



# **Land Use Change in the Southland region**

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## **Technical Report**

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# 1 Executive Summary

A comprehensive investigation and review of land use changes in the Southland region was initiated as part of Environment Southland's Land and Soil State of the Environment (SOE) reporting obligations. The knowledge gained will assist Council in understanding the extent and magnitude of land use changes and intensification, enabling better resource management decisions to take place.

The purpose of the report is to investigate land use change and intensification across the Southland region, with a focus on change within the agricultural and forestry sectors, particularly since 1995, to meet SOE reporting timeframes.

Since the arrival of the first humans in Southland, the region has undergone extensive land cover and land use changes. Indigenous-dominated vegetation communities have declined by 37% regionally and by over 50% across lowland parts of the region as a result of extensive Polynesian burning and subsequent agricultural expansion and associated land clearance. Indigenous plant communities have declined rapidly to the extent that only 0.3% of communities considered “threatened” by the Land Environment NZ classification system are under legal protection within the Southland lowlands. Sixty eight percent of acutely threatened communities reside on private land with less than 8% under legal protection, while 90% of the region’s wetlands have been lost since 1850.

Land cover dominated by pasture and forestry has expanded to occupy over 43% of mainland Southland’s land area and occupies 69% of private land. Most of this expansion took place from the late 19<sup>th</sup> century through to the late 20<sup>th</sup> century. Since 1985, agricultural expansion into undeveloped areas has largely stopped, however transitions in land use are still occurring with the expansion of dairy land into previously sheep and beef pastoral and arable land. This has been the single biggest and ongoing land use change over the past 20 years.

Sheep farming dominated the rural landscape of Southland during the 20<sup>th</sup> century to reach a peak in 1984 of over 9 million sheep. Deregulation of the agricultural sector coupled with strengthening dairy returns and low land prices saw dairying increase from 23,000 hectares in 1992 to 196,000 hectares in 2011. Correspondingly, dairy cow numbers increased from 46,656 in 1990 to 614,648 in 2011. This expansion has led to sheep numbers falling to 4,113,000 in 2011, a level not seen in Southland since the 1950s.

Total stock units in Southland have remained largely stable since the early 1980s at around 9 million stock units. 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 increased stock units) has ceased.

The pressures from these land use changes on the environment can be severe. The large scale loss of indigenous vegetation across the region has accelerated erosion processes, reduced biodiversity and led to the increased sedimentation of the region’s water bodies. The recent shift to high nutrient loss, intensive land uses such as dairying and winter cropping has increased pressures on the region’s soil, water and air resources to the extent that we are seeing significant declines in soil and water quality across the region. However, this cannot solely be attributable to the expansion in dairying. The pan-agricultural sector intensification and expansion of intensive pastoralism into parts of the landscape previously considered unsuitable for intensive agriculture, due to productive or development expense limitations, is also placing further stress on these resources.

Recent land use changes have largely been driven by economic reasons and this is likely to continue to be a driver. The resultant effects from these changes are having adverse impacts on the environment, highlighting the need for any future changes in land use and intensification to be carefully managed to protect Southland's soil, water, air and biodiversity resources for future generations to utilise and enjoy.



## 2 Introduction

### 2.1 Background

Under Section 35(2) (a) of the Resource Management Act 1991, local authorities must monitor the “state of the whole or any part of the environment of its region or district to the extent that is appropriate to enable the local authority to effectively carry out its functions under this Act”. However, while the Act requires councils to undertake SOE monitoring, the nature and scope of SOE reporting is not specified. The Act also requires councils to monitor and report on policy and plan effectiveness every five years and this process is generally informed by SOE reporting.

While regional-level SOE reporting is not a legislative requirement, most councils produce a comprehensive state of the environment report for their district or region every few years (MfE, 2007). This report is required to contribute technical information to the Land Use SOE report. The aim of the Land Use SOE report is to review the current state and trend in land use and land management practices (pressures) and the current state of the Southland region’s soil, water and air resources. Understanding current states and trends in land use in Southland enables the Council and public to understand the extent and speed of land use change and provides 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 identify future monitoring needs.

Previous SOE reporting by Environment Southland (ES) has been limited to Southland Water SOE reports (ES 2000 & 2010) and the State of Southland's Coastal Marine Environment report in 2005. The Southland Water 2010 SOE report quantified the state and trends of Southland’s fresh water resources and highlighted declines in fresh water quality in Southland’s lowland water bodies. One of the knowledge gaps identified within this report was the lack of information surrounding land use extent and changes in land use and their effects on water quality.

In part, this technical report is a response to this knowledge gap and will enable Council to be better-informed on changes in land use and intensification. However, this report does not attempt to quantify the potential effects of these changes on water quality, which will be the focus of future reports. In addition, two other Land Use SOE technical reports focussing on land management changes, soil quality and soil stability will complement this report, to provide a comprehensive picture of land use changes and impacts for the Southland region.

### 2.2 Objectives

The terms of reference for this report were to review the current extent (or “state”) and historical change (or “trends”) in land use across the Southland region, including land use intensification.

The specific objectives of this report are to review:

- *State:* Describe the current state of land use and farming intensity across the Southland region.
- *Trend:* Quantify land use changes and changes in farming intensification that have occurred across the Southland region as accurately as possible, with a particular focus on the last 10-15 years.
- *Transition:* Discuss the timing of significant land use changes which are likely to influence changes in water quality.
- *Information and methodology:* Assess land use data quality, quantity and availability in order to make future reporting and analysis easier and consistent.

### **2.2.1 Focus**

This report reviews and quantifies the major land use changes the Southland region has experienced since human arrival, and the current state of land use in the region. The report focuses on changes in the extent and intensity of agricultural farming systems, exotic forestry and indigenous vegetation, with particular emphasis on changes between 1995 and 2011. This is to meet SOE reporting timeframes but also, in part, to provide better resolution to the recent rapid changes these sectors have undergone during this period.

The report intends to establish a baseline of data which future changes in land use and intensity can be compared against. The report also reviews the quality of the datasets utilised and highlights datasets recommended for use in future reporting. Data deficient land use changes and practices of significance are also highlighted.

Finally, the report briefly highlights the potential environmental effects of each land use activity, particularly the activities' effects on water quality and/or biodiversity.

### **2.2.2 Out of Scope**

This report is not intended to be an exhaustive review of all land use changes in the Southland region. There are a number of land uses and changes that have a minimal impact on the environment (water quality, soil quality, air quality or biodiversity) or are minor in their spatial extent across Southland. The choice to use these datasets has to be rationalised against their impact on the environment and the quality of the data available. Consequently, minor land use changes or activities, unless significant in their potential environmental impact on soil or water quality, are not included in the scope of this report. In particular, this report does not cover:

- quantifying the change in land use production across Southland except where it may indicate a change in land use intensity such as stock units or milk solids production per hectare;
- changes in land management practices such as wintering activities (e.g. barn vs wintering pad);
- attempts to quantify minor rural land uses such as specialist livestock farms or mining/gravel extraction;
- an in-depth investigation into the impacts of various land uses, or land use intensity on the environment, in particular water quality. Other reports such as the AgResearch report on land use impacts on water quality (Monaghan et al. 2010), and reports commissioned through the Council's regional focus activities e.g. wintering (Monaghan 2012.); hill country development (Ledgard and Hughes 2012) provide more detail on the impacts of land use activities on water quality;
- lifestyle block, peri-urban and urban land use changes;
- natural successional changes within indigenous dominated ecosystems.

## **2.3 Key Words**

Land Use; Intensification; Southland region; Land Use Change; Land Cover; State; Trend; Statistics; Hectares; Dairy; Cropping; Sheep; Beef; Deer; Indigenous Vegetation; Wetlands; Forestry.

## 2.4 List of abbreviations used

GIS	Geospatial Information System (spatial mapping and analysis software)
DairyNZ	Dairy New Zealand
DM	Dry matter
DOC	Department of Conservation
ES	Environment Southland (brand name of Southland Regional Council)
FAR	Foundation for Arable Research
LCDB	Land Cover Database (versions 1, 2 & 3)
LENZ	Land Environments New Zealand
LIC	Livestock Improvement Corporation
LUC	Land Use Capability Classification
MPI	Ministry for Primary Industries, formerly MAF (Ministry of Agriculture and Forestry)
NEFD	National Exotic Forest Description
NZLRI	New Zealand Land Resource Inventory
QVNZ	Quotable Valuations New Zealand
SU	Stock unit
SWC	Southern Wood Council
Statistics NZ	Statistics New Zealand
WONI	Wetlands of National Importance

## 2.5 Southland in a national context

### 2.5.1 Current overview

Southland is the southernmost region in New Zealand covering approximately 3,176,000 ha. It is the second largest region nationally, occupying 12.5% of New Zealand's total land area. The region extends from Awarua Point (Tasman Sea) on the West Coast to Brothers Point (Pacific Ocean) on the East Coast. Foveaux Strait forms mainland Southland's southern coastline, with Stewart Island, New Zealand's third largest island, lying to the south of Foveaux Strait, making up the remainder of the region. In all, 53% of the region is managed as public conservation land, most of which resides in the two national parks, Fiordland National Park and Rakiura National Park. By contrast, 76% of the remaining land (about 36% of the region) is occupied by pastoral land, with the region having 1,124,000 hectares of farmland, just under 8% of the national total.

Natural resources largely drive Southland's economy. The main industries are primary sector and export driven in the areas of agriculture, manufacturing and mining, with the region contributing just under 3% of New Zealand's Gross Domestic Product (Statistics NZ 2008). Despite this, tourism is a major contribution to the local and national economy and Southland provides many natural attractions to both domestic and international tourism with Fiordland National Park alone attracting over 440,000 tourists in 2008 (DOC 2008).

Southland's intact natural resources are a key asset and drive its productivity as a region. A strong and resilient environment has been important to the social and economic wellbeing of the Southland community. Many recreational activities in Southland such as swimming, fishing and seafood harvesting are reliant on clean and stable fresh and salt-water resources while the productivity and cleanliness of our agricultural and forestry practices

relies on good environmental stewardship and management. Southland's water quality has been declining in intensively farmed lowland catchments throughout the region. The trends show increasing deterioration in water quality in the region's lowland rivers, streams and estuaries (Environment Southland 2010). In a national context, Southland is similar to many other regions with some catchments remaining deteriorated and some improving while others in fair condition are trending towards poor condition (Ballantine et al. 2010). The deterioration observed in lowland pastoral catchments is being observed nationally (Ballantine et al. 2010) and in Southland this has implications for the sustainable management of land-based primary industries such as agriculture and forestry, which are dominant land uses in this region.

## **2.6 Southland's land resource**

### **2.6.1 Geology**

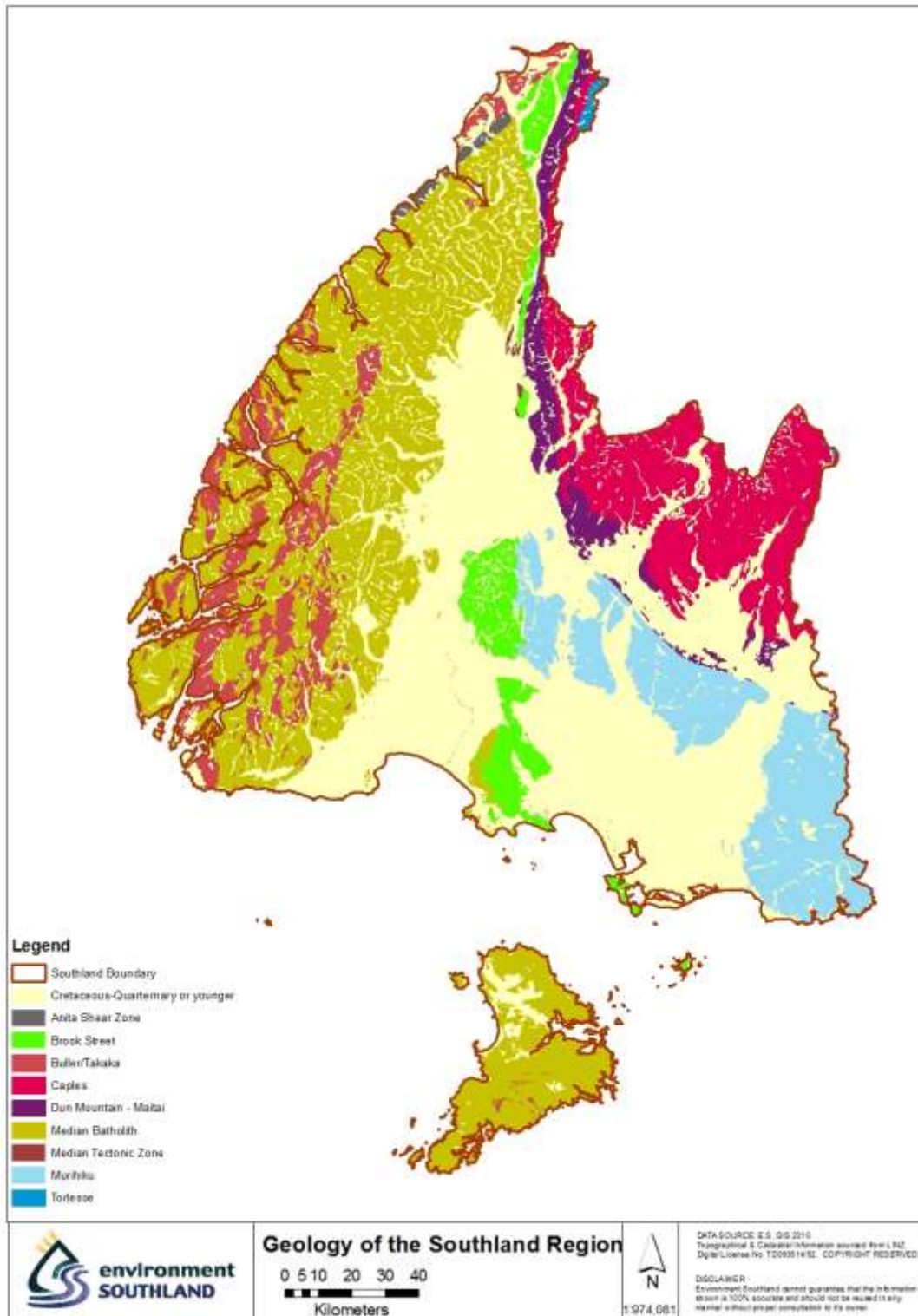
The Southland region is distinguished by its diverse geological landscapes. Several distinct physiographic regions are present throughout Southland, being controlled by underlying geology and influenced by quaternary erosion and late Cenozoic tectonics (**Figure 1**).

In the west of the region, the strike slip faults generated by the clash between the Pacific and Australian plates have given rise to the steep valleys and fiords of Fiordland. These valleys and fiords have been carved into plutonic rocks of the Median Batholith by the extensive and successive glacial events of the Quaternary period. Few of these glacial deposits are preserved, except in the western basins of the Te Anau and Waiau where moraines and outwash terraces cover Cenozoic rocks (Turnbull et al. 2010). These plutonic rocks of the Median Batholith extend below Fiordland to the south-east giving rise to the landscape of Stewart Island, which is much more benign in its topography due to the limited tectonic activity and uplift in comparison to the Fiordland region.

East of Fiordland are the inland basins and glacial outwash plains of northern Southland and the Southland Plains. The Livingstone, Eyre, Garvie and Umbrella mountain ranges border the north of the Southland region. These extensive mountain ranges, formed from the Caples Terrane, are dominated by low grade metamorphic rocks such as Hasst Schist. Immediately to the south, the volcanic and ultramafic rocks of the Dunn Mountain – Maitai Terrane lie underneath and to the sides of the Waimea Plains, which has subsequently been overlain by quaternary outwash gravel deposits from the headwater catchments of the Oreti, Mataura and Waikaia Rivers and their tributaries.

Further to the south are the rocks of the Murihiku Terrane. These are displayed most conspicuously by the Southland Syncline, formed from strike ridges of alternating harder sandstone and soft mudstone and effectively dividing northern Southland from the Southland Plains. The expansive Southland Plains are formed by the same quaternary gravel outwash deposits which formed the inland basins with the older terraces mantled by wind-blown loess, while the lower terraces are modified by the meander and redeposition of riverine gravels and silts.

Evidence of volcanism in the region is restricted to the Takitimu and Longwood Ranges and isolated extrusions such as Bluff Hill and Ruapuke Island. These features consist of uplifted volcanic rocks of the Brooke Street Terrane which are some of the oldest rocks in New Zealand and underlie much of the lower Southland Plains.



**Figure 1: Geology of the Southland region**  
 (Source QMAP data series; Fiordland (2010), Murihiku (2003), Wakatipu (2000))

## 2.6.2 Climate

The climate of Southland is heavily influenced by its topography and prevailing weather systems, making it one of the most diverse climatic regions in New Zealand. Prevailing west to south-west winds bring moisture-laden winds off the Tasman Sea and Southern Ocean creating large rainfall gradients. This happens because these winds are intercepted by the western ranges of Fiordland and foothills of the Southland Plains creating an orographic rain shadow effect, which leaves inland basins north of the Southland Syncline comparatively drier (**Figure 2**).

The Fiordland region is distinguished by its high rainfall, with annual precipitation ranging between 4,000 and 7,500 mm. Rainfall along the southern coasts and Stewart Island is still comparatively high, ranging between 1,000 to 1,250 mm per annum. Rainfall steadily declines inland from the coast and eastwards from Fiordland. This is particularly noticeable in the inland basins and ranges of northern Southland where the climate is more akin to the drier climate of Central Otago. These basins are protected from the west by the Fiordland mountains and to the south by the Southland Syncline limiting their exposure to coastal moisture laden winds, with annual precipitation ranging from 750 mm in the drier eastern Waimea basin to 1,000 mm in the Te Anau basin to the west.

Temperature gradients are more extreme away from the coast, with inland areas receiving more frosts in the winter and higher sunshine hours in the summer. Temperatures in coastal areas are more stable due to their proximity to the sea. The Topoclimate South survey measured growing degree days at sites across Southland to provide better information on the potential agricultural productivity of the region. The results highlighted that lower-lying areas in inland basins were limited by the higher frequency of frosts, with growing degree days ranging from 1,700–2,000 days per annum. However there are still inland areas of a northerly aspect with growing degree days in excess of 2,200 days per annum. Coastal areas and the lower Southland Plains consistently have growing degree days ranging between 2,000 and 2,200 days per annum highlighting the reduced frequency of frosts experienced in the more temperate coastal areas.

Snowfalls in lowland Southland are infrequent with only the ranges of Fiordland and northern Southland receiving regular snowfalls in winter. Winter snow provides an important recharge source for the region's main river systems and groundwater reservoirs, which drain these areas.

Wind plays an important factor in the climate of Southland's coastal regions. Invercargill is New Zealand's third-windiest city behind Wellington and New Plymouth (Weather Watch 2008) and the productivity for industries such as cropping and forestry in its coastal regions is limited to an extent by exposure to the prevailing salt laden west to south-west winds.

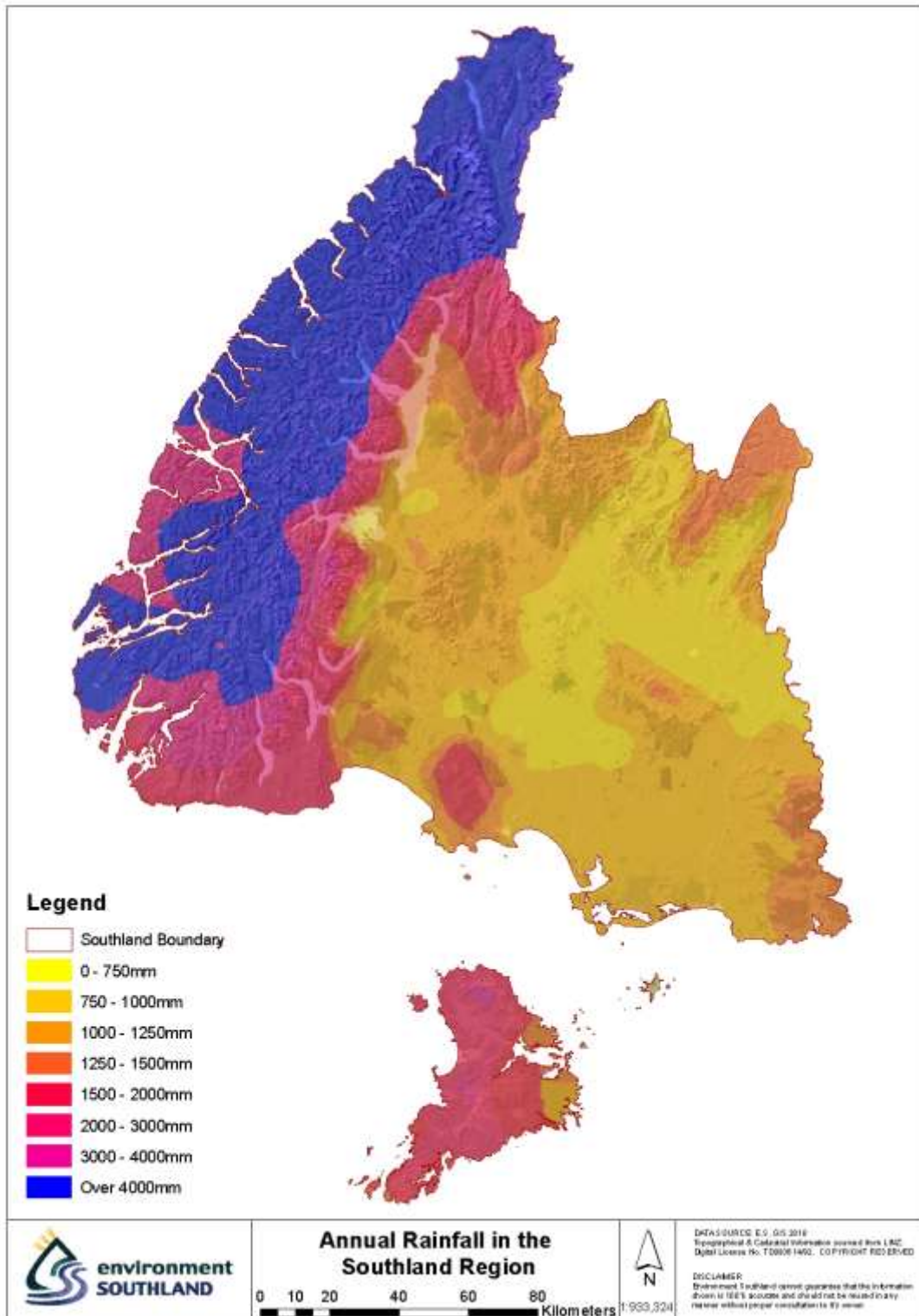


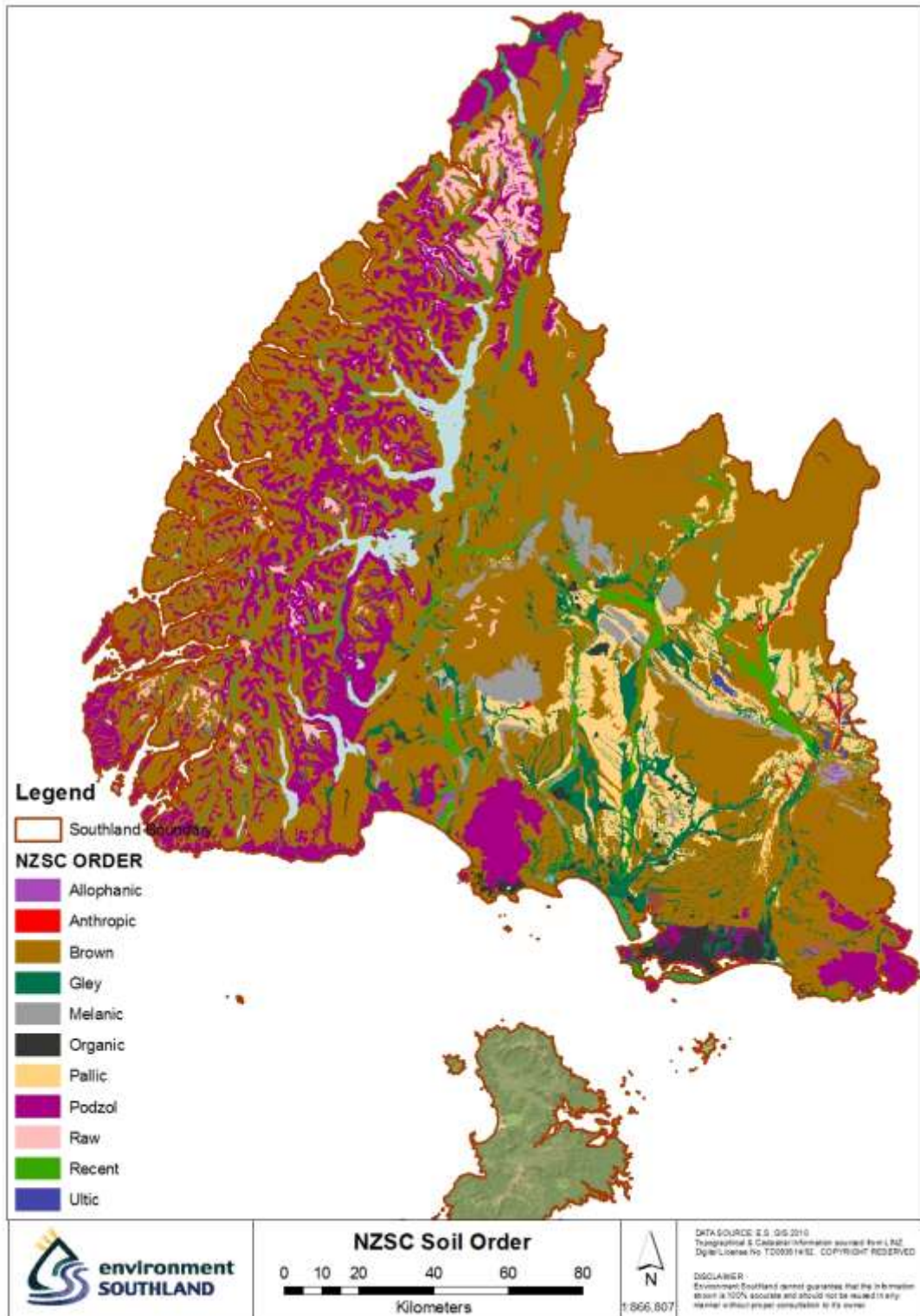
Figure 2: Mean annual rainfall in the Southland region between the period 1960 and 2010  
(Source: NIWA 2010)

### 2.6.3 Soils

Soils are diverse across Southland and reflect the recent geological and climate history of the region. The high rainfall and mountainous lands of Fiordland and Stewart Island are characterised by skeletal, raw and recent soils in the more dynamic environments, while those more stable landscapes are typically overlain by Podzols, Brown soils and Organic soils, as classified by the New Zealand Soil Classification (Hewitt 1998) (**Figure 3**). Outside of mountainous regions, Brown soils are the predominant soil order across the region and comprise the bulk of farmed soils. Across the plains and lowlands, Pallic, Gley and Recent soils are also common, reflecting stable loessial surfaces, poorly drained areas, and recent floodplains respectively. On the Southland Plains there are small, but environmentally sensitive areas of Organic Soils, mostly in low-lying coastal areas. Melanic soils are also widely distributed across the hill country of central Southland (Hokonui Hills and adjacent to the Waimea Plains).

