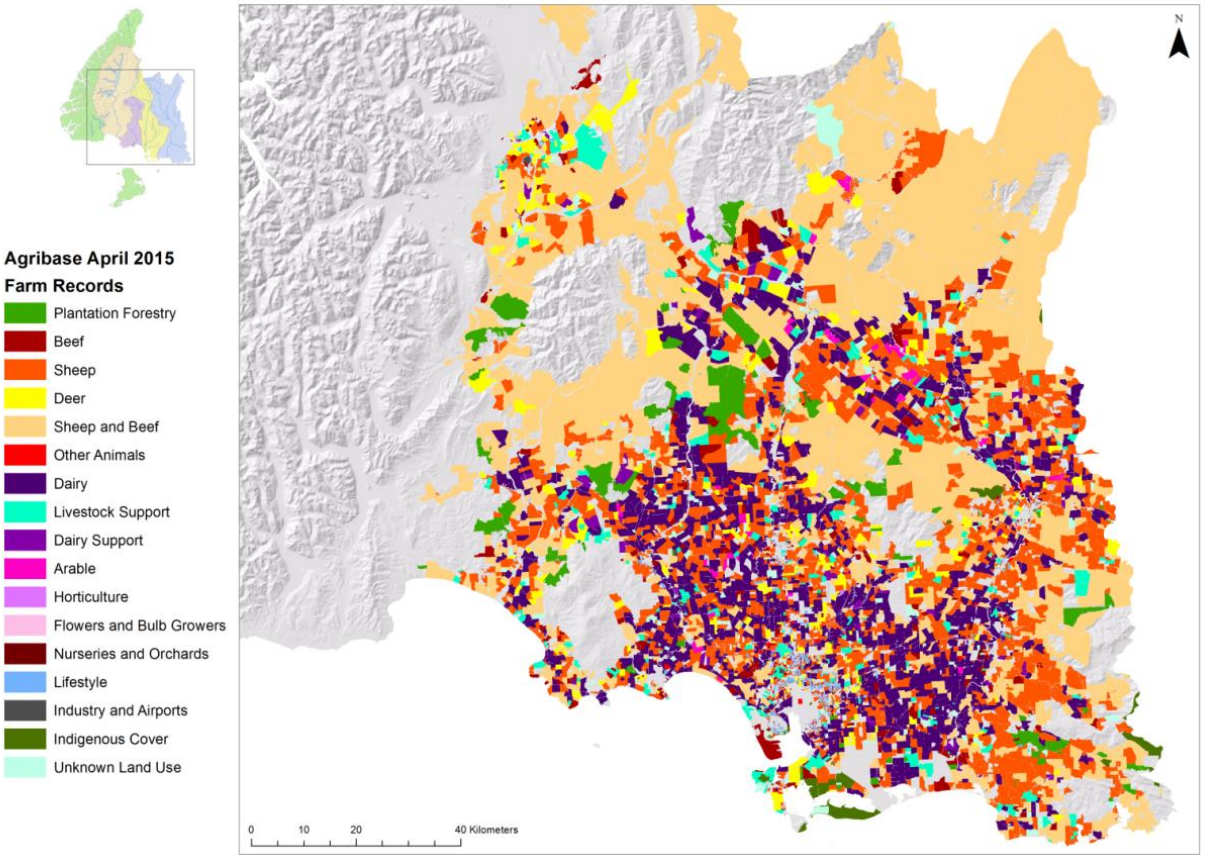
Properties that were not able to be classified by RULEs 1-9 are classified as unknown land use (UNK). These properties will be reclassified through other data sources where possible.

RULE 10: Properties remaining in Agribase without an 'Agri_Code' are classified as Unknown (UNK).

Agribase Reclassification Summary

Rules 1-9 allowed for the reclassification of 6104 polygons (98%) in the Agribase_April_2015 dataset (Figure 9). The reclassification process greatly improved the representation of arable, deer and mixed livestock properties, while reducing the number of sheep only properties. The reclassification process removed the bias in the farm type classification, as many farms are no longer influenced by a landowner/occupier land use classification, and are not classified by a presence or absence of stock on the property.

There were 97 polygons that were given a classification of Unknown by Rule 10. These polygons are often new farms to Agribase™ (Agribase Farm Type NEW) and remain to be verified. These polygons typically contain no land use information other than a property boundary and a Farm ID. Unknown polygons will be classified along with other unknown parcels by LCDB 4.1 (Section 6.2).



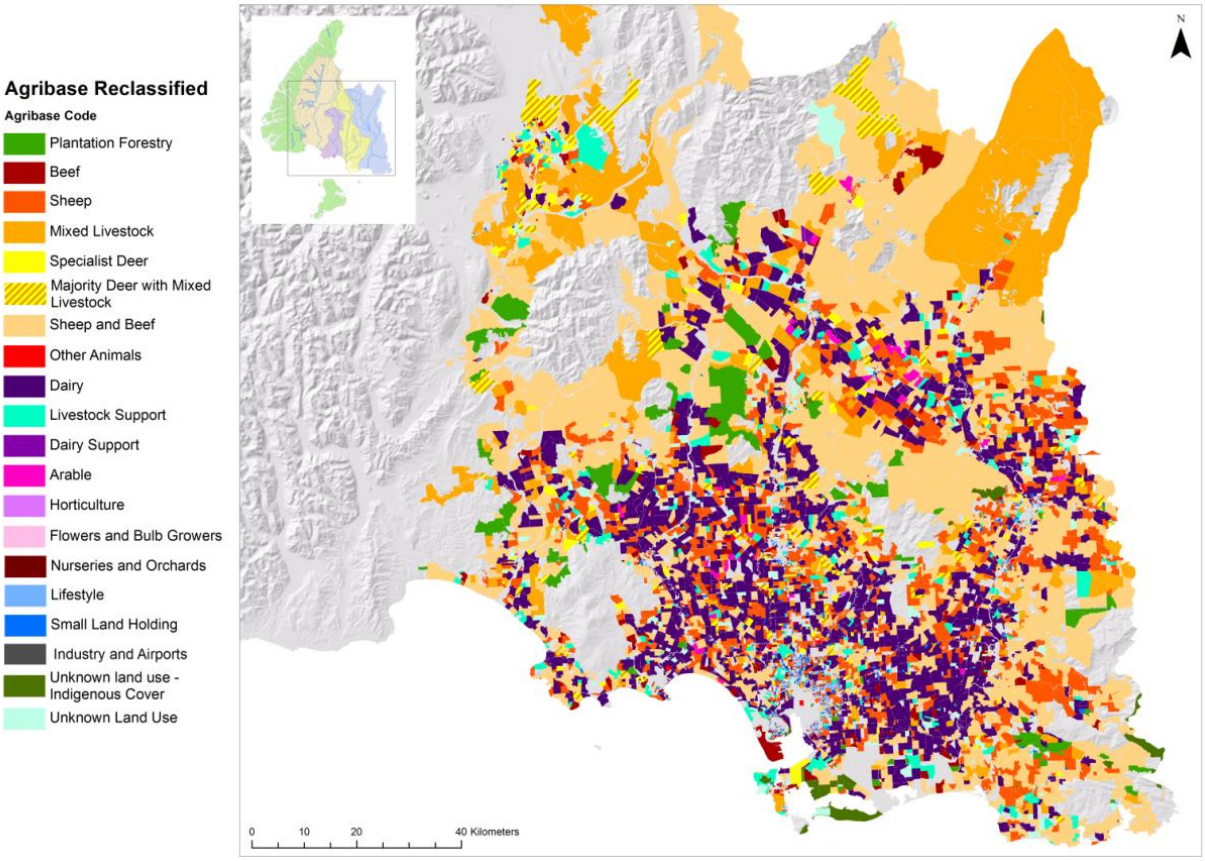


Figure 9: Agribase classification before (top) and after (bottom) Environment Southland's classification rules were applied.

6.1.6. Modification of LCDB4.1

The land cover categories of LCDB4.1 were simplified to combine land covers of similar land use. The 33 land cover categories were simplified to 16 categories and given a LCDB code for easy identification (Table 7). Table 5 shows the LCDB4.1 categories which were combined to produce a land cover classification. This land cover layer was then intersected with the land use map to provide land cover in hectares for each parcel.

Wetlands in the Southland Land Use Map are identified currently by LCDB4.1. ES is currently producing a higher resolution layer of wetland locations on private property mapped directly from aerial photography (Ewans, 2015). This layer was incomplete at the time the Southland Land Use Map was constructed; however in future updates this layer could be used to improve spatial locations of wetlands.

Table 7: LCDB v4.1 land use categories for additional land uses/land cover.

Land cover	LCDB 4.1 categories	LCDB CODE
Native Forest	Indigenous forest, Broadleaved Indigenous Hardwoods	NAT
Exotic Forest	Exotic forest, Forest Harvested, Deciduous hardwoods	EXTFOR
Native Scrub and Shrubland	Flaxland, Fernland, Manuka and/or Kanuka, Matagouri or Grey Scrub, and Sub-Alpine Shrubland.	NSCRUB
Exotic Scrub and Shrubland	Gorse and/or Broom, Mixed Exotic Shrubland	ESCRUB
Pasture	High producing exotic grassland Low producing grassland and depleted grassland	PAS LPAS
Alpine grass and Tall Tussock	Alpine grass/Herbfield, Tall Tussock Grassland	TUSSOCK
Arable	Short rotation cropland	ARAB
Horticulture	Orchard, Vineyard or Other Perennial Crop	HORT
Bare Ground	Gravel or Rock, Sand or Gravel, Landslide	BARE
Permanent Snow and Ice	Permanent Snow and Ice	PERMS
Wetlands	Herbaceous Freshwater Vegetation	WETL
Surface Mines and Dumps	Surface Mine or Dump	MINE
Road	Transport Infrastructure	ROAD
Residential	Built-up Area (settlement)	RES
Recreation	Urban Parkland/Open Space	REC
Hydro	Estuarine Open Water, Lake or Pond, River	HYDRO
Estuary	Herbaceous Saline Vegetation	ESTR

6.2. Primary Parcels Southland Land Use Map

To combine the individual data sources into a land use map, the Primary Parcel layer was used as a framework for which land uses classifications were assigned. Priority was given to data sources which were identified as the most recent source for each land use. The order in which data sources were used is as follows:

- Rates 2012
- Recreation - Golf
- Environment Southland Industry
- Plantation Forestry and Indigenous forestry
- Environment Southland Dairy (Milking platform only)
- Modified Agribase
- Modified PAN-NZ
- QEII Covenants
- LCDB v4.1
- Arable cropping farms

Modified LCDB4.1 was used to classify the unknown land uses of pastoral use, indigenous cover, and non-agricultural in the Southland Land Use Map. The land cover layer can also be used in conjunction with the land use map (by overlaying the two layers) to examine the relationship of land use to land cover, as illustrated in Figure 10. Land cover provides spatial representation of effective area (grazed) compared to ineffective areas on farms (woodlots, wetlands), intensive pasture compared to extensive pastoral grazing (tussock grasslands), and the overlapping of agricultural industries. For example, arable, tulip bulb growers, horticulture and support land uses are those most often located on properties which are identified as other land uses. This is due to the rotation of crops and the reliance on lease land from other agricultural sectors (i.e. sheep and beef). LCDB v4.1 was used to identify areas which were not under pasture to spatially represent the areas of additional land uses or ineffective areas on properties, especially in the sheep, beef and deer industries. It was also used to identify exotic forestry on private land, which contributes to forestry production in Southland. The layer was also used to improve land cover information for native vegetation into more defined categories, such as scrub and shrubland and alpine and tussock grasslands, identify areas of exotic scrub and shrubland, wetlands, bare ground, permanent snow and ice and surface mines.

Illustrated above the Southland Land Use Map in Figure 10, are the layers to identify where ES policies will apply, either by FMU or Physiographic Unit. The LINZ property layer can also be used in conjunction with the land use map so private property details i.e. names and addresses are not included within the land use map and remain confidential to external users.

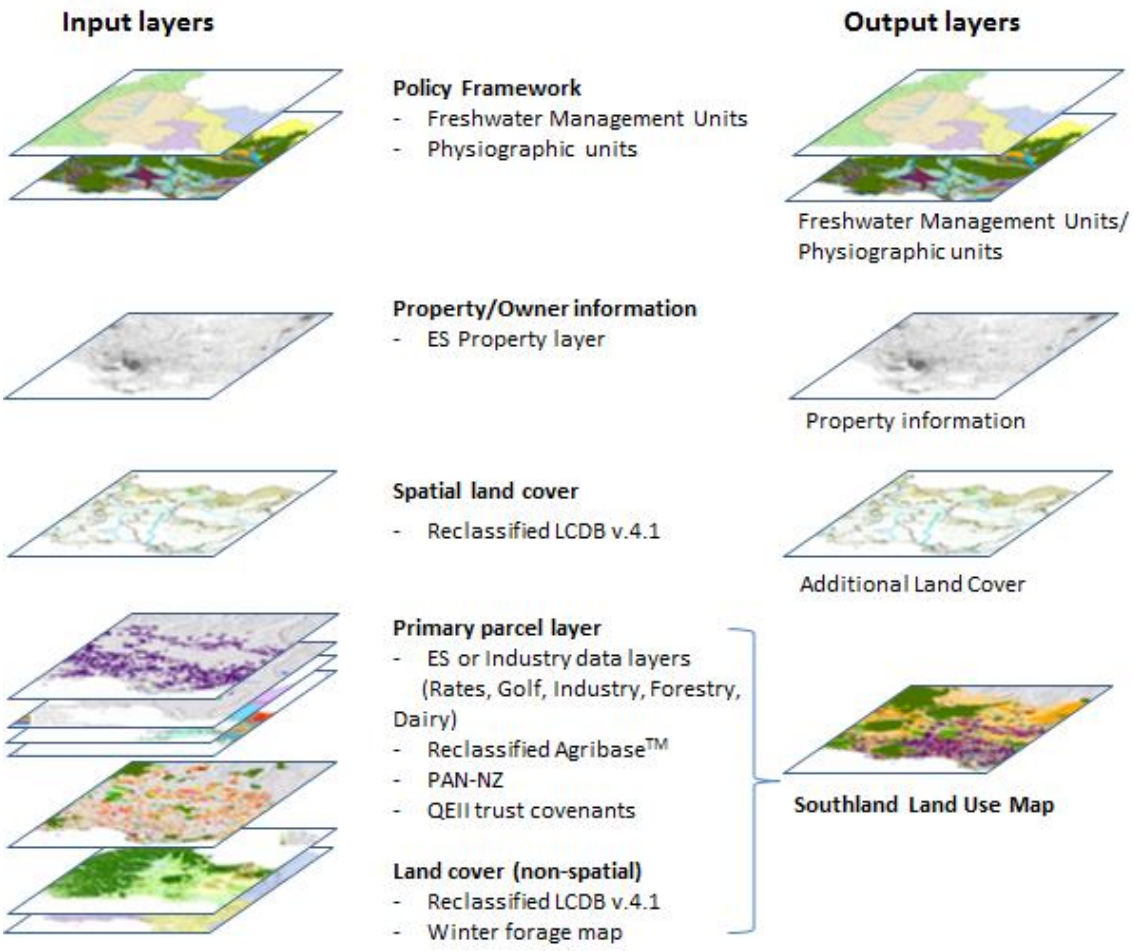


Figure 10: Hierarchy for compiling the Southland Land Use Map and associated layers.

6.2.1. Classification of parcels within the primary parcel layer

Land use classification of parcels was done by populating data into the text fields added in Section 6.1.1. The primary parcels layer was named 'LINZ_Parcels_Southland'. Prior to the addition of data sources to 'LINZ_Parcels_Southland', the land use information contained within this layer for roads, rail and hydro parcels were classified with the aid of Topo50 map series data. The Topo50 data was used select features within the 'LINZ_Parcels_Southland' layer that were of interest, but the data from Topo50 was not directly inputted into the primary parcel layer.

Roads were identified using the 'Select by location' feature between 'LINZ_Parcels_Southland' and 'Road_Centrelines' ('Target Layer' as LINZ_Parcels_Southland, 'Source Layer' as 'Road_Centrelines' with spatial selection method 'intersect the source layer feature'). Within the selection, a 'Select by attributes' was made with the parcel intent as 'Road' and the result classified as 'ROAD' in 'ES_Code' using the field calculator (Appendix 2a). This method was repeated with the Rail_Centrelines to identify Rail and classified as 'RAIL' in 'ES_Code' (Appendix 2b). If a road/rail parcel did not have a centerline directly on the parcel it remains unclassified. This aids in the identification of paper roads, which will be classified by the land use of the property they are on in subsequent steps.

Parcel intent of 'Hydro' was selected within the 'LINZ_Parcels_Southland' layer to preliminarily classify lakes and rivers by assigning an ES Code of HYDRO (Appendix 2c). This Hydro classification could get over written by other data sources in subsequent steps; especially as river channels have been modified since the surveying of the primary parcels layer.

6.2.2. Addition of data sources

To add land use information to the primary parcel layer ('LINZ_Parcels_Southland') the polygons were converted to points using the 'Feature to points' tool (points within polygon) (Figure 11). The data source was spatially joined to the Primary Parcel points (intersect method), which was in turn joined (by feature of Parcel_ID) to the Primary Parcels. The information from the attribute table was copied into the relevant attribute fields, and the join removed once all information was replicated between the data source and the primary parcel points. Additional fields were added as necessary to copy all desired table attributes from the data source. This method allows for information to be aligned with a polygon in the primary parcels layer even if the polygon shape is not identical. Where there are differences in polygon shape, the data is now constrained to the legal property boundary. For specific commands of how each data source was added see Appendix 2: Classifying Land Parcels.

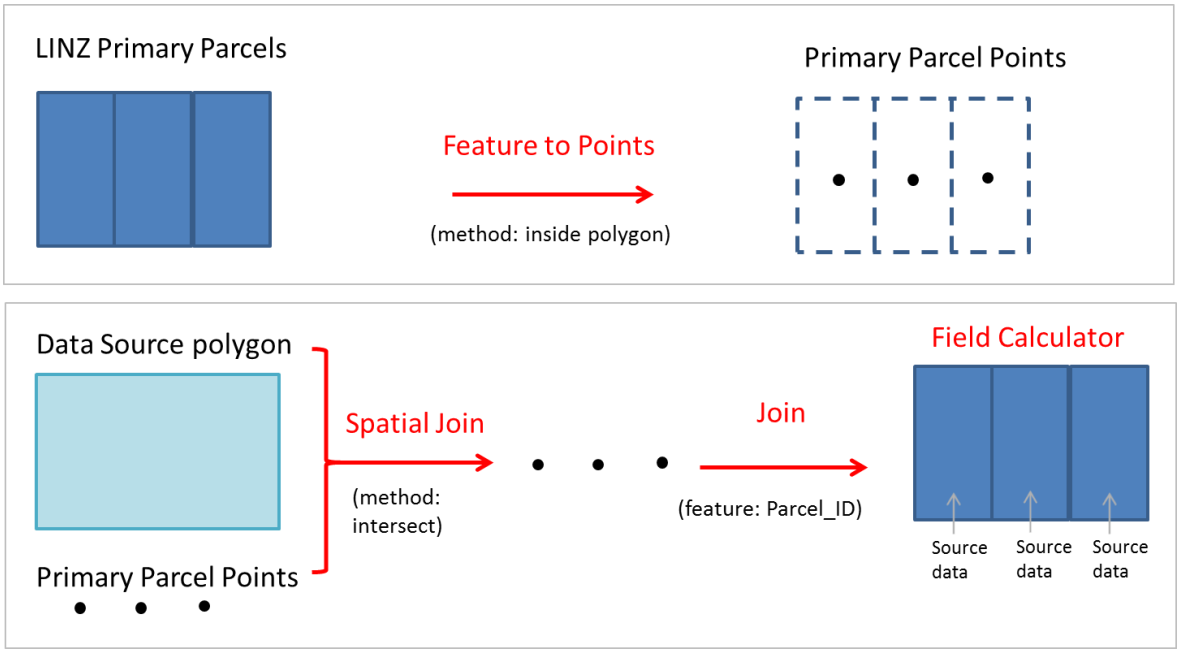


Figure 11: Input method for data sources to parcels.

The following data was added to the primary parcel layer using the above methodology.

ES Rates 2012 - Rates codes were used to inform decisions on selected land use classifications. The following six classes were attributed directly to the ES land use code ('ES_Code') within the primary parcel layer. The rates classes of 'Commercial', 'Industry', 'Public', 'Recreation', 'Residential', and 'Airports' directly received respective ES_Code's of 'COM', 'IND', 'PUB', 'REC', 'RES', and 'AIR' (Appendix 2d).

Recreation – Golf – Recreation areas including golf courses were given an ES code of REC in the step above. This data source was used to assign the ES Code2 with the code GOLF and course name in the details field (Appendix 2e).

Environment Southland Industry – This layer was used to add additional data, such as industry type to properties classified as IND by the rates 2012 data (Appendix 2f).

Plantation Forestry and Indigenous forestry – Exotic plantation forestry was assigned an ES Code of EXTFOR, while indigenous forestry was classified as INDFOR (Appendix 2g).

Environment Southland Dairy layer – Dairy cow parcels were assigned an ES Code of DAICOW and dairy sheep parcels were assigned an ES Code of DAISHP (Appendix 2h). After the addition of dairy data, the layer was exported as 'Post_Dairy_Inclusion _Export.shp'. The layer export was done after each major data addition to provide an output layer, which could be returned to in case of error in later steps.

Reclassified Agribase – The Agri Code was assigned to ES Code and Agri Code2 assigned to ES Code 2 (Appendix 2i). After the addition of the reclassified Agribase data, the layer was exported as 'Post_Agribase_9_02.shp'.

Conservation and Protected Areas (PAN-NZ) – Noted as a limitation with the PAN-NZ layer in Section 4.3, overlapping polygons exist where areas are classified as protected under two or more protection schemes, which causes the land area to be counted multiple times. The effects of these overlaps were removed by creating a hierarchy to add the source data within the PAN-NZ database to the Primary Parcel layer (Appendix 2j). PAN-NZ code, attributed in Section 6.1.3, was used to allocate the ES Code. The sequential order, based on source within PAN-NZ, was as follows:

- DOC public conservation areas
- National parks
- LINZ marginal strips
- Ngā Whenua Rāhui
- LINZ parcels with statutory actions

After the addition of PAN-NZ data, the layer was exported as 'Post_PANNZ_11_02.shp'.

Foundation of Arable Research Cropping Farms – Additional areas of arable land were identified through the cropping farms layer sourced from FAR (Figure 7). Parcels that had an Agribase record of various livestock types were assigned an ES Code2 of ARA, while parcels without any previous information were identified as ES Code ARA (Appendix 2m).

6.2.3. Addition of QEII Covenants

QEII covenants were added to the primary parcel layer ('Post_PANNZ_11_02.shp') using a different method to the data input method above. A separate shapefile containing the locations of QEII covenants was chosen over the PAN-NZ 2014 data as it was more recent, obtained from the QEII Trust in May 2015. To cut the QEII shape from the base framework of the primary parcel layer, the union tool was used. The resulting polygons were given an ES_Code of 'CON' to

indicate 'Conservation'. After the addition of QEII data, the layer was exported as 'PostQEII_11_02'. See Appendix 2k for further information.

6.2.4. Addition of LCDB.4.1

The properties yet to be assigned a ES Code, either do not possess an Agribase™ record, applicable ES Rates information, an ES consented farming enterprise, are not identified by numerous industry groups, or the protected areas network (PAN-NZ). These properties must then be classified as 'Unknown' with a sub-classification using the identified land cover (LCDB v4.1).

The classification rules were as follows:

LCDB RULES

1. The effective hectares (Eff_ha) of a parcel are calculated through an addition of arable, exotic scrub, horticultural, pastoral, and tussock hectares attributed to the land parcel.
2. The ineffective hectares (Ineff_ha) of a parcel are calculated through an addition of bare soil, estuarine, hydro, mine, indigenous forest, exotic forest, native scrub, permanent snow, residential, road, and wetland hectares attributed to the land parcel.
3. Parcels with greater than 50% of the area identified as exotic forest are classified as Plantation Forestry (FOREXT)
4. Parcels with greater than 50% of the area identified as orchard, vineyard or other perennial crop are classified as 'Horticulture' (HORT)
5. Parcels with greater than 50% of the area identified as short rotation cropland are classified as 'Arable' (ARA)
6. Parcels with greater than 50% of the area identified as native forest or native scrub are classified as 'Unknown land use – Indigenous Cover' (CON_2)
7. Parcels with greater than 50% of the area identified as effective pasture tussock or scrub are classified as 'Unknown land use – Pastoral' (PAS)
8. Parcels with greater than 50% of the area identified as ineffective forest, water, or bare ground are classified as 'Unknown land use – Non Agricultural' (UNK)

Parcels classified using LCDB v4.1, were given a 'Source' of 'LCDBv4.1' within the attribute table, to identify the Land Cover Database as the source of the information. After the addition of LCDB v4.1 data, the layer was exported as 'Post_LCDB_15_02.shp'. For further information see Appendix 2l.

6.2.5. Land Use Classification from ES Code

Once ES codes had been assigned to all parcels, they were grouped into land use classifications based on the combination of codes present for each parcel. The combination of ES codes to determine land use categories are shown in Table 8. For properties with both ES codes used, either combination of the codes, produce the same land use classification. The colours used to display the land use categories are provided in red, green, blue (RGB) format in Appendix 6.

A text field was added to the attribute table, titled 'Land_Use_C'. Definition queries were used to search for all code combinations within a category and assign a land use classification (Table 6, Appendix 2o).

Table 8: Land use categories identified by the combination of ES codes.

Category	Sub-category	Description	ES Code 1	ES Code 2
Conservation	Conservation	National parks, DOC Estate, Maori Trusts	CON	NULL
	QEII	Queen Elizabeth II National Trust	CON	NULL
Plantation Forestry	Commercial	Pinus Radiata, Douglas Fir, Eucalyptus	FOREXT	NULL
	Sustainable	Native Forest	FORNAT	NULL
Sheep and Beef	Sheep	Sheep only (other livestock <50 SU)	SHP	NULL
	Beef	Beef only (other livestock <50 SU)	BEF	NULL
	Sheep and Beef	Sheep and beef	SNB	NULL
	Mixed Livestock	Sheep, Beef and Deer	SND	NULL
			BND	NULL
			SBD	NULL
Dairy	Cows	Cow milking platform (>100 cows), structure details	DAICOW	NULL
	Cows	< 100 cows	DAI	
	Sheep	Sheep milking	DAISHP	NULL
Deer	Specialist	Deer only	DEE	NULL
	Mixed	Deer with other livestock	DEESHP	NULL
			DEEBEF	NULL
			DEESNB	NULL
Other Animals		Horses, pigs, poultry, goats, alpacas, bees, dogs etc.	OAN	NULL
Dairy Support		Runoff blocks - not on milking platform	DAISUP	DAI
				DAICOW
				ARA
Livestock Support		Graziers	LIVSUP	NULL
				LIVESTOCK
				ARA
Arable	Specialist	Short rotation crops	ARA	NULL
	Mixed Livestock	Arable and other livestock	ARA	SHP
				BEF
				DEE
				SNB
				SND
				BND
				SBD
Horticulture		Fruit and Vegetables	VEG	NULL
			HORT	NULL
Nurseries		Plant Nurseries and Orchards	NUR	NULL
			FRU	NULL
Flowers		Tulip bulb growers	FLO	NULL
Lifestyle Blocks		Sized between 0.1-5 ha	LIF	NULL
Small holdings		Sized between 5-40 ha, unknown use	SMH	NULL
Residential		Territorial authority town boundaries	RES	NULL
Commercial		Commercial properties within town boundaries	COM	NULL
Industrial and Airports		Dairy factories, Freezing works, Timber processors etc.	IND	NULL
			AIR	NULL
Public use		Schools, churches, cemeteries, etc.	PUB	NULL
Recreation and Tourism	Recreation	Sports grounds, camp grounds, tourism, etc.	REC	NULL
			TOU	NULL
	Golf	Golf courses	REC	
Lakes and Rivers		Waterbodies	HYDRO	NULL
Road and Rail		Road and Rail	ROAD	NULL
			RAIL	NULL
Unknown land use	Pastoral	Unknown use pastoral cover	PAS	NULL
	Indigenous	Unknown use indigenous cover	CON_2	NULL
	Non-agricultural	Unknown use non-agricultural	UNK	NULL

6.2.6. Land Use Classification Summary

The primary parcels land use layer is produced for the Science and GIS Teams use only and not for wider distribution around ES or external use. This layer contains all the methodology fields used to classify land uses, as well as all metadata from sources and method rules applied. Rule fields allow for the determination of how each parcel was classified and source fields to identify data source and date received/collected. Each parcel within a property contains information for the whole property and could easily be misinterpreted, which is the reasoning behind restricted access. This version can be used to track land use change at the parcel scale and produce the Southland Land Use Map at the property scale.

A summary of data sources, GIS commands and construction order for the Southland Land Use Map are shown in Figure 12. Yellow boxes represent external data sources, blue are ArcGIS tools or processes, green are GIS tool outputs, and white are construction outputs of regional land use.

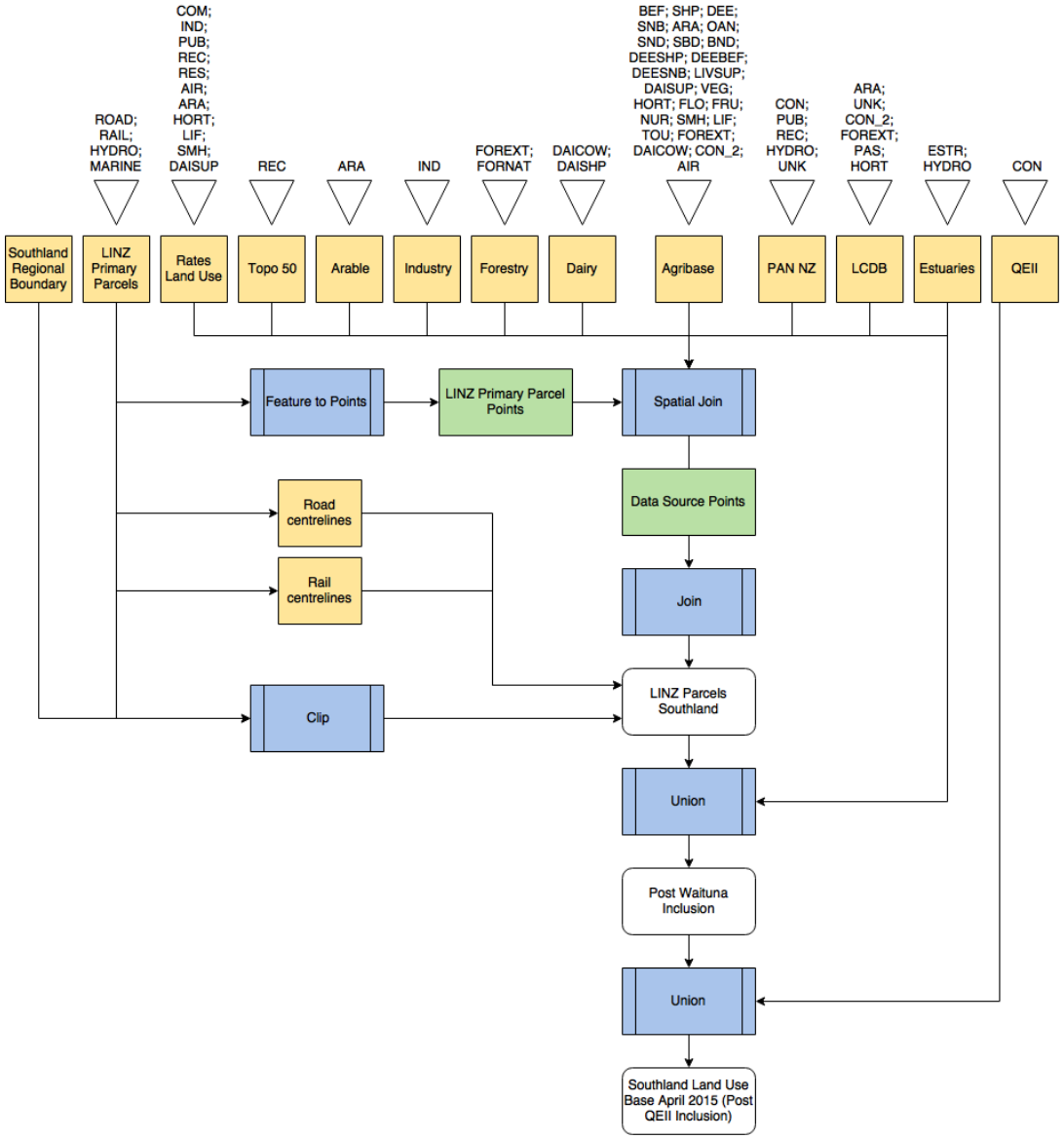


Figure 12: Summary of Land Use Map construction.

6.3. Property Scale Southland Land Use Map

To make a Land Use Map suitable for general use at Environment Southland, the land use information needs to be presented at the property scale. Although, land use is identifiable at the parcel scale in the primary parcel layer, it is difficult to determine which parcels are grouped together to form a property. The metadata contained in the attribute table is also replicated in each parcel.

To produce a land use map at a property scale, the primary parcel layer was used to dissolve parcels by Agribase Farm_ID or ES IrisID, LINZ property owner name and address, as well as other Source_Data fields including Source_Class and ES_Code's (Figure 13). By amalgamating parcels by Agribase Farm_ID or ES IrisID, properties (and ultimately land uses) are identified by the primary decision maker on the land, which may not directly correspond to land owner. The resulting GIS layer produced from the dissolve geoprocessing tool was titled 'Southland_Land_Use_Base_April_2015_Property_Scale'.

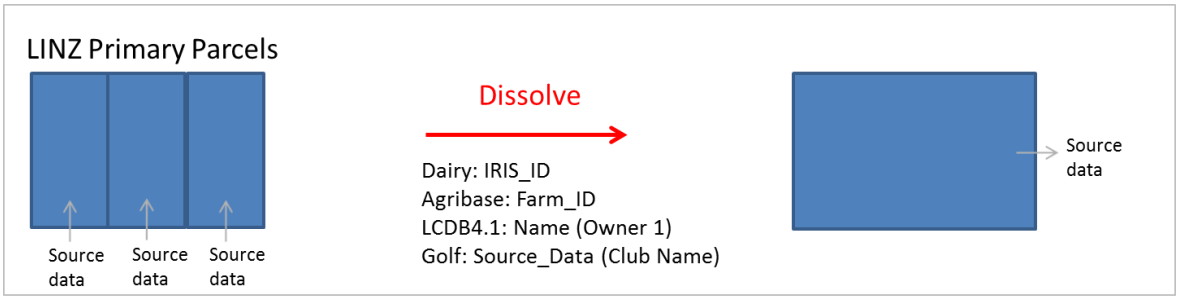


Figure 13: Dissolve method from multiple data sources at parcel scale to property scale.

6.3.1. Land Cover Information

The attribute table of the property scale map contains the LCDBv4.1 land cover information to determine effective and ineffective areas within a property. A text field ('Eff_area') was added to the attribute table to sum the total hectares which are effective. Effective hectares are calculated for pastoral land uses only; which include pasture, arable, exotic scrub, horticulture, and tussock land covers. An 'Ineff_area' text filed was also added to calculate the ineffective area on the property. Ineffective areas include bare ground, native forest, exotic forest, hydrology parcels (lakes, rivers, ponds), mines, native scrub, permanent snow and ice, residential areas, roads and wetlands.

6.3.2. Winter Grazing Information

The winter forage layer was spatially joined to the Southland Land Use Map. Attribute fields of 'Forage_ha', 'Useable_ha', and 'Percentage' were added to the attribute table and respective areas calculated for the purpose of the Winter Forage Assessment undertaken in 2014 (Pearson and Couldrey, in prep). The 'Forage_ha' is a combinatory area in hectares of paddocks identified as winter forage through spectral appearance, while the 'Useable_ha' is a summary of slopes within the property suited to growing winter forage crops. The 'Percentage' field is a calculation

of the percentage of this potentially cultivated useable hectare that was cropped in 2014. Winter forage areas were not represented spatially in the Southland Land Use Map, but each property has this information attributed to it.

6.3.3. Refinement of 'Unknown Land Use – Pastoral (PAS) parcels with multiple data sources

The final process in the methodology to create the Land Use Map used a combination of ES Rates data, LCDB4.1 to reclassify areas that were previously classified by LCDB as 'Unknown Land Use – Pastoral'. The Rates 2012 information was able to identify additional areas of arable, horticulture, lifestyle, dairy support, small land holdings, sheep and beef and mixed livestock. See Appendix 3b for further information.

Rates codes for arable (ARA), horticulture (HORT) and lifestyle (LIF, <5ha) were used to directly replace 'Unknown Land Use – Pastoral' (PAS) in the ES code field and Land Use classification.

Areas identified as 'dairying' in the rates data, were given a new land use classification of 'Dairy Support'. The dairy support classification was used as they hadn't been classified by the Resource Consent Database as currently discharging dairy effluent, and are therefore, unlikely to be on the milking platform.

Unknown properties identified as 'Lifestyle', through the rates information between 5 and 40 hectares (>5ha or <40ha) were given the classification of 'Small Land Holding' (SMH).

'Specialist Livestock' greater than 40 ha, were given the classification 'Mixed Livestock' (SBD). 'Finishing Livestock', and 'Store Livestock', and greater than 40 ha, were given the classification 'Sheep and Beef' (SNB).

ADDITIONAL RULES

1. For parcels classified as PAS by LCDB with a Rates codes of 'ARA', 'HORT', 'LIF' (<5ha); replace ES code of 'PAS' with respective Rates code and classification ('Source' ES Rates 2012).
2. For parcels classified as PAS by LCDB with a Rates code of 'DAI'; replace ES code of 'PAS' with 'DAISUP' ('Land Use C' 'Dairy Support', 'Source' ES Rates 2012).
3. For parcels classified as PAS by LCDB with a Rates code of 'LIF' within >5ha and <40ha; replace ES code of 'PAS' with 'SMH' ('Land Use C' 'Small Land Holding', 'Source' ES Rates 2012).
4. For parcels classified as PAS by LCDB with a Rates code of 'SPLIV' (>40ha), replace ES code of 'PAS' with 'SBD' ('Land Use C' 'Mixed Livestock', 'Source' ES Rates 2012).
5. For parcels classified as PAS by LCDB with a Rates code of 'FINLIV' or 'STORELIV' (>40ha), replace ES code of 'PAS' with 'SNB' ('Land Use C' 'Sheep and Beef', 'Source' ES Rates 2012).

6.4. Southland Land Use Map Summary

The Property Scale Land Use Map allows for ES staff to answer questions such as “How many farms in Southland?”, “What is their land use?”, and “How many properties are likely to be affected by the implementation of a policy?” These types of questions were previously unable to be answered as easily prior to this project. Figure 14 and 15 provides an example of how the Southland Land Use Map can be used to show number of properties and land use for the agricultural and forestry sectors in Southland. The GIS map layer produced will also be used for distributing case study farm data from the Southland Economic Project, as financial information can only be distributed at the property scale.

The Southland Land Use Map is displayed in Figure 16. Land use categories can be grouped further depending on the level of detail required by the user. Land cover information is contained in the attribute table.

Land cover information, displayed over land use in Figure 17, allows the user to determine the likely intensity of the agricultural activity based on the presence of tussock and alpine grasslands, or scrub and shrublands. Land cover can also be used to identify spatially where farm forestry blocks and other ineffective areas, such as wetlands, occur within a property. In conservation areas, the land cover may be a mix of native forest, tussock grasslands, wetlands, bare ground or snow cover. Conservation may also include areas of pastoral cover, under stewardship protection, which are not represented in Figure 17.

The method used to identify dairy properties, is not technically at the property scale as the milking platform and support blocks have been mapped separately. This method of mapping aligns with DairyNZ, who prefer to identify dairy as dairy milking hectares only, as it aligns with their industry reporting. The mapping method allows for the identification of dairy properties with support blocks (often used for wintering off), and those without. Figure 14 shows the number of dairy properties by the ‘Dairy’ land use category and of those properties, how many own support blocks and how many also run other livestock. The land area used for these activities is shown in Figure 15. Included in the attribute table of the land use map is infrastructure details (barn, wintering pads etc.) allowing some assumptions to be made as to whether cows are wintered on (milking platform or own support block) or if a grazier is used (winter off) over the winter months.

