Otago Regional Council – Industry Advisory Group

Farmers and Growers in Otago

Otago Regional Council

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Acknowledgements

All of the farmers and growers who invested their time and supplied their data and knowledge, in some cases over several years.

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Image 1: Mokopuna watching sheep at Papanui Inlet, Ōtākou Peninsula
Source: Edward Ellison

ORC Economic Work Programme: *This report is the first in a series of reports from Otago Regional Council's Economic Work Programme, which was designed to support the development of the Land and Water Regional Plan.*

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Disclaimer: *All industry specific content has been developed together with the respective industry groups. In general, Otago Regional Council has not contributed directly to this analysis and is not responsible for the accuracy of their content. This report is not a policy document.*

Cover image: *Totara Estate, Ōamaru. In the late 1860s a slaughterhouse was built on this farm to supply sheep meat for the first shipment of frozen meat and butter to London in 1882, from which "a new economy and society was created" (https://nzhistory.govt.nz/). As a locality, Totara is also well-known for arable farming and market gardening. Photo credit: Emma Moran*

ORC Industry Advisory Group

This report is first of two main outputs from the Farmer and Grower Workstream within Otago Regional Council's Economic Work Programme for the new Land and Water Regional Plan (LWRP). The second output is research testing the impacts on farmers' and growers' businesses of actions for freshwater management, which will be completed in early 2023. To undertake the Farmer and Grower Workstream as robustly as possible, Otago Regional Council formed a group of industry-good organisations in October 2021. These organisations are all actively involved in this work and collectively they are referred to as the *Industry Advisory Group* for the purposes of this work. The organisations and their representatives are as follows:

Beef + Lamb New Zealand: Andrew Burtt (Chief Economist) and Jane Chrystal (Principal Science Advisor – Farm Systems)

Deer Industry New Zealand: Tony Pearse (Producer Manager – retired) and Lindsay Fung (Producer Manager)

Foundation for Arable Research: Abie Horrocks (Research Manager - Environment)

DairyNZ: Carina Ross (Senior Regional Policy Advisor) and David Cooper (Principal Regional Policy Advisor)

Horticulture New Zealand: Rachel McClung and Leanne Roberts (Environmental Policy Advisors) and Stuart Ford (Director, The AgriBusiness Group)

Central Otago Wine Growers Association: Andy Wilkinson (Advocacy Lead / Owner and Director, Misha's Vineyard Wines)

Ministry Primary Industry: Matthew Newman (Team Leader – Farm Monitoring).
Through the Farm Monitoring Programme, MPI has provided funding to support industry organisations for the collation of sufficient detailed farm level data from Otago farmers and growers to assist with analysis.

Executive Summary

This report was developed by Otago Regional Council's Industry Advisory Group and it is the first in a series of five reports that are outputs from the Council's Economic Work Programme. In completing this first report, the organisations involved have created a valuable resource for Otago and shown their commitment to the region.

The report covers a lot of territory – both spatially, as it surveys farming and growing across Otago and temporally, spanning over at least 150 years of the region's land development that itself extends over 24,500 km2. In essence, it is a window into rural businesses and their production systems in 2022 – a time when the region (and New Zealand) appears to be heading into territory that is new. There are an ever-growing number of issues to resolve in the near future that suggest change, from those occurring locally to the ones arising in overseas markets for the region's products.

The immediate purpose is to characterise farming and growing businesses in Otago ahead of Otago Regional Council's development of the new Land and Water Regional Plan. The new regional plan will include setting, and operating within, environmental 'limits' for water quality and water quantity, under the National Policy Statement for Freshwater Management 2020. Once operative, this new regional plan will manage a host of activities relevant to both rural and urban communities, replacing the *Regional Plan Water: for Otago* that has been in place since 2004 (with amendments over time via plan changes).

Most primary production systems were not originally set up to fully account for all their uses of fresh water, although change is underway across the landscape. Consequently, a firm understanding of how farming and growing occurs in a region is a 'necessary condition' for developing a policy response to address freshwater issues. Although this statement may seem obvious, it is particularly the case in Otago, where the region's distinct environments influence the scale, distribution and nature of rural land use, and their relationship with fresh water. This report explores these characteristics, highlighting the diversity, connectivity and flexibility of farmer and grower's production systems within each industry along the way. It confirms for Otago a conclusion made 20 years ago by Dr Jan Wright (then Parliamentary Commissioner for the Environment) that each individual farm can be thought of as a modified ecological system in its own right.

The nature of the landscape, climate, and soils in Otago marks it out in comparison with the rest of New Zealand. Otago is dominated by strong metamorphic geology, which influences its topography, altitude and climate. The region has limited rainfall (away from the Southern Alps and the Catlins) and limited flat land. The differing combinations or mixes of characteristics in each locality create a pattern of different land use options across the region, and a variable texture to the production systems that may occur within each land use, even down to a property-scale. It is these differing mixes of characteristics that help make farming and growing in Otago diverse.

Since land development began with its acquisition from Ngāi Tahu by the Crown, these patterns have shifted over time. It has often occurred in a cyclical fashion, with the evolution of different industries – influenced by factors such as new technologies, shifts in government policy direction, and changing access to overseas export markets. New technology has allowed local conditions to be modified and/or changed the scale of land uses. For example, the development of refrigerated shipping (and super-phosphate fertiliser) in Otago led to closer settlement and more family-owned properties – while multi-generational family farms are an enduring feature of Otago, they are fewer than a generation ago and the trend now is towards increasing scale.

Otago has a predominance of hill and high country and limited flat land, particularly at low altitude, contrasting with the expansive plains of Southland and Canterbury. The region is, however, strongly connected to farming and growing in those neighbouring regions as well as related economic activities – particularly for processing and manufacturing. With limited flat land there is competition, as different land uses jostle for position, which tends to translate into higher land prices and more pressure on production systems. The development of irrigation has created more opportunities and certainty, but fresh water too is limited. The result appears to be more interdependence within land uses across different topographies as well as more complexity and diversity in production systems than elsewhere. Where variability occurs it likely improves the region's resilience.

After an introductory chapter, Chapter 2 presents general information on the landscape, climate, and soils of Otago through a series of eight maps. The main body of the report is divided into six industry-specific chapters:

Chapter 3: Sheep and beef cattle farming

Chapter 4: Deer farming

Chapter 5: Arable growing

Chapter 6: Dairy farming

Chapter 7: Horticulture

Chapter 8: Viticulture

The structure and content of each industry chapter reflects the unique nature of that industry. This said, the six chapters are broadly consistent, following a general flow of size and distribution, an historical overview, main features, and connections with processing facilities and markets. Each chapter includes a summary at the start of the report. The main limitation of this research has been complex issues relating to data, which is currently being addressed (at least in part) by the Ministry for Primary Industries Farm Monitoring and Benchmarking Project.

Contents

1 Introduction

As is happening around New Zealand, the Otago Regional Council is required to implement the National Policy Statement for Freshwater Management 2020[1] in Otago, as well as regulations in the National Environmental Standards for Freshwater, those relating to both stock exclusion and water takes, and in the future, certified Freshwater Farm Plans. Importantly, these requirements include the setting of, and operating within, environmental 'limits' for water quality and water quantity.

For Otago, all of these legislative requirements are within the development of a new Land and Water Regional Plan[2], which will manage a host of activities relevant to both rural and urban communities. Otago Regional Council will notify a proposed Land and Water Regional Plan by the end of 2023 and, once it has been through appropriate planning processes, will also replace the *Regional Plan Water: for Otago* that has been operative since 2004.

This report focuses on rural communities, and specifically the production systems of sheep and beef farmers, deer farmers, dairy farmers, arable growers, orchardists, market gardeners, and grape-growers. These production systems range from a singular focus on a specific enterprise to complex mixes of enterprises that span, in some cases, across several properties. Many have existed for multiple generations and are part of the social fabric of their community. Rarely are they static.

In designing their production systems, farmers and growers work to balance their use of inputs and outputs in producing food and/or fibre efficiently[3] and profitably (Moran, Pearson, Couldrey, & Eyre, 2017). Fresh water is a vital component, being used as an input in production, for things like stock drinking, washdown processes, and the irrigation of crops. Water also transports waste products (e.g., excess nutrients, sediment, microbes, pesticides, and herbicides) that are created alongside outputs, such as meat, crops, and milk. These uses of fresh water have a value to farmers and growers as well as everyone else in their value chains, including the final consumers of their products in both domestic and export markets (Moran et al., 2017).

Although change is occurring across the landscape, most primary production systems were not originally set up to fully account for all their uses of fresh water (Moran et al., 2017). As with any human activity, where the use of water is not accounted for and it is affecting other values, then all of society is, in effect, subsidising that activity (Moran et al., 2017). This situation is the case **regardless** of the economic sector being considered across urban and rural communities (e.g., agriculture, horticulture, forestry, mining, manufacturing, tourism, or local government).

1 https://environment.govt.nz/assets/Publications/Files/national-policy-statement-for-freshwater-management-2020.pdf

2 https://www.orc.govt.nz/plans-policies-reports/developing-a-new-land-and-water-regional-plan-for-otago

3 Efficiency in this context refers to productive efficiency, which is about producing a good or service in ways that are both technically efficient and account for the costs of production. Technical efficiency is when resource use is minimised for each unit of a good or service. Productive efficiency is one dimension of economic efficiency, which also includes two more dimensions: 1) how well resources are distributed (or shared) between the different good and services being produced in an economy and 2) how resources are used in such a way that community wellbeing improves over time. These last two dimensions are known as allocative efficiency and dynamic efficiency. Note that productive efficiency is not the same as cost effectiveness, which is simply a 'cost per unit of output' measure. A useful reference for further reading is The Australian Productivity Commission (2013) "On efficiency and effectiveness: some definitions", which is available at: https://www.pc.gov.au/research/supporting/efficiency-effectiveness/efficiency-effectiveness.pdf

A firm understanding of how farming and growing occurs in a region is a 'necessary condition'[4] for developing a policy response to address environmental issues. Although this statement may seem self-evident, it is particularly the case in Otago, where the region's distinct environments influence the scale, distribution and nature of rural land uses, and their relationship with fresh water. This report explores these characteristics, highlighting the diversity, connectivity and flexibility of farmer and grower's production systems within each industry along the way.

> *A farm is a place where agricultural activities occur to produce food and/or fibre from plants and/or animals. Each individual farm can be thought of as a system in its own right – a modified ecological system that includes people, crops, and livestock within a broader environmental, social, and economic context.*
>
> ***Dr Jan Wright Parliamentary Commissioner for the Environment, 2004: p20***

Image 2: Pounawea Estuary (South Otago), which sits at the bottom of the Catlins River Catchment and the Owaka River Catchment
Source: Emma Moran

[4] A necessary condition is a condition that must be present for something to occur although alone it is not sufficient to cause it. In other words, all the necessary elements must be there. There have been many examples over the years of where there have been unintended but foreseeable consequences (e.g., the loss of undeveloped land of ecological value resulting from the 1950 Marginal Lands Act) (Moran, 2019).

1.1 Report purpose

Report 1: Farmers and Grower in Otago

The immediate purpose of this report (Report 1) is to characterise farming and growing in Otago in order to improve general understanding of these topics ahead of development of the new Land and Water Regional Plan. Longer-term, the report is intended to be a resource for the region.

This report was developed by Otago Regional Council's Industry Advisory Group and it is the first in a series of reports that are outputs from the Council's Economic Work Programme[5]. In completing this report, the organisations involved in the Industry Advisory Group have created a valuable resource for Otago and, in doing so, they have shown their commitment to the region.

Report 2: Summary of Otago's Catchment Stories

This report consolidates and summaries the various themes that have emerged from research into the stories of individual catchments across Otago. It highlights the context, background and structure of the groups involved, along with the key themes that have emerged. The report (Report 2) will include a summary of the actions, successes and practices being implemented across Otago's catchments to date, alongside the local scale issues and challenges.

Report 3: Testing the Impacts of Environmental Actions

The research contained in Report 1 will be used to support subsequent work that tests, through modelling and analysis, the impacts of possible environmental actions on the businesses of around 50 farmers and growers in Otago as case studies. This subsequent work will use data sources developed by the industry groups for the Ministry for Primary Industries' Farm Monitoring and Benchmarking Project and will be brought together in a compendium report (Report 3).

Report 4: An Otago Economic Profile for Fresh Water and Land

As Report 1 looks at farming and growing in Otago, in places it touches on the contribution of each industry to Otago's economy using existing sources. However, this topic is largely saved for Report 4: ***An Otago Economic Profile for Fresh Water and Land.*** That research will be based on a Multi-Regional Input-Output Table for Otago and its five districts: Clutha, Dunedin City, Central Otago, Queenstown Lakes, and (part of) Waitaki. It will consider each economic sector's use of natural resources (land and fresh water) using a range of measures including income (value added) and employment. This economic profile will improve understanding of the region's dependence on the environment.

Report 5: Fresh water and the economies of Kāi Tahu and Māori in Otago

The final report explores the socioeconomic impact of freshwater management decisions in Otago on mana whenua and other Māori. Specifically, it will; 1) outline a historical narrative on the place of wai māori in the Kāi Tahu economy in Otago, and how it has evolved over time; 2) consider the socio-economic consequences of these changes for Kāi Tahu and other Māori; and 3) forecast the likely impacts of proposed policy direction in the Land and Water Regional Plan on these outcomes.

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[5] The Otago Regional Council's Economic Work Programme is supporting development of the new Land and Water Regional Plan. However, while the new Land and Water Regional Plan is the driver, the Economic Work Programme is designed to establish a strong foundation for the future, particularly as climate change gathers pace. More information on the Economic Work Programme is available at: https://www.orc.govt.nz/media/12003/otago-regional-council-economic-work-programme-16-march2022.pdf

1.2 Report structure and methodology

This report (Report 1) covers a lot of territory but, in essence, its structure is fairly simple.

The report begins with a chapter that briefly describes Otago's landscape, climate and soils to explain how they influence patterns in farming and growing in the region. This contextual chapter touches on land drainage as one of the main technologies or tools that are used to adjust these capabilities (others include fertiliser and irrigation). It ends with a section on Māori agribusiness because it is relevant to the topic of the report.

The main body of the report is divided into six industry-specific chapters:

Chapter 3: Sheep and beef cattle farming

Chapter 4: Deer farming

Chapter 5: Arable growing

Chapter 6: Dairy farming

Chapter 7: Horticulture

Chapter 8: Viticulture

The structure and content of each industry chapter reflects the unique nature of that industry. This said, the six chapters are broadly consistent, following a general flow of size and distribution, an historical overview, main features, and connections with processing facilities and markets. While it is a technical report that involves a lot of jargon, it is designed for a general readership. Efforts have been made to not assume knowledge of relevant topics and include links to further information.

Representatives within the Industry Advisory Group have authored their respective industry's chapter, along with support from the main author of this report. The industry authors have had different information resources to draw on – whether it is specialist expertise, local knowledge, and industry databases. Where important knowledge gaps were identified, their research was supplemented as far as possible by individual interviews with local experts, farmers, and growers.

Where possible, individual chapters were ground-truthed with reviews by industry leaders and experts in Otago. Finally, the report was reviewed by Kim Reilly (National Farm Environmental Manager, Landpro[6]) who has at least ten years relevant policy experience in the region and undertook *Otago's Catchment Stories* (Report 2).

[6] https://landpro.co.nz/

2 Otago Context

This report covers a lot of territory – both spatially, as it surveys farming and growing across different environments in Otago, and over time, spanning generations of effort invested in land settlement and development. In New Zealand, a pre-requisite for the settlement and development of land was its ownership by the Crown. For the area that eventually became the Otago (Ōtākou) region in 1989[7], this process began with the acquisition of land from Ngāi Tahu via the Otago Deed of Purchase in 1844 and the Murihiku Deed of Purchase in 1853[8].

In essence, this report is a window into a specific set of rural land uses and their production systems at a point in time when Otago (and New Zealand) is heading into territory that is new. As of 2022, this window is roughly:

- 30 years since the rapid expansion of dairy farming and viticulture began;
- 40 years since the economic restructuring of the 1980s;
- 50 years since Britain entered the common market;
- 50 years since deer farming began and the development of modern irrigation schemes in drier parts of Otago;
- 70 years since the 1950s wool boom, fuelled by the Korean War, and just before that, the start of aerial top-dressing;
- 100 years since cheaper fertiliser and new varieties of pasture grasses and arable crops became available;
- 140 years since the first successful refrigerated shipment of sheep meat, butter and cheese, the start of the production of superphosphate, and the beginning of railway construction into the Otago interior;
- 150 years since the first co-operative dairy factory was established
- 160 years since the 1860s gold rushes, the start of horticulture, and the first viticulturalists;
- 170 years since the establishment of large pastoral runs, which marked the beginning of sheep and beef farming and arable farming
- 180 years from the signing of the Treaty of Waitangi in 1840; and
- Pre-1840 land and water in Otago was predominantly used for mahinga kai.

Against this backdrop, there are an ever-growing number of environmental and economic issues to resolve in the near future that suggest a period of transition is coming for those who are producing and consuming food, drink, and fibre locally. Similar challenges exist for producers and consumers in other regions of New Zealand and in many of the overseas markets for Otago's products.

Economic activities, including rural land uses, that may appear on the surface as distinct from each other are directly and/or indirectly connected. In some cases, these connections are to an industry's advantage and, in other cases, a disadvantage as activities are both co-operative and competitive in their use of scarce resources.

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[7] Before this time Otago was a province.

[8] Information on the Otago Deed and the Murihiku Deed, which is directly relevant to the Otago region, is included at https://ngaitahu.iwi.nz/ngai-tahu/te-whakataunga-celebrating-te-kereme-the-ngai-tahu-claim/. A map of Murihiku is available in Te Tangi a Tauira – The Cry of the People (Batchelor, Jolly, & Tau, 2008).

In New Zealand, farming systems were established as early as 1914 on different types of country – mixed crop and livestock farming on the plains and downlands, pastoral farming on hill country, and extensive pastoralism in the mountains and semi-arid lands – and have lasted to the present day (Peden, 2011). Similarly, market gardens and orcharding found its place in the landscape early on. This fundamental pattern applied as equally to Otago as elsewhere. However, it has long been recognised that Otago is one of the most diverse regions in New Zealand:

> *The land district of Otago, comprising the counties of Waitaki, Waihemo, Waikouaiti, Taieri, Peninsula, Bruce, Clutha, Tuapeka, Lake, Vincent, and Maniototo, contains the greatest variations in climatic conditions, topography, and soil types.*
>
> ***G. Elliott, Fields Superintendent, Department of Agriculture, Dunedin (Elliott, 1958)***

Where and how the industries within the agriculture sector, as well as those in the horticulture and viticulture, occur in Otago is strongly influenced by landscape factors. Geology, topography, soils, and climate are all inputs into, and constraints on, rural land uses and production systems. Technologies, particularly earthworks, land drainage, irrigation, and fertiliser[9], are used to modify some of these constraints and, in turn, influence the pattern of rural land uses[10]. The following section presents general information on the landscape, climate, and soils of Otago to lay down essential context for the land uses covered in the following chapters.

Image 3: Use of irrigation for frost fighting on orchard in Central Otago.
Source: Sam Hobbs (Summerfruit Grower, Roxburgh)
Note: Sprinklers are used to cover the plant in a mist of water that then freezes. As the ice forms it releases heat that keeps a thin layer of water around the plant, which protects it from frost.

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9 Kempthorne Prosser & Co's N.Z. Drug Company's plant at Burnside was the first in New Zealand produce superphosphate by mixing sulphuric acid and bone dust (Farquhar, 2006). Before this, sulphuric acid was brought from Australia as deck cargo, and it was the first commodity jettisoned when the weather was severe. Guano brought in sailing ships from the Pacific Islands from 1867 was also used with the acid. As a result, there were often shortages. Around 1930 a rival manufacturer of fertiliser, Dominion Fertiliser Co. Ltd was established at Ravensbourne on the Otago Harbour. Phosphate rock from the Pacific Islands of Ocean and Nauru was landed at a jetty built out from the works, and small wagons delivered the raw material to the processing plant. Milburn Lime & Cement Co. Ltd, dominated lime (and cement) production in Otago and Southland (Farquhar, 2006). Lime production was mainly at Milburn and the company went on to absorb other lime, cement and phosphate companies.

10 Recently, some farms in Otago have been turning to other technologies, such as diverse cover crops and minimum or no tillage. However, in many cases it is more about following the pasture growth curve with good pasture management, recalling the old adage 'nothing grows grass like grass' (J. Somerville, ex-Chair of New Zealand Deer Farms Association, October 2022).

2.1 Landscape

Author: Dr. Lisa Pearson (Land & Water Science)[11]

Otago is the second largest region geographically, covering a land area of approximately 32,000 km2 (or 3.2 million hectares). There is approximately 24,500 km2 of developed land and 7,500 km2 of conservation estate and other protected areas (Otago Land Use Map, 2021). The region's population is approximately 246,700 (4.8% of New Zealand) located predominantly in the urban centres of Dunedin, Ōamaru, Balclutha, and Alexandra as well as the major tourist centres Queenstown and Wānaka (Figure 1).

The region is dominated by the ranges and basins of Central Otago, surrounded by the Southern Alps to the west, and coastal plains, the Catlins hill country and the volcanic Otago Peninsula to the east. An important landscape feature of Otago is the large glacial lakes formed from recent and ancient glacial activity. Lakes Wakatipu, Wānaka, and Hāwea are the headwaters for the Clutha/Matau-au River, which reaches the coast near Balclutha.

The Clutha/Matau-au River is the largest river by volume in New Zealand, with a catchment area of 20,630 km2 (64.4% of the region). New Zealand's fourth-longest river, the Taieri, is also in Otago, rising from rough hill country to the east of the Clutha River. It has a catchment area of 5,700 km2 or 17.8 per cent of the region. Along its course it forms two notable geographic features – the broad high valley of the Strath Taieri in its upper reaches, and the fertile Taieri Plains as it approaches the ocean. Located in the upper reaches of the catchment is the Taieri Scroll Plain, a large wetland complex spanning the Styx (Paerau) basin, the Maniototo basin and the lower Lake Taieri. It is the only scroll-plain in New Zealand, resulting in a unique combination of wetland habitats.

2.1.1 Topography

Otago is a relatively wide zone of low mountain ranges and intervening basins (e.g., Ida Valley). The mountain ranges have rolling slopes over most of the region and become progressively steeper and more rugged towards the northwest, into the southern part of the Southern Alps (Figure 1). In comparison to Southland and Canterbury, where there are large plains, Otago is constrained in terms of flat land.

The Dunstan Mountains separate Cromwell from Alexandra. The Kakanui Range is a range of high hills inland from Ōamaru which forms the boundary between the northern valley of the Waitaki River in Canterbury, and the high Maniototo plateau, and the upper watershed of the Taieri River to the southwest. In west Otago, the Blue Mountains rise up between the valleys of the Clutha and Pomahaka rivers.

Notably between Queenstown and Cromwell, Cromwell and Clyde, and Alexandra and Millers Flat (between Roxburgh and Lawrence), the rivers were established before the land was uplifted and over time they have cut gorges into the uplifted rock (Craw et al., 2007).

11 This section draws on information resources created for LandscapeDNA: https://landscapedna.org/; https://www.farmersweekly.co.nz/putting-water-on-the-map/

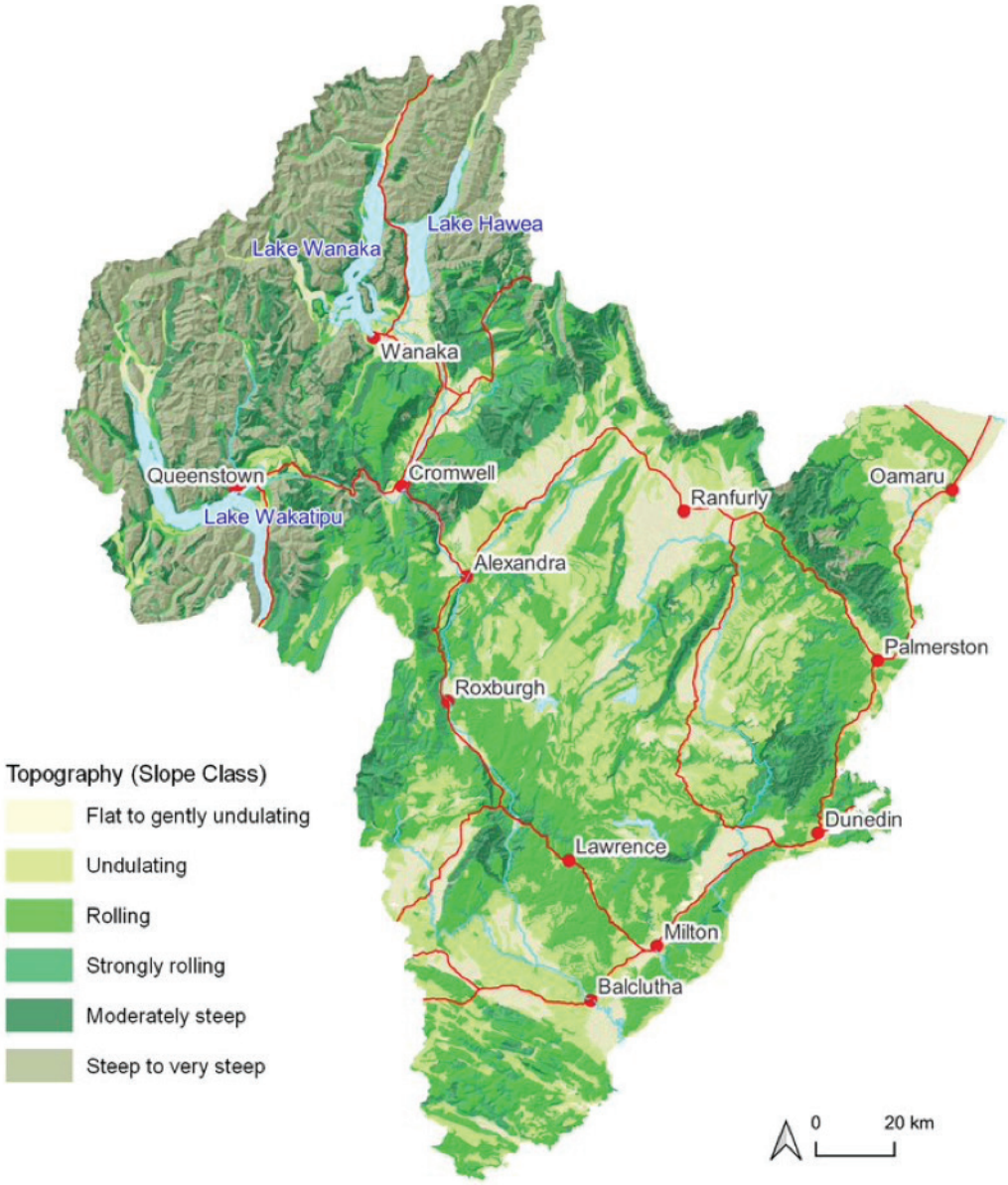

Figure 1: Topography of Otago
Notes: Slope Classes are defined as 0-4° flat to gently rolling, 4-8° undulating, 8-16° Rolling, 16-21° Strongly rolling, 21-26° Moderately steep, and greater than 26° steep to very steep (Newsome et al., 2008). Red lines on map are state highways and the towns were selected on the basis of being references points to help with orientation, rather than population size.
An interactive slope map is available at https://landscapedna.org/maps/other-information/slope/ .

2.1.2 Geology

The geology of a region or catchment is the primary controlling influence over elevation, hydrology, soil type, and sediment generation. Geology is used to assess weathering processes, such as erosion, where unconsolidated material or weak rocks are more erosion prone than strong more resistant rocks.

The geology of Otago is dominated by metamorphic schist (Figure 2). The schist has been formed through transformation of the existing greywacke (a strong sedimentary sandstone) under high temperatures and elevated pressure, changing the physical and chemical composition of the rock. The schist can be either weak or strong depending on the degree of metamorphism and the strength of the original rock. The thick block of Otago Schist was part of the 85-million-year-old Zealandia continent, the surface of which

was eroded over 60 million years and then uplifted in the last 2 million years (terra.govt.nz). The uplift in Central Otago was not as dramatic as that which produced the Southern Alps, but it reactivated faults, producing the alternating ranges and basins found across the region (Youngson et al., 1998).

The Central Otago towns of Alexandra and Cromwell are found in the intermontane basins between block mountains. Accumulating in the valleys is unconsolidated material eroded by ice, water, and wind from the surrounding bedrock over millennia. The schist bedrock influence extends to the eastern part of Otago, where remnant volcanics mark its edge (Youngson et al., 1998). Otago Harbour sits on the remains of Miocene volcanics. Elsewhere, basalt outcrops (a strong volcanic rock) can be found along the coast and inland northeast (Figure 2).

Inland of Ōamaru is the source of Ōamaru stone, a strong sedimentary limestone[12], used on many of the public buildings in the towns and cities of the southern South Island, particularly Ōamaru and Dunedin.

Located to the southeast of the region is the Catlins, an area of rough hill country, that geologically forms part of the Murihiku terrane (comprising strong and weak sedimentary rock, Figure 2). This accretion extends inland through the Hokonui Hills in the Southland region and forms part of the Southland Syncline, which links to similar formations in Nelson which have been offset by movement of the Alpine Fault (see Figure 2 insert). The Catlins ranges are strike ridges composed of Triassic and Jurassic sandstones, mudstones, and other related sedimentary rocks.

Image 4: Schist rock outcrop at Butchers Dam (built during the Great Depression to create a water reservoir for the nearby town of Alexandra)
Source: Simon Moran
Note: Gold was discovered in Butchers Gully (now submerged under Butchers Dam). Water was essential for mining the gold and for survival. European settlers quickly learnt the value of water in the dry Central Otago climate. Butchers Dam is itself a legacy to the need for water reserves in an environment that makes water the equivalent of "liquid gold"[13].

12 A pure bryozoan limestone (https://www.sciencelearn.org.nz/images/492-oamaru-stone) that is also commonly known as 'whitestone'.

13 https://www.doc.govt.nz/parks-and-recreation/places-to-go/otago/places/flat-top-hill-conservation-area/things-to-do/butchers-dam-loop-track/

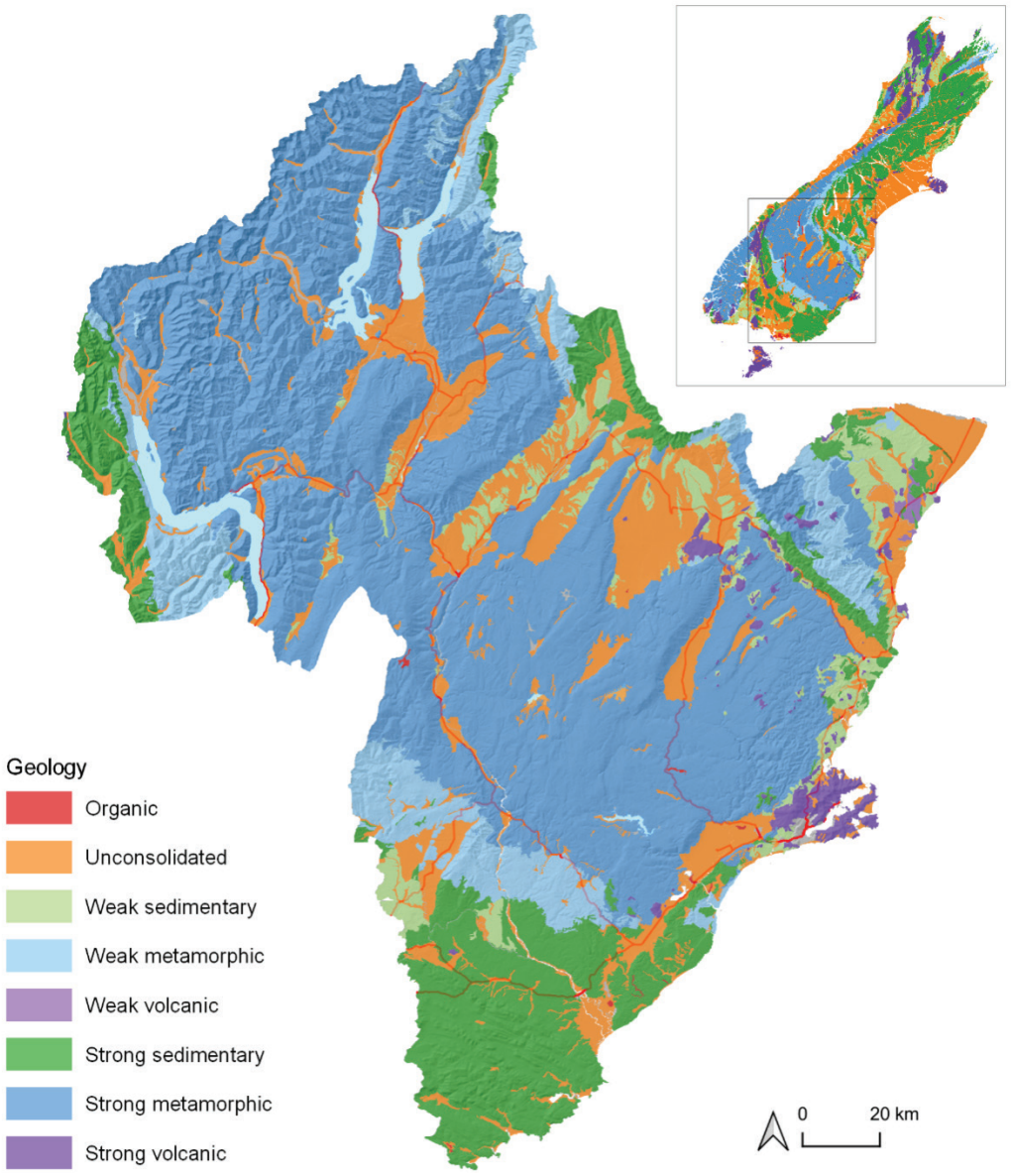

Figure 2: Geology of Otago by rock type
Note: Red lines on map are state highways.
An interactive version of this map is available at https://landscapedna.org/maps/other-information/base-rock-strength/

2.1.3 Altitude

Altitude reflects land use gradients, with highest land use in lowland areas and minimal land use in high altitude alpine environments (Figure 3). The highest peak in Otago is Mount Aspiring/Tititea on the Southern Alps. There are some areas of Dunedin City that are below sea level. Altitude and topography are the main influence (or 'primary controls') over Otago's climate.

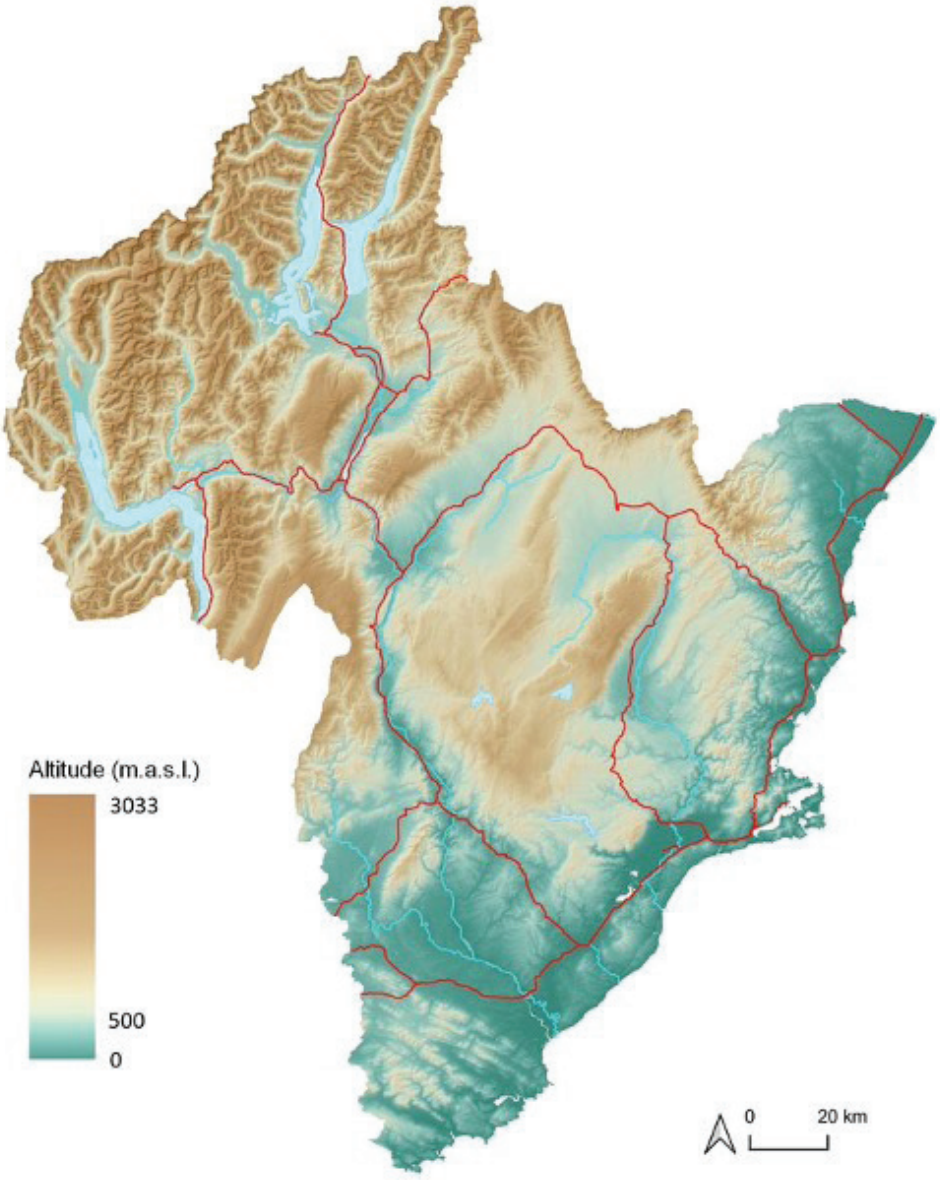

Figure 3: Altitude of Otago
Note: Red lines on map are state highways.
An interactive version of this map is available at https://landscapedna.org/maps/other-information/altitude/

2.2 Climate

Otago has the most diverse climate of any region in New Zealand (Macara, 2015). The main divide of the Southern Alps acts as a barrier to the prevailing westerlies, separating the wettest region in New Zealand (West Coast) from the driest (Central Otago). The region can be separated into two main climate types: the coastal climate of the coastal regions and the more continental climate of Central Otago. Central Otago is the only place in New Zealand where a continental climate is found. For a detailed description of the climate of Otago see Macara (2015).

2.2.1 Temperature

Average air temperatures typically reach highs between 18 to 24 °C in the summer and lows between -2 to 3 °C in winter. However, the inland areas of Central Otago can exceed temperatures of 30 °C in summer with lower lows in winter. Average annual temperature is shown in Figure 4 and represents the annual average 24-hour temperature. The extreme highs and lows of Central Otago are averaged out and result in a similar annual average temperature to the north-eastern coast. Coastal Otago has some of the lowest sunshine hours in New Zealand.

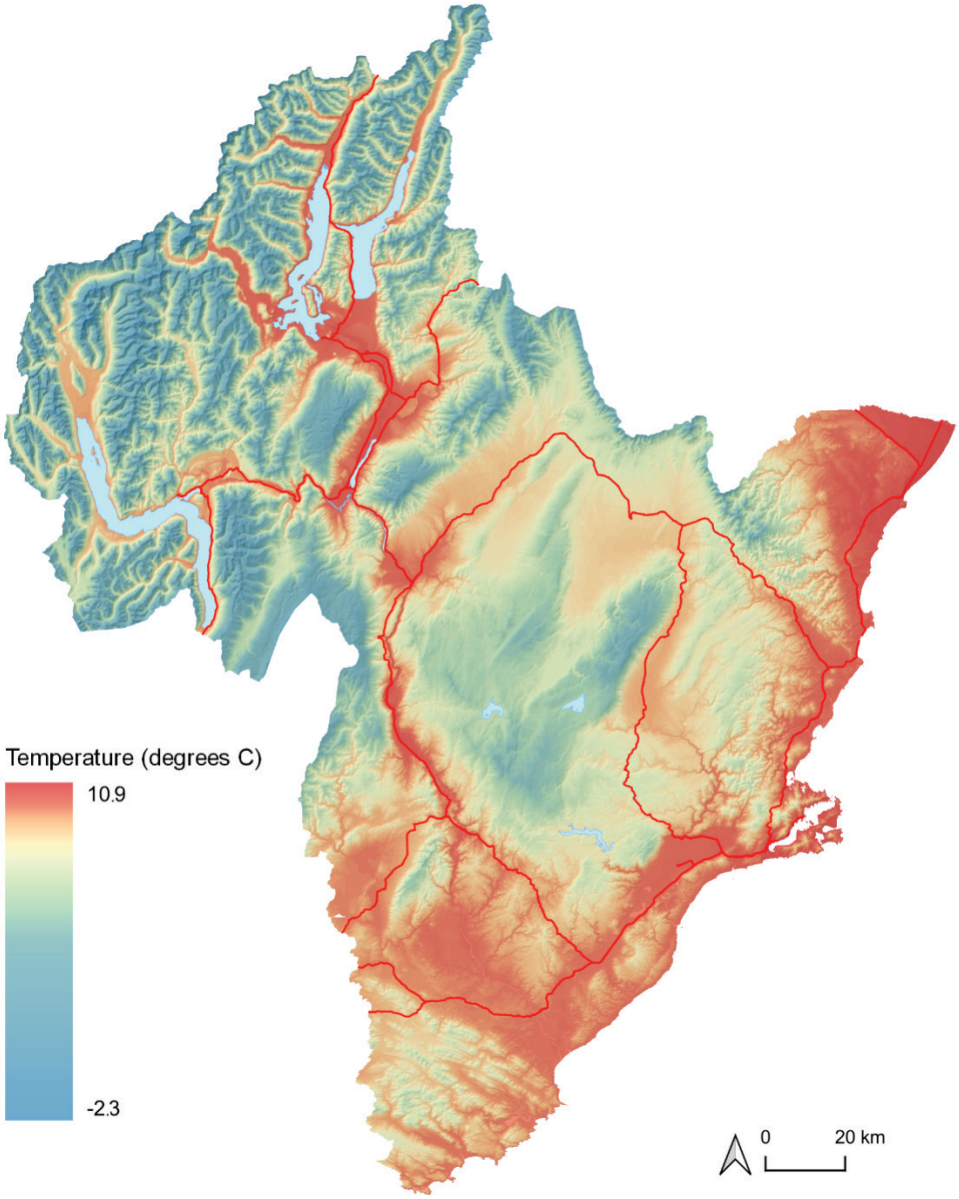

Figure 4: Average annual sir temperature for Otago (Leathwick et al., 2002)
Note: Red lines on map are state highways.
An interactive version of this map is available at https://landscapedna.org/maps/other-information/temperature/.

2.2.2 Precipitation

Annual rainfall ranges from greater than 8,000 mm per year in the Southern Alps decreasing to around 700-1,000 mm per year at the eastern coast (Figure 5). Exposed coastal locations often experience strong westerly winds while the winds are lighter inland. Winter is often the least windy and driest season for many areas of Otago.

With less than 400 mm annually, Central Otago is the driest area of New Zealand with frequent dry spells that often extend longer than two weeks. Otago is the only region in New Zealand to experience a near continental climate, having the hottest summers and coldest winters in New Zealand. For comparison, the insert on Figure 5 shows the rest of the South Island. The Strath Taieri, in common with other areas at the edge of Central Otago, has a contrasting climate of dry hot summers and cold winters. Ice is common in winter, and snow will cover the ranges for several weeks. Annual precipitation is approximately 480 mm/year however much of this rain is evaporated and very little enters the groundwater system (Wilson and Lu, 2011).

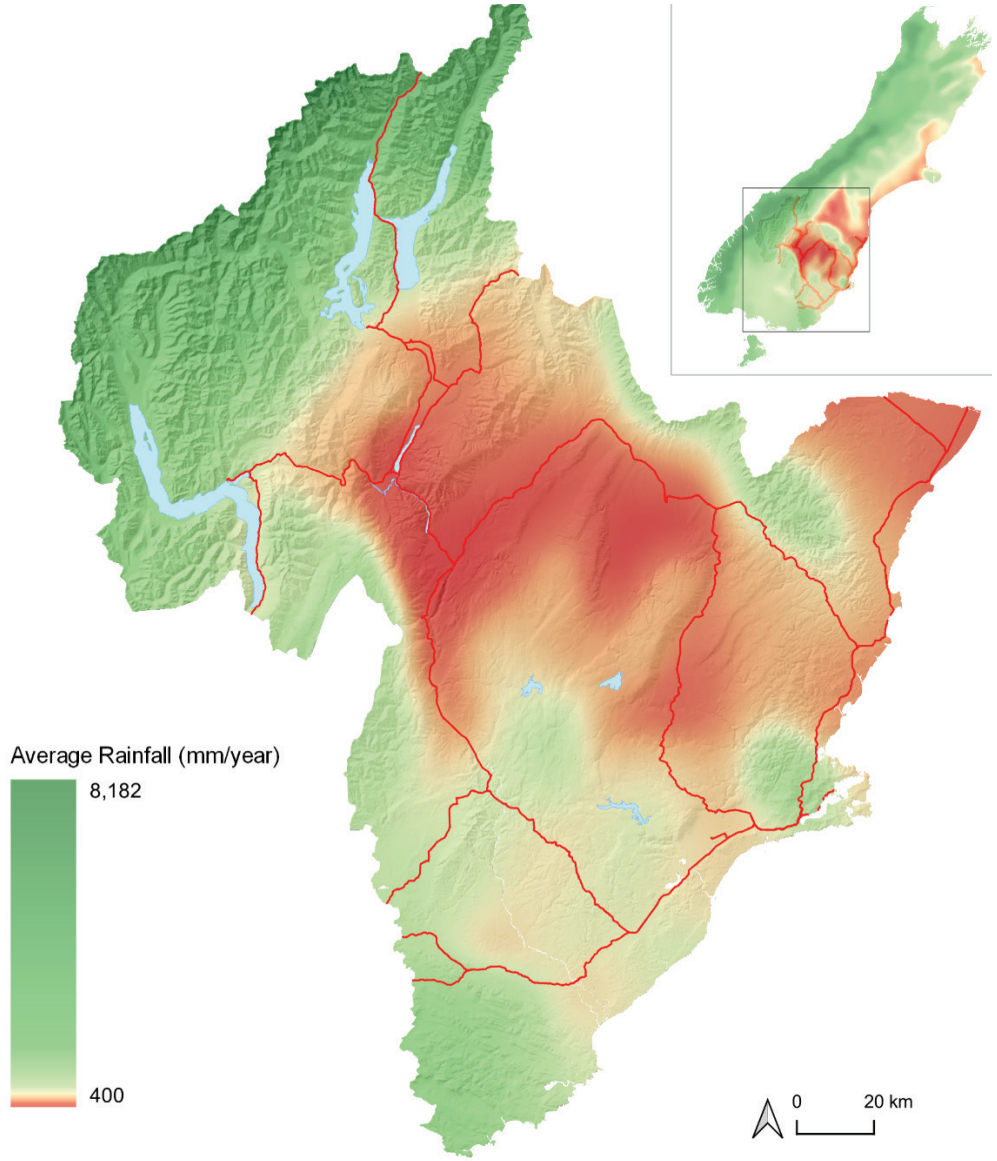

Figure 5: Average annual rainfall for Otago (Ministry for the Environment and Statistics New Zealand, 2017)
Note: The transition from green to red occurs at approximately 800 mm/year. Red lines on map are state highways.
An interactive version of this map is available at [https://landscapedna.org/maps/other-information/rainfall/.](https://landscapedna.org/maps/other-information/rainfall/)

The Catlins experiences considerably higher precipitation than most of the South Island's east coast. While heavy rain occurs infrequently, drizzle is common and the area averages around 150 days of rain per year (Macara, 2015). The average annual rainfall is about 1,300 mm (Figure 5).

2.2.3 Climate change

Otago's climate is changing with long-term trends in climate and sea level changes already being observed. Further change to the climate is expected over the coming decades in Otago. The rate of future climate change depends on how fast greenhouse gas concentrations increase in the atmosphere.

Climate projections for the region include warmer air temperatures, with more hot days and fewer frosts. Future annual average warming spans a wide range: 0.5 – 1.5 °C by 2040, and 0.5 – 3.5 °C by 2090 (Macara et al., 2019). By 2050, this may mean an increase of 4.1 – 6.1 days over 25 °C (currently 17.8 days) and a decrease of 13.6 to 19.6 nights less than 0 °C (currently 64.6 days; Ministry for the Environment, 2018). There will also be considerable variability between coastal and southernmost parts of Otago compared to Central Otago. The number of extreme hot days (days >30°C) in Central Otago are projected to increase by 30 to 40 days by 2090 and the number of frost days (days <0°C) is expected to decrease throughout the region. Largest decreases are expected in inland areas with 10 to 15 fewer frost days per year by 2040, and 20 to 40 fewer frost days per year by 2090.

Annual rainfall in Otago is expected to increase slightly by mid-century (0 – 10 %), while the increase spans 10 to 20 per cent (with a larger increase in the western part of the region) at the end of the century. Winter (Dunedin City) and spring (Queenstown Lakes) are expected to be wetter, with large decreases in seasonal snow likely (Ministry for the Environment, 2018, Tonkin and Taylor, 2021). Overall, the seasonality of climate in the region is expected to become more pronounced.

More severe extreme weather events are anticipated with increased rainfall intensity, wind extremes, and more thunderstorms. The severity and frequency of windy days is also predicted to increase. By the end of the century, average annual river flows are expected to increase by greater than 50 per cent across the region, except the headwaters of the Taieri and North Otago. Even with dramatic reduction of greenhouse gas emissions, sea level rise is expected for the next 100 years and more (Tonkin and Taylor, 2021). Increased hazards, such as flooding and landslides, drought, coastal inundation and erosion, and increased instances of wildfire are associated with these changes in climate (Tonkin and Taylor, 2021).

For more information on predicted climate scenarios see NIWA's report Climate change projections for the Otago region (Macara et al., 2019).

2.3 Soils

Soils are essential for land-based primary production systems and are, essentially, a non-renewable resource because they take years to centuries to develop. Along with topography and climate, they influence what land uses are possible and where these uses generally occur in the landscape. Otago's soils reflect the age, parent materials, climate, topography, and biological activity (microbes and vegetation) of the time when the soil was formed (Molloy and Christie, 1998) (Figure 6 and Table 1).

The New Zealand Department of Scientific and Industrial Research were surveying and mapping soils in Otago by the early 1920's at a scale of 1:63,000 (inch:mile; e.g., Ferrar, 1929), and this work continued

after World War II (e.g. Leamy and Saunders, 1967; Orbell, 1974) up until the 1980s. This process involved in-depth descriptions of the landscape, the physical properties of the soil, and detailed chemical analysis of soil samples. The original soils maps are still used by farmers and growers in Otago, although the scale of the map units represents landform features that mean there may be more than one soil type mapped within a defined area.

These soil surveys were combined and digitised as part of the Land Resource Inventory for New Zealand, from which the national Fundamental Soil Layer was produced (Manaaki Whenua Landcare Research). The Fundamental Soil Layer updated the soil genetic group classification to the New Zealand Soil Classification (NZSC), a 5 level – hierarchical classification according to Hewitt (2010). At the most generalised national level, there are 15 soil orders of which 10 soil orders are identified in Otago (Figure 6, Table 1). Many farmers and growers will be familiar with level 4 of the classification (soil series or family), which typically uses a local name to describe the soil at that location (e.g., Dunstan, Teviot, Wehanga). More recent soil mapping has been undertaken by Manaaki Whenua Landcare Research and interactive maps are available online at https://smap.landcareresearch.co.nz/.

Brown soils are extensively distributed across the region, covering just under half of the land area. They are mature soils that have well developed top and subsoil horizons. Iron oxides give the soil a yellow to brown colour. Brown soils occur where summer dryness is uncommon and when not waterlogged in winter (Hewitt, 2010). There are at least 70 soils classified as Brown soils in Otago with the most extensive being Dunstan, Moonlight, Teviot, Wehenga, and Kaikoura soil series.

Pallic soils cover just over one quarter of the region and are identifiable from their pale colours (low iron oxides), weakly weathered high base status, high slaking potential, and dense subsoils. They have water deficits in summer and soil water surpluses in winter and spring (Hewitt, 2010). The most extensive Pallic soils are the Arrow, Blackstone, and Pukerangi.

Image 5: St Bathans (North Otago)
Source: Simon Moran

Semiarid soils occur extensively in Central Otago. The key identifying feature of these soils is a semiarid soil moisture regime. They are very weakly weathered and weakly leached soils due to the water limitation. The most extensive Semiarid soils are the Conroy, Becks, and Alexandra.

Podzol soils are found in the high country of Otago where there are high rainfall rates and are usually associated with forest species that produce an acid litter. They have a high organic matter content in the upper soil horizons and have a naturally high fertility due to the high organic matter content. The most extensive Podzol soils are the McKerrow, Haast, and Hinahina. Recent soils are young soils found on recent alluvial floodplains or at elevation where conditions are suitable for soil to develop a topsoil. The concept of the order relates predominantly to weak soil development rather than to the length of time of soil formation (Hewitt, 2010). The most extensive Recent soils are the Matukituki, Clutha, and Matarae.

Many of the limiting properties of the soils in Otago have been overcome with human intervention. The largest modification to soils has been the use of synthetic fertilisers to address nutrient deficiency and the installation of artificial drainage and irrigation reducing climate limitations.

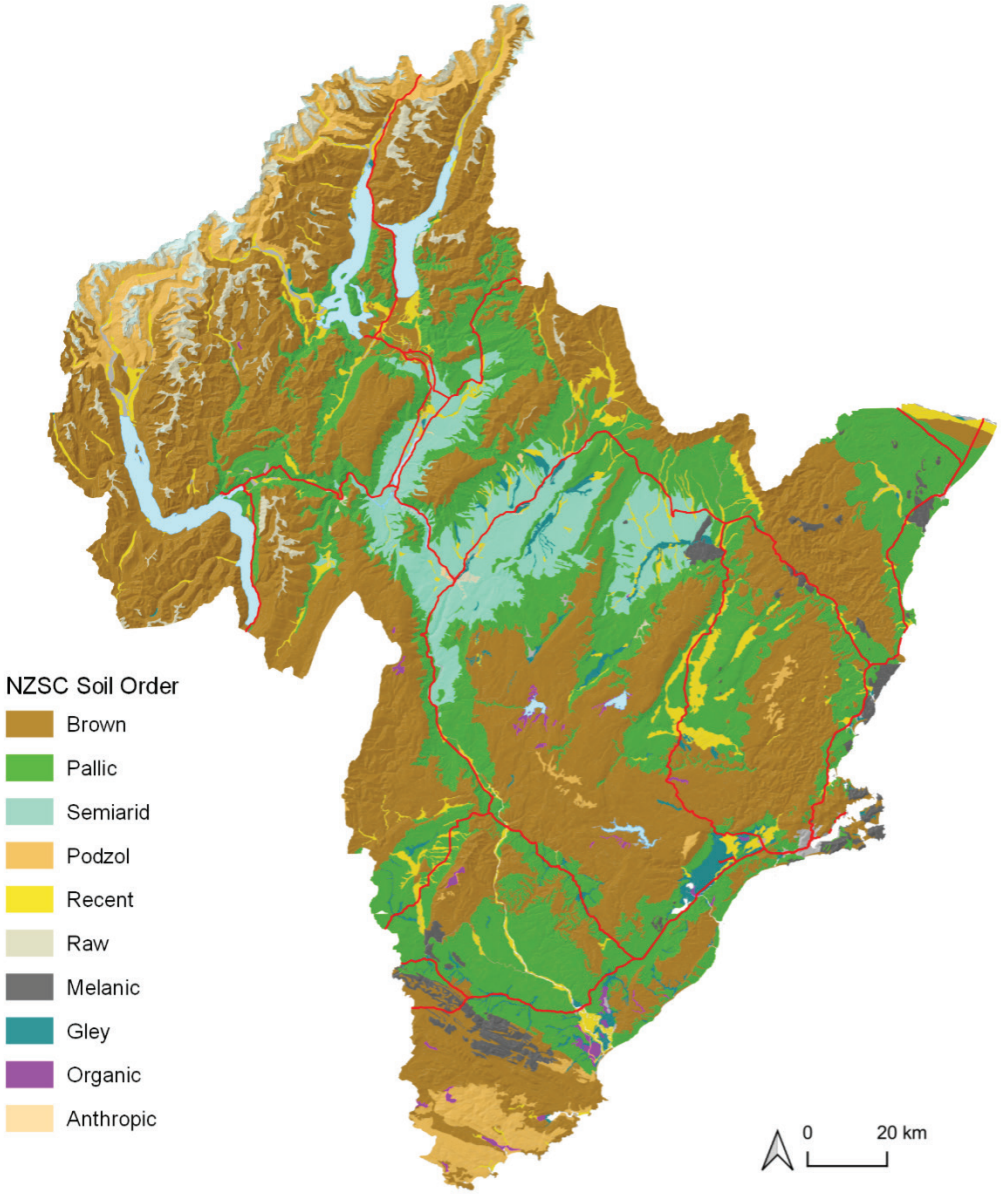

Figure 6: New Zealand Soil Classification Orders in Otago
Note: Red lines on map are state highways.

Table 1: NZ Soil Classification Soil Orders of Otago

NZSC Soil Order	Mapped area (ha)	Percentage of region
Brown	1,551,484.07	48.7
Pallic	832,203.83	26.1
Semiarid	207,829.81	6.5
Podzol	156,546.16	4.9
Recent	119,419.60	3.8
Raw	93,304.71	2.9
Melanic	52,228.77	1.6
Gley	47,084.20	1.5
Organic	11,197.08	0.4
Anthropic	2,157.75	0.07

Data source: Fundamental Soil Layer, Manaaki Whenua Landcare Research.

For more information on the soils present in the Otago Region see SmapOnline (https://smap.landcareresearch.co.nz/) and https://soils.landcareresearch.co.nz/topics/soil-classification/nzsc/.

2.3.1 Soil drainage

Soil drainage is one of the key factors when assessing suitability of a soil for production, with the most favoured land typically being flat and well drained. However, what is ideal soil drainage conditions is strongly dependent on the product being produced. For example, the semi-arid soils of Central Otago are sought after for wine production and do not match the typical description of soil suitability. Figure 7 shows the drainage class of the soils of Otago as they would be without any modification by artificial drainage.

Artificial drainage improves the drainage of water by speeding up its lateral flow through the soil to waterways. However, the ability of the soil to reduce water quality contaminants is also reduced by reducing the soils attenuation capacity. The limitation of wetness is reduced by reducing the moisture in soil and thereby increasing the amount of air which provides conditions for optimal growth of crops. This has allowed areas previously considered unsuitable for agriculture to be developed, especially to the southeast of the region. Artificial drainage can include surface ditches, in addition to subsurface, mole and tile drains. Open ditch drainage is typically used to lower the water table. Open ditches together with subsurface drainage are used to improve drainage through poorly drained soil. A prediction of the extent of artificial drainage in Otago is shown in Figure 8 (Pearson and Rissmann, 2021). The actual extent of subsurface drainage may never be known as many drains were installed decades ago (without records of their location) and this knowledge has been lost with changes in property ownership.

The nature of the landscape, climate, and soils in Otago marks it out in comparison with the rest of New Zealand. Otago is dominated by strong metamorphic geology, which influences its topography, altitude and climate. The region has limited rainfall (away from the Southern Alps and the Catlins) and limited flat land. The differing combinations or mixes of characteristics in each locality create a pattern of land use options across the region, and a variable texture to the production systems that may occur within each land use, even down to a property-scale. It is these differing mixes of characteristics that help make farming and growing in Otago diverse.

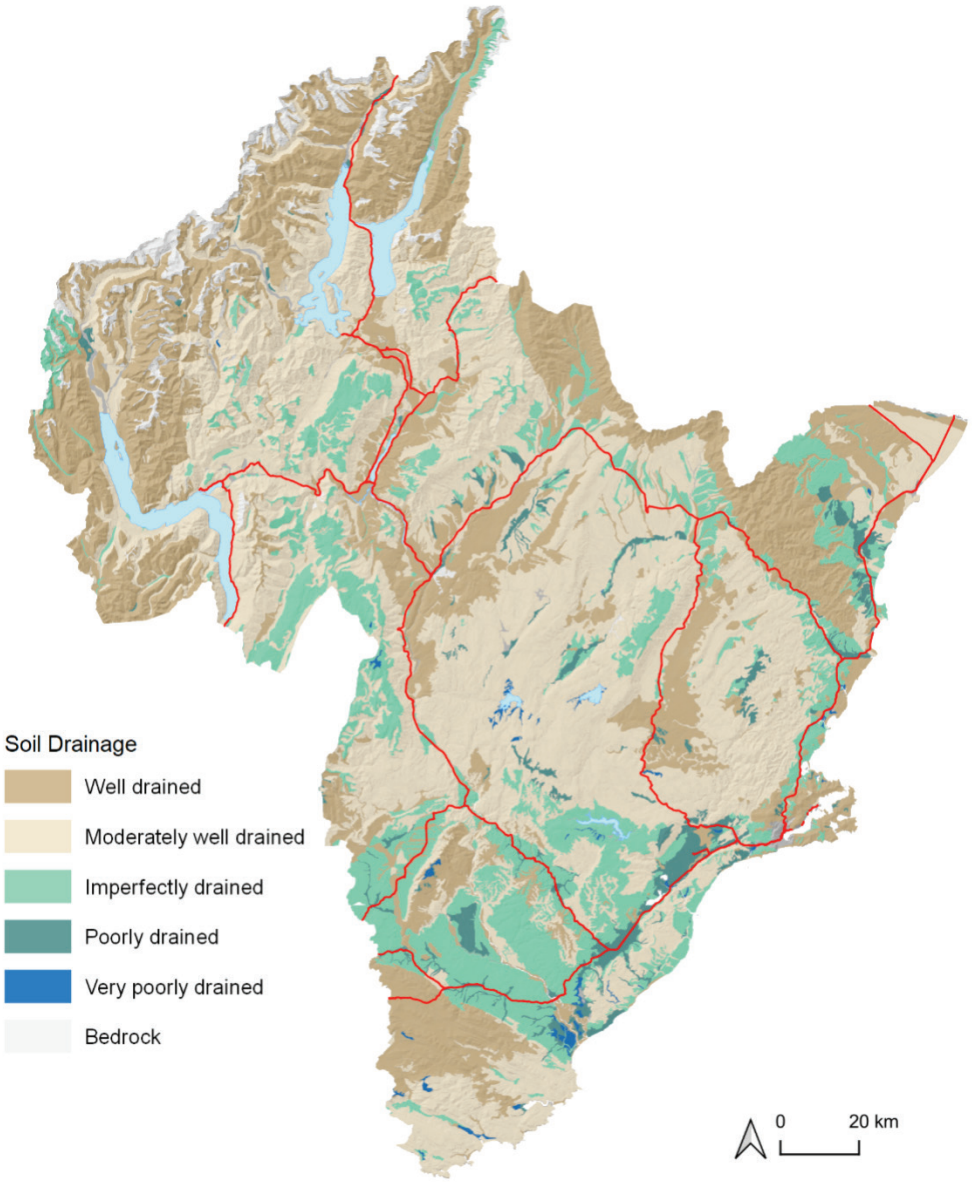

Figure 7: Soil drainage in Otago (Pearson and Rissman, 2021)
Note: Red lines on map are state highways.

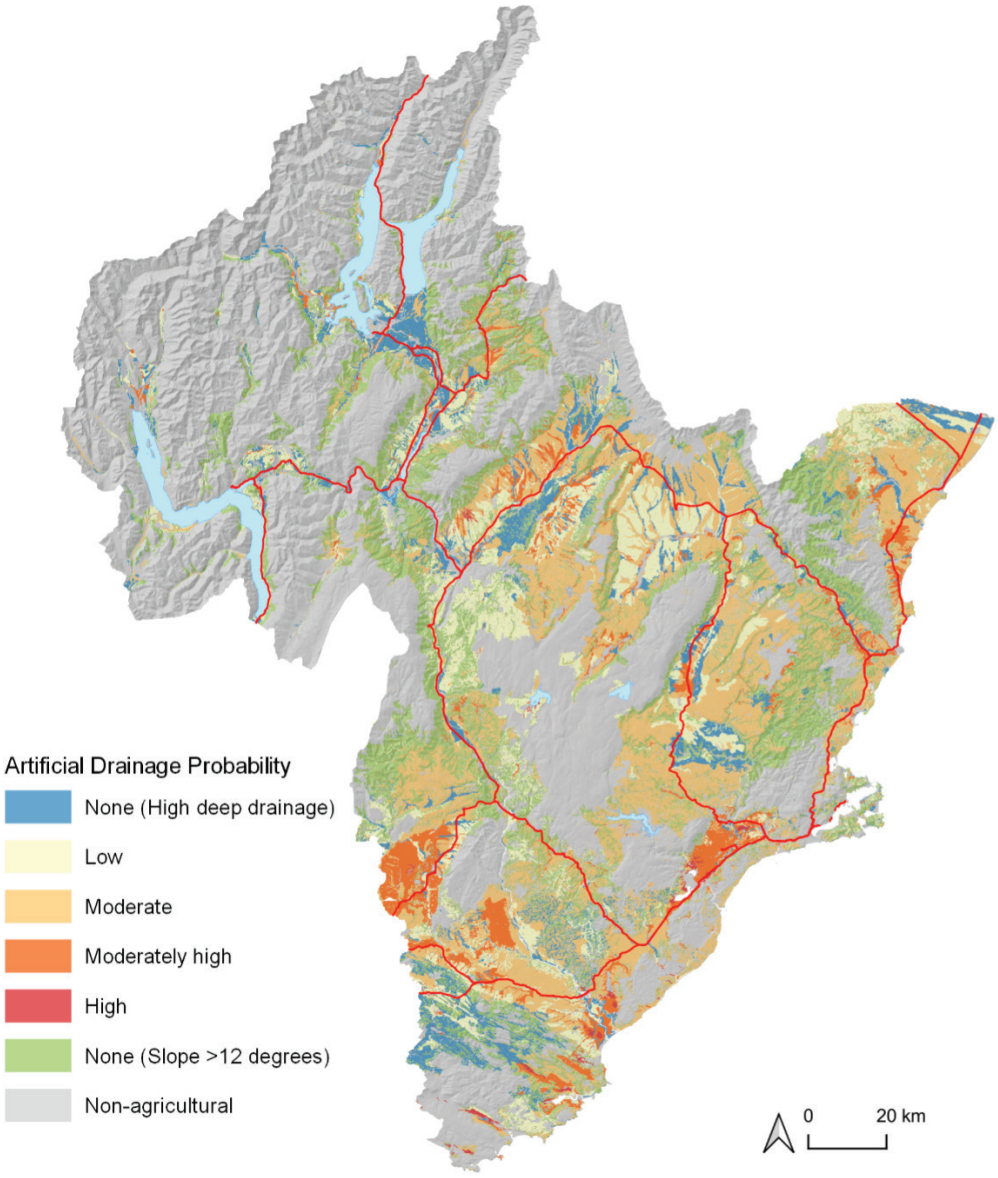

Figure 8: Predicted artificial drainage density in Otago
Note: Red lines on map are state highways.

An interactive version of this map is available at [https://landscapedna.org/maps/hydrology/artificial-drainage/.](https://landscapedna.org/maps/hydrology/artificial-drainage/)

2.4 Māori agri-business in Otago

Māori agribusiness consists of a broad range of enterprises typically involving collectively owned and managed Māori freehold land[14], general land that is owned and farmed together with Māori freehold land, and Māori farming general land on their individual account (MAF, 2011). *"Māori-owned agribusinesses are significant producers of food and fibre, yet Māori face a unique set of challenges when developing their whenua"* (David Carter, Minister of Agriculture in MAF, 2011). Some of these challenges revolve around similar topics to those faced by other owners of agribusiness (e.g., governance, succession, administration, and compliance costs). However, in the case of many Māori-owned agribusinesses, the land is governed by Te Ture Whenua Māori Act 1993 (the Māori Land Act 1993), which recognises that[15]:

> *…the land is a taonga tuku iho of special significance to Māori people and, for that reason, to promote the retention of that land in the hands of its owners, their whanau, and their hapu, and to protect wahi tapu: and to facilitate the occupation, development, and utilisation of that land for the benefit of its owners, their whanau, and their hapu.*
>
> ***Excerpt from Preamble of Te Ture Whenua Māori Act 1993***

Lending institutions have been reluctant to allow Māori freehold land to be used as security for several reasons including lack of ease if the land needs to be liquidated. This circumstance has resulted in Māori Agribusinesses not having access to capital when the main asset is Māori freehold land. It limits investment back into the whenua and has prevented and excluded many Māori from participating in the primary sector.

For historical reasons around the Crown's acquisition of land[16], Māori freehold land in Te Wai Pounamu (South Island) accounts for just less than five per cent of the total Māori land in New Zealand (MAF, 2011)[17]. In Otago[18] there are fewer traditional sheep and beef Māori farms in comparison to parts of Te Ika a Maui (North Island) (H. Ellison, pers. comm., August 2022). However, there are some examples, such as those sheep and beef farming enterprises on Māori freehold land at Karitane and Otakou. The Māori agribusinesses that have developed in Otago tend to be in coastal areas (a reflection of the allocation of reserves in the nineteenth century). Anecdotally, many of these agribusinesses tend to be lower intensity production systems that are not heavily dependent on irrigation.

Some entities are exploring land use change that is viewed as more complementary to Te Ao Māori views of land management. For example, one incorporation has land that is used for sheep and beef grazing but is also considering opportunities that may have less environmental footprint, such as carbon farming or freshwater aquaculture.

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14 'Māori Land' means Māori customary land (land held by Māori in accordance with tikanga Māori) and 'Māori Freehold Land' (land where the Māori Land Court has determined the beneficial ownership by freehold order) (Part 6 of Te Ture Whenua Māori Act 1993). 'General land owned by Māori' means general land that is owned for a beneficial estate in fee simple by a Māori or by a group of persons of whom a majority are Māori.

15 Te Ture Whenua Act provides joint objectives for the management of Māori land – the retention of customary Māori land in Māori ownership and the development of that land for the benefit of the owners (MAF, 2011). There can be a tension between these objectives – retention for cultural reasons constrains economic use – that result in a generally conservative approach, where owners are unwilling to accept actions that place the land at risk (T. Kingi as cited in MAF, 2011: p5).

16 In the Ngāi Tahu Settlement, the Waitangi Tribunal concluded that, in acquiring some 34.5 million acres of land from Ngāi Tahu for £14,750, the Crown acted unconscionably and in repeated breach of the Treaty of Waitangi. The Tribunal considered that the Crown's actions left Ngāi Tahu with insufficient land to maintain its way of life, and to enable the tribe's full participation in subsequent economic development (https://www.beehive.govt.nz/feature/ngai-tahu-settlement-4). Note: 34.5 million acres is equivalent to just under 14 million hectares.

17 A useful resource for information on Māori land is http://maorilandonline.govt.nz

18 The designation of Māori Land status does not reflect the way in which the land is owned and being used. In Otago Land that has papakāinga status is that which can be linked to ancestral connections and guided by Tikanga Māori. As an example, some land at Karitane has over the years lost its status as Māori Freehold land from what was originally surveyed in the 19th Century, but it may still be owned by the descendant(s) of the original grantees.

The Ministry for Primary Industries' Agribusiness regional kaimahi work to support Māori landowners and agribusinesses in the sustainable development of their primary sector assets through three main programmes:

1. Māori Agribusiness Pathway to Increased Productivity (MAPIP) programme
2. Māori Agribusiness Extension (MABx) programme
3. Sustainable Food and Fibres Futures (SFFF) programme

The aim of the Māori Agribusiness Directorate is *"to support Māori on their primary sector journey, such as creating a pathway towards getting farm environment plans developed"* (H. Ellison, pers. comm., July 2022). The Māori agribusinesses receiving this support are just a segment of these enterprises that occur in Otago.

Image 6 & 7: Farm at Okia Flat (Ōtākou Peninsula) (top photo looking across to the Pyramids and bottom photo mustering lambs for docking)
Source: Edward Ellison

3 Sheep and Beef Cattle Farming

Authors: Angie Fisher (Senior Agricultural Analyst – On Farm) with contributions from Andrew Burtt (Chief Economist), Jenny McGimpsey (Economic Service Manager – Southern South Island) and Sharyn Price (Economic Service Manager – Central South Island)[19].

This chapter outlines the sheep and beef cattle industry in Otago and is based on in-depth information (long-term data series and expert commentary) about Otago commercial sheep and beef farms[20] sourced from the B+LNZ Sheep and Beef Farm Survey[21]. The quality of this resource reflects farmers' long-term commitment to the industry. B+LNZ estimates there are around 910 commercial sheep and beef farms in Otago[22] with a considerable range of farm systems, practices, farm policies and profitability across the region.

3.1 Summary

The sheep and beef industry is important to Otago and New Zealand and vice versa. One-in-five of New Zealand's sheep are in Otago (more than any other region) and nine per cent of the country's beef cattle herd. New Zealand's meat industry (meat being the country's second largest export) began in Otago – at Totara Estate, near Ōamaru – in 1882 – and now more than 90 per cent of the country's meat and wool production is exported. In the south of the South Island (Otago and Southland combined) sheep and beef farming and the meat processing sectors combined makes up 12 per cent of economic activity and employment.