The distribution of these soils and associated climatic limitations has, in many cases, dictated the level of agricultural development different soil orders have received. However, new land development techniques and higher land prices has seen soils traditionally considered unsuitable for intensive farming e.g. organic soils, developed into intensive pasture across low-lying parts of the region.





**Figure 3: Soil distribution across Southland**  
(data from Fundamental Soil Layers (Wilde et al 2000) + Topoclimate soils)

## 3 Methodology

There is a wide variety of land uses across the Southland region. The first step was to select land uses to be analysed in this report. Based on their extent and/or potential environmental impacts several key land uses were chosen for analysis. This report focuses on indigenous vegetation, deer farming, cropland, sheep and beef farming, dairy farming and forestry land use classes.

### 3.1 Data Suitability

The second step of this report was to collate and review data on the chosen land uses. There are numerous datasets that offer land cover, land use and land use change information for the Southland region. Some of these offer Southland-wide data in a national context while others are more detailed and offer sub-regional data whereby comparisons can be made within Southland.

Aside from text datasets such as Statistics NZ data or DairyNZ data there are a number of spatial and spatially derived datasets available with information at the regional and sub-regional scale. Determining which of these datasets were suitable for this report required a large data collation and review exercise to assess which datasets were accurate and detailed enough to use in this report.

In assessing whether a dataset was suitable for use within this report, specific data standards were developed. The ability of the chosen datasets to meet these standards is discussed in Section 3.2.2, however the definition of the standards is outlined below:

- **Data collection:** Did the data have robust data collection methodologies? Datasets which were exposed to a degree of subjectivity were avoided. Datasets subject to large changes in collection methodologies were also excluded.
- **Data extent and Resolution:** Did the dataset have regional resolution and extent? Datasets that provided pan-regional resolution and extent were favoured over datasets that were limited by their temporal and/or spatial resolution and extent across the region.
- **Data Accuracy:** Was the data accurate? Accuracy is critical in a dataset to ensure reported changes are not a product of methodology variation or survey efficacy but of real change. Derived datasets reported in other documents were avoided if the original could be obtained to ensure accuracy.
- **Data Age and Updates:** Is the data current? Data that was current and regularly updated was preferred to older data, although if a particular dataset held the only and most recent data available then this was used and its currency was explained.
- **Data Availability:** Was the data available? Some datasets were unobtainable or financially unjustifiable to obtain. Consequently, there are some land uses where better resolution could have been offered; however this was rationalised against the quality of the data and existing datasets that were available.

### 3.2 Data Analysis

For each land use data analysis in the report the methodology behind the data calculations is outlined within the respective section. **Table 1** identifies the primary datasets used in the report to analyse land use, the elements utilised and the outputs generated. Many of these datasets were manipulated in GIS software to produce both figures and text data such as hectares of land use types within Southland. The methodology behind the data manipulation process is displayed in **Appendix 1**.

**Table 1: Databases and datasets utilised within this report to generate statistics on land use extent, change and intensification in the Southland region**

<b>Database</b>	<b>Dataset</b>	<b>Non Spatial/ Spatial</b>	<b>Years</b>	<b>Elements Analysed</b>	<b>Outputs</b>
LCDB	LCDB1	Spatial	1996	Land Cover	Hectares, Mapped Extent
	LCDB2	Spatial	2002	Land Cover	Hectares, Mapped Extent
	LCDB3	Spatial	2008	Land Cover	Hectares, Mapped Extent
NZLRI	LUC	Spatial	1978 - on-going	Land Use Capability Class	Hectares, Mapped Extent
	LENZ	Spatial	2003	Land Environment Threat Categories	Hectares
Topoclimate South	Growing Degree Days	Spatial	2000	Growing Degree Days	Reference
	Soils	Spatial	2000	Soil Order	Hectares, Mapped Extent
Environment Southland	Ratings Database	Spatial		Land Use Types	Hectares
	Consents Database	Spatial	2000-2011	Dairy Farm Locations	Hectares, Mapped Extent
	Southland Wetlands	Spatial	2011	Wetland Type and Location	Hectares, Mapped Extent
FAR	Cropping Areas	Spatial	2010	Cropping Farm Locations	Hectares, Mapped Extent
MPI	MAXA Data	Text *	1975-1994	Land Use Type and Production	Hectares, Production
	NEFD	Text	1995-2011	Forest Location and Type	Hectares, Ownership
	Monitor Farms	Text	2002-2011	Modelled farm statistics (Sheep and Beef Hill country & Intensive pastoral)	Production
Beef and Lamb Economic Service	Sheep and beef farm statistics	Text	1998-2011	Winter fodder crop statistics	Production
Statistics NZ	Agricultural Production Survey	Text	2002-2011	Agricultural Statistics	Hectares, Production
	New Zealand Yearbooks	Text	1902-1975	Agricultural and Land Use Statistics	Hectares, Production
	Infoshare	Text	1990-2011	Agricultural Statistics	Hectares, Production
DairyNZ		Text	1994-2011	Dairy Statistics	Hectares, Production

\*Data derived from Statistics NZ

Other derived datasets or data were utilised to supplement gaps in the primary datasets outlined in **Table 1**, or when they would apply better resolution to the primary data. For example, to supplement data from Statistics NZ on deer farming in Southland, annual Deer Industry New Zealand reports and survey data were utilised. In these instances, the methodology has been outlined within the respective section.

### **3.2.1 Datasets not used**

There were datasets that have been used in similar regional land use assessments elsewhere that were considered but not used in this report. Two key datasets not used in this report were the Quotable Valuations New Zealand (QVNZ) and Assure Quality AgriBase™ datasets. Each of these datasets has a degree of limited accuracy, for example AgriBase™ was calculated to have 65% coverage of land (excluding national parks) in the Southland region in 2000, while in 2009 this had increased to approximately 90% (*pers comm.* Ingrid Darragh, GIS Analyst, ES). QVNZ data was only obtainable as far back as 2005 and required extensive GIS manipulation to spatially map and was not considered for this reason. In addition, the cost of purchasing the AgriBase™ dataset was a deterrent in its use.

Another dataset not considered was the Food and Agriculture Organisation statistics as these statistics were derived from the Statistics NZ dataset which was a primary data source for this report. The Land Use and Carbon Analysis System (LUCAS) dataset was also not utilised as the Land Cover Database (LCDB) 3 dataset incorporated much of this information.

### **3.2.2 Data Limitations**

It is important to recognise that primary datasets used within this report, although considered the most suitable available, did have their own limitations which restricted the outputs that could be generated for the report. Datasets that were restricted in their use because they did not fully meet one or more the data quality standards are outlined below.

#### ***Data Collection***

Sheep, beef and deer farming operations were unable to be individually spatially distinguished. Consequently, only hectare figures for each of the farming classes are given, and when the classes are mapped they are mapped as one class of land use (sheep/beef/deer). Similarly, cropping land, which is often a sub component of a farming system, was unable to be accurately spatially reported, with the exception the FAR dataset which reports arable farms on a whole farm scale.

Historic indigenous vegetation extent derived from McGlone (1989, 2001) was limited in its resolution by the scale of the mapping across the Southland region, making accurate digitisation and subsequent analysis difficult. As this dataset is a prediction of vegetation extent, the outputs should only be viewed as an estimate.

The only dataset used that was limited in its spatial extent across the region was the Topoclimate soils and growing degree days data. The survey was limited to measuring soils and growing degree days on primarily Land Use Capability (LUC) (Lynn et al. 2009) class 1-5 land across the region. Consequently, reporting on these datasets is limited to what is considered high-class (class 1-5) land in the region.

The land use classes within Environment Southland's rating database were also limited in their use due to the accuracy of the data. Polygons were limited to whole property classifications giving a coarse representation of land uses within the Southland region.

### ***Data Extent and Resolution***

Cropping data from the Beef and Lamb Economic Service did not distinguish between crops grown on-farm to support stock and crops used for dairy support grazing, making the distinction between dairy winter grazing and sheep and beef winter grazing impossible. The DairyNZ winter cropping data was amalgamated across the Otago and Southland regions, limiting the degree of interpretation that could occur at a regional level.

Some early statistics extracted from the New Zealand Yearbook were based on the Land District boundaries, which did not exactly align with today's Southland region boundary. Nevertheless, the numbers were considered small and the error negligible when comparing them to recent figures so they were included in the analysis. Total stock numbers (sheep, beef, deer, dairy) for the Southland region were not collected in 1997, 1998, 2000 and 2001 by Statistics NZ. Consequently, graphs depicting these numbers have used averaged estimates for these years.

### ***Data Accuracy***

Data accuracy is reliant on robust data collection methodologies. Any significant change in data collection methodologies within a dataset or between two datasets has been acknowledged in the report. However, the older figures derived from New Zealand Yearbooks, prior to 1975, are considered as accurate but not absolute due to variations in survey efficacy and methodology.

Data accuracy is often reliant on data resolution. The poor resolution obtained from the McGlone (1989, 2001) maps has impeded the accuracy of figures derived from the data, but not to the extent that would cause significant error in the figures derived. Similarly, temporal comparison within classes dominated by small polygon sizes in the LCDB dataset (e.g. short rotation cropland) have been treated with a degree of caution due to significant mapping error within measures.

### ***Data Age and Updates***

Unfortunately, some datasets were collected sporadically (e.g. Statistics NZ cropping data) making the currency of the data variable. Fortunately, most of the primary datasets utilised fall within three years of the end of the reporting period (2010/11), however it is acknowledged that even within three years there can be significant changes in land use or intensification.

## **3.2.3 Data Gaps**

There were some significant land uses in Southland where there was a paucity of data available. Key gaps identified were:

- information on the extent and type of crops grown in Southland, both arable and fodder, was difficult to interpret from the datasets available. As cropping systems such as winter fodder crops have been identified as high nutrient loss systems (Monaghan et al. 2010) better information is required on these systems to help understand their extent and impact in Southland;
- being able to spatially distinguish between sheep/beef/deer properties in Southland would add better resolution to land use maps generated and provide context to transitions in land use. Farm scale stock unit data on sheep/beef/deer farms would also be beneficial;

- wetland clearance and drainage are comparatively minor activities in their extent, however they can have severe water quality and biodiversity impacts. Better information on wetland clearance, consented and unconsented drainage is required to help understand the extent and impacts of these actions;
- indigenous vegetation clearance is also a minor activity in extent but can have significant impacts on biodiversity and water quality. Datasets such as the LCDB were unable to identify with confidence areas that had been converted to pasture. Future versions of this database may highlight longer term changes in the region, however supplementary data from consents or specialist mapping may be required to give better resolution to this land use change.

### 3.3 Recommendations for future reporting

The next SOE report on land use in Southland will be in approximately four years' time. Land use changes can occur fast and the currency, accuracy and resolution of datasets are important in allowing the accurate analysis of land use change. The main datasets used in this report were chosen because they met these qualities and it is recommended that they are continued to be used in the next report to allow temporal comparisons.

One dataset that was not used and should be considered for future reporting is the AgriBase™ dataset. If data accuracy and currency is achieved, this may overcome the issue of spatial resolution between sheep/beef/deer farming enterprises, which could not be achieved in this report. It may also offer better resolution to the spatial extent of cropping in Southland. Similarly, LCDB4, which is due for release in 2014, should be utilised in future reports to map and analyse land cover and change.

Southland specific winter cropping data was difficult to obtain. Due to its potential to severely impact soil and water quality, better data on the location and type of winter cropping in Southland is essential. The generation of this data, whether Council-led, or in collaboration with other agencies and industry partners, should be a priority to fill this data gap.

Some land tenure data on QEII covenants and Department of Conservation (DOC) tenure review purchases was unattainable in time for this report. These data would provide better accuracy to figures surrounding land tenure and areas of indigenous vegetation under legal protection and should be sought for future reports. Similarly, data on wetland vegetation clearance and drainage should be more thoroughly investigated to better understand and report on the extent of these practices. Mapping current wetland extent in the future should incorporate wetland classes identified in LCDB. This was not done in this report with only the Clarkson et al. (2011) wetland assessment utilised, which only classified wetlands over 5 ha. Using the LCDB wetland classes in conjunction with this classification could offer considerable resolution to the mapped area of current wetland extent.

No attempt was made to report on quantifying irrigation (both farm dairy effluent and deficit irrigation), however, this should be considered in future reports as irrigation is increasing across the region and is linked with increased intensification and nutrient losses (Liquid Earth 2012). Peri-urban and lifestyle block spread was also not included in this report but should be considered for future reporting.

This report analysed land use changes and intensification across the Southland region. Strong consideration should be given towards undertaking some sub-regional or catchment scale analyses which will provide better resolution for some of the current data deficient land uses and management activities such as wetland clearance, irrigation and cropping.

Soil and water quality is strongly dependent on land use and land use management practices. Better linkages need to be made between the effects of land use change and intensification on soil and water quality. The integration of land use change, water quality and soil quality SOE and technical reports into a co-ordinated release would provide a clearer picture of the cause and effects of land use change, intensification and management practices on water and soil quality.

Lastly, with such a variety of data sources and geospatial analysis techniques used to generate the data used in this report, data management and metadata processes need to be robust. In future reports, assigning good practice data management, metadata and archiving practices, using GIS spatial tools such as ArcGIS Model Builder, is essential to be able to recreate data and understand data generation processes.

## 4 Current land use

This section describes the current extent of the major land uses in mainland Southland and quantifies the distribution of land use activities across different LUC classes. Temporal changes within and between each of the main land use types and the intensification of these is described in detail in later sections of the report.

The Southland region encompasses 3,176,450 hectares. Of this, 94% (2,968,418 ha) of the land mass is located on the South Island while the remaining 6% (208,032 ha) is divided between Stewart Island/Rakiura (5%) and various small offshore islands (2%). Stewart Island and the offshore islands do not currently have any intensive land-based primary industries with land cover dominated by indigenous vegetation. Therefore, the analysis of recent land use change is not relevant to the offshore islands and this report's land use change analysis focuses on mainland Southland.

### 4.1 Regional land use

The major land uses in Southland as of 2010/11 are displayed in **Figure 4**. Dairy farm data is obtained from the ES consents database (2011), while the remainder of the classes are amalgamations derived from LCDB3. It is important to note that the high-producing grassland and low-producing grassland layers are primarily occupied by sheep/beef/deer farms. Arable cropping data is available, however it is a minor component of the total land use coverage in Southland (c.14,000 ha) and has only been included in **Figures 5 and 6**. Cropping will be dealt with in a later section of the report but for the purpose of a regional overview it has been incorporated into the high-producing grassland category in **Figure 4**.



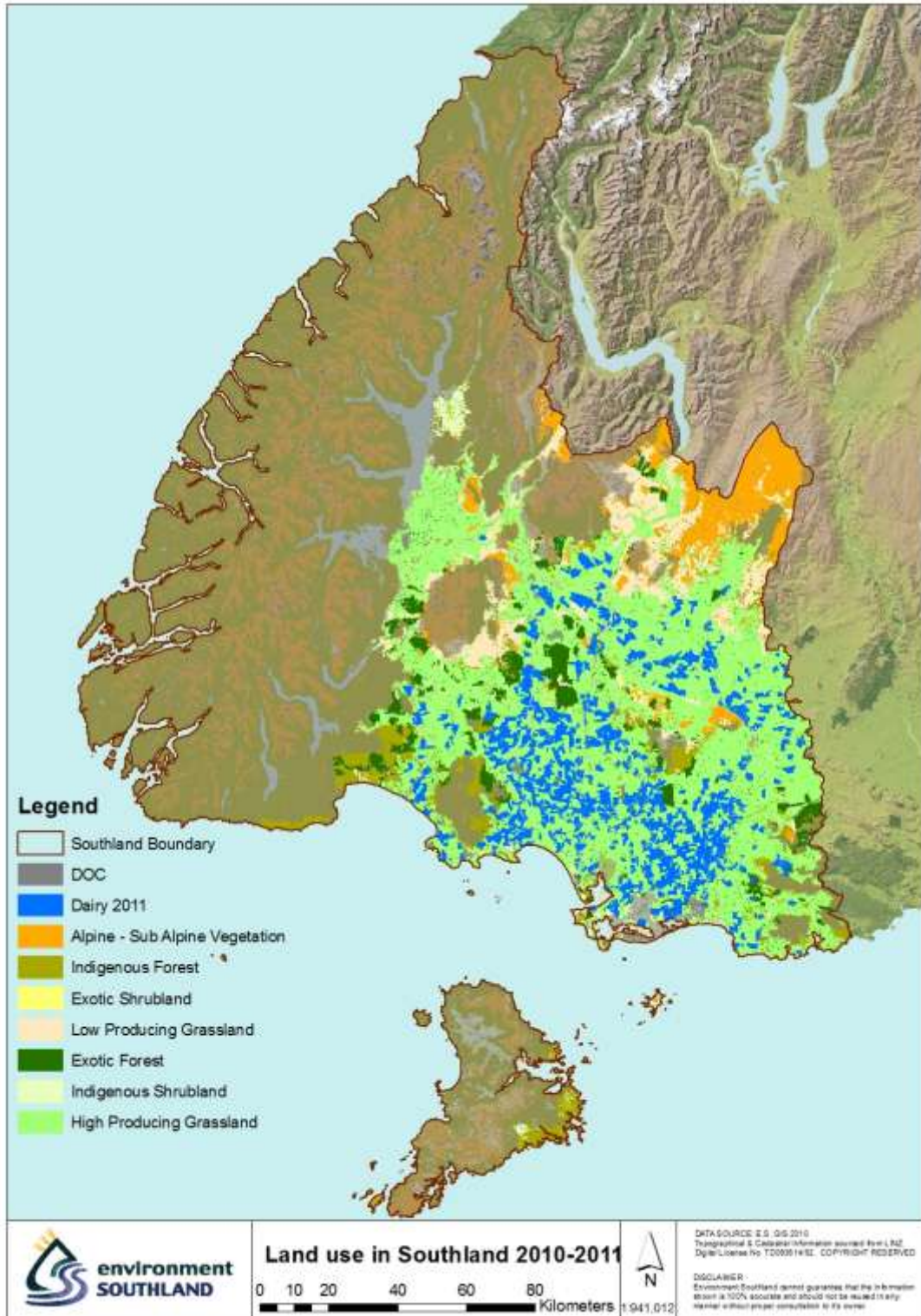
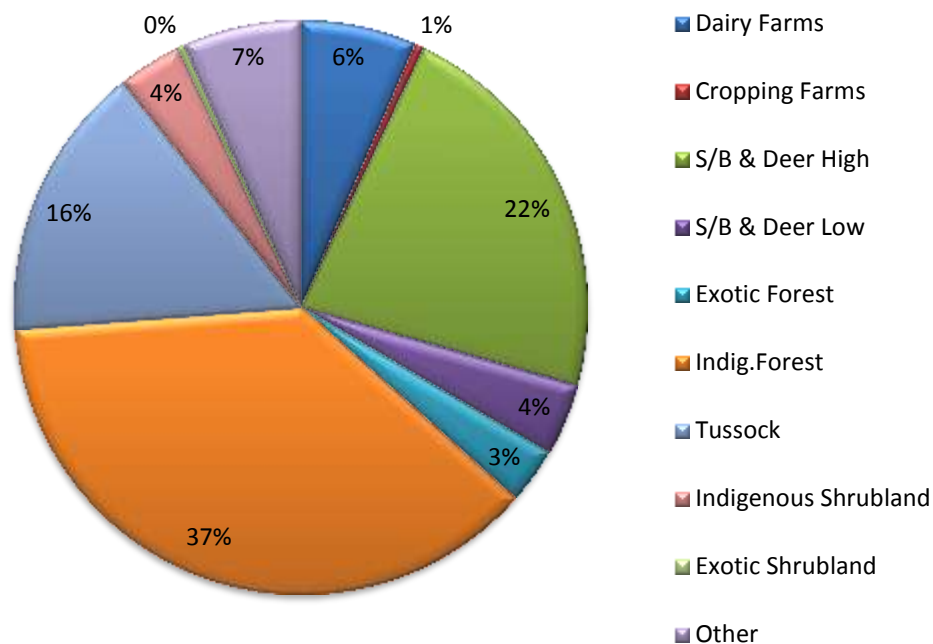


Figure 4: Land use in the Southland region as at the end of the 2010/11 financial year

Today, the coverage of mainland Southland is still dominated by indigenous forest, which occupies a third of the region (**Figure 5**). Other indigenous vegetation communities, in combination with indigenous forest, cover 57% of mainland Southland. Of this, 97% is under protection for conservation purposes, making land designated for conservation purposes the most dominant land use in mainland Southland. The next largest land use, occupying just over 25% of the region, is sheep/beef/deer farming. This figure was calculated by removing land occupied by dairy (ES 2011) and cropping (FAR 2010) from the LCDB3 High Producing Grassland and Low Producing Grassland area to produce the sheep/beef/deer figures. Distinguishing between these three stock types is difficult as many farms have all or a combination of these stock types making it difficult to accurately break down this class of land use into separate classes for sheep, beef and deer.

In **Figure 5** the next largest land use class is dominated by “Other” (201,000 ha). This class is a catch-all of LCDB3 classes not captured under recognisable land use definitions. The class comprises of mainly aquatic dominated or influenced systems, primarily lakes, riverbeds and other associated fresh water bodies or ecosystems. Also within this class are urban areas, approximately 5,500 ha, or less than 0.2% of Southland’s mainland area. The next largest land use class is dairying, occupying 6% (196,000 ha) of the land area, followed by exotic forestry at 3% (95,000 ha). The remainder of classes are very minor in their extent and constitute less than 2% of mainland Southland.