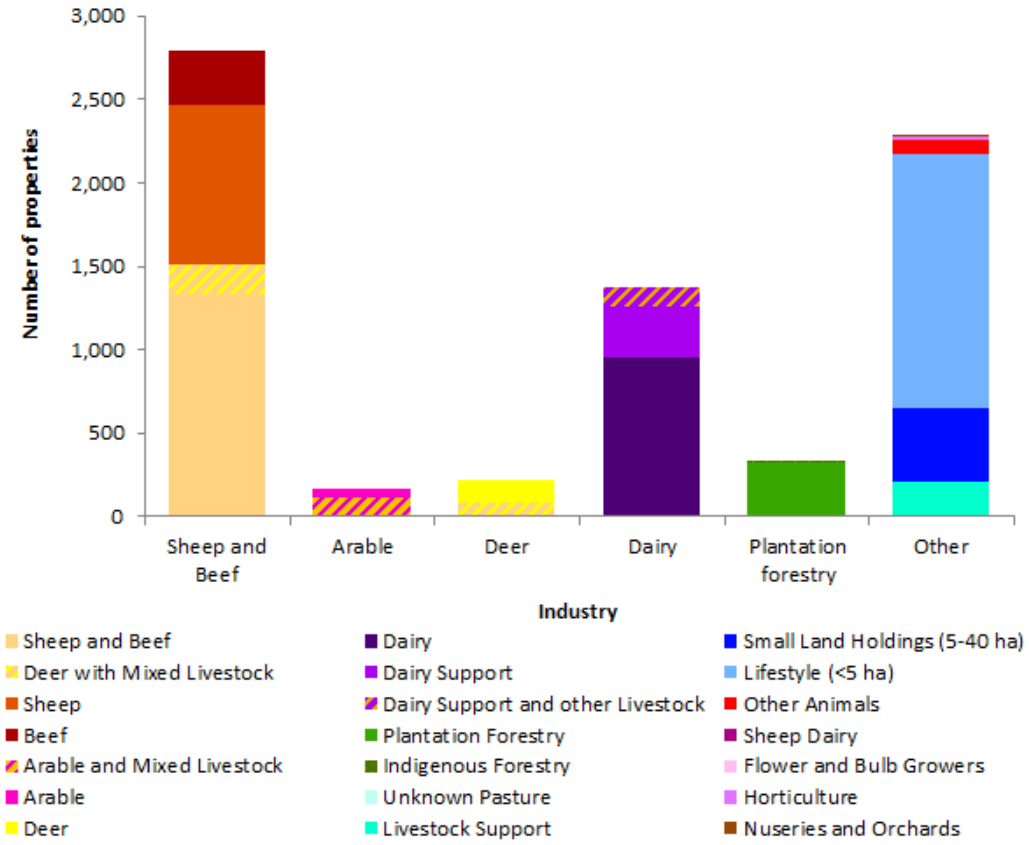


Figure 14: Number of properties in the Agricultural and Forestry Sectors in Southland determined by the Land Use Map.

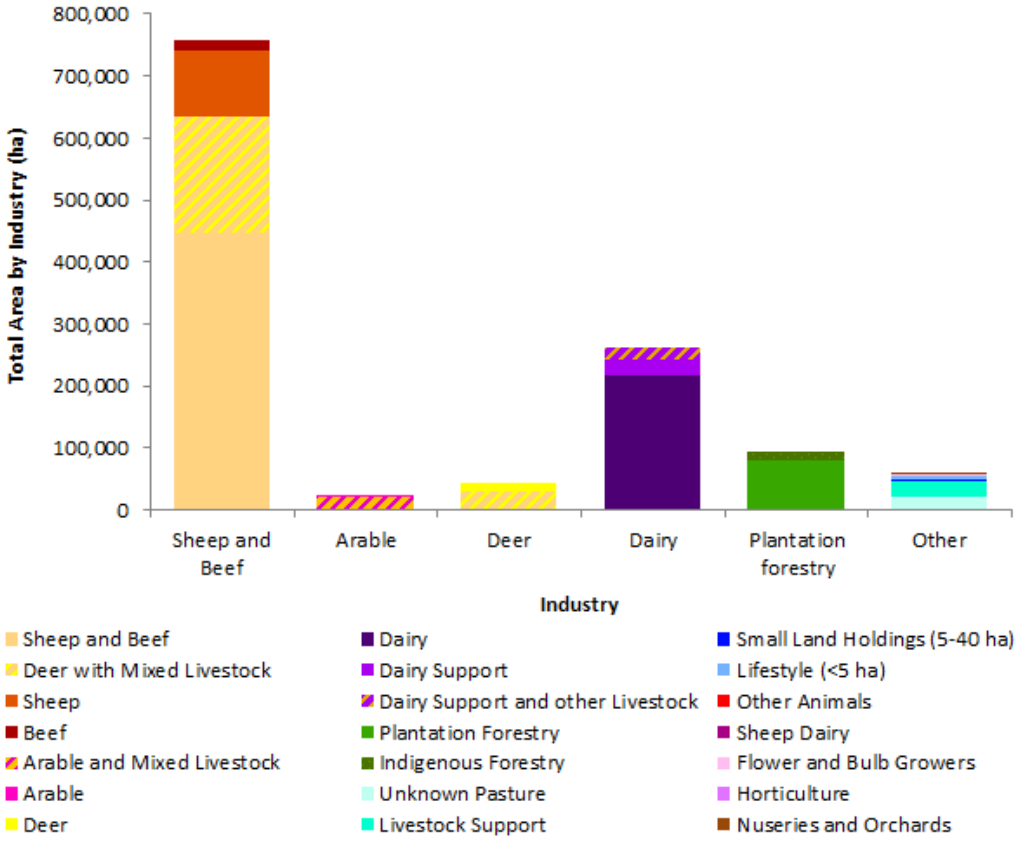
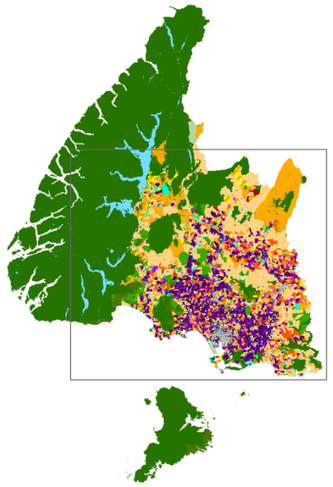


Figure 15: Total land area of the Agricultural and Forestry Sectors in Southland determined by the Land Use Map.



Southland Land Use Map

- Conservation
- Recreation and Tourism
- Plantation Forestry
- Indigenous Forestry
- Beef
- Sheep
- Specialist Deer
- Sheep and Beef
- Mixed Livestock (sheep, beef, deer)
- Majority Deer with Mixed Livestock
- Other Animals
- Dairy
- Livestock Support
- Dairy Support
- Dairy Sheep
- Dairy Support and Other Livestock
- Arable
- Mixed Livestock and Arable
- Horticulture
- Flower and Bulb Growers
- Nurseries and Orchards
- Small Land Holding
- Lifestyle
- Industry and Airports
- Commercial Use
- Residential Use
- Public Use
- Unknown Land Use - Pastoral
- Unknown Land Use - Indigenous Cover
- Unknown Land Use - Non-agricultural
- Lakes and Rivers
- Road and Rail

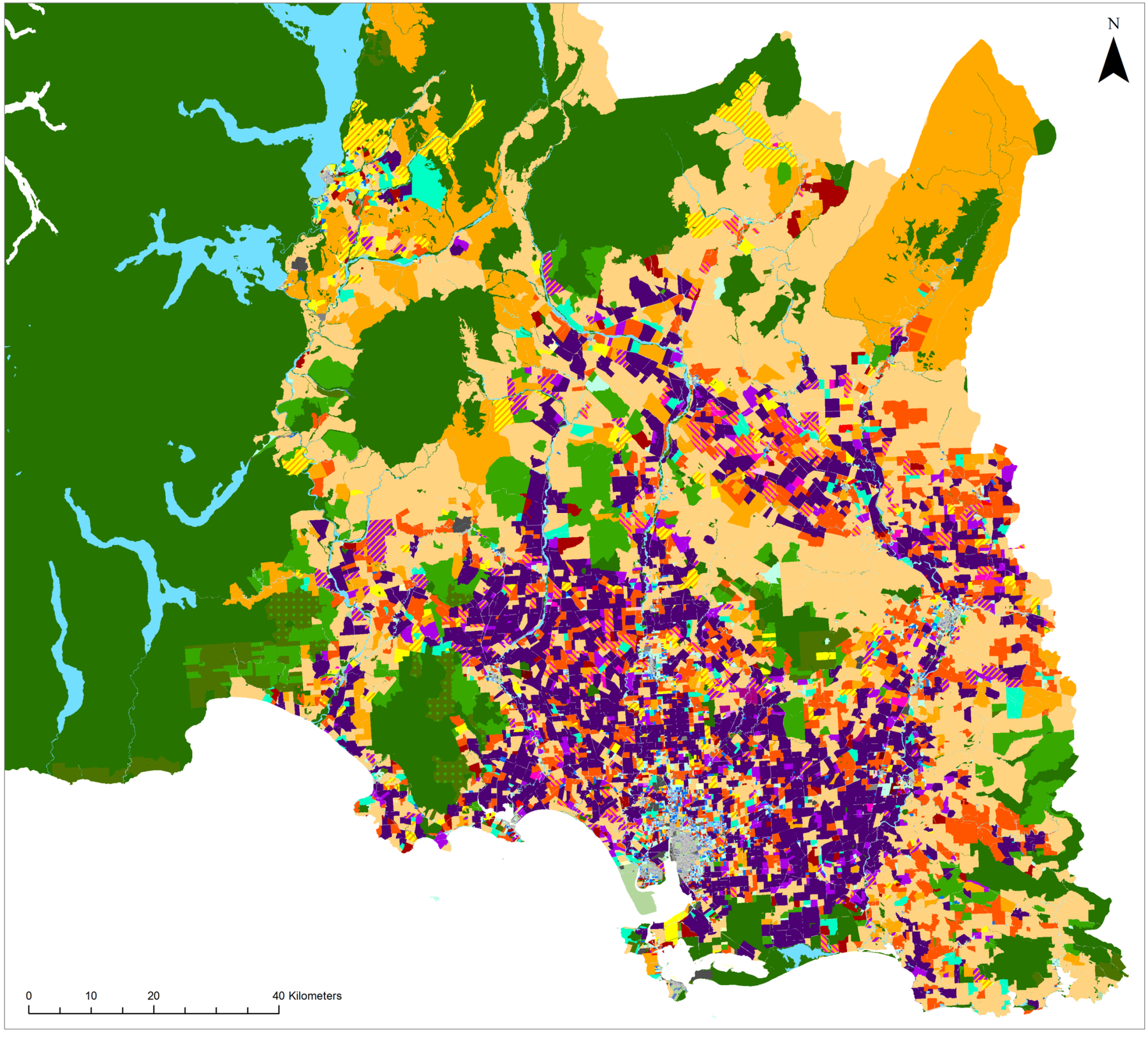
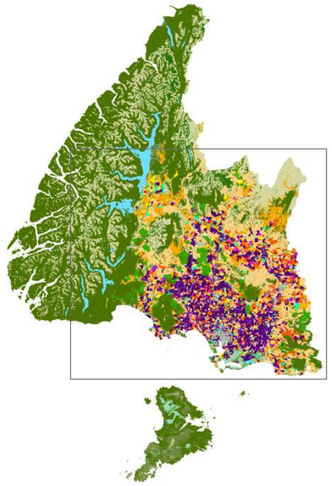


Figure 16: Land Use Map of Southland as of April 2015.



Southland Land Use Map

- Conservation
- Recreation and Tourism
- Plantation Forestry
- Indigenous Forestry
- Beef
- Sheep
- Specialist Deer
- Sheep and Beef
- Mixed Livestock (sheep, beef, deer)
- Majority Deer with Mixed Livestock
- Other Animals
- Dairy
- Livestock Support
- Dairy Support
- Dairy Sheep
- Dairy Support and Other Livestock
- Arable
- Mixed Livestock and Arable
- Horticulture
- Flower and Bulb Growers
- Nurseries and Orchards
- Small Land Holding
- Lifestyle
- Industry and Airports
- Commercial Use
- Residential Use
- Public Use
- Unknown Land Use - Pastoral
- Unknown Land Use - Indigenous Cover
- Unknown Land Use - Non-agricultural
- Lakes and Rivers
- Road and Rail

Land Cover (LCDB v4.1)

- Indigenous Forest
- Exotic Forest
- Native Scrub and Shrubland
- Exotic Scrub and Shrubland
- Alpine Grass and Tall Tussock grassland
- Bare Ground
- Permanent Snow and Ice
- Wetlands
- Surface Mines and Dumps

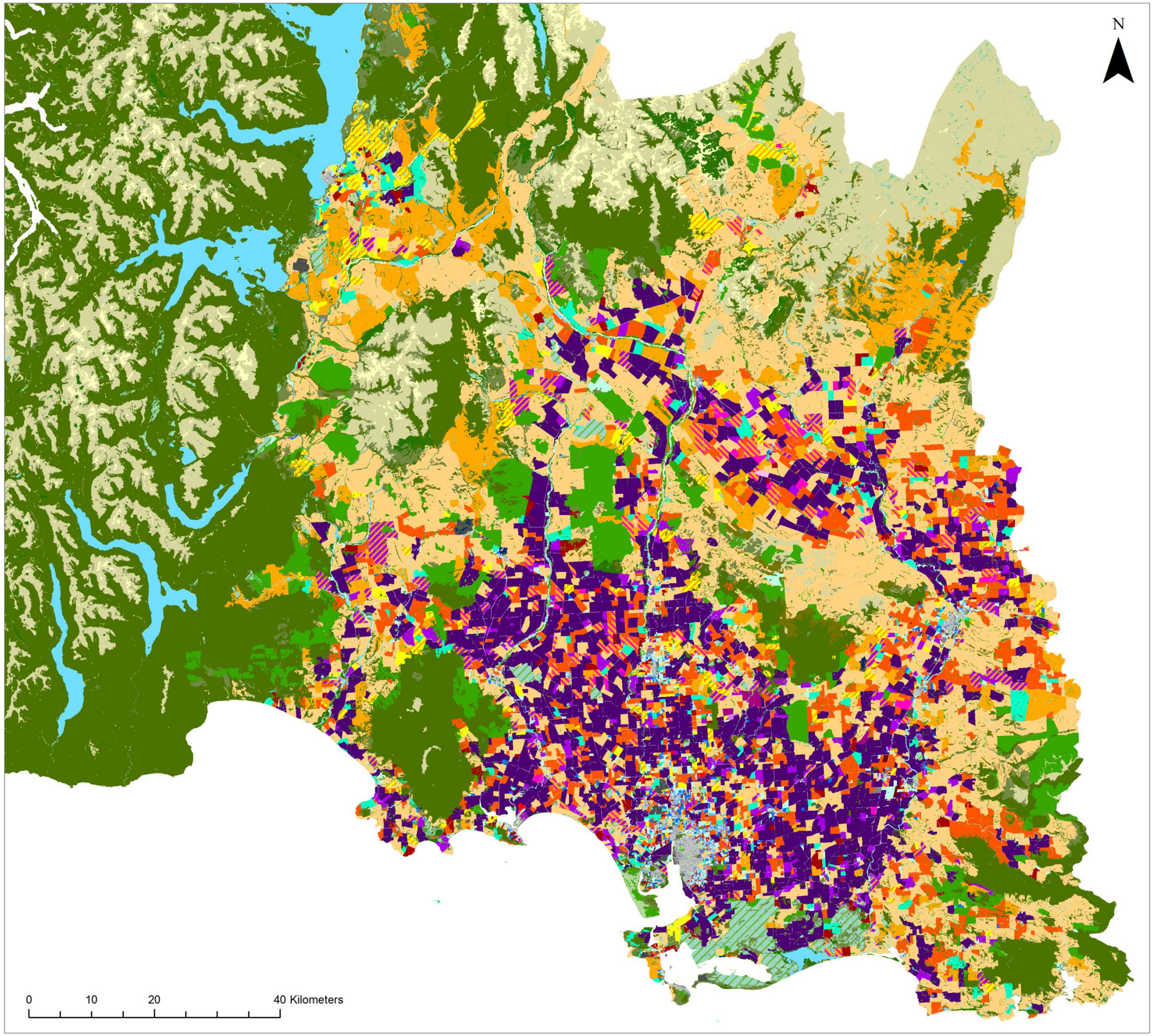


Figure 17: Land Use and Land Cover Map of Southland (as of April 2015). Pastoral land cover has been removed to show the underlying land use on the property.

7. Technical Southland Land Use Map

A technical version of the land use map is required for the Science Programme and Economic Project to drive estimates of contaminant losses from different land uses across Southland (for Stage 2). The technical land use layer adds biophysical, land management (cropping areas, infrastructure), and controls over water chemistry (Physiographic Units) to the Land Use Map to make more detailed analysis of land use and likely contaminant losses from agriculture (Figure 18). The Technical Land Use Map essentially breaks Southland up into basic "OVERSEER® blocks" for each farm type using slope, soils, and climate, as well as a range of management practises, to estimate nutrient losses from agriculture at a catchment or FMU scale.

This section discusses the technical layers and their properties, and the methodology used to create a Technical Land Use Map.

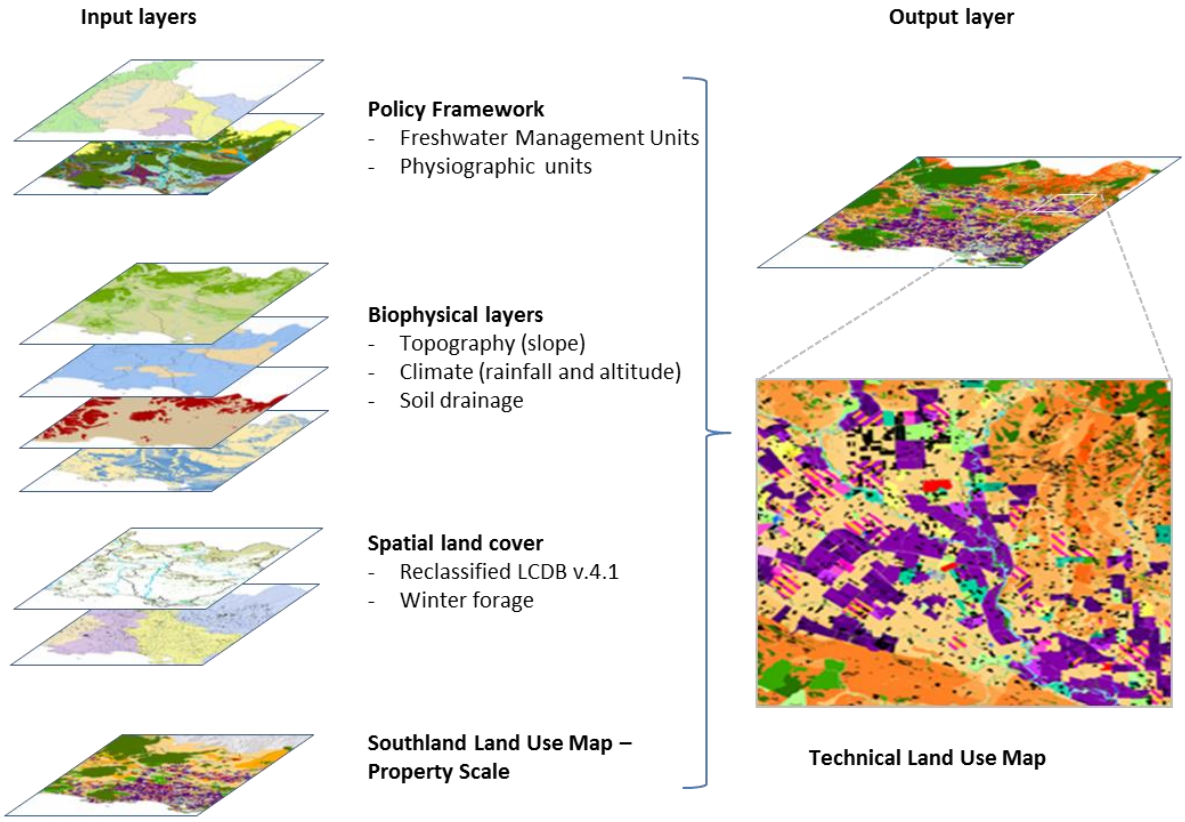


Figure 18: GIS-layers used to produce a technical land use map.

7.1. Biophysical layers

The main factors which determine contaminant loss from agricultural activities are the intensity of the land use activity, and the biophysical factors of topography, climate (rainfall and altitude), and soil drainage. The topography, or slope, of the area is the driver behind surface runoff (overland flow) production, which is the main transport pathway for phosphorus, sediment and micro-organisms to be lost from agricultural land. Soil drainage is necessary to determine the

rate at which a contaminant, especially nitrogen, can be lost through the soil by leeching. Climate, more specifically rainfall, is the factor which determines the frequency of events. As contaminants are transported by water, the amount of rainfall is critical to determining the rate or amount of contaminant loss from a property on an annual basis.

7.1.1. Topography (Slope)

Environment Southland has GIS layers of topography at a resolution of 8 meters. However, when modelling properties in OVERSEER®, this is higher resolution than what is typically entered into the model following best practice input standards (Overseer, 2015). Therefore, it was determined that slope will determined by the Land Resource Inventory (LRI) survey polygons at a resolution of approximately 25 meters (Figure 19). As farm data is assessed through OVERSEER®, the topography classes used in the model for assigning block data was determined to be the most consistent method for grouping slope ranges (Table 9).

Table 9: Topography classes as determined by OVERSEER (Overseer, 2015).

Topography class	Access description	Slope
Flat		0-7 degrees
Rolling	Area mostly navigable by tractor	8-15 degrees
Easy Hill	< 50% area navigable by tractor	16-25 degrees
Steep Hill	> 50% area navigable by tractor	> 26 degrees

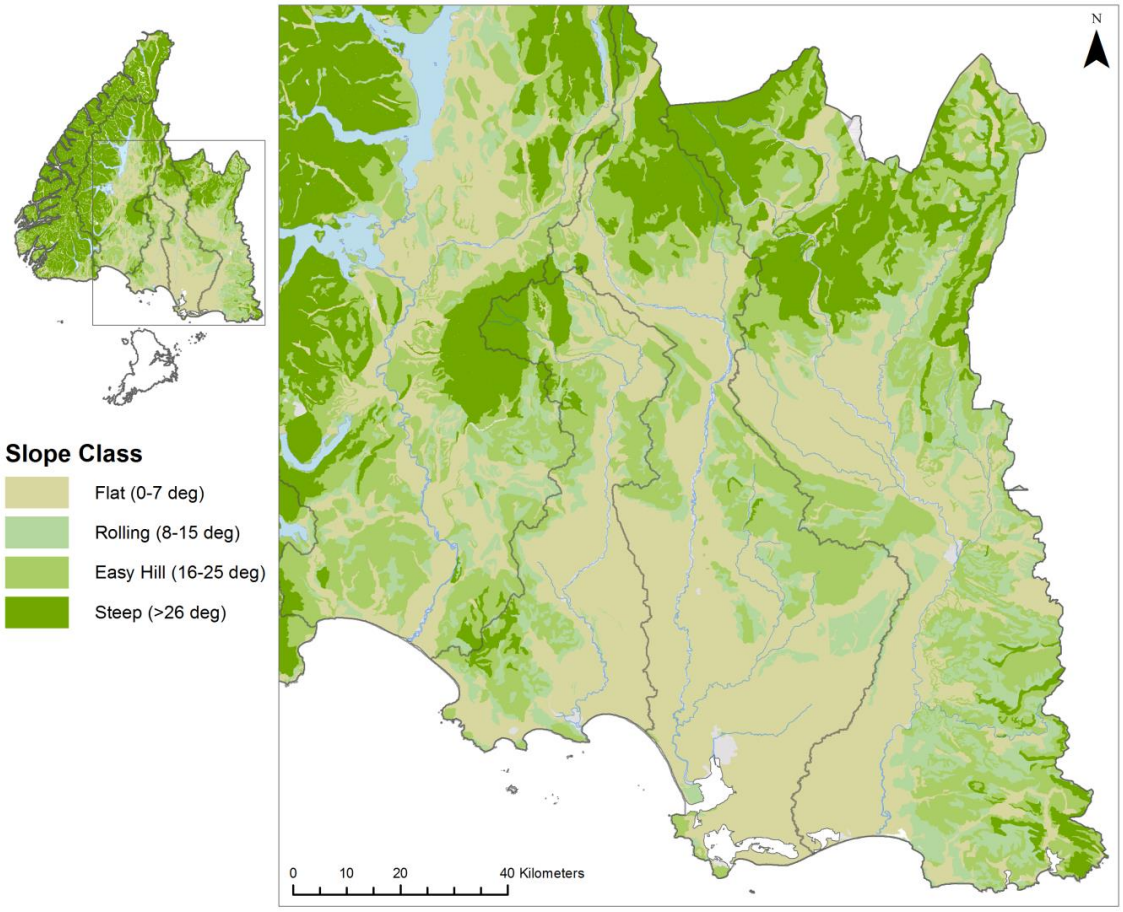


Figure 19: Slope classes of flat, rolling, easy hill and steep hill.

7.1.2. Climate

Altitude

Altitude is often a limiting factor on farm activities as the climate (especially temperature and snow accumulation), shorten the time that these areas can be used for agriculture. Agricultural areas greater than 600m above sea level are traditionally considered 'High Country' and often extensively farmed. In Southland, 600 m altitude corresponds to an average temperature of 8°C. Figure 20 shows the area above 600m in Southland.

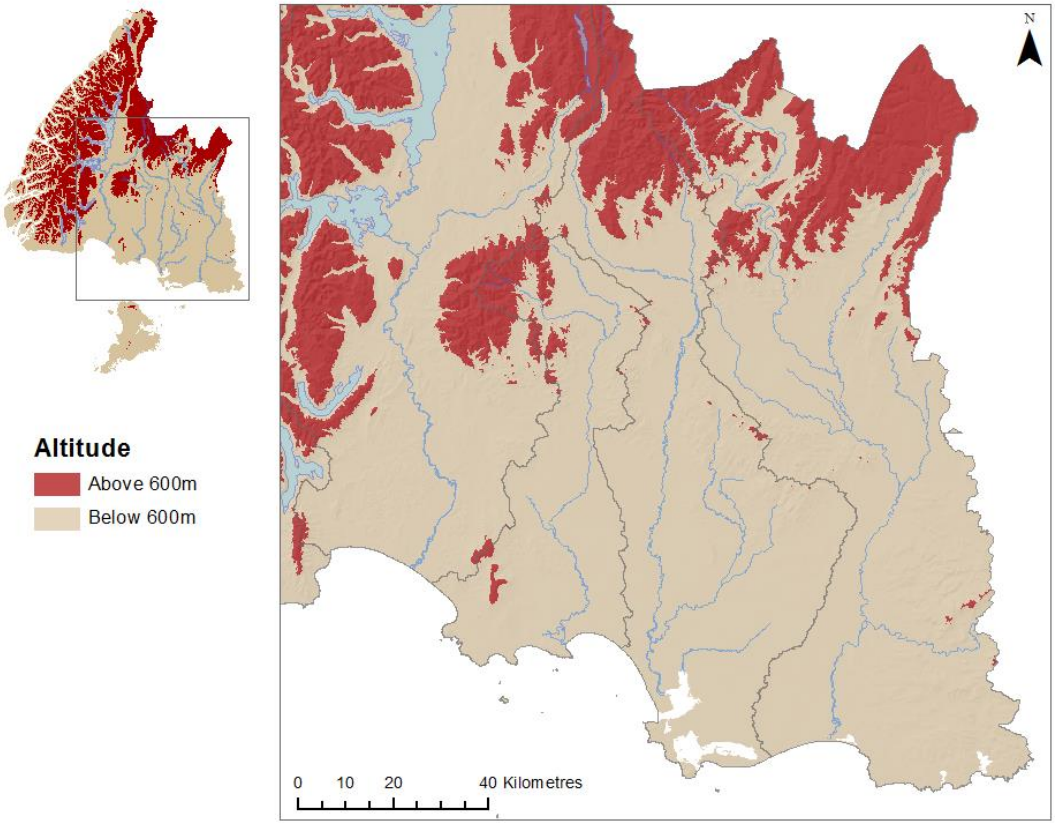


Figure 20: Altitude of above and below 600m above sea level. Agricultural land above 600 m is classified as High Country.

Rainfall

Climate data used in OVERSEER® is derived from the National Institute of Water and Atmospheric Research (NIWA) 0.5 km Virtual Climate Station Network (VCN), based on entered and selected climate properties (Wheeler, 2015). NIWA used the 0.5 km VCN to compile a database comprising 30-year average monthly values of rainfall, air temperature, and potential evapotranspiration (PET) based on the period 1981-2010. From this rainfall was produced by calculating the above 30-year statistics at climate station locations with available data, then interpolating these statistics onto a 500m spatial resolution grid. Figure 21 shows rainfall over the 1981-2010 time period received from NIWA (with permission from Overseer®).

The rainfall variation over agricultural areas in Southland spans the 1000 mm boundary roughly separating a dryer north and wetter south. Therefore, rainfall classes of above 1000 mm and below 1000mm were used to select representative survey farms for the Southland Economic Project. The layer produced to integrate into the technical land use map is shown in Figure 22.

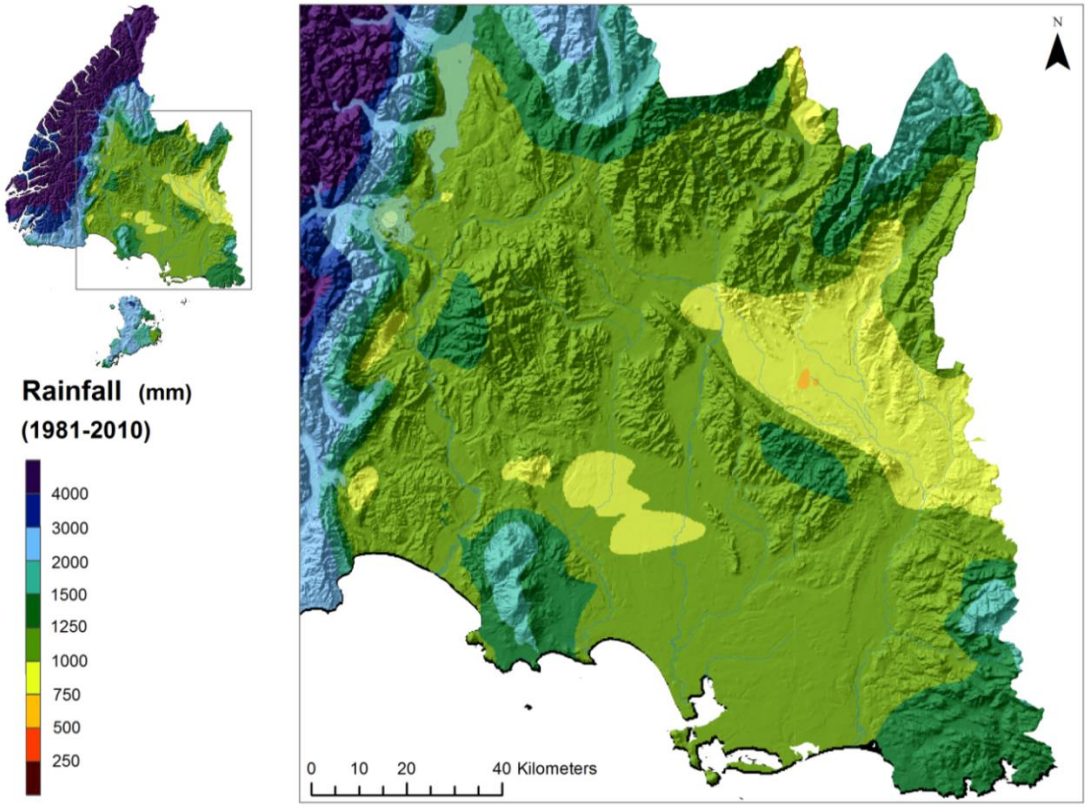


Figure 21: Average rainfall for Southland calculated between 1981 and 2010 (data obtained from NIWA with permission from OVERSEER®).

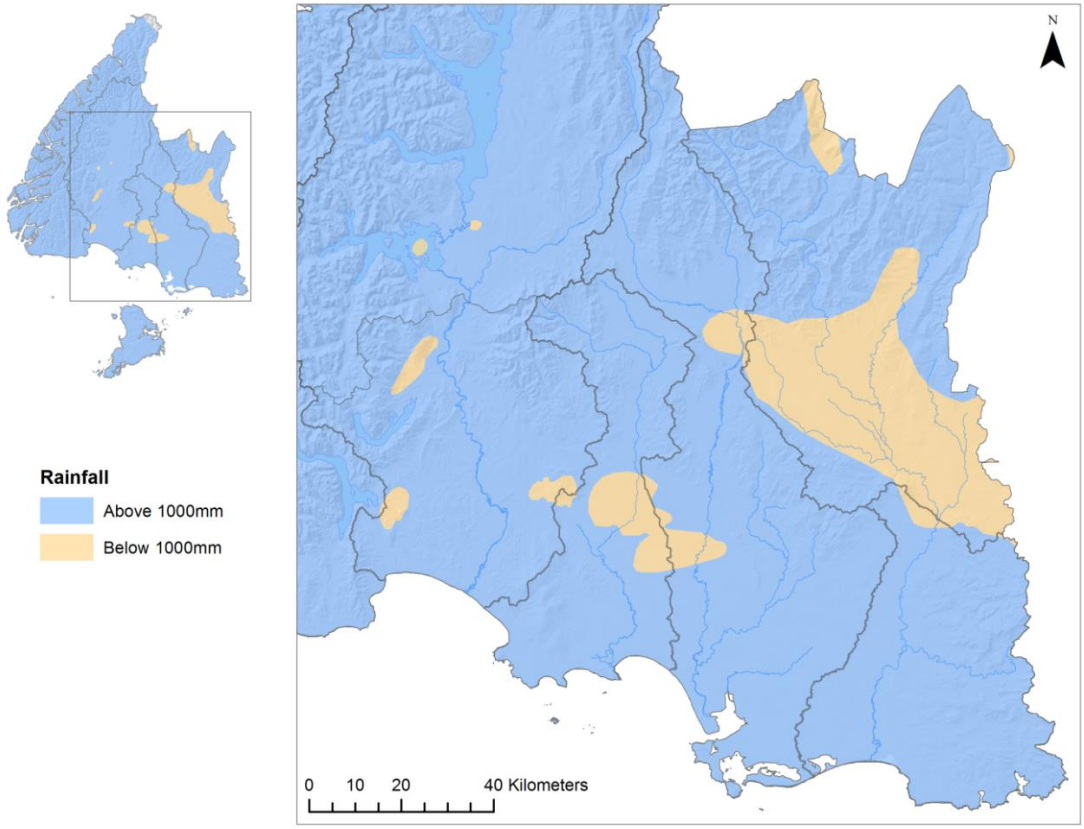


Figure 22: 30-year average rainfall simplified to above and below 1000 mm produced for technical land use map.

7.1.3. Soil Drainage

A combined soil layer has been created by Environment Southland to achieve complete coverage of soils in the region. The layer comprises a combination of three soil surveys: the 2001 Topoclimate South (TCS) soil survey (1:50,000 scale) and associated technical sheets (Crops for Southland, 2002), the 1986 Wallace County soil survey (1:50,000 scale; O'Byrne, 1986) and the 1968 Land Resource Inventory (LRI) soil survey (1:50,000 and 1:63,360 scale; DSIR, 1968). Soil maps were assembled according to the following hierarchy Topoclimate>Wallace County>LRI reflecting the age and level of detail available from the respective surveys.

Soil drainage classes are assessed using criteria of soil depth and water table inferred from soil colours and mottles. Drainage classes used here are the same as those used in the NZ Soil Classification (Hewitt, 1993) and Milne et al. (1995):

- **Well drained (5) –** These soils have adequate aeration year round.
- **Moderately well drained (4) –** These soils have adequate aeration all year except winter at depths usually below 0.45 m and generally below 0.9 m.
- **Imperfectly drained (3) –** These soils have aeration limitations in the upper 0.45 m for <6 months during winter, part of spring and part of autumn.
- **Poorly drained (2) –** These soils are potentially anaerobic for 6 – 10 months in most of the upper 0.45 m layer, and commonly all year below 0.45 m.
- **Very poorly drained (1) -** These soils are anaerobic for most of the year.

These five classes were simplified to either well drained (classes 5 and 4) or poorly drained (classes 1-3) before intersection with the land use map to align with data collection for the Southland Economic Project (Figure 23).

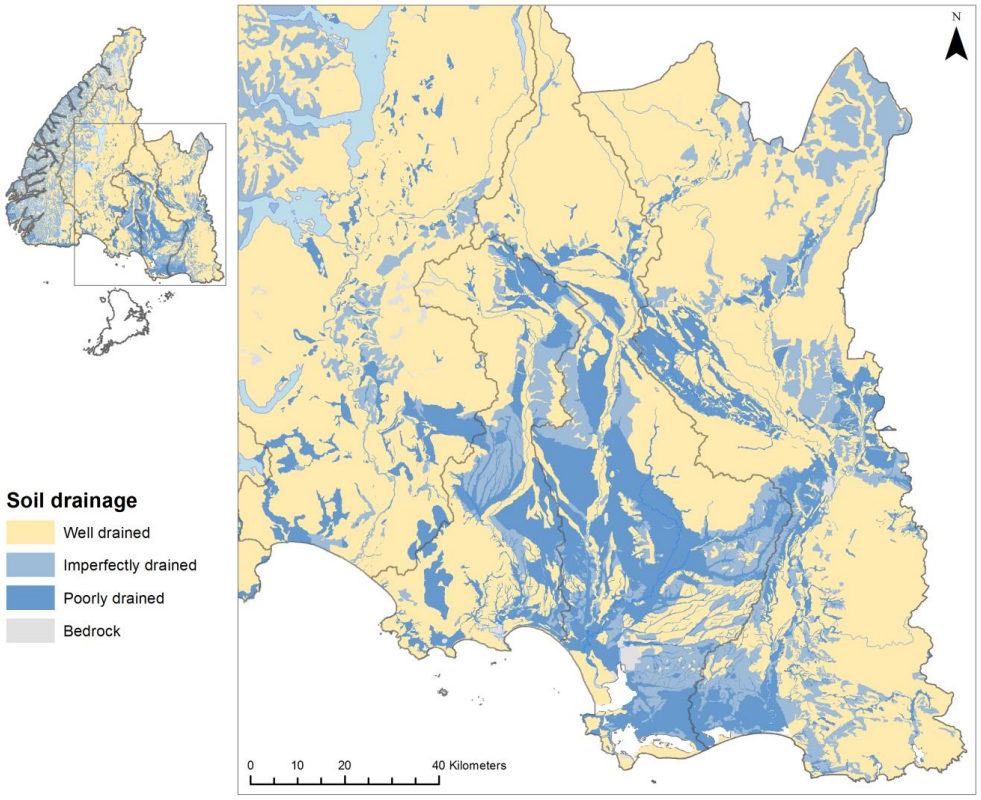


Figure 23: Soil drainage in Southland showing groupings of well drained (yellow) and poorly drained areas (blue).

7.2. Land cover

7.2.1. Non-pastoral areas

To identify areas not in pastoral use, the modified LCDBv4.1 layer produced in Section 6.1.6 was used (Figure 24). This layer has been previously incorporated as metadata in the attribute table of the Southland Land Use Map and is now represented spatially in the Technical Land Use Map. Pastoral areas have intentionally been left blank to display additional land covers occurring in conjunction with other land uses. These non-pastoral areas will be assigned a contaminant loss estimate based on the land cover, rather than the land use classification of the pastoral areas within a property, to better represent the intensity of the area of land identified by the land cover. This is especially important to identify areas of farm forestry, separate from the main pastoral land use.

