Monitoring the extent of braided river cover classes in Canterbury – a 2012 and 2024 comparison

Environment Canterbury Science Summary:
R25/38

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Key messages

❖ **Background:** Braided rivers are dynamic ecosystems with high biodiversity and ecological values. They form a rich mosaic of terrestrial and aquatic habitats that support threatened species, including nesting and feeding birds. The structure and arrangement of these habitats over time are driven by natural processes but also impacted by anthropogenic influences. Waitaha/Canterbury contains about 60 per cent of New Zealand's braided rivers; however, these rivers are under threat due to human activities like flood protection, land use intensification, gravel extraction, and invasive species.

❖ **The problem:** The last comprehensive assessment of Waitaha's braided river habitat mosaics was completed using 2012 data. This evaluated the gravel and vegetation cover of braided riverbeds and margins using satellite imagery. Updated data is needed to understand how these habitats have responded to floods and erosion, and human activities, in the intervening period. This information can help inform progress towards achieving regional policies and outcomes aimed at protecting braided rivers.

❖ **What we did:** We repeated the methods of Pompei et al. (2019) using updated 2024 Sentinel-2 satellite imagery. The beds and margins of 76 braided river areas were automatically classified into eight ground cover classes relating to gravel characteristics and vegetation density. These results were validated against field observations in the upper Rakaia River, and the automated process calibrated. We then mapped and compared the resultant cover class data from 2024 against that obtained using 2012 imagery.

❖ **What we found:** The data we produced can be used to examine consistency or changes in riverbed cover class extent at different scales, including for individual river reaches across or within catchments. Patterns of change are likely to vary between river reaches depending on differences in natural processes (e.g., flood magnitude and erosion) and human-induced impacts (e.g., flood control or weed invasion). Overall, the comparison of 2012 and 2024 satellite imagery confirmed that braided riverbeds are dynamic environments and cover class distributions have changed over time. Raw riverbed cover increased by 127 per cent (from 12,950 ha to 29,450 ha) across the region. Moderate vegetation cover nearly doubled, while high and dense vegetation cover declined. Almost 75,000 ha of riverbed transitioned from mature (e.g., more densely vegetated) to early successional (e.g., raw riverbed) states. Approximately 32,900 ha of riverbed transitioned to later successional states. These changes will have altered the structure of braided river habitat mosaics, and the availability and extent of aquatic and terrestrial habitats. For example, 86,820 ha of braided riverbed was categorised as useable braided river bird nesting habitat for 2012. This increased to 119,070 ha in 2024.

❖ **Next steps:** The braided river cover class information we have generated is limited by several caveats. First and foremost, the analysis needs to be conducted more frequently to better align with timelines of vegetation succession and flood cycles. This will help ensure that the dynamic nature of braided river habitat mosaics is captured accurately. The data, and the methods used to produce it, can have several useful applications. These include helping to monitor bird habitats and identify prime nesting areas, assess the effectiveness of weed control programs, and support flood protection infrastructure planning. We recommend that future studies use the data to explore drivers of habitat change and ecological impacts in discrete braided river reaches. Integrating cover class data with hydrological and ecological information may help better understand braided river dynamics and inform management strategies.

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1   Introduction

Braided rivers are unique and significant ecosystems, yet they are threatened globally, with intact systems found in only a few countries worldwide. They exist in areas that contain ample space to move coupled with highly erodible geology and high rainfall. This combination of features creates dynamic river environments characterised by high sediment transport, high energy flows, and shifting channels/braids that migrate laterally, back and forth across wide gravel braid plains (Gray & Harding, 2007; Stanford, 1998; Tockner & Stanford, 2002). Recently eroded areas of riverbed typically follow a successional process of gravel stabilisation and/or vegetation growth over time, resulting in more successionally mature habitats (Reinfelds & Nanson, 1993). Over time, migrating channels create ever-changing and renewing mosaics of both terrestrial and freshwater habitats. These diverse mosaic habitats support high biodiversity values, including a wide range of species many of which are threatened or endangered (Gray et al., 2016; Gray & Harding, 2009; Harris et al., 2024).

Nationally, these natural characteristics and processes of braided rivers have become modified (Brower et al., 2024; Gray et al., 2017; Williams et al., 2012). This is due to various human-induced environmental pressures including climate change, water and gravel extraction, flood protection works, adjacent land use intensification, and the spread of exotic weeds and pests. Consequently, braided river habitats are considered endangered ecosystems in New Zealand (Holdaway et al., 2012).

Waitaha/Canterbury is home to approximately 60 per cent of the country's braided river systems (Hibbert & Brown, 2001), the significance of which is recognised under numerous regional planning documents. These include the Canterbury Regional Policy Statement (Environment Canterbury, 2025) Canterbury Water Management Strategy (CWMS; Canterbury Mayoral Forum, 2019), and Canterbury Land and Water Regional Plan (LWRP, 2023). Each of these documents outline objectives, policies, and targets aimed at preserving the natural character, ecosystem health, and biodiversity of braided rivers. The Ahuriri, Rangitata and Rakaia rivers are also protected by national Water Conservation Orders, which recognise their outstanding natural, cultural, and recreational values. These legal protections help preserve the ecological integrity of the rivers and safeguard water quality.

An important ecological function of braided river habitats is their provision of nesting and foraging areas for birds. This is recognised as a target in the CWMS that aims to "*increase habitat area usable by all species of braided river indigenous birds*" by the year 2040. Braided river birds, many of which are endangered (Robertson et al., 2021), rely on gravel islands formed by the mobile braids to lay eggs and rear chicks in safety from introduced predators. Many also use braided rivers for feeding. The structure and arrangement of gravels and vegetation covering braided riverbeds impact the availability and suitability of nesting habitats. This ground cover arrangement is determined by the erosional processes and anthropogenic influences described above that structure the braided habitat mosaic.

To provide a baseline for the CWMS target mentioned above, Pompei et al. (2019) analysed the extent of braided river cover classes to inform an assessment of usable braided river bird habitats in Canterbury. Using 2012 remote sensing imagery and Geographic Information System (GIS) software, they classified braided riverbed areas into distinct ground cover classes and evaluated their suitability for bird use. In the Canterbury Region, 86,820 ha of braided riverbed area was identified as useable braided river bird nesting habitat, and 111,540 ha was useable feeding habitat. The relative proportion of each ground cover class, and therefore braided river bird habitat suitability, varied between individual rivers.

The satellite imagery assessed by Pompei et al. (2019) is now over 12 years old. Since then, riverbed ground cover classes, and the habitat mosaic, of braided river reaches in Canterbury will have changed. The degree of change will vary between locations depending on where in the catchment each reach is located, for example in regard to their proximity to riverbed management activities, and the recency of flood and erosion processes.

The purpose of this report is to re-analyse and re-examine the recent extent of braided river cover classes across Waitaha using contemporary imagery datasets. We broadly repeat the methods employed by Pompei et al., (2019) and compare 2012 and 2024 cover class information. We do not investigate the drivers of the observed changes, nor do we attempt to describe the implications of cover class observations for bird or other flora and fauna habitats in the region. The report and associated

dataset will, however, contribute to a body of information to inform on the above topics. In future, this body of information may support reporting on the braided river outcomes and targets contained in regional documents such as the CWMS and the management of braided rivers generally.

2 Methodology

2.1 Overview

A quantitative analysis of the recent distribution of braided river ground cover classes was undertaken for 76[1] Waitaha braided riverbed and margin areas (Figure 2-1 to Figure 2-3). To achieve this, we broadly repeated the classification methodology described in Pompei et al. (2019) using 2024 satellite imagery and field validation methods. This process is summarised below and explained in further detail in Section 2.2.

Riverbed and margins ground cover was classified according to the presence or absence of water, gravels and vegetation, and the depth, type, and density of each, respectively (Table 2-1). We used automated remote sensing techniques to assign preliminary, computer-generated ground cover classes to areas of braided riverbed and margins. This was undertaken in an unsupervised classification[2] and subsequent supervised classification[3]; see Section 2.2. The results were then compared against observational ground cover data collected during a field visit to a sample river reach in upper Rakaia River (Figure 2-4; Appendix 1). The calibrated data for the upper Rakaia River then informed an automated classification for all the braided riverbed and margin areas in the study.

Following the classification process, the region-wide cover class data for 2024 was analysed and compared against 2012 data from Pompei et al. (2019). To achieve this, we combined the 2024 and 2012 geospatial datasets into a single geospatial dataset (Figure 2-5). This allowed the cover class data from both time periods to be simultaneously displayed for any discrete area of riverbed. The attribute data was then exported to Microsoft Excel to compare cover class extent between the two time periods on a river-by-river basis.

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[1] The Ashburton River North Branch and Ashburton River (lower) have been merged into a single section—Ashburton River (lower)/Hakatere—due to their similar characteristics. As a result, the total count has decreased to 76, compared to the 77 reported by Pompei et al. (2019).

[2] Unsupervised classification: a method where the computer automatically groups pixels into clusters based on their spectral similarities, without prior knowledge of what the clusters represent. The software analyses the image data and identifies inherent patterns, grouping similar pixels into classes. A digital signature can be created from an unsupervised classification.

[3] Supervised classification: a method used to categorise pixels in an image into predefined classes, based on information contained in a digital signature file.
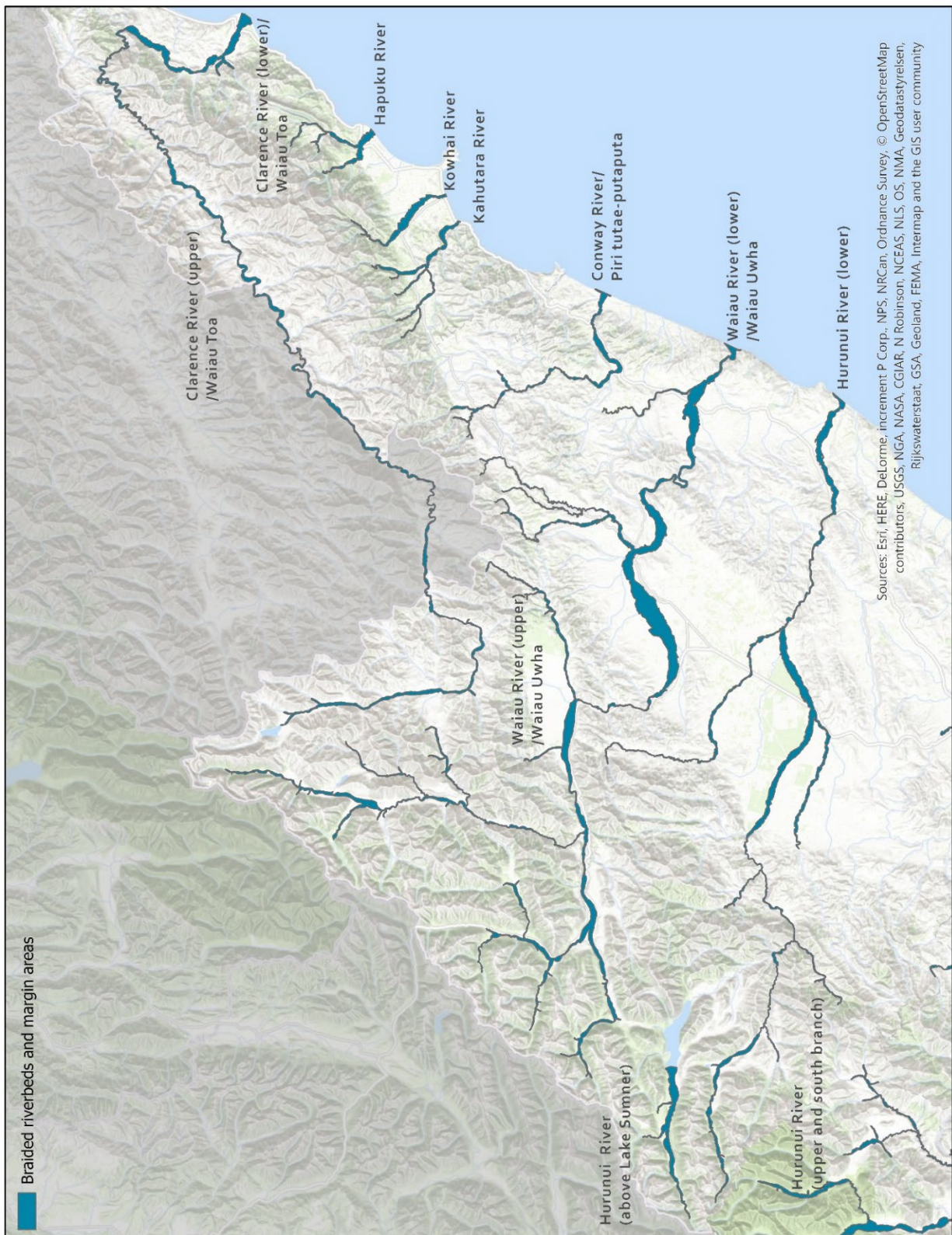
Figure 2-1: **Braided riverbeds and margin areas, in northern Waitaha, used in the ground cover classification (O'Donnell, 2000).**
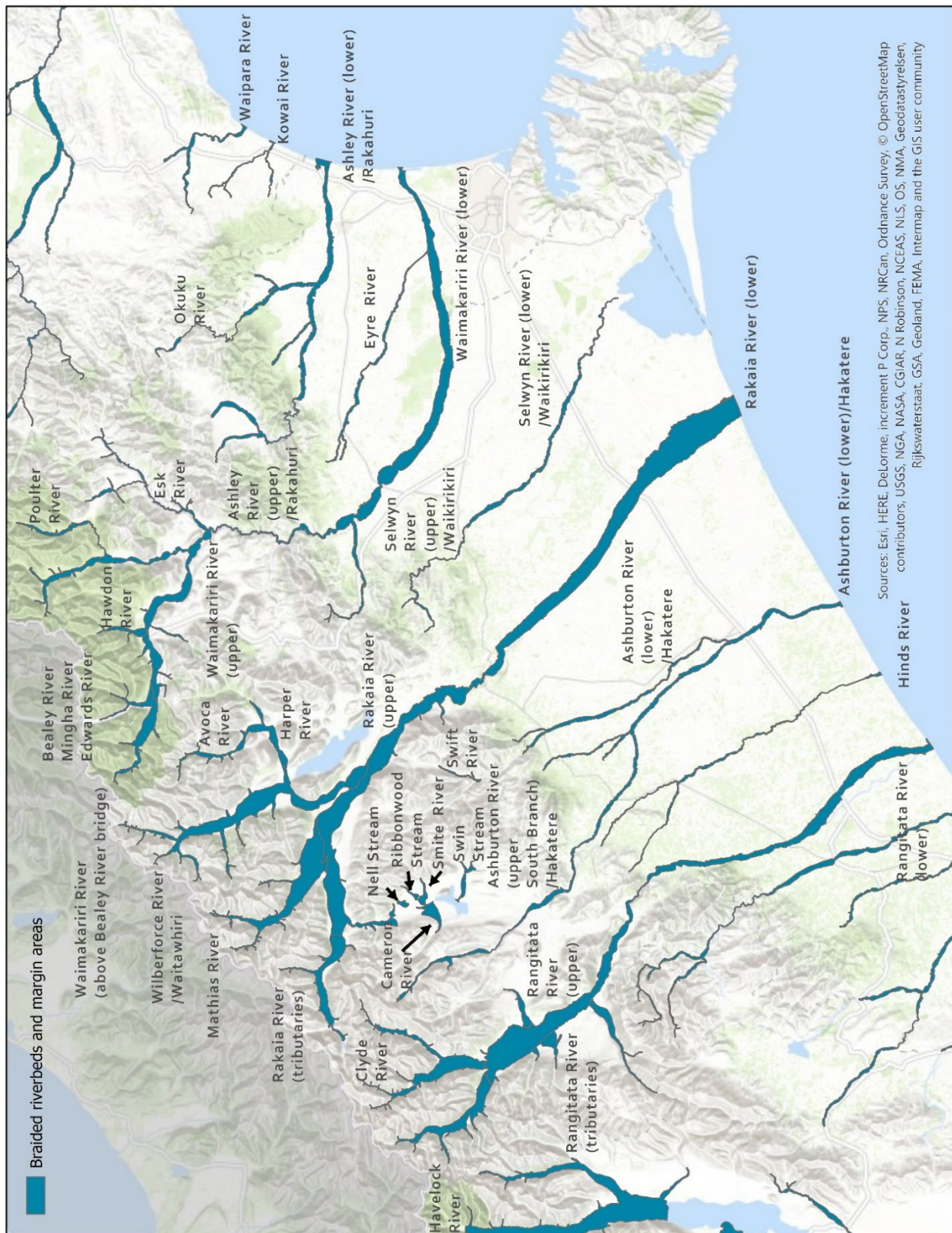
Figure 2-2: **Braided riverbeds and margin areas, in central Waitaha, used in the ground cover classification (O'Donnell, 2000).**
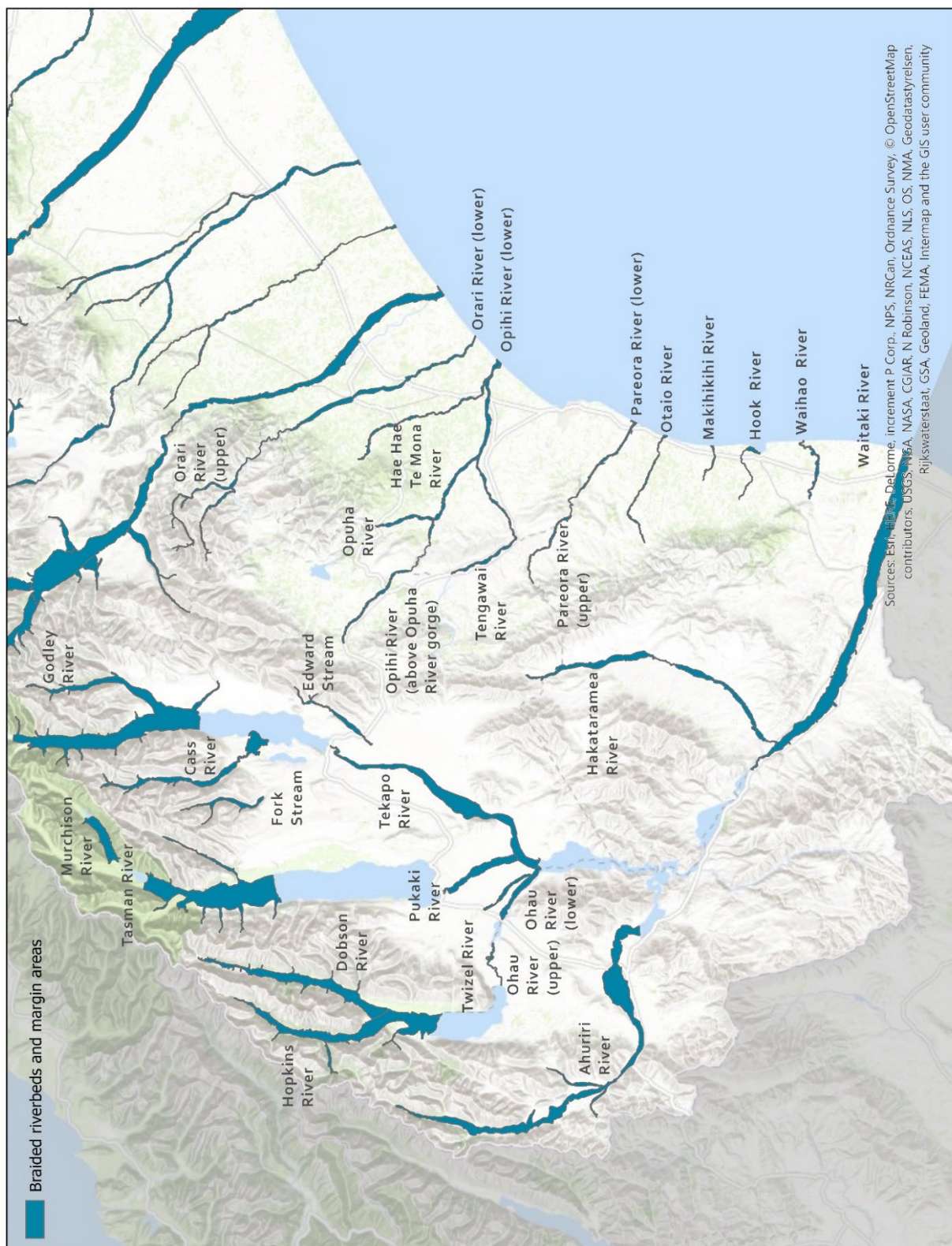
Figure 2-3: **Braided riverbeds and margin areas, in southern Waitaha, used in the ground cover classification (O'Donnell,2000).**

