Section 32 Evaluation Report for the Proposed Otago Land and Water Regional Plan

Chapter 2: Land and Freshwater in Otago

This Section 32 Evaluation Report should be read together with the Proposed Otago Land and Water Regional Plan

Otago Regional Council

Contents

List of Figures

Abbreviations

CAP	Catchment Action Plan
FMU	Freshwater Management Unit
ICM	Integrated Catchment Management
NES	National Environmental Standard
NPSFM	National Policy Statement for Freshwater Management 2020
ORC	Otago Regional Council
pLWRP	Proposed Otago Land and Water Regional Plan 2024
RPW	Regional Plan: Water
RMA	Resource Management Act 1991

1. Overview of land and fresh water in Otago[1]

1. The development of the pLWRP is required to address issues with fresh water and freshwater ecosystems in the region as well as to respond to direction in regional and national policy statements that has not yet been implemented in Otago. This section describes the land and fresh water in Otago and summarises their state and trends, where this information is available.

1.1. Regional overview

2. At 32,000 km^2, the Otago region is the third largest region in New Zealand, making up 12% of New Zealand's land mass (Otago Regional Council, 2024). The region's eastern edge is entirely marine, extending 12 nautical miles out to sea from a scenic and varied coastline.

3. Otago meets Canterbury at the southern bank of the Waitaki River, its northern border following the river upstream then branching off along Awamoko Stream, following the north branch of the Kakaunui River before heading inland once again along the Hawkdun Range, following catchment boundaries and ridgelines into the Southern Alps at Otago's westernmost border.

4. In the south, beginning at Brother's Point in the Catlins, the border with Southland tends northwesterly, taking in the Pomahaka River catchment, and running along the eastern side of Umbrella and Kōpūwai Ranges to encompass the headwaters of the glacial alpine lakes, Whakatipu-Waimāori/Lake Wakatipu, Wānaka, and Hāwea.

5. For the purposes of freshwater management, the region has been divided into five areas known as Freshwater Management Units (FMUs).

1.2. FMUs and rohe

6. Freshwater management unit or FMU is defined in the NPSFM as "all or any part of a water body or water bodies, and their related catchments, that a regional council determines under clause 3.8 is an appropriate unit for freshwater management and accounting purposes."[2] ORC has identified five FMUs: Clutha Mata-au, Taiari, North Otago, Dunedin & Coast, and Catlins. Due to its size, the Clutha Mata-au FMU has been further divided into sub-units called rohe: Upper Lakes, Dunstan, Manuherekia, Roxburgh, and Lower Clutha (see Figure 1 below). There is more information on the development of the FMUs and rohe in Chapter 4 section 6.1 of this report.

[1] Most of the information in this section has been compiled from section 3.2 of the Regional Plan: Water for Otago and Ozanne, Levy, & Borges, States and trends of Rivers, Lakes, and Groundwater in Otago 2017 - 2022, 2023. All of the maps and graphs except for Figure 1 and Figure 5 were created using information from the Otago Land Use Map 2022. More information on patterns of land use and water use for irrigation is included in Yang and Cardwell, Otago Region Economic Profile for Land and Water, 2023 (Yang & Cardwell, 2023).

[2] Clause 1.4, NPSFM

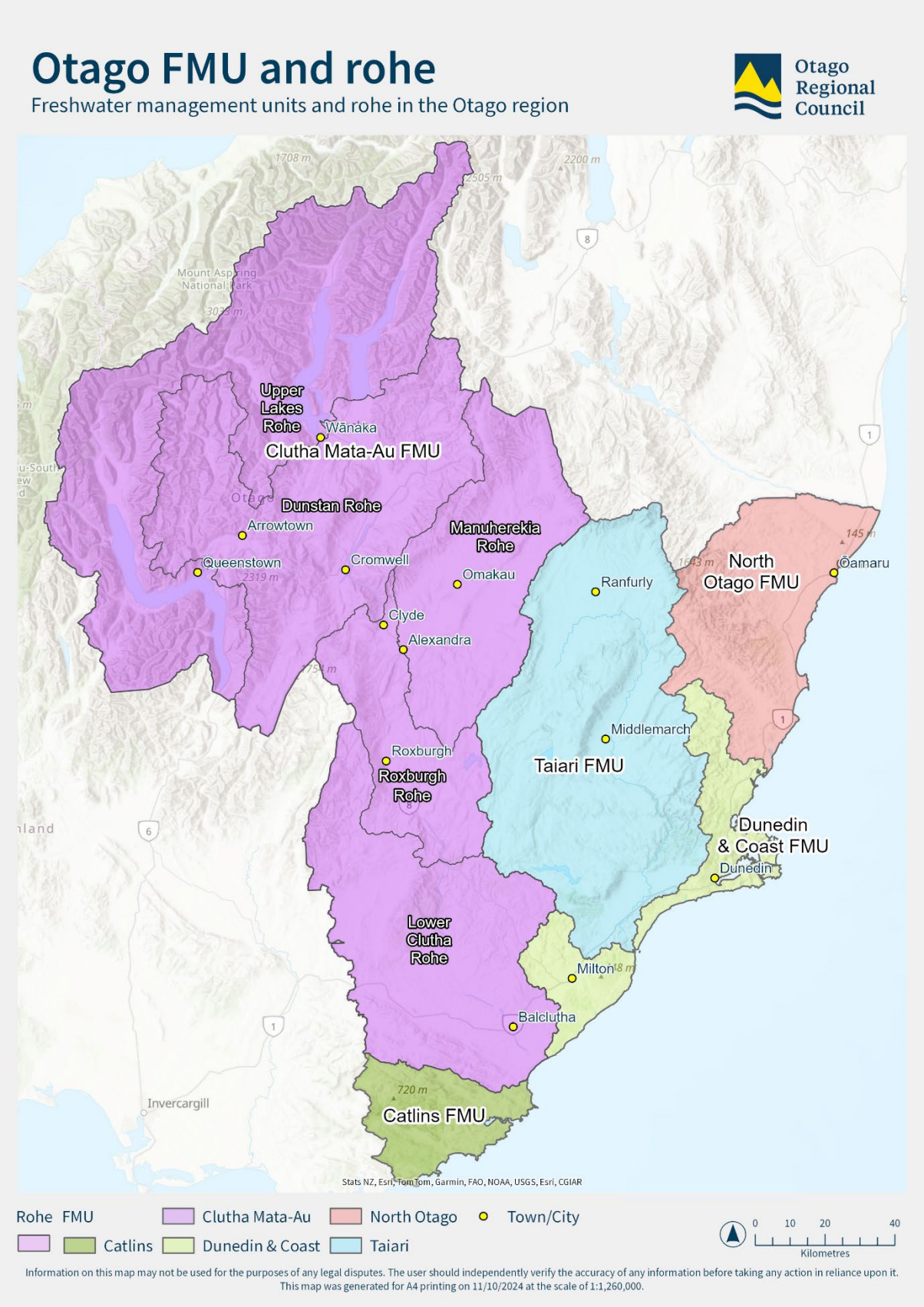

Figure 1: Otago's FMUs and rohe

7. The Clutha Mata-au FMU encompasses the full extent of the river catchment, while the five rohe allow for a more nuanced and appropriate scale for setting freshwater objectives and limits.

    a. The Upper Lakes rohe encompasses Whakatipu Waimāori/Lake Whakatipu, Lake Wānaka, and Lake Hāwea and all the tributaries that flow into them.

    b. The Dunstan rohe runs from the outlets of Lakes Wānaka, Whakatipu-Waimāori/Lake Wakatipu and Hāwea down to the Clyde Dam, and includes the Kawarau, Nevis/Te Papapuni, Shotover/Kimiākau, Upper Clutha/Mata-au, Hāwea, Cardrona River/Ōrau, Arrow, and Lindis Rivers.

    c. The Manuherekia rohe is based upon the catchment area of the Manuherekia River from the border with Canterbury to where the Manuherekia meets the Clutha/Mata-au at Alexandra.

    d. The Roxburgh rohe is bounded by the Clyde Dam in the north and Beaumont in the South, and includes catchments such as the Fraser River, Lake Onslow, and the Teviot River and the Benger Burn.

    e. The Lower Clutha rohe runs from Beaumont to the Pacific Ocean, where the Clutha Mata-au discharges to the sea near Balclutha, and includes catchments such as the Poumāhaka, Waitahuna and Puerua.

8. The landscape and climatic conditions influence the land use patterns across the region, creating different mosaics for each of the five FMUs and the five Clutha Mata-au rohe. Figure 2 shows an estimate of the distributions of land uses across the region[3], while Figure 3 and Figure 4 indicate how this plays out by FMU/rohe and by district (respectively). Both spatial perspectives are important for understanding the distribution of benefits and costs of the pLWRP between local communities, because an FMU may contain one or more districts and vice versa.

9. Since land development began in Otago, land use patterns have not been constant. They continually change over time in response to shifts in markets, government policy and the evolution of differing industries. The pace of change has become more rapid over time, particularly since New Zealand's market deregulation in the 1980s.

10. Otago has a predominance of hill and high country and more limited flat land, particularly at low altitude, compared with the expansive fertile plains found in Southland and Canterbury. The limited flat land leads to greater competition across land uses, translating to higher land prices and higher pressure amongst the farm businesses.

11. Of its primary production area, Otago has more dry stock use, less dairying and more forestry land than New Zealand proportionally. This sheep and beef land largely has few alternative land uses and there is a marked interdependence within and between land uses as well as high levels of complexity and diversity in the farm production systems.[4] Where variability in land use patterns exist this likely improves the region's resilience.

[3] The land use maps are indicative only. An updated regional land use map is currently being produced.

[4] More information on rural land use in Otago is available in Farmers and Growers in Otago (Moran (Ed.) 2022) Otago's rural businesses and environmental actions for fresh water (Moran (Ed.) 2023) and a more general discussion of land use in the region in Otago Region Economic Profile for Land and Water (Yang & Cardwell, 2023).

12. The development of irrigation has created more opportunities and certainty, but fresh water too is limited. These farm systems over the last 20 years have increased in stocking rates, got larger in size plus improved productivity per hectare.

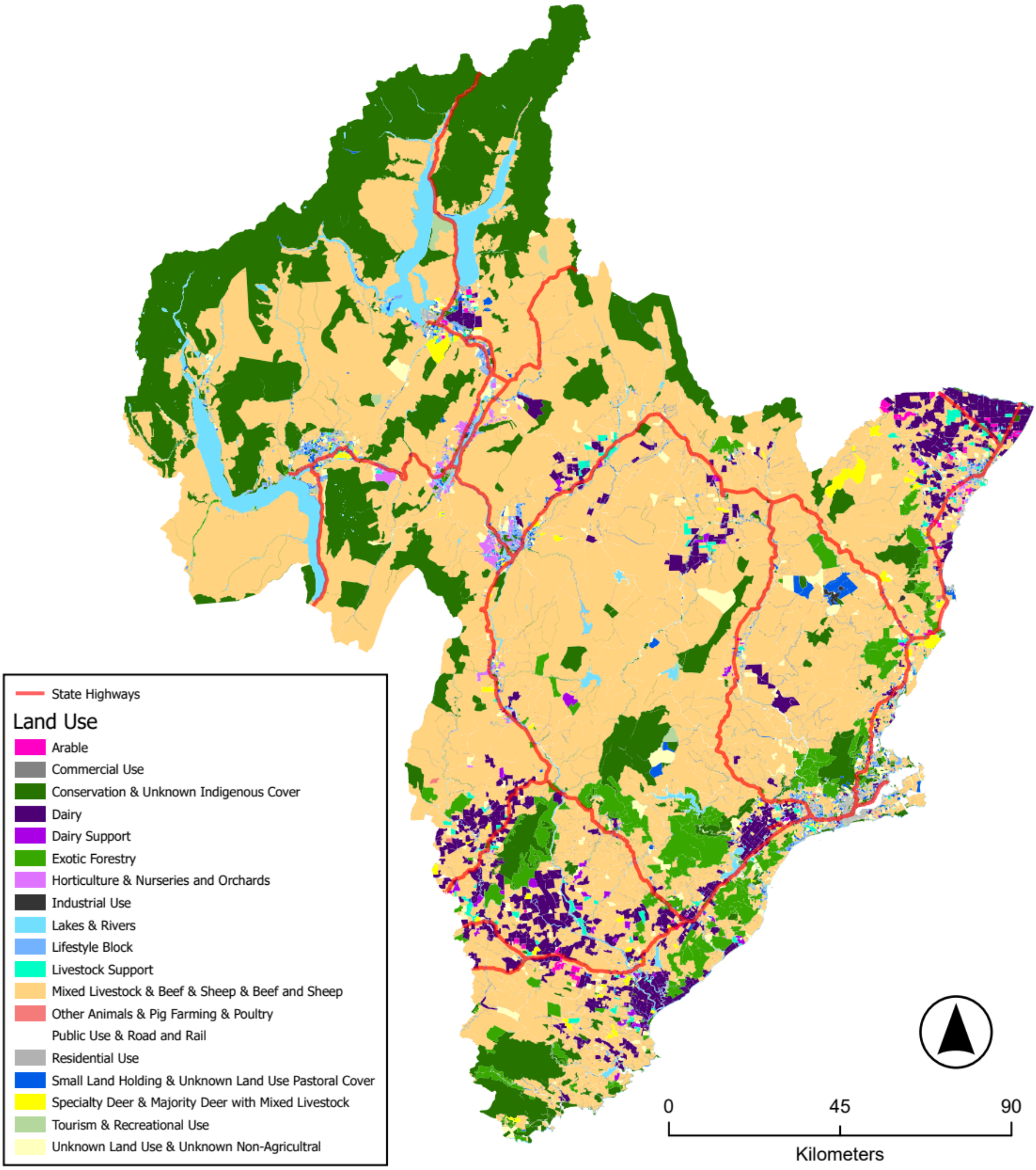

Figure 2: Estimated regional land use patterns for Otago in 2022

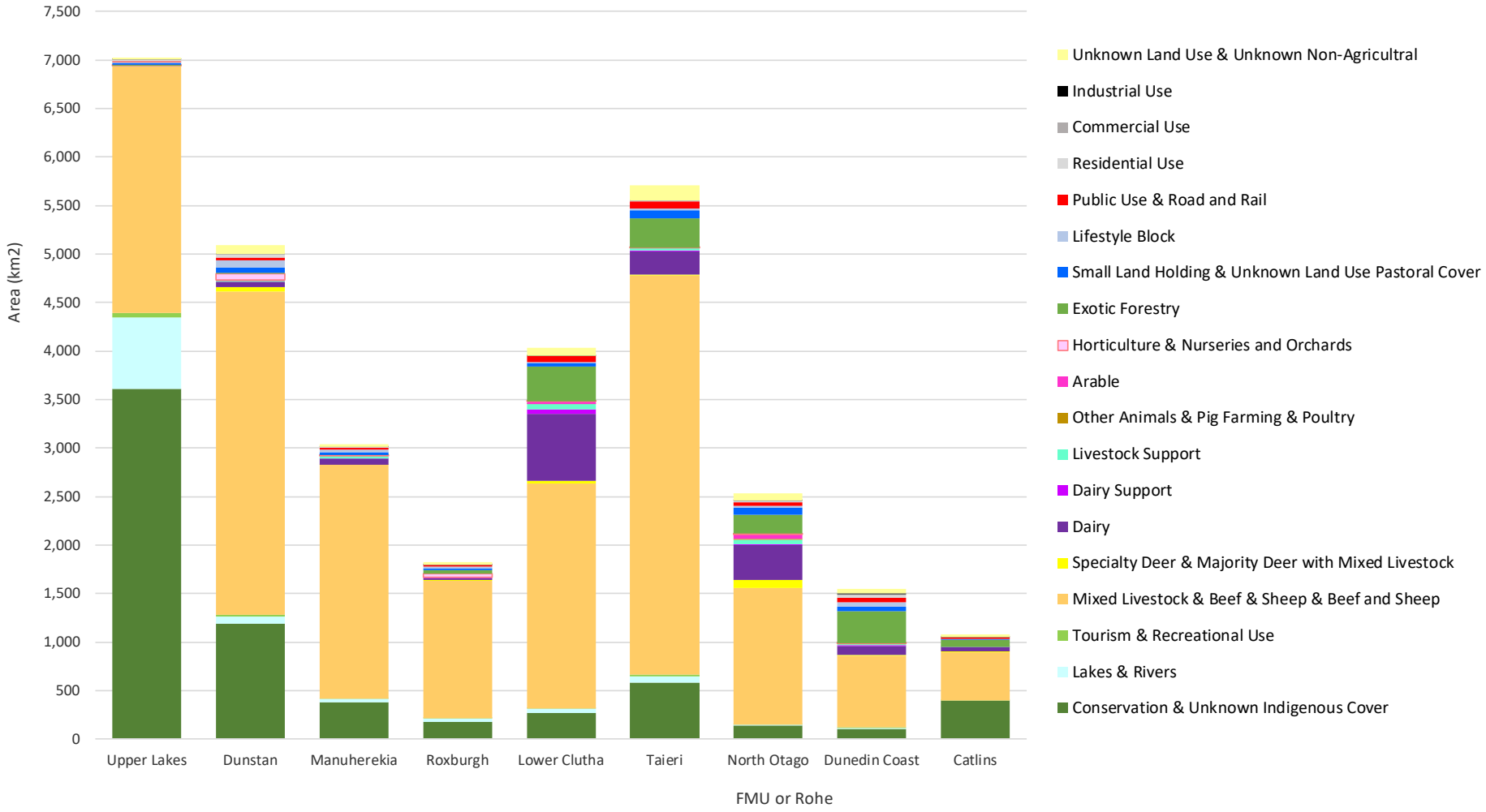

Figure 3: Estimated distribution of land uses in Otago by FMU (and the five rohe in the Clutha FMU) in 2022. Note: The first five columns in the graph are the five rohe in the Clutha FMU, the last five columns are the remaining four FMUs in Otago.

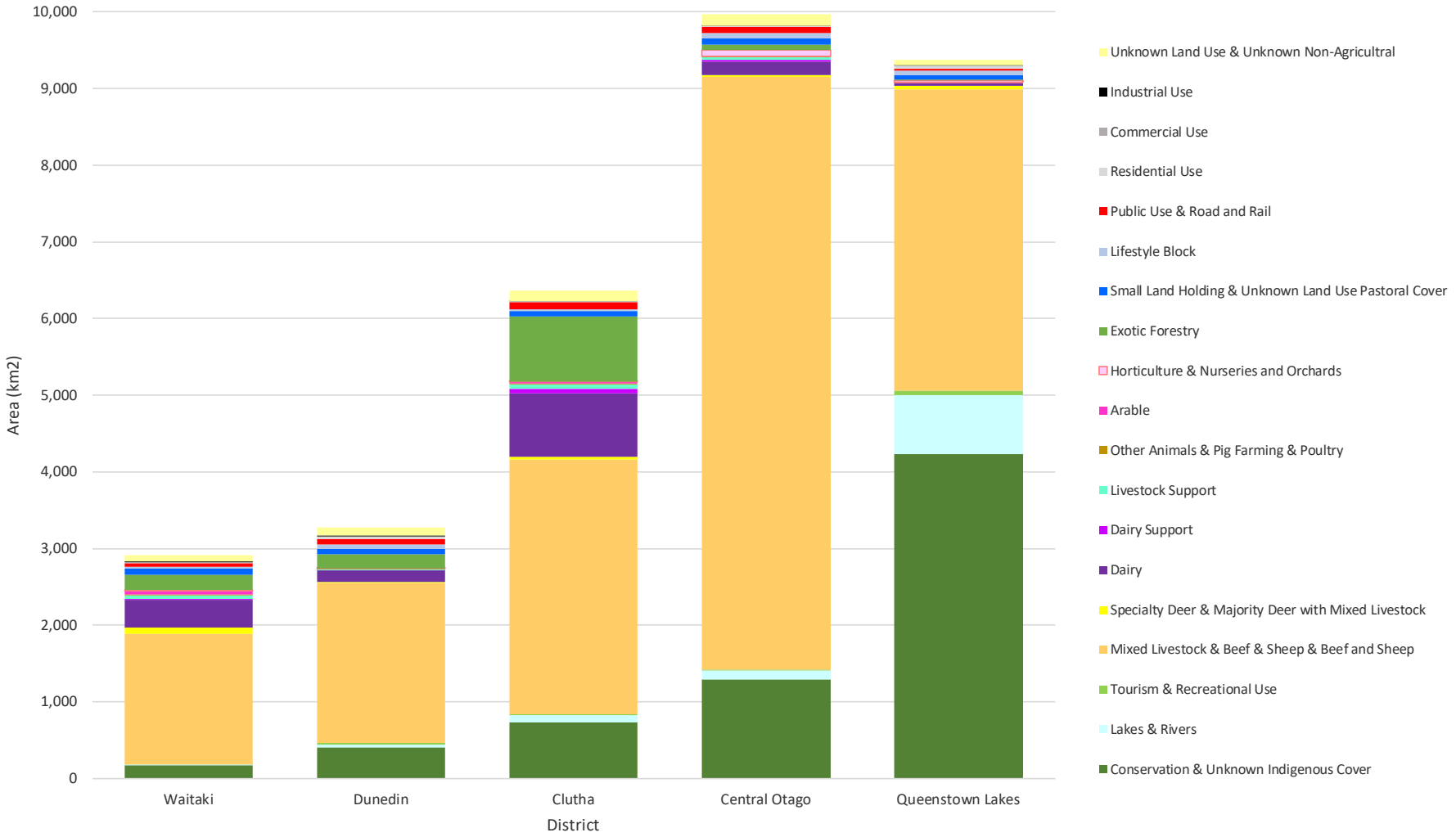

Figure 4: Estimated distribution of land uses in Otago by district in 2022

13. The following sections provide a regional and FMU based overview of different parts of Otago's environment under the following headings:

- Water quantity,
- Water quality,
- Wetlands,
- Estuaries, and
- Indigenous freshwater species

1.3. Water quantity[5]

14. The north-western parts of Otago have extremely high rainfall, with annual rainfall totals declining rapidly southeast of the catchments of Lakes Hāwea, Wānaka and Whakatipu-Waimāori/Lake Wakatipu. Along the coast, there is a north to south gradient for rainfall, with the Catlins typically being wetter than North Otago. In terms of catchment yields of fresh water, the distribution is similar to rainfall, with high yields upstream of the large lakes, and lower yields in Central Otago and coastal North Otago. Despite the generally large water volumes present in the region, some parts of Otago are among the driest areas in New Zealand. The lack of water is observable in many small stream stretches, which dry up each summer, but may still have high values. In many of the catchments with lower freshwater yields there is also high water use demand and therefore potential for over allocation of freshwater.