Sheep and beef farming is the predominant land use in Otago, covering 70 per cent of developed land in the region – which is often land that has few alternative land uses. Otago is the most diverse region for sheep and beef farming in New Zealand – ranging from high country stations, of which Otago has the most of any region – to coastal properties. There is a high level of integration within sheep and beef farming because of this diversity, with commercial relationships between breeders and finishers. Further, there is important integration between farms and processors, exporters and wide range of service industries in Otago and across its borders.

Sheep and beef cattle generate a range of revenue streams with almost all commercial sheep and beef farms having some form of revenue other than from sheep and beef cattle, though around 95 per cent of farm revenue is from the core species – sheep (from wool and meat) and beef cattle. Sheep and beef farm profitability varies from season to season as elsewhere in New Zealand subject to the conditions of a complex set of interactions. Weather plays a critical role in pasture and animal production. On-farm inflation in the price of inputs for 2021-22 was just over 10 per cent in a climate of inflationary pressure continuing to drive up prices..

Farming productivity has improved substantially over the last 30 years as part of continuous improvement in efficiency to respond to customer needs and create more output with fewer resources. 'Winter grazing'

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19 All Beef + Lamb New Zealand (B+LNZ).

20 A commercial sheep and beef farm is defined by several criteria, the most important of which are that the farm winters at least 750 sheep and beef stock units, earns at least 70 per cent of its gross revenue from sheep, beef cattle, long-term dairy grazing and crops, and/or has more than 80 per cent of stock units being sheep and cattle.

21 The B+LNZ Sheep and Beef Farm Survey has been running since 1950 and provides a sound base for the B+LNZ Economic Service's forecasts of meat and wool production as well as existing trends – linking physical production together with financial returns and the capital structure of farms. The trends shown by the survey data are published in several key reports, including the Stock Number Survey, New Season Outlook, Lamb Crop, Mid-Season Update, and On-Farm Inflation Report. https://beeflambnz.com/data-tools/sheep-beef-farm-survey

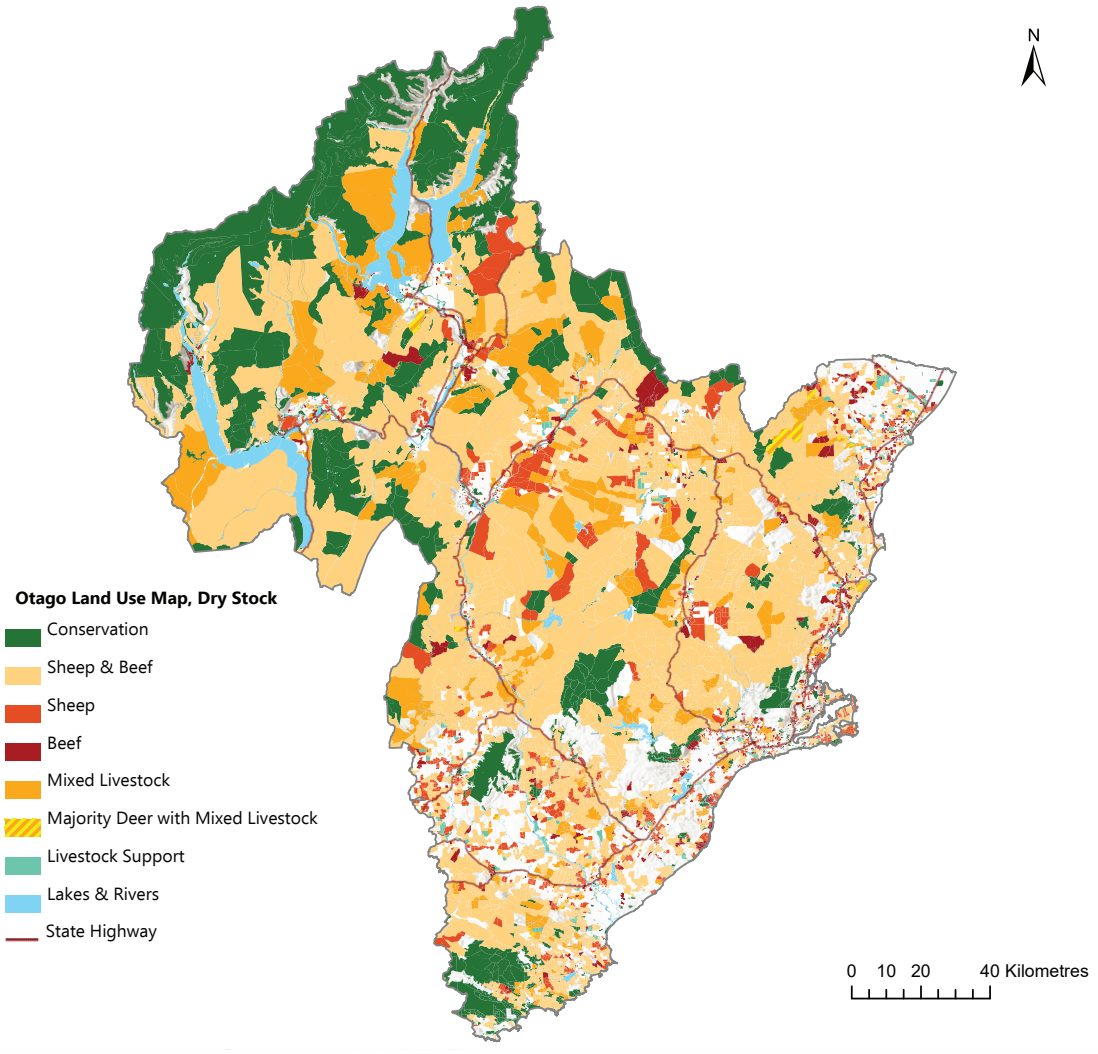
22 Estimated by B+LNZ in conjunction with Stats NZ Tatauranga Aotearoa from Agricultural Production Statistics.

is a common farming practice on sheep and beef farms and at least 90 per cent of sheep and beef farms in Otago have crops. Overall, fertiliser use on sheep and beef farms in Otago is very low and highly targeted.

Relationships between farmers and between farmers and processors do not necessarily align with Freshwater Management Unit (FMU) or Rohe boundaries[23]. Farmers and communities in South Otago for example focus on relationships with farmers, processors, and communities in Southland rather than elsewhere in Otago because they are geographically closer. Objective information shows the average age of farmers has decreased, which is contrary to the rhetoric, and demonstrates succession is occurring.

3.2 Size and distribution

Sheep and beef cattle farming is the predominant land use in Otago, and as at 2022 it covers roughly 70 per cent of the region's developed land. The Otago Land Use Map below shows the extent of sheep and beef farms across the region. Over the past 30 years, improvements in productivity have outweighed decreases in total livestock numbers and land areas, and as a result production levels are similar, albeit with fewer sheep. In 2019-20, there were just under 4.9 million sheep or 20 per cent of New Zealand's flock in Otago – the highest proportion of any region – and just over 325,000 beef cattle, nine per cent of the country's herd (StatsNZ[24]).



Source: Otago Land Use Map 2022, Otago Regional Council

23 https://www.orc.govt.nz/

24 https://www.stats.govt.nz/indicators/livestock-numbers accessed 1 May 2022.

In New Zealand, sheep and beef cattle are typically run together because the two types of stock complement each other in a range of ways. For example, sheep and beef cattle have different feed requirements so pasture growth and use can be balanced within a farm across the year. Sheep and cattle can also be used to manage pasture while minimising their individual exposure to parasites. Together, they create two main revenue streams, which is a way of diversifying the farm business, and most farms also earn income from other sources (e.g., deer, arable crops, grazing other people's livestock, and farm forestry). The mix of multiple revenue streams and situations means that sheep and beef farm businesses are diverse and complex to operate, analyse and understand.

The topics of size and distribution are threads that run throughout the rest of this chapter.

3.3 Historical overview

Sheep and beef cattle farming has been a mainstay of Otago's agricultural sector since the mid-19th Century. From the 1850s until the introduction of refrigerated shipping in the 1880s, the country's main pastoral export was wool to Britain (because it was non-perishable), particularly for the worsted[25] trade in Yorkshire (McAloon, 2011).

There was a domestic market for beef in the 1860s when large mobs of cattle were fattened and driven to Otago and the West Coast to supply meat to miners during gold rushes (Peden, 2011). However, the export market for wool, and later sheep meat, as well as the nature of the land meant sheep were by far the most profitable livestock long-term until the 1970s when wool prices declined in the face of competition from cheap cotton and synthetic fabrics (Brooking and Pawson, 2011).

During the second half of the 19th Century sheep in New Zealand tended to be farmed on great estates. To give some sense of their scale, Teviot Station (Tuapeka) carried over 42,000 sheep on 64,000 acres (or just under 26,000 hectares) of land on both sides of the Clutha Mata Au – and its woolshed had an estimated capacity of 8,000 sheep[26]. Even larger was Morven Hills Station, which at its zenith stretched over from the Lindis Pass down to the Cromwell Gorge and up to Lake Wānaka (Patterson, Brooking and McAloon, 2013).

In the 1880s, there were two achievements in North Otago related to meat production that influenced the future development of New Zealand (Currie, 1974). The first came in 1882 when William Soltau Davidson and Thomas Brydone (both of the New Zealand and Australian Land Company) supplied sufficient carcasses from Totara Estate near Ōamaru for an experimental shipment of frozen meat (along with butter and cheese) sent in a refrigerated sailing ship from Port Chalmers[27] to England (Currie, 1974 and NZ History[28])[29].

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25 A fine smooth yarn spun from combed long-staple wool that is used to make a close-textured fabric.

26 https://www.heritage.org.nz/the-list/details/336

27 Ōamaru's harbour works were incomplete, so the carcasses were sent by rail to Port Chalmers for freezing aboard the Dunedin, which sailed for London on 15 February 1882 and landed its cargo in perfect condition. In Ōamaru itself there are two other pioneering meat trade sites: Sumpter Wharf and the old Humber Street freezing works (1885-86) behind the railway tracks, a few hundred metres north of the historic precinct. (https://nzhistory.govt.nz/media/photo/totara-estate).

28 More information on Totara Estate is available at https://nzhistory.govt.nz/media/photo/totara-estate, https://www.heritage.org.nz/the-list/details/7066 and https://www.odt.co.nz/regions/north-otago/totara-estates-unique-view-past

29 In the same year, Kempthorne Prosser and Co. established a superphosphate works and the meat industry produced valuable fertiliser by-products, although there was no material benefit until the 20th Century when reasonable quantities became available and seed drills with fertiliser boxes were developed (Malcolm, 1983).

The success of the shipment[30] was a 'signal event' and set meat production in New Zealand "*onto a viable path*" (Brooking and Pawson, 2011: p17). Over several decades New Zealand's great estates in the low country were broken up into smaller farms suitable for families and encouraged 'closer' settlement (i.e., more people living in a locality)[31]. By the early 1890s farmers had begun to take up specialist fat lamb farming and were operating 'middling' sized pastoral farms of a few hundred acres (Brooking and Pawson, 2011). About this time, a distinction was created between pastoral farming on the largely freehold low country and pastoralism[32] in the semi-arid and mountain lands that were usually leased as 'runs' from the Crown – and the term 'high country' for these lands began to be commonly used (Peden, 2011). However, in the foothills of Otago (as well as those in Southland and some in Canterbury) the distinction between the two systems remained blurred.

Image 8: Frederick Tudgay (1841-1921), The "Dunedin" off the English Coast, 1875, oil on canvas. The "Dunedin" carried the first shipment of frozen meat to Britain in 1882.
Source: Hocken Collections – Uare Taoka o Hākena, University of Otago
Note: The 140th anniversary of the first shipment of frozen New Zealand lamb from Port Chalmers in Dunedin occurred in 2022. The New Zealand Land Company chartered the Dunedin for nine other voyages, making 10 consecutive passages in all. The ship practically "died in harness", being lost in 1890 and no trace ever being found.[33]

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30 The "Dunedin" sailed from Port Chalmers on 15 February 1882 and was reported off the Lizard on 18 of May 1882. Its cargo arrived in London in excellent condition, mainly, it was stated, owing to the care and attention given by Captain Whitson. https://nzetc.victoria.ac.nz/tm/scholarly/tei-Bre01Whit-t1-body-d66.html

31 The farmers of small farms in the 1870s had two advantages over the earlier runholders (Hamel, 2001). First, road and rail transport systems that developed rapidly in Otago (paid for by gold revenues and built to encourage further gold production) gave small farmers direct access for their products to domestic markets (Hamel, 2001). Second, when fencing wire began to be imported in sufficient quantities, small farmers were able to fence their own and the runholders' stock away from their crops (Hamel, 2001).

32 A valuable discussion of topics and issues relating to pastoralism that are relevant to Otago, such as burning, rabbits, overstocking and overgrazing, and the adaptation of farming practices to suit the land is available in Peden (2011) "Pastoralism and the Transformation of the Open Grasslands", which is Chapter 5 in Brooking and Pawson (2011) *Seeds of Empire: The Environmental Transformation of New Zealand*. Chapter 10 "Remaking the Grasslands: the 1920s and 1930s" by Brooking and Star (2011) in the same book may also be of interest to the reader.

33 By the 1970s in North Otago lucerne was making a valuable contribution on the free draining 'low country' by extending the life of grazing to 10 years with an average carrying capacity of 9 stock units per hectare (Currie, 1974).

The second achievement in North Otago in the 1880s was when James Little established a new breed of sheep at Corriedale (near Windsor in the Waiareka Valley) to produce both meat and wool (Currie, 1974)[34]. By the start of World War I, there was a clear pattern of differentiation of sheep types suited to local environmental conditions and economic considerations (Peden, 2011: p91). The Corriedale replaced the Merino, which had been the early dominant breed, on *"the easier high country, dry hill country and light plains".* In the wetter parts of Otago, the Romney Marsh superseded the Merino because of its hardiness and resistance to footrot, while the Border Leicester was better suited for the drier parts. *"The economics of meat-growing meant that it was particularly important to ensure fast growth of stock"* (McAloon, 2011: p111).

While still largely reliant on the natural fertility of the land, any growth in livestock numbers on sheep and beef farms in Otago was slow in the decades up to 1910. However, they gradually increased during the first half of the 20th Century as new technologies were developed and implemented on farms and access to fertiliser improved. It was not until post-World War II though that New Zealand's sheep flock rose rapidly – as aerial topdressing was used to deliver superphosphate to the high country and the 'wool boom' occurred driven by the Korean War (Brooking, 2006)[35]. Figure 9 shows that in 1921, Tuapeka and Waitaki were the most dominant counties for sheep farming in Otago but by 1961 they had both been overtaken by Clutha County (McLintock, 1966).

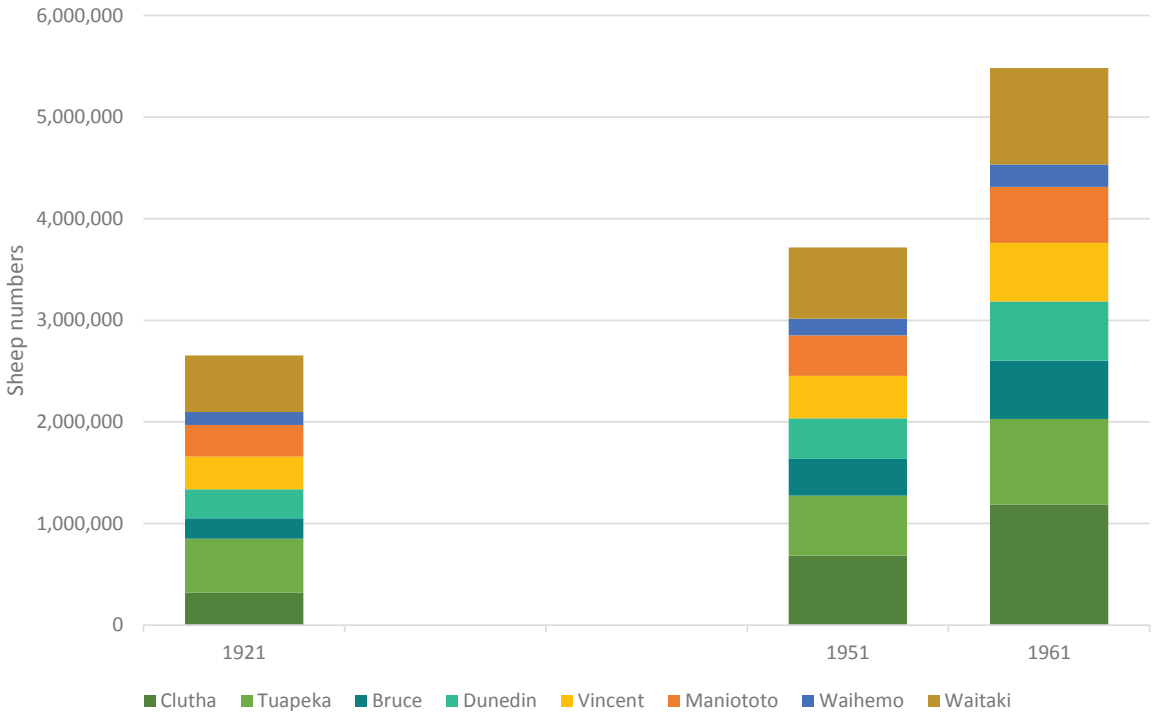

Figure 9: Sheep flock by county in Otago Province during the mid-20th Century
Source: An Encyclopaedia of New Zealand (McLintock, 1966)
Note: The years reported in the graph (1921, 1951, and 1961) were all that was available in the source reference.

34 Information on the Corriedale breed is available at https://nzsheep.co.nz/corriedale/

35 In New Zealand, "sheep numbers soared from 32 million in 1949 to 70 million by 1980, and cattle numbers from four to nearly eight million" (Brooking, 2006: p3). A record number of farms were in operation by the late 1950s and farm amalgamation accompanied the resurgence in sheep farming. Many smaller dairy farms disappeared along with scores of local dairy factories (Brooking, 2006). Some diversification started to occur from the late 1960s, including farm forestry, and the domestication of deer for venison production.

From 1951 to 1961, the sheep flock in Otago grew from just over 3.7 million to just under 5.5 million (+48%) (McClintock, 1966). However, this increase was *"sustained differentially"* with *"the favoured parts"* applying new techniques and practices to carry *"the burden of the growth"* (McClintock, 1966: p732). In the interior basins, the *"old turf"* was replaced with improved pastures that included clover to build up the nitrogen content of the soils and the use of fertiliser and lime increased. An important development at the time was the recognition of lucerne as *"the vital factor in providing winter fodder"* (McLintock, 1966: p732). The Otago *"wool returns"* reached record levels and Dunedin maintained its position as the largest South Island wool-selling centre (with just under 190,000 bales) and the third largest in New Zealand (McLintock, 1966)[36].

In 1966, the Encyclopaedia of New Zealand described farming in Otago as follows[37]:

> *By the 1960s a highly productive zone of mixed farming existed in North Otago, surrounding Ōamaru (similar to that on the Canterbury Plains at the time) – although the hills south of Waitaki (where the lowland is restricted to around Palmerston) were less productive. The Taieri-Tokomairiro Plains south of Dunedin were a fertile area for sheep and 'fat lamb' farms (as well as dairy). In South Otago a system of mixed farming prevailed, the bulk of income being derived from livestock, 'fat lambs', and wool, and small seeds and crops. The richest farming areas in the province were in Bruce and Clutha counties and the downlands of South Otago (stretching between Balclutha, Clinton and Waikoikoi). Around 55 per cent of the increase in sheep numbers during the 1950s occurred In Clutha, Tuapeka and Bruce counties.*

During the 1970s the agricultural sector in New Zealand started to face political and economic headwinds. The most important event in the long-term was when Britain, New Zealand's main export market for sheep meat and wool at the time, joined the 'Common Market' in 1973 (i.e., the European Economic Community (EEC), which later became the European Union (EU)). This event effectively ended New Zealand's guaranteed market for its lamb exports. By 1974-75 the ratio of sheep to cattle on sheep and beef farms in Otago had declined to 15:1, which turned out to be the lowest point in the 50 years from 1970-71 to 2020-21 (the average over this period was 43:1)[38].

The 1980s was a decade of well-documented changing fortunes for the sector, with the removal of farm subsidies. By 1984-85, the sheep-cattle ratio had climbed steadily to a peak of 53:1 but then dropped sharply before reaching the same level again in 1990-91. From 1990 to 2021, the number of sheep in Otago[39] declined by around 2,545,000 (-37%) and the number of beef cattle increased by around 72,000 (+38%) – in response to market distortions that had existed as a result of government policy and farmers more fully responding to customer demand. The period from the 1990s to the present is covered in some detail in the remainder of this chapter.

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36 Central Otago was described in the 1980s as the best fibre-producing area in New Zealand: "the quality of wool and goat fibre is high, and the potential is large" (Kelly, 1987: p14).

37 Over the years the New Zealand Grasslands Association has produced several overviews of farming in Otago that are relevant to the sheep and beef industry. In 1958, A. G. Elliott (Fields Superintendent, Department of Agriculture, Dunedin) considered the early settlement and development of grasslands throughout the extremely widely varying climatic, soil, and topographical conditions of the Otago Province (Elliott, 1958). A useful description of sheep and beef farming in Central Otago was written by J.M. Hercus (Ministry of Agriculture, Dunedin) (Hercus, 1966). A similar survey of sheep and beef farming in North Otago was written by J.D. Currie (Ministry of Agriculture and Fisheries, Ōamaru) (Currie, 1974).

38 As a comparison, the sheep to cattle ratio was 23:1 in 2020-21.

39 Stats NZ Tatauranga Aotearoa

Image 9: Hoggets coming down in late summer, Puketoi Station (Maniototo)
Source: Emma Crutchley

Figure 10a shows the shifting trends in the ratio of sheep to cattle on sheep and beef farms in Otago over the 50 years since Britain joined the Common Market. These trends are usually in response to multiple and varying drivers, but it is possible to identify the impacts of particular events, such as the Global Financial Crisis in the late 2000s. Figure 10b shows that for the 30 years since 1990 there has also been a general reduction in total **stock units** in Otago (the increase of 72,000 beef cattle was less than the decrease of 2,545,000 sheep in terms of stock units).

Both Figures 10a and 10b use production years (or 'seasons'), which run from start of July to end of June. A 'stock unit' means **different types of animals can be compared, based on the food they eat and how much they weigh.** A stock unit is based on the annual feed needed for a 55 kg ewe rearing a single lamb (i.e., one stock unit = one ewe with a lamb 'at foot'), which requires around 595 kg dry matter per year (Parker, 1998).

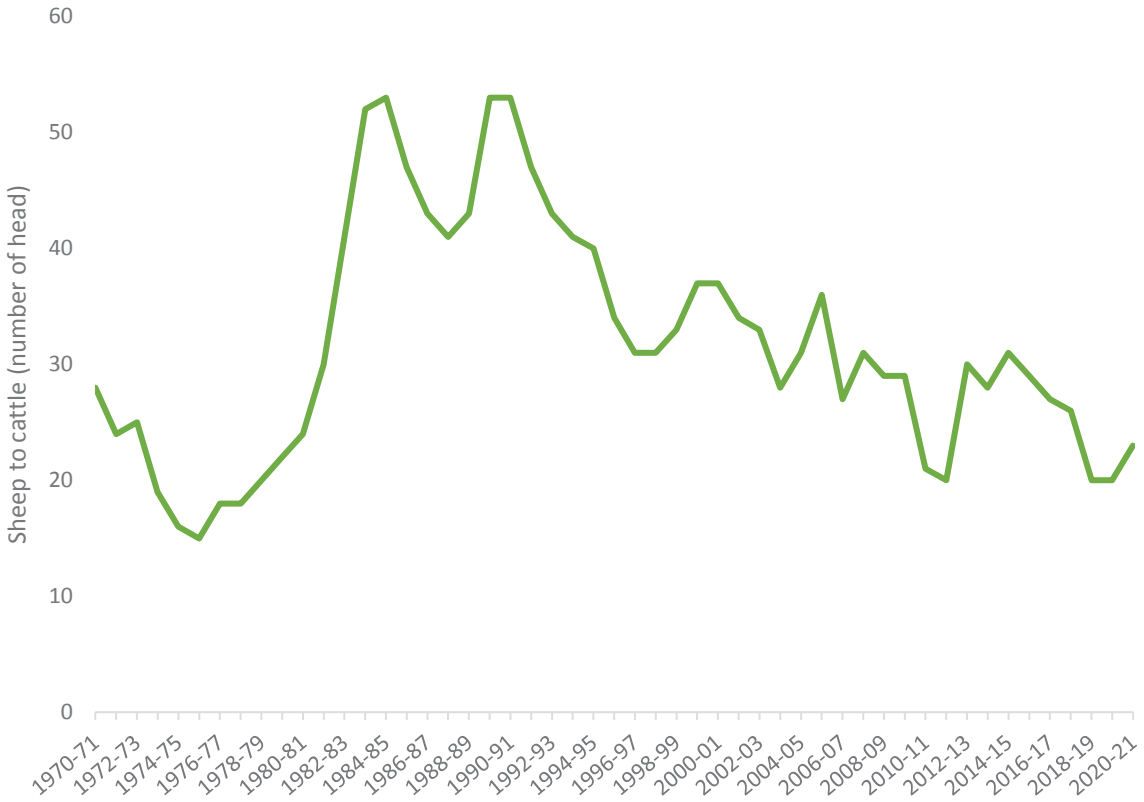

Figure 10a: The number of sheep for each head of cattle on sheep and beef farms in Otago 1970 to 2020
Source: B+LNZ Economic Service, StatsNZ

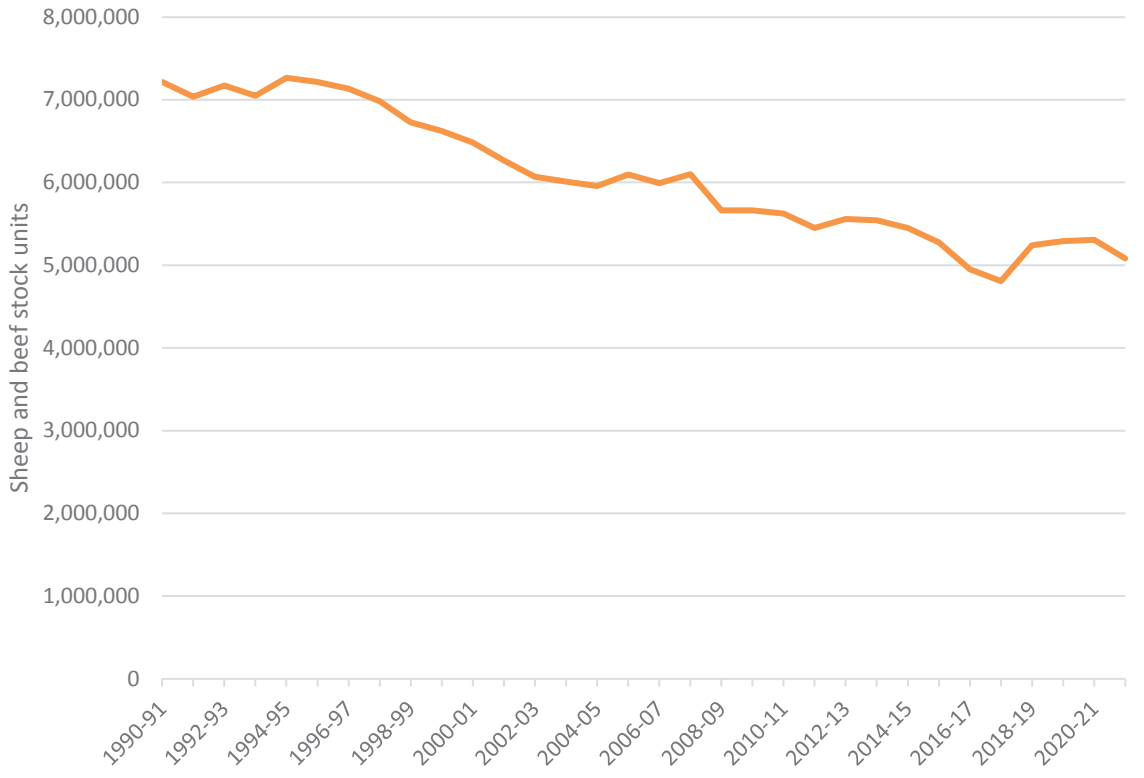

Figure 10b: Total sheep and beef cattle stock units in Otago 1990-2021
Source: B+LNZ Economic Service, StatsNZ

3.4 Main Features

Sheep and beef farming in Otago has a range of specific features. For instance, Otago contains more than half of New Zealand's high-country stations, which is more than any other region. However, the most numerous type of farm in Otago is on rolling hill country with a higher carrying capacity and farming operations focussed on finishing and breeding livestock. In contrast with other regions, Otago and Southland have a high ratio of sheep to beef cattle, reflecting how the sheep and beef farmers have adapted to their local environmental conditions.

To represent the diversity in the industry across New Zealand, the B+LNZ Sheep and Beef Farm Survey is a random sample of commercial sheep and beef farms[40] from New Zealand's Business Frame, which is a database of the individual economic units that make up the New Zealand economy[41]. While generally referred to as 'farms', which can bring to mind more of a pastoral ideal, commercial sheep and beef farms are businesses and have to provide for their owners' livelihoods. Farms are classified in the B+LNZ Sheep and Beef Farm Survey using a system of eight Farm Classes divided between the South Island (five Farm Classes) and the North Island (three Farm Classes).

The Farm Class system is distinct from the Land Use Capability Class system (that also uses the numbers 1 to 8), which is used to rate the versatility of land for agricultural uses by physical attributes, such as soil and slope. While two neighbouring farms may have a similar Land Use Capability Class (or Classes), the way in which the farms are managed and farmed as businesses means they may be in different Farm Classes. In Otago, B+LNZ classifies sheep and beef farms into four of the eight farm classes (the relevant four are highlighted in blue below). Climate and topography vary greatly within Otago and are the two main factors that underlie farm classifications.

Farm Class 1: South Island High Country – Extensive run country located at high altitude. These farms run a diverse mix of operations, which include breeding sheep, often fine wooled, breeding cows and deer. Stocking rate is typically up to three stock units per hectare. Located mainly in Marlborough, Canterbury, and Otago.

Farm Class 2: South Island Hill Country – Traditionally store stock[42] producers with a proportion sold prime in good seasons. Carrying between two and seven stock units per hectare, they usually have a sizeable proportion of beef cattle.

Farm Class 3: North Island Hard Hill Country – Steep hill country or low fertility soils with most farms carrying six to 10 stock units per hectare. While some livestock are finished a sizeable proportion are sold in store condition.

Farm Class 4: North Island Hill Country – Easier hill country or higher fertility soils than Class 3. Mostly carrying between seven and 13 stock units per hectare. A high proportion of sale stock sold is in forward store or prime condition.

Farm Class 5: North Island Finishing Farms – Easy contour farmland with the potential for high production. Mostly carrying between eight and 15 stock units per hectare. A high proportion of stock is sent to slaughter and replacements are often bought in.

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40 The B+LNZ Economic Service defines a commercial sheep and beef farm as, among other things, one that carries over 750 stock units.

41 https://datainfoplus.stats.govt.nz/Item/nz.govt.stats/75a135f9-5913-4ce6-b930-b33b76155f6f/8

42 Store-stock are livestock sold from a farm for purposes other than processing. The buyer of store stock will be buying either for breeding or adding value by growing stock on to prime condition.

Farm Class 6: South Island Finishing-Breeding Farms – Farms which breed or trade finishing stock and may do some cash cropping. A proportion of stock may be sold as store, especially from dryland farms. Carrying capacity ranges from six to 11 stock units per hectare on dryland farms and over 12 stock units per hectare on wetter or irrigated farms. Found mainly in Canterbury and Otago, this is the dominant farm class in the South Island.

Farm Class 7: South Island Finishing Farms – High producing grassland farms carrying about nine to 14 stock units per hectare, with some cash crop. Located in Southland, South and West Otago.

Farm Class 8: South Island Mixed Cropping and Finishing Farms – Located mainly on the Canterbury Plains. A high proportion of their revenue is derived from grain and small seed production, as well as stock finishing or grazing.

Figure 11 shows the estimated distribution of sheep and beef farms across New Zealand by farm class[43]. The most common in Otago is Farm Class 6 Finishing-Breeding farms, which comprise 54 per cent of the region's commercial sheep and beef farms. Within Otago, sheep and beef farming is carried out on a myriad of soil types, climatic zones, and topographies.

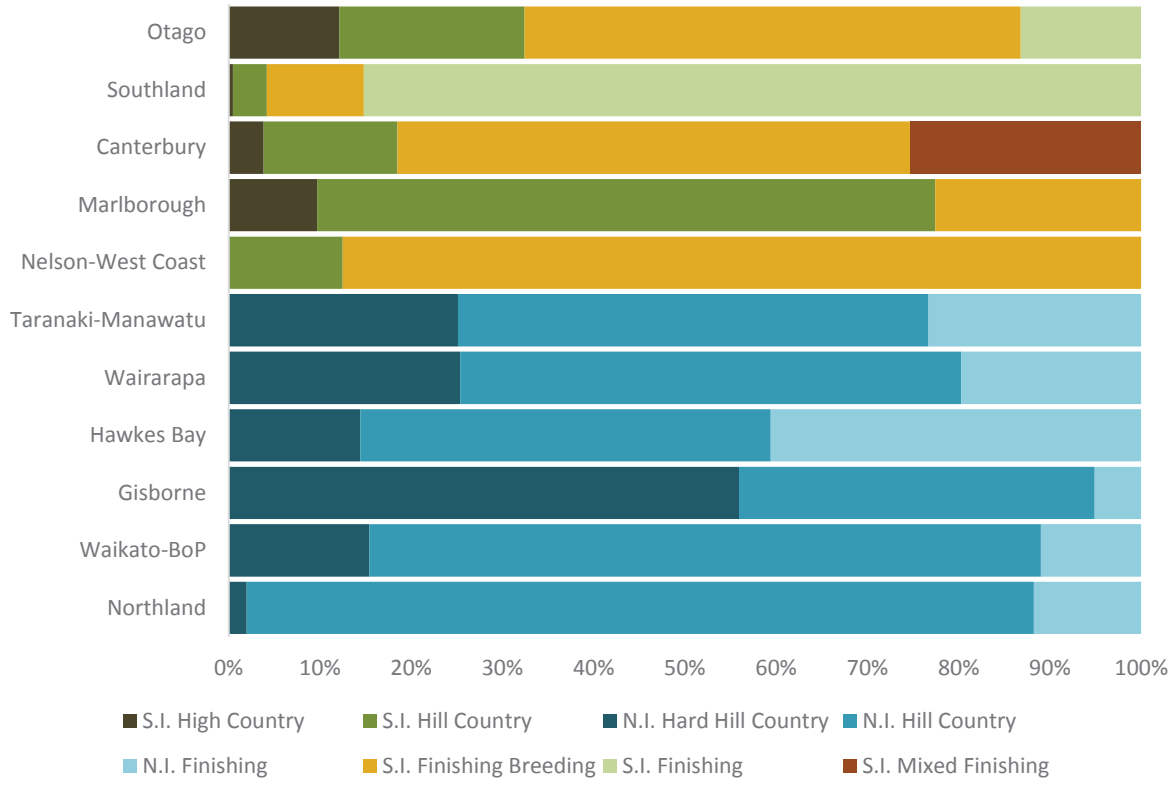

Figure 11: Estimated percentage of farms by farm class and region 2020-21
Source: B+LNZ Economic Service Sheep and Beef Farm Survey

43 B+LNZ estimates in collaboration with Statistics New Zealand, which produces New Zealand's official agriculture statistics from the Agriculture Production Census and Survey ("APC" and "APS" respectively).

Table 2 gives the main physical and production characteristics of New Zealand sheep and beef farms for the four farm classes relevant to Otago. Although the information is averages, it underlines the diversity across the industry. Many sheep and beef farms in Otago also carry other stock, particularly deer and occasionally some goats.

Table 2: Characteristics of Otago farms by farm class in 2020-21

Characteristic	Farm Class 1 South Island High Country	Farm Class 2 South Island High Country	Farm Class 6 South Island Finishing Breeding Farms	Farm Class 7 South Island Finishing Farms	Weighted Average All Farm Classes
Number of farms in B+LNZ survey sample	7	10	17	7	41
Total farm area (hectares)	7,345	1,225	633	360	1,529
Grazed area (hectares)	6,292	1,061	525	338	1,306
Non-grazed (forestry and 'set aside')	14%	13%	17%	6%	15%
Labour units (FTE per farm)	3.29	1.84	1.59	1.45	1.83
Number of sheep	9,353	5,028	4,077	3,197	4,792
Number of cattle	414	255	157	131	205
Number of deer	65	58	3	69	30
Sheep to cattle ratio	23	20	26	24	23
Sheep stock units	8,189	4,660	3,648	3,001	4,317
Cattle stock units	1,559	1,256	745	543	923
Deer stock units	108	102	5	114	52
Total stock units	10,206	6,004	4,404	3,749	5,344
Stocking rate (stock units/grazed ha)	1.6	5.7	8.4	11.1	4.1
Lambing performance*	109.9%	124.0%	135.3%	141.1%	128.6%
Calving performance*	79.3%	82.9%	85.2%	-	83.6%
Wool sold (kg/sheep 'at open')**	4.85	4.25	4.75	5.15	4.70
Wool sold (kg)	45,316	21,371	19,371	16,468	22,531
Number of lambs sold	2,731	3,805	3,677	3,289	3,537
Number of sheep sold	2,704	849	719	623	972
Number of cattle sold	264	129	101	107	127
Number of deer sold	27	34	0	26	14

Source: B+LNZ Economic Service Sheep and Beef Farm Survey

*Note: * 100% performance is an average of one lamb for every ewe or one calf for every cow. ** 'At open' refers to the start of each new farming year or 'season', which runs from 1 July to 30 June. Grazed and non-grazed areas are explained in Section 3.4.5.*

There are considerable differences in farm size. Farms range from high-country stations (Farm Class 1) with 10,000 to 11,000 stock units (on average) and an average stocking rate of 1.6 stock units per grazed hectare to finishing farms (Farm Class 7) with an average 3,749 stock units and an average stocking rate of 11.1 stock units per grazed hectare. In total there are around 910 sheep and beef farms in Otago (each 'farm' is a commercial farm business and may include more than one property or block of land under farming operations).

There are around 110 Farm Class 1: South Island High Country farms (or stations) in Otago[44] and they are usually found in inland parts of the region although they vary vastly in their characteristics. While most 'finish'[45] at least some of their own livestock, some farms may have a limited number of paddocks for making hay, while others with irrigation grow their own fodder crops. The sheep and beef farms in Otago that include deer (as opposed to deer farms that include sheep or beef) tend to be found in the more expansive landscapes of Central Otago, Queenstown Lakes, Upper Waitaki and heading up towards the Mackenzie Basin in Canterbury[46].

Farm Class 2: South Island Hill Country is a more extensive style of pastoralism, where store stock makes up a considerable proportion of the farm's output. There are around 185 Farm Class 2 farms in Otago and these farms have higher stocking rates than Farm Class 1, but stocking rates are still relatively low in comparison to Farm Class 7 finishing farms. On average, Farm Class 2 farms tend to be larger than farms in other classes (except Farm Class 1) but there is still a range from very small farms to very large within that farm class.

Farm Class 2 farms tend to have some sort of physical limitation, which influences management of the farming business. The limitation could be climate (e.g., uneven distribution of rainfall throughout the year) or topography (e.g., steep land). There can be marked differences between farms in Farm Class 2. For example, Farm Class 2 farms in Central Otago could be flat farms on valley floors, without irrigation. The lack of irrigation reduces the potential carrying capacity of that land. In comparison, Farm Class 2 farms in the Catlins in the southeast of the region are more likely to be limited by topography – the farms' relatively steeper land limits their carrying capacity.

Farm Class 6: South Island Finishing-Breeding is the most numerous farm class, with around 595 commercial farms in Otago. Farm Class 6 farms are finishing and breeding farms that are usually able to finish most of their stock to prime, but also sell some of their store stock if needed (e.g., in a dry season). Farm Class 6 farms tend to be in rolling hill country with adequate soil moisture for most of the year, although some seasonal deficits may be experienced. Farm Class 6 farms usually have a higher carrying capacity than Farm Class 2 farms in similar locations.

There is a lot of overlap between Farm Classes 6 and 7 farms, but Farm Class 7: South Island Finishing farms need a lot of pasture late in the season and are generally on easier contour or flat land, such as around the Taieri Plains and in West Otago and South Otago.

> *Neighbouring farms could be in different farm classes based as much on their farming policies (i.e., decisions made by the owners and/or managers of the business) as on the physical nature of the land they are farming.*[47]

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44 Based on StatsNZ analysis for B+LNZ of the Ag Production Census returns/results.

45 Grow young livestock through to when they are ready for processing.

46 A valuable resource is the High Country Lake Catchments Environment Project, which focused on three stations in Otago: Mt Aspiring Station in the Lake Wānaka catchment, Mt Burke Station in the Lake Wānaka and Lake Hāwea catchments, and Rees Valley Station in the Lake Wakatipu catchment (Arbuckle and van Reenen, 2017).

47 B+LNZ Economic Service Managers interview April 2022.

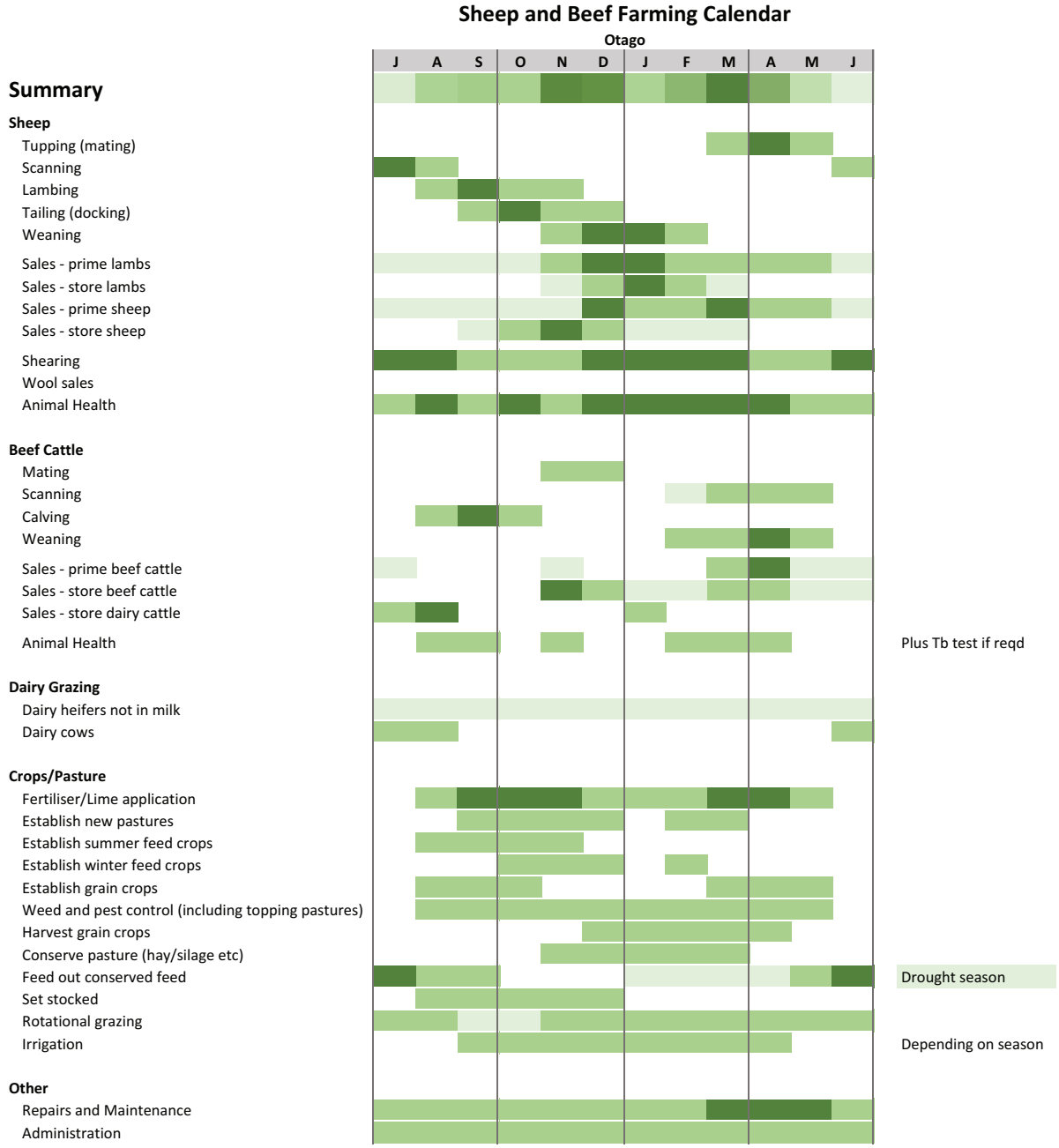
There are around 120 Farm Class 7 Finishing farms in Otago. However, Farm Class 7 Finishing is not a classification that is used in Central Otago or the Dunedin City District because of a decision that was made when the B+LNZ Sheep and Beef Farm Survey began in 1950. At that time, every farm in New Zealand was visited and classified, even though there may have been a few Farm Class 7 farms identified in these localities that fit its description. Similarly, farms situated in the Waitaki (Otago) that are Farm Class 7 Finishing or Farm Class 8 South Island Mixed Cropping and Finishing farms are included in the B+LNZ Marlborough/Canterbury region (seen in Figure 11 in Canterbury). Farm Class 8 is typically used for mixed cropping farms that winter dairy cattle or finish lambs. From the mid-2010s there has been a shift on these farms towards finishing lambs, partly due to increased profit margins for sheepmeat, but also pressure on some soils.

Image 10: Sheep and beef farm at Moeraki Boulders Beach
Source: Emma Moran

The B+LNZ Sheep and Beef Farm Survey does not contain specific information on irrigation use but it does collect data on irrigation charges as part of the financial analysis. It indicates that irrigation, while not used extensively on sheep and beef farms, is an important component of some production systems – such as Farm Class 6 Finishing-Breeding farms on the valley floors of Central Otago – because adding water increases the farm's ability to carry livestock and helps improve its resilience to Otago's climatic variability. The data also indicates some irrigation occurs on Farm Class 1 and 2 farms where the irrigated area is a small proportion of total farm area.

3.4.1 Calendar of farming activities

Figure 12 is an indicative calendar of activities on sheep and beef farms in Otago. It is indicative because every farm differs in such a complex and diverse environment. For example, ewe mating on Farm Class 1 South Island High Country farms is later than it is on Farm Class 6 South Island Finishing-Breeding Farms. As a result, lambing is earlier on Farm Class 6 farms than on Farm Class 1 farms, and the timing of lamb sales is different. Nevertheless, the calendar provides a useful overview of the multiple activities that sheep and beef farmers must manage.



This calendar is indicative (not definitive) showing the activities that occur on-farm, with darker colours indicating key periods.
Sheep and beef farming is complex and diverse so individual farm plans will determine timing for each farm.
Source: B+LNZ, Oct 2022

Figure 12: Indicative Sheep and Beef Farming Calendar for Otago

Image 11: Halfbred ewes in their summer country on Minzion Station
Source: Dougal Macdougall

3.4.2 Profitability

As with all industries, profitability in sheep and beef farming fluctuates over time – being influenced by many external factors such as government regulation, exchange rates, product prices, market access, and seasonal conditions. Profitability weakened during the 1980s and 1990s, following deregulation, and improved in the early 2000s, as depreciation of the New Zealand dollar boosted revenue. Subsequent fluctuations have been driven by market prices, exchange rates and climatic conditions. Factors that influence sheep products (meat and wool) have a larger effect in Otago than those for beef cattle products because of the focus on sheep farming. In 2020-21 revenue from sheep (wool and meat combined) made up 82 per cent of total farm revenue.

Since 1990, Otago sheep and beef farms have tended to be slightly more profitable than the New Zealand average across the whole farm business – but less profitable on a per hectare basis. Profitability on a per hectare basis, shows Otago follows a similar pattern to the rest of New Zealand but generates less profit. This result reflects the larger scale of Otago farms when averaging all farm classes because of the size of Farm Class 1: South Island High Country Stations. On average, Otago farms tend to be larger in area and carry more livestock but with a lower stocking rate (i.e., fewer stock units per hectare) than for New Zealand as a whole, reflecting the environment (broadly defined) in the region.

Together, Figures 13 and 14 compare the weighted average 1) profitability per farm and 2) profitability per grazed hectare for Otago compared to New Zealand as a whole (using Earnings before Interest, Tax, Rent and Management or EBITRm). EBITRm makes it possible to compare farms on an equivalent basis – as if they are freehold, debt-free, and owner-operator. From EBITRm farm businesses have additional expenditure including payments of interest, tax, and rent, as well as repayments of principal, farm capital purchases and personal drawings for the farm family[48].

48 New Zealand sheep and beef farms are overwhelmingly family owned (over 90 percent) with an average of five people living on each farm and many other operations are Māori Trusts. More information is available at Making Meat Better website

Figure 13: Sheep and beef farm profitability per farm for Otago and New Zealand (year to June) 1990-2020
Source: B+LNZ Economic Service Sheep and Beef Farm Survey

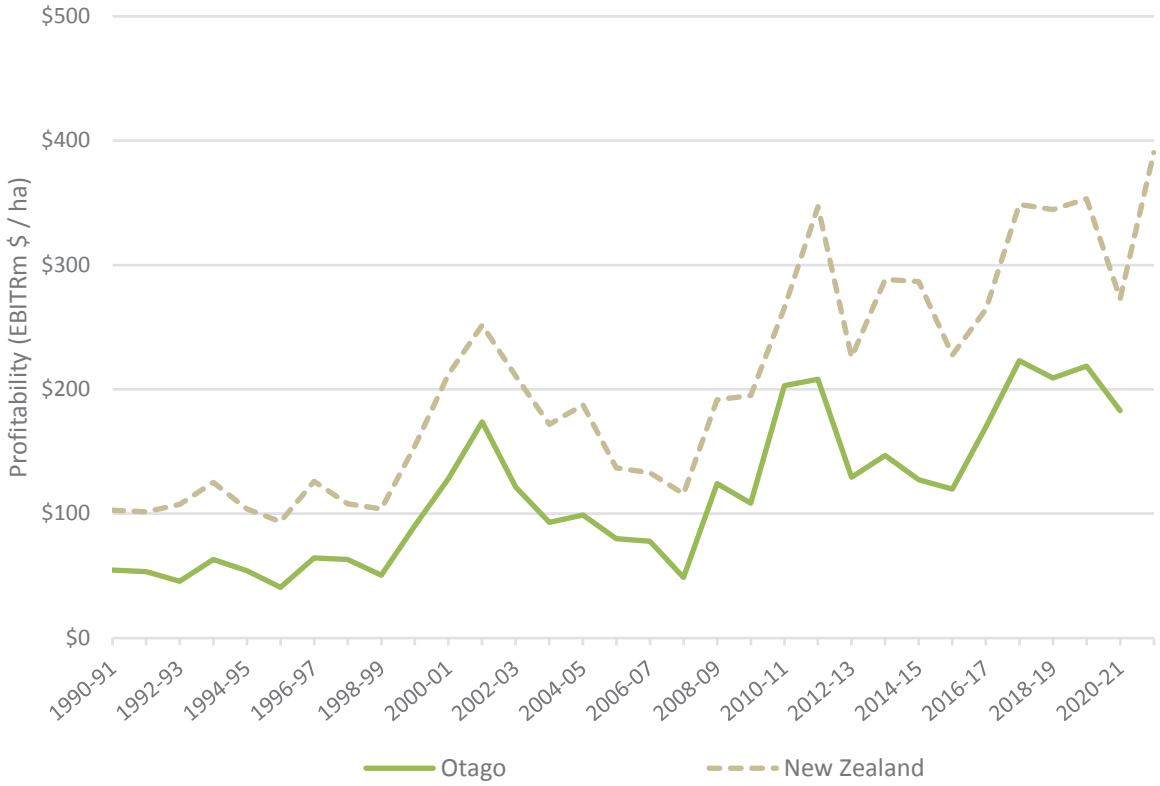


Figure 14: Farm profitability per hectare for Otago and New Zealand (year to June) 1990-2020
Source: B+LNZ Economic Service Sheep and Beef Farm Survey

On-farm inflation, which is a measure of changes in the prices of farm inputs, from 1990 to 2020 was a cumulative 62 per cent. In 2007-08 the average sheep and beef farm profit was one of the lowest in at least 50 years and coincided with the highest exchange rate in United States dollar terms (to that season). Figure 15 shows the variability in profitability per grazed hectare between the four farm classes in Otago.

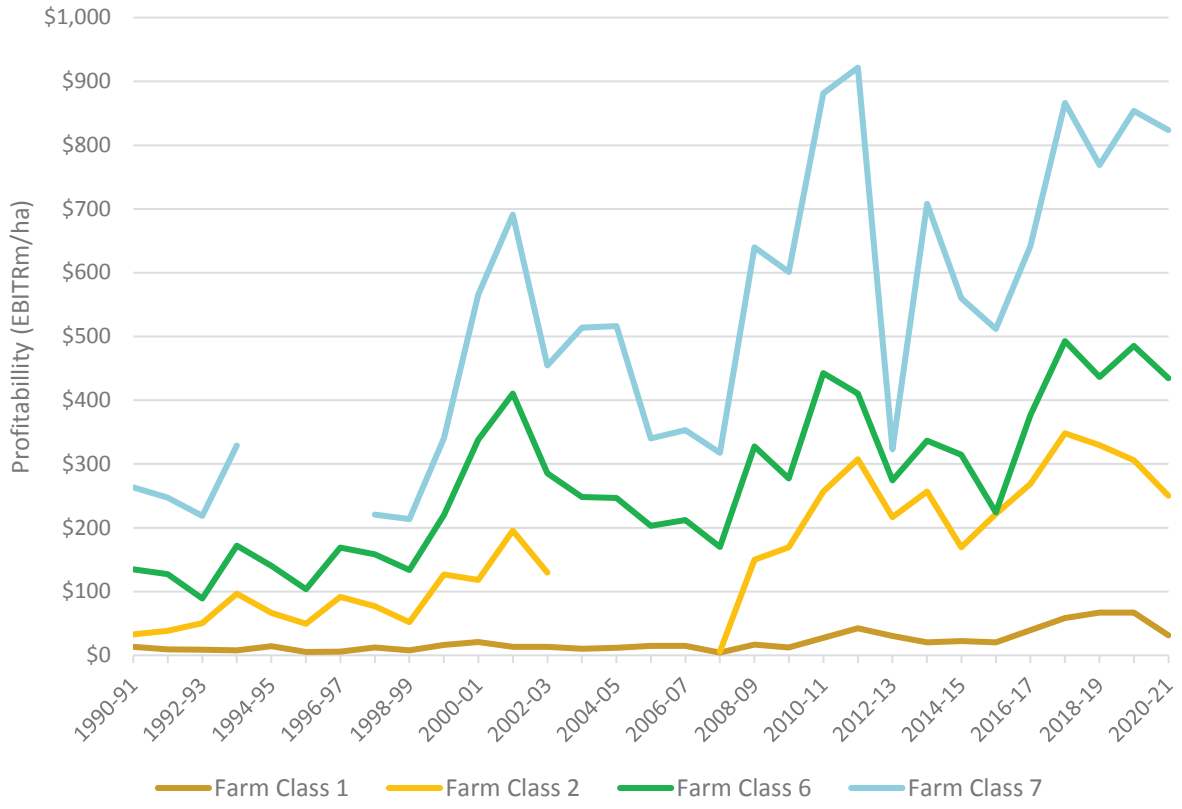


Figure 15: Sheep and beef farm profitability per hectare for the four farm classes in Otago 1990 to 2020
Source: B+LNZ Economic Service Sheep and Beef Farm Survey

Deregulation of the New Zealand economy in the mid-1980s was a watershed moment for New Zealand (now almost 40 years ago). Since this time the sheep and beef farming has consolidated. There has been a steady rise in lamb and beef prices over time (allowing for some variability from one year to the next, which can have marked impacts on profitability), and the diversity of revenue streams helps farmers manage risk. Sheep and beef farmers have focused their attention on improving productivity, through genetics and the use of inputs such as fertiliser. They also monitor and control farm expenditure and the use of farm inputs, the prices of which have increased over time.

Table 3 gives changes in key measures for sheep and beef farms between 1990 and 2020 with the main trends being increased stocking rates and increased size of grazed areas on fewer farms. The decline in the estimated number of farms by more than half is similar to New Zealand as a whole. In Otago this trend has largely occurred in Farm Class 6 Finishing-Breeding and Farm Class 7 Finishing (refer to Figure 16).

Table 3: Comparison of key metrics (as weighted averages across farm classes) for Otago sheep and been farms in 2020-2021

Metrics	1990-91	2020-21	% Change
Commercial sheep and beef farms (number)	2,010	910	-55%
Stocking Rate (stock units/farm)	4,158	5,344	+29%
Grazed area (hectares/farm)	1,118	1,306	+17%
Stocking Rate (stock units/grazed hectare)	3.7	4.1	+11%

Source: B+LNZ Economic Service Sheep and Beef Farm Survey

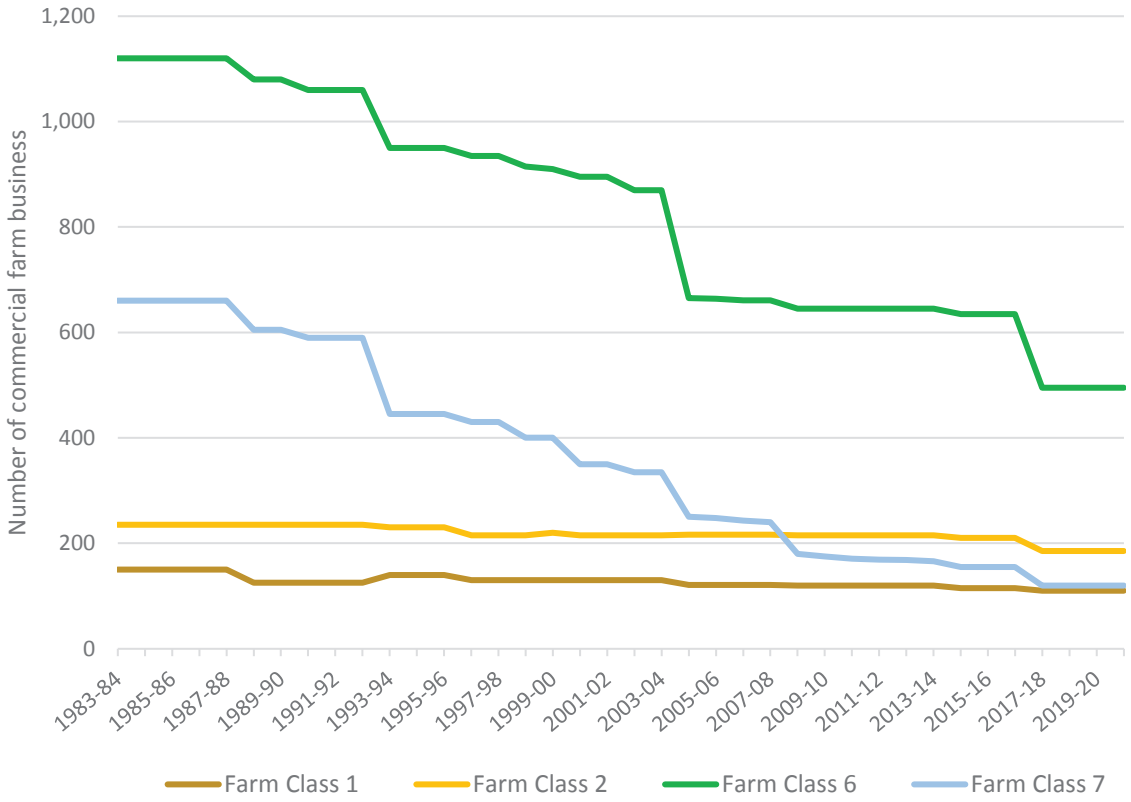


Figure 16: Estimated number of farms by farm class in Otago 1983-2020
Source: B+LNZ Economic Service Sheep and Beef Farm Survey

While the number of farms has decreased, the size of the farms by grazed area has, on average, increased by 17 per cent for all farm classes over the 30 years (refer to Section 3.4.4). Some of this change is due to the consolidation of neighbouring properties. The stocking rates per farm (+29%) has increased at a much faster rate than the stocking rates per grazed hectare (+11%). Figure 17 shows the change in stocking rates per grazed hectare by the four farm classes in Otago.

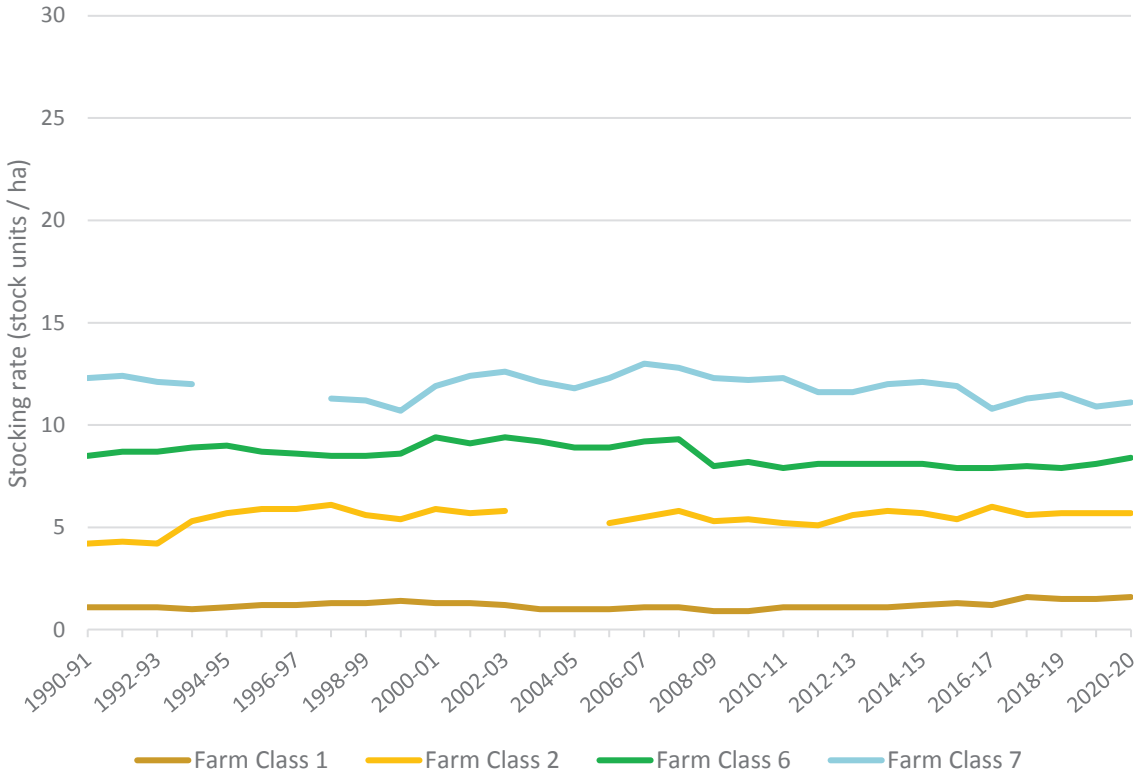


Figure 17: Stocking rates on all farm classes in Otago 1990-2020
Source: B+LNZ Economic Service Sheep and Beef Farm Survey
Note: The scale of 0 to 30 stock units on the y axis reflects the full range of stocking rates across pastoral farming in Otago.

3.4.3 Productivity and production

A common indicator of productivity gains is the change in lambing performance over time, noting that lambing percentages[49] vary between years as a result of the impact of climatic events that can occur prior to mating, during the ewe's pregnancy, through to after lambing until lambs are counted. On average, sheep and beef farms in Otago in 2020-21 produced almost 30 more lambs per 100 ewes than in 1990-91 (i.e., the average ewe lambing percentage for Otago was 100% or one lamb for every ewe on average in 1990-91 and it was around 130% in 2020-21). Figure 18 shows the improvement in lambing performance for Otago compared to New Zealand over the past 30 years (refer to the linear trend line). The impact of snowstorms, such as in 1992 and 2010, on lambing performance are clearly evident in the graph, highlighting the importance of nutrition from autumn through to spring, which relates to winter crop and fertiliser use.

Improved productivity (as indicated by lambing percentages) has meant sheep and beef farmers can reduce their capital livestock (i.e., those that are used for breeding)[50]. The later start to the growing season in Otago than further north means the period from weaning to selling lambs is critically important to success in the region – growing lambs quickly for sale influences both the availability of feed during mating in autumn as well as next year's lambing performance. Historically, finishing farms had a breeding

49 Number of lambs marked or tailed per ewe mated in the previous year.
50 Capital livestock are stock on hand at the start of the farming year (1 July) or at end of that year (30 June). They are recorded in the farm business balance sheet as a dollar value 'at open' and 'at close' of each year.

ewe flock and finished all their own stock as well as bringing lambs in from elsewhere to finish. Over time many of these farms have concentrated on increasing lambing percentages and finishing their own stock at heavier weights rather than bringing in stock to finish. However, Farm Class 6 farms, as the most numerous in Otago, are still a reliable outlet for Farm Classes 1 and 2 to sell store stock.

Figure 18: Lambing performance for Otago and New Zealand 1990-2020
Source: B+LNZ Economic Service Sheep and Beef Farm Survey

Sheep and beef farms produce a complex range of products, although currently the focus is on meat and the products from an animal. They are part of an integrated value chain: farmers themselves and farmers and processors are interdependent – the value to consumers is through consumption of the processed cuts of meat or use of other products into which other products of the livestock are raw materials. In Otago, net meat production[51] per grazed hectare has increased, on average, since 1990, particularly from beef cattle, across all farm classes. Lamb meat production per grazed hectare from Farm Class 6 farms gained strongly in the 1990s, and since then has been relatively steady. Lamb meat production is higher than beef cattle meat production for all farm classes in the region. Figure 19 shows the improvements in lamb and beef cattle meat production for Farm Class 6 farms over the past 30 years.

51 Net meat production recognises that some meat is produced on a breeding farm, with further value (i.e., liveweight) being added by the finishing farm before it is processed. The quantum of meat coming onto a finisher's farm is deducted from their final production. Net meat production highlights the integration of the livestock production 'value chain' between Farm Classes.

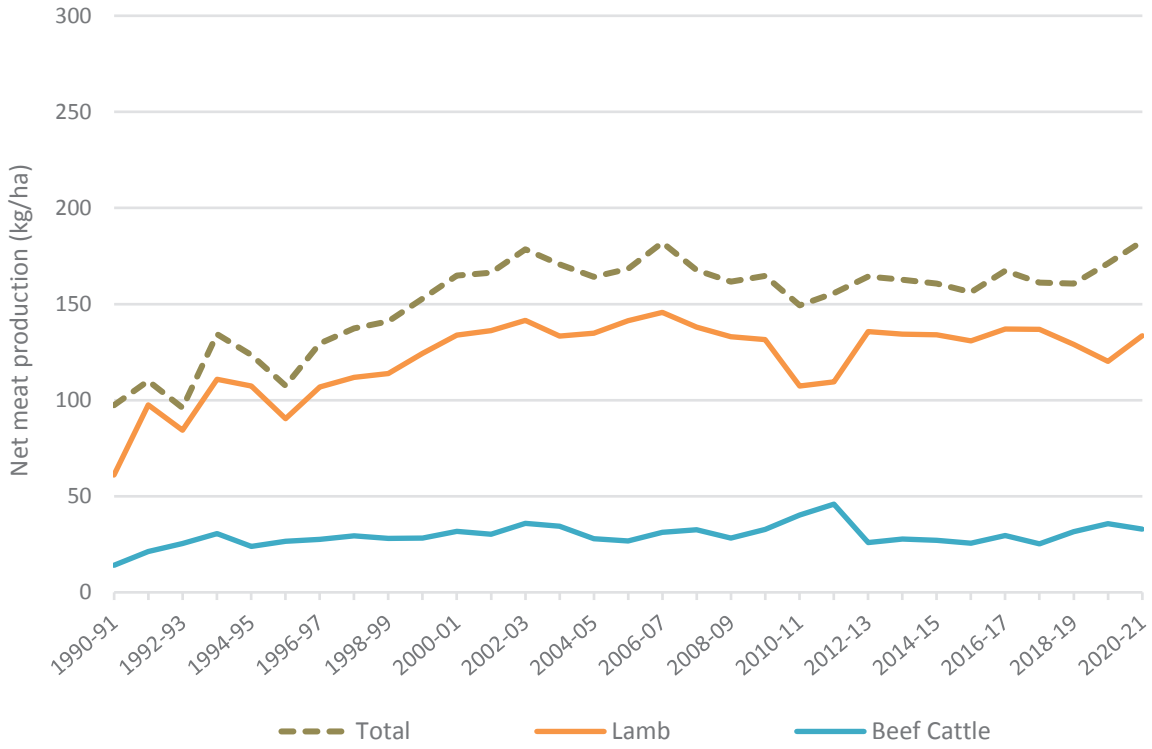


Figure 19: Net meat production for Farm Class 6 – South Island Finishing Breeding Farms in Otago 1990-2020
Source: B+LNZ Economic Service Sheep and Beef Farm Survey

Productivity and production are not necessarily an assurance of profitability. Profitability depends on a complex mix of factors, including livestock weights, growth rates, and losses, and expenditure. The most profitable farmers tend to be those who are skilled at adapting their production system to the local environment and achieving their goals, rather than focusing on a single aspect of their business.

Generally, most sheep and beef farms are self-sufficient (i.e., almost all feed consumed is produced on-farm). Although some Otago farmers pay for grazing or occasionally buy-in feed for their livestock because of climatic conditions, the production systems have been adapted to meet the individual natural pasture growth curves. Many farmers use technologies to conserve feed from peak pasture growth (e.g., hay, silage, or baleage) to make the best use of that feed. As well, the area of a farm devoted to growing winter feed is particularly important. In the B+LNZ Sheep and Beef Farm Survey, over 90 per cent of farms use less than 10 per cent of their grazed area for winter cropping. The seasonality in feed availability carries through to the lambing period and ultimately influences meat processing patterns.

3.4.4 Farm size and topography

The size and mix in topography of each of the 41[52] Otago farms in the B+LNZ Sheep and Beef Farm Survey in 2020-21 is diverse. The 41 farms surveyed ranged in area from less than 200 hectares to between 10,000 and 20,000[53] hectares. Overall, just under three-quarters of the farms had a total farm area of less than 1,000 hectares. Average farm size for each Farm Class in Otago in 2020-21 is reported in Table 2 (above).

52 The number of farms in the B+LNZ Sheep and Beef Farm Survey varies slightly each year. In 2021-22 there were 41 farms surveyed in Otago and in 2020-21 there were 43 farms.
53 To maintain individual confidentiality, a range is given for the largest farm sizes.

Image 12: Hill country sheep and beef farm, Owaka Valley (South Otago)
Source: Emma Moran

In addition to variation in size, each sheep and beef farm has its own blend of topography, including flat, rolling, and steep land, which influences other characteristics of the farm business. Around 15 per cent of the farms in the B+LNZ Sheep and Beef Farm Survey have no flat land – these farms are found in Farm Classes 2 and 6. Other farms range from having less than 10 per cent flat areas on farm up to 100 per cent. The proportion of rolling land ranges from zero to 80 per cent of total farm area, while steep land ranges from zero to more than 90 per cent. Just under 30 per cent of farms have more than half of their farmland classified as steep[54].

Farm size and topography have changed considerably since the 1980s for reasons ranging from tenure review of Crown pastoral leases to changes in relative profitability of sheep and beef farming and other rural land uses. Comparing the B+LNZ Sheep and Beef Farm Survey results for Otago in 2020-21 to those from 1983-84:

Farm Class 1 farms (South Island High Country Stations) are slightly smaller than in the 1980s, but their flat land has stayed reasonably constant over time at four per cent of total land. This equates to around 350 hectares of flat land (although it can be much more), or roughly the size of a Farm Class 7 farm in 2021-22, but it is usually at much higher altitude and so has different growing conditions.

Farm Class 2 farms (South Island Hill Country) decreased in size over the 1990s and then increased from the early 2000s, although are still not quite as large as 30 years ago. These farms now include considerably less flat land than they did in the early to mid-1990s.

Farm Class 6 farms (South Island Finishing-Breeding) are 229 hectares larger (+57%) larger than in the 1980s and have more rolling country and steep land (refer to Figure 20).

Farm Class 7 farms (South Island Finishing) are 160 hectares larger (+80%) than in the 1980s but have substantially more flat land than in the 1980s, along with the introduction of a small amount of steep land.

54 Flat, rolling, and steep descriptions used here are based on the groupings of Land Use Capability (LUC) slope groups: flat = slope groups A & B, rolling = slope groups C & D, steep = slope groups E, F & G.