Table 2-1: **Names, descriptions and bird habitat use for eight braided riverbed ground covers classified by spectral analysis (adapted from Pompei et al., 2019).**

Cover Class	Description	Bird Habitat Suitability
Water 1	Deep water channel (>25 cm) and with the image pixel consisting mainly of water.	Useable feeding habitat.
Water 2	Shallow water channel (<25 cm) and/or image pixel consisting of a composite of water and exposed riverbed gravels.	Useable feeding habitat.
Raw riverbed	Gravels and fine sediments (reworked and deposited sediments from flood events) with a fresh raw appearance (steep bank edges) and no vegetation (Figure A1-1 and Figure A1-2). Frequently inundated during freshes / small to moderate flood flows.	Useable feeding and nesting habitat.
Older riverbed	Smooth gravels and sediments (rounded bank edges); some signs of weathering rinds or lichens on gravels and limited establishment of low stature vegetation (Figure A1-3 and Figure A1-4). May be inundated during moderate to high flood flows.	Useable feeding and nesting habitat.
Sparse vegetation cover	<30 per cent herbaceous or shrub vegetation cover with extensive exposed gravels and/or finer sediments (Figure A1-5 and Figure A1-6). May be inundated during moderate to high flood flows.	Useable feeding and nesting habitat.
Moderate vegetation cover	30-50 per cent herbaceous or shrub vegetation cover with exposed gravels and/or finer sediments (Figure A1-7 and Figure A1-8). Inundated during high annual flood events.	Useable feeding and nesting habitat.
High vegetation cover	50-80 per cent herbaceous or shrub vegetation cover with some exposed gravels and/or finer sediments (Figure A1-9 and Figure A1-10). May be inundated during high annual floods as well as more occasional larger flood events.	Unsuitable.
Dense vegetation cover	>80 per cent herbaceous or shrub vegetation cover with little to no exposed gravels and/or finer sediments (Figure A1-11 and Figure A1-12). Generally, not inundated	Unsuitable.
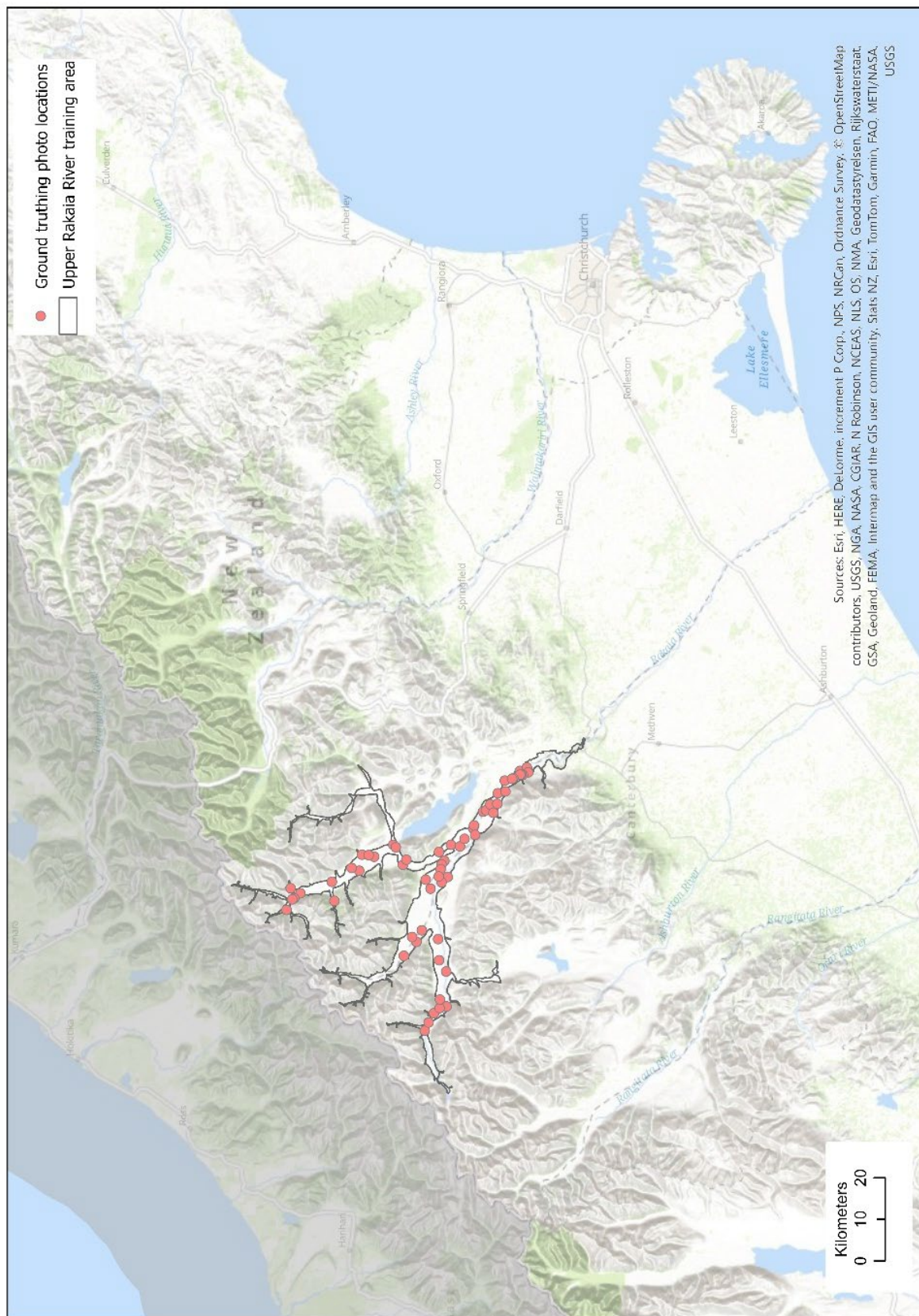
Figure 2-4:   Upper Rakaia River training area and ground truthing photo locations.
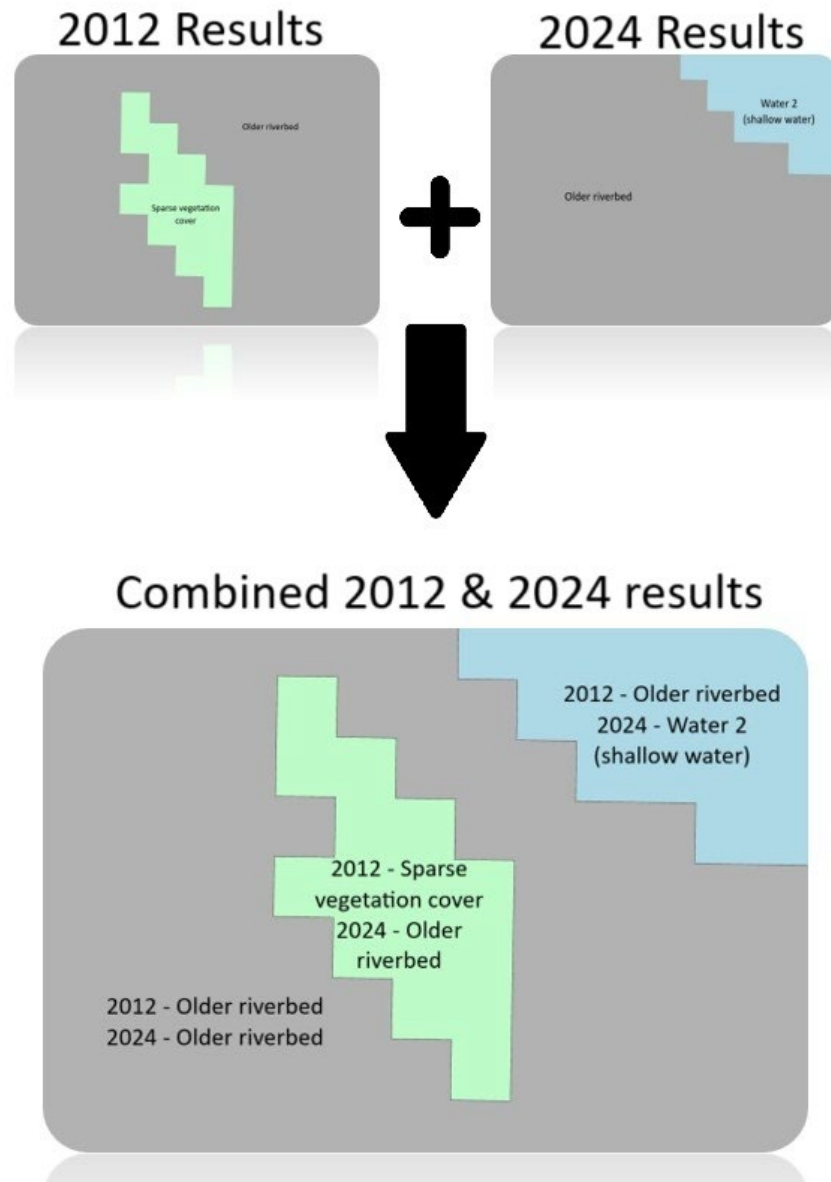
Figure 2-5: **Schematic representing how the datasets from 2012 and 2024 were spatially combined using the ArcGIS Union tool. The top-left (2012) and top-right (2024) represent areas of the same riverbed. The Union tool creates a single shapefile that combines cover class attributes from both time periods (bottom image).**

2.2 Classification process and results validation

The following outlines the new imagery and methods we used in this analysis, as compared to Pompei et al. (2019), and how they were applied in the classification process. It describes some of the process outlined in Section 2.1 above, but in more detail.

The range and type of remote sensing imagery has increased significantly since the last cover class analysis was conducted by Pompei et al. (2019). In this investigation, we used imagery captured from the more recent Sentinel-2 satellite, as opposed to the SPOT 2012 imagery used in the past. The benefits of Sentinel-2 satellite imagery include its high spatial and temporal resolution, which enables detailed and frequent monitoring of land and water features. The presence of two satellites in the Sentinel-2 constellation allows for extensive area coverage, often captured at the same point in time, with regular revisit intervals enhancing the consistency and reliability of observations.

2.2.1 Training area classification

As a first step in the classification process, we needed to create a new digital signature file[4] for the classification. The new digital signature file was specific to the imagery derived from Sentinel-2 2024 as opposed to SPOT 2012 imagery. To generate the digital signature file, we used part of the upper Rakaia River (Figure 2-4) as a training area for the regional analysis. The area clearly displayed the full range of cover classes required for the classification. The upper Rakaia River was also used in the previous methodology by Pompei et al. (2019).

The extent of braided river used for the analysis corresponded to the braided river sections named and described in the Environment Canterbury "Native bird habitat" geospatial layer and accompanying technical report by O'Donnell (2000). There are several different river boundary datasets available for use and new boundary lines are frequently created. For consistency, this analysis adopted the boundary lines developed by O'Donnell, which were previously utilised by Pompei et al. (2019). The braided riverbed and margins study areas were not intended to define bed and margins of braided rivers for statutory or planning purposes; rather to define an 'area of interest' for the purpose of identifying and monitoring extent of useable native bird habitat within braided riverbed environments.

To create the digital signature for the upper Rakaia River training area, we downloaded a recent, single 10 m resolution geospatial tile from the Sentinel-2 imagery collection using the Copernicus Data Space Browser. We then performed an unsupervised classification on the imagery using ERDAS Imagine, 2014, developed by Hexagon Geospatial. The unsupervised classification created the digital signature subsequently used in a supervised classification of the training area. The classification process created areas consisting of eight cover classes within the river boundary. The eight river ground covers classes are described in detail in Table 2-1.