15. The Clutha Mata-au catchment is the largest in Otago. The Clutha River/Mata-au drains much of the Otago region and is the largest river in New Zealand for the quantity of water carried each year. Its catchment area totals 21,000km^2 and 75% of the total flow of the Clutha Mata-au at Balclutha (near the coast) results from the catchments of the three major lakes: Lakes Hāwea, Wānaka and Whakatipu-Waimāori/Lake Wakatipu. Larger rivers feeding into the Clutha/Mata-au catchment include the Cardrona River/Ōrau, Lindis, Shotover/ Kimiākau, Nevis/Te Papapuni, Fraser, Manuherekia, Teviot, Pomahaka/ Poumāhaka, Waitāhuna, and Waiwera/Te Waiwhero rivers. The Clutha Mata-au and its principal tributary, the Kawarau River, pass through gorges, two of which are dammed for hydro-electricity generation resulting in Lake Dunstan and Lake Roxburgh.

16. The second largest catchment in Otago is that of the Taiari River, which has a catchment area of 5,060km^2. Rising in the uplands of Central Otago, the river meanders between mountain ranges before passing through an incised gorge and crossing the Taiari Plain. There it joins the waters of the Lake Waipori/Waipōuri and Waihola/Waihora catchments and becomes tidal before making its way through another gorge to the sea at Taiari Mouth.

17. Other notable Otago rivers drain the coastal hills in catchments of differing character. In the north, the Kakanui/Kākaunui, Waianakarua, Shag/Waihemo and Waikōuaiti Rivers rise in high country and pass through predominantly dry downlands. Although most of the Waitaki River is located in the Canterbury region, part of the Lower Waitaki catchment is located in Otago. The Tokomairiro/Tokomairaro River flows through Milton, south of Dunedin, and

[5] Statement of Evidence of Roderick Donald Henderson on behalf of the Otago Regional Council, 7 December 2020. In the matter of the Water Permits Plan Change – proposed Plan Change 7 to the Water Plan (Statement of Evidence of Roderick Donal Henderson on Behalf of the Otago Regional Council, 2020)

drains rolling country between the Taiari and Clutha Mata-au catchments. Rivers in the south of Otago, particularly the Catlins area, emerge from wetter, often forested hills.

18. Approximately 23% of New Zealand's total lake surface area is in Otago. Otago has a wide diversity of lakes including glacial, riverine, coastal and lowland lakes, wetlands and artificially constructed lakes. Lakes vary greatly in size from Whakatipu-Waimāori/Lake Wakatipu at 29,400 hectares through to lakes of less than 1 hectare. Otago lakes are highly valued for recreation and scenic values, as habitat, for drinking water and irrigation, and they also contribute to flood mitigation and New Zealand's electricity generation.

19. Groundwater is also a precious part of the water cycle in Otago and is used across the region as a critical source of water for drinking, irrigation, industry and stock water supply. There are a number of places in Otago where groundwater is of particular significance due to existing use or potential demand. In addition, groundwater discharges significantly affect stream flows, water quality, and ecology in various catchments across the region (e.g., in the Kākaunui-Kauru, Shag/Waihemo). The status and use of many bores across the FMU is unknown.

20. In contrast to the extensive gravel aquifers found in some parts of New Zealand (e.g., the Canterbury Plains, Hawke's Bay) most of Otago's aquifers are small and occur within various geological settings. These settings are mainly disconnected basins that are associated with glacial outwash or moraine deposits in river valleys (i.e. alluvial/fluvial depositional environments) and can contain multiple aquifers depending on the environment in which they were formed.

21. Otago Regional Council (Otago Regional Council, 2021b) lists the geological strata where aquifers have been identified within the Otago region as:

    a. Quaternary outwash and recent alluvial gravel (unconfined aquifers);

    b. Tertiary units of varying properties (normally confined/semi-confined aquifers);

    c. Claybound alluvial gravels and sediments in older terrace settings (unconfined aquifers);

    d. Volcanic deposits; and

    e. Other units (limestone, fractured schist, and basal quartz conglomerates).

22. Although groundwater is present within the substrata of most localities within Otago, there are limited areas where bores can sustain a reliable supply of water. Where it is available, groundwater can be an important resource for economic activity.

23. Otago's weather patterns, with higher rainfall and snow in the north-west of the region, are reflected in the mean flows of FMUs, with the Clutha Mata-au mean flow totalling 88% of the overall mean flow in Otago, despite covering 67% of the region's area.

24. The vast majority of water take consents are for surface water (approximately 92%) with more consents located in drier areas such as the North Otago FMU, Dunstan rohe and Manuherekia rohe. There are some catchments in Otago where water abstraction poses a medium to high risk to ecological values due to lower flows for longer periods than would

naturally occur. These catchments may require higher minimum flows and/or lower allocation to decrease their risk level.[6]

25. In its decision on PC7, the Environment Court noted that there is a high degree of uncertainty in the reliability of the existing water quantity information held by ORC.[7] The Court also noted evidence on the range of issues affecting the coverage and continuity of flow recording in Otago. These issues included a lack of monitoring in some catchments, few or no measurements for smaller tributaries, diversions in/out of catchments, abstractions for out of stream use, and manipulation of flows due to storage.[8]

1.4. Water quality[9]

26. The most recent reporting on surface water quality is *State and Trends of Rivers, Lakes, and Groundwater in Otago 2017-2022* (Ozanne, Levy, & Borges, State and trends of Rivers, Lakes, and Groundwater in Otago 2017 - 2022, 2023). This report assessed state and trends in rivers, lakes, and groundwater quality across Otago. River and lake state results show that water quality across Otago is spatially variable, water quality is best at lakes, river and stream reaches located at high or mountainous elevations under predominantly native cover. These sites tend to be associated with the Upper Lakes rohe as well as the upper catchments of the region's larger rivers (e.g., Lindis River, Pomahaka River, Nevis River) and the large lakes (e.g., Wānaka, Hāwea and Whakatipu-Waimāori/Lake Wakatipu). Other areas, such as urban streams in the Dunedin & Coast FMU, intensified catchments in the North Otago FMU and some tributaries in the Lower Clutha rohe have poorer water quality. When considering the major four contaminants (nitrogen, phosphorus, *E.coli* and sediment), *E.coli* is most often the attribute for which sites and segments fail to comply with the national bottom line.[10] However, many FMUs have sites which also fail to comply with clarity bottom lines and the total nitrogen and total phosphorus nutrient criteria which provide for the periphyton bottom lines. This indicates that measures which reduce loads of these contaminants are required.

27. The regional aggregation of trend results indicates that, over the 20-year trend period, both phosphorus and ammoniacal nitrogen levels are improving (i.e., the levels in water are decreasing). However, dissolved inorganic nitrogen, total nitrogen, *E.coli*, and turbidity are degrading (i.e. the concentrations in water are increasing). Over the 10-year trend period, the regional results indicate improving phosphorus, ammoniacal nitrogen, and turbidity. *E.coli* is likely to be degrading across the region and the outcomes from total nitrogen and dissolved inorganic nitrogen are uncertain. These patterns are consistent with national patterns indicating intensification. In the context of the existing Water Plan, increasing nitrogen and *E.coli* levels across the 20-year period indicate the plan has not managed water

[6] The information is this section is from LWRP surface water quantity programme summary retrieved from https://www.orc.govt.nz/media/pc5fjbbn/memo_lwrp-surface-water-quantity-programme-summary_j-augspurger_march-2024.pdf (Augspurger & Dyer, 2024)

[7] Decision No. [2021] NZEnvC 164 – Interim Decision of the Environment Court, Annexure 5, para [18] (Interim Decision of the Environmental Court, 2021)

[8] Decision No. [2021] NZEnvC 164 – Interim Decision of the Environment Court, Annexure 5, para [9] (Interim Decision of the Environmental Court, 2021)

[9] The information in this section is compiled from State and Trends of Rivers, Lakes and Groundwater in Otago 2017-2022 (Ozanne, Levy, & Borges, State and trends of Rivers, Lakes, and Groundwater in Otago 2017 - 2022, 2023)

[10] A national bottom line is an attribute state as defined in the National Policy Statement for Freshwater Management (2020). Sites where an attribute falls below the national bottom line state must be improved unless specific exceptions apply.

quality or land use intensification adequately. The 10-year results for nitrogen indicate that while some areas are likely improving, others are likely to be degrading.

28. The latest information on groundwater quality is reported in *State of the Environment: Groundwater quality in Otago* (Otago Regional Council, 2021b). This report summarises the state of groundwater quality as well as the potential effects of groundwater nutrient concentrations[11] on surface water quality.

29. Figure 5 below shows the location of Otago's FMUs/rohe and aquifers.

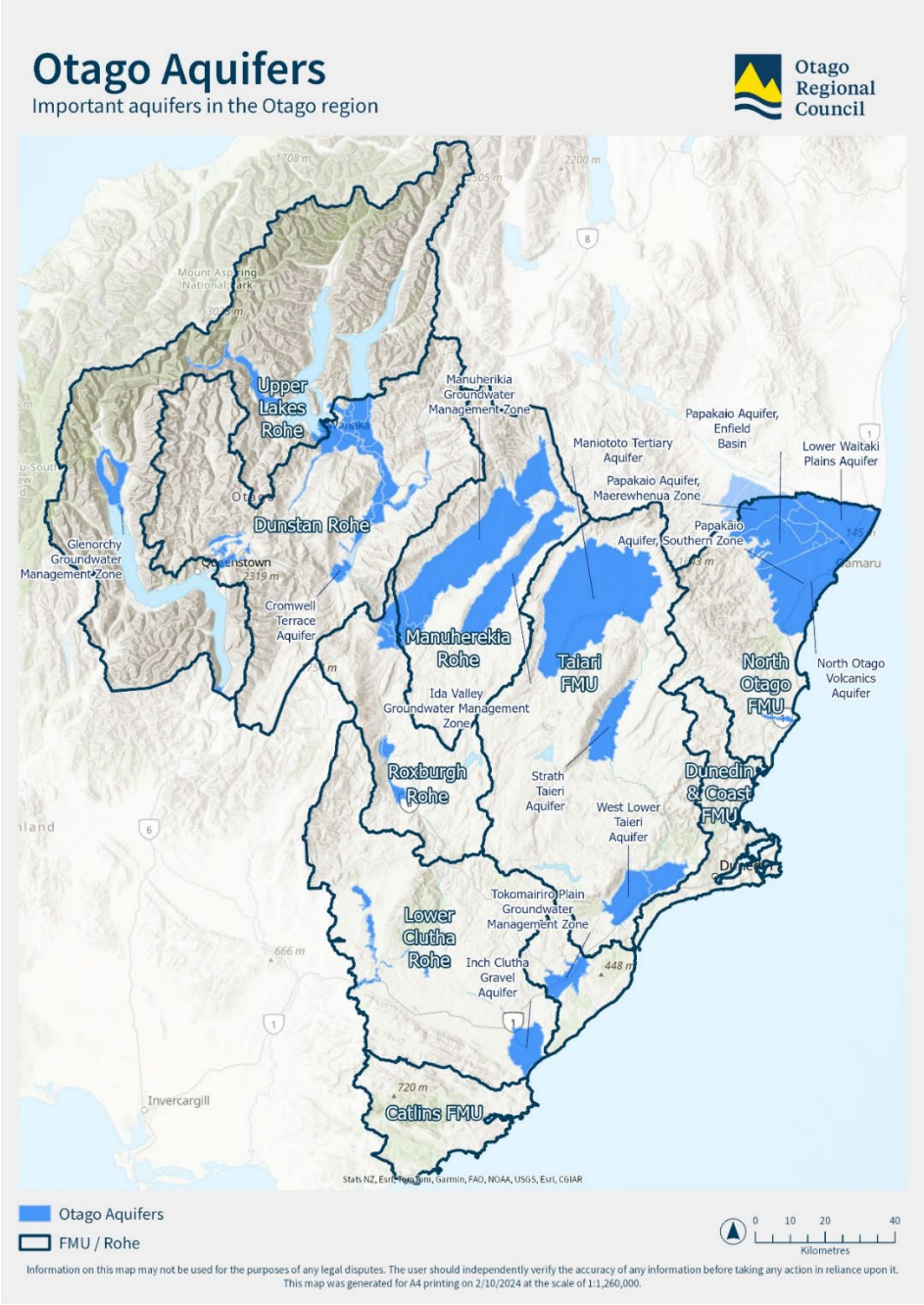

Figure 5: FMUs and rohe boundaries and aquifer locations in Otago

[11] Nitrate nitrogen, DRP, and ammoniacal nitrogen (ammonia).

30. The groundwater quality monitoring network currently consists of 55 monitoring bores with varying degrees of borehead security. The bores are located across the five FMUs, however their distribution is uneven with only one bore in the Dunedin and Coast FMU and too very recent bores in the Catlins FMU. Additionally, there are some aquifers that are not currently monitored.

31. The groundwater quality assessment shows that, similar to surface water, groundwater quality across the region is highly variable. Sections 2 to 6.5 below describe the results in each FMU and rohe.

32. In recent years various community groups have been established across the region, raising awareness and carrying out projects to look after the health of the region's freshwater resources. Further opportunities are currently arising with the staged roll-out of ORC's Integrated Catchment Program (ICM) whereby ORC seeks to facilitate the development and implementation of integrated Catchment Action Plans (CAP) in collaboration with iwi and community. These are long -term plans that focus on providing for environmental health as well as human wellbeing values and will, together with proposed Land and Water Regional Plan's (pLWRP) regulatory framework, assist with achieving the pLWRP's objectives.[12]

1.5. Wetlands[13]

33. Wetlands are an important component of Otago's water. They provide a diverse set of landscape elements, including high altitude blanket bogs and string bogs, saline areas, swamp forest remnants, shallow lake complexes, estuarine saltmarshes and valley floor swamps. These are of particular significance due to their scarcity and ecological and cultural values.

34. Upland wetlands such as those on Otago's block mountain ranges, are often considered important for supporting summer stream flows, as well as their near-pristine ecosystems. The most common wetlands in the hill country are Carex-dominant swamps in gullies, as well as copper tussock swamp and marsh wetlands in montane areas.

35. Lowland and montane wetlands provide important habitat for birds, including the Australasian bittern and South Island fernbird, particularly in eastern Otago as well as in the upper Taiari River, upper Manuherekia River, lower Dart River/ Te Awa Whakatipu and Mātakitaki.

36. There are many ephemeral wetlands in the dry montane basins of inland Otago. These wetlands are considered a Critically Endangered and historically rare ecosystem type and are important habitats for Threatened and At-Risk plant species as well as for bird such as the pied stilt and banded dotterel.

37. Distinctive scroll plains occur in the upper Taiari River and, to a smaller extent, the inflows of the Loganburn Reservoir and Lake Onslow. These scroll plains provide important habitat for rare plant species. The Upper Taiari Scroll Plains and the large Waipōuri/Waihola wetland complex are wetland systems of significance for a range of indigenous wildlife.

[12] A more detailed overview of the ICM programme is included in section 11.1.1 of Chapter 21 of this report.

[13] The information in this section is compiled from An overview of the state of indigenous biodiversity in the Otago region (Wildlands, 2020b) and Wetlands of the Otago Region (Peter N. Johnson, 2022)

38. Coastal wetlands are ecologically important ecosystems, providing ecosystem services such as water filtration (taking up nutrients and sediment filtration, among other pollutants) coastal protection (eg. flooding, storm surges) and through enhancing biodiversity (via the habitat). Estuarine saltmarsh wetlands are the predominant coastal wetland in Otago with approximately 1143ha across Otago, with these systems providing the same ecosystem services and home to an array of biodiversity (including a threatened species such as *Lachnagrostis tennis* an endemic grass).

39. Nationally, there has been significant loss of wetland area, with only 10% of the original wetlands remaining (Ausseil, et al., 2008). Despite a requirement on regional councils to protect wetlands from 1996 to 2018, 5,761 hectares of wetland area were lost, with 87% of this being caused by conversion to exotic grassland (Ausseil, et al., 2008). Within Otago, this loss has largely occurred in lowland and montane environments. While wetlands in hill country gullies can often persist in modified environments, montane wetlands are significantly affected by drainage. Therefore, these ecosystems are highly vulnerable to the effects of exotic invasions, open-cast mining, and pastoral intensification. Over 800m above sea level, Otago's upland wetlands are relatively intact. However, they are more vulnerable to modification from activities such as intensification of farming and large developments (such as the Lake Onslow pumped storage system). Coastal salt marsh wetlands have declined by 61% across Otago with these wetlands affected by drainage, installation of flood gates, invasive species and various types of activities associated with urban and rural development.

1.6. Estuaries

40. Estuaries are partially enclosed coastal bodies of water that are saltier than freshwater but not as salty as sea water. Usually, they have one or more rivers or streams flowing into them and have a connection to the open ocean. Estuaries provide a transition from the river environments to the sea, and are dynamic, tidal environments that provide a unique and rich environment for plants and animals.

41. The state of an estuary is a reflection of land use practices throughout the river catchment. Intensive agricultural practices, forestry practices, urbanisation and water discharge practices can all harm our estuaries. Sediment is flushed into rivers during heavy rainfall and flood events. It is then carried to, and deposited within, estuaries and near coastal areas. Fine sediments are among the most widespread contaminants of New Zealand rivers and estuaries. Sediment particles also carry other contaminants, such as microbes, heavy metals and nutrients. These sediments reduce light levels in coastal waters and smother sea grass and animals in and on the seabed and reduce ecosystem functioning (and other ecosystem services) such as nitrogen cycling.

42. Excessive nutrient input (eutrophication) threatens many Otago estuaries causing ecological problems, such as algal blooms and poor physical and chemical conditions for estuarine life. The problems arise because the nutrients affect the trophic condition of the estuary, essentially overfeeding algae, causing very high growth and then poor oxygen and other conditions as the algae respire and decay. Until recently, guidance on how to assess the extent of eutrophication was limited.

1.7. Indigenous freshwater species[14]

43. Otago river catchments, particularly those of the Clutha River/Mata-au and Taiari River, are strongholds for threatened endemic galaxias species. Thirteen non-migratory species have been confirmed. Small, fragmented populations of these fish with restricted ranges are vulnerable to catastrophic decline and are disappearing. Many of New Zealand's indigenous fish (e.g. whitebait, tuna/eel, kanakana/lamprey, redfin bully) migrate to and from the sea as part of their life cycle. Maintaining connections between freshwater habitats and migration routes is essential.