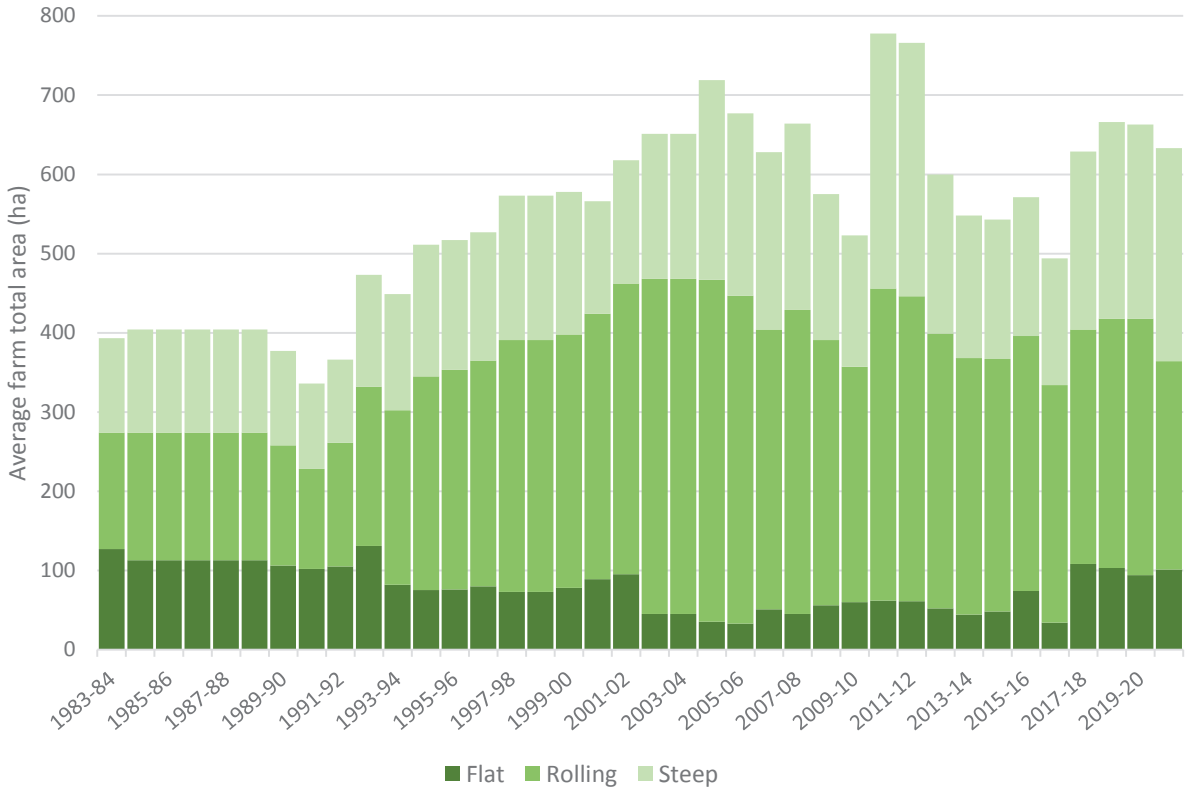


Figure 20: Farm size and topography for Farm Class 6 farms in Otago 1983-2020
Source: B+LNZ Economic Service Sheep and Beef Farm Survey

To illustrate the influence of topography, the large inland plain that extends across Maniototo and Strath Taieri is bordered by block mountains on each side. The production systems are different on the inland plains and valleys from the mountains. Climatic patterns complicate matters further. Closer to Dunedin, there is more moisture in the soil, which is reflected on-farm. What a farmer can grow, and the success of seasons, can vary greatly, even within a small area. One of the most extreme changes in rainfall over a short distance happens between Ettrick and Moa Flat. Despite being only about sixteen kilometres apart, there is a difference of about 500mm in annual rainfall, with Moa Flat being the wetter. The physical landscape from what is considered one to the other goes from summer dry grassland to a lush green landscape within a short distance.

A single rural community is often spread across several catchments and does not necessarily relate to geographic borders such as catchment boundaries. A good example is West Otago, which geographically connects to the Lower Clutha, but in practice, the community can see themselves as more connected to Gore in Southland. Similarly, people in the Maniototo have a connection to Dunedin because roading networks make it an easier direction for them to travel. Taieri is relatively sparsely populated, and the largest settlements/towns are Mosgiel and Middlemarch in the south-east of the river catchment, towards Dunedin, and Omakau and Ranfurly in the north-west. Ranfurly is the main service town for many farms.

3.4.5 Grazed and non-grazed

The grazing part of a sheep and beef farm includes pastures, crops, and agroforestry[55], which produce food and fibre, while the non-grazing part relates to forestry blocks and areas of bush, scrub, wetlands, tussock, riparian zones and similar that are sometimes referred to as areas that are 'set aside' (these areas used to be referred to as 'un-improved' or 'ineffective'). For clarity, the grazeable part of a farm also includes the area occupied by the farmhouse and some curtilage (the land attached to the house up to one hectare), fenced tracks (known as 'lanes' or 'races' on dairy farms), unfenced tracks, and roads (if any).

Average grazing area in the Otago production region from the 2020-21 B+LNZ Sheep and Beef Farm Survey is 6,292 hectares for Farm Class 1; 1,061 hectares for Farm Class 2; 525 hectares for Farm Class 6; and 338 hectares for Farm Class 7. The range in grazing areas across the farms in the sample in 2020-21 was 170 hectares to around 12,000 hectares. Many Otago farms have sizeable areas of land that are set aside, with the general pattern being that larger farms tend to have a larger proportion of non-grazed areas, although climatic factors and regulations may constrain farm forestry on High Country stations (Farm Class 1).

Figures 21 to 24 show changes in non-grazing part of a farm over the past 30 years for each Farm Class – some of the variation between years is because the sample of farms in the B+LNZ Sheep and Beef Farm Survey is continually being refreshed, however farms are surveyed for an average of about seven years, which means trends are well measured. Overall, the long-term trend for sheep and beef farms in Otago is an increasing proportion of non-grazed areas, particularly those being set aside.

Figure 21: Average proportion of non-grazed areas for Farm Class 1 in Otago 1990-2020
Source: B+LNZ Economic Service Sheep and Beef Farm Survey

55 An area that has been planted but provides grazing until the pasture production is negligible when shaded out by the trees.

Figure 22: Average proportion of non-grazed areas for Farm Class 2 in Otago 1990-2020
Source: B+LNZ Economic Service Sheep and Beef Farm Survey

Figure 23: Average proportion of non-grazed areas for Farm Class 6 in Otago 1990-2020
Source: B+LNZ Economic Service Sheep and Beef Farm Survey

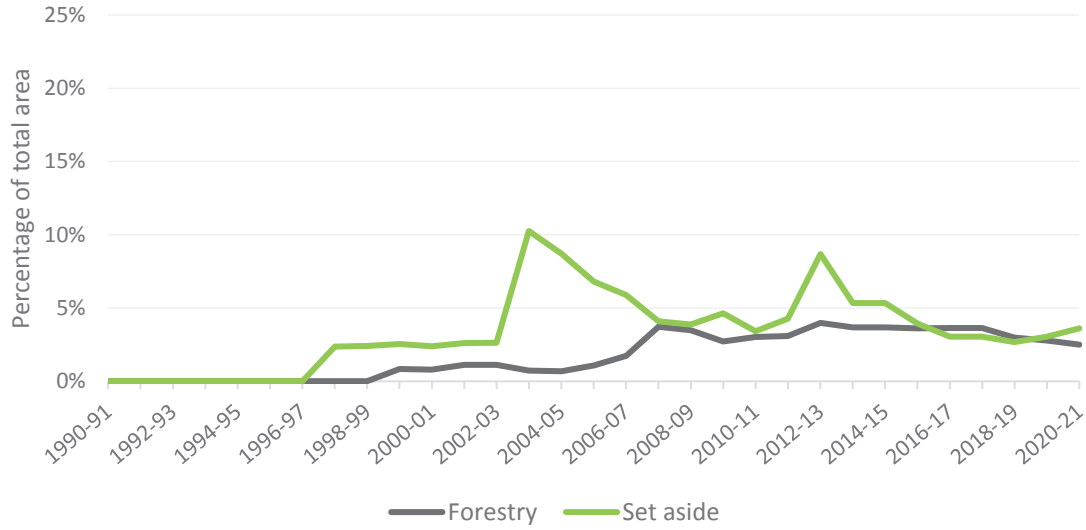


Figure 24: Average proportion of non-grazed areas for Farm Class 7 in Otago 1990-2020
Source: B+LNZ Economic Service Sheep and Beef Farm Survey

3.4.6 Livestock mix

While the weighted average ratio of sheep to cattle numbers (of head) is 23:1 in Otago, the livestock mix on farm is not fixed. With the decrease in total sheep stock units over the past 30 years there has been a change in the ratio of sheep to beef cattle stock units from 90 per cent sheep in 1990-91, to 81 per cent in 2020-21 (for the weighted of all farm classes). Regionally, the trend has been an increase in the proportion of cattle on farm, although it is more pronounced on some farm classes than others.

Farm Class 1 High Country stations had a relatively steady proportion of sheep stock units across thirty years, while beef cattle ranged between 10 and 20 per cent with deer being the balance of livestock.

On Farm Class 2 Hill Country farms, the proportion of beef cattle has gradually increased from eight per cent of total stock units in 1990-91, to 21 per cent in 2020-21. Reasons for this shift will include market prices and profitability, both the reduction in prices for wool and relative gains to be made from selling beef cattle to finishers or processors. Further, the level of management which is generally lower for beef cattle than sheep, and labour has become more limited, such as for shearing.

Image 13: Sheep and beef farm, near Clinton (South Otago)
Source: Emma Moran

Farm Class 6 Finishing-Breeding farms followed a similar trend to Farm Class 2, with nine per cent beef cattle in 1990-91, and 17 per cent in 2020-21. Deer is a relatively uncommon stock type for this farm class with a subset of farms having a small number of deer.

Farm Class 7 Finishing farms tended to have a very high proportion of sheep (averaging 97% of total stock units) – with few beef cattle and no deer – throughout the 1990s and early 2000s. More recently there has been a shift towards cattle, with around 17 per cent beef (a situation similar to the 1970s), and some deer. These farms are typically very adaptable to market and climatic conditions, which is reflected in their stocking decisions over time.

Overall, the weighted average ratio of sheep to beef cattle stock units for Otago moved from 90 per cent sheep and nine per cent beef cattle in 1983-84, to 81 per cent sheep and 18 per cent beef cattle in 2020-21. This gradual shift contrasts with a more dramatic change for New Zealand, which moved from 81 per cent sheep in 1983-84, to 58 per cent in 2020-21. Figure 25 shows trends in sheep and beef cattle (as measured using stock units) as a proportion of a farm's livestock mix across all Farm Classes in Otago and New Zealand over the last 50 years.

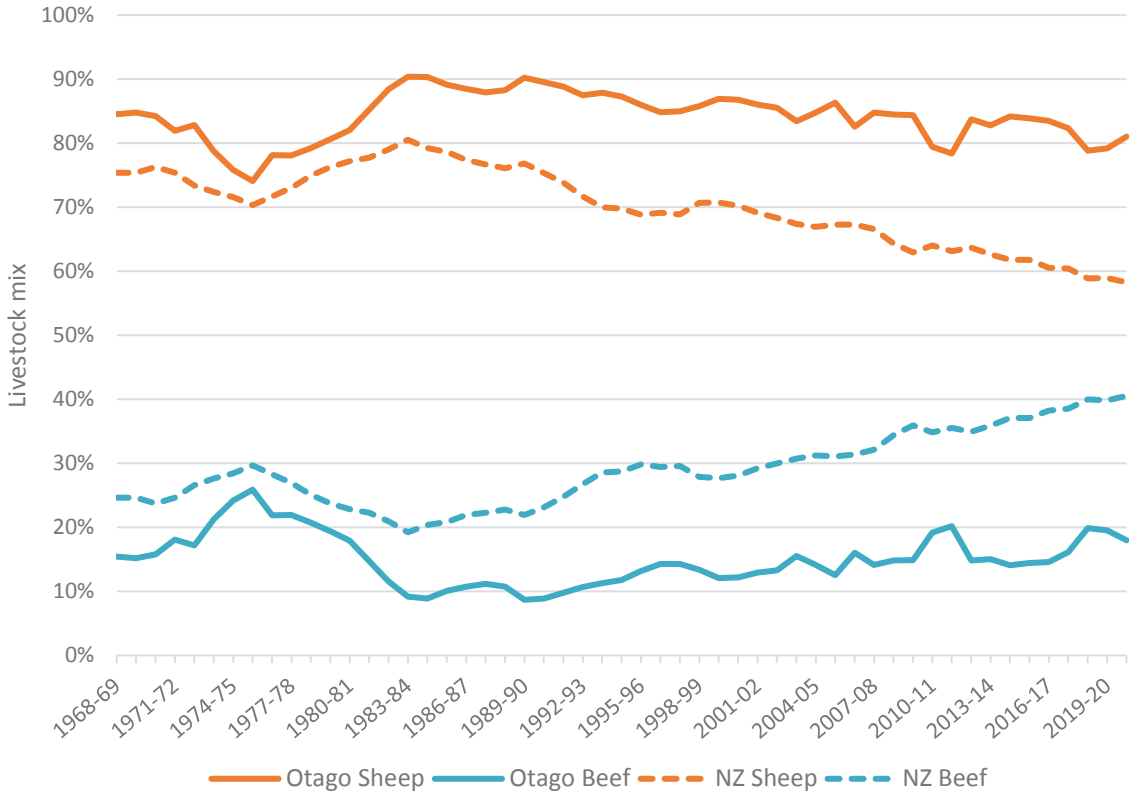


Figure 25: Average mix of sheep and beef cattle stock units across all Farm Classes in Otago from 1968-2020
Source: B+LNZ Economic Service Sheep and Beef Farm Survey

3.4.7 Cropping and winter practices

The grazing of livestock on crops[56] in winter is a common farming practice on sheep and beef farms and is commonly referred to as 'winter grazing'. It is estimated that in 2020-21 at least 90 per cent of sheep and beef farms in Otago had up to 10 per cent of total area in crop for this purpose.

Cash crops[57] are rarely grown on Farm Classes 1, 2 and 6 farms, however, around one in four Farm Class 7 Finishing farms may have areas of cash crop, reflecting their larger proportion of flat land.

There is considerable planning, negotiating and risks taken when planting cash crops or other crops to generate revenue for the farm. Around 12 to 18 months may elapse from the time of planting the crop through to harvesting and final payment, during which time the farmer has outlaid for numerous expenses before final payment on delivery of the crop (payment for contracted crops is typically negotiated before

56 A winter crop is one that is grown for the purpose of in situ grazing by livestock during the winter months (May-September) (J. Chrystal, pers. comm., September 2022).
57 A cash crop is one that sheep and beef farmers grow to be sold (J. Chrystal, pers. comm., September 2022).

farmers plant cash crops). Farm input prices increased sharply in 2021-22, and expectations are for prices to continue to rise – including many inputs essential for cropping such as fertiliser, contractors, fuel, agri-chemicals.

Currently interest rates have increased pushing up the cost of borrowing and overdraft rates, which farm businesses require for cashflow. There are also climate and pest risks during the growing of crops. Overall, given the time horizon, potential risks to the crop itself and pre-negotiated contract rate for the sale of the crop, much thought and planning goes into cash crops as a revenue stream for sheep and beef farmers.

Total crop area as a percentage of grazeable land increased for all farm classes in Otago between 1990-91 and 2020-21. The main driver of increased crop area has been winter feed area, which grew from a very low base, across the weighted average for farm classes in Otago.

> *One driver of the increased need for winter feed for livestock is farmers seeking to maintain their production against the loss of high-quality land to other land uses, such as dairying, horticulture, and urban development. Sheep and beef farms on Land Use Capability Classes 1 to 3 have changed hands over time and farmers require more feed from the remaining land.*[58]

Figures 26 and 27 show trends over time for the four Farm Classes for:

1. total crop area as a proportion of grazeable area (i.e., %); and
2. the area of winter feed in absolute terms (e.g., hectares)[59].

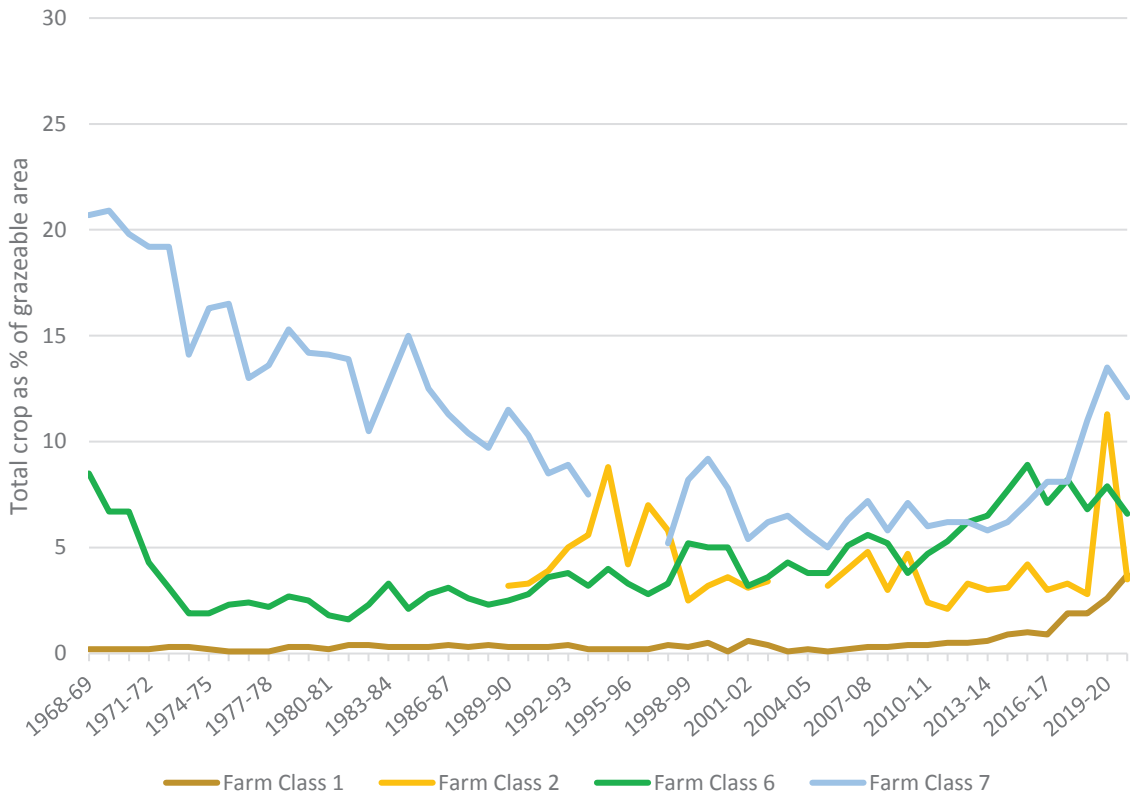


Figure 26: Total crop area as a proportion of a farm's grazeable area for all farm classes in Otago 1968-2020
Source: B+LNZ Economic Service Sheep and Beef Farm Survey

58 B+LNZ Economic Service Managers interview April 2022.
59 Total crop area includes areas of winter feed crop, other feed crop and cash crops.

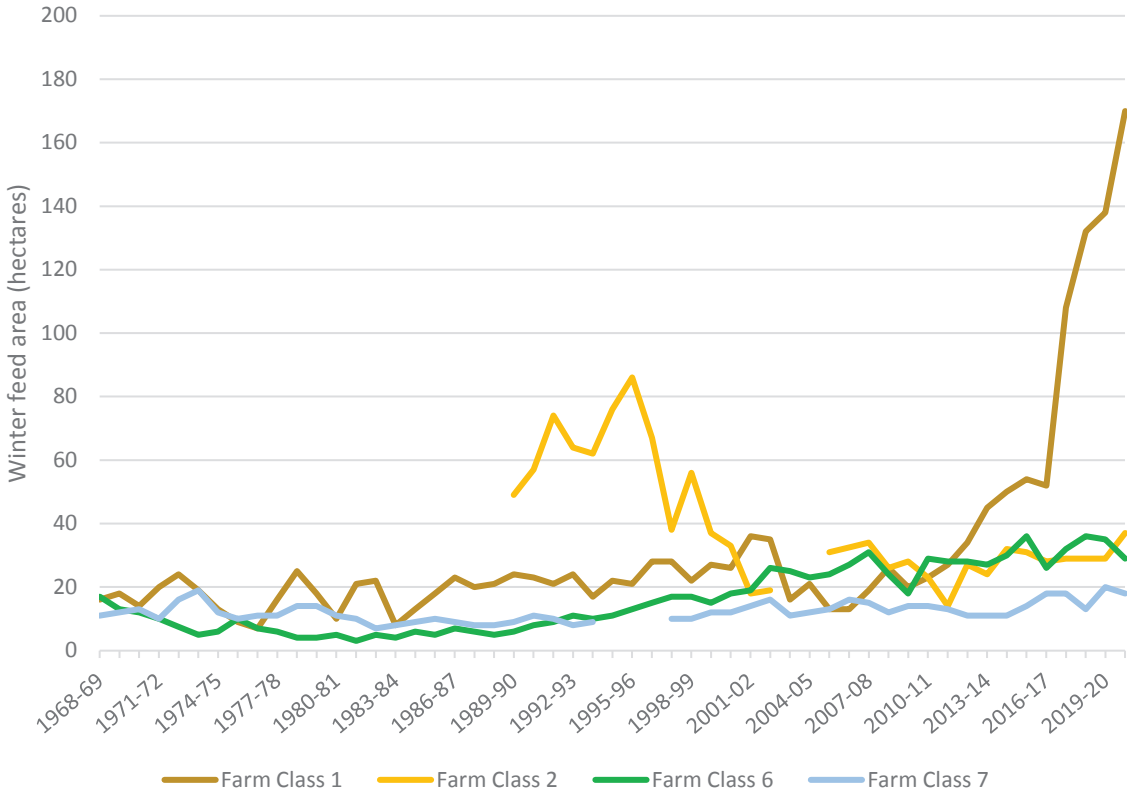


Figure 27: Winter feed area for all farm classes in Otago 1968-2020
Source: B+LNZ Economic Service Sheep and Beef Farm Survey

One reason for gradual increases in the winter feed area per farm over time is the increasing size of sheep and beef farms in Otago (total area and stock units) while there are fewer farms (i.e., some consolidation and scale). For Farm Class 1, the recent increase in winter grazing area was influenced by the continual refresh in the survey sample rather than a change in practice.

Wintering practices in Lower Clutha and Catlins are closely aligned with what happens in Southland because they have similar production systems (wintering of heavier stock off-paddock or off-farm). In drier areas however, physical limitations mean that a farmer needs either extensive hill country to move livestock between blocks to graze, or supplementary feed[60] to carry stock through the long winters. Supplementary feed could be crops grown on-farm or bought feed. In some seasons, farmers in Otago can grow a lot of pasture and may even have a surplus of feed that they can sell (e.g., baled silage or 'baleage'), while in other seasons pasture growth is limited and farmers will have to buy feed. It is preferable to get feed from as close as possible due to the cost of moving it, fortunately, because Otago has a variety of sub-climates, there is usually enough to be shipped around the region. This again highlights the integration between farms and interdependence across the region.

> *Having lighter animals on a lower yielding crop is seen as a better option than heavy animals that damage soils. There has also been a shift away from growing the heaviest yielding crops. A fodder beet crop yielding 30 tonnes of dry matter to the hectare will require a large number of animals to eat it. It is increasingly being seen as preferable to grow a lower yielding feed that is suitable for lambs. Less money will be made, but the paddock is left in better order.*[61]

60 Supplements are any feed type provided in addition to grazed pasture and are incorporated into pasture-based systems for any of numerous reasons (Kay, McCarthy, and Roche, 2014).
61 B+LNZ Economic Service Managers interview April 2022.

In Waitaki District, when it was climatically difficult to grow pasture in 2019-20, Farm Class 2 farms tended to have between five and 10 per cent of their grazeable farm area in winter feed crops (ranging from rapeseed through to fodder beet). This situation differed from the rest of Otago where a weighted average of 3.5 per cent of grazeable farm area was in winter feed crop in the same year. Farm Class 6 farms typically have 10 to 20 per cent of their grazeable farm area in winter crop. Conversations with survey farmers indicate that reasons for this difference include familiarity with the consent process and a tendency to make the most of irrigated land.

3.4.8 Nutrient management

Overall, fertiliser use on sheep and beef farms in Otago is very low and highly targeted – primarily being used to supply the nutrients needed for: crops, pasture renovation (or re-grassing), or to boost pasture on silage paddocks when making supplements (to a lesser degree)[62]. Fertiliser use tends to vary between years because of environmental factors, such as seasonal conditions (e.g., drought or a cool damp spring), that impact feed availability as well as financial considerations (e.g., the absolute and relative prices of fertilisers). Applications of fertiliser increased in Otago over 1990 to 2020 for both cropping and pasture areas on farm, corresponding with increased winter feed area (i.e., for growing winter feed crops) and pasture renovation following the crop. In more recent years some dairy cows have been wintered on sheep and beef farms, which also require winter crops for feed.

Pasture renovation typically occurs after an arable or winter feed crop has been harvested/used. The harvesting of a crop is followed by the replanting of pasture, and fertiliser applications are used to support both crop growth and pasture growth. However, **fertiliser applications are not equal to fertiliser losses** – young crops and new pasture are very efficient at using fertiliser as they mature. Fertiliser application rates are relatively low on sheep and beef farms on newly planted crops and pasture. Nitrogen is applied sparingly at peak pasture growth rate times, which reduces the risk of losses. Farmers' decisions about fertiliser are influenced by a complex mix of soil fertility, fertiliser prices, production objectives, regulation, and revenue considerations.

Fertiliser use was low in the 1980s, and there has been a small gradual increase in its use on pasture in the decades since 1990, mostly for Farm Class 7. Within each farm class there is a range of fertiliser usage between farms. On average, farms in the B+LNZ Sheep and Beef Farm Survey used a rate of 13kg of nitrogen per hectare per year (kg N/ha/year) on pasture in 2020-21. In the same year around 30 per cent of sheep and beef farmers used less than 10kg N/ha/year on their pasture. Over half of the farms applied 20kg of phosphorus per hectare per year (kg P/ha/year) or less to pasture in 2020-21.

Figures 28 and 29 show, in turn, the use of elemental[63] nitrogen and elemental phosphorus over four decades across the four farm classes in Otago. Importantly, these are application rates not nutrient losses from the farm system. Circumstances, such as economic restructuring during the 1980s, the improvement in returns in the early 2000s, followed by a decline around the Global Financial Crisis (GFC) in late 2000s, had flow-on impacts for phosphorus fertiliser use and are clearly evident in Figure 29 for Farm Classes 6 and 7. Note: The National Environmental Standards for Freshwater Regulations 2020 includes a nitrogen cap for pastoral land in a landholding of 190 kg N/ha/year (excluding land used to grow annual forage crops).

62 One way to think about nutrients is they are the 'food' used to grow food.
63 That is, the actual nutrient applied, which is carried by a "filler" when fertiliser is spread.

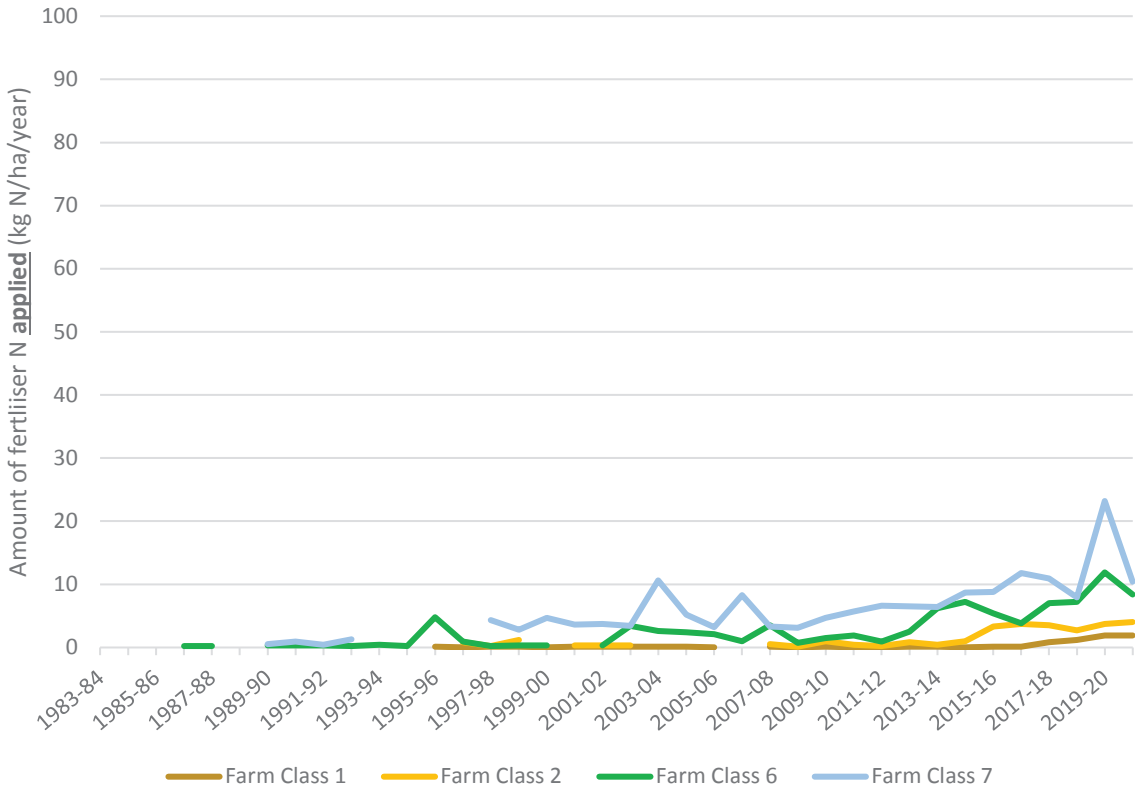


Figure 28: Application rates of nitrogen fertiliser on sheep and beef farms in Otago 1983-2020
Source: B+LNZ Economic Service Sheep and Beef Farm Survey y axis

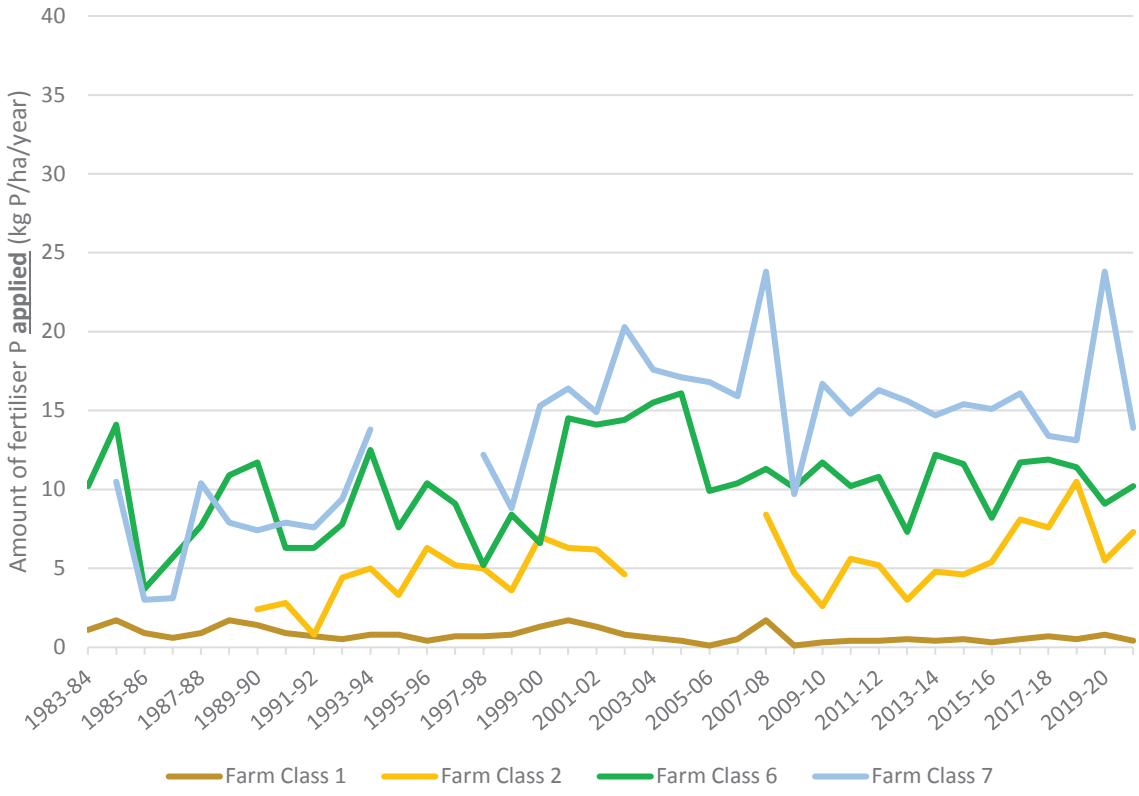


Figure 29: Application rates of phosphorus fertiliser on sheep and beef farms in Otago 1983-2020
Source: B+LNZ Economic Service Sheep and Beef Farm Survey

Farm Class 1 South Island High Country farms

The average area of winter feed as a percentage of total grazeable area has increased over recent years for two reasons. First, total winter feed area doubled in 2017-18 (on average) from the previous year, and winter feed area as a percentage of grazeable land increased from 0.8 per cent to 2.7 per cent. Second, average total area (i.e., grazed and non-grazed) has decreased as Crown Pastoral Leases were removed, pushing farming activities and the need for greater feed production onto a smaller area. Winter feed is the main reason for using fertiliser on Farm Class 1 farms. Around 10 to 15 per cent of farms have some dairy grazing animals on farm either year-round for young stock or over winter for larger dairy cows (6-8 weeks).

Farm Class 2 South Island Hill Country farms

These farms typically use fertiliser on pasture renovation areas and use some nitrogen on pasture to make silage for supplementary feed. Farms in this Farm Class are generally constrained by water, which means that any crop areas are small, and so cropping does not usually suit their farm systems well. Further, other limitations, such as topography, mean these farms are less likely to carry any dairy grazing stock. Farm Class 2 farms were also affected by the removal of Crown Pastoral Leases, which has reduced their overall grazeable area.

Farm Class 6 South Island Finishing Breeding farms

Crop fertiliser usage (per hectare) has been relatively static, which may be due to a change in the type of fertiliser used over time and greater use of technology to ensure efficient nutrient management. Overall, winter feed area and crop area increased from around two or three per cent of grazeable area in the 1990s, to an average of six per cent in the 2010s. The increase in pasture fertiliser is due to the increase in crop and thus pasture renewal area.

Farm Class 6 farms cut silage or hay when conditions are favourable and in 2020-21 had nine hectares of hay and/or silage on average (down from a decade average of 23 ha from 2010-11 to 2019-20). Winter was drier in 2020, impacting pasture growth in spring and the ability to conserve feed (silage making). Farmers needed to destock animals in spring 2020 at a greater rate than normal due to a lack of feed. Conditions over summer were more favourable for making hay.

Farm Class 7 South Island Finishing farms

The average crop areas increased from 2016-17 for roughly 15 per cent of farms and is likely related to providing feed for dairy grazing stock. Farms in this Farm Class often have cash crops as well as crops for winter feed. Pasture fertiliser, including nitrogen, is generally applied to areas re-grassed following cropping and so there is greater use of pasture fertiliser given the higher levels of cropping on this class of farm. Winter feed area as a percentage of grazeable area has averaged between four and five per cent over the past thirty years.

Fertiliser applications to crops were higher than those to pasture from 1990 to 2020 for all farm classes. The use of phosphate has decreased in recent years to an average 29kg P/ha/year in 2020-21, while the use of nitrogen on crops has increased to around 50kg N/ha/year. Over 40 per cent of farms used 50kg N/ha/year or less in 2020-21, on their crop. For phosphate, 73 per cent of farms used 50kg P/ha/year or less in 2020-21.

3.4.9 Revenue streams

Sheep and cattle generate a range of revenue streams for the farm business so running both stock types is a way diversifying to help manage risk. Almost all commercial sheep and beef farms also have some form of revenue other than from sheep and beef cattle, such as from deer, arable crops, grazing other people's livestock, and farm forestry. The proportion of income generated on sheep and beef farms in Otago from sheep and beef cattle was around 95 per cent (from sheepmeat, wool and beef) (Figure 30). These multiple revenue streams, and the way that different livestock classes complement each other and interact, mean the farm businesses are complex to operate, analyse and understand. It also means they are diverse: two farms of similar size in the same location with similar topography and climate may run very different farming operations despite appearing relatively similar from the outside.

The timing of revenue during the year is irregular depending on sales of livestock (e.g., finished 'prime' or sold as 'store') and contracts or negotiations farmers enter as they make decisions using market information. Revenue comes not only from processors buying livestock from farms but also from other sheep and beef farm businesses as farmers buy and sell different classes of livestock throughout the year. The irregular timing of revenue means annual cash budgets and monthly cashflows are of critical importance for sheep and beef farmers.

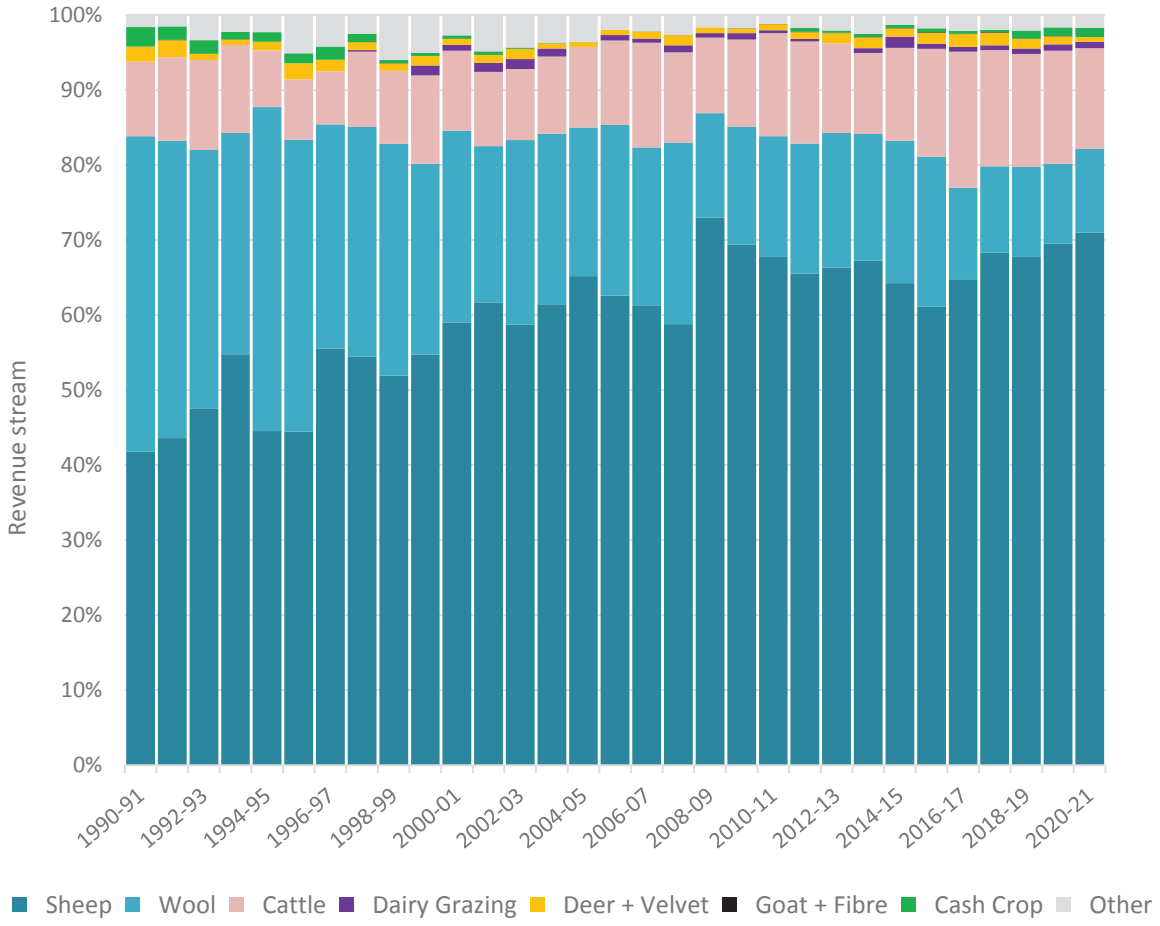


Figure 30: Proportion of revenue for all farm classes in Otago 1990 to 2020
Source: B+LNZ Economic Service Sheep and Beef Farm Survey

The integration of different enterprises (e.g., deer, arable, farm forestry) happens within and across farm types. Farmers that are primarily arable may not see themselves as sheep and beef farmers, but their farms are still classed as Farm Class 8 in the B+LNZ Sheep and Beef Farm Survey. It is important to include such farms because they play a key part in the vertical integration of the sheep and beef industry, with some arable farmers finishing as many as 10,000 lambs a year, which is much higher than some farms that are exclusively sheep and beef. B+LNZ estimates that around 15 per cent of all lambs are finished on arable farms in New Zealand.

Dairy grazing in Otago is a minor source of revenue on average but it may be more material for some individual farm businesses. Dairy grazing is more likely to fit in the production systems of Farm Class 7 Finishing farms and, to a lesser extent, Farm Class 1 High Country stations and Farm Class 6 Finishing-Breeding farms. For Farm Class 7, the average amount of dairy grazing revenue as a proportion of gross farm revenue peaked at 8.3 per cent in 2002-03, and subsequently declined to 2.3 per cent in 2020-21. Dairy grazing can either be year-round of young heifers that are being raised as replacements for dairy cows or six to eight weeks for dairy cows during winter. Dairy grazing is a means of further diversifying income for sheep and beef farmers, which reduces risk from variation of market prices for sheepmeat, beef and wool.

3.4.10 Expenditure and on-farm inflation

Profitability is the sum of the various revenue streams minus expenditure. Increased farm input prices reduce profit margins, and input prices tend to increase upwards over time rather than decrease (generally) in comparison with fluctuating market prices for sheepmeat and beef sold by farmers. Total Farm Expenditure and some of its major components are shown in Figures 31 and 32. Farm Working Expenses include fertiliser, repairs and maintenance, wages, shearing contractors and other agricultural services, rates and more. There are also items like interest and rent – 'Standing Charges'.

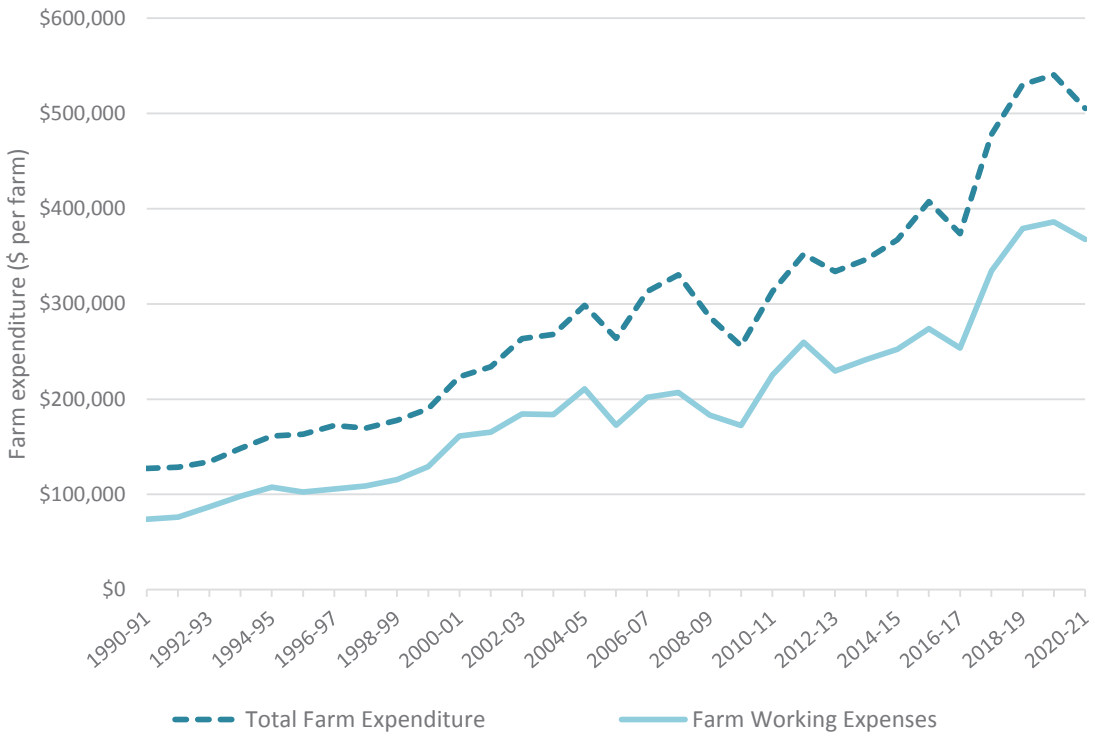


Figure 31: Farm expenditure across all farm classes in Otago 1990-2020
Source: B+LNZ Economic Service Sheep and Beef Farm Survey

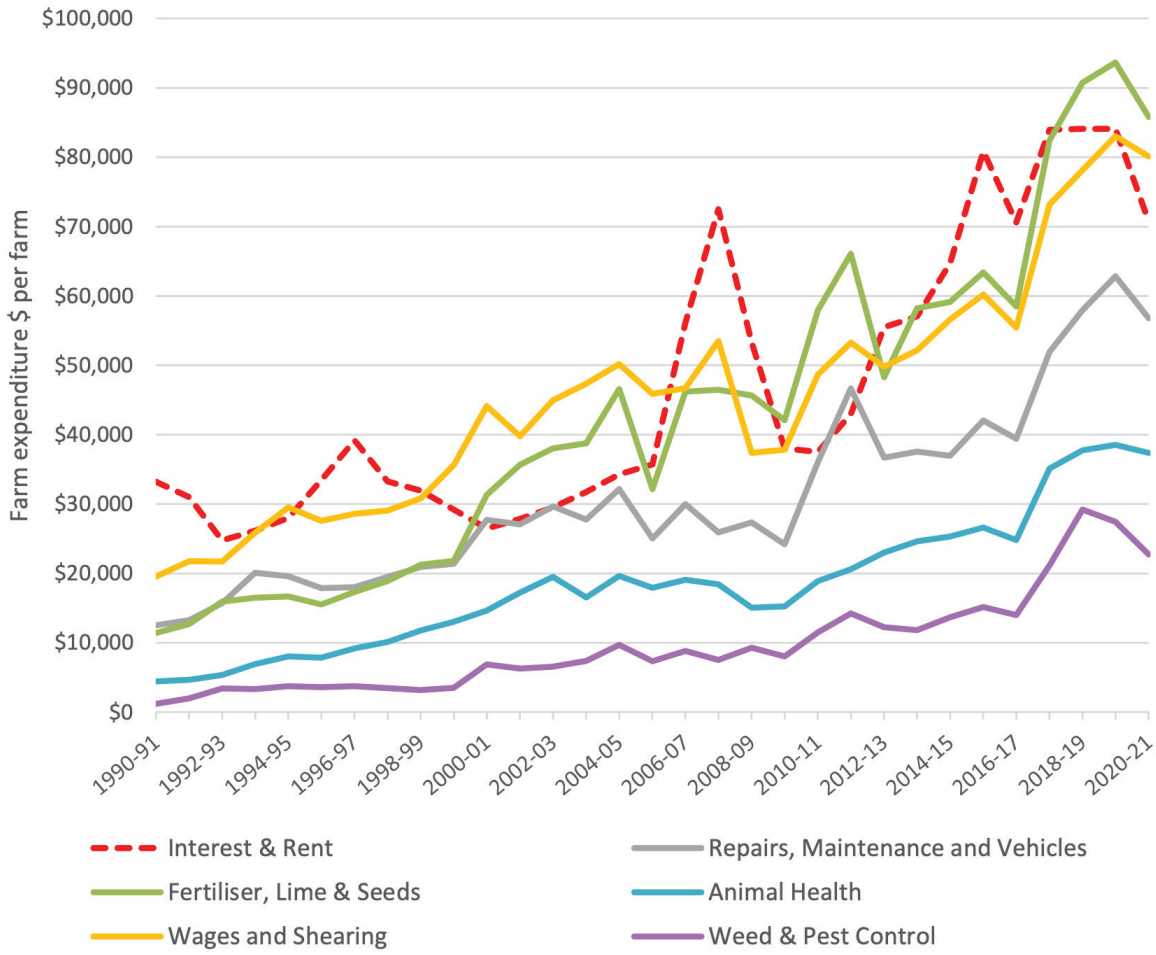


Figure 32: Key areas of farm expenditure across all farm classes in Otago 1990-2020
Source: B+LNZ Economic Service Sheep and Beef Farm Survey

Total Farm Expenditure **per farm** is estimated to have increased 73 per cent from 2010 to 2020 in Otago (i.e., the weighted average per farm for all Farm Classes), bearing in mind there has also been an increase in farm size (area and stock units) albeit to a lesser degree. Since 2020-21, the last completed B+LNZ Sheep and Beef Farm Survey season for Otago, the costs of inputs have increased sharply. Four main areas of expenditure comprise around 60 per cent of total farm expenditure for sheep and beef farmers: 1) fertiliser, lime, and seeds, 2) interest and rent, 3) wages and shearing, and 4) repairs, maintenance, and vehicles.

On-farm inflation for 2021-22 was 10.2 per cent in a climate of inflationary pressure continuing to drive up prices. Expectations are for input prices to increase over the 2022 calendar year and likely into 2023. Fertiliser prices increased 23 per cent between April 2021 and March 2022 and continue to increase with global supply reduced, global demand at high levels and supply chain issues for New Zealand farmers. Current expectations are for fertiliser prices to remain high for several years. Transport and fuel prices increased 11 per cent and 54 per cent respectively in the year to March 2022 for sheep and beef farms. Underlying on-farm inflation excluding interest (i.e., the dashed line on the graph) was higher than on-farm inflation including interest during a period of low interest rates (see Figure 33). In other words, the input prices without interest rates have climbed at a higher rate, although this circumstance may change in the future.

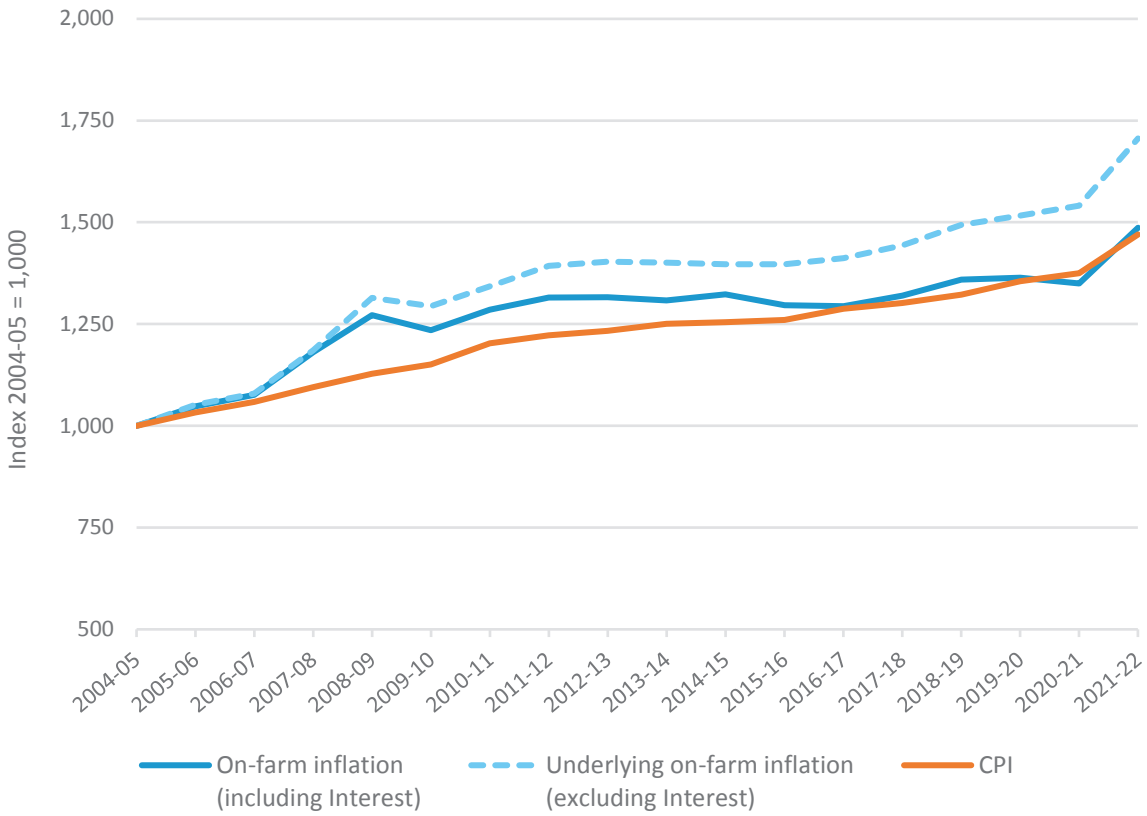


Figure 33: On-farm inflation in comparison to the Consumer Price Index (CPI) 2004-2021
Source: B+LNZ Economic Service Sheep and Beef Farm Survey

On-farm inflation, measuring the change in farm input prices for sheep and beef farms, from 2004-05 to 2021-22 was just under 49 per cent, which was similar to the Consumer Price Index (CPI) over the same time period (47%) (refer to Figure 33). However, underlying on-farm inflation, which measures changes in price inputs excluding interest and so reveals the operational running costs for farmers, was considerably higher than the consumer price inflation from 2007-08 to 2015-16. From 2004-05 to 2021-22, underlying on-farm inflation was over 70 per cent, 24 percentage points higher than consumer inflation for the same period.

Every business' experience of inflation is individual, depending on the nature of their production system and their use of inputs and debt as a business management tool. Farmer decision-making is impacted by inflation as alternatives are weighed, calculations are made about the potential drop in revenue from changing management practices on-farm, and forward contracts or deferred spending is carefully considered.

Image 14: Charolais on sheep and beef farm in coastal Otago
Source: Emma Moran

3.4.11 Farm succession

After a period of increase, the average age of sheep and beef farmers in the south of the South Island (Otago and Southland), declined from 56 to 54 years between 2007-08 and 2020-21, according to the B+LNZ Sheep and Beef Farm Survey. That the average age of farmers **decreased** over time (after a period of the opposite trend) suggests a new generation of farmers is coming into farm ownership. Modes of ownership are also changing – at one time the landholder entity and farming entity were one and the same, which is not necessarily the case now.

Succession varies from farm to farm and depends on the individual position and circumstances of each family rather than there being a definitive, or 'one size fits all, approach. Small farms, however, have fewer options than larger farms because of the difficulty of supporting multiple generations of a family, and farms with relatively low profitability are likely to find it particularly challenging. Some farmers in Otago in the early stages of their career have leased the family farm from their parents who have retired. However, it can be difficult to secure finance to purchase a farm for smaller farming operations[64].

More farmers are now retiring and leasing their farm for the ongoing revenue stream (rather than selling the farm). This trend has implications for lessees and lessors complying with regulations and understanding their rights and responsibilities. As profitability and standard of living for farmers varies greatly throughout Otago, no generalisations to farm types or geographical areas can be made. Often it depends on where the farmer is at within the farming life cycle. Some may carry on farming in their retirement and be happy with a very small income, others may be highly indebted and need to carry on working very hard during their later years.

64 B+LNZ Economic Service Managers interview April 2022.

3.5 Beyond the farm gate

The sheep and beef cattle industry is important to Otago and New Zealand because of the value it adds to the economy and the jobs it involves. In Otago and Southland combined, the 'red meat' industry, which is the integration of the sheep and beef farming and the meat processing sector, makes up 12 per cent of economic activity and employment[65]. This section gives a brief overview of the main processors in Otago and key export markets for lamb and beef. Export markets are particularly relevant for the future prospects of the sheep and beef industry.

3.5.1 Main processors

Silver Fern Farms Limited is based in Dunedin. It is a 50:50 partnership between Silver Fern Farms Co-operative Limited and Shanghai Maling Aquarius Limited that was established in December 2016. The origins of Silver Fern Farms are as a farmer-controlled co-operative company, representing more than 16,000 sheep, cattle, and deer farmer shareholders throughout New Zealand. It is the largest livestock processing entity in New Zealand, employing around 7,000 people at the peak season and has annual sales over $2.5 billion to over 60 countries. The company has 14 plants, one of which is at Finegand, near Balclutha in South Otago[66].

Alliance Group Limited (based in Invercargill) is "New Zealand's only 100% farmer owned red meat co operative"[67]. It is one of the world's largest processors of sheepmeat and New Zealand's largest producer of lamb. According to its Annual Report 2021[68], turnover was $1.8 billion, and it has seven processing plants, one of which is at Pukeuri in North Otago[69] .

Oamaru Meats Limited, which is a sister company of Binxi Foods, operates a plant on the outskirts of Oamaru in North Otago[70].

Companies that are based, or have processing plants, in Otago are some of the largest in New Zealand, and some of the largest lamb producers in the world. They are major contributors to New Zealand's lamb exports. The pattern of sheep and beef exports from Otago is similar to that for New Zealand as a whole.

The progressive reconfiguration of the meat processing sector resulting from commercial decisions has meant some Otago farmers have their livestock processed outside the region, depending on the commercial relationships that they have with processors. It demonstrates that Otago and other South Island regions, particularly Southland, are integrated. For example, some farmers send lambs to Southland plants for processing, while others send their livestock north from the region.

65 https://beeflambnz.com/sites/default/files/news-docs/NZRM-Industry-summary.pdf
66 https://silverfernfarms.com/nz/en/our-company
67 https://www.alliance.co.nz/about-us/
68 https://e.issuu.com/embed.html?d=annualreport2021_final&u=alliance12
69 https://www.alliance.co.nz/ and https://www.alliance.co.nz/contact-us/plant-locations/
70 https://www.bxfoods.co.nz/ and https://www.bxfoods.co.nz/oml/

3.5.2 Market shares

The New Zealand Meat Board is a statutory body governed by the Meat Board Act 2004 and its statutory functions include establishing and operating quota management systems. Tariff-Rate Quotas (TRQ) provide favourable access to a market. The New Zealand Meat Board makes allocations of New Zealand's TRQs for exports of sheep and goat meat and high-quality beef to the United Kingdom and the European Union (EU-27) and for beef and veal exports to the US. These TRQ allocations indicate New Zealand meat processors' production volumes.

Four companies in New Zealand with TRQ allocations for sheep and goat meat to the European Union and beef and veal to the United States have processing plants in Otago: Alliance Group Ltd, ANZCO Foods Ltd, Binxi Foods NZ Ltd, and Silver Fern Farms Ltd (Table 4). In total, these companies account for between 54 and 58 per cent of New Zealand's Tariff-Rate Quota for the European Union, United Kingdom, and United States.

Table 4: Tariff-Rate Quota Allocations (tonnes and % of total) for four meat processing companies with a presence in Otago

Market	**European Union (EU-27)**		**United Kingdom**		**United States**
Products	**Sheep and goat meat**	**High-quality beef**	**Sheep and goat meat**	**High-quality beef**	**Beef and veal**
Alliance Group Ltd	30,356	63	30,361	34	23,478
	27%	7%	27%	7%	11%
ANZCO Foods Ltd	10,872	127	10,874	68	34,377
	10%	15%	10%	15%	16%
Binxi Foods NZ Ltd	1,739	-	1,739	-	297
	2%	0%	2%	0%	0%
Silver Fern Farms Ltd	21,140	264	21,144	142	64,943
	19%	31%	19%	31%	30%
Total	**64,107**	**454**	**64,119**	**244**	**123,096**
	56%	**54%**	**56%**	**54%**	**58%**

Note 1: Sheep and goat meat and beef and veal is for 2022 while high-quality beef is for 2022-23.
Note 2: Figures have been rounded.
Source: New Zealand Meat Board[71]

Table 5: Share of New Zealand sheep and beef cattle products exported 2020-21

Product	**Export share**	**Export value ($million)**	**Change from 2014-15**
Wool	91%	$417	-48%
Lamb*	95%	$3,353	+22%
Mutton*	98%	$840	+48%
Beef and Veal*	90%	$4,400	+24%
Total		**$9,010**	

** Includes co-products*
Source: B+LNZ Economic Service, Statistics New Zealand[72]

71 https://www.nzmeatboard.org/assets/Documents/
72 B+LNZ Economic Service P11018 Master Presentation (139549).pptx downloaded 15 June 2022.

New Zealand's sheep and beef industry mainly focuses on the export of meat and meat products. Over 90 per cent of lamb and mutton, and 90 per cent of beef production[73] is exported (see Table 5). As a result, New Zealand, including meat processors and exporters, and their suppliers of livestock, generates considerable economic activity and wellbeing from producing products that meet customer and consumer needs in a wide range of markets globally.

Lamb

New Zealand exports lamb to over 90 countries but there are some key export markets. In 2020-21[74], China, the United States, the United Kingdom, Germany, and the Netherlands accounted for over three-quarters of total value and total volume. The United Kingdom is a longstanding market for New Zealand lamb, with the export trade to London having started from Port Chalmers and Totara Estate in Otago in 1882. For over a century, it was the single largest single country market by value. In 2016-17, China became the largest export market for New Zealand lamb by value, having become the largest by volume in 2014-15. The United States and the United Kingdom alternate between being the second and third largest markets by value. In 2007-08, China was the eighth most important market by value. There is a marked difference in the value of the products (measured in $/tonne Free On Board (FOB)) between the markets, reflecting the type of demand that the meat processing and exporting industry has developed in each market.

Beef

China is also the largest market by value for beef exports. New Zealand has a long history of supplying lean beef to the United States and Canada, primarily for blending with and adding value to fat trimmed from steers and heifers that are finished in feedlots – in the United States (mostly) and Canada – to produce ground beef, which is the most common form that Americans consume beef. Frozen New Zealand beef is a valuable ingredient because, among other things, it is consistent, production is reliable, it has superior food safety credentials, and there are well-established supply chains – including processing in New Zealand, shipping services, business practices, commercial and legal remedies if needed, and distribution through the US system. New Zealand exports beef to over 70 countries.

Market significance is reflected through export volumes, which are predominantly ingredient beef and sold at a low price per tonne compared with prime cuts. Export volumes to China increased from less than 500 tonnes in 2007-08, to over 200,000 tonnes for 2020-21 as the market has been developed and New Zealand exporters established business-to-business relationships. Exporters have developed relationships with Japan, South Korea, and Taiwan and they are currently New Zealand's third, fourth and fifth largest customers for beef and veal, respectively.

New Zealand's domestic market is also important for lamb and beef cuts in the retail and service sectors.

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73 As a rough estimate, around half of exported beef production originates from dairy farms and it highlights the inter-dependency between industries within the agricultural sector.

74 The meat export season (or year) is from October to September.

Image 15: Beef cattle in Central Otago
Source: B+LNZ

Co-products

As already highlighted, what is traditionally thought of as 'the meat industry' produces and exports a wide range of products (often referred to as 'co-products'). The range includes well-known items such as skins and hides, tallows and other fats, and high-value items used in production of pharmaceuticals. The sheep and beef industry also contributes shorn wool (fine and coarse), which is processed and exported.

Wool

There are numerous wool stores or brokers in Otago where wool is collected, locations include Stirling, Milton, Taieri, Omakau, and Mosgiel. Ōamaru boasts the largest wool spinner operation in Australasia, Summit Wool Spinners. Farmers may also work directly with the likes of a boutique producer or NZ Merino for example, or in some instances create a brand themselves and market directly to consumers. Historically, woollen milling was one of our first large secondary industries with the first mill opened in Mosgiel in 1871 and others followed along the east coast of the South Island[75]. The Rosyln Woollen Mill in Dunedin (1879) was the first mill in the Southern Hemisphere to produce worsted[76]. These products also make valuable contributions to New Zealand's merchandise exports.

75 Ross & Glendining - New Zealand Fashion Museum (nzfashionmuseum.org.nz)
76 Roslyn Woollen Mill | NZHistory, New Zealand history online

4 Deer Farming

Authors: Tony Pearse (DINZ: Producer Manager – retired), Solis Norton (DeerPRO: Project Manager), and Lindsay Fung (DINZ: Producer Manager) with review by John Scurr (New Zealand Deer Farmers Association President 2001 to 2008 and Deer Industry New Zealand Chair 2005 to 2009).

This chapter outlines the deer industry in Otago and is based on expert local knowledge supported by data from Deer Industry New Zealand (including DeerPRO[77]) and Statistics NZ.

4.1 Summary

The industry is based on the farming and husbandry of introduced red deer (Cervus elaphus) with strains of European and English breeds and the larger North American derived Elk, providing world class genetics for modern-day Otago breeding programmes. The industry annually exports around 12,000 tonnes of venison and around 1,000 tonnes of velvet antler. Deer products exported currently have a combined value of close to $300 million. Otago accounts for about 10 per cent of the national industry (both in herd size and revenue).

Today the industry is concentrated in three main areas (Upper Lakes; South Otago and inland Otago). Overall, around 200 deer farms run approximately 120,000 deer over roughly 53,000 hectares of land and at least 500 people are directly involved in some form of the supply chain (farmers, stock agents, transport, velvet and venison processors and marketers, and other rural professionals). Deer systems are diverse in size, location, and intensity. The farms range in area from 100 to 5,000 hectares. Typically, larger more extensive ones are on drier country in Central Otago. Intensive irrigated systems are also present while large finishing operations are on more summer safe country. Smaller operations are generally in eastern Otago and along the coast.

Deer farms are described in terms of their production system, which place an emphasis on preferred choices for breeding replacements, venison, velvet, or stud stock including trophy antler and guided hunting and other tourism ventures. For all production systems, exemplary management and commitment to sustainable environmental stewardship is a key management goal.

AgResearch Invermay in Mosgiel and the Disease Research Laboratory at Otago University have, over time, formed an important 'research nucleus' in Otago for the deer industry nationally. New Zealand deer farming has just celebrated its first 50 years and, Otago along with Southland and Canterbury, form the industry's stronghold, and for most it has proven to be a stable long-term investment.

The deer industry has been formally proactive in highlighting good environmental stewardship since 2001 and minimising environmental impacts of deer systems has become a focus over the last decade. Industry resources have been developed to assist and equip farmers well to prioritise and implement effective stewardship. Management of contaminant loss from wallowing and fence pacing are deer specific issues but the relative impacts of these are likely declining as deer husbandry is well established and deer become increasingly domesticated.

77 DeerPRO is a branded unit of Deer Industry New Zealand. http://deerpro.org.nz/

4.2 Introduction

Deer farming is a young, innovative, and important part of New Zealand agriculture. It annually exports around 300,000 deer as venison and around 1,000 tonnes of velvet antler, which is one of the most prized ingredients in Oriental medicine and valued as a health food ingredient[78]. Otago is an important region for deer farming, with some of the industry's oldest farms and a full spread of the four main deer production systems (described in Section 4.4): venison, velvet, stud, and trophy.

Most deer farmers concentrate on the annual production of venison and/or velvet and share many similarities with sheep and beef farming (Fung & Pearse, 2017). A handful focus more on stud breeding and/or trophy breeding for safari hunting. The main deer species farmed in New Zealand is red deer, but over time elk/wapiti[79] (a North American species of deer, second only to the moose in size) and from 1983 imported Canadian elk were crossbred into the national herd. The red deer genetics were boosted with the importation of larger East European red deer during the late 1980s and 1990s. Deer farms can be run over a variety of Land Use Capability classes as either a specialised operation or, more commonly, an enterprise within a mixed dry stock farm (i.e., alongside sheep and/or beef cattle).

Deer have different seasonal feed requirements to sheep and beef. The three stock types are usually seen as complementary for maximising outputs from good quality pasture management (even though it takes extra investment in deer fencing). For specialist deer farms (i.e., predominantly deer), maximising pasture quality and meeting seasonal variations can be achieved by using larger mobs of velvet antler stags as 'cattle by proxy' to clear and control poorer pasture (Fung & Pearse, 2017). Understanding normal behaviours in deer is central to managing deer in a farming sense, including providing the right environment for their needs and recognising abnormal behaviour that may signal illness or stress or risk for the safety of deer handlers[80].

4.3 Size and distribution

At its peak in the early 2000s, deer farming occurred across all of Otago, but the industry is now focused in three main areas, each with its own climate, geology, soils, and topography, which together influence the broad deer production systems:

1. Upper Lakes – from Cromwell and the Lindis Valley, to the hill and high country around Queenstown, Wānaka, and Hāwea;
2. South Otago – stretching from Millers Flat and Tapanui, around the Blue Mountains and south to Owaka in the Catlins, and east to Milton south of Dunedin; and
3. Inland Otago – extending north from the Taieri plains and Lake Mahinerangi through Strath Taieri to the Maniototo and Styx Basins, and west to the Ida Valley, the Manuherekia Valley, and St Bathans.

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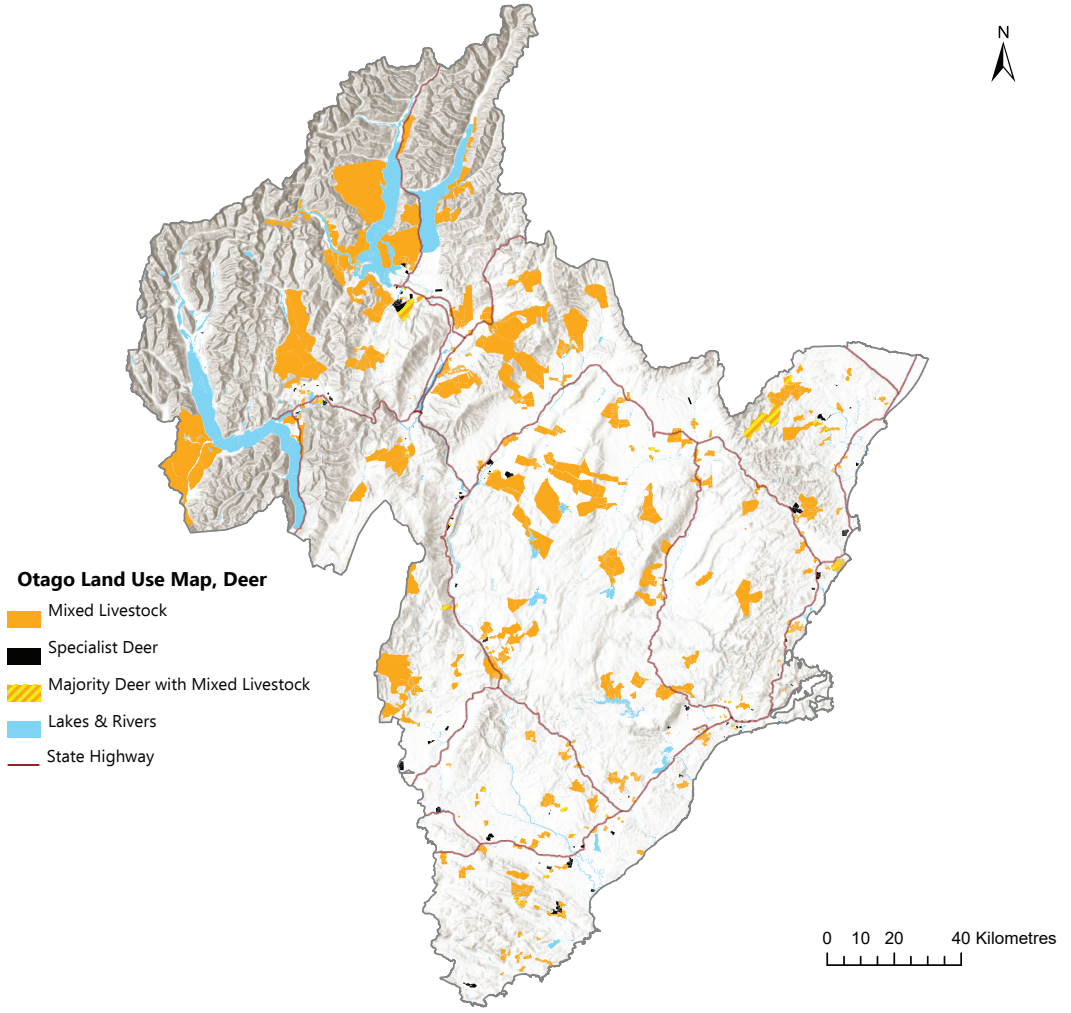
78 https://deernz.org.nz/home/our-great-products/deer-velvet/

79 The name 'wapiti' is Native American in origin, meaning 'white' and refers to the pale rump and tail of the American elk (https://fwf.net.nz/wapiti/). The original wapiti, or North American elk, were introduced to New Zealand from their native North America in 1905, were as in part a gift when 18 animals of the *Cervus elaphus nelsoni* (now called *Cervus canadensis nelsoni*) species were released at the head of George Sound, Fiordland and became quickly established. Ten of these animals were a gift from American President Theodore Roosevelt, the balance was purchased by the New Zealand government. Virtually all the wapiti cows except for studs are predominantly New Zealand wapiti by origin and slowly being upgraded with their breeding programmes using elk semen or imported live bulls. More information is available at the elk and wapiti Society of New Zealand's website is https://www.elkwapitisociety.co.nz/wapiti-or-elk-

80 https://www.deernz.org/deer-hub/handling-and-welfare/behaviour/

Deer farming is less common in coastal North Otago (i.e., in and around the Waitaki District). There are a few properties along the foothills of the Kakanui Range (inland from Moeraki and Ōamaru), or around Kurow, Windsor, Five Forks, and Palmerston. Overall, there are around 200 deer farms in Otago covering roughly 53,000 hectares of land[81] and at least 500 people are likely to be directly involved in the deer industry in one way or another. The Otago Land Use Map below shows the extent of deer farms across the region.