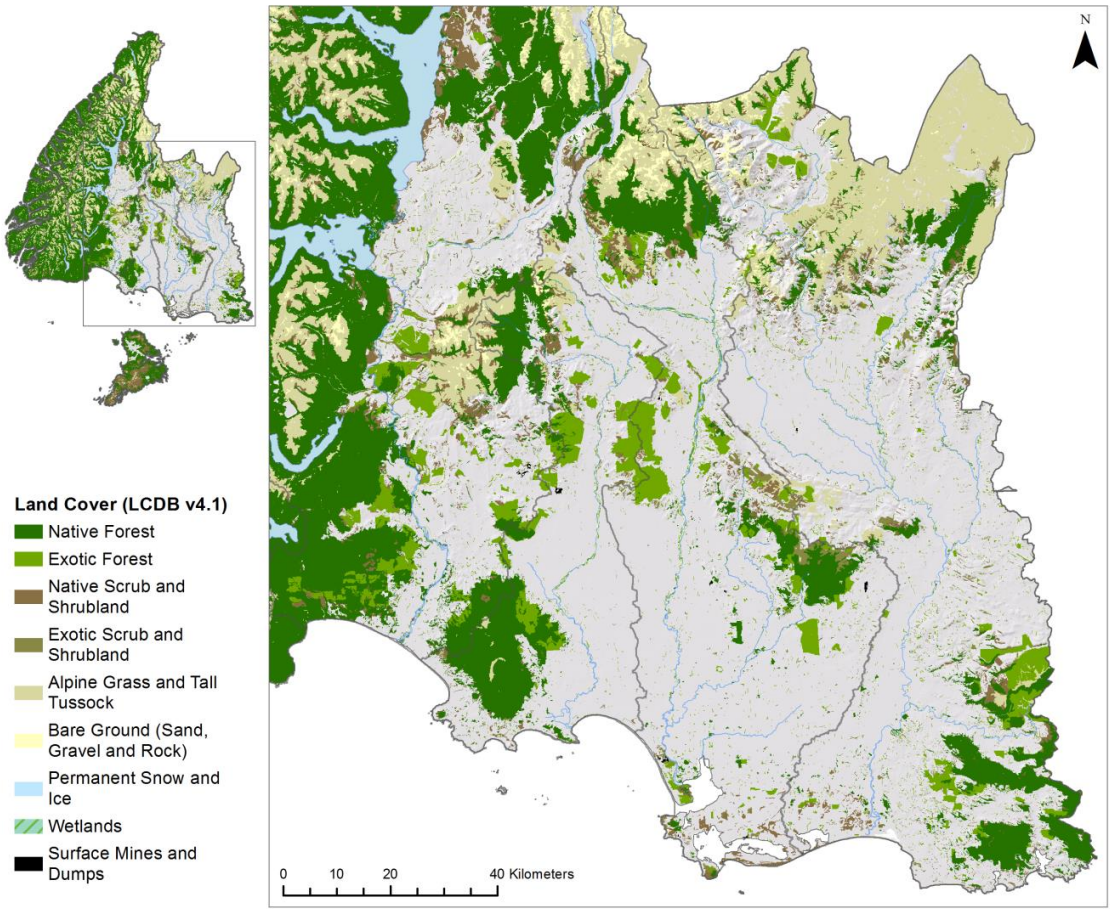


Figure 24: Modified Land Cover Database (LCDBv4.1) showing intermediate level classifications without pastoral areas (grey).

7.2.2. Winter forage

Winter forage areas are a significant contributor to nutrient losses from a property and can be displayed spatially on the Technical Land Use Map (Figure 25). Specific nutrient losses associated with forage crops can be applied to these areas calculated from Overseer modelling. Spatial

locations of winter forage crop rotate within pastoral block(s) from year to year but as stock numbers are likely to stay relatively constant between years; these areas are likely to represent the amount of cropping occurring on a property in subsequent years. The nutrient loss estimates from this activity are associated with in situ grazing, and as a result will over estimate contaminant losses in areas where management practices differ (i.e. properties which lift fodder crop to feed out on structures.

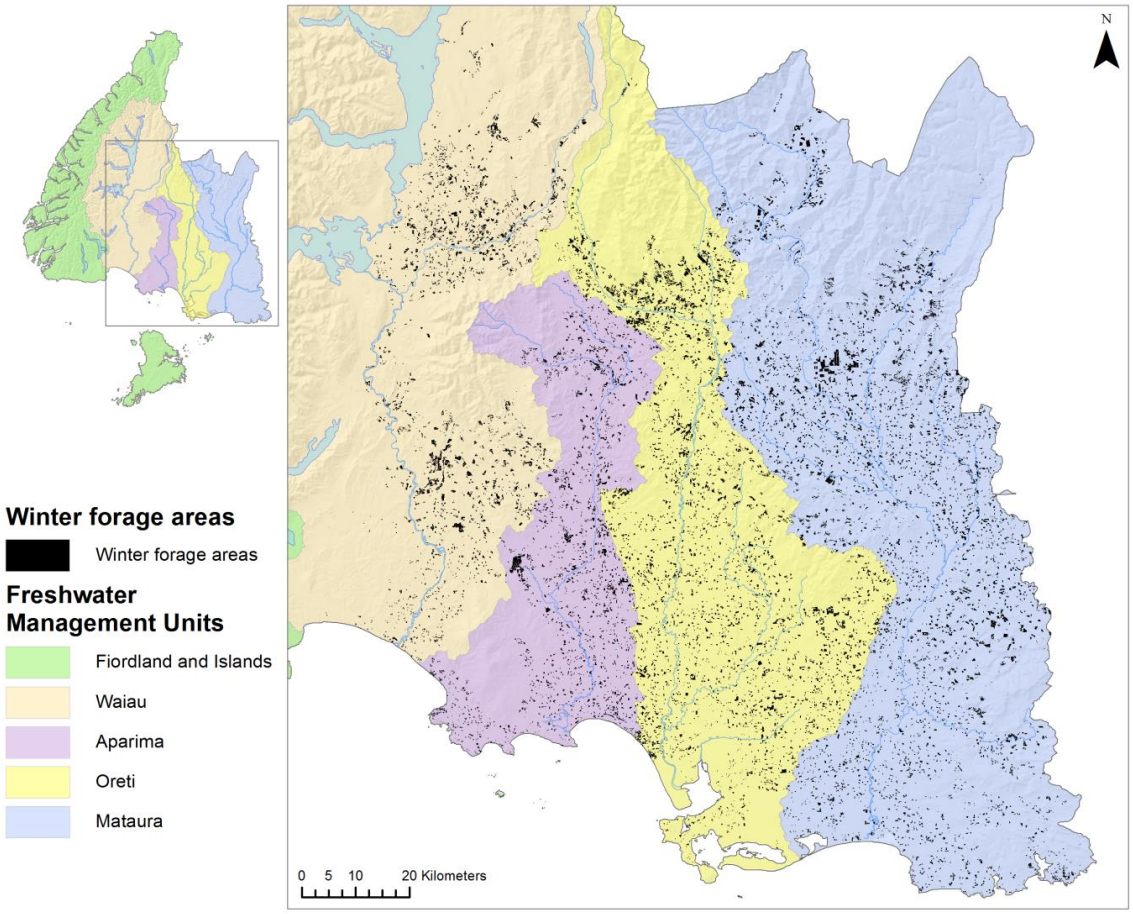


Figure 25: Winter forage crop in Southland over winter 2014 (Pearson and Couldrey, in prep).

7.3. Policy Framework - Freshwater Management Units and Physiographic Units

To assess the possibility of different policies applying to different FMUs or Physiographic units, both layers, identified in Section 2.2, were included in the Technical Land Use Map. The addition of policy zones allows for direct querying of land use within these areas.

The physiographic units, which groups the Southland landscape into areas of similar inherent properties and influences on water quality, allow for the determination of areas where there is increased attenuation potential for contaminants within an environment. This means that the land has a higher capacity to compensate for intensive activities occurring on the land surface as contaminants are converted to or retained in non-reactive forms. The Technical Land Use Map will be an important tool in determining whether water quality outcomes are a result of low

input or contaminant load to a catchment, or rather due to a high assimilative capacity of the receiving environment.

Linking areas of high attenuation and land use can determine where intensive land uses are best suited in Southland. However, identifying where land uses are best suited is currently outside the scope of the current NPS-FM Science Programme.

7.4. Technical Land Use Map Methodology

A new geodatabase was created to house files for the Technical Land Use Map, titled 'LRI Technical'. The technical layers detailing topography (slope), climate (rainfall), soil drainage, land cover, winter forage areas, FMUs and Physiographic Units were combined by using the geo-processing tool – Union (Figure 26). The GIS layers were added in the following order:

- LRI Slope
- Rainfall
- Soil drainage
- Modified LCDB
- Winter forage
- Physiographic zones
- FMU
- Southland land use map – property scale

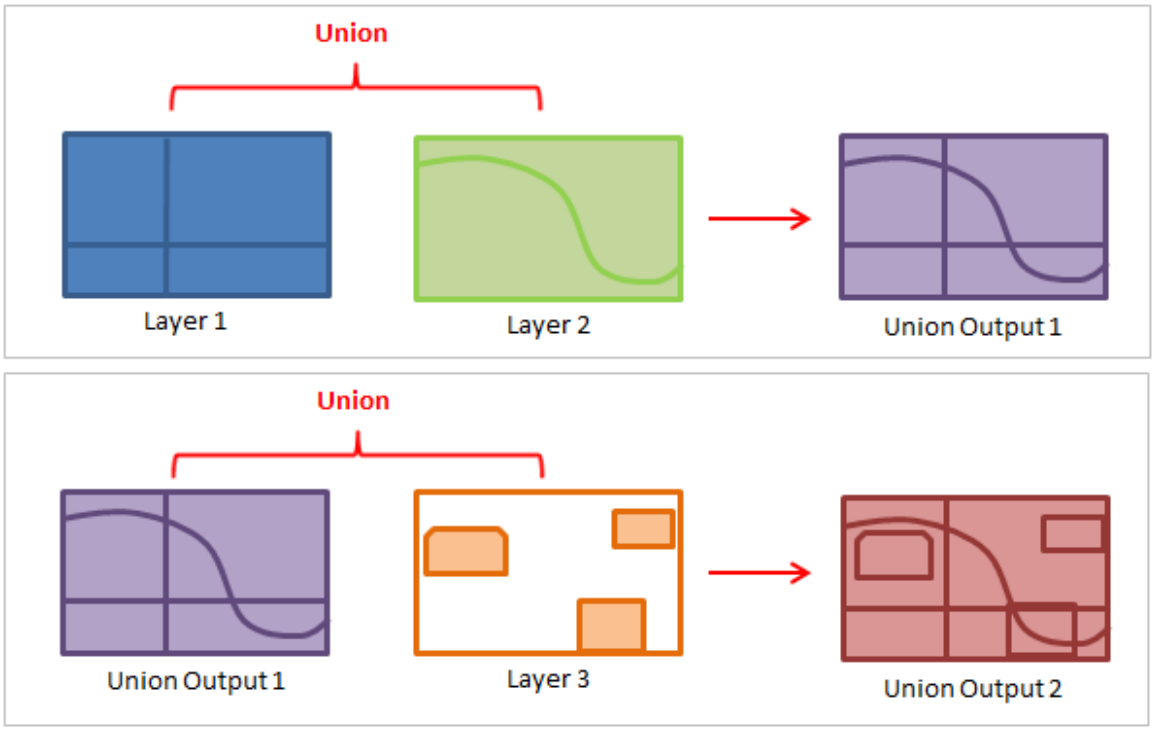


Figure 26: Union method to combine multiple technical layers into one layer.

The layer was then clipped to the Southland boundary to remove any area outside the region. To reduce the number of polygons in the layer for manageability, the output layer was dissolved by the attribute fields. This produces an output with one multi-part polygon for each possible combination of the above data. For GIS commands see Appendix 4 – Technical Land Use Map.

7.5. Technical Land Use Map Summary

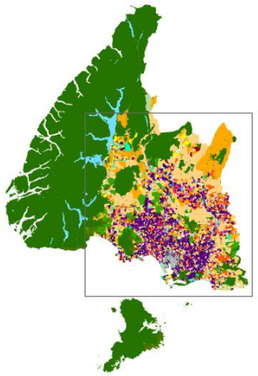
The purpose of the Technical Land Use Map is to determine the number of hectares in Southland with similar biophysical characteristics to apply a nutrient loss as determined by the range of activities that occur on that landscape, as described in Section 2.3. The range of activities will be determined by investigating the OVERSEER® nutrient budgets for survey farms at the block level[13]. For example, all cropping blocks for winter forage can be used to estimate an average loss from winter cropping across Southland, regardless of species of crop. This information can be further refined by stock type grazing the crop, if significant differences are observed in the model outputs, and distributed spatially via the land use categories.

The Technical Land Use Map can be used in multiple ways to answer a number of possible questions proposed by the council. By altering the grouping of categories, any possible combination of biophysical (slope, soil, rainfall), activity (winter forage cropping, farm forestry), or policy framework (FMU, Physiographic Unit) can be displayed or queried. The technical map can be used to answer 'number of hectare' questions in more specific detail. For example, dairy hectares on poorly drained soil or hectares of sheep and beef on slopes less than 4 degrees, to the more complex questions such as hectares of winter forage crop grown on sheep and beef properties in the Mataura FMU.

Figure 27 shows the Technical Land Use map as a representation of likely groupings for estimating nutrient loss for the Southland Economic Project. Sheep, Beef, Sheep and Beef and Mixed livestock categories have been grouped into one class and displayed by both rainfall and slope. Specialist deer and Majority deer have also been grouped and displayed by rainfall and slope. Dairy, Dairy Support, Dairy support with other livestock, Arable, Arable and mixed livestock, and Livestock support are activities that typically occur on flat to undulating areas so are therefore displayed by rainfall and soil drainage only. Unknown land use is displayed by rainfall and soil drainage but will likely need to include slope in the final assessment. Winter cropping and wetlands have also been added as nutrient losses from these categories have been modelled in Overseer® and applied spatially on the Technical Land Use Map. Wetlands which are under conservation order are shown as conservation. Other land use categories have not been split biophysically, due to the limited amount of nutrient loss data for these land uses.

The Technical Land Use Map allows for further understanding of different activities within a land use by combining land cover. Figure 28 shows the land cover for the Agricultural and Forestry Sectors in Southland. This can be related to how these sectors report agricultural statistics, which is commonly by effective area (Figure 29). For a pastoral farming system the effective area is where stock and crops are grazed/grown. For forestry operations, the effective area is that planted in trees.

[13] A farm in OVERSEER is modelled by dividing the farm into blocks on the basis of land uses, management systems (i.e. effluent and/or sludge applied, irrigation applied, cut and carry, support block/runoff), soils, topography and enterprise. Typical blocks will be: Pastoral, Pasture block with fodder crop rotation, Cut and carry, Crop, Tree and scrub, Riparian, Wetlands (non-dairy only), and House. For further information see Overseer Best Practice Data Input Standards Version 6.2.0 April 2015.



Technical Land Use Map

Sheep and Beef (Deer)
- Above 1000mm, Steep
- Below 1000mm, Steep
- Above 1000mm, Easy Hill
- Below 1000mm, Easy Hill
- Above 1000mm, Rolling
- Below 1000mm, Rolling
- Above 1000mm, Flat
- Below 1000mm, Flat

Deer
- Above 1000mm, Steep
- Below 1000mm, Steep
- Above 1000mm, Easy Hill
- Below 1000mm, Easy Hill
- Above 1000mm, Rolling
- Below 1000mm, Rolling
- Above 1000mm, Flat
- Below 1000mm, Flat

Dairy
- Above 1000mm, Poorly Darined
- Below 1000mm, Poorly drained
- Above 1000mm, Well Drained
- Below 1000mm, Well Drained

Dairy Support
- Above 1000mm, Poorly drained
- Below 1000mm, Poorly drained
- Above 1000mm, Well drained
- Below 1000mm, Well drained

Dairy Support and Other Livestock
- Above 1000mm, Well Drained
- Below 1000mm, Well Drained
- Above 1000mm, Poorly drained
- Below 1000mm, Poorly drained

Arable
- Above 1000mm, Well Drained
- Below 1000mm, Well Drained
- Above 1000mm, Poorly Drained
- Below 1000mm, Poorly Drained

Arable and Mixed Livestock
- Above 1000mm, Well Drained
- Below 1000mm, Well Drained
- Above 1000mm, Poorly Drained
- Below 1000mm, Poorly Drained

Livestock Support
- Above 1000mm, Well Drained
- Below 1000mm, Well Drained
- Above 1000mm, Poorly Drained
- Below 1000mm, Poorly Drained

Unknown Land Use - Pastoral
- Above 1000mm; Poorly Drained
- Below 1000mm; Poorly Drained
- Above 1000mm, Well Drained
- Below 1000mm, Well Drained

Forestry
- Plantation Forestry
- Indigenous Forestry

Other
- Other Animals
- Small Land Holding
- Lifestyle
- Horticulture
- Flower and Bulb Growers
- Nurseries and Orchards
- Conservation
- Recreation and Tourism
- Industry and Airports
- Commercial Use
- Residential Use
- Public Use

Land Cover
- Lakes and Rivers
- Wetlands
- Winter Forage Crop

N

0 10 20 40 Kilometers

Figure 27: Technical land use map by industry group. Sheep, beef and deer properties are displayed by rainfall and topography. Dairy and other industries on flat and rolling land are displayed by rainfall and soil drainage.

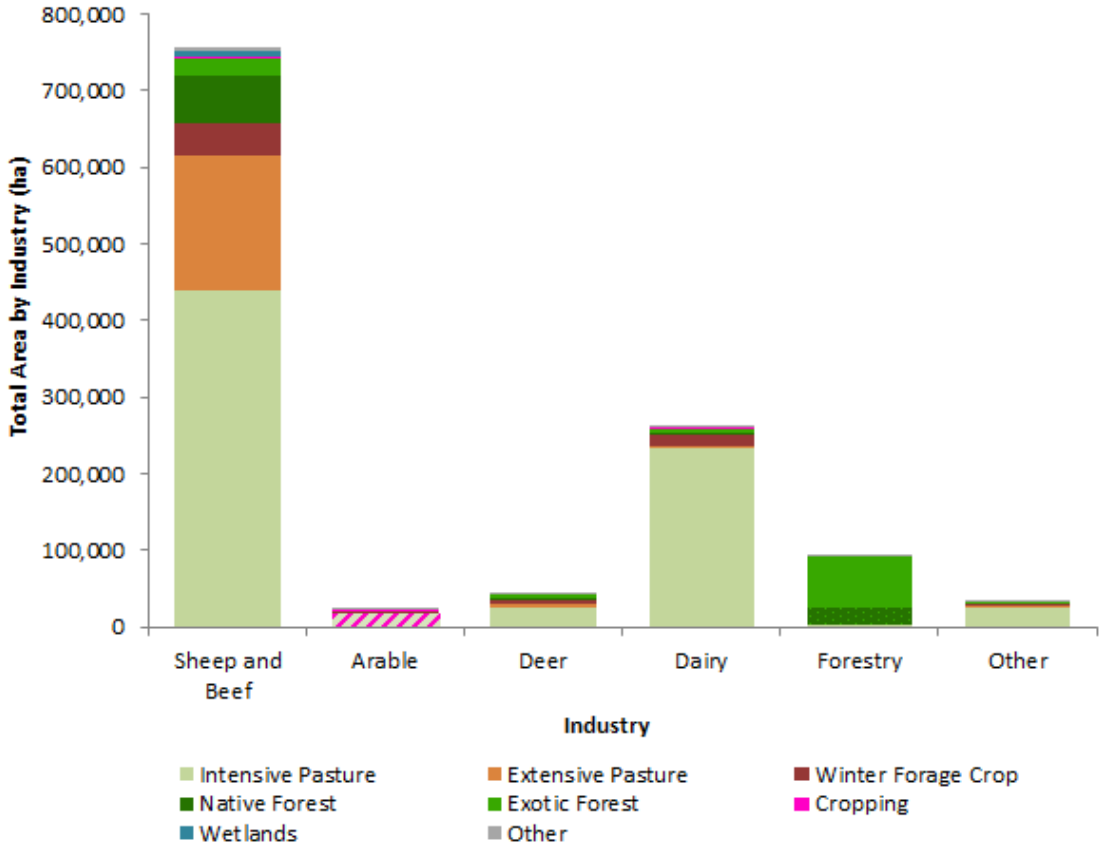


Figure 28: Land cover for the Agricultural and Forestry Sectors in Southland determined by the Technical Land Use Map.

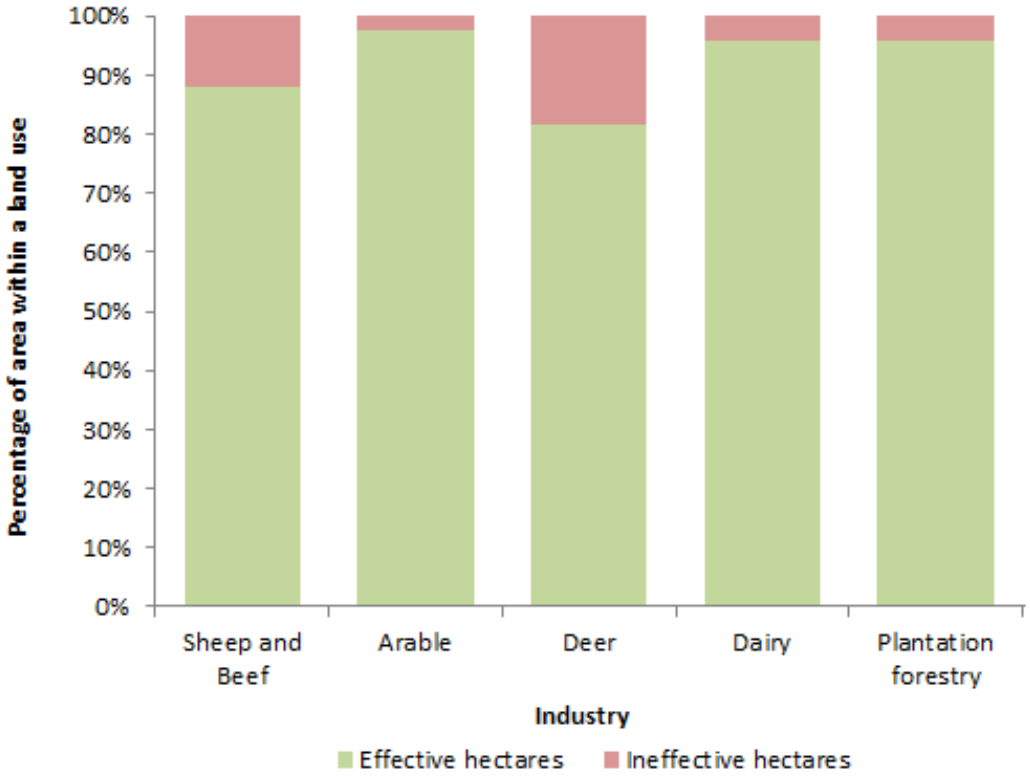


Figure 29: Effective and ineffective areas by percentage within the Agricultural and Forestry Sectors determined by the Technical Land Use Map.

8. Historical Land Use Maps

Historical land use maps are required by the NPS-FM Science Programme, specifically the 'Ecosystem Response' theme to estimate historic nutrient and sediment loads to estuaries, lakes and other catchment receiving environments. However, without the use of a detailed agricultural data source, such as Agribase™, a new method was required to map land use using land cover to infer land use. The primary parcel layer, used as a framework for the Southland Land Use Map is also unavailable for the Southland region prior to 2001. Therefore, it was decided by the project team that a new method for historical land use mapping was required to be consistent across all periods, combine land use information with land cover and agricultural statistics to infer land use intensity, and show spatially how land use has changed over time in Southland.

The time period where data is available to produce historic GIS-based land use maps for is from 1996 to 2015. This covers the time period when LCDB imagery is available. As large scale land clearing had largely ceased over this time period (Ledgard, 2013), with only minor pasture improvement with agricultural properties, the LCDB imagery was deemed suitable to represent a range of years between imagery dates.

The set of biophysical layers developed for the Technical Land Use Map (Section 7) were incorporated into the historic mapping methodology. The biophysical data adds value to the historic map layer by allowing these attributes to be used as a proxy for land use and intensity. For example, pastoral land not identified by Environment Southlands resource consent database for dairy, is likely to be used for sheep and beef farming, and to a lesser extent deer. These stock types have been collectively grouped as drystock. In addition, intensive pasture on flat to rolling land is likely used at a higher intensity (stock units, fertilizer application) than intensive pasture on hill to steep land; which is proportional to the contaminant load lost under this land cover.

To compare the differences between the two mapping methodologies, a 2015 version is necessary using the historic methodology (land cover from 2012 and the ES 2015 dairy extent). Comparisons between the Southland Land Use Map and the Historic 2015 Land Use Map will allow the Science Team to undertake sensitivity analysis between the two methods, and understanding the level of detail required by the NPS-FM Science Programme around nutrient inputs and estimated losses.

A pre-Maori land cover map (c. 1000 AD) was also developed to aid the Science Team in estimating natural state nutrient and sediment load to receiving waterbodies. This layer will provide a reference state for Southland prior to Maori settlement.

This section details the sources and modification of input data and methodology to produce the Historic Land Use Maps and the Pre-Maori Land Cover Map. A summary of the input layers and maps produced in this section is shown in Figure 30.

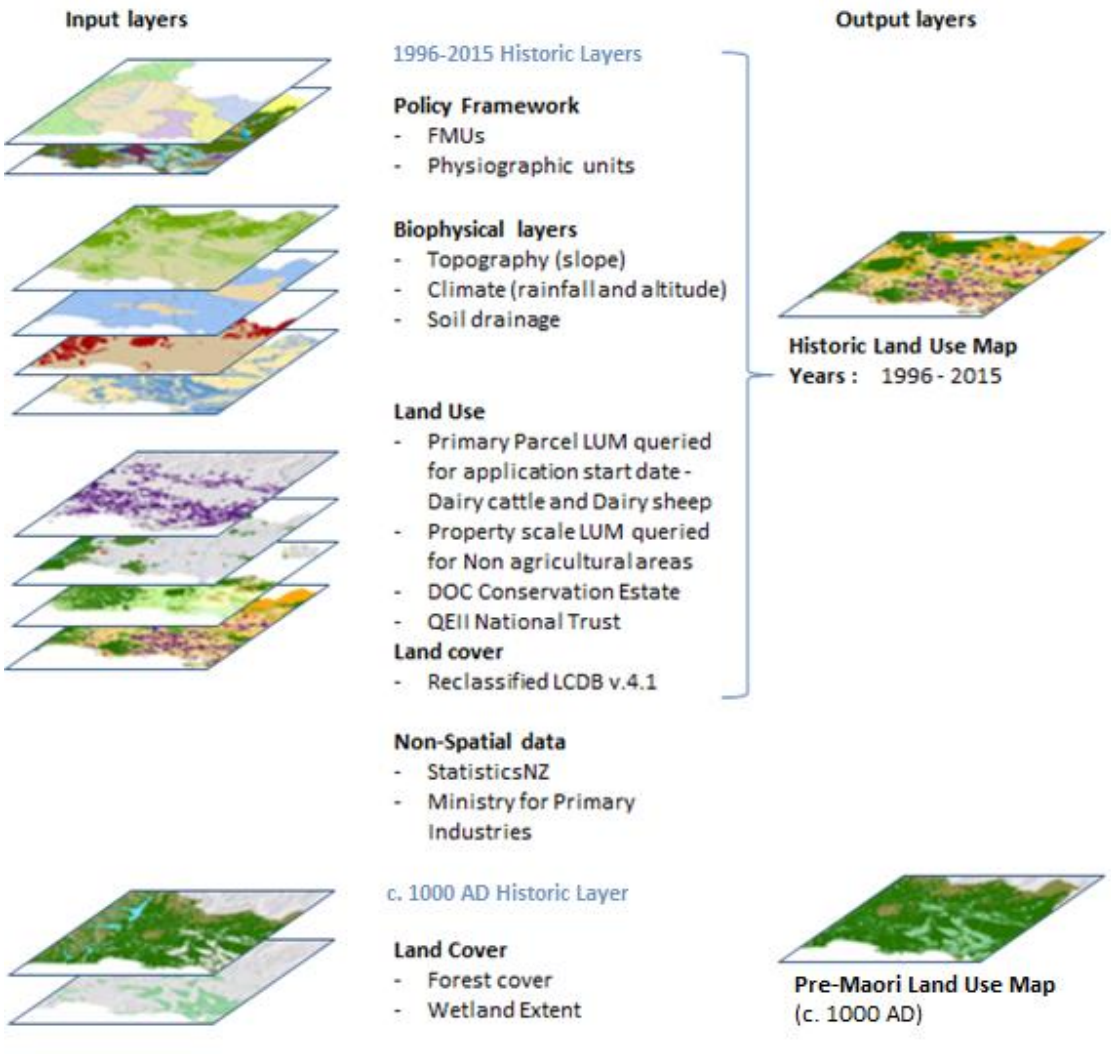


Figure 30: GIS-layers used to produce historical land use maps.

8.1. Historical Land Use Maps - 1996 to 2014

8.1.1. Data Sources and Modification

Historic land use in Southland can be represented spatially by a combination of data sources, specifically:

- Land cover database
- DOC Public Conservation Areas
- QEII National Trusts
- Environment Southland's Resource Consent database for dairy
- Selected non-agricultural land as determined by the Southland Land Use Map

To aid in the classification of land use and intensity the following technical layers were also incorporated:

- LRI Slope
- Rainfall
- Altitude

- Soil drainage
- Physiographic Unit
- FMU

Non-spatial data from StatisticsNZ and Ministry for Primary Industries (MPI) were also used to assess differences in reported production or determine intensity of use.

Land Cover Database

The land cover database currently has four versions produced from imaging carried out in 1996, 2001, 2008 and 2012. LCDBv4.1 reprocessed the imagery from previous versions and applied a consistent classification across each survey. Each survey year in LCDB4.1 was modified to match the classification categories identified in the Southland Land Use Map (Table 7).

Conservation Areas

Over the past 20 years, there has been a significant increase in conservation estate, managed by the Department of Conservation (DOC). Spatial data for conservation estates were obtained from the DOC Public Conservation Areas layer[14]. This layer has the date each parcel was obtained by DOC allowing for the data to be queried and modified using the 'Start Date'.

Spatial data for QEII covenant areas was obtained through a data agreement between ES and the QEII National Trust. Each polygon has a date field that records when the covenant was established. The area of land managed by the QEII National Trust has increased substantially over the last 20 years, from 1,355 ha in 1996 to 6,570 ha in 2015.

Environment Southland Resource Consent - Dairy

ES Resource Consent requirements for dairying began in 1993. Since this date, as part of the resource consent application, spatial data on the milking platform area has been provided to ES and collated in a GIS database. A text field for 'Dairy Year' exists in the attribute table of the Primary Parcel Land Use Map, which identifies the year the land parcel first gained resource consent. As the date field is identified for a parcel of land, the change in milking platform area of an individual farm has been recorded. By selecting for specific years by definition query, the parcels which were Dairy in the year of interest can be displayed.

Non-agricultural land- Southland Land Use Map

The 2015 Land Use Map was used to create a non-agricultural land layer. A definition query was used to select for residential, commercial, industry, public use, recreation and tourism, roads and rail. These land uses were exported as a non-agricultural layer to use as a data source in the historical maps. This layer will potentially overestimate residential land area; however urban expansion is relatively small compared to area used for roads and public use, which is mapped as pasture in LCDB. This data source is titled LUM 2015.

Technical Layers

The biophysical and policy framework layers produced in Section 7.4 were added to the historic maps. These layers are based on either inherent properties of the landscape (slope, altitude, soil drainage, Physiographic Units), or cover the time period of interest (rainfall), and also represent areas for policy application (FMU, Physiographic Units). Therefore, these layers are appropriate

[14] https://koordinates.com/layer/754-doc-public-conservation-areas/

to represent historic conditions in Southland. The exception to this, is applying climate data for the Pre-Maori Land Cover Map version, however for consistency of mapping and comparison between map units, the technical layers were applied to the c. 1000 AD version without further modification.

Non-spatial data: Arable cropping (Statistics New Zealand)

Arable land is difficult to map spatially by satellite imagery. Crop production results in a range of spectral signatures occurring for the activity over the course of a year. Often these spectral signatures appear similar to those within a pastoral land use, as many livestock farms produce arable crops to feed stock. Agricultural statistics, collected by StatisticsNZ, can be used to provide an estimate of arable land used for the production of wheat, barley and oats in Southland. Land used for arable production has ranged between 7,400 and 11,200 ha since 1996, which is relatively small compared to other land uses. Therefore, any disagreement between spatial area, identified by LCDB, and production area, recorded by StatsticsNZ, is likely to be insignificant to overall catchment assessments. Table 10 shows the amount of arable land in Southland from different data sources.

Table 10: Hectares of arable land in Southland as determined by LCDB and StatisticsNZ.

	1996	2001	2008	2012	2015
LCDB1	6,523				
LCDB2		6,549			
LCDB3			7,408		
LCDB4.1	6.523	5,464	6,604	6,169	
StatisticsNZ	10,104	10,536	7,408	8,200	11,200

Non-spatial data: Stock units in Southland - Ministry for Primary Industries

Ministry for Primary Industries (MPI) have been monitoring pastoral land uses since the mid nighties. The change in the intensity of land use over this time, within an industry, can be shown by changes in stock units per hectare by the different farm types (Table 11).

MPI last ran the Farm Monitoring Programme in 2012 and it has since been replaced by partnerships with Beef+LambNZ and DairyNZ. However, due to differences in sampling and reporting, this data was unable to be extended past 2012 in its current form.

Table 11: Stock intensity by cows/ha for dairy and stock units/ha for Sheep and Beef, and Deer (MPI, 2000-2012).

	1997	1998	1999	2000	2001	2002	2003	2004
Dairy (cows/ha)	-	2.5	2.5	2.6	2.6	2.6	2.7	2.7
Deer (SU/ha)	-	11.6	11.3	11.8	12.3	12.9	12.9	15.7
Lowland - Sheep and Beef (SU/ha)	-	13.4	13.4	13.5	13.5	13.5	13.5	13.5
Hill Country - Sheep and Beef (SU/ha)	-	7.8	7.9	8.3	8.5	8.5	8.7	8.5
High Country - Sheep and Beef (SU/ha)	-	1.1	1.1	1.1	1.1	1.1	1.1	1.1

	2005	2006	2007	2008	2009	2010	2011	2012
Dairy (cows/ha)	2.7	2.8	2.9	2.8	2.7	2.6	2.6	2.7
Deer (SU/ha)	15.9	15.3	15.8	13.7	11.1	11.6	11.6	11.5
Lowland - Sheep and Beef (SU/ha)	13.6	13.9	13.0	13.7	13.8	13.1	14.7	14.8
Hill Country - Sheep and Beef (SU/ha)	8.3	8.3	8.4	7.7	9.0	8.9	9.5	9.6
High Country - Sheep and Beef (SU/ha)	1.1	1.1	1.1	1.0	1.0	1.1	1.0	1.1

To remove the impact of environmental and economic factors, which can alter the stocking rates from one year to the next, a liner regression trend analysis was applied to the data (Figure 31). Due to the large stocking rate changes in deer, a trend line was not applied. However, as deer is unable to be differentiated from sheep and beef in the historic land use maps, and has a similar stocking intensity to lowland sheep and beef, the same linear relationship is assumed.

The dairy industry presents stocking intensity by cows per hectare (Table 11), which to show in comparison with the drystock industry needs to be converted into stock units. Stock units for a lactating dairy cow range from 6.5 to 8.5 depending on the breed of the dairy cow[15], therefore a value of 7.5 SU is used to show dairy cows in Figure 31, with error bars showing the upper and lower range of 8.5 and 6.5 SU/ha respectively.

In addition, intensity changes within a land use have also been investigated by Monaghan and De Klein (2013) and Snelder and Legard (2014). These studies estimate a 2% increase in nitrogen loss per year.

These assessments of intensity change within a land use will be used by the Science Team to determine changes in nutrient loss to not only the conversion from one land use to another but also include intensification within an industry.

[15] http://portal.beeflambnz.com/tools/benchmarking-tool/definitions

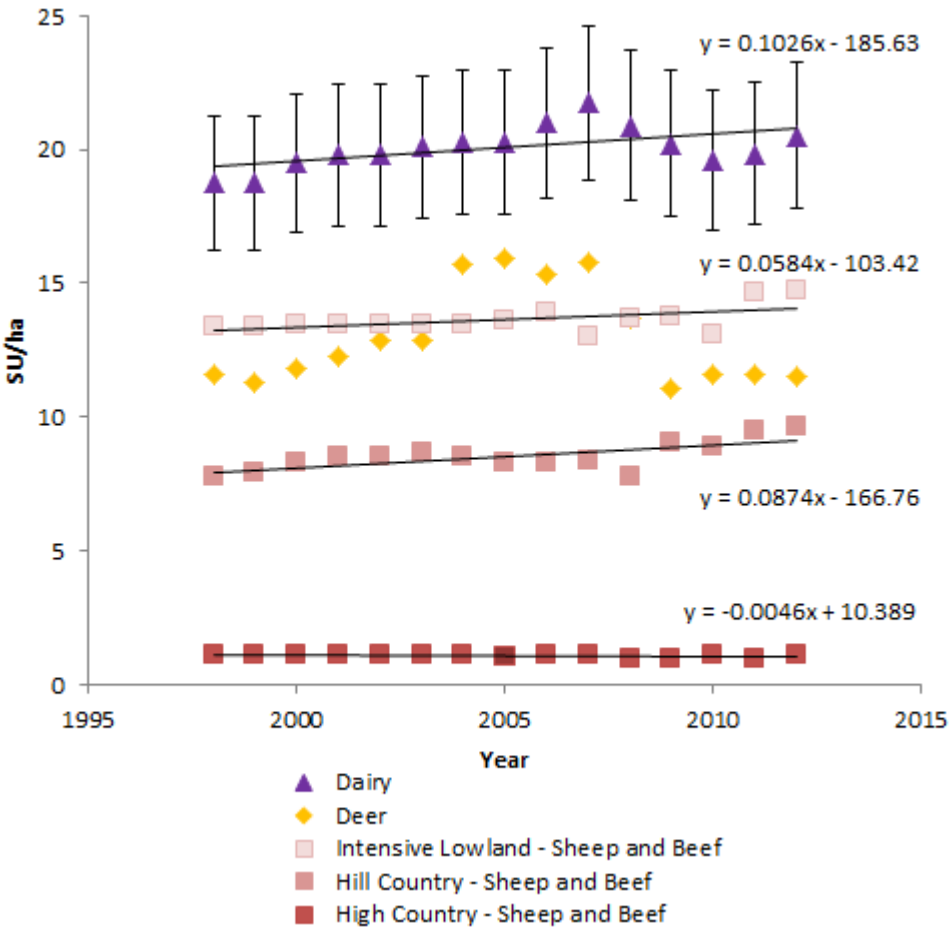


Figure 31: Intensity of land use as shown by stock units per hectare. Note the range of likely SU/ha for dairy estimated from reported cows/ha.

8.1.2. Historical Land Use Map Categories

The categories and data sources used to identify land use for historic maps are shown in Table 12. It is important to note that without Agribase™ it was no longer possible to identify sheep, beef, deer and other livestock farm types. Therefore, a method was developed which classifies the land cover of intensive and extensive pastoral areas, and tussock grasslands first; and secondly inferred land use by refining the categories by the topography and altitude.

To display the land use, a combination of topography and altitude were used to identify land use categories of high country, hill country and lowland drystock by grouping the classes of intensive pasture, extensive pasture and tussock grassland. The altitude was used to identify high country farms, defined as areas 600 m above sea level[16]. The remaining pastoral areas (below 600 m altitude) were differentiated by topography into two categories, lowland (flat and rolling slopes, <16 degrees) and hill country (easy hill to steep hill, >16 degrees). Although some other pastoral land uses will be included in this classification, the resulting difference is likely to be insignificant and will be assessed by comparison of the 2015 version with the Southland Land Use Map.

[16] https://www.landcareresearch.co.nz/__data/assets/pdf_file/0020/77033/1_5_Morris.pdf

Table 12: Historical land use categories and data sources.