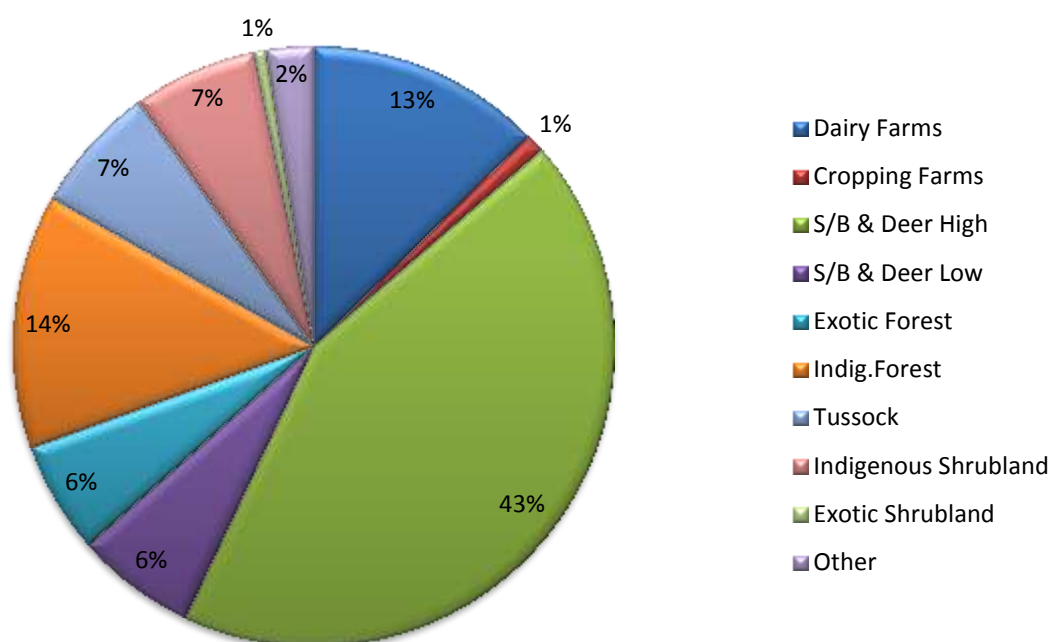


**Figure 5: Percentage cover of different land use classes in mainland Southland**  
(Data is derived from LCDB3 (2008); FAR (2010), ES Dairy consents data (2011))

The ability of Council to control environmental effects resulting from different land uses is largely restricted to anthropogenic (human) land uses such as forestry, farming and urban land use. Variation in indigenous dominated landscapes is more likely to be a result of natural processes, unless these environments are severely modified by weed or pest encroachment. For this reason, conservation land has largely been excluded from further analysis in this section of the report except as a comparison to determine the degree of land use change or modification by anthropogenic influences.

## 4.2 Land use on private land

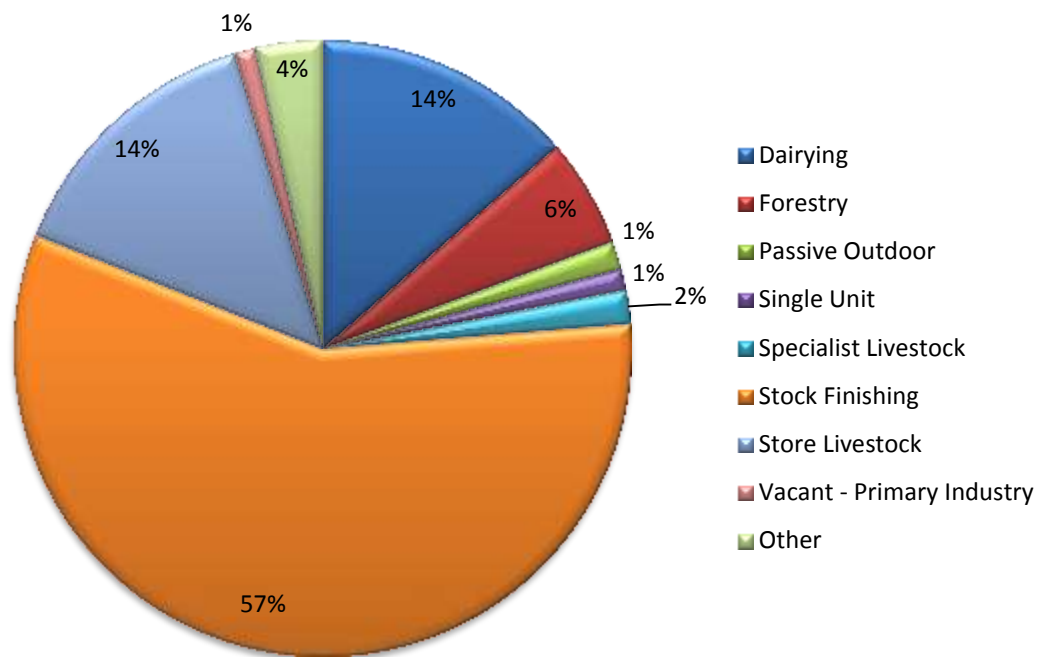
The land use data presented in **Figure 5** can be further analysed to reveal what land uses for predominantly private land by the removal of conservation land (DOC managed land) from the analysis. **Figure 6** quantifies land use coverage on land not managed by DOC. The sheep/beef/deer and dairy land use classes dominate coverage, occupying over 62% of land cover. It is important to note that the tussock class will have a component of extensive sheep/beef/deer occupying this unit which is essentially a land cover class as opposed to a land use class *per se*. Overall, agricultural and forestry land uses dominate land cover on private land in the Southland region covering 69% of the privately owned landscape.



**Figure 6: Percentage cover of different land use classes in mainland Southland excluding DOC land**

(Data is derived from LCDB3 (2008); FAR (2010), ES Dairy Farms (2011))

Another way of way of looking at what area different land use types occupy within mainland Southland is to look at rating data used by Environment Southland. Within the rating database, each property unit is given a specified land use class derived from its dominant land use type. **Figure 7** identifies the major rating classes occupying >1% of land parcels in the mainland Southland region. These classes are defined by the predominant land use of that parcel of land. Whether it is being used for this land use will differ according to a number of management factors. For example, a parcel of land could be rated for stock finishing even though a third of the land area may still be peat land and not farmed. In this instance, the entire parcel will still be rated as stock finishing. This is important as it renders the dataset as a more coarse depiction of land use but it does enable some comparisons between the two datasets and their potential use in future SOE reports.



**Figure 7: Land cover classes as defined by the Environment Southland rating database occupying >1% of land in Southland (2011)**

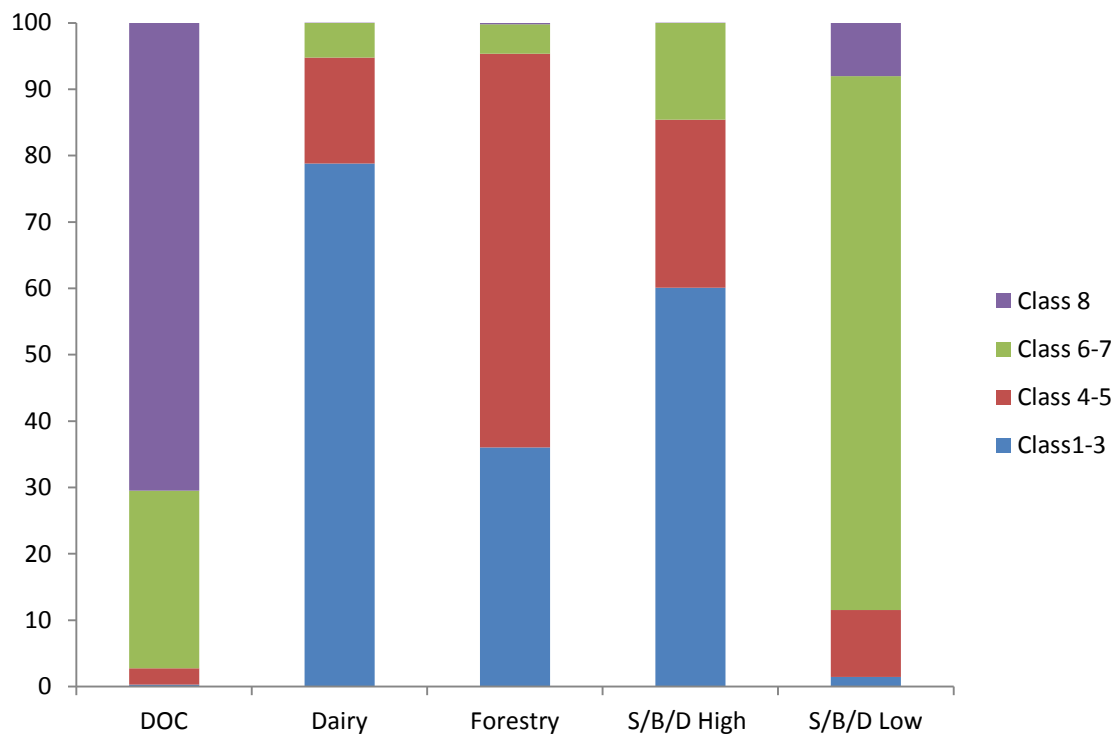
Primary industries (forestry, dairy, and the livestock classes, specialist and store livestock and stock finishing) occupy over 93% of Southland’s rateable land under private ownership, highlighting that much of the land use classes identified in **Figure 6** are encompassed under these farming-related rating classes. This identifies that much of Southland’s privately owned indigenous vegetation communities are present on properties rated for farming activities. This can have implications for conservation which will be discussed in the following section. The remainder of private land that is rated under residential or industrial-related classes constitutes only 7% of mainland Southland’s rateable land.

### 4.3 Land Use Capability

Farming and forestry are the dominant activities in Southland occurring on private land. Because they can seriously impact the environment if managed poorly, it is useful to know what land resources they occupy and the environmental sensitivity of these. The Land Use Capability (LUC) assessment is a description of land according to its long-term productive ability and is based on the land’s physical limitations of climate, wetness, erodibility or soil characteristics (Lynn et al. 2009). Land Use Capability classes span from 1-8, with Class 1 land being highly suitable for agriculture while Class 7 or 8 land being better suited for conservation purposes due to its productive limitations. These productive limitations are often associated with adverse environmental effects if the land were to be inappropriately developed.

Recently this classification has been endorsed as an adequate assessment of environmental risk of different farming activities under the Horizons Regional Council One Plan decision. In the absence of other region-wide datasets assessing the productive and environmental limitations of different landscape units, the classification is still arguably the best resource available to assess the productive and environmental suitability of different land uses on different landscapes within Southland.

Looking at the key land use classes present in Southland, the LUC can provide a picture of where the distributions of classes lie within different land use activities and can also highlight if the land use activity is appropriate for the given class of land. **Figure 8** below highlights the distribution of LUC classes *within* the key land use classes identified within this report: dairy, forestry, sheep/beef/deer (including any arable cropping land) and conservation land. **Table 2** displays the distribution of LUC classes *between* these land uses and as a percentage of the national total. Forestry data was derived using the LCDB3 exotic forestry data layers, dairy data was derived from the ES consents database layers, DOC land was obtained from DOC databases, while sheep/beef/deer land has been split into high producing, derived from the LCDB3 high producing exotic pasture layer, and low producing, derived within the LCDB3 low producing exotic pasture layer. The percentage of the national total figure was derived from Rutledge et al. (2010).



**Figure 8: Percentage land cover of LUC class groupings within Department of Conservation (DOC), dairy, exotic forestry (forestry) and high and low producing sheep/beef/deer (S/B/D) grassland in mainland Southland**

**Table 2: Percentage land cover of LUC class groupings between Department of Conservation (DOC), Dairy, Exotic forestry (Forestry) high and low producing sheep/beef/deer (S/B/D) grassland in mainland Southland**

(Proportion of NZ total indicated in far right column)

	DOC	Dairy	Forestry	S/B/D High	S/B/D Low	Total Hectares	% NZ total*
<b>Class 1-3</b>	1	22	5	73	0	707,417	14
<b>Class 4-5</b>	11	9	15	60	6	360,068	11
<b>Class 6-7</b>	58	1	1	17	23	720,769	7
<b>Class 8</b>	99	0	0	0	1	1,121,533	20
<b>Total Hectares</b>	1,567,437	193,721	91,281	855,353	201,995		

\*Source: Rutledge et al. (2010)

As expected, public conservation land managed by DOC is dominated by lower-class land (land with more limitations), particularly class 8 land, of which 99% occurs within this land use. Nationally, 20% of this LUC class lies within Southland. Low producing sheep/beef/deer farming is dominated by class 6 and 7 land, high producing grassland is dominated by class 1-3 land (60%), while 79% of dairy land resides on class 1-3 land. Forestry, interestingly, although occupying the smallest land area when analysed at a regional scale, is dominated by higher class 1-5 land (>90%). The distribution of these classes in **Figure 8** fits well with what would be the expected classes of land occupied by these land uses, with higher intensity farming systems occupying the better classes of land, perhaps with the exception of forestry, which can often dominate higher land use classes elsewhere in New Zealand.

Looking at the total occupancy of these LUC classes, high-producing sheep/beef/deer grassland occupies 73% of all class 1-3 land, while dairy land occupies 22%. This highlights that even though the dairy industry has expanded rapidly, the majority of high class (LUC class 1-3) land on the Southland mainland is still under sheep/beef/deer farming. A similar pattern is reflected in class 4-5 land. However, for class 6 and above land conservation land dominates.

## 4.4 Conclusions

The current extent of land use or land cover in Southland is still dominated by indigenous vegetation, most of which is managed by DOC. Excluding DOC estate, land use is dominated by the main primary industries, dairy, sheep/beef/deer, and forestry. Despite a large increase in dairying, land used for sheep, beef and deer farming still dominates the Southland landscape with forestry occupying a comparatively small portion of the land.

The distribution of these primary industries across LUC classes correlates well with the land capability of these classes for the mapped land use. Dairying and high producing sheep/beef/deer grassland occupy the bulk of the highly productive land on the Southland mainland, while lower productivity land is dominated by low producing sheep/beef/deer grassland and conservation land. Any expansion in either of the pastoral land uses (dairy or sheep/beef/deer) would result in either the utilisation of high class land under another pastoral land use or through land becoming available from the conversion of forestry to pastoral land. If the recent expansion of dairying was to continue, the main available resource of highly productive land for conversion is occupied predominantly by sheep/beef/deer farms with small amounts available in the arable and forestry sectors. Alternatively expansion could occur into classes of land considered less suitable (classes 5–7). This is discussed in further detail in the Dairy section of this report.

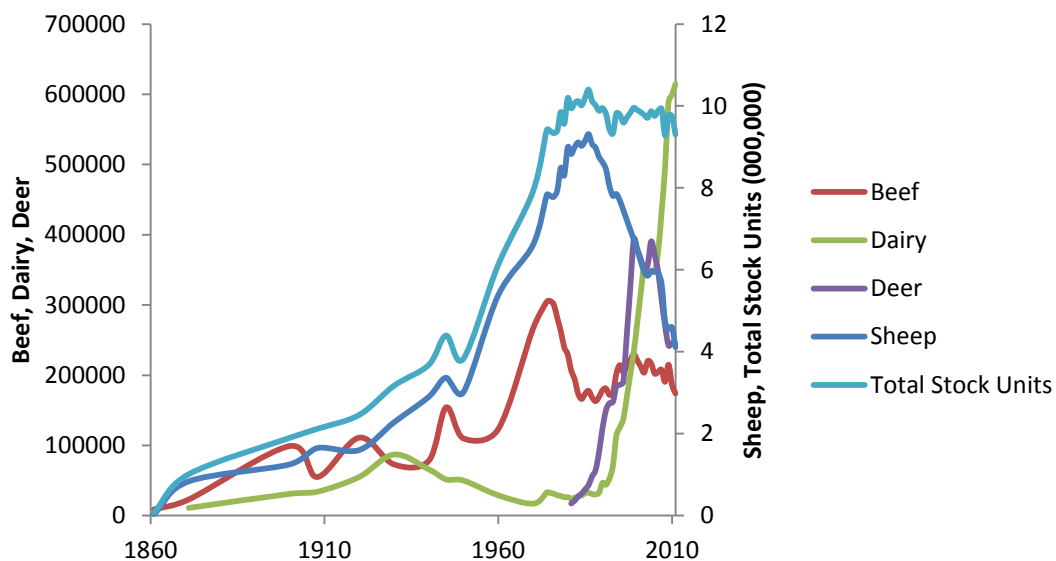
# 5 Land use change and intensification

## 5.1 Introduction

This section describes historic changes across the major land uses in the Southland region from pre-human times through until 2011. It begins with a brief overview of land use change in the region and then reviews indigenous vegetation change, the first and single biggest land use change the region has undergone. Thereafter the report focuses on changes in rural land use, the intensification of these activities and their environmental effects.

The drivers of land use change were once commonly thought to be driven by population expansion and limited food availability, however, it is now widely recognised that modern day land use changes are driven by economic factors (Moller 2008). Southland is no exception, as economic drivers have been behind many of the large land use changes observed in Southland since the European colonisation of the region. The recent rapid dairy expansion across the region is a prime example of this phenomenon.

The landscape of Southland has undergone major changes in land use and intensification over the last 150 years. The early colonisation of Southland during the 1860s brought about large land use changes as pastoralism expanded across the region. Unlike the drier eastern areas of the South Island, large tracts of Southland were forested, with very few tussock grasslands in southern and western parts of the province (McGlone 1989). From the 1870s, increasing wheat, meat and dairy prices saw the rapid expansion of pastoralism across the Southland region. Areas such as the Waimea Plains were developed for cereal production, while large tracts of forest were cleared for agriculture on the Southland plains (Cutt 2006). Up until this point, extensive pastoralism had been limited to the tussock grasslands of northern Southland, where no major land development was required to produce New Zealand's primary export product of the day, wool (Cutt 2006). However, over the next 60 years Southland was to experience a large expansion in the agricultural sector.



**Figure 8: Stock numbers in the Southland region 1860–2011**  
(Source: Statistics New Zealand, Agricultural Statistics)

Between 1890 and 1932 the dairy industry experienced its first period of significant expansion. The first dairy factory in Southland opened in Edendale in 1882 (today, occupied by the Fonterra milk processing plant) and by 1932 the province had 80 dairy factories (Cutt 2006). However, during the mid-20th century, many dairy farmers switched to sheep farming as meat and wool prices climbed. In the 50 years from 1920, cow numbers in Southland declined five-fold while sheep numbers increased four-fold (**Figure 9**). Nationally, between 1920 and 1970 the area of developed pasture remained quite stable, however, average stocking units increased on average by 150% (Molloy 1980), with wool production tripling and meat production doubling (Molloy 1980; Langer 1990). Southland's agricultural area was still in expansion during this period with more isolated parts of Southland brought into intensive agricultural production, boosted by the introduction of aerial topdressing. These areas included:

- the Upper Waiau Valley along the shores of Lakes Te Anau and Manapōuri;
- the southern and eastern sides of the Tākitimu Mountains and west of Nightcaps;
- a small area to the south of the Hokonui Hills;
- coastal land east of Invercargill, much of it swamp (Grant 2009).

During this period of intensification, diversification was occurring with less traditional primary land uses such as horticulture, agroforestry and goats being adopted (McLeod & Moller 2006).

The deregulation of the agricultural sector and subsequent removal of subsidies in the early 1980s changed the farming climate in Southland with farmers encouraged to achieve higher and higher levels of productivity (PCE 2004). Further diversification occurred with deer and forestry expanding throughout Southland. During this period, sheep numbers in Southland dipped from 9 million in 1985 to 4.15 million in 2011, while dairying boomed during this period on the back of cheap land prices and rising international prices for dairy products. In 2010/11, the average Southland herd size was 555 cows – over four times that before the 1990s “boom” (LIC 2011).

**Figure 9** displays an interesting trend in total stock units in Southland. Total stock units (as defined by Fleming (2003)) in Southland rose sharply through last century to reach a peak of just over 10 million in the early 1980s. Since this time, peak numbers have stabilised, indicating that net growth in stock units has been static. Interestingly, Statistics NZ records show that in 1920 there were a total of 1.28 million hectares of land “occupied” for primarily agricultural purposes in Southland. In 1975 and 1995 this figure was estimated at 1.11 and 1.26 million hectares respectively, while in 2011, 1.12 million hectares were estimated to be occupied for primarily agricultural purposes. Molloy (1980), in his assessment of land resources in New Zealand, found that between 1920 and 1970 the area of sown pasture remained fairly stable, yet stocking rates increased by 150%. Southland was no exception albeit a little slower to start this rapid increase in stocking rates. Between 1860 and 1950, stock units rose steadily in the region to 3.8 million, however, over the next 20 years stock numbers in the region rose by 240% to 9.14 million in 1974. After this, the growth began to slow and eventually stabilised by the mid-1980s. Considering that the net area of land available to farming changed relatively little over this 20 year period, the rapid increase in stock numbers was a likely result of rapid intensification and improvement of existing pastoral land.

It therefore appears that the plateauing of stock units in Southland from the early 1980s through until today is likely be a product of the relative decline in pastoral land improvement into previously marginal pastoral lands in the region, in comparison to the early and mid-20<sup>th</sup> century, coupled with a relative plateauing of intensification and the conversion of some 50,000 ha of pastoral land into forestry. Nevertheless it will be interesting to see if stock units and the relative intensification of land increases significantly in future years and what the future drivers of these changes are if they occur.



## 5.2 Indigenous vegetation change

This section describes three key phases of vegetation loss in Southland - post-Polynesian arrival, European colonisation and recent agricultural expansion. It is important to document early vegetation losses to give context to the landscapes that can be seen across Southland today. Large changes have occurred and this section outlines these. However, today the many small remnants that can be seen within the largely pastoral landscape often offer significant biodiversity value. Consequently, there is a focus on the region's remaining indigenous vegetation extent within the production landscape, its threats and opportunities to protect it.

Southland has undergone a large and rapid reduction in indigenous vegetation cover since Polynesian arrival, making the loss of indigenous vegetation the single biggest land cover change that the region has undergone since human arrival. Hundreds of years of Polynesian burning followed by the clearance of vegetation for pastoralism has eradicated much of Southland's original vegetative cover, with over 90% of its former lowland forested areas now being under pastoral cover.

Southland's land cover began changing rapidly post Polynesian arrival. It has been estimated that New Zealand's pre-Polynesian land cover was over 85% forest-dominated and Southland was no exception, with lowland areas dominated by tall conifer broadleaf forest and upland areas dominated by *Nothofagus* forests (McGlone 1989). There were relatively few tussock and shrubland areas comparatively, however, Polynesian burning led to a transition from forest to shrubland in drier, more fire-prone parts of the region. Burning, although much of it possibly accidental, was a tool used by Polynesians to hunt food such as moa, encourage the growth of bracken fern, a key food source, and clear tracts of land for easier access and travel (McGlone 1989).

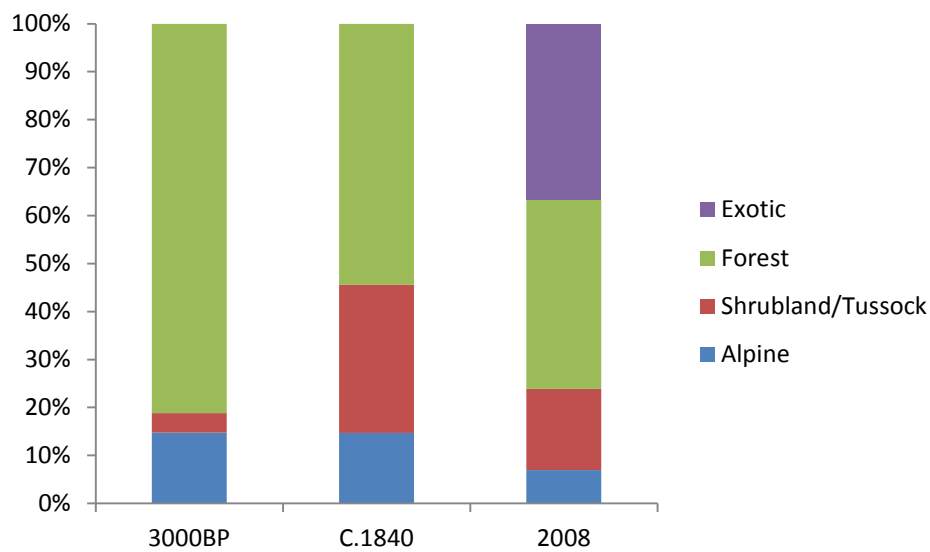
By the time Europeans began to settle in Southland the landscape had been altered significantly. Early historic accounts describe the land to the north-east of Invercargill as dominated by native grasses (Star 2005) and early survey maps show the upper Southland Plains as being a mosaic of tussock grassland, forest and some bogs. The coast to the south-east of Invercargill was dominated by peat lands and swamps which are known today as the Waituna wetland complex, while to the east of the city was the vast expanse of the Seward Forest covering approximately 8,000 hectares (Star 2005).