In order to calibrate the analysis, we required field data describing each class. Ten polygons from each cover class (Table 2-1) were selected. Polygons for the two water classes ('water 1 (deep water)' and ('water 2 (shallow water)') were excluded because of the high variability associated with changing river flows and depths with time. The polygons that were selected were as large and homogenous as possible. The georeferenced centre point for each polygon was recorded and subsequently visited using a helicopter on 26 February 2024.

At each location, we hovered approximately 30 m above ground level and took a geo-referenced vertical photo (Appendix 1). We then moved approximately 20 m to the side of the centre point, took an oblique photo (Appendix 1) and briefly described the vegetation or ground cover. The photos and descriptions were compared with photographs obtained in 2013 (Appendix 2) to ensure the classes were comparable. The timing of the fieldwork was similar to the timing of the satellite imagery captured and used in the regional classification.

2.2.2 Regional classification

For use in the regional classification, we downloaded Sentinel-2 standardised/flattened imagery of the South Island at 10 m resolution. The Sentinel-2 image was captured in the summer of 2023/24 and supplied by New Zealand Ministry for Environment. Using Imagine, we clipped the imagery to the Waitaha Region and merged the spectral bands 2, 3, 4, and 8 into a new image file. Bands 2, 3, and 4 correspond to the visible colour bands — blue, green, and red, respectively — while band 8 is the near-infrared band. These bands are particularly effective for vegetation classification because they capture key regions of the electromagnetic spectrum that are sensitive to plant characteristics. They are useful for distinguishing vegetation from soil and water due to differences in reflectance properties. This was followed by an unsupervised classification on the upper Rakaia River training area and creation of a new digital signature.

To develop the most fit-for-purpose digital signature, we generated multiple signatures with varying standard deviations and class numbers. The digital signature that produced the most accurate classification for most cover classes, compared to visual observations in the field and of satellite imagery, was selected. The 'water 1 (deep water)' class was, however, not well defined. To resolve this, the 'water 1 (deep water)' signature was sourced from a different digital signature where it was more

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[4] A digital signature file is used to classify a satellite image. It contains reflectance values from the image's spectral bands, representing known land cover types.

accurately represented and then integrated into the primary signature. A final regional supervised classification was performed using this updated signature.

The classification results were validated against ground-truthing data and field photographs, and recent aerial imagery. For validation against ground-truthing field data and photographs, we compared the exact locations in the classified image with the centre points of geo-referenced field images. For validation against recent aerial photos, 80 random points were generated, one for each river or tributary. Each point in the aerial photo was compared to the classification results. Additionally, the Image Alarm tool was used to assess classification accuracy. This tool displays image pixels that matched the signature definitions and identified any overlaps with other signatures. Following the classification process, we exported the classified results to Esri ArcGIS Pro, 2024.

Gaps in the data, present in both the 2012 and 2024 imagery, were classified as 'no data' (Appendix 3, Table 3-1). These gaps typically result from satellite imaging issues, such as cloud cover or topographical features obscuring the riverbed. For the upper Clarence River/Waiau Toa, some 'no data' areas were consistent across both years due to the river's narrow gorge obstructing the satellite's view. Another example is shown in Figure 2-6 and Figure 2-7 which display an example of 'no data' areas in the upper Rakaia River. The gaps occur in and around the active riverbed, where the river is obscured by cloud or mist. 'No data' consisted of one per cent or less of all riverbed areas analysed.

The 2024 results were produced using improved processing techniques, resulting in a more refined delineation of the river extent. To ensure consistency and overlap, the 2012 dataset was adjusted to align with the 2024 extent. These adjustments are reflected in the habitat class totals presented in Appendix 4. Prior to adjustment, the 2012 areas were 87,050 ha for nesting habitat and 111,910 ha for feeding habitat.

We then used the Union tool in ArcGIS to spatially combine the 2024 and 2012 results (Figure 2-5). This generated a single polygon shapefile with ground cover class attribute data from both the 2012 and 2024 time periods. We then exported the data to Microsoft Excel for display using pivot tables, where the data was rounded to the data to the nearest 10 ha for ease of reading. Lastly, a change analysis was conducted. A change analysis is a method often used with remote sensing and GIS data to identify, quantify, and understand differences or transformations between two or more states of a system over time. This was undertaken for the 2012 and 2024 time periods with results tabulated into matrices.
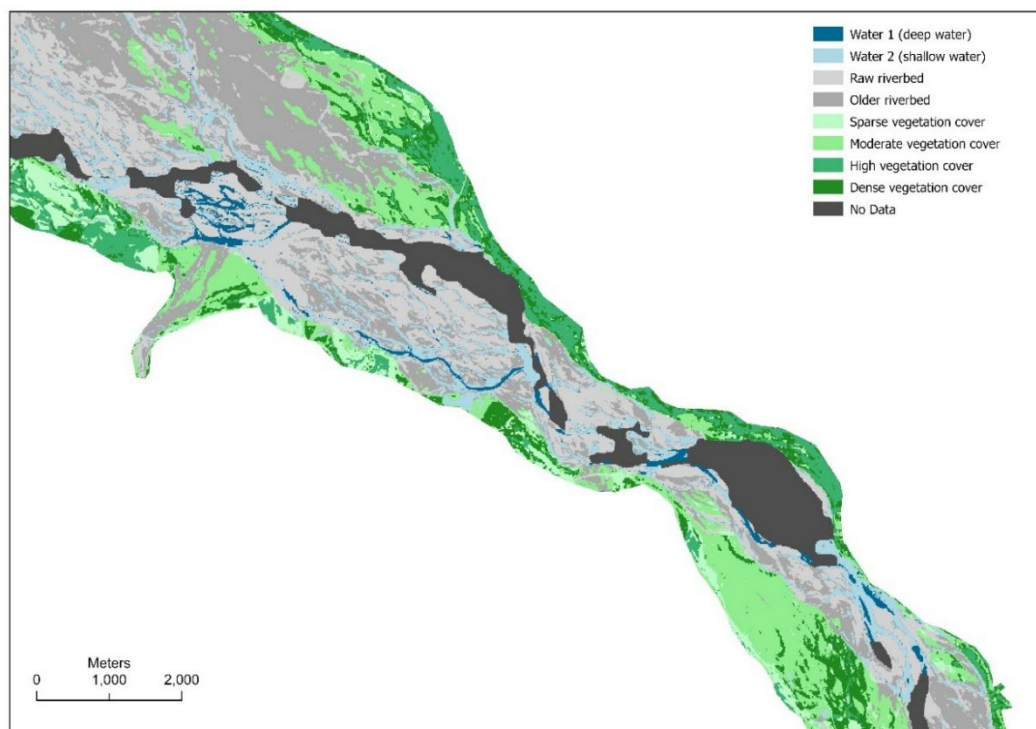
Figure 2-6: **A section of upper Rakaia River showing 2024 classification results. Areas of 'no data' shown in dark grey.**
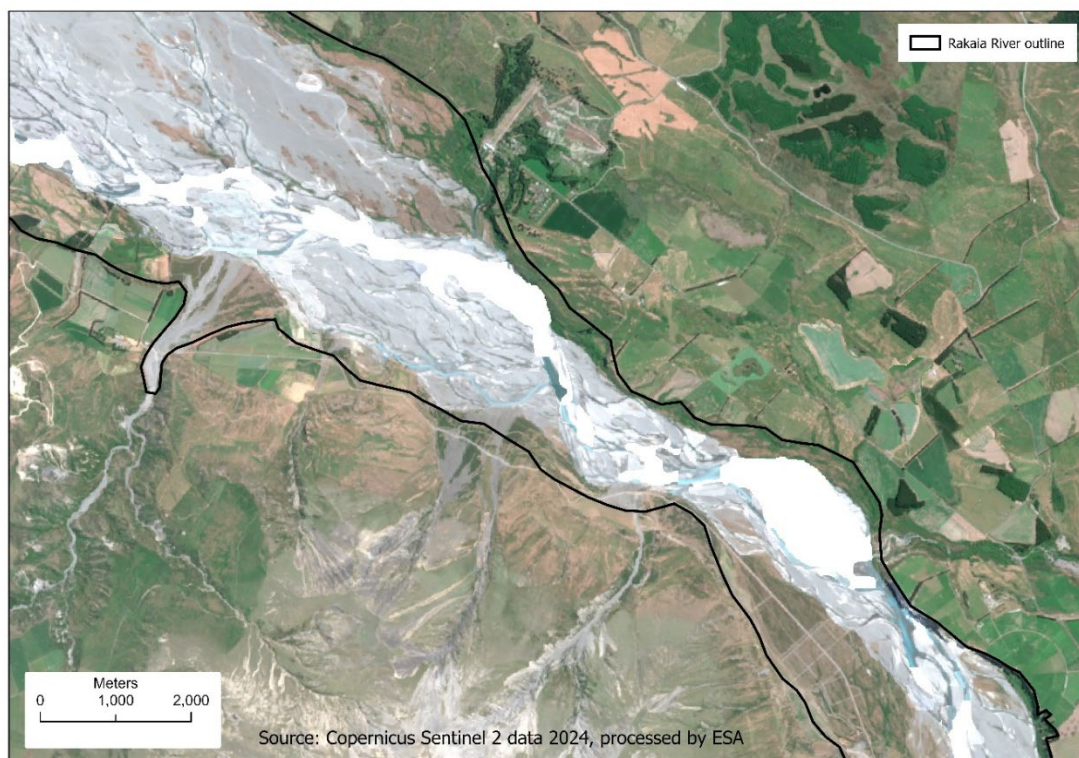
Figure 2-7: **2024 Sentinel-2 image of upper Rakaia River depicted in Figure 2-6, with 'no data' areas shown in white.**

3 Results

3.1 Regional classification

The cover classification results for each braided river study area in Waitaha is shown in Table 3-1. The change in total region-wide cover class area between 2012 and 2024 is presented in the matrix in Table 3-2. Regionally, the most extensive cover class was 'high vegetation cover' (51,720 ha) followed by 'moderate vegetation cover' (37,060 ha). 'Water 1 (deep water)' had the lowest area across all the rivers (3,590 ha). Appendix 4 presents the corresponding classification results from the 2012 assessment (Pompei et al., 2019).

Table 3-2 also includes the total areas of change from one specific cover class to another (e.g., 'raw riverbed' to 'sparse vegetation cover', and vice versa), and the total areas that remained the same. For example, the total region-wide 'no data' cover class area increased from 5,180 ha to 6,050 ha. 'Water 2 (shallow water)' increased from 15,560 ha to 17,570 ha between 2012 and 2024. In contrast, the area of 'water 1 (deep water)' decreased by 61 per cent from 9,160 ha to 3,590 ha.

The region-wide area of 'raw riverbed' increased substantially from 12,950 ha to 29,450 ha, the largest proportional increase of any cover class (127 per cent). This change included 11,120 ha of braided river area that was formerly classified as 'older riverbed' in 2012 (Table 3-2). Despite this shift in 'older river riverbed' areas to 'raw riverbed', total regional 'older riverbed' loss was compensated by new areas formed from those classified as 'raw riverbed' and 'sparse vegetation cover' in 2012. Overall, the region-wide area of 'older riverbed' decreased from 29,230 ha in 2012, to 26,410 ha in 2024.

An evaluation of the vegetation cover classes found that 'sparse vegetation cover' remained similar in total area between 2012 and 2024, only increasing from 25,730 ha to 26,150 ha. 'Moderate vegetation cover' nearly doubled in area increasing from 18,910 ha to 37,060 ha. This represented the largest area gained among all cover classes. 'High vegetation cover' reduced by 25 per cent in 2024. 'Dense vegetation cover' decreased by 30 per cent in area to 28,560 ha of the region-wide braided river cover class.

The changes across vegetation cover classes generally occurred due to shifts in one vegetation cover class type to another (i.e., change in vegetation successional stage, such as sparse to moderate vegetation cover; Table 3-2). For example, the greatest absolute change in cover class type (13,590 ha) came from areas previously mapped as 'high vegetation cover' in 2012, to 'sparse vegetation cover' in 2024. Large areas of 'dense vegetation cover' also changed to 'high vegetation cover' in 2024 (13,020 ha), and vice versa where areas of 'high vegetation cover' changed to 'dense vegetation cover' (10,290 ha). Overall, 56 per cent (20,680 ha) of 'moderate vegetation cover' in 2024 was previously identified as a different vegetation cover class in 2012. Only seven per cent of areas mapped as a vegetation class in 2012 changed to a non-vegetated class (excluding 'no data') in 2024.

In summary, the data shows some notable changes in cover classes between 2012 and 2024, with 'water 1 (deep water)' decreasing and 'raw riverbed' substantially increasing. Among the vegetation cover classes, 'moderate vegetation cover' experienced the most significant growth in region-wide area, while 'high' and 'dense vegetation cover' saw reductions. 'Sparse vegetation cover' remained relatively similar between the two time periods.

Table 3-1:   Cover classification results for each braided river study area in Waitaha for 2024.

	No data	Water 1 (deep water)	Water 2 (shallow water)	Raw riverbed	Older riverbed	Sparse vegetation cover	Moderate vegetation cover	High vegetation cover	Dense vegetation cover	Total
Ahuriri River	10	<10	330	540	80	3,820	1,410	2,610	850	9,630
Ashburton River (lower)/Hakatere	40	<10	270	500	410	330	470	3,010	360	5,400
Ashburton River (upper South Branch)/Hakatere	<10	0	50	120	170	300	370	130	210	1,350
Ashley River (lower)/Rakahuri	30	20	330	630	40	420	220	2,250	310	4,270
Ashley River (upper)/Rakahuri	10	0	160	30	50	50	240	410	220	1,170
Avoca River	<10	0	80	20	290	50	340	30	230	1,060
Bealey, Mingha, Edwards Rivers	<10	0	40	10	40	<10	90	40	60	290
Cameron River	0	0	10	30	150	90	180	30	140	620
Cass River	<10	<10	260	200	920	450	760	170	160	2,920
Clarence River (lower)/Waiau Toa	<10	30	170	220	190	180	340	280	300	1,720
Clarence River (upper)/Waiau Toa	1,190	0	800	360	250	450	660	410	330	4,460
Clyde River	<10	30	230	840	1,020	250	890	50	340	3,660
Conway River/Piri tutae-putaputa	<10	<10	120	50	140	110	240	560	170	1,380
Dobson River	<10	10	300	1,120	500	490	690	810	540	4,460
Edward Stream	<10	0	<10	130	<10	400	130	10	10	690
Esk River	<10	0	200	80	160	20	240	80	210	1,000
Eyre River	<10	0	<10	160	50	160	90	560	170	1,200
Fork Stream	<10	0	10	100	120	180	290	<10	30	740
Godley River	20	220	820	2,600	3,100	1,300	2,630	580	1,110	12,370
Hae Hae Te Moana River	<10	0	10	10	<10	100	40	640	50	850
Hakataramea River	<10	0	30	10	<10	2,080	140	680	270	3,220
Hapuku River	<10	0	130	<10	50	40	140	280	180	830
Harper River	<10	0	70	40	170	260	230	40	110	920
Havlock River	<10	10	160	920	680	180	560	70	240	2,830
Hawdon River	<10	0	20	20	100	10	130	60	190	520
Hinds River/Hekeao	<10	0	<10	20	<10	160	70	880	130	1,270
Hook River	<10	0	0	0	0	30	<10	170	10	210
Hopkins River/Te Awa Aruhe	180	20	600	1,650	340	900	610	1,950	530	6,770
Hurunui River (above Lake Sumner)	<10	0	100	30	80	20	190	710	160	1,290
Hurunui River (lower)	80	10	550	440	210	560	450	2,290	430	5,030
Hurunui River (upper and South Branch)	<10	0	190	20	120	50	370	370	420	1,550
Kahutara River	<10	0	10	10	80	80	160	440	240	1,030
Kowai River	<10	0	<10	10	<10	110	<10	240	30	390
Kowhai River	<10	0	20	<10	100	30	80	360	230	820
Makikihi River	<10	0	<10	<10	0	40	<10	50	20	120
Mathias River	<10	<10	320	360	1,480	470	990	420	1,600	5,650
Murchison River	0	80	30	310	140	430	400	50	50	1,480
Nell Stream	0	0	10	0	20	20	30	10	30	120
Ohau River (lower)	0	0	50	10	30	130	490	80	110	910
Ohau River (upper)	<10	<10	50	10	<10	30	80	10	10	190
Okuku River/Rakahuri	<10	0	20	10	10	30	50	100	40	260
Opihi River (above Opuha River gorge)	<10	0	<10	10	10	90	80	510	60	760
Opihi River (lower)	120	0	90	80	<10	260	70	870	100	1,600
Opuha River	<10	0	10	<10	<10	20	30	310	80	460
Orari River (lower)	<10	0	30	280	40	230	140	1,090	120	1,930
Orari River (upper)	<10	0	60	230	60	270	160	250	220	1,260
Otaio River	<10	0	0	10	<10	100	50	230	50	430
Pareora River (lower)	<10	0	10	10	<10	120	40	280	50	500
Pareora River (upper)	<10	0	<10	0	0	30	30	240	80	370
Poulter River	10	0	390	130	470	40	610	380	730	2,750
Pukaki River	<10	0	20	280	70	40	1,100	20	40	1,580
Rakaia River (lower)	1,230	1,010	690	2,710	1,170	810	1,080	4,780	2,930	16,410
Rakaia River (upper tributaries)	<10	90	160	340	530	390	740	180	760	3,200
Rakaia River (upper)	460	220	960	2,120	2,740	680	1,750	1,270	1,790	11,980
Rangitata River (lower)	330	150	470	1,070	160	440	360	2,120	810	5,900
Rangitata River (tributaries)	<10	0	30	250	520	230	930	90	290	2,340
Rangitata River (upper)	220	70	850	1,660	2,060	460	1,750	700	1,220	8,990
Ribbonwood Stream	0	0	0	<10	30	<10	20	<10	50	100
Selwyn River (lower)/Waikirikiri	<10	0	10	120	30	350	180	830	330	1,850
Selwyn (upper)/Waikirikiri	<10	0	20	<10	20	20	80	270	90	500
Smite River	0	0	<10	10	60	50	80	20	20	250
Swift River	0	0	20	<10	60	10	30	<10	40	160
Swin Stream	<10	0	0	70	10	60	170	10	70	390
Tasman River	330	610	450	2,260	1,270	1,350	2,010	250	740	9,260
Tekapo River	<10	20	180	510	80	1,270	2,790	560	340	5,760
Tengawai River	<10	0	10	<10	<10	110	90	590	120	920
Twizel River	0	0	<10	<10	0	60	70	200	110	440
Waiau River (lower)/Waiau Uwha	80	150	870	1,070	320	790	930	2,860	590	7,660
Waiau River (upper)/Waiau Uwha	90	<10	760	450	440	520	1,310	1,860	1,090	6,520
Waihao River	<10	0	10	10	0	90	30	230	50	420
Waimakariri River (above Bealey River bridge)	<10	0	150	240	480	70	410	160	570	2,090
Waimakariri River (lower)	420	710	1,090	1,980	750	540	770	2,670	1,360	10,290
Waimakariri River (upper)	40	10	820	820	810	50	1,270	180	590	4,610
Waipara River	<10	<10	30	40	10	230	90	440	80	910
Waitaki River	1,020	100	2,050	180	20	1,150	680	4,950	920	11,060
Wilberforce River/Waitawhiri	70	10	770	890	2,820	360	1,640	400	1,260	8,200
Total	6,050	3,590	17,570	29,450	26,410	26,150	37,060	51,720	28,560	226,570