44. There are 32 indigenous fish species found in Otago, sixteen are diadromous (meaning they migrate to and from the sea) and the remainder non-diadromous (meaning they complete their full life cycle in freshwater). In terms of their threat classifications:

    a. 15 (47%) are considered Threatened and have the highest risk of extinction, comprising:

        i. Four that are Nationally Critical, meaning they are most severely threatened and facing an immediate high risk of extinction,

        ii. Five are Nationally Endangered, meaning they are facing high risk of extinction in the short term,

    b. Six are Nationally Vulnerable, meaning they are facing high risk of extinction in the medium term, and

    c. Nine (28%) are considered At Risk, meaning they are not threatened but could quickly become so, comprising:

        i. Seven are At Risk – Declining, meaning the population is declining but still moderately common,

        ii. Two are At Risk – Naturally Uncommon, meaning they have a naturally small population and are therefore susceptible to harmful influences, and

    d. Eight (25%) are Not Threatened.

45. In relation to aquatic macroinvertebrates, there are 14 threatened freshwater invertebrates present in Otago, comprising:

    a. Eight that are Nationally Critical,

    b. Two that are Nationally Vulnerable, and

    c. Two are At Risk – Declining.

46. The key threats to indigenous freshwater species are predation and competition with introduced species as well as loss of habitat due to:

    a. Modification of water ways;

    b. Water abstraction;

    c. Water quality deterioration;

[14] Statement of Evidence of Richard Mark Allibone on behalf of the Otago Regional Council, 7 December 2020. In the matter of the Water Permits Plan Change – Plan Change 7 (Statement of Evidence of Richard Mark Allibone on behalf of the Otago Regional Council, 2020)

d. Barriers to fish passage; and

e. Predation by native taxa that are outside of their normal range.

2. Clutha Mata-au FMU

47. Due to its size, the Clutha Mata-au FMU is divided into five rohe, which are discussed in turn below.

2.1. Upper Lakes rohe[15]

48. The Upper Lakes rohe defines the headwaters of the Clutha Mata-au catchment. The rohe contains the glacial lakes Wānaka, Hāwea and Whakatipu-Waimāori/Lake Wakatipu and their tributaries. It also incorporates the mountain ranges of the Southern Alps in the north and terraced valleys in the south. The rohe is around 7,000 km2 dominated by conservation land, with much of the remainder managed by high country sheep farming (Figure 6 shows estimated land use in the rohe[16]). Over the last 30 years conservation land area has increased as indigenous forest and tussock grasslands became protected under covenants. The urban settlements at Queenstown and Wanaka are surrounded by low density urban-rural land use, and resident population has been increasing at a high rate since the early 2000s, and this growth is expected to continue.

49. Overall, there is a high degree of naturalness in the Upper Lakes rohe, and as such, changes in land use have the potential to impact water quality both within the rohe and the rest of the Clutha/Mata-au catchment downstream. The rohe is also vulnerable to climate change impacts which may influence the amount of water and timing of water availability within the rohe and the downstream catchment.

[15] Information in this section is compiled from Science summary: Upper Lakes rohe. Available from https://orc.govt.nz/media/10921/upper-lakes-rohe-science-summary.pdf (Te Ao Marama Inc., Aukaha, and Otago Regional Council, 2023d).

[16] The land use maps are indicative only. An updated regional land use map is currently being produced.

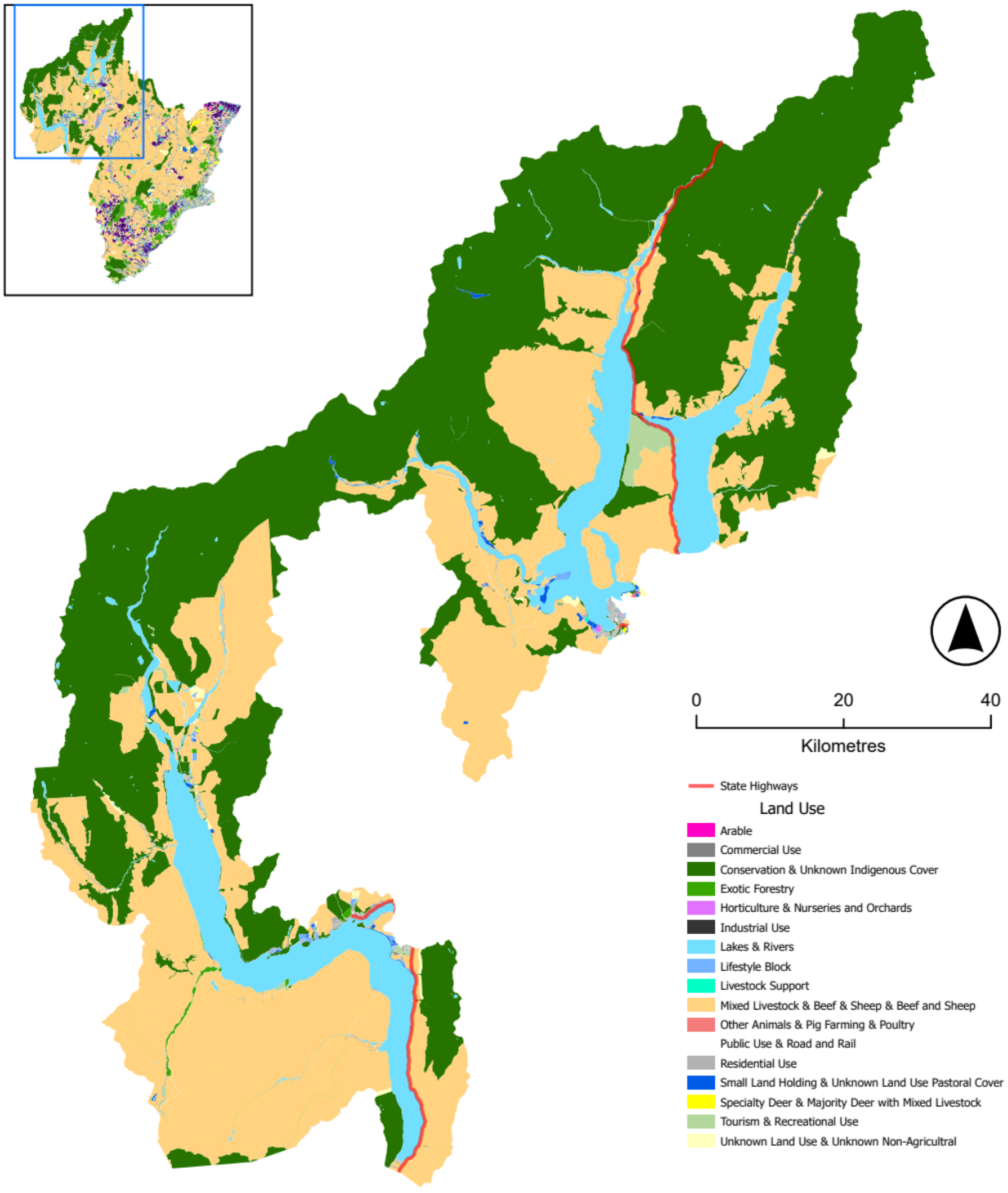

Figure 6: Estimated land use patterns in the Upper Lakes rohe in 2022

51. The Upper Lakes rohe holds significance to Kāi Tahu as an area of plentiful and stable mahika kai practices, with historical evidence of both permanent and seasonal settlements of Kāi Tahu whānau, reinforcing the importance of the area to Kāi Tahu memories and traditions.

52. The conservation estate dominates the Upper Lakes landscape with 54% in indigenous, tussock cover and covenants with a further 12% in rock, snow and ice. Grasslands which are principally farmed as sheep and beef farms makes up a further 30%, with most of these farming activities occurring on river, lakes and valley bottoms. Changes in the past decade has seen an increase in the conservation estate with a declining pastoral farming area, but stocking numbers have remained static.

2.1.1. Water quantity

53. The Upper Lakes rohe has a steep rainfall gradient and the highest precipitation rates occur in the mountains at the northern edge of the rohe. These mountains drain to the alpine lakes which act as significant water reservoirs, the levels of which are higher in spring due to snowmelt. The Upper Lakes rohe provides the majority of the flow to the downstream Clutha/Mata-au catchment.

54. ORC currently monitors flow at six sites within the Upper Lakes rohe, with access to historical records at other sites, as well as sites monitored by NIWA. Hydrological modelling[17] was completed to provide water allocation information for the un-monitored rivers and streams. The principal water use is non-consumptive hydro-electricity production, followed by water supply. There is very little irrigation use in the rohe.

55. Groundwater use in the Upper Lakes rohe is generally low, with most water used for community and domestic supplies. The rohe contains two Ground Water Management Zones (GWMZ), composed of shallow alluvial aquifers, which are located around the townships of Glenorchy and Kingston.

2.1.2. Water quality[18]

56. Water quality in the Upper Lakes rohe is generally very good with the upper catchments extending into Mt Aspiring National Park and many of the catchments originating along the eastern boundary of the Southern Alps and are fed by permanent glaciers. These pristine catchments feed the Southern Great Lakes with large volumes of water of exceptional quality. All lake sites achieved 'A' band for all parameters assessed. In lower river reaches and urban areas higher *E.coli* and nutrient enrichment counts occur due to stormwater runoff and presence of wildfowl in the stream. Bullock Creek does not meet the national bottom line for periphyton and *E.coli* due to stormwater and wildfowl and as it is spring fed, with a stable flow, very low turbidity and high ammoniacal nitrogen and nitrate-nitrite-nitogren (NNN) concentrations, conditions are ideal for periphyton growth. Sites affected by naturally occurring processes, such as glacial flour, are not required to meet the national bottom line for sediment.

[17] Friedel MJ, Stewart D, Lu X, Stevenson P, Manly H, Dyer T. 2023. A simple stacked ensemble machine learning model to predict naturalized catchment hydrology and allocation status. Dunedin, New Zealand: Otago Regional Council. (Friedel, Stewart, Lu, Stevenson, & and Dyer, 2023)

[18] The information in this section is compiled from State and Trends of Rivers, Lakes and Groundwater in Otago 2017-2022 (Ozanne, Levy, & Borges, State and trends of Rivers, Lakes, and Groundwater in Otago 2017 - 2022, 2023)

57. The Dart/Te Awa Whakatipu and Matukituki/Mātakitaki River sites have been monitored for a sufficiently long period of time to undertake trend analysis. In the Mātakitaki, NNN has shown to be increasing over the past ten years. In both the Mātakitaki and Dart/Te Awa Whakatipu Rivers, TP trends are improving. In the lakes, total nitrogen TN is showing improving trends at the outlets of both Whakatipu-Waimāori/Lake Wakatipu and Lake Wānaka, but turbidity is showing declining trends in Lakes Hāwea and Wānaka.

58. Groundwater quality is generally good in the Upper Lakes rohe. Groundwater data from the two GWMZ indicates some issues, with elevated *E. coli*, nutrients and arsenic levels. Elevated *E.coli* and nutrients are likely due to high septic tank density and shallow boreheads. Elevated arsenic is likely due to the local schist lithology. The results from the Upper Lakes rohe generally show compliance with the Drinking Water Standards for New Zealand (Drinking Water Standards), although elevated *E. coli* counts were measured in some bores. Elevated dissolved arsenic concentrations were also measured in some bores, although their source is likely to be geological, i.e. the prevalent schist lithology. Nitrate concentrations are generally below the Drinking Water Standards for nitrates. High DRP (dissolved reactive phosphorous) and nitrate concentrations were measured in some Kingston and Glenorchy bores, likely due to high septic tanks density, shallow bores, and poor borehead security. These can potentially adversely affect water quality in Whakatipu-Waimāori/Lake Wakatipu, although groundwater (and nutrient) fluxes into the Lake are likely to be substantially lower than the surface water inflows.

2.1.3. Wetlands[19]

59. The Upper Lakes rohe contains a number of rare and vulnerable ecosystems including ephemeral wetlands. These types of ecosystems contribute disproportionately to national biodiversity by having rare and threatened species; however they are often threatened through pressures, such as land use change and invasive species. Although rare and vulnerable ecosystems are particularly sensitive environments to human activity, little is usually known about their extent and condition, including in the Upper Lakes rohe.

60. Within the Upper Lakes rohe 18 sites are recognised as Regionally Significant Wetlands (RSW). These are swamps (4 sites); swamps associated with lagoons (10); or systems having ephemeral wetlands (2). In these environments most wetlands are small, with copper tussock sedgeland and carex sedgelands the most widespread types.

61. On the east side of Lake Hawea, is the shallow Dingle Lagoon (25 ha) Makarora Flat Swamp Complex (60-70 ha) is mainly marsh with carex sedgelands, juncus marshes, and willows. Across the low saddle between Lakes Hawea and Wanaka, The Neck Wetlands (11 ha) are a group of bedrock depressions. On the west side of Lake Wanaka, Minaret Bay Swamp (23 ha) has marsh and swamp on stream deltas at the bay head.

62. The lower Matukituki Valley/ West Wanaka area has several wetlands, the largest being the Matukituki Valley Wetland Management Area (76 ha), Big Boggy Swamp (13 ha), adjacent to the valley road, has a mix of lagoon ponds, and on a smaller scale Little Boggy Swamp (0.2 ha) has a raupo-fringed pond and Scaifes Lagoon (5 ha), alongside the Glendhu Bay road is likewise mainly raupo swamp. The Matukituki Bluff Ephemeral Wetland Management Area (23 ha) is less swampy, and includes ephemeral wetlands, occupying a river terrace.

[19] The information in this section is compiled from Wetlands of the Otago Region (Peter N. Johnson, 2022)

63. At the head of Lake Wakatipu the Diamond Lake Wetland (49 ha) and nearby Lake Reid Wetland (40 ha) are shallow lakes, stream-fed, with aquatic vegetation and fringes of sedge swamps.

64. Kinloch Wetland (11 ha) is mainly marshes, on the west side of the Dart River delta, while the Rees River delta is associated with the Glenorchy Lagoon Wetland (128 ha), a Department of Conservation Wildlife Management Area having lagoons with swampy shores, islands, and willows. Just south of Glenorchy, Little Stoney Bog (7 ha) / 'Lake Fyfe' is a small lake in a bench hollow with margins of turf, fen, and rushland.

65. Close behind Queenstown, along Gorge Road, the Matakauri Wetland (11 ha) is a swamp with carex sedgelands. On the west side of Lake Wakatipu, to the south of the Von River mouth, Mt Nicholas Lagoon (91 ha) has swamp margins and islands, while the much smaller Signal Hill Swamp (2 ha), is located just to the east. The much larger wetland system of the Von Valley Wetland Management Area (545 ha) is one of valley heads and once-glaciated hill crests with a scattering of depressions holding, tarns, kettles, and swamp communities. Many wetlands of the Upper Lakes rohe have not yet been identified.

2.1.4. Estuaries

66. There are no estuaries in this rohe.

2.1.5. Indigenous freshwater species

67. The Upper Lakes rohe has a diverse range of native freshwater fish, invertebrates, birds, plants, and a bat that depend on freshwater ecosystems. The seven native freshwater fish include three non-migratory galaxias, one migratory galaxias (koaro), one eel and two bullies. All the non-migratory galaxias are threatened. Freshwater invertebrates include freshwater crayfish and freshwater mussels.

68. A high proportion of native birds depend on freshwater ecosystems, either as permanent or transient (migratory) populations. Threatened birds include Australasian bittern, black-billed gull, blue duck, and southern crested grebe. Many plants are freshwater-dependent, including the threatened *Brachyscome linearis*, *Crassula peduncularis*, *Crassula multicaulis*, and *Carex strictissima*. The introduced sports fishes include brown trout, rainbow trout, and chinook salmon. Information is often missing at a species level, particularly for freshwater invertebrates, non-vascular plants, and algae. Many native freshwater species are under threat and continue to decline.

2.2. Dunstan rohe[20]

69. The Dunstan rohe extends from the Lindis river catchment in the northeast, from the Shotover river catchment and the shores of Lake Wanaka and Lake Hawea in the northwest, to the Nevis River catchment in the south. It includes Lake Hayes and Lake Dunstan and the Clutha Mata-au River and its tributaries: the Cardrona, Arrow, Kawarau, Shotover, Lindis, Nevis among others. Exotic grasslands, primarily used for farming, cover 37% of the rohe and 23% is conservation land. Sheep and beef plus mixed livestock are the dominant farming activities making up 65% of the grasslands area. Dairy, nurseries/vineyards/orchards occur on 1% of the area (Figure 7 shows estimated land use in the rohe[21]).

70. The notable trends in land use change over the past three decades have been an increase in the conservation estate and urban development. There has also been an increase in horticultural use for nurseries/vineyards/orchards. The dry-stock farming has decreased by 25%, although it is still the most common land use in the Dunstan area.

[20] Information in this section is compiled from Clutha Mata-Au Freshwater Management Unit (FMU): Dunstan Rohe. Available from https://www.orc.govt.nz/media/15529/dunstan-rohe-science-summary.pdf (Te Ao Marama Inc., Aukaha, and Otago Regional Council, 2023b).

[21] The land use maps are indicative only. An updated regional land use map is currently being produced.

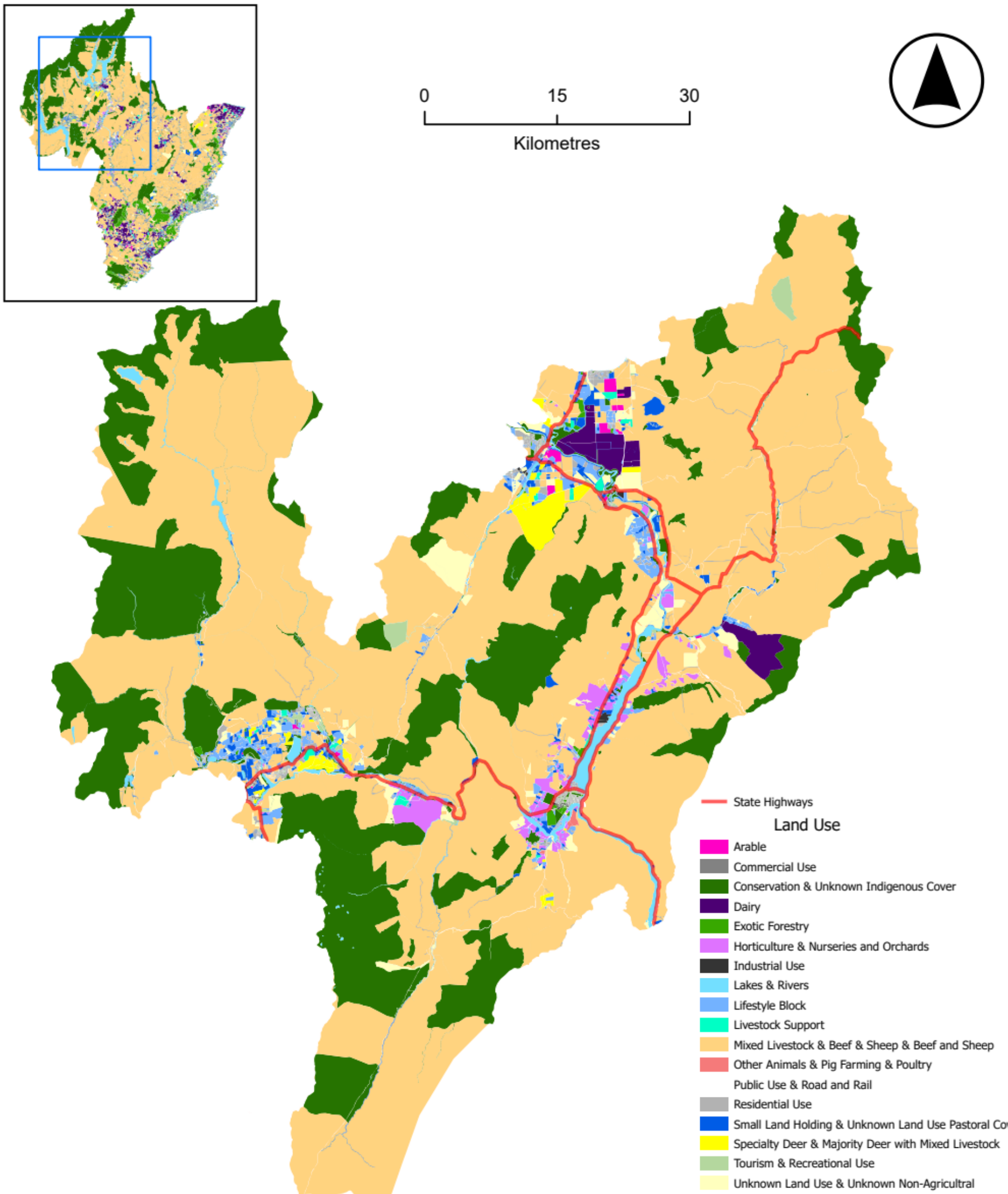

Figure 7: Estimated land use distribution in the Dunstan rohe in 2022

71. Air temperatures from -10°C to 36°C have been recorded in the Upper Clutha/Mata-au Valley. In the headwaters of the Shotover River/Kimiākau, where it is close to permanent snow and ice, temperatures less than -10°C are likely.