The most common business model tends to be reasonably small, family owned and operated farms with a balance of venison and velvet production systems. However, there are also large stations with deer, particularly in the Upper Lakes District, often with finishing properties located on 'easier' country. Greater scale in deer farming usually improves management flexibility and resilience. Smaller farms tend to have fewer management options, especially those not supported by off-farm income. Consequently, they tend to be less resilient: their financial reserves and ability to borrow can be limited, as is their ability to secure external services like agricultural contractors and labour. They effectively do almost all the on-farm work by themselves.



Source: Otago Land Use Map 2022, Otago Regional Council
Note: Following advice from Deer Industry New Zealand, deer properties were categorised for the Otago Land Use Map as: specialist deer (100% deer), mixed deer (>45% deer), mixed sheep, beef, and deer (<45% deer).

81 DINZ database (2022).

4.4 Farm systems

Deer farms are usually described in terms of their production system, which place an emphasis on either venison, velvet, or stud, and in some cases include trophy. From its production system, a deer farm generates a range of income streams from either deer products (e.g., velvet, venison, co-products, trophy antler) or the breeding of stock (e.g., 'weaners'[82] for finishing as venison, replacement hinds, and velvet stags and elite sire stags). Deer farmers are always on the lookout for new opportunities to supply deer products to consumers (e.g., deer milk or collagen from hides[83]) that, as a relatively new industry, are still being discovered.

The various mixes of age classes in each production system (venison, velvet, or stud) present different environmental risks on-farm because of the size and seasonal, sex or age-related behaviours of deer (Fung & Pearse, 2017). The main characteristics of the four production systems are:

Venison Production System – Prime young deer typically processed at 10 to 18 months of age, having been carried over one winter. On farm the capital stock (consisting of a breeding hind herd and a smaller group of selected breeding stags) produce these young finishing animals plus replacements to maintain the breeding capacity. A typical annual replacement rate for breeding hinds might be 10-15 per cent per annum usually based on increasing age and any failed conceptions or dentition wear. At eight to ten years most breeding hinds will have had a fully productive life.

Velvet Production System – Stags that produce heavy velvet antlers[84] with a good configuration for the velvet market – they are retained for many years as the weight of the velvet antler grown increases annually to peak at between five and ten years of age[85]. There is a selected breeding herd of hinds, or some farmers regularly buy surplus quality velvet genetics from larger breeders and/or other velvet operations. Non-breeding young female deer and young males not retained for velvet production, are either on-sold to other farms or processed for venison. Older breeding hinds and velvet stags are culled as lower quality venison, as they generally do not qualify to meet the Cervena® elite venison market standards of age and tenderness.

Stud Production System – Breeding lines of high genetic value for sales to velvet (predominantly), venison or trophy antler markets. The progeny (or offspring) of stags is sold to production farms or breeders, usually at two to three years of age for elite males, or at 12-20 months of age for elite females. Velvet and venison production also commonly occur on the same farm.

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82 'Weaners' are young stock that have just been weaned from the hinds on to pasture.

83 Collagen is usually extracted from donkey hides.

84 Antlers are male secondary sexual characteristics, and so only grown by stags, although in the wider Cervidae family, they also grow in female reindeer (also known as 'caribou' in North America). Antlers are quite unlike the horns of cattle and develop as velvet antler and hard antler. Velvet antler is the growing antler, which contains a blood and nerve supply and a fully intact skin with a covering of soft fine hair. Hard antler is the antler when growth has ceased, calcification has occurred, and the skin, nerve and blood supply are no longer functional (https://www.deernz.org.nz/deer-hub/velvet-and-antlers/antlers/). An antler is composed of a major beam, with branches or tines arising from the beam, and the number, configuration, and spatial orientation of tines is species-specific. Velvet antler is soft and lacks the mineralized characteristics of hard antler, which is bone (Woodbury and Haigh, 2007).

85 Some farmers prefer not to keep stags in a herd for too long because aggression issues can arise between younger and older ones. It can be reduced by keeping stags within similar age ranges.

Trophy Production System – Guided commercial hunting of stags as game animals[86] on 'game estates'[87] (noting that game estates are **not** deer farms). Those deer farmers that develop a trophy hunting business as a further revenue stream operate it as separate enterprise from their deer farms. Guided hunting in Otago also offers luxury lodge accommodation in unique locations with options including, trout fishing, chamois and thar hunting. The desired antler configuration for trophy stags is quite different to that required for the velvet market.

4.4.1 On-farm feed and animal management

Hinds' and fawns' demand for feed is more constant than pasture production, which typically peaks in spring and then declines, although their demand also reaches a peak in late spring or early summer (Nicol and Barry, 1992). Surplus pasture in spring must be conserved for winter and forage and fodder crops are an important part of deer farm feeding systems. They are grown as a supplement for late summer hind lactation, or as a partial winter ration. Typically, quality surplus late spring and summer pasture is conserved as pit silage or individually wrapped baleage for an additional winter supplement. The region's winter conditions mean deer farms may rely heavily on purpose planted crops and silage and baleage supplements.

Some change is already happening towards alternative wintering systems (e.g., self-fed silage on feeding pads where runoff can be contained and managed), especially where there are poorly-drained soils. There are occasional examples of winter shelters or 'barns' (as there are in Southland) to reduce pressure on land during wetter winters. Such structures tend to be re-purposed farm buildings (purpose-built barns are still the exception), and particularly suit velvet stags that can grow good quality product for around 12 years. In some cases, they will be used for velveting stags up until 'button-drop' and then for hinds to relieve pressure on paddocks and get pasture growth going (S. Elmes, pers. comm., September 2022). However, deer barns may not even need to be considered as an option in many situations.

In the drier parts of the region the deer systems with irrigated areas can reliably grow crops with much heavier yields than those without irrigation. Access to water allows a farm to be more productive and it imparts flexibility to feed these crops to the most valuable stock classes at the time, which can shift both within and between years.

A deer farm's breeding system is carefully organised. Commonly up to 20 per cent of the top hinds are mated to sires selected on genetic breeding values for producing quality breeding hind replacements. The remaining hinds are mated to terminal sires[88] which are sires with breeding values for offspring with high growth rates and good carcass conformation. Terminal sires are often European types of red deer or elk/wapiti for their high growth rates. Productivity gains come from the use of genetics in breeding programmes rather than multiple births, as twinning does occur but is very uncommon[89].

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86 The New Zealand Game Animal Council is tasked with sustainable managing game animals and hunting for recreation, commerce and conservation (https://nzgameanimalcouncil.org.nz/what-we-do/). Its specific responsibilities are described in section 7 of the Game Animal Council Act (2013). A game trophy export levy is paid on animal hunting souvenirs from New Zealand (not including velvet, velvet antlers, or the hide of a deer).

87 'Game estate' means an enclosed area of private land with natural or man-made barriers (generally accepted as species-specific fencing), that keeps game animals in and other animals out, and is operated primarily for hunting. To qualify as a game estate, industry-agreed standards must be met that cover fencing, disease surveillance, animal welfare, client safety, minimum area, and the environment among other things. The New Zealand Association of Game Estates is a voluntary organisation for professional hunting guides with its own code of ethics and operating standards. The New Zealand Game Animal Council is the statutory body for hunting https://nzgameanimalcouncil.org.nz/

88 A terminal sire is used to breed animals for meat, not for further breeding. A terminal sire is selected to produce fast-growing progeny that have higher yielding carcass traits, and it may be higher growth rate European Reds or elk/wapiti.

89 Red deer and elk/wapiti are behaviourally a strongly social herding animal whereas deer species that produce multiple births (e.g., whitetail deer) are generally solitary dwellers that do not naturally herd (Tony Pearse, pers. comm., May 2022).

Image 16: Mob of deer on Criffel Station (Wanaka)
Source: Criffel Station

Image 17: Hinds with fawns in Central Otago
Source: Tony Pearse

Traditionally, the deer industry centred on venison production, reflecting its origins, and demand for venison continues to be strong, with prices steadily recovering in 2022 after an interruption caused by Covid-19 restrictions in export markets. Figure 34 shows the current distribution of venison production system across the region. Early research into elk and cross-breeding to get animals up to processing weight quickly had a profound influence on the way deer farms are 'set up' (or configured)[90]. The efficient handling and management of deer without causing undue stress to the animals is key to the farming of deer[91].

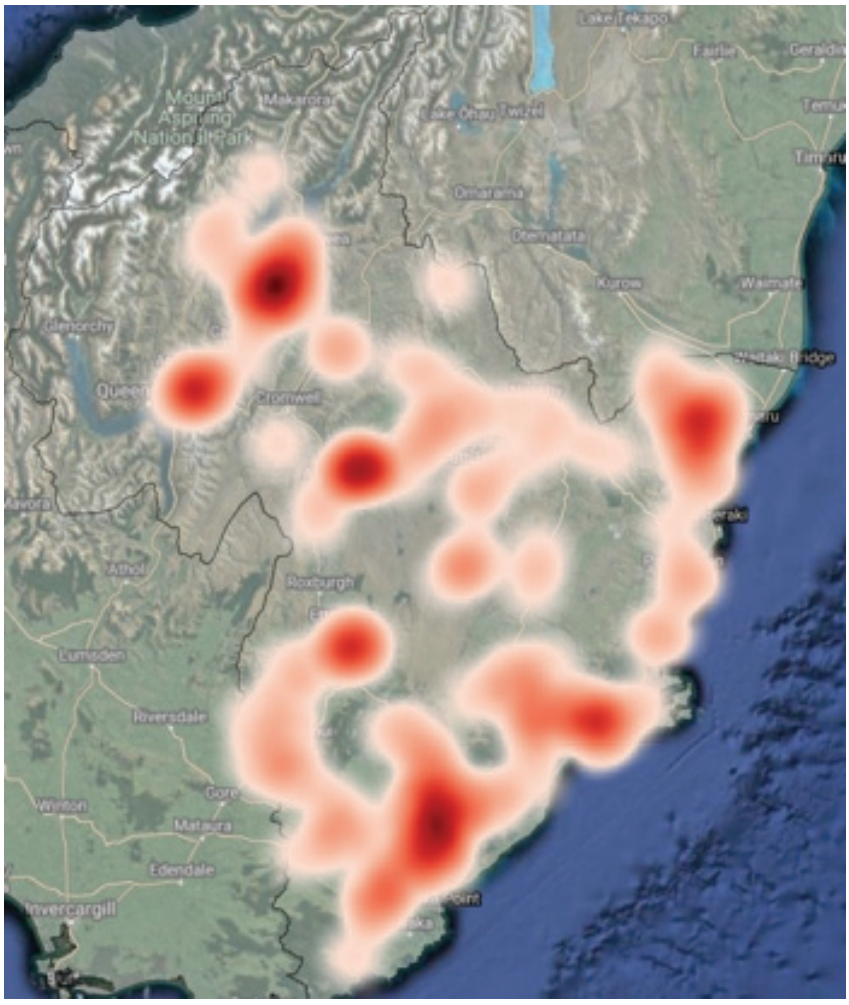

Figure 34: Heat map showing the areas of Otago where most deer are farmed for venison
Source: DeerPRO

Venison is still the dominant production system, but the margin is increasingly slim as interest in velvet has grown dramatically in recent years. Strong returns have made velvet highly competitive: the five-year average price (NZ$) per kg of velvet from 2016-17 to 2020-21 was $116.50 and ranged between $102.50 and $132.50). In the last five years exports have increased from 500 tonnes of velvet (once seen as the market limit) in 2010-11 to around 1,000 tonnes in 2020-21 with continued strengthening of produce value per kilogramme for the premium grades.

90 The ways in which deer farmers have adapted the design and use of their facilities for both human and animal safety to be able to farm elk, red deer, and crossbreeds (e.g., yards, gates, lead-in laneways, pens, and deer 'crush'). Elk are much larger than red deer.

91 https://www.deernz.org/deer-hub/handling-and-welfare/handling/

Image 18: Mixed age stags
Source: Tony Pearse

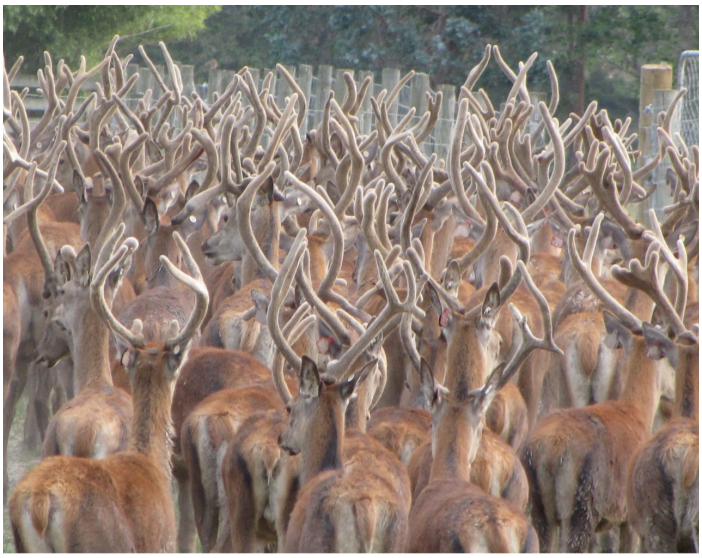

Image 19:Spikers
Source: Tony Pearse

Next to South Canterbury, Otago is as important as any region for producing velvet (by volume). Central Otago acts as something of a 'nursery' for velvet producers with several buyers and processors based there, as well as around Dunedin. Velvet quality is dependent on the breeding, feeding and health of velvet herds, as well as the humane removal of velvet at the optimum growth stage[92]. Supplementary feed is a key addition to quality pasture grown and may include high energy and protein winter crops, specially formulated deer nuts for stags and, in some cases, imported palm kernel extract.

The growth and management of velvet antler production is somewhat complex but suits deer farming systems reasonably well. Stags are managed in age group cohorts as yearling stags (spikers) and commonly two-, three- and four-year-olds as discrete separate age groups, beyond that sire stags and stags between five and 10 years old are grouped as 'mixed age' stags. The time of harvest is typically 60-70 days after 'button drop' (the 'button' is a calcified bony cap on the pedicle formed following the previous seasons harvest). Mature stags cast first and after 60-70 days growth reach the optimal stage of market value and velvet grade. For ease of management, stags are retained in their age cohorts and on large herd s may form a separate herd based on the timing of button drop.

Velveting must meet strict regulations related to hygiene and deer welfare[93]. The optimal stage of velvet antler quality and weight is reached at between 55 and 70 days of antler growth, depending on genetics and spring/early summer nutrition quality. After this time the process of mineralisation begins from the base of the antler. Once this process begins the commercial value of velvet and its biological activity decreases rapidly with antlers fully grown and mineralised at 100-120 days following casting[94].

Figure 35 (on next page) uses information on the number of mature stags processed to give a coarse distribution of velvet production in Otago. Although the map is only indicative (for commercial reasons), it suggests most velvet production occurs in the Upper Lakes and Central Otago Districts where the dry cold winter and abrupt abundant spring flush perfectly suits the antler and velvet growth cycles and seasonal nutrition requirements. South Otago also has strong velvet production but can face challenges with heavy wet soils over winter and spring (depending on the year).

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92 https://deernz.org.nz/home/our-great-products/deer-velvet/

93 Through DINZ administration, the industry is overseen the National Velvetting Standards Body a partnership between the NZ Veterinary Association and NZ Deer Farmers Association that reports annually to MPI.

94 For further Information see https://deernz.org/home/our-great-products/deer-velvet/

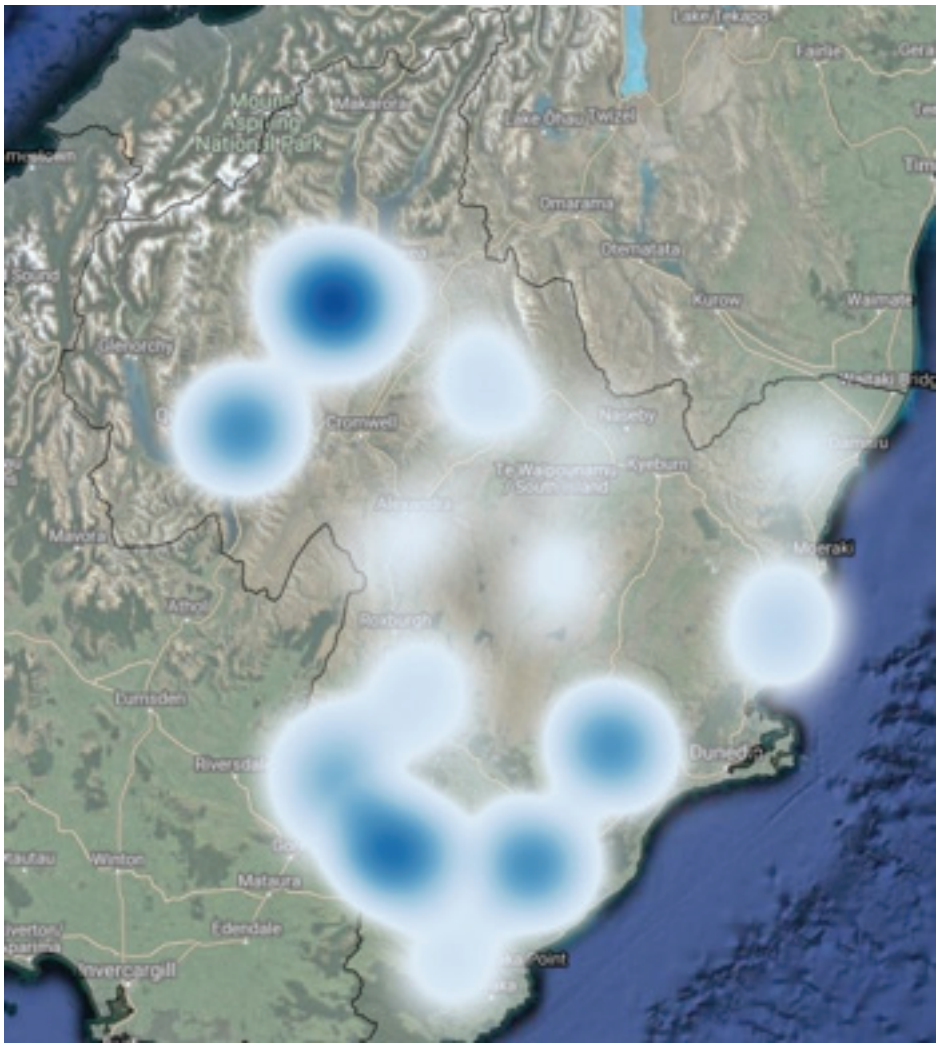

Figure 35: Heat map showing the areas of Otago where most deer are farmed for velvet
Source: DeerPRO

The Deer Production Calendar (on the following page) summarises the main deer stock class activities for venison and velvet across the year (April to March). The calendar is designed around the peak season for the European chilled venison market (September to November). The harvest of velvet antler takes three to four months for the first cut for peak quality (and an additional month to 'clean up' regrowth): the first cut starts in September or October with regrowth and continues through to late January for older stags and February for spikers.

The Deer Production Calendar highlights the complexity involved in managing different stock classes (and so the range of knowledge and skills needed), as well as the inherent adaptability of deer farming. Over time a deer farmer may shift emphasis from one income stream to another depending on the financial returns available at the time. It is the returns, rather than type of production system, that are more likely to influence a farm's productive intensity.

Many deer farms also include sheep and/or beef enterprises, which introduce additional layers of activities into the farming schedule. The widespread use of sheep and/or cattle (as well as cropping) beyond the four deer production systems means it is challenging to characterise 'typical' deer farms (Fung & Pearse, 2017). The proportion of beef and/or sheep that a deer farmer runs will vary depending on their commitment to deer, and the mix can change over time as they work to optimise the relative returns from each stock class.

Deer Production Calendar

Month	Adult breeding stags	Adult velvet stags	Yearling stags (or 'spikers')	Weaned adult hinds	Un-weaned adult hinds	Elite hinds (all ages)	Yearling hinds (first calvers)	Weaner stags	Weaner hinds
April	Mating activity, semen collection from elite stags	On farm, settled and separated from other stock ideally managed in respective age groups	Last of up to weight stags for processing	In mating groups. Majority weaned pre-rut		Late artificial insemination & embryo transfer	Mating spikers or selected single sires	Later weaning (hill country), first live sales, animal health (e.g., parasites, minerals) and NAIT tags registered	
May	Stags removed from mobs					Pregnancy scanning and foetal aging	Pregnancy scanning	Weaner sales to finishers, post-rut weaning	
June	On farm wintering Quality nutrition post rut			Pregnancy scanning from early June Non-pregnant hinds sent to works Tb Testing if applicable	Post rut weaning and cull hinds sent to works. Pregnancy scanning	Elite stud stock female sales	Non-pregnant hinds sent for processing	Last weaner sales	
July			Rising 1-year-olds sent for processing (peak schedule prices)					Introduced to winter crops or supplementary winter feed	
Aug	Quality feeding levels lifted for mature stags	Cull stock sent for processing						Assess target weights for chilled season	
Sept	Antlers cast, velvet starts growing in mature stags, Tb testing if applicable							High growth rate weaners sent for processing as premium chilled venison for peak prices	
Oct	Velvet growth and harvest for 4-year-old and older stags		Retained spikers now rising 2-year-old velvet growth, velvet harvest for 2- and 3-year-olds		Cull if it was cost effective to carry over winter	Pre-fawning health and set fawning mobs			
Nov		Cull stock sent for processing		Set stock in mating groups Fawning and lactating		Calving and lactating			
Dec	North Island stag sales	Velvet regrowth removal	Velvet harvest and cull					Weaners sent for processing as chilled or frozen venison	
Jan	South Island Stag sales		Rising 1- & 2-year-old stags selected for specialist velvet herd	Lactating		Lactating		Sent for processing as frozen venison	
Feb	Selection of stags for breeding groups				Aged dry or wet dry (lost fawns) culled				
March	Mating activity (rut or roar)			Early weaning		Early weaning, oestrus synchronization for artificial insemination and embryo transfer		Pre-rut weaned and first live sales	Replacements for mating

4.5 Main features

Deer farming in Otago, together with Southland and Canterbury, is the traditional heartland for the deer industry. Otago was a key 'cradle' for modern deer farming from the 1960s and there are important synergies between the three regions for breeding studs and high-end commercial farms, specialist transportation and venison processing companies. The Otago deer industry's main features are a dominance of family owned and operated farm businesses, the full range of production systems, close connections with the tourism sector, and long-standing scientific research and environmental management capabilities.

With fewer new entrants over recent years[95], the industry in Otago and New Zealand is becoming increasingly reliant on those passionate about deer farming and well-organised farm succession. The diversity of production systems on Otago deer farms reflects the climate variability across the region and there may be more interdependence between farms than elsewhere. Deer farmers with access to water for irrigation are able to have mixed production systems, typically 'doing a bit of everything', while those who are dryland farming are more likely to specialise. Deer farming in some environments lends itself to tourism with the inclusion of trophy animals for safari hunting and farm-stays.

In terms of science, deer farmers have always had a strong interest in knowing more about the biology and behaviours of deer and how the needs of deer can be accommodated with their production systems. AgResearch Invermay[96] in Mosgiel and the Disease Research Laboratory at Otago University have, over time, supplied much of this knowledge and, in doing so, formed an important 'research nucleus' in Otago for the New Zealand deer industry.

4.5.1 The first 50 years

Commercial deer farming in New Zealand evolved from a niche wild venison export industry. With entrepreneurial expertise, those exports spun-off efforts to dramatically reduce wild deer on public and private land across. Otago was at the forefront of wild venison exports and its progression into deer farming.

European settlers released seven species of deer into the wild in Otago and elsewhere in New Zealand between 1861 and 1910 for sport and food (Gray, 2021)[97]. However, as early as the 1920s[98] deer numbers in the wild had become an issue of public concern (Gray, 2021). In response, deer control operations commenced and at least 40,000 animals were culled annually (although less during World War II) up until the late 1950s when the number of deer culled declined sharply as they became more elusive and commercial hunting stepped up with the development of venison exports (Gray, 2021).

Sir Tim Wallis (Wānaka) and Robert Wilson (of Dunedin-based Wilson Neill) established a wild venison export business in Otago, with Wallis supplying the venison (from deer carcasses recovered by helicopter)

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95 https://www.odt.co.nz/business/farming/knack-required-work-deer

96 Invermay was previously a research campus for the Department of Agriculture and is now part of AgResearch. https://agresearch.recollect.co.nz/nodes/view/203

97 The liberation and management of wild deer was overseen by regional acclimatisation societies. The Otago Acclimatisation Society first sourced 'Scotch' deer because most of the members regarded Scotland as home. The young deer arrived in two shipments, the first of which was on the City of Dunedin in October 1870. These shipments were released on Morvern Hills Station and on Bushey Park estate (near Palmerston). (https://nzetc.victoria.ac.nz/tm/scholarly/tei-DruExot-t1-body1-d5.html). A history of the introduction of deer to Otago is available in Parker (1973) Protectors of our environment : Otago Acclimatisation Society.

98 Erlton Wilson, a trophy hunter in the Makarora area (at the head of Lakes Wānaka and Hāwea) in the 1920s, noted the decline in condition of wild deer herds due to overgrazing: "*As far as [trophy] heads go, they appear to be a thing of the past … the stags' antlers are poor timber and have neither length nor spread … all flats well eaten out and the few ribbonwood and broadleaf trees eaten bare.*" (Yerex, 2001: p. 26 as cited in Drew, 2008).

and Wilson taking care of the sales and exports (Gray, 2021). However, the use of helicopters in deer recovery was fiercely competitive and wild deer were *"fast becoming a limited resource"* (Gray, 2021: p20). The question was how to supply a rapidly growing wild venison industry while maintaining deer numbers and the answer – the live capture of deer – set in motion the start of deer farming in New Zealand (Gray, 2021: p20).

Wallis started the live capture and relocation of wild deer in 1968 to a property by Wanaka Golf Course and went on to develop Criffel Game Park (Gray, 2021)[99]. By 1970, Wallis and Wilson were supplying live capture hinds for a new deer farm at West Dome in Southland, which Wilson used as a 'basic blueprint' for later ventures in the South Island (Gray 2021). Dr Ken Drew (Invermay Agricultural Research Centre) and Les Porter (Ministry of Agriculture and Fisheries, Dunedin) visited the West Dome farm and arranged for the loan of hinds (and later stags), marking the start of a new research era (Gray 2021).

When the first deer farming licence was issued in 1970,[100] to a property in the King Country, the adoption of live capture and relocation techniques created a ready supply of livestock for emerging deer farms from Fiordland and the Southern Alps. Strong research capabilities in Otago[101] , along with tax incentives, attracted entrepreneurs, city-based businessmen and innovative farmers into New Zealand's fledgling deer industry, which in turn accelerated its development[102] .

> *It is a much-changed landscape because of the influence of Invermay in the early days. People were getting into deer and there were small deer farms all over the place. In 1975, over 600 people came to a field day at Invermay associated with a Dunedin Deer Industry Conference. The farmer / shareholder / businessman model was in full swing and the search for information was huge.*
>
> ***Tony Pearse***[103]

By the 1990s, the deer industry had matured (DINZ, 2021) and was evenly split between the North Island and South Island (Gray, 2021). The industry reached a peak in 2004 with 1.76 million farmed deer in New Zealand and 206,000 in Otago (at this time 60% of all farmed deer were in Canterbury, Otago, and Southland). From 2004 there was a consolidation of the industry over a decade or so, and the industry's balance has continued to shift towards the South Island. Always part of its heartland, deer farming in Otago has become more of a stronghold for the deer industry – as is Canterbury and Southland.

Consolidation is typical of many nascent industries with developing markets but was exacerbated by competition for land from dairy and dairy support[104]. As a result, more deer farms have disappeared from the plains and foothills of coastal Otago (in a continuous stretch from Owaka to Ōamaru) than further inland, where there appears to be increasing farm size (i.e., greater scale). An industry leader and

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99 https://criffelstation.com/

100 Before 1970 deer farming was limited to the raising of deer on aristocratic estates in Europe for hunting or in small enclosures in Asia for velvet production.

101 In September 2022, AgResearch celebrated 50 years of deer-based research at Invermay.

102 https://www.odt.co.nz/rural-life/rural-life-other/deer-industry-story-features-early-champion?msclkid=15e638b1cf3511ec915be6a5cee408cb

103 A 'stalwart' of the industry, Otago's Tony Pearse became manager of Invermay's deer research farm in 1983, manager of MAF Deer in 1989, and Deer Industry New Zealand's first producer manager in 2002 (Gray, 2021) – a position he held for roughly 20 years.

104 From 2004 to 2015, the number of farmed deer in New Zealand fell by 857,000 (or 49%) while national dairy cow herd increased by more than 1.33 million (or 26%). The increase in dairy cows largely occurred in the South Island, especially on the fertile flats of Southland, Otago, and Canterbury (Gray, 2021).

Otago deer farmer, John Scurr reflected the deer industry *"never anticipated the rate of land use change due to dairying: it happened a lot faster than we thought it would, and we simply couldn't compete"* (Gray, 2021: p204). Using Otago as an example, the number of farmed deer in the region decreased by 40,000 (or just under 20%) over five years to 2009 while dairy cows increased by around 83,000 (or just under 48%) over the same period[105].

Not surprisingly the drop in deer numbers was linked with an exodus of deer farmers who either sold up and retired or went into dairying but, as *The Deer Farmer* emphasised at the time, deer farming 'might be down but it was not out' (Gray, 2021: p204). The deer industry's response was to develop the *Venison Productivity Strategy* which turned attention to new ways of managing the supply chain and improving productivity (Gray, 2021). This strategy recognised that advances in deer farming productivity have been muted in relation to other livestock industries but the potential for dramatic improvement clearly existed. It had two basic outcomes: *"more calves conceived, born earlier and surviving to sale, and heavier prime animals supplied earlier in the season"* (Pearse and Fung, 2007: p73). It supported existing moves to extend consumer demand for chilled venison from a four-month traditional game season to the whole year in key markets and establish new markets (Pearse and Fung. 2007).

Figure 36 shows the changing fortunes of the deer industry in Otago over the past 30 years, with an upturn in deer numbers since 2015, suggesting it is following the cyclical nature of other land uses. By 2019, Otago's farmed deer herd was around 121,000 head (a decrease of 41% from the 2004 peak), or roughly 15 per cent of the national deer herd (an increase from 11% in 2004). Figure 37 shows a decline in the number of deer farms over the past decade. The increasing number of farmed deer since 2015 while the number of deer farms has continued to decline (albeit more slowly from 2018) suggest increases in the scale of the remaining deer farms and possibly more deer on sheep and beef farms.

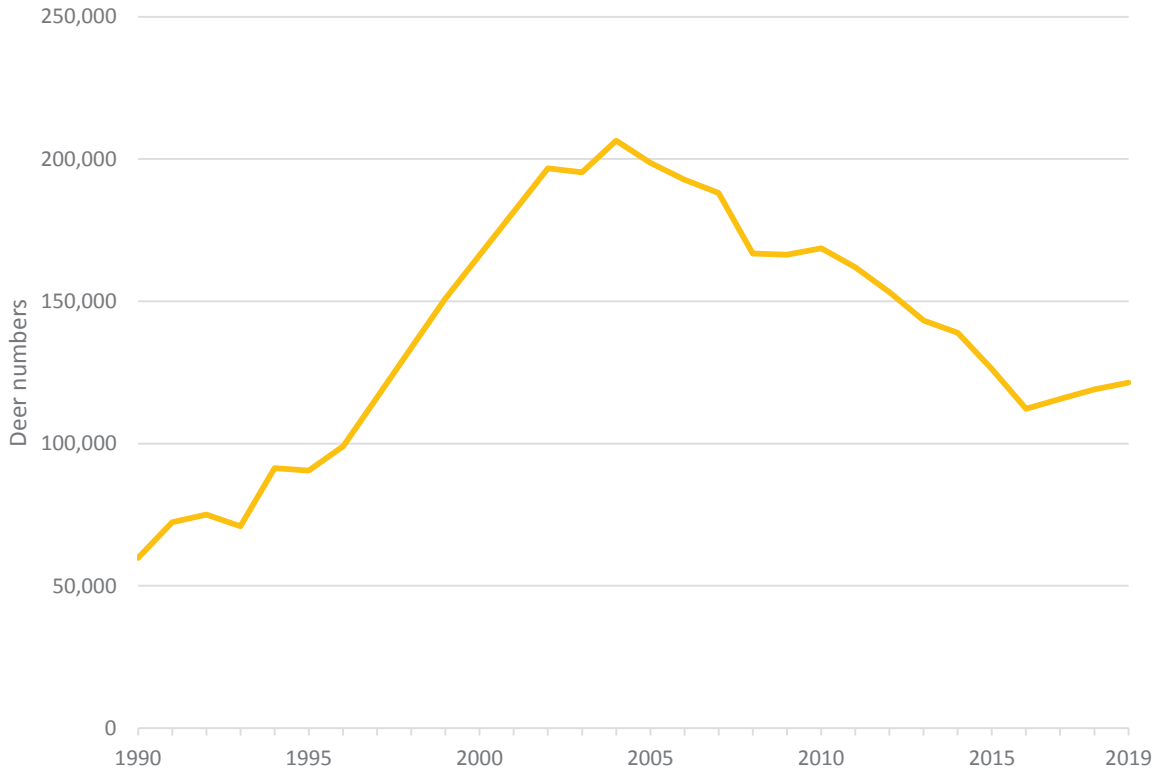

Figure 36: Deer herd in Otago 1990-2019
Source: StatsNZ (the 1997-1998 and 2000-2001 datapoints were estimated based on the mid-point of the surrounding years).

105 https://www.stats.govt.nz/indicators/livestock-numbers accessed 1 May 2022.

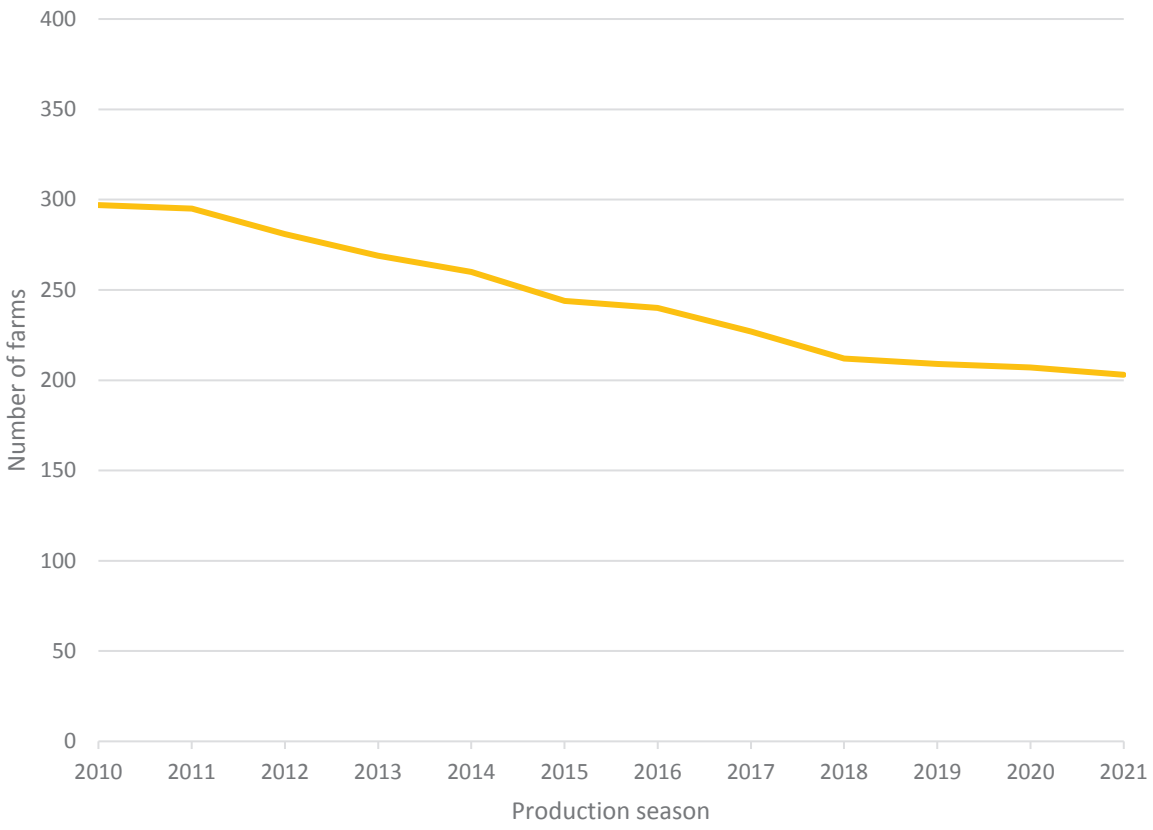

Figure 37: Estimated number of deer farms in Otago 2010-2021
Source: DeerPRO

4.5.2 Deer farming today

Deer farming in New Zealand has just celebrated its first 50 years and, Otago along with Southland and Canterbury, form the industry's stronghold. For those who have 'stuck with it', deer farming has proven a stable long-term investment. Most of the farmers that remain in the industry are committed to deer farming – their farms are usually family owned and operated and many have existed since the early years. Through farm succession, some of these farms are now being run by third generation deer farmers. The larger farms are typically either corporate-owned or family-owned with corporate management and governance structures.

Pāmu farms (previously Landcorp) have long been important to the industry, and at one point they collectively held around twenty per cent of the national breeding herd. Pāmu's deer herds included an elk/wapiti herd producing terminal sires based at Landcorp Orokonui just north of Dunedin. That herd was relocated to the Te Anau basin in the late 1980s and farmed as part of the Crown elk/wapiti herd to improve the genetics and hunting of the Fiordland-based elk/wapiti, which in turn had a considerable influence on cross-breeding with red deer. Otago, Southland, and Canterbury remain the centre of elk/wapiti breeding and farming predominantly for their prized velvet antler and their major role as terminal sires, which are crossed with red deer hinds for fast finishing venison production to meet the peak chilled venison export season (September to November).

Many deer farms operate with little need for permanent additional on-farm labour, so the deer industry is less susceptible to the farm labour issues that some other industries experience – however workload pressures at certain times of the year, such as velveting, can often be challenging. Velvet farmers with substantial herds may spend three to five days per week in the yards managing the harvesting of six to ten deer per hour depending on technique (e.g., mechanical restraint and local anaesthesia in purpose-built deer handling workrooms and hydraulic chutes or by chemical sedation and local anaesthesia). However, the workload is predictable and, with good record keeping and assembling smaller groups, it is relatively easily managed[106]. Variation in climate, topography and soils means there are likely to be examples of most of New Zealand deer production systems present in Otago – from high country stations around the upper lakes in Central Otago to properties in the Catlins on rolling hill country.

In general, the production systems in South Otago (with wet winter and heavier soils) have similarities to Eastern Southland, while Waitaki is more akin to South Canterbury, and Central Otago to the Canterbury high country. The range of production systems is also evident within a locality. For example, Central Otago is characteristically dry on the plains and, where possible, irrigation is a usual part of the infrastructure, yet Mt Aspiring Station in the Matukituki Valley at the headwaters of Lake Wānaka has rainfall almost like the West Coast.

Deer farming in Otago has traditionally focused on the breeding and selling of weaners for venison finishing, along with some strong interest in producing velvet and antler. However, the variation in landscape can create considerable diversity even within a locality. For example, the stations around Wānaka are large producers of venison. Those with irrigation and lucerne crops may buy in weaners, particularly from Southland, to finish before processing. Some will breed large numbers of their own weaners before sending them elsewhere in autumn, including to other regions, for final finishing. Others have sufficient rolling country to be able to breed and finish their own venison (e.g., West Wanaka Station).

Other properties across Otago either breed and finish weaners or focus on finishing, so most of their revenue will come from finished venison rather than breeding weaners for sale (e.g., Andrews Farm at Kokonga in the Maniototo, The Ranch[107] at Awamungu north of Balclutha, and Awakino Station[108] near Kurow). Some may have separate properties or close associations with farms in easier environments to help finish their young stock. Pāmu has several large-scale properties with deer breeding and finishing properties near Lake Mahinerangi, (Fortification) and used to finish large numbers of deer at Hindon in the Lee stream area (although this has now ended).

There are also a handful of stud farms in Otago (e.g., Clachanburn Station[109] and Black Forest Park[110]), but fewer than in Southland. Sales are held on-farm for specialist sires for both venison and velvet antler, or occasionally by private treaty sale, particularly for the supply of trophy stags. Clachanburn is a renowned elk/wapiti terminal sire supplier while Black Forest Park is amongst the leaders in both growth rate and carcass yield for venison (East European bloodlines) and for velvet and trophy antler sires. Characteristically in Otago, farm businesses tend to be more dependent on the trading of stock

106 Velveting is supported by the National Velveting Standards Body, which allows farmers to pass both theoretical and practical assessment of skills and facility standards, accreditation, and audit, to be approved to remove antlers on farm.
107 https://www.odt.co.nz/rural-life/red-meat/focus-production-hectare
108 https://nzfarmlife.co.nz/vision-coming-to-fruition/ ; https://www.odt.co.nz/rural-life/rural-people/family-%E2%80%98farming-next-generation%E2%80%99
109 Smart co-operation helps with deer success | Otago Daily Times Online News (odt.co.nz)
110 About | Black Forest Park

than in other regions where breeding and finishing on the same property is easier. That said, many large well-performing farms concentrate on genetic improvement, with the selection of sires and hinds based around the relevant Deer Select Breeding Values (known as 'eBVs')[111] .

In addition to deer farming, Otago's deer farmers are also involved in the tourism sector. The region is well represented with trophy operations, although there are fewer than in Canterbury. Spotts Creek Station (formerly Spotsburn Station, Cardrona Valley), for example, was one of the first to offer safari game hunting[112]. Stations, such as Glen Dene[113] and Minaret Station[114] offer luxury accommodation, guided trophy hunting and other high-end tourist experiences such as heli-skiing, backcountry hiking and fishing for international clientele. Usually, these trophy operations are associated with mixed dry stock properties. Other farms offer farm stays, lodges, or 'glamping' (i.e., glamourous camping), and many rely on having farmed or feral deer on their properties as a unique selling point.

Image 20: Criffel Station (Wanaka)
Source: Criffel Station

Some of these farms and stations are in close proximity to conservation land, such as Mt Aspiring National Park and the Rock and Pillar Conservation Area, and there are situations where public access exists over farmland. Where this is the case tourism can create pressure for farming operations[115].

111 Deer Select Breeding Values includes selection for superior growth rates (weaning weight and 12month weight of potential sires), loin eye muscle area (as a proxy for higher carcase saleable muscle yield), CARLA value (a genetic resilience to parasite infestation) and selection for two-year-old velvet weight as a genetic boost to high velvet antler weight.
112 https://safariclub.org/ph-spotlight-aesaa%C2%AC-john-scurr-cardrona-safaris/
113 https://glendenehunting.com/
114 https://minaretstation.com/
115 https://www.rnz.co.nz/national/programmes/countrylife/audio/2018650484/high-country-farming-with-a-live-audience

4.5.3 Research and development

The early pioneers' search for information on deer farming turned into a quest for knowledge as the industry evolved and has left many deer farmers with a keen interest in scientific research and development. The close relationships between veterinary, diagnostic, and farming groups, which are particularly evident in Otago, have been essential for the deer industry's success and will continue to be so in the future.

AgResearch Invermay is an agricultural research centre that became internationally renowned for its deer research group and large deer research farm (a major focus on the centre) that has played a leading role in science associated with deer health, genetics, animal welfare, productivity, and the development of genomic resources. A large research farm was established over 1972 and 1973 with a deer research team led by Dr Ken Drew – and 50 years of deer science at Invermay was celebrated in September 2022[116]. AgResearch Invermay was also a founding member of the group of pioneering farmers (including Sir Tim Wallis) and industry leaders that met in Christchurch in 1975 to form the New Zealand Deer Farmers Association. Dr Jimmy Suttie and his team at Invermay were world leaders in velvet antler research until this capability ended with restructuring at Invermay a decade ago[117].

From 2011 AgResearch have run the Deer Progeny Test programme to 1) better measure the venison production genetics available to the New Zealand deer industry and 2) allow commercial farmers to better use genetics to improve productivity and profitability (Ward and Archer, 2014). The Invermay site is home to New Zealand's national deer recording database, DEER Select[118]. AgResearch are involved in environmental research using comparative field trials around deer behaviours[119]. For example, this project is nearing completion: *Long-term monitoring of deer impacts on waterways in hill- and high-country systems*[120].

Dr Colin Mackintosh, a veterinary scientist who worked at Invermay for over 40 years, contributed substantially to Invermay's association with Professor Frank Griffin[121] and his team at the University of Otago's Disease Research Laboratory. This relationship was essential in overcoming critical animal health challenges related to Bovine tuberculosis and Johne's disease that at one point threatened the viability of the deer industry[122]. In particular, the Disease Research Laboratory and AgResearch ran an extremely successful project that closely studied Johne's disease in deer on a farm at Milton in Otago and developed the Paralisa test, which was a transformative step in responding to this devastating disease. The Disease Research Laboratory is now in private ownership and based at Invermay. Dunedin is also the base of DeerPRO, a national animal health and productivity programme with a primary focus on the control of Johne's disease in farmed deer.

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116 https://www.agresearch.co.nz/news/huge-gains-for-industry-in-50-years-of-deer-farming-science/

117 Velvet Antler Research of New Zealand (VARNZ) was originally established in 1994 as a joint venture between the Game Industry Board (operating as Deer Industry New Zealand from 2002) and AgResearch with the twin objectives of: undertaking research on deer velvet and co-products; and controlling and managing the outputs of such work for the benefit of the New Zealand deer industry (https://www.velvet.org.nz/what-is-velvet/velvet-research). Jimmy Suttie left Invermay in 2011, and two years later Dr Chunyi Li also departed, returning to China to lead the world's largest dedicated deer antler research group (Gray 2021).

118 https://www.deernz.org/deer-hub/breeding/deer-select/

119 https://www.deernz.org/deer-hub/handling-and-welfare/behaviour/

120 https://www.agresearch.co.nz/news/deer-impacts-on-water-quality-being-studied/

121 Professor Griffin now runs the post-graduate course, Agricultural Innovation, at Otago University.

122 The Veterinary School at Massey University is also an 'active player' in deer research and extension. Professor Peter Wilson's leadership led to the forming of the Deer Branch of the NZ Veterinary Association. This is the primary group for reporting and publishing research on the topic of deer health and deer farming and it has close relationships with the deer industry.

4.5.4 Environmental stewardship

In addition to this research nucleus, the deer industry acted early in creating environmental management initiatives. Lead by the vision of Sir Peter Elworthy[123], the Biennial Deer Industry Environmental Awards[124] were introduced in 2001 to showcase the practices of Supreme Elworthy award winners and individual category winners through field days on their properties[125]. The Environmental Awards and field days are arranged by New Zealand Deer Farmers Association and remain a key part of the deer industry calendar.

The deer industry's original environmental management publication, *The New Zealand Deer Farmers' Landcare Manual*, was first published in 2004 and revised in 2104 and 2018 to keep the principles and best practices relevant and current. The original manual was "by farmers for farmers" and designed as a practical and comprehensive 'go-to' reference. It contained examples of environmental management plans that were in place and working on deer farms across the country based around farmer experience and practicality. The manual formed the basis for the *Deer Industry Environmental Management Code of Practice* (2018)[126], which contains up-to-date advice on how to manage the adverse environmental effects of deer, such as fence pacing and wallowing behaviours.

The industry's pioneering spirit has always attracted innovation[127]. Otago's Advance Parties[128] are 'turbo-charged' local farm discussion groups (Gray, 2021: p239) supported by the deer industry's 'Passion2Profit' programme. Through an Advance Party, highly motivated deer farmers meet to share their personal and business development experience, as well as to show opportunities to the deer farming community[129]. For example, "The Ranch" near Awamangu, which is part of the South Otago Advance Party, recently hosted an in-depth farm tour for rural professionals (Stewart, 2020). The Central Otago Advance Party has a specific interest in environmental actions.

More broadly, there are many examples of deer farms across the region that have invested in environmental protection, either formally through QEII covenants (e.g., 900 hectares of Remarkables Station) or actions such as planting out wide riparian margins. However, a few farmers have moved out of deer rather than fence their tussock gullies, which can be particularly valued for fawning.

The co-operative, solutions-based approach is serving the deer industry well. Since 2015 the lessons on deer farming have been documented in a series of "*DEER Facts*", which are distributed to all deer farmers as part of the deer industry's Passion2Profit strategy[130]. The topics include best practices, breeding, biosecurity, environment, handling, health, management for profit, and nutrition. The series is collated as a Deer Farming Resource Kit to help New Zealand deer farmers run profitable, resilient, and sustainable farming businesses[131]. In essence, it reflects sensible farming practice.

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123 Sir Peter Elworthy who was a South Canterbury farmer and the founding chair of the New Zealand Deer Farmers Association, among other achievements.

124 https://www.deernz.org/home/deer-industry-new-zealand/industry-awards/environmental-awards/

125 As examples for Otago, in 2019 John and Mary Falconer of Clachanburn Station (Central Otago) were the winners of two individual category awards and in 2008 Grant and Andrea Cochrane won the Premier Elworthy Award, Landcare Trust Award and Fish and Game NZ Award and in the same year Mike and Chris Stephens were winners of the Firstlight Award (Total sustainability).

126 https://www.deernz.org.nz/deer-hub/farm-and-environment/environmental-code-of-practice/

127 For example, John Falconer's hydraulic, remote-controlled deer crush https://www.odt.co.nz/rural-life/rural-people/innovation-rewarded

128 Advance Parties | Advance Parties (ap.org.nz)

129 https://www.odt.co.nz/rural-life/red-meat/widespread-support-advance-parties

130 https://www.deernz.org/deer-hub/support-services/deer-facts/

131 https://www.deernz.org/deer-hub/support-services/p2p-a-deer-industry-initiative/

4.6 Processing and markets

As an additional dry stock industry with a mix of production systems, deer farming in Otago helps to diversify the regional economy, which adds to its resilience. The New Zealand deer industry is almost entirely focused on exports (venison and co-products, hides and leather, and velvet and antler), generating $254 million of export earnings in 2020-21 despite Covid-19 restrictions, which particularly impacted venison and trophy. The industry has earned an international reputation for consistent product quality and food safety (including strict animal welfare controls with high standards), free-range farming systems in a relatively clean environment (compared with other parts of the world), and its credibility and professionalism.

In 2021-22, Otago accounted for about 12 per cent per cent of New Zealand's venison production of 19,000 tonnes, and roughly 10 per cent of the country's velvet antler production. In addition to venison and velvet, there are also livestock sales for both store stock (deer sold to another farm for venison finishing) and stud deer. Otago is well serviced by venison processing plants and specialist deer transport businesses that have committed to the industry. Figure 38 shows trends in the number of deer processed in Otago since 2010.

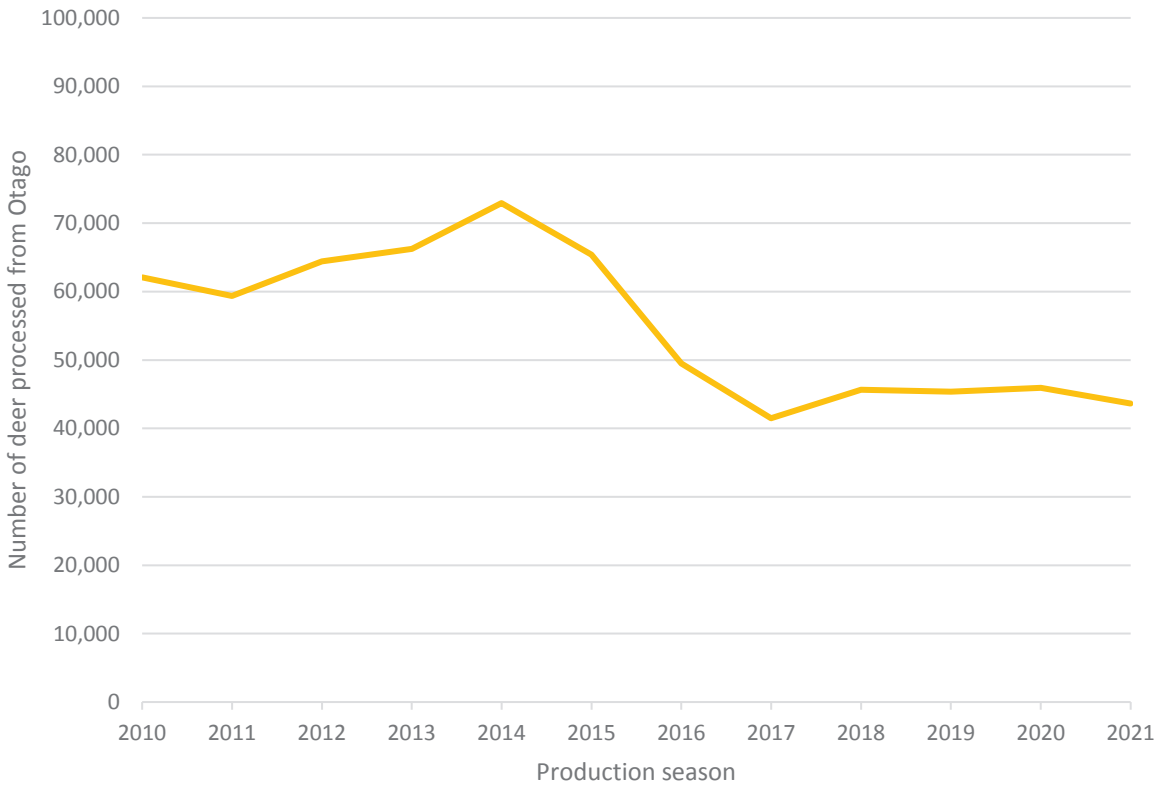


Figure 38: Number of deer processed from Otago in a production season 2010-2021
Source: DeerPRO

Some venison is processed within Otago at Duncan New Zealand's specialist venison processing plant located in Mosgiel. However, most venison is processed outside of the region at the Alliance Group or Silver Fern Farms plants in Southland (Lorneville and Kennington), South Canterbury (Smithfield and Pareora) or the West Coast (Hokitika). Some processing also occurs at the Mountain River New Zealand Venison plant in mid-Canterbury (Selwyn). All four companies are licensed to sell New Zealand premium farmed venison as Cervena® (chilled and frozen products)[132]. Deer co-products include skins and leather, edible offal, and the tails, pizzles and tendons favoured in traditional oriental medicine.

Venison exports for the year ended September 2021 were valued at $155 million, and $179 million when co-products, skins and leather are included[133]. This represented a drop of 19 per cent in value on the previous season, despite the 21 per cent lift in volume sold. This was reflected in values received for both frozen and chilled venison, and the shift in demand from higher-value chilled to frozen product. Venison is exported for retail and restaurant trade, with the bulk being exported as a frozen product. Increasingly markets are demanding the high-value chilled product that is produced from August to November. Chilled venison contributed 17 per cent of total trade value for 2020-21, compared with 26 per cent of trade value in 2019-20.

The traditional export markets for venison are in Europe, however, the United States has become the most important individual market in recent years (refer to Table 6). China is a developing market for venison with huge potential: there was an 80 per cent increase in value of venison exports in 2021-22 and 27 per cent increase in volume over the previous season[134]. Confidence in market diversification, which has been pushed along by the impacts of Covid-19 restrictions, is holding farmgate prices for venison steady as retail and foodservice industries recover.

Table 6: New Zealand venison and co-product exports by value in NZ$ millions (FOB[135], year end September)

Market	2015	2016	2017	2018
United States	$34.82	$37.02	$52.42	$81.92
Germany	$52.67	$41.37	$40.47	$50.99
Belgium/Netherlands	$39.31	$33.45	$32.75	$39.24
Switzerland	$14.76	$12.44	$12.95	$10.67
Finland/Sweden	$12.50	$12.39	$8.22	$11.56
Others	$47.77	$51.99	$48.36	$51.10
Total	**$201.83**	**$188.66**	**$195.16**	**$245.48**

Source: StatsNZ

A few farms in the region, such as Kauru Hill Venison[136] in North Otago, sell their product at local farmers markets and supply local restaurants.

132 https://www.nzvenison.com/n80,4.html

133 https://www.deernz.org/home/deer-industry-new-zealand/statistics/

134 https://www.deernz.org/home/our-stories/dinz-news-in-brief-issue-87/

135 Free On Board (FOB) is a trade term indicating the point at which a buyer or seller becomes liable for goods being transported on a vessel (https://www.investopedia.com/terms/f/fob.asp).

136 https://www.kauruhill.co.nz/ ; https://www.nzherald.co.nz/the-country/news/north-otago-deer-venture-enters-new-territory/R5WXXZRNMUD4V6RECQYYFZAENQ/

Velvet production (based on levy paid) increased 14 per cent to 956 tonnes for 2020-21 from strong levy compliance and natural growth in production. The average velvet price fell by about 15 per cent to $102.50 per kg in 2020-21 reportedly because of a risk discount by importers in response to uncertainty around the impact of Covid-19 on supply lines. Shipping disruptions, considerable increases in freight costs and port closures did all eventuate, creating additional costs in getting velvet to the market. The 2021-22 season indicated a strong return to values with Super A and A Grades reaching up to $140 per kg and a confident outlook is anticipated for the immediate future.

Most velvet is exported as a frozen raw product to Asia, particularly China, Taiwan, and South Korea[137] (refer to Table 7). There is surging demand from large corporations in these countries (as well as interest more broadly) for its use in healthy functional food products to strengthen immune function and for vitality and longevity, as an equivalent animal product to ginseng. Market expansion in China is strongly supportive of the New Zealand Deer Velvet Coalition[138]. Returns for velvet are continuing a longer-term upward trend, despite recent challenges, and it is estimated that total farmgate revenue will pass $120 million for 2021-22, up from around $100 million for 2020-21[139]. There are velvet exporters in Otago, although New Zealand's largest exporter of velvet is PGG Wrightson (based in Christchurch). Some velvet is processed in New Zealand for health food supplements.

Table 7: New Zealand deer velvet exports – top markets by value in NZ$ millions (FOB, year end September)

Market	2015	2016	2017	2018
China	$24.83	$21.51	$39.41	$42.00
Republic of Korea	$10.24	$16.34	$13.07	$20.05
Australia	$0.40	$0.27	$0.45	$0.65
Japan	$0.24	$0.32	$0.39	$0.56
Hong Kong	$2.06	$2.90	$4.39	$0.55
Others	$1.28	$1.13	$1.05	$0.89
Total	**$39.05**	**$42.47**	**$58.75**	**$64.70**

Source: StatsNZ

The Alpine Group[140] (formerly Alpine Deer) founded by Sir Tim Wallis in 1963, is based in Wānaka and has a 50-year history in the deer product business. Largely in partnership with Robert Wilson of Wilson Neill Ltd., the business pioneered the development of deer carcass co-products, as well as velvet, for specialist Asian markets. Aerial-based wild venison is exported via licenced game packing houses, which include AsureQuality inspection and certification, to international markets as a distinct product from farmed venison.

Deer dairying, for use in cheese and skincare products, was also first trialled in Otago (Gray, 2021). However, deer milk is an emerging product and it is too early to say whether dairying will ever become established as a deer production system.

137 Statistics - Deer NZ
138 https://www.odt.co.nz/rural-life/rural-life-other/velvet-shifting-medicine-health-food
139 https://www.deernz.org/home/our-stories/dinz-news-in-brief-issue-87/
140 The Alpine Group. https://www.alpinegroup.co.nz/

5 Arable Cropping

Author: Abie Horrocks (Research Manager – Environment) with contributions from Turi McFarlane (Research Leader - Environment), Ivan Lawrie (General Manager – Business Operations), Andrew Pitman (General Manager – Research, Development & Extension) and Tabitha Armour (Senior Researcher) (all Foundation for Arable Research).

This chapter outlines the arable industry in Otago, including information from 15 informal interviews with local arable growers and historical commentary from Ross Mitchell (Ashton Glen Farms). These interviews were undertaken by the Foundation for Arable Research alongside the collection of data for the Ministry for Primary Industries' Farm Monitoring and Benchmarking Project[141]. FAR estimates there are close to 100 commercial arable farms in Otago, each with their own mix of crop and, in many cases, livestock rotations.

5.1 Summary

Arable cropping involves the growing of cereals (for either human consumption or stock feed), herbage and vegetable seed, as well as a multitude of other crops for both domestic and export markets. Arable crops are central to New Zealand's pastoral industries as the seed source for animal pastures, vegetable seeds, and cereal and silage for complementary animal feed.

New Zealand arable growers have some of the most diverse crop rotations in the world. However, as growers juggle a range of agronomic issues and external drivers there is a high degree of diversity, agility, and flexibility in cropping rotations, even for those in close proximity, and it is challenging to describe 'typical' arable production systems. The sectors agility means that new crops, systems, and production methods can be adopted relatively quickly in response to changing market signals, but the small scale of the industry also means it has limited processing infrastructure (e.g., mills and maltsters), which can act as a constraint.

The main features of arable farming in Otago are its mix of crop rotations by locality, the integration of livestock within these rotations, connections with winter grazing, and contrasting irrigated versus dryland cropping. In Otago, although "serious growers" of arable crops who remain in the industry are now seen as an increasingly "rare breed", because of the high level of integration of arable and pastoral enterprises, the lines of distinction between different land uses (e.g., dry stock, arable, dairy support, dairy) are not always clear.

Most arable growers in Otago include livestock enterprises in their production system, with activities ranging from breeding stock to finishing and wintering. In general terms, the traditional 'mixed cropping' system is still common in the region. This system combines cropping and livestock enterprises where two to four years of arable crops are followed by two to four years of pasture (i.e., a four-to-eight-year full

141 https://www.mpi.govt.nz/funding-rural-support/farming-funds-and-programmes/productive-and-sustainable-land-use/farm-monitoring-and-benchmarking-project/

rotation). Integration of livestock into crop production means arable can restore soil quality by inclusion of restorative crops (e.g., ryegrass) that build soil organic matter but in addition to soil quality, nutrient cycling and cashflow, weed control are other reasons why arable growers have livestock.

Otago has a rich history of arable cropping, which continues to adapt to changes in processing infrastructure and markets, with businesses often re-framing decision-making as a consequence of extra costs of taking on irrigation opportunities in recent years.

5.2 Introduction

Arable cropping involves the growing – for either human consumption or stock feed – of cereals[142] (e.g., wheat, barley, and oats), herbage and vegetable seed (e.g., ryegrass, carrot), and other crops (e.g., seed rape, field peas). Crops are grown in sequences as flexible 'rotations' – the crops grown in the rotation need to be marketable and, in making decisions about the rotation, growers are very responsive to a range of moving parts. A crop rotation influences profitability (Lawrence-Smith and Fraser, 2022), and its design involves considering drivers, such as forecast demand (using a range of tools[143]) and constraints (e.g., biophysical, availability of contracts, proximity to mills). The design also involves managing nutrients and soil quality as well as controlling a range of agronomic issues such as weeds, pests, and diseases.

Growers need to juggle agronomic issues and external drivers, which results in a high degree of diversity between cropping rotations, even those in close proximity, and there is no 'typical' arable system[144]. Each grower will grow different crops from year to year and, while the basic rotation will be repeated, it may not be exactly the same, and the end use may change over time depending on demand.

Most arable growers in Otago include livestock enterprises in their production system, with activities ranging from breeding stock to finishing and wintering. In general terms, the traditional 'mixed cropping' system is still common in the region. This system combines cropping and livestock enterprises where two to four years of arable crops are followed by two to four years of pasture (i.e., a four-to-eight-year full rotation). Otago, like Southland, has a greater degree of livestock integration compared to regions such as Canterbury, which have more of a 'continuous' approach to cropping and with it, less livestock integration (Lawrence-Smith, Beare, Tregurtha, Hu, 2019).

142 Grains are mostly obtained from cereals. Cereal crops such as oats, barley and wheat can also be grown for forage as a green feed crop or for whole crop silage.

143 For example, New Zealand's Exchange (NZX) produces regular grain and feed insight price reports, which in the July 2022 issue contained a summary of the United States Department of Agriculture's world agricultural supply and demand estimates, key market indicators, weekly regional feed prices, international feed prices, soil moisture deficit and the last 15 days rainfall, and regional pasture growth indices for 2021 and 2022.

144 The Arable Industry Marketing Initiative Survey is a New Zealand survey of cereal areas and volumes grown and a useful source of information to assess regional trends. Seed crops (herbage and vegetable), peas and other pulses and supplementary feed crops, which include forage brassicas (swedes, turnips, and kale), silage, maize (green feed) and other crops grown in Otago, are not included.

5.3 Size and distribution

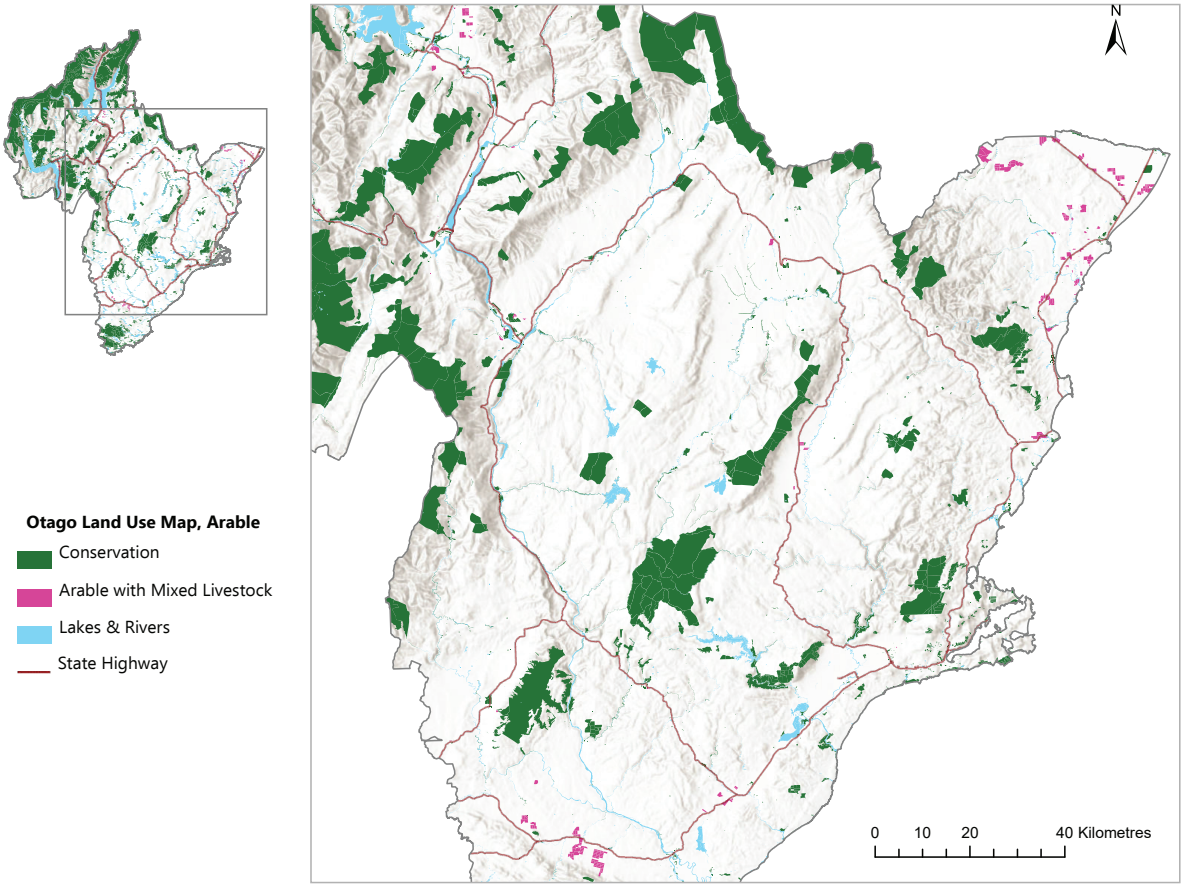
New Zealand's arable growers are amongst the most productive in the world, having held world yield records for both wheat and barley[145]. Growers' ability to produce high crop yields is the result of a generally favourable climate, good soils, high performing cultivars, effective use of irrigation, and the expertise of growers. Arable cropping was once ubiquitous across the landscape in Otago but consolidated in extent both in Otago and nationally over time. The industry is small in size in comparison to other land uses in New Zealand, and also internationally. New crops, systems, and production methods can be adopted relatively quickly in response to changing market signals, but the small scale of the industry also means it has limited processing infrastructure (e.g., mills and maltsters), which can act as a constraint.

In 2021, New Zealand's arable industry contribution to Gross Domestic Product was $684 million in grains and pulses and $247 million in seeds (Robertson and Hurren, 2021). However, the industry's size does not fully account for its flow-on contributions, particularly given its close connections with agriculture as well as with horticulture. Arable crops are central to New Zealand's pastoral industries as the seed source for animal pastures, vegetable seeds, and cereal and silage for complementary animal feed[146]. Growers across the country grow more than 40 grain and seed crops, with some businesses producing up to 20 crops in a single year[147].

Image 21: Irrigated spring barley crop in January 2021, Puketoi Station (Maniototo)
Source: Emma Crutchley

145 Currently a Canterbury farmer holds the wheat record, which is a record previously held in Southland.
146 The level of integration between the arable industry and other industries in the agricultural sector is reflected in Statistics New Zealand's Business Frame, where arable crops are covered by three classifications: 'Grain-Sheep and Grain-beef Cattle Farming', 'Other Grain Growing', and 'Other Crop Growing (includes fodder crops)'. This complexity makes it challenging to gain data specific to the arable industry (Mathers, 2017).
147 https://www.afic.co.nz/wp-content/uploads/2022/07/AFIC-Economic-Impact-2021.pdf

Based on the area harvested (as recorded in the StatsNZ 2017 Agricultural Production Census), arable farming in Otago covered an estimated area of 23,000 hectares (or roughly 8% of arable land in New Zealand) – not including lucerne and forage brassicas, which covered a similar amount of land. From this land, growers harvested a total of 53,670 tonnes of wheat, barley, oats and other cereal grains, field/seed peas and other pulses. At the time, Otago accounted for roughly eight per cent of the 284,000 hectares of cropping land in New Zealand. However, these figures may have changed markedly as total grain and pulse production nationally has increased by 30 per cent and seeds for sowing production has grown by 40 per cent across the country between 2018 and 2021 (Robertson and Hurren, 2021). The Otago Land Use Map below shows the extent of arable farms across the region.



Source: Otago Land Use Map 2022, Otago Regional Council

Figure 39 shows the areas of wheat and barley harvested in arable regions around New Zealand in 2020 – Canterbury is clearly the most dominant region with Otago and Southland being important secondary regions, particularly in terms of issues for food security[148]. For example, growing small seed crops in several areas reduces the potential risk of cross pollination[149]. Also, wet weather in an area can decrease pollination and crop yields (as occurred at the end of 2021, which was one of the worst seasons on record everywhere except for Southland) (MPI, June 2022). Although there are fluctuations from one year to the next, the area harvested in Otago remained relatively stable from the mid-2000s to 2017, after declining markedly from the mid-1980s.

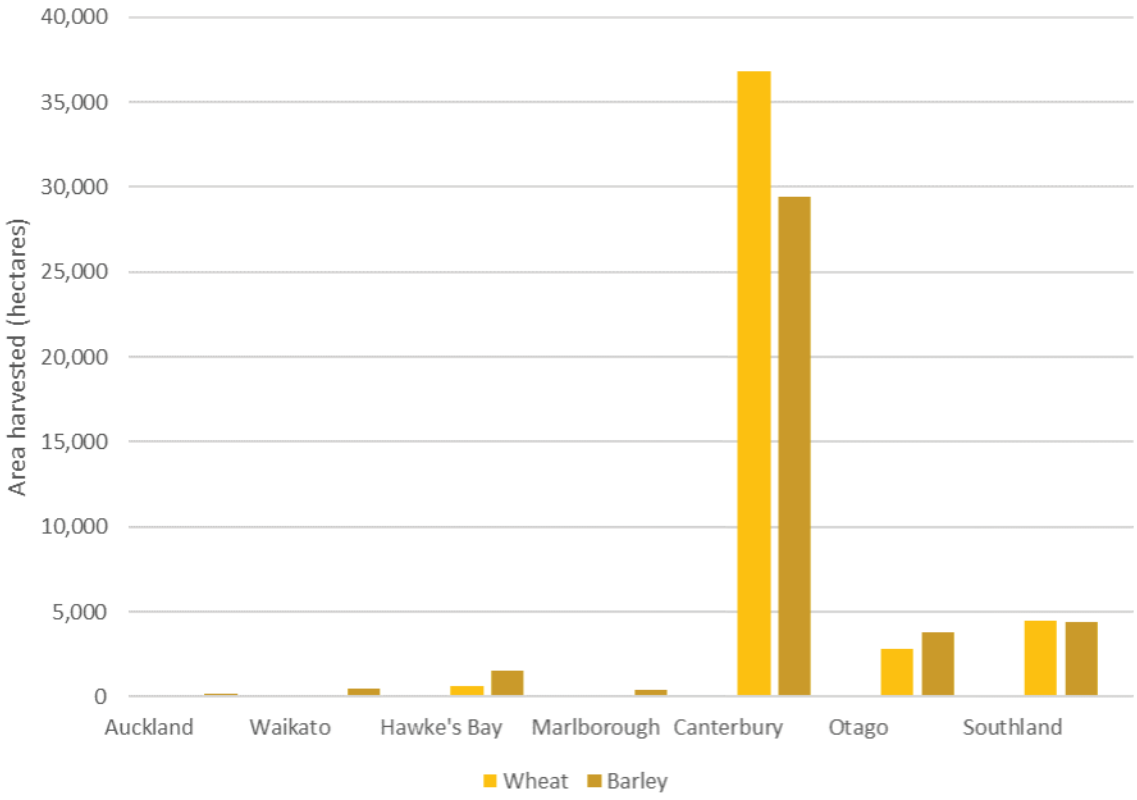


Figure 39: Area of wheat and barley harvested by main arable regions in 2020
Source: StatsNZ Agricultural Production Statistics (June 2020 Final)

In 2020, arable growers in Otago grew 25,300 tonnes (~6%) of the country's wheat, and 26,700 tonnes (8%) of its barley – largely for use as stock feed. By contrast, in 1980 Otago accounted for 13.4 per cent of the total wheat area in New Zealand and in 2010 (40 years on) the region was 4.5 per cent of the total area (Millner and Roskruge, 2013 and StatsNZ).