### 5.2.1 Historic Forest loss in the Southland region

Historic longitudinal data on indigenous vegetation extent in Southland is limited, however there have been various surveys that serve as a snapshot in time of indigenous vegetation extent across the region. McGlone (1989, 2001) mapped national forest distributions based on pollen records, extant remnants of forest, early settler surveys and other interpretive techniques over two time periods – pre-Polynesian (ca. 3000 yr B.P.) and upon European arrival (ca. 1840). These maps are the most accurate estimate of indigenous vegetation cover available for these periods. More recently, remote sensing surveys such as LCDB have been utilised to quantify recent state and trends in national indigenous vegetation cover.

In an attempt to quantify historic vegetation change, vegetation classes in the LCDB3 dataset were amalgamated to align as closely as possible to those used in McGlone (1989, 2001). Land cover classes aligned accurately and **Figure 10** depicts the drastic reduction in forest during the period between Polynesian and European arrival and the transition to tussock and scrub dominated communities, particularly across drier parts of Southland receiving rainfall <1,000 mm per annum (McGlone 2001). During this period, the wetter southern and western parts of Southland still remained relatively unmodified by fire.

However, European arrival saw the rapid depletion of these remaining lowland forests and the transition of Southland’s lowland forest and tussock plains to a pastoral landscape dominated by introduced plant species.



**Figure 9: Approximate percent coverage of major vegetation communities in Southland including Stewart Island and offshore islands 3,000 B.P., ca.1840 and 2008**

(Data derived from McGlone (1989, 2001) and LCDB3 (2008))

### 5.2.2 Current extent and threats

Today, most of Southland’s existing indigenous forestland is under legal protection, whether it be on public conservation land or privately covenanted. However, many of the region’s transitional (seral) shrub land communities, which often contain threatened plants or vegetation associations, are present on private land and not protected, which poses risks for their long-term security. Southland’s fertile, warm, lower-elevation landscapes have lost almost all of their indigenous vegetation and what little remains is threatened and poorly protected (Walker et al. 2008).

Furthermore, the expansion of intensive agriculture into higher altitude, previously extensively farmed, pastoral landscapes is jeopardising previously intact seral vegetation communities on land once considered surplus to productive use. Poor legal protection has been identified as an important risk factor to the long-term preservation of these seral communities and the ecosystem services they offer (Walker et al. 2008).

The area of land legally protected (i.e. not under private ownership) varies between the different indigenous vegetation communities and is outlined in **Table 3** below. To create this table the dominant indigenous vegetation communities used in **Figure 10** were extracted from LCDB3, with the Tussock/Shrubland community being split into two to produce the communities outlined in **Table 3**. These dominant indigenous vegetation communities mapped under LCDB3 occupy a total of 61% of Southland’s land area (3,176,450 ha). Of this area occupied by indigenous vegetation, 10% is under private ownership, the bulk of which being within the Forest and Tussock classes (84%). Within the shrubland class almost 41% occurs on private land, a considerably higher percentage of occupancy than any of the other classes, which mostly occur on protected land. These shrubland ecosystems are particularly vulnerable as they are disproportionately threatened by farming and fire due to their propensity to reside in dryland, fertile landscapes, much of which has been developed, consequently heightening their threat status and need of

protection. Furthermore, these classes are underrepresented in areas already protected, reinforcing their need for protection.

**Table 1: Protection status of indigenous vegetation communities within the Southland region**

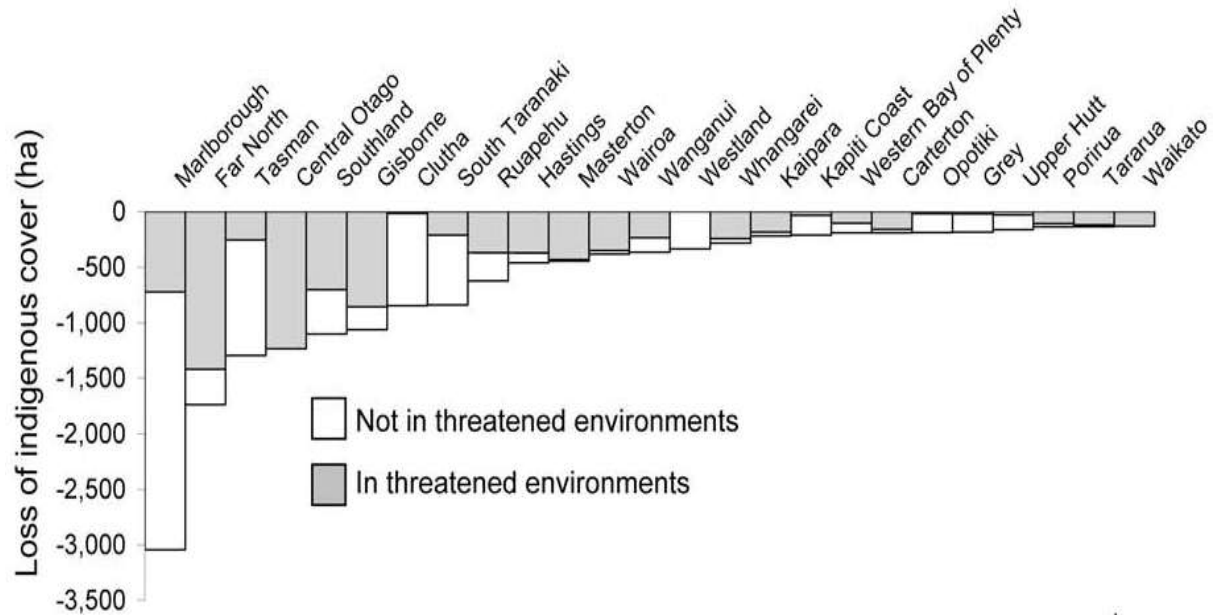
	Alpine		Forest		Shrubland		Tussock	
	ha	%	ha	%	ha	%	ha	%
<b>Protected</b>	205,521	95	1,136,263	93	55,061	59	354,581	84
<b>Not Protected</b>	9,917	5	85,073	7	38,666	41	65,133	16
<b>Southland Total</b>	215,438		1,221,335		93,727		419,714	

Walker et al. (2008) highlight the need for the protection of these remnant communities in Southland. In their research, the New Zealand Threat Classification System (Molloy et al. 2002) was applied to threatened environments identified from the LENZ classification system (Leathwick et al. 2003) in a national assessment of biodiversity most at risk, which included Southland. The parameter for indicating if an environment was at threat was if it occupied <20% of its original extent as defined under level IV of LENZ. If this was the case, then the environment was placed into one of six threat categories that can be seen in **Table 4**. These extents were then calculated across regions at a national level.

**Table 4: The six Land Environment threat categories and defining criteria**

No	Category	Criteria
1	Acutely Threatened	< 10% indigenous cover remaining
2	Chronically Threatened	10–20% indigenous cover remaining
3	At Risk	20–30% indigenous cover remaining
4	Critically Under protected	> 30% indigenous cover remaining, < 10% legally protected
5	Under protected	> 30% indigenous cover remaining, 10–20% legally protected
6	Less reduced and better protected	> 30% indigenous cover remaining, >20% legally protected

One aspect that was looked at within this study was the loss of vegetation within these threatened environments. Regions were compared nationally to quantify indigenous vegetation losses in threatened and non-threatened environments. The Southland region was ranked fifth out of 25 regions in New Zealand for vegetation loss between 1996 and 2008, with approximately 1,101 hectares of vegetation loss of which 703 hectares was within threatened environments (**Figure 11**).



**Figure 10: Loss of indigenous vegetation cover within each of the New Zealand regional councils between 1996 and 2002**

(Source: Walker et al. 2008)

**Table 5** outlines the distribution of private and protected indigenous vegetation across the various LENZ (Level IV) threat categories within the Southland region. Within the region there are approximately 136,461 ha of indigenous vegetation considered in need of protection (Classes 1-5), of this 72,445 ha (53%) occurs on private land. Although occupying a proportionally smaller area across all threat classes (1-6) than indigenous vegetation communities on protected land, indigenous communities on private land occupy a disproportionately higher percentage of threat classes considered ‘at risk’ or in need of protection (classes 1-5). Within threat class 1, “Acutely Threatened”, 68% of this class has no legal protection and on average 50% of land within threat classes 2-5 still has no legal protection. This analysis highlights and further reinforces that many of Southland’s important vegetation communities reside on what is essentially private land. Much of this land has no legal protection, further increasing their risk of degradation or loss, unless placed under some manner of formal protection in the future.

**Table 2: Hectares of Indigenous Vegetation within Land Environment Threat Categories in Southland as of 2011**

LENZ (Level IV) Threat Class

	<b>1</b>		<b>2</b>		<b>3</b>		<b>4</b>		<b>5</b>		<b>6</b>		<b>Total</b>	
	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%
<b>DOC</b>	3,220	28	10,749	53	6,977	39	12,656	58	29,247	45	1,673,090	94	<b>1,735,938</b>	<b>90.3</b>
<b>QEII</b>	527	5	469	2	418	2	61	0	385	1	3,168	0	<b>5,028</b>	<b>0.3</b>
<b>Not Protected</b>	7,908	68	9,059	45	10,604	59	9,173	42	35,009	54	109,328	6	<b>181,081</b>	<b>9.4</b>
<b>Total</b>	<b>11,655</b>	<b>100</b>	<b>20,277</b>	<b>100</b>	<b>17,998</b>	<b>100</b>	<b>21,890</b>	<b>100</b>	<b>64,641</b>	<b>100</b>	<b>1,785,586</b>	<b>100</b>	<b>1,922,047</b>	<b>100</b>

The QEII National Trust provides an opportunity for private landowners to protect significant areas of indigenous vegetation on their properties. The covenanting process involved allows landowners to protect these areas in perpetuity over the title of the land. Private land protected under a QEII covenant has increased in Southland, with 5,875 ha currently covenanted (QEII 2012). However, this is only a minor component of those environments that warrant protection. Areas with and without QEII protection in Southland under the various threat classes developed in LENZ are also outlined in **Table 5**.

### **5.2.3 Wetland loss**

Wetlands were an integral part of Southland's landscape. With high rainfall and impeded drainage, in a landscape dominated by alluvial outwash plains, wetlands spanned vast parts of the landscape prior to European arrival. A wide range of wetland types were present from swamps, fens and bogs to dune slacks, coastal estuaries and marshes. These spanned complex hydrological gradients, intergrading between salt and fresh water ecosystems (Clarkson et al. 2003).

Today, the extent and quality of many wetlands in Southland has severely diminished. The advent of pastoralism in Southland saw the rapid drainage of many wetlands throughout the region for the creation of productive pasture. Innovations, such as the mole plough and drag line, and more recently the excavator, further sped up the drainage of many wetland areas with previously inaccessible parts of Southland, such as the Seaward Downs, rapidly drained and converted to pasture. Many of the natural functions and processes of Southland's wetlands cease to exist today, with weeds and drainage an ever present threat. However, there are still many wetlands of regional, national and international significance present in Southland and the region still has a large number of quality, intact wetlands.

Clarkson et al. (2011) analysed and ground-truthed the WONI (Ausseil et al. 2008) layers for Southland, excluding Stewart Island. Based on a minimum wetland size of 5 hectares the WONI layers were analysed using expert opinion and local knowledge to estimate wetland extent for both ca. 1840 and 2008. The result was a revised estimate of wetland extent for Southland over both these periods and is displayed in **Figure 12**.

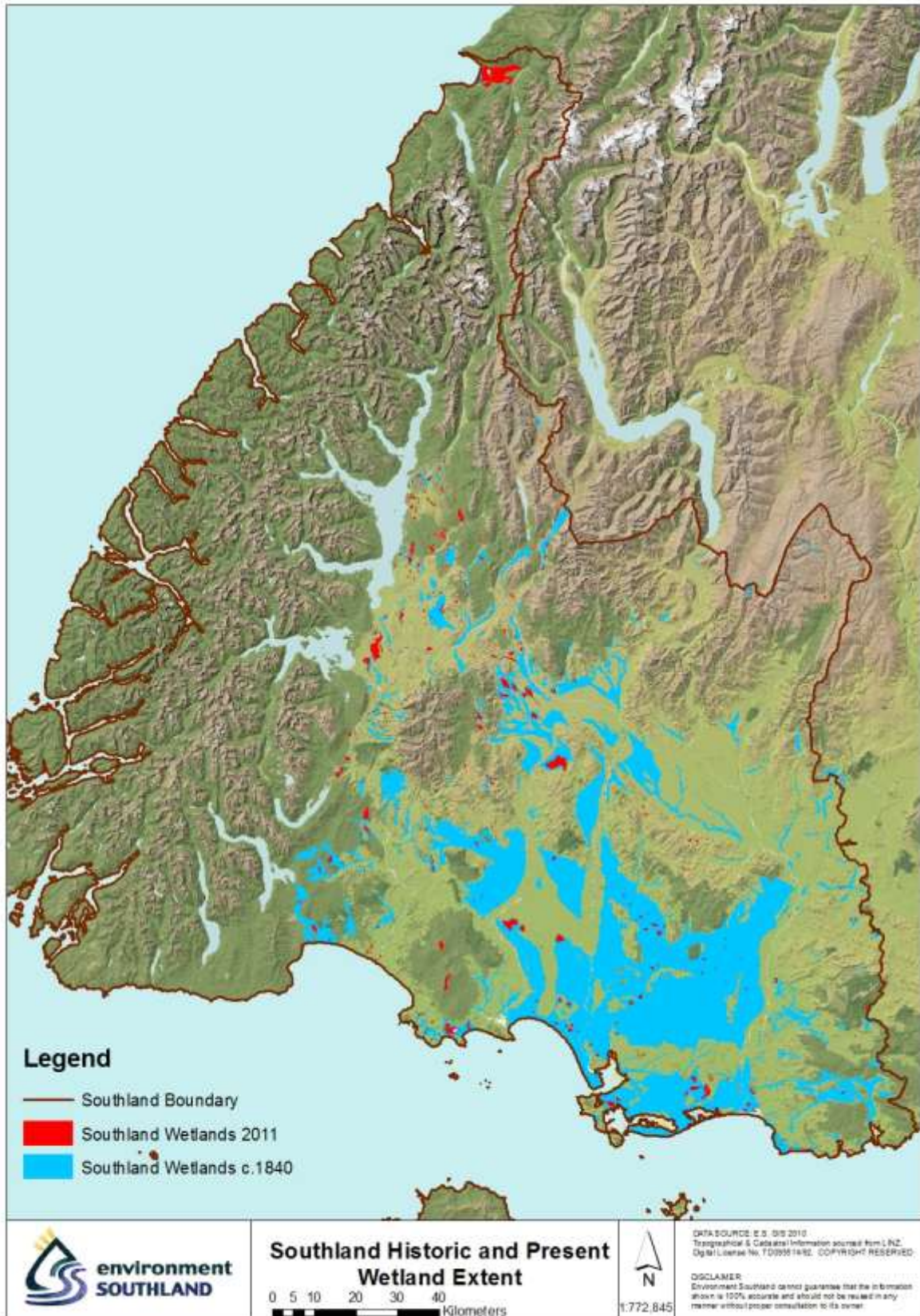


Figure 11: Extent of wetland areas in Southland ca.1840 vs. 2010  
(Source: Clarkson et al. 2011)

While it is estimated that wetlands occupied over 272,000 hectares in the Southland region in 1840, today only 10% remain (**Table 6**). The extent of loss varies according to wetland classes (Clarkson et al. 2011). Bogs are relatively well-represented and Southland is considered a national stronghold, however other classes such as fen, marsh and swamp now only occupy fractions of their original extent (Clarkson et al. 2011).

**Table 3: Wetland extent\* in 1840 and 2011 for the Southland region (excluding Stewart Island)**

Wetland Class	Current Area (ha)	Historic Area (ha)	% Remaining
Bog	19,590.1	30,741.5	64
Fen	5,855.1	46,111.1	13
Marsh	284.2	6,819	4
Swamp	2,084.9	188,612.1	1
<b>Total</b>	<b>27,814.4</b>	<b>272,283.7</b>	<b>10</b>

\* wetlands <5 hectares were not included in this calculation

Wetland clearance is still occurring today. Peat bogs are still being converted to pasture and tile drainage is still regularly used to drain degraded wetland habitats for the development of pasture. The true extent of wetland loss however is unknown. Many of Southland's wetlands are under 5 ha (i.e. not mapped in **Figure 12**) and are often in a severely degraded condition. Unconsented wetland drainage and development of these smaller wetlands is occurring throughout Southland, however there is no current formal monitoring of wetland loss in the region. It is not just active development that is threatening wetlands. Weed invasions, altered hydrological inputs and animal incursions all threaten the integrity of Southland's wetland ecosystems. The further degradation and decline in wetland area in Southland will continue unless formal monitoring, strong advocacy and protection of these smaller, more vulnerable wetlands take place.

## 5.2.4 Conclusions

During the course of human occupation in Southland, the single biggest land cover change that has occurred is the loss of indigenous forest, shrubland and wetlands and its replacement by agricultural farming systems dominated by exotic species. This loss has disproportionately affected lowland ecosystems with both wetlands and forests occupying less than 10% of their original extent across the region in these areas.

The widespread change in land cover has had significant impacts on biodiversity, soil stability and water quality. The loss or modification of habitats brought about through woody vegetation loss has fragmented landscapes and resulted in the loss of much of Southland's lowland indigenous terrestrial biodiversity. The modification of riparian habitats and the increased sedimentation resulting from the transition from forest and shrubland to low-stability short tussock and grassland species has likely had significant detrimental effects to aquatic biodiversity in the region's rivers, estuaries and coastal environments. It is likely this historic loss of vegetation has weakened the resilience of these fragmented terrestrial and aquatic indigenous ecosystems, making them more vulnerable to pressures from current day land uses.

Today, with recent high commodity and land prices for both the dairy and sheep and beef sectors, there has been an increased incentive to develop and improve previously marginal parts of the agricultural landscape, including parts that often hold significant pieces of remnant vegetation or wetland. The ecosystem services that these remnants provide (clean water, biodiversity, carbon storage etc) are integral in supporting Southland's environmental health and wellbeing. The



conservation and protection of Southland's remaining indigenous vegetation is essential. These ecosystems are vulnerable and if not protected many of these communities could be lost.

Environment Southland's current legislation and monitoring methods need to be assessed to determine if Council can:

1. reliably inventory and monitor indigenous vegetation communities, and;
2. be assured that legislation and regulatory authority response adequately protects these at risk communities.

Unless Council is able to achieve these with confidence there is the risk of losing these highly vulnerable communities forever and impacts on remaining communities will increase.

### 5.2.5 Summary

- Indigenous vegetation provides a multitude of ecosystem services from clean water and land stabilisation to refugia for native fauna.
- Mainland Southland has lost 50% of its indigenous forests since human arrival.
- Shrublands went through a period of expansion post Polynesian burning and much of these have been lost to pastoral expansion.
- Today exotic dominated plant communities occupy 37% of mainland Southland.
- Ten percent of Southland's indigenous vegetation is under private ownership while 41% of the region's shrublands are legally unprotected.
- 68% of acutely-threatened communities in Southland do not have legal protection while 42% of indigenous communities classified as critically under-protected in New Zealand do not have legal protection in Southland.
- 90% of Southland's wetlands have been lost.
- Native vegetation is still being cleared.
- It is hard to quantify how much vegetation is being cleared and of what value it is, as there is no detailed formal monitoring of indigenous vegetation health and change on private land within Southland.

## 5.3 Deer in Southland

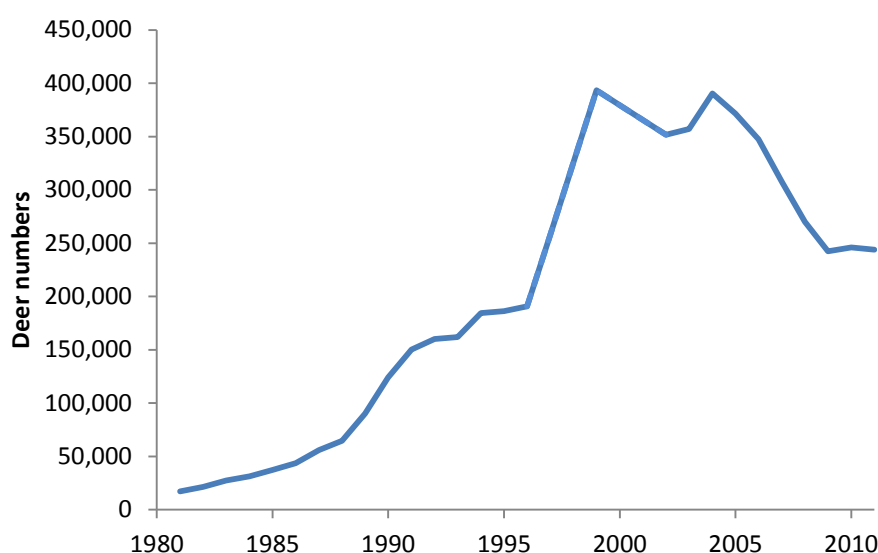
Data on the extent of deer farming in Southland is limited. This section outlines the growth of the industry since its inception in the region in the early 1970s and briefly considers the risks that deer pose to the environment.

### 5.3.1 History

Deer farming is a relatively new industry in Southland in comparison to dairy or sheep and beef farming. Southland can lay claim to being the birthplace of deer farming with deer being farmed since the early 1970s (Cutt 1996), however, official records of deer numbers in the region do not start until 1982. The industry steadily grew in Southland with deer farms establishing throughout the region, often as an extension to existing sheep and beef farming operations. Some specialist deer farms were established, particularly in the Te Anau Basin where Landcorp Farming significantly invested in building their deer numbers in the 1980s. This period of early development in the industry saw steady growth right through until the late 1990s (**Figure 13**).

### 5.3.2 Deer farming 1995-2011

Today, Southland still remains a stronghold for deer farming. In 1995, 15% of the national herd was located in Southland. This increased to 22% by 2002 and has remained between 21 and 22% over the past decade (Statistics NZ, Agricultural Statistics). Between 1995 and 2002 there was a considerable rise in numbers, despite the Asian Economic Crisis stymieing growth in other primary sectors, and by 2004 there were 290,000 deer in Southland. However, since 2004 these numbers have slowly fallen away to only 244,000 in 2011. Although local data was unavailable, nationally the total number of deer farm numbers dropped 29% between 2002 and 2007 (Statistics NZ, Agricultural Statistics). A parallel survey conducted by the Deer Industry New Zealand (2009) also highlighted that a number of respondents had an intention to decrease deer numbers the following year by approximately 1.4% nationally. Both these statistics reflect the drop in deer numbers observed in Southland between 2004 and 2009 (**Figure 13**). The drivers behind these fluctuations are likely to be varied; fluctuating prices for velvet and venison, the demand for dairy land and recent increases in lamb and wool prices are all likely to be significant.



**Figure 12: Deer numbers in Southland 1982-2011<sup>1</sup>**

(Source: Statistics NZ, Agricultural Statistics)

The deer numbers outlined in **Figure 13** have been obtained from Agricultural Production Surveys conducted by Statistics NZ. There is some suggestion that these estimates may underestimate the deer population as the sampling design does not adequately capture small herds, and there may be some underreporting to reduce individual tax bills (Nixon 2004). Nevertheless, in the context of the regional herd number, these factors are only expected to account for minor variability.

Little accurate information is available on the total number of hectares of deer farms in Southland. Some information is captured under rating data at Environment Southland. However, deer farms are only rated as deer when they are specialist producers and most farms are primarily sheep and beef, with deer being a varying component. Consequently, utilising this dataset would grossly underestimate the area in deer farming in Southland. An investigation into the hectares occupied by deer farms was conducted by ES in 2013 as part of a riparian fencing investigation. From this investigation it was estimated that there was approximately 27,000 ha of land used for deer farming in Southland (unpublished data ES 2013). It is estimated that only 19% of the national herd are

<sup>1</sup> Between 1996 and 2002 only one year was sampled (1999). 2004 deer figures are not directly comparable with 2002 and 2003 figures. Statistics New Zealand estimates an undercount of about 70,000 deer at 30 June 2002, and 50,000 at 30 June 2003.

farmed on specialist deer farms, while 70% are found on sheep and/or beef farms (Deer Industry New Zealand 2012). This is likely to be representative of the situation in Southland as well.

Intensification within the deer industry appears to be at a standstill when deer numbers are considered. National surveys conducted in 2008 by the Deer Industry New Zealand indicate that farmer intentions were to reduce hind and stag numbers by approximately 18,000 that year. This appears to be the case in Southland, with a stabilisation in deer numbers since 2009 after a sharp fall between 2004 and 2009 (Figure 13). Data was not available to analyse herd size and farm numbers in Southland.