72. New Zealand's weather is affected most by westerly winds, which carry wet weather to the west of the main mountains and dry weather to the east coasts. The Southern Alps give the South Island sharp contrasts in weather and climate between the areas west and east of the Alps. Parts of the Dunstan rohe are in both areas, so the climate is very diverse. It includes some of the wettest, driest, warmest, and coldest places in New Zealand. Annual Rainfall in the headwaters of the Shotover/Kimiākau is more than 3000mm per year, while in parts of the Upper Clutha Mata-au Valley, rainfall is less than 400mm per year. There is a steep rainfall gradient from west to east, with the Shotover/Kimiākau headwaters only about 50 km from the low-rainfall Upper Clutha Mata-au area.

73. While the whole of the Clutha/Mata-au River is important to Kāi Tahu, Te Wairere (Lake Dunstan) is also significant for many cultural and historical reasons, such as its location meaning that it was an important point for journeys on the Mata-au. Consequently, wāhi taonga is present in the area and a significant part of Kāi Tahu tradition.

2.2.1. Water quantity

74. The diverse weather and climate in this rohe results in a similar diversity in river and stream flows. There is abundant water in the rivers where rainfall or snow melt is plentiful or where they are fed by the alpine lakes, as in the Shotover/Kimiākau, Kawarau and Clutha/Mata-au Rivers headwaters. However, there is much less water in the smaller rivers and streams in the Upper Clutha/Mata-au Valley, that receive only about 10% of the rainfall of the Shotover/Kimiākau headwaters.

75. This rohe contains the large hydroelectricity reservoir, Lake Dunstan/Te Wairere and hydroelectric power generation is the largest water use in the Dunstan rohe. Water use for other purposes varies in this rohe. Very little water is taken from the Shotover/Kimiākau and Nevis Rivers/Te Papapanui. There is significant water use in the upper Clutha/Mata-au Valley from the Clutha River/Mata-au, and the Hāwea and Dunstan/Te Wairere lakes. Here, irrigation is the lifeblood of farming, and some of the smaller streams run dry in summer.

76. Groundwater in the Dunstan rohe has been greatly affected by glacial advances and retreats in the past. These cycles have created several large basins that hold relatively deep gravel aquifers and shallow alluvial ribbon aquifers near rivers. These include the Hawea Basin, Wanaka & Cardrona Basin, Whakatipu Basin, Cromwell Terrace Aquifer, Lower Tarras/Bendigo Aquifer, and the Lowburn Alluvial Aquifer. Groundwater use in the rohe is high with approximately 1,000 completed bores registered with the ORC. The primary groundwater uses are domestic and stock water, irrigation, community supply, and monitoring. There are around 240 resource consents to abstract groundwater in the rohe, with a total annual consented volume of about 89.874 million m^3 per year.

2.2.2. Water quality[22]

77. Water quality is generally very good in the Dunstan rohe with few sites falling below national bottom lines, largely because of the large area of high country and the relatively small (although growing) area occupied by intensive farming and urban development. Suspended fine sediment (visual clarity) is the main water quality concern, with a third of the sites monitored not meeting the national bottom line. The bacteria *E.coli* is measured to indicate safety for human contact. *E. coli* results did not meet the national bottom line at Mill Creek.

78. Lake Dunstan meets the highest band for all attributes reflecting the very good water quality in the Clutha River/Mata-au. Lake Hayes lies in a shallow depression formed by glaciation, over the years it has become a eutrophic lake, water clarity can be low due to frequent algae blooms. Monitoring shows that Chl-a in Lake Hayes falls below the national bottom line and TN, and TP are in the 'C' band – this all reflects the eutrophic status of the lake.

79. Groundwater monitoring results from the Dunstan rohe generally show compliance with the Drinking Water Standards. However, some bores have had elevated *E.coli* concentrations. Elevated dissolved arsenic concentrations were also measured in some bores, although their source is likely to be geological, i.e. the prevalent schist lithology. Nitrate concentrations in most sites were also below the threshold for intensive land use.

2.2.3. Wetlands[23]

80. In the Dunstan rohe, ten sites are recognised as Regionally Significant Wetlands under the Water Plan. These are swamp (4 sites), fen (3), marsh (2), and bog (1). On the delta where the Upper Clutha/Mata-au runs into Lake Dunstan/Te Wairere, the Bendigo Wetland (244ha) has developed swampy, willow-edged river margins. This wetland provides a habitat for diverse wildlife, especially valuable for birds and angling. Further upstream, above Luggate, the Campbells Reserve Pond Margins (1 ha) is a small marsh, spring-fed from seepage off the terraces above. Butterfield Wetland (2 ha), on an old Hāwea River terrace, is of similar origin, with a raupo-edged pond.

81. Two sites in the Nevis Valley, Nevis Red Tussock Fen (44 ha) and Schoolhouse Flat Red Tussock Fen (9 ha), have communities of red tussock and various carex species distributed according to the soil wetness. At the head of the Nevis/Te Papapuni, in its Roaring Lion catchment, is New Zealand's largest string bog system, which also extends into the Nokomai catchment, Southland. This system combines terraced tarns, fens, bogs, and snowbanks.

82. In the Queenstown area, Lake Hayes/Waiwhakaata Margins (17 ha) has lake fringes of raupo, crack and grey-willows, and some carex swamp. Moke Creek Swamp (1 ha) and Moke Lake/Punamāhaka/Waikāmāhaka Bog (12 ha) have both bog and swamp types. In one of the heads of the Shotover/Kimiākau, the Polnoon, the Church Hill Wetland Complex (103 ha) occupies a fault-derived basin with glacial moraines, bogs, fens, tarns, and ephemeral wetlands. Two additional sites are Queenstown Hill; a Conservation Covenant-protected site of cushion bog and tarn communities; and the head of Pisa Range Roaring Meg, with sedge and cushion bogs and tarns.

[22] The information in this section is compiled from State and Trends of Rivers, Lakes and Groundwater in Otago 2017-2022 (Ozanne, Levy, & Borges, State and trends of Rivers, Lakes, and Groundwater in Otago 2017 - 2022, 2023)

[23] The information in this section is compiled from Wetlands of the Otago Region (Peter N. Johnson, 2022)

2.2.4. Estuaries

83. There are no estuaries in this rohe as it is entirely land-locked.

2.2.5. Indigenous freshwater species

84. Many species depend on freshwater and ecosystems in the Dunstan rohe, including fishes, invertebrates, plants, and birds. There have been 65 threatened freshwater-dependent species identified. The rohe provides habitat for native fishes, including three non-migratory galaxias, four migratory galaxias (whitebait), two eel and five bullies. Some of these fish are threatened, for example, the lamprey and all non-migratory galaxias. Freshwater invertebrates include koura, mussels, and threatened stoneflies.

85. Threatened freshwater-dependent plants include *Chenopodium detestans* and *Triglochin paluste*. Many birds also depend on these ecosystems, permanently or transiently, including the threatened Australasian crested grebe and black-fronted tern. Many native freshwater species are under threat and continue to decline in numbers.

2.3. Manuherekia rohe[24]

86. The Manuherekia catchment includes two major depressions: the Manuherekia valley and the Ida valley, which are connected by the Poolburn Gorge. The Manuherekia valley is aligned north-east to south-west. The upper northern catchment of the Manuherekia valley is divided into the Dunstan Creek catchment and the upper Manuherekia which are divided by the St Bathan's Range which rises up to 2000 metres. The river's headwaters are in the Hawkdun Range, and the catchment is surrounded by mountainous terrain, except to the south-west, where it joins the Clutha River/Mata-au at Alexandra. The eastern Ida Valley drains the eastern and south-eastern Otago uplands (Rough Ridge/Wairua-ā-pō) where the Idaburn River drains through a single gorge into the Manuherekia River. The Ida valley is drier than the Manuherekia valley and is prone to quite severe dry periods.

87. The whole catchment of the Clutha/Mata-au River is important for mahika kai and producing food resources, including the Manuherekia Valley. Exotic grasslands, primarily used for farming, cover a large area of the rohe and only 13% is conservation land. Sheep and beef plus mixed livestock are the dominant pastoral farming types on these grasslands followed by a small area of dairy and dairy support. Nurseries /vineyards/orchards plus lifestyle blocks occur on about 1% of the area (Figure 8 shows the estimated land use in the rohe[25]). It has been noted that land use in the catchment has intensified with an increase in the irrigated area, dairy and dairy support, vineyards, lifestyle block development and some urban growth.

[24] Information in this section is compiled from the Manuherekia rohe (area) information on the ORC website available from https://www.orc.govt.nz/your-council/plans-and-strategies/water-plans-and-policies/freshwater-management-units/cluthamata-au/manuherekia-rohe-area/ (Otago Regional Council, n.d.)

[25] The land use maps are indicative only. An updated regional land use map is currently being produced.

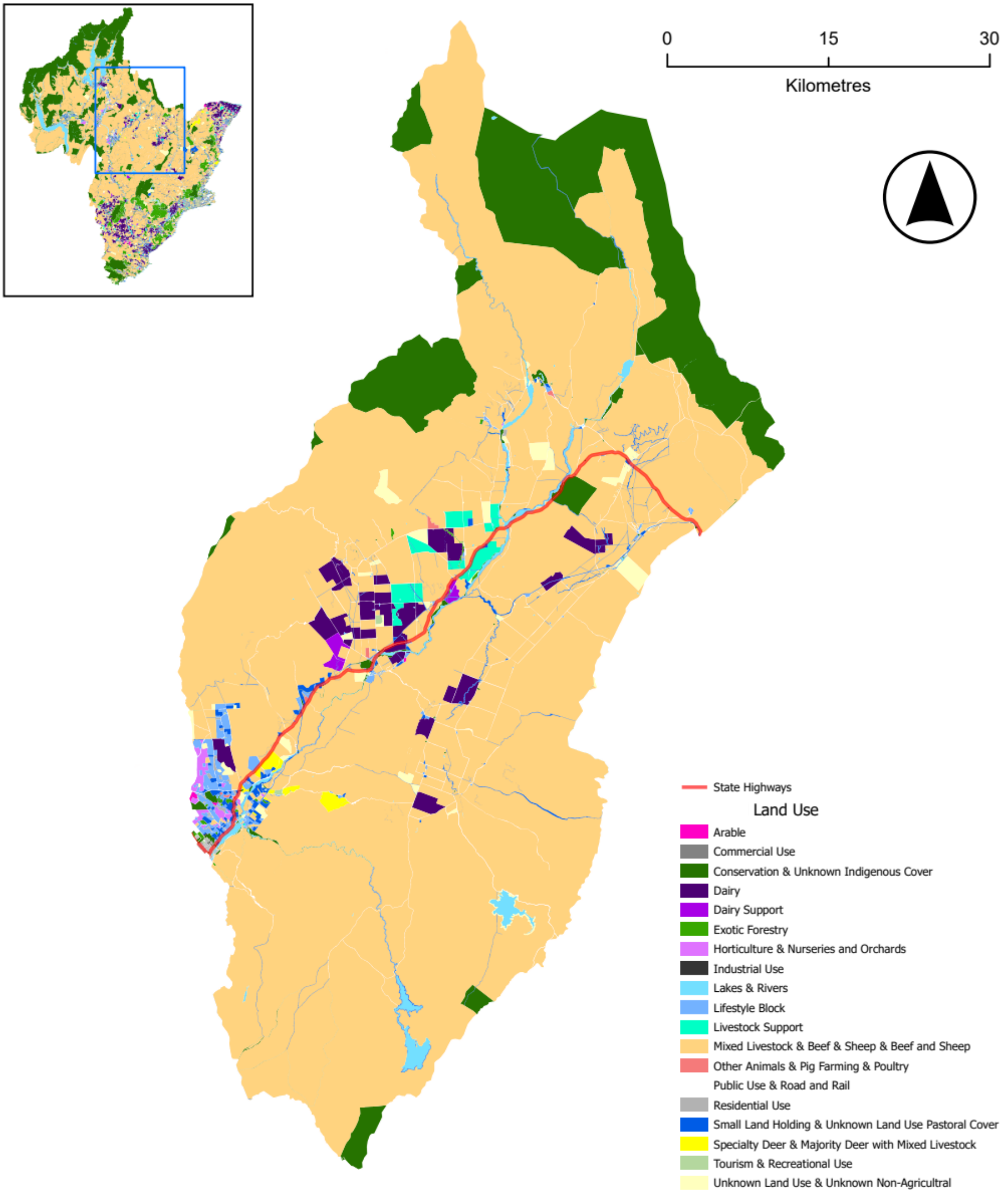

Figure 8: Estimated land use patterns in the Manuherekia rohe in 2022

2.3.1. Water quantity

88. The Manuherekia catchment is one of the driest in New Zealand, sheltered from rain-bearing storms by surrounding mountainous landscape, and due to its location in central Otago, away from the effects of the sea. Low rainfall in the valley bottoms led to the early development of extensive water storage and irrigation schemes. Consequently, three reservoirs were established in the Manuherekia catchment to provide water for irrigation. Falls Dam was built in 1935 to capture the high rainfall water supply in the northern high-altitude part of the catchment, with a capacity of 11 million m^3. Poolburn Reservoir was constructed in 1931 with capacity of 26 million m^3, while Manorburn Reservoir was built in 1935 and has a capacity of 51 million m^3.

89. Flows in the Manuherekia River are partly influenced by releases from Falls Dam. Several irrigation schemes (Blackstone Hill, Omakau, Manuherekia, and Galloway) take water out of the Manuherekia River and distribute the water through a network of open water channels to irrigate the Manuherekia valley. The Poolburn Reservoir is used to store water to irrigate the Ida Valley and water from the Manorburn Reservior is either taken by the upper Galloway Irrigation Scheme or used for irrigation in the Ida Valley.

90. The first rights to take water from the Manuherekia were issued under mining legislation in the late 1860s for the purpose of gold mining. As gold mining became progressively uneconomic, many of the rights to take water and associated conveyance infrastructure were used for irrigation as agriculture and horticulture ventures developed. Agricultural water use in the Manuherekia catchment differs from mainly extensive orchard production near Alexandra and Clyde, to partially semi-extensive farming in the partially irrigated area, to very extensive run units where winter feed production is used for dairy support.

91. There are approximately 195 water takes in the Manuherekia catchment,[26] the rate of water actually taken is complicated as it is a mixture of both stored water and run of the river water and potential double-counting of water at multiple points of take.

2.3.2. Water quality[27]

92. Upstream of the Falls Dam, water quality is generally very good for all attributes measured. In the upper Manuherekia, water quality is also very good for all attributes other than *E.coli* which is 'B' band. In the lower Manuherekia, water quality generally decreases down the catchment with concentrations of attributes increasing. In the Manuherekia catchment soils with poorer drainage characteristics are found on the true right of the Manuherekia River, particularly around the Thomsons Creek and Lauder Creek catchments. The implication of poor soil drainage is that water runs-off land rather than infiltrates through the soil. Run-off entrains soil, bacteria and nutrients which is transported to the nearest watercourse. Poor water quality is common in all smaller creeks originating in the Dunstan Mountains with water quality deteriorating as the tributaries flow over productive farmland towards the Manuherekia (the tributaries (Poolburn and Thomsons Creek) have poor water quality across all attributes other than toxicity, mainly achieving 'D' bands.

[26] This figure is subject to change as consent renewals are processed.

[27] The information in this section is compiled from State and Trends of Rivers, Lakes and Groundwater in Otago 2017-2022 (Ozanne, Levy, & Borges, State and trends of Rivers, Lakes, and Groundwater in Otago 2017 - 2022, 2023)

93. Five of the eight monitored sites had elevated suspended sediment concentrations. Historic gold mining tailings in the area below Falls Dam may contribute to elevated suspended solid concentrations in the main-stem Manuherekia (Blackstone, Ophir and Galloway) during higher flows. The Upper Catchment site, just below Falls Dam and Dunstan Creek both achieved an attribute band of 'A'.

94. Trend analysis shows that there are a number of sites with degrading water quality trends for *E.coli*, NNN and turbidity over ten years and *E.coli*, NNN and TN over 20 years. Tributary sites which are below the national bottom line are most likely contributing to the degrading trends in the mainstem.

95. Groundwater quality in the Manuherekia rohe is generally good, with no *E. coli* detections and low-median nitrate-N concentrations in most bores. Arsenic concentrations in all bores were substantially below the Drinking Water Standards.

96. The 10-year trend shows a mixed pattern, with most sites show 'unlikely' to 'very unlikely' improving trends in nitrate-N for both the 5 and 10-year trends, but one site showing a likelihood of improvement. These varied results may be due to localised land uses.

2.3.3. Wetlands[28]

97. Within the Manuherekia rohe 11 sites are recognised as Regionally Significant Wetlands in the Water Plan. These are classified as inland saline (5 sites), marsh (4), swamp (1), and fen (1). At the head of the Manuherekia valley Kirkwoods Creek Wetland Management Area (256 ha) spans an altitudinal range from stream valley fens of copper tussock, sedgelands, and sphagnum, up to the crest of the Hawkdun Range. Comparable stream valley wetlands are identified in the Hut Creek Swamps (12 ha, north of Falls Dam, and Hawkduns Runs Road Marsh (51 ha, north of St Bathans).

98. Inland saline sites to the north of Alexandra, mainly on salty and alkaline toe slopes are centred on the Galloway area: Galloway No 1 Inland Saline Wetland Complex (3 ha), Galloway No 2 Inland Saline Wetland Management Area (6 ha). Also in this vicinity, Long Gully Marsh (1 ha) is a pond with raupo and carex margins. Two further saline sites, north of Alexandra are Dunard Inland Saline Wetland Management Area (3 ha., on Moutere Station) and Rockdale Inland Saline Wetland Management Area (3 ha, near Chatto Creek). At the south end of the Ida Valley basin, a further saline site is the Moa Creek Inland Saline Wetland (3 ha), and the copper tussock/carex wetland of the Kirk Creek Headwaters Marsh Complex (7 ha).

99. The Lower Manorburn Dam Margins (18 ha) are a marsh and swamp fringe of raupo and willows. Other wetland sites, not yet listed for the Manuherekia rohe include periodically submerged turf vegetation of reservoir margins e.g. Greenland Reservoir, Poolburn Reservoir, and Falls Dam, and various streamside and oxbow communities of copper tussock, sedgelands, and sphagnum mosslands in the Little Valley and Hopes Creek tributaries of the Manorburn.

2.3.4. Estuaries

100. There are no estuaries in this rohe.

[28] The information in this section is compiled from Wetlands of the Otago Region (Peter N. Johnson, 2022)

2.3.5. Indigenous freshwater species

101. The rohe supports important habitat for indigenous species, particularly indigenous biodiversity in some of the tributaries and the braided mainstem above Falls Dam. Indigenous freshwater species include bullies, nationally threatened galaxias, and at-risk species of longfin eel (tuna) and koura/crayfish. Non-migratory galaxias species are endemic to the area and highly valued. The rohe contains 11 Regionally Significant Wetlands below 800 m, which are listed in the Water Plan.

102. The catchment vegetation supports a diverse invertebrate community, as well as significant lizard species, including Scree Skinks (nationally vulnerable) and Green Skinks (at risk). The braided upper mainstem, along with streams, ponds and reservoirs throughout the catchment provide nesting and foraging habitat for a diverse array of birdlife, including at-risk or vulnerable birds such as banded dotterels, wrybill, black-fronted tern, pied stilt and oyster catchers.

2.4. Roxburgh rohe[29]

103. The Roxburgh rohe is in the heart of Central Otago and is subject to typical weather conditions for this area with generally hot, dry summers and cold, frosty, dry winters. The rohe is impacted by the sheltering effect of the Southern Alps, creating a rain shadow. A mountain range on the western border of the Roxburgh rohe also provides a sheltering effect from rain coming from the southwest. Temperatures can range from -10°C in winter to more than 38°C in summer. Evaporation in the rohe is very high, especially in the lowlands, where it usually exceeds precipitation, resulting in a moisture deficit.

104. The Clutha Mata-Au River is important in Kāi Tahu traditions and history. There is an ongoing relationship of mana whenua with wāhi tupuna and mahika kai values. This area has galaxiids, wetlands, and landscapes with high natural character. The Roxburgh rohe has a large area of exotic grasslands predominantly in mixed livestock and sheep and beef with a small area in conservation estate (approximately 10%). Forestry and horticultural areas account for a further 2% (figure 9 show estimated land use in the rohe[30]).

[29] Information in this section is compiled from Clutha Mata-Au Freshwater Management Unit (FMU): Roxburgh Rohe Report Summary available from https://www.orc.govt.nz/media/15695/roxburgh-lwrp-report-science-summary.pdf (Te Ao Marama Inc., Aukaha, and Otago Regional Council, 2023c).

[30] The land use maps are indicative only. An updated regional land use map is currently being produced.