Table 3-2: **Matrix of region-wide cover class change for all 76 rivers. The 'total' row (2024) and column (2012) show the region-wide area (ha) for each corresponding cover class for each assessment year. Within each row, numbers represent the areas of 2024 cover class (top row) formerly identified as a corresponding cover class in 2012 (left column). Shaded grey cells show the riverbed area for each cover class that have remained the same between 2012 and 2024. Dark purple cells are where cover class has changed in area by greater than 10,000 ha. Light purple cells are where cover class has changed in area by between 5,000 and 10,000 ha.**

	2024 Area (ha)									
2012 Area (ha)	No data	Water 1 (deep water)	Water 2 (shallow water)	Raw riverbed	Older riverbed	Sparse vegetation cover	Moderate vegetation cover	High vegetation cover	Dense vegetation cover	Total
No data	600	10	180	240	180	1,510	450	1,280	740	5,180
Water 1	620	710	3,230	2,050	1,190	360	650	210	140	9,160
Water 2	720	740	3,600	3,830	2,770	770	2,000	540	590	15,560
Raw riverbed	350	360	1,790	3,720	5,510	150	910	60	90	12,950
Older riverbed	1,470	1,120	3,520	11,120	8,560	670	2,210	210	340	29,230
Sparse vegetation cover	560	310	2,720	4,410	5,290	2,360	7,280	1,290	1,490	25,730
Moderate vegetation cover	190	70	420	1,270	1,010	3,400	10,160	930	1,460	18,910
High vegetation cover	910	120	700	1,280	710	13,590	7,190	34,180	10,290	68,970
Dense vegetation cover	620	150	1,400	1,520	1,190	3,340	6,210	13,020	13,420	40,870
Total	6,050	3,590	17,570	29,450	26,410	26,150	37,060	51,720	28,560	226,570

3.2　River-specific classifications

3.2.1　Overview

Examining changes in the regional dataset is complicated. This is because it is difficult to determine meaningful patterns of riverbed change at a broad scale given cover classes will be arranged over time according to smaller catchment and reach-scale influences (e.g., floods and river management activities). Analysing individual cover classes on a river reach-by-river reach basis is, therefore, more useful. Table 3-1 provides the total cover class size (in hectares) for each of the 76 river survey areas assessed in Waitaha. Rakaia River (lower) was the largest survey reach (16,410 ha) classified, followed by the Godley River (12,370 ha). Appendix 5 contains matrices of cover class type change between 2012 and 2024 for each individual river survey area.

The cover class data we have mapped can help us visually identify discrete areas of riverbed and margins that are different, or the same, in 2012 and 2024. An example is shown in Figure 3-1, which illustrates the survey reach at Waimakariri River (adjacent Bealey River bridge) and shows areas of riverbed that are the same cover class in 2024 and 2012. It can potentially allude to areas of more, or less, riverbed stability and/or disturbance, but is subject to requiring more frequent, repeated measures of cover class distributions over time. Appendix 6 provides more examples of how the geospatial maps can indicate cover class change between 2012 and 2024 for individual river survey areas.

The report sections below provide two case studies that briefly examine how cover class change can be explored at the river reach scale.
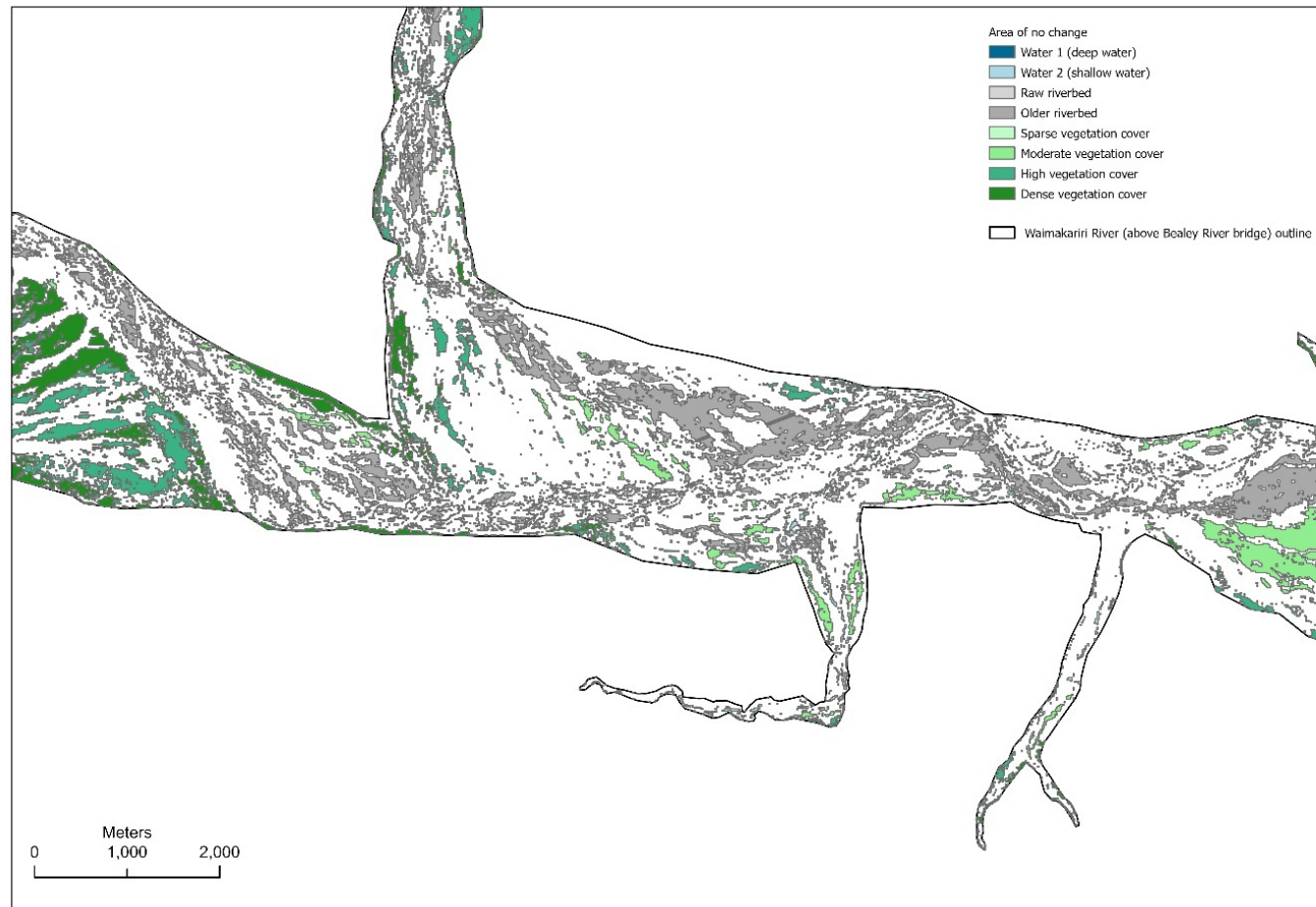
Figure 3-1: A section of Waimakariri River (above Bealey River bridge) showing areas that have remained the same in 2012 and 2024 (coloured areas). White areas have changed from one cover class to another over time.

3.2.2 Case study 1: Rakaia River

Riverbed cover classes in the Rakaia River catchment were analysed across numerous survey reaches as per Pompei et al. (2019). This included in the upper and lower reaches of the main branch, but also across its smaller and larger tributaries (e.g., Wilberforce River/Waitawhiri). The summary below provides a snapshot comparing two of these reach-specific datasets.

The upper Rakaia River had a 90 per cent increase in 'moderate vegetation cover' between 2012 and 2024 (Table 3-3). In contrast, 'high vegetation cover' almost halved, due primarily to a shift in riverbed areas to the dense vegetation and sparse vegetation cover classes. The total area of 'water 1 (deep water)' decreased by 520 ha, whereas 'water 2 (shallow water)' increased by 240 ha. Between 2012 and 2024, there were large areas (greater than 800 ha) 'raw riverbed' the changed to 'older riverbed', and vice versa. However, in total, 'raw riverbed' increased by only 18 per cent, while the area of 'older riverbed' remained relatively consistent. All other classes show only minor changes in total riverbed area.

Table 3-3: **Cover class change matrix for upper Rakaia River. Shaded grey cells show the riverbed area for each cover class that have remained the same between 2012 and 2024. Dark purple cells are where cover class has changed in area by greater than 800 ha. Light purple cells are where cover class has changed in area by between 300 and 800 ha.**

	2024 Area (ha)									
2012 Area (ha)	No data	Water 1 (deep water)	Water 2 (shallow water)	Raw riverbed	Older riverbed	Sparse vegetation cover	Moderate vegetation cover	High vegetation cover	Dense vegetation cover	Total
No data	<10	0	0	0	0	0	0	0	0	<10
Water 1	70	60	140	250	190	<10	20	<10	<10	740
Water 2	40	30	120	210	230	<10	60	10	30	720
Raw riverbed	60	40	230	500	850	<10	90	<10	10	1,790
Older riverbed	210	80	300	890	1,010	20	150	10	20	2,690
Sparse vegetation cover	20	10	70	120	250	20	270	20	50	820
Moderate vegetation cover	10	<10	20	70	90	140	500	50	50	920
High vegetation cover	10	<10	20	30	40	400	270	810	880	2,460
Dense vegetation cover	30	<10	50	50	90	110	390	360	750	1,830
Total	460	220	960	2,120	2,740	680	1,750	1,270	1,790	11,980

Analysing tributary datasets provides information on riverbed cover class changes that have occurred further upstream. When compared to changes in the higher order mainstem rivers, it may provide insight into catchment-scale patterns and drivers. In the Rakaia River tributaries survey area, 'water 1 (deep water)' and all vegetation cover classes (except 'high vegetation cover') increased modestly in area between 2012 and 2024 (Table 3-4). The most notable change overall was, however, a 77 per cent decline (610 ha) in 'high vegetation cover'.

Table 3-4: **Cover class change matrix for Rakaia River tributaries. Shaded grey cells show the riverbed area for each cover class that have remained the same between 2012 and 2024. Dark purple cells are where cover class has changed in area by greater than 200 ha. Light purple cells are where cover class has changed in area by between 100 ha and 200 ha.**

2012 Area (ha)	No data	Water 1 (deep water)	Water 2 (shallow water)	Raw riverbed	Older riverbed	Sparse vegetation cover	Moderate vegetation cover	High vegetation cover	Dense vegetation cover	Total
No data	<10	0	0	0	0	0	0	0	0	<10
Water 1	0	<10	10	10	10	0	<10	0	0	30
Water 2	0	20	30	50	50	0	10	0	<10	160
Raw riverbed	0	10	30	50	120	<10	20	0	0	230
Older riverbed	0	50	40	190	210	<10	50	<10	<10	540
Sparse vegetation cover	0	10	30	20	90	20	130	10	10	320
Moderate vegetation cover	0	<10	10	10	30	130	390	10	40	620
High vegetation cover	0	<10	<10	<10	10	220	70	140	340	790
Dense vegetation cover	0	<10	10	10	20	10	70	20	380	520
Total	<10	90	160	340	530	390	740	180	760	3,200

There are several consistent patterns when comparing cover class change in the upper Rakaia River and its tributaries. Notably, there was a substantial decrease in the areas of 'high vegetation cover' across both datasets. This is consistent with the region-wide pattern of change observed in 'high vegetation cover' (Table 3-2), albeit change was at a greater magnitude. Patterns of change in the 'raw riverbed' and 'moderate vegetation cover' cover classes were also consistent across the three datasets. Specifically, they each increased in area both regionally and in the upper Rakaia and tributary datasets.

3.2.3   Case study 2: Waitaki Catchment

In this case study, we briefly examine cover class information for survey reach examples in the Waitaki River catchment. On this occasion, however, the analysis explores different ways of examining changes in individual cover classes over time (Table 3-5 and Figure 3-2). These types of analyses can be used to provide a more holistic or complete assessment of cover class change in all the region's catchments using the reach-specific data in Appendix 5.

In 2012, the Hopkins River contained a total of 730 ha of 'sparse vegetation cover' (Table 3-5). Approximately 110 ha of this riverbed area remained unchanged as 'sparse vegetation cover' in 2024. In comparison, 270 ha reverted to 'raw riverbed' and 140 ha changed to 'moderate vegetation cover'. These were the largest changes to occur to the extent of sparse vegetation cover identified in 2012.