Although Southland contains a considerable portion of the national herd, deer only make a minor contribution to the total stock pool in Southland. Deer can have a significant effect on water quality, particularly suspended sediment, from behaviour such as wallowing and fence walking (McDowell 2008). This is exacerbated in landscapes where relief creates preferential overland flow paths for water carrying contaminants and where riparian areas are unfenced. Any future expansion in deer numbers in Southland needs to be managed carefully with respect to these risks, especially in hill country landscapes where fencing riparian zones remains difficult and overland flow paths to waterways are abundant.

### **5.3.3 Summary**

- Deer farming has only been present in Southland since the early 1970s.
- The industry experienced strong growth through until 1999 where it reached a peak of 393,000 deer. Numbers have since declined by 40% to 242,000 in 2011.
- Deer farming is estimated to cover approximately 27,000 ha in Southland.
- Deer are known to have a significant detrimental effect on water quality and soil stability through behaviours such as fence walking and wallowing. Riparian protection is a key to avoiding this.
- Spatial data on the extent of deer farming in the region was unable to be obtained for this report and is a gap that needs to be addressed to better understand their impacts on the riparian environment.

## **5.4 Cropland in Southland**

This section outlines the historical change in crop area and production within the region, highlighting the shift from arable crops to fodder crops. Data on the coverage of cropland in the region is scarce, however, there are a few sources of data and these have been analysed to determine their accuracy and suitability for use in future reports. Winter fodder crops are recognised as a key nutrient-loss activity when grazed. This section attempts to quantify the area of this crop type grown in Southland along with providing a brief overview of the environmental effects of cropping.

Cropland is an all-encompassing term that covers a variety of plant species and farm systems. Arable or horticultural crops may be the primary source of income for some farms while fodder crops may only form a minor component of a pastoral farm as part of its pasture renewal cycle. Due to the variable nature of data available for these different cropping systems this section will deal with each of these crop types individually.

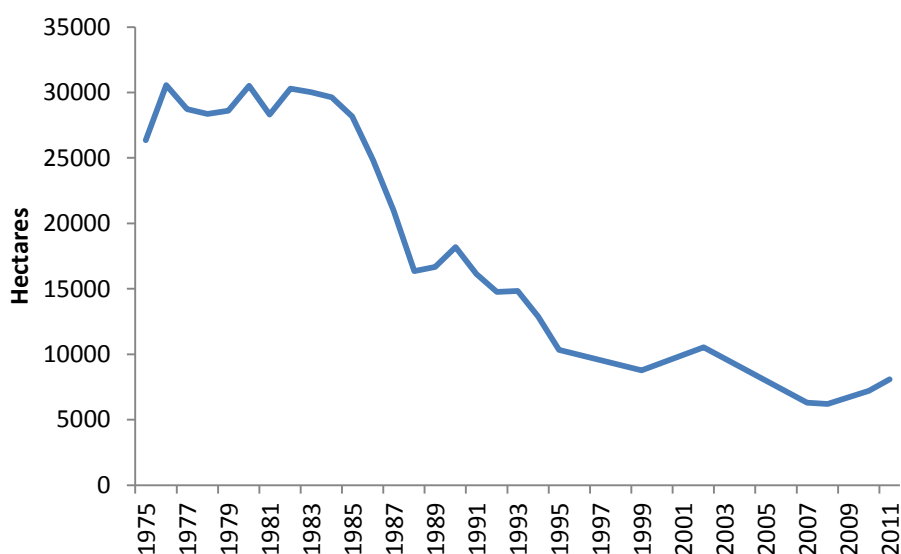
### **5.4.1 History**

In Southland, the dominance of cropping in the landscape has transitioned from primarily arable crops in the early 20<sup>th</sup> century to the pastoral fodder crops that are widespread today. This transition is partially attributable to poor arable crop prices in comparison to other agricultural products, however it is also a result of the transition to more intensive pasture-based systems

which requires fodder crops to supplement winter feed shortages. Data on cropland in Southland is limited and variable, especially when trying to examine specific crop types, such as winter feed crops or vegetable crops. Early survey data on acres of arable land or cropped land vary in their presentation through the decades rendering the data incomparable over the long term. Nevertheless, there are some data sources that have been able to capture crop coverage and change in Southland.

Historically, oats were the major crop grown in Southland. Records show that in 1870, 4,000 hectares of oats were grown in comparison to only 813 hectares of barley (MacFie 2006). The development of the wheat board in the 1930s saw wheat yields increase in the region up until the 1980s when the deregulation of the industry saw significant decreases in the area sown. Arable cropping remained a key land use during the early agricultural development of the region, however as the dairy and meat and wool sectors began to dominate in the 20<sup>th</sup> century, arable cropping declined in significance. In the early 1900s, arable land occupied over 50,000 hectares in Southland, however by 1994 this had reduced to only 12,000 hectares, a reduction of 75% (Statistics NZ, Agricultural Statistics).

This decline in arable land area is illustrated by data obtained from Statistics NZ displaying the total hectares of arable crops grown in Southland from 1975–2011 (**Figure 14**). After 1984, around the time the industry was deregulated and the wheat board disbanded, the total area of arable crops grown in Southland fell sharply, by almost 50% over five years, and continued to decline to a low of 6,000 hectares in 2008.



**Figure 13: Hectares of arable land sown in the Southland region 1975-2011**  
(Source: Statistics NZ, Agricultural Statistics)

### 5.4.2 Cropland 1995-2011

Post 1995, data on both arable and fodder crops is more readily available through datasets such as the LCDB and Statistics NZ Agricultural Production Surveys, and research conducted by DairyNZ and the Beef and Lamb Economic Service. Recent changes in arable and fodder crop extent, post 1994, are summarised from the datasets available in the following sections.

#### *LCDB Cropland*

Cropland, referred to as “short rotation cropland” is captured by LCDBs 1, 2 and 3. As defined by the LCDB, the class includes land used for growing cereal crops, root crops, annual seed crops, annual vegetable crops, hops, strawberry fields, annual flower crops, and open ground nurseries.

This classification is far more encompassing than other definitions of cropland, however, this is a product of the focus on land imagery data as opposed to individual farm information relating to the crop type.

The accuracy of the data is consistent between LCDB 2 and 3, where information was supplemented by additional data extracted from Agribase™, a spatial database describing “Farm Types” and maintained by AgriQuality New Zealand Ltd. Supplementation enables Agribase™ survey data to be coupled with spectral imagery to create an enhanced layer encompassing these various arable and horticultural crops. **Table 7** outlines the hectares of Short Rotation Cropland<sup>2</sup> as defined by LCDB 3 over the three time periods, 1996, 2001 and 2008 and breaks it down by Land Use Capability (LUC) class. LUC classes 1-4 are considered suitable for cropping (Lynn et al. 2009), so hectares of short rotation cropland are split into two sub-units, land use classes 1-4 and land use classes 5-7.

**Table 4: Hectares of Short Rotation Cropland in LUC classes for 1996, 2001 and 2008**  
(Source: LCDB1 (2006); LCDB2 (2001); LCDB3 (2008))

	1996	%	2001	%	2008	%
<b>LUC (1-4)</b>	6,420	98	6,449	98	7,265	98
<b>LUC (5-7)</b>	76	2	76	2	113	2
<b>Total</b>	<b>6,523</b>	<b>100</b>	<b>6,549</b>	<b>100</b>	<b>7,408</b>	<b>100</b>

The figures outlined in **Table 7** reveal relatively little change over the 12-year survey period with only a slight increase in short rotation crops of 885 ha, with 98% of crops occurring in LUC classes 1-4 in each measurement. This estimate of cropland in Southland appears to be a gross underestimate of total cropland when compared to other available data sources. However, the estimate is more closely aligned with the figures for arable cropland collected by Statistics NZ (**Figure 15**). It is suggested that this dataset is not used in the future for such comparisons. These other data sources are investigated in detail below.

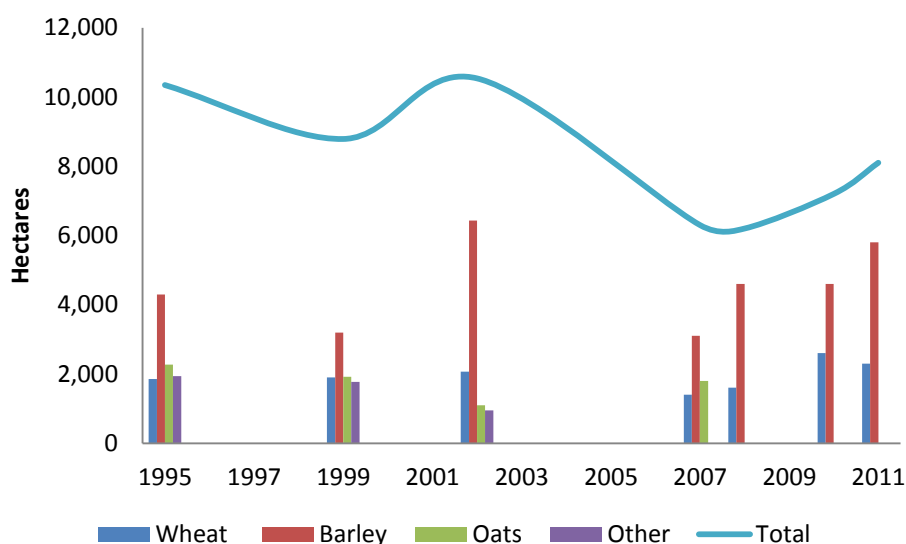
### *Arable Cropland*

Today, arable crops comprise only a minor component of Southland’s landscape. After 1995, regular data available on arable cropping area and yields is scarce and variable. However, there is reliable data on some arable crops that is captured through the Agricultural Production Surveys conducted by Statistics NZ.

Total arable crop area in Southland appears to have declined over the past 15 years, but on closer inspection, each of the grain crops measured in a given year has remained relatively stable over this period. For example, in **Figure 15**, barley, which is Southland’s leading arable crop by area sown, has remained stable. Similarly, the wheat crop has remained stable, while oats was not recorded after the 2007 survey, which has resulted in lower totals post-2007. These data indicate that although small in comparison to other land uses and winter fodder crop coverage, the arable cropping sector has remained relatively stable between 1995 and 2011 with only a small decline in coverage during this period.

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<sup>2</sup> Short rotation cropland is defined as land used for growing cereal crops, root crops, annual seed crops, annual vegetable crops, hops, strawberry fields, annual flower crops, and open ground nurseries.



**Figure 15: Hectares of crop grown in the Southland region 1995-2011**

(Source: Statistics NZ, Agricultural Statistics). *Note: Data on Oats and Other not collected after 2007 and 2002 respectively.*

The Foundation for Arable Research (FAR) distributed figures of known cropping farms in Southland in 2010. These farms totalled 14,948 ha. This estimate is double that of the Statistics NZ figures for that year (7,200 ha), however the figure encompasses the total area of crop farms, not the amount of crop grown in that year. Regardless of this, discrepancy it highlights that arable cropping in Southland remains a relatively minor land use and only occupies 6% of LUC classes 1-7, even at the higher FAR estimate (**Table 8**).

**Table 5: Hectares of arable cropping farms within Land Use Capability Classes 1-7**

LUC Class	1	2	3	4	6	7
FAR Crop ha	26	5,338	8,945	615	608	210
% of class	0	1	3	2	0	0

### *Horticultural Crops*

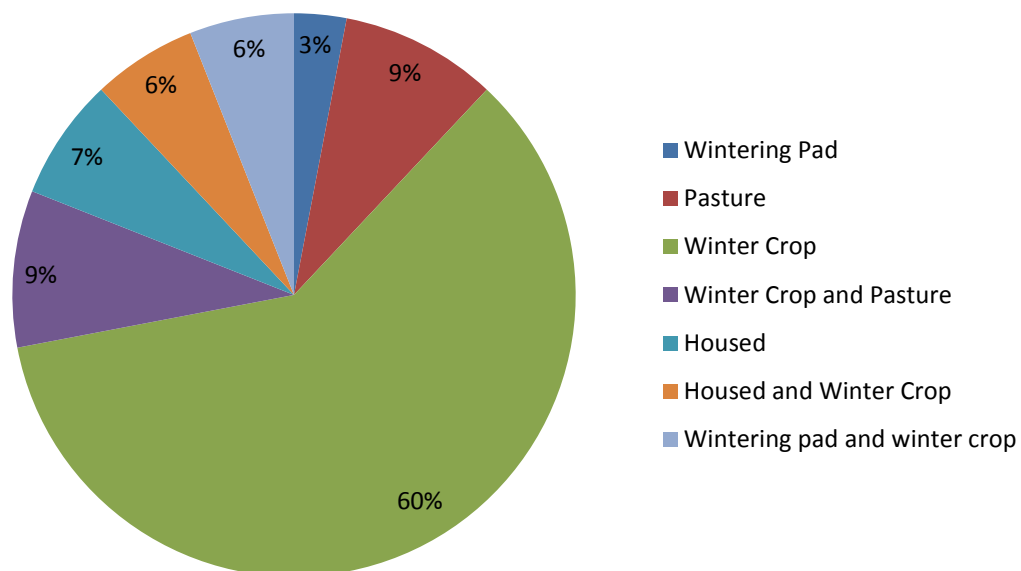
Horticulture and vegetable statistics are furthermore scarce to come by in Southland and the only reliable figures come from Statistics NZ data collected in the Agricultural Production Surveys. The LCDB does attempt to capture some of these categories under the “Orchard Vineyard and other Perennial Crops” category, however, this only produces five sites for the whole of Southland, which is a gross underestimate. This is likely due to the minimum scale of the mapping procedure, which is set at 1 ha (Thompson et al. 2003). With most of these crop types occupying areas smaller than 1 ha they have not been picked up in the mapping procedure. The LCDB would pick up some larger scale vegetable production under its “Short Rotation Crops” category, however it does not distinguish horticultural crops from others within this category.

The last Agricultural Production Survey that captured any statistics on vegetable, fruit and nut production in Southland was the 2007 survey. In 2007, there were 63 ha of potatoes, 11 ha of table brassicas, 233 ha of “other” vegetables, 12 ha of fruit and 30 ha of nuts. Today, the major vegetable producers in Southland (Pypers Produce and Southern Cross Produce) produce approximately 400 ha of vegetables, while bulb growing occupies a further 200 ha.

### Fodder Crops

Typically, dairy farmers in Southland require the equivalent around 12-20% of their farm area in winter forage crop (Chakwizira & De Ruiter 2009; Monaghan 2010). In their study of Southland winter feeding programmes, Chakwizira & De Ruiter (2009) calculated that an average-sized dairy farm (497 cows, 191 effective ha) required between 23 and 35 ha of winter crop depending on Dry Matter (DM) yields, 12 t/DM/ha and 18 t/DM/ha respectively. Based on the 2011 Southland dairy cattle numbers from the Statistics NZ Agricultural Statistics (614,648), the total hectares of crop can be calculated by taking the average amount of hectares of crop required per cow and multiplying this by the total cow numbers in Southland. At optimum yields of 18 t/DM/ha, this equates to 28,443 ha of crop and at the sub-optimum yield of 12 t/DM/ha this equates to 43,285 ha of crop. Tarbotton *et al.* (2012) calculated for South Otago and Southland that 60% of cows are wintered on brassica crops alone and that at least approximately a further 10% were wintered on mixed feed systems (e.g. winter crop and pasture) (**Figure 10**). Based on an estimate that 70% of cows in Southland are utilising some form of winter crop, this equates to a revised estimate of 19,910 ha and 30,299 ha for the two respective DM yields calculated above.

It must be noted that the Statistics NZ dairy cattle estimate, derived from the Agricultural Production Surveys is likely to overestimate the number of cattle wintered as it includes bobby calves as at 30 June each year. Nevertheless, this is counterbalanced somewhat by the conservative estimate (70%) of winter grown crops calculated from **Figure 16**. It is acknowledged there are other variables, which will influence the total hectares of dairy winter crop grown in the region. Wintering cows out of the region, conversion to herd homes and imported feed and supplements to the region all affect the amount of winter crops required. However, this at least serves as a broad estimate of the winter crop requirements to service Southland's cow numbers in 2011.



**Figure 16: Wintering systems of 204 farms in South Otago and Southland, winter 2010**  
(Source: Tarbotton *et al.* 2012)

**Figure 16** only accounts for the winter crop requirements of dairy cows, and there are still large amounts of crop grown to support sheep, beef and deer operations in Southland. Data on winter crop coverage in the Otago and Southland region for sheep and beef farms was supplied by the Beef and Lamb New Zealand Economic Service. It is important to note that this data represents winter crops grown *on* sheep and beef farms as opposed to *for* sheep and beef cattle. There will be crop within this figure that is grown to support dairy cattle grazed on these properties during the winter. From the sampled farms, an estimate of winter forage crops has been generated and is outlined in **Table 9** below.

**Table 6: Percent winter crop coverage on different sheep and beef farm types in the Otago-Southland region**

(Source: Beef and Lamb New Zealand Economic Service 2012)

	<b>High Country</b>	<b>Hill Country</b>	<b>Finishing Breeding</b>	<b>Intensive Finishing</b>	<b>All Classes</b>
Average Farm Size (ha)	6332	1069	665	250	757
% of farm* in crop	0.6	3.4	4.8	10.8	4.0

\*Effective hectares only

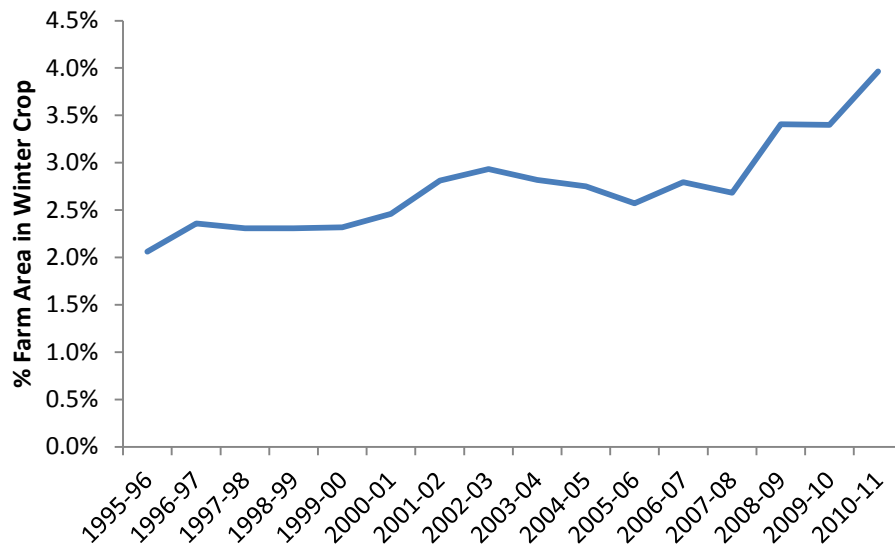
**Table 11** highlights that sheep and beef farms with higher production tend to have larger percentages of the farm in winter crop. It is estimated that there are 668,000 hectares mapped as High Producing Grassland (LCDB3) in Southland that are occupied by sheep/beef/deer farming (derived from **Figure 6**). If the average winter cropping percentage is taken (4.0%) and multiplied across this area of High Producing Grassland, this equates to 26,720 ha of winter crop grown on sheep and beef farms in Southland. This could potentially be an underestimate, as the relative proportions of intensive finishing sheep and beef properties compared to the more extensive hill and high country properties is unknown and quite likely higher. The value of 4.8-10.8% of the farm in winter crop on more intensive systems concurs with the general perception that an average farm will undergo a 1:10 to 1:20 year pasture renewal cycle across its total effective area, where winter crop is typically used to initiate the pasture renewal cycle and to build up fertility prior to re-grassing.

Bringing together the estimates for dairy winter crop with those for sheep and beef winter crop, horticultural and arable crops is estimated at between 54,000 ha and 64,000 ha for the Southland region (due to the high and low dairy winter crop estimates). However, this figure must be treated with caution as overlap will occur with sheep and beef farms, providing some of the area calculated for the dairy cattle winter crop requirements. This is really a best guess estimate based on the current data available. There are many factors that will influence a change in these numbers, such as a shift to using more imported supplements, relocating stock out of the region for winter grazing purposes or more sheep and beef farms providing contract winter grazing for the dairy industry. Nevertheless it serves as a benchmark figure against which to test in the future. More complete survey data or aerial surveys of winter crop in the region are the only way to be certain of the true figure of crop grown in Southland and should be considered if an accurate picture is of high importance.

### ***Intensification***

Data on winter crop coverage in the Otago and Southland region for sheep and beef farms supplied by the Beef and Lamb New Zealand Economic Service suggests that the hectares of winter crops grown in this sector are increasing. **Figure 17** shows a steady increase in the percentage of crop grown on sheep and beef farms in the Otago-Southland region, with a noticeable sharp increase of over 2% from 2007/08 to 2010/11.





**Figure 17: Percentage of farm area in winter crop on sheep and beef farms in the Otago-Southland region 1995-2011**

(Source: Beef and Lamb New Zealand Economic Service, 2012)

No published data was obtained on dairy winter crop intensification (changes in DM yields per hectare or percent farm coverage) in the Southland region. There are differences in yield between crop types used for winter grazing. The following yields have been recorded for the main crops utilised in Southland: Swedes = Turnips < Kale = Fodder Beet (Scott 1971). As kale and fodder beet produce higher dry matter yields they are able to support either larger number of animals or utilise a smaller area of land. This increases intensification of crop grazing on that particular site. However, there is no information available on shifts in the usage or hectares of each crop type grown in Southland so comparisons cannot be made.

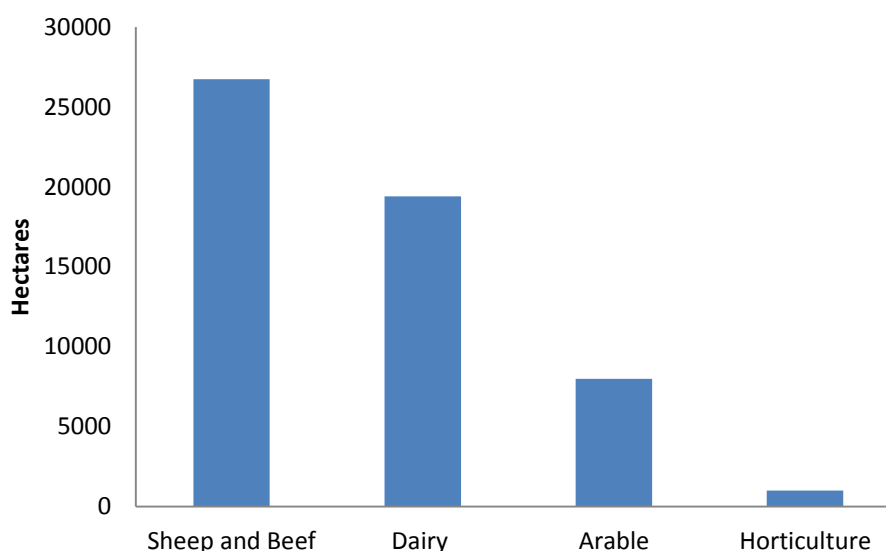
Fodder beet is being increasingly used in New Zealand and is a more intensively grazed crop type when compared to swedes or turnips. Unfortunately there are no data for Southland and little information on the relative environmental effects (Chakwizira & De Ruiter 2009). There is also little information available around summer feed crops or cereal crops harvested for winter stock feed in the region.

Although a minor component of cropping in Southland, arable crop yields per hectare are obtainable for the region from Statistics NZ Agricultural Production Survey data. Yields have remained stable between 1995 and 2011 with wheat yields staying between 6 to 9 tonnes per hectare, barley yields between 5 to 7 tonnes per hectare and oats between 5 and 6 tonnes per hectare (no data was available for oat yields after 2007).

### **Conclusions**

It is difficult to obtain an accurate estimate of cropping land grown in Southland, particularly for winter crops. The amount of winter fodder crop grown from year to year is likely to be stable for sheep and beef farmers who typically place 4-10% of their effective farm area in crop to support their own stock feed requirements and re-grassing program. Contract winter dairy grazing has led to some sheep and beef farmers reducing stocking rates to take on dairy grazing, or placing more of the farm in crop to support dairy grazing. Dairy farmers also own dairy support land and place some of their milking platform in crop. Consequently, calculating the total area under winter crop in Southland is difficult and has many variables influencing the amount of crop grown. Accurate arable and horticultural crop data is also difficult to estimate on a year-to-year basis, with datasets sporadic in their collection frequency and variable in their accuracy.