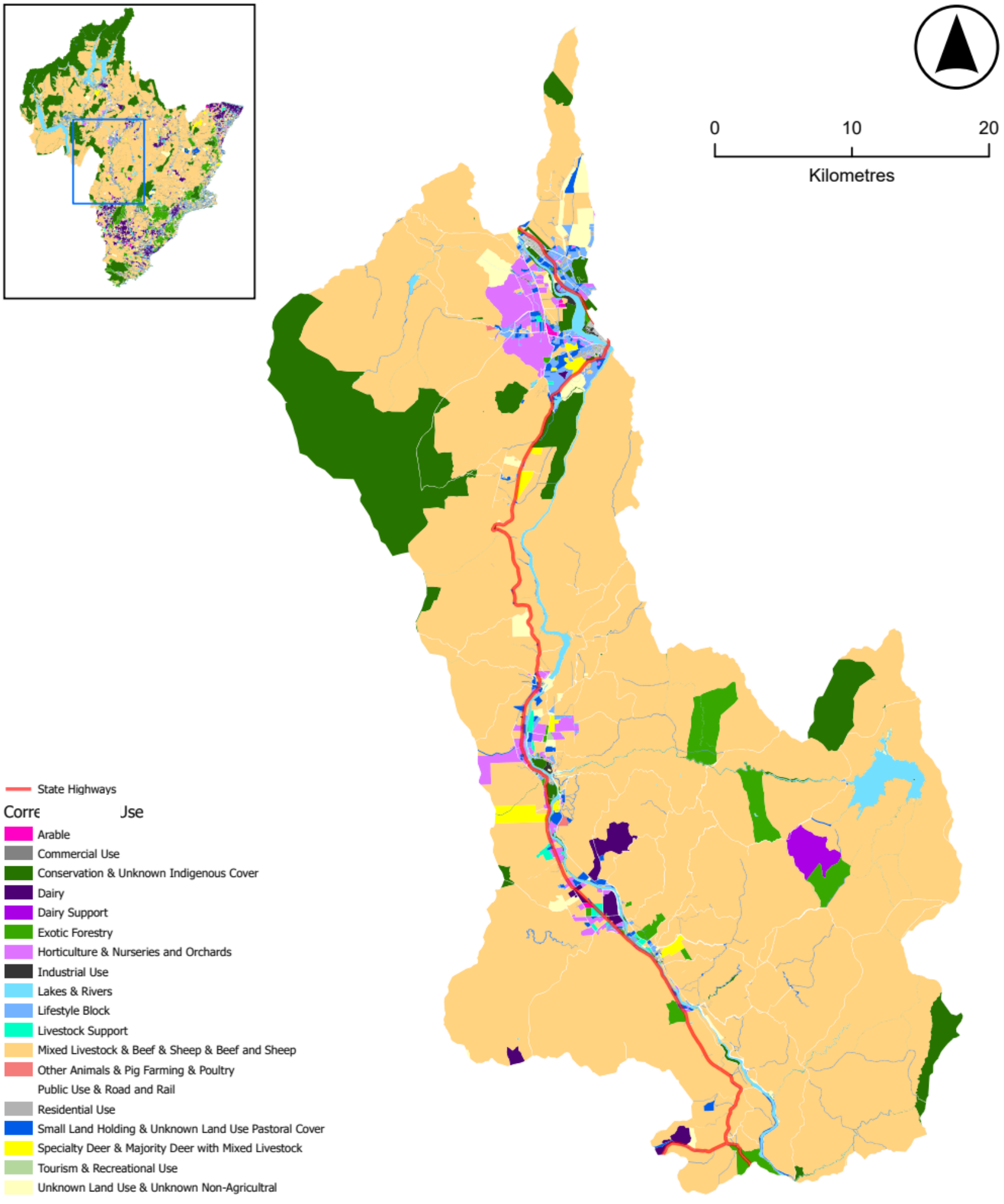

Figure 9: Estimated land use patterns in the Roxburgh rohe in 2022

2.4.1. Water quantity

105. The Roxburgh rohe is in the heart of Central Otago and is subject to typical weather conditions for this area. Mean annual rainfall ranges from about 1200mm on the Obelisk/Old Man Mountain ranges, and around 900mm on the hills south of the mountains, to about 360mm near Alexandra, and 450-500mm further south.

106. The Clutha River/Mata-au runs through the Roxburgh rohe and has a healthy flow throughout the year, although the Roxburgh dam also strongly controls flows. The main tributaries are the Fraser and Teviot, and Lake Onslow. Rivers and streams originating in this rohe do not have large flows and generally have very low flows in summer.

107. Water use for irrigation is high from all the rivers and streams in this rohe due to the extreme dryness in the spring, summer, and autumn months. In summer, the smaller streams and rivers can run dry due to both natural losses to groundwater and irrigation abstraction. Hydroelectricity generation at Roxburgh Dam is also an important control on water quantity in the rohe.

108. The Roxburgh rohe contains several recognised groundwater basins and associated aquifers. The basins include Alexandra Basin in the north (including the Dunstan Flats, Earnscleugh Terrace, and some of the Manuherekia Claybound aquifers), Roxburgh (Roxburgh East & West aquifers) and Ettrick basins. The aquifers in the rohe are mainly found in glacial outwash deposits. There is high variability in aquifer geology, parameters (e.g. water table depth, transmissivity), and groundwater interaction with surface water bodies (e.g. the Benger Burn, Fraser, Clutha/Mata-au, and Manuherekia Rivers) across the rohe. Water loss from surface water bodies and irrigation schemes are important sources of recharge for groundwater. The primary uses of groundwater are domestic, stock water, community supply and irrigation. Some areas, e.g., Ettrick, are experiencing rapid development and land use change that are likely to put pressure on the supply and quality of groundwater.

2.4.2. Water quality[31]

109. Water quality in the Roxburgh rohe is generally good with the Teviot river, Fraser river and Clutha River/Mata-au meeting 'A' bands for all attributes other than suspended fine sediment, which is nationally occurring due to glacial meltwater and tannin staining from tussocks. However, there are signs of degraded water quality in some indicators, particularly in the Benger Burn. The source of the river is in the Mt Bengerburn, where land use in the higher country is mainly extensive sheep and beef, although this becomes more intensive when the river reaches the flat of the Ettrick basin. The reason for both the high bacteria concentration and the low clarity has not been established. Potential pressures on water quality include pastoral farming, orcharding and plantation forestry. At times these stresses on water quality may be made worse by low flows in the tributaries.

110. Lake Onslow is a man-made lake, formed in 1890 by the damming of the Teviot River and Dismal Swamp. TN achieves a 'B' band and TP a 'C' band. It has some algal growth issues associated with higher nutrient concentrations which is typical of a shallow lake draining a tussock environment. For the river sites, trends for the Clutha River/Mata-au shows likely

[31] The information in this section is compiled from State and Trends of Rivers, Lakes and Groundwater in Otago 2017-2022 (Ozanne, Levy, & Borges, State and trends of Rivers, Lakes, and Groundwater in Otago 2017 - 2022, 2023)

improvements in nutrients over 20 years. However, due to the size and volume of the Clutha River/Mata-Au catchment, it is preferable to look at the trends from tributaries discharging to the Clutha River/Mata-au.

111. Groundwater quality appears to show some issues in the Roxburgh rohe, notably *E. coli* detections in most bores and high median nitrate-N concentrations. These results are potentially due to the intensive farming and septic tanks in the Ettrick area, where further land use intensification and housing expansion continues to occur. Dissolved arsenic concentrations in most monitoring bores are substantially below the Drinking Water Standards.

2.4.3. Wetlands[32]

112. Twelve sites are mapped as Regionally Significant Wetlands in the Water Plan. These are classified as inland saline (4 sites), ephemeral wetland (1), fen (3), and marsh (4). Wetlands are common in upland areas, with copper tussock, sedgeland and herbfield the most widespread plant types in the rohe. The streams draining into Lake Onslow from the south (Boundary and Fortification Creek) are perhaps the most distinctive and impressive upland wetlands in Otago, if not nationally. The northern parts of the rohe, on the margins of the Manuherekia, support several saline wetlands.

113. The inland saline sites are all in the Conroys Gulley area: Conroys Dam Inland Saline Wetland Management Area (18 ha), Conroys Road Inland Saline Wetland Complex (7 ha), Chapman Road Inland Saline Area (7 ha), and Blackmans Inland Saline Wetland Management Area (12 ha). They are mainly hillside toe slopes, intermittently wet with seepage from groundwater. These areas have saline and alkaline soils and support salt-tolerant plants that otherwise occur in coastal salt marshes. They also have some annual species that are dormant in dry seasons, which is unusual in native plants. Flat Top Hill Ephemeral Wetlands (5 ha) form on surface depressions of hill-crest plateaus. These wetlands also have native annual plants that tolerate both ponding and drought.

114. The most extensive wetlands in the rohe occupy the valleys that feed Lake Onslow from the south. These wetlands are Fortification Creek Wetland Management Area (526 ha, includes the Teviot River South Branch), Boundary Creek Fen (94 ha), and Middle Swamp (67 ha). In these fen wetlands, valley floors with gentle gradients have developed meandering systems on a smaller scale and at a higher altitude than the broad scroll plains of the upper Taiari. These have complex patterns of sinuous stream channels, cutoffs, oxbows, and old river channels. Copper tussock grassland grows in the alluvial flats, along with sedgelands, turf communities in the hollows, aquatic plants, and sphagnum fens at the valley sides.

115. The Water Plan also identifies four small marsh sites in the Ettrick to Roxburgh area: Island Block Pond Marshes (4 ha), Upper Black Stream Marshes (3 ha), Rigney Pond Marshes (0.5 ha), and Gilmour Road Marsh (1 ha).

116. Another large wetland not currently listed in the Water Plan is Teviot Swamp (Te Ao Marama Inc., Aukaha, and Otago Regional Council, 2023c). This is a large fen complex found in a basin at the head of the south branch of the Teviot River at 1000 m altitude. Fed by groundwater and seepages from the top of the Lammerlaws range, sphagnum moss is the main peat-forming plant on the wettest ground. As water movement changes with time across the fen

[32] The information in this section is compiled from Wetlands of the Otago Region (Peter N. Johnson, 2022)

fans, the vegetation changes to cushion plants. In the uppermost tributaries, the moss and cushion communities are part of small string bog systems, with pools in terrace sequences. Other fingers of valley wetlands at upper altitudes also occur in the heads of the Fraser River, west of Alexandra.

2.4.4. Estuaries

117. There are no estuaries in this rohe.

2.4.5. Indigenous freshwater species

118. Diverse species depend on freshwater habitats and ecosystems in the Roxburgh rohe, including fishes, invertebrates, plants, and birds. The Roxburgh rohe has had 40 threatened freshwater-dependent species identified within its area. The threatened freshwater fishes include the Clutha flathead galaxias, Teviot flathead galaxias, dusky galaxias, and lamprey. Threatened freshwater invertebrates include a moth, a true bug, and a stonefly. *Triglochin palustris* and *Crassula multicaulis* are examples of freshwater-dependent plants found here that are threatened.

119. Many native birds depend on freshwater ecosystems, permanently or as transient residents, including the threatened Australasian crested grebe and black-fronted tern. Information is often missing at a species level, particularly for freshwater invertebrates, non-vascular plants, and algae. Exotic fishes found in the rohe include perch and three salmonids.

2.5. Lower Clutha rohe[33]

120. The Lower Clutha rohe merges the entire river catchment from all five rohe within the Clutha/Mata-au FMU. The Lower Clutha rohe covers approximately 4,000km^2 and is home to more than 7,000 people. This rohe includes the Pomahaka/Pōumahaka catchment and several other river catchments that feed the Clutha Mata-au. The rohe also includes Lake Tuakitoto, a small shallow lake with an adjoining wetland of a type that is now rare in Otago.

121. The Clutha Mata-Au River is important in Kāi Tahu traditions and history. There is an ongoing relationship of mana whenua with wāhi tupuna and mahika kai values. The river and its tributaries once supported seasonal settlements and plentiful mahika kai. The Pomahaka/Poumāhaka River was important for people who settled in the Catlins and Tautuku areas. The coastal area at the mouth of the Clutha Mata-Au River offered a bounty of mahika kai, including eeling and harvest of other freshwater fish in lagoons and up the river.

122. In the south and west, and on the river plains of the coast mixed livestock and sheep and beef is the predominant land use (56%), with a significant amount of dairy farming (17%). The rohe also supports forestry at 9% and its conservation estate has increased over the last 30 years to 7% (figure 10 shows the estimated land use in the rohe[34]).

[33] Information in this section is compiled from the Lower Clutha Rohe information on the ORC website available from https://www.orc.govt.nz/your-council/plans-and-strategies/water-plans-and-policies/freshwater-management-units/cluthamata-au/lower-clutha-rohe/ (Otago Regional Council, n.d.)

[34] The land use maps are indicative only. An updated regional land use map is currently being produced.

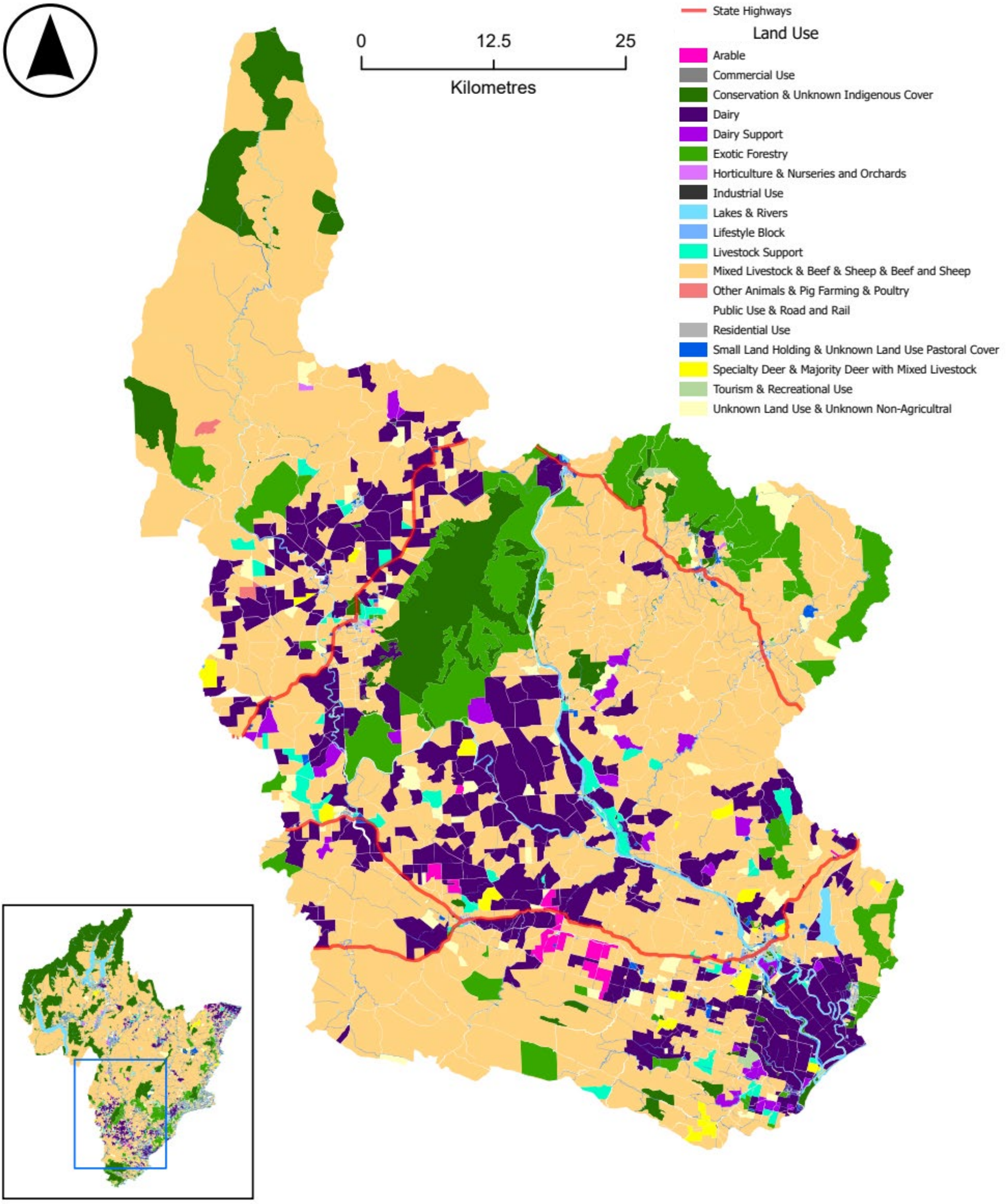

Figure 10:Estimated land use patterns in the Lower Clutha rohe in 2022

2.5.1. Water quantity

123. The most significant water feature in the Lower Clutha rohe is the Clutha River/Mata-au, which flows to the coast and into the Pacific Ocean downstream of Balclutha. The Roxburgh power station highly modifies the flows at Balclutha.

124. The Clutha/Mata-au has many tributaries in this rohe. The largest is the Pomahaka/Poumāhaka catchment which covers about 60% of the rohe area. The Pomahaka/Poumāhaka can significantly affect the flows at Balclutha when it floods. About one-third of the water used in this rohe is in the Pomahaka/Poumāhaka catchment. Other significant tributaries are the Tuapeka, Waitāhuna and Puerua tributaries. There are water take consents from both the main stem and tributaries, with various demand pressures depending on the catchment.

125. The Lower Clutha rohe contains the Pomahaka/Poumāhaka Alluvial Ribbon Aquifer and the Inch Clutha Gravel Aquifer. The Inch Clutha Gravel Aquifer is a potentially significant resource for groundwater, given the aquifer's size and thickness, but generally, groundwater use is low. The Pomahaka/Poumāhaka Alluvial Ribbon Aquifer is a series of narrow slivers which follow the Pomahaka/Poumāhaka River from the upper Kelso basin to the lower Clydevale sub-basin. The gravels of the Pomahaka Alluvial Ribbon Aquifer occur along gravel boundaries deposited by the Pomahaka/Poumāhaka River. The aquifer connects to the Pomahaka/Poumāhaka River, so groundwater bores within the ribbon aquifer are assigned to surface water. Groundwater is often taken from fractured rock across the rohe, especially in the Pomahaka/Poumāhaka Basins and into the Catlins FMU. This water resource is not mapped as an aquifer but is a locally important water source, particularly for stock water or servicing dairy sheds.

2.5.2. Water quality[35]

126. Water in the Lower Clutha rohe is generally degraded, with high bacteria, high nutrient concentrations and poor water clarity. High-intensity agriculture dominates land use, and drainage via tile and mole drains has been a significant source of water contamination. The Pomahaka/Poumāhaka catchment is the largest in the rohe and shows a gradual deterioration from the upper Pomahaka/Poumāhaka which has good water quality and achieves 'A' bands across all attributes to the lower Pomahaka/Poumāhaka which achieves 'C' or 'D' bands for all attributes.

127. The Waipahi River originates in a wetland and the low clarity found at this site is likely to be due to tannin from the wetland, rather than suspended sediment. Waipahi receives a 'D' band for periphyton. The Waipahi is a nutrient rich river and at Waipahi the river is generally dominated by macrophytes. Abundant periphyton growth will occur during the summer months particularly in the absence of flushing flows.

128. 14 of 15 river sites we monitor for bacterial water quality failed to meet the national bottom line for *E. coli*. About half of all river sites in this rohe also did not meet the national bottom line for suspended fine sediment, which indicates water clarity. Five sites had high

[35] The information in this section is compiled from State and Trends of Rivers, Lakes and Groundwater in Otago 2017-2022 (Ozanne, Levy, & Borges, State and trends of Rivers, Lakes, and Groundwater in Otago 2017 - 2022, 2023)

phosphorus, and aquatic insect life did not meet the national bottom line at three sites (measured by the Macroinvertebrate Community Index).

129. Lake Tuakitoto is a large freshwater wetland situated in the Lower Clutha River Rohe, Lovells Creek is the main inflow into the Lake. Lovells Creek scores poorly across all attribute states other than NH4-N and reflects the catchment, which is dominated by intensively grazed pasture supporting sheep, beef, dairy farming, and plantation forestry.

130. The 20-year analysis showed degrading trends were likely across the river sites, particularly for nutrients (nitrogen and phosphorus). The 10-year analysis indicated improving trends for most parameters across most sites in the rohe. The 10-year trends for Lake Tuakitoto/ Roto-nui-a-Whatu show a degrading trend for phosphorus but improving trends for *E.coli* and suspended solids (water clarity).

131. ORC monitoring shows that the groundwater in the Lower Clutha rohe has high ammonia and naturally occurring arsenic compared to the Drinking Water Standards.