Table 3-5: **Cover class change matrix for sparse vegetation cover in the Hopkins River. Numbers represent the area of riverbed formerly classified as sparse vegetation in 2012 that is now covered by other cover class types in 2024 (adapted from Table A5.6).**

River	No data	Water 1 (deep water)	Water 2 (shallow water)	Raw riverbed	Older riverbed	Sparse vegetation cover	Moderate vegetation cover	High vegetation cover	Dense vegetation cover	2012 Sparse vegetation cover
					2024					
Hopkins River/Te Awa Aruhe	20	<10	50	270	70	110	140	40	30	730

The change in area of a specific cover class can also be represented by maps and explored using geospatial software. For example, Figure 3-2 illustrates a section of the Tasman River, and the area identified as 'older riverbed' in 2024. It shows that areas of 'older riverbed' were generally concentrated

on the true right of river's braid plain in 2024. These were formerly classed as clusters of 'sparse vegetation cover' or 'raw riverbed' in 2012. Some areas remained unchanged. The patterns of change in cover classes may be indicative of the flow patterns that have recently occurred in the river, or patterns in other drivers of change.
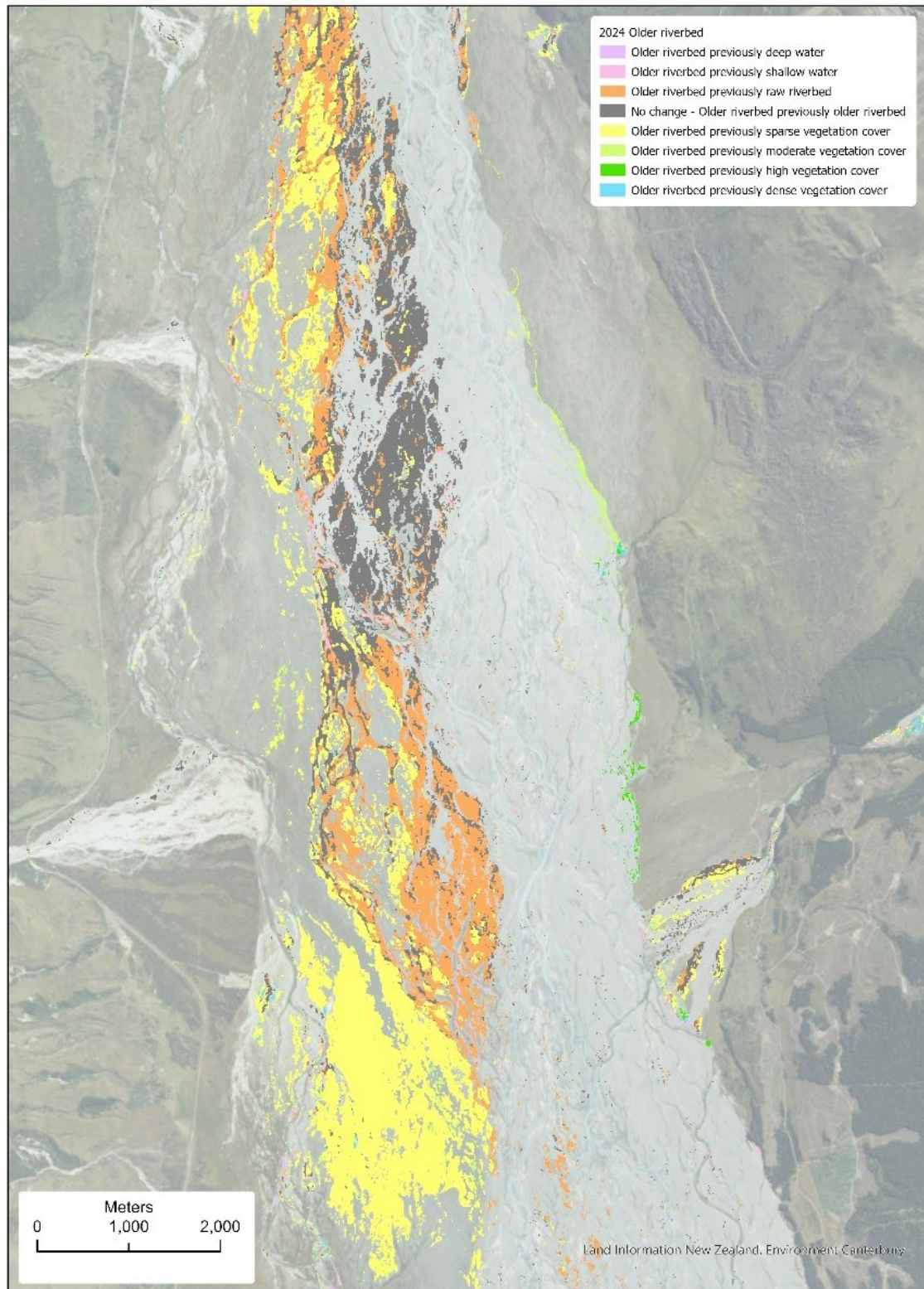
Figure 3-2: **A section of Tasman River displaying areas of 'older riverbed' in 2024 and the corresponding cover class they were classified as in 2012.**

4   Discussion

4.1   Change over time

We calculated river cover classes for 76 braided river areas across the Waitaha Region based on 2024 satellite imagery. This was compared to site-specific cover class information obtained in an analogous assessment based on 2012 imagery. The findings from the analysis can contribute to a broader understanding that may inform progress toward achieving the intended CWMS outcomes, or braided river management more generally.

In 2012, 86,820 ha of braided riverbed had moderate or lesser levels of vegetation cover and potentially supported bird nesting habitats. This increased to 119,070 ha in 2024. Likewise, potential bird feeding habitat increased from 111,540 ha to 140,230 ha. The dynamic nature of braided river systems is illustrated by the changes we observed between the riverbed and vegetation classes. In contrast, some cover class areas remained unchanged between 2012 and 2024; however, given the 12-year time interval in the dataset, there is the potential that some of these locations cycled through other classes in the interim (Hicks et al., 2007; Reinfelds & Nanson, 1993). This makes it difficult to conclude whether there are any trends occurring in bird habitat availability over time.

Areas of braid plain that are temporarily unaffected by erosional processes follow a successional trajectory of becoming more densely vegetated over time. This can be represented in the dataset by areas that have moved along the cover class continuum, specifically from highly disturbed 'raw riverbed' towards highly stable 'dense vegetation cover'. Conversely, areas that have moved in the opposite direction, from more densely vegetated cover classes to less vegetation cover or exposed gravels, are likely to be those that have experienced more recent disturbance through flood inundation and/or erosion.

The 2024 data indicates that 32,890 ha of riverbed and margins transitioned from an early successional state to a more stable, mature successional state since 2012. Conversely, 74,550 ha have changed from a mature state to early state. Hicks et al. (2003) notes that approximately two-thirds of the lower Waimakariri River bed undergoes significant vertical change (>0.2 m of erosion or deposition) annually. Based on this rate, Hicks et al. (2003) estimates that the entire available bed could be reworked within five years. In contrast, Reinfelds and Nanson (1993), using aerial photography and dendrochronology, proposed that the upper Waimakariri River reworks its entire bed approximately every 250 years. Thus, different reaches and different rivers have different rates or turnover and proportions of each successional stage in their mosaics.

Erosive processes from flooding are the primary driver of the character of the habitat mosaic in braided rivers. However, there are multiple anthropogenic effects that impact these rivers. These include flood management, land encroachment and productive land use, and invasive weeds. Stopbanks and other bankside defences (e.g., groynes and willow planting) encourage river flows to the centre of the engineered channel and inhibit the lateral migration of channels (Gray et al., 2017). Land encroachment can cumulatively add to this effect by further stabilising lateral areas of the river. Invasive woody weeds serve to bind up gravels and stabilise channels reducing lateral migration and eventually homogenising the habitat mosaic. In contrast, weed management and clearance opens up the riverbed and allows the river channels room to migrate across the braid plain. This, in turn, renews early successional terrestrial and freshwater habitats.

4.2   Future uses of the data

The degree of anthropogenic influence on braided river habitat mosaics will vary between rivers and their reaches. In the headwaters of many rivers there are limited constraints on river braiding, due to the relative paucity of invasive weeds and low demand for flood and erosion control. The habitat mosaic here may be expected to approximate a natural state. However, in the middle and lower reaches of many rivers (outside of designated flood and erosion control reaches) woody weeds are more prolific and may significantly constrain rivers if not managed. The character and turnover of the habitat mosaic will reflect the degree of weed invasion with commensurate effects on ecological values. Within flood and erosion control areas, fairways are typically kept clear, while dense berm vegetation is maintained.

The habitat mosaic is likely to consist of either open gravels or dense vegetation with intermediate successional stages relatively absent.

In each of these sections of river the turnover of habitat patches and mosaic character will be quite different, with ramifications for river values. Future studies applying the methods described in this report could consider the spatiotemporal patterns in the habitat mosaic across river reaches with similar or contrasting suites of anthropogenic pressures. These studies should address drivers and trajectories of change in the habitat mosaic, ramifications of change for the values it supports, and inform any management response.

Our high-resolution spatial datasets and methodology can show change between riverbed cover classes for an entire river or a smaller section within the river. The data can be used to monitor the encroachment of invasive plant species or the success of vegetation clearance in the riverbeds. The latter includes the Environment Canterbury Regional Biodiversity Team's weed control programs in the upper Rakaia River, Rangitata River, Waimakariri River, and Clarence River/Waiau Toa.

Braided rivers are habitat for over 80 indigenous bird species, including six threatened species (O'Donnell and Moore, 1983). Further inspection of the cover class data would help identify and monitor prime and high value habitat areas for birds. Prime habitats are island areas with older riverbed and sparse vegetation cover suitable for nesting, with appropriate ground cover and good feeding opportunities. These prime island habitats offer nesting birds some protection from predators and flooding. High value habitats include raw riverbed, older riverbed, and sparse vegetation cover within ten meters of water.

River managers can also potentially use the cover class data for flood protection infrastructure assessments. River berm width and density are critical for flood protection infrastructure. The data can supplement aerial images already used to assess conditions to allow for early detection and red flags, identifying sparse or fractured areas within the berm or narrow areas needing work.

We recommend consideration is given to repeating this cover class analysis using later rounds of satellite imagery at more frequent intervals that reflect the successional processes of the vegetation present and periodicity of large erosive events. For example, invasive weeds such as gorse, broom and lupin rapidly colonise areas of bare riverbed and may result in a shift between cover classes in as little as three years. We also recommend more focussed analyses of the dataset as further iterations accrue. These should investigate specific topics related to drivers and trajectories of change in the habitat mosaic, and any ramifications of change on river values. In particular comparing cover class change to hydrological, ecological and river management information will provide valuable insights into the spatiotemporal processes that regulate the form and function of Waitaha braided rivers.

4.3   Assumptions and limitations

We used Sentinel-2 imagery captured during the summer of 2023/24. While most of the Waitaha data was captured on a single date, imagery for some river areas consisted of those collected from multiple dates. For example, Figure 4-1 illustrates a section of the lower Waimakariri River and highlights the concentration of different Sentinel-2 images used to capture the riverbed and surrounding area. The range of image capture dates in the river area led to inconsistencies with the 'water 1 (deep water)' and 'water 2 (shallow water)' cover classes. Specifically, it was possible to see deep water occurring in one image and then shallow water in the directly adjacent image due to the change in flows which occurred in between the capture dates. This is worth bearing in mind when examining and interpreting the water classes in the dataset.
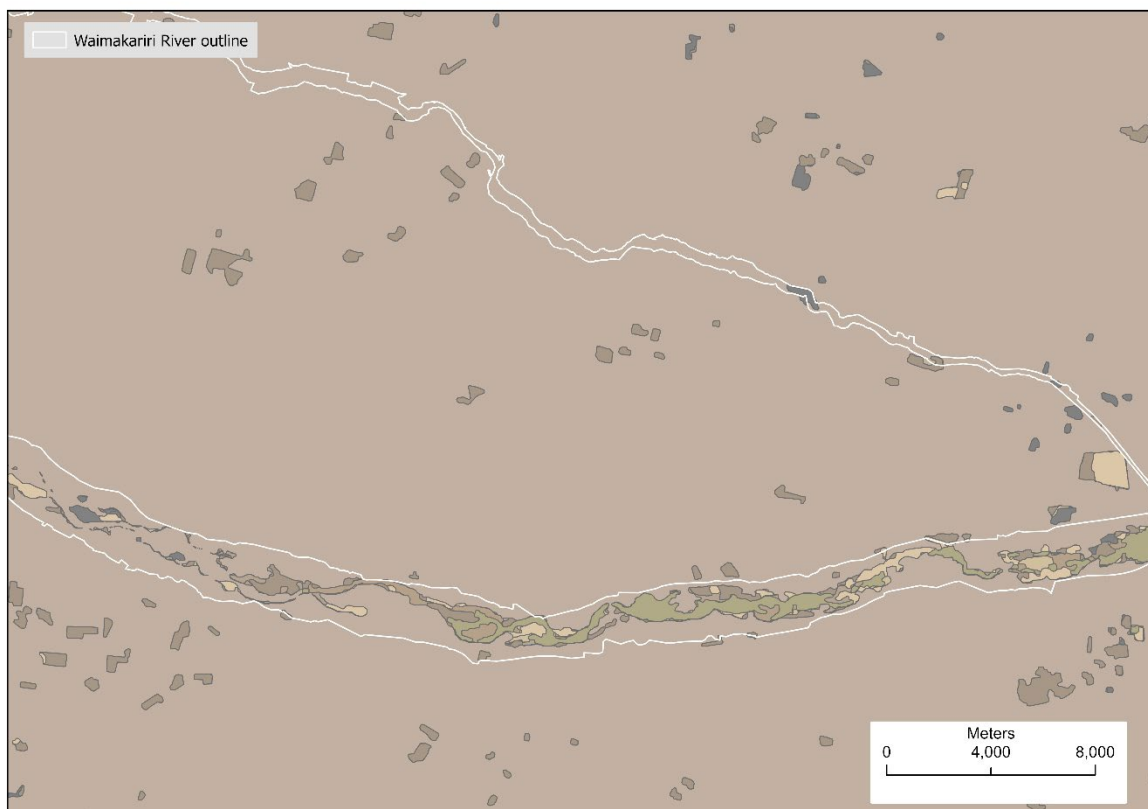
Figure 4-1:   **A section of the lower Waimakariri River, and surrounding area, showing concentration of Sentinel-2 images used to capture the riverbed. Different colour shades represent images captured on one of 70 different days between October 2023 to April 2024.**

Another limitation of the dataset is that in some areas, agricultural land use occurs within the defined river boundaries used during the analysis (i.e., O'Donnell (2000). Land management practices can create bare land or vigorous growth, depending on the growth stage of the pasture or crop. These productive land areas can produce contrasting results between the study years, even though both the 2012 and 2024 images are captured in the same growing season. The areas tend to be small relative to that of the functional riverbed; however, their presence can distort resultant datasets and do not represent the influence of riverine processes. Depending on the purpose of future investigations, it is possible to clip data polygons to an adjusted river boundary to omit areas of production land uses.

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6 Acknowledgements

Appendix 1: Riverbed ground cover classification photo examples captured in 2024

Figure A1-1: Example of raw riverbed class – vertical view.

Figure A1-2: Example of raw riverbed class – oblique view.

Figure A1-3: Example of older riverbed class – vertical view, note the abundance of larger, smooth, river gravels in contrast to the raw riverbed class.

Figure A1-4: Example of older riverbed class – oblique view.

Figure A1-5: Example of sparse vegetation cover - vertical view.

Figure A1-6: Example of sparse vegetation cover - oblique view.

Figure A1-7: Example of moderate vegetation cover - vertical view.

Figure A1-8: Example of moderate vegetation cover - oblique view.

Figure A1-9: Example of high vegetation cover - vertical view.

Figure A1-10:   Example of high vegetation cover - oblique view.

Figure A1-11:   Example of dense vegetation cover - vertical view.

Figure A1-12:   Example of dense vegetation cover - oblique view.

Appendix 2: Riverbed ground cover classification photo examples captured in 2013

Figure A2-1: Example of raw riverbed class – vertical view.

Figure A2-2: Example of older riverbed class – vertical view, note the abundance of larger, smooth, river gravel in contrast to the raw riverbed class.

Figure A2-3: Example of sparse vegetation cover - vertical view.

Figure A2-4: Example of moderate vegetation cover - vertical view.

Figure A2-5: Example of high vegetation cover - vertical view.

Figure A2-6: Example of dense vegetation cover - vertical view.