Partially compensating for the decline in overall cropping area, yields of wheat and barley have steadily increased, although more so for wheat than barley (Millner and Roskruge, 2013). In the case of wheat, the lift in yields has been helped by increased use of higher-yielding winter feed wheat cultivars and inputs (e.g., irrigation, nitrogen fertiliser, pesticides, and growth regulators) (Millner and Roskrugne, 2014). In New Zealand, fluctuations in the area planted in wheat year-on-year usually reflect prices for wheat and alternative crops – the total area planted in barley is generally greater than that in wheat, but total

148 Much of the decline in the total area planted in wheat from the 1980s occurred in secondary regions, such as Otago, Southland, and Manawatu-Wanganui (Millner and Roskruge, 2013) – meaning that New Zealand's wheat production has become even more reliant on Canterbury over recent decades.
149 https://www.odt.co.nz/rural-life/horticulture/southern-seed-sector-set-grow

production is similar because of barley's lower yields (Millner and Roskrugne, 2013). Arable growers in the North Island tend to grow maize grain rather than wheat or barley. There are instances of maize being grown in Otago, but only occasionally.

The main arable crops[150] grown on farms across Otago include barley, wheat (both feed and milling grades), oats, field peas, oil seed rape, and small seeds. Forage and fodder crops are grazed by livestock either in situ or as a 'cut and carry' crop – and include annual ryegrass, forage oats, forage brassicas (e.g., turnips, swedes, kale), fodder beet, and cereals (e.g., oats and barley). Some arable growers focus their business on dairy grazing, growing mostly kale and fodder beet but also crops like spring barley and some grass seed. Table 8 gives details from StatsNZ 2017 Agricultural Production Census (the latest available at the time of writing) for arable crops grown on all farms in Otago (i.e., not just the farms where arable cropping is the main activity).

Table 8: Arable crops harvested on all farms in Otago in 2017

Crop	Area (hectares)	Tonnes	Proportion of area harvested in NZ
Wheat for bread/milling	80	579	0.6%
Wheat for other uses	1,835	19,812	6.9%
Barley	3,859	26,506	9.2%
Oats	565	3,842	9.3%
Other cereal grains	352	1,522	8.5%
Maize grain (not sweet corn)	-	-	0.0%
Field/seed peas	304	991	3.0%
Other pulses	127	418	12.1%
Herbage seeds harvested for seed	446	-	1.4%
Vegetable seed growing	227	-	2.0%
All other grain & seed crops	910	-	12.6%
Supplementary feed crops	**Area (hectares)**	**Tonnes**	**Proportion of areas harvest in NZ**
Maize silage	301	-	0.7%
Cereal, silage or cereal baleage	4,833	-	18.9%
Other crops silage	2,859	-	16.0%
Lucerne	18,152	-	35.8%
Maize green feed	986	-	8.8%
Forage brassicas (swedes, turnips, kale)	43,495	-	18.4%
Other supplementary feed crops	5,191	-	7.7%

StatsNZ Agricultural Production Statistics (June 2017 Final)

150 An arable grower will draw a distinction between main crops and break crops. Traditionally, the main crops would be cereals and ryegrass and various other crops, such as peas or brassicas are included into the rotation to break disease cycles. Arable growers do not refer to cash crops, which is terminology used by pastoral farmers who may see an opportunity to improve their cashflow by putting in a cereal crop.

5.3.1 Crops by district

Arable soils are generally thought of as "those on which it is possible to operate a tractor" (Lunn and Smethan, 1966). Crops are generally grown on flat land or gentle slopes and require good quality soils with high fertility. For example, grains and seeds (e.g., grass, clover, lucerne) are usually grown on flatter free-draining land, usually silt loams and alluvial soils. Forage and fodder crops, such as brassicas and beets, are grown on both flat and rolling land. Arable cropping in Otago roughly divides into three sub-regions, North Otago, South Otago, and (to a lesser extent now) Central Otago. Topographic and climatic variability mean that arable farms in North Otago have similar rotations to South Canterbury, whereas the South Otago farms have rotations more akin to Southland.

Figures 40 to 42 show the distribution by district of arable crops grown on all farms in Otago in 2017 (i.e., not only on arable farms). Figures 40 and 41 show the grain, cereal, herbage, and seed crops by area and then by tonnage respectively. Figure 42 shows the area of arable crops used for supplementary stock feed (tonnage data is not available). Many farms in Otago grow arable crops as supplementary feed for their own livestock or those owned by others, which may be grazed in situ or as 'cut and carry', and some pastoral farms will grow arable crops for human consumption.

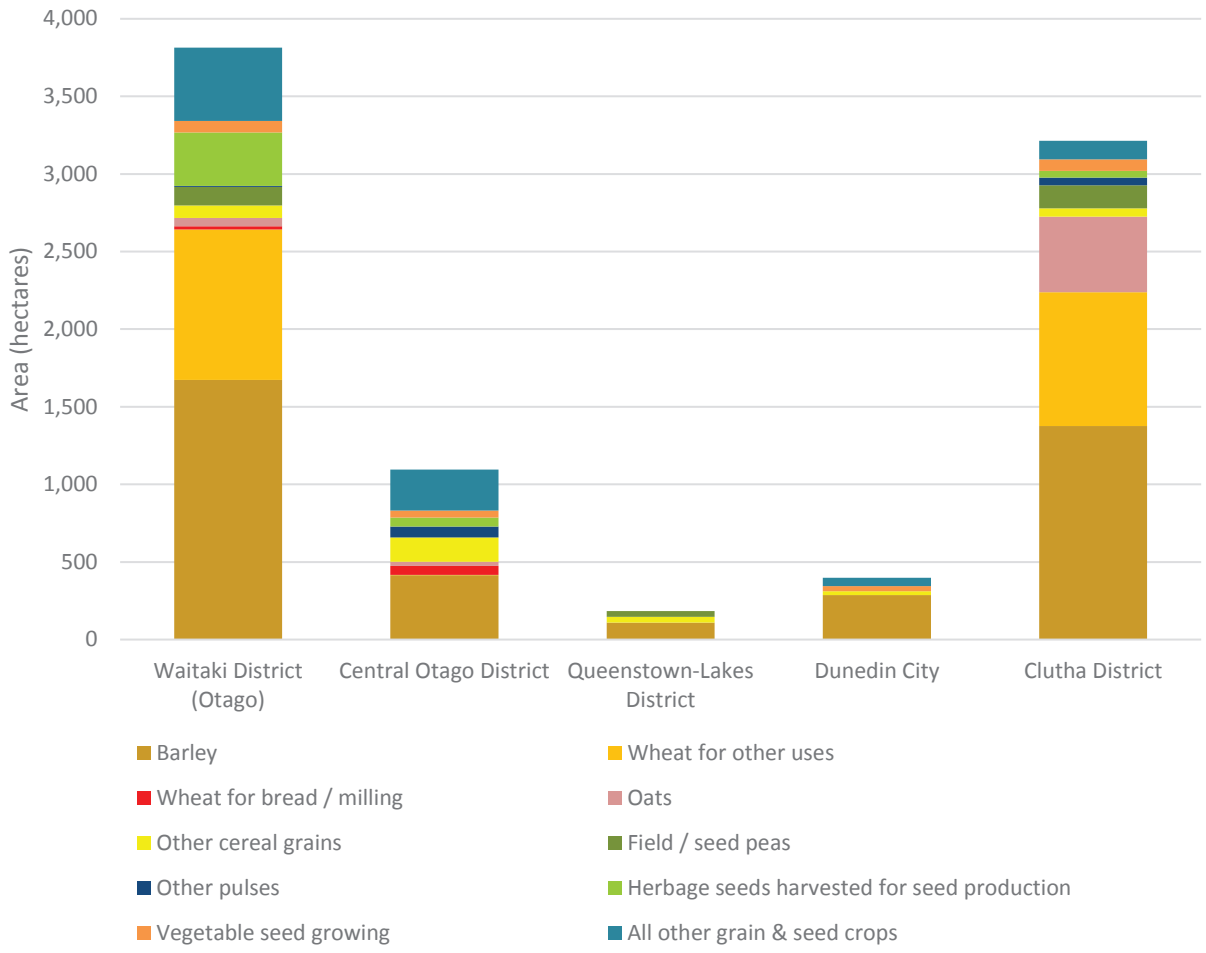


Figure 40: Distribution by area of all grain, cereal, herbage, and seed crops grown on all farms across Otago in 2017
Source: StatsNZ Agricultural Production Statistics June 2017 (final)

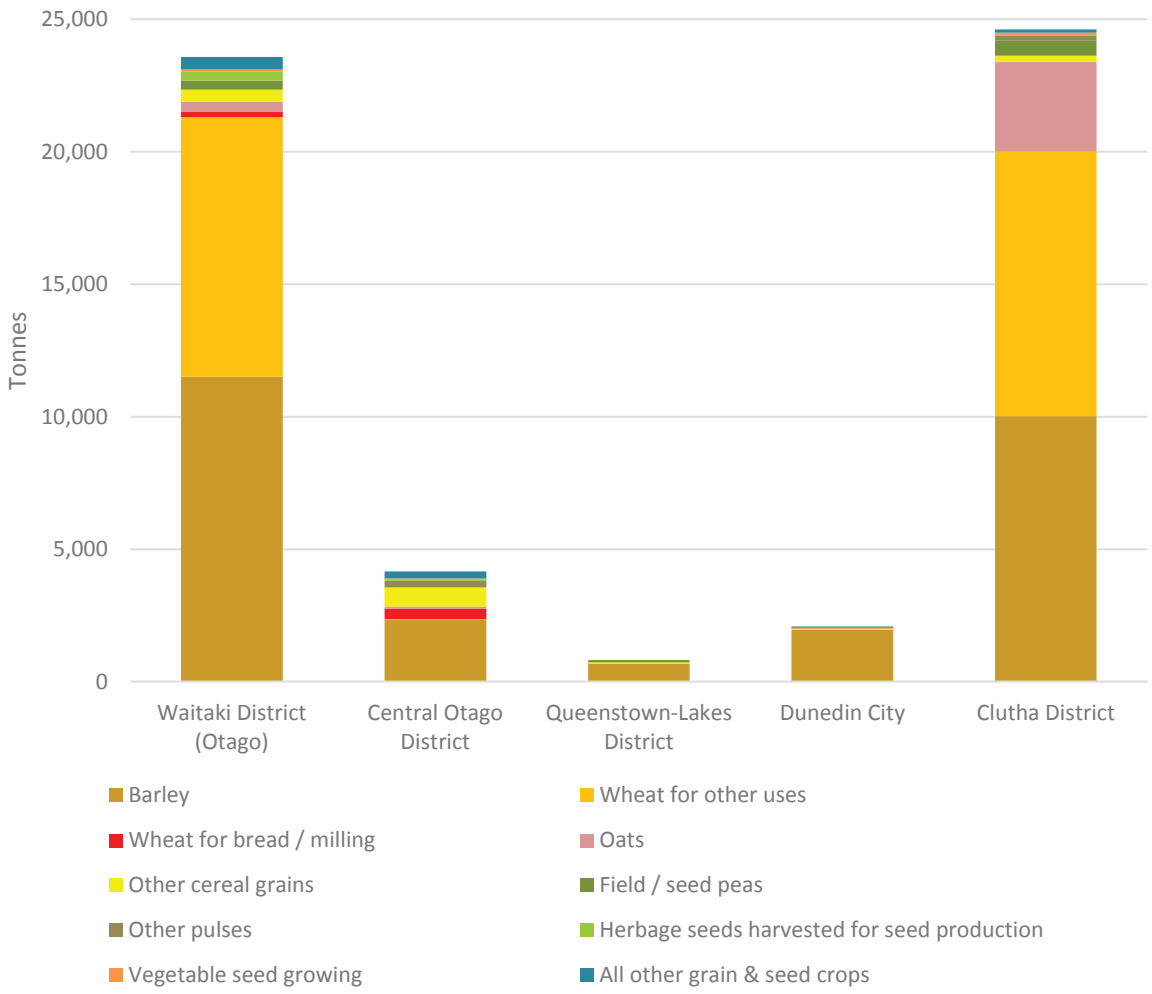


Figure 41: Distribution by weight of all grain, cereal, herbage, and seed crops grown on all farms across Otago in 2017
Source: StatsNZ Agricultural Production Statistics June 2017 (final)

Image 22: Oil seed rape crop in North Otago, November 2018
Source: Peter Mitchell

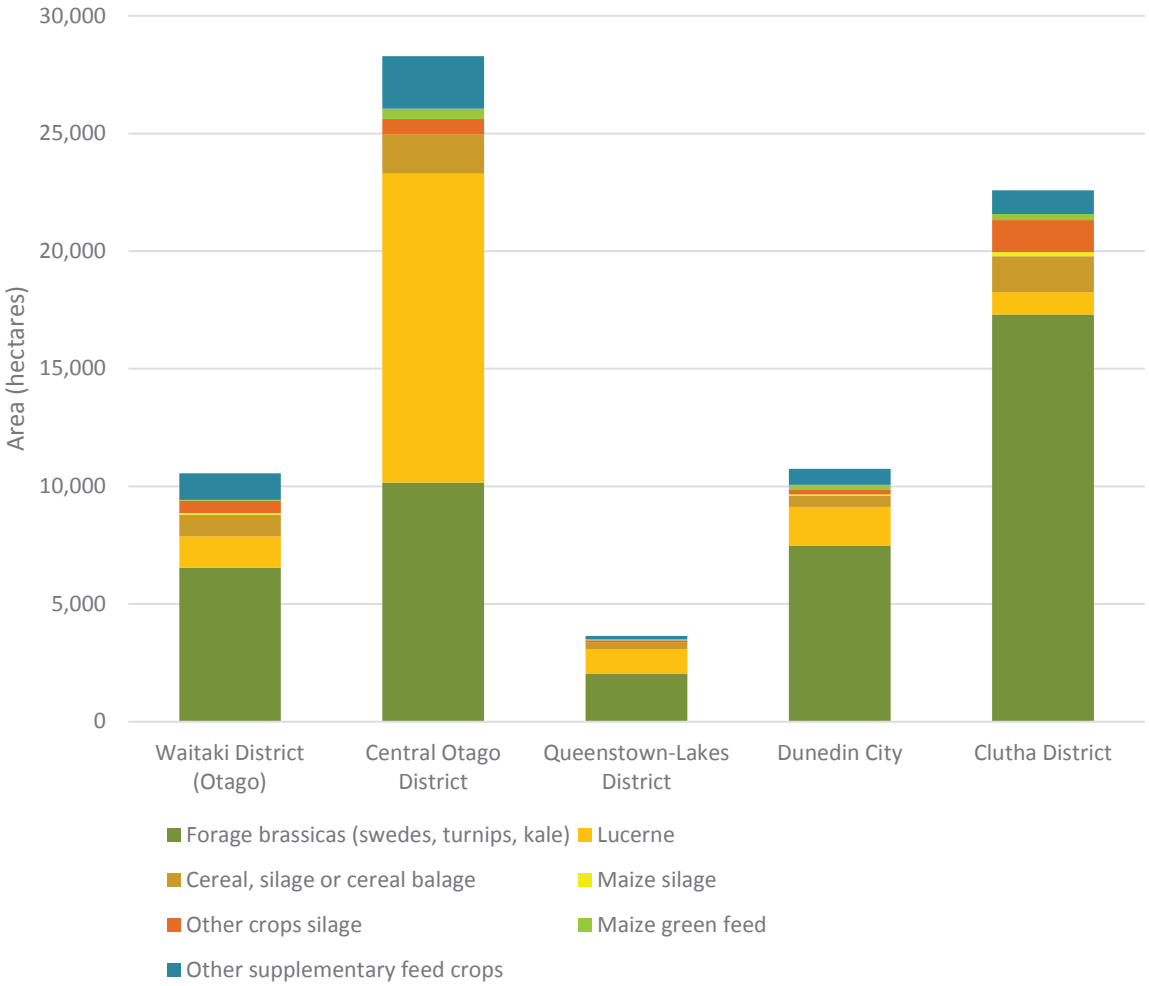


Figure 42: Distribution by area of all arable crops grown as supplementary feed grown on all farms across Otago in 2017
Source: StatsNZ Agricultural Production Statistics June 2017 (final)
Note: Not included is the 'pasture/lucerne (hay, silage and baleage)' grown on arable farms

5.4 Historical overview

Arable cropping in Otago was established during the mid-to-late 19th century on plains and tussock-covered downs (being relatively easy to clear[151]) as large pastoral runs were broken up for closer settlement (Bevin, 1946). By the turn of the 20th century Otago was, along with Canterbury, considered to be the *"granary of New Zealand"* (Bevin, 1946; Malcolm, 1983). For example, as early as the 1870s at least four annual shipments of Otago-grown ryegrass seed were exported from Dunedin directly to California (Pawson and Wood, 2011).

Over time the uses of arable crops have changed as has their processing and markets. For example, barley was largely grown for malting up until the end of World War II, and thereafter for stock feed (Malcolm, 1983) while much of the oats grown were to feed horses up until the tractor became generally adopted.

151 The growing of grain was not usually an option in areas where there was bush clearance because the cutting and burning of the trees usually left their tangled roots untouched in the soil and made ploughing impossible (Brooking and Pawson, 2011).
152 Wheat production generally falls into two main categories: wheat for milling (predominantly bread baking) and feed wheat used in the livestock industries. Milling wheat used for bread generally has hard grain texture and high protein content, particularly gluten, whereas milling wheat used for biscuits and cakes has soft grain and low protein content (Millner and Roskruge, 2013).

Prior to deregulation of the wheat industry[152] in the 1980s, milling wheat dominated production, but is now secondary to feed wheat (Millner and Roskruge, 2013).

The importance of arable cropping, particularly wheat and barley, is evident in the dozens of flour mills (as well as maltsters and breweries) that were located across the region, some of which still exist as historic buildings. An early example was McGill's flour mill in 1857 beside the Tokomairaro River where Mill Town, which became Milton[153], was established a few years later. Other examples were the Brunswick Mill (Frankton), which was the first flour mill in Central Otago[154], the Phoenix Mill near Ōamaru[155], the Waiwera Mill at Clinton[156], and the Waianakarua Mill[157], the Maniototo Mill at Naseby, the Tiger Dale Flour Mill at Omakau, and the Ida Valley Mill[158].

In Dunedin, the first steam-driven flour mill began operations in 1867[159], later it was upgraded to steel rollers and became a Crown Roller Mill[160]. This mill operated for 130 years, finally being decommissioned in 1997 by Goodman Fielder when its flour production shifted to Canterbury. Dunedin is also the home of Harraway & Sons Ltd, "one of Otago's enduring family businesses", with Henry Harraway and his 11 sons and then the Hudsons after World War II (Reid, 2018). Flour milling started on the current site in Green Island in 1867 and, 155 years later, it is New Zealand's only oat mill.

North Otago was considered the best wheat-growing area in New Zealand for many years. By 1900, there were at least thirteen flour mills in and around Palmerston and Ōamaru (often constructed out of Ōamaru stone) with many updating their machinery from traditional millstones to cylindrical steel rollers for grinding. In the twentieth century the introduction of new wheat varieties meant grain could be grown more extensively across Otago. The local market was quite static, freight was expensive (although relatively simple by train or through the ports (Bevin, 1946), and imported wheat and flour from Australia now competed with the local products[161]. By the 1930s, cropping was changing with the expansion of sheep and beef farming. By 1940, four mills remained in North Otago: Meek's Crown Flour Mill and Ireland's Anchors in Ōamaru, Clarks Mill in Maheno, and Milligans Mill at Ngapara (McDonald, 1962: p.240)[162].

Flat alluvial land is limited in North Otago, but much of the rolling downs was seen as 'arable' land (Currie, 1974). In the 1970s, there was roughly 20,000 hectares of high-quality arable land in the Waitaki, Kakanui and Waiareka valleys (Currie, 1972). At the time 'cash cropping' was an important part of the local economy with some 16,000 hectares of grain and seed crops harvested annually: 5,000 hectares of wheat; 5,000 hectares of barley, 1,500 hectares of oats, 1,200 hectares in total of kale, rape, linseed, peas, and sunflowers, and between 1,200 and 2,400 hectares of small seeds (Currie, 1974).

153 https://milton-district.co.nz/history/
154 https://hocken.recollect.co.nz/nodes/view/25402
155 https://www.heritage.org.nz/the-list/details/2313
156 https://www.orc.govt.nz/media/2410/waiwera-info-sheet-2014-with-cover-for-web2.pdf
157 https://www.themillhouse.net.nz/History/
158 https://natlib.govt.nz/records/22640768
159 Previously, Duncan's flour mill on the Water of Leith (Ōwheo) began operations in 1859 (Otago Witness, 13 August 1859) but it burnt down in 1872. https://paperspast.natlib.govt.nz/newspapers/OW18671004.2.12
160 https://www.heritage.org.nz/the-list/details/366
161 https://www.heritage.org.nz/the-list/details/2285
162 More information on early flourmills and flourmillers in Otago is available at: https://nzetc.victoria.ac.nz/tm/scholarly/tei-Cyc04Cycl-t1-body1-d4-d25-d19.html and https://www.heritage.org.nz/the-list

Image 23: Colourised photo showing the Brunswick Flour Mill opened in 1867. On the other side of the Kawarau River is the homestead founded by Queenstown pioneer William Rees.
Source: https://commons.wikimedia.org/wiki/File:Kawarau_Falls_circa_1867.jpg[163]

Image 24: Sunflower seed crop in North Otago, January 2018
Source: Peter Mitchell

163 This file is licensed under the Creative Commons Attribution-Share Alike 4.0 International license: https://creativecommons.org/licenses/by-sa/4.0/deed.en

In the 1970s, there were numerous medium-sized prime lamb and mixed cropping farms in North Otago (Currie, 1974) and, although the total area where milling wheat was grown had declined, the returns from cropping were still relatively attractive, and it was a reliable source of revenue within a pasture renewal programme. There was considerable seasonal variation in yields, but irrigation development from the 1970s was the key to stability in yields and crop diversification – at the time rape oil[164], lupins and beans were seen as potentially filling a growing demand for high-protein yielding crops, and the packet seed trade was also a possibility (Currie, 1974). In 1974 the first sunflower crop was planted in the area for birdseed and since then the crop has become an annual attraction in the area.

The decline in the overall cropping of milling wheat was largely related to the closure of Clarks Mill in the mid-1970s[165] and the Meek's Mill in the 1980s. Irrigation also resulted in land use conversions to dairy farming and consequent increases in land values, both of which had implications for arable growers. Milligans Eclipse Mill at Ngapara closed in 2016[166].

Image 25: Harvesting at Rosedale in the early 1930s using a tin threshing mill.
Source: Ross Mitchell Collection
Note: Henry Mitchell first bought land in Weston in 1874 and moved from Dunedin to live on the farm in 1878. Rosedale was farmed in its own right from 1914.

Image 26: Mark Mulligan and the team transporting grain from Rosedale in the 1930s
Source: Ross Mitchell Collection

164 In 1985 it was noted that two types of rape were grown for oil: spring sown annuals and autumn-sown biennials (Wynn-Williams and Logan, 1985: 97). The biennial type had been grown in Canterbury and Otago for many years for seed production to sow as a forage but the number of growers with much experience of the crop was small (Wynn-Williams and Logan, 1985: 97).
165 Clarks Mill, however, has been restored by the New Zealand Historic Places Trust having been in commercial operation for over 100 years. It is also considered of historic interest as it is seen as a 'time clock' recording the different milling technologies which were developed over the years since it was built in 1865 (McKinnon and Tempest, 2015).
166 https://www.odt.co.nz/regions/north-otago/era-ends-north-otago-flour-not-economic%E2%80%99

Cropping was also extensive in Central Otago around 1900 (Hercus, 1966). Areas such as the Teviot Valley, the Upper Clutha Valley, and Crown Terrace were cropped *"year after year on a 'grow oats to feed horses to grow oats to feed horses' basis, with a large acreage of wheat as well"* (Hercus, 1966: p25). Barley was also an important crop – as a representative season, in 1924-25 17 per cent of the area grown in New Zealand was in Central Otago and the average yield from then up to 1946 was 1.94 tonnes per hectare, which was roughly 25 per cent higher than pre-1900 (Malcolm, 1983). Up until the 1940s most barley was malted for brewing and the remainder used for feedstuffs, but from then it was mostly used for stock feed (Malcolm, 1983).

On poorer soils the heavy cropping in Central Otago became unsustainable, and as yields declined some land reverted to grassland (Hercus, 1966). However, in the 1960s, pockets of deep rich soils continued to be used for mixed cropping around Tarras, Hāwea, Wānaka, and Queenstown. The principal crops were wheat, peas, barley, and small seeds, and although the cropped areas were small, the yields achieved were high (Hercus, 1966).

Alternative crops were explored in South Otago. For example, from 1936 to 1976 the Department of Agriculture investigated sugar beet as a crop for a possible sugar industry, particularly for use in producing ethanol. This research began through a series of trials across most climatic zones and soil types in Otago and Southland (Greenwood, 1980). These investigations included working with the South Otago Sugar Beet Investigation Company Ltd[167] with the results showing that sugar beet crops grown in South Otago using specialised machinery were capable of producing high yields of sucrose[168] (Greenwood, 1980). However, the trials ended in the mid-1960s when three deterrents were identified: 1) imported sugar was cheaper than the protected price of locally produced sugar; 2) local sugar production would upset overseas trade relations, and 3) there was insufficient farmer support, mainly because of the extra work involved in the process, even with full mechanization (Greenwood, 1980). An example of an alternative crop in North Otago in 1970-71 was a small commercial planting of peppermint for oil by the Dominion Yeast Company (Wynn-Williams and Logan, 1985).

By 1980, the decision to farm sheep, fatten cattle plus integrate wheat growing was described by Mr J.C. Mitchell[169], a South Otago arable grower from Wairuna (west of Clinton), as *"complementary to each other"* (Mitchell, 1980: p29). *"The growing of wheat, as against all sheep, is a matter of costs and profits, plus available labour… Consistent yields of wheat, plus the known price up to eighteen months in advance, gives confidence in planning farm improvements and/or capital expenditure – or that holiday."* Mr Mitchell identified the wheat growing areas in South Otago as being the Hilton Plains and easy undulating areas of Warepa, Waiwera, Wairuna, Popotunoa and Clydevale (Mitchell, 1980). At this time, fodder beet was a crop grown on a small scale for stock feed (Martin, 1980).

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167 The South Otago Sugar Beet Investigation Company was formed in 1961 and formally dissolved in 1975 http://www.nzlii.org/nz/other/nz_gazette/1975/6.pdf

168 A sugar industry based on locally grown beets has been advocated many times since it was proposed in 1870 and Government subsidies were first offered in 1871 (Greenwood, 1980). In the 1970s, the rapid increase in the price of imported oil and questions around future supplies, led to renewed interest in plant biomass as source of liquid fuel. Of the various systems available, the single step fermentation of plant sugars to produce ethanol was seen as the least capital intensive and the most readily accessible as the technology required was well proven (NZERDC, 1979).

169 Mr Mitchell's name was incorrectly recorded in the original paper as "J.E. Mitchell"

In 1980 Mr Mitchell described his farm and swedes – wheat – barley rotation:

> *At 125 metres above sea level (450 feet), spring is late in arriving at Wairuna and plant growth can be slow; feed is at a premium during September lambing. Fifteen to twenty hectares of swedes is grown each year, enabling all dry stock to graze on the swedes till at least the end of September. The lambing over, the swedes eaten off, the ground can then be cultivated for wheat. Second and third crops complete the wheat area. A crop of barley harvested usually early February enables the paddock to be sown in grass to complete the rotation. Indications are that a crop of peas may be grown after three wheat crops, then a further three sowings of wheat. The results have been very satisfactory, our intentions are to try one area this year in that rotation of peas followed by three further crops of wheat.*
>
> *The rotation takes fifteen years to cover the complete farm. The areas in permanent pasture remain in pasture for ten or eleven years. Because of fertility build up, pastures become predominantly ryegrass, with strong vigorous growth, unsuitable for fattening lambs. After the swedes-wheat-barley rotation, clovers establish particularly well, ideal for fattening lambs and cattle for at least the first four or five years.*

Mr Mitchell's son, Ross Mitchell (also a mixed cropping farmer who now farms the neighbouring farm just over the fence) has updated his father's commentary for the 42 years from 1980 to 2022:

> *Wheat in the late 1970's and early 1980's was all for milling and under government regulations the mills were obliged to take it. The criteria for milling wheat became too high for southern growers and most gave up on it, leaving it to our Canterbury counterparts with a more conducive climate to supply the mills. Eventually the southern mills disappeared. Feed wheat wasn't grown then as there was no market for it, in contrast to present day. Autumn sown wheat in the south is now quite common, in most part because of huge demand from the dairy industry. Malting barley was also grown in the 1980's, but eventually the market dried up – Wilson's Whiskey in Dunedin closed, and the Chinese export market petered out.*
>
> *The 15-year rotation in 1980 would have been partly because there were fewer grain contracts and markets, so the variety of crops and area grown was much less. Again, the demand from dairying has altered this situation and rotations are now seven years cropping and five years in pasture. It is helped out by the larger variety of crops that we can now grow in the south and gives us more flexibility in the rotations. Apart from oats, which have been traditionally grown in the south, the last 42 years has seen a shift to feed wheat & barley, oil seed rape, bok choy and peas. The peas that are grown are 'Maples' variety for human consumption and white peas for stock feed.*
>
> *Since the 1980s lamb production has improved. Drivers include better sheep genetics improving meat, growth, survivability, ewe fertility and wool production. The stud sheep are now scanned for Eye Muscle Area, Intra-Muscular Fat, methane testing (for carbon emissions) – even pregnancy scanning and Body Condition Scoring. None of these where even a remote thought in 1980. All of this is to produce a more efficient animal to get more $/ha. Lambing percentages have increased from 120 per cent – 150+ per cent to the ram. While lambs were $15 then, they are $150 now. Wool, unfortunately, is the only thing not improved – $12 then to $9 today.*
>
> *Improved stock pastures have improved this productivity along with strong selection/culling of animals. The better pastures have gone a long way toward this, but unfortunately pastures now do not last more than five years and so run out much sooner than 42 years ago. Fodder beet is a new crop since 1980 although not for sheep it is very good for cattle.*

Image 27: 2020 harvest of an autumn sown feed wheat – Ashton Glen Farms
Source: Ross Mitchell

Although there have always been fluctuations in crop growing across Otago, since the 1980s there has been a decline in the total number of mixed cropping farms as growers converted to dairy farming (Milner and Roskruge, 2013). As the profitability of dairy farming rose, relative to other land use options for arable land, land prices followed suit and now drive decision-making around land use and how to manage risks and opportunities (A. Pitman, pers. comm., August 2022). There are only a handful of large cropping farms solely oriented around cropping (with many others more aligned with pastoral industries but still growing sizeable areas of crop).

In Otago, those "serious growers" of arable crops who remain in the industry are now seen as an increasingly "rare breed". The skills required to successfully grow crops, as well as manage stock, are wide-ranging and there are fewer new entrants.

> *"No one is converting to arable – you are either big or just dabbling. It used to be that there were smaller holdings but that is dying away. The ones that are still in business are a lot smarter now in pushing yields along. The guys that are in are doing it right." (Otago Arable Grower, pers. comm., 2022)*

Where export crops (e.g., small seeds) are an important part of the rotation, growers face operational costs associated with New Zealand's high land values beyond those of some international competitors[170] and the costs of environmental regulations may add new uncertainties to land use decisions (A. Pitman, pers. comm., August 2022).

Many arable farms are intergenerational family businesses and at various stages of succession, which can bring with it greater debt, particularly as growing competition for arable land inflates land prices. Partnerships with parents and parents-in-law are common, although some arable growers reach retirement age without a succession plan. Anecdotally, farm succession is influencing changing attitudes to farming practices, including environmental stewardship. Farm succession can also highlight a grower's connection to the land, with one grower commenting: *"We are fourth generation – we want to look after the farm and are not out to ruin water and land."*

170 https://pdf.euro.savills.co.uk/uk/rural---other/spotlight-global-farmland-index---sep-2020.pdf

Image 28: Next generation playing in barley windrows, Puketoi Station (purchased 1939)
Source: Emma Crutchley

5.5 Main features

Otago is a traditional arable region and cropping is central to both pastoral farming and horticulture. In addition to the few remaining "serious growers" and family businesses, the main features of arable farming in Otago are its mix of crop rotations by locality, the integration of livestock within these rotations, connections with winter grazing, and contrasting irrigated versus dryland cropping.

5.5.1 Crop rotations

A grower's crop rotations are pivotal to their financial and environmental sustainability. The sequencing of crops used influences overall crop profitability, nutrient capture, and soil quality as well as pest and disease incidence on the farm (Lawrence-Smith and Fraser, 2022). An essential characteristic of mixed cropping is the ability of arable growers to respond to a range of drivers that inform decision making. Although the crops grown in a rotation need to be marketable, the rotation itself is used as a tool to manage a range of agronomic issues within a farm's physiographic constraints, for example, nitrogen, weeds, and soil quality. As growers manage their own ever-changing set of circumstances there is a high degree of diversity, agility, and flexibility in cropping rotations, even for those in close proximity, and it is challenging to describe 'typical' arable production systems.

Arable growers consider a range of factors when making decisions about what crops to sow, aside from the availability of contracts and speculating about the drivers of supply and demand[171]. For instance: *"Our main cropping component is grass seed and clover seed but sometimes cereals need to be in the rotation to keep the ground clean, primarily from rip gut broom – some years are better than others and when it is not clean then we use more cereals".* This decision-making is becoming more challenging as growers are 'squeezed' by merchants and brokers. It is especially dependent on the existence of good relationships: *"developing all the contracts is risky if there isn't trust and goodwill".*

171 Knowing where there may be shortages and over supply can help with deciding what to sow. If there are a lot of certain crops being stored/carried over then this will inform speculation around where demand is likely to be. For example, if there is a large quantity of stored milling oats then fewer milling oats will likely be sown.

Image 29: Establishing seed mustard in South Otago (foreground) and in distance (clockwise from front left): radish seed, freshly cut grass for silage, pasture, and peas.
Source: T.A. Whiteside

As production costs increase (including land prices) there is more pressure for growers to "*push the system"* and make decisions governed by short term returns rather than long-term rotation benefits. They feel like *"you can't have paddocks not earning dollars".* One of the 15 growers interviewed is now factoring in legumes into their rotation decisions, *"our thinking is around what crops are going to help in terms of nutrients with fertiliser prices going up, like clover and peas, which may not make the money but leave the nitrogen."* Some growers feel vulnerable being dependent on dairy farming in their rotation decisions. *"If the dairy price is good this has positive flow on effects for us, but we need to be looking at alternative crops that could have markets in our region, so we are less reliant on dairy."*

Otago's crop rotations depend on availability of supply contracts for main crops, demand for other crops, suitability of climate for production, and proximity to processing facilities as logistical issues and transport costs reduce profitability (T. Armour, pers. comm., July 2022). A small amount of milling wheat is still grown in North Otago to supply the nearest mill in South Canterbury (Famers Mill in Timaru) although it still depends on the availability of supply contracts (T. Armour, pers. comm., July 2022).

Conversely, little to no milling wheat or malting barley is grown in South Otago because the mills and maltsters are now some distance away. There is also a higher risk of crops not meeting quality standards if there is wet weather at harvest (T. Armour, pers. comm., July 2022). Milling oats tend to be grown in South Otago for Harraways & Sons but the crop is not as evident in North Otago[172].

172 Based on the observations from the 15 interviews these groupings appear to be a good reflection of the differences in trends in cereals grown between North and South Otago


Image 30 and 31: Seed radish crop, including honey bee pollination (in distance are oats for grain on left, and feed barley on right), December 2017
Source: Peter Mitchell

In both South Otago and North Otago, autumn-sown feed wheat tends to be the crop of choice because of local demand for dairy and other animal feeds such as poultry and pigs. When asked about milling wheat, one North Otago grower said they "can't supply enough feed (wheat) as it is". Over half the crops are autumn-sown so that the land is not sitting 'empty' over the winter months – arable growers 'get their cereals in' soon after harvest. A Central Otago Grower commented that for inland Otago most growers are larger sheep/cattle farmers with small cropping interests, typically growing around 20-40 hectares of crops, and there are only a few larger growers.

In North Otago, the coastal climate and soils lend themselves to commodity grains and oil seed rape, and two actual examples of crop rotations (out of a much wider set) are:

1. Perennial ryegrass, oil seed rape, milling wheat and feed wheat.
2. Fodder beet, oats, autumn and spring wheat, grass seed, peas[173] (or red clover seed). Spring barley is also seen as "*fitting nicely after fodder beet*".

In South Otago, two examples of crop rotations are:

1. Oilseed, export seed peas, feed wheat, barley, and oats.
2. Winter wheat, spring barley, peas (break), green feed, mostly for feed which they sell direct to their own local clients.

One arable grower in Central Otago was looking at implementing more of a Canterbury-style cropping production system: "We're heading more towards arable and small seed crops, such as carrot seed, with some beef fattening and wintering". Some growers also see the potential for growth in small seeds in South Otago as suppliers seeking more seeds to be grown out of traditional production regions, such as

173 Peas are important as a valuable spring sown break crop, but growers may see peas as 'risky' because yields are temperamental, depending on the season. For example, herbicides in previous crops can cause damage to peas, peas will not normally germinate readily at lower soil temperatures, peas can be susceptible to diseases, and they are badly affected by competition from weeds. In 2002 a Pea Industry Development Group was formed to address declining interest in growing peas by providing information on how to overcome key constraints and grow a profitable pea crop. More recently, in-depth analysis was undertaken to explore the viability of pea and fava bean protein extraction – a key finding for growing was while dried peas and fava beans are not high value crops compared to others (e.g., carrots and maize) growing areas can be increased but only if the economic incentives are there for growers. The report describes these crops as a low-carbon, sustainable crop option offering improved soil health, and diversified land-use, cropping rotations and income streams (PWC, 2022).

Canterbury[174]. Some growers are looking to transition to reduced tillage methods,[175] which offer some benefits for fresh water and soil. 'Minimum tillage' is where a crop is established using one or two non-inversion cultivation passes, while crop establishment with 'no tillage' or 'direct drilling' results in soil surface disturbance that is limited to the seed row (Poole, 2009). However, as one grower commented *"there are no silver bullets, direct drilling only works in some situations but requires a large investment in new machinery".*

5.5.2 Integration with livestock

As already highlighted, an important feature of the arable industry in Otago is the high level of integration of arable and pastoral enterprises. Although many crop rotations include livestock at some stage, the integration of livestock takes many different forms. A common example is that a grower may carry their own breeding sheep and/or cattle all year round and the rotation includes mixed cropping, where non-crop areas will be in pasture for 2-3 years (common in Otago) before being sown into crop. Table 9 shows the results of the Arable Crop Sequence Survey where 93 per cent of respondents across New Zealand indicated the inclusion of livestock within their farming systems, with the length of grazing varying by crop type (included four growers from Otago – all with around 400 ha of land) (Lawrence-Smith and Fraser, 2022).

Table 9: Duration of crop grazing for a sample of 371 growers across New Zealand in 2021

Crop grazed	Less than a month	1 to 4 months	5 to 8 months	9 to 12 months	More than a year
Cereal grain crop – post harvest	2	4	1		
Cereal grain crop – pre harvest	3	3			
Cereal green feed e.g., oats	1	40	3		
Fodder beet/swedes/turnips	1	33	2		
Grass pasture	2	9	11	9	27
Grass seed crop – post harvest	2	18	8	1	2
Grass seed crop – pre harvest	1	26	16	3	1
Grass silage		3	4		
Green feed brassica		57	2	1	
Green feed mix	1	7	2		
Lucerne	1	4			2
Maize/maize silage		**2**	**1**		
Other		11	7	3	
Pasture mix			4	5	9
White clover post-harvest	3	10			
White clover pre harvest		1	1		1
TOTAL	**17**	**228**	**62**	**22**	**42**

Source: New Zealand arable cropping sequences survey 2021-2022 (Lawrence-Smith and Fraser, 2022).

174 https://www.odt.co.nz/rural-life/horticulture/southern-seed-sector-set-grow

175 More information on reduced tillage techniques, including the results of trials, is available in https://www.far.org.nz/assets/files/uploads/Iss_01_Non_Inversion_Agronomy_May_09.pdf

Although there are examples of systems that are predominantly cropping, most arable farms include livestock enterprises in their production system, with activities ranging from breeding stock to finishing and wintering. Crop rotations may not include a long-term pastoral phase. Some growers may just bring on livestock for short periods to graze post-harvest or to fatten over winter on an annual crop planted for that purpose. For example, store lambs for fattening are on the farm for just a part of the year (typically between February and September) – they will clean up paddocks after harvest (e.g., post-harvest regrowth of ryegrass) and go onto crops sown specifically for fattening (e.g., green feed oats). The store market is based on supply and demand of feed so the crop and season are the main drivers for how many a grower may bring in. Some mixed cropping farms have areas too steep to crop that are permanently in pasture.

To illustrate the diversity in the integration of livestock with cropping, one North Otago grower produces several thousand lambs per year, another grower includes a few hundred beef cattle, and a third grows some grain and whole crop but concentrates on running bulls. Although new entrants are uncommon, some mixed cropping farms are looking to increase their cropping enterprise (e.g., if they were 30:70 then they may be shifting towards 40:60): *"We are trending towards more cropping and the driver for this is financial".* However, "*big decisions can mean large capital outlay. If we want to put more grain in to increase the cropping part of the business, then we need to update the combine harvester and put in more silo storage."*

A key driver for the extent of integration in Otago is topography. Comments were made that not all of the region is suited to cropping: "*We do a bit of both, cropping on the flat land, run sheep and beef on rolling"*. Also, differing informal arrangements are made with neighbouring pastoral farms. Supplying feed and selling direct is common but also there are some 'land swap and crop' arrangements such as where, *"the neighbour puts their stock on our pasture (we have pasture in for three to four years) on the cropping farm, in return for us growing a six-month crop on their farm".*

Some growers expressed concerns with the risk to soil quality if restorative crops for in-situ grazing are dis-incentivised by regulation. New Zealand arable growers have some of the most diverse crop rotations in the world. In comparison to arable soils overseas, the degree of livestock integration means arable soils are in a better condition because rotations that include livestock can support inclusion of restorative crops (e.g., ryegrass) that build soil organic matter. Integration of livestock into crop production also creates sources of manure as a soil organic amendment. In addition to soil quality, nutrient cycling and cashflow, there are other reasons why arable growers have livestock. These include weed control, natural tillering (managing height and bulk of grass seed crops), crop residue management and rotation fit.

As already noted, Otago tends to have more integration of livestock than is seen in other regions further north. One grower made the point that *"Clutha and South Otago cropping systems are very similar to Southland cropping systems – a lot more mixed cropping than say in Canterbury – and the pastoral phase is important for building the soil organic matter."* Soil sampling in Southland between 2013 and 2018 shows a trend of higher carbon concentration compared to Canterbury soils and is likely to be indicative of the trend in Otago because the region has similar length pasture phases to Southland (4-10 years in duration), compared to shorter periods in pasture for 'mixed cropping farms' in Canterbury (Lawrence-Smith et al., 2019). The carbon concentrations from mixed cropping in Canterbury averaged 2.7% compared to it being closer to 4% in Southland (Figure 43).

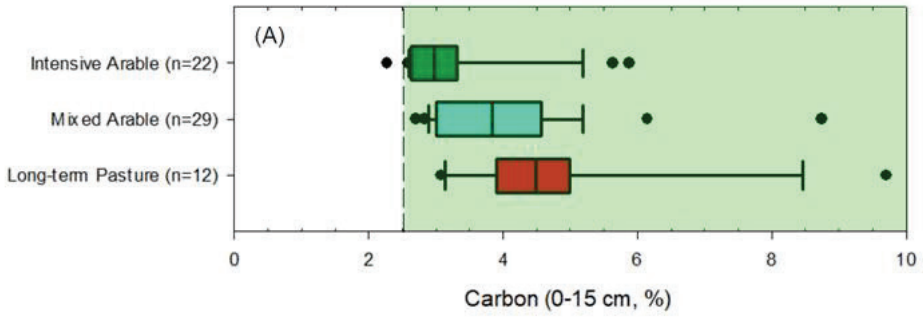


Figure 43: Soil carbon percentage (0-15cm) measured between 2013 and 2018 in Southland for different land uses
Source: Lawrence-Smith et al., 2019

The growing of arable crops is, as previously noted, also an integral part of many pastoral farms, especially those on the downlands and plains of coastal Otago and where there is water availability further inland. Consequently, the lines of distinction between different land uses (e.g., dry stock, arable, dairy support, dairy) are not always clear.

5.5.3 Winter grazing

The use of forage and fodder crops to 'carry' stock over winter has its origins in Victorian 'high farming'[176]. These crops are key components of pastoral farms (dairy and dry stock) in southern New Zealand where pasture growth is not usually sufficient to provide stock with the necessary nutrition over winter. Although the use of forage and fodder crops is a traditional practice, it has changed markedly over the 20th century with the introduction of new technologies (e.g., electric fences, modern tractors, and crop varietals)[177].

The wintering of dairy cows was described by growers as *"still a growth market"*. Many growers brought dairy herds on to their farms for winter grazing *"to help make irrigation pay"*, although one grower commented: *"I used to get dairy grazing but now have gone to hogget grazing as I found that cattle were too hard on the soil."* One grower who was mostly dairy grazing with some cropping, still described themselves as 'arable', growing mostly kale and fodder beet along with crops like spring barley and some grass seed. They expressed frustration, *"A lot of guys do this, but we don't fit in anywhere and there is a clear lack of understanding by ORC around how things work."*

In South Otago, some growers are moving towards winter grazing of dairy cows because their farm has a diversity of soils that are considered suitable for the practice, while others are moving away from dairy grazing to protect their more vulnerable soils. Growers' comments range from: *"They make a mess, don't winter well in the heavy clay"* to "*This country suits it, the soils can cope compared to other regions and so we don't want to be disincentivised by regulation."* One grower commented that *"I don't sell baleage as too many nutrients go off the farm."*

176 The term 'high farming' is ambiguous and easily misunderstood but "the existence and widespread extent of the phenomenon in nineteenth century Britain, especially from about 1840 to 1880, can scarcely be questioned". In the general sense it may be taken to mean "improved and, as far as environmental circumstances permitted, intensive farming dependent on investment; in the narrower sense it may be equated with intensive livestock husbandry linked with root and cereal production, the high feeding of eastern England and the Scottish borders in particular" (Perry, 1984: p156).

177 By the 1860s there were bone mills in Otago selling bone dust to farmers for use in fields of turnips grown for winter feed, to prepare the soil for permanent pasture or support the crop rotation (Brooking and Pawson, 2011).

A North Otago grower commented that they see *"things going back to more of the mixed system – a mixture of winter grazing and lamb finishing/green feed crops is needed to make irrigation pay and to have consistent feed – a lot of feed cereals are informally contracted to local dairy guys and there is a strong straw market in support of dairy."* However, intensive winter grazing has been identified as a practice with higher environmental risks, which may change its feasibility. A South Otago grower ran a lot of sheep but also grows green feed oats and barley: *"The barley just goes as stock feed to a dairy farmer near us."*

5.5.4 Irrigation vs dryland

An important change in farming practices that has occurred in Otago is the increased use of irrigation. The 'old school' way (i.e., pre-irrigation) was to keep paddocks fallow to conserve moisture for the next crop. Crops had different requirements – kale and rape seed crops require a long fallow to promote their establishment and yields of peas and linseed are very dependent on summer rainfall (Currie, 1974). While a few still use this practice, growers with irrigation now try to always have a crop growing.

Businesses that have turned to irrigation in recent years have had to reframe their decision making. One grower noted: *"High-cost irrigation is a big factor, you need to think about returns more seriously and the risk of the crops, some crops are riskier than others if the season does not set up right, peas for example."*

In North Otago the ratio of irrigated to dryland (i.e., non-irrigated) cropping is estimated to be around 60:40, although there is more dryland in South Otago. Under dryland conditions, crop performance is more likely to vary depending on the season and rainfall. Of the growers interviewed, the North Otago farms were mostly either all irrigated (some only recently having made the transition) or had a 50:50 split between dryland and irrigated, whereas more of the South Otago farms were dryland and so the sub-region is not as reliant on irrigation. Several South Otago farms had old field tiles, with there being comments such as, *"They were put in by my father and some have not been looked at for 40 years".*

North Otago growers face the additional cost of irrigation. *"Winter grazing is being squeezed in to help make irrigation pay"* and *"I joined an irrigation scheme about five years ago so have had to shift to having more livestock than before for the required income. No such thing as a winter fallow anymore."* However, another grower in North Otago commented that, *"On dryland farms winter fallow is a way of conserving moisture for spring sowing, cover crops over winter may not always be suitable and can lead to lost yield in subsequent crops due to moisture issues."*

Where there have been recent transitions to irrigation in some cases different crops have become a focus, *"Water came on, took irrigation opportunity, pushed into a lot of small seeds to try and make it pay, it's expensive and small seeds can actually pan out to be risky, one good year and a few bad years."* The presence of irrigation schemes in North Otago encourages more progress around Farm Environment Plans compared to South Otago where there are fewer schemes and support available (T. MacFarlane, pers. comm., August 2022).

178 New Zealand Grain and Seed Trade Association https://www.nzgsta.co.nz/

5.6 Processing and markets

Arable exports are mainly seeds for sowing pasture and crops and a smaller amount are grains and pulses for human consumption (I. Lawrie, pers. comm., September 2022). Pasture and crops grown from New Zealand seed (mostly from Canterbury) supply the country's agriculture sector with the quantity of pasture seed harvested annually being sufficient to renew more than 350,000 hectares of New Zealand farmland. That quantity of forage crop seed is sufficient to sow 396,000 hectares (based on proprietary sales)[178].

Exports of small seeds (herbage and vegetable seeds) have increased in importance, with New Zealand currently producing about half the world's hybrid radish and carrot seed production. New Zealand is one of the few places in the Southern Hemisphere that is well suited for small seed production. The main reason is the country's latitude, as the cool temperatures and day length drive reproductive growth (countries in the Northern Hemisphere at this latitude include Oregon and some parts of Europe (P. Rolston, pers. comm., September 2022).

Pea seed is grown mostly for the domestic market (vining peas for domestic frozen table peas), although some are exported. Similarly, seed brassicas are grown for the local forage brassica production and only have a small export market (to Australia and South America). All oil seed rape grown in Otago is transported to Rolleston for processing at the Pure Oil New Zealand plant (for domestic consumption) (P. Rolston, pers. comm., September 2022).

Malting barley grown in Otago mainly supplies Malteurop New Zealand[179], which is the only large-scale malting company in New Zealand. One of the world's leading producers of malt, Malteurop is a French company that in 2008 acquired grain storage facilities in Ashburton, a barley breeding programme at Irwell, and the Marton Maltings (a malthouse near Feilding in the North Island). Malting barley is transported north from the Malteurop plant in Ashburton by rail or coastal shipping to Wanganui. There are a handful of small New Zealand-owned malting companies supplying the craft beer market, such as Gladfield Malt[180] in Dunsandel.

For milling wheat, the closest processing facilities are in Timaru, and beyond that, Christchurch. The Farmers Mill[181] in Timaru (Canterbury) mills soft flour for biscuits (from cultivars that are similar yielding to feed) and milling wheat for bread and other baking on contract for Goodman Fielder, New Zealand's largest baked goods company in New Zealand. As already noted, limited processing infrastructure acts as a constraint on the arable industry. For example, *"Even though coastal North Otago is good seed brassica growing country, there is not the infrastructure and South Pacific Seeds are too far away and is too far away for reps to keep an eye on the crop."*

179 https://www.malteurop.com/en/new-zealand
180 https://www.gladfieldmalt.co.nz/about
181 https://www.farmersmill.co.nz/

Preference for contracts has usually gone to growers who have supplied the mills in the past, however demand for milling wheat is higher than supply because the international situation has resulted in lower production, which is opening opportunities for new growers. Increased demand for milling wheat competes with existing high demand for feed wheat, which yield higher and have fewer quality requirements. As an example, in mid-July 2022 the average price of milling wheat in Canterbury was $629 per tonne and the average price of feed wheat was $595 per tonne (NZX, July 2022). Transport costs for regional short haul to a flour mill is estimated to be at least $30 per tonne if hauling from Otago to Canterbury.

As already mentioned, South Otago's milling oats tend to be grown for Harraways & Sons in Dunedin and the domestic market (some of which may end being processed for oat milk by Boring Oat Milk[182] in Hawke's Bay).

Image 32: Seed radish crop in South Otago, November 2022
Source: T.A. Whiteside

182 https://boringmilk.com/

6 Dairy Farming

Author: Carina Ross (Regional Policy Advisor) with contributions from David Cooper, Guy Michaels, Justin Kitto and Dawn Dalley.

This chapter outlines the dairy industry in Otago, drawing on official dairy statistics from Livestock Improvement Corporation (LIC) and DairyNZ, as well as industry knowledge and expertise.

6.1 Summary

While most early European settlers had one or two dairy cows for their own use, the dairy sector has grown and is today exporting most of the milk produced. Dairy farming in Otago has had its ups and downs over the last 130 years. From the 1970s the number of dairy cows increased from a low of around 20,000 to just above 270,000 in the 2021/21 season. Since 2013, industry growth has plateaued and is quite stable in terms of the cow number, land area and herd size. Few conversions to dairy farming are currently taking place, mainly because of the requirements of the National Environmental Standards for Freshwater 2020.

Dairy statistics estimates that there are currently around 440 dairy farms in Otago with a range of farm practices and performance, influenced by locality. Clutha and Waitaki are the main dairy districts with 46 and 33 per cent of the region's dairy herds respectively. They differ in terms of herd size, cows per hectare and farm practises such as the use of irrigation, with Waitaki having larger herds and slightly higher number of cows per hectare. This could be due to the use of irrigation providing a more secure source of feed and a lower need for imported supplements. Dairy-related roles are particularly important in the Clutha and Waitaki districts, representing 13.5 per cent and 8.1 per cent of total employment respectively.

Pastoral farming in New Zealand is primarily about balancing feed supply and demand. This means winter management practices are integral to dairy farming in Otago, particularly as dairy farms must contend with less pasture production over winter than in regions further north. As a result, many dairy farms rely on forage cropping to feed their cows over winter: from the conservation of feed as baleage and the production of silage through to the growing of forage and fodder crops (e.g., kale, fodder beet and swedes).

6.2 Historical overview

Otago, and Dunedin specifically has a long association with the dairy industry. Dairy cows were introduced in New Zealand with the early European settlers, first in the North Island and later the South Island. Most European settlers had some cows for domestic use, the cows provided milk, butter, and other dairy products. The first cows to arrive were Shorthorns, a breed that gave good milk and also excellent meat (Stringleman and Scrimgeour, 2008).

A drop in the price of butter, a lack of good roading and the associated need to reduce transport costs led to the origins of New Zealand's first co-operative dairy factory opening on the Otago Peninsula in 1871, when the Peninsula Cheese Factory was established. In 1871, about a third of the Peninsula had been divided into small farms but since many were too steep and too small to profitably grow crops or farm sheep, many of the mostly Scottish settlers had dairy cows, at an average stocking rate of one cow per hectare. The cows were of mixed breeding, known as "colonial cows", but mostly Ayrshire since the breed was believed tough enough to forage the hill country (Trebilcock, 2021).

The development of infrastructure and technology saw rapid growth in the industry from the 1880s, when further factories were built around the country. Several factors contributed to the rapid growth of an export industry in the decades that followed: improved transport networks, refrigeration in both factories and transportation, cream separators, new testing methods, and selective breeding. Combined exports of butter and cheese grew from 5,000 tonnes in 1881, to 300,000 tonnes in 1901 (Murray, 2012-2022).

The number of dairy cows in Otago have shifted over the 1900s with a peak in the 1930s (Figure 44). The early growth of dairy herds was related to the availability of refrigeration for the export of butter from 1882, and the development of butter and cheese factories. Other factors influenced over the next century. The following note from StatsNZ digitalized Yearbook (1930) gives some insight into the state of dairy farming in the early 1930s:

> *An important factor responsible for the improved position of dairy cattle in New Zealand is the milking-machine, which is making the farmer more independent of hired labour. With the higher price of land there is a gradual tendency towards smaller farms and the keeping of fewer but better cows. Also, there is a growing realization of the necessity for a more liberal system of feeding, particularly in the direction of growing special fodder crops to maintain the milk-flow at all seasons of the year. Generally, dairy-farming in New Zealand is being conducted on a sound basis, and the industry now ranks fully with meat and wool production in importance.*

After a decline in the regional dairy herd from the mid 1930's, numbers of dairy cows increased again from early 1960's. The 1964 Agricultural Development Conference set a target of an increase in livestock numbers of 3.5 per cent a year and the National Development Conference in 1969 revised the rate to 2.6 per cent a year. The increase in dairy cattle well exceeded that target from mid-60's and onwards.

The economic reforms of the 1980s had a major effect on agriculture, with a complete (overhauling) of economic drivers leading to dramatic changes in the way that New Zealand farmers farmed. Prior to the reforms, exports of wool, meat and dairy products were strictly controlled by producer boards, limiting the potential revenue, but also guaranteeing farmers an income from subsidies from what was produced, even if it may not have been economically viable. For example, in 1983, 40 % of the income from sheep farming came from subsidies. With the removal of export controls and other economic reforms, commodities with declining demand, especially wool, were no longer economically sustainable to produce. Farmers needed to adapt what they produced, and turned to diversified farms (Vitalis, 2007).

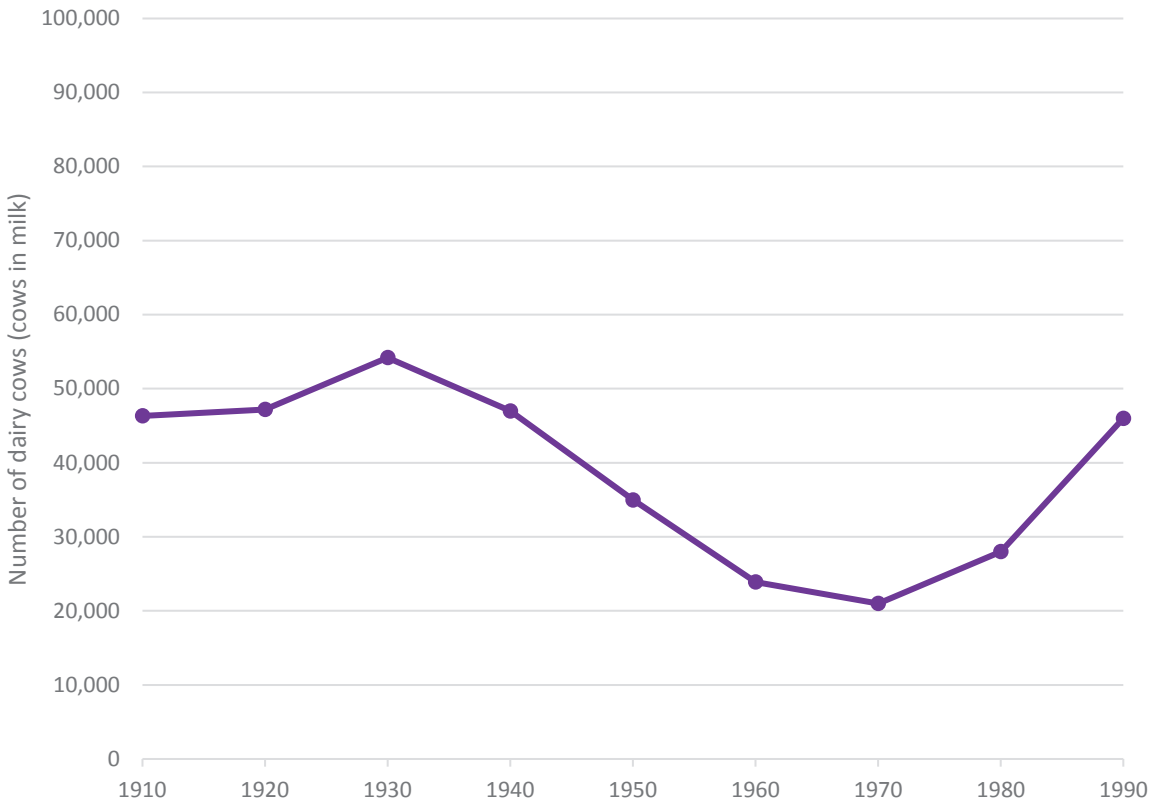


Figure 44: Dairy herd in Otago at decadal intervals 1910-1990
Source: New Zealand Yearbooks

The development of dairy farming for Otago's main dairy farming districts is briefly described in the following sub-sections.

6.2.1 Clutha District

Early European settlers recognized the potential for farming in South Otago. The climate and topography of the area was similar to Scotland and the stock could be wintered by supplementing grass with crops such as swedes. Large sheep runs were initially established in the area, and they dominated farming in South Otago from 1860s to late 1800s. The establishment of the Land for Settlements Act 1894 led to the breakup of runs and sub-division into smaller landholdings opening the area to a large influx of settlers and the population grew. Over time, changes in agricultural production have made it increasingly difficult to make a profit from smallholdings, resulting in smaller farms merging and a shift towards larger production units. The Clutha district is predominantly an agriculturally based economy today (Clutha Heritage, 2022).

The Clutha district has the largest proportion of dairy farming in Otago. The number of dairy cows has increased by 143 per cent from 1998 to 2020/21, along with an increase in number of herds, hectares, and herd size.

6.2.2 Dunedin City

Despite initially being a focal point for dairying in Otago, over the last few decades there has not been the same rate of increase in dairy farming in the Dunedin district as there has been in other areas of Otago. The number of dairy herds decreased from the late 1990s, while the number of cows and effective area being farmed remained relatively stable resulting in an increase in average herd size over the years. The number of cows per hectare has also increased slightly from 2.8 to 3.0 cows/ha between 1998 and 2021 (Tables 11 and 12).

6.2.3 Waitaki District

Historically, agriculture in North Otago has been largely based on sheep grazing and arable cropping. Pastoral grazing began in 1848 with the European settlement and by 1877 total sheep numbers had reached over 500,000. In 1973-74, 60 per cent of North Otago's gross revenue was derived from sheep farming. Dairy farming had declined to around 3,100 head of cattle (from around 7,000 in the early 1900s), mostly restricted to town milk supply farms near Ōamaru. The low, and variable rainfall limited early agriculture, and the expansion of pastoral farming has been closely tied to irrigation. In North Otago, rural water supply schemes were initially pioneered on the downlands, followed by the development of more sizeable schemes. A water race was established from the Waitaki River to service Ōamaru as early as 1877 and irrigation investigations with border-dyke trials commenced in the 1940s. In 1974, approximately 5,500 hectares were irrigated in North Otago (Currie, 1974).

Irrigation on the Waitaki Plains (the Waitaki District, Otago, and Waimate District, which is in Canterbury), together with the use of nitrogen fertiliser and increased pasture production led to a dramatic increase in the number of dairy cows (Davis, 1996). By 1998/99 there were just over 36,000 cows and the average dairy herd size was 499 cows. In 2020/21 this had increased to 105,000 cows in the Waitaki District alone and the average dairy herd size was 725 cows (Tables 11 and 12).

At present, the Lower Waitaki Irrigation Company, a farmer owned co-operative, irrigates some 20,000 hectares covering 99 per cent of the Lower Waitaki plains east of Black Point, including 2500 hectares on adjacent hill country. Irrigation on the plains began as early as 1912, however the scheme itself was constructed between 1974 and 1982. Current land use is made up of 81 per cent dairy and dairy support, nine per cent sheep and beef, and 10 per cent cropping and horticulture (Lower Waitaki Irrigation Company Ltd, 2022).

Another large scheme drawing water from the Waitaki river, is the North Otago Irrigation Company. It was officially opened in 2006 and delivers water to 20,000 hectares of productive farmland across the North Otago downlands. It is further described in Section 6.4.5 *Irrigation practices.*

6.2.4 Central Otago

The dry climate, soil conditions and topography are limiting factors for agricultural production in Central Otago and have influenced the establishment and development of dairy farming in the district. Nevertheless, pastoral farming has a long history in Central Otago, beginning in the 1850s, mainly associated with sheep and beef raising and more recently dairy farming.

Access to water is, and has been, essential to any growth in pastoral dairy farming under dry conditions. The first commercial irrigation started in 1873, when a former gold miner was granted a water right to irrigate vegetables and a vineyard near Clyde (Wills, 2014). In Central Otago, water rights were initially issued for sluicing and classified as mining rights under the Mining Act 1898. They were later used to irrigate grasslands through flood irrigation when land use changed from mining to pastoral farming.

Government had a large role in the growth of irrigation in Central Otago up until the end of the 1920s. They assisted farmers to use their water resources more efficiently by constructing irrigation infrastructure such as storage dams and distribution channels. The facilities were owned and operated by the government, with minimal finance from water users for operation and maintenance (Heiler, 2008).

The 1920s also saw experimental plant introductions seeking productive species capable of growing under dry, depleted conditions. This set the scene for ongoing pastoral hill country development. Sheep, beef, and deer raising have been the dominant forms of pastoral farming, and dairy conversions have occurred slowly. By 1986, the district was home to around 1,000 dairy cattle. Dairy conversations and land used for dairy winter grazing was seen as a potential for the region, and increased over the next decade (Wills, 2014).

As already noted, it is not possible to fully follow the development of the dairy industry in the District because of how the statistics have been collected over the years. However, it is known that in 1998/99 there were five dairy herds in the District, totaling just over 3,500 dairy cows (Table 11); with this increasing to 33 herds and 26,000 cows by 2020/21 (Table 12). The district has the lowest number of dairy herds (7% of total number of herds) of the four main dairy districts in Otago. However, the average herd size is large in comparison with the other districts, and so the total number of dairy cows is similar to the number in the Dunedin District (Table 12). The growth from 2008/09 to 2020/21 is shown in Figures 46 to 50.

6.3 Size and distribution

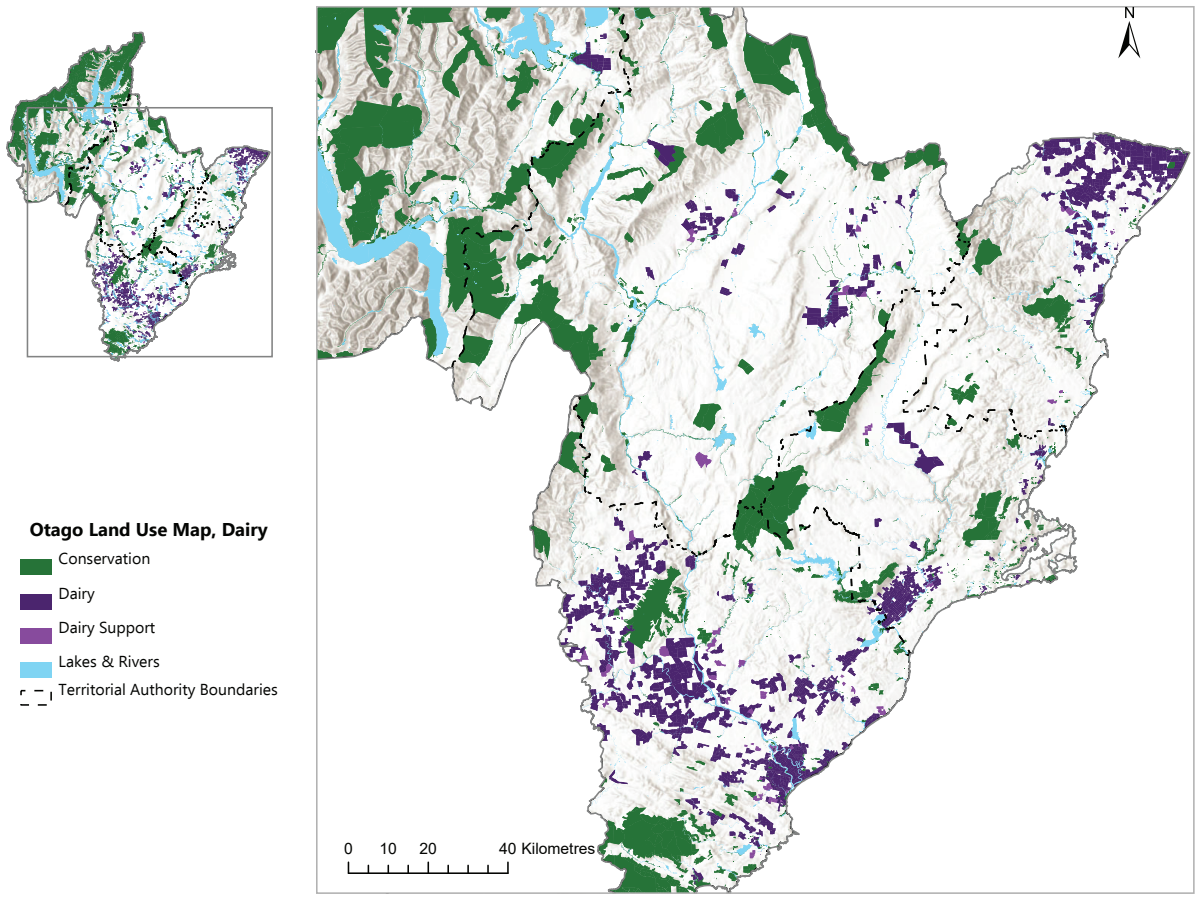
Information on the dairy industry in Otago is gathered by both LIC Dairy Statistics[183] and Statistics New Zealand. Each data source uses different methods and is undertaken for a different purpose. In this report data is used from the LIC Dairy Statistics as this is the data source of reference for the dairy industry[184] In the LIC Dairy Statistics, Central Otago was reported separately in 1998, but from 1999 until 2008 it was included with Waitaki District. In 2016 the reporting for Central Otago changed again to include the Queenstown Lakes District reflecting the fact that new dairy farms were appearing further inland. However, Queenstown Lakes District currently has few dairy farms and is not described separately in this overview.

183 https://www.lic.co.nz/about/dairy-statistics/

184 LIC Dairy Statistics provides production, herd improvement, evaluation, and reproduction statistics for the New Zealand dairy industry. New Zealand Dairy Statistics is the census of the national dairy herd. The report provides the largest and most comprehensive range of statistical analyses on current, historic, and emerging trends in the New Zealand dairy industry. Each year LIC jointly publish the New Zealand Dairy Statistics alongside DairyNZ. Data is sourced from the LIC Herd Improvement Database, New Zealand dairy companies, Animal Evaluation database, TB Free New Zealand, Real Estate Institute of New Zealand, and Statistics New Zealand. https://www.lic.co.nz/about/dairy-statistics/

Since the 1990s, dairy farming has expanded in Otago – although to a lesser extent than in Canterbury and Southland over the same timeframe. By 2020-21 Otago represented roughly four per cent of New Zealand's dairy herds, 5.6 per cent of the dairy cows, and 5.4 per cent of its dairy land (effective hectares not total hectares[185]). Expansion of the dairy industry in Otago has tailed off in recent years after an average increase of just under 9,500 dairy cows each year from 1998 to 2014 (Dairy Statistics, 2021).

There are important differences in dairy farming within Otago that are largely related to climatic variability, topography, and soils. These factors tend to drive the distribution, location, and size of the dairy farms across the region. Broadly speaking, dairying in Clutha (South Otago) has similarities to Eastern Southland, while dairying in Waitaki (North Otago) tends to have more in common with how it is occurring across the Waitaki River in South Canterbury. Herd sizes in Waitaki and Central Otago Districts are a similar size to those in Waimate and Timaru Districts, and typically larger than those in Clutha and Dunedin Districts. Herds in Clutha District are a similar size to those across the Southland region. Larger herds are typically seen on farms with irrigation as a way of financing the investment in irrigation infrastructure, and because of more reliable access to feed.



Source: Otago Land Use Map 2022, Otago Regional Council

185 The New Zealand Dairy Statistics do not include hectares that are not grazed (ineffective hectares), such as houses, shed, tracks, bush, water bodies and steep areas. The effective hectares in the New Zealand Dairy Statistics include dairy milking platforms and exclude any dedicated support blocks.