132. Results from the Lower Clutha rohe indicate some water quality issues, with elevated *E. coli* and nitrate concentrations, likely due to land use around the bores (e.g., farming), their shallow depths, and poor bore security, which allows easy entry of contaminants to the bore. Dissolved arsenic concentrations are substantially below the Drinking Water Standards. The Inch Clutha gravel aquifer has elevated arsenic concentrations potentially caused by arsenic sourced from organic matter or schist sediments. There are low nitrate-N levels which may be due to the bore's depth and reducing conditions (which may also increase arsenic mobility), where nitrates break down. Nitrate-N concentrations in groundwater may be masked by these geochemical processes which may not reflect the impact of land use on groundwater quality.

2.5.3. Wetlands[36]

133. There are 28 sites in the rohe recognised as Regionally Significant Wetlands in the Water Plan. These are swamp (12 sites), marsh (7), fen (6), and bog (2). These wetlands are found within five areas: Inch Clutha, Kaitangata, Clinton, Tapanui, and Lawrence.

134. On the seaward end of Inch Clutha, is the Molyneux Bay Swamp (150 ha) which is a lagoon with swamp-edged fingers. Also in the Inch Clutha area is the Clutha Mata-Au River Mouth Lagoon (29 ha), an elongated water body with marsh margins and the Clutha Matau Wetlands (21 ha), a river-margin swamp. Further upriver, the Culcairn Oxbow Marsh (8 ha) is a curved pond of a former oxbow channel, marsh-fringed, in farmland. Finegand Lagoon Marsh (6ha), south of Balclutha, is a stream pond with willows and juncus marsh.

135. Lake Tuakitoto Wetland (546 ha) is located near Kaitangata. It is a shallow lowland lake bordered by sedge and rush swamp but with many crack willows. Smaller wetlands occupy fingers of stream valleys, as rush marshes, some with ponds and willows, or swamps with flax, shrubs, and red tussock. These smaller wetlands include the Frasers Stream Headwaters Marsh Complex (26 ha); Stirling Marsh Complex (11 ha); Camp Stream Swamp (8 ha); Two Stone Hill Stream Swamp (5 ha); and East Benhar Swamp (2 ha).

136. Wetland sites in the Clinton district are remnants of former copper tussock country, which are the boggiest sites. These typically contain copper tussock, wire rush, sphagnum, sedges,

[36] The information in this section is compiled from Wetlands of the Otago Region (Peter N. Johnson, 2022)

some heathland, and coprosma shrubland. These are all in farmland settings: Dunvegan Fen Complex (87 ha); Three Stones Fen Complex (58 ha); Hazeldale Fens (10 ha); and Willowburn Bog (4 ha), where silver birch trees behave as weeds in the peatland. Macfarlane Road Oxbow Swamp (2 ha) and Marana Swamp (2 ha) are small, isolated hollows with ponds and willows. To the east of the Blue Mountains, John O'Groats Hill Fen (22 ha) and Blackcleugh Burn Swamp (3 ha) have red tussock wetlands on valley flats. The tops of the Blue Mountains, at around 900m altitude, have sphagnum and cushion bogs, but these are not currently listed in the RPW.

137. Three small marsh sites are located on farmland near Tapanui: the Clifton Hill Marshes (4 ha) with copper tussock, the Pomahaka/Poumāhaka River Oxbow Marshes, Dalvey (4 ha) and Koi Creek (2 ha), both with ponds and willows.

138. North of Lawrence, Bungtown Bog (28 ha, and partly Scientific Reserve) is a bog with sphagnum, wire rush, and bog pine. Glendhu Swamp (22 ha) has valley floor copper tussock, while Malones Dam Margins (2 ha) has a small swamp at one end. In the northern portion of the rohe, there are more upland wetlands (cushion bogs, snowbanks, sedge fens), which are not currently listed in the RPW. These are found in the headwaters of the Pomahaka/Poumāhaka by the Umbrella Range.

2.5.4. Estuaries

139. The Clutha River/Mata-au has a tidal mouth where it joins the sea. It is categorised as a 'Shallow, short residence time tidal river (<3 days)' with adjoining lagoon estuaries. This means the water at the river mouth is replaced regularly. In these types of estuaries, the risk of contaminants building up is lower than in estuaries where longer residence times give contaminants more time to settle out onto the estuary bed.

140. The area at the mouth of the Clutha/Mata-Au is mainly freshwater due to the river's flushing; therefore, most fine sediments and nutrients are exported to the sea. No estuarine related stressor conditions exist due to these features, and no limits/attributes can be measured or set for the river/coast interface. In addition, due to the thoroughly flushed nature of the Clutha River/Mata-au mouth, no estuary nutrient modelling has been done as all nutrients and sediments are flushed out to sea.

2.5.5. Indigenous freshwater species

141. The Lower Clutha rohe contains many species that depend on freshwater habitats and ecosystems, including fishes, invertebrates, plants, and birds. There have been 32 threatened freshwater-dependent species identified within the rohe. Threatened species include the freshwater fishes Clutha flathead galaxias, gollum galaxias, Pomahaka/ Poumāhaka galaxias, dusky galaxias, and lamprey.

142. Freshwater invertebrates include koura and mussels, and a threatened moth, caddisfly, and stoneflies. *Carex strictissima* and *Ranunculus ternatifolius* are examples of threatened freshwater-dependent plants found here. Many native birds depend on freshwater ecosystems as permanent or transient residents, including the threatened Australasian bittern, black-fronted tern, and the at-risk, black-billed gull. Information is often missing at a species level, particularly for freshwater invertebrates, non-vascular plants, and algae. Many native freshwater species are under threat and continue to decline in numbers.

3. Taiari FMU[37]

143. The Taiari FMU encompasses the entire catchment of the Taiari River. The Taiari River is the fourth-longest in New Zealand, draining the eastern Otago uplands and following a U-shaped path from its source to the sea.

144. The Taiari FMU extends from Ida Range/Kakanui Mountains and Naseby in the north, to the Lammermoor/Lammerlaws in the west to Mosgiel and Taiari mouth in the south. Notable freshwater bodies in the FMU include the Taiari River and its tributaries (e.g. the Kyeburn, Sow Burn, Deep Stream), the Taiari Scroll Plain wetlands, Lake Mahinerangi, Lake Waipori/Waipōuri, and Waihola/Waihora. Mosgiel is the largest settlement in the Taiari, with a population of just over 13,000, followed by Ranfurly and Naseby in the upper Taiari, other settlements include Middlemarch and Outram.

145. Kāi Tahu used all areas of the Taiari catchment, with many mahika kai sites and settlements associated with the many waterways, lakes, and wetlands in the FMU. Although the Taiari FMU continue to support a diverse and unique array of freshwater values, some water bodies, such as Taiari Lake/Tunaheketaka, have been changed or lost due to resource use and development.

146. The predominant land use is mixed livestock and sheep and beef (71%), however there are concentrations of dairy farming (4%) around the Maniatoto/Maniototo plains and south-west of Mosgiel on the Taiari plains. Conservation estate is around 10% of the FMU and forestry accounts for 5% (figure 11 shows estimated land use in the FMU[38]).

[37] Information in this section has been taken from Taieri Freshwater Management Unit available from https://www.orc.govt.nz/media/15698/taieri-lwrp-science-report-summary.pdf (Te Ao Marama Inc., Aukaha, and Otago Regional Council, 2023f).

[38] The land use maps are indicative only. An updated regional land use map is currently being produced.

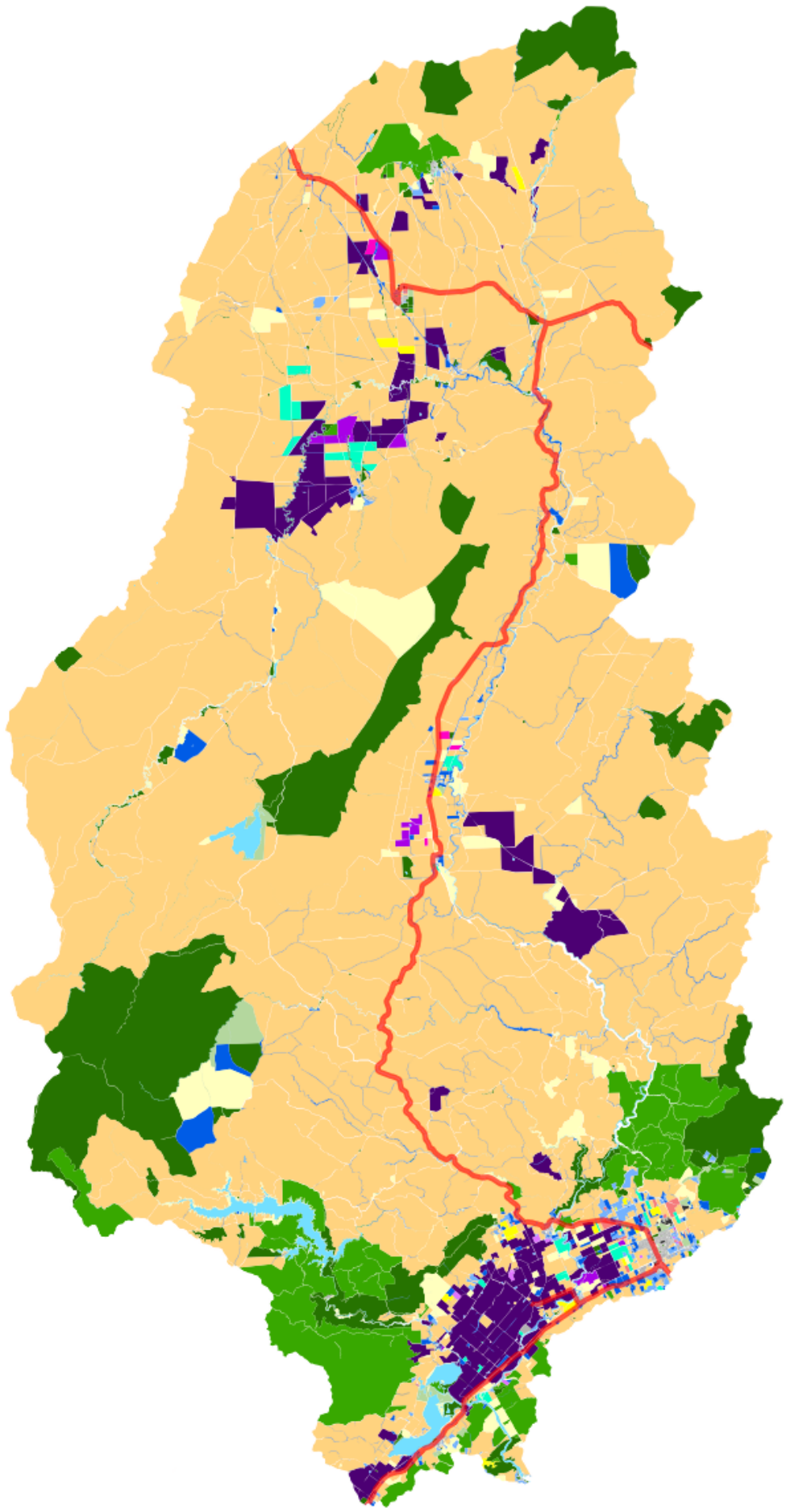

Figure 11: Estimated land use patterns in the Taiari FMU in 2022

3.1. Water quantity[39]

147. The weather and climate of the Taiari catchment are diverse. The Southern Alps provide shelter from the westerly airstream, and the catchment also receives shelter from the southern and easterly quarters by hills and mountains.

148. As a result of this sheltering effect, the catchment upstream of Sutton, except for the Taiari headwaters, experiences typical Central Otago weather and climate conditions with generally hot, dry summers and cold, frosty, dry winters. Temperatures can range from -13°C in winter to above 38°C in summer, and annual rainfalls range from about 1600mm in the Taiari headwaters to 400mm in the Maniototo/Maniatoto Basin and the Strath Taieri.

149. Downstream of Sutton, the catchment becomes more exposed to the southerly and easterly quarter weather systems. Temperatures are much less extreme, and annual rainfalls range from around 1200mm on the coastal hills to between 600mm-700mm on the Taiari Plains.

150. In its lower reaches, the Taiari River flows out onto the flat Taiari plains. It becomes tidal from around Allanton to Taieri Mouth on the East Coast and is also influenced by the drainage schemes.

151. The Taiari is an important water source for irrigation, and low flows are significantly affected during the irrigation season. Three hydroelectricity plants operate in the FMU, two in the Upper Taiari (Paerau and Patearoa) and the other in the Waipōuri catchment. Most of the Dunedin City water supply is sourced from Deep Creek and Deep Stream, tributaries of the Taiari River.

152. The Taiari FMU has three aquifers: The Maniototo/Maniatoto Tertiary, Strath Taieri, and the Lower Taiari aquifers. Groundwater can be used for domestic supply, irrigation, stock water, dairy sheds. The Maniototo/Maniatoto is Otago's largest aquifer by area. Groundwater in the Maniototo/Maniatoto is found in two types of aquifer systems: shallow Quaternary deposits and deeper Tertiary sediments. According to the ORC database, there are 255 bores in the aquifer. Most bores are either <20m or 60-80m deep.

3.2. Water quality[40]

153. Water quality in the Taiari FMU is generally good; however, some lower Taiari plain tributaries are degraded. Some sites here have among the poorest water quality in the Otago region. Water quality is affected by pressures such as intensive agricultural land use, stream modification and hosting the largest settlement in the Taiari, Mosgiel, with its associated stormwater infrastructure in the township and many lifestyle blocks that use septic tanks for their wastewater.

154. About half of the 22 river monitoring sites did not meet the required national standard (National Policy Statement for Freshwater Management, 2020) for suspended fine sediment (visual clarity). Five sites in the lower Taiari did not meet the national standard for *E. coli* (human health indicator). Two sites, Taiari at Creamery and Owhiro Stream, did not meet

[39] Information in this section is compiled using the Statement of Evidence of Roderick Donald Henderson on behalf of the Otago Regional Council, 7 December 2020. In the matter of the Water Permits Plan Change – proposed Plan Change 7 to the Water Plan (Statement of Evidence of Roderick Donal Henderson on Behalf of the Otago Regional Council, 2020)

[40] The information in this section is compiled from State and Trends of Rivers, Lakes and Groundwater in Otago 2017-2022 (Ozanne, Levy, & Borges, State and trends of Rivers, Lakes, and Groundwater in Otago 2017 - 2022, 2023)

the national standard for Dissolved Reactive Phosphorus. Excess phosphorus can cause algae growth and poor river health. Lake Waihola usually has 'C' band results for nutrients and chlorophyll-a (a measure of algae in the water). This result is consistent with the nutrient-enriched state of the lake, which has episodes of algal blooms.

155. Our trend analysis found most sites have some degrading trends. Degradation for nutrients, *E. coli* and turbidity (visual clarity) were calculated for most Taiari sites in our 20-year trend results. However, our 10-year analysis showed less sites with degrading trends for nutrients and improving trends for turbidity at most sites. For Lake Waihola, there were degrading long-term (18-year) trends for nutrients, *E. coli*, and turbidity. However, the 10-year analysis showed improving trends for turbidity and chlorophyll-a are likely.
ORC monitors groundwater quality in the Maniototo/Maniatoto aquifer at two bores, and the results show high nitrate concentrations and some *E. coli* detections. Some nitrate results were moving towards the Maximum Acceptable Value for nitrate of 11.3mg/L in the Drinking Water Standards. Arsenic concentrations did not exceed the limits in these two bores. However, due to the prevalence of schist (a natural source of arsenic) in the area, it is recommended that bore users regularly test their water.

156. Strath Taiari basin is monitored at one bore. The results show several *E. coli* exceedances, which are likely to be due to poor bore security. There was one exceedance of the dissolved arsenic Maximum Acceptable Value, which may have been an isolated event and could be due to an analytical error. Checking of arsenic concentrations is also recommended in this area. The highest nitrate concentration was 4.7mg/L, slightly below ½ of the Maximum Acceptable Value, although most samples range between approximately 1.0 and 1.7mg/L.

157. Outside these two aquifers, ORC monitors groundwater quality in four other bores in the lower Taiari. Results indicate potential risk for faecal contamination, with *E. coli* exceedance measured in all three of the FMU's aquifers. Groundwater nitrate concentrations are all below the Maximum Acceptable Value of 11.3mg/L. However, some concentrations were over half the Maximum Acceptable Value (i.e., over 5.5mg/L). Dissolved arsenic concentrations were all below the Maximum Acceptable Value. The assessment against the Water Plan surface water limits indicates potential issues, with several exceedances of the nutrient limits. It is likely that some of these elevated results are due to monitoring bores being shallow, insecure, and located near dairy farms and/or septic tanks. Nevertheless, these can potentially adversely affect surface water quality.

3.3. Wetlands

158. Within the Taiari FMU, 33 sites are recognised in the Water Plan as Regionally Significant Wetlands. These are classified as swamp (13 sites), marsh (8), fen (7), and inland saline (5).

159. The wetlands of Lakes Waihola/Waihora and Waipōuri are the remains of the Taiari Plain extensive wetland system which has been drained in the last 200 years. This wetland system, including Te Nohoaka o Tukiauau/ Sinclair Wetlands, is well known. Six much smaller ponds with swamp and willow margins are recognised as RSW sites on the Taiari Plain. Takitoa Swamp (68 ha), with flax, shrubland, and carex sedgelands, occupies the bed of a side valley at the top of the Taiari gorge.

160. The scroll plains of the upper Taiari are of quite different origins and character to the lower area. These wetland systems are still present on a grand scale. They hold the broad river meanders of the current river course as it wanders across the floodplains, along with ponded

oxbows and old water channels which show the river's history. These scroll plains are recognised as special to Otago, and ORC is working on better understanding them to support their ongoing management.

161. Ephemeral wetlands are scattered, and their flora and fauna are diverse, rare, and often nationally threatened. These wetlands can have various origins, for example, glacial moraines, dune hollows, oxbows, or sinkholes. But the characteristic type in inland Otago are surface depressions on the plateau crests of rolling schist country. Examples of ephemeral wetlands in the Taiari FMU include Nenthorn Ridge (67 ha), Red Bank (122 ha), and the Styx (11 ha) Wetland Management Areas. At Taieri Mouth, there are estuarine communities and wooded wetlands (known as carrs).

3.4. Estuaries

162. The Taiari river estuary is a shallow, short-residence time tidal river estuary. The zone between high and low tide (intertidal area) is 9.96% of the estuary. The estuary is important in terms of ecological, scenic, recreational, and cultural values. The estuary is susceptible to both nutrient and sediment stress. However, these stressors do not have much effect because of the small intertidal area, high flushing from the river, and lower light due to river depth. Only small patches of nuisance algae and mud occur along the edges of the water around rushes. There has been some historical reclamation of wetland areas, but the estuarine area is mainly intact, with large areas of rushland found along some margins.

3.5. Indigenous freshwater species

163. There have been 72 threatened freshwater-dependent species identified in the Taiari FMU. Threatened freshwater fishes include the Central Otago roundhead galaxias, Taiari flathead galaxias, dusky galaxias, Eldon's galaxias, and lamprey.

164. Freshwater invertebrates include koura, shrimp, mussels, and threatened caddisflies, moths, stoneflies, and clam shrimp. Cardamine mutabilis, Chenopodium detestans, Crassula peduncularis, and Triglochin palustris are examples of threatened freshwater-dependent plants.

165. Many birds depend on freshwater ecosystems, permanently or as mobile residents, including the threatened Australasian bittern, black-fronted tern, and the at-risk marsh crake and black-billed gull. Information is often missing at a species level, particularly for freshwater invertebrates, non-vascular plants, and algae. Many native freshwater species are under threat and continue to decline in number.

4. North Otago FMU[41]

166. The North Otago FMU extends from Waitaki bridge, down through Ōamaru, Moeraki, and Palmerston townships and to the Pleasant River in the south. High natural character values exist in the upper catchments of the Kakanui/Kākaunui, Waianakarua and Trotters Gorge.

167. Rich, volcanic soils produced food crops for early Māori and now for farmers, despite the dry climate. Land use has tended towards more water-demanding activities since the late 1990s, with water quantity pressures, faced most acutely during dry and low flow periods. Oamaru dominates the main urban areas. The semi-rural areas have a mixture of residential activities, including retirement homes, lifestyle blocks, and medium-sized farm holdings. The predominant land use is mixed livestock and sheep and beef (58%), however there is a large area of dairy farming at the northern end of the FMU (12%) which is an increasing trend along with growth in forestry (currently at 7%) and conservation estate (6%) (Figure 12 show the estimated land use[42]).