Land use/cover	Categories	Data Source
Conservation	Conservation Estate extent from relevant year	DOC Register
QEII	QEII covenants from relevant year	QEII Trust
Exotic Forest	Exotic forest, Forest Harvested, Deciduous hardwoods	LCDB4.1
Indigenous Cover	Indigenous Forest (not within Conservation Estate), Flaxland, Fernland, Manuka and/or Kanuka, Matagouri or Grey Scrub, Broadleaved Indigenous Hardwoods and Sub-Alpine Shrubland	LCDB4.1
Wetlands	Herbaceous Freshwater Vegetation	LCDB4.1
Lakes and Rivers	Lake or Pond, River	LCDB4.1, LUM 2015
Recreation	Recreation and Tourism	LUM 2015
Residential and Commercial	Residential and Commercial	LCDB4.1
Public use	Public use	LUM 2015
Industrial	Industrial	LUM 2015
Road and Rail	Road and Rail	LUM 2015
Arable	Short-rotation cropland	LCDB4.1
Horticulture	Orchard Vineyard and Other Perennial Crops	LCDB4.1
Intensive Pasture	High producing exotic grassland without Dairy Platform	LCDB4.1, Altitude, Slope
Extensive Pasture	Low producing grassland, Depleted grassland, Gorse and/or Broom, Mixed Exotic Shrubland, (Insignificant areas of Permanent Snow and Ice, Gravel or Rock, Sand or Gravel, Landslide, Surface Mine or Dump**)**	LCDB4.1, Altitude, Slope
Tussock Grassland	Alpine grass/Herbfield, Tall Tussock Grassland	LCDB4.1, Altitude, Slope
Dairy	Environment Southland Dairy Milking platform layer from relevant year	LUM 2015

8.1.3. Methodology for 1996 – 2015 Land Use Maps

The modified LCDB4.1 layer was used as a base to create a land use map for each year. Text fields for each year between 1996 and 2015 ('LU_1996' … 'LU_2015') were added to the attribute table of the combined data source layer, 'Historic_NEW'.

A field titled 'CON_Year' was added to the DOC public conservation area layer and populated with the last 4 digits of the 'Start Date' field to easily query for the year in which the polygon was added to the DOC estate. A union between 'Historic_NEW' and DOC public conservation areas was undertaken to identify protected areas spatially. For these areas, the Land Use Classification for the relevant year ('LU_1996' to 'LU_2015') was reclassified with 'Conservation' as the primary land use and the previous land cover information as a secondary classification i.e. 'Conservation – Indigenous Forest'.

A field titled 'QEII_Year' was added to the QEII National Trust covenant areas layer and populated with the last 4 digits of the 'DateRegd' field to easy query for the year in which the polygon was registered with the QEII National Trust. A union between the base layer and the QEII areas was undertaken to identify these areas spatially. For these areas, the Land Use Classification for the relevant year ('LU_1996' to 'LU_2015') was reclassified with 'QEII' as the primary land use and the previous land cover information as a secondary classification i.e. 'QEII – Indigenous Forest'.

The Primary Parcel Land Use Map was used to identify dairy and non-agricultural areas as it already contained a combined dataset for this information, without the need to recreate multiple input layers. In the Primary Parcel Land Use Map, a definition query was applied for 'Dairy' or 'Dairy Sheep'. The Primary Parcel Land Use Map was subsequently incorporated in to the above output by a union. For each LU year, the 'Dairy Year' field was selected for parcels under a dairy land use in the corresponding year. For these areas, the relevant Land Use Class ('LU_1996' to 'LU_2015') was reclassified with either 'Dairy' or 'Dairy Sheep' classifications.

To classify the polygons, the 'Select by Attribute' feature was used to identify the LCDB4.1 classification for Indigenous Forest, Exotic Forest, Wetlands, Lakes and Rivers, Arable, Horticulture and Residential and Commercial in turn. For years between 1996 and 2000, the 1996 LCDB4.1 classification was applied. For years between 2001 and 2007, the 2001 LCDB4.1 classification was applied. For years between 2008 and 2011, the 2008 LCDB4.1 classification was applied. For 2012 to 2015, the 2012 LCDB4.1 classification was applied.

To classify pastoral and tussock grassland areas, biophysical information was also included to infer intensity within the classification. LRI Slope classification layer and the Climate (Altitude) layer were used to identify areas of intensive lowlands, hill country and high country likely farm types. For example, High producing exotic grassland above 600 metres in elevation received a classification of 'High Country Intensive Drystock', while areas of High producing exotic grassland below 600 metres in elevation were separated into 'Hill Country Intensive Drystock' (Slope = 'Easy Hill' or 'Steep') and 'Lowland Intensive Drystock' (Slope = 'Flat' and 'Rolling').

Non Agricultural areas such as 'Public', 'Recreation and Tourism', 'Industry and Airports', 'Lakes and Rivers', and 'Road and Rail' were added through a union with a layer titled 'Technical_NonAg' which was created by applying a definition query to the Property Scale Land Use Map. It was assumed that these areas hadn't significantly changed in the last 20 years.

For specific methodology see Appendix 5.

8.1.4. Historical Land Use Map Summary – 1996-2015

There have been a number of land use changes in Southland over the past 20 years, as shown in Figure 32 which was produced from the output of each historic land use map between 1996 and 2015. Much of the large land use changes have been on paper only, with the creation of protected areas, through Department of Conservation estate. The Takitimu Mountains, Eyre Mountains and Snowdon Forest were included in the DOC estate in 1997 and 1998, and Rakiura National Park (Stewart Island) opened in March 2002. Figure 33-36 shows the historic land use maps for the year's corresponding to LCDB imagery dates (1996, 2001, 2008 and 2012) and Figure 37 shows the land use in 2015.

Dairying in Southland has increased steadily since the early 1990's, primarily on the Southland Plains, then further north to the Waimea Plains (Figure 33-37). This expansion has come from previously sheep and beef (to a lesser extent deer and arable) properties converting to dairying. Intensive/Extensive pasture represents the likely area of sheep, beef and to a lesser extent deer (and mixed arable) in Southland. However, without the use of spatial agricultural data, there is a low level of certainty regarding the amount of hectares used for sheep, beef and deer farming.

Agricultural statistics can be used in conjunction with land cover to infer intensity by change in stock numbers and stocking rates (Ledgard, 2003a). The conversion of pastoral land to dairying has driven the sheep and beef, and deer industries to utilise more hill country, shown through the conversion of extensive pasture (and scrubland) to intensive pasture, whilst the conversion of conservation estate has restricted extensive sheep, beef and deer grazing from the high country (Figure 33-37).

Arable production is not well represented through this methodology as many arable farms in Southland are mixed with pastoral land uses (typically sheep and beef). These discrepancies in reporting were shown earlier in Table 11. Historically, arable land was a large part of agricultural land use with approximately 30,000 hectares used for production between 1975 (when agricultural reporting began) to 1985 (Ledgard, 2003a). Since 1985, arable land has been in decline reaching a minimum of 7,000 ha in 2008. The increase in arable crop production in recent years is likely due to the increased demand for feed from the expanding dairy industry.

To assess the differences between the two mapping methodologies, the Historical Land Use Map 2015 version can be directly compared with the Technical Southland Land Use Map. It is important to understand the differences in the level of detail provided by the two methodologies especially when they are being used to assess nutrient inputs and estimated losses from agricultural areas in Southland.

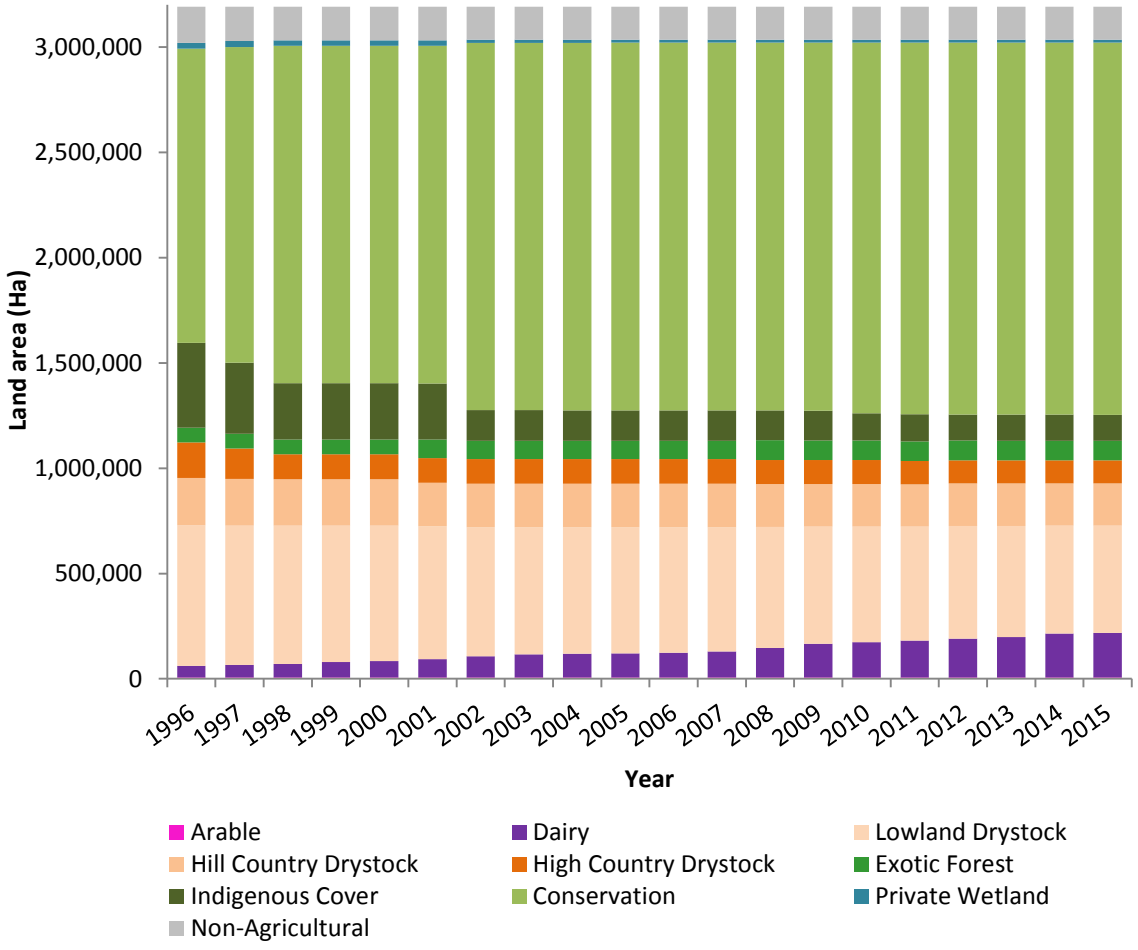


Figure 32: Land use change from 1996 to 2015.

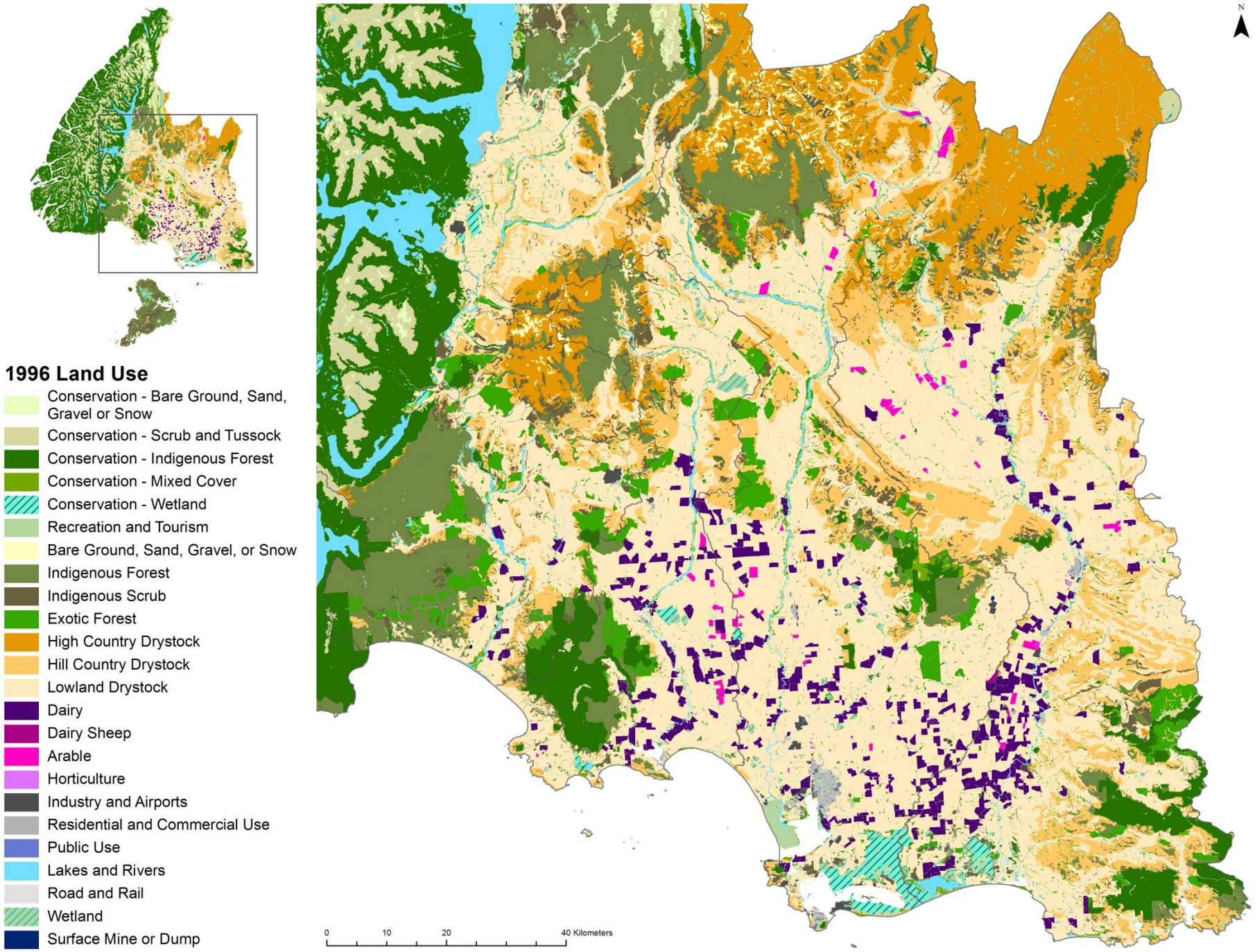


Figure 33: Land use in Southland in 1996.

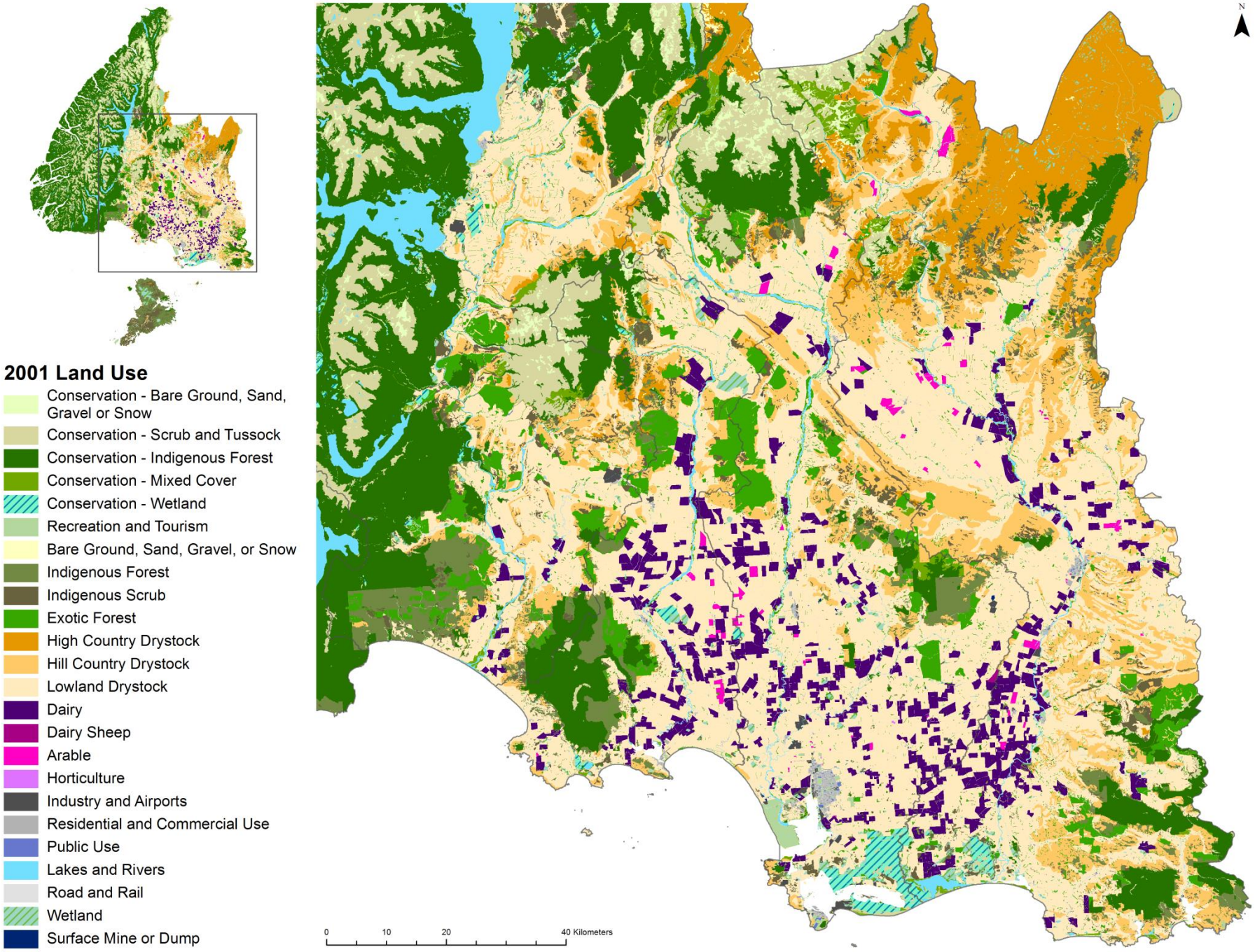


Figure 34: Land use in Southland in 2001.

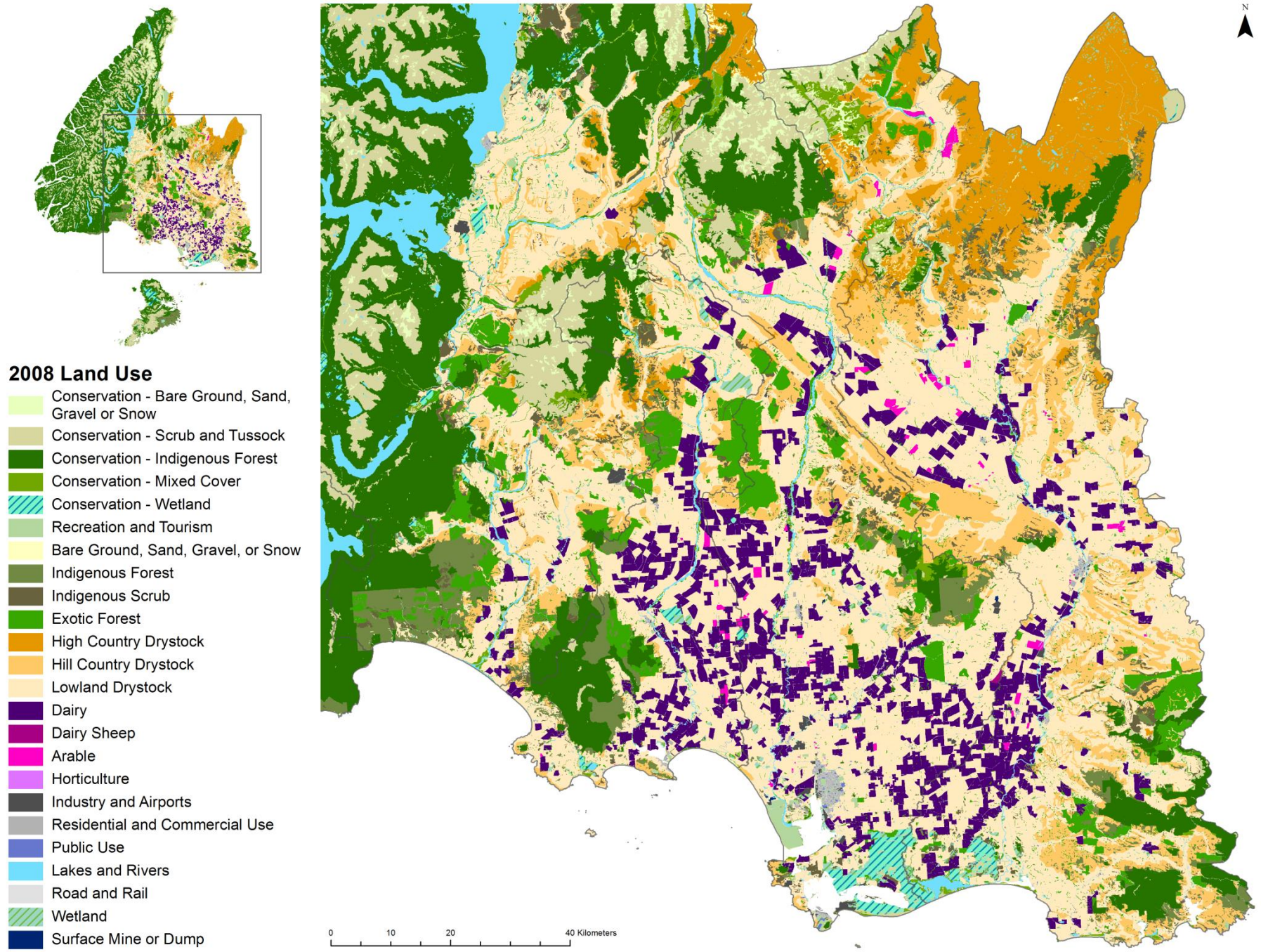


Figure 35: Land use in Southland in 2008.

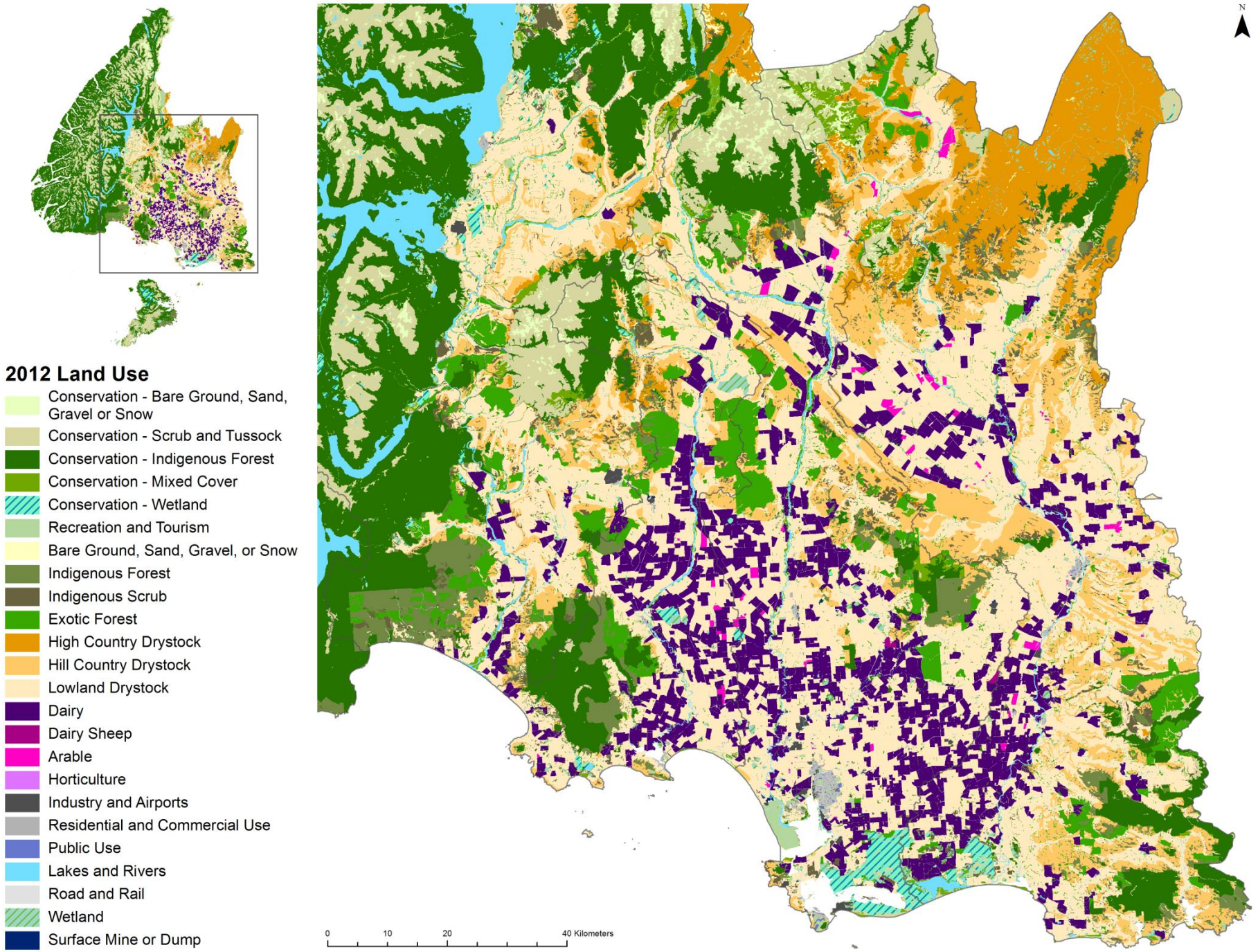


Figure 36: Land use in Southland in 2012.

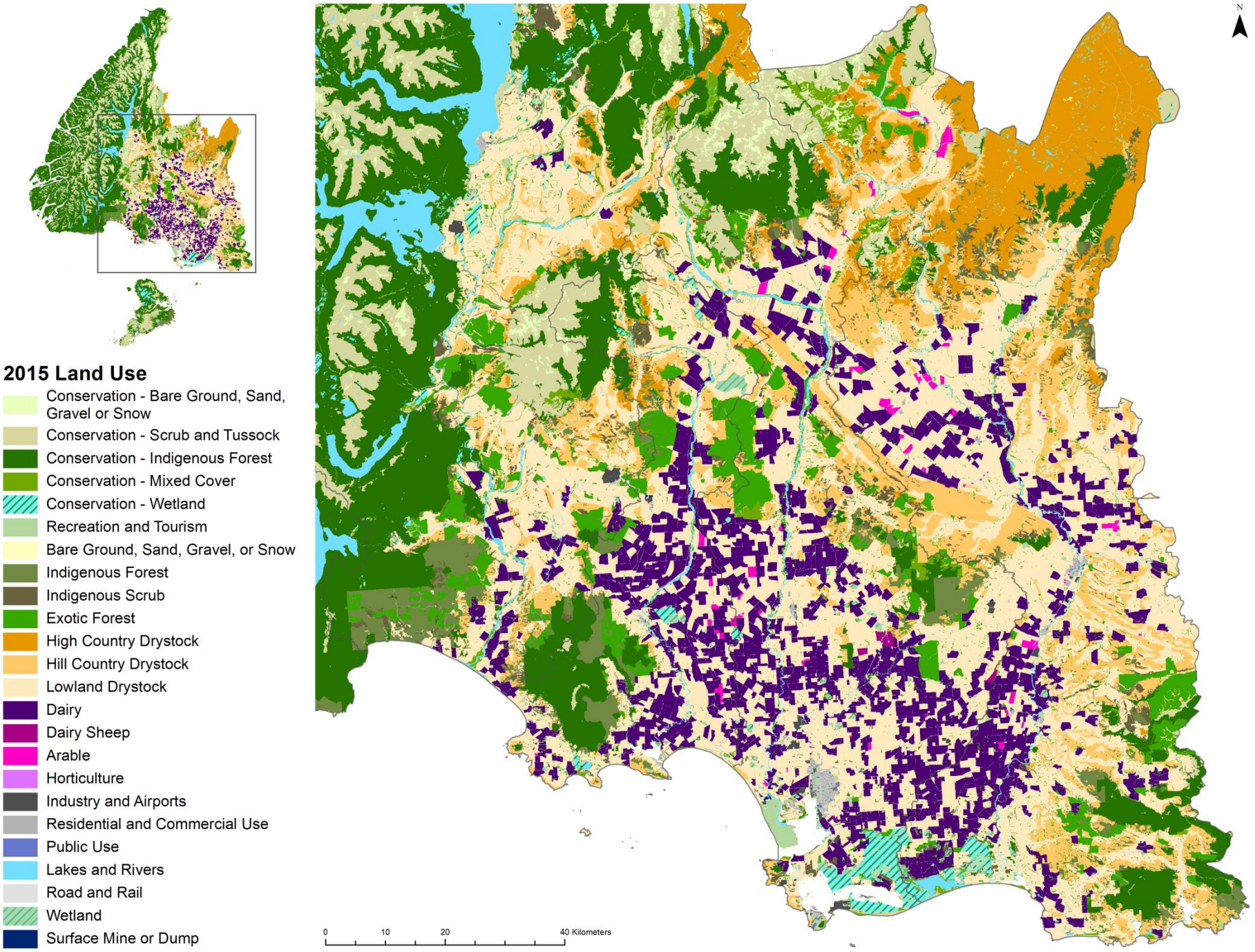


Figure 37: Land use in Southland in 2015.

8.2. Pre-Maori Land Cover Map (c. 1000 AD)

A pre-Maori land cover map was developed to aid the Science Team in estimating natural state nutrient and sediment load to receiving waterbodies. This layer will provide a reference state for Southland prior to Maori settlement (c. 1000 AD).

8.2.1. Data Sources and Modification

Pre-Maori land use in Southland can be represented spatially by a combination of data sources, specifically:

- Potential Natural Vegetation (PNV)
- Wetland extent
- Physiographic Units (PU)
- Combined Soil Layer (CSL)

For comparison with the previous maps, the following technical layers were also incorporated:

- LRI Slope
- Rainfall
- Altitude
- Soil drainage
- Physiographic Unit
- FMU

Potential Natural Vegetation

Forest extent in Southland is obtainable from Landcare Research - Our Environment[17]. The PNV layer provides an estimate of what New Zealand's vegetation cover would have been in the absence of humans (Figure 38). It was generated from largely raster data using statistical tools both for the interpolation of point climate data and the analysis of spatial patterns to reconstruct the likely biological character of New Zealand's pre-human past (Leathwick et al., 2012; Leathwick, 2001).

This layer was modified using the **Physiographic Units** to refine tussock grassland extent to the 'Alpine' Physiographic Unit. The Alpine unit defines the tree line boundary with higher resolution than the 1km grid used in the original PNV layer. This layer forms the base data layer for the pre-Maori land cover map.

[17] To view layer: http://ourenvironment.scinfo.org.nz/ourenvironment#p=home
Downloaded from: https://lris.scinfo.org.nz/layer/289-potential-vegetation-of-new-zealand/?nc=&z=5&c=-40.65085651522624%2C173&mt=OpenStreetMap

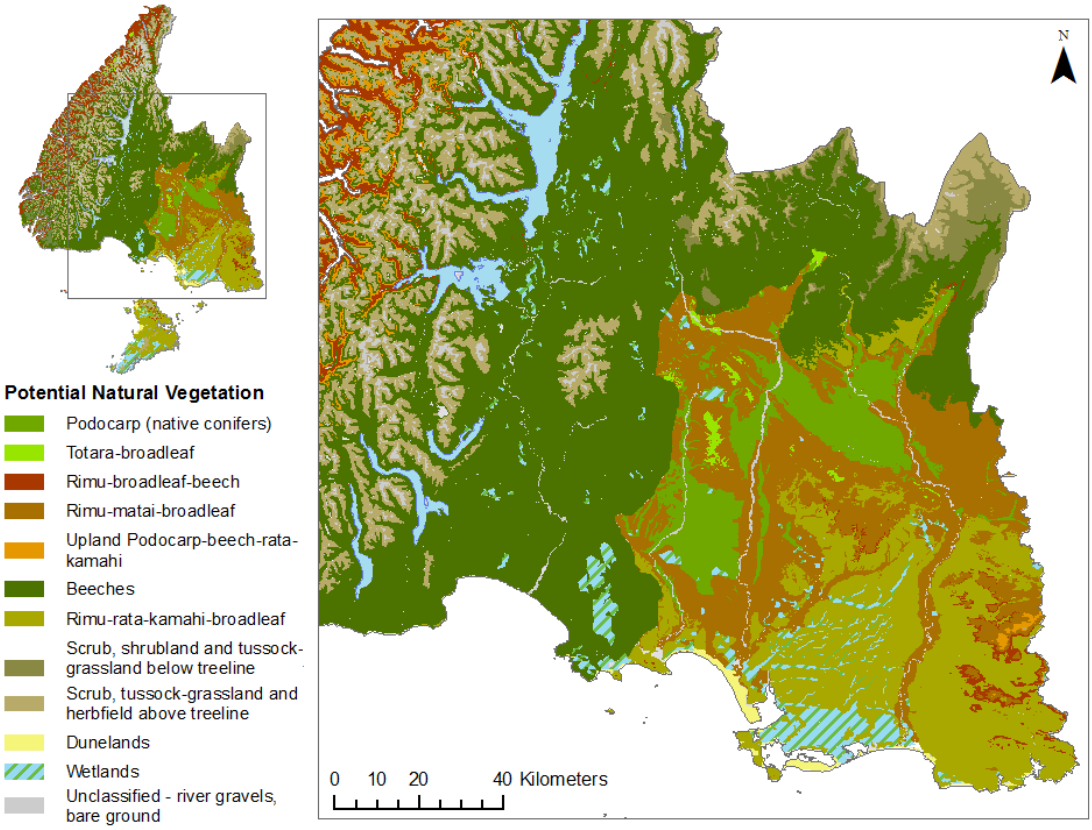


Figure 38: Potential natural vegetation of Southland (Landcare Research – Our Environment).

Wetland Extent

A wide range of wetland types were present in Southland from swamps, fens, and bogs, to dune slacks, coastal estuaries and marshes (Ledgard, 2003a). Wetland extent in Southland was originally mapped as part of the Wetlands of National Importance (WONI) survey (Ausseil et al., 2008). The WONI layer was produced using soil information from the Land Resource Inventory (LRI) and a 15m digital elevation model (DEM) to refine soil boundaries. This layer is available online from Landcare Research - Our Environment[12]. The WONI layer was refined by Clarkson et al. (2011), using expert opinion and local knowledge to reanalyse wetland extent from that estimated in WONI (Figure 39). This layer does not include Fiordland National Park.

The Clarkson layer was modified using the **Combined Soils Layer** (CSL, Section 7.1.3) to further refine wetland extent. Clarkson et al. (2011) retained the polygons used in the original WONI survey, and provided a percentage of wetland area for the polygon. The CSL was combined with the Clarkson layer using the union geoprocessing tool. Wetland polygons were adjusted to the extent of imperfectly drained to very poorly drained soils to improve the spatial representation of the wetland extent. This was done as many of the Clarkson et al. (2011) polygons detailed partial coverage of the polygon area. Additional areas were added where soil profile drainage was very poor. The CSL was produced from more recent soil information in agricultural areas than the LRI survey used to classify the original wetland polygons.

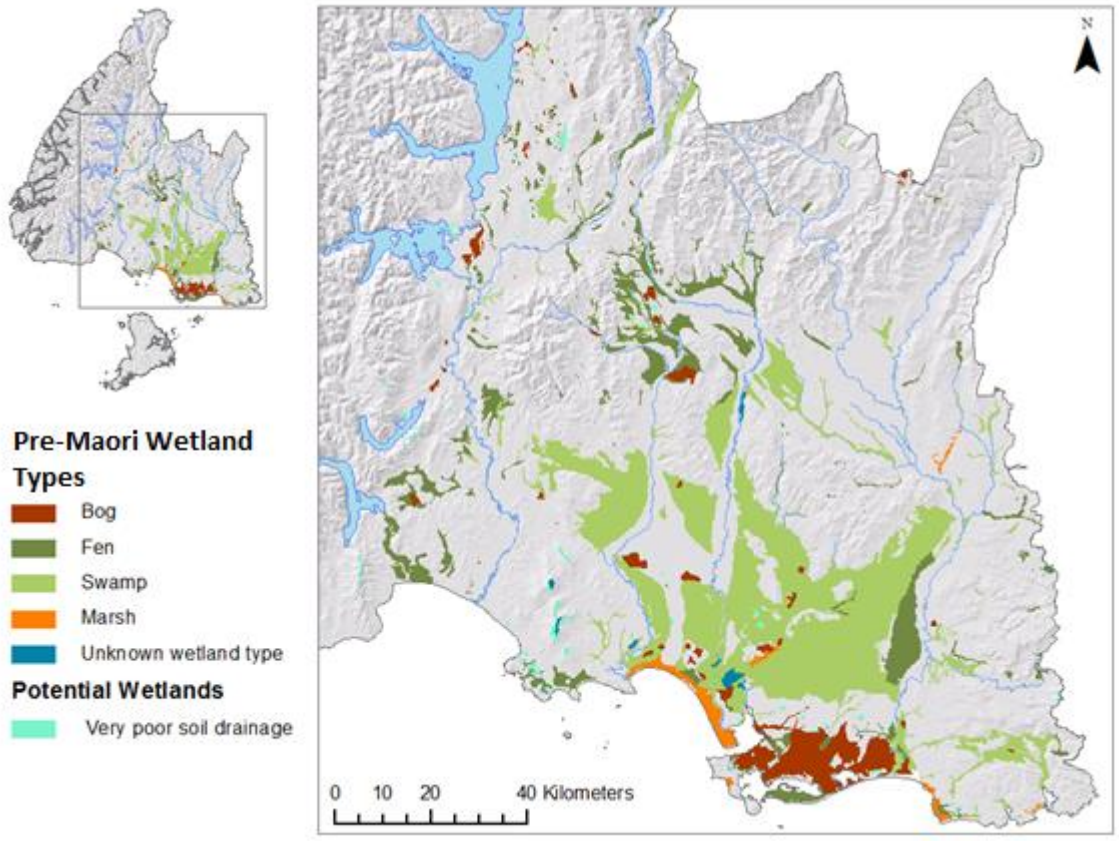


Figure 39: Pre-Maori wetland type and extent (Clarkson et al. 2011) and potential wetland areas based on very poor soil profile drainage (Combined Soil Layer).

8.2.2. Pre-Maori Land Cover Categories

The categories and data sources used to identify land cover for the pre-Maori land cover map are shown in Table 13.

Table 13: Pre-Maori land cover categories.

Land use/cover	Categories	Data Source	ES Code
Indigenous Forest	Podocarp (native conifers), Totara-broadleaf, Rimu-broadleaf-beech, Rimu-matai-broadleaf, Upland Podocarp-beech-rata-kamahi, Rimu-rata-kamahi-broadleaf, Beeches.	PNV	INDFOR
Alpine tussock	Scrub, tussock-grassland and herbfield above the tree line as defined by the Alpine Physiographic Unit.	PNV, PU	ALPTUS
Scrub and Tussock grassland	Scrub, shrubland and tussock grassland below treeline as defined by the Alpine Physiographic Unit.	PNV, PU	SCRTUS
Dunelands	Dunelands	PNV	DUNE
Wetlands	Swamps, fens, peat bogs, dune slacks, coastal estuaries and marshes on imperfectly, poorly, and very poorly drained soils – add. areas of very poorly drained soils that were not identified previously	Clarkson/CSL	WET
Bare ground	Bare ground, gravel or ice	PNV	BARE
Lakes and Rivers	Lake or Pond, River	PNV	HYDRO

8.2.3. Methodology for Pre-Maori Land Use Map

The modified potential natural vegetation layer was used as a base to populate with land cover information to create a map representative of pre-Maori Southland (c. 1000 AD). Text fields for 'ES_Code', 'Land Use Class', 'Source' and a Double field for 'Hectare' were added to the attribute table of the land cover layer. These fields were populated according to Table 13.

A union between the PNV base layer and wetland extent (Clarkson/Combined Soils layer) was undertaken to identify historic wetlands spatially, as these areas were more accurate than the PNV wetland extent. For these areas, ES Code was changed to 'WET', Land Use Class to 'Wetland' and Source as 'Clarkson/CSL'; see Appendix 6 for specific details.

The map was symbolised according to the table in Appendix 7.

8.2.4. Pre-Maori Land Cover Summary

The c. 1000 AD layer shows the extent of potential land cover prior to Maori arrival (Figure 40). Indigenous forests covered most of Southland, primarily beech, podocarp and broadleaf species. Large, expansive wetlands extended across Southland's poorly drained areas, predominantly on the Southern plains.