The values presented in **Figure 18** highlight that almost 27,000 ha of crop grown in Southland occur within the sheep and beef sector. Much of this will be grown to support on-farm stock, however an unknown portion will also be set aside for contract grazing for the dairy sector. Data from DairyNZ shows that a conservative estimate of 19,000 ha of crop is potentially required to support the Southland dairy sector's winter crop requirements. Although there will be some cross-over between these two figures, it clearly demonstrates that a large proportion of Southland's crops – potentially over 75% excluding summer feed crops – is grown for the sheep/beef and dairy sectors and is principally for winter grazing purposes. The arable sector is comparatively minor with only 8,000 ha of crop grown in Southland and figures fluctuating between measurement periods by as much as 50%. These figures are only approximates produced from the best data available across the different sectors. The figures do not account for winter feed cereal crops nor summer feed crops and there are a number of factors which may influence the figures in any one year e.g. arable crop prices, imported supplements and wintering dairy cows on crops outside the region.



**Figure 18: Estimated maximum total area (ha) of crops grown per annum between different agricultural sectors in the Southland region <sup>3</sup>**

Cropping can have serious effects on soil and water quality. Winter crops have been found to be a significant contributor of contaminants (Nitrogen, Phosphorous, *Escherichia coli* – *E. coli*<sup>4</sup> and Suspended Sediment) to the region's water resources (Monaghan et al. 2010; Monaghan 2012) and arable and horticultural crops are also known to lose high rates of nutrients and sediments in some cases (Monaghan et al. 2010). Soil quality can be severely impacted particularly in soils that have a high structural vulnerability such as Gley or Pallic soil orders (Monaghan 2012) which are common throughout the region. The relative environmental risks of stock type when winter cropping has been outlined by Monaghan (2012), with Deer winter cropping > Dairy > Sheep for P and Sediment loss and Dairy > Deer = Sheep for N loss. However, it acknowledged that further work needs to be done in this area as recent trial work (Moir et al. 2010) indicates sheep urine N losses

<sup>3</sup> There is likely to be considerable cross over between the Sheep and Beef and Dairy totals, with the total figure between the two (46 130ha) considered the maximum area. The true area is likely to be smaller due to crop accounted for in the Dairy calculation being located on Sheep and Beef land along with other factors such as dairy cattle being wintered out of the region. The Dairy crop figure is based on optimal yields (18T/DM/Ha) to generate the area of crop required to support Southland dairy cattle in 2011.

<sup>4</sup> *E. coli* is a type of bacteria that is usually found the lower intestine of warm-blooded organisms. It is used as an indicator of faecal contamination of waterways and as an indicator of the risk of exposure to disease-causing micro-organisms.

from winter crop grazing can approach levels similar or greater than those from cattle-grazed winter crops.

It is important to get a better understanding of the distribution and management of these crops in Southland, particularly winter crops, which dominate the land area under crops in Southland. Stock type, crop type, topography, soils and management are all key factors which will influence contaminant losses and soil quality effects from cropping operations. Understanding the extent and location of crops, and their relative risk to soil degradation and contaminant losses within the landscape is vital if farmers and council are going to effectively manage the negative environmental impacts of cropping.

### 5.4.3 Summary

- Arable crops have declined in the region from 50,000 ha in the early 1900s to less than 10,000 ha in 2011.
- Horticultural crops occupy less than 1000 ha of land in Southland.
- Statistics New Zealand figures provide the most reliable estimate of horticultural and arable crops grown in the region.
- Data on hectares of fodder crop grown in Southland, their spatial distribution across the region and for what sector (dairy or sheep, beef and deer) is scarce.
- It is estimated 75% of crops grown in Southland are fodder crops.
- Stock movements out of region, cost of supplements, system changes etc. all influence the amount of crop grown in any one year.
- Based on DM requirements for a wintered dairy cow there is an estimated 20-30,000ha of crop required to support Southland's dairy herd.
- In total it is estimated that Southland grew between 54,000-64,000 ha of crop in the 2010-11 season.
- Cropland can contribute large amounts of nitrogen, phosphorous and sediment to the environment if not managed properly. Winter cropping has been identified as a high N loss practice in the region.

## 5.5 Sheep and Beef

As sheep and beef production typically occurs on the same farm in Southland, this section encompasses figures from both stock types and displays historical trends in numbers along with analysing recent trends in stock numbers and intensification.

### 5.5.1 History

Sheep and beef production has been the cornerstone of Southland's pastoral farming for the past 150 years. However, the sector has not been without its fluctuations in terms of stock numbers and land coverage. Accurate long-term figures on the hectares occupied by sheep and beef farming operations are absent so stock numbers are used as a surrogate to identify the expansion and the intensification of the sector.

Cattle numbers increased steadily in Southland from 1860 – 1995, although the decadal fluctuations observed prior to 1960 (**Figure 20**) may be a product of survey efficacy as opposed to real-time fluctuations. Nevertheless beef cattle numbers rose to a peak in the 1970s of 301,000 and then steadily declined, falling to a low of 172,000 in 1992.

Sheep products (meat and wool) have been the cornerstone of Southland's agricultural production, with the advent of frozen meat trade and wool price spikes driving numbers of sheep up consistently through the late 19<sup>th</sup> and early 20<sup>th</sup> centuries. In 1950, the Southland sheep flock had

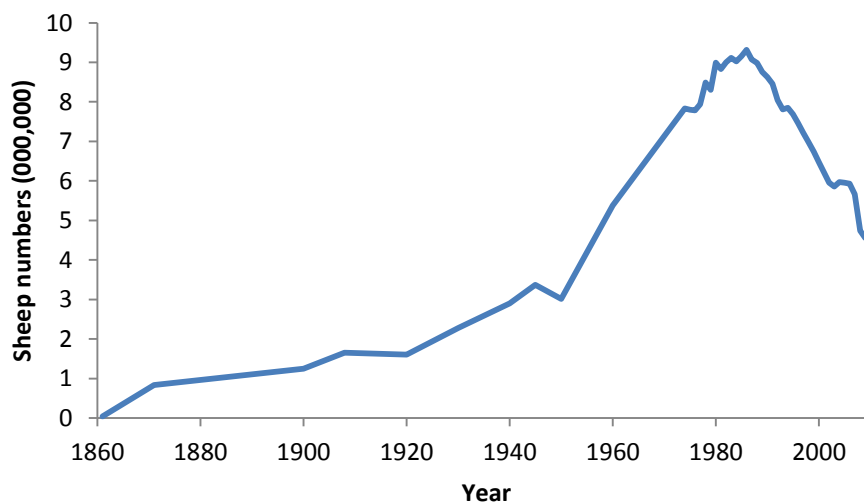
risen to 3 million, and the subsequent wool boom drove numbers up to over 9 million by 1985. During this period many dairy farms were converted to the more profitable meat and wool production (Cutt 2006).

The subsequent deregulation of the markets in the late 1970s and early 1980s led to the largest land use change the region has seen in recent decades. Depressed meat and wool prices in the late 1980s coincided with a resurgence of dairy prices and many sheep and beef farms converted to dairying.

Since 1985, a steady decline in sheep numbers can be observed (Figure 19). They were a result of depressed prices, diversification and conversion to more profitable land uses such as dairying. Interestingly, cattle numbers in Southland have remained relatively stable over this period (Figure 20), which is possibly a reflection of the better financial performance of beef cattle when compared to sheep.

### 5.5.2 Sheep and Beef 1995-2011

Although beef numbers have remained relatively stable, sheep numbers in Southland have drastically declined since 1985. In the last 15 years, numbers have fallen consistently to levels below those recorded in the 1960s. Despite falling numbers, the intensity of sheep farming has not declined (MPI Farm Monitoring Reports 2010; 2012) indicating that the decline in numbers is likely to be a product of land use change.

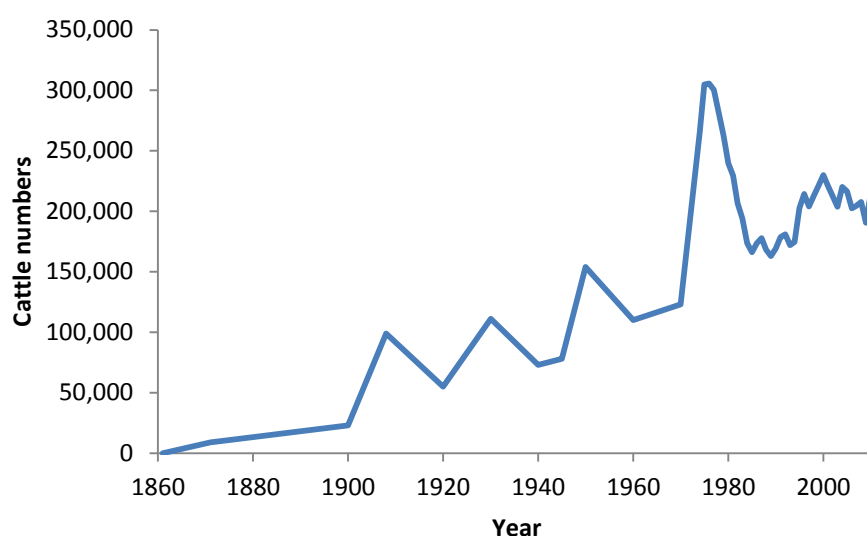


**Figure 19: Sheep numbers in Southland 1861-2011**

(Source Statistics NZ, Agricultural Statistics)

The shift in land use from sheep and beef farming to dairying and the associated decline in sheep numbers are supported by data from modelled sheep and beef production from MPI monitor farms in South Otago and Southland. Between 2006 and 2008, sheep numbers in Southland fell by over a million. However, modelled data from monitor farms (Table 11) showed stocking rates have remained very stable over the measurement period (2006/07 – 2010/11), with lowland sheep and beef farms achieving a mean stocking rate of 13.5 SU/ha with a range of 13.0-13.9 SU/ha. Hill country sheep and beef monitor farms had a mean stocking rate of 8.6 SU/ha and range of 7.7-9.5 SU/ha over this period. The results suggest that while sheep numbers have dropped, stocking rates have increased, indicating that the decline in sheep numbers is likely to be a result of the conversion of sheep and beef land to dairy pastoral land as opposed to a decline in productivity. Corroborating this hypothesised change in land use is the increase in dairy farm numbers and a corresponding decrease in sheep and beef farm numbers between 1999 and 2007. Between this period, sheep and beef farms measured in the respective Statistics NZ Agricultural Production Surveys declined from 2,274 to 2,169, while dairy farm numbers increased from 564 to 630, a net

increase of 66 dairy farms and net decrease of 105 sheep and beef farms. This is further supported by **Figures 21** and **22** whereby the pastoral land use being occupied by dairying in 2011 was primarily sheep/beef/deer land in 2000.



**Figure 20: Beef cattle numbers in Southland 1861-2011**

(Source Statistics NZ, Agricultural Statistics).

An estimate of land coverage of primarily sheep and beef dominated land can be calculated using figures available in the Statistics NZ 2010 Agricultural Statistics. The 2010 Agricultural Statistics identified that there was a total of 1,188,251 ha of farmland in Southland. Analysis of the FAR cropping data, horticultural data and the Environment Southland dairy layer (2011) concluded that these activities occupied approximately 235,000 ha. The remainder leaves 955,053 ha. Some of this land will be occupied by other primary land uses (e.g. specialist livestock) however these are only minor land uses so the figure should accurately reflect the area under sheep and beef pastoralism in Southland. Assessing the area under cropland in Southland reveals that it has remained relatively stable over the past 15 years. The same can be said for most other primary land uses with the exception of Dairy. **Table 10** has been calculated utilising data from the Agricultural Statistics for the stated years with the exception of total farm area in 2000, which is an estimate taken from the closest recorded year (2002). The estimated land area under sheep and beef was calculated by subtracting the total area of dairy (calculated for each year), arable, deer, cropping and horticulture (averaged figure applied across all years). There will be some error as other specialist land use classes could not be calculated; however the trend shows a clear decline in sheep and beef land cover of approximately 15% during this period.

**Table 7: Total hectares of farmland in Southland and estimated area and proportion of sheep and beef farms**

(Source: Statistics NZ, Agricultural Statistics)

	Total area of farm land (ha)	Estimate of Sheep and Beef	% of farmland in Southland
1992	1,227,266	1,175,090	96
2000	1,198,388	1,068,602	89
2005	1,275,630	1,104,678	87
2010	1,188,251	955,053	80

### 5.5.3 Intensification

Data from the sheep and beef model farms for the South Otago-Southland region, produced by MPI gives an insight into productivity and intensification across the lower South Island. **Table 11** highlights a trend on the modelled hill country farms towards increasing sheep numbers resulting in increased stocking rates over the past six years. Beef numbers have fluctuated and there is no clear trend. On the intensive sheep and beef farms mean sheep numbers have fluctuated but were at their highest in the 2011/12 season and are predicted to rise to 3,345 in the 2012/13 season, indicating that sheep stocking rates are most likely intensifying. Overall, although the total area and number of sheep and beef farms have declined in Southland, there appears to be a trend towards increased intensification with sheep numbers climbing during this seven-year period and cattle numbers remaining relatively stable. Analysing long term trends in carcass weights could also be a method of interpreting intensification changes however no reliable long term data was able to be obtained for analysis.

**Table 8: Modelled mean stock numbers and stocking rates for hill country and intensive sheep and beef farms for the South Otago/Southland regions**

(Source: MPI Farm monitoring reports 2010; 2012)

	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12
Hill Sheep	5,203	5,052	4,642	5,529	5,476	5,951
Hill Beef	817	930	961	1010	943	938
<b>Hill SU/ha</b>	<b>8.3</b>	<b>8.3</b>	<b>7.7</b>	<b>9</b>	<b>8.9</b>	<b>9.5</b>
Intensive Sheep		2440	3098	3119	2952	3329
Intensive Beef		90	108	108	108	108
<b>Intensive SU/ha</b>		<b>13</b>	<b>13.7</b>	<b>13.8</b>	<b>13.1</b>	<b>14.7</b>

### 5.5.4 Conclusions

A steady rise in lamb prices from 2008-2011 along with a general drive to increase productivity is likely to be behind the gradual intensification of sheep and beef farms observed. However, overall sheep numbers are still declining in Southland as more sheep and beef properties are converted to dairying or dairy support operations. Beef numbers have fluctuated but have fallen overall by 30,000 since 1995, sheep numbers have dropped by 3.34 million over the same period.

Although not in a period of expansion regionally, sheep and beef farms are still intensifying at the property level and this has the potential to result in increased adverse environmental effects. Although considered to have lesser adverse effect on water and soil quality when compared to dairy farming (Monaghan et al. 2010), there are still opportunities for increased environmental impacts which must be managed for within the sheep and beef farming sector. Access to waterways, intensive winter grazing and inappropriate land development have been identified as contributing elevated sources of contaminants from sheep and beef farming systems and efforts still need to be made to reduce these effects, particularly in the face of a trend towards increasing intensification within the sheep and beef sector.

### 5.5.5 Summary

- Sheep and beef farming has been the cornerstone of Southland's agricultural economy.
- Sheep numbers steadily climbed through to 1950 to reach 3.0 million. In the next 35 years, stock numbers climbed 300% to reach 9.1 million.
- Agricultural reforms in the 1980s led to a decline in sheep numbers to 4.1 million in 2011.
- Beef numbers have steadily increased in the region since European arrival to reach 215,000 in 2011.

- Land occupied by sheep and beef farms has fallen from occupying 96% of farmland in the region to 80% of farmland in 2011 reflecting the decline in stock numbers.
- This decline has been a result of the rapid expansion in dairying across the region, with land sales being driven by poor lamb and wool prices relative to dairy prices and high land prices.
- Although sheep numbers have been declining, sheep and beef farms have still been increasing their stocking rates with an average increase of 0.20 and 0.34 SU/ha/yr for hill country and intensive sheep and beef farms respectively since 2007.

## 5.6 Dairy

Dairying can be a high nutrient-loss activity and its impacts on water quality have received much attention nationally and locally. There are a number of sources of dairy related data available. This section reviews a number of historical and current data sources to review the change in dairying in the Southland region. It focuses on the change in the extent of dairying across Southland and the suitability of soils/landscapes for dairying. Cow and herd numbers are also assessed as is the intensity of dairying and its effects on the environment in Southland.

### 5.6.1 History

Dairying has had a long history in Southland. With the first large herd developed in the region around 1880, the industry slowly grew to 87,000 cows by 1930. Herd sizes were small comparative to today's standards. A dairy farm could make a good living from 50 - 70 cows while many sheep and beef farms also milked a small number of cows to diversify their income (Cutt 2006).

As sheep numbers steadily climbed on the back of strong meat and wool prices from the 1950s, dairy cow numbers fell, due to comparatively poor returns, to a low of 17,000 by 1970. During this period many farms were converted to the more profitable meat and wool production (Cutt 2006) and stock numbers remained static for the next 15 years. From a low of 24,000 dairy cows in 1980, numbers steadily climbed to 44,000 in 1991, and then almost tripled over the next four years to reach 126,000 by 1995 (**Figure 21**).

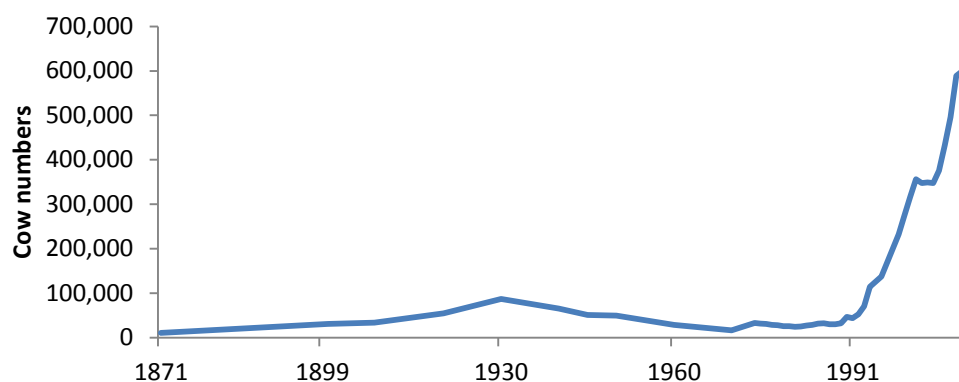
### 5.6.2 Dairy 1995-2011

The expansion of dairying and dairy support since 1990 is the biggest land use change Southland has experienced after the deregulation of the agricultural sector in the early 1980s. This is reflected both in dairy stock numbers and the hectares of land dairying now occupies in Southland.

Dairy cow numbers are reliably calculated in Southland by both the Statistics NZ (Agricultural Statistics) and the joint DairyNZ and Livestock Improvement Corporation (LIC) annual NZ Dairy Statistics. We have chosen to utilise the Statistics NZ data, as their dataset dates back beyond the timeframe used in this section (1995-2011), allowing easy comparison to pre-1995 data. The NZ Dairy Statistics data begins in 1992 and is only used in this section when assessing the change in dairying intensity. There are differences between the two datasets, most noticeably the absence of data from 1997-1998 and 2000-2001 in the Statistics NZ data, hence it is not used for short-term temporal comparisons and calculations of dairy intensity. The definition of cow numbers varies between the two datasets with the NZ Dairy Statistics calculated as the number of cows milked at peak milking in November, while Statistics NZ calculates cow numbers including bobby calves and cows not milking as of June 30 each year. This accounts for approximately a 16% lower annual number of cows reported in the NZ Dairy Statistics data, however both datasets track each other consistently.

Spatial data on dairy farm area in Southland is available from a number of sources e.g. AgriBase™, Quotable Valuations New Zealand (QVNZ) and the Environment Southland (ES) consents database. Each of these sources has a degree of error which has been outlined in **Section 3** in this

report. It was concluded that dairy farm data derived from the ES consent database, which was reliably collected back to 2000, was the best source data for this exercise. The data is derived from consents data held by ES and is matched with the property layer from QVNZ held within ES's rating database. Ground-truthing the data against data from the NZ Dairy Statistics for hectares of dairy farms in Southland shows that the ES dataset generally produces a higher estimate of land occupied by dairying than the NZ Dairy Statistics dataset measured over the years (range 0-14%). Part of this discrepancy is attributable to the NZ Dairy Statistics being calculated for effective land area only, while the ES dataset does not discriminate between effective and undeveloped land on any individual property. Furthermore, some of this difference may be accounted for by land tenure and lease agreements not accounted for by the ES dataset. Nevertheless the expansion of dairying across Southland detailed in NZ Dairy Statistics and Statistics NZ data is reflected well in relative terms by the ES spatial data and it represents an accurate picture of the expansion of dairying across Southland. The exception is the 1992 spatial layer of dairy farms which is derived from a different data source (Fonterra Cooperative Group Ltd.) and is considered to underrepresent the area of dairying at the individual polygon level and must be viewed as an indicative location and occupation of land in Southland during that period, rather than an absolute coverage of the same reliability as the ES 2000-2011 dataset.



**Figure 21: Dairy cow numbers in Southland 1871–2011**

(Source: Statistics NZ, Agricultural Statistics)

Today, 10.7% of the national dairy herd is located in Southland. However, in the 1994/95 season, Southland only 3.5% of the national herd was located in Southland (New Zealand Dairy Statistics) signifying the degree of rapid expansion the industry has gone through in the region in concert with industry expansion nationally.

Dairy cow numbers have been rising rapidly in Southland since the late 1980s, and in the period between 1995 and 2011, dairy cow numbers increased over four-fold by 488,842 cows (**Figure 21**). Cheap land, relative to prices of established dairy land in the North Island, along with a strengthening dairy sector have seen the rapid expansion of the industry throughout Southland. The growth in dairy cow numbers has been maintained through until 2011 with a slight plateauing in numbers between 2002 and 2006 and again from 2009 until 2011. The current rapid rise in dairying is elevated in its significance in the region when compared to the previous 'dairy boom' in Southland during the 1920s and 1930s. During this earlier spike in dairy cow numbers, the population of cows in Southland peaked at 87,000. Today, this number has increased over six-fold to a peak of 614,648 cows in 2011.

During the most recent spike in cow numbers from 1989, traditional historic dairy areas in Southland were the first to be occupied. The earliest spatial file of dairy farm locations in Southland is from 1992 and can be observed in **Figure 22**. As mentioned earlier, the location of



the properties in the 1992 layer is accurate, however the relative size to the other mapped years is inconsistent. These older farms were located on the lower Southland Plains, mainly around Edendale, the site of the only milk processing plant in Southland at the time, with scattered farms elsewhere around the central and western Southland Plains. Soils in these areas are heavier, receive regular rainfall and are highly productive, making them more suitable for dairying. By 2000, dairy farms were entering areas not traditionally considered for dairying such as the Waimea Plains, upper Aparima, mid Waiau and Castlerock – Five Rivers regions. Many of these areas have shallower soils, lower rainfall, and the viability of dairying has only been made possible with high milk solid prices (comparative to pre-1990) or the utilisation of irrigation to maintain pasture production. By 2011, the net area of dairy farms in the region had doubled since 2000 to cover over 195,000 ha (**Table 12**).

Today, dairying is well-established across all these areas. Areas of expansion beyond current dairy areas are limited to the outer limits of Southland's low-lying areas with several new farms in the Catlins and upper reaches of the major river systems in Southland. Potential areas of expansion are in the Te Anau basin and further into the upper reaches of the major river catchments in Southland.