168. In Kāi Tahu tradition, the creation of the Kakanui/Kākaunui River relates in time to Te Waka o Aoraki, the shaping of the island and the stocking of the waterways and forests. Historically, this river was an essential part of the coastal trails north and south. It was also part of the seasonal trail of mahika kai, resource gathering, and hapū and whānau bonding. There are surviving rock art remnants and rock shelters associated with these activities, which are a particular taoka of the area and give a unique record of the lives and beliefs of tūpuna.

[41] Information in this section has been taken from North Otago FMU information on the ORC website available from https://www.orc.govt.nz/your-council/plans-and-strategies/water-plans-and-policies/freshwater-management-units/north-otago-fmu/ (Otago Regional Council, n.d.)

[42] The land use maps are indicative only. An updated regional land use map is currently being produced.

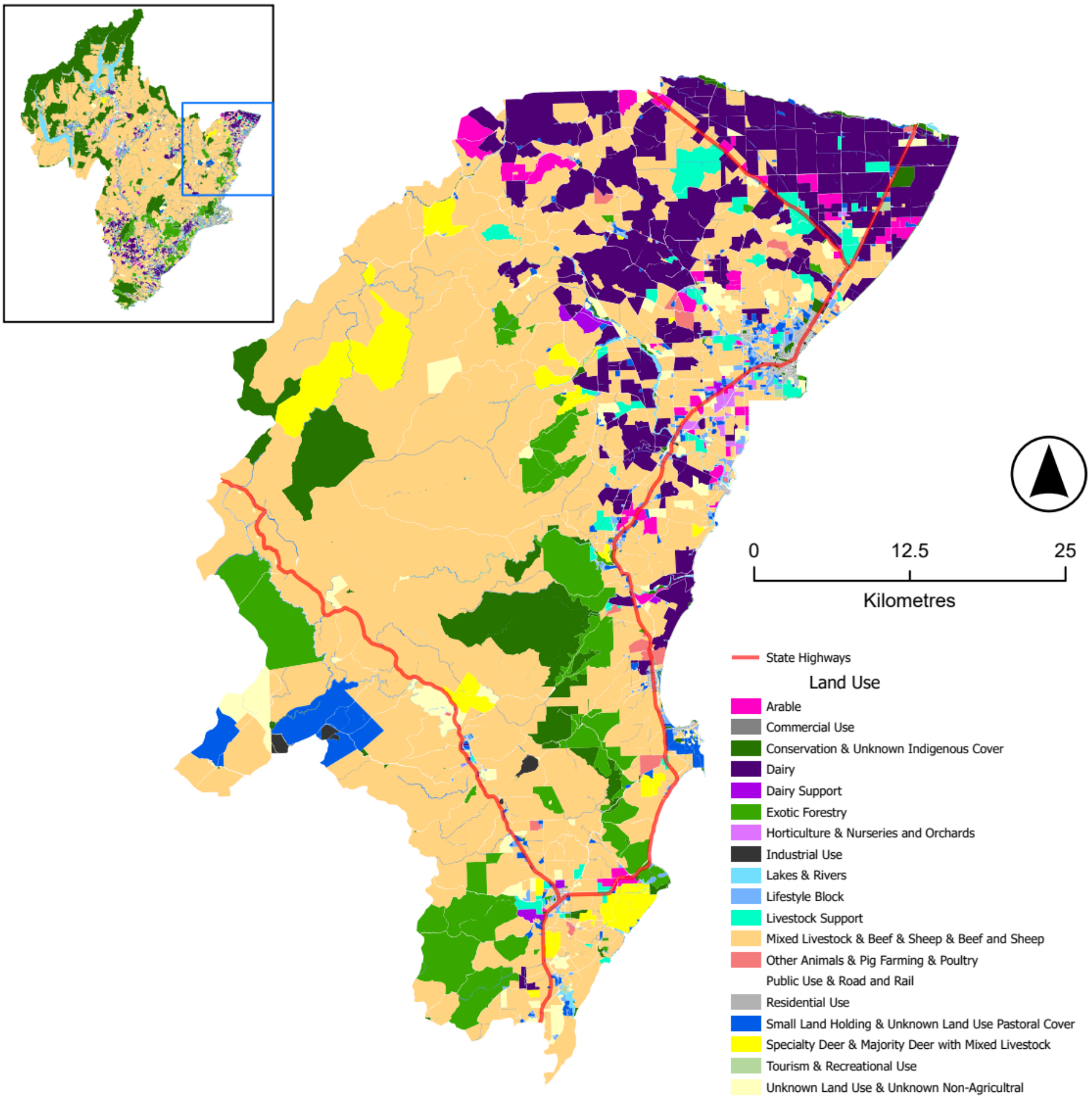

Figure 12: Estimated land use patterns in the North Otago FMU in 2022

4.1. Water quantity[43]

169. Generally, North Otago is sheltered from wind and rain from the west but is exposed from the east. Predominantly westerly quarter winds and rainstorms affect the west and south of the South Island but bring very dry conditions to North Otago which occasionally bring droughts especially in summer and autumn.

170. The less frequent storms bringing easterly quarter winds and rain to this region provide the occasional heavy rainfalls which can bring floods to the North Otago rivers and streams. A prolonged lack of these storms usually results in drought-like conditions in North Otago.

171. The main water use in this area is for irrigation especially in very dry seasons, and low flows can be significantly affected by this. The construction and operation of the North Otago Irrigation Scheme has slightly eased the low flow situation in the Kakanui/Kākaunui catchment, especially the Waiareka tributary. This scheme, which abstracts water from the Waitaki River, has the capacity to extend further into, and south of, the Kakanui/Kākaunui catchment and further ease pressure on low flows during dry periods. Extension of this Scheme into the Shag/Waihemo Catchment is currently not feasible.

172. The North Otago FMU contains several different aquifer types, including confined, unconfined, and alluvial ribbons. Unconfined, shallow aquifers within this FMU include the Lower Waitaki Plains Aquifer, the Kauru-Kakanui/Kākaunui Alluvial Ribbon Aquifer, and the Shag/Waihemo Alluvial Aquifer. The deep, confined Papakaio Aquifer underlies a large portion of the northern section of the North Otago FMU.

4.2. Water quality[44]

173. Water quality in the North Otago FMU generally shows some degree of degradation. There is pressure from land use and, at times, from low flows. Rivers in dry catchments have less dilution and flushing capacity. They are more susceptible to high nutrients and other water quality pressures associated with high-intensity land use.

174. Fourteen of sixteen sites monitored did not meet the required standard for at least one measurement, according to the National Policy Statement for Freshwater Management (2020). Water quality is the most degraded in the Waiareka and Oamaru Creeks. Water quality at these sites does not meet the national bottom line for *E. coli* (faecal indicator bacteria), phosphorus and aquatic insect life (measured by the MCI - Macroinvertebrate Community Index). Oamaru Creek is significantly degraded and has the most 'D' band results, likely due to urban run-off. Aquatic insect life and *E. coli* results did not meet the national bottom line at about half of the monitored sites in this FMU.

175. Trend analysis for the North Otago FMU rivers showed some degradation at most sites, with many trends appearing in both the 20-year and 10-year analysis periods. The Waianakarua River and Waiareka Creek show likely degrading trends for nutrients, *E. coli*, and turbidity. The results from the North Otago FMU indicate significant groundwater quality issues,

[43] Statement of Evidence of Roderick Donald Henderson on behalf of the Otago Regional Council, 7 December 2020. In the matter of the Water Permits Plan Change – proposed Plan Change 7 to the Water Plan (Statement of Evidence of Roderick Donal Henderson on Behalf of the Otago Regional Council, 2020)

[44] The information in this section is compiled from State and Trends of Rivers, Lakes and Groundwater in Otago 2017-2022 (Ozanne, Levy, & Borges, State and trends of Rivers, Lakes, and Groundwater in Otago 2017 - 2022, 2023)

particularly regarding *E. coli* exceedances and elevated nitrate concentrations, which are the highest in the region.

176. The Lower Waitaki Plains Aquifer has elevated nutrient loads, such as nitrate and DRP (dissolved reactive phosphorous), when compared to the Drinking Water Standards. South of Oamaru is the North Otago Volcanic Aquifer where monitoring shows high nitrate concentrations and DRP (ORC, 2021). The Kauru-Kakanui Alluvial Ribbon Aquifer and the Shag Alluvial Aquifer are ribbon aquifers highly connected to surface water. The high connectivity means contaminants in groundwater can affect surface water quality and vice versa. Groundwater use from these two alluvial ribbon aquifers is allocated against surface water. The Papakaio Aquifer underlies a large portion of the northern section of the North Otago FMU. The aquifer is hosted within Cretaceous-aged gravels and contains water dated to nearly 25,000 years old. Due to the old age of the groundwater and the naturally elevated iron, manganese, and dissolved reactive phosphorous, the water has limited appeal for domestic use, stock water or irrigation. The Papakaio aquifers are not available for further allocation.

177. Potential faecal contamination is also a concern, with elevated *E. coli* measured in some bores in each of the aquifers within the FMU. The results indicate potential adverse effects on surface water quality, with elevated nutrient concentrations substantially exceeding the Water Plan standards and NPSFM national bottom lines, and this FMU having the region's most degraded groundwater quality. Dissolved arsenic concentrations in all the monitoring sites across the FMU were substantially below the Drinking Water Standards.

4.3. Wetlands[45]

178. Within the North Otago FMU, 17 sites are recognised in the Water Plan as Regionally Significant Wetlands (RSWs). These are classified as swamp (8 sites), marsh (3), saltmarsh (3), and unclassified (3). Except for Red Bank Wetland Management Area (122ha) in the Macraes area uplands, all sites are coastal, mainly lagoons and estuaries associated with river and stream mouths.

179. Inland, several rare wetland habitats are found. The only inland RSW, Red Bank Wetland Management Area, has wetlands among snow tussock, shorter grassland, and shrubland. The wetter soils have red tussock grassland, schoenus fens, sphagnum moss land, and examples of ephemeral wetlands. Ephemeral wetlands are common and associated with uplands around Nenthorn on the ancient schist peneplain. Several threatened plant species (e.g. Isolepis basilaris and Myosurus minimus subsp. novae zelandiae) are associated with these ephemeral wetlands.

180. No wetland sites have been identified yet in the RPW from the Kakanui/Kākaunui Mountains. Potential areas for further recognition are in the Dansey Ecological District, e.g., near Mt Stalker and Mt. Dasher. Wetlands in these uplands include copper tussock grasslands and cushion bogs.

[45] The information in this section is compiled from Wetlands of the Otago Region (Peter N. Johnson, 2022)

4.4. Estuaries

181. There are three estuaries in the North Otago FMU, the Kakanui/Kākaunui, Shag/Waihemo and Pleasant River. Modification and pressures vary from more intensive agricultural land use in the Kakanui/Kākaunui to forestry and low-intensity agriculture in the other catchments. The estuaries cover a range of ecological conditions, and they are habitats for many wildlife, such as bar-tailed godwits, variable oystercatchers, flounder, and shellfish beds. ORC regularly monitors all the estuaries in the North Otago FMU.

182. The Kakanui/Kākaunui estuary is a shallow, short-residence time tidal river estuary that can close to the sea when flows are low. It is vulnerable to nutrients and shows eutrophication via macroalgal blooms, especially when flows are low, or the mouth is closed.

183. The Shag River is under stress from sediment and showing signs of nutrient enrichment with nuisance algae growth below the tide but not between high and low tide areas. The areas with high mud content are primarily in sheltered arms in the upper estuary and along channel banks and sheltered areas in the main basin. There is a large expansive salt marsh, and the estuary supports a variety of substrates; this, combined with the sediment issues, places the estuary in a "fair" condition for ecological health.

184. The Pleasant River Estuary supports an extensive saltmarsh complex with marginal shrublands, a diverse range of bird species and an important poorly described invertebrate fauna. The Pleasant River estuary is more degraded than the other estuaries and has large areas of high enrichment conditions. It has nuisance macroalgae, high mud content and poorly oxygenated sediment, especially in the side arms and deposition areas. These are signs of sediment and nutrient stress. The indicators of estuary health in the Pleasant River range from "fair" to "poor", except for the salt marsh. The salt marsh is still extensive around the estuary and in a "very good" condition.

185. Other estuaries and lagoons along the coast include additional distinctive lagoon and estuarine habitats, depending on the behaviour of the rivers as they near the coast. Many of these are protected and part of active restoration programmes, and many are also subject to regular livestock grazing and historic drainage which is still affecting current saltmarsh.

4.5. Indigenous freshwater species

186. The North Otago FMU contains many species that depend on freshwater habitats and ecosystems, including fishes, invertebrates, plants, and birds. There have been 44 threatened freshwater-dependent species identified in North Otago FMU. The threatened freshwater fishes include Canterbury mudfish, lowland longjaw galaxias, Taiari flathead galaxias, and lamprey.

187. Threatened freshwater invertebrates include moths and a stonefly, with koura being at risk. Freshwater-dependent plants that are threatened include Carex strictissima, Ranunculus ternatifolius, and Myosurus minimus subsp. novae-zelandiae. Many native birds depend on freshwater ecosystems as permanent or transient residents, including the threatened black stilt and black-fronted tern and the at-risk, black-billed gull. Information is often missing at a species level, particularly for freshwater invertebrates, non-vascular plants, and algae.

188. Exotic fishes include perch, tench, and three salmonids. Many native freshwater species are under threat and continue to decline in numbers.

5. Dunedin & Coast FMU[46]

189. The Dunedin & Coast FMU is 1,112 km2 and runs from Waikōuaiti in the north to the Clutha/Mata-au mouth in the south, and is spilt into two halves by the mouth of the Taiari catchment/FMU. The FMU encompasses Dunedin City, the largest urban area with the largest population in Otago. The largest catchment is the Waikōuaiti, with other main catchments being the Waitati River, Leith Stream and Kaikorai/Kaikarae Stream catchments within Dunedin City and the Tokomairiro/Tokomairaro River in the southern part of the FMU.

190. The Dunedin & Coast FMU has many outstanding features, including the natural character and form of coastal landscape (e.g., Otago Peninsula), ecological values including forests (cloud forests of the Leith and Ōrokonui Ecosanctuary), healthy estuaries (e.g., Hoopers/Papanui, Blueskin, Tokomairiro/Tokomairaro, Akatore, Pūrākaunui), wetlands (e.g., Swampy Summit Swamp), notable wildlife (e.g., hoiho, northern royal albatross, seals, sea lions, redbilled gulls, black-billed gulls), and healthy marine habitats. It is also home to threatened species (e.g., lamprey in coastal streams). The urban streams (Water of Leith, Lindsay's Creek and the Kaikorai/Kaikarae Stream) have catchment-specific water quality issues due to infrastructure and stormwater runoff from urban surfaces.

191. There are numerous wāhi tapu and mahika kai sites and associations within the Dunedin & Coast FMU, particularly in the Otago Harbour catchment. These are discussed in greater detail in the Kāi Tahu ki Otago Natural Resources Management Plan, but include mahika kai like kaimoana, eeling, waterfowl, sea bird egg gathering and plant resources like harakeke, fern and tī root. (Kāi Tahu ki Otago, 2005)

192. The Dunedin & Coast FMU contains high-producing grassland (44%) used for grazing (wool, lamb, beef, dairy) and deer farming. Areas of plantation forestry (27%) and native cover (15%) are also widespread. While this FMU has the most significant urban centre in Otago, it comprises only 4% of the land area (figure 13 shows the estimated land use in the FMU[47]).

[46] Information in this section has been taken from Dunedin & Coast Freshwater Management Unit (FMU) available from https://www.orc.govt.nz/media/15632/dunedin-coast-lwrp-science-summary-final-oct-22.pdf (Te Ao Marama Inc., Aukaha, and Otago Regional Council, 2023e).

[47] The land use maps are indicative only. An updated regional land use map is currently being produced.

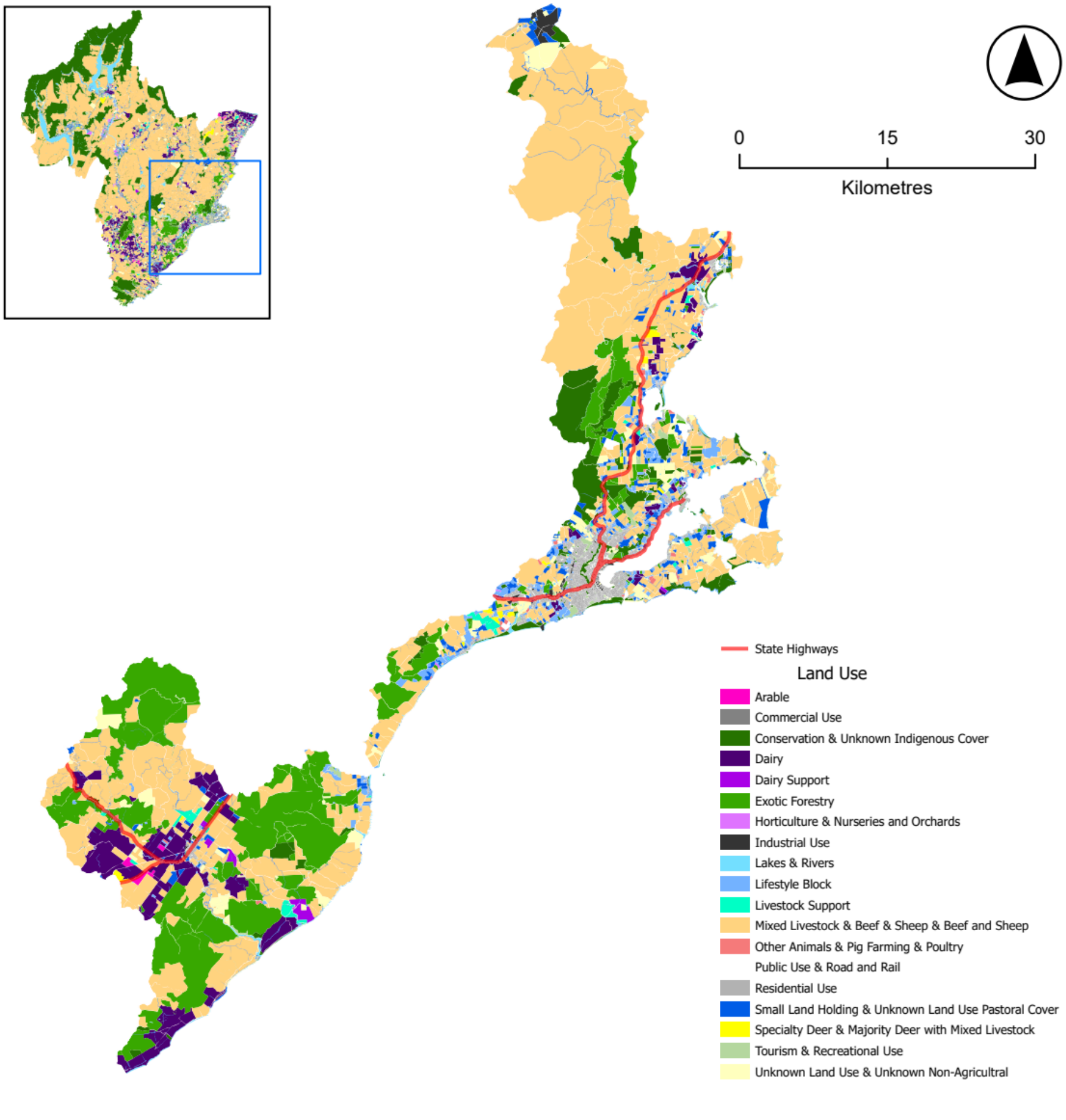

Figure 13: Estimated land use patterns in the Dunedin & Coast FMU in 2022

5.1. Water quantity

193. Surface water use in the Dunedin & Coast FMU is relatively low. In the northern part of the FMU, the Dunedin City water supply includes water take consents on the Leith and Waitati catchments. However, as most of the city's water supply currently comes from the neighbouring Taiari FMU, these takes are now only for emergency supply and are not presently used. In the southern part of the FMU, surface water is used for dairy sheds and stock water, mining and landfill activities, rural domestic water supply, and a small amount of irrigation.

194. Similar to surface water, groundwater use in the FMU is also low. The primary groundwater resource in the FMU is the Tokomairiro/Tokomairaro Groundwater Management Zone, and the main uses include domestic supply, stock water, irrigation, and dairy sheds. The consented allocation is a small proportion of the current Mean Annual Recharge.

5.2. Water quality[48]

195. Water quality monitoring indicates high bacteria and nutrient concentrations at many sites. The Kaikorai has an ammonia toxicity band of 'C' placing it below the national bottom line, it is the only site in Otago that has a NH4-N toxicity below band 'B'. Nitrate-N toxicity across the FMU achieved an 'A' band, other than the Tokomairaro at Blackbridge and the Kaikorai Stream which achieved 'B' band when compared to the Q95 nitrate-N statistic.