Settlement of the Southland plains began in the mid-1850s after Walter Mantell purchased Murihiku – Southland, "the tail end (of the land)", from the local Maori iwi, specifically for European settlement[18]. The area of land negotiated was approximately 2,800,000 hectares, and after this purchase sheep farmers (runholders) and former whalers took up pastoral leases. Southland's Hundred Line marked the northern limit of Southland farmland and is so named because land was divided into hundreds - blocks capable of supporting one hundred people. The Hundred Line originates at Ship Cone in the Hokonui Hills and extends 68 kilometres west to the Otautau Stream at Scotts Gap. North of the line the land was much more sparsely settled and used for vast sheep and cattle runs. A survey map of the Southland region from 1857 can be found in Te Ara – The Encyclopaedia of New Zealand[19].

No attempt has been made to estimate likely land use/cover between the c. 1000 AD and 1996 land use maps, as spatial data on the large scale vegetation clearing that occurred in Southland is limited. Wheeler et al. (2013) estimated the effect of historic land use in the Tukituki catchment, Hawkes Bay, by adjusting the nutrient loss from the land over time to represent likely farm scenarios for time periods when spatial data was unavailable. This approach will be investigated further in Stage 2.

[18] http://www.teara.govt.nz/en/1966/murihiku
[19] http://www.teara.govt.nz/en/interactive/20105/survey-map-of-southland

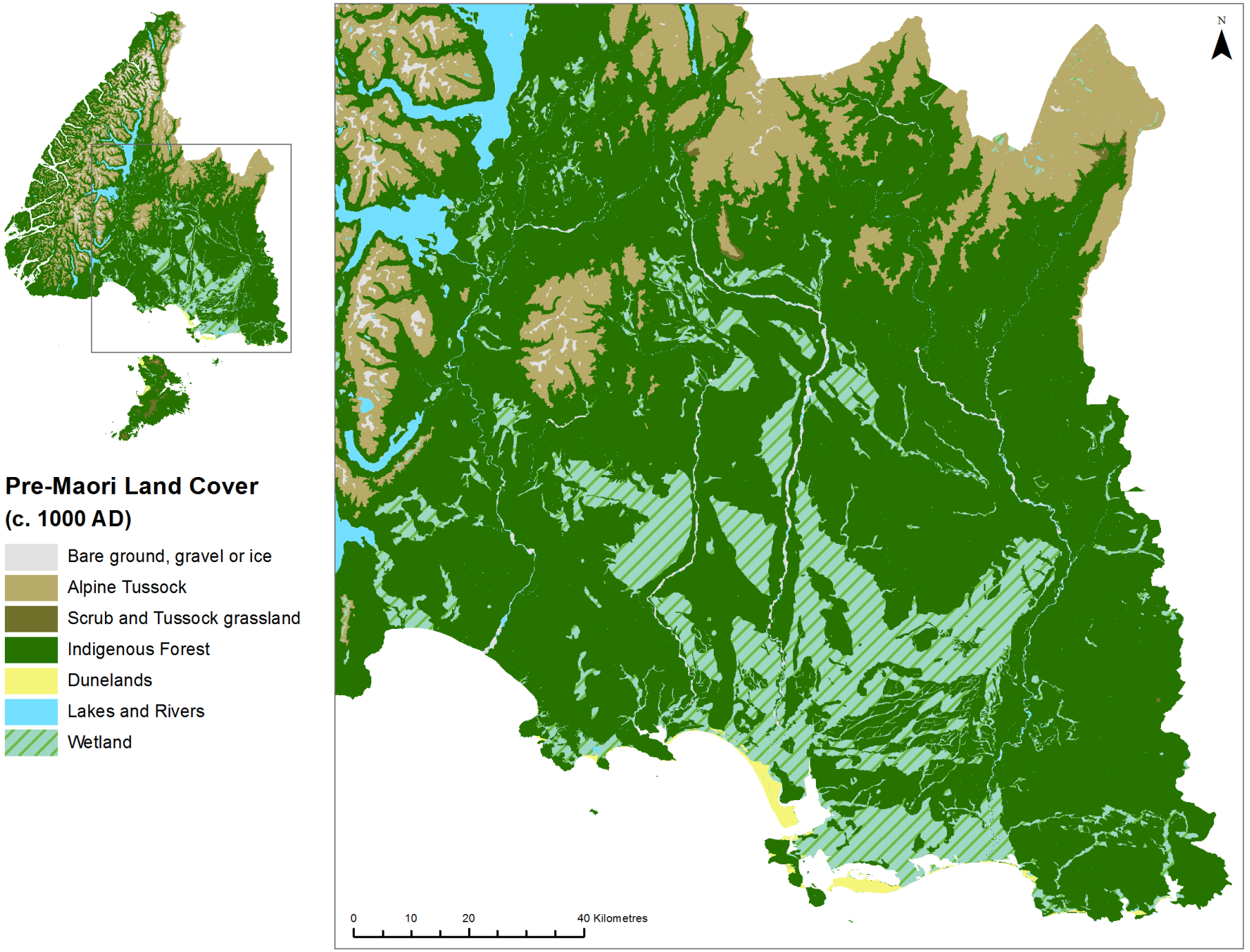


Figure 40: Land cover in Southland c. 1000 AD.

9. Updating Land Use Information

9.1. Provenance of Southland Land Use Map

The date of the land use map reflects the land use information Environment Southland held at the time the map was produced. The date of the Southland Land Use Map is April 2015, which was when Agribase™ was received from AsureQuality, and the extraction of ES Resource Consents from the database was undertaken. The provenance of the map is determined by the records within each data source, i.e. when Agribase collected the farm information, unless known to be current i.e. ES resource consent information. The provenance of the data will vary depending on the source of the input databases and how regularly they can be updated. Figure 41 shows spatially which data source was used to classify land use for each parcel in Southland.

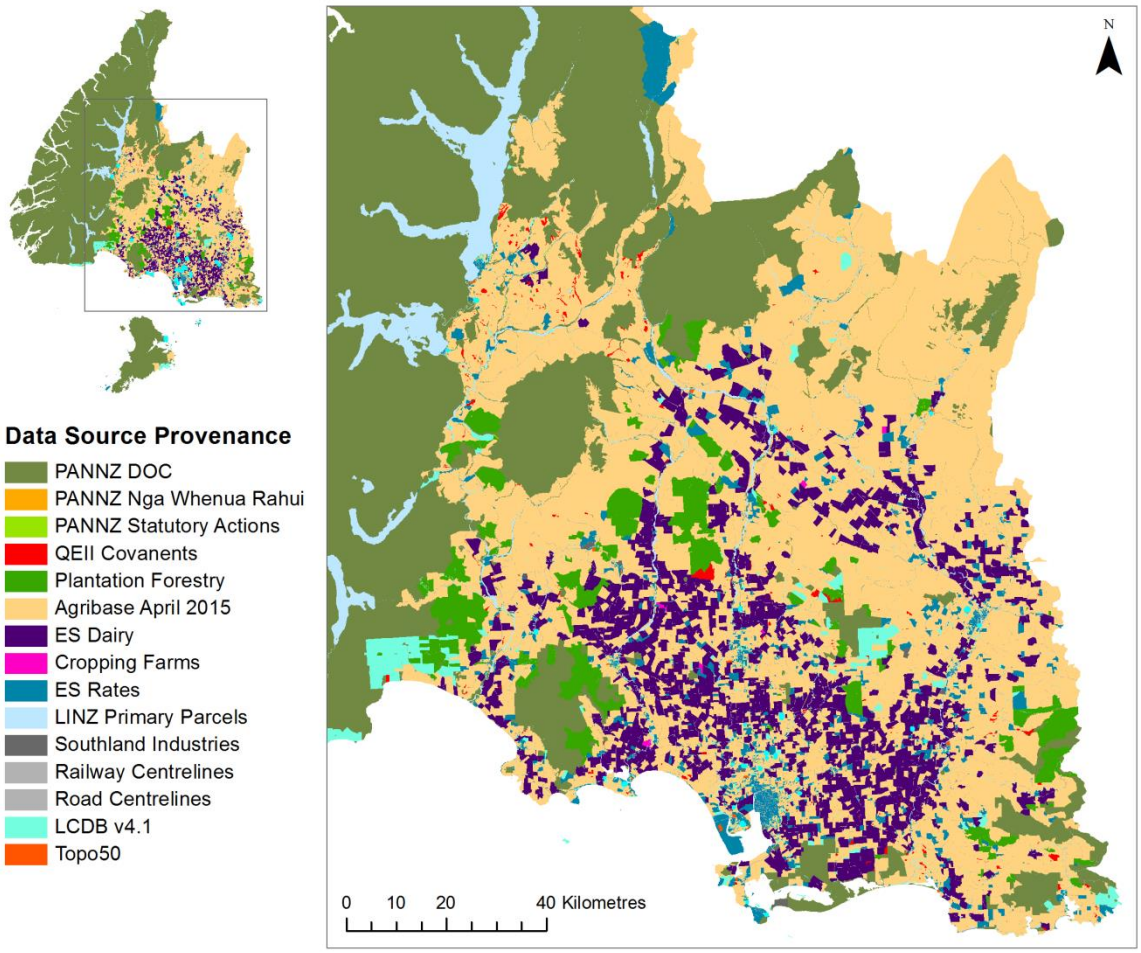


Figure 41: Map of data source provenance.

Over 95% of records in the Southland Land Use Map are Tier 1 national statistics[20]. Figure 42 shows spatially the year a record was obtained within the data source used. Records which were current (obtained from live databases) at the time of input have the date 2015. The hectares of land classified by both data source and date for the Land Use Map are shown in Table 14. PAN-NZ was used to classify the largest percentage of land area in Southland, as 55% of the region is in conservation estate (Figure 43a). Agribase covers 28% of land area in Southland, which is equal to 63% of non-conservation area (Figure 43b). A further 15% of non-conservation area was identified by ES Dairy Resource Consents. LCDBv4.1 represents the area of land which was not able to be assigned a land use, and was represented in the Southland Land Use Map as Unknown Use – pastoral, indigenous cover or non-agricultural. The area of unknown land use is 2.5% of the Southland region or 5.5% of the non-conservation area.

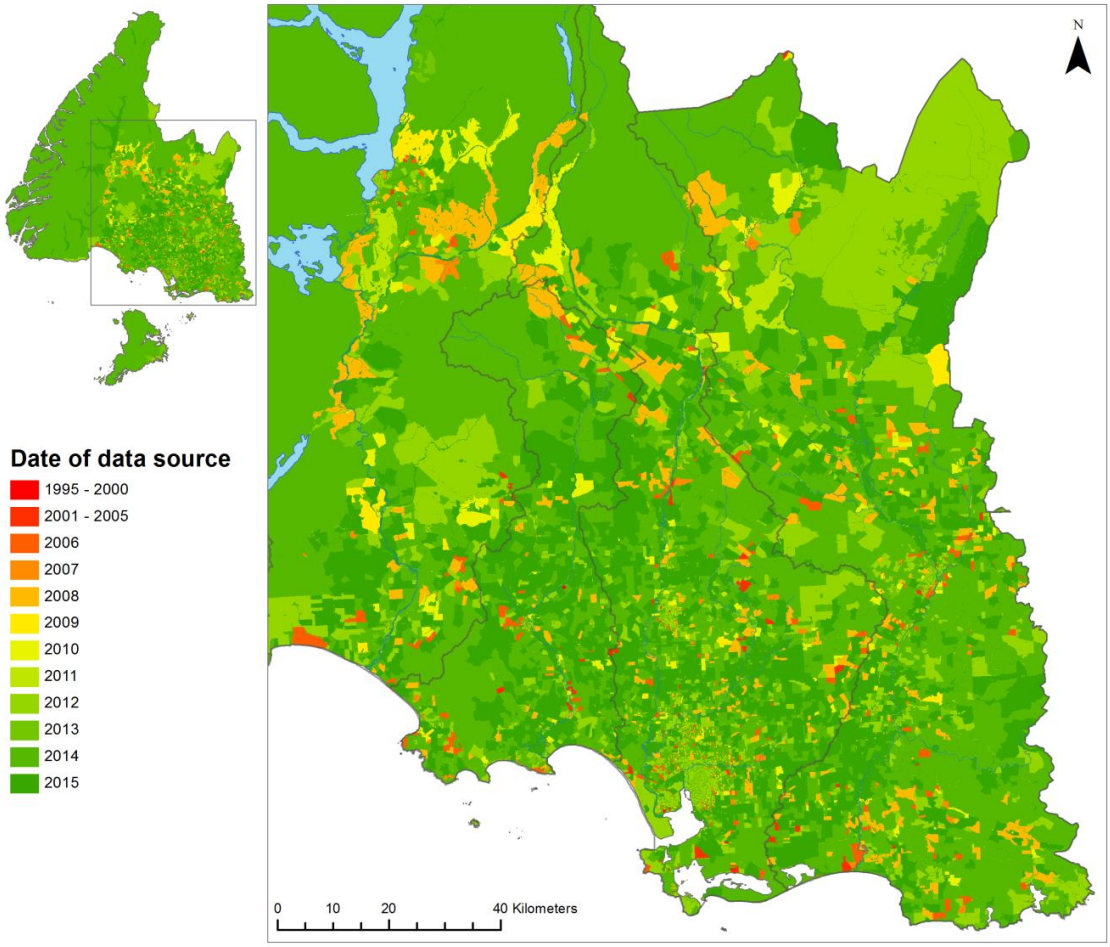


Figure 42: Map of source date provenance.

[20] A record sourced within the last 5 years.

Table 14: Hectares of land in the Southland Land Use Map as determined by each data source and record date.

Data Source	1995-1999	2000-2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total (Ha)
PANNZ DOC												1,771,396		**1,771,396**
Agribase	79	3,870	432	14,897	5,546	75,660	16,204	32,294	10,975	179,423	18,775	492,000	35,049	**885,207**
ES Dairy													216,884	**216,884**
LINZ Primary parcels													86,433	**86,433**
Plantation Forestry													84,221	**84,221**
ES Rates 2012										68,804				**68,804**
LCDBv4.1										45,391				**45,391**
Road centrelines													19,350	**19,350**
QEII													6,628	**6,628**
ES Industry													1,412	**1,412**
Topo50													736	**736**
FAR Arable										730				**730**
PANNZ Statutory Actions												616		**616**
Railway centrelines													524	**524**
PANNZ Nga Whenua Rahui												130		**130**
Total	**79**	**3,870**	**432**	**14,897**	**5,546**	**75,660**	**16,204**	**32,294**	**10,975**	**294,348**	**18,775**	**2,264,142**	**451,236**	**3,188,461**

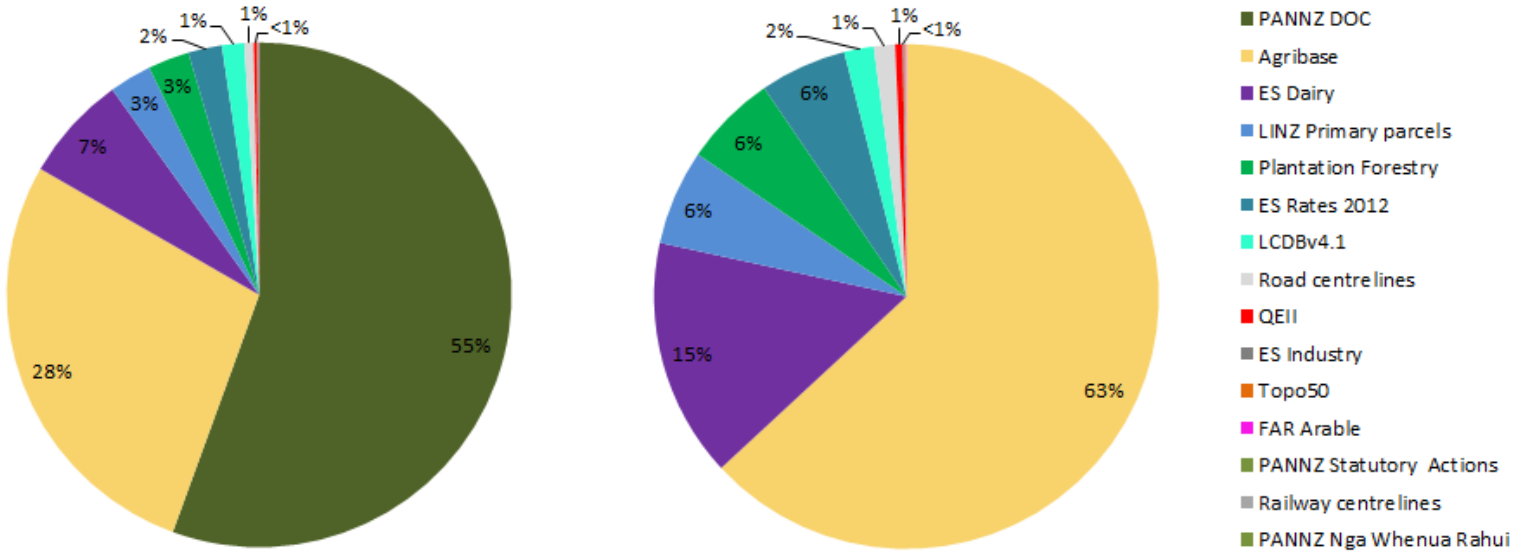


Figure 43: Hectares of a) Southland and b) non-conservation areas classified by each data source. Southland includes Stewart Island and other offshore islands.

9.2. Updating the Southland Land Use Map

9.2.1. Data Sources

Data sources used for the Southland Land Use Map can be updated at the following frequencies:

- The **Primary Parcel Layer**, sourced from LINZ, has weekly rolling updates. The current version of this layer can be downloaded when the Southland Land Use Map needs updating.
- Updates of **Agribase™** from Assure Quality are received on a six monthly basis (April and October), until 30 April 2017. After the expiry of the current data agreement, either a new contract will need to be negotiated or not required due to ES data capture developments (see Section 11.2.1).
- **Environment Southland's Consent Database** can be exported at any time. The data export from this source was timed to correspond with Agribase updates.
- **Other industry inputs** do not currently have an update schedule and are made on request.
- **PAN-NZ** database is available on request to Landcare Research, although it is unclear how frequently this source is updated. The latest version was compiled 2012.
- **QEII Trust** covenants are sourced directly from the QEII Trust, with ES receiving updates approximately every four months.
- The **Land Cover Database** (LCDB), from Landcare Research has been updated at a frequency of every 4-5 years since the first version in summer 1996/7. The current version LCDB4.1 uses imagery from the summer of 2012/13. However, there is uncertainty around continued availability of this data source.
- **Topographic data (LINZ)** is updated at least annually, although these updates vary in frequency and coverage. Topo50 is not an important data requirement for the land use map.

9.2.2. Update Methodology

Environment Southland currently has the capability to update the Land Use Map on a six-monthly basis.

To update the map the previous Primary Parcel Land Use Map is used as a data input in the updated version. This method ensures modifications to the map from additional inputs are recorded and transferred. It also means the process of assembling all data sources is less time consuming as only records where data has changed need to be updated.

Updating the Southland Land Use Map in the future will follow the following steps:

1. Obtain updated source data – including primary parcel layer from LINZ, Agribase™ from AsureQuality, PAN-NZ from Landcare Research, LCDB from the LRIS portal (if new version available), and other industry sources (FAR, DINZ, Forestry companies).
2. Extract current GIS layers from Consent database – Dairy Farm Area and Industrial Discharges. Check for current status.
3. Spatially join the previous Land Use Map to the primary parcel layer (using method defined in Section 6.2.2)

4. In new version of Agribase™, identify records with a source date after version used in the current Land Use Map.
5. Assess record against the Agribase™ modification rules defined in Section 6.1.5 and change if necessary.
6. Populate the Primary Parcel Layer following the methodology to input a data source by spatially joining records which have been updated from data sources identified in steps 3 – 6 (Section 6.2.2). This will replace the record from the previous land use map with the updated information.
7. Dissolve by IRIS_ID, Argribse Farm_ID or property name to produce LU map at property scale (Section 6.3).

10. Key Assumptions, Validation and Limitations

10.1 Key assumptions

When classifying land use using the available data sources there are a number of key assumptions made. These are as follows:

- The definition of a property is the same as the Agribase definition; with the exception of dairy farms where the dairy support land has been mapped as a separate classification to the milking platform.
- The classification to determine farming type (sheep, beef, sheep and beef etc.) are aimed only at the presence of a stock type rather than stock intensity. Beef + Lamb have identified that stock present on a farm can change significantly from one year to the next, depending on the return for a farmer or management practices on farm. Fewer changes are made when infrastructure changes are needed (ie. deer fences). Therefore, Agribase™ stock information (including stock factors) are used only as a guide as to the presence or absence of stock on a property, rather than determining stocking rates or intensity. When using the Land Use Map for catchment accounting, these classifications are likely to be simplified into broad stock categories i.e. Sheep and Beef (Sheep, Beef, Sheep and Beef, Mixed livestock) or Deer (Specialist deer and Majority deer), and the intensity of the industry represented by the range of survey farms.
- LCDB v4.1 (2012) classification for unknown parcels is the most recent information about land cover in 2015. Aerial photography can be used as a cross check but requires manual inspection and was not undertaken for all properties.
- LCDB v4.1 is suitable for determining effective vs ineffective land areas with the key assumption that wetlands are not grazed areas.
- Recreation areas such as rural golf courses are not grazed by stock, unless winter forage crop is present or an Agribase™ record exists.
- For historical land use mapping land cover is used to infer land use. Pastoral areas not in dairy use (identified by ES consent database) are most likely to be sheep and beef and to a lesser extent deer. Ledgard (2013a) provides a detailed analysis of stock numbers present in Southland from 1860.
- Historical stock intensities can be assumed within a land cover category by biophysical parameters of elevation and slope combined with reported agricultural statistics.

10.2. Validation

ES Staff need to know how accurate land use information is, in order to effectively use the GIS-layer in daily business. Attribute fields for data source and date, within the layer provides a user with the origin and age of the data for a specific property. While the methodology used to construct the Southland Land Use Map attempted to remove as much potentially erroneous information as possible, there will still be some inconsistencies. A validation process which checks records against the Land Use Map data sources provides additional confidence in the decisions made during methodology development. Validation of the Southland Land Use Map can be done either internally, through ES staff, or externally, by the organisations that maintain the spatial data.

10.2.1. Internal validation

To internally validate the Southland Land Use Map, the attribute fields of 'Val_Source', 'Val_Person', 'Val_date' and 'Val_Flag' were added to the Property scale map to track internal validation. Where Val_Source is used to identify the source of the information (land holder, owner etc.), Val_Person is the ES staff member that validated the information, Val_date the date the validation was undertaken and Val_Flag for properties that are incorrectly classified. The Val_Flag field will be used to detail the correct ES land use code or combination of codes. This validation process is more important for agricultural properties where the Agribase classification has been amended. Land use information provided to ES as part of resource consent applications i.e. Dairying, does not need to be validated and is deemed to be accurate.

The Land Use Map can be validated against:

- Land Sustainability Farm Focus Plans
- Environment Southland field staff property visits – through Land Sustainability, Consents, Compliance, Biosecurity, and Environmental Data divisions.
- Personal communication with land holder/occupier
- ES Rates Information

10.2.2. External validation

Due to agreements made by ES with Assure Quality on the purchase of Agribase, there can be no external validation of the land use map by the public or any other organisation. Assure Quality perform their own checks on data quality, which is likely to be sufficient for the needs of Environment Southland. In Section 9.1, Figure 42 showed the providence of the Land Use Map data, of which over 95% of the area of land in Southland was considered up-to-date for national reporting.

Misclassified land use can be corrected by property owners by updating information with Assure Quality Ltd to update the Agribase™ database or by providing ES with the information necessary to determine land use based on the rules defined above. Environment Southland is currently exploring options and determining capacity to receive land use information from land holders directly.

10.3. Limitations

There are two ways that erroneous information can be displayed in the Southland Land Use Map. Firstly, through the primary parcel framework, and secondly, through the data sources used. These limitations are described further below.

10.3.1. Primary Parcels

A major limitation that remains within the Southland Land Use Map is the difference between the mapped primary parcels and what is identified as a property boundary on the ground. The primary parcel layer is constantly evolving, with weekly updates of parcels for existing properties or new parcels surveyed for subdivision and development. The idea of a parcel title is that the boundary does not change or move without the owner's consent or remuneration. However, natural borders and margins like rivers and streams or coastlines will move overtime and may vary between surveying from one side of the river and the other.

The definition of a property used in this methodology refers to the area of the legal landholding. The base framework is restricted by the limitations of the surveyed parcel or property title. Ground-truthing and/or comparison with aerial photography with this map will show that the property boundaries near rivers often extend into the water course. This difference is due to the accretion and erosion of river banks over time, catchment management and straightening occurring along a river reach and the challenging task of re-surveying land parcels. Alternatively, intensive pastoral land uses may be found on parcels classified as 'Lakes and Rivers'. The process of legally obtaining region wide parcels that no longer contain the river channel due to the movement of the flow path and the subsequent accretion of the river bank is very expensive and lengthy.

10.3.2. Data Sources

The limitations of each data source were identified in Section 4. Steps were taken to minimise these as much as possible throughout the methodology development. Land use classifications have been mapped at the highest resolution possible. Aggregation of some classes to represent an industry group would minimise the assumptions made. For example, 'Sheep and Beef' could be amalgamated with sheep, beef, sheep and beef, and mixed livestock categories as they are represented by Beef + Lamb NZ. 'Deer' could be identified by specialist deer and majority deer with mixed livestock categories as these properties are most likely represented by DINZ. An example of representation by industry groups was used to display the Technical Land Use Map in Figure 27.

Land use classifications of 'Dairy Support', 'Dairy Support and Other Livestock' and 'Livestock Support' are not represented well by any industry group. For the process of estimating nutrient losses in Stage 2, the location of winter forage crops added as part of the Technical Land Use Map (Pearson and Couldrey, 2016), can be used to attribute relative contaminant nutrient losses to the identified areas, reducing the limitations around the lack of industry input around this land use.

11. Recommendations

The main limitation for the Southland Land Use Map is the dependence on external data sources to provide land use information. Some of this data requires extended funding or industry input, while other sources require the time and input to collate. This was also identified in the Landcare Research Review of the methodology by Rutledge et al. (2016). This on-going support is unlikely to be available past the length of the Southland Economic Project and Science Programme. Therefore, it is recommended that Environment Southland develop their own capability for data collection of land use and nutrient budgeting information in a form that does not require further processing before use.

11.1. Land Use Mapping and Nutrient Loss Estimates

Under the National Policy Statement for Freshwater Management 2014, Regional Councils are required to establish freshwater objectives and set limits on water quality. Along with the development of Environmental Monitoring and Reporting (EMaR) nationally, councils will need to collect more information about land use in future in order to better manage water quantity and quality in their regions. Therefore, future efforts should be focused on gathering land use information which will also inform nutrient management decisions in a catchment.

There are also increasing requirements around New Zealand for agricultural industries to be more transparent about the impact their operations have on the environment, especially with the introduction of NPS-FM. For example, Fonterra, New Zealand's largest dairy co-operative, has applied a number of programmes, such as the Dairying and Clean Streams Accord and Nitrogen Reporting, all in the aim of increasing environmental awareness and improving sustainability in the industry (Hutchings, 2010). Agricultural companies, such as milk and meat processors, or fertilizer companies, which collect information from a number of industries, may be a useful resource in future.

The requirements of the NPS-FM have increased interest in and the use of a range of tools and models, especially OVERSEER® Nutrient Budgets. Regional Councils have realised the need for guidance on the appropriate and consistent use of such models and are working towards developing a national approach for using OVERSEER® to set and manage water quality limits (Freemen et al. 2016). This document highlights how different methods used to estimate source nutrient loads differ in their strengths, challenges, resource implications and uncertainty.

Environment Southlands approach of using case study farms (95 farms), collected through the Southland Economic Project, by industry representatives, requires a high investment in data collection, and challenges around consistency between different modellers and industry approaches. There is more transparency around collection, analysis and quality of data obtained from some industries compared to others, usually due to confidentiality restrictions. Methods of reporting and environmental modelling also differ between industries. This process is labour intensive in both data collection and analysis (creating look up tables, calculating losses and determining catchment loads). Therefore, Environment Southland would be significantly more informed if they could capture region wide data for farming activities, such as stock present, cropping, winter grazing and irrigation occurring directly on a property from the land holder,

without the need for third party inputs. This would significantly reduce the uncertainty around nutrient losses for individual properties and improve land use classifications.

Environment Southland currently has two options which would provide suitable land use information. However, it is recommended a combination of both be used to obtain the level of data required to inform limit setting and future catchment management. The two options are as follows:

- Environment Southland's Proposed Water and Land Plan requires all properties to have a Farm Management Plan (Appendix N of Water and Land Plan), which includes a Nutrient Budget and Good Management Practices sections. This requirement could provide a suitable approach to collecting land use information as well as nutrient loss information for catchment load estimates. Environment Southland could provide a template for land holders to guide reporting.
- Through Farm Focus Plans, which are GIS based farm management plans developed by the Land Sustainability Team. A significant advantage of the Farm Focus Plans is the collection of data on the ground, therefore accurate mapping of fence lines, laneways, areas grazed, and property boundaries as well as the education and advice provided to the farmer on reducing nutrient and sediment losses. However, this option is limited by the teams current capacity to develop farm plans, which is approximately 200 per year.

11.2. Potential Tools

To aid in the collection and management of data received by the council, and for providing mitigation advice to farmers, there are some potential tools available to Environment Southland.

11.2.1 Farm Portal – Environment Canterbury

The Farm Portal is Environment Canterbury's tool designed to calculate nitrogen losses at Good Management Practice (GMP), as defined by industry groups. The portal also determines if the land use activities require resource consent from Environment Canterbury. Farm Portal was developed out of the need to have a way for the public to access the Matrix of Good Management (MGM) for the Canterbury region (Ragnarsson and Stiven, 2016).

Initially, Environment Canterbury staff envisioned that the MGM project would deliver a series of lookup tables (matrices) where a user could look-up their soil, climate and farming systems to find a representative loss rate at GMP. This lookup table could also be used for catchment modelling. Given the number of soil, climate and farming system combinations the concept of providing a lookup table became unworkable.

An alternative approached was developed at Environment Canterbury, whereby an online portal was developed where a user could use their own Overseer file that would have all the necessary inputs to apply GMP. This approach provides a more realistic comparison between the current loss rate of a farm based on their Overseer file and a GMP loss rate based on the same Overseer file. The outcome of this approach is that a lookup table or matrix is not used, but GMP is applied to the users Overseer file making it a simpler process to get a GMP loss rate.

Environment Canterbury's regional plan is reliant on farmers having OVERSEER® budgets produced for their property or properties.

Environment Canterbury's Farm Portal requires the following input from land holders:

- Agribase™ Farm ID, legal description, street address or a nearby locality to locate the property.
- Irrigation scheme details or area in hectares of the farm that is irrigated.
- Baseline OVERSEER® XML files (2009-2013) at the latest version of OVERSEER®.
- Last four years of OVERSEER® XML files at the latest version of OVERSEER®.

For farmers who do not need an Overseer file, a high level catchment matrix (lookup table) was developed where farmers answer some basic farming system questions and the appropriate rows from the catchment matrix are returned giving a representative loss rate for the farm. The long term outcome is that over time a spatial representation of all farms in Canterbury will be developed with actual and/or GMP loss rates associated with those farms, which will give a region wide picture of nutrient loss. The Farm Portal produces a best management practice report based on the specific data entered for the property for the land holder/manager to aid in their future decision making on farm.

For Environment Southland, where OVERSEER® budgets are not specifically required by the council, the second application of Farm Portal could be a suitable option for collecting land use information, determining whether resource consent is required, and estimating nutrient losses from a property. Developing the capability now to capture land use information for individual properties would make a smoother transition to after the NPS-FM Science Programme is completed. It would also provide a validation source for land use data.

11.2.2 MitAgator – Ballance Agri-Nutrients

To aid Environment Southland staff in providing mitigation advice a tool is being developed currently by Balance Agri-Nutrients. 'MitAgator' is a GIS-based water quality decision support tool that links with OVERSEER® to refine the latter models output (Stafford and Peyroux, 2013). The MitAgator model is then able to provide greater insight into the spatial variability of nutrient (as well as sediment and microbial) loss within a farm landscape. Users are able to identify critical source areas ('hot spots') for nitrogen, phosphorus, sediment and microbial loss within the farm landscape.

MitAgator works by taking the input and output data from a given OVERSEER® file, and links it with other spatial data layers, including a geo-referenced farm map, a soil map and a digital elevation model (DEM). Using the added spatial data sets, a hydrological flow model is produced that describes risk of water movement through the soil (driving leaching) and across the landscape (driving runoff). Targeted application of mitigation and management strategies to these critical source areas will help to provide more cost-effective environmental management solutions for farmers.

For Land Sustainability Officers, this tool could increase the level of advice provided to a farmer during a site visit. For properties where OVERSEER® files are available, this tool could be applied to help staff identify critical source areas and assess appropriate mitigation approaches prior to a farm visit, with the aim of reducing the time taken to complete a Farm Focus Plan. The use of

this tool will be limited by the requirement for land holders to have an existing OVERSEER® budget and the availability and cost of running this model. However, as this tool is currently unreleased the practical application and implementation cost is currently unknown.

12. Project Summary

GIS-based land use maps are an essential part of understanding and modelling the effects of land use on water quality. The NPS-FM Science Programme and the Southland Economic Project together are building understanding to inform the setting of catchment limits for water quality in Southland. The land use maps and associated datasets will have multiple roles within Environment Southland, primarily to inform catchment nutrient load calculations and economic impact assessments of policy options to meet water quality limits. Three GIS-based Land Use Map layers have been produced for different purposes within Environment Southland:

Primary Parcel Land Use Map/Layer – This GIS layer has been produced for the Land Use Map project team and GIS staff use only. The map has been constructed by combining the following data sources; a modified version of Agribase, Land Cover Database (LCDB version 4.1), Protected Areas Network (PAN-NZ 2014), Environment Southland's Resource Consent and Rates 2012 database, and input from primary industries, into a framework provided by the LINZ primary parcels layer.

The Primary Parcel layer is the methodology layer used to classify land uses in Southland. It contains all metadata from sources and method rules applied in its construction. Rule fields track how each parcel was classified and source fields identify data source and age of record. Due to the way data is entered, each parcel within a property contains replicate information for the whole property, which is the reason this layer is for project team use only. This layer will be used to identify changes in land use at the parcel scale over time, as new versions of the Land Use Map are produced (updated six monthly). This layer is used as the base for the Property Land Use Map layer.

Property Land Use Map/Layer – This GIS layer has been produced for the use of Environment Southland staff and external collaborators within the NPS-FM Science Programme and the Southland Economic Project. This version is produced from the Primary Parcel land use layer. The land use information is now presented at the property scale. Properties are determined by Agribase (Farm_ID) or IrisID (Dairy farms) or by LINZ property owner name and address when other information was unavailable. By amalgamating parcels by Agribase Farm_ID or ES IrisID, properties (and ultimately land uses) are identified by the primary decision maker on the land, which may not be the same as the land owner.

Within the Property Land Use Layer, raw data and methodology attribute fields have been removed for ease of use. Source and date of record are retained for the identification of data inputs. Additional attribute fields for land cover, effective and ineffective hectares on agricultural properties, and winter forage crop hectares have been added for the property. Within the urban environment, residential, commercial, industrial, public use, and recreation

areas are identified. This map can be used to answer number of properties undertaking an activity or hectares of an activity in Southland type questions. This layer is used as the base for the Technical Land Use Map layer.

Technical Land Use Map/Layer – This GIS layer has been produced for the NPS-FM Science Programme and the Southland Economic Project (and other technical users within council). This technical version uses the Property Land Use Map and incorporates additional spatial data for policy frameworks (FMU, Physiographic Unit), land cover (simplified LCDB, winter forage crop areas), and biophysical attributes (topography, climate, and soil drainage).

The technical land use map layer will be used to distribute case study farm data collected for the Science Programme and Southland Economics Project. The technical map can be used to answer questions around the number of hectares in more specific detail. For example, dairy hectares on poorly drained soil or hectares of sheep and beef on slopes less than 4 degrees, to the more complex questions such as hectares of winter forage crop grown on sheep and beef properties in the Mataura FMU.

In addition to the three Land Use Map versions, additional GIS-layers have been produced to provide further information around land cover, intensive activities and historical land use. These layers are as follows:

Land Cover Layer – This layer can be used together with the Property Land Use Map to show land cover across the region spatially and is one of the layers incorporated into the Technical Land Use Map. The land cover layer was created by simplifying the categories from LCBD4.1. The metadata of this layer is contained within the Property Land Use Map.

Winter grazing Layer – This layer shows the estimated distribution of forage crops in Southland during winter 2014. It was created using the winter forage assessment undertaken by Landcare Research (North and Belliss, 2015). The layer can be used to determine areas where dairy/livestock support is likely to be occurring. For further information on this layer see 'Spatial analysis of winter forage cropping in Southland' (Pearson and Couldrey, in prep).

Historic Land Use Maps/Layers – Historic land cover maps have been created for the years 1996 to 2014. Historical land use information is required by the NPS-FM Science Programme to assess how contaminant losses and loads to receiving environments have changed in the region over time. These map layers contain a combination of land use and land cover (to infer land use where specific land use information is unavailable).

Historic Land Use Maps were produced using data contained within LCDB4.1 as a base and incorporating specific land use information were possible. The land cover data was applied to all years between the imagery dates, with specific land use information incorporated for each year. Therefore, the map for 1998 is produced from land cover imaged in 1996 with land use from 1998. Conservation areas were identified through the DOC Public Conservation layer and QEII National Trusts by identifying the establishment date. Environment Southland's Resource Consent Database was utilised to show the growth of dairy over this time period. Non-dairy pastoral land (from LCDB4.1) was separated into three drystock categories, intensive flats, hill

country and high country (above 600 metres above sea level), to align with Ministry of Primary Industries (MPI) agricultural reporting and infer intensity of land use.

Identifying individual properties from these maps are not possible due to primary parcel layers being unavailable for all years. The historic land use maps can be used to answer questions around land use change over time by number of hectares. For example, change in drystock hectares between 1998 and 2008 in the Aparima FMU.

For comparison with the Southland Land Use Map, a 2015 version was created using the historic methodology (land cover from 2012 and the ES 2015 dairy extent). This layer will be used for sensitivity analysis between the two methods, and understanding the level of detail required by the NPS-FM Science Programme around nutrient inputs.

A pre-Maori land use layer was also produced by combining historical forest cover and wetland extent in the region c. 1000 AD. This layer will be used as a reference point to aid the Science Team in determining historical load estimates for sensitive receiving environments, such as estuaries and lakes.

Limitations and Recommendations - All Land Use Maps were produced by using the primary parcel layer as a framework and are limited by inconsistencies of surveyed parcels compared to what is physically located on the ground. This limitation is significant at the farm scale around waterways, where either natural or human modification has altered the position of the waterway since the primary parcel was surveyed. However, these inconsistences regionally are minimal.

Requirements are increasing around New Zealand for agricultural industries to be more transparent with the impact their operations have on the environment, especially with the introduction of National Policy Statement for Freshwater Management. The development of Environmental Monitoring and Reporting (EMaR) nationally will drive Regional Councils to collect more information about land use and nutrient management in future. Therefore, it is recommended that Environment Southland develop their own capability for data collection of land use information to extend this valuable resource past the length of the NPS-FM Science Programme and the Southland Economic Project.

13. Acknowledgements

The authors would like to acknowledge Landcare Research for their review of a previous version of this report, with special thanks to Daniel Rutledge for holding a workshop with Environment Southland staff to share his knowledge and expertise.

Funding support, in the form of an Envirolink Advice Grant (ESRC274), was used to make the review and workshop possible.

Industry Sectors

Thanks to the following industry representatives for your time and commitment to getting the mapping as accurate as possible:

Arable – Diana Mathers (Foundation for Arable Research)

Sheep and Beef – Andrew Burt and Carly Sluys (Beef + Lamb NZ)

Deer – Tony Pearse and Lindsay Fung (DeerNZ), John Somerville (Southland Deer Farmers Association) and Solis Norton (Johne's Management Ltd)

Dairy – Matthew Newman and Carla Muller (DairyNZ)

Plantation Forestry – Steve Chandler (Rayonier/Matariki Forests) and Graeme Manley (Southwood Export Ltd.)

Environment Southland

This project would not have been possible without the significant contributions from:

Emma Moran, Project leader - Southland Economic Project
The GIS team - Andrew Wilson, Dean Petricevich and Ingrid Darragh.

14. References

Ausseil, A.G., Chadderton, W.L., Gerbeaux, P., Stephens, T., Brown, D., Leathwick, J. 2008. Wetland ecosystem of national importance for biodiversity: criteria, methods and candidate list of nationally important wetlands. Landcare Research Contract Report LC0708/158. 174p.