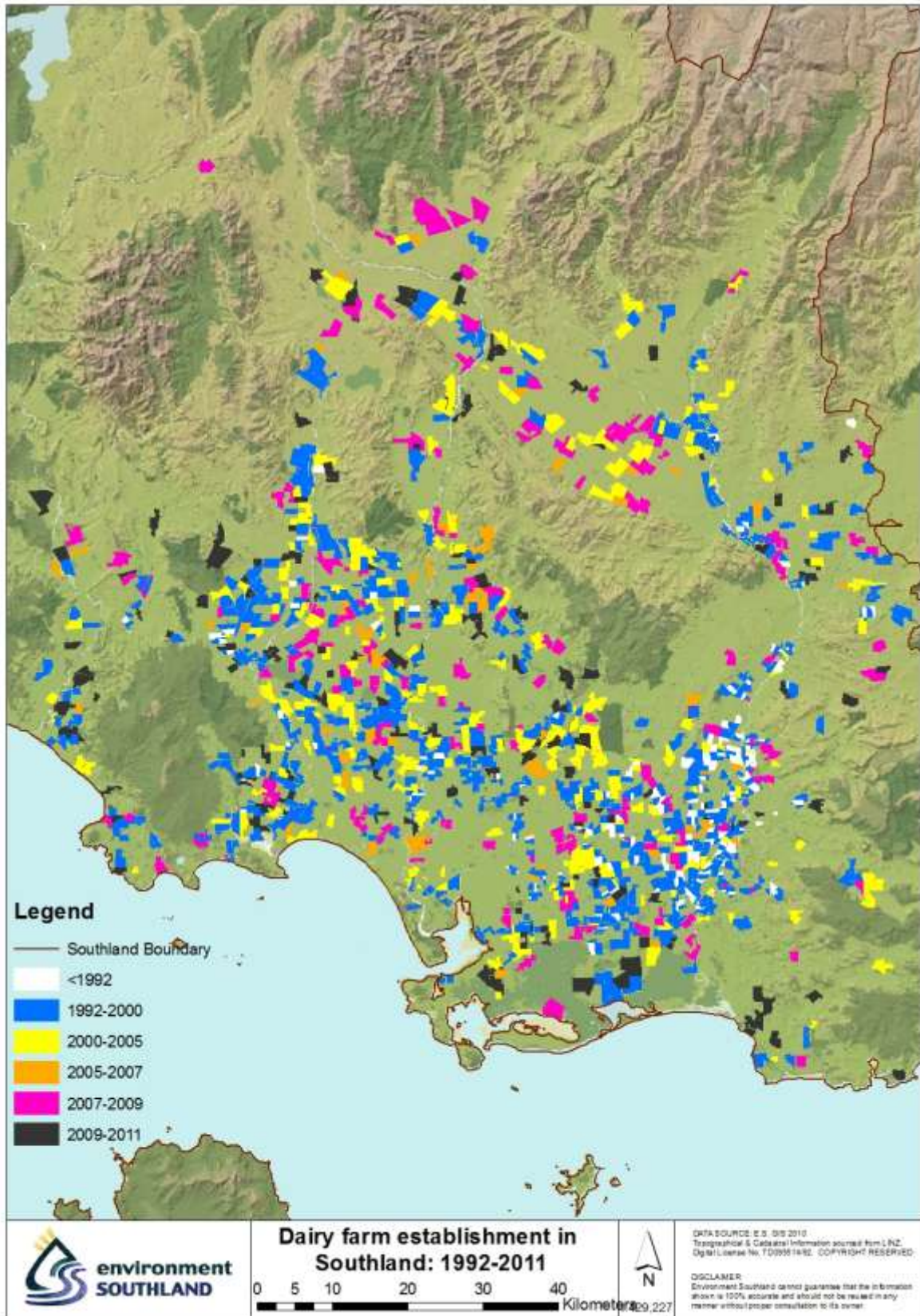


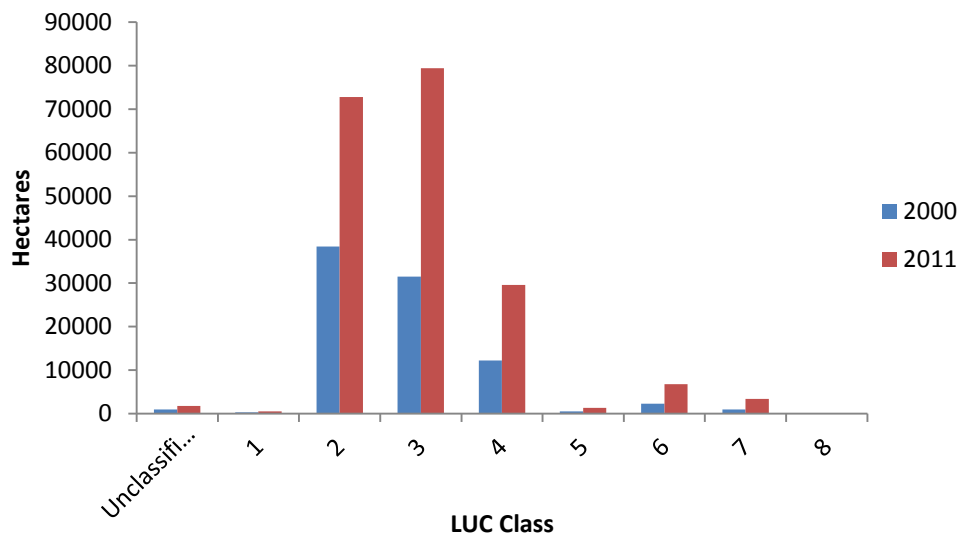
Figure 22: Dairy farm expansion across Southland from 1992 to 2011  
 (Source: ES 2011; Fonterra 1992)

**Table 9. Hectares of dairy farms in Southland 2000 -2011**

(Source: ES 2011)

Year	2000	2005	2007	2009	2011
Hectares - Dairy	87,109	128,469	137,895	168,924	195,500

The expansion in dairying has led to some soil types and land use classes traditionally considered unsuitable for dairy farming (due to environmental constraints such as lower growing degree days and summer drought) being converted into dairying in Southland. Analysis of the LUC classification, which takes into account environmental constraints on the productivity of landscape units has seen the proportion of dairy land on the different LUC classes remain relatively stable between 2000 and 2011 (Figure 23). The proportion of lower-class land in classes 4, 5, 6 and 7 occupied by dairying has remained relatively the same, however as more land is sought for dairying an increasing amount of lower-class land, particularly class 4 land, is being utilised for dairying. If dairy expansion continues, there could be a slow shift to a higher percentage of occupancy of these less-suitable land use classes and this will need to be monitored and managed for to avoid the elevated environmental risks these land use classes are predisposed to.

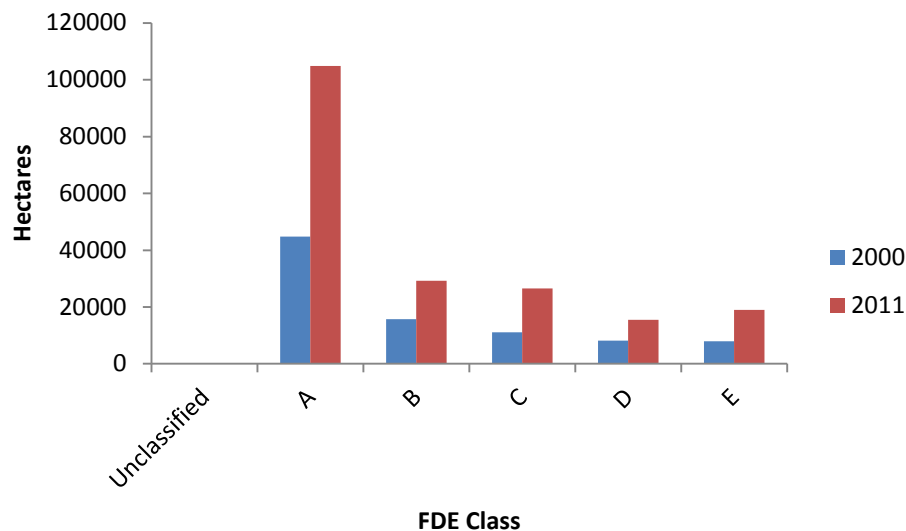


**Figure 23: Hectares of dairy land in 2000 and 2011 across LUC classes, including Unclassified land**

Another tool available to assess the risk of different land types to contaminant losses from dairying is the Farm Dairy Effluent (FDE) risk layer (Houlbrooke & Monaghan 2009). The layer utilises the Topoclimate soil data and other landscape factors to assess the vulnerability of different soil types to contaminant losses from FDE applications. The categories developed not only assess soil structural and physical risk factors but also includes risk associated from sloping ground and subsurface drainage. These layers can offer a good proxy to determine the relative risk of a landscape unit to contaminant losses from dairying, whether via leaching or overland flow.

Across all risk categories, there is a uniform increase in coverage between the years measured, corresponding with the expansion of dairying over this period. The risk category with the highest occupancy by dairy land (c. 54%) is category A. Category A soils have artificial drainage or coarse

soil structure and are identified by having the propensity to lose nutrients and contaminants via preferential flow paths as its dominant limitation. Irrigation of FDE, or the application of contaminants (e.g. animal excreta), prior to or while soils are saturated, results in the elevated risk of contaminants being lost to water via these preferential flow paths (Houlbrooke & Monaghan 2009). Category B and C soils are most vulnerable to overland flow losses, whilst categories D and E are most vulnerable to leaching losses. This applies particularly for category E soils which are well-drained stony soils. **Figure 24** highlights that the most prevalent potential contaminant loss pathway on dairy farms in Southland is via preferential flow (Category A) which provides useful information on where targeted advice could be given to mitigate losses from these soil and landscape associations.

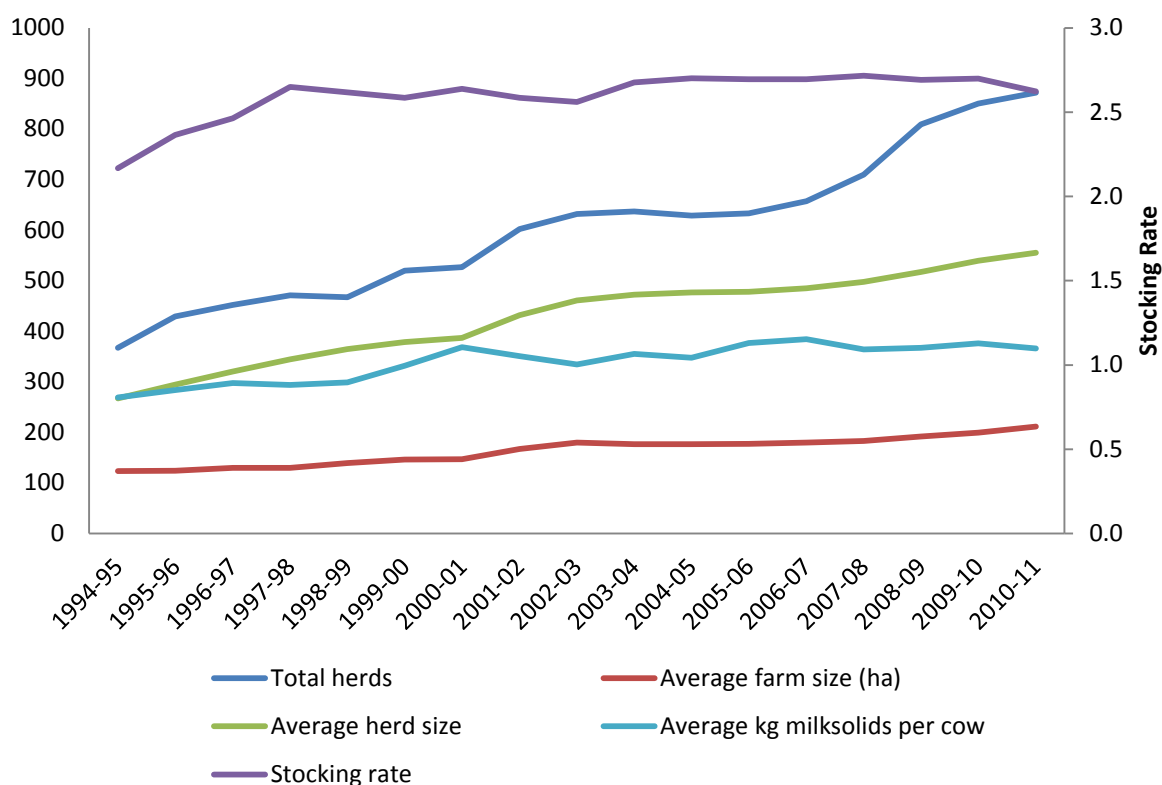


**Figure 24: Hectares of dairy land under each FDE class in the Southland region**

### 5.6.3 Intensification

With the increase in dairying there has been a net intensification of agricultural land in many parts of Southland. In addition to this, on farm practices, particularly increases in stocking rates, have led to the intensification at a individual farm level in many instances. For the purposes of investigating dairy intensification, stocking rate as calculated by cows per hectare and kilograms of milk solids per cow are used as surrogates for intensification. Increases in both surrogates have been found to broadly correlate with increased nitrogen leaching losses (Ledgard et al. 1997, 2006; Monaghan et al. 2007; Hennessey 2012). Clearly there are management practices that could be adopted to reduce losses and ultimately challenge the use of these surrogate measures, however the literature reviewed indicates that these two serve as adequate regional measures of intensification for dairying.

DairyNZ survey data displays stocking rates in the Southland region climbing from 2.2 cows/ha to 2.6 cows/ha between the 1994/95 and 1997/98 milking seasons. However, since the 1997/98 milking season the stocking rate has remained stable at around 2.65 cows/ha. During this period the average milk solids per cow has steadily climbed from 269 kg of milk solids per cow in the 1994/95 milking season to just over 366 kg of milk solids per cow in the 2010/11 milking season. There is some evidence of a plateau in milk solids production post the 2006-07 milking season. Interestingly, the average herd size in Southland is steadily increasing along with the total number of herds which correlates with the increase in total cow numbers displayed in **Figure 21**. Average farm sizes are also still increasing in size from 123 ha in 1994/95 to 212 ha in the 2010/11 season. These results display a picture of the dairy industry still expanding across Southland with intensification increasing through the increase in production per cow rather than an increase in stocking rate (**Figure 25**).



**Figure 25: Temporal changes in average herd size, farm size, milk solid production, stocking rate and number of total herds in the Southland region between the 1994/95 and 2010/11 milking seasons**  
 (Source: NZ Dairy Statistics)

### 5.6.4 Conclusions

In the last decade, the increased environmental impacts of dairying has resulted in significant changes in the way Regional Councils manage land use and intensification associated with the expansion of the dairy industry. Southland is no exception, with poor water quality in our lowland rivers and streams being linked with the rapid intensification of land use in the region (Environment Southland 2000; Hamill & McBride 2003; Monaghan et al. 2007; Environment Southland 2010). Dairying is a key contributor to this issue due to the high number of cows in the region and high nitrate and phosphorous loadings in excreta and urine in comparison to other stock types (Monaghan et al. 2007; Monaghan et al. 2010; Robson et al. 2011).

There are a number of management actions that can take place to mitigate nutrient and contaminant losses from dairy farming systems, and the associated soil structural issues from intensive dairying. However, the assimilative capacity of the soil and water to these contaminant loadings is finite and the continued expansion of dairying without appropriate management actions to mitigate these effects is likely to lead to further deterioration of Southland's soil and water resources. The dairy industry is forecast to expand a further 30% in New Zealand over the next 10 years to meet forecast global dairy demands (Moynihan 2012) and Southland is likely to be no exception. At current, dairy sector growth rates in Southland, dairy hectares and the number of cows milked is increasing by 9% per annum (LIC 2011). There are still more than 300,000 ha of land in LUC Class 2 and 3 not in dairy production that could be utilised within Southland. This area, combined with land currently under dairying could support upwards of 1.3 million cows in the region if current stocking rates are maintained. This is a possible doubling in cow numbers. The rapid increase in dairy cow numbers on land that has many limitations to nitrogen attenuation, coupled with excessive winter and spring soil moisture conditions and little pasture uptake over the

winter months, exposes the region's water resources to excessive nutrient contamination. This is already a significant issue for the region's groundwater and surface water bodies which are both showing increasing nitrate contamination. The future expansion of dairying or any other high nitrogen loss system i.e. cropping, needs to be carefully considered if the region's water resources are to meet water quality guidelines.

### 5.6.5 Summary

- Southland has had a strong history of dairying (since the 1800s) with New Zealand's first dairy factory built in Edendale.
- Dairying had a peak in the early 1900s with cow numbers reaching 87,000.
- Between 1989 and 2011 dairy cow numbers rose from 32,000 to 614,000.
- During this period, dairying expanded from traditional dairying areas on the lower Southland Plains to cover many parts of the Southland Plains, inland basins and river valleys
- In 2011 93% of dairying was on class 1-4 land.
- 54% of dairy land is on land classified as having artificial drainage and coarse soil structure which are elevated in their risk of losing contaminants via preferential flow paths.
- Stocking rates have remained stable at around 2.65 cows per hectare since 1998.
- Between 1995 and 2011, average milk solid production per cow has risen by 90kg.
- New farms and increased farm sizes appear to be driving the increase in cow numbers rather than an increase in cow numbers per hectare.
- There are still significant amounts of high class (LUC 1-3) land available for dairy expansion if growth rates continue.
- Dairying is a high nutrient loss land use activity and poses a significant risk to the region's ground and surface water quality; further expansion within the region will exacerbate this risk unless significant reductions in nutrient losses are achieved.

## 5.7 Forestry in Southland

Commercial forestry, both exotic and native, has had a long history in Southland. Much of Southland's farmland was cleared from cut-over native forest in the late 19<sup>th</sup> and early 20<sup>th</sup> century. This section focuses on exotic plantation forestry in Southland which has dominated the commercial forest industry since native logging declined in the latter half of the 20<sup>th</sup> century.

### 5.7.1 History

The area occupied by plantation forests in Southland has steadily risen over the last century. In 1900, Southland's plantation forests totalled 445 ha, and by 1970 there were 17,300 ha planted. After 1970, there was a steady rise with the plantation forestry estate in Southland totalling 57,000 ha, or 4.8% of productive land in the region by 1995 (**Table 13**). The downturn in land values in the late 1980s, coinciding with strengthening log prices, paved the way for a rapid expansion of forestry plantings in the region in the early 1990s. Between 1993 and 1996, new plantings rose over 15,000 ha, with a diversification away from traditional *Pinus radiata* plantings to emerging plantation species such as *Eucalyptus* spp. and Douglas fir (*Pseudotsuga menziesii*). *Eucalyptus* spp. were typically established on farmland, mainly in the Catlin's and western Southland, while Douglas fir, a much hardier species, was planted in high altitude catchments in the inland basins. Both species were contentious in their plantings; Eucalyptus for being planted on what was often good quality farmland (Fairweather et al. 2000) and Douglas fir for its aesthetic impacts and wilding spread risk (Ledgard & Langer 1999). Much of this forestry expansion was driven by corporate forestry investors and forestry companies, however there were also significant plantings on private land by farmers wishing to diversify their operations.

**Table 10: Land coverage of exotic forestry in Southland on “Productive” land 1975-1994**  
(Source: Houghton et al. 1996)

	1975	1980	1985	1990	1994	1994
	(%)	(%)	(%)	(%)	(%)	(000 ha.)
<b>Exotic plantation</b>	1.6	2.2	2.9	3.7	4.8	57

## 5.7.2 Forestry 1995-2011

Today, Southland has over 91,000 ha of exotic forest spread across the Southland region, of which 84,000 ha is recognised as plantation forestry (NEFD: MAF 2011), with the remainder being captured as shelter and amenity plantings (NEFD: MAF 2011). In the context of New Zealand, Southland is a rather minor contributor to the total forest area, with only 4.8% of the national exotic forest coverage. Seventy percent of the regions exotic forestry occurs on LUC classes 5, 6 and 7, almost all being within hill country catchments. While the majority of the remainder (28%) are limited to lower-lying areas within and around these hill country catchments on LUC class 3 or 4 land. **Figure 26** displays areas of exotic forest >100 ha in the Southland region as captured by LCDB 3. Areas less than 100 ha were discounted for the visual clarity of the figure.

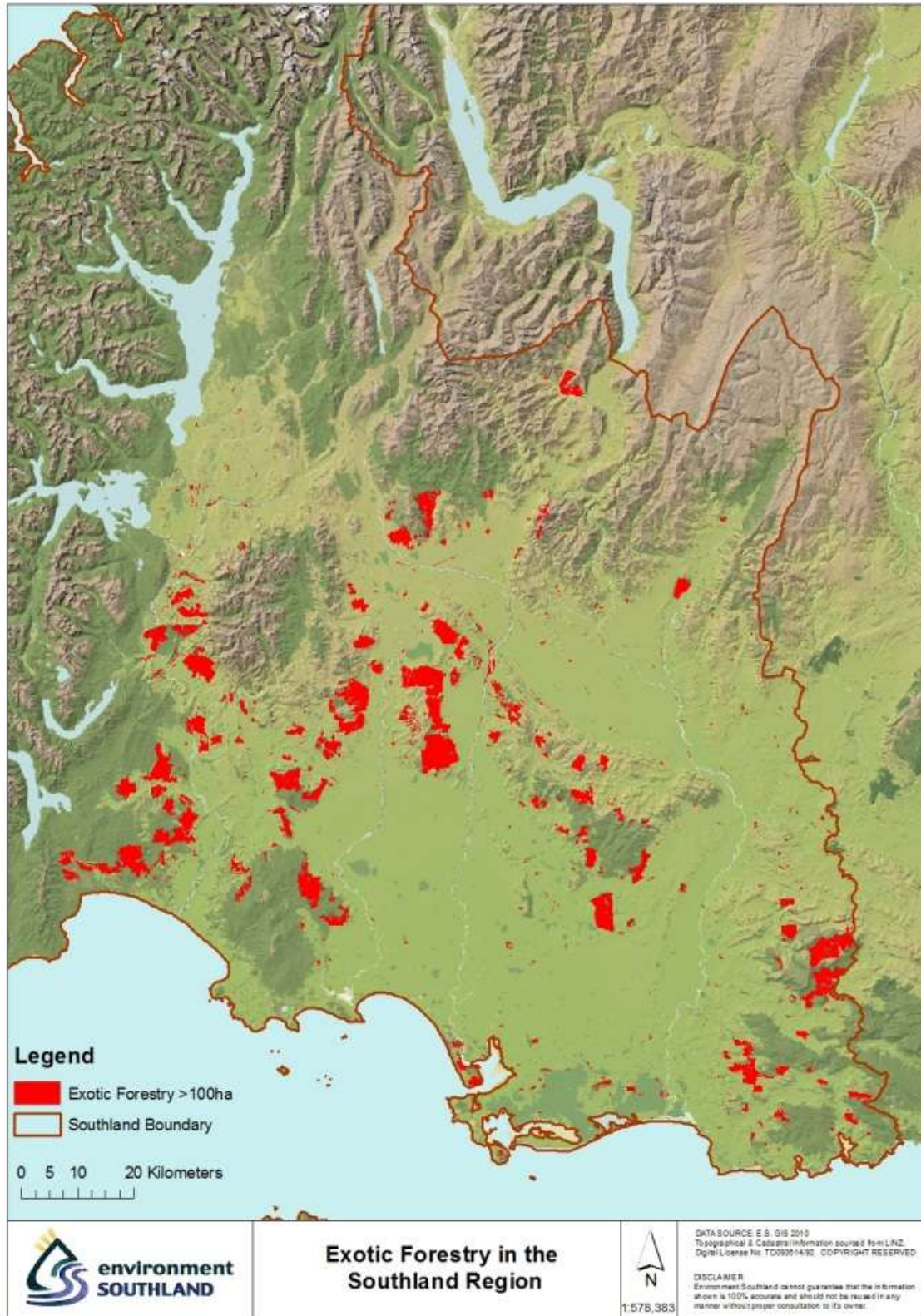
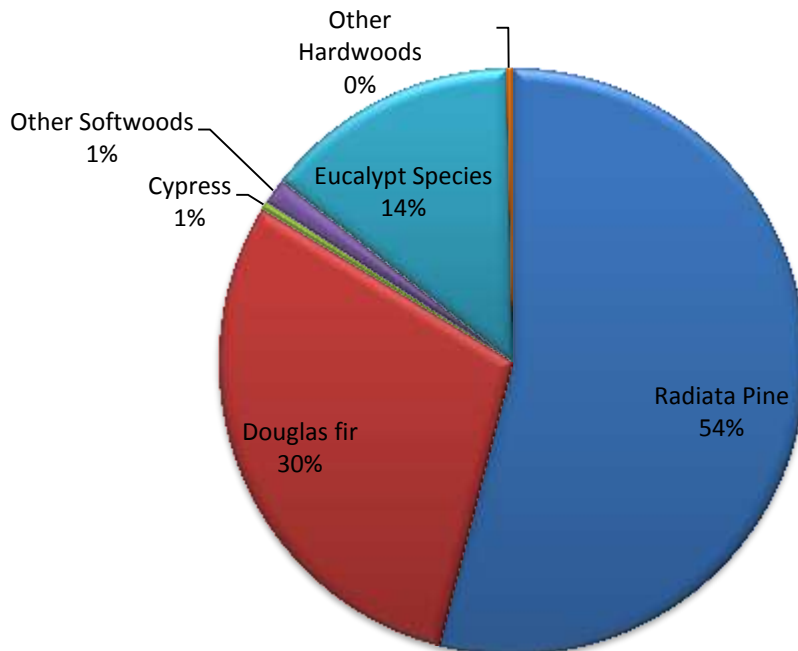


Figure 26: Exotic forest coverage for woodlots >100ha in Southland in 2008  
 (Source: LCDB3)



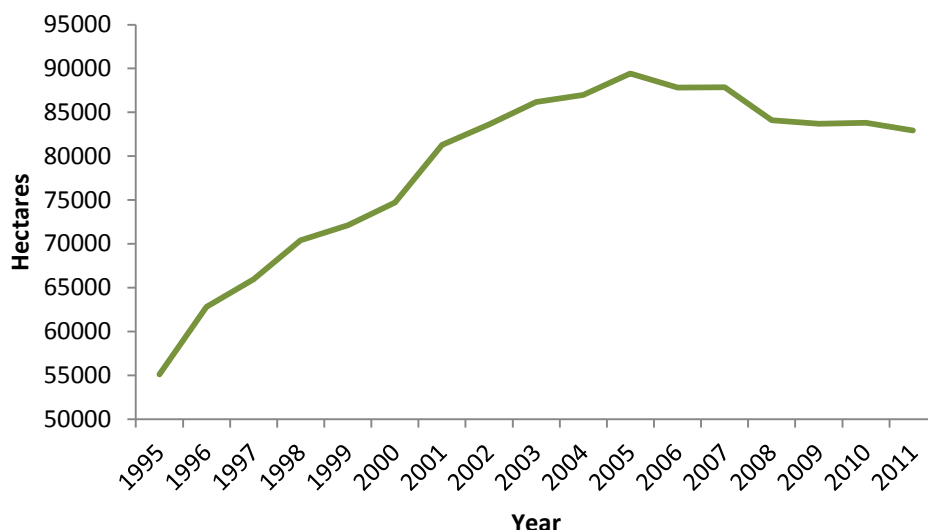
Forestry plantings undertook a rapid expansion in Southland between 1991 and 2005. During this period the forest estate in Southland expanded from 35,000 hectares in 1991 to a peak of 89,000 hectares in 2005 (**Figure 28**). During this period of expansion, two new plantation species for Southland, *Eucalyptus* spp. and Douglas fir, dominated new plantings in the region (NEFD: MAF 2011). Today, approximately 54% of the plantation resource is *Pinus radiata*, while Douglas fir (30%) and *Eucalyptus* species (14%) are the other major two species (**Figure 27**).