196. *E. coli* was below attribute band 'C' in six of the eight sites monitored. The Kaikorai, Leith and Lindsay's Creek are Dunedin urban streams, their catchments have a high degree of urbanisation in their lower reaches. Urbanisation comes with associated stormwater drains that discharge directly into the rivers. The quality of stormwater is generally poor with elevated nutrients and *E. coli* concentrations. All urban sites and sites in the Tokomairaro catchment have high median bacteria concentrations which may indicate an *E. coli* source that is affecting water quality even under low flow conditions. In agricultural settings this could be the presence of waterfowl, stock, or artificial drainage and in urban streams this could be due to point source discharges. The Kaikorai and Leith streams within the Dunedin urban area fail to meet the national bottom line for the macroinvertebrate community index (MCI). The trend analysis shows that these urban streams are continuing to degrade. However, the sites in rural parts of the FMU indicate improving trends. Waikōuaiti achieved 'A' bands for all attributes.

197. Trend analysis shows that water quality trends over 10-years is improving for all sites other than the Kaikorai Stream and the Tokomairiro at Blackbridge. Of the urban streams, the Kaikorai stream continues to degrade over the 10-year trend (all attributes), however the Leith and Lindsay's creek show improving trends across all attributes, other than for DRP with is 'unlikely' to be improving at both sites. The Tokomairiro at Blackbridge has degrading trends for *E. coli*, TN, and turbidity, when the upstream site at West Branch Bridge shows improving trends. The poor water quality with high nutrient concentrations at the bottom of the Tokomairaro catchment will likely affect ecosystem health of the Tokomairiro estuary. There is only one groundwater quality monitoring bore, located in the Tokomairiro/Tokomairaro Plain Groundwater Management Zone. The information is

[48] The information in this section is compiled from State and Trends of Rivers, Lakes and Groundwater in Otago 2017-2022 (Ozanne, Levy, & Borges, State and trends of Rivers, Lakes, and Groundwater in Otago 2017 - 2022, 2023)

therefore not representative of the entire FMU. Quarterly monitoring results generally show good groundwater quality, with low *E. coli* and nitrate concentrations are low, with a maximum reading that is substantially below the Maximum Acceptable Value in the Drinking Water Standards. Ammonia concentrations are also low. However, there is only one monitoring bore in the FMU currently.

5.3. Wetlands[49]

198. Within the Dunedin and Coast FMU 16 sites are recognised as Regionally Significant Wetlands in the Water Plan. These are presently classified mainly as swamp (8 sites), several grading to saltmarsh (2), marsh (4) and bog (1).

199. Swampy Summit bog (48 ha) holds several tarns with margins of sphagnum bog grading to tussock and shrubland with peat substrate that contains subfossil stumps and moa gizzard stones. Black swamp is an isolated 6 ha dome of peat on a ridge crest inland from Milton, having wire rush, sphagnum, and sedge communities, and heath scrub including manuka and dracophyllum.

200. The other identified wetlands are close to the coast and can be grouped into three broad forms. There are the freshwater marshes and swamps of lowland stream valleys: Measly Beach Wetland Complex (46 ha), Tokomairiro River Swamp (175 ha), Akatore Creek (69 ha), Lower Coutts Gulley Swamp (33 ha; SW of Taieri Mouth), Te Matai Marsh (1 ha; near Okia Flat), Jennings Creek Marsh (8 ha), and Whareakeake Marsh, (2 ha; near Murdering Beach). Stream-mouth lagoons infrequently open to the sea, with brackish water: Lower Otokia Creek (3 ha; behind Brighton), Kaikorai Lagoon (63 ha), and Tomahawk Lagoon (31 ha). There are also a number of larger tidal embayments on the Otago Peninsula and in Otago Harbour: Hoopers Inlet Swamp site (32 ha), Papanui Inlet Saltmarsh (5 ha), Okia Flat (222 ha) Aramoana Saltmarsh (75 ha.).

5.4. Estuaries

201. There are eight estuaries within the Dunedin & Coast FMU, ranging from natural to modified ecosystems depending on the surrounding land use. Tokomairiro/Tokomairaro and Kaikorai/Kaikarae estuaries are the most affected by sedimentation and nutrient enrichment due to upstream land use and have “fair” and “poor” state gradings, respectively. The Kaikorai/Kaikarae estuary, has experienced high modification and habitat loss due to urban development. Blueskin Bay and Purakaunui estuary are less modified, with native and plantation forests and low-intensity agriculture. Consequently, this estuary is in a “good” state, although it is vulnerable to habitat loss and modification of estuary margins. Papanui/Makahoe and Hoopers inlet both have large seagrass beds, which is a good sign of estuarine health; however, like all estuaries, they are susceptible to human activity and vulnerable to modification. The Akatore estuary is in relatively good condition for some indicators, with large areas of salt marsh and almost no nutrient issues, however it is under stress from sedimentation with sediment entering the estuary creating expanding areas of mud which reduces diversity and functioning.

[49] The information in this section is compiled from Wetlands of the Otago Region (Peter N. Johnson, 2022)

202. The Waikōuaiti estuary supports various substrate types, small high-value seagrass beds and extensive salt marsh areas, with a healthy cockle bed in the lower estuary. However, there are signs of sediment stress in the upper estuary with higher mud content in depositional areas and side arms. Low levels of nuisance macroalgae are present in patches indicating some nutrient stress is influencing the estuary.

5.5. Indigenous freshwater species

203. Dunedin is known as the "wildlife capital of New Zealand" due to the rare and endangered species near the city. The FMU has areas of outstanding biodiversity, including the Otago Peninsula, a globally renowned wildlife and eco-tourism destination, and Ōrokonui Ecosanctuary, a wildlife reserve where rare species can be found, including forest birds, reptiles, and plants.

204. The Dunedin & Coast FMU contains many species that depend on freshwater habitats, including fishes, invertebrates, plants, and birds. Native freshwater fishes include three non-migratory galaxias, four migratory galaxias (whitebait), two eel and five bullies. The lamprey and all non-migratory galaxias in this FMU are threatened. Freshwater invertebrates include koura, shrimp, and mussels. Threatened freshwater-dependent plants include Crassula peduncularis, Gunnera hamiltonii, and Leptinella nana.

205. Many native birds depend on freshwater ecosystems, as permanent or transient (migratory) individuals or populations, including the threatened Australasian bittern and the at-risk black-billed gull. Information is often missing at a species level, particularly for freshwater invertebrates, non-vascular plants, and algae. Exotic fishes include goldfish, perch and four salmonids. Many native freshwater species are under threat and continue to decline.

6. Catlins FMU[50]

206. The Catlins FMU is located along the southern coast of Otago. It contains many unmodified river, coastal and estuarine ecosystems, including an extensive spread of indigenous land cover. The landscape is made up of low ridges running in a north-west/southeast direction, which support indigenous forest and high-producing grasslands. The Catlins FMU has extensive freshwater biodiversity values, including rare and threatened ecosystems and species, including nineteen native freshwater fish and invertebrates, and native birds and plants.

207. The Catlins FMU is sparsely populated with urban areas making up 0.1% of land cover. Approximately 1,000 people live in the Catlins. The largest urban centres in the FMU are Kaka Point and Ōwaka, with about 300 residents living in each. Land uses in the Catlins are dominated by Conservation estate (29%) and sheep and beef dry-stock farming (38%). Dairying mainly in pockets in the Catlins river catchments (currently 7%) and forestry (currently 7%) are increasing in the FMU (figure 14 estimated land use[51]).

208. Significant mahika kai areas in the Catlin FMU, such as Tautuku and Kaka Point, are important parts of Kāi Tahu history and traditions. Wāhi tapu and wāhi taonga are found throughout the area in accordance with Kāi Tahu occupation and settlement patterns.

209. The Catlins FMU is the first FMU for which a CAP is being prepared as part of the Otago Regional Council's ICM program. Work on the Catlins FMU CAP commenced in June 2023 and the plan is scheduled to be finalised in October 2024.

[50] Information in this section has been taken from Catlins Freshwater Management Unit (FMU) available from https://www.orc.govt.nz/media/15528/catlins-lwrp-report-summary.pdf (Te Ao Marama Inc., Aukaha, and Otago Regional Council, 2023a).

[51] The land use maps are indicative only. An updated regional land use map is currently being produced.

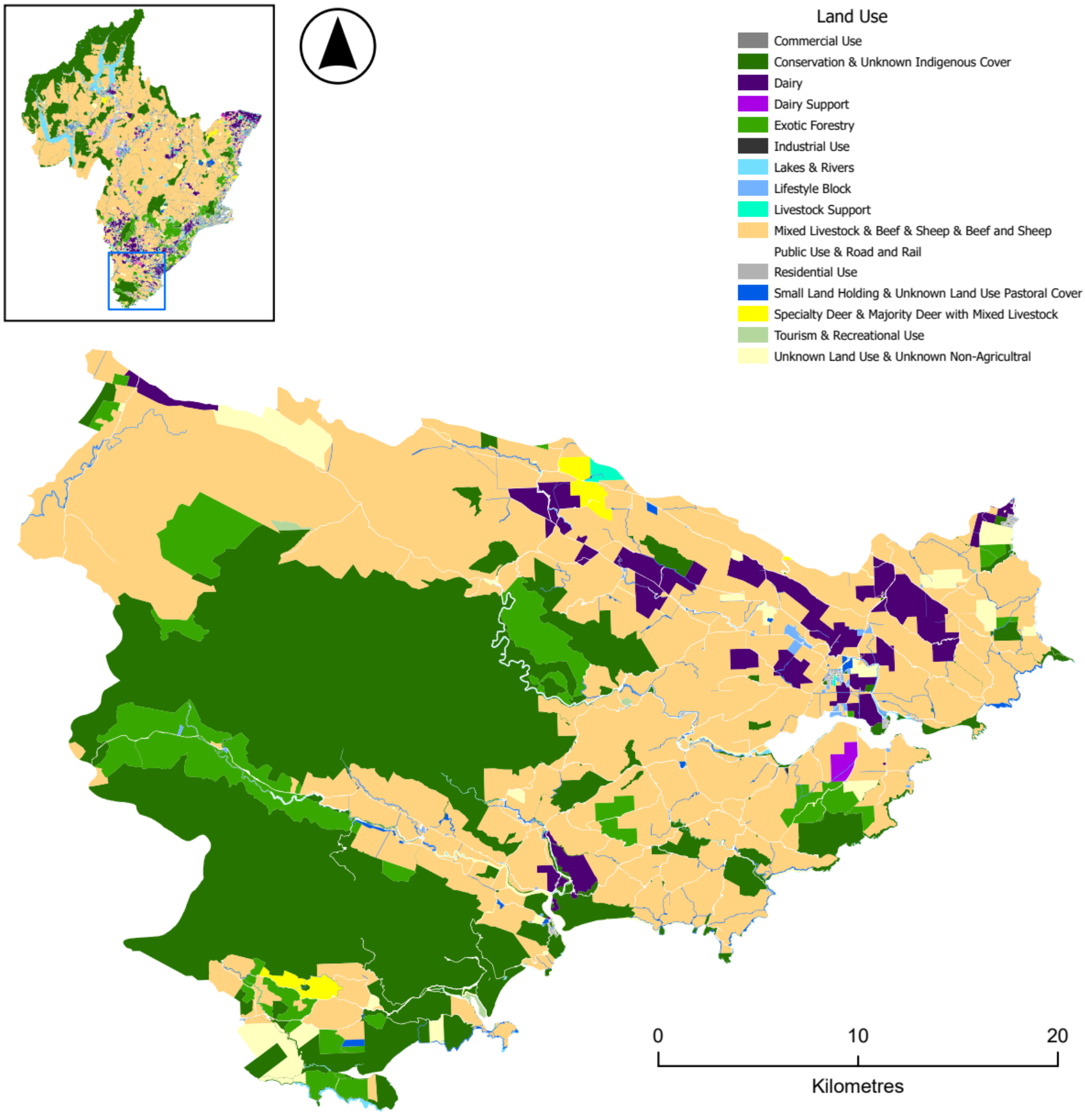

Figure 14: Estimated land use patterns in the Catlins FMU in 2022

6.1. Water quantity

210. Demand for water in the Catlins FMU is relatively low compared with water availability, as rainfall is high, and evapotranspiration is low. As a result, calculating naturalised flows for water use allocation is unnecessary at this time, and observed flows can be used instead. ORC currently monitors the flow of two river sites in the FMU: the Catlins/Pounawea and Ōwaka Rivers. Hydrological modelling provides flow estimates for the remaining catchments. Most water use occurs within the Ōwaka River catchment, with water mainly taken for rural supply and dairy sheds.

211. Groundwater in most of the Catlins FMU is hosted in fractured rock. This circumstance differs from most of Otago, where groundwater is mainly found in alluvial deposits. Groundwater use in the Catlins is generally low, with 20 bores in the FMU, which are used for community supply, stock, domestic supply, and industry. There are five current consents to take groundwater in the FMU. The rates of take are low, which further indicates the low use of groundwater in the FMU.

6.2. Water quality[52]

212. The Catlins FMU is expected to have good water quality due to the intact nature of the headwaters and native vegetation, however cleared valleys allow intensive farming activities and there are indicators of degraded water quality for some monitored parameters. All sites return 'A' or 'B' bands for ammonia and nitrate-N toxicity. The Owaka, Catlins and Tahakopa return 'D' bands for *E. coli*. Suspended fine sediment returns 'D' bands at all sites. Water in the Catlins FMU has naturally highly coloured brown water or tannin stained, the Catlins Rivers are an exception because the low the clarity is naturally occurring, rather than occurring through high sediment input.

213. Trend analysis results for the Catlins River are mixed, depending on the time period for the trend: the 20-year period indicate high likelihood of degrading water quality for the attributes of *E.coli*, NNN, TP and TN, while the 10-year trend indicates likely improvements for many of the attributes. This means that trends have become relatively stable over the last 10 years.

6.3. Wetlands[53]

214. Within the Catlins FMU 26 sites are recognised in the Water Plan as Regionally Significant Wetlands. These are classified mainly as swamp (12 sites), marsh (7) and fen (4), with wetlands in valley headwaters, along floodplains and coastal dune wetlands. The Catlins area is exceptional in New Zealand for retaining examples of natural sequences where forest adjoins swamps, bogs and marsh wetlands, as water-courses cross flood plains or are disrupted behind levees or dunes. Ponded hollows in these landscapes create a range of wetlands reflecting age, type of substrate and water regime and many retain linkages to adjoining beech, hardwood, or conifer-rich forest.

[52] The information in this section is compiled from State and Trends of Rivers, Lakes and Groundwater in Otago 2017-2022 (Ozanne, Levy, & Borges, State and trends of Rivers, Lakes, and Groundwater in Otago 2017 - 2022, 2023)

[53] The information in this section is compiled from Wetlands of the Otago Region (Peter N. Johnson, 2022)

215. Most of the regionally significant Wetlands in the Catlins are either wetlands that occupy valley floors, or the broad fingers of stream headwaters. The largest wetlands are found in estuaries and swamps near river mouths, notably in the McLennan River, Molyneux Bay Swamp and Tahakopa River Bogs. The Tahakopa/McLennan wetlands are a nationally significant example of the complex landforms in lower reaches of rivers near the sea. The Catlins retains examples of unmodified dune wetlands.

6.4. Estuaries

216. The Catlins FMU contains four estuaries: Waipāti/Chaslands Estuary, Tautuku River Estuary, Tahakopa Estuary, and the Catlins River/Pounawea Estuary. The Catlins River/Pounawea Estuary is the most affected by human activity. It experiences nuisance algal growth, increased sedimentation, and poor sediment oxidation compared to the other three estuaries, which are in less-modified catchments. The Tahakopa estuary is under slightly increased stress from sediments in some areas and is vulnerable to higher sediment generating land uses.

217. The Catlins FMU contains some of Otago's more unmodified estuaries, such as the Tautuku and Waipāti/Chaslands estuaries. They are predominantly fringed by native forest, containing a natural transition between the estuary to dunes/salt marsh/wetland into native forest, and have low mud content. While there are good examples of more 'natural' estuarine systems, the effects of sedimentation and excess nutrients can accumulate, degrading these sensitive receiving environments.

6.5. Indigenous freshwater species

218. The Catlins FMU has extensive freshwater biodiversity values, including rare and threatened ecosystems and indigenous species. The Catlins FMU has a diverse range of indigenous fish, invertebrates, birds, plants, and a bat that depend on freshwater ecosystems. The nineteen indigenous freshwater fish species include two eels, five bullies, four migratory galaxias (whitebait), lamprey, smelt, torrent fish, estuarine triplefin, black flounder, and three non-migratory galaxias. The threatened freshwater fish are non-migratory galaxias and the lamprey. Freshwater invertebrates include crayfish, mussels, and shrimp.

219. A high proportion of native birds depend on freshwater ecosystems, either as permanently or transient (migratory) populations. Threatened birds include Australasian bittern, black stilt, and black-billed gulls. Many plants are also freshwater-dependent, including the threatened heart-leaved kohuhu.

220. Information for the Catlins FMU is often missing at a species level, particularly for freshwater invertebrates, non-vascular plants, and algae. Many native freshwater species in the FMU are under threat and continue to decline.

7. Summary of freshwater issues in Otago

221. As discussed in sections 1 – 6, the primary freshwater management issues for the region include:

a. Some catchments are water short and/or water quantity is overallocated. Many catchments in Otago have a medium to high ecological risk due to water abstraction.

b. River and lake state results show that water quality across Otago is spatially variable, water quality is best at lakes, river and stream reaches located at high or mountainous elevations under predominantly native cover. When considering the major four contaminants (nitrogen, phosphorus, *E.coli* and sediment), *E.coli* is most often the attribute for which sites and segments fail to comply with the national bottom line.

c. There has been a significant loss of wetlands through the region and only 6% of those remaining have a form of legal protection. These ecosystems are highly vulnerable to the effects of exotic invasions, open-cast mining, and pastoral intensification.

d. Excessive nutrient input (eutrophication) threatens many Otago estuaries causing ecological problems, such as algal blooms and poor physical and chemical conditions for estuarine life.

e. Indigenous freshwater species are subject to pressure from predation and competition with introduced species as well as loss of habitat due to modification of water ways, water abstraction, water quality deterioration, barriers to fish passage, and predation by native taxa that are outside of their normal range.

f. There is a range of issues affecting the coverage and continuity of flow recording in Otago. These issues included a lack of monitoring in some catchments, few or no measurements for smaller tributaries, diversions in/out of catchments, abstractions for out-of-stream use, and manipulation of flows due to storage.

222. As discussed in sections 2 – 6, the primary freshwater management issues for the FMUs include:

a. Clutha Mata-au FMU – in the lower river reaches and urban areas of the Upper Lakes rohe, higher *E.coli* and nutrient enrichment counts occur due to stormwater runoff and presence of wildfowl in the stream. Groundwater data indicates some issues, with elevated *E. coli*, nutrients and arsenic levels.

Groundwater monitoring results from the Dunstan rohe generally show compliance with the Drinking Water Standards. However, some bores have had elevated *E.coli* concentrations.

In the Manuherekia rohe, trend analysis shows that there are a number of sites with degrading water quality trends for *E.coli*, NNN and turbidity over ten years and *E.coli*, NNN and TN over 20 years.

Rivers and streams originating in the Roxburgh rohe do not have large flows and generally have very low flows in summer. Groundwater quality appears to show some issues in the Roxburgh rohe, notably *E. coli* detections in most bores and high median nitrate-N concentrations.

The Pomahaka/Poumāhaka catchment is the largest in the Lower Clutha rohe and shows a gradual deterioration from the upper Pomahaka/Poumāhaka which has good

water quality and achieves 'A' bands across all attributes to the lower Pomahaka/Poumāhaka which achieves 'C' or 'D' bands for all attributes.

b. Taiari FMU – the Taiari is an important water source for irrigation, and low flows are significantly affected during the irrigation season. Water quality in the Taiari FMU is generally good; however, some lower Taiari plain tributaries are degraded. Some sites here have among the poorest water quality in the Otago region.

c. North Otago FMU – water quality in the North Otago FMU generally shows some degree of degradation. There is pressure from land use and, at times, from low flows. Rivers in dry catchments have less dilution and flushing capacity. They are more susceptible to high nutrients and other water quality pressures associated with high-intensity land use.

d. Dunedin & Coast FMU – water quality monitoring indicates high bacteria and nutrient concentrations at many sites. The quality of stormwater is generally poor with elevated nutrients and *E. coli* concentrations. The Kaikorai/Kaikarae estuary, has experienced high modification and habitat loss due to urban development.

e. Catlins FMU – the Catlins River/Pounawea Estuary is the most affected by human activity. It experiences nuisance algal growth, increased sedimentation, and poor sediment oxidation compared to the other three estuaries, which are in less-modified catchments.