Clarkson, B., Briggs, C., Fitzgerald, N., Rance, B., Ogilvie, H. 2011. Current and historic wetlands of Southland Region: Stage 2. Landcare Research Contract Report LC4125, Hamilton. 45 p.

Cutt, J. 2006. In: Sorrell, P. (Ed.). Murihiku: the Southland story. Invercargill: Southland to 2006 Book Committee. Pp. 151-166.

Crops for Southland. 2002. Topoclimate Southland Soil Technical Data Sheet No. 1-115. *Venture Southland.*

DSIR. 1968. General survey of the soils of South Island, New Zealand. New Zealand Department of Scientific and Industrial Research, Soil Bureau Bulletin 27.

Environment Southland. 2000. Southland's State of Environment Report for Water. Environment Southland, Invercargill. ES Publication No. 2000-21. 48 p.

Environment Southland and Te Ao Marama Inc. 2010. Our Ecosystems: How healthy is the life in our water and our freshwater ecosystems? Part 2 of Southland Water 2010: Report on the State of Southland's Freshwater Environment. Environment Southland, Invercargill. ES Publication No. 2011-7. 122 p.

Ewans, R. 2015. Environment Southland Wetland Inventory Project: monitoring wetland extent on non-public conservation land in the Southland region. Report for 2015. Eco-South, Report prepared for Environment Southland. 63p.

Freeman, M., Robson, M., Lilburne, L., McCallum-Clark, M., White, L., Cooke, A., and McNae, D. 2016. Using OVERSEER – Establishing a national approach for the appropriate and consistent use of OVERSEER by regional councils in setting and managing water quality limits, July 2016. Report prepared by Freeman Environmental Ltd for the OVERSEER Guidance Project Board.

Hewitt, A.E. 1993. Methods and Rationale of the New Zealand Soil Classification. *Landcare Research Science Series, Manaaki Whenua Press, Lincoln New Zealand*.

Hughes, B., Wilson, K., Rissmann, C., Rodway, E. 2016a. Physiographics of Southland Part 2: Delineation of regional physiographic units. Environment Southland Technical Report, Publication No. 2016/4. Version 1 – Preliminary. 76 p.

Hughes, B., Wilson, K., Rissmann, C., Rodway, E. 2016b. Physiographics of Southland Part 3: Application of the Physiographics of Southland – using physiographic zones to manage land use in Southland according to water quality risk. Environment Southland Technical Report, Publication No. 2016/5. Version 1 – Preliminary. 76 p.

Hutchings, J. 2010. Sustainable management is important for Fonterra's trading opportunities and New Zealand. In: Farming's future: Minimising footprints and maximising margins. (Eds L.D. Currie and C.L. Christensen). Occasional Report No. 23. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand. 1 p.

Ledgard, G. 2014a. Land Use Change in the Southland region. Environment Southland Technical Report, 2014-14. 74 pp.

Ledgard, G. 2014b. Nitrogen, Phosphorus and Sediment losses from rural land uses in Southland. Environment Southland Technical Report, 2014-7. 21 pp.

Lesslie, R. 2004. Land Use and Land Management Practices: Concepts, Terms and Classification Principles. Australian Department of Agriculture, Fisheries, and Forestry, Bureau of Rural Sciences, Canberra.

Leathwick, J., McGlone, M. and Walker, S. 2012. New Zealand's potential vegetation pattern. Landcare Research.

Leathwick, J. R. 2001. New Zealand's potential forest pattern as predicted from current species-environment relationships. New Zealand Journal of Botany 39: 447-464.

Milne, J.D.G., Clayden, B., Singleton, P.L. and Wilson, A. D. 1995. Soil Description Handbook. *Manaaki Whenua Press, Lincoln New Zealand.*

Moller, H., MacLeod, C., Haggerty, J., Rosin, C., Blackwell, G., Perley, C., Meadows, S., Weller, F. and Gradwohl, M. 2008. Intensification of New Zealand agriculture: Implications for biodiversity. New Zealand Journal of Agricultural Research 51, 254-264.

Monaghan, R.M., and De Klein, C.A.M. 2013. Integration of measures to mitigate reactive nitrogen losses to the environment from grazed pastoral dairy systems. Journal of Agricultural Science. Nitrogen workshop special issue paper. Pg 1-12.

Moran E. In prep. Southland: Agriculture and Forestry. Environment Southland Report.

Moreau, M. and Hodson, R. 2015. Trends in Southland's water quality: a comparison between regional and national monitoring sites for groundwater and rivers. GNS Consultancy Report 2014/61. 110p.

North and Belliss, 2015. Winter livestock forage map – Southland Region 2014. Landcare Research report, prepared for Environment Southland.

O'Byrne, T. N. 1986. Soils of part Wallace County, South Island, New Zealand. NZ Soil Bureau.

OVERSEER® Best Practice Data Input Standards. April 2015. Overseer version 6.2.0.

Pearson, L. 2015a. Overland flow risk in Southland. Environment Southland Technical report.

Pearson, L. 2015b. Artificial subsurface drainage in Southland. Environment Southland Technical report.

Pearson, L., and Couldrey, M. in prep. Spatial analysis of winter forage cropping in Southland and the implications for water quality management. Environment Southland Technical Report.

Rissmann, C., Rodway, E., Beyer, M., Hodgetts, J., Snelder, T., Pearson, L., Killick, M., Marapara, T.R., Akbaripasand, A., Hodson, R., Dare, J., Millar, R., Ellis, T., Lawton, M., Ward, N., Hughes, B., Wilson, K., McMecking, J., Horton, T., May, D., Kees, L. 2016. Physiographics of Southland Part 1: Delineation of key drivers of regional hydrochemistry and water quality. Environment Southland Technical Report, Publication No. 2016/3. Version 1 – Preliminary. 352 p.

Rudledge, D., Ausseil, A-G., Belliss, S., Lilburne, L., Manderson, A. and Price, R. 2016. Methodology for a GIS-based Land Use Map for Southland: A Review. Landcare Research Contract Report LC2491. Prepared for Environment Southland.

Rudledge, D., Price, R., Briggs, C., and Cowell, S. 2009. Geospatial Land-use Classification for New Zealand: Review and Recommendations. Official Statistics Research Series, Vol. 5.

Smith and Monaghan, 2012. Nitrogen leaching losses from a winter-grazed forage crop on a free draining soil in Northern Southland. AgResearch report, prepared for Environment Southland.

Snelder, T., and Legard, G. 2014. Assesment of Farm Mitigation Options and Land Use Change on Catchment Contaminant Loads in the Southland Region. Aqualink report, prepared for Environment Southland. C13055/04.

Stafford A., and Peyroux, G. 2013. Clearview (Balance PGP) – A first look at new solutions for improving nutrient and phosphorus management. Fertiliser and Lime Research Centre, Conference proceedings. Massey University.

Wheeler, D.M. 2015. OVERSEER® Nutrient Budgets Technical Manual for the Engine (Version 6.2.0) – Climate. www.overseer.org.nz

Wheeler, D., Benson, M., Milner, I., and Watkins, N. 2013.OVERSEER® Nutrient budgets modelling for the Tukituki catchment. Report prepared for Hawke's Bay Regional Investment Company Limited. AgResearch RE500/2013/016.

Young, A. 1994. Land Resources: Now and for the Future, Cambridge University Press, Cambridge.

Appendix 1: Modification of Data Sources

Appendix 1a – Modification of LINZ Primary Parcel Layer

nz_primary_parcels (Source = LINZ Data Service, Source_Date = 19-01-2016)
Regional_Bdy_NZTM (Source = M:\GIS\Data\Political\Regional_Bdy_NZTM.shp, Source_Date = 19-01-2016)
Clip to Regional_Bdy_NZTM
LINZ_Parcels_Southland
Intersect
(Input Features = LINZ_Parcels_Southland only)
LINZ_Parcels_Intersect – 2 overlapping polygons or 1 error

LINZ_Parcels_Southland
Delete Record
id = 764626 – 101,566 total records
LINZ_Parcels_Southland
Add Attribute Fields
'ES_Code' = Text
'ES_Code2' = Text
'Source' = Text
'Source_Data' = Text
'Source_Class' = Text
'Source_Date' = Text
'Details' = Text

Appendix 1b – Modification of Rates Information

Database: M:\GIS\Projects\ArcMap\Environmental Info\Land Use 2015 DeanP\Land Use Reviewed\April 2015\Method Files.gdb
Feature Class: Dec_2012_Rates

Dec_2012_Rates
Add Attribute Fields
'Rates_Code' = Text
Definition Query: Rates_Code IS NULL

Select by Attributes
Create new selection = Land_Use IN ('Residential', 'Residential Multi-Unit', 'Residential Single Unit excluding Bach', 'Vacant Residential', 'Single Unit', 'Special Accommodation', 'Multil-Use within Residential', 'Multi-Unit', 'Communal Residence Dependent on Other Use' , 'Bach', 'Communal Residence Dependent on Other Use')
Field Calculator
'Rates_Code' = "RES"

Select by Attributes
Create new selection = Land_Use IN ('Carparking' , 'Commercial' , 'Communications' , 'Defence' , 'Electricity' , 'Entertainment' , 'Multi-Use within Commercial' , 'Multi-Use within Utility Services' , 'Offices' , 'Other Utility Services' , 'Parking' , 'Personal and Property Protection' , 'Public Communal - Licensed' , 'Public Communal - Unlicensed' , 'Retail' , 'Services' , 'Utility Services' , 'Vacant Commercial' , 'Vacant Utility Services' , 'Water' , 'Wholesale')
Field Calculator
'Rates_Code' = "COM"

Select by Attributes
Create new selection = Land_Use IN ('Cemeteries and Crematoria', 'Community Services', 'Educational', 'Halls', 'Medical and Allied Hospitals', 'Multi-Use within Community Services', 'Religious', 'Sanitary', 'Vacant Community Services', 'Water Supply')
'Rates_Code' = "PUB"

Select by Attributes
Create new selection = Land_Use IN ('Building Materials other than Timber', 'Chemicals, Plastics, Rubber and Paper', 'Depots, Yards', 'Engineering, Metal Working, Appliances &', 'Industrial', 'Industrial Food, Drink and Tobacco', 'Gas', 'Industrial Textiles, Leather and Fur', 'Industrial Timber Products and Furniture', 'Mineral Extraction', 'Multi-Use within Industrial', 'Other Industries', 'Vacant Industrial')
Field Calculator
'Rates_Code' = "IND"

Select by Attributes
Create new selection = "Rates_LU" IN ('Active Indoor', 'Active Outdoor', 'Multi-Use within Recreational', 'Passive Indoor', 'Passive Outdoor', 'Recreational', 'Vacant Recreational')
Field Calculator
'Rates_Code' = "REC"

Rates Code for other parcels

Unknown parcels within urban areas
Database: M:\GIS\Projects\ArcMap\Environmental Info\Land Use 2015 DeanP\LandUse.gdb
Feature Class: RPMS
Select by Attributes
Create new selection = Land_Use IN (' ', 'Vacant', 'Vacant/Indeterminate')
Select by Location
Selection Method = select from current selection (Target layer = LINZ_Parcels_Southland, Source layer = 'RPMS', spatial selection method = have their centroid within the source layer feature)
Field Calculator
'Rates_Code' = "URBUNK"

Unknown parcels outside of urban areas
Select by Attributes
Create new selection = Land_Use IN (' ', 'Vacant', 'Vacant/Indeterminate')
Field Calculator
'Rates_Code' = "UNK"

Dairy
Select by Attributes
Create new selection = Land_Use = 'Dairying'
Field Calculator
'Rates_Code' = "DAI"

Arable
Select by Attributes
Create new selection = Land_Use = 'Arable Farming'
Field Calculator
'Rates_Code' = "ARA"

Livestock Finishing
Select by Attributes
Create new selection = Land_Use = 'Stock Finishing'
Field Calculator
'Rates_Code' = "FINLIV"

Specialist Livestock
Select by Attributes
Create new selection = Land_Use = 'Specialist Livestock'
Field Calculator
'Rates_Code' = "SPLIV"

Store Livestock
Select by Attributes
Create new selection = Land_Use = 'Store Livestock'

Field Calculator
'Rates_Code' = "STORELIV"

Forestry
Select by Attributes
Create new selection = Land_Use = 'Forestry'
Field Calculator
'Rates_Code' = "FOR"

Horticulture
Select by Attributes
Create new selection = Land_Use = 'Market Gardens and Orchards'
Field Calculator
'Rates_Code' = "HORT"

Other Agricultural areas
Select by Attributes
Create new selection = Land_Use IN ('Multi-Use within Rural Industry', 'Rural Industry', 'Vacant or Idle - Primary Industry')
Field Calculator
'Rates_Code' = "AGRI"

Lifestyle
Select by Attributes
Create new selection = Land_Use IN ('Lifestyle', 'Multi-Use within Lifestyle', 'Single Unit')
Field Calculator
'Rates_Code' = "LIF"

Transport
Select by Attributes
Create new selection = Land_Use IN ('Air Transport', 'Multi-Use within Transport', 'Rail Transport', 'Road Transport', 'Transport', 'Water Transport')
Field Calculator
'Rates_Code' = "TRANS"

Remove Definition Query

Appendix 1c – Modification of PAN-NZ

PANNZ_2014_Southland (Source = M:\GIS\Projects\ArcMap\Environmental Info\Land Use 2015 DeanP\Land Use Reviewed\April 2015\PAN-NZ_2014_ForDistribution.gdb)

Reclassification of Statutory Actions

Southland_PANNZ
Definition Query
Source = 'LINZ_Parcels_with_Statutory_Actions_2014'

Add Attribute Field
"PANNZ_Code" = TEXT
Select by attributes
StatusPhrase IN ('Government Purpose Reserve (Lighthouse)', 'Government Purpose Reserve (Police)', 'Government Purpose Reserve (Purpose Not Specified)', 'Historic Reserve', 'Local Purpose Reserve (Access and Car Park)', 'Local Purpose Reserve (Accessway)', 'Local Purpose Reserve (Afforestation)', 'Local Purpose Reserve (Beautification)', 'Local Purpose Reserve (Car

Park)', 'Local Purpose Reserve (Cemetery)', 'Local Purpose Reserve (Childcare Centre)', 'Local Purpose Reserve (Community Buildings)', 'Local Purpose Reserve (Community Centre)', 'Local Purpose Reserve (Community Hall and Education)', 'Local Purpose Reserve (Drainage)', 'Ferry Reserve', 'Esplanade Strip', 'Crown Land (Water Race)', 'Crown Land (Cemetery Reserve)', 'Burial Ground (Private Land)', 'Burial Ground', 'Amenity Area', 'Conservation Park', 'Ecological Area', 'Local Purpose Reserve (Esplanade)', 'Local Purpose Reserve (Fire Station)', 'Local Purpose Reserve (Floodway)', 'Local Purpose Reserve (Gravel)', 'Local Purpose Reserve (Hall)', 'Local Purpose Reserve (Kindergarten)', 'Local Purpose Reserve (Landscape)', 'Local Purpose Reserve (Library)', 'Local Purpose Reserve (Municipal)', 'Local Purpose Reserve (Museum)', 'Local Purpose Reserve (Plantation)', 'Local Purpose Reserve (Playcentre)', 'Local Purpose Reserve (Plunket)', 'Local Purpose Reserve (Public Convenience)', 'Local Purpose Reserve (Public Hall)', 'Local Purpose Reserve (Public Utility)', 'Local Purpose Reserve (Purpose Not Specified)', 'Local Purpose Reserve (Quarry)', 'Local Purpose Reserve (Refuse Disposal)', 'Local Purpose Reserve (River Control)', 'Local Purpose Reserve (Road)', 'Local Purpose Reserve (Segregation Strip)', 'Local Purpose Reserve (Service Lane)', 'Local Purpose Reserve (Soil Conservation and River Control)', 'Local Purpose Reserve (Utility)', 'Local Purpose Reserve (War Memorial)', 'Local Purpose Reserve (Water Supply)', 'Maori Reservation (Marae)', 'Marginal Strip (Fixed)', 'River Protection', 'Road Reserve', 'Soil Conservation and River Control', 'Water Conservation Reserve', 'Water Race Reserve', 'Water Reservoir', 'Water Supply Purposes', 'Waterworks')

Field Calculator

PANNZ_Code = “PUB”

Select by attributes

StatusPhrase IN ('Local Purpose Reserve (Environment and Landscape Protection)', 'Local Purpose Reserve (Conservation)', 'Government Purpose Reserve (Wildlife Management)', 'Wildlife Management Reserve' , 'Wilderness Area' , 'Stewardship Area', 'Scientific Reserve (Private Land)' , 'Scientific Reserve' , 'Scenic Reserve (Private Land)' , 'Scenic Reserve', 'Nature Reserve' , 'National Park' , 'Marine Reserve')

Field Calculator

PANNZ_Code = “CON”

Select by attributes

StatusPhrase IN ('Local Purpose Reserve (Recreation)', 'Recreation Reserve', 'Local Purpose Reserve (Recreation, Cultural Buildings and Associated Activities)', 'Local Purpose Reserve (Recreation)')

Field Calculator

PANNZ_Code = “REC”

Select by attributes

StatusPhrase IN ('Sea Bed', 'River Bed')

Field Calculator

PANNZ_Code = “HYDRO”

Select by attributes

StatusPhrase = ''

Field Calculator

PANNZ_Code = “UNK”

Appendix 1d – Modification of Agribase

Agribase_April2015

Intersect

Input = Agribase_April2015

Agribase_Duplicate – Identified 329 duplicates

Agribase_April2015

Export

Agribase_Reclass – This layer is where all changes are made.

Add Fields

'Agri_Code' = Text
'Agri_Code2' = Text
'Source' = Text
'Source_Data' = Text
'Source_Class' = Text
'Source_Date' = Text
'Details' = Text

RULE 1: Remove duplicate and overlapping land parcels

Agribase_Reclass

Add Field

"Rule1" = TEXT

Definition Query

NOT Farm_Type = NAT – Removed 16 duplicates

Manual Edit

Visual inspection of 'Agribase Reclassified' with 'Agribase_Duplicate' to identify which rule to apply

Rule a – If the two farm shapes are identical

Identify

Record with most recent 'SOURCE_DAT'

Field Calculator

Rule1 = "a" – 25 polygons

Delete Duplicate

Rule b and c– If the two farm shapes are not the same shape

Identify

Record with most recent 'SOURCE_DAT'

Field Calculator

Rule1 = "b" – 70 polygons

Reshape Polygons Tool or Delete

Manually cut polygon of record with oldest 'SOURCE_DAT' or Delete Polygon if area contained by polygon b

Field Calculator

Rule1 = "c" – 88 polygons

Definition Query

Agri_Code IS NULL

RULE 2: Speciality land types

Add Attribute Field

"Rule2" = TEXT

Rule 2a – Speciality land uses

Select by attributes
FARM_TYPE IN ('FOR', 'ARA', 'FLO','FRU', 'NUR', 'TOU', 'VEG')
Field Calculator
Rule2 = “a” – Classified 155 properties
Agri_Code = [FARM_TYPE]

Definition Query
Agri_Code IS NULL OR Agri_Code = ‘ARA’ – to allow for Agri Code2 to be classified

Rule 2b – Other Animals
Select by attributes
FARM_TYPE IN ('API', 'ALA','DOG', 'GOA', 'HOR', 'OAN', 'OST', 'PIG', 'POU', 'ZOO')
Field Calculator
Rule2 = “b” – Classified 89 properties
Agri_Code = “OAN”

RULE 3: Support Blocks

Add Attribute Field
“Rule3” = TEXT
“Stock_Factor” = DOUBLE
“SF_Ha” = DOUBLE
“DairyStockF” = DOUBLE
“BeefStockF” = DOUBLE
“DeerStockF” = DOUBLE
“SheepStockF” = DOUBLE
“Fodd_perHA” = DOUBLE

Field Calculator
“DairyStockF” = [dai_nos]*8
“BeefStockF” = [bef_nos]*5.5
“DeerStockF” = [dee_nos]*2
“SheepStockF” = [shp_nos]
“Stock_Factor” = [DairyStockF] + [BeefStockF] + [DeerStockF] + [SheepStockF]
“SF_Ha” = [Stock_Factor]/ [SIZE_HA]
“Fodd_perHA” =([Fodd_ha]/[SIZE_HA])*100

Rule 3a – Dairy Support
Select by attributes
FARM_TYPE = ‘DRY’
Field Calculator
Rule3 = “a” – Classified 61 properties
Agri_Code = “DAISUP”

Rule 3b – Livestock Support
Select by attributes
FARM_TYPE = ‘GRA’
Field Calculator
Rule3 = “b” – Classified 227 properties
Agri_Code = “LIVSUP”

Rule 3c – Other Livestock Support
Select by attributes
FARM_TYPE = ‘OPL’ AND Fodd_perHA >= 50 AND Stock_Factor <50
Field Calculator
Rule3 = “c” – Classified 4 properties

Agri_Code = “LIVSUP”

Definition Query
Agri_Code IS NULL OR Agri_Code IN ('ARA', 'DAISUP', 'LIVSUP') – to allow for Agri_Code2 to be classified if necessary

RULE 4: Dairy

Add Attribute Field
“Rule4” = TEXT

Rule 4a - Non-Consented Dairy Farms
Select by attributes
dai_nos >=10 AND dai_nos <100 AND (BeefStockF+ DeerStockF+ SheepStockF <50) AND Agri_Code IS NULL
Field Calculator
Rule4 = “a1” – Classified 9 properties
Agri_Code = “DAICOW”

Select by attributes
dai_nos >=10 AND dai_nos <100 AND (BeefStockF+ DeerStockF+ SheepStockF <50) AND NOT Agri_Code IS NULL
Field Calculator
Rule4 = “a2” – Classified 6 properties
Agri_Code2 = “DAICOW”

Rule 4b - Consented Dairy Farms
Select by attributes
dai_nos >= 100 AND (BeefStockF+ DeerStockF+ SheepStockF < 50) AND Agri_Code IS NULL
Field Calculator
Rule4 = “b1” – Classified 584 properties
Agri_Code = “DAI” – Intermediate classification - will be reclassified as DAICOW or DAISUP when added to Primary Parcel Layer

Select by attributes
dai_nos >= 100 AND (BeefStockF+ DeerStockF+ SheepStockF < 50) AND NOT Agri_Code IS NULL
Field Calculator
Rule4 = “b2” – Classified 35 properties
Agri_Code2 = “DAI” – Intermediate classification - will be reclassified as DAICOW or DAISUP when added to Primary Parcel Layer

Rule 4c – Non-Consented Dairy and Other Livestock
Select by attributes
dai_nos >=10 AND dai_nos <100 AND (BeefStockF+ DeerStockF+ SheepStockF > 50) AND Agri_Code IS NULL
Field Calculator
Rule4 = “c1” – Classified 29 properties
Agri_Code = “DAISUP”
Agri_Code2 = “LIVESTOCK” – Intermediate classification - will be reclassified under Rule 5

Select by attributes
dai_nos >=10 AND dai_nos <100 AND (BeefStockF+ DeerStockF+ SheepStockF > 50) AND NOT Agri_Code IS NULL
Field Calculator
Rule4 = “c2” – Classified 5 properties
Agri_Code2 = “LIVESTOCK” – Intermediate classification - will be reclassified under Rule 5

Rule 4d – Consented Dairy Farms and Other Livestock

Select by attributes
dai_nos >= 100 AND (BeefStockF+ DeerStockF+ SheepStockF > 50) AND Agri_Code IS NULL
Field Calculator
Rule4 = “d1” – Classified 97 properties
Agri_Code = “DAI”
Agri_Code2 = “LIVESTOCK” – Intermediate classification - will be reclassified under Rule 5

Select by attributes
dai_nos >= 100 AND (BeefStockF+ DeerStockF+ SheepStockF > 50) AND NOT Agri_Code IS NULL
Field Calculator
Rule4 = “d2” – Classified 21 properties
Agri_Code2 = “LIVESTOCK” – Intermediate classification - will be reclassified under Rule 5

RULE 5: Other Livestock (Sheep, Beef, Deer)

Add Attribute Field
“Rule5” =TEXT

Definition Query
Agri_Code IS NULL OR Agri_Code2 IN ('ARA', 'DAISUP', 'LIVSUP', 'LIVESTOCK') – to allow for Agri Code2 to be reclassified if necessary

Speciality farm type – One stock type

Rule 5a – Sheep Farms
Select by attributes
SheepStockF >=50 AND BeefStockF <50 AND DeerStockF <50 AND Agri_Code IS NULL
Field Calculator
‘Rule5’ = “a1” – Classified 1011 properties
‘Agri_Code’ = “SHP”

Select by attributes
SheepStockF >=50 AND BeefStockF <50 AND DeerStockF <50 AND NOT Agri_Code IS NULL
Field Calculator
‘Rule5’ = “a2” – Classified 69 properties
‘Agri_Code2’ = “SHP”

Rule 5b – Beef Farms
Select by attributes
BeefStockF >=50 AND SheepStockF <50 AND DeerStockF <50 AND Agri_Code IS NULL
Field Calculator
‘Rule5’ = “b1” – Classified 319 properties
‘Agri_Code’ = “BEF”

Select by attributes
BeefStockF >=50 AND SheepStockF <50 AND DeerStockF <50 AND NOT Agri_Code IS NULL
Field Calculator
‘Rule5’ = “b2” – Classified 87 properties
‘Agri_Code2’ = “BEF”

Rule 5c – Deer Farms
Select by attributes
DeerStockF >=50 AND SheepStockF <50 AND BeefStockF <50 AND Agri_Code IS NULL
Field Calculator

'Rule5' = "c1" – Classified 125 properties
'Agri_Code' = "DEE"

Select by attributes
DeerStockF >=50 AND (SheepStockF+ BeefStockF) <50 AND NOT Agri_Code IS NULL
Field Calculator
'Rule5' = "c2" – Classified 4 properties
'Agri_Code2' = "DEE"

Mixed farm type – Two or more stock types

Rule 5d – Sheep and Beef Farms
Select by attributes
(SheepStockF + BeefStockF)>=50 AND DeerStockF =0 AND Agri_Code IS NULL
Field Calculator
'Rule5' = "d1" – Classified 979 properties
'Agri_Code' = "SNB"

Select by attributes
(SheepStockF + BeefStockF)>=50 AND DeerStockF =0 AND NOT Agri_Code IS NULL
Field Calculator
'Rule5' = "d2" – Classified 52 properties
'Agri_Code2' = "SNB"

Rule 5e – Sheep and Deer Farms
Select by attributes
(SheepStockF + DeerStockF)>=50 AND BeefStockF =0 AND Agri_Code IS NULL
Field Calculator
'Rule5' = "e1" – Classified 87 properties
'Agri_Code' = "SND"

Select by attributes
(SheepStockF + DeerStockF) >=50 AND BeefStockF =0 AND NOT Agri_Code IS NULL
Field Calculator
'Rule5' = "e2" – Classified 2 properties
'Agri_Code2' = "SND"

Rule 5f – Beef and Deer Farms
Select by attributes
(BeefStockF + DeerStockF) >=50 AND SheepStockF =0 AND Agri_Code IS NULL
Field Calculator
'Rule5' = "f1" – Classified 40 properties
'Agri_Code' = "BND"

Select by attributes
(BeefStockF + DeerStockF) >=50 AND SheepStockF =0 AND NOT Agri_Code IS NULL
Field Calculator
'Rule5' = "f2" – Classified 0 properties
'Agri_Code2' = "BND"

Rule 5g – Sheep, Beef and Deer Farms
Select by attributes
(SheepStockF + BeefStockF + DeerStockF) >=50 AND Agri_Code IS NULL
Field Calculator

'Rule5' = "g1" – Classified 148 properties
'Agri_Code' = "SBD"

Select by attributes
(SheepStockF + BeefStockF + DeerStockF) >=50 AND NOT Agri_Code IS NULL
Field Calculator
'Rule5' = "g2" – Classified 3 properties
'Agri_Code2' = "SBD"

Mixed farm types – Majority deer farms with other livestock (reclassification of RULES 5e-g)

Rule 5h – Majority Deer with Other Livestock
Select by attributes
Agri_Code = 'SND' AND DeerStockF >SheepStockF
Field Calculator
'Rule5' = "h1" – Reclassified 33 properties
'Agri_Code' = "DEESHP"

Select by attributes
Agri_Code2 = 'SND' AND DeerStockF >SheepStockF
Field Calculator
'Rule5' = "h2" – Reclassified 0 properties
'Agri_Code2' = "DEESHP"

Select by attributes
Agri_Code = 'BND' AND DeerStockF >BeefStockF
Field Calculator
'Rule5' = "h3" – Reclassified 30 properties
'Agri_Code' = "DEEBEF"

Select by attributes
Agri_Code2 = 'BND' AND DeerStockF >BeefStockF
Field Calculator
'Rule5' = "h4" – Reclassified 0 properties
'Agri_Code2' = "DEEBEF"

Select by attributes
Agri_Code = 'SBD' AND DeerStockF >(SheepStockF +BeefStockF)
Field Calculator
'Rule5' = "h5" – Reclassified 25 properties
'Agri_Code' = "DEESNB"

Select by attributes
Agri_Code2 = ' SBD' AND DeerStockF >(SheepStockF +BeefStockF)
Field Calculator
'Rule5' = "h6" – Reclassified 1 property
'Agri_Code2' = "DEESNB"
Remove Definition Query

RULE 6: Arable and Other Livestock (Dairy, Sheep, Beef, Deer)

Add Attribute Field

“Rule6” =TEXT

“Ara_perHA” = DOUBLE

Field Calculator

“Ara_perHA” = ([Ara_ha]/[SIZE_HA])*100

Definition Query

Rule4 IN ('a1', 'b1', 'c1', 'd1') OR Rule5 IN ('a1' , 'b1', 'c1', 'd1', 'e1', 'f1', 'g1', 'h1', 'h3', 'h5')

Select by attributes

Ara_perHA >= 20 AND Agri_Code2 IS NULL

Field Calculator

Rule6 = “a”

Agri_Code2 = “ARA”

RULE 7: Lifestyle Properties

Definition Query

Agri_Code IS NULL

Lifestyle Properties

Add Attribute Field

“Rule7” =TEXT

Select by attributes

SIZE_HA <= 5

Field Calculator

Rule7 = “a”

Agri_Code = “LIF”

Small Holdings

Select by attributes

SIZE_HA >5 AND SIZE_HA <=40

Field Calculator

Rule7 = “b”

Agri_Code = “SMH”

RULE 8: Native Properties

Add Attribute Field

“Rule8” =TEXT

Select by attributes

FARM_TYPE = 'NAT'

Field Calculator

Rule8 = “a”

Agri_Code = “CON_2”

RULE 9: Remaining Agribase Dairy, Sheep, Beef and Deer farm types

Remove Definition Query

Add Attribute Field

“Rule9” = TEXT

Select by attributes

Agri_Code IN ('LIF', 'SMH') AND "FARM_TYPE" IN ('SHP', 'BEF', 'SNB', 'DEE', 'DAI')

Field Calculator
Rule9 = “a”
Agri_Code2 = [FARM_TYPE]

Select by attributes
Agri_Code IS NULL AND "FARM_TYPE" IN ('SHP', 'BEF', 'SNB', 'DEE', 'DAI')
Field Calculator
Rule9 = “b”
Agri_Code = [FARM_TYPE]

Select by attributes
Agri_Code IN ('LIF', 'SMH') AND BeefStockF+ SheepStockF >=50 AND dai_nos =0
Field Calculator
Rule9 = “c”
Agri_Code2 = “SNB”

Select by attributes
Agri_Code IN ('LIF', 'SMH') AND BeefStockF + DairyStockF + SheepStockF >=50 AND dai_nos >=1
Field Calculator
Rule9 = “c”
Agri_Code2 = “SBDAI”

RULE 10: Other farm types

Add Attribute Field
“Rule10” = TEXT
Select by attributes
Agri_Code IS NULL
Field Calculator
Rule10 = “a”
Agri_Code = “UNK”

Appendix 1e – Modification of LCDB4.1

LCDB_v4_1___Land_Cover_Database_version_4_1__Mainland_New_Zealand (Source = M:\GIS\Data\Land_Cover\LCDB V4.1\lcdb-v41-land-cover-database-version-41-mainland-new-zealand.gdb)

LCDB v4.1 (Source = M:\GIS\Projects\ArcMap\Environmental Info\Land Use 2015 DeanP\Land Use Reviewed\April 2015\Method Files.gdb)

LCDB_v4_1___Land_Cover_Database_version_4_1__Mainland_New_Zealand
Clip
LCDB_v4_1___Land_Cover_Database_version_4_1__Mainland_New_Zealand
Regional_Boundary_ NZTM
LCDB v4.1

LCDB v4.1
Add Attribute Field
LCDB_Code = TEXT
Select by Attributes
Name_2012 = 'Short-rotation Cropland'
Field Calculator
LCDB_Code = “ARA”

Select by Attributes
Name_2012 IN ('Sand or Gravel', 'Landslide', 'Gravel or Rock')
Field Calculator
LCDB_Code = “BARE”

Select by Attributes
Name_2012 IN ('Gorse and/or Broom', 'Mixed Exotic Shrubland')
Field Calculator
LCDB_Code = “ESCRUB”

Select by Attributes
Name_2012 = 'Herbaceous Saline Vegetation'
Field Calculator
LCDB_Code = “ESTR”

Select by Attributes
Name_2012 IN ('Forest - Harvested', 'Deciduous Hardwoods', 'Exotic Forest')
Field Calculator
LCDB_Code = “EXTFOR”

Select by Attributes
Name_2012 = 'Orchard, Vineyard or Other Perennial Crop'
Field Calculator
LCDB_Code = “HORT”

Select by Attributes
Name_2012 IN ('Estuarine Open Water', 'Lake or Pond', 'River')
Field Calculator
LCDB_Code = “HYDRO”

Select by Attributes
Name_2012 = 'Surface Mine or Dump'
Field Calculator
LCDB_Code = “MINE”

Select by Attributes
Name_2012 IN ('Indigenous Forest', 'Broadleaved Indigenous Hardwoods')
Field Calculator
LCDB_Code = “NAT”

Select by Attributes
Name_2012 IN ('Flaxland', 'Fernland', 'Manuka and/or Kanuka' , 'Sub Alpine Shrubland', 'Matagouri or Grey Scrub')
Field Calculator
LCDB_Code = “NSCRUB”

Select by Attributes
Name_2012 = 'High Producing Exotic Grassland'
Field Calculator
LCDB_Code = “PAS”

Select by Attributes
Name_2012 IN ('Depleted Grassland', 'Low Producing Grassland')
Field Calculator
LCDB_Code = “LPAS”

Select by Attributes
Name_2012 = 'Permanent Snow and Ice'
Field Calculator
LCDB_Code = “PERMS”

Select by Attributes
Name_2012 = 'Urban Parkland/Open Space'
Field Calculator
LCDB_Code = “REC”

Select by Attributes
Name_2012 = 'Built-up Area (settlement)'
Field Calculator
LCDB_Code = “RES”

Select by Attributes
Name_2012 = 'Transport Infrastructure'
Field Calculator
LCDB_Code = “ROAD”

Select by Attributes
Name_2012 IN ('Alpine Grass/Herbfield', 'Tall Tussock Grassland')
Field Calculator
LCDB_Code = “TUSSOCK”

Select by Attributes
Name_2012 = 'Herbaceous Freshwater Vegetation'
Field Calculator
LCDB_Code = “WETL”

Appendix 2: Classifying Land Parcels

Appendix 2a – Road Parcel Identification

Road_Centrelines (Source = GISDATA.SDEADMIN.CENTRELINES, Source_Date = 20-01-2016)
LINZ_Parcels_Southland
Select by Location
(Target layer = LINZ_Parcels_Southland, Source layer = Road_Centrelines, Selection method = intersect the source layer feature) – returns 24,254 of 101,566 parcels
Select by Attributes
(Method = select from current selection, parcel_int = 'Road' – returns 12,254 of 101,566 parcels

Classify Road Parcels
Field Calculator
'ES_Code' = "ROAD" – 12,254 parcels classified as 'ES_Code', "ROAD"

Definition Query
"ES_Code" = ' ' Definition query removes polygons with an ES_Code

Appendix 2b – Rail Parcel identification

Railway (Source = GISDATA.SDEADMIN.RAILWAY, Source_Date = 20-01-2016)
LINZ_Parcels_Southland
Select by Location
(Target layer = LINZ_Parcels_Southland, Source layer = Railway, Selection method = intersect the source layer feature) – returns 251 of 101,566 parcels
Select by Attributes
(Method = select from current selection, parcel_int = 'Railway' – returns 166 of 101,566 parcels

Classify Rail Parcels
Field Calculator
'ES_Code' = "RAIL" – 166 parcels classified as 'ES_Code', "RAIL"

Appendix 2c – Classifying Lakes and Rivers

LINZ_Parcels_Southland
Select by Attributes
Method = create new selection, parcel_int = 'Hydro' – returns 1,484 of 101,566 parcels

Classify Lakes and River Parcels
Field Calculator
'ES_Code' = "HYDRO" – 1,484 parcels classified as 'ES_Code', "HYDRO"

Manual correction
Lake Monowai's 'parcel_intent' not classified as 'Hydro'
Select by Attributes
Method = create new selection, id = '4256244'
'ES_Code' = "HYDRO" – 1,485 parcels classified as 'ES_Code', "HYDRO"

Appendix 2d - Assigning Rates Land Use Information to all Parcels

LINZ_Parcels_Southland

Feature to Point

(Input = LINZ_Parcels_Southland, Inside the Polygon)

LINZ_ParcelsFeatureToPoints

Spatial Join

(Target layer = LINZ_ParcelsFeatureToPoints, Join Features = Property_Landuse2012_Rates2, Operation = ONE_TO_ONE, Match = INTERSECT, Keep all Target Features = KEEP_ALL)

LINZ_Parcels_RatesPoints

LINZ_Parcels_Southland

Add Attribute Fields

'Rates_Code' = Text

'Rates_LU' = Text

Join Data

(Join attributes from a table, join field = id, LINZ_Parcels_RatesPoints, join field = id, join options = keep all records) – validation = match of 101,566 of 101,566 parcels

Field Calculator

"Rates_Code" = [LINZ_Parcels_RatesPoints.Rates_Code]

"Rates_LU" = [LINZ_Parcels_RatesPoints.Land_Use]

Classify Residential Properties

Select by Attributes

Rates_Code = 'RES'

Field Calculator

ES_Code = "RES" – 45,574 parcels classified as 'ES_Code', "RES"

Classify Commercial Properties

Select by Attributes

Rates_Code = 'COM'

Field Calculator

ES_Code = "COM" –2,811 parcels classified as 'ES_Code', "COM"

Classify Public Use Areas

Select by Attributes

Rates_Code = 'PUB'

Field Calculator

ES_Code = "PUB" – 1,299 parcels classified as 'ES_Code', "PUB"

Classify Industrial Properties

Select by Attributes

Rates_Code = 'IND'

Field Calculator

ES_Code = "IND" – 2,409 parcels classified as 'ES_Code', "IND"

Classify Recreation Areas

Select by Attributes

Rates_Code = 'REC'

Field Calculator

ES_Code = "REC" – 4,214 parcels classified as 'ES_Code', "REC"

Classify Airports

Select by Attributes

Rates_Cod' = 'TRANS' AND Rates_LU = 'Air Transport'

Field Calculator

ES_Code = "AIR"

Populate 'Source' information

Select by Attributes

Create new selection = "ES_Code" IN ('COM', 'IND', 'PUB', 'REC', 'RES',' AIR')
Field Calculator
'Source' = "LINZ_Parcels_RatesPoints", 'Source_Class' = [Rates_LU], 'Source_Date' = "21-01-2016"

Remove Join

Appendix 2e – Refining the Recreation ('ES_Code', "REC") classification

Golf clubs are identified as a potentially high loss land use within the REC classification. Therefore Golf Club names are identified by the 'Source Data' field.