Otago Regional Council has divided Otago into five freshwater management units (FMUs) and the Clutha Mata/Au is further divided into five Rohe (areas) (ORC, 2021). A FMU can be all or any part of a water body or water bodies, and their related catchments, that a regional council determines is an appropriate unit for freshwater management and accounting purposes. Table 10 shows the number of dairy farms in each FMU and Rohe as of 2020, using information on dairy farm location from DairyNZ and FMU/Rohe boundaries from ORC. It also shows dairy land use for each FMU. The total dairy land use for the region is slightly higher using this method compared to the official dairy statistics but it gives a good indication of in which FMUs most of the dairy farming is found. The FMUs do not coincide with the district boundaries and cannot be compared with the official dairy statistics on a district level.

Table 10: Number of dairy farms in Otago FMU and Rohe in 2021 (total number of dairy farms = 455)

FMU / **Rohe**	**Clutha Mata Au**					**Catlins**	**Dunedin**	**North Otago**	**Taieri**
	Upper Lakes	**Lower Clutha**	**Roxburgh**	**Dunstan**	**Manuherekia**				
Number of dairy farms	0	183	0	1	13	27	25	140	66
Dairy land (ha)	42,580					5,257	5,308	27,237	14,040

Source: Number of dairy farms based on DairyNZ data and official FMU / Rohe boundaries from ORC data portal (August 2022). Dairy land use based on Otago Regional Council land use analysis.

Image 33: Dairy cows coming in for milking near Clinton (South Otago)
Source: DairyNZ

6.4 Main features

The following section gives an overview of dairy farming in Otago based on official dairy statistics and information from DairyNZ. Table 12 gives a breakdown of the extent of dairy farming by district within Otago for 2020/21 (the most recent year available) using LIC Dairy Statistics[186]. Clutha District had the highest number of dairy cows and largest area of dairy land (effective hectare) and Waitaki and Central Otago districts had larger herd sizes. However, there was a difference in stocking rate with the number of dairy cows per hectare being the lowest in the Central Otago District and the highest in Waitaki. The average herd size and milking cows per hectare for Otago was slightly below the South Island average.

Comparing regional statistics from 1998/99 (Table 11) to 2020/21 (Table 12), the number of dairy cows in Otago increased by 143 per cent from 1998/99 to 2020/21, and the effective dairy farming area increased by 65 per cent from 2002 to 2020. Prior to 2002, the area for dairy farming was only reported as an average area per farm and not as a total per district, which means that the same time period cannot be used to compare number of cows and land used for dairy farming. The increase in number of cows was driven mainly by an increase in dairy land (larger farms and an increase in the number of farms)[187], particularly in Clutha and Waitaki, whereas stocking rate has influenced this growth to a lesser extent and remained fairly constant, at just below three milking cows per hectare for the region. Since 2013, industry growth has plateaued and is quite stable in terms of the regional dairy herd (i.e., number of cows in milk), land area and herd size (Figure 45). Few conversions to dairy farming are currently taking place, largely because of the requirements of the Resource Management (National Environmental Standards for Freshwater) Regulations 2020[188].

Table 11: Dairy Statistics for Otago by District in 1998-99

District	Individual herds	Average effective hectares	Average herd size	Total milking cows	Average milking cows / effective ha
Clutha	125	142	372	46,533	2.8
Dunedin	99	98	264	26,117	2.8
Central Otago	5	260	704	3,521	2.9
Waitaki[189]	73	180	499	36,406	2.9
Otago (total)	**302**	**139**	**373**	**112,577**	**2.8**
South Island (total)	**2,027**	**130**	**330**	**668,752**	**2.6**

Source: LIC Dairy statistics
Note: The Waitaki District is in both Otago and Canterbury regions.

186 The statistics include number of cows lactating (producing milk) in the season 2020/21.
187 Area does not include area for wintering.
188 *The Resource Management (National Environmental Standards for Freshwater)* Regulations 2020 require consents for those seeking to convert land to dairy farming or increase irrigated area.
189 The Waitaki District straddles both the Canterbury and Otago Regional boundaries. As a result, the LIC Dairy statistics for the Waitaki District will incorporate an unquantified number of dairy farms and herds that are situated in the Canterbury region.

Table 12: Dairy Statistics for Otago by District in 2020-21

District	Effective area (ha)		Individual herds		Average	Total milking	Average milking
	Amount	Proportion	Number	Proportion	herd size	cows	cows / effective ha
Clutha	40,138	42%	203	46%	560	113,655	2.83
Dunedin	9,349	10%	63	14%	446	28,092	3.00
Central Otago & Lakes	9,943	10%	33	7%	797	26,304	2.65
Waitaki	32,318	38%	145	33%	725	105,189	3.25
Otago	**91,748**	**100%**	**444**	**100%**	**615**	**273,241**	**2.98**
South Island	**684,458**	**-**	**3,189**	**-**	**647**	**2,064,659**	**3.02**

Source: LIC Dairy statistics

Note: The data for the Waitaki District in Table 12 and Figures 46 to 50is for Otago region only. The data for individual herds, total milking cows Waitaki dairy land in Otago was calculated by summing the Clutha, Dunedin and Central Otago Districts and subtracting them from the totals for the Otago region. It was not possible to re-calculate the averages, which are for the Waitaki District as a whole (i.e., in Otago and Canterbury).

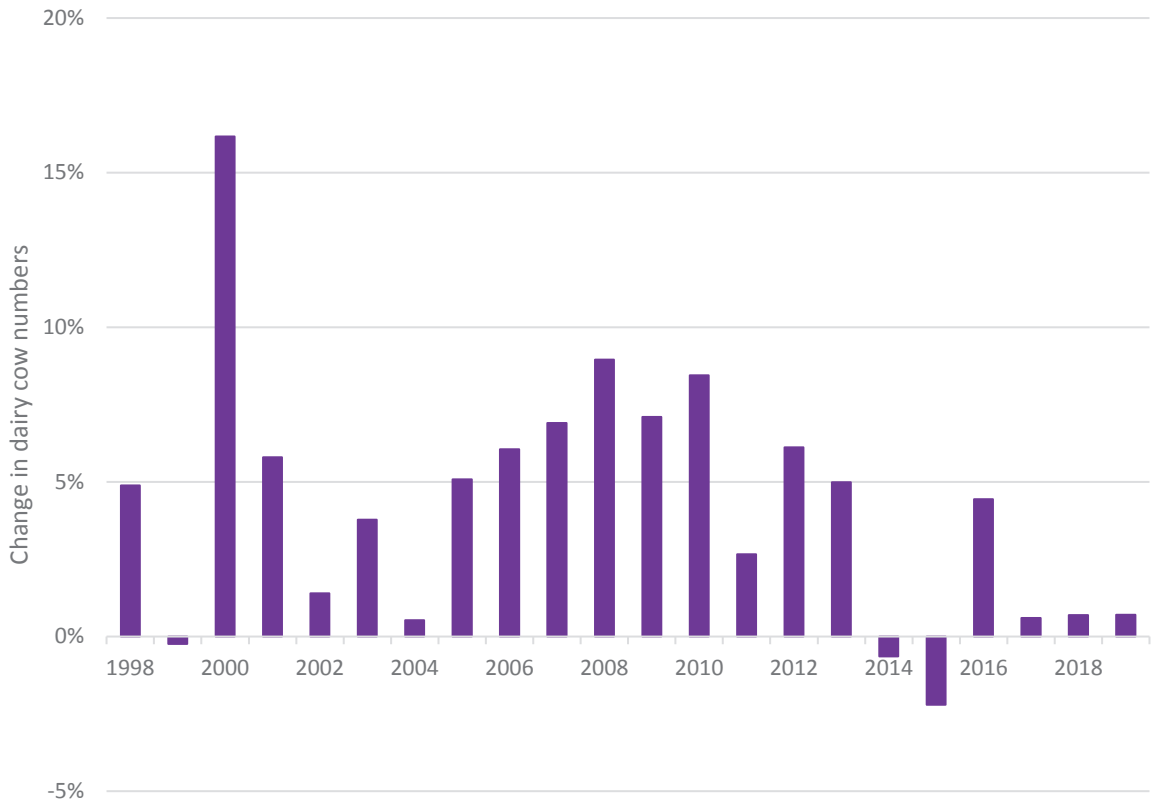


Figure 45: Annual percentage change in Otago dairy herd 1998-2019
Source LIC Dairy Statistics

Figures 46 and 47 show trends in effective area (2002-2020) and number of milking cows (1998-2020) by district. The largest increase can be seen in the Clutha and Waitaki districts, where the number of dairy cows has increased by 144 per cent and 189 per cent respectively from 1998 to 2020.

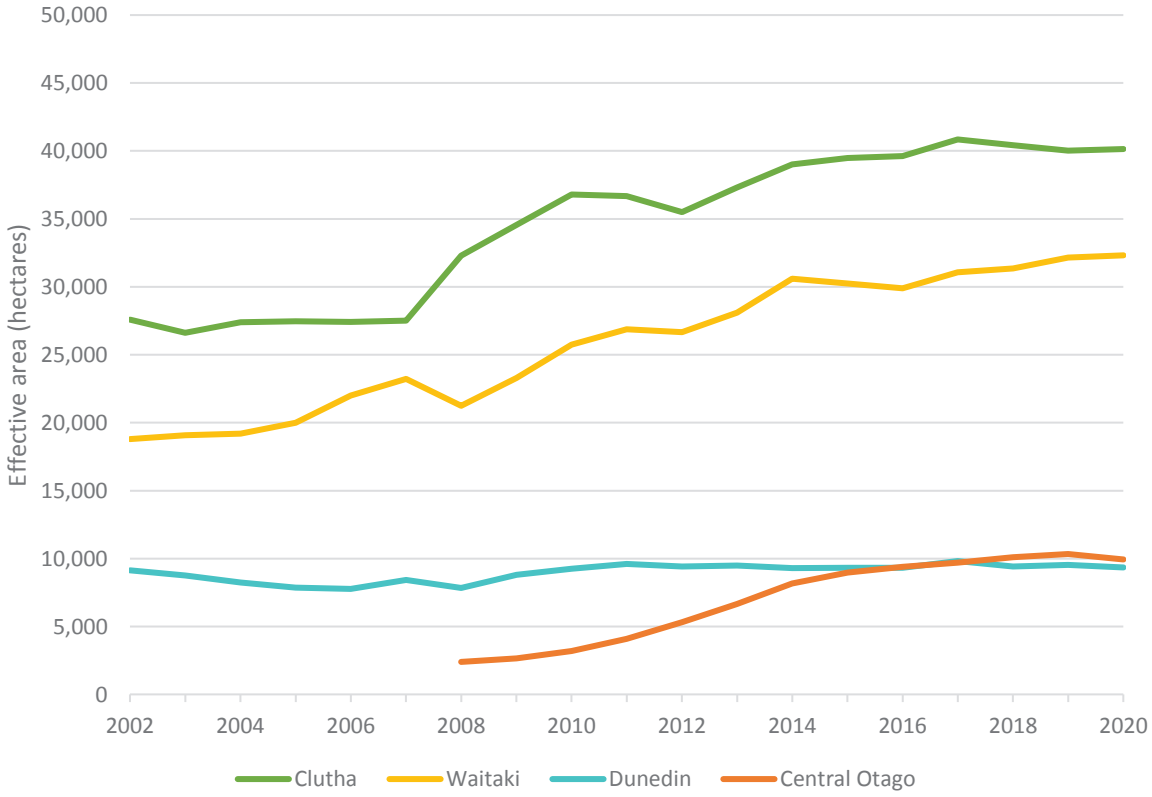


Figure 46: Change in effective area In Otago by District 2002-2020
Source: LIC Dairy Statistics

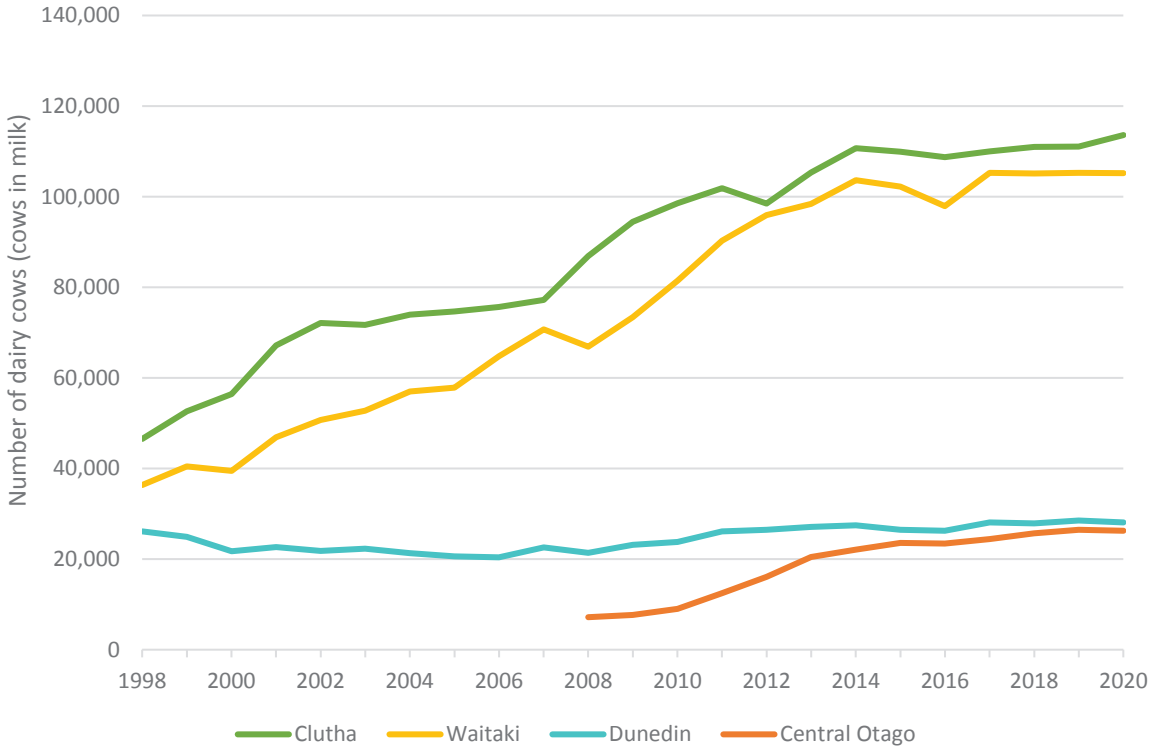


Figure 47: Change in the number of dairy cows in Otago by District 1998-2020
Source: LIC Dairy Statistics

Figures 48 to 50 show how dairy farming in each district in Otago has changed in terms of the number of individual herds, individual herd size and stocking rates over the past two decades. Growth of dairy farming has mainly been in the Clutha, Waitaki and Central Otago districts. The total number of herds has been increasing alongside the average herd size, and there is evidence of increasing scale in dairy farming across most of the region although the changes in stocking rates are more mixed. Waitaki had the highest stocking rate, peaking at 3.6 cows per effective hectare in 2012 but this declined to 3.25 milking cows for the 2020/21 season.

Traditionally, stocking rates (the number of cows per effective hectare) has been an indication of pasture supply (i.e., the feed available) on farm but this relationship has weakened with the increasing use of imported supplementary feed. However, a higher number of cows per hectare is not in all cases directly related to a larger environmental footprint. The link between cow number and nitrogen losses to water and air is complex, with on-farm management decisions such as pasture species, grazing management, irrigation type and amount, application of fertiliser (type, amount, and rates/application) and investment in off-paddock infrastructures influencing what is lost to the environment[190]. Soil type and climate will also affect the loss of nutrients to the environment from a farm.

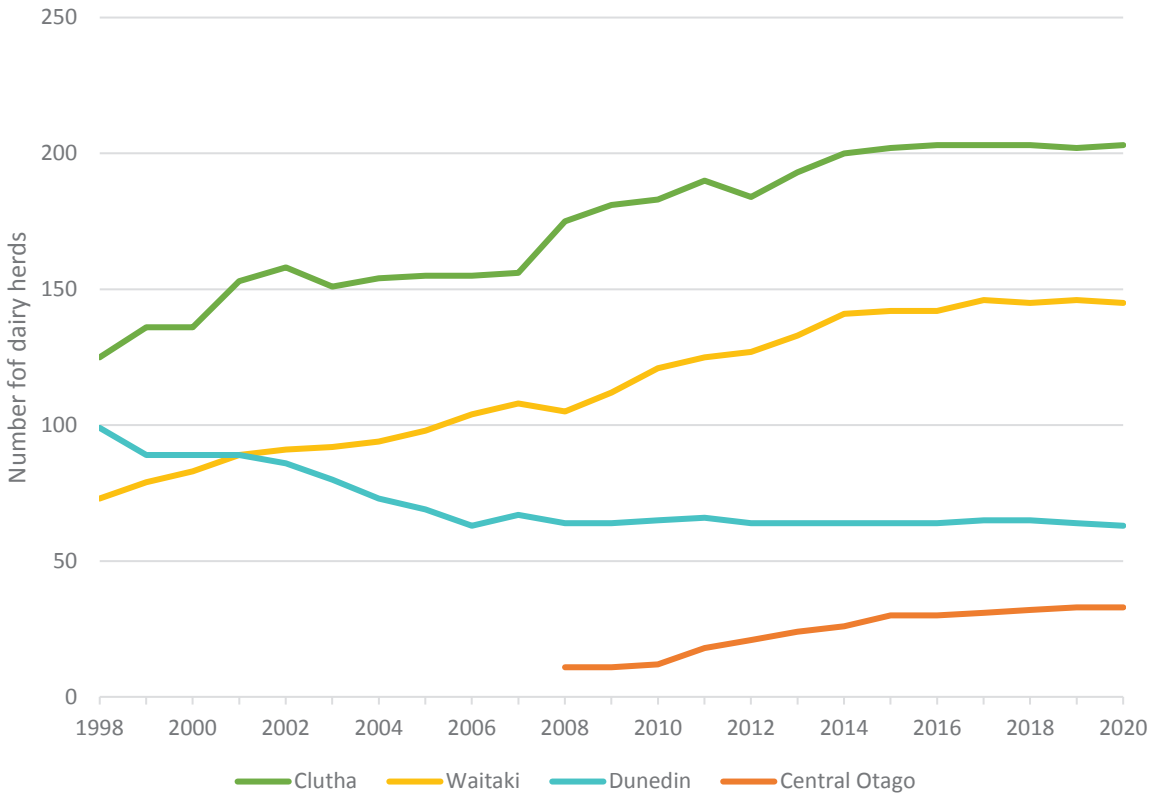


Figure 48: Change in number of individual dairy herds in Otago by District 1998-2020
Source: LIC Dairy Statistics

190 Nitrogen intake in most pasture-based diets is surplus to the requirements of dairy cattle. This surplus is excreted as urine (70-80%) and dung (20-30%). Nitrogen in the urine patch exceeds plant requirements and some is leached below the root zone or lost to the atmosphere as nitrous oxide gas (N2O) (DairyNZ, 2022).

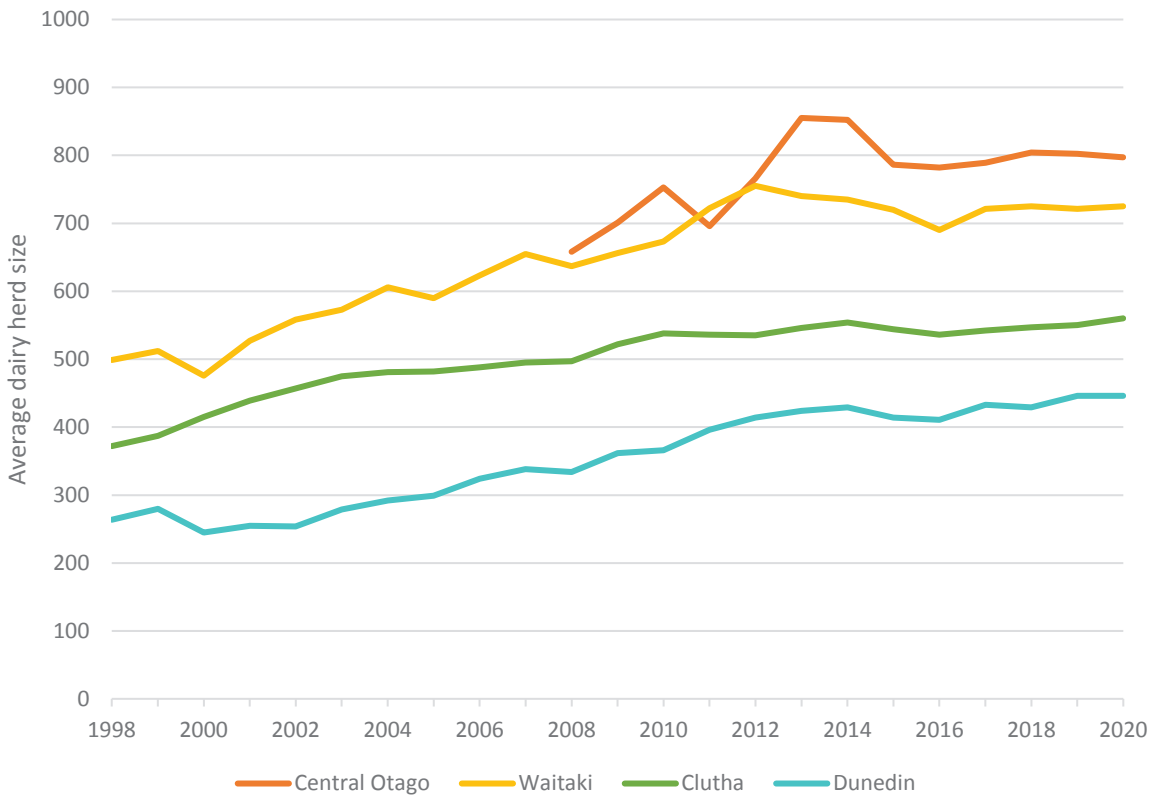


Figure 49: Change in average individual herd size for Otago by District 1998-2020
Source: LIC Dairy Statistics

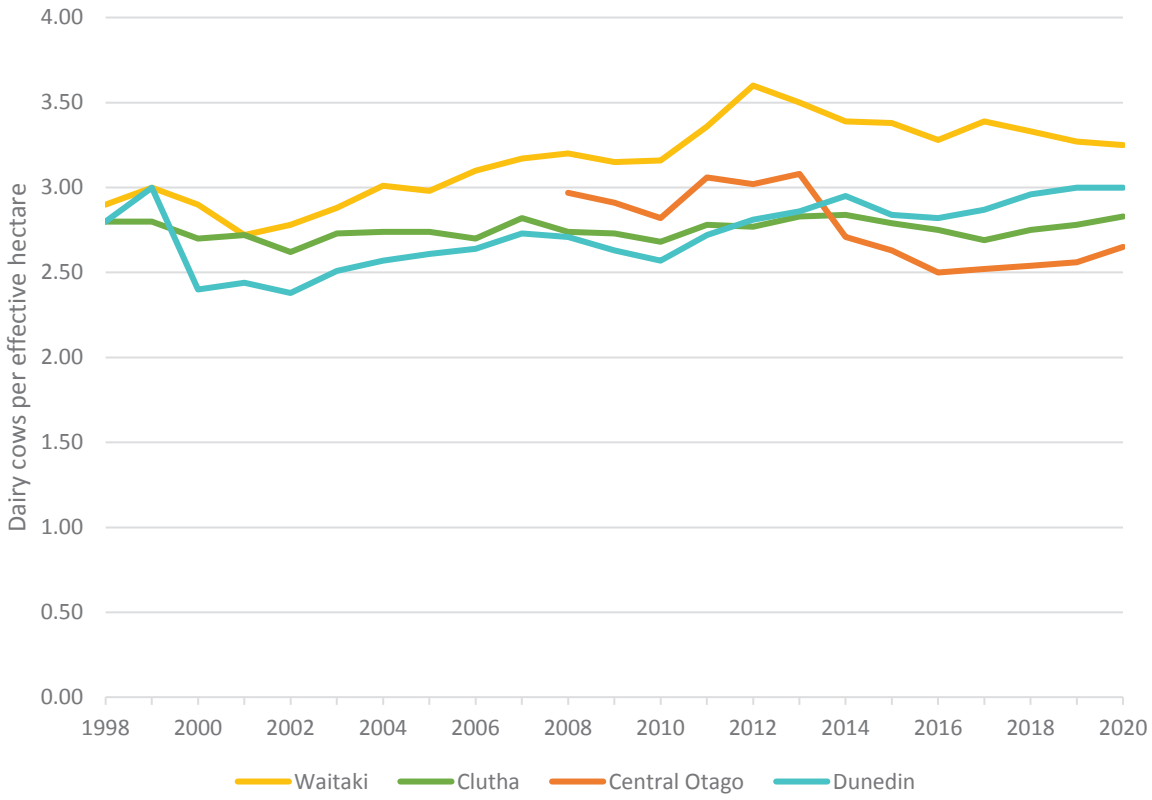


Figure 50: Changes in stocking rates for Otago by District 1998-2020
Source: LIC Dairy Statistics

6.4.1 Production systems

Pastoral farming in New Zealand is primarily about balancing feed supply and demand[191]. DairyNZ uses five production systems based primarily on 1) when imported feed is fed to dry or lactating cows during the season and 2) the amount of imported feed and/or off-farm grazing. The production system classification makes it possible to compare different farms across the country with the same type of farm system. The production system definitions do not include grazing or feed for young stock. When assessing the environmental footprint of a farm, and how any changes to the farm system might change its footprint, it is important to also consider where wintering of stock is taking place, for example whether it is on or off farm and where the replacement stock is being grazed.

Although there is no region-wide data collection that captures the type of production system for all dairy farms (and it can shift over time), DairyBase[192] captures a sample of farms that have voluntarily supplied data and defined their production system, which gives an estimate of the distribution of farm systems in Otago. The number of farms adding their data to DairyBase varies from year to year and the collection of environmental information is not part of the minimum requirements. For the season of 2020/2021, a total of 63 dairy farms in Otago have been used for the overview of production systems.

System 1 – All grass self-contained, all stock on the dairy platform. No feed is imported. No supplement fed to the herd except supplement harvested off the effective milking area and dry cows are not grazed off the effective milking area.

System 2 – Feed imported, either supplement or grazing off, fed to dry cows. Between one and 10 per cent of total feed is imported. There is a large variation in percentage as in high rainfall areas and cold climates such as Southland, most of the cows are wintered off.

System 3 – Feed imported to extend lactation (typically autumn feed) and for dry cows. Between 10 and 20 per cent of total feed is imported.

System 4 – Feed imported and used at both ends of lactation and for dry cows. Between 20 and 30 per cent of total feed is imported onto the farm.

System 5 – Imported feed used all year, throughout lactation & for dry cows. Between 25 and 40 per cent (but can be up to 55%) of total feed is imported.

Based on the 63 farms in DairyBase, Otago has few System 1 or System 5 farms (Figure 51), and the most dominant system varies across the region. A dairy farm's production system is often not static, and for example, it does not take much to move a farm from a System 2 to a System 3 farm since most farm systems have some form of in-shed feeding.

Most dairy farms in South Otago (79%) are System 2 or System 3 as they export a proportion of their herd off-farm for winter grazing or bring in feed for winter grazing (Figure 52). Dairy farms in Central Otago may also tend to be 'low to medium' input systems (Systems 1 to 3).

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191 https://www.dairynz.co.nz/business/the-5-production-systems/

192 DairyBase uses financial and physical indicators to benchmark dairy farm performance (Otago and Southland are combined as one region in DairyBase). Individual farmers' details are kept confidential and are not provided to councils. DairyNZ's Baseline Project is an extension of DairyBase and provides more detailed data to the dairy industry. For example, the amount of feed and fertiliser being used by a farmer is normally collected for DairyBase and in the Baseline Project more detailed information is collected, such as the timing around feed, how it is fed, when fertiliser is applied, at what rates and which parts of the farm it is applied to. Information from the Baseline Project is used to respond to policy pressures, dairy industry statistics, and other DairyNZ projects and research https://www.dairynz.co.nz/business/dairybase/

Most of the dairy farms in Waitaki (82%) are System 3 or System 4. Dairy farms in Dunedin are also likely to be 'medium to high' input systems (Systems 3 to 5).

As the pay-out cycle fluctuates, there will be a corresponding shift up or down of systems across the board. The small sample size means that the information per region should be interpreted as an indication of production system only, and variations will occur.

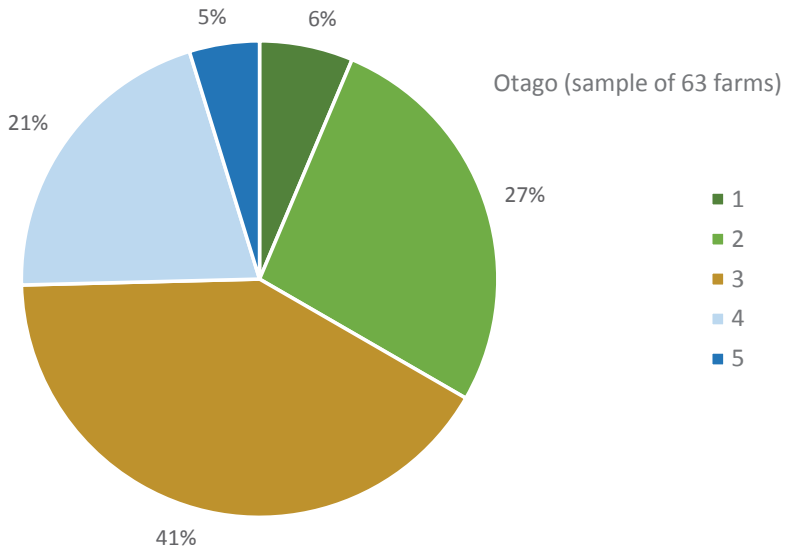

Figure 51: Farm Systems for a sample of 63 dairy farms in Otago for 2020-21 season (14% of all dairy farms in region)
Source DairyBase, DairyNZ

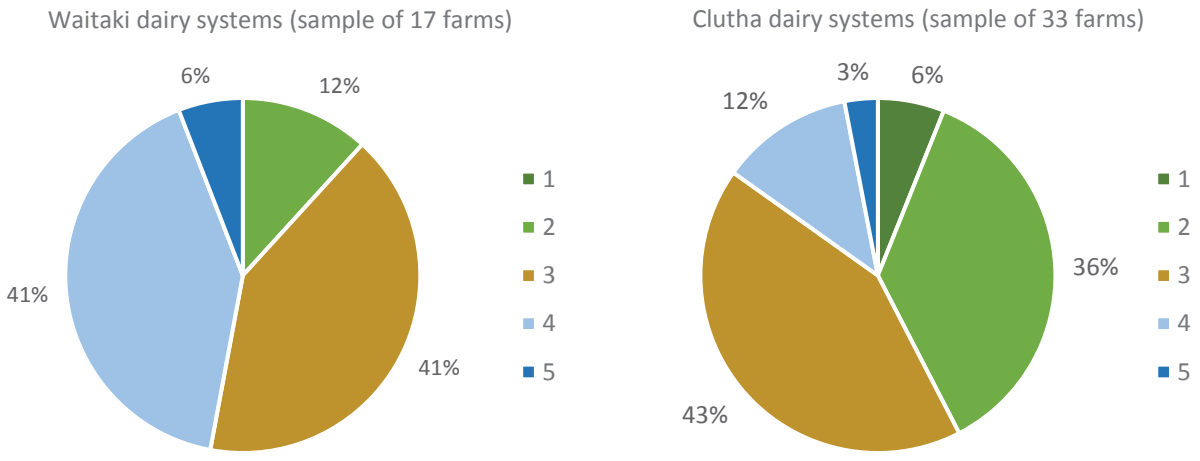

Figure 52: Farm systems for Waitaki District and Clutha District from the same sample of 63 dairy farms in Otago (14% of all dairy farms in region)
Source: DairyBase, DairyNZ

6.4.2 Productivity and production

In 2020-21 Otago produced just under 111 million kilogrammes of milksolids,[193] or an average of 406 kilogrammes of milksolids per cow and 1,2 per effective hectare (Dairy Statistics, 2021). The region's milk production has increased over the last 20 years, driven mainly by an increase in cow numbers and to a smaller extent by an increase in milksolids per cow. Milksolids production increased by 371 per cent during the period 1995-2015, 56 per cent of which could be attributed to improved milk production per cow and 316 per cent due to more cows (Figure 53).

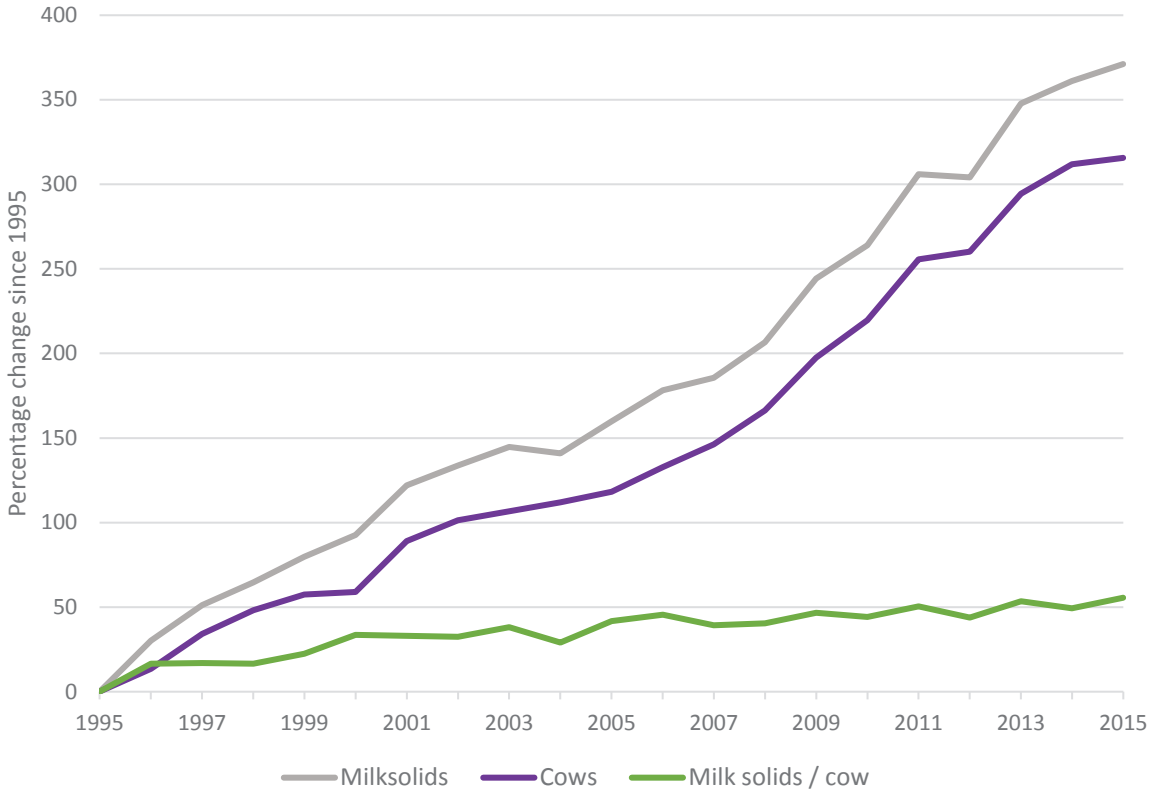

Figure 53: Trend in total milksolids produced in Otago and its drivers (size of dairy herd and milk production/cow) 1995-2015
Source: Reproduced from Edwards (2017)

Historically, there have been differences in breed type according to the land being farmed, but that happens less nowadays. The Jersey breed dominated the national dairy herd until the late 1960s. Changes in farm management practices and farmers raising larger number of dairy calves for beef meant that by 1970 Holstein-Friesian was the dominant dairy breed. In general, across the country, there has since been a shift from using Holstein-Friesians (usually simply referred to as Friesians) towards the lighter crossbreed Friesian/Jersey and this is the main breed used today in New Zealand dairy farming (Dairy Statistics, 2021).

A similar shift in breed can also be seen in Otago, however, in some areas, like the Taieri Plain and possibly the Matau Paratai area on either side of the Clutha River, the Holstein-Friesian is still the predominant breed. Friesians are typically bigger framed and heavier than other dairy breeds and traditionally have been farmed for their higher milk volume. Now that all farmers are paid on a milksolid basis cow size is less of a driver for production. The reason for farming Friesians in some areas of Otago is purely historical.

193 'Milksolids' are the dried powder left after the water is removed from liquid milk.

Previously, many town supply farms had liquid milk contracts with the Cadbury factory in Dunedin and kept bigger Holstein-Friesian animals, and this practice has continued in some parts of Otago.

The breed of cow will, to some extent, influence farming practices and many farms with predominantly the heavier Holstein-Friesian breed have adopted off-paddock infrastructure such as a feed pad, stand-off pad or freestall barn, for use over winter and in the shoulders of the season.

Image 34: Rotary milking shed.
Source: Luke Kane

6.4.3 Farm ownership

New Zealand has seen dairy farming come and go over the last 130 years. Much of the dairying being carried out today in Otago is likely to have started in the 1990s. During the mid-90s there was an influx of people, from outside the region, entering Otago's dairy industry. This increase in dairy was more prevalent in South Otago to areas such as Clinton and Clydevale. It is probable that the increase of dairying in Central Otago resulted from people moving up from Southland, as well as existing sheep and beef farms in the area converting to dairy.

Post-2000, the increase in dairy farms in Otago has mainly been from land use change (i.e., sheep and beef farms converting to dairy). During the period of the early 2000s to 2010, lamb returns were unreliable, and many farmers chose to keep their farms within the family but to change their land use.

Today, many farms in Otago are still family-owned but there are also a few large farm businesses. One such business owns 12 or 13 farms around Wānaka and, due to the small number of farms in that area, dominates supply. This operation also owns the tankers that supply milk to Open Country. Corporate ownership of farms is also widespread in Otago, with Dairy Holdings Ltd owning many farms in the south, perhaps more in Southland than in South Otago, but some in the Clydevale area.

The way a dairy farm is operated can influence on-farm decision making and as a consequence of that, the production. The main operating structures found across the country are owner operators, sharemilkers and to a lesser extent, contract milkers. Owner operators is the largest group of all operating structures. They are farmers who own and operate their own farms, or who might employ a farm manager to run the daily operations.

Contract milkers are contracted to milk a herd at a set price per milksolids produced. Sharemilking, on the other hand, can be set up in different ways; herd-owning sharemilkers (also called 50/50) or variable-order sharemilking. Either agreement involves operating a farm on behalf of the farm owner for an agreed share of the farms receipts as opposed to a set wage in the contract milker situation. A herd-owning sharemilker owns the herd and any equipment needed to farm the property. In this situation, the owner is usually responsible for any expenses related to maintaining the property.

The 444 dairy herds in Otago included 52 per cent owner-operators, 31 per cent sharemilkers and 11 per cent contract milkers in 2020/21 (Dairy Statistics, 2021). This is comparable with the situation in Southland, which had the same percentage of herds owner-operated and under a sharemilking agreement, but a slightly higher percentage of herds with contract milkers. There is also a small proportion of herds with unknown operating structure (Dairy Statistics, 2021).

6.4.4 Winter practices

Winter management practices are integral to dairy farming in Otago, particularly as dairy farms must contend with less pasture production over winter than in regions further north. As a result, many dairy farms rely on forage cropping to feed their cows over winter: from the conservation of feed as baleage and the production of silage through to the growing of forage and fodder crops (e.g., kale, fodder beet and swedes).

These crops can be grown on the milking platform or support blocks or grazed on properties that are owned or leased by the farmer. Winter feed is either used in situ or harvested as cut and carry to use on feed pads and in wintering barns. Alternatively, stock can be grazed off farm, on the properties of graziers providing winter grazing services[194].

Winter is a critical part of the year for dairy farming as it is the time when the farming business sets up for the next lactation. The pasture cover on the milking platform at the start of calving and the condition of stock at the end of winter affect reproduction and production in the following season. On the Waitaki Plains, where less than three per cent of annual grass production occurs in June and July, the practice of wintering cows off-farm had begun by the early 1990s.

Decisions around wintering of herds on-farm versus off-farm can be driven by several factors. In some cases, milking platform soils may not be suitable for wintering, or a farmer may seek to maintain pasture covers on farm due to low winter and early spring growth. Control over wintering outcomes and the financial position of the business are also important drivers. A dominant factor in decision making is the supply and reliability of winter crop. Farmers will consider sending cows off-farm when there is sufficient supply of crop on the market.

194 The term 'graziers' refers to farmers who sell winter grazing (either on a dry matter basis or per head per week) to dairy farmers. These farmers usually have other enterprises e.g., sheep, beef, cropping, seeds etc.

When the milk pay-out drops, farmers have the flexibility to control costs by wintering a portion of their herd on-farm. However, at the present time, the NES-F regulations state that farmers require a consent to increase their area of winter grazing on farm, to crop on land that was not cropped on during the baseline period or to convert land to dairy farming. As a consequence, the option of making the change to bringing young stock or wintering stock on-farm might come at a considerable cost if a wintering or land use change consent is needed.

The 'right system' depends on a range of factors and the important thing is for farmers to pick a system that is appropriate for their goals and values, the physical environment they operate within, to ensure they can comply with regulations, and that it remains profitable.

The practice of 'grazing-off' means that dairy farming and dry-stock farming is currently linked. The supply of a winter grazing service by sheep, beef and arable farmers has a number of benefits including an additional source of revenue, an opportunity to diversify and as a result, providing for different production opportunities and increased land values.

Image 35: Delivering extra feed to milking cows' shelter in a paddock on dairy farm in Tapanui, 29 September 2020. Source: Luke Kane
Note: Each year is different – at the same time of year in 2022 this farm was experiencing record pasture growth.

Increased awareness around the risks associated with winter grazing on crop (including regulation of these practices) has resulted in an increase in dairy farmers experimenting with different wintering options. Farmers are trialling the use of 'grass-baleage' systems, diverse species pastures (multiple pasture species beyond the traditional rye-grass clover mix), paddocks that have separate crop and pasture areas within the same paddock and crop establishment techniques. Other farmers have either invested in off-paddock infrastructure or are considering this as a future option.

Anecdotally, housed cow systems are still relatively rare in Otago and their number is slow growing. Off paddock infrastructure options can be expensive, given the initial capital costs, ongoing operation costs and interest costs on any debt associated with the infrastructure. Effluent management systems are likely to need investment as well if off paddock infrastructure is used. Effluent management systems often come with extra complexity and added costs.

Wintering practices differ around the region. Higher rainfall and heavier soil types in the southern regions mean that intensive winter grazing is a riskier activity in South Otago and Southland compared to other parts of Otago. On heavier soils there is increased risk of sediment laden runoff from wet soils, and there are often delays with planting a catch crop, a subsequent winter crop or re-sowing pasture.

In South Otago there is more focus and awareness of industry good practice around intensive winter grazing, for example back fencing and having contingency options for wet weather[195]. In the drier, free draining areas of North and Central Otago animal welfare risks related to muddy soils are typically experienced less frequently, but still need to be managed appropriately.

These different conditions have led to a lot of movement of dairy animals from South Otago and Southland up to Central Otago and North Otago for winter grazing. Other South Otago farmers have preferred to winter on-farm, usually on grass and silage rather than planting winter grazing crops. By doing this the farmer starts with a firmer surface for the animals than would be possible if the land was cultivated to plant a crop.

In South Otago where most of the winter milk is produced, there is more of a move to using off-paddock infrastructure such as a feedpad, or stand-off pad than in Central or North Otago. This could be due to the heavier Friesian breed used in some areas of South Otago.

DairyNZ (with dairy farmer levies) and AgResearch are investing heavily in the Southern Dairy Hub, which while located in Southland, represents many of the sub regions across Otago. The Southern Dairy Hub was established to be able to address dairy challenges specific to Southland and Otago through local research and demonstrations.

One of the key research projects currently in the planning is investigating alternative wintering systems. This includes conventional and lower impact winter crop, grass-baleage and a range of off-paddock solutions. The off-paddock solutions are currently being designed with the aim of being ready to use in winter 2023. A recently completed 4-year study has compared kale and fodder beet for winter feeding to identify opportunities for nutrient loss reduction.

195 A Plan B option for wintering is a plan for when conditions are not ideal, and animals need to be moved off a paddock or crop and onto a suitable lying surface for a period ranging from a few hours to a few days. It could also mean offering stock more area on a crop.

6.4.5 Irrigation practices

The history of investment in large-scale irrigation infrastructure in Otago reflects that of New Zealand as a whole. Initial investment was focused in the drier areas of Otago, predominantly Central Otago, and funded largely through government investment programmes prevalent over the 1910-1940 period. This trend continued through various investment programmes aimed at boosting production and employment. These programmes were driven by a view that the farmers using irrigation water could not obtain the finance, technology and labour required to develop and maintain the schemes.

This trend of central government investment continued until the mid to late 1980s, when economic restructuring occurred. Central government began to transfer ownership of the Crown schemes to farmers from the late 1980s, and no irrigation schemes now remain in Crown ownership. In 1991, responsibility for approving schemes was devolved to local government under the Resource Management Act 1991. While central government retained a level of investment, the focus shifted towards funding science and technology development (Irrigation NZ).

Several important irrigation schemes have been developed in Otago in recent years, many of which support dairy productivity today. Two examples are discussed below: *North Otago Irrigation Company (NOIC) and the Maniototo Irrigation Company.*

The **North Otago Irrigation Company** was incorporated in 1990 to investigate and deliver large-scale irrigation to the North Otago downlands area. The scheme proceeded through the feasibility and development phases before moving to 'Stage One' of development in 2006, when pressurised water was first delivered to farmers. North Otago Irrigation Company then extended supply infrastructure until the development of 'Stage Two' was completed in 2017, with record daily volumes of irrigated water delivered in 2020[196]. The scheme serves 175 farmer-shareholders, including several dairy farms.

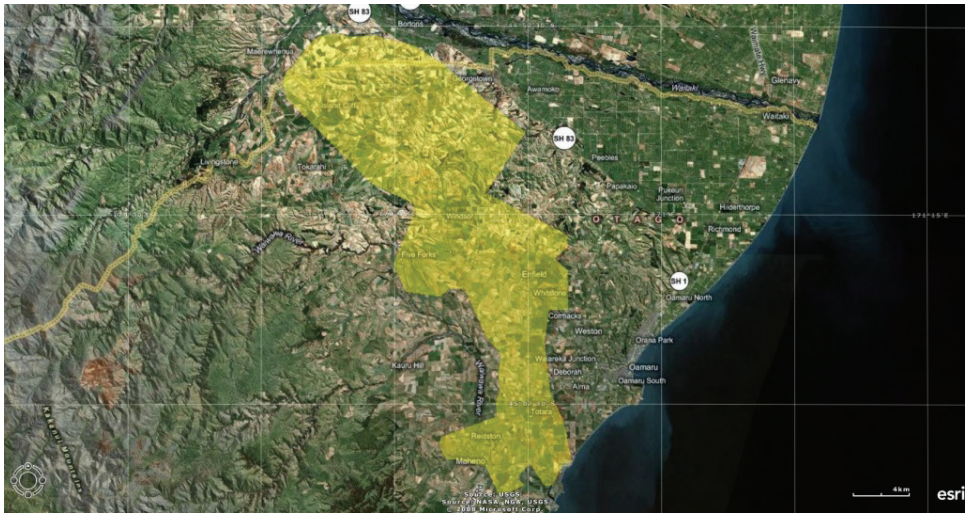

Image 36: The area covered by the North Otago Irrigation Company as of 2021
Source: The Waitaki Irrigators Collective

196 Our Story » North Otago Irrigation Company Ltd (noic.co.nz)

The North Otago Irrigation Company is not only focused on water quantity. Environment Canterbury consent conditions for the water take include those relating to environmental management. To deliver on these responsibilities North Otago Irrigation Company shareholders are required to have an audited farm environment plan setting out what each farm is required to do to ensure the scheme's consent conditions are met, including actions related to irrigation, effluent and nutrient management, and stock exclusion from waterways. The North Otago Irrigation Company has worked with the shareholders to improve compliance and environmental management, realising that this is a part of their social licence to operate (North Otago Irrigation Company).

Development of the **Maniototo Irrigation Company** in Central Otago began in 1973 and was the last of the large community irrigation schemes built by the Ministry of Works and Development[197]. Construction was halted in 1984 when it was only 40 per cent completed, with the assets sold to the farmers receiving the water[198]. The Maniototo Irrigation Company (MIC) is located in the Taieri catchment and supplies water from the upper Taieri, and water stored in Loganburn Reservoir to a little under 10,000 ha via three distribution companies: East Side, West Side and Waipiata. Water is used for irrigation, and stock and domestic water supply.

Irrigation in Otago initially started in Central Otago during the late 1800s using mining privileges and dams, races and other structures originally developed for gold mining. The different water schemes have encouraged land use change (Ward & Russel, 2010) resulting in increased employment for the region[199]. Investment in irrigation is more likely to be seen on farms across Central Otago and North Otago than in South Otago. Of the surveyed farms in DairyBase in 2020/21, all the farms in Waitaki had irrigation whereas only a small proportion of farms in Clutha were irrigated. This is however based on a non-statistical representation of farms across Otago and variations within sub regions do occur.

Irrigation across Otago is done using a range of systems and different water sources depending on location (Table 13). Using irrigation can mean a higher security in production of pasture (feed) for the cows, and production will generally be higher. As an example, the average production of milksolids per cow in Clutha is, in general, lower than in the Waitaki district. North Otago FMU has almost 100% of dairy land under irrigation compared to around 17 per cent in the Clutha Mata-Au FMU. The irrigated dairy land is just above 40 per cent of the total effective area in the region, based on the land used for dairy in 2020/21.

The increased security in pasture production using irrigation is entirely dependent on the security of the water source and consistent access to water during the milking season. If less pasture is available, farmers will have to bring in supplement feed to make up the reduced pasture growth or reduce feed demand through earlier culling or drying cows off.

197 https://www.odt.co.nz/business/farming/maniototo-scheme-lifeblood-area
198 https://www.odt.co.nz/business/farming/story-irrigation-told-book
199 https://www.odt.co.nz/business/farming/maniototo-scheme-lifeblood-area

Table 13: Dairy land in different types of irrigation as proportion of total irrigated land in Otago by FMU

Type	Clutha Mata-Au	Dunedin & Coast	North Otago	Taieri	Grand Total (hectares)	Percentage of total irrigated in Otago (percentage)
	Freshwater Management Unit (hectares)					
Border-dyke	36	-	4,083	62	4,181	39
Drip/micro	4	-	3	-	7	0
Gun	197	-	583	-	780	21
K-line/Long lateral	1,040	-	8,433	745	10,218	38
Lateral	-	-	30	-	30	22
Linear boom	24	-	55	-	79	25
Pivot	4,953	-	9,392	3,846	18,191	44
Rotorainer	39	-	1,153	63	1,255	34
Solid-set	81	-	20	-	101	15
Unknown	568	30	3,372	314	4,284	20
Wild flooding	150	-	36	-	186	2
Grand Total	**7,092**	**30**	**27,160**	**5,030**	**39,312**	**32**

Source: Otago Regional Council (irrigation data is based on Aqualinc's irrigation map).

The assessment of land use and irrigation types indicates that just under 4,200 hectares of dairy land has border-dyke irrigation[200] based on intersecting irrigation and land use maps. This estimate equates to around 44 farms, not considering dairy support. They are almost exclusively concentrated in lower Waitaki Plains (north of Ōamaru), with a few small areas in Manuherekia and Upper Taieri. Anecdotally, farmers in the lower Waitaki are in the process of converting to pivots as Environment Canterbury (who issue the consent for the Lower Waitaki irrigation Scheme take from the Waitaki River) is requiring this move later this decade as a condition of scheme consent renewal. Within five years there is likely to be virtually no border-dyke dairy land in this area (B. Mackey, ORC, personal communication, 23 June 2022).

Consents for taking of water for irrigation are assessed under the Regional Plan: Water for Otago Provisions, against which consents will be assessed, include those relating to the efficiency of the proposed water transport, storage, and application system. As a result, future consent applications for the taking of water will require applicants to demonstrate they are using the water resource efficiently. This requirement will most likely result in a move away from border-dyke and flood irrigation towards spray irrigation.

200 Border-dykes are a permanent type of irrigation that are built into a slanting paddock. They work by a channel at the top of the slant, closing one gate inside it which means the water dams up, and flows over the edge of the channel into the paddock.

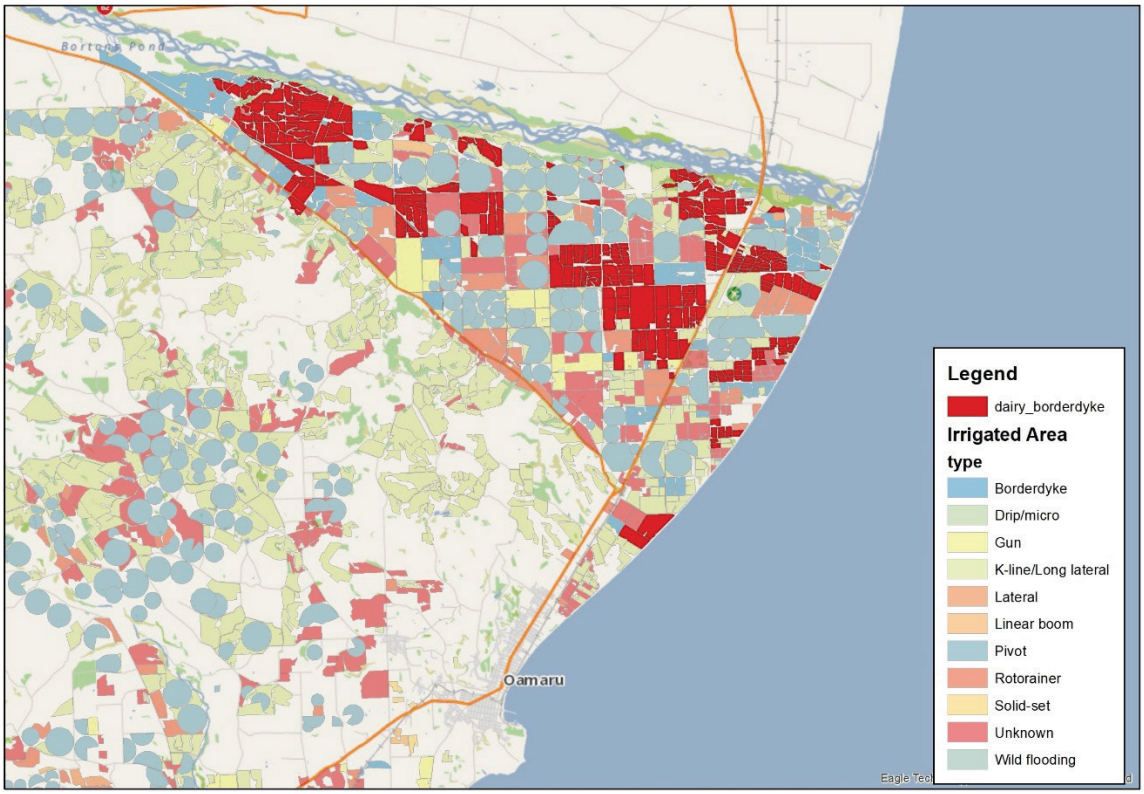

Image 37: Dairy farmland with border-dyke irrigation in North Otago
Source: Otago Regional Council

6.5 Processing and markets

As already noted, Dunedin was the birthplace of the co-operative system that typifies the New Zealand dairy processing industry. The country's first co-operative dairy factory was established by eight shareholders at John Mathieson's 'Springfield' farm on the Otago Peninsula in 1871 and the Otago Peninsula Co-operative Cheese Factory Company began producing Scottish style 'Dunlop' cheese in the same year. A second dairy factory was established on the Otago Peninsula in 1877[201] and the following year saw the first export of refrigerated cheese from Port Chalmers, an event that secured an export future for the industry[202].

The development of infrastructure and technology resulted in growth in the industry beyond Dunedin and the Otago Peninsula: to the north through Palmerston, Hampden, and Ōamaru to the Waitaki and on up to Kurow, across the Taieri Plains, and south from Maungatua to Milton, Balclutha and Ratanui in the Catlins. The principal milk supply company in the Dunedin area at the time was the Taieri & Peninsula Milk Supply Company, which operated from 1871 to 1942.

201 This factory was destroyed by bush fires that swept the Peninsula in 1881 (Petchey, 1998).
202 This shipment of export cheese was lost when the Tararua was wrecked, but a consignment of butter on the pioneer refrigerated sailing ship Dunedin the following year, successfully reached London (Farquhar, 2005).

In 1922, the Co-operative Dairy Company of Otago was formed in Dunedin, owned entirely by those who supplied cream with 'no dry shareholders': 284 individuals operating home separators took 68 per cent of the initial share allocation, while eight small Otago factories (Momona, Mosgiel, Milton, Goodwood, Waikouaiti, Merton, Omimi, and Maungatua) took the remaining 32 percent of the allocation.

In 1923 this new co-operative bought the Dunedin Dairy Company, which included the Huia brand, and in 1942 it bought out the butter business of the Taieri & Peninsula Milk Supply Company, taking on its factory in Ōamaru. The Co-operative Dairy Company of Otago (later known as the Otago Co-operative Dairy Company) produced Huia brand butter and cheese for 75 years[203]. Other notable dairy companies and brands include the Otago Cheese Company (based at what is now the Fonterra Stirling dairy processing plant near Balclutha)[204] and Mainland (based in Dunedin from 1966 to 2006[205]).

Fonterra is by far the largest processor, both in terms of annual turnover and milk products processed (Frontier Economics, 2019). However, there are more than 100 dairy processing enterprises in New Zealand, many of which are small-to-medium and niche processors serving the domestic market by providing premium products and serving local consumers (Coriolos, 2017). Other large-scale processors include Goodman Fielder, Danone, Synlait, Mataura Valley Milk and Open Country. Fonterra's share of milk solid volume has reduced since 2000 but remains dominant (Frontier Economics, 2019).

Currently, Fonterra have almost 400 supplying farms in Otago. These farms average 570 cows in herd size. These farms have added nearly one billion dollars to the regional economy over the previous dairy season. Of the 398 Fonterra farms in Otago, 305 have a Farm Environment Plan in place, through a programme delivered by Fonterra since 2018.

The Fonterra Stirling site employs around 120 staff with a focus on export cheese manufacture. Fonterra exports about 95 per cent of the production nationwide to more than 130 countries. The Stirling site exports to customers in more than 10 countries including Japan and South Korea.

Open Country Dairy have 30 dairy farmers supplying milk in Otago. They are an important part of the production even though not a large number in comparison with the number of farmers supplying to Fonterra. As with Fonterra, Open Country promote a Farm Environment Plan programme. A smaller number of farms supply milk to other dairy companies for example Danone, with a number of suppliers around Balclutha, and Oceania, with suppliers in the Waitaki district. In addition, there are several 'boutique' cheese retailers, including Whitestone cheese in Ōamaru[206] and Evansdale Cheese in Karitane.[207]

Most of the milk being produced in South Otago goes to the Mataura Valley milk processing plant in Southland, with some to Open Country at Awarua near Invercargill. Some of Otago's milk also goes to the Danone Nutricia Dairy Plant situated at Balclutha and to the Fonterra Stirling cheese factory near Balclutha. Depending on plant maintenance, milk is sometimes brought east from Southland to the Stirling cheese factory and similarly, sometimes Otago's milk is taken west to Fonterra's Southland processing plant at Edendale instead of to Stirling. Much of the milk produced in North Otago is processed in Canterbury, including at the nearby Oceania Dairy plant or the Fonterra Studholme plant.

203 https://builtindunedin.com/2019/10/26/co-operative-dairy-company-of-otago/
204 https://www.odt.co.nz/rural-life/dairy/further-success-stirling-plant
205 https://www.mainland.co.nz/our-craft/the-mainland-story.html
206 Artisan Cheese, Oamaru, North Otago, New Zealand (whitestonecheese.com)
207 Evansdale Cheese - a little taste of perfection

6.5.1 Economic contribution

The modern dairy industry supply chain is comprised of four main components: milk production, milk collection, processing, and marketing of processed goods. In terms of volume, milk processing is largely undertaken by farmer owned cooperatives, as is the case in many other countries, although there are different ownership models, including both supplier-owned and investor-owned models.

What is uncommon, in comparison to other countries, is the sizeable share of New Zealand dairy production that is exported, some 95 per cent. This circumstance makes the processing and marketing of milk products to overseas markets critical to the dairy industry's success (Frontier Economics, 2019).

The dairy industry is an important component of the New Zealand economy and one of the country's largest exporters by value, generating annual export revenue of around $19.1 billion in 2021. It is expected that the dairy industry will generate 41.2 per cent of the primary industries' export revenue in 2022, corresponding to a growth of three per cent from 2021. In 2021, New Zealand's top five dairy export markets were China, Australia, Indonesia, United States and Japan (Ministry for Primary Industries, 2021). New Zealand dairy exporters are largely 'price takers', in that they must accept the prevailing prices in the market rather than influencing the market price itself (Commerce Commission, 2016), which limits the ability for farmers and processors to pass on costs, including those associated with environmental management[208].

Nationally, dairying employed around 50,000 people in 2019, with around 70 per cent of these jobs being on farms and the remainder in milk and milk product manufacturing, providing $3.4 billion in wages (Sense Partners, 2020).

Dairying creates 5.6 per cent of all employment opportunities in rural Otago (those areas outside Dunedin city and the main towns), which is about four times higher than the national average for rural areas (Infometrics, 2020). Directly, dairy production and processing made a combined economic contribution to the Otago economy of $525 million in 2019, or 3.9 per cent of regional Gross Domestic Product (Sense Partners, 2020). Dairy-related roles are particularly important in the Clutha and Waitaki districts, representing 13.5 per cent and 8.1 per cent of total employment respectively (Infometrics, 2021).

Dairy production and processing also indirectly contribute to the Otago economy through employment of farm support services, for example, transport, packaging and dairy farm supplies and agricultural services. Dairy farmers are constantly seeking improvements in their farming systems, and this results in spending on new stock, fertiliser, and other inputs, upgrading equipment and infrastructure, improving land, and repaying debt.

Although surveys of the environmental expectations of consumers in major markets indicated New Zealand's 'clean green' image positively (Ministry for the Environment, 2001) and were willing to pay a premium for positive environmental and social attributes, it may be that in the future these expectations are fundamental consumer expectations in developed markets.

208 https://www.stuff.co.nz/business/farming/opinion/300590422/higher-farming-costs-will-quickly-start-eating-into-dairy-profits

7 Horticulture

Author: Leanne Roberts (Senior Environmental Policy Advisor) with contributions from Rachel McClung (Environmental Policy Advisor) and Ailsa Robertson (Environmental Policy Team Leader)[209].

This chapter outlines the horticultural sector in Otago, and includes information sourced from a variety of sources including interviews with an orchardist and market gardener, industry research and data[210], data from Statistics New Zealand, and reviews by product groups for summerfruit, apples and vegetables.

7.1 Summary

Horticulture has been long established in Otago having origins from the 1860s and the gold rush. Otago's climate and environment have resulted in a diverse range of horticultural crops being produced. Currently, the Central Otago area has become a hub for summerfruit production, with export cherries emerging as a dominant crop. There tends to be a more diverse range of crops grown in the Waitaki, Kakanui and other more coastal areas of the region.

Many factors contribute to successful horticultural operation in Otago, with climate, topography, soils, access to water and freight being some of the key contributors. Labour continues to be an ongoing challenge for horticulturalists in the region.

7.2 Size and distribution

Otago is an important horticultural production area in New Zealand. The region's unique climate and topography have created inland basins that have ideal growing conditions for orcharding (summerfruit[211] and pipfruit[212]) as well as river and coastal terraces that suit vegetable production. A wide range of crops are grown to support the local, domestic and export markets.

The distribution of commercial growing operations has evolved over time with changes in crops grown, locations and scale changing due to a range of factors such as market opportunities and succession planning. In 2021 there were over 190 growers in the Otago region[213] producing a wide variety of horticultural crops. Currently, the highest concentrations of growers are in the Central Otago and Waitaki Districts, with small numbers of growers located outside of these areas.

The land use maps in Appendix 1 highlight the key growing areas and locations of horticultural areas in Otago (HortNZ, 2022).

209 All Horticulture New Zealand.
210 A key source was Fresh Facts https://www.freshfacts.co.nz/
211 Summerfruit – stone fruit such as cherries, apricots, peaches, and nectarines
212 Pipfruit – the common name for pome fruit, e.g., apples and pears
213 Horticulture NZ and Product group industry records.

7.2.1 Changing scale in operations

The scale of operations of commercial fruit and vegetable production in Otago has changed, both spatially over the landscape, and over time. In general, there has been a decrease in overall growing area in recent times, and a possible consolidation of growing operations leading to a decrease in overall number of individual growing businesses. This section draws upon Statistics New Zealand information to depict these trends.

Figure 54 below shows the change in 'geographic units'[214] (i.e., a property) in horticulture over the past two decades. Since 2002 there has been a steady decrease in the number of geographic units in horticulture. This may be due to a general consolidation of smaller geographic units into larger ones across horticulture, as well as an increase in overall scale of orchards, and a gradual move from mixed fruit orchards to orchards centered on a single fruit – currently either cherries or apples.

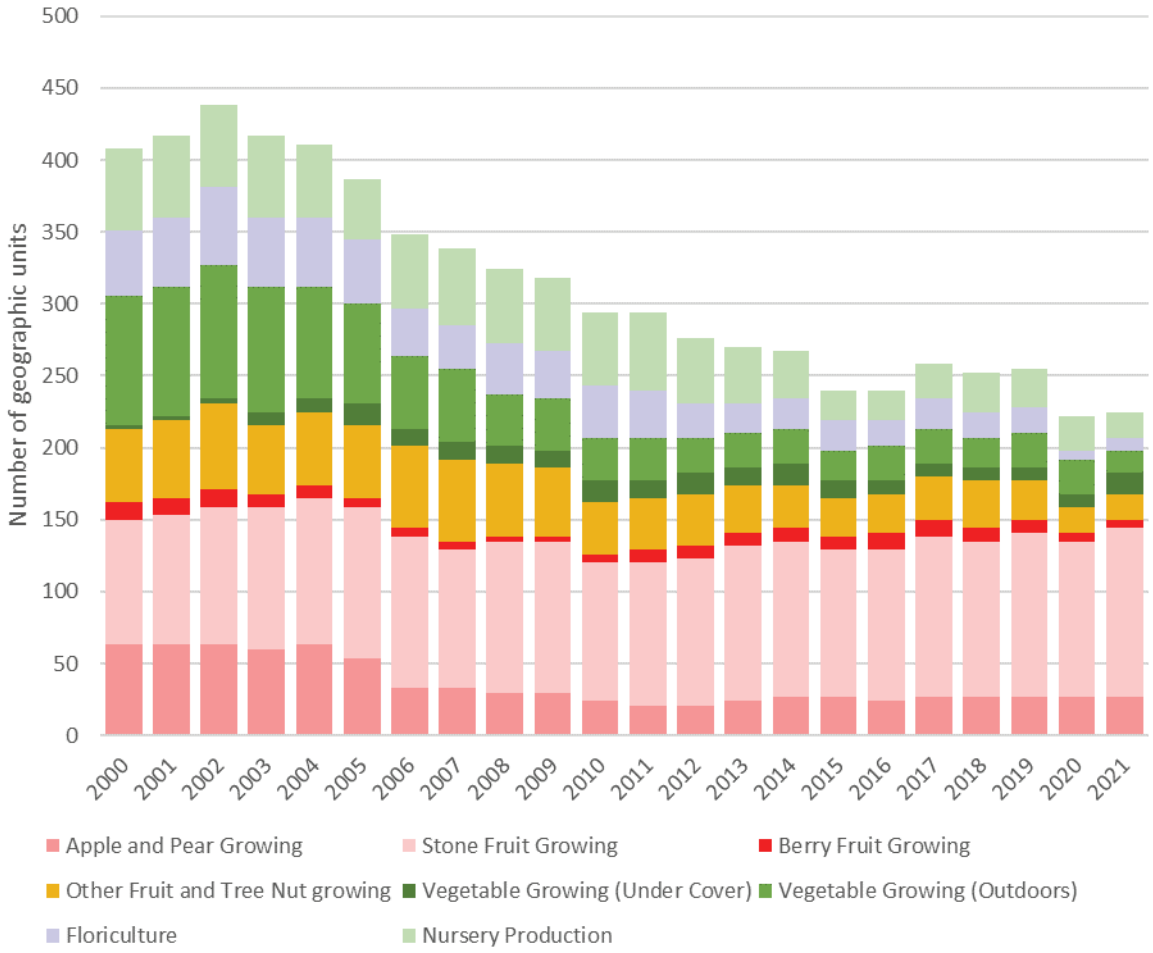

Figure 54: Geographic business units by horticulture industry in Otago 2000-2021
Source: StatsNZ

214 The geographic unit represents a business location engaged in one, or predominantly one, kind of economic activity at a single physical site or base (e.g., a factory, a farm, a shop, an office). Geographic units are unique to enterprises and an enterprise unit can have one or many geographic units (business locations). Typically, an enterprise unit only has a single geographic unit, unless the enterprise has paid employees who permanently work at more than one location. Geographic units can be transferred between enterprises (e.g., enterprise B purchases a factory, a geographic unit, as a going concern from enterprise A). https://datainfoplus.stats.govt.nz/Item/nz.govt.stats/bdb02aa2-866e-418f-83e8-342234867a0f

Figures 55 and 56 on the following pages show trends in the spatial extent of fruit and vegetable crops across Otago from 2002 to 2017 based on data availability (largely the years when NZStats Agricultural Production Surveys were undertaken). Over this time there was an overall decrease in the total land area planted in fruit, nuts, and olives across the region, particularly pipfruit (-50%) (Figure 55).

To illustrate this point, it was during this time that the four remaining apple orchardists on the Taieri Plains exited the industry – one turned to other fruit and vegetables, two are lifestyle blocks where the apple trees still exist, and one is now a residential subdivision (P. Russell, pers. comm., September 2022). A decline in berryfruit, however, occurred just before this time – from 59 hectares in 1998 to 15 hectares in 2002 – and then increased to 36 hectares in 2017. There has also been a marked decline in the total area of vegetables grown in 2017 when compared with 2002 with roughly 320 less hectares (-43%), with peas and beans no longer evident and all other crops except potatoes less extensive (Figure 56).

Various horticultural crops require differing growing conditions and a crop's total land area does not always fully reflect its importance. Some crops tend to use more land than others and, even within a crop type, the land required for economic or commercial viability can also depend on the production system. For example, the Upright Fruiting Offshoots (UFO) method of growing is higher density compared with traditional cherry tree orchards and can influence fruit quality, yields, and production efficiencies[215]. Further to this, hydroponic operations have high production on a small land area footprint. There are also examples of orchards being grown in artificial crop protection structures (e.g., Clyde Orchards[216]).

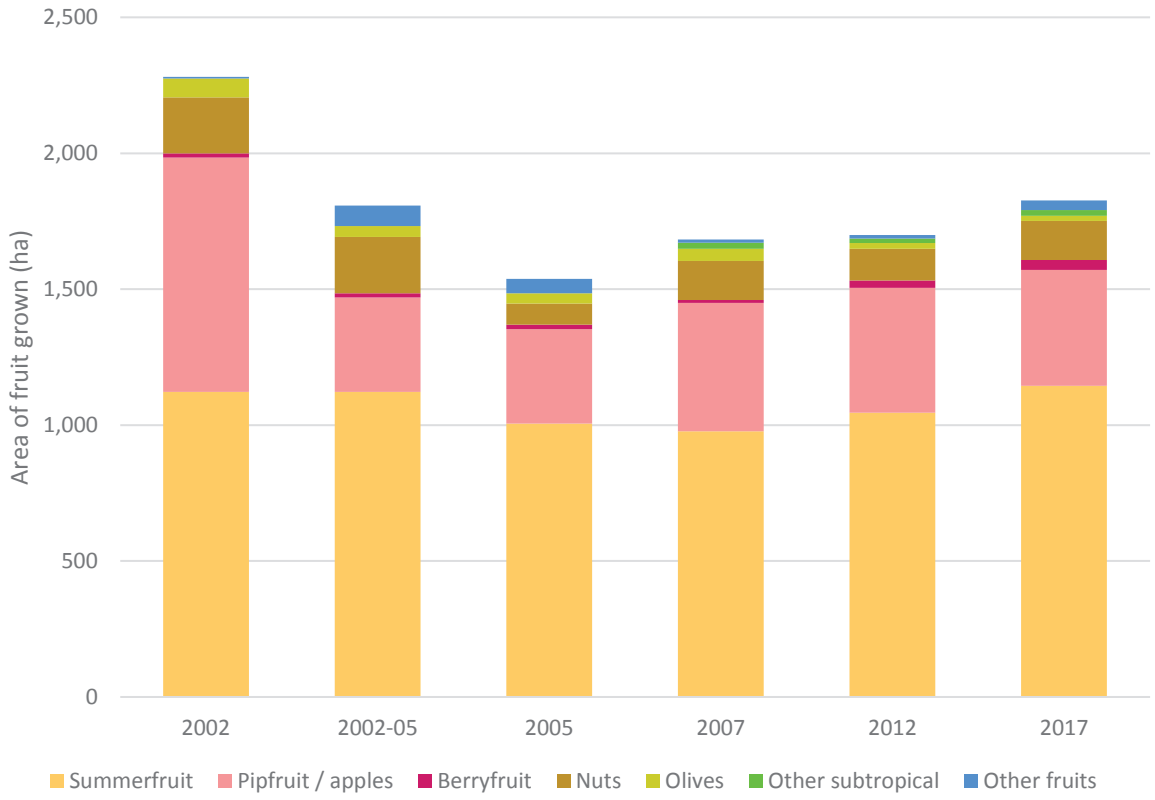

Figure 55: Changes in the extent of fruit crops grown in Otago (for years data was available) 2002 - 2017
Source: Fresh Facts 2005-2018[217]

215 How UFOs can improve sweet cherry production - ASHS
216 https://www.clydeorchards.co.nz/
217 https://www.freshfacts.co.nz/

Figure 56 shows the trend of vegetable production by crop and area in Otago from 2002 to 2017. While vegetable production can be harder to track because of crop rotations and the use of lease land, the general trend in the region is a decline in overall vegetable production area. This situation may be partly explained by urban development into vegetable production areas close to larger urban centres.