**Figure 27: Hectares of the dominant commercial forest species in Southland** (NEFD; MAF 2011)

Since 2005, the total exotic plantation forest area in Southland has declined by approximately 5,000 ha and forecasts for wood supply in the Southland and Otago regions indicate the region is likely to experience a relatively low rate of deforestation, estimated at about 3,900 hectares between 2010 and 2020 (Manley 2006). Government carbon storage initiatives such as the Permanent Forest Sink Initiative and the Afforestation Grant Scheme, initiated in 2008 and 2007 respectively, appear to have made no appreciable difference to the region’s net exotic forest area. The halting of these initiatives in 2011, coupled with the dramatic downturn in carbon prices, could stymie any carbon-related forestry investments in the region, reinforcing the predicted decline in net forest area within the region.

Large corporate forestry companies own the majority of the forest estate in Southland. Fifteen forest owners in the region have plantation holdings of more than 1,000 ha, and six with estates of over 10,000 ha. Small growers, principally farmers, own about 37% of the estate across the Southland and Otago wood supply region (SWC 2011).



**Figure 28: Hectares of exotic forest in Southland 1995-2011**  
(NEFD: MAF 2011)

Indigenous forestry was once the mainstay of Southland’s forestry industry and exports. The gradual replacement of this resource by exotic softwoods and a tightening of legislation surrounding native forest logging and exports led to many native forest logging operations ceasing in Southland during the early 1990s (Griffiths 2002). Since this period there have been a limited number of parties undertaking native logging in Southland. Currently there are 12,882 ha of indigenous forestry with Sustainable Forest Management plans in the Southland region, most of which covers sustainably harvested silver beech from the Rowallan, Woodlaw and Longwood forests in western Southland (MPI 2012).

Forest operations can have significant environmental effects during the afforestation phase. Shrub clearance and infrastructure works can expose soil and elevate sediment losses, and herbicides can enter waterways if not carefully controlled, leading to loss of sensitive biodiversity. As afforestation takes place, water yields decline; however water quality often improves if it is replacing pastoral land (Wilcox et al. 2008). In the case of spread-prone species, such as Douglas fir, wilding spread onto adjacent farm or conservation land can become an issue as trees reach coning age. A local example of this can be seen at Mid Dome in northern Southland. Spread-prone species were planted over a 250 ha area in the 1950s and 1960s to prevent erosion from steep high-altitude hill slopes. Wildings from these plantings spread eastwards with the prevailing wind into extensive pastoral tussock grasslands and conservation areas, where control has been difficult and expensive. Today, the area has a wilding management program spanning some 80,000 ha in an attempt to bring this spread under control.

It is during the harvesting phase that the most significant damage to biodiversity and water quality can occur. Harvesting exposes and often loosens soil, making it vulnerable to the erosive forces of rainfall, resulting in the potential for large sediment loads entering waterways. Due to much of the plantation forestry in Southland occurring within hill country catchments, there is an elevated risk of such activities to water quality, especially via sediment contamination. An expansion in exotic forest coverage is not forecast to occur in Southland; however areas of existing forestry still have the potential to severely affect water quality during periods of harvesting, if not properly managed. Currently, councils do not monitor for contaminants coming from forestry operations and companies are largely left to self-enforce best practice. Council or independent audits on forestry operators are needed to ensure best practice is occurring. Water quality monitoring would be another valuable tool in assessing the relative impacts of forestry operations on water quality, in particular monitoring suspended sediment loads. If a rapid expansion in plantation forestry in Southland did occur in the future, thoughts would need to be given to the appropriateness or

extent of forestry operations in some catchments in Southland in regards to their environmental risk.

### 5.7.3 Summary

- Plantation forestry has significantly expanded and diversified in the region since 1990.
- Radiata pine makes up 54% of the forest estate with Douglas fir and Eucalyptus occupying 30% and 14% respectively.
- In 2011 there were 91,000 ha of forestry in the region, of which 84,000 ha are recognised as plantation forestry.
- Since 2005, the amount of hectares of exotic forest in Southland has declined by 5,000 ha and this decline is forecast to continue until 2020.
- Significant sedimentation issues can arise from poorly-managed forestry operations. Water yields can also be impacted.

## 5.8 Potential losses from land use types

Linking land use change and the effects on the environment (e.g. water quality) is not a focus of this report. The latter will be dealt with in subsequent technical reports, however highlighting that different land uses can have quite different impacts on the landscape and environment puts into context the changes in land use that have occurred in Southland over the past 10 -15 years and previous.

Where possible, any trends in intensification within a land use type have been described in previous sections of this report, along with the key environmental impacts of each land use type. However, a comparison between the losses of different land use types offers a valuable insight into the potential effects of a land use on environmental parameters such as water quality. This section looks at the broad environmental impacts of different land use activities discussed in this report.

Due to the limited spread of agriculture into non-agricultural areas in Southland it is the intensification associated with agricultural land use change rather than the change in pastoral land area *per se* that is likely to have an increasing environmental effect in the future. Within the pastoral landscape, some land use changes are exposing the region to increased risk of environmental degradation. The net shift to more cows in the region in concentrated parts of the landscape creates soil health and stability issues as well as increased nutrient loss opportunities. Soil compaction and erosion increases with increasing stock density and body weight, particularly under winter grazing, and can limit the productive capacity of the soil and cause severe erosion and sediment loss which poses risks for the region's water quality. Elevated nutrient levels in Southland's waterways are also of concern. Dairying is a high nutrient loss land use. While the net stocking rate of the region has remained unchanged over the past twenty years, the change in land use from comparatively low nutrient loss, sheep-dominated farming systems to dairy-dominated systems in Southland exposes the region to increased net nutrient losses and associated risks to water quality. This, coupled with the further intensification of remaining sheep and beef farming systems, has increased the net pressure on our freshwater and terrestrial ecosystems through increased nutrient losses, deteriorating water quality and declining biodiversity.

Monaghan et al. (2010) summarised the potential for nitrogen, phosphorous and sediment loss from different land uses in the Southland region. The data utilised to rank each land use according to their risk to water quality comes from around the country, including studies undertaken in Southland. This study, coupled with a previous review undertaken by Meneer et al. (2004) for the Bay of Plenty Regional Council, reveals a consistent risk ranking of contaminant losses from different land use types. Of the land use systems considered, the potential for causing nitrate leaching typically follows this order: vegetable cropping > cattle winter grazing > dairy farming > arable > mixed cropping > sheep/beef/deer farming > forestry. Within the sheep/beef/deer land use type, losses from sheep are generally the lowest.

Phosphorous losses typically follow the following order: Deer & winter forage crop > cattle & winter forage crop > sheep & winter forage crop = FDE treated pasture > cattle pasture > sheep pasture. Forestry losses can be very high, even greater than from winter forage crops; however they are periodic in their occurrence and are considered to contribute the least net amount of phosphorous to waterways followed by hill country sheep farming (Meneer et al. 2004).

Sediment losses often mimic phosphorous losses and typically follow the following order: Deer > cattle & winter forage crop > Sheep & winter forage crop > cattle grazed pasture = sheep grazed pasture. Microbial contaminant losses can be high across all livestock categories if poor riparian management occurs.

Dairy systems can be high source areas of P, N and *E. coli*, particularly if FDE applications are inappropriately managed, while deer farming systems can also be key sources of P, N, sediment and *E. coli* if deer have access to riparian areas. Poor soil and FDE irrigation management leading to overland flow, or tile drainage losses are both key loss pathways of microbial contaminants to water, however if best practice is adhered to, microbial losses can largely be mitigated for.

Biodiversity losses are hard to quantify and often vary within a land use type as much as they do between land uses (Moller et al. 2008). Consequently, ranking land use types by biodiversity losses has not been undertaken.

The reviews by Meneer et al. (2004) and Monaghan et al. (2010) highlight key land use activities that elevate phosphorous, suspended sediment and nitrogen losses to the environment. Winter forage crops are key sources of both N and P losses to water and are a land use that has increased significantly throughout the region, primarily to support the dairy sector. Of the pastoral land use classes, dairy is of the most concern having elevated losses of both N and P, with sediment and phosphorous of concern from deer and particularly relevant to hill country landscapes. Across all pastoral land use classes, sheep on pasture are considered to have the lowest risk of contaminant losses, while forestry is only of a concern for sediment.

When these land use changes are ranked by their environmental effect it is clear that dairy pasture and the intensive grazing of winter forage crops are likely to be a major source of nutrients, faecal microbes and sediments in the Southland region. Intensification within these land uses has the potential to further exacerbate these effects unless carefully managed. Nitrogen losses from dairying are a particular concern with over 60% of dairy farms on land that is classified as having a high leaching vulnerability. Similarly large areas of intensive winter grazing occur on soil prone to leaching or overland flow. This is not to say that other land use types do not have their effects; future shifts in land use may expose the region to a raft of different environmental effects. Different land use activities will have different effects depending on their intensity, management and position within the landscape, so there is a complexity of factors influencing the environmental effects of different land uses in different parts of the landscape.

There have clearly been large changes in land use in Southland in the past ten years, let alone since European arrival. Water quality in Southland is deteriorating across developed catchments in the region. Quantifying the effects of land use change and different land management activities on Southland's water quality and yield, soil, aesthetic and biodiversity values is complex, but there are key activities and land uses that have been identified as leading contributors to the deterioration of these resources. This report has provided a platform to enable the state and trend in land use and intensification within Southland to be assessed against water quality and biodiversity condition and trends. Understanding the impact of these land use and intensification changes needs to be the focus of future research to enable Environment Southland to understand and manage Southland's land and water resources.

## 5.9 Synthesis of change

Southland has undergone some extensive and rapid land use changes since the arrival of humans. Since 1990, these changes have been accelerated within the agricultural and forestry sectors, giving rise to concerns about the environmental effects and sustainability of land use changes and practices. However, since human colonisation, the largest change observed has been the large-scale modification and clearance of indigenous vegetation during the settlement phases of both Polynesian and European arrival in the region.

Polynesian burning induced a transition in the Southland landscape from forest-dominated communities to a mosaic of shrubland, tussock, wetlands and forests. Over the course of Polynesian settlement in the region, prior to European arrival, it is estimated that 27% of forest in the region was transitioned into tussock and shrubland through burning. These changes were particularly pronounced in the drier inland and eastern parts of the region, where forest loss was the greatest. Upon European arrival, the expansion of pastoralism across the region saw the rapid transition of these indigenous communities into farmland, dominated by exotic pasture. Extensive deforestation and wetland clearance also occurred with an estimated 90% of wetlands on Southland's mainland being lost since 1840. A further 14% of forest was also lost post-1840, along with much of the region's lowland shrubland and tussock communities. Many of these natural lowland ecosystems are now nationally threatened and, unless legally protected, are highly vulnerable to further agricultural development.

The area of protected conservation land has remained stable in the region since 1995; however, areas of indigenous vegetation on private land still remain vulnerable. This has been particularly noticeable over the last decade where the development of native-dominated communities for pasture, most notably in the hill country, has been accelerating. The covenanting of areas of indigenous vegetation through the QE11 Trust is still on the rise in Southland; however its contribution is relatively small when compared to areas of indigenous vegetation on private land that are still unprotected. Southland has many threatened plants and vegetation communities on private land, and these communities are underrepresented in their protection status. Many of these ecosystems are nationally threatened and unless under legal protection are highly vulnerable to further agricultural development. Losses in these communities and other indigenous ecosystems are difficult to quantify without robust inventory data. However, it is clear that species and ecosystems are being lost throughout Southland and are in need of better protection.

From its humble beginnings with the first settlers arriving in Southland, agriculture has expanded across the region to become the backbone of Southland's economy. As new areas were developed and farming operations increased in intensity, stock numbers rose across all sectors throughout the region (**Figure 9**). Sheep farming has always dominated the region; however since the 1980s it has lessened in its prominence, giving way to a large and rapid increase in dairying across the region. Other sectors such as forestry and deer have also expanded in the late 20<sup>th</sup> century, while arable cropping has stagnated after significant declines in the 1970s.

Since 1990, dairying has expanded rapidly throughout the region. In the last decade, dairying has doubled its land coverage, reaching 195,500 hectares by 2011. This amounts to approximately 13% of mainland Southland, excluding conservation areas. Conversely, sheep and beef land has declined over this period as land has been converted to dairying. Forestry, although static in its land area at present, increased in coverage in the early part of the past decade, and along with dairying is the only noticeable increase in land use that can be observed between 1999 and 2011 in **Figures 29** and **30**. Other land uses such as deer and arable cropping are now a minor land uses in comparison to the past when they occupied significantly larger land areas during the early and latter part of the 20<sup>th</sup> century respectively. Cropping to produce stock feeds, predominantly in the form of winter forage crops, has risen sharply to meet the demands for supplementary feed requirements in the dairy sector, with many sheep and beef farms and dairy support blocks having this activity as a dominant land use. It is estimated that there are potentially somewhere between 26,000 and 46,000 ha of winter crop grown in Southland across the sheep/beef/deer and dairy sectors; however without accurate and complete surveys available for Southland, this figure serves only as a benchmark against which to further refine.

The recent land use change from sheep/beef/deer to dairying in the region has not affected overall stocking rates within the region, with the increase in dairy stock units being offset by the decline in sheep stock units over the same period. Although sheep numbers have been declining, sheep and beef farms have still been increasing their stocking rates with an average increase of 0.20 and 0.34 SU/ha/yr for hill country and intensive sheep and beef farms respectively since 2007. Analysis of dairying data has highlighted stable stocking rates in Southland over the past decade with the increase in cow numbers primarily generated from the conversion of sheep/beef/deer pasture to dairy pasture. Presumably, if the demand for dairy land continues to shorten the supply of purchasable land, this may force a shift to intensifying land use to maintain production increases as opposed to purchasing new land.

There is little data to suggest a significant expansion of agriculture into previously non-pastoral areas with the estimate of pastoral land in Southland remaining relatively unchanged since the 1920s. Some forestry has replaced native tussock and shrub land communities on what was extensive pastoral land in the Tarangatura Hills region. However, no significant areas of forestry have been converted back to pasture as has been seen in the last decade in Canterbury and the Central North Island. The total number of stock units has also remained stable in Southland since the late 1970s indicating that although there have been big changes in pastoral land use there has been no significant change in the total carrying capacity of the region. This could be an indication of Southland's net productive land area limiting stock carrying capacity. Any further significant increase in the region's stock units could potentially be driven by agricultural intensification rather than expansion into undeveloped farmland.

The negative effects on soil, air and water quality associated with land use changes within the Southland region have been of concern to Environment Southland and the wider public, with water and soil quality data suggesting that recent land use changes in the region are having a detrimental impact on these resources. This report has highlighted a number of significant land use changes the region has undergone; however it has not attempted to quantify their effects on air, soil or water quality in depth. Having a better understanding of the effects the changes in land use and intensification are having on the region's environmental resources is vital if Environment Southland is to sustainably manage these resources for future generations to utilise and enjoy. Consequently, the next step in addressing the region's environmental issues is to understand the relationship between land use and intensification and declines in water, air, soil and biodiversity quality. Until these relationships are understood it is difficult to manage these land uses and mitigate their effects.



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# 8 Appendix 1: GIS metadata and calculations for figures used in the Land Use Change SOE Report

## Section 4: Southland Landmass

This figure was calculated from the polygon for the Southland region M:\GIS\Data\Political\Southland\_Bdy.shp. The mainland Southland landmass was derived from this by excluding polygons from offshore islands, including Stewart Island.

### Figure 4: Land use in Southland 2010/11

This figure was generated using ES 2011 Dairy layer, DOC land register layer (a merge of the Otago and Southland Conservancies clipped to the Southland Boundary), and LCDB3 (2008) classes. The LCDB3 merged classes were as follows:

*Alpine – Sub Alpine Vegetation* = Alpine Grass/Herbfield; Sub Alpine Shrubland; Tall Tussock Grassland

*Indigenous Forest* = Broadleaved Indigenous Hardwoods; Indigenous Forest

*Mixed exotic shrub land* = Deciduous Hardwoods; Gorse and/or Broom

*Low Producing Grassland* = Depleted Grassland; Low Producing Grassland

*Exotic Forest* = Exotic Forest

*Indigenous shrub land* = Fernland; Flaxland; Manuka and/or Kanuka; Matagouri or Grey Scrub

*High Producing Grassland* = High Producing Exotic Grassland

Classes with low spatial coverage e.g. Bare Rock, were minor in extent and not included in the analysis.

### Figure 5: Mainland Southland land use (Excluding Stewart Is and Offshore Is)

To generate this data we utilised the LCDB3 layer clipped to mainland Southland to extract hectares of Exotic Forestry (both harvested and standing), Sheep/beef/deer low intensity and high intensity (all low and high producing grassland respectively excluding dairy and crop areas), ES Dairy 2011 layer and Cropping farms from the FAR layer. The remainder were calculated from the LCDB3 classes utilised in the 2010-11 land use map (Figure x). See Excel spread sheet for calculations : <\\esfile\georgel\Soils\LU Change SOE\LCDB3 land use across Southland incl 2011Dairy and 2010FAR crop.xlsx>

### Figure 6: Mainland Southland private land use (Excluding DOC estate)

These figures were calculated using the same process as Figure 4, however DOC land was removed from the calculations.

### Figure 7: Land cover from ES ratings database

To generate this figure we extracted all the land area data from ratings database shape file and the extracted rural land use categories that occupied  $\geq 1\%$  of the total land area in the ratings database. Note: Arable land constituted  $<1\%$  of the land area and was thus excluded.

File link <\\esfile\georgel\Soils\LU Change SOE\Historic stock and land use numbers SLD.xlsx> .

### Figure 8: Use of land use classes by the major land use types

Table 2 and Figure 8 are a reproduction of each other. The data was generated by intersecting the dominant land use classes for the region (DOC, ES Dairy 2011, LCDB3 Forestry, LCDB3 Low and High producing grassland excluding Dairy (S/B/D Low and High respectively)) with LUC classes to determine how many hectares of each land use class resides in each LUC class. File link <\\esfile\georgel\Soils\LU Change SOE\Historic stock and land use numbers SLD.xlsx>

### **Figure 10: Historic land cover in Southland region**

To generate this data we digitised McGlone's 3000BP and c.1840 land cover maps of the South Island and aligned them as best as possible with the Southland Boundary shape file. We then extracted the hectares under each vegetation class for each of these time periods. We then merged LCDB3 land cover classes to best represent the same classes as the 3000BP and c.1840 calculations. These calculations are only approximates, hence some variation in Alpine land cover, but it provides a relative picture of change between these time periods.

The classes of land cover in 2008 were derived from merged LCDB3 classes that represented these classes. They were merged as follows:

*Alpine* = Alpine Grass/Herbfield; Sub Alpine Shrubland; Alpine Gravel and Rock; Permanent Snow and Ice

*Forest (Indigenous)* = Broadleaved Indigenous Hardwoods; Indigenous Forest

*Shrubland/Tussock (Indigenous)* = Fernland; Flaxland; Manuka and/or Kanuka; Matagouri; Depleted Tussock Grassland; Tall Tussock Grassland; Grey Scrub

*Exotic* = All other classes excluding classes covering open water (rivers, ponds lakes and estuaries), which were not included in the total.

File Link: [\\esfile\georgel\Soils\LU Change SOE\LCDB2\\_Veg\\_covers.xlsx](\\esfile\georgel\Soils\LU Change SOE\LCDB2_Veg_covers.xlsx)

### **Table 3: Protection status of merged LCDB indigenous cover classes**

This was calculated utilising the merged classes as found in the LCDB3GL file (Indigenous classes only). The classes were the same as those outlined for the classification of Figure 10 above with the exception of the Shrubland/Tussock class which was separated into two categories. These were then clipped to DOC (Merged DOC and Reserves layer) and QEII (2012 Shape file) to calculate area under 'protection' and the remainder not protected. [\\esfile\georgel\Soils\LU Change SOE\LCDB2\\_Veg\\_covers.xlsx](\\esfile\georgel\Soils\LU Change SOE\LCDB2_Veg_covers.xlsx). Areas of open water were not included.

### **Table 5: Distribution of private and protected indigenous vegetation across the various LENZ (Level IV) threat categories within the Southland region**

This table was produced by extracting the Indigenous veg communities from LCDB3 and clipping the various land tenure/protection status to them to extract the hectares of indigenous land cover for lands of differing protection status.

### **Figure 12: Southland's Wetlands**

This figure utilises the WONI historic wetland extent layer (Ausseil et al. 2008) and the current wetland extent layer created by Clarkson et al. (2011).

### **Table 7: Changes in LCDB3 Short Rotation Cropland**

This figure was calculated by simply comparing the hectares of land classed as Short Rotation Cropland between LCDB measurements (1996, 2002 & 2008) and intersecting these with merged LUC classes (1-4 and 5-7)

### **Table 8: Distribution of FAR arable cropping farms within LUC classes**

This table was produced by intersecting the FAR arable crop farm layer with LUC classes to produce a distribution of land area under cropping under LUC classes. Percent occupancy of each class was calculated by dividing hectares of cropping by the total hectares within each class.

### **Figure 22: Dairy farm expansion across Southland 1992 – 2011**

The data used in this figure was from two sources, Fonterra (1992) and the ES consents database (2000-2011). The spatial images for each time period in **Figure 23** were generated by extracting new consents activated after the 1<sup>st</sup> of July in the first year indicated e.g. 2000 but prior to the 1<sup>st</sup> of July at the end of the given time period e.g. 2005. This could not be done for the 1992 – 2000 period and this image displays all consents active prior to the 1<sup>st</sup> of July 2000. Spatial images were then layered in reverse chronological order with the oldest (1992) layer on top and the youngest (2011) on the bottom. This is

also displayed numerically in Table 12 with the total hectares occupied by dairying given for each year except 1992 where the data was not of a quality to compare quantitatively.

**Figures 23 & 24: Hectares of dairy land under LUC and FDE Risk classes**

Both these figure were generated by intersecting the 2000 and 2011 ES Dairy layers with the LUC classes and FDE Risk classes to produce figures of hectares of land occupied within each of these classes.

**Figure 26: Exotic Forestry in the Southland region**

This figure was created by utilising the LCDB3 Exotic Forest layer (2008) however polygon size was restricted to >100ha so the map was not cluttered with small polygons.

**Figures 29 & 30: Land Use change 1999-2000 and 2010-2011**

Both figures were produced in identical fashion. The 2010-2011 map is the same map produced in Figure 4. The 1999-2000 map was produced using the LCDB1 (1996) data and the 2000 ES dairy layer data. The same DOC shape file (generated 2011) was utilised for both maps as historic data on land acquisitions between 2000 and 2010 could not be obtained from DOC.