Golf Club (Source = M:\GIS\Projects\ArcMap\Environmental Info\Land Use 2015 DeanP\Additional Files\Golf Club.shp)

LINZ_ParcelsFeatureToPoints
Spatial Join
Target layer = LINZ_ParcelsFeatureToPoints, Join Features = Golf Club, Operation = ONE_TO_ONE, Match = INTERSECT, Keep all Target Features = KEEP_COMMON (uncheck box)
LINZ_Parcels_GolfPoints

LINZ_Parcel_Southland
Remove Definition Query
Join Data
(Join attributes from a table, join field = id, LINZ_Parcels_GolfPoints, join field = id, join options = keep all records) – validation = match of 112 of 101,566 parcels
Select by Attributes
Create new selection = NOT LINZ_Parcels_GolfPoints.Club_Name IS NULL
Field Calculator
'Source' = "Topo50", 'Source_Data' = [LINZ_Parcels_GolfPoints.Club_Name],
'Source_Date' = "21-01-2016
'ES_Code' = "REC" – 4,220 total parcels classified as 'ES_Code', "REC"
'ES_Code2' = "GOLF"
Remove Join

Appendix 2f – Refining the Industry ('ES_Code', "IND") classification

Major industries are identified as a potentially high loss land use within the IND classification. Therefore industry names are identified by the 'Source_Data' field to allow for searching for specific industry types.

Southland_Industries (Source = M:\GIS\Projects\ArcMap\Environmental Info\Land Use 2015 DeanP\Land Use Reviewed\Land Use Landcare 2015.gdb)

LINZ_ParcelsFeatureToPoints
Spatial Join
Target layer = LINZ_ParcelsFeatureToPoints, Join Features = Southalnd_Industries, Operation = ONE_TO_ONE, Match = INTERSECT, Keep all Target Features = KEEP_COMMON (uncheck box)
LINZ_Parcels_IndustryPoints

LINZ_Parcel_Southland
Join Data
(Join attributes from a table, join field = id, LINZ_Parcels_IndustryPoints, join field = id, join options = keep all records) – validation = match of 62 of 101,566 parcels
Select by Attributes
NOT LINZ_Parcels_IndustryPoints.Source_Class1 IS NULL
Field Calculator
'Source' = "Southalnd_Industries.shp"
'Source_Data' = [Source_Class1]

'Source_Date' = "21-01-2016"
'ES_Code' = "IND" – 2,417 total parcels classified as 'ES_Code', "IND"
Remove Join

Definition Query
Definition query to remove polygons with an ES_Code
"ES_Code" = ' '

Appendix 2g – Assigning Forestry Information to Parcels

Major_Forestry (Source = M:\GIS\Projects\ArcMap\Environmental Info\Land Use 2015 DeanP\Forestry\Major_forestry.shp)

LINZ_ParcelsFeatureToPoints
Spatial Join
Target layer = LINZ_ParcelsFeatureToPoints, Join Features = Major_Forestry, Operation = ONE_TO_ONE, Match = INTERSECT, Keep all Target Features = KEEP_COMMON (uncheck box)
Major_Forestry_Points

LINZ_Parcel_Southland
Join Data
(Join attributes from a table, join field = id, Major_Forestry_Points, join field = id, join options = keep all records) – validation = match of 471 of 101,566 parcels
Select by Attributes
Create new selection = (Major_Forestry_Points.Source_Class1 IS NULL)
Switch Selection
Field Calculator
'Source' = "Major_Forestry.shp", 'Source_Class' = [Major_Forestry_Points.Source_Class1], 'Source_Date' = "29-01-2016"
'ES_Code' = "FOREXT" – 471 parcels classified as 'ES_Code', "FOREXT"
Select by Attributes
Create new selection, "Source_Class" = 'Lindsay and Dixon Ltd'
Field Calculator
'ES_Code' = "FORNAT" – 11 parcels reclassified from "FOREXT" to 'ES_Code', "FORNAT"
Remove Join

Appendix 2h – Assigning Dairy Consent Information to Parcels

DairyConsent_17April15 (Source = M:\GIS\Projects\ArcMap\Environmental Info\Land Use 2015 DeanP\Land Use Reviewed\April 2015\Method Files.gdb)

Dairy with parcel center point inside dairy consent polygon

Definition Query
"Status" IN ('Current', 'Expired –S. 124 Protection ')

LINZ_ParcelsFeatureToPoints
Spatial Join
Target layer = LINZ_ParcelsFeatureToPoints, Join Features = DairyConsent_17April15, Operation = ONE_TO_ONE, Match = INTERSECT, Keep all Target Features = KEEP_COMMON (uncheck box)
Dairy_Points_Current

LINZ_Parcel_Southland
Add Attribute fields
'IRIS_ID' = Text
'DAI_Struct' = Text
'Notes' = Text

'MaxConsen' = Double
'MaxWintOn' = Double
Join Data
(Join attributes from a table, join field = id, Dairy_Points_Current, join field = id, join options = keep all records)
– validation = match of 7,845 of 101,566 parcels
Select by Attributes
Create new selection = (Dairy_Points_Current.Source_Class1 IS NULL)
Switch Selection
Field Calculator
'Source' = "DairyConsent_17April15.shp",
'Source_Date' = "17-04-2015"
'IRIS_ID' = [Dairy_Points_Current.IRIS_ID]
'DAI_Struct' = [Dairy_Points_Current. DAI_Struct]
'Notes' = [Dairy_Points_Current. Notes]
'MaxConsen' = [Dairy_Points_Current. MaxConsen]
'MaxWintOn' = [Dairy_Points_Current. MaxWintOn]
'ES_Code' = "DAICOW" – 7,845 parcels classified as 'ES_Code', "DAICOW"
Select by Attributes
Create new selection, "Notes" = 'Sheep Milking'
Field Calculator
'ES_Code' = "DAISHP" – 22 parcels reclassified from "DAICOW" to 'ES_Code', "DAISHP"
Remove Join

Dairy without parcel center point inside dairy consent polygon

Manual Edit
Visual assessment of dairy areas not added by the above method – identified 20 properties,
Parcel_ID: 6555826; 6554988; 6797640; 4225541; 6542781; 6616471; 4201871; 4217895; 4217921; 4252749; 4264541; 4267468; 4274621; 4274780; 4226249, 7196198, 424920 and 4208098; 4245441 and 4214646; 4279676 and 4265282; 424246512 and 4254815.
Total records: 101,566
Cut polygon tool
Draw shape of dairy farm guided from DairyConsent_17April15
Manually populate data fields
'Source' = "DairyConsent_17April15.shp",
'Source_Date' = "17-04-2015"
'IRIS_ID' = [DairyConsent_17April15.IRIS_ID]
'DAI_Struct' = [DairyConsent_17April15. DAI_Struct]
'Notes' = "Cut polygon"
'MaxConsen' = [DairyConsent_17April15. MaxConsen]
'MaxWintOn' = [DairyConsent_17April15. MaxWintOn]
'ES_Code' = "DAICOW"

Already classified areas

Aerial photography NZAM Orthophotos – photographed 2014-2015
(Source = M:\GIS\Data\Imagery\OrthoPhotos\OrthoPhotos.gdb)

Dairy milking platform areas that are already classified are treaded in one of two ways:

If dairy milking platform occurs on already classified land, the ES_Code becomes "DAICOW" if aerial photography supports the classification of dairy.

Select by Attributes
Create new selection = 'ES_Code' IN ('RES', 'REC', 'COM', 'PUB', 'IND')
Sort field 'IRIS_ID', manually select those with an 'IRIS_ID' ('Reselect Highlighted' option)
Field Calculator
'ES_Code2' = [ES_Code]
'ES_Code' = 'DAICOW'
'Notes' = "Mixed dairy and other use" – 26 parcels reclassified from either 'RES', 'REC', 'COM', 'PUB', or 'IND' to 'ES_Code', "DAICOW" with the original classification in 'ES_Code2'.

If the entirety of the parcel was clearly not on the dairy milking platform the original classification remained.

Select by Attributes

Create new selection = 'ES_Code' IN ('RES', 'REC', 'COM', 'PUB', 'IND')

Sort field 'IRIS_ID', manually select those with an 'IRIS_ID' ('Reselect Highlighted' option)

Field Calculator

'ES_Code' = no change

'Notes' = "Not Dairy, checked aerial photography - OrthoPhotos" – 61 parcels remain classified as either 'RES', 'REC', 'COM', 'PUB', or 'IND', even though they have dairy consent information.

Export

"z1_PostDairyInclusion_Export" – 101,596 polygons

Appendix 2i – Assigning Modified Agribase Information to Parcels

Agribase _Reclass (Source = M:\GIS\Projects\ArcMap\Environmental Info\Land Use 2015 DeanP\Land Use Reviewed\April 2015\Method Files.gdb)

Spatial Join

Target layer = LINZ_ParcelsFeatureToPoints, Join Features = Agribase _Reclass, Operation = ONE_TO_ONE, Match = INTERSECT, Keep all Target Features = KEEP_COMMON (uncheck box)

Agribase_Points – 30,438 records

z1_PostDairyInclusion_Export

Join Data

Attributes from a table ('id', 'Agribase_Points', 'id', 'keep all records') – validation = 30,438 of 101,596

Definition Query

PostDairyInclusion_Export.ES_Code = ' '

Select by attributes

Agribase_Points.Agri_Code = 'DAICOW'

Select from current selection

Agribase_Points.Rule4 = 'a1'

Field Calculator

PostDairyInclusion_Export.ES_Code = "DAICOW"

Select by attributes

Agribase_Points.Agri_Code = 'DAICOW'

Field Calculator

PostDairyInclusion_Export.ES_Code2 = [Agri_Code2]

PostDairyInclusion_Export.ES_Code = 'DAISUP'

Select by attributes

Agribase_Points.Agri_Code IN ('ARA', 'FRU', 'VEG', 'FLO', 'NUR', 'LIF', 'SMH', 'NAT', 'DAISUP', 'LIVSUP', 'OAN', 'BEF', 'SND', 'BND', 'SBD', 'DEE', 'DEESHP', 'DEEBEF', 'DEESNB', 'SHP', 'SNB', 'TOU', 'UNK')

Field Calculator

PostDairyInclusion_Export.ES_Code2 = [Agri_Code2]

PostDairyInclusion_Export.ES_Code = [Agri_Code]

Select by attributes

Agribase_Points.Agri_Code = 'FOR'

Field Calculator

PostDairyInclusion_Export.ES_Code = "EXTFOR"

Already classified areas

Remove Definition Query
Select by attributes
Agribase_Points.id = 7231170
PostDairyInclusion_Export.ES_Code = [Agri_Code] (Residential replaced with Vegetables)
Select by attributes
Agribase_Points.id IN ('3274116', '3247893', '3253430', '3228491', '3260872', '3262668', '3280012')
PostDairyInclusion_Export.ES_Code = [Agri_Code] (Commercial replaced with Sheep and Beef)

Export – retain join
"z2_PostAgribase_9_02" – 101,596 polygons

Appendix 2j – Assigning Modified PAN-NZ Information to Parcels

Southland_PANNZ (Source = M:\GIS\Projects\ArcMap\Environmental Info\Land Use 2015 DeanP\Land Use Reviewed\April 2015\PAN-NZ_2014_ForDistribution.gdb)

Data sources within PAN-NZ are added separately

DOC Public Conservation Areas

Southland_PANNZ
Definition Query
"Source" = 'DOC_Public_Conservation_Areas_2014'

Spatial Join
Target layer = LINZ_ParcelsFeatureToPoints, Join Features = PANNZ_2014_Southland, Operation = ONE_TO_ONE, Match = INTERSECT, Keep all Target Features = KEEP_COMMON (uncheck box)

PANNZDOC_Points – 4,146 records

z2_PostAgribase_9_02
Join Data
Attributes from a table ('id', 'PANNZDOC_Points', 'id', 'keep all records') – validation = 4146 of 101,596

Remove Conservation areas within a town boundary
Select by Attributes
NOT DOC_Points.id IS NULL
Select from current selection
"PostAgribase_9_02.ES_Code" IN ('REC', ' ', 'HYDRO') – 2,949 parcels selected
Select by Location
Method = remove from the currently selected features in
Target layer = PostAgribase_9_02
Source layer = RPMS_Zone
Spatial Selection = within the source layer feature
Field Calculator
ES_Code = "CON" – 2,946 parcels classified as "CON"
'Source_Class' = [PANNZDOC_Points.StatusPhrase]
'Source_Data' = "DOC_Public_Conservation_Areas_2014"

Removing 'Conservation' Classification on 'Hydro' areas
Select by Attributes
DOC_Points.StatusPhrase IN ('Marine Mammals Sanctuary', 'Marine Reserve') OR DOC_Points.StatusPhrase

= 'National Park' AND "PostAgribase.parcel_int" = 'Hydro' OR “PostAgribase.id” IN (‘4256244’, ‘4401908’, ‘4401911’)

Field Calculator

ES_Code = “HYDRO” – 92 parcels classified as “HYDRO”

Remove Join

National Parks

Southland_PANNZ

Definition Query

“Source” = ‘National_Parks_LINZ_Appellation_2014’

Spatial Join

Target layer = LINZ_ParcelsFeatureToPoints, Join Features = PANNZ_2014_Southland, Operation = ONE_TO_ONE, Match = INTERSECT, Keep all Target Features = KEEP_COMMON (uncheck box)

PANNZNationalPark_Points – 161 records

z2_PostAgribase_9_02

Join Data

Attributes from a table (‘id’, ‘PANNZNationalPark_Points’, ‘id’, ‘keep all records’) – validation = 161 of 101,596

Select by Attributes

NOT PANNZNationalPark_Points.id IS NULL – all records previously classified as ‘CON’, no records amended

Remove Join

LINZ Marginal Strips

Southland_PANNZ

Definition Query

Source = 'LINZ_Marginal_Strips_Movable_2014'

Spatial Join

Target layer = LINZ_ParcelsFeatureToPoints, Join Features = PANNZ_2014_Southland, Operation = ONE_TO_ONE, Match = INTERSECT, Keep all Target Features = KEEP_COMMON (uncheck box)

PANNZMarginalStrips_Points – 6 records

z2_PostAgribase_9_02

Join Data

Attributes from a table (‘id’, ‘PANNZMarginalStrips_Points’, ‘id’, ‘keep all records’) – validation = 6 of 101,596

Select by Attributes

NOT PANNZMarginalStrips_Points.id IS NULL – check records, 4 parcels previously classified as ‘CON’ by ‘PANNZDOC_Points’, 2 parcels classified as ‘SNB’ previously by ‘Agribase April 2015.shp’

Remove Join

Nga Whenua Rahui

Southland_PANNZ

Definition Query

“Source” = ‘Nga_Whenua_Rahui_Kawenata_2014’

Spatial Join

Target layer = LINZ_ParcelsFeatureToPoints, Join Features = PANNZ_2014_Southland, Operation = ONE_TO_ONE, Match = INTERSECT, Keep all Target Features = KEEP_COMMON (uncheck box)

PANNZNgaWhenuaRahui_Points – 1 record

z2_PostAgribase_9_02

Join Data
Attributes from a table ('id', 'PANNZNgaWhenuaRahui_Points', 'id', 'keep all records') – validation = 1 of 101,596

Select by attributes
NOT 'PANNZNgaWhenuaRahui_Points.id' IS NULL
Field Calculator
'Source_Class' = [PANNZNgaWhenuaRahui_Points.StatusPhrase]
'ES_Code' = "CON" – 1 parcel classified as "CON"

Remove Join

LINZ Parcels with Statutory Actions

Southland_PANNZ
Definition Query
"Source" = 'LINZ_Parcels_with_Statutory_Actions_2014'

Spatial Join
Target layer = LINZ_ParcelsFeatureToPoints, Join Features = PANNZ_2014_Southland, Operation = ONE_TO_ONE, Match = INTERSECT, Keep all Target Features = KEEP_COMMON (uncheck box)
PANNZStaturatoryActions_Points – 3,724 records

z2_PostAgribase_9_02
Join Data
Attributes from a table ('id', 'PANNZStaturatoryActions_Points', 'id', 'keep all records') – validation = 3,724 of 101,596

Select by Attributes
NOT PANNZStaturatoryActions_Points.id IS NULL – 3,724 parcels selected
Select from current selection
PostAgribase_9_02.ES_Code = ' '
Field Calculator
'Source_Class' = [PANNZStatutoryActions_Points.StatusPhrase]
'ES_Code' = [PANNZ_Code] – 342 Parcels classified as Appendix 1c codes

Remove Join

Export
"z3_PostPANNZ_11_02" – 101,596 polygons

Appendix 2k – Classifying QEII

z3_PostPANNZ_11_02

Clip
QEII_CovPolyWeb_20150528
Regional_Boundary_ NZTM
QEII_CovPolyWeb_28_05_2015_Clip

QEII_CovPolyWeb_28_05_2015_Clip
Explode Multipart
Union
z3_PostPANNZ_11_02

QEII_CovPolyWeb_28_05_2015_Clip
Export
“z4_PostQEII_11_02” – no. of polygons increased from 101,596 to 102,192 parcels

Select by attributes
NOT "CovNumber" = ‘ ‘
Field Calculator
Notes = [Comment]
ES_Code2 = [ES_Code]
ES_Code = [CON]
Source = [QEII_CovPolyWeb_20150528]
Source_Date = “28/05/2015”

Appendix 2l – Classifying remaining polygons by LCDB4.1

z4_PostQEII_11_02
Adding Land Cover Information
LCDB v4.1
(Source = M:\GIS\Data\Land_Cover\LCDB V4.1\lcdb-v41-land-cover-database-version-41-mainland-new-zealand.gdb/ LCDB_v4_1___Land_Cover_Database_version_4_1__Mainland_New_Zealand)

Refer to Table 4 and Appendix 1e for Code Classification
LCDB v4.1
Dissolve
Dissolve Fields = LCDB_Code
LCDBCode_Dissolve

LCDBCode_Dissolve
Union
LCDBCode_Dissolve
z4_PostQEII_11_02
PostQEII_LCDB_Union

Add Field
“ara_ha” = DOUBLE
“bare_ha” = DOUBLE
“escrub_ha” = DOUBLE
“estr_ha” = DOUBLE
“extfor_ha” = DOUBLE
“hort_ha” = DOUBLE
“hydro_ha” = DOUBLE
“mine_ha” = DOUBLE
“natfor_ha” = DOUBLE
“nscrub_ha” = DOUBLE
“pas_ha” = DOUBLE
“lpas_ha” = DOUBLE
“perms_ha” = DOUBLE
“rec_ha” = DOUBLE
“res_ha” = DOUBLE
“road_ha” = DOUBLE
“tussock_ha” = DOUBLE
“wet_ha” = DOUBLE

Select by Attributes
LCDB_Code = 'ARA'
'ara_ha' = Calculate Geometry
Units = Hectares [ha]

Complete for all "…_ha" fields

Dissolve
PostQEII_LCDB_Union
Dissolve Fields = check all fields present in z4_PostQEII_11_02 i.e. ES_Code, ES_Code2, Source, id etc.
Statistics Field(s) = ara_ha = SUM, bare_ha = SUM, escrub_ha = SUM, estr_ha = SUM, extfor_ha = SUM, hort_ha = SUM, hydro_ha = SUM, mine_ha = SUM, natfor_ha = SUM, nscrub_ha = SUM, pas_ha = SUM, lpas_ha = SUM, perms_ha = SUM, res_ha = SUM, road_ha = SUM, tussock_ha = SUM, wetl_ha = SUM
PostQEII_LCDB_UnionDISS

Estimating Effective and Ineffective land uses

New Attribute Field
"Eff_area" = DOUBLE
Field Calculator
[arab_ha] + [escrub_ha] + [hort_ha] + [pas_ha] + [tussock_ha] + [lpas_ha]

New Attribute Field
"Ineff_area" = DOUBLE
Field Calculator
[bare_ha]+ [estr_ha]+ [extfor_ha]+ [hydro_ha]+ [mine_ha]+ [natfor_ha]+ [nscrub_ha]+ [perms_ha]+ [res_ha]+ [road_ha]+ [wetl_ha]

Classifying Unknown Parcels

Select by attributes
("extfor_ha" / "Shape_Area" *1000000) >=50 AND "ES_Code" IN (' ','UNK')
Field Calculator
Source = "LCDBv4.1.shp"
Source_Class = "Exotic Forest"
Source_Date = 01-01-2012
ES_Code = "FOREXT" – 368 records classified as ES Code, FOREXT

Select by attributes
("natfor_ha" / "Shape_Area" *1000000) >=50 AND "ES_Code" IN (' ','UNK')
Field Calculator
Source = "LCDBv4.1.shp"
Source_Class = "Indigenous Forest"
Source_Date = 01-01-2012
ES_Code = "CON_2" – 664 records classified as ES Code, CON_2

Select by attributes
("nscrub_ha" / "Shape_Area" *1000000) >=50 AND "ES_Code" IN (' ','UNK')
Field Calculator
Source = "LCDBv4.1.shp"
Source_Class = "Native Scrub"
Source_Date = 01-01-2012
ES_Code = "CON_2" – 208 records classified as ES Code, CON_2

Select by attributes
("hort_ha" / "Shape_Area" *1000000) >=50
Field Calculator

Source = “LCDBv4.1.shp”
Source_Class = “Orchard, Vineyard or Other Perennial Crop”
Source_Date = 01-01-2012
ES_Code = “HORT” – 6 records classified as ES Code, HORT

Select by attributes
("arab_ha" / "Shape_Area" *1000000) >=50 AND "ES_Code" IN (' ','UNK')
Field Calculator
Source = “LCDBv4.1.shp”
Source_Class = “Short rotation cropland”
Source_Date = 01-01-2012
ES_Code = “ARA” – 30 records classified as ES Code, ARA

Select by attributes
("Ineff_area"/ "Shape_Area" *1000000) >=50 AND "ES_Code" IN (' ','UNK')
Field Calculator
Source = “LCDBv4.1.shp”
Source_Class = “Ineffective forest, water, or bare ground”
Source_Date = 01-01-2012
ES_Code = “UNK” – 1658 records classified as ES Code, UNK

Select by attributes
("Eff_area" / "Shape_Area" *1000000) >=50 AND "ES_Code" IN (' ','UNK')
Field Calculator
Source = “LCDBv4.1.shp”
Source_Class = “Effective pasture, scrub, or tussock”
Source_Date = 01-01-2012
ES_Code = “PAS” – 9237 records classified as ES Code, PAS

Export
z5_PostLCDB_15_02 – 102,192 records

Appendix 2m – Other changes

z5_PostLCDB_15_02
Arable Industry Data
Cropping _Farms (Source = M:\GIS\Projects\ArcMap\Environmental Info\George's Dairy Layers\Land Use change report analysis\Cropping_Farms.shp)

Project
(Input = Cropping_Farms, coordinate system = GD_1949_New_Zealand_Map_Grid; Output = Arable_FarmsNZTM, coordinate system = NZGD_2000_New_Zealand_Transverse_Mercator)

Arable_FarmsNZTM

Spatial Join
Target layer = LINZ_ParcelsFeatureToPoints, Join Features = Arable_FarmsNZTM, Operation = ONE_TO_ONE, Match = INTERSECT, Keep all Target Features = KEEP_COMMON (uncheck box)

ArableFarms_Points – 350 records

Select by attributes
NOT "ArableFarms_Points.id" IS NULL AND "PostLCDB_15_02.ES_Code" = ' '
Field Calculator
Source = “Cropping Farms.shp”
ES_Code = “ARA” – 23 records classified as ES Code, ARA
Select by attributes

NOT "ArableFarms_Points.id" IS NULL AND PostLCDB_15_02.ES_Code2" = ' ' AND NOT "PostLCDB_15_02.ES_Code" IN ('ARA', 'LIF', 'RES', 'FOREXT', 'UNK')

Source = “Cropping Farms.shp”

ES_Code2 = “ARA”– 261 records classified as ES Code2, ARA

Coastal Marine Areas

Select by attributes

Manual selection of ‘parcel_int’ = ‘Hydro’ within coastal marine areas

Field Calculator

ES_Code = “MARINE” – 81 records classified as ES Code, MARINE

Estuaries

Estuaries (Source = M:\GIS\Data\Hydrology\Estuaries.shp)

Spatial Join

Target layer = LINZ_ParcelsFeatureToPoints, Join Features = Estuaries, Operation = ONE_TO_ONE, Match = INTERSECT, Keep all Target Features = KEEP_COMMON (uncheck box)

Estuaries_Points – 153 records

Select by attributes

NOT "Estuaries_Points.id" IS NULL AND "PostLCDB_15_02.ES_Code" = ' '

Field Calculator

Source = “Estuaries_Points.shp”

Source_Class = [Estuaries_Points.Name]

Source_Data = [Estuaries_Points.Type]

ES_Code = “ESTR” – 147 records classified as ES Code, ESTR

Waituna lagoon – polygon not included in parcel layer

Estuaries

Select by attributes

Name = ‘Waituna Lagoon’

Union

Estuaries.shp

PostLCDB_15_02

z6_PostWaituna_Inclusion – no of polygons increased from 102,192 to 102,193 parcels

Field Calculator

Source = “Estuaries_Points.shp”

Source_Class = “Waituna Lagoon”

Source_Data = “Lagoon”

ES_Code = “HYDRO” – 1 record classified as ES Code, HYDRO

Appendix 2n – Land Use Classifications

z6_PostWaituna_Inclusion

Export

Southland_Land_Use_Base_April_2015

M:\GIS\Projects\ArcMap\Environmental Info\Land Use 2015 DeanP\Land Use Reviewed\Final

Converting ES_Code to Land Use Classification

Add attribute field

Land_Use_C = TEXT

Definition Query

Land_Use_C = ' '

Select by Attributes and Field Calculator

Conservation
"ES_Code" = 'CON'– 3409 records classified as Land Use Class, Conservation

Recreation and Tourism
"ES_Code" IN ('REC', 'TOU') – 1857 records classified as Land Use Class, Recreation and Tourism

Plantation Forestry
"ES_Code" = 'FOREXT' – 855 records classified as Land Use Class, Plantation Forestry

Indigenous Forestry
"ES_Code" = 'FORNAT'– 11 records classified as Land Use Class, Indigenous Forestry

Beef
"ES_Code" = 'BEF'– 1234 records classified as Land Use Class, Beef

Sheep
"ES_Code" = 'SHP' – 4186 records classified as Land Use Class, Sheep

Specialist Deer
"ES_Code" = 'DEE' – 422 records classified as Land Use Class, Specialist Deer

Sheep and Beef
"ES_Code" = 'SNB' – 6702 records classified as Land Use Class, Sheep and Beef

Mixed Livestock
"ES_Code" IN ('SND', 'BND', 'SBD') – 1353 records classified as Land Use Class, Miked Livestock

Majority Deer with Mixed Livestock
"ES_Code" IN ('DEESHP', 'DEEBEF', 'DEESNB') – 426 records classified as Land Use Class, Majority Deer and Mixed Livestock

Other Animals
"ES_Code" = 'OAN' – 207 records classified as Land Use Class, Other Animals

Dairy
"ES_Code" = 'DAICOW' – 7206 records classified as Land Use Class, Dairy

Livestock Support
"ES_Code" = 'LIVSUP' – 730 records classified as Land Use Class, Livestock Support

Dairy Support
"ES_Code" = 'DAISUP' AND "ES_Code2" IN ('ARA',' ', 'DAI', 'DAICOW') OR "ES_Code" = 'LIVSUP' AND "ES_Code2" IN ('DAICOW', 'DAI', 'DAISUP') – 1153 records classified as Land Use Class, Dairy Support

Sheep Milking
"ES_Code" = 'DAISHP' – 22 records classified as Land Use Class, Sheep Milking

Dairy Support and Other Livestock
"ES_Code" = 'DAISUP' AND NOT "ES_Code2" IN ('ARA',' ', 'DAI', 'DAICOW') – 614 records classified as Land Use Class, Dairy Support and Other Livestock

Arable
"ES_Code" = 'ARA' AND "ES_Code2" = ' ' – 125 records classified as Land Use Class, Arable

Mixed Livestock and Arable
"ES_Code2" = 'ARA' AND NOT "ES_Code" IN ('DAICOW', 'DAISHP') OR "ES_Code" = 'ARA' AND NOT "ES_Code2" = '' – 496 records classified as Land Use Class, Miked Livestock and Arable

Horticulture
"ES_Code" IN ('VEG', 'HORT') – 15 records classified as Land Use Class, Horticulture

Flowers and Bulb Growers
"ES_Code" = 'FLO' – 30 records classified as Land Use Class, Flowers and Bulb Growers

Nurseries and Orchards
"ES_Code" IN ('FRU', 'NUR') – 14 records classified as Land Use Class, Nurseries and Orchards

Small Land Holding
"ES_Code" = 'SMH' – 1012 records classified as Land Use Class, Small Land Holding

Lifestyle

"ES_Code" = 'LIF' – 2192 records classified as Land Use Class, Lifestyle

Industry and Airports
"ES_Code" IN ('IND', 'AIR') – 2430 records classified as Land Use Class, Industry and Airports

Commercial Use
"ES_Code" = 'COM' – 2788 records classified as Land Use Class, Commercial Use

Residential Use
"ES_Code" = 'RES' – 35106 records classified as Land Use Class, Residential Use

Public Use
"ES_Code" = 'PUB' – 1572 records classified as Land Use Class, Public Use

Unknown Land Use - Pastoral
"ES_Code" = 'PAS' – 9527 records classified as Land Use Class, Unknown Land Use – Indigenous Cover

Unknown Land Use – Indigenous Forest
"ES_Code" = 'CON_2' – 978 records classified as Land Use Class, Unknown Land Use – Pastoral

Unkown Land Use – Non-agricultural
"ES_Code" = 'UNK' – 1645 records classified as Land Use Class, Unknown Land Use – Non-Agricultural

Lakes and Rivers
"ES_Code" = 'HYDRO' – 1287 records classified as Land Use Class, Lakes and Rivers

Road and Rail
"ES_Code" IN ('ROAD', 'RAIL') – 12360 records classified as Land Use Class, Road and Rail

228 records do not have a Land Use Class; however these areas are identified as estuaries and the open ocean.

Appendix 3: Property Scale Map

Conversion of parcels to property extent polygons
Feature Dataset: GISDATA.SDEADMIN.Cadastral
Feature Class: GISDATA.SDEADMIN.Property

Appendix 3a: Parcels to Polygons

Property

Dissolve
Dissolve Fields = Name, PropertyAd
PropertyAddress_Dissolve

Add Field
"Duplicate" = SHORT INTERGER
Field Calculator
Select the 'Python' Parser
Checkbox 'Show Codeblock'
Enter to the Pre-Logic Script Code box the following:

```
"uniqueList = []
def isDuplicate(inValue):
  if inValue in uniqueList:
    return 1
  else:
    uniqueList.append(inValue)
    return 0"
```

Within the lower expression box
'isDuplicate(!Shape_Area!)'

Definition Query
NOT 'Duplicate' = 1

Spatial Join
Target layer = LINZ_ParcelsFeatureToPoints, Join Features = PropertyAddress_Dissolve, Operation = ONE_TO_ONE, Match = INTERSECT, Keep all Target Features = KEEP_COMMON (uncheck box)
PropertyAddress_Points

Southland_Land_Use_Base_April_2015
Join Data
Attributes from a table ('id', 'PropertyAddress_Points', 'id', 'keep all records'

Dissolve
Dissolve Fields = ES_Code, ES_Code2, Source, Source Class, IRIS_IS, farm_id, Land_Use_Class. Name, Address, Name_FID, Rates_Code
Southland_Land_Use_Base_April_2015_Property_Scale

Appendix 3b: Classification of Unknown Land Use – Pastoral with Rates 2012 Information

Southland_Land_Use_Base_April_2015_Property_Scale

Definition Query
"Land_Use_Class" = 'Unknown Land Use – Pastoral'
Classify Arable Properties
Select by Attributes
Create new selection = "Rates_Code" = 'ARA'
Field Calculator
'ES_Code' = "ARA"
'Source' = "ES Rates Information 2012"
'Source_Class' = [Rates_Class]
"Land_Use_Class" = 'Arable'

Classify Horticultural Properties
Select by Attributes
Create new selection = "Rates_Code" = 'HORT'
Field Calculator
'ES_Code' = "HORT"
'Source' = "ES Rates Information 2012"
'Source_Class' = [Rates_Class]
"Land_Use_Class" = 'Horticulture'

Classify Dairy Support Properties
Select by Attributes
Create new selection = "Rates_Code" = 'DAI'
Field Calculator
'ES_Code' = "DAISUP"
'Source' = "ES Rates Information 2012"
'Source_Class' = [Rates_Class]
"Land_Use_Class" = 'Dairy Support'

Classify Lifestyle Properties
Select by Attributes
Create new selection = "Rates_Code" = 'LIF' AND 'Shape_Area <5
Field Calculator
'ES_Code' = "LIF"
'Source' = "ES Rates Information 2012"
'Source_Class' = [Rates_Class]
"Land_Use_Class" = 'Lifestyle'

Classify Small Land Holding Properties
Select by Attributes
Create new selection = "Rates_Code" = 'LIF' AND 'Shape_Area >5 AND 'Shape_Area <40
Field Calculator
'ES_Code' = "SMH"
'Source' = "ES Rates Information 2012"
'Source_Class' = [Rates_Class]
"Land_Use_Class" = 'Small Land Holding'

Classify Sheep and Beef Properties
Select by Attributes
Create new selection = "Rates_Code" IN ('FINLIV', 'STORELIV') AND 'Shape_Area >40
Field Calculator
'ES_Code' = "SNB"
'Source' = "ES Rates Information 2012"

'Source_Class' = [Rates_Class]
"Land_Use_Class" = 'Sheep and Beef'

Classify Mixed Livestock Properties
Select by Attributes
Create new selection = "Rates_Code" = 'SPLIV' AND 'Shape_Area >40
Field Calculator
'ES_Code' = "SBD"
'Source' = "ES Rates Information 2012"
'Source_Class' = [Rates_Class]
"Land_Use_Class" = 'Mixed Livestock'

Appendix 3c: Winter Forage Property Information

Southland_Land_Use_Base_April_2015_Property_Scale
(Source = M:\GIS\Projects\ArcMap\Environmental Info\Land Use 2015 DeanP\Land Use Reviewed\Final)
Winter_Forage_Areas
(Source = M:\GIS\Projects\ArcMap\Environmental Info\Land Use 2015 DeanP\MattLandUse\Winter Grazing)

Union
Southland_Land_Use_Base_April_2015_Property_Scale
Winter_Forage_Areas
Forage_Property

Add Fields
Forage_ha = DOUBLE

Select by attributes
NOT FID.Forage_ha = -1

Calculate Geometry
Units = Hectares [ha]

Dissolve
Winter_Forage_Property
Dissolve Fields = ES_Code, ES_Code2, Source, Source Class, IRIS_IS, farm_id, Land_Use_Class. Name, Address, Name_FID, Rates_Code
Statistics Field(s) = Winter_Forage_ha = SUM
Forage_Property_Dissolve

Appendix 3d: LCDB Property Information

Forage_Property_Dissolve

LCDB_Code_Dissolve
(Source = M:\GIS\Projects\ArcMap\Environmental Info\Land Use 2015 DeanP\Land Use Reviewed\April 2015\Method Files.gdb)

Intersect
Forage_Property_Dissolve
LCDB_Code_Dissolve
LCDB_Property

Add Fields
ara_ha = DOUBLE
bare_ha = DOUBLE
escrub_ha = DOUBLE
estr_ha = DOUBLE
extfor_ha = DOUBLE
hort_ha = DOUBLE
hydro_ha = DOUBLE
mine_ha = DOUBLE
natfor_ha = DOUBLE
nscrub_ha = DOUBLE
pas_ha = DOUBLE
lpas_ha = DOUBLE
perms_ha = DOUBLE
res_ha = DOUBLE
road_ha = DOUBLE
tussock_ha = DOUBLE
wetl_ha = DOUBLE

Select by attributes
LCDB_Code = ARA

Calculate Geometry
Units = Hectares [ha] – repeat for all fields

Dissolve
LCDB_Property
Dissolve Fields = ES_Code, ES_Code2, Source, Source Class, IRIS_IS, farm_id, Land_Use_Class. Name, Address, Name_FID, Rates_Code, Forage_ha
Statistics Field(s) = ara_ha = SUM, bare_ha = SUM, escrub_ha = SUM, estr_ha = SUM, extfor_ha = SUM, hort_ha = SUM, hydro_ha = SUM, mine_ha = SUM, natfor_ha = SUM, nscrub_ha = SUM, pas_ha = SUM, lpas_ha = SUM, perms_ha = SUM, res_ha = SUM, road_ha = SUM, tussock_ha = SUM, wetl_ha = SUM
LCDB_Property_Dissolve

Appendix 4: Technical Land Use Map

Conversion of the property scale land use map in to land use, land cover, and landscape blocks that can be used for the process of estimating losses

Southland_Land_Use_Base_April_2015_Property_Scale (Source = M:\GIS\Projects\ArcMap\Environmental Info\ Land Use 2015 DeanP\Land Use Reviewed\Final)

Feature Dataset: Southland_Land_Use_Base_April_2015_Property_Scale

Appendix 4a: Modification of existing data sources

Topography (Slope)

LRI_Southland

M:\ GIS\ Data\ LRI\ LRI_Southland

LRI_Southland

Project

(Input = LRI_Southland, coordinate system = GD_1949_New_Zealand_Map_Grid; Output = LRI_NZTM, coordinate system = NZGD_2000_New_Zealand_Transverse_Mercator)

LRI_NZTM

Add new field

Slope_Name = TEXT

Select by attributes

SLOPE IN ('A', 'A'', 'A +B', 'A +C', 'A +D', 'A +E', 'A /B', 'B', 'B'', 'B'' +A', 'B'' +C', 'B +A', 'B +C', 'B +D', 'B +D /E' , 'B +E' , 'B +F' , 'B +G')

Field Calculator

Slope_Name = “Flat”

Select by attributes

SLOPE IN ('B /C', 'B /C +E', 'C', 'C'', 'C'' +B', 'C'' +E', 'C +A', 'C +B', 'C +D', 'C +E', 'C +F', 'C +G')

Field Calculator

Slope_Name = “Rolling”

Select by attributes

SLOPE IN ('C /D', 'C +D /E', 'C /D +F', 'D', 'D +B', 'D +C', 'D +E', 'D +F', 'D +G', 'D /E', 'D /E +C', 'E', 'E +B', 'E +C', 'E +D', 'E +F', 'E +G')

Field Calculator

Slope_Name = “Easy Hill”

Select by attributes

SLOPE IN ('E /F', 'F', 'F +B', 'F +C', 'F +D', 'F +E', 'F +G', 'F /G', 'G', 'G +C', 'G +D', 'G +E', 'G +F')

Field Calculator

Slope_Name = “Steep”

Turn off all fields except [Slope_Name]

Climate (Rainfall)

OVERSEER_Rainfall

M:\ GIS\ Projects\ ArcMap\ Environmental Info\ Land Use 2015 DeanP\ Land Use Reviewed\ Technical\ OVERSEER_Rainfall.shp

Data, including raster images obtained through NIWA at the request of NIWA and OVERSEER

New - Shapefile

Name = OVERSEER_Rainfall

Feature Type = Polygon

Edit - Create Features
Polygon

Trace
Rain_SthIs.png

Climate (Altitude)

Southland_Bdy_NZTM
M:\ GIS\ Data\ Political
sdemMOS13
M:\ GIS\ Data\ Imagery\ NIWA DEM 2014\ southland_DEMv3.gdb\ southland_DEMv3.gdb
Contour (spatial analyst)
sdemMOS13
Contour interval = 100 metres
Base contour = 0
Z factor = 1
600mline
Select by attributes
CONTOUR = 600
Clip
Southland_Bdy_NZTM
Southland_600mline
Edit
Select All
Merge
Stop Editing
Southland_600mline

Southland_Bdy_NZTM
Export
Elevation600m
M:\ GIS\ Projects\ ArcMap\ Environmental Info\ Land Use 2015 DeanP\ Land Use Reviewed\ Technical
Southland_600mline
Edit
Split Polygons
Target = Elevation600m
Cluster Tolerance = 0.001 Metres
Save Edits
Add Field
Elevation = TEXT (String)
Manual Selection – those polygons below 600 metre mark
Field Calculator
Elevation = “Below 600m”
Manual Selection – those polygons above 600 metre mark
Field Calculator
Elevation = “Above 600m”
Save Edits – Stop Editing
Southland NZTM
Dissolve
Dissolve_Fields: Name; Elevation
Elevation600m

Soil Drainage

FINAL_Soils
M:\ GIS\ Projects\ ArcMap\ Environmental Info\ Land Use 2015 DeanP\ Matt Land Use\ FMU_Landuse_Soils\ FINAL_Soils.shp

Turn off all fields except [Drainage_C]

LCDB v.4.1

LCDB v4.1
M:\ GIS\ Projects\ ArcMap\ Environmental Info\ Land Use 2015 DeanP\ Land Use Reviewed\ April 2015\ LCDBv4.1.shp

Turn off all fields except [Name_2012] and [LCDB_Code]

Winter Forage Information

This was included in the property scale shapefile as the winter forage map was created. Refer to winter forage assessment for specific methodology (Pearson and Couldrey, 2016). Yet exact spatial location was required to display the blocks of winter forage crops necessary for nutrient loss calculations.