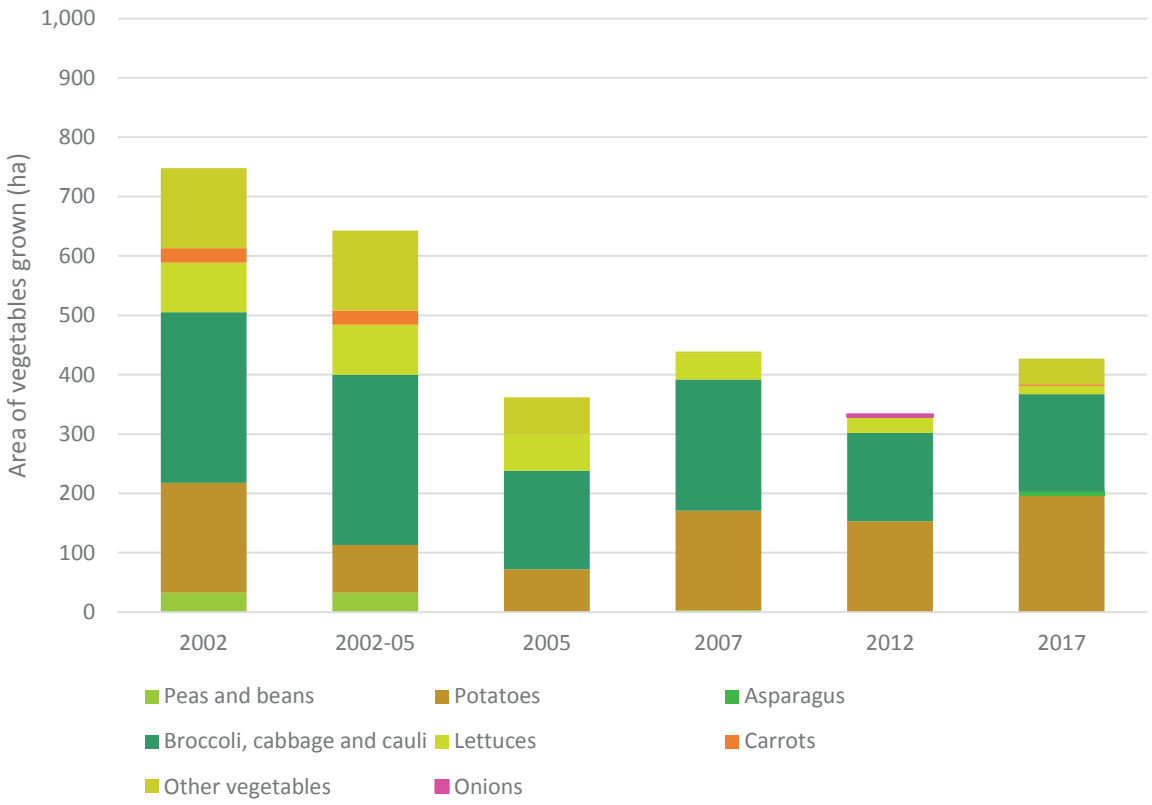

Figure 56: Changes in the extent of vegetables crops grown outdoors in Otago (for the years data was available) 2002-2017
Source: Fresh Facts 2005-2018

Horticulture in general, and particularly fruit production, is a low emission land use option. It is anticipated that summerfruit production in Central Otago will increase by 15 per cent by 2025-26, including some from new orchards[218]. However, this future growth is dependent on water availability and reliability, which is an ongoing challenge. Water and other resource constraints (land and labour) are covered in following sections.

7.3 Growing hubs

The distribution of growers has been influenced by various factors, such as land and labour availability, topography, the quality of soils, climate, and distance to markets. Over time, these factors have changed the demand for land through the influence of better transport links, as well as the emergence of technologies, such as greenhouse, cool stores, irrigation, and frost fighting. More recently, other factors have emerged to create more competition for land and water (e.g., dairying in Waitaki, housing subdivisions in Mosgiel).

218 38290 A4 REPORT Central Otago Labour Survey.pdf (codc.govt.nz)

In the past, there were many growers in and around Dunedin, although their numbers are now limited (5%), and most are now concentrated in the Central Otago District (85%) and Waitaki District (10%). Many horticultural operations have developed in satellite areas of townships, and critical infrastructure (e.g., roading) gives ease of access and transportation of produce into larger markets based in urban centres, such as Dunedin. Areas where there was once market gardens and commercial vegetable operatons, such as the lower Taieri, have now been developed into housing. An overview of the history of horticulture in Otago is included in Section 7.11.

Different areas within Otago have become hubs for different crops. Central Otago is generally known for summerfruit and pipfruit, which are perennial crops[219]. The climate and topography lend themselves well to orcharding in Central Otago. Waitaki tends to focus on fresh vegetables (e.g., brassicas, potatoes, and lettuce) and some fruit (e.g., tomatoes), which as annuals can shift quickly to meet market demand. There are also a small number of hydroponic and covered cropping operations in Otago[220]. Overall, there are far fewer commercial vegetable growers operating compared with a generation ago. This said, there are still growers of all crop types scattered across the region, as well as growers of berry fruits[221].

There are other examples of the diverse range of horticultural operations. Plantings of hazelnuts and walnuts along with olives have occurred as well (e.g., Central Nuts, Hazelnut Estate[222], Dunford Grove[223]) that add to the diversity of crops grown, although they do tend to be more lifestyle-scale enterprises. A small area of sub-tropical fruits is grown in Otago, which may be crop trials. Other crops include cut flowers, flower seeds and bulbs (e.g., Alpine Blooms[224] and Wanaka Lavender[225]).

7.3.1 Central Otago – orcharding hub

The hot, dry summers and cold, dry winters in Central Otago comes close to a continental-style climate and means the area is especially well suited to growing a range of high-quality crops[226]. Central Otago is the main commercial growing area in New Zealand for summerfruit and accounts for 59 per cent of the country's planted summerfruit orchards. Other summerfruit regions include Hawkes Bay (31%), north of Auckland, Marlborough, and Canterbury (10% combined)[227].

Around half of New Zealand's summer fruit production is based in Central Otago, with cherries and apricots being the dominant crops[228]. In addition, cherries make up about half of New Zealand's summerfruit production, and 70 per cent of cherries are exported. Nectarines, peaches, and plums are almost exclusively produced for the domestic market, and 70 per cent of the apricots are for the domestic market[229]. Central Otago's fruit production season extends that of the North Island so fresh summerfruit is available for three to four months (rather than just one to two months).

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219 In addition to Horticulture New Zealand, summerfruit growers are represented by Summerfruit New Zealand https://www.summerfruitnz.co.nz/about-us/ and pipfruit growers are also represented by New Zealand Apples and Pears: http://pipfruitnzstories.co.nz/#welcome

220 Horticulture NZ industry statistics.

221 https://waitakiorchards.co.nz/

222 https://www.otagofarmersmarket.org.nz/hazelnut-estate

223 https://dunfordgrove.com/

224 https://www.alpineblooms.co.nz/what-we-grow-in-wanaka/

225 https://www.wanakalavenderfarm.com/

226 NIWA Otago Climate WEB (002).pdf (niwa.co.nz)

227 https://www.summerfruitnz.co.nz/industry/ . It includes issues of the Summerfruit magazine, which was produced from April 2015 to September 2020, and the Prunings newsletter, as well as annual reports and market updates.

228 Peaches, nectarines, plums, and other stone fruit also grown in Central Otago but at a smaller scale. Industry - Summerfruit NZ

229 https://www.freshfacts.co.nz/files/freshfacts-2020.pdf

Cherries have been expanding rapidly as a crop since 2013 after a series of successful growing seasons, the development of higher density growing systems, and growing international demand for a premium product, particularly from China (Witheford, 2018). An important feature is the high diurnal temperature range (the difference between daytime and night-time temperatures). Due to the continental-type climate in Central Otago, the diurnal temperature range is large and contributes to the sweetness and firmness of Central Otago cherries and is one of the main reasons why Central Otago is a highly desirable location for summerfruit production (Witheford, 2018).

In contrast, the soils tend to be poor (although there are some exceptions) and need irrigating – they are not usually an important consideration in the district other than that they are free draining (S. Ford, pers. comm., June 2022). With that said, there are areas within Otago that have Land Use Capability Class 1 to 3 soils[230]. Dry Central Otago soils generally have low organic matter. However, there are pockets of soils, such as the Waenga fine sandy loam, that are well suited to orcharding and the addition of water allows plant growth and deposition of fresh organic matter, which increases the organic matter over time (Leamy and Saunders, 1967).

There are different growing considerations up and down the Clutha catchment (S. Webb, pers. comm., May 2022). At Ettrick (south of Roxburgh) land is more readily available but there are not the same climatic advantages of the Cromwell Basin and labour can be relatively more difficult to come by. In the Cromwell Basin the climate is hotter and dryer, and so has more horticultural 'heat units', which helps to control of pests and disease as well as increase the growing size of the fruit. Climatic factors are more important than versatile soils – orchards in areas with soils that range between Land Use Capability Classes 3 to 5, not considered the most productive soils for arable cropping but suitable for orcharding[231]. Frost is an ever-present issue for growers.

7.3.2 Waitaki and Dunedin – vegetable production hubs

The Waitaki area, particularly surrounding Ōamaru has a high proportion of Land Use Capability class 1-3 land, meaning it is highly productive or well suited to horticultural production[232]. Typically, the land is flatter, as with other coastal areas in Otago. There is comparatively less rainfall around Ōamaru compared with Dunedin and surrounds, but more than what is experienced in the Central Otago area[233]. These factors have traditionally lent Waitaki towards more diversity in horticultural production – there are more commercial vegetable operations in this area than compared with inland areas of Otago although there has been a marked decline in recent years. This situation is attributed to reasons such as challenges with supermarkets, business succession, increased urbanisation, and climatic conditions.

Dunedin and surrounds included Mosgiel, Outram and Waikouaiti[234]. The average number of days where 1mm or more rainfall recorded for Dunedin is 178 days, with peak rainfall occurring in Late Autumn (April). In contrast, dry spells, when there is less than 1mm of rainfall is recorded for 15 or more consecutive days occur once every thirteen months in Dunedin. Comparatively, for the Otago region, Dunedin has more rainfall and fewer dry spells than other areas[235]. There is a significant area of Land Use Capability Classes 1 to 3 land, particularly in the Taieri/Mosgiel area. The presence of high value soils is a key reason why this area has been an important location for commercial horticultural production in the past. The gentler topography means the area is better suited for commercial vegetable production, in particular[236].

230 Land Use Capability » Maps » Our Environment (scinfo.org.nz)
231 Land Use Capability » Maps » Our Environment (scinfo.org.nz)
232 Land Use Capability » Maps » Our Environment (scinfo.org.nz)
233 Otago Climate WEB (002).pdf (niwa.co.nz)
234 Land Use Capability » Maps » Our Environment (scinfo.org.nz)
235 NIWA Otago Climate WEB (002).pdf (niwa.co.nz)
236 Land Use Capability » Maps » Our Environment (scinfo.org.nz)

7.4 Economic overview

Growing is one part of the food supply system. Fruit and vegetables grown in Otago are packed and distributed to domestic and export markets through packhouses, processors and wholesale distributors. In some cases, produce will be transported to wholesalers and wholesale markets in larger centres like Christchurch and Dunedin. In other cases, more local packhouse and processing facilities specific to a crop or a market will facilitate the packaging and distribution of produce[237]. The economic value to Otago extends beyond the grower's gate and includes these market supply and infrastructure services.

Packhouses range in scale and purpose. From single grower-packhouse operations to large-scale packhouses processing multiple growers' produce for a range of markets. CAJ van der Voort packhouse is an example of a local, specialised packhouse based in the Teviot area of Central Otago primarily packing and exporting pipfruit grown in the Otago area.

Since the development of cool storage allowed for the transport of fresh produce, New Zealand's exports of horticultural products (not including wine) have been predominantly fresh fruit crops that either have a relatively high value and/or longer shelf-life (e.g., apples and kiwifruit). Figure 57 shows how the mix of horticultural exports has changed since 1965, reflecting a range of factors, including changes in market access (e.g., the Australia apples dispute[238]), new trade agreements, shifts in consumer demand (especially in Asia), as well as the development of new crops (e.g., kiwifruit and avocadoes), crop varietals and production systems. Cherries and apples are currently Otago's two most valuable horticultural exports, cherries being New Zealand's fourth highest horticultural earner (behind kiwifruit, apples, and avocados)[239].

In contrast, vegetable crops grown in Otago tend to be for the domestic market. The local markets revolve around supplying supermarkets, wholesalers, and restaurants across the region[240]. There will be some direct farm-gate sales and through well-established farmers markets (e.g., Cromwell, Ōamaru, and Dunedin). The commercial growers who supply fruit and vegetables to the Otago Farmers Market[241] in Dunedin tend to come from Kakanui, Wingatui, and Central Otago.

Through these avenues many growers have direct relationships with their consumers and now have their own websites, which usually includes their individual food story. This reflects the shrinking scale of the commercial vegetable industries in Otago with more instances of growers growing for local farmers markets. The local wholesale market has declined in recent years with fewer vegetable growers and a move towards centralized distribution for supermarkets. Direct sales – as well as the backpackers – are evidence of connections between horticulture and tourism and are more evident in the summerfruit and pipfruit industries.

Following the poor apple harvest in 2004-05, the value of New Zealand's apple exports has been climbing from around $350 million in 2012 to $900 million in 2020 – with Otago's share being five per cent (roughly $45 million) based on area planted (Fresh Facts Data Tool, May 2022; Fresh Facts, 2020). The value of New Zealand's pears has sat fairly consistently between $8 million and $11 million since 2009, with the exception of a drop in 2012 (Fresh Facts Data Tool, May 2022).

237 story | CAJ Apples
238 https://www.mfat.govt.nz/en/trade/trade-law-and-dispute-settlement/previous-wto-disputes/australia-apples-dispute/
239 https://www.freshfacts.co.nz/files/freshfacts-2018.pdf
240 KPMG-2017-NZ-domestic-vegeable-production-.pdf (hortnz.co.nz)
241 https://www.otagofarmersmarket.org.nz/

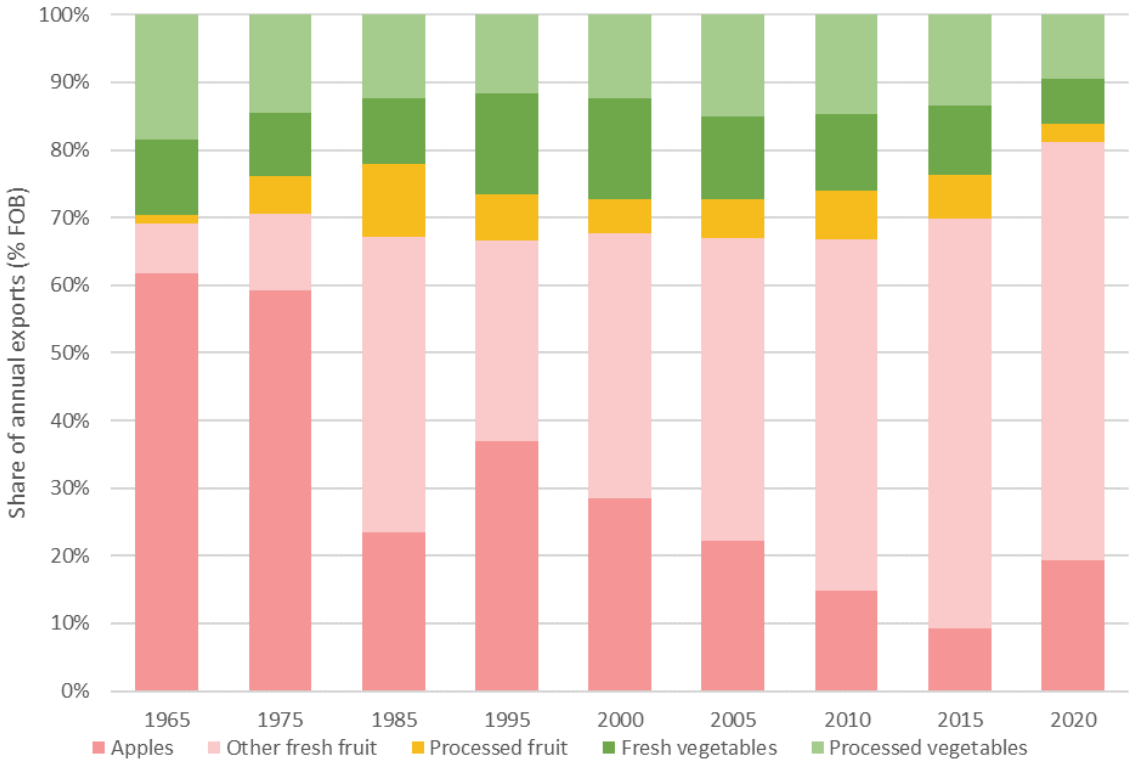

Figure 57: Mix of horticultural exports (not including wine) from New Zealand 1965-2020
Source: Fresh Facts 2005-2018[242]

New Zealand cherries receive a consistent price of 50% or more over key competitors, such as Chile, and the value of this country's cherry exports reached over $80 million in 2018 and otherwise has been around $70 million since 2016[243]. The value of exports of apricots from New Zealand (almost all of which are grown in Central Otago[244]) has ranged since 2002 between $2 million in 2016 and over $10 million (Fresh Facts Data Tool, May 2022). Small volumes of peaches, nectarines, and plums are also exported – mostly to the Pacific and the USA, with recent interest from Hong Kong for peaches and nectarines[245].

The input costs of production for growers across the country have increased since 2019 across key areas like fuel, fertiliser, and labour – in some case dramatically. Growers, particularly those supplying the domestic market, are usually price takers and have not received a significant increase in the first point of sale price for over 15 years. Despite the increases in the cost of some fruit and vegetables experienced by consumers, growers are often not seeing those returns to compensate for increasing costs of production[246]. Consequently, growers are looking for internal ways to create cost efficiency or having reduced margins. This situation contrasts with the prices that consumers paid[247].

242 https://www.freshfacts.co.nz/
243 Horticulture New Zealand submission to proposed Otago Regional Policy Statement 2021
244 https://www.centralotagofruit.co.nz/our-growers
245 https://www.summerfruitnz.co.nz/industry/export/
246 Annual inflation reaches 30-year high of 6.9 percent | Stats NZ
247 HortNZ-Submission-nz-grocery-code-of-conduct.pdf

7.5 Highly productive land

Otago's most fertile and versatile soils are predominantly coastal[248]. Traditionally, coastal areas have been hubs for horticulture, both because of their soils and close proximity to markets and consumers. The topography lends itself well to commercial vegetable production.

Horticulture needs fertile and versatile land to be able to thrive. The National Policy Statement for Highly Productive Land 2022 requires local authorities to protect the most versatile soils (i.e., Land Use Capability Classes 1 to 3) for use in land-based primary production. However, there are pockets of other soils in Central Otago growing area (i.e., Land Use Capability Class 3 and 4) that can be better suited to summerfruit orchards but are less useful for other types of primary production.

Vegetable production requires rotation of crops in specific sequences, on different parcels over space and time, to manage soil health and plant pest and diseases. Vegetables are grown most efficiently and sustainably on the best and most versatile soils, Land Use Capability Classes 1 to 3. Vegetable production is constrained by the location and availability of owned and leased land parcels. The productive capacity of the soils is not limited to the soil properties and favorable climate – it also includes the size of land parcels to be able to manoeuvre production machinery, the location and distance from packing/processing and market, degree of fragmentation of blocks across the landscape, and availability of water to grow the crops.

With the decline in the number of vegetable growers and increases in land prices, the competition for land has resulted in changes in land use in the lower Taieri and Waitaki.

7.6 Land ownership, leased land and crop rotations

Horticulture is a complex sector encompassing a wide range of crops, growing systems, and industries[249]. Within each product group, there are many different growing methods commercial operations use to produce vegetables. A range of considerations are important when determining whether a site is suitable for horticultural use, and it can be dependent on the crop to be grown.

One unique feature commonly found in commercial vegetable operations, is the use and reliance on lease land for vegetable production. Lease land is an effective tool for managing crop rotation as it provides new land to incorporate into a rotation plan. In many cases rotation is an important tool for managing disease and pathogens that can be present in soil for years in the absence of a susceptible crop[250]. Crop rotation can also assist with nutrient management as well as pest and disease (including weeds) management[251]. In many cases, an arable crop may be integrated into the rotation as these species differ from vegetables crops and make good rotational partners, with stock grazing crop residue[252] .

It is usual for a vegetable growing operation to have a mix of all or part-lease land as part of its growing area. As such it can be difficult to identify and define the level of vegetable production in any locality around New Zealand. A growing operation may be quite large, but the proportion of owned land may be small. This circumstance may impact on a growers' ability to secure finance for changes to their operations.

248 Land Use Capability » Maps » Our Environment (scinfo.org.nz)
249 About us | Horticulture New Zealand — Ahumāra Kai Aotearoa (hortnz.co.nz)
250 Importance of Crop Rotation (bayer.com)
251 Importance of Crop Rotation (bayer.com)
252 Importance of Crop Rotation (bayer.com)

Planning the order of crops in a rotation is designed to minimise soil-borne pathogens that appear when the same/related crops are grown in sequence in the same soil. For example, brassica crops like cauliflower and broccoli suffer clubroot disease if grown recently after another brassica crop, the pathogens can remain active in soil for decades. Production location and timing is carefully managed to ensure reliability of supply and match crop with soil characteristics. Planning a rotation is done over a year in advance as seeds and many other inputs must be ordered in time to ensure availability. Most vegetable seed used in New Zealand is sourced overseas, and with recent pandemic related supply challenges, growers have needed to order more than required, and be trialling new varieties, to respond to fluctuations in supply, market demands, and weather.

Horticulture in Otago uses a small land area in comparison with other sectors and produces large yields of high value crops per hectare of land. Consequently, there is a wide range in the sizes of growing businesses, and a minimum economic unit can be as small as a couple of hectares for some crop types and production systems. Over time horticultural business are becoming fewer in number but larger in size – individually and in total. The current trend is towards larger corporate operations establishing that has contributed to the rapid growth of cherry production in Otago. Summerfruit and pip fruit growers do use lease land, usually on longer term leases or as a lease of an existing orchard or management services as tree crops are in place for a number of years. Reliable water supply and length of consents are contributing factors in an orchard's planning and infrastructure.

In the Waitaki District, the rich loamy soils and microclimate are well-suited to high-quality vegetable production. Over the past generation more traditional crops, such as peas, beans, and carrots, have tended to be phased out and a much wider variety of fruit and vegetable crops are grown, including some using organic production systems. These crops include yams, carrots, courgettes, leeks, cabbage, pumpkin, potatoes, lettuce, broccoli, cauliflower, silverbeet, spring onions, celery, leafy greens, salad greens, Brussels sprouts, tomatoes, asparagus, cucumber, apples, pears, nectarines, peaches, plums, blackcurrants, raspberries, strawberries, and cherries. Ōamaru's Jersey Benne potatoes are sought-after, especially at Christmas time. In addition to market gardens around Ōamaru, there are summerfruit and pipfruit orchards and berry farms around Georgetown in the Lower Waitaki Valley.

7.7 Labour and employment

The mix of pipfruit and summerfruit (along with viticulture) creates an extended labour season in Otago, with work typically available for up to six or seven months in Otago (Druce, 2018). The seasonal labour force is usually supplied by workers imported into New Zealand through the Government's Recognised Seasonal Employment (RSE) scheme, backpackers and during the holidays, by domestic students. It is likely that much of what is earnt is returned to the regional economy via the service sector, which includes tourism[253]. Seasonal work has become a feature and a draw card for many working holiday visa holders and the horticulture industry creates opportunities to attract working-holiday visa holders.

Figure 58 shows the change in employment in horticulture over the past two decades and, in contrast to the decrease in the number of geographic units, it highlights a steady increase overall in the number of jobs, especially since 2006.

During this time period some industries have had mixed fortunes (e.g., floriculture) while others (e.g., vegetable growing) have remained relatively stable. This suggests that some types of horticultural production that are more labour intensive may have increased in scale, while other horticultural types,

253 38290 A4 REPORT Central Otago Labour Survey.pdf (codc.govt.nz)

which may be less labour intensive, have reduced in scale. Together, the changes in 'geographic units' (see Section 7.2) and employment suggest increasing scale in the summerfruit industry. The peak employment season for summerfruit is December to January during harvest. Most harvesting is still done by hand, with a large demand for seasonal workers and there is considerable pressure to find accommodation to house the additional workers needed through this period (Huffadine, 2021). This situation is made more difficult by the high cost of housing in Otago.

Covid-19 has caused a lot of disruption and has been keenly felt through acute labour shortages that are expected to continue through the current and potentially future seasons[254]. The labour shortages have brought to the fore many discussions about technology and the ability to alleviate labour supply issues in the future.

Figure 58: Employment by horticultural industry in Otago 2000-2021
Source: StatsNZ
Notes: The data is a headcount of all salary and wage earners in February of each year and does not include business owner-operators.

254 Labour considerations and preparations | Horticulture New Zealand — Ahumāra Kai Aotearoa (hortnz.co.nz)

7.8 Food security

While New Zealand is a net exporter of food, many vegetable crops and some fruit crops are only grown for domestic food supply. Growing fruit and vegetables in a variety of locations across New Zealand is efficient because it takes advantage of the different climates, harvest timings, close proximity to population centres, and minimises risk from disruptive events (e.g., weather event, natural disaster, biosecurity incursion).

The growing of vegetables for domestic supply is integrated with vegetables grown for export in crop rotations. The national food producing system relies on growing vegetables and fruit in pockets of highly productive land, with good climate and access to fresh water. Fruit and vegetables are essential for the human health of New Zealanders. Otago has a mixture of horticultural crops grown for produce, processing export and domestic markets.

The decline in commercial vegetable production leaves Otago more dependent on other growing areas around the country. With the advent of centralized distribution of supermarket goods, much of the produce Otago needs for its community comes from further north. Supply chain disruptions, as seen after the Canterbury and Kaikoura earthquakes and as a result of Covid-19, are likely to cause greater impact on a community reliant on food being supplied from outside of region, than production areas. Summerfruit crops such as apricots, peaches, nectarines and plums are produced primarily for the domestic market and are seasonable rather than year-round.

There are three main distribution channels: retail, foodservice and exports (Deloittes, 2018). For most vegetable crops, the primary market is the domestic market, but many growers also produce export crops within their rotations for practical (soil health) and economic reasons. For example, onions, which are predominantly grown for export, are grown with other vegetables crops in rotation. Onions when grown in rotation with non-allium crops promote soil health.

New Zealand has an important role in exporting fresh vegetables to the Pacific Islands, which have limited ability to grow their own[255]. New Zealand and the neighbouring Pacific Islands are too remote to import many fresh vegetables from elsewhere in the world. Most vegetables that New Zealand imports are processed. In 2019, the most imported vegetables were preserved tomatoes and frozen potatoes.[256]

Some fruit crops grown in New Zealand have a predominantly export focus – for example, it has been estimated that 95 per cent of kiwifruit (although not grown in Otago) and 83 per cent of apples are exported[257]. These two crops account for approximately 75 per cent of New Zealand's fruit and vegetable exports[258]. Cherries, which are grown extensively in Central Otago, are the fourth largest export crop[259]. Many growers of apples and cherries tend to focus on exports (e.g., Darlings Fruit[260] and 45 South[261]).

255 https://wits.worldbank.org/CountryProfile/en/Country/WSM/Year/2019/TradeFlow/Import/Partner/all/Product/16-24_FoodProd

256 Plant and Food, Fresh Facts 2019

257 NZIER, 2019. Farm share of retail prices. Analysis of domestic farmer margins in a globalised world.

258 Fresh facts 2020 data, as a proportion of total horticultural exports (excluding wine, hops, and 'other horticulture').

259 Industry - Summerfruit NZ

260 https://www.darlingsfruit.co.nz/

261 https://45s.co.nz/

7.9 Irrigation systems and management

Access to water and irrigation are important aspects to any horticultural operation. In areas such as Central Otago, the land being irrigated does not receive enough rainfall to ensure crop survival[262]. Irrigation can have a dual purpose, in orchards overhead sprinklers can be used for frost protection as well as for maintaining soil moisture.

The purpose of irrigation is to maintain optimum soil moisture levels for crops to thrive. Growers, be that orchardists or commercial vegetable growers, employ a variety of tools, methods, and services to help make good decisions for their operations. Some larger operations may have their own tensiometers[263] installed to directly measure their soil moisture levels, other operations use services of advisers specifically trained in this area to take measurements, design and install irrigation systems, and offer irrigation advice. Fertigation[264] can also be run through some irrigation infrastructure. Most operations will have irrigation systems in place that best meet the needs of their crops. Overwatering can cause leaching of nutrients and anaerobic soil activity that limits root growth[265]. Just as underwatering can negatively impact a plant's growth, so can overwatering.

Table 14 gives crop water demand and use varies throughout a season. It refers to crop water demand at different stages of plant growth and through the growing season and is based on the water demand requirements of a mature orchard. A new operation with younger plants may have different requirements. This does not account for water used for any other purpose than crop growth (e.g., frost protection, washing).

Table 14: Irrigation Parameters for Cherries and Apricots[266]

Crop	Kc[267] (initial, middle, end)	Rooting depth (metres)
Cherries	0.8, 1.12, 0.85	1.0
Apricots	0.8, 1.15, 0.85	1.0

Source: Allen et al. (1991)
Note: 'initial, middle, end' indicate how crop water use varies during the season

Demand for irrigation peaks during October – April[268] and, as mentioned earlier, some parts of Central Otago are considered arid and, without access to irrigation, crops would not receive enough water from rainfall to survive. Orchardists focus on water and efficiency as part of their operations and, as trees are a permanent crop, they need water reliability for continued viability.

Vegetable crops are predominantly grown around Ōamaru. Vegetables are largely irrigated using travelling gun irrigators, centre pivots and moveable aluminum pipes[269]. Vegetable operations generally use crop rotation as a best practice for soil and plant health, so water needs for a commercial vegetable operation will vary from month to month, season to season and year to year depending on the stage of a grower's crop rotation plan[270].

262 Irrigation in New Zealand : IrrigationNZ
263 Tensiometer - an overview | ScienceDirect Topics
264 Fertigation is the application of liquid fertilisers through and irrigation system
265 Irrigation Scheduling | Fruition Horticulture

Image 38: The effects of sprinkler frost protection at a summerfruit orchard at Hercules Flat (Roxburgh)
Source: Sam Hobbs (Summerfruit Grower, Roxburgh)

Some orchards may use one or a combination of four irrigation systems:

Movable aluminum pipes: While less common, there are still some rare cases of orchards using this method of irrigation in Otago. Pipes are towed, put into place, connected to water, and left to irrigate sections of an operation at a time. Once the irrigation is complete, pipes are deconstructed and moved to another area of the operation to irrigate. The pipes can be towed by a tractor and moved through an orchard or to another site as a grower requires. While this system is less efficient with water use it can be useful for smaller orchard blocks[271]. Vegetable growers may use this system of irrigation as infrastructure is less permanent and more easily able to be moved.

Overhead sprinklers: These can be used for frost protection and for irrigation of crops. Some operations have frost fans in place as well as use overhead sprinklers. The use of irrigation for frost fighting works via the latent heat of fusion. When liquid becomes solid, or molecules change state, energy is released. Continual application of water is required to ensure this method of frost protection is effective and can be used to protect against frosts down to -6 degrees Celsius[272]. If the water supply stops, heat is lost, and refrigeration occurs[273]. Frost fans work by drawing down warmer air from the invection layer into the orchard and are effective for protecting against frost down to -2 degrees Celsius[274]. Often the two systems can be run in conjunction with one and other.

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266 aqualinc-irrigation-guidelines-2015.pdf (orc.govt.nz)
267 Kc – Crop coefficients for irrigation
268 aqualinc-irrigation-guidelines-2015.pdf (orc.govt.nz)
269 aqualinc-irrigation-guidelines-2015.pdf (orc.govt.nz)
270 Importance of Crop Rotation (bayer.com)
271 Personal communication with Summerfruit technical advisor
272 Microsoft Word - 2022-02-01 Field Notes-Frost Protection.docx (rainbird.com)
273 *Frost protection using sprinklers: how it really works – wineanorak.com*
274 Review-of-District-Plan-Frost-Fan-Provisions-2022.pdf (hortnz.co.nz)

Under canopy sprinklers: These are spaced evenly between trees to water the root system of trees. Irrigation lines can be subsoil or above soil.

Drip-line irrigation: Drip-line Irrigation is a considerable investment but is considered the most efficient method of irrigation in terms of water use. Many drip-line systems are run in conjunction with smart tools and telemetry, so water use is monitored in real-time and precise.

7.10 Advisory services and nutrient management

Growers use external consultants and trusted advisors, as well as in-house expertise and teams. Growers seek advice on topics ranging from production and production efficiency to regulations and consents. Some growers can use upwards of eight to ten different advisers to manage their growing operations. The horticultural support industry is substantive and provides a range of decision-making support tools and advisers for growers.

Some orchards choose to engage an external management organisation to run the day-to-day decisions on orchard and fulfil compliance requirements. In-house expertise is another form of advisory service in horticulture more typical in large vegetable growing corporates. Large corporates can employ hundreds of staff, from seasonal employees for planting and harvest, to full-time operational teams of crops specialists and agronomists, responsible for the day-to-day operations for specific crops and rotations. These businesses may also engage external providers for specific products and services, for example, seeds, fertilisers, engineering design, and resource consents.

Importantly, growers and producers are at the heart of the advisory system. Relationships and trust are the foundation for advisory services provision, and producers perceive advice to be legitimate if they have an established and long-term relationship with an advisor. Some consultancies offer an overlap in management areas, however despite this, growers will tend to work with individual advisers they know and trust, rather than a one-stop-shop. This is similar to client-consultant relationships in other sectors like engineering.

The horticultural sector has invested in research and development over the years which has informed much of the advice and best practice guidance in place today[275]. In addition, each product group runs research projects specific to their crops or grower locations. This can be done in collaboration with product groups or through a forum such as the Vegetable Research and Innovation Board[276]. This research helps identify new innovative ways for the industry to address environmental challenges and grow crops more sustainably[277]. The horticultural sector has a close working relationship with Plant and Food Research[278] and can use product groups, grower networks and industry accreditation programmes to promote research-driven change through the industry.

Growers use Good Agricultural Practice (GAP) programmes to meet market and regulatory requirements. GLOBALG.A.P. is used by growers to meet overseas market requirements, and NZGAP is used by growers supplying the domestic market. Growers can be both GLOBALGAP and NZGAP certified. GAP schemes certify that growers are producing fruit and vegetables safely and sustainably and meet the applicable

275 Reports & research | Horticulture New Zealand — Ahumāra Kai Aotearoa (hortnz.co.nz)
276 Vegetable Research & Innovation Board - VR & I (vri.org.nz)
277 Resources | Horticulture New Zealand — Ahumāra Kai Aotearoa (hortnz.co.nz)
278 Sustainable, resilient food supply · Plant & Food Research (plantandfood.com)

market and regulatory requirements. In many cases, markets, and customers require NZGAP or GLOBAL GAP as a requirement before a grower will be approved to sell through that market. The GAP programmes are designed in a modular approach, where growers can meet requirements for food safety, employment law, and environmental regulation, through one process and audit. GAP has been providing assurance to markets and New Zealand regulators for almost 25 years.

Growers use GAP to manage environmental challenges of freshwater and climate change. For example, growers using the Environment Management System add-on to GAP, can use over 60 practices to manage their nutrients, soils, and irrigation to good and best management practice. GAP requires growers to takes a holistic approach to nutrient management: from a businesses' environmental policies to staff training, soil testing and crop budgets, fertiliser recommendations, to the control of each fertiliser application in each paddock (right product, right rate, right time, right place) for each crop. This process requires checks and balances throughout a grower's decision-making, that is subject to the scrutiny of independent audit and re-certification. Over 90 per cent of commercial fruit and vegetable growers in New Zealand are GAP certified.

7.11 History and local features

The long history of horticulture in Otago and its close connections to local communities, through income, employment, and the supply of a wide range of fresh fruit and vegetables, has resulted in an industry that is an important part of the character of the region. The industry's main features are multi-generational family businesses, immigration and multi-culturalism, a diverse range of high-quality crops and production systems (with a fairly unique productive capacity in Central Otago), and an ongoing dependence on water availability to maintain crop quality and yields. Orcharding and market gardening is viewed as an important part of the rural character within Otago by the local community[279].

The story of the Chinese market gardens and growers in Otago is important and particularly well documented in the book Sons of the Soil (Lee and Lam, 2012) so is not repeated here.

7.11.1 Dunedin and surrounds

Market gardening was established in and around Dunedin by the 1860s. Chinese goldminers set up and worked in market gardens in and around Dunedin from 1867, and by the early 1900s around 160 Chinese men were working in gardens scattered across the city, particularly in Forbury. During the 1920s and 1930s the market gardens shifted beyond Dunedin's main urban areas and, following World War II, concentrated around Outram-Momona (on the Taieri Plains) and Waitati (north of Dunedin). At its peak in the late-1960s there were 24 Chinese market gardens on the Taieri Plains.

Outram had fewer frosts being closer to the Taieri River, and growers were able to grow produce earlier in the season than south of the township where frost was more of an issue, but they had to irrigate because the water passed through their sandy soils quickly.

279 BM200096_05_Vincent_Spatial_Plan_Document_20220404.pdf (codc.govt.nz)

Outram-Momona

Market gardening occurred on the Taieri Plains mainly because of its proximity to Dunedin. Most of the large market gardeners were Chinese: possibly three-quarters of the number of growers, but more in terms of total land area (Neville Ferguson, pers. comm., August 2022). Non-Chinese growers were usually smaller, and many went into berry fruit (Neville Ferguson, pers. comm., August 2022).

The Chinese growers focused on main crop vegetables and were located around the outskirts of Outram on the Allanton Road down to Allanton, with a few out towards Momona and Berwick. Their soils were heavier than around Outram and they did not use irrigation (N. Ferguson, pers. comm., August 2022). The Chinese growers all eventually moved on to other opportunities or retired as their children chose to go to university and went on to professional careers. One of the largest was the Fergusons (Balmoral Gardens) and another long-standing grower was the McArthurs (McArthurs' Berry Farm). Both families were in business for over 50 years but have now sold their land and retired.

As an illustration of a growing operation, Frank Ferguson started market gardening in Outram as a returning soldier after World War 2. He purchased a property on the boundary of the township, which was grass paddocks at the time, and grew 'early' season crops, particularly potatoes and lettuces for 27 years. The business grew when Frank started a roadside shop, and he went on to acquire three other properties. His eldest son Neville took over the business in the 1970s and worked as grower for 30 years up until 2003. *"At the end I was growing about 100 to 150 acres, much of it for potatoes, and I leased a lot of land."* A glass house was used to grow tomatoes for the shop, but the rest was all outside growing. The market garden provided full-time work for four or five permanent staff, as well as after school and holiday work for schoolchildren from Outram and Mosgiel.

> *Over the Christmas period I would have about 15 children working for me, and my wife Cathy would have up to 30 children working in the raspberry patch. We were also involved with the local community, through fund-raisers and sponsorship of local sports clubs (e.g., rugby, cricket and hockey) around Outram and Mosgiel. It was a good lifestyle but very busy, being seven days a week. In the early days it was quite rewarding but as time went on it just got harder and harder and less satisfying.*
>
> *With the shop, we ventured out into a range of vegetables as well as berry fruit, such as raspberries and blackcurrants, because people were asking for it. We did about a third of our business through the roadside shop – and the rest of the produce went into markets in Dunedin. In those days it was the auction system and now it is all private treaty. The main reason I got out of market gardening was the supermarkets were dictating prices and they made it hard work.*
>
> *I can't see market gardening coming back down this way. There isn't sufficient land available for the scale needed and the price of farmland is so great. When I finished up, I had 11 tractors so imagine what someone starting now would have to outlay. Some growers around Kakanui have given up too but, with their soils and climate, that will most probably be the area where things are grown in the future. The older growers are giving up because they have done their time and the younger ones aren't coming through.*
>
> ***Neville Ferguson, retired market gardener (pers. comm., August 2022)***

Changes in the industry, particularly a shift from twice weekly to daily markets to meet the needs of supermarkets, lead to a decline in the number of market gardens in the 1980s and 1990s. The pressure for urban development in close proximity to Dunedin resulted in much of the land previously used for market gardening being developed into housing.

Waitati

The lower Waitati Valley was *"well suited to market gardening"* with its *"fertile alluvial soils, equable climate, and proximity to the Dunedin market"* (Church, I., Strachan, S, and Strachan J., 2007). The first grower was a nurseryman who moved to the area in or around 1910[280] and delivered his vegetables by wheelbarrow to the train station. A Chinese market garden was established in 1931 on 30 acres of a sheep farm – the mix of vegetables grown included beetroot, brassicas, spinach, and Brussels sprouts, which were transported by train to Dunedin, but also up to Timaru and Christchurch, and in winter Brussels sprouts were sent as far as Wellington (Church et al., 2007).

From the 1940s several other market gardens were established around Waitati, with some either including or becoming plant nurseries (e.g., Blueskin Nurseries[281]). However, the area was prone to flooding – in a large flood in 1968 the vegetables were "washed out and were left hanging on the fences" (Church et al., 2007). Local children *"could always get a holiday job… and Saturday morning work"* to help with produce such as peas, gooseberries, carrots, and parsnips. There are still a handful of small growers in the area (e.g., Habitat Nursery & Taste Nature Gardens[282]).

7.11.2 Waitaki

Market gardening in the Waitaki District started in the 1870s, with a Chinese market garden at Ōamaru (Lee and Lam, 2012) and later grape vines. A plaque on an Ōamaru stone post at the entrance to Riverview Grower records that the site was *"part of the original 'Kakanui Vineries" built about 1900 by Mr McDonald who established the first glasshouses nearby in 1875".* An entry in the New Zealand Gazette (March 13, 1917)[283] notes a Mr Robert MacDonald Watson (Grape-grower, "The Vineries," Kakanui) was called up for service with the New Zealand Expeditionary Force.

The main development in the area came from the 1920s onwards (Lee and Lam, 2012). In 1929, a hailstorm (with hailstones "*as large as pigeon eggs*") either damaged or destroyed the glasshouses of several of the Kakanui vineries, which at the time were *"the largest in the Dominion and represent a big portion of the supply from the grape-growing industry. Ōamaru and the harvest area escaped"*[284]. Market gardening received a boost in 1942 when the need to supply fresh vegetables to the Allied Forces based in the South-West Pacific boosted New Zealand's vegetable production (Chapter 16: Rural Waitaki District Plan; Currie, 1974).

Riverview Growers began in 1955 and it was here Alan Naish developed the world-renowned Supertom tomatoes (this business eventually closed in 2016)[285]. Peter Lee, worked as a grower for at least 60 years, also started around this time – his wife Betty, the only local flower grower, grew carnations[286] (Lee and Lam, 2012).

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280 William Hitchcocks was a florist, and he and his wife moved to Waitati from Belvedere Gardens in the Leith Valley (Dunedin) where they ran a 1.5 acre flower and bulb nursery (https://nzhistory.govt.nz/suffragist/eliza-hitchcock).
281 https://www.blueskinnurseries.co.nz/
282 https://www.odt.co.nz/lifestyle/home-garden/sweet-taste-success
283 http://www.nzlii.org/nz/other/nz_gazette/1917/44.pdf
284 https://paperspast.natlib.govt.nz/newspapers/TS19290205.2.142
285 https://www.odt.co.nz/regions/north-otago/home-supertom-closing
286 https://www.stuff.co.nz/timaru-herald/news/113133182/oamaru-man-with-60-years-experience-in-market-gardens-receives-queens-birthday-honour

By the 1970s income from commercial horticulture in North Otago (market gardening, glasshouses, berry fruit, and orchards) was making an important contribution to the regional economy (Currie, 1974). About 500 hectares was devoted to market gardening and growers specialized in crops that were most suited to local growing conditions and the economics of transport, notably Brussels sprouts, early potatoes, lettuces, cauliflowers, and carrots (Currie, 1974). Market gardening was largely concentrated on the coast at Kakanui (just south of Ōamaru) (Currie, 1974). The crops grown around Kakanui and Totara were earlier than in Outram because they were fairly frost-free, being close to the sea, and had a different type of soils (N. Ferguson, pers. comm., August 2022).

Market gardening is still present in the Waitaki District, particularly around Kakanui, Totara and Alma (north of Kakanui), and to a less extent near Palmerston and localised areas east of Georgetown (Rural chapter). There are still long-established growers in the area (e.g., Kakanui Produce[287], Armstrong and Co[288], Rangeview[289], Ōamaru Organics[290]) using fields and/or glasshouses and a pioneer of soil health (Jim Gorman[291]). Each operation includes a wide variety of crops that can respond with relative agility to market demand: from Jersey Benne potatoes and leafy greens to cucumbers, peppers, beans, chillies, herbs, tomatoes, silver beet, zucchinis, citrus, spring onions, and celery.

Image 39: Crop of Brussels sprouts, Alma (South of Ōamaru)
Source: Emma Moran

287 https://www.otagofarmersmarket.org.nz/kakanui-produce
288 https://www.odt.co.nz/rural-life/horticulture/jersey-benne-grower-it-long-run
289 https://rangeview.co.nz/about/
290 https://www.otagofarmersmarket.org.nz/oamaru-organics
291 https://www.rnz.co.nz/national/programmes/countrylife/audio/2018810015/dirt-doctor-fixes-damaged-soil

7.11.3 Central Otago

Fruit orchards have been a feature of Central Otago since the 1860s when John Desiré Feraud, a French immigrant, established a small fruit orchard at his Monte Christo vineyard near Clyde, and the Tamblyn brothers (Joseph, John and James) planted fruit orchards at Coal Creek (near Roxburgh)[294]. The water races built by the gold miners supplied water for irrigation as gold mining became less economic, and the use of 'paddock mining'[295] opened up the ground for the planting of fruit trees.

An ex-gold miner John Dawson employed Chinese miners to help develop and work on his orchard[296] in Conroys Gully (just south of Alexandra), and with his wife Ellen, developed the Dawson cherry as a specialty and the varietal remains hugely popular. There are many examples of pioneering and multiple generation orchardists, such as (but are in no way limited to) the McIntosh family (Earnscleugh[297]), the Bennetts family (Roxburgh), the Webb family (Cromwell), and the Paulin family (Clyde and Earnscleugh[298]). John Bennetts, as President of the Roxburgh Railway League, promoted the extension of the railway from Lawrence to Roxburgh for transport of produce to markets[299].

In 1894 a government pomologist, Mr Blackmore, identified the climatic advantages and potential for growth in his tour of inspection of the orchards of Central Otago[300]. By the end of World War I, commercial orchards were well-established throughout Central Otago and fruitgrowers associations were being established (e.g., at Teviot in 1901[301] and at Ettrick in 1916[302]) and photos of the harvest around the area featured in the Otago Witness. Fruit from the area was exported to the markets as far afield as Covent Garden, London (King and Darling, 2016).

Image 40: Orchard in Conroys Gully (south of Alexandra)
Source: Emma Moran

294 https://nzetc.victoria.ac.nz/tm/scholarly/tei-Cyc04Cycl-t1-body1-d5-d51-d16.html
295 Diggers pegged a claim of a certain size, known as a paddock, on the riverbanks and hole by hole they dug up 'wash-dirt' and panned it for gold (https://www.aworldofdifference.co.nz/x,963,574,0/gold-story.html)
296 https://natlib.govt.nz/records/35844955
297 http://www.mcintoshorchard.co.nz/orchard-history.html
298 https://www.odt.co.nz/rural-life/horticulture/orcharding-family-celebrates-centennial
299 https://nzetc.victoria.ac.nz/tm/scholarly/tei-Gov03_02Rail-t1-body-d28.html)
300 Mr Blackmore also noted the quality of Winter Nelis pears at Mr Dawson's orchard and the apricots and nectarines at Mr McCracken's https://nzetc.victoria.ac.nz/tm/scholarly/tei-Stout73-t18-body-d4.html
301 https://nzmuseums.co.nz/collections/8426/objects/1049017/booklet-teviot-fruitgrowers-association-centenary
302 A history of fruitgrowing in the Ettrick District was written for the centennial of the Ettrick Fruitgrowers Association (King and Darling, 2016). It details the history, memorable moments, and stories of owners and orchards from Beaumont through to Millers Flat, on to Ettrick, and up to Dumbarton (south of Roxburgh).

As part of its soldiers' settlement programme, the Government planted 60,000 fruit trees at Bald Hill Flat (between Roxburgh and Alexandra) and renamed the area Fruitlands, but few trees survived the harsh frosts, and the scheme was largely unsuccessful[303]. The area of orchards expanded with the development of irrigation schemes during the 1920s and 1930s, and possibly the gradual replacement of gravity fed systems (used in flood and farrow irrigation[304]) with pumping.

Image 41: Giant Fruit Sculpture, Cromwell
Source: Simon Moran
Note: The idea for the giant fruit was conceived by Otto Muller a designer from Ripponvale, as a way to celebrate the contribution of the fruit industry to Central Otago. The sculpture was built by the Cromwell Rotary Club and installed in 1990[305].

Following World War II, orcharding in Central Otago continued to benefit from increased immigration with the arrival of new orchardists and its importance was reflected in community events such as Alexandra Blossom Festival, which began in 1957. The 1960s and 1970s saw a relatively "*static*" horticultural industry (Kelly, 1987: p12). Figure 59 shows the area planted in pipfruit in 1965 was 600 hectares (producing 15,000 tonnes) and the area in 'stonefruit' (i.e., summerfruit) was 793 hectares (producing 6,000 tonnes) (Kelly, 1987).

303 https://www.doc.govt.nz/parks-and-recreation/places-to-go/otago/places/alexandra-area/mitchells-cottage/
304 Flood and Furrow Irrigation | Agriculture, Technology, and Business Market (agrotechnomarket.com)
305 https://sculpturemap.nz/listing/nz/giant-fruit-cromwell/

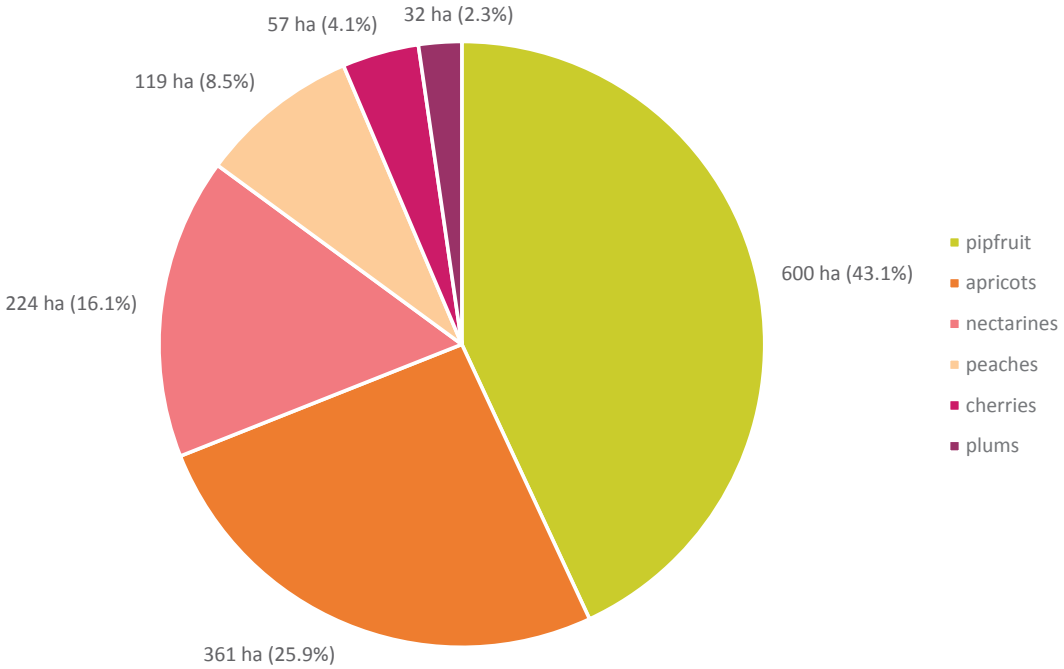


Figure 59: Area planted in horticultural crops grown in Central Otago in 1965
Source: Kelly (1987)

At the beginning of the 1980s orchards in Central Otago were mostly family-orientated businesses (e.g., Roberts from 1961 and Jackson since 1969). During this decade advances in frost-fighting technology (a shift from the use of diesel pots to overhead irrigation to protect crops) became commonplace and changed the industry. Most orchardists invested in the new irrigation system, gaining more certainty for the crop from one year to the next and, as a result, improved profitability, and the improved profitability encouraged new entrants. Other growers were unable to afford the expense and struggled to remain competitive, with some eventually being forced to exit.

New varieties were introduced in the 1980s to take advantage of the benefits of the changing irrigation systems, with crops such as apricots, nectarines and apples becoming more profitable, and orcharding expanded. The "*dramatic upsurge*" in tree plantings was expected to dramatically increased production: forecasts for 1990 were 22,000 tonnes of pipfruit (+47% from 1965) and 9,500 tonnes of stonefruit (+58% from 1965) (Kelly, 1987). "*The emphasis has been on nectarines and peaches but latterly the emphasis has switched to apricots, apples, and cherries. The cherries are being targeted specifically at the recently opened Japanese market.*" (Kelly, 1987).

The promise of profitability brought corporate new entrants who exported fruit, particularly nectarines, to Australia until a local market developed across the Tasman a few years later. At the time *"the number of syndicates and special partnerships"* was noted as *"a feature of the recent developments"* with about ten being underway and more planned (Kelly, 1987). Many of the corporate-owned properties did not survive and were bought by experienced and well-established Central Otago family growers (e.g., Hinton and Van der Voort).

By the 1990s orchards in Central Otago were 'mixed' with many being set up with separate blocks of apricots, nectarines, peaches, and cherries. Most growers were hands on, picking and packing their own fruit and their markets were quite diverse: apricots, cherries and apples were primarily exported while peaches and nectarines were grown for the local market. The development of the Clyde Dam and the forming of Lake Dunstan allowed for more irrigation and, although some of the best orchards were

Image 42: The original Jackson Orchards Orchard located in the Alex-Cromwell Gorge – now flooded to make way for the Clyde Dam. The new orchard was relocated to 73 Luggate-Cromwell Road where it thrives today. Source: Jackson Orchards

flooded as a result, the industry has expanded with increased water security. Central Otago became a more attractive place to live following the Dam's construction and there was an influx of people moving into the area, which helped with casual seasonal staffing (e.g., semi-retired Southland farmers).

Over the 1990s and early 2000s orchards consolidated and became more focused on specific crops. While apples were profitable in the early 1990s other crops were less so, but the situation had changed by the late 1990s. In 2001, the Apple and Pear Marketing Board's monopoly ended and, together with a very poor apple harvest in 2005, it created uncertainty for growers and changed the nature of the industry in Cromwell and Earnscleugh (south-east of Clyde).

Some orchardists who predominantly grew apples exited because the crop had become uneconomic at the time. Others removed or reduced their apples and tended to replant in cherries (often multiple varieties e.g., Sarita Orchard has 13 varieties[306]), which was the highest value crop in the early 2000s. Mixed orchards also removed their blocks of peaches, nectarines, and apricots, particularly around Cromwell, and became largely cherry orchards. Orchards in Earnscleugh kept some of their peaches and nectarines to keep diversity of supply for the local market. However, Central Otago remains New Zealand's largest apricot-growing region[307].

Since the early 2000s, a lot of smaller new entrants (roughly ten hectares or less) and several larger new entrants with two or three sizeable blocks have entered the industry as purely cherry growers. Cherries are also now celebrated by the community event, 'Cherry Chaos' in Roxburgh[308]. By 2010, apples had regained ground as a high value crop and since then there has been growth in apples, although it has consolidated in Central Otago to a few medium-sized growers and one large grower, as well as some organic apple growers. In 2010, Gary Bennetts, then Chairman of Summerfruit New Zealand, described Central Otago's fruit industry as in "*a period of stabilisation*"[309].

306 https://www.saritaorchard.co.nz/cherries.html
307 https://www.centralotagofruit.co.nz/our-growers
308 https://cherrychaos.co.nz/
309 https://www.odt.co.nz/lifestyle/magazine/growing-gold

8 Viticulture

Author: Central Otago Winegrowers Association[310] (Andy Wilkinson with review by Jake Tipler) and contributions from New Zealand Winegrowers[311], including Sustainable Winegrowing New Zealand[312]

8.1 Summary

Viticulture in Otago is largely concentrated in and around Central Otago: the semi-arid inland basins consist of seven old river terraces with scarps and fans that increase in age from the flood plain and valley floor to the oldest at the foot of the mountains. As a wine region, Central Otago is relatively young and one of the most southern wine regions in the world.[313]

The growing of vines began in the 1970s and picked up pace in the 1990s (Ballantyne, 2011). Over the past 50 years, Central Otago has successfully developed a strong regional brand founded on the growing of Pinot Noir grapes. Around 81 per cent of the grapes grown now are of that varietal making Central Otago the most Pinot Noir-focussed region in the world.

The specialisation and expertise of viticulture for Pinot Noir in Central Otago has developed an enviable international reputation for a style of Pinot Noir that is fruit expressive, complex and structured. International wine writers have frequently identified Central Otago as one of the three most suited regions for this fickle grape – Burgundy France being the home of Pinot Noir, Willamette Valley in Oregon United States at latitude 45 degrees North and Central Otago in New Zealand at latitude 45 degrees South. The international recognition is reflected in the premium prices for Central Otago wines.

Image 43: Hand Picking Pinot Noir at Mud House Wines Claim 431
Source: Central Otago Winegrowers Association

310 https://centralotagowine.co/
311 https://www.nzwine.com/
312 https://www.nzwine.com/en/sustainability/swnz/
313 In comparison to 45° north where the population is well over 100 million, there are only 400,000 people living in the 45° south strip, and this is reflected in the lack of pollution and disease pressure that is seen in the Central Otago wine region.

Central Otago's climate is also well suited to growing a range of exceptional cool climate aromatic white wines including Pinot Gris, Riesling, Sauvignon Blanc, Gewürztraminer and Chardonnay (Figure 60). A small amount of other red wine varietals, including Shiraz, Tempranillo and Gamay, are also grown and as the region warms there may be opportunity to increase planting of some of these varietals. Generally, the water needs of the different varietals is similar.

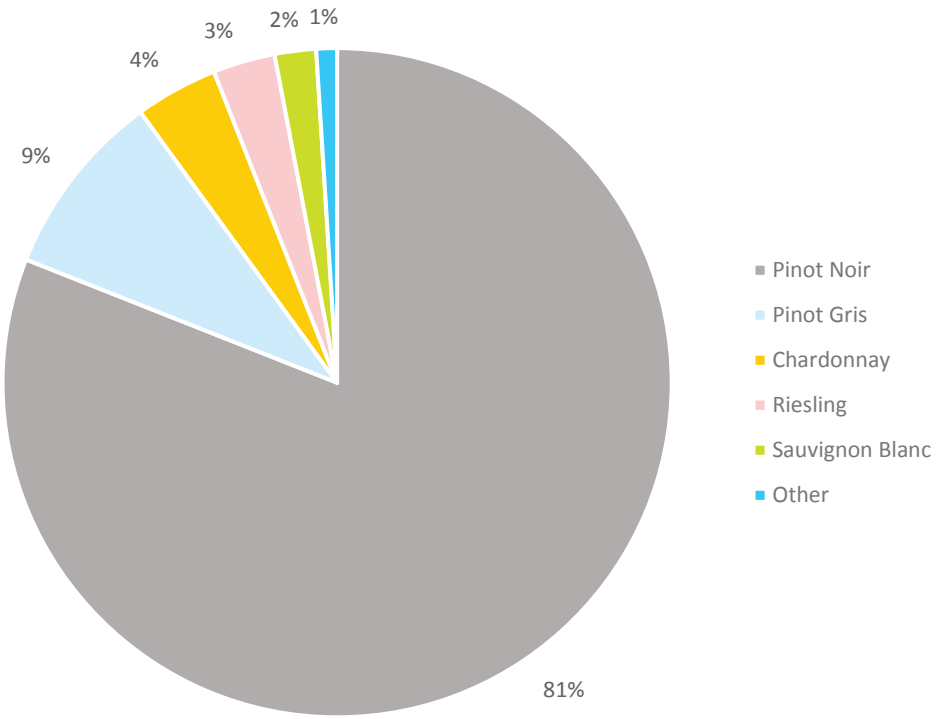


Figure 60: Grape varieties as a proportion of total vineyard area in Central Otago
Source: Central Otago Winegrowers Association

Viticulture is unique in the way land and water is used, it diversifies both the regional and national economies, and plays an important part of the identity of local communities. Grape-growing is one of the most efficient forms of primary production in terms of water use, with a low nutrient input. Its seasonality means water use, spray programmes and the application of nutrients are restricted to the growing season of October to April, and grapevines are also a permanent crop – they remain in place during dormancy and are farmed with minimal soil disturbance. The productive lifespan of a vine varies, with some replaced at 30 to 50 years and others retained for over a century.

8.2 Size and distribution

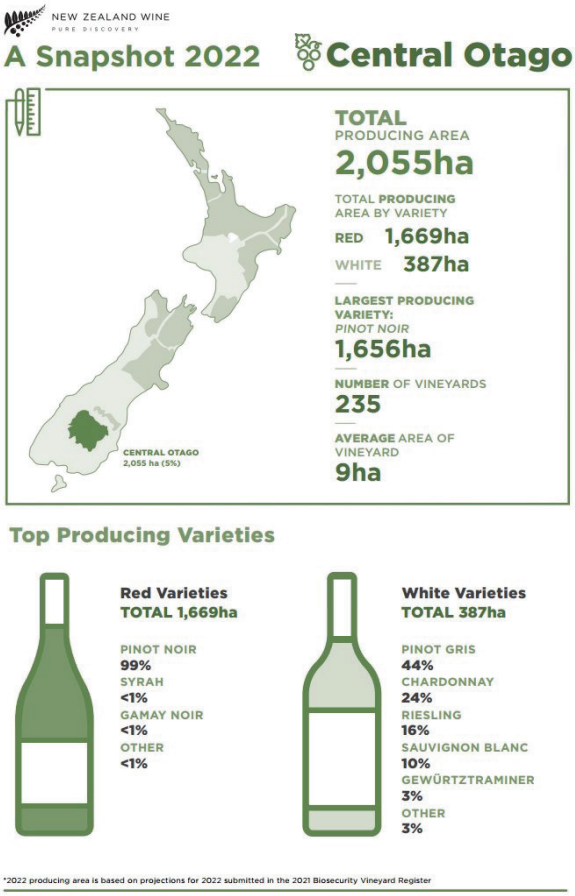


Image 44: Central Otago Winegrowing Region Snapshot 2022

Central Otago is the fourth largest wine growing region in New Zealand for production (Marlborough, Hawkes Bay, and Gisborne being larger), and the third largest wine region by vineyard area (Gisborne produces more wine from fewer vines). Importantly, Central Otago is the second largest wine growing region for the number of individual vineyards – largely because there are relatively more small family-owned businesses.

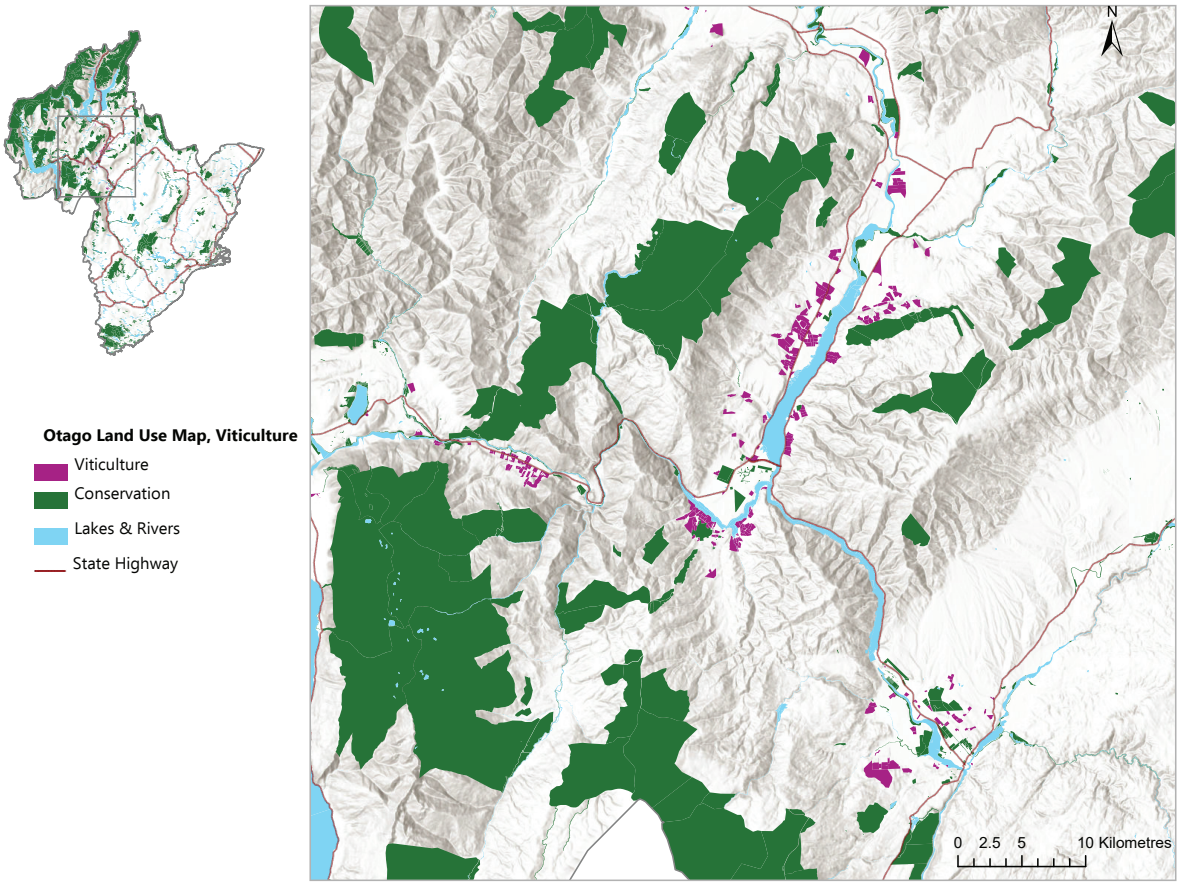
In 2022 (using the most recent data available[314]) there were 235 vineyards[315] in the Central Otago wine region and collectively they total 2,055 hectares of planted area[316]. Smaller vineyards are the most common: 175 vineyards (74%) have an area planted in vines of less than ten hectares, and at the other end of the continuum three vineyards (~1%) have an area of more than 50 hectares. However, (using data from earlier in 2022) 164 smaller vineyards accounted for 581 hectares of land (31%) while ten large vineyards accounted for 554 hectares (29%) (i.e., a similar land area).

314 This data is the latest update of data used further on in this chapter, which was for earlier in 2022. https://www.nzwine.com/en/regions/centralotago/

315 The term winery is not an exact term and generally covers any company that through either their own vineyard or winery produces a wine for sale. Many 'wineries' are in effect wine producers that do not own a wine production facility as such – those vineyards that do not produce a finished product are generally referred to as 'growers.

316 As a comparison, the Hawkes Bay has more viticultural land but fewer wine producers (i.e., wineries) than Central Otago. There are premium wine producers in the Hawkes Bay, but the industry is dominated by growers and a large proportion of the wine – largely Sauvignon Blanc – is blended with that from Marlborough.

The contribution to Otago's economy from the wine industry is considerable. In 2018, an estimated 820 people were permanently employed in the industry (Deloitte and ANZ, 2018) and this workforce grew to over 1,000 during harvest. Additionally, the ancillary industry workforce that supports the viticulture and winery industry includes transportation, warehousing, irrigation, earthworks, trade industries and professional services (accounting, legal, surveying etc) is sizeable. In 2020, the industry held an estimated $650+ million in tangible assets and the price premium for Central Otago wines over other New Zealand wine producing regions added $36 million per annum to revenues (COWA Strategic Review, 2020). The brand value was assessed at close to $1 billion with an aggregate balance sheet of $1.65 billion (COWA Strategic Review, 2020).



Source: Otago Regional Council

The Otago Land Use Map above shows the extent of viticulture across Central Otago. Figure 61 shows the distribution of vineyards in the Central Otago wine region across a range of size categories and Figure 62 compares this distribution to the total planted land within each of those size categories (i.e., total land is calculated as the number of vineyards by the size of each vineyard). For example, there are just under 25 vineyards in the 10 to 15 hectares size category and combined they account for just under 300 hectares of land planted in grapes, which equates to 16 per cent of all viticultural land.

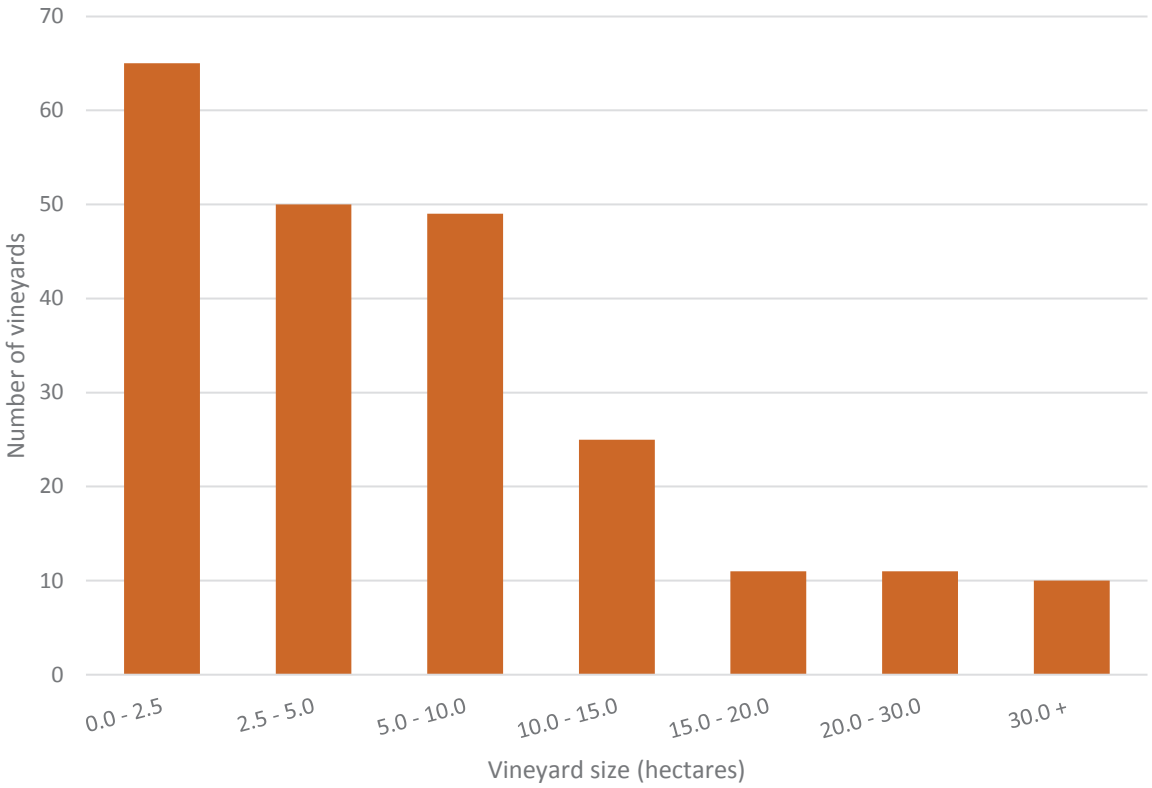


Figure 61: Distribution of 221 vineyards in Otago by size category in 2022
Source: Sustainable Winegrowers New Zealand Database

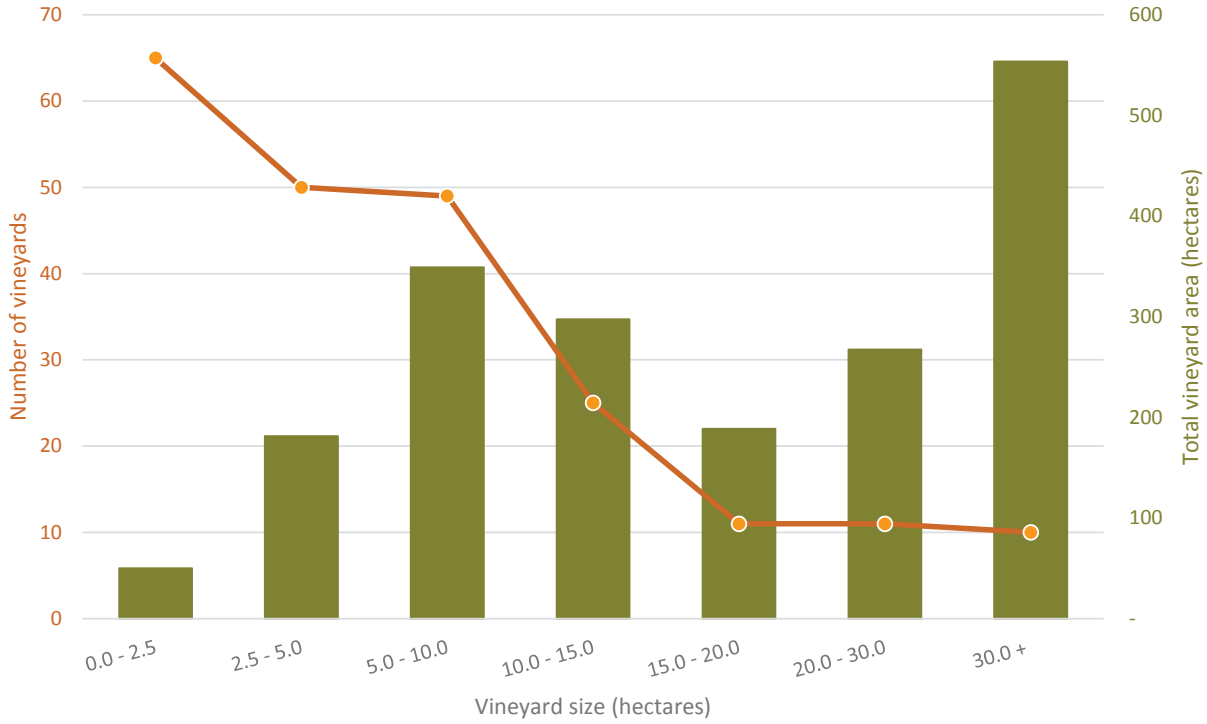


Figure 62: Distribution of 221 vineyards and total vineyard area by size category in 2022
Source: Sustainable Winegrowers New Zealand

8.2.1 Central Otago sub-regions

In contrast to other New Zealand wine-growing regions, the Central Otago wine growing region is inland and at higher altitude – it spans from 150 metres above sea level in Alexandra to over 400 metres in Gibbston. The local growing conditions vary considerably, with those around Alexandra and Earnscleugh being particularly distinct. There is a wide range of microclimates and soils, and along the Mata Au (Clutha River) alluvial wash means there are more gravels. Heat accumulation[317] figures vary across Central Otago, as does annual rainfall, which is typically higher in Wānaka and Gibbston Valley and lower in Bannockburn. Vineyards higher up on McArthur Ridge are influenced by the Dunstan Range and so have some similarities to Bendigo and Northburn terroirs (more wind-blown loess over schist rock)[318].