Appendix 3: 'No data' class by river area, 2012 and 2024

Table A3-1: **'No data' class as area and percentage of total river area for all rivers for 2012 and 2024.**

River name	2012			2024		
	No data (ha)	Total (ha)	% No data	No data (ha)	Total (ha)	% No data
Ahuriri River	2,900	9,630	30	10	9,630	0
Ashburton River (lower)/Hakatere	10	5,400	0	40	5,400	1
Ashburton River (upper South Branch)/Hakatere	0	1,350	0	<10	1,350	0
Ashley River (lower)/Rakahuri	20	4,270	0	30	4,270	1
Ashley River (upper)/Rakahuri	0	1,170	0	10	1,170	1
Avoca River	<10	1,060	0	<10	1,060	0
Bealey, Mingha, Edwards Rivers	<10	290	0	<10	290	0
Cameron River	0	620	0	0	620	0
Cass River	190	2,920	7	<10	2,920	0
Clarence River (lower)/Waiau Toa	0	1,720	0	<10	1,720	0
Clarence River (upper)/Waiau Toa	410	4,460	9	1,190	4,460	27
Clyde River	<10	3,660	0	<10	3,660	0
Conway River/Piri tutae-putaputa	0	1,380	0	<10	1,380	0
Dobson River	130	4,460	3	<10	4,460	0
Edward Stream	0	690	0	<10	690	0
Esk River	<10	1,000	0	<10	1,000	0
Eyre River	<10	1,200	0	<10	1,200	0
Fork Stream	120	740	16	<10	740	0
Godley River	<10	12,370	0	20	12,370	0
Hae Hae Te Moana River	<10	850	0	<10	850	0
Hakataramea River	640	3,220	20	<10	3,220	0
Hapuku River	0	830	0	<10	830	0
Harper River	<10	920	0	<10	920	0
Havlock River	<10	2,830	0	<10	2,830	0
Hawdon River	<10	520	0	<10	520	0
Hinds River/Hekeao	0	1,270	0	<10	1,270	0
Hook River	0	210	0	<10	210	0
Hopkins River/Te Awa Aruhe	230	6,770	3	180	6,770	3
Hurunui River (above Lake Sumner)	0	1,290	0	<10	1,290	0
Hurunui River (lower)	<10	5,030	0	80	5,030	2
Hurunui River (upper and South Branch)	0	1,550	0	<10	1,550	0
Kahutara River	0	1,030	0	<10	1,030	0
Kowai River	0	390	0	<10	390	0
Kowhai River	0	820	0	<10	820	0
Makikihi River	0	120	0	<10	120	1
Mathias River	<10	5,650	0	<10	5,650	0
Murchison River	0	1,480	0	0	1,480	0
Nell Stream	0	120	0	0	120	0
Ohau River (lower)	0	910	0	0	910	0
Ohau River (upper)	0	190	0	<10	190	0
Okuku River/Rakahuri	0	260	0	<10	260	1
Opihi River (above Opuha River gorge)	10	760	1	<10	760	0
Opihi River (lower)	<10	1,600	0	120	1,600	7
Opuha River	0	460	0	<10	460	0
Orari River (lower)	0	1,930	0	<10	1,930	0
Orari River (upper)	10	1,260	1	<10	1,260	0
Otaio River	0	430	0	<10	430	0
Pareora River (lower)	30	500	5	<10	500	0
Pareora River (upper)	0	370	0	<10	370	0
Poulter River	<10	2,750	0	10	2,750	0
Pukaki River	10	1,580	1	<10	1,580	0
Rakaia River (lower)	0	16,410	0	1,230	16,410	8
Rakaia River (upper tributaries)	<10	3,200	0	<10	3,200	0
Rakaia River (upper)	<10	11,980	0	460	11,980	4
Rangitata River (lower)	0	5,900	0	330	5,900	6
Rangitata River (tributaries)	<10	2,340	0	<10	2,340	0
Rangitata River (upper)	10	8,990	0	220	8,990	2
Ribbonwood Stream	0	100	0	0	100	0
Selwyn River (lower)/Waikirikiri	<10	1,850	0	<10	1,850	0
Selwyn (upper)/Waikirikiri	<10	500	0	<10	500	0
Smite River	0	250	0	0	250	0
Swift River	0	160	0	0	160	0
Swin Stream	0	390	0	<10	390	0
Tasman River	10	9,260	0	330	9,260	4
Tekapo River	<10	5,760	0	<10	5,760	0
Tengawai River	80	920	9	<10	920	0
Twizel River	0	440	0	0	440	0
Waiau River (lower)/Waiau Uwha	<10	7,660	0	80	7,660	1
Waiau River (upper)/Waiau Uwha	10	6,520	0	90	6,520	1
Waihao River	0	420	0	<10	420	0
Waimakariri River (above Bealey River bridge)	<10	2,090	0	<10	2,090	0
Waimakariri River (lower)	<10	10,290	0	420	10,290	4
Waimakariri River (upper)	0	4,610	0	40	4,610	1
Waipara River	0	910	0	<10	910	0
Waitaki River	300	11,060	3	1,020	11,060	9
Wilberforce River/Waitawhiri	10	8,200	0	70	8,200	1
Total	5,180	226,570	2	6,050	226,570	3

Appendix 4: Classification results for 2012

Table A2-1: Riverbed cover class classification results for 2012 (adapted from Pompei et al., 2019).

River name	No data	Water 1 (deep water)	Water 2 (shallow water)	Raw riverbed	Older riverbed	Sparse vegetation cover	Moderate vegetation cover	High vegetation cover	Dense vegetation cover	Total
Ahuriri River	2,900	140	140	20	60	550	1,030	4,290	500	9,630
Ashburton River (lower)/Hakatere	10	60	270	20	80	830	120	2,410	1,600	5,400
Ashburton River (upper South Branch)/Hakatere	0	0	20	30	120	190	210	600	180	1,350
Ashley River (lower)/Rakahuri	20	190	260	10	40	480	40	2,310	920	4,270
Ashley River (upper)/Rakahuri	0	30	80	10	10	170	10	600	260	1,170
Avoca River	<10	10	60	90	120	180	120	260	210	1,060
Bealey, Mingha, Edwards Rivers	<10	10	40	<10	90	40	20	40	60	290
Cameron River	0	0	10	10	80	80	50	320	90	620
Cass River	190	60	230	430	210	550	380	690	180	2,920
Clarence River (lower)/Waiau Toa	0	10	420	160	220	290	110	240	280	1,720
Clarence River (upper)/Waiau Toa	410	370	960	60	510	560	200	270	1,110	4,460
Clyde River	<10	10	180	100	1,730	400	390	570	280	3,660
Conway River/Piri tutae-putaputa	0	40	170	40	10	320	20	200	600	1,380
Dobson River	130	160	330	580	500	470	200	1,290	810	4,460
Edward Stream	0	<10	<10	0	10	60	170	420	30	690
Esk River	<10	30	90	20	170	220	70	230	160	1,000
Eyre River	<10	0	10	0	0	110	10	600	470	1,200
Fork Stream	120	0	<10	20	80	140	40	270	60	740
Godley River	<10	390	1,010	1,690	2,490	2,120	1,350	2,390	930	12,370
Hae Hae Te Moana River	<10	<10	10	0	<10	40	20	580	200	850
Hakataramea River	640	10	30	0	<10	60	60	2,060	340	3,220
Hapuku River	0	30	300	<10	<10	30	<10	70	400	830
Harper River	<10	10	30	40	120	120	230	300	70	920
Havlock River	<10	<10	110	110	1,450	300	300	330	210	2,830
Hawdon River	<10	<10	20	10	110	60	110	140	60	520
Hinds River/Hekeao	0	<10	10	0	<10	30	70	730	440	1,270
Hook River	0	<10	<10	0	0	<10	<10	70	130	210
Hopkins River/Te Awa Aruhe	230	510	430	310	1,090	730	270	2,130	1,080	6,770
Hurunui River (above Lake Sumner)	0	60	80	20	40	160	20	680	230	1,290
Hurunui River (lower)	<10	300	340	30	80	890	90	2,020	1,300	5,030
Hurunui River (upper and South Branch)	0	80	160	20	30	260	50	450	510	1,550
Kahutara River	0	<10	80	20	<10	210	<10	180	530	1,030
Kowai River	0	<10	<10	0	<10	30	<10	270	80	390
Kowhai River	0	<10	70	10	0	60	<10	90	590	820
Makikihi River	0	<10	<10	0	<10	10	<10	30	70	120
Mathias River	<10	60	250	1,200	390	510	280	1,640	1,320	5,650
Murchison River	0	40	60	50	290	320	430	220	70	1,480
Nell Stream	0	0	<10	10	<10	30	10	50	30	120
Ohau River (lower)	0	40	30	0	0	140	320	170	200	910
Ohau River (upper)	0	30	20	<10	<10	30	50	20	40	190
Okuku River/Rakahuri	0	10	30	0	0	20	10	130	70	260
Opihi River (above Opuha River gorge)	10	0	10	0	<10	100	20	510	100	760
Opihi River (lower)	<10	100	70	<10	30	100	100	910	280	1,600
Opuha River	0	<10	20	0	0	30	20	280	110	460
Orari River (lower)	0	10	30	<10	50	230	120	810	660	1,930
Orari River (upper)	10	<10	20	10	70	230	130	620	170	1,260
Otaio River	0	0	10	<10	<10	20	<10	220	180	430
Pareora River (lower)	30	30	30	<10	0	20	10	230	170	500
Pareora River (upper)	0	<10	<10	0	0	10	<10	270	80	370
Poulter River	<10	140	230	140	340	450	180	680	580	2,750
Pukaki River	10	<10	<10	10	280	150	910	110	110	1,580
Rakaia River (lower)	0	960	1,270	550	3,520	860	350	5,650	3,260	16,410
Rakaia River (upper tributaries)	<10	30	160	230	540	320	620	790	520	3,200
Rakaia River (upper)	<10	740	720	1,790	2,690	820	920	2,460	1,830	11,980
Rangitata River (lower)	0	300	250	80	980	600	240	1,350	2,110	5,900
Rangitata River (tributaries)	<10	0	20	60	360	350	500	840	230	2,340
Rangitata River (upper)	10	420	610	550	2,490	870	1,120	2,490	440	8,990
Ribbonwood Stream	0	0	<10	<10	20	10	<10	10	50	100
Selwyn River (lower)/Waikirikiri	<10	<10	30	<10	<10	130	20	1,310	360	1,850
Selwyn (upper)/Waikirikiri	<10	<10	10	0	0	40	10	260	180	500
Smite River	0	0	0	<10	10	50	70	100	20	250
Swift River	0	<10	10	<10	20	40	40	20	20	160
Swin Stream	0	0	0	0	40	50	60	210	30	390
Tasman River	10	480	880	1,110	1,530	1,460	1,550	1,690	570	9,260
Tekapo River	<10	80	120	30	160	400	2,040	2,370	570	5,760
Tengawai River	80	<10	20	0	<10	40	10	610	150	920
Twizel River	0	<10	10	0	<10	30	20	200	180	440
Waiau River (lower)/Waiau Uwha	<10	430	630	130	630	1,400	230	2,770	1,440	7,660
Waiau River (upper)/Waiau Uwha	10	330	720	120	310	880	170	1,600	2,360	6,520
Waihao River	0	30	20	0	<10	20	<10	180	170	420
Waimakariri River (above Bealey River bridge)	<10	30	80	110	500	340	220	420	380	2,090
Waimakariri River (lower)	<10	330	1,260	320	2,210	1,240	310	2,390	2,230	10,290
Waimakariri River (upper)	<10	430	300	200	1,560	550	570	400	600	4,610
Waipara River	0	10	40	<10	10	140	20	530	180	910
Waitaki River	300	1,300	940	40	160	920	320	4,460	2,620	11,060
Wilberforce River/Waitawhiri	10	290	670	2,320	590	1,010	1,150	900	1,260	8,200
Total	5,180	9,160	15,560	12,950	29,230	25,730	18,910	68,970	40,870	226,570

Appendix 5: Cover class matrices for 2024 and 2012

Table A5-1: Cover class change matrix for 'no data' cover class for all rivers for 2024 and 2012.

					Area (ha)					
					2024					2012
River name	No data	Water 1 (deep water)	Water 2 (shallow water)	Raw riverbed	Older riverbed	Sparse vegetation cover	Moderate vegetation cover	High vegetation cover	Dense vegetation cover	No data
Ahuriri River	<10	0	100	130	40	860	220	960	590	2,900
Ashburton River (lower)/Hakatere	10	0	0	0	0	0	0	0	0	10
Ashburton River (upper South Branch)/Hakatere	0	0	0	0	0	0	0	0	0	0
Ashley River (lower)/Rakahuri	0	0	0	<10	0	<10	0	10	<10	20
Ashley River (upper)/Rakahuri	0	0	0	0	0	0	0	0	0	0
Avoca River	<10	0	0	0	0	0	0	0	0	<10
Bealey, Mingha, Edwards Rivers	<10	0	0	0	0	0	0	0	0	<10
Cameron River	0	0	0	0	0	0	0	0	0	0
Cass River	0	0	10	<10	50	20	70	<10	20	190
Clarence River (lower)/Waiau Toa	0	0	0	0	0	0	0	0	0	0
Clarence River (upper)/Waiau Toa	410	0	0	0	0	0	0	0	0	410
Clyde River	<10	0	0	0	0	0	0	0	0	<10
Conway River/Piri tutae-putaputa	0	0	0	0	0	0	0	0	0	0
Dobson River	0	0	10	40	30	10	20	10	10	130
Edward Stream	0	0	0	0	0	0	0	0	0	0
Esk River	<10	0	0	0	0	0	0	0	0	<10
Eyre River	0	0	0	0	0	0	0	0	0	<10
Fork Stream	0	0	<10	20	20	40	40	0	<10	120
Godley River	<10	0	0	0	0	0	<10	0	0	<10
Hae Hae Te Moana River	<10	0	0	0	0	0	0	0	0	<10
Hakataramea River	<10	0	<10	<10	0	510	20	70	40	640
Hapuku River	0	0	0	0	0	0	0	0	0	0
Harper River	<10	0	0	0	0	0	0	0	0	<10
Havlock River	<10	0	0	0	0	0	0	0	0	<10
Hawdon River	<10	0	0	0	0	0	0	0	0	<10
Hinds River/Hekeao	0	0	0	0	0	0	0	0	0	0
Hook River	0	0	0	0	0	0	0	0	0	0
Hopkins River/Te Awa Aruhe	<10	0	20	30	30	20	40	60	30	230
Hurunui River (above Lake Sumner)	0	0	0	0	0	0	0	0	0	0
Hurunui River (lower)	0	0	0	0	0	0	0	0	0	<10
Hurunui River (upper and South Branch)	0	0	0	0	0	0	0	0	0	0
Kahutara River	0	0	0	0	0	0	0	0	0	0
Kowai River	0	0	0	0	0	0	0	0	0	0
Kowhai River	0	0	0	0	0	0	0	0	0	0
Makikihi River	0	0	0	0	0	0	0	0	0	0
Mathias River	<10	0	0	0	0	0	0	0	0	<10
Murchison River	0	0	0	0	0	0	0	0	0	0
Nell Stream	0	0	0	0	0	0	0	0	0	0
Ohau River (lower)	0	0	0	0	0	0	0	0	0	0
Ohau River (upper)	0	0	0	0	0	0	0	0	0	0
Okuku River/Rakahuri	0	0	0	0	0	0	0	0	0	0
Opihi River (above Opuha River gorge)	0	0	0	0	0	<10	<10	<10	<10	10
Opihi River (lower)	<10	0	0	0	0	<10	0	<10	0	<10
Opuha River	0	0	0	0	0	0	0	0	0	0
Orari River (lower)	0	0	0	0	0	0	0	0	0	0
Orari River (upper)	0	0	<10	<10	<10	<10	<10	<10	<10	10
Otaio River	0	0	0	0	0	0	0	0	0	0
Pareora River (lower)	0	0	0	0	0	10	<10	10	<10	30
Pareora River (upper)	0	0	0	0	0	0	0	0	0	0
Poulter River	0	0	0	0	0	0	0	0	0	<10
Pukaki River	<10	0	0	<10	<10	0	<10	0	0	10
Rakaia River (lower)	0	0	0	0	0	0	0	0	0	0
Rakaia River (upper tributaries)	<10	0	0	0	0	0	0	0	0	<10
Rakaia River (upper)	<10	0	0	0	0	0	0	0	0	<10
Rangitata River (lower)	0	0	0	0	0	0	0	0	0	0
Rangitata River (tributaries)	<10	0	0	0	0	0	0	0	0	<10
Rangitata River (upper)	<10	0	0	0	0	<10	0	<10	0	10
Ribbonwood Stream	0	0	0	0	0	0	0	0	0	0
Selwyn River (lower)/Waikirikiri	0	0	0	0	0	0	0	0	0	<10
Selwyn (upper)/Waikirikiri	0	0	0	0	0	0	0	0	0	<10
Smite River	0	0	0	0	0	0	0	0	0	0
Swift River	0	0	0	0	0	0	0	0	0	0
Swin Stream	0	0	0	0	0	0	0	0	0	0
Tasman River	0	0	0	<10	0	<10	<10	<10	<10	10
Tekapo River	<10	0	0	0	0	0	0	0	0	<10
Tengawai River	<10	0	<10	0	0	10	20	40	20	80
Twizel River	0	0	0	0	0	0	0	0	0	0
Waiau River (lower)/Waiau Uwha	<10	0	0	0	0	0	0	0	0	<10
Waiau River (upper)/Waiau Uwha	<10	0	<10	0	<10	<10	<10	<10	<10	10
Waihao River	0	0	0	0	0	0	0	0	0	0
Waimakariri River (above Bealey River bridge)	<10	0	0	0	0	0	0	0	0	<10
Waimakariri River (lower)	0	0	0	0	0	0	0	<10	0	<10
Waimakariri River (upper)	<10	0	0	0	0	0	0	0	0	<10
Waipara River	0	0	0	0	0	0	0	0	0	0
Waitaki River	120	10	40	10	0	20	10	90	10	300
Wilberforce River/Waitawhiri	10	0	0	0	0	0	0	<10	0	10

Table A5-2: Cover class change matrix for 'water 1 (deep water)' class for all rivers for 2024 and 2012.