Winter_Forage_Areas
M:\GIS\Projects\ArcMap\Environmental Info\Land Use 2015 DeanP\MattLandUse\Winter Grazing\Winter Forage Areas

Turn off all fields

Physiographic Units

Physiographic Units
M:\GIS\Projects\ArcMap\Planning\Physiographic Zones.lyr

Turn off all fields except [PhysiographicUnit] (Name*) and [Variant]

Freshwater Management Units

Freshwater Management Units
M:\GIS\Projects\ArcMap\Planning\Freshwater Management Unit

Turn off all fields except (Name)

Appendix 4b: Combining modified data sources

Southland_Land_Use_Base_April_2015_Property_Scale
LRI_NZTM
OVERSEER_Rainfall
FINAL_Soils
LCDB v4.1
Winter_Forage_Areas
Physiographic Zones
Freshwater Management Units
Add Geodatabase
M:\GIS\Projects\ArcMap\Environmental Info\Land Use 2015 DeanP\Land Use Reviewed\Technical\LRI Technical.gdb
Make Default Geodatabase

Union
LRI_NZTM
OVERSEER_Rainfall

LRI_Rain

Union
LRI_Rain
FINAL_Soils

LRI_Rain_Drain

Union
LRI_Rain_Drain

LCDB v4.1

LRIRainDrainLCDB

Union

LRIRainDrainLCDB

Winter Forage Areas

LRIRainDrainLCDBWF

Union

LRIRainDrainLCDBWF

Freshwater Management Units

LRIRainDrainLCDBWF_FMU

Add field

Forage = TEXT

Select by attributes

NOT FID_Fianl_Forage_MERGE = -1

Field Calculator

Forage = “Yes”

Select by attributes

FID_Fianl_Forage_MERGE = -1

Field Calculator

Forage = “No”

Union

LRIRainDrainLCDBWF_FMU

Physiographic Zones

LRIRainDrainLCDBWF_FMUPhizz

Union

LRIRainDrainLCDBWF_FMUPhizz

Southland_Land_Use_Base_April_2015_Property_Scale

LU_Technical

Clip

LU_Technical

Regional_Boundary_NZTM

LU_Technical_Clip

Dissolve

Input = LU_Technical_Clip

Output = LU_Technical_Dissolve

Dissolve_Field(s)

FID_Southland_Land_Use_Base_April_2015_Property_Scale; Source; Land_Use_C; Useable_ha; Forage_ha; Percentage; Class; Slope_Name; Drainage_C; Variant; Name; Name_2012; LCDB_Code; Rainfall_Class; Forage, FMU_Name

LU_Technical_Dissolve

Add field

Hectare = DOUBLE

Calculate Geometry

Hectare

Property = Area

Coordinate System = use coordinate system of the data source (NZGD 2000 New Zealand Transverse Mercator)

Units = Hectares [ha]

Appendix 5: Historical Land Use Mapping 1996-2015

Default Geodatabase
M:\ GIS\ Projects\ ArcMap\ Environmental Info\ Land Use 2015 DeanP\ Land Use Reviewed\ Technical\ Historic2.gdb

The Historic Land Use maps area a union between the Land Cover Data Base classification for that particular time period, the Conservation Estate/QEII covenants, and the consented Dairy platform extents from a specific year. Different field were created for the 20 year time periods from 1996 – 2015.

Appendix 5a: Modification and combination of data sources

Southland_Land_Use_Base_April_2015
M:\ GIS\ Projects\ ArcMap\ Environmental Info\ Land Use 2015 DeanP\ Land Use Reviewed\ Final
Definition Query
"Land_Use_C" IN ('Dairy', 'Dairy Sheep') AND NOT "IRIS_ID" = ' '
Turn all fields off except “DairyYear” and “Land_Use_C”
LCDBv41
M:\ GIS\ Projects\ ArcMap\ Environmental Info\ Land Use 2015 DeanP\ Land Use Reviewed\ April 2015\ Method Files.gdb
Turn all fields off except “Class_1996”; “Class_2001”; “Class_2008”; “Class_2012” and “Name_1996”; “Name_2001”; “Name_2008”; “Name_2012”
Union
Southland_Land_Use_Base_April_2015
LCDBv41
a_Base

LRI_NZTM
M:\ GIS\ Projects\ ArcMap\ Environmental Info\ Land Use 2015 DeanP\ MattLandUse
Turn all fields off except “LUC”; “SLOPE”; “LUC_Class” and “Slope_Name”
Union
a_Base
LRI_NZTM
b_Base_LRI

Technical_NonAg
M:\ GIS\ Projects\ ArcMap\ Environmental Info\ Land Use 2015 DeanP\ Land Use Reviewed\ Technical\ Historic2.gdb
Turn all fields off except “Land_Use_C”
Union
b_Base_LRI
Technical_NonAg
c_Base_NonAg

QEII_CovPolyWeb_28_05_2015_Clip
M:\ GIS\ Projects\ ArcMap\ Environmental Info\ Land Use 2015 DeanP\ Land Use Reviewed\ April 2015\ Method Files.gdb
Turn all fields off except “DateRegd”
Add Field
QEII_Year = Short
Field Calculator
QEII_Year = Right ([DateRegd], 4) – repeats final 4 digits of the ‘DateRegd’ date field from the right hand side so “26/09/2000” = “2000”
Union
c_Base_NonAg
QEII_CovPolyWeb_28_05_2015_Clip
d_Base_QEII

doc-public-conservation-areas
M:\ GIS\ Projects\ ArcMap\ Environmental Info\ Land Use 2015 DeanP\ Land Use Reviewed\ April 2015\ doc-public-conservation-areas
Turn all fields off except “Start_Date” and “Name”
Add Field
Con_Year = Short

Field Calculator
Con_Year = Right ([Start_Date], 4) – repeats final 4 digits of the 'Start_Date' date field from the right hand side so "26/09/2000" = "2000"
Union
d_Base_QEII
doc-public-conservation-areas
eBase_DOC_1 – temporary file (delete when clipped)
Clip
eBase_DOC
Southland_Bdy_NZTM
eBase_DOC

Elevation600m
M:\ GIS\ Projects\ ArcMap\ Environmental Info\ Land Use 2015 DeanP\ Land Use Reviewed\ Technical
Simplify Polygon
Simplification Algorithm = BEND_SIMPLIFY
Simplification Tolerance
Reference Baseline = 50 metres
Minimum Area = 0 square metres
Handling Topographical Errors = NO_CHECK
Elevation_Simple
M:\ GIS\ Projects\ ArcMap\ Environmental Info\ Land Use 2015 DeanP\ Land Use Reviewed\ Technical\ Historic2.gdb
Union
e_Base_DOC
Elevation_Simple
fBase_Elevation
Export
Historic_ NEW

Historic_ NEW
Add Field
LU_1996 … LU_2015 = TEXT
Select by attributes
Land_Use_C IN ('Public Use', 'Recreation and Tourism', 'Lakes and Rivers', 'Road and Rail', 'Industry and Airports')
Field Calculator
"LU_1996" … "LU_2015" = [Land_Use_C]

Appendix 5b: Addition of primary land use classifications

Dairy

Select by attributes
DairyYear <= 1996 AND Land_Use_C = 'Dairy'
Field Calculator
LU_1996 = "Dairy"
… 2015

Dairy Sheep

Select by attributes
DairyYear <= 1996 AND Land_Use_C = 'Dairy Sheep'
Field Calculator
LU_1996 = "Dairy"
… 2015

Wetland

Select by attributes
LU_1996 IN (NULL, 'Dairy', 'Dairy Sheep') AND Name_1996 = 'Herbaceous Freshwater Vegetation'
Field Calculator
LU_1996 = "Wetland"
… 2000

Select by attributes
LU_2001 IN (NULL, 'Dairy', 'Dairy Sheep') AND Name_2001 = 'Herbaceous Freshwater Vegetation'
Field Calculator
LU_2001 = “Wetland”
… 2007
Select by attributes
LU_2008 IN (NULL, 'Dairy', 'Dairy Sheep') AND Name_2008 = 'Herbaceous Freshwater Vegetation'
Field Calculator
LU_2008 = “Wetland”
… 2011
Select by attributes
LU_2012 IN (NULL, 'Dairy', 'Dairy Sheep') AND Name_2012 = 'Herbaceous Freshwater Vegetation'
Field Calculator
LU_2012 = “Wetland”
… 2015

Bare Ground, Sand, Gravel, or Snow

Select by attributes
LU_1996 IN (NULL, 'Dairy', 'Dairy Sheep') AND Name_1996 IN ('Sand or Gravel', 'Landslide', 'Gravel or Rock', 'Permanent Snow and Ice')
Field Calculator
LU_1996 = “Bare Ground, Sand, Gravel, or Snow”
… 2000
Select by attributes
LU_2001 IN (NULL, 'Dairy', 'Dairy Sheep') AND Name_2001 IN ('Sand or Gravel', 'Landslide', 'Gravel or Rock', 'Permanent Snow and Ice')
Field Calculator
LU_2001 = “Bare Ground, Sand, Gravel, or Snow”
… 2007
Select by attributes
LU_2008 IN (NULL, 'Dairy', 'Dairy Sheep') AND Name_2008 IN ('Sand or Gravel', 'Landslide', 'Gravel or Rock', 'Permanent Snow and Ice')
Field Calculator
LU_2008 = “Bare Ground, Sand, Gravel, or Snow”
… 2011
Select by attributes
LU_2012 IN (NULL, 'Dairy', 'Dairy Sheep') AND Name_2012 IN ('Sand or Gravel', 'Landslide', 'Gravel or Rock', 'Permanent Snow and Ice')
Field Calculator
LU_2012 = “Bare Ground, Sand, Gravel, or Snow”
… 2015

Exotic Forest

Select by attributes
LU_1996 IN (NULL, 'Dairy', 'Dairy Sheep') AND Name_1996 IN ('Forest - Harvested', 'Deciduous Hardwoods', 'Exotic Forest')
Field Calculator
LU_1996 = “Exotic Forest”
… 2000
Select by attributes
LU_2001 IN (NULL, 'Dairy', 'Dairy Sheep') AND Name_2001 IN ('Forest - Harvested', 'Deciduous Hardwoods', 'Exotic Forest')
Field Calculator
LU_2001 = “Exotic Forest”
… 2007
Select by attributes
LU_2008 IN (NULL, 'Dairy', 'Dairy Sheep') AND Name_2008 IN ('Forest - Harvested', 'Deciduous Hardwoods', 'Exotic Forest')
Field Calculator
LU_2008 = “Exotic Forest”
… 2011
Select by attributes

LU_2012 IN (NULL, 'Dairy', 'Dairy Sheep') AND Name_2012 IN ('Forest - Harvested', 'Deciduous Hardwoods', 'Exotic Forest')
Field Calculator
LU_2012 = “Exotic Forest”
… 2015

Indigenous Forest

Select by attributes
LU_1996 IN (NULL, 'Dairy', 'Dairy Sheep') AND Name_1996 = 'Indigenous Forest'
Field Calculator
LU_1996 = “Indigenous Forest”
… 2000
Select by attributes
LU_2001 IN (NULL, 'Dairy', 'Dairy Sheep') AND Name_2001 = 'Indigenous Forest'
Field Calculator
LU_2001 = “Indigenous Forest”
… 2007
Select by attributes
LU_2008 IN (NULL, 'Dairy', 'Dairy Sheep') AND Name_2008 = 'Indigenous Forest'
Field Calculator
LU_2008 = “Indigenous Forest”
… 2011
Select by attributes
LU_2012 IN (NULL, 'Dairy', 'Dairy Sheep') AND Name_2012 = 'Indigenous Forest'
Field Calculator
LU_2012 = “Indigenous Forest”
… 2015

Indigenous Scrub

Select by attributes
LU_1996 IN (NULL, 'Dairy', 'Dairy Sheep') AND Name_1996 IN ('Flaxland', 'Fernland', 'Manuka and/or Kanuka', 'Broadleaved Indigenous Hardwoods', 'Sub Alpine Shrubland', 'Matagouri or Grey Scrub')
Field Calculator
LU_1996 = “Indigenous Scrub”
… 2000
Select by attributes
LU_2012 IN (NULL, 'Dairy', 'Dairy Sheep') AND Name_2012 IN ('Flaxland', 'Fernland', 'Manuka and/or Kanuka', 'Broadleaved Indigenous Hardwoods', 'Sub Alpine Shrubland', 'Matagouri or Grey Scrub')
Field Calculator
LU_2001 = “Indigenous Scrub”
… 2007
Select by attributes
LU_2012 IN (NULL, 'Dairy', 'Dairy Sheep') AND Name_2012 IN ('Flaxland', 'Fernland', 'Manuka and/or Kanuka', 'Broadleaved Indigenous Hardwoods', 'Sub Alpine Shrubland', 'Matagouri or Grey Scrub')
Field Calculator
LU_2008 = “Indigenous Scrub”
… 2011
Select by attributes
LU_2012 IN (NULL, 'Dairy', 'Dairy Sheep') AND Name_2012 IN ('Flaxland', 'Fernland', 'Manuka and/or Kanuka', 'Broadleaved Indigenous Hardwoods', 'Sub Alpine Shrubland', 'Matagouri or Grey Scrub')
Field Calculator
LU_2012 = “Indigenous Scrub”
… 2015

Arable

Select by attributes
LU_1996 IS NULL AND Name_1996 = 'Short-rotation Cropland'
Field Calculator
LU_1996 = “Arable”
… 2000
Select by attributes
LU_2001 IS NULL AND Name_2001 = 'Short-rotation Cropland'

Field Calculator
LU_2001 = “Arable”

… 2007

Select by attributes
LU_2008 IS NULL AND Name_2008 = 'Short-rotation Cropland'
Field Calculator
LU_2008 = “Arable”

… 2011

Select by attributes
LU_2012 IS NULL AND Name_2012 = 'Short-rotation Cropland'
Field Calculator
LU_2012 = “Arable”

… 2015

High Country Extensive Pasture

Select by attributes
LU_1996 IS NULL AND Name_1996 IN ('Depleted Grassland', 'Low Producing Grassland', 'Gorse and/or Broom', 'Mixed Exotic Shrubland') AND Elevation = 'Above 600m'
Field Calculator
LU_1996 = “High Country Extensive Pasture”

… 2000

Select by attributes
LU_2001 IS NULL AND Name_2001 IN ('Depleted Grassland', 'Low Producing Grassland', 'Gorse and/or Broom', 'Mixed Exotic Shrubland') AND Elevation = 'Above 600m'
Field Calculator
LU_2001 = “High Country Extensive Pasture”

… 2007

Select by attributes
LU_2008 IS NULL AND Name_2008 IN ('Depleted Grassland', 'Low Producing Grassland', 'Gorse and/or Broom', 'Mixed Exotic Shrubland') AND Elevation = 'Above 600m'
Field Calculator
LU_2008 = “High Country Extensive Pasture”

… 2011

Select by attributes
LU_2012 IS NULL AND Name_2012 IN ('Depleted Grassland', 'Low Producing Grassland', 'Gorse and/or Broom', 'Mixed Exotic Shrubland') AND Elevation = 'Above 600m'
Field Calculator
LU_2012 = “High Country Extensive Pasture”

… 2015

High Country Intensive Pasture

Select by attributes
LU_1996 IS NULL AND Name_1996 = 'High Producing Exotic Grassland' AND Elevation = 'Above 600m'
Field Calculator
LU_1996 = “High Country Intensive Pasture”

… 2000

Select by attributes
LU_2001 IS NULL AND Name_2001 = 'High Producing Exotic Grassland' AND Elevation = 'Above 600m'
Field Calculator
LU_2001 = “High Country Intensive Pasture”

… 2007

Select by attributes
LU_2008 IS NULL AND Name_2008 = 'High Producing Exotic Grassland' AND Elevation = 'Above 600m'
Field Calculator
LU_2008 = “High Country Intensive Pasture”

… 2011

Select by attributes
LU_2012 IS NULL AND Name_2012 = 'High Producing Exotic Grassland' AND Elevation = 'Above 600m'
Field Calculator
LU_2012 = “High Country Intensive Pasture”

… 2015

High Country Tussock

Select by attributes

LU_1996 IS NULL AND Name_1996 IN ('Alpine Grass/Herbfield', 'Tall Tussock Grassland') AND Elevation = 'Above 600m'

Field Calculator

LU_1996 = “High Country Tussock”

… 2000

Select by attributes

LU_2001 IS NULL AND Name_2001 IN ('Alpine Grass/Herbfield', 'Tall Tussock Grassland') AND Elevation = 'Above 600m'

Field Calculator

LU_2001 = “High Country Tussock”

… 2007

Select by attributes

LU_2008 IS NULL AND Name_2008 IN ('Alpine Grass/Herbfield', 'Tall Tussock Grassland') AND Elevation = 'Above 600m'

Field Calculator

LU_2008 = “High Country Tussock”

… 2011

Select by attributes

LU_2012 IS NULL AND Name_2012 IN ('Alpine Grass/Herbfield', 'Tall Tussock Grassland') AND Elevation = 'Above 600m'

Field Calculator

LU_2012 = “High Country Tussock”

… 2015

Hill Country Extensive Pasture

Select by attributes

LU_1996 IS NULL AND Name_1996 IN ('Depleted Grassland', 'Low Producing Grassland', 'Gorse and/or Broom', 'Mixed Exotic Shrubland') AND Elevation = 'Below 600m' AND Slope_Name IN ('Easy Hill', 'Steep')

Field Calculator

LU_1996 = “Hill Country Extensive Pasture”

… 2000

Select by attributes

LU_2001 IS NULL AND Name_2001 IN ('Depleted Grassland', 'Low Producing Grassland', 'Gorse and/or Broom', 'Mixed Exotic Shrubland') AND Elevation = 'Below 600m' AND Slope_Name IN ('Easy Hill', 'Steep')

Field Calculator

LU_2001 = “Hill Country Extensive Pasture”

… 2007

Select by attributes

LU_2008 IS NULL AND Name_2008 IN ('Depleted Grassland', 'Low Producing Grassland', 'Gorse and/or Broom', 'Mixed Exotic Shrubland') AND Elevation = 'Below 600m' AND Slope_Name IN ('Easy Hill', 'Steep')

Field Calculator

LU_2008 = “Hill Country Extensive Pasture”

… 2011

Select by attributes

LU_2012 IS NULL AND Name_2012 IN ('Depleted Grassland', 'Low Producing Grassland', 'Gorse and/or Broom', 'Mixed Exotic Shrubland') AND Elevation = 'Below 600m' AND Slope_Name IN ('Easy Hill', 'Steep')

Field Calculator

LU_2012 = “Hill Country Extensive Pasture”

… 2015

Hill Country Intensive Pasture

Select by attributes

LU_1996 IS NULL AND Name_1996 = 'High Producing Exotic Grassland' AND Elevation = 'Below 600m' AND Slope_Name IN ('Easy Hill', 'Steep')

Field Calculator

LU_1996 = “Hill Country Intensive Pasture”

… 2000

Select by attributes

LU_2001 IS NULL AND Name_2001 = 'High Producing Exotic Grassland' AND Elevation = 'Below 600m' AND Slope_Name IN ('Easy Hill', 'Steep')

Field Calculator
LU_2001 = “Hill Country Intensive Pasture”

… 2007

Select by attributes
LU_2008 IS NULL AND Name_2008 = 'High Producing Exotic Grassland' AND Elevation = 'Below 600m' AND Slope_Name IN ('Easy Hill', 'Steep')
Field Calculator
LU_2008 = “Hill Country Intensive Pasture”

… 2011

Select by attributes
LU_2012 IS NULL AND Name_2012 = 'High Producing Exotic Grassland' AND Elevation = 'Below 600m' AND Slope_Name IN ('Easy Hill', 'Steep')
Field Calculator
LU_2012 = “Hill Country Intensive Pasture”

… 2015

Hill Country Tussock

Select by attributes
LU_1996 IS NULL AND Name_1996 IN ('Alpine Grass/Herbfield', 'Tall Tussock Grassland') AND Elevation = 'Below 600m' AND Slope_Name IN ('Easy Hill', 'Steep')
Field Calculator
LU_1996 = “Hill Country Tussock”

… 2000

Select by attributes
LU_2001 IS NULL AND Name_2001 IN ('Alpine Grass/Herbfield', 'Tall Tussock Grassland') AND Elevation = 'Below 600m' AND Slope_Name IN ('Easy Hill', 'Steep')
Field Calculator
LU_2001 = “Hill Country Tussock”

… 2007

Select by attributes
LU_2008 IS NULL AND Name_2008 IN ('Alpine Grass/Herbfield', 'Tall Tussock Grassland') AND Elevation = 'Below 600m' AND Slope_Name IN ('Easy Hill', 'Steep')
Field Calculator
LU_2008 = “Hill Country Tussock”

… 2011

Select by attributes
LU_2012 IS NULL AND Name_2012 IN ('Alpine Grass/Herbfield', 'Tall Tussock Grassland') AND Elevation = 'Below 600m' AND Slope_Name IN ('Easy Hill', 'Steep')
Field Calculator
LU_2012 = “Hill Country Tussock”

… 2015

Lowland Extensive Pasture

Select by attributes
LU_1996 IS NULL AND Name_1996 IN ('Depleted Grassland', 'Low Producing Grassland', 'Gorse and/or Broom', 'Mixed Exotic Shrubland') AND Elevation = 'Below 600m' AND Slope_Name IN ('Flat', 'Rolling')
Field Calculator
LU_1996 = “Lowland Extensive Pasture”

… 2000

Select by attributes
LU_2001 IS NULL AND Name_2001 IN ('Depleted Grassland', 'Low Producing Grassland', 'Gorse and/or Broom', 'Mixed Exotic Shrubland') AND Elevation = 'Below 600m' AND Slope_Name IN ('Flat', 'Rolling')
Field Calculator
LU_2001 = “Lowland Extensive Pasture”

… 2007

Select by attributes
LU_2008 IS NULL AND Name_2008 IN ('Depleted Grassland', 'Low Producing Grassland', 'Gorse and/or Broom', 'Mixed Exotic Shrubland') AND Elevation = 'Below 600m' AND Slope_Name IN ('Flat', 'Rolling')
Field Calculator
LU_2008 = “Lowland Extensive Pasture”

… 2011

Select by attributes
LU_2012 IS NULL AND Name_2012 IN ('Depleted Grassland', 'Low Producing Grassland', 'Gorse and/or Broom', 'Mixed Exotic Shrubland') AND Elevation = 'Below 600m' AND Slope_Name IN ('Flat', 'Rolling')
Field Calculator
LU_2012 = “Lowland Extensive Pasture”

… 2015

Lowland Intensive Pasture

Select by attributes
LU_1996 IS NULL AND Name_1996 = 'High Producing Exotic Grassland' AND Elevation = 'Below 600m' AND Slope_Name IN ('Flat', 'Rolling')
Field Calculator
LU_1996 = “Lowland Intensive Pasture”

… 2000

Select by attributes
LU_2001 IS NULL AND Name_2001 = 'High Producing Exotic Grassland' AND Elevation = 'Below 600m' AND Slope_Name IN ('Flat', 'Rolling')
Field Calculator
LU_2001 = “Lowland Intensive Pasture”

… 2007

Select by attributes
LU_2008 IS NULL AND Name_2008 = 'High Producing Exotic Grassland' AND Elevation = 'Below 600m' AND Slope_Name IN ('Flat', 'Rolling')
Field Calculator
LU_2008 = “Lowland Intensive Pasture”

… 2011

Select by attributes
LU_2012 IS NULL AND Name_2012 = 'High Producing Exotic Grassland' AND Elevation = 'Below 600m' AND Slope_Name IN ('Flat', 'Rolling')
Field Calculator
LU_2012 = “Lowland Intensive Pasture”

… 2015

Lowland Tussock

Select by attributes
LU_1996 IS NULL AND Name_1996 IN ('Alpine Grass/Herbfield', 'Tall Tussock Grassland') AND Elevation = 'Below 600m'
Field Calculator
LU_1996 = “Lowland Tussock”

… 2000

Select by attributes
LU_2001 IS NULL AND Name_2001 IN ('Alpine Grass/Herbfield', 'Tall Tussock Grassland') AND Elevation = 'Below 600m'
Field Calculator
LU_2001 = “Lowland Tussock”

… 2007

Select by attributes
LU_2008 IS NULL AND Name_2008 IN ('Alpine Grass/Herbfield', 'Tall Tussock Grassland') AND Elevation = 'Below 600m'
Field Calculator
LU_2008 = “Lowland Tussock”

… 2011

Select by attributes
LU_2012 IS NULL AND Name_2012 IN ('Alpine Grass/Herbfield', 'Tall Tussock Grassland') AND Elevation = 'Below 600m'
Field Calculator
LU_2012 = “Lowland Tussock”

… 2015

Residential and Commercial Use

Select by attributes
LU_1996 IS NULL AND Name_1996 IN ('Urban Parkland/Open Space', 'Built-up Area (settlement)')

Field Calculator
LU_1996 = “Residential and Commercial Use”
… 2000
Select by attributes
LU_2001 IS NULL AND Name_2001 IN ('Urban Parkland/Open Space', 'Built-up Area (settlement)')
Field Calculator
LU_2001 = “Residential and Commercial Use”
… 2007
Select by attributes
LU_2008 IS NULL AND Name_2008 IN ('Urban Parkland/Open Space', 'Built-up Area (settlement)')
Field Calculator
LU_2008 = “Residential and Commercial Use”
… 2011
Select by attributes
LU_2012 IS NULL AND Name_2012 IN ('Urban Parkland/Open Space', 'Built-up Area (settlement)')
Field Calculator
LU_2012 = “Residential and Commercial Use”
… 2015

Horticulture

Select by attributes
LU_1996 IS NULL AND Name_1996 = 'Orchard, Vineyard or Other Perennial Crop'
Field Calculator
LU_1996 = “Horticulture”
… 2000
Select by attributes
LU_2001 IS NULL AND Name_2001 = 'Orchard, Vineyard or Other Perennial Crop'
Field Calculator
LU_2001 = “Horticulture”
… 2007
Select by attributes
LU_2008 IS NULL AND Name_2008 = 'Orchard, Vineyard or Other Perennial Crop'
Field Calculator
LU_2008 = “Horticulture”
… 2011
Select by attributes
LU_2012 IS NULL AND Name_2012 ='Orchard, Vineyard or Other Perennial Crop'
Field Calculator
LU_2012 = “Horticulture”
… 2015

Surface Mine or Dump

Select by attributes
LU_1996 IS NULL AND Name_1996 = 'Surface Mine or Dump'
Field Calculator
LU_1996 = “Surface Mine or Dump”
… 2000
Select by attributes
LU_2001 IS NULL AND Name_2001 = 'Surface Mine or Dump'
Field Calculator
LU_2001 = “Surface Mine or Dump”
… 2007
Select by attributes
LU_2008 IS NULL AND Name_2008 = 'Surface Mine or Dump'
Field Calculator
LU_2008 = “Surface Mine or Dump”
… 2011
Select by attributes
LU_2012 IS NULL AND Name_2012 ='Surface Mine or Dump'
Field Calculator
LU_2012 = “Surface Mine or Dump”
… 2015

Appendix 5c: Reclassification of primary land use to secondary land use

Conservation - Bare Ground, Sand, Gravel, or Snow

Select by attributes

LU_1996 = 'Bare Ground, Sand, Gravel, or Snow' AND Con_Year <= 1996 AND NOT Con_Year IS NULL

Field Calculator

LU_1996 = ' Bare Ground, Sand, Gravel, or Snow - Conservation'

… 2015 – repeat for all Land Use years (ie. "LU_1996" – "LU_2015")

QEII - Bare Ground, Sand, Gravel, or Snow

Select by attributes

LU_1996 = 'Bare Ground, Sand, Gravel, or Snow' AND QEII_Year <= 1996 AND NOT QEII_Year = 0

Field Calculator

LU_1996 = ' Bare Ground, Sand, Gravel, or Snow - QEII'

… 2015

Conservation – Scrub and Tussock

Select by attributes

Name_1996 IN ('Alpine Grass/Herbfield', 'Tall Tussock Grassland','Flaxland', 'Fernland', 'Manuka and/or Kanuka', 'Broadleaved Indigenous Hardwoods', 'Sub Alpine Shrubland', 'Matagouri or Grey Scrub') AND Con_Year <=1996

Field Calculator

LU_1996 = 'Conservation – Scrub and Tussock'

… 2015

QEII – Scrub and Tussock

Select by attributes

Name_1996 IN ('Alpine Grass/Herbfield', 'Tall Tussock Grassland','Flaxland', 'Fernland', 'Manuka and/or Kanuka', 'Broadleaved Indigenous Hardwoods', 'Sub Alpine Shrubland', 'Matagouri or Grey Scrub') AND QEII_Year <=1996 AND NOT QEII_Year =0

Field Calculator

LU_1996 = 'QEII – Scrub and Tussock'

… 2015

Conservation – Indigenous Forest

Select by attributes

Name_1996 IN ('Indigenous Forest') AND Con_Year <=1996

Field Calculator

LU_1996 = 'Conservation – Indigenous Forest'

… 2015

QEII – Indigenous Forest

Select by attributes

Name_1996 IN ('Indigenous Forest') AND Con_Year <=1996

Field Calculator

LU_1996 = 'Conservation – Indigenous Forest'

… 2015

Conservation – Wetland

Select by attributes

LU_1996 = 'Wetland' AND Con_Year <= 1996 AND NOT Con_Year IS NULL

Field Calculator

LU_1996 = 'Conservation - Wetland'

… 2015

QEII – Wetland

Select by attributes

LU_1996 = 'Wetland' AND QEII_Year <= 1996 AND NOT QEII_Year = 0

Field Calculator

LU_1996 = 'QEII - Wetland'

… 2015

Conservation – Mixed Cover

Select by attributes

Con_Year <= 1996 AND NOT Con_Year IS NULL AND LU_2015 IS NULL

Field Calculator

LU_1996 = “Conservation – Mixed Cover”

… 2015

QEII – Mixed Cover

Select by attributes

QEII_Year <= 1996 AND NOT QEII_Year IS NULL AND LU_2015 IS NULL

Field Calculator

LU_1996 = “QEII – Mixed Cover”

… 2015

Historic_NEW

Dissolve

Dissolve_Fields: Name_1996; Name_2001; Name_2008; Name_2012; LU_1996; LU_1997; LU_1998; LU_1999; LU_2000; LU_2001; LU_2002; LU_2003; LU_2004; LU_2005; LU_2006; LU_2007; LU_2008; LU_2009; LU_2010; LU_2011; LU_2012; LU_2013; LU_2014; LU_2015; QEII_Year; Con_Year

Historic

Add Field

Hectare = DOUBLE

Calculate Geometry

Hectare = Units [ha]

Appendix 6: Pre-Maori Land Cover

Potential Natural Vegetation
M:\GIS\Projects\ArcMap\Environmental Info\Land Use 2015 DeanP\Land Use Reviewed\Historic Land Use\Data.gdb\PotentialVege

LENZ – Potential Natural Vegetation of New Zealand (https://lris.scinfo.org.nz/layer/289-potential-vegetation-of-new-zealand/?nc=&z=5&c=-40.65085651522624%2C173&mt=OpenStreetMap)

Physiographic Units
M:\GIS\Projects\ArcMap\Environmental Info\Physiographic Units\Physiographic Units 2016 Version.gdb

Appendix 6a: Modification of existing data sources

Output:
Clarkson Wetlands refined
M:\GIS\Projects\ArcMap\Environmental Info\Land Use 2015 DeanP\Land Use Reviewed\Historic Land Use\Clarkson_CSL.shp

Inputs:
Clarkson layer
M:\GIS\Data\Wetlands\Southland Wetlands Past and Present\Southland_wetlands_historic_v6.shp

FINAL_Soils
M:\ GIS\ Projects\ ArcMap\ Environmental Info\ Land Use 2015 DeanP\ Matt Land Use\ FMU_Landuse_Soils\ FINAL_Soils.shp

FINAL_Soils
Select by attributes
"Drainage_C" IN ('Very poorly drained', 'Poorly drained', 'Imperfectly drained')
Intersect
Southland_wetlands_historic_v6.shp
FINAL_Soils
Clarkson_CSL1 – temporary file (delete after use)

FINAL_Soils
Select by attributes
"Drainage_C" = 'Very poorly drained'
Union
FINAL_Soils
Clarkson_CSL1
Clarkson_CSL

Appendix 6b: Combining modified data sources

PotentialVege
Clip
PotentialVege
Regional_Boundary_ NZTM
PotentialVege_Southland
Add Field
ES_Code = TEXT
Land_Use_Class = TEXT
Source = TEXT
Union
PotentialVege_Southland
Physiographic Units
PreMaori_Phizz

Definition Query
ES_Code IS NULL

Select by attributes
PhysiographicUnit = 'Alpine' AND NOT Vege_type = 'unclassified'
Field Calculator
ES_Code = “ALPTUS”
Land_Use_Class = “Alpine Tussock”
Source = “PNV and PU”

Select by attributes
Vege_type ='Dunelands'
Field Calculator
ES_Code = “DUNE”
Land_Use_Class = “Dunelands”
Source = “PNV”

Select by attributes
Vege_type IN ('Scrub, tussock-grassland and herbfield above treeline', 'Scrub, shrubland and tussock-grassland below treeline') AND NOT PhysiographicUnit = 'Alpine' – remaining scrub not above the new treeline (Alpine)
Field Calculator
ES_Code = “SCRTUSS”
Land_Use_Class = “Scrub and Tussock grassland”
Source = “PNV and PU”

Select by attributes
Vege_type = 'unclassified'
Field Calculator
ES_Code = “BARE”
Land_Use_Class = “Bare ground, gravel or ice”
Source = “PNV”

Select by attributes
Vege_type = '' – Selects the all remaining polygons that were created in the Clip and the remaining unnamed Vegetype polygons i.e. the lakes and rivers
Field Calculator
ES_Code = “HYDRO”
Land_Use_Class = “Lakes and Rivers”
Source = “PNV”

Select by attributes
Select All – Selects the remaining polygons that were in place before Clip i.e. the remaining forest and the wetlands (which will be replaced with a more accurate layer (Clarkson_CSL))
Field Calculator
ES_Code = “NAT”
Land_Use_Class = “Indigenous Forest“
Source = “PNV”

Remove Definition Query

PreMaori_Phizz
Union
PreMaori_Phizz
Clarkson_CSL
PreMaori

Select by attributes
NOT FID.PreMaori = -1 OR PhysiographicUnit = 'Peat Wetlands' – selects all the polygons identified by the Clarkson_CSL Layer
Field Calculator
ES_Code = “WET”

Land_Use_Class = “Wetland”
Source = “Clarkson/CSL”

PreMaori
Dissolve
Dissolve_Fields: Vege_type; ES_Code; Land_Use_Class; Source; PhysiographicUnit
PreMaori_DISS
Add field
Hectare = DOUBLE
Calculate Geometry
Hectare = Units [ha]

Appendix 7: Land Use Map Display Colours

Property Land Use Map

Category	ArcGIS Colour	RGB
Conservation	Fir green	38, 115, 0
Recreation and Tourism	Sage dust	180, 215, 158
Plantation Forestry	Leaf green	56, 168, 0
Indigenous Forestry	Fir green with leaf green dots	38, 115, 0 and 56, 168, 0
Beef	Tuscan red	168, 0, 0
Sheep	Fire red	225, 85, 0
Specialist Deer	Solar yellow	255, 255, 0
Sheep and Beef	Mango	255, 211, 127
Mixed Livestock (sheep, beef, deer)	Electron gold	255, 170, 0
Majority Deer with Mixed Livestock	Solar yellow with electron gold hatch	255, 255, 0 and 255, 170, 0
Other Animals	Mars red	255, 0, 0
Dairy	Ultramarine	76, 0, 115
Dairy Sheep	Cattleya orchid	168, 0, 132
Livestock Support	Tourmaline green	0, 225, 197
Dairy Support	Anemone violet	169, 0, 240
Dairy Support and Other Livestock	Anemone violet with electron gold hatch	169, 0, 240
Arable	Ginger pink	255, 0, 197
Mixed Livestock and Arable	Electron gold and ginger pink hatch	255, 170, 0 and 255, 0, 197
Horticulture	Heliotrope	224, 115, 255
Flower and Bulb Growers	Rhodolite rose	255, 190, 242
Nurseries and Orchards	Raw umber	168, 112, 0
Small land holding	Cretan blue	0, 12, 255
Lifestyle	Yogo blue	115, 178, 255
Industry and Airports	Grey 70%	104, 104, 104
Commercial Use	Grey 50%	130, 130, 130
Residential Use	Grey 30%	178, 178, 178
Public Use	Pacific blue	102, 119, 205
Unknown Land Use - Pastoral	Indicolite green	190, 255, 242
Unknown Land Use - Indigenous Forest	Spruce green	76, 115, 0
Unknown Land Use - Non-agricultural	Yucca yellow	255, 255, 190
Lakes and Rivers	Apatite blue	115, 224, 255
Road and Rail	Grey 10%	225, 225, 225

Land Cover (LCDB v4.1)

Category	ArcGIS Colour	RGB
Indigenous Forest	Spruce green	76, 115, 0
Exotic Forest	Leaf green	56, 168, 0
Native Scrub and Shrubland	Moss green	114, 137, 68
Exotic Scrub and Shrubland	Dark olivenite	115, 115, 0
Alpine Grass and Tall Tussock	Lime dust	215,215, 158
Bare Ground	Yucca yellow	225, 225, 190
Permanent Snow and Ice	Sodalite blue	190, 232, 255
Wetlands	Turquoise dust with green hatch	158, 215, 194 and 109, 187, 67
Surface Mines and Dumps	Dark navy	0, 38, 115

Historic Land Use 1996-2015

Category	ArcGIS Colour	RGB
Conservation – Bare Ground, Sand, Gravel, or Snow*	Olivine Yellow	233, 255, 190
Conservation – Scrub and Tussock*	Lime dust	215,215, 158
Conservation – Indigenous Forest*	Fir green	38, 115, 0
Conservation – Mixed Cover*	Tarragon green	112, 168, 0
Conservation – Wetland*	Turquoise dust with green hatch	158, 215, 194 and 109, 187, 67
Recreation and Tourism	Sage dust	180, 215, 158
Bare Ground, Sand, Gravel, or Snow	Yucca yellow	225, 225, 190
Indigenous Forest	Moss green	114, 137, 68
Indigenous Scrub	Dark brown	105, 98, 63
Exotic Forest	Leaf green	56, 168, 0
High Country Drystock**	Seville orange	230, 152, 0
Hill Country Drystock**	(intermediate gradient between Seville orange and Sahara Sand)	255, 201, 102
Lowland Drystock**	Sahara Sand	255, 235, 190
Dairy	Ultramarine	76, 0, 115
Dairy Sheep	Cattleya orchid	168, 0, 132
Arable	Ginger pink	255, 0, 197
Horticulture	Heliotrope	224, 115, 255
Industry and Airports	Grey 70%	104, 104, 104
Residential and Commercial Use	Grey 30%	178, 178, 178
Public Use	Pacific blue	102, 119, 205
Lakes and Rivers	Apatite blue	115, 224, 255
Road and Rail	Grey 10%	225, 225, 225
Wetland	Turquoise dust with green hatch	158, 215, 194 and 109, 187, 67
Surface Mine or Dump	Dark navy	0, 38, 115

*Conservation is a grouping of DOC estate and QEII covenant areas.

**High Country, Hill Country, and Lowland Drystock are a grouping of respective Intensive/Extensive Pasture, and Tussock classifications.

Pre-Maori Land Use (c. 1000 AD)

Category	ArcGIS Colour	RGB
Bare ground, gravel or ice	Grey 10%	225, 225, 255
Alpine Tussock	Light brown	184, 171, 106
Scrub and Tussock grassland	Medium brown	112, 112, 43
Indigenous Forest	Fir green	38, 115, 0
Dunelands	Medium yellow	245, 245, 122
Lakes and Rivers	Apatite blue	115, 224, 255
Wetlands	Turquoise dust with green hatch	158, 215, 194 and 109, 187, 67