This diversity is reflected in the seven distinct sub-regions: Gibbston, Wānaka, Bannockburn, Bendigo, Lowburn, Pisa, and Alexandra. Bannockburn, Bendigo, Lowburn, and Pisa are all within the Cromwell Basin. Each sub-region has a local viticultural community that are broadly similar and tend to be closely connected. The Central Otago Wine Growers Association represents the whole of Central Otago and the Alexandra Basin Winegrowers Association was set up to better represent their local area – although many Alexandra growers are now members of both associations.

Gibbston is the highest sub-region and the most westerly, especially when the small plantings near Lake Hayes are included. It was the first location to be planted in Pinot Noir. Grapes are planted on the north facing valley of the Kawarau Gorge, around 350m above sea level and receives around 600mm rainfall. Soils are heavy loess deposits over schist rock and river gravels. The climate is cooler than other sub-regions and the hillside vines ripen later than neighbouring sub-regions, giving lighter though still intense wines.

Wānaka is the northern-most sub-region with a cooler and slightly wetter climate than either Gibbston or Cromwell. There tend to be fewer frosts because of the proximity of Lake Wānaka. The Wānaka sub-region sits at 290 to 320 metres above sea level with an average rainfall of around 600mm. The soils are thin layers of loess over schist rock.

The 'Cromwell basin' is an intermountain basin surrounded by the Pisa Range and Dunstan Range and was carved by successive glaciers from the Tertiary to early Pleistocene periods5. It is centrally located between the other three sub-regions Gibbston, Wānaka and Alexandra. Around 74 per cent of all grapes grown in Central Otago come from the Cromwell Basin, which generally has warmer conditions and less rainfall than the other subregions due to the rain-shadow effect of the Pisa Range on the western side of the valley. While most soils are wind-blown loess over schist rock or river gravels on the valley floor, many vineyards are also planted on gold-mining tailings from the gold rush days. These soils are well suited for grape-growing due to the good drainage and removal or fracturing of the larger rock base from the gold mining activities.

Alexandra is the most southerly sub-region and is generally towards the middle of the heat accumulation range for Central Otago's microclimates although is also prone to the extremes of temperature including exposure to frost in the early part of the growing season (November) and the harvest period (April). This sub-region covers a large inland basin surrounded by gentle hills to rocky punctuated by rocky schist escarpments. The vineyards are around 175 metres above sea level and receive around 340 mm annual rainfall. Soils are typically fine sands and river gravels, which are free-draining with a fine loess topsoil.

317 In viticulture, heat accumulation is measured in Growing Degree Days, which are the total number of degrees Celsius above a base threshold temperature and below a maximum temperature (Tbase) each day during a defined period (Stats NZ).
318 'Terroir' is, in essence, a sense of place – how a particular region's climate, soils and aspect (terrain) affect the taste of wine.

8.3 Early development

The potential of Central Otago for viticulture was recognised in the 19th century by Romeo Bragato. The first grapes in Central Otago were planted at Bendigo on adjoining plots by gold miners Jacques Bladier[319] and Jean Desirė Feraud[320]. Bladier gained a small subsidy from the Otago Provincial Government and imported 600 grape vine cuttings from Victoria to plant the first vineyard in Dunstan in 1864 – but sold his property to Feraud the next year after a dispute over a mine claim (McCraw, 2003). Feraud planted the grapes on his plot and named it Monte Christo, then bought Bladier's property and expanded operations and started making award winning wine. Despite their initial success, both Bladier and Feraud had returned to Australia by the 1880s and their farms were taken over by dairy farmers who removed nearly all of the vines (Carpenter, 2016).

In 1895 Dalmatian-born Romeo Bragato[321] was brought over by the New Zealand Government from Victoria, Australia to tour the country with pomologist J.C. Blackmore and report on the suitability of different localities "to the pursuit of viticulture" (Bragato, 1895). Travelling from Queenstown through to Dunedin, he noted there were certain areas around Queenstown, Arrowtown, Cardrona and Wānaka, where a good aspect and well-sheltered spots are available, the cultivation of the vine may be undertaken with caution because of the cold climate. At Arrowtown Bragato was presented with his first glass of New Zealand wine that "*reflected great credit upon the producer*". Queensberry (south of Luggate) was identified as the first he had visited where "*the cultivation of the vine for wine-making purposes may be entered upon in the open air to anything like a large extent*".

Bragato inspected open air vines at Clyde, which he proposed was well-suited as a site for a government experimental station for vine and fruit-growing, and saw potential in the surrounding area, such as Waikerikeri Valley (along the base of the Dunstan Ranges), Earnscleugh and Blackman's Flat. He was surprised to see 'vineries' (the glass structure under which vines are grown) at Conroy's Gully and Fraser's Flat, which in his view were "absolutely an unnecessary expenditure". Bragato went on to inspect several vineries and orchards at Roxburgh and Teviot, areas that were "*pre-eminently suited to the vine and deciduous fruits*". In Dunedin Bragato gave a public lecture to the Chamber of Commerce and following the lecture the Central Otago Vine and Fruitgrowers' Association was formed[322].

Issues raised in Bragato's report were a loss of soil from goldmining, the need for irrigation, distance to railway lines, and need to encourage settlers and development of viticultural skills. Bragato and Blackmore's 'independent testimony' on the potential of Central Otago was used by the Otago Central Railway League to promote the continuation of the railway inland[323]. However, despite the early success of viticulture and its recognised potential, sheep farming, stone-fruit orchards, and dairying dominated Central Otago until the 1970s when new vineyards started to establish (Carpenter, 2016).

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319 After selling his plot in 1865, Frenchman Bladier shifted to Lake Mahinapua near Hokitika to continue gardening, selling produce from his store in Revell Street and in 1869 purchased and ran Hokitika's iconic Café de Paris.

320 Venice-born Jean Desiré Feraud came from Ballarat to Central Otago, where his Frenchman's Point gold claim 'turn[ed] out almost fabulous quantities of gold,' through 1864. Feraud submitted wine to the 1867 Paris exhibition where he earned a 'first award'. In 1871 he sold his claim to 'commence the manufacture of colonial wine, French liqueurs, and cordials' and a year later the Tuapeka Times declared Feraud's 'ducal grape wine, cherry brandy, orange bitters, and orange wine' to be 'excellent in every respect'. In the early 1880s Feraud was rewarded with prizes for his liqueurs, fruit syrups and wines at International Exhibitions in Australia.

321 New Zealand Wine's Bragato Research Institute https://www.nzwine.com/en/about-us/bri/

322 https://paperspast.natlib.govt.nz/newspapers/OW18950523.2.10 . The Clyde correspondent for the Otago Witness raised some doubts about Bragato's observations and in response, the Dunstan Times published examples of the grape production that year in a few of the gardens in Clyde and Alexandra "to prove to the public that in Central Otago we can at least grow grapes, and good ones in abundance." https://paperspast.natlib.govt.nz/newspapers/DUNST18950517.2.13

323 https://nzetc.victoria.ac.nz/tm/scholarly/tei-Stout73-t18-body-d1.html

During the 1970s, the Department of Scientific and Industrial Research in Central Otago trialled several experimental plantings, which led to the establishment of several vineyards and the start of the commercial production of Pinot Noir in Otago. In the late 1970s several people started, independently of each other, planting grapes for winemaking (Oram, 2004). "*Most knew nothing about viticulture or winemaking, but they disagreed with the 'experts' who told them they were wasting their time*" (Oram, 2004: p5). Since the 1970s viticulture in Otago has experienced a 'new industry' lifecycle: a pioneer phase, a gold rush phase, and a consolidation phase (see diagram below).

The viticulture 'pioneers' in Central Otago were people like Rolfe and Lois Mills[324] who were certain they could grow grapes in the Rippon Valley near Wānaka and Ann Pinckney[325] who was sure of the grape's commercial potential and planted the first Pinot Noir vines at Queenstown; Alan Brady[326] and the Hay brothers[327] who developed rabbit-ravaged properties in the Gibbston Valley; Bill Grant[328], Verdun Burgess[329] and Sue Edwards at Black Ridge, transforming the landscape around Alexandra.

With viticulture came the winemakers, such as Tony Bish at Rippon Vineyard, Rudi Bauer at Bendigo, and Mike Wolter (e.g., Taramea Vineyard and Two Paddocks). These winegrowers made wine for growers beyond those at their vineyard: for example, Bill Grant, of William Hill vineyard, and Verdun Burgess, of Black Ridge, sent their grapes to Rippon vineyard in Wānaka to be made into wine by Tony Bish (Oram, 2004). Mike Wolter set up the Central Otago Wine Company, making wine for six different wine producers[330].

These and other pioneer winegrowers, such as Ken Boddy (Kenley Vineyard) and Sam Neill (Two Paddocks), established themselves in the region from the 1980s through to the mid-1990s and tended to operate with strong stewardship principles for the land. The pioneers recognised that they were too small to develop individual market clout, so developing a premium image for the region was a whole was a crucial first step. Pinot Noir is difficult to grow and make into premium quality wine and, despite being competitors, they worked together to build their knowledge and increase regional awareness (Caple, Ballantyne, and Thyne, 2010).

The 'gold-rush' phase occurred from the mid-1990s to around 2005-07. Many vineyards established during this phase were between five and 30 hectares in size. They were often family-owned operations, and the people were passionate about what viticulture and stewardship of the land was 'drummed into them' by the pioneers who they went to for advice. Knowledge was shared across the region and modified in its use at each winery, improving regional standards but maintaining the diversity of each winery's skills, methods, and outputs (Caple, Ballantyne, and Thyne, 2010). It allowed Central Otago to emerge rapidly over the 2000s as the leading producer of Pinot Noir wines in New Zealand.

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324 Rolfe and Lois Mills moved from Christchurch in 1973 to Rippon Farm beside Lake Wānaka, planting 200 vines as an experiment while raising angora goats, which subsequently became Rippon Vineyard (Oram, 2004: p6).

325 Ann Pickney planted a trial plot near Queenstown in 1976, then created her Taramea winery to produce the first locally made wine for sale in more than a century (Oram, 2004: p6).

326 Alan Brady, a Dunedin journalist, bought land in Gibbston Valley to escape the 'rat race' and, although it was not his original intention, 400 vines were planted in 1981 – his property eventually became Gibbston Valley Wines (Oram, 2004: p6).

327 Rob Hay completed a three-year winemaking course in Germany and then bought a run-down orchard in 1986 where he and his brother Greg created Chard Farm Vineyard (Oram, 2004: p6). The Chard Farm story is a useful example of land use change over the years: https://www.chardfarm.co.nz/our-story/our-history/

328 Bill and Margaret Grant planted several varieties of grapes in the early 1970s 'to see what would grow' although a lack of finance delayed their first vintage of William Hill wine until 1987 (Oram, 2004: p6).

329 Verdun Burgess bought a rocky outcrop near Alexandra in 1981 and, together with Sue Edwards, created Black Ridge – but 'had to declare war on rabbits to make a go of it' (Oram, 2004: p7).

330 https://www.twopaddocks.com/the-story/a-tribute/

More recently, Central Otago's viticulture industry has consolidated as the amount of land planted in vines has increased but the number of businesses has decreased. People who entered the industry during the 'gold rush' period without sufficient resources behind them have tended to shift from producing their own wine to growing grapes for inclusion in other wine brands. In some cases, a viticulture company will grow grapes for wine producers on their land and the grapes will be transported by truck to Marlborough to be blended with either the same varietal or other varietals. For instance, up to half of Central Otago's pinot production is shipped to Marlborough for winemaking or is blended with Marlborough Pinot Noir. The number of people in control of producing their own product is reducing over time, which may have implications for environmental stewardship.

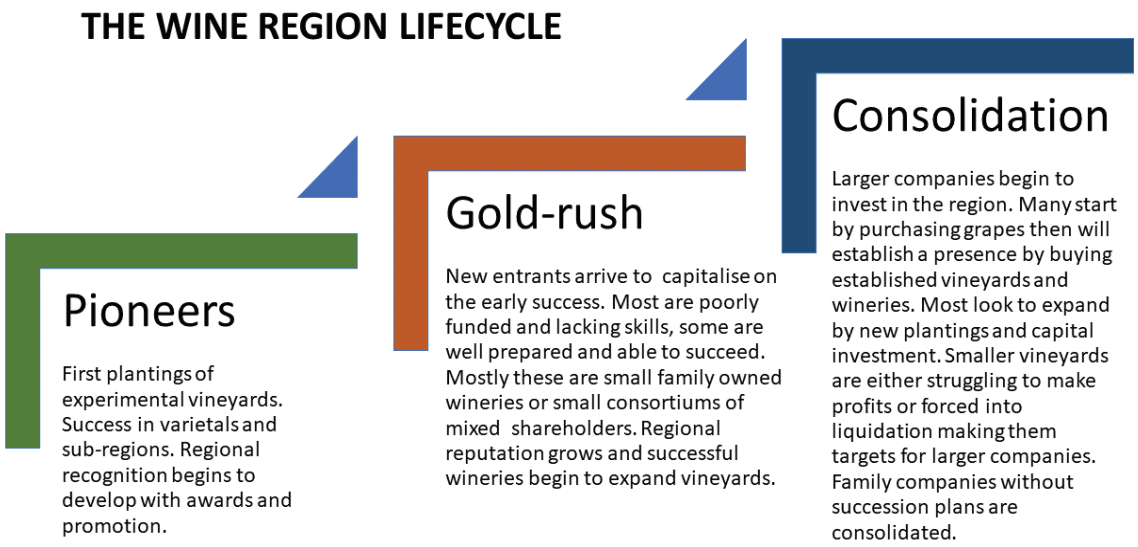

Image 45: The Wine Region Lifecycle
Source: Central Otago Winegrowers Association

Vineyard ownership is still predominantly New Zealanders, although the owners are often people from other parts of New Zealand moving to Central Otago rather than locals. More corporate activity is starting to occur and there is also a fairly recent increase in overseas ownership. For example, Constellation Brand bought vineyards including at Bendigo Station, and United States-based company Foley Family Wines owns Mt Difficulty Wines and recently bought Zebra Vineyards at Bendigo Station[331]. Some people come to the region from the wine industries in Europe, but mainly as seasonal workers.

Although the family-ownership is a strong feature in Otago in agriculture and horticulture, viticulture is challenging for a family business because it needs a high level of capital input, particularly in relation to its profitability. Only a handful of vineyards and/or wineries in Central Otago have been passed on to the next generation through family succession. Viticulture is a people-orientated industry and those involved usually do it because it is something they love doing – it is a passion – rather than purely the returns on investment.

The spatial nature of wine production means sense of place is important in the branding and marketing of wine and a region's characteristics include the quality of the wine, the varietals grown, and the terroir[332]

331 There are 24 distinct vineyards within the Bendigo sub-region.
332 In this context, terroir includes not just the unique combination of soils, climate, and topography, but also the human and cultural elements; the unique stories and heritage of a place that weave together to create a cultural landscape (Charters, 2006; Leader-Elliott, 2006).

(Fountain and Dawson, 2014). Central Otago has successfully developed a strong regional brand over a relatively short time span, drawing on its natural and historic heritage while becoming renowned as a producer of premium Pinot Noir (Fountain and Dawson, 2014). Many newcomers have been attracted to Central Otago for the lifestyle and amenity values (Fountain and Dawson, 2014).

Many elements that are important to the regional brand feature prominently in the naming of the wineries, particularly landscape features based on the mountains and rocky terrain and a history of wine pioneers, pastoralism, and goldmining. Long-established wineries are much more likely to use names and labels derived from landscape features while more recent wineries tend to refer to personal heritage and experience (Fountain and Dawson, 2014).

8.4 Main features

8.4.1 Climate and soils

Central Otago has a semi-continental climate with a grape growing season between October and April. The seasons are distinct, and the diurnal temperature range is from 35°C by day to -10°C at night. There are over 2,000 sunshine hours annually and solar radiation (UV) is higher than the grape-growing regions of northern Europe. Rainfall is fairly evenly spread throughout the year. However, high evapo-transpiration leads to low soil moisture levels during the growing season. Humidity is low – during the growing season, it usually sits around 65 per cent in the mornings dropping to 30 per cent (or less) by mid-afternoon.

Wind speeds are usually light to moderate, the lowest being in the Alexandra basin. Generally, winters are calm, while spring and early summer can be windy. The most damaging winds for vineyards are the strong northwest wind (a Föhn wind) and the cold downhill wind (a Katabatic wind) that develops in spring when skies are clear and heavy snow lies on the mountains – although both are fairly infrequent. Frost is possible at any time of the year, with late November frosts being the most problematic and cause issues for viticulture around one year in five. An inversion layer[333] is common on clear, calm, frosty nights in winter and spring, usually measuring around 60-80 metres deep, but sometimes up to 180 metres. Most frost events in Otago are from clear still air. The Katabatic winds from the higher mountains whilst cold, have less of an impact due to the moving air and faster dissipation.

Spring frost can be devastating - especially in the early part of the season as new fragile shoots are emerging and beginning to develop. Damage to both new buds and the new shoots can arise from sub-dermal water freezing during long periods of sub-zero temperatures. Young buds and shoots are effectively 'burned' by the frozen air causing cell damage which can kill a primary shoot. Depending on the extent and severity there is sometimes subsequent development of a shoot from the secondary growing point, however these do not have good (or sometimes any) fruit production. The damage can also affect the production of fruitful buds for the next season.

In general, the soils of the Central Otago wine region are layers of loess, at various depths, interspersed with river gravels and sandy soils formed by water erosion. Loess layers are formed over successive ice ages by glaciers grinding schist rock into fine particles that are distributed over the valley by wind. The

333 Warm air collecting on top of cold air ponding in valley floors.

soils are free draining, even when heavy in texture and the low rainfall reduces leaching, maintaining a good level of minerality with low levels of organic matter. The result is soil that is low in vigour and high in mineral richness, where irrigation can be used to control vine stress and optimise fruit quality. Figure 63 shows the distribution of soils across vineyards in Central Otago[334].

The viticulture region of Central Otago and its designated sub-regions have common characteristics of climate and soils that are recognised and generally accepted as influencing the resulting wines. However, there are also distinct differences from vineyard to vineyard within those sub-regions. Vineyards may have slightly different direction aspects with the sloping faces giving more benefit of ripening, the row directions may be driven by the steepness of the hillside and soils may vary with varying age of glacial deposits and location of clay pans. The combination of the common characteristics and the vineyard specific characteristics allow subtle differences in grapes grown to reflect the specific site in the finished wine.

The climate, soils and aspect of Central Otago make this region unique in having the ideal environment for producing Pinot Noir and very high quality aromatic white wines. These highly productive vineyard soils are distinctive, neither vibrantly fertile nor rich in bio-matter or natural nutrient. Their suitability for grape growing comes from the very characteristics that make these soils less well suited to other uses. High quality wines are produced from grapes that are subject to a level of stress from their environment. The vine in reacting to the lack of water, nutrients and soil fertility produces higher concentration of flavours in the grapes – a process of focus on reproduction for survival as has been described in viticulture education.

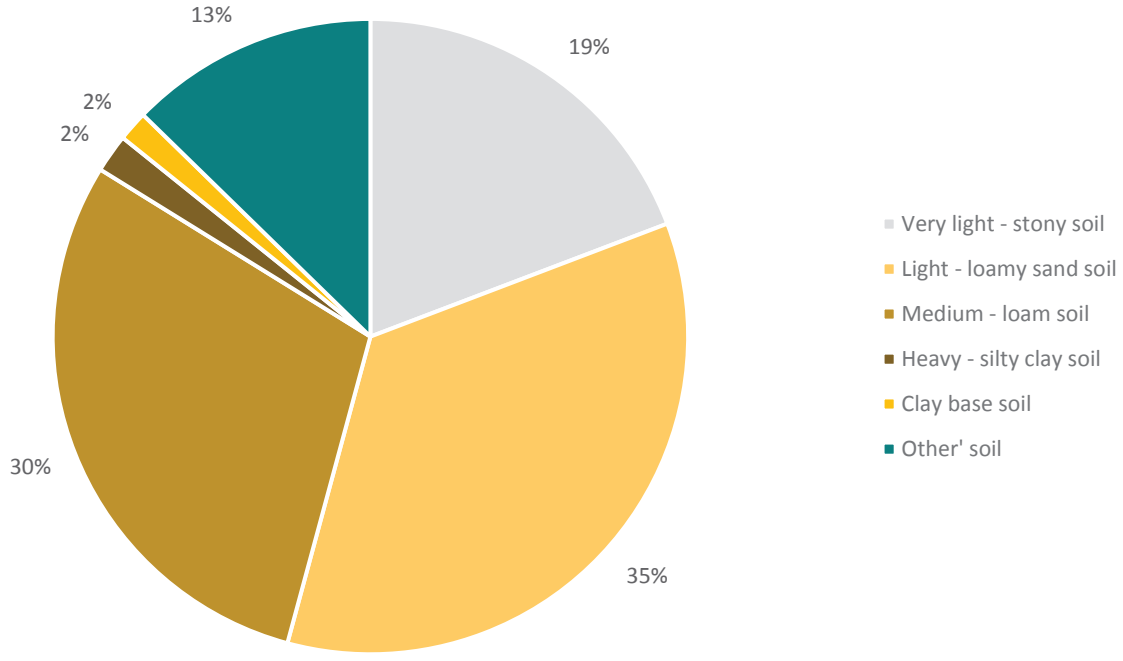

Figure 63: Distribution of soil types across 221 vineyards in Otago in 2022
Source: Sustainable Winegrowers New Zealand

334 Five periods of moraine building and aggradation in the Wānaka-Hāwea basin and upper Clutha Valley were due to glaciations (McKellar, 1959). It is thought most probable that large schist blocks in the centre of the basin between Clyde and Alexandra were transported to near their present position by ice at the extreme limit of the earliest valley glaciation, known as the Clyde Advance.

8.4.2 Water use

There are very few dry-farmed vineyards in the Central Otago wine region due to the low rainfall and the free draining soils. Most vineyards, regardless of their size, use water for irrigation and rely on water for survival of the vines. A lack of water for most vineyards would not just result in a crop loss for a season, but the permanent loss of vines with the potential for many years of no production and high costs as new vines are sourced, replanted and become productive.

Almost all viticulture irrigation uses highly efficient driplines for delivering water to vines. Some driplines lay on the ground to reduce splash and run-off – others are slightly raised to allow under-vine cultivation. There are also a small number of sprinkler systems that are used for frost fighting. Sprinklers are not suited to irrigation of grapes as water on the leaves and grape bunches can promote the introduction of moulds, mildews and disease. Grape vines are efficient at water use with a narrow area of wet surface sufficient to be taken up by the vine.

Overwatering grapevines produces too much vigour, with too much vegetative growth resulting in poor quality grapes. Consequently, water management is a critical part of the viticultural regime. A small amount of water not taken up by vines and cover crops, continues into groundwater or evapo-transpiration.

Some vineyards are striving to further reduce their water use. As an example, Felton Road[335] vineyard and many others use organic compost to mulch drier parts of the vineyard to help retain moisture and minimise the need for irrigation, which is usually necessary during the later dry summer months. Soil moisture levels are carefully monitored with water applied only when necessary to maintain appropriate soil moisture levels. Another example is Amisfield vineyard, which has been trialling below-ground mid-row irrigation[336] trials to 'attract' vine roots to seek moisture deeper in the soils whilst reducing water available to in-row weeds.

In addition to irrigation, some vineyards also use water for sprinkler frost protection during the early part of the season (normally the frost risk is in November) and in the later part of the season in April. Water usage is more variable both within and between each vineyard size category. Overall, 1,731 hectares of total planted vineyard area is irrigated (92%). Total water used in viticulture for irrigation in the 2021-22 season was just over 2.5 million cubic metres[337].

Figure 64 shows the use of irrigation, sprinkler frost protection, and water storage by vineyard size. For example, 80 per cent of the planted area on '2.5 to 5.0' hectare vineyards is irrigated and 23 per cent has sprinkler frost protection. These small vineyards account for 10 per cent of total planted area in the Central Otago wine region (refer back to Figures 61 and 62). In general terms, the use of water for sprinkler frost protection is most common on medium sized vineyards, although most of the sprinkler frost protection (by area) occurs on the large vineyards.

335 https://feltonroad.com/our-land-and-vines/vineyards/

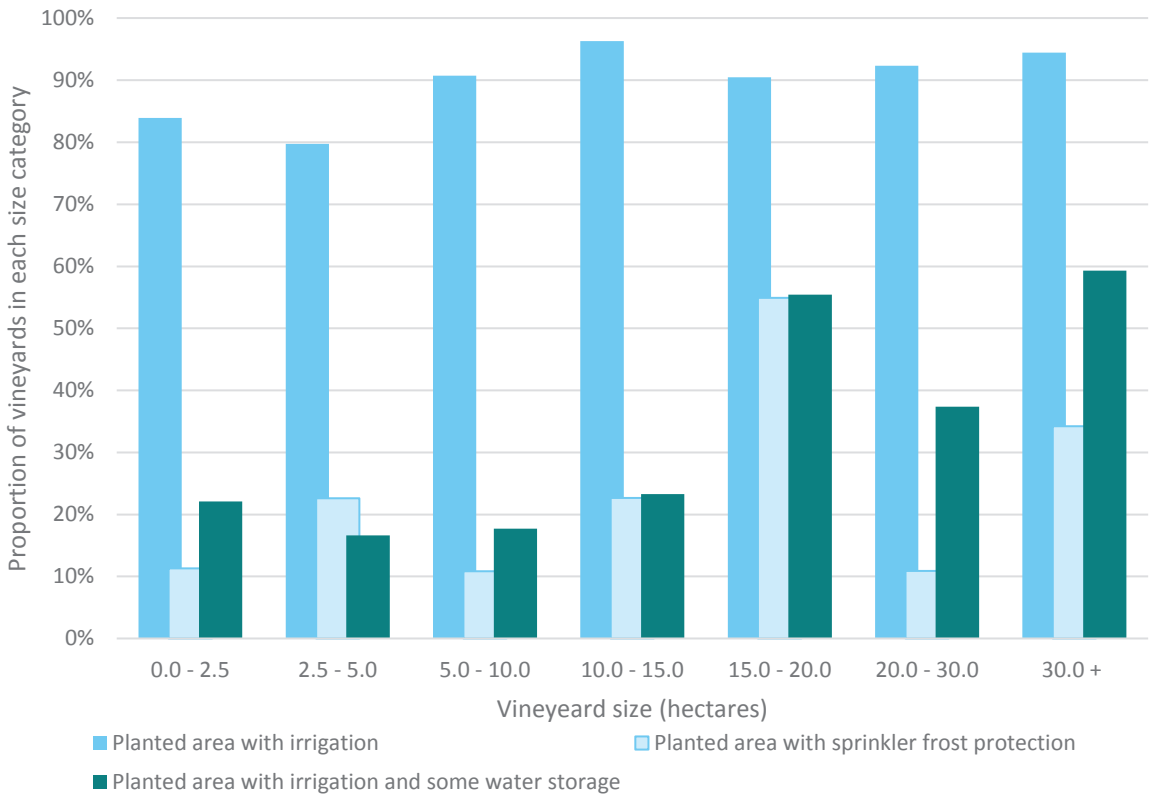

Figure 64: Proportional use of irrigation, water storage and frost protection across 221 vineyards in Otago in 2022
Source: Sustainable Winegrowers New Zealand

Those without sprinklers tend to rely on fans or natural slope drainage for frost mitigation. Frost fans that tend to be powered by diesel engine generators that are run for a short period of time during a frost event. However, there are two main factors that can make frost fans ineffective: 1) the height of the inversion layer and 2) the depth (i.e., temperature) and duration of the frost.

Many vineyards with water storage use the water for sprinkler frost protection and a few just use the water for irrigation. Figure 64 shows the distribution of vineyards who have some water storage amongst those who have irrigation, highlighting that water storage is needed to use sprinklers for frost protection.

Minimum flows and allocation limits are important to protect the health of the Clutha Mata Au Catchment, especially with a changing climate. Uncertainty around future water availability is currently a constraint on further development of the viticulture industry.

Plan Change 7[338] was an interim measure that limits new water permits or renewals of existing water permits in Otago to a term of no more than six years. These short-term consents will limit expansion of planted area on existing vineyards and restrict the establishment of new vineyards because the length of time needed to develop a vineyard exceeds six years.

336 https://www.ruralnewsgroup.co.nz/wine-grower/wg-general-news/making-organic-vineyards-sustainable-the-novel-amisfield-approach

337 This water is taken from different points across the whole Clutha River / Mata Au catchment, which has an area of 21,022 km2 (the largest in New Zealand). The Clutha River / Mata Au has a mean annual flow of 575 m3 per second, of which roughly 75 per cent is derived from the upper sub-catchments that feed Lake Hāwea, Lake Wānaka and Lake Wakatipu. https://www.lawa.org.nz/explore-data/otago-region/river-quality/clutha-rivermata-au/ The mean annual flows of tributaries to the Clutha River / Mata Au from other sub-catchments is far less.

The risk of trapped assets – land that has been prepared for viticulture but is not yet planted – means it is likely to be more challenging to gain funding for such projects. Some wine-growing sub-regions (e.g., Alexandra) may be more at risk than others, particularly because of existing over-allocation issues, and water allocation downstream of the Clutha dam compared with upstream.

8.4.3 Non-planted vineyard land

Central Otago is still considered to be an 'emerging' wine region and there is still some land with potential for viticulture. The proportion of unplanted land varies greatly from vineyard to vineyard and is usually either the nature of the terrain is unsuitable for vines, or the land is yet to be planted (although the proportion of vineyards with land yet to be planted may be quite low). Where the intent is to plant land with vines in the future it may be a question of a vineyard's stage in its business development. Each vineyard faces the need to balance any increases in production (i.e., supply) with what can be sold (i.e., demand) and so the existence of immediate markets and how it fits with their individual values.

A few vineyard owners have shaped and flattened their terrain (e.g., clearing rocks and smoothing gullies) to plant the largest possible number of vines. Many others are moving to protect the natural landscape and see the rugged hills, exposed rocky outcrops, native Kowhai, snow-capped mountains, and pristine lakes as part of their product: it is part of what winemakers sell, part of taking people to their vineyard and showing them the diversity of the landforms – the land is the 'hero'. Some vineyards have fenced off their deep gullies and re-established as small plots of natives on the edges of the vineyard. A few have joined Project Gold, a DOC initiated project aimed at re-establishing kowhai trees in Otago. However, re-vegetation is particularly challenging in Central Otago conditions.

As an example, at Te Kano Estate a large seedling propagation system was set up with a greenhouse and water systems. To date, thousands of plants propagated from their own seeds have been planted, achieving a much higher strike rate than in the past. Te Kano Estate actively encourages other vineyards to follow their lead in this area and holds open days to share native plant knowledge. It is understood that some Catchment Groups are starting to use these techniques to help farmers who have had similar experiences with low plant survival.

Other vineyards have had limited success with re-establishing native plants. One vineyard bought and planted golden kowhai on various sites across the property but had a strike rate of less than half. Another 300-400 native plants bought and planted along a boundary, but again had a 50 per cent survival. The work at Te Kano is showing other vineyards they may have more success if they take cuttings and seeds from plants already established on their site. It also highlights the importance of water for native plant restoration. As another example, Amisfield created a wetland to recycle wastewater generated in the winemaking process within their vineyard[339].

338 Plan Change 7 (Water Permits) to the Regional Plan: Water (orc.govt.nz)

Image 46: Using bird netting to protect vines
Source: Central Otago Winegrowers Association

8.4.4 Nutrients and organics

Nutrient use in viticulture is highly controlled by Sustainable Wine New Zealand. For viticulture, typical seasonal phosphorus application is through fertigation systems. A commonly used product is Kristalon Yellow (details of % on YarraLiva website) which is high in phosphorus and applied at around 5kg per planted hectare. This product is applied late October or early November to promote root movement and sets up vines for season. A Kristalon White product may also be applied a little later in the season, which has less phosphorus and more nitrogen, again at around 5kg per planted hectare. These products leave negligible trace in soils because the nutrients are almost fully taken up by the plant while drip-line application prevents surface run-off.

Most nitrogen applied to grapevines is fixed in the grapes and vine, and nitrogen leaching from vineyard land is typically very low. Between 2016 and 2021, New Zealand Winegrowers with support from MBIE conducted a New Zealand vineyard ecosystem research project to gather data comparing the environmental aspects of conventional vineyard operations to those of a reduced chemical input vineyard. The results showed the range of nitrogen leaching for viticulture across the regions – in the range of 3kg to 7kg of nitrogen per total hectare per year (comparable to that from plantation forestry).

In comparison to other wine regions in New Zealand, Central Otago has the highest proportion of organically managed viticulture. An estimated 17 per cent of Central Otago's wine production area is organic, with another six per cent under three-year conversion process, which will result in just under one-quarter of production area being organic[340]. Work is currently being done to determine how long it would take to reach 50 per cent organically farmed viticulture in Central Otago. Organic viticulture incorporates practices in the vineyard production system that follow principles of organic farming, which excludes the use of artificial chemical fertilizers, pesticides, fungicides and herbicides.

339 https://www.ruralnewsgroup.co.nz/wine-grower/wg-profiles/amisfield-wetland
340 central otago leads the way in organic viticulture (organicwinenz.com)

8.4.5 Sustainable Winegrowing

Launched in 1995, Sustainable Wine New Zealand is widely recognised as a world-leading sustainability programme and was the first to be established for a wine industry at a national scale. At least 97 per cent of all viticultural land across New Zealand is under a regime of sustainable wine growing standards and audits. To be certified, all member vineyards must:

1. Submit an annual submission that covers the effects of the vineyard over six focus areas (soil, water, plant protection, waste, people, and (more recently) climate change.
2. Submit a full spray diary that documents all agrichemical applications made to the vineyard that season.
3. Undergo regular on-site audits conducted by an independent verification company. The spray diaries are processed for compliance to ensure that only approved products have been used and specific rules of use have been adhered to.

In addition, Sustainable Wine New Zealand provides members with information on changes to agrichemical regulations and advises on best practices in viticulture. The Sustainable Wine New Zealand programmes provide empirical evidence to show sustainability credentials of grape growing and winemaking practices to local councils and central government. It also provides individual benchmarking reports that highlight areas for improvement, supporting members to make decisions that improve resource efficiency and financial sustainability. Regular reports include the Sustainability Report, the National Plant Protection Report, the National Water Report and the National GHC Emission & Energy Report.

Image 47: Cover crops at Felton Road's Calvert Vineyard, Bannockburn
Source: Central Otago Winegrowers Association

341 https://centralotagonz.com/tourism-central-otago/

8.4.6 Wine tourism

Wine is an important part of Central Otago's tourism product, having grown exponentially since around 2010 (except for the interruption from Covid-19). Along with adventure tourism and cycling, wine and food features in the Tourism Central Otago Destination Management Plan[341]as one of their main drivers of visitor numbers. The wine industry offers tastings and sales at over 60 cellar doors throughout the region, as well as through supporting the region's cafes, restaurants, and wine merchants to stock local produce. Wine tourism is also used internationally by Tourism New Zealand and by Air New Zealand to attract visitors.

As most wineries in Central Otago are small and privately owned, cellar door sales can make up a considerable proportion of their revenue. However, the relative importance of cellar door sales varies greatly. As an example, for one medium-sized vineyard, roughly 50 per cent of production is exported, 35 to 40 per cent is sold domestically through a distributor, and the remaining 10 to 15 per cent is sold directly at the cellar door. In cases where a winery does not have export markets or distribution, the cellar door is their only source of revenue. Wine tourism is a rapidly growing and high-value activity for the wine growing region and wineries host thousands of visitors every year from New Zealand and abroad. Pre-Covid, an estimated 75 per cent of customers in cellar doors were international visitors and 25 per cent were domestic visitors (particularly from Auckland).

8.4.7 Employment, production and profitability

Vineyard size has implications for employment, production, and profitability. The '1 to 5 hectare' vineyards tend to be family enterprises where they are managing the work themselves and have cellar-door sales at full retail sufficient to earn an income. The '5 to 15 hectare' vineyards tend to not be large enough to have good wholesale distribution but face higher costs because they need help to operate the vineyard. The '15 to 35 hectare' vineyards fit more of a small business model where they have staff to do most of the work but their production has to be of premium quality, and they have distribution in multiple markets. Vineyards above 35 hectares are fully commercial scale with a company structure and staff across viticulture, winemaking, sales, and management.

Image 48: Carrick bees, Bannockburn (Central Otago)
Source: Central Otago Winegrowers Association

Image 49: Sauvignon Blanc harvest 2018
Source: Central Otago Winegrowers Association

Employment in the viticulture industry is decreasing because of costs and labour availability. With more corporate owners entering the industry there has been a notable increase in the use of machine harvesting because these operations are on larger sites on the valley floors. However, the many family-owned vineyards away from the valley floors and the landscape does not allow for large scale automation. At a similar time, growing pressure on labour force is meaning that there simply are not enough people available. Despite these pressures, the Central Otago wine region will continue to be an important employer, developing a highly skilled workforce across winemaking, viticulture, wine management, wine sales, tourism, hospitality, and all ancillary businesses. Hiring occurs across the age distribution from school leavers joining in winery, vineyard and cellar door roles to retirees working in the vines in pruning, harvest, and machinery roles.

Central Otago has a high proportion of women in the industry, including vineyard managers, winemakers and sommeliers – some of whom are renowned internationally. A few examples of exceptional women are Jen Parr at Valli Wine – New Zealand Winemaker of the Year 2020, Lucie Lawrence at Aurum Wines – finalist of New Zealand Winemaker of the Year 2022, Claire Mulholland at Burn Cottage Vineyard, Sarah-Kate Duneen at Maude Wines and Rosie Menzies at Carrick Winery, and Michelle Dacombe – Vineyard Manager at Misha's Winery. Misha Wilkinson is currently on the New Zealand Wine Growers Board. However, there is still room for improvement, particularly in upper management or larger wine companies. Women in Wine (a New Zealand Wine mentoring programme) supports Central Otago's achievements and those in other regions.

Technological advancements are helping winegrowers further reduce their carbon footprints and improve profitability. Smart machines (electric powered autonomous vineyard vehicles) are already being produced that can carry out numerous tasks throughout the vineyard simultaneously, so reducing the number of passes a tractor would otherwise have to make. However, these advancements cannot be

342 In 2022, this vineyard was only able to find eight casual workers and had to adapt, largely due to Covid-19 and the lack of available seasonal workers.

used on all vineyards, and where they are used the automation of manual tasks does reduce employment opportunities. Machine harvesting is much more noticeable in areas like Marlborough, Hawkes Bay, Nelson, and Canterbury, where there are large, flat swathes of viticulture land. At present it is only possible on roughly 20 per cent of the vineyards in Central Otago because of the topography. One medium-sized vineyard typically employs around 12 casual workers throughout the season up to April, rising to 16 casual workers for the harvest[342].

All vines (and varietals) are able to be either abundant or constrained in their yields and production is about quality versus quantity. The ability to produce high-quality fruit is often the result of having a vine struggle with its environment – forcing the vine to focus less on a large production of fruit and canopy and more on survival in the form of less fruit but far more concentration – its natural process to reproduce to survive. As an environment, Central Otago is on the edge for grape growing. Vines such as Pinot Noir will defer to lower yields to survive producing more concentrated fruit flavours in the lower numbers of bunches per vine. Additional viticultural intervention helps reduce the bunch weights further allowing more vine energy to be directed into less fruit to ensure good ripening.

Figure 65 shows the range in production for vineyards across the Central Otago Growing Region. In 2022 average vineyard production in Central Otago ranged from around five tons of grapes per hectare on smaller vineyards (those below 15 hectares) to just over six tons of grapes per hectare on large vineyards. As a comparison, Pinot Noir in Marlborough is sometimes cropped at 10 to 14 tonnes per hectare[343]. Similarly, the very small level of planting of Sauvignon Blanc in Central Otago is cropped at seven to nine tonnes per hectare compared to Marlborough at up to 21 tonnes per hectare.

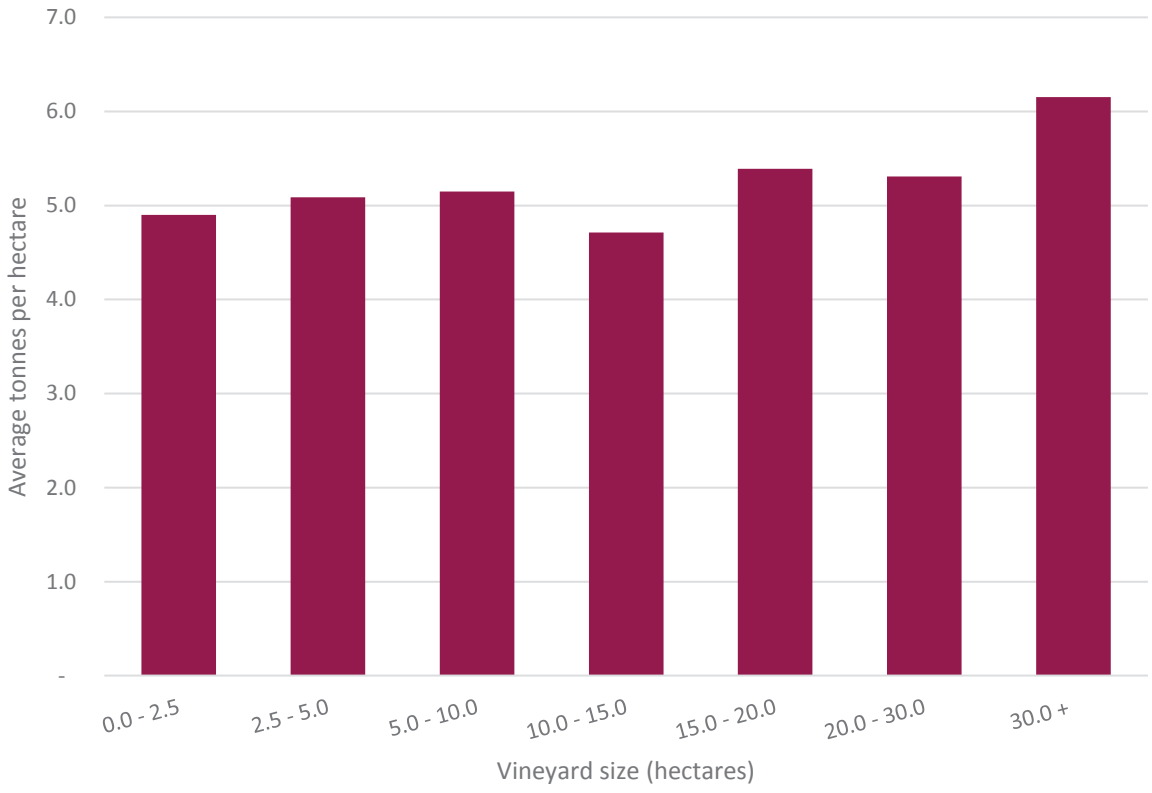

Figure 65: Average grape production per hectare across 221 vineyards in Otago in 2022
Source: Sustainable Winegrowers New Zealand

343 Over the last four years the regional average for Marlborough was six to eight tonnes per hectare, while it was three to five tonnes per hectare was in Central Otago.

Larger wineries (those with a turnover of $20 million+) consistently achieve the highest average profit after tax (e.g., 18.7% in 2018) and their general profitability increased with size due to economies of scale (Deloitte and ANZ, 2018). Smaller wineries have the highest costs and the lowest profitability as a percentage of sales. They also typically generate 10 to 15 per cent of revenue through means other than wine sales (e.g., grape sales and hospitality) (Deloitte and ANZ, 2018).

There is some evidence of a relationship between innovation (including new plant and equipment technologies and digital tools) and the financial performance of wineries. Larger wineries were more likely to prioritise innovation spending than smaller ones. Smaller wineries were also using technology, often using relatively low-cost digital tools to engage with customers.

Achieving a certain scale (i.e., the small business model of 15-35 hectares) is important for the profitability of Central Otago's winegrowers (Deloitte and ANZ, 2018). However, the proliferation of smaller-sized vineyards, means profitability within the industry remains economically fragile with relatively high levels of debt and little contingency reserves to address unplanned costs lower yield seasons. Many winegrowers are looking to vineyard expansion over time to maintain their returns in the future. Some winegrowers want to increase their area planted in grapes while others will achieve scale by consolidating vineyards. Both are dependent on access to water.

8.4.8 Vineyard establishment – an example

Establishing a new vineyard is a considerable undertaking and may take seven or eight years from time of the land purchase to reach full crop production. As an example, Table 15 sets out a basic timeline with milestones for Misha's Vineyard, which was converted from a sheep and beef property near Cromwell[344] to a medium-sized vineyard, to reach the point where it was at full production.

Table 15: Misha's Vineyard establishment timeline

2001-2003	Develop a long-term plan and then search for land following a strict set of criteria[345]
2003	Bought 57-hectare property, applied for water consent, established irrigation company
Mid-2003-Nov 2004	Cleared land, installed rabbit proof fences, road, power, irrigation scheme, main lines, filter sheds, pumping systems, distribution systems
Nov 2004	Planted vineyard
April 2008	First commercial crop
2008-2010	Increasing crops each season
2010	Full production levels reached

344 Misha's Vineyard was previously Sheep Run 238 and, in the past, a Chinese goldmining site, for whom 8 is a lucky number. When the vineyard was planted in 2004, a ground-breaking ceremony was held where an antique Chinese gold coin was placed under each of the first eight vines that were planted, "to return the old gold to the land to bring the new gold – pinot noir". An old gold miner's cottage was also recreated in the style of old cottages that can still be found up Raupo Creek. Kowhai and other natives were planted around the cottage.

345 For example: natural frost drainage, high number of growing degree days, north facing aspect as heat is needed to ripen fruit, fast diurnal shifts to increase fruit acids, and access to water.

Establishing a vineyard is not an investment to be taken on lightly and long-term planning is essential. For Misha's vineyard the first step was to develop a 10-year business plan and a marketing plan. The business plan was based on aggregated data available from other vineyards and included considerations such as the varietals to be grown and the degree of difficulty of the land site. In the early 2000s the 'rule of thumb' was $200,000 per hectare to establish grape vines and an individual vine cost around $7. At Misha's Vineyard 65,000 vines were planted on 26 hectares of the 57-hectare property (46% of the total area), and there is an intention to plant another seven to nine hectares in the future. Additional to the cost of the vines was the cost of rabbit-proof fencing around the perimeter of the property, fencing of the gullies and other areas they wanted to protect, and fencing to divide the vineyard up into manageable blocks.

The global financial crisis occurred at the time Misha's Vineyard was producing wine for sale and the number of markets needed expanded. The original marketing plan estimated five markets[346], but this has increased over time to 15 markets as it was realised that the marketing had to be far more widespread than initially anticipated. Today, they have one domestic distributor and 14 international export market distributors who represent the business in different countries.

> *Some people believe that they can just give up working in an office in Auckland, arrive down in Otago, buy some land, plant some grapes and the next year go out and sell wine. Unfortunately, it does not work that way – constant inputs of capital are needed until the vineyard is established. Those that have tried to do that are now likely to be either growing grapes to supply to someone else or have gone out of the business completely.*
>
> ***Andy Wilkinson, Misha's Vineyard***

8.5 Winemaking and markets

Whilst the focus of this chapter is on the viticultural aspects of the wine industry in Otago, the process of converting grapes to wine is of equal importance and employs many highly skilled workers as well as casual seasonal workers. The economic contribution to the region is significant and continues to expand as new wineries are established. Unlike many of the traditional winegrowing countries, New Zealand has developed a model where much of the wine processing is done through contract wineries that provide winemaking services for multiple brands. These larger winemaking facilities provide services that allow smaller producers to access modern winemaking equipment and share the services of an in-house winemaker to produce their finished wines.

Within Central Otago there are two large service only winemaking facilities – wineries that do not have their own brand of wine but only do contract winemaking – and several branded wineries that also offer contract winemaking services for other wine brands.

346 A 'market' is typically a country or defined market segment within a country that has multiple wine outlets that are serviced by an importer/distributor.

For the year ended June 2018, 83 per cent of wine by volume exported from New Zealand went to just three markets: United States, United Kingdom, and Australia (Deloittes, 2018). The United States market was 36 per cent, but due to strong bottled and bulk pricing was 38 per cent in terms of value (Deloittes, 2018). Markets in Asia accounted for 2.5 per cent of New Zealand's wine exports, but the prices obtained for New Zealand wine in countries such as China, Hong Kong, Singapore, and Japan were twice the average export price and returns from other markets like Canada, Norway and Finland was 25 per cent higher than average (Deloittes, 2018). These countries were all identified as growth markets at the time.

Most premium wine producers went through a difficult period during the Global Financial Crisis. During this period there was a general shift for New Zealand wines from premium bottled wines exported to United Kingdom, Australia, Europe, and some Asian markets to large volume bulk wines to the United States and the United Kingdom. This process began when large scale bottling facilities in Marlborough were left with a large volume of Sauvignon Blanc that wine producers were unable to bottle. Much of this wine was shipped in tank containers to the United Kingdom for bottling and to supply private brand labels wines for supermarkets. Bulk wine now accounts for about 50 per cent of all wines exported from New Zealand and the United States has become New Zealand's largest wine export market.

Image 41: Folding Hill, Gibbston Valley (Central Otago)
Source: Central Otago Winegrowers Association

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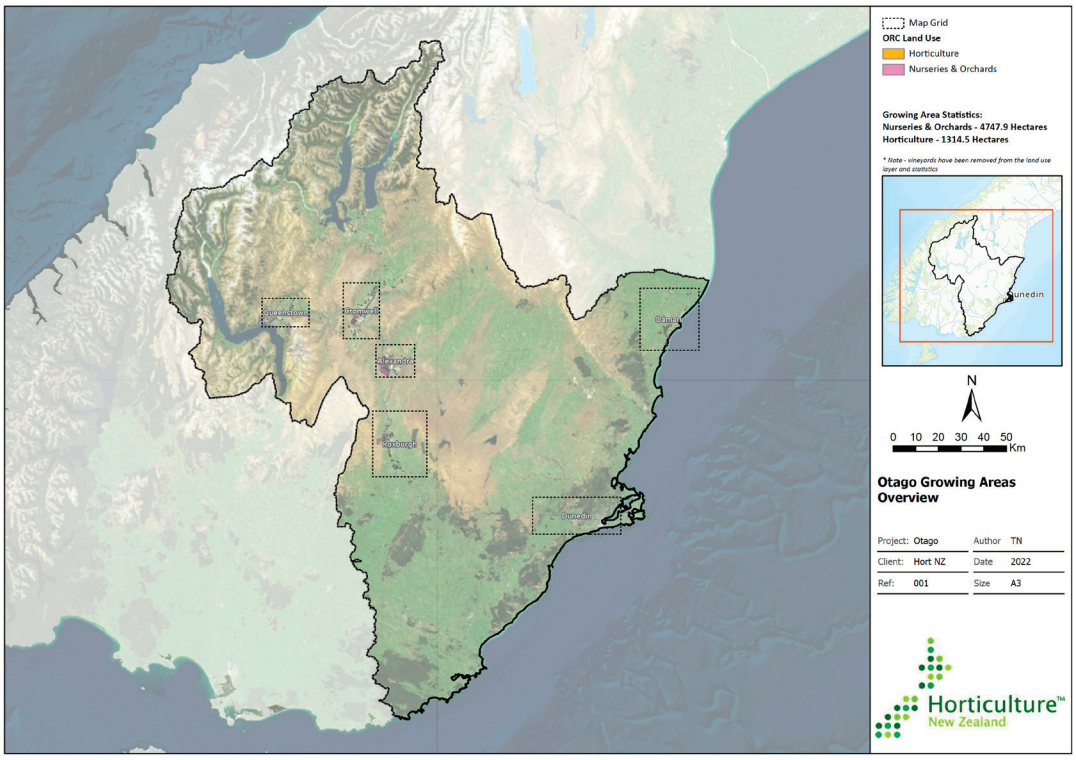
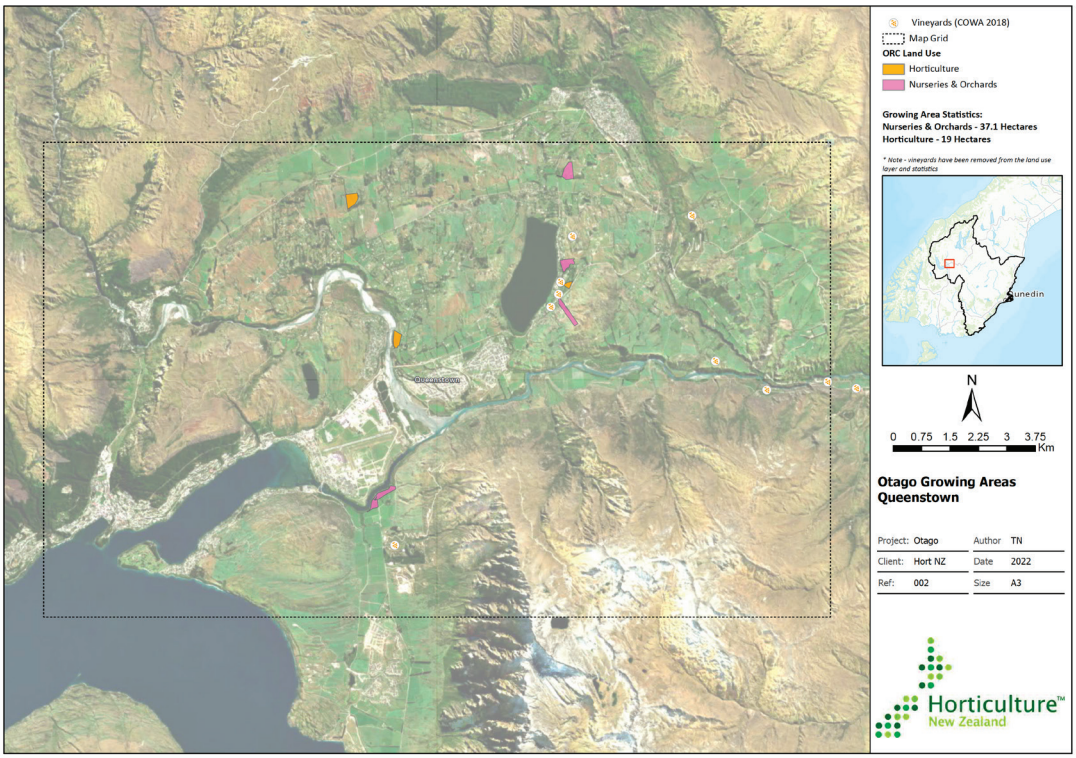
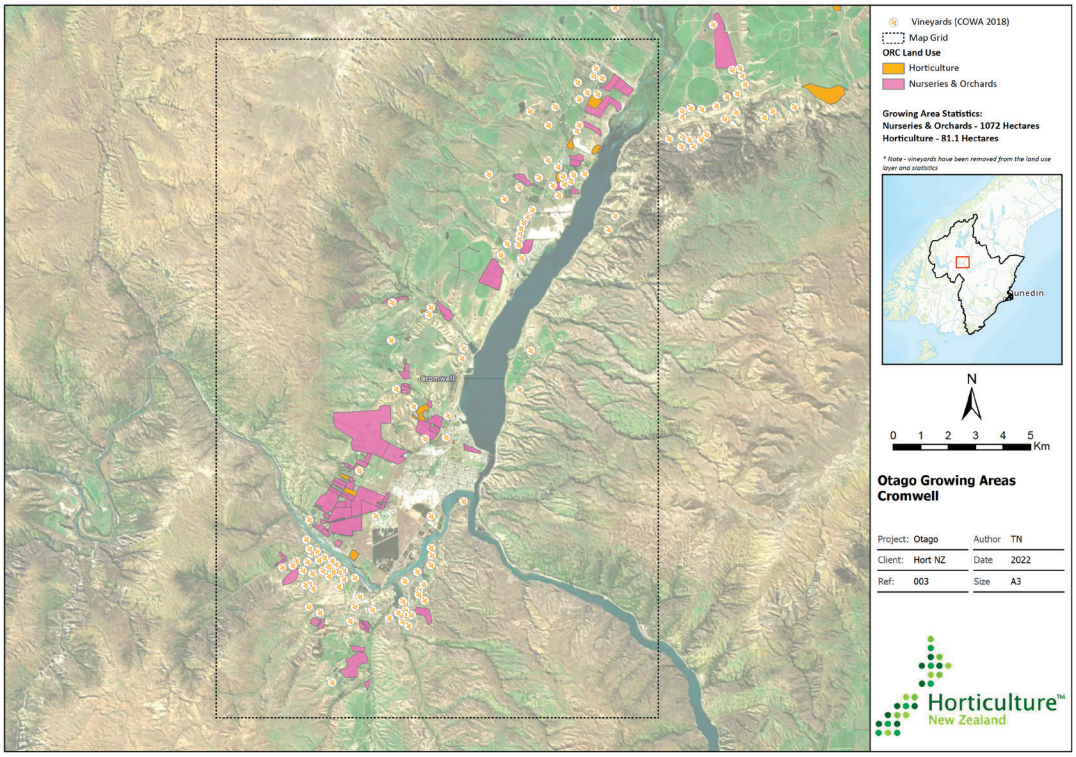
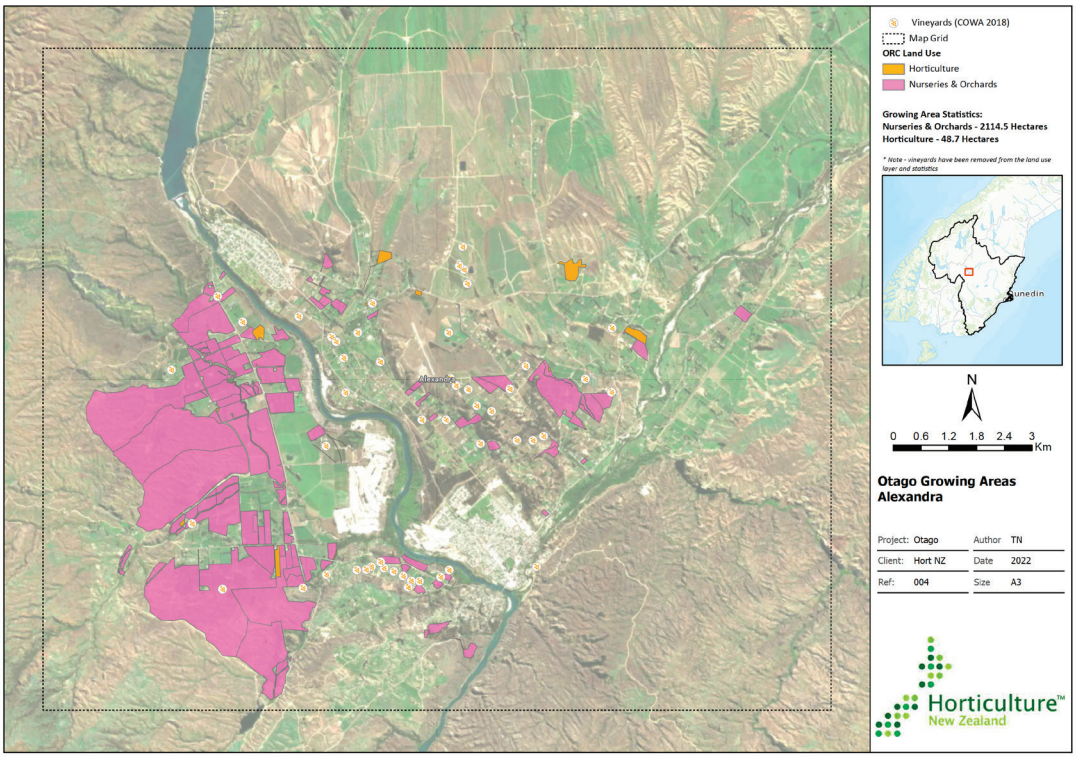
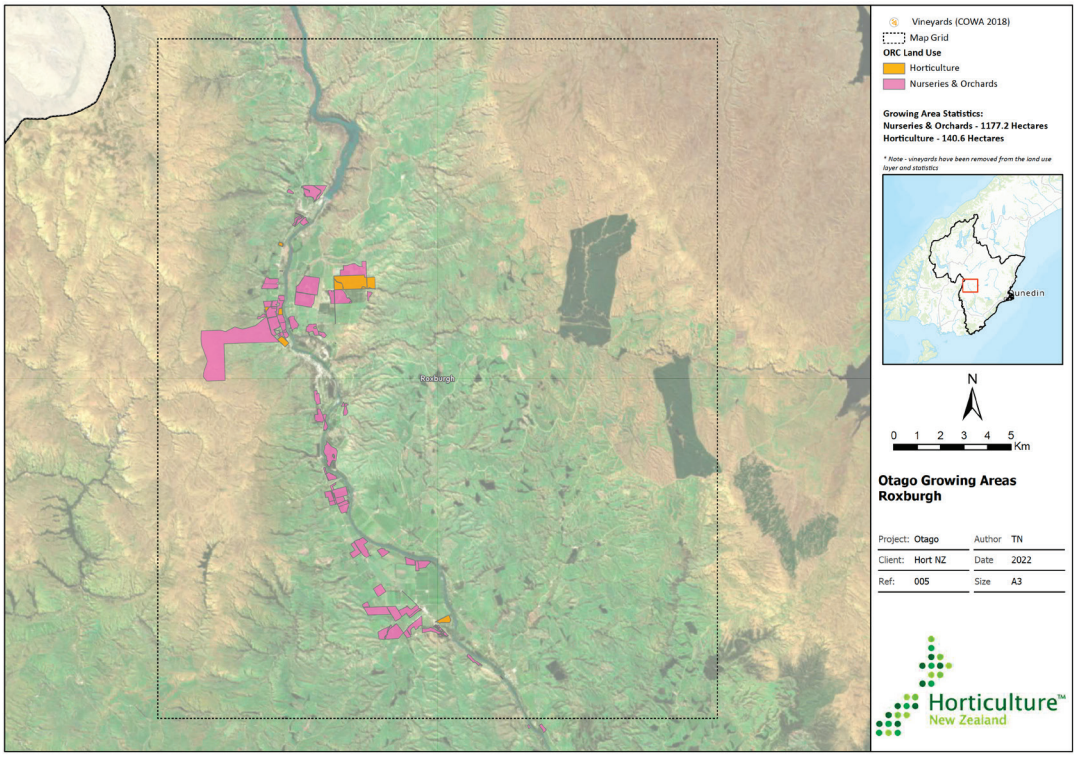
10 Appendix 1 – Horticulture Maps for Otago

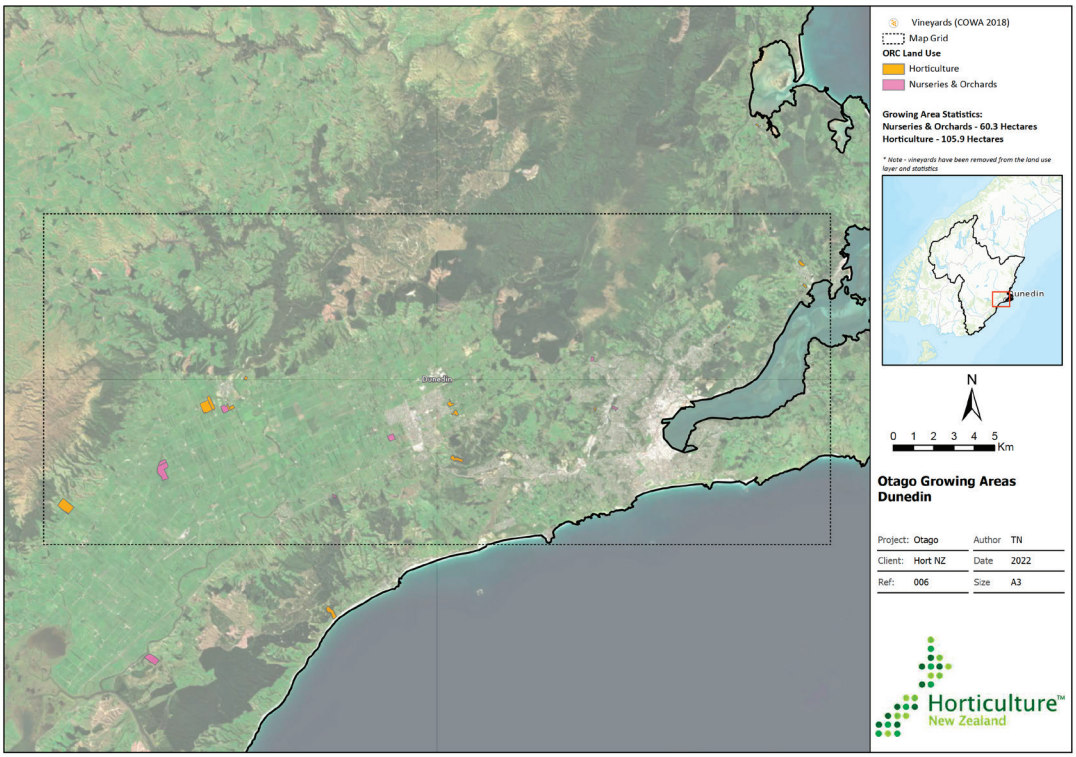


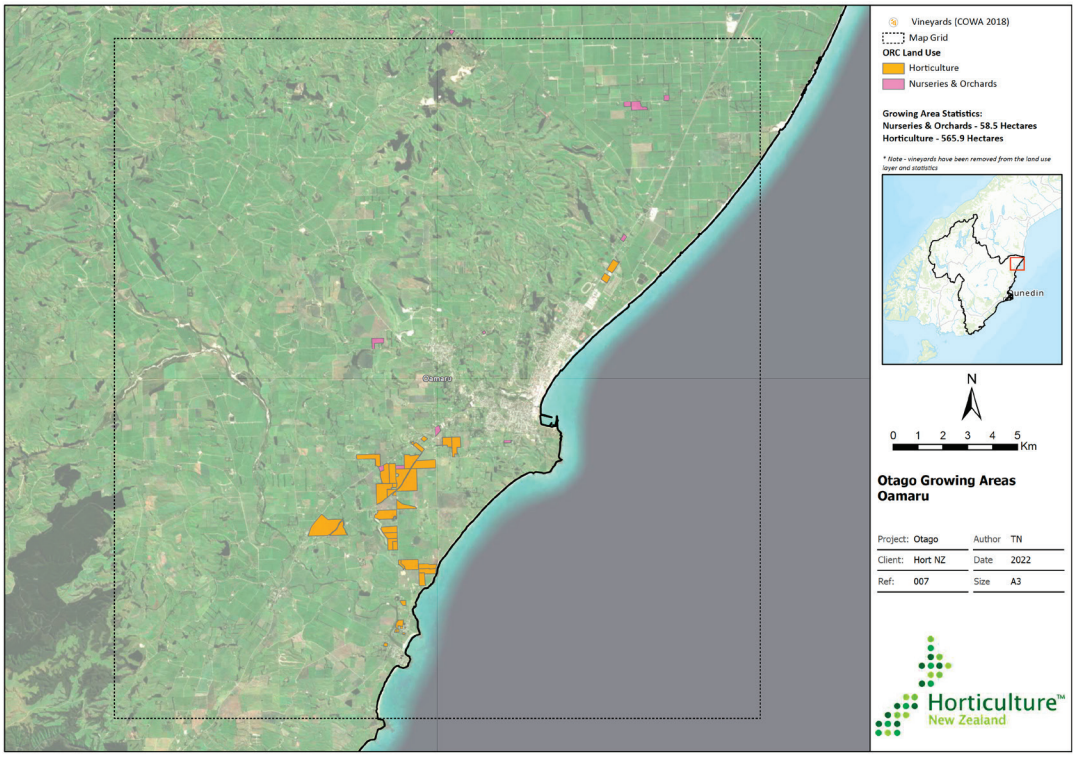



Vineyards (COWA 2018)
Map Grid
ORC Land Use
Horticulture
Nurseries & Orchards
Growing Area Statistics:
Nurseries & Orchards - 1072 Hectares
Horticulture - 81.1 Hectares
* Note - vineyards have been removed from the land use layer and statistics
Dunedin
N
0 1 2 3 4 5
Km
Otago Growing Areas
Cromwell
Project: Otago
Author TN
Client: Hort NZ
Date 2022
Ref: 003
Size A3
Horticulture™
New Zealand


Vineyards (COWA 2018)
Map Grid
ORC Land Use
Horticulture
Nurseries & Orchards
Growing Area Statistics:
Nurseries & Orchards - 2114.5 Hectares
Horticulture - 48.7 Hectares
* Note - vineyards have been removed from the land use layer and statistics
Dunedin
N
0 0.6 1.2 1.8 2.4 3
Km
Otago Growing Areas
Alexandra
Project: Otago
Author TN
Client: Hort NZ
Date 2022
Ref: 004
Size A3
Horticulture™
New Zealand


Vineyards (COWA 2018)
Map Grid
ORC Land Use
Horticulture
Nurseries & Orchards
Growing Area Statistics:
Nurseries & Orchards - 1177.2 Hectares
Horticulture - 140.6 Hectares
* Note - vineyards have been removed from the land use layer and statistics
Dunedin
N
0 1 2 3 4 5
Km
Otago Growing Areas
Roxburgh
Project: Otago
Author TN
Client: Hort NZ
Date 2022
Ref: 005
Size A3
Horticulture™
New Zealand


Vineyards (COWA 2018)
Map Grid
ORC Land Use
Horticulture
Nurseries & Orchards
Growing Area Statistics:
Nurseries & Orchards - 60.3 Hectares
Horticulture - 105.9 Hectares
* Note - vineyards have been removed from the land use layer and statistics
Dunedin
N
0 1 2 3 4 5
Km
Otago Growing Areas
Dunedin
Project: Otago
Author TN
Client: Hort NZ
Date 2022
Ref: 006
Size A3
Horticulture™
New Zealand


Vineyards (COWA 2018)
Map Grid
ORC Land Use
Horticulture
Nurseries & Orchards
Growing Area Statistics:
Nurseries & Orchards - 58.5 Hectares
Horticulture - 565.9 Hectares
* Note - vineyards have been removed from the land use layer and statistics
Dunedin
N
0 1 2 3 4 5
Km
Otago Growing Areas
Oamaru
Project: Otago
Author TN
Client: Hort NZ
Date 2022
Ref: 007
Size A3
Horticulture™
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