River name	No data	Water 1 (deep water)	Water 2 (shallow water)	Raw riverbed	Older riverbed	Sparse vegetation cover	Moderate vegetation cover	High vegetation cover	Dense vegetation cover	2012 Water 1 (deep water)
Ahuriri River	0	0	60	40	<10	20	10	10	<10	140
Ashburton River (lower)/Hakatere	<10	0	10	20	10	<10	10	<10	<10	60
Ashburton River (upper South Branch)/Hakatere	0	0	0	0	0	0	0	0	0	0
Ashley River (lower)/Rakahuri	<10	10	90	60	<10	10	10	<10	<10	190
Ashley River (upper)/Rakahuri	0	0	20	<10	<10	0	10	0	<10	30
Avoca River	0	0	0	<10	0	<10	<10	0	0	10
Bealey, Mingha, Edwards Rivers	0	0	0	0	<10	0	<10	0	0	10
Cameron River	0	0	0	0	0	0	0	0	0	0
Cass River	0	<10	20	10	30	0	<10	<10	0	60
Clarence River (lower)/Waiau Toa	0	<10	<10	<10	<10	<10	<10	0	<10	10
Clarence River (upper)/Waiau Toa	160	0	150	20	10	<10	30	<10	<10	370
Clyde River	0	0	0	0	0	0	0	0	0	10
Conway River/Piri tutae-putaputa	0	<10	10	<10	<10	<10	10	<10	<10	40
Dobson River	0	<10	40	60	30	10	10	<10	<10	160
Edward Stream	0	0	<10	0	0	0	<10	0	0	<10
Esk River	0	0	10	0	10	0	0	0	0	30
Eyre River	0	0	0	0	0	0	0	0	0	0
Fork Stream	0	0	0	0	0	0	0	0	0	0
Godley River	0	20	80	160	110	<10	10	<10	<10	390
Hae Hae Te Moana River	0	0	<10	0	0	<10	<10	<10	0	<10
Hakataramea River	0	0	<10	0	0	10	<10	<10	<10	10
Hapuku River	0	0	10	0	0	0	10	0	0	30
Harper River	0	0	<10	<10	10	0	<10	0	0	10
Havlock River	0	0	0	<10	<10	0	<10	0	0	<10
Hawdon River	0	0	0	0	0	<10	0	0	<10	0
Hinds River/Hekeao	0	0	0	0	0	0	0	0	0	<10
Hook River	0	0	0	0	0	0	0	0	0	<10
Hopkins River/Te Awa Aruhe	20	10	220	200	30	10	20	<10	<10	510
Hurunui River (above Lake Sumner)	0	0	30	<10	10	0	10	0	<10	60
Hurunui River (lower)	10	<10	120	70	20	20	30	10	<10	300
Hurunui River (upper and South Branch)	0	0	50	<10	<10	0	20	0	<10	80
Kahutara River	0	0	<10	0	0	0	<10	0	<10	<10
Kowai River	0	0	0	0	<10	<10	0	0	0	<10
Kowhai River	0	0	<10	0	0	0	<10	0	0	<10
Makikihi River	0	0	0	0	0	0	0	0	0	<10
Mathias River	0	0	20	10	30	0	10	0	0	60
Murchison River	0	10	0	20	<10	0	<10	0	0	40
Nell Stream	0	0	0	0	0	0	0	0	0	0
Ohau River (lower)	0	0	30	0	0	<10	10	<10	<10	40
Ohau River (upper)	0	<10	30	0	0	0	<10	0	0	30
Okuku River/Rakahuri	0	0	<10	0	0	0	<10	0	0	10
Opihi River (above Opuha River gorge)	0	0	0	0	0	0	0	0	0	0
Opihi River (lower)	10	0	40	10	0	20	10	10	<10	100
Opuha River	0	0	0	0	0	0	<10	0	0	<10
Orari River (lower)	0	0	<10	<10	0	<10	<10	0	0	10
Orari River (upper)	0	0	<10	0	0	0	<10	0	0	<10
Otaio River	0	0	0	0	0	0	0	0	0	0
Pareora River (lower)	0	0	<10	<10	0	10	<10	<10	<10	30
Pareora River (upper)	0	0	0	0	0	0	0	0	0	<10
Poulter River	<10	0	70	20	40	0	10	0	0	140
Pukaki River	0	0	<10	<10	0	0	0	0	0	<10
Rakaia River (lower)	170	160	100	280	150	20	50	10	20	960
Rakaia River (upper tributaries)	0	<10	10	10	10	0	<10	0	0	30
Rakaia River (upper)	70	60	140	250	190	<10	20	<10	<10	740
Rangitata River (lower)	20	30	70	110	20	20	20	<10	<10	300
Rangitata River (tributaries)	0	0	0	0	0	0	0	0	0	0
Rangitata River (upper)	20	20	120	120	120	<10	10	0	<10	420
Ribbonwood Stream	0	0	0	0	0	0	0	0	0	0
Selwyn River (lower)/Waikirikiri	0	0	0	<10	0	0	0	0	0	<10
Selwyn (upper)/Waikirikiri	0	0	0	0	0	0	0	0	0	<10
Smite River	0	0	0	0	0	0	0	0	0	0
Swift River	0	0	0	0	0	0	0	0	0	<10
Swin Stream	0	0	0	0	0	0	0	0	0	0
Tasman River	20	250	90	90	10	<10	10	0	<10	480
Tekapo River	0	<10	30	20	<10	10	10	0	<10	80
Tengawai River	0	0	0	0	0	0	<10	<10	0	<10
Twizel River	0	0	0	0	0	0	0	<10	<10	0
Waiau River (lower)/Waiau Uwha	10	20	190	130	30	20	30	10	<10	430
Waiau River (upper)/Waiau Uwha	10	0	160	50	30	10	60	<10	10	330
Waihao River	0	0	<10	<10	0	10	<10	10	<10	30
Waimakariri River (above Bealey River bridge)	0	0	10	10	10	0	<10	0	<10	30
Waimakariri River (lower)	20	50	100	80	50	10	20	<10	<10	330
Waimakariri River (upper)	<10	<10	250	80	60	10	30	<10	<10	430
Waipara River	0	0	<10	<10	<10	<10	<10	<10	0	10
Waitaki River	70	30	750	50	10	130	110	110	50	1,300
Wilberforce River/Waitawhiri	10	<10	80	60	120	0	10	0	<10	290

Table A5-3:   Cover class change matrix for 'water 2 (shallow water)' class for all rivers for 2024 and 2012.

	Area (ha)									2012
			2024							
River name	No data	Water 1 (deep water)	Water 2 (shallow water)	Raw riverbed	Older riverbed	Sparse vegetation cover	Moderate vegetation cover	High vegetation cover	Dense vegetation cover	Water 2 (shallow water)
Ahuriri River	0	<10	30	40	<10	30	20	20	10	140
Ashburton River (lower)/Hakatere	10	0	40	70	60	20	60	10	10	270
Ashburton River (upper South Branch)/Hakatere	0	0	<10	<10	10	0	<10	0	0	20
Ashley River (lower)/Rakahuri	<10	10	60	110	10	40	30	10	10	260
Ashley River (upper)/Rakahuri	<10	0	30	<10	10	<10	30	<10	10	80
Avoca River	0	0	20	<10	30	0	10	0	<10	60
Bealey, Mingha, Edwards Rivers	0	0	10	<10	10	0	10	0	<10	40
Cameron River	0	0	0	0	<10	0	<10	0	<10	10
Cass River	0	0	70	20	120	<10	10	0	0	230
Clarence River (lower)/Waiau Toa	0	10	70	60	70	30	110	20	40	420
Clarence River (upper)/Waiau Toa	130	0	420	110	110	20	140	10	20	960
Clyde River	0	10	40	50	60	<10	20	0	<10	180
Conway River/Piri tutae-putaputa	0	<10	40	10	30	10	50	10	20	170
Dobson River	0	<10	60	130	70	10	30	<10	<10	330
Edward Stream	0	0	0	0	0	0	0	0	0	<10
Esk River	0	0	40	10	20	0	20	0	<10	90
Eyre River	0	0	0	<10	<10	<10	<10	0	<10	10
Fork Stream	0	0	<10	0	<10	0	<10	0	0	<10
Godley River	0	50	180	380	330	10	50	10	10	1,010
Hae Hae Te Moana River	0	0	<10	0	0	<10	<10	<10	<10	10
Hakataramea River	0	0	<10	<10	0	20	10	10	<10	30
Hapuku River	0	0	90	<10	40	20	90	40	30	300
Harper River	0	0	10	<10	10	0	10	0	<10	30
Havlock River	0	<10	10	50	30	0	10	0	<10	110
Hawdon River	0	0	<10	0	10	0	10	0	<10	20
Hinds River/Hekeao	0	0	0	0	0	0	<10	0	<10	<10
Hook River	0	0	0	0	0	<10	0	<10	0	<10
Hopkins River/Te Awa Aruhe	20	<10	80	200	40	30	50	20	10	430
Hurunui River (above Lake Sumner)	0	0	20	<10	10	<10	30	<10	10	80
Hurunui River (lower)	10	<10	90	60	30	40	60	30	20	340
Hurunui River (upper and South Branch)	0	0	60	<10	20	<10	60	<10	20	160
Kahutara River	0	0	<10	0	10	<10	20	10	30	80
Kowai River	0	0	0	0	0	<10	0	0	0	<10
Kowhai River	0	0	10	<10	20	<10	20	10	10	70
Makikihi River	0	0	0	0	0	<10	0	0	0	<10
Mathias River	0	0	70	20	100	0	50	0	10	250
Murchison River	0	10	<10	40	10	0	<10	0	0	60
Nell Stream	0	0	0	0	<10	0	0	0	0	<10
Ohau River (lower)	0	0	10	0	0	<10	10	<10	<10	30
Ohau River (upper)	0	0	10	<10	0	<10	<10	0	0	20
Okuku River/Rakahuri	0	0	10	<10	<10	<10	20	0	<10	30
Opihi River (above Opuha River gorge)	0	0	0	0	0	<10	10	<10	<10	10
Opihi River (lower)	10	0	10	10	0	20	10	10	<10	70
Opuha River	0	0	<10	0	0	<10	10	<10	<10	20
Orari River (lower)	0	0	<10	10	<10	10	10	<10	<10	30
Orari River (upper)	0	0	<10	<10	<10	<10	10	0	<10	20
Otaio River	0	0	0	<10	0	<10	<10	<10	<10	10
Pareora River (lower)	0	0	<10	<10	0	10	10	<10	<10	30
Pareora River (upper)	0	0	0	0	0	<10	<10	<10	<10	<10
Poulter River	0	0	80	20	70	<10	60	<10	10	230
Pukaki River	0	0	<10	<10	0	0	<10	0	0	<10
Rakaia River (lower)	230	170	110	400	170	40	80	30	40	1,270
Rakaia River (upper tributaries)	0	20	30	50	50	0	10	0	<10	160
Rakaia River (upper)	40	30	120	210	230	<10	60	10	30	720
Rangitata River (lower)	20	20	50	80	20	20	20	20	10	250
Rangitata River (tributaries)	0	0	<10	<10	10	0	<10	0	<10	20
Rangitata River (upper)	30	10	140	190	190	10	30	<10	10	610
Ribbonwood Stream	0	0	0	0	0	0	0	0	0	<10
Selwyn River (lower)/Waikirikiri	0	0	<10	10	<10	10	10	0	<10	30
Selwyn (upper)/Waikirikiri	0	0	<10	0	<10	<10	10	<10	<10	10
Smite River	0	0	0	0	0	0	0	0	0	0
Swift River	0	0	<10	0	10	0	<10	0	<10	10
Swin Stream	0	0	0	0	0	0	0	0	0	0
Tasman River	80	110	90	490	50	10	40	<10	10	880
Tekapo River	0	<10	30	40	10	10	20	<10	<10	120
Tengawai River	0	0	<10	0	0	10	10	<10	<10	20
Twizel River	0	0	0	0	0	<10	<10	<10	<10	10
Waiau River (lower)/Waiau Uwha	10	20	160	180	50	50	90	40	30	630
Waiau River (upper)/Waiau Uwha	10	<10	210	90	100	40	210	30	40	720
Waihao River	0	0	<10	<10	0	<10	0	<10	<10	20
Waimakariri River (above Bealey River bridge)	0	0	20	20	30	0	10	0	10	80
Waimakariri River (lower)	80	230	250	450	120	50	50	20	20	1,260
Waimakariri River (upper)	<10	<10	90	60	60	<10	60	<10	20	300
Waipara River	0	<10	10	10	<10	<10	10	<10	<10	40
Waitaki River	30	30	420	40	<10	160	70	130	60	940
Wilberforce River/Waitawhiri	10	<10	170	90	330	<10	70	<10	10	670

Table A5-4: Cover class change matrix for 'raw riverbed' class for all rivers for 2024 and 2012.

River name	No data	Water 1 (deep water)	Water 2 (shallow water)	Raw riverbed	Older riverbed	Sparse vegetation cover	Moderate vegetation cover	High vegetation cover	Dense vegetation cover	2012 Raw river bed
Ahuriri River	0	0	<10	10	<10	<10	<10	0	0	20
Ashburton River (lower)/Hakatere	<10	0	<10	10	<10	<10	<10	0	0	20
Ashburton River (upper South Branch)/Hakatere	0	0	10	10	10	0	<10	0	0	30
Ashley River (lower)/Rakahuri	0	0	<10	<10	0	<10	0	0	0	10
Ashley River (upper)/Rakahuri	0	0	<10	0	<10	0	<10	0	0	10
Avoca River	0	0	20	<10	60	0	10	0	<10	90
Bealey, Mingha, Edwards Rivers	0	0	<10	0	<10	0	<10	0	0	<10
Cameron River	0	0	0	<10	10	0	<10	0	0	10
Cass River	0	0	70	20	320	0	10	0	0	430
Clarence River (lower)/Waiau Toa	0	10	20	40	30	20	20	10	10	160
Clarence River (upper)/Waiau Toa	<10	0	10	10	20	<10	10	0	0	60
Clyde River	0	<10	20	30	40	0	10	0	0	100
Conway River/Piri tutae-putaputa	0	0	10	<10	10	<10	10	0	0	40
Dobson River	0	<10	70	300	140	20	50	<10	<10	580
Edward Stream	0	0	0	0	0	0	0	0	0	0
Esk River	0	0	10	<10	10	0	<10	0	0	20
Eyre River	0	0	0	0	0	0	0	0	0	0
Fork Stream	0	0	<10	<10	10	0	<10	0	0	20
Godley River	0	40	150	710	710	10	70	0	<10	1,690
Hae Hae Te Moana River	0	0	0	0	0	0	0	0	0	0
Hakataramea River	0	0	0	0	0	0	0	0	0	0
Hapuku River	0	0	<10	<10	<10	<10	<10	0	0	<10
Harper River	0	0	10	0	20	0	0	0	0	40
Havlock River	0	0	10	30	50	<10	20	<10	<10	110
Hawdon River	0	0	<10	0	<10	0	10	0	0	10
Hinds River/Hekeao	0	0	0	0	0	0	0	0	0	0
Hook River	0	0	0	0	0	0	0	0	0	0
Hopkins River/Te Awa Aruhe	10	<10	40	170	30	10	30	<10	<10	310
Hurunui River (above Lake Sumner)	0	0	<10	<10	<10	0	10	0	<10	20
Hurunui River (lower)	<10	0	10	10	<10	<10	<10	<10	0	30
Hurunui River (upper and South Branch)	0	0	10	<10	10	0	10	0	<10	20
Kahutara River	0	0	<10	0	<10	<10	<10	10	<10	20
Kowai River	0	0	0	0	0	0	0	0	0	0
Kowhai River	0	0	<10	0	<10	<10	<10	<10	0	10
Makikihi River	0	0	0	0	0	0	0	0	0	0
Mathias River	0	<10	140	200	760	<10	110	0	<10	1,200
Murchison River	0	<10	<10	20	30	0	<10	0	0	50
Nell Stream	0	0	<10	0	<10	0	<10	0	0	10
Ohau River (lower)	0	0	0	0	0	0	0	0	0	0
Ohau River (upper)	0	0	0	0	0	0	0	0	0	<10
Okuku River/Rakahuri	0	0	0	0	0	0	0	0	0	0
Opihi River (above Opuha River gorge)	0	0	0	0	0	0	0	0	0	0
Opihi River (lower)	0	0	0	<10	0	<10	0	0	0	<10
Opuha River	0	0	0	0	0	0	0	0	0	0
Orari River (lower)	0	0	0	<10	0	<10	<10	0	0	<10
Orari River (upper)	0	0	<10	<10	<10	<10	0	0	0	10
Otaio River	0	0	0	<10	0	0	0	0	0	<10
Pareora River (lower)	0	0	0	0	0	0	0	0	0	<10
Pareora River (upper)	0	0	0	0	0	0	0	0	0	0
Poulter River	0	0	40	<10	50	0	30	0	<10	140
Pukaki River	0	0	<10	<10	0	0	0	0	0	<10
Rakaia River (lower)	90	80	50	180	80	20	30	10	20	550
Rakaia River (upper tributaries)	0	10	30	50	120	<10	20	0	0	230
Rakaia River (upper)	60	40	230	500	850	<10	90	0	10	1,790
Rangitata River (lower)	10	<10	20	30	10	<10	10	<10	<10	80
Rangitata River (tributaries)	0	0	<10	10	40	0	<10	0	0	60
Rangitata River (upper)	30	10	110	160	200	10	20	<10	<10	550
Ribbonwood Stream	0	0	0	0	<10	0	0	0	0	<10
Selwyn River (lower)/Waikirikiri	0	0	0	0	0	0	0	0	0	<10
Selwyn (upper)/Waikirikiri	0	0	0	0	0	0	0	0	0	0
Smite River	0	0	0	0	<10	0	0	0	0	<10
Swift River	0	0	<10	0	<10	0	0	0	0	<10
Swin Stream	0	0	0	0	0	0	0	0	0	0
Tasman River	70	110	90	470	310	10	50	<10	<10	1,110
Tekapo River	0	<10	10	10	<10	<10	<10	0	0	30
Tengawai River	0	0	0	0	0	0	0	0	0	0
Twizel River	0	0	0	0	0	0	0	0	0	0
Waiau River (lower)/Waiau Uwha	<10	10	40	50	10	10	10	<10	<10	130
Waiau River (upper)/Waiau Uwha	10	0	30	20	20	10	30	<10	10	120
Waihao River	0	0	0	0	0	0	0	0	0	0
Waimakariri River (above Bealey River bridge)	0	0	10	20	60	0	10	<10	<10	110
Waimakariri River (lower)	20	40	60	120	40	10	10	<10	<10	320
Waimakariri River (upper)	<10	0	70	30	60	<10	30	<10	<10	200
Waipara River	0	<10	<10	<10	0	0	0	0	0	<10
Waitaki River	<10	<10	20	<10	0	<10	10	10	<10	40
Wilberforce River/Waitawhiri	30	<10	340	450	1,340	<10	150	<10	10	2,320

Table A5-5: Cover class change matrix for 'older riverbed' class for all rivers for 2024 and 2012.

					Area (ha)					
					2024					2012
River name	No data	Water 1 (deep water)	Water 2 (shallow water)	Raw riverbed	Older riverbed	Sparse vegetation cover	Moderate vegetation cover	High vegetation cover	Dense vegetation cover	Older river bed
Ahuriri River	<10	0	10	40	<10	10	<10	<10	0	60
Ashburton River (lower)/Hakatere	10	0	10	30	10	10	10	<10	<10	80
Ashburton River (upper South Branch)/Hakatere	0	0	10	30	60	<10	10	0	0	120
Ashley River (lower)/Rakahuri	0	0	10	30	0	<10	<10	0	0	40
Ashley River (upper)/Rakahuri	0	0	10	<10	<10	0	<10	0	0	10
Avoca River	0	0	20	10	80	0	10	0	0	120
Bealey, Mingha, Edwards Rivers	0	0	20	<10	30	0	30	<10	<10	90
Cameron River	0	0	<10	10	60	0	10	0	0	80
Cass River	0	0	20	50	130	0	<10	0	0	210
Clarence River (lower)/Waiau Toa	0	<10	30	70	50	20	30	10	10	220
Clarence River (upper)/Waiau Toa	140	0	90	160	70	20	30	<10	0	510
Clyde River	0	20	130	650	740	10	170	0	<10	1,730
Conway River/Piri tutae-putaputa	0	0	<10	<10	<10	<10	<10	0	0	10
Dobson River	0	<10	50	290	90	20	50	<10	<10	500
Edward Stream	0	0	0	10	0	<10	<10	0	0	10
Esk River	0	0	70	50	40	<10	10	0	0	170
Eyre River	0	0	0	0	0	0	0	0	0	0
Fork Stream	0	0	<10	40	30	<10	10	0	0	80
Godley River	0	60	250	940	1,100	20	120	0	<10	2,490
Hae Hae Te Moana River	0	0	0	0	0	<10	0	<10	0	<10
Hakataramea River	0	0	0	0	0	<10	0	0	0	<10
Hapuku River	0	0	0	0	0	0	0	0	0	<10
Harper River	0	0	20	10	60	<10	10	<10	<10	120
Havlock River	0	10	110	670	470	10	180	<10	10	1,450
Hawdon River	0	0	10	10	50	0	40	0	<10	110
Hinds River/Hekeao	0	0	0	<10	0	0	0	0	0	<10
Hook River	0	0	0	0	0	0	0	0	0	0
Hopkins River/Te Awa Aruhe	90	<10	140	630	100	30	90	<10	10	1,090
Hurunui River (above Lake Sumner)	0	0	10	<10	10	0	20	0	<10	40
Hurunui River (lower)	<10	<10	20	30	10	10	10	<10	<10	80
Hurunui River (upper and South Branch)	0	0	10	<10	10	0	10	0	<10	30
Kahutara River	0	0	0	0	<10	0	0	0	0	<10
Kowai River	0	0	<10	0	0	<10	0	0	0	<10
Kowhai River	0	0	0	0	0	0	0	0	0	0
Makikihi River	0	0	0	<10	0	0	0	0	0	<10
Mathias River	0	0	40	80	240	<10	20	0	<10	390
Murchison River	0	40	<10	200	30	<10	10	0	0	290
Nell Stream	0	0	0	0	<10	0	0	0	0	<10
Ohau River (lower)	0	0	0	0	0	0	0	0	0	0
Ohau River (upper)	0	0	0	<10	0	0	0	0	0	<10
Okuku River/Rakahuri	0	0	0	0	0	0	0	0	0	0
Opihi River (above Opuha River gorge)	0	0	0	0	0	<10	<10	0	0	<10
Opihi River (lower)	<10	0	<10	10	0	10	<10	<10	<10	<10
Opuha River	0	0	0	0	0	0	0	0	0	0
Orari River (lower)	0	0	<10	30	<10	10	<10	<10	<10	50
Orari River (upper)	0	0	10	40	10	10	10	0	0	70
Otaio River	0	0	0	<10	0	0	0	0	0	<10
Pareora River (lower)	0	0	0	0	0	0	0	0	0	0
Pareora River (upper)	0	0	0	0	0	0	0	0	0	0
Poulter River	<10	0	100	50	150	0	50	0	<10	340
Pukaki River	0	0	10	230	20	<10	20	0	0	280
Rakaia River (lower)	470	420	270	1,240	520	110	270	70	150	3,520
Rakaia River (upper tributaries)	0	50	40	190	210	<10	50	<10	<10	540
Rakaia River (upper)	210	80	300	890	1,010	20	150	10	20	2,690
Rangitata River (lower)	130	30	150	430	60	70	70	20	30	980
Rangitata River (tributaries)	0	0	10	130	200	<10	20	0	0	360
Rangitata River (upper)	60	20	290	950	1,080	20	70	<10	<10	2,490
Ribbonwood Stream	0	0	0	<10	20	0	0	0	0	20
Selwyn River (lower)/Waikirikiri	0	0	0	<10	0	<10	<10	<10	<10	<10
Selwyn (upper)/Waikirikiri	0	0	0	0	0	0	0	0	0	0
Smite River	0	0	0	<10	10	0	<10	0	0	10
Swift River	0	0	<10	<10	20	0	<10	0	0	20
Swin Stream	0	0	0	30	<10	0	<10	0	0	40
Tasman River	110	100	60	800	330	30	80	<10	10	1,530
Tekapo River	0	<10	30	80	10	10	20	<10	0	160
Tengawai River	0	0	0	0	0	<10	0	0	0	<10
Twizel River	0	0	0	0	0	0	0	0	0	<10
Waiau River (lower)/Waiau Uwha	20	40	150	250	50	50	60	10	10	630
Waiau River (upper)/Waiau Uwha	20	0	60	80	40	20	70	10	10	310
Waihao River	0	0	0	0	0	0	0	0	0	<10
Waimakariri River (above Bealey River bridge)	0	0	70	130	200	<10	90	<10	10	500
Waimakariri River (lower)	170	230	420	810	330	100	90	30	30	2,210
Waimakariri River (upper)	20	<10	320	550	480	10	150	<10	10	1,560
Waipara River	0	0	<10	<10	0	<10	0	0	0	10
Waitaki River	<10	<10	70	10	<10	20	20	20	10	160
Wilberforce River/Waitawhiri	10	<10	70	150	320	<10	30	<10	<10	590

Table A5-6: Cover class change matrix for 'sparse vegetation cover' for all rivers for 2024 and 2012.

River name	Area (ha)									2012
					2024					Sparse vegetation cover
	No data	Water 1 (deep water)	Water 2 (shallow water)	Raw riverbed	Older riverbed	Sparse vegetation cover	Moderate vegetation cover	High vegetation cover	Dense vegetation cover	
Ahuriri River	<10	<10	60	180	20	170	70	40	10	550
Ashburton River (lower)/Hakatere	10	0	120	240	200	70	150	20	20	830
Ashburton River (upper South Branch)/Hakatere	0	0	10	40	60	10	60	<10	<10	190
Ashley River (lower)/Rakahuri	10	<10	70	200	10	80	50	40	20	480
Ashley River (upper)/Rakahuri	<10	0	60	10	20	<10	60	<10	10	170
Avoca River	0	0	20	10	80	<10	70	<10	10	180
Bealey, Mingha, Edwards Rivers	0	0	<10	0	<10	0	20	<10	10	40
Cameron River	0	0	<10	10	40	<10	30	0	<10	80
Cass River	0	0	50	70	230	10	190	0	<10	550
Clarence River (lower)/Waiau Toa	0	10	20	30	20	30	90	30	50	290
Clarence River (upper)/Waiau Toa	130	0	70	40	20	80	190	10	20	560
Clyde River	0	<10	20	50	100	10	200	<10	20	400
Conway River/Piri tutae-putaputa	0	0	40	20	70	30	90	40	20	320
Dobson River	0	<10	40	180	80	40	100	20	20	470
Edward Stream	0	0	<10	40	<10	10	10	0	0	60
Esk River	0	0	50	10	60	<10	80	<10	10	220
Eyre River	0	0	<10	40	20	20	20	10	10	110
Fork Stream	0	0	<10	40	40	10	50	0	0	140
Godley River	<10	20	80	220	670	120	960	20	40	2,120
Hae Hae Te Moana River	0	0	<10	<10	<10	20	10	10	<10	40
Hakataramea River	0	0	<10	<10	<10	30	10	10	10	60
Hapuku River	0	0	10	<10	<10	<10	10	10	<10	30
Harper River	0	0	20	10	50	<10	30	<10	10	120
Havlock River	0	<10	10	60	60	20	120	<10	20	300
Hawdon River	0	0	<10	<10	20	<10	30	<10	10	60
Hinds River/Hekeao	0	0	0	<10	0	10	10	<10	<10	30
Hook River	0	0	0	0	0	<10	0	<10	0	<10
Hopkins River/Te Awa Aruhe	20	<10	50	270	70	110	140	40	30	730
Hurunui River (above Lake Sumner)	0	0	20	10	20	<10	60	20	40	160
Hurunui River (lower)	20	<10	180	170	90	130	150	90	50	890
Hurunui River (upper and South Branch)	0	0	40	10	50	10	120	10	30	260
Kahutara River	0	0	10	<10	40	20	50	60	20	210
Kowai River	0	0	<10	<10	0	20	<10	<10	<10	30
Kowhai River	0	0	<10	<10	20	<10	20	10	<10	60
Makikihi River	0	0	0	0	0	10	0	<10	<10	10
Mathias River	0	0	30	30	230	10	190	<10	20	510
Murchison River	0	10	20	30	60	50	150	<10	<10	320
Nell Stream	0	0	<10	0	10	<10	10	0	<10	30
Ohau River (lower)	0	0	10	<10	30	10	90	<10	<10	140
Ohau River (upper)	0	0	<10	10	<10	<10	10	0	<10	30
Okuku River/Rakahuri	0	0	<10	<10	<10	<10	10	0	<10	20
Opihi River (above Opuha River gorge)	0	0	<10	<10	<10	40	40	10	10	100
Opihi River (lower)	20	0	10	10	<10	40	10	10	<10	100
Opuha River	0	0	<10	<10	0	10	10	<10	10	30
Orari River (lower)	0	0	10	110	10	60	40	10	<10	230
Orari River (upper)	0	0	20	100	30	30	40	<10	10	230
Otaio River	0	0	0	0	0	10	10	<10	<10	20
Pareora River (lower)	0	0	<10	<10	0	10	<10	<10	<10	20
Pareora River (upper)	0	0	0	0	0	<10	<10	<10	<10	10
Poulter River	0	0	70	20	120	<10	190	10	40	450
Pukaki River	0	0	10	40	40	<10	60	<10	<10	150
Rakaia River (lower)	80	70	50	210	80	50	110	80	130	860
Rakaia River (upper tributaries)	0	10	30	20	90	20	130	10	10	320
Rakaia River (upper)	20	10	70	120	250	20	270	20	50	820
Rangitata River (lower)	70	20	80	200	30	60	60	40	40	600
Rangitata River (tributaries)	0	0	10	60	150	10	110	<10	10	350
Rangitata River (upper)	20	10	100	120	320	40	220	10	30	870
Ribbonwood Stream	0	0	0	<10	10	0	<10	0	0	10
Selwyn River (lower)/Waikirikiri	0	0	<10	20	10	40	20	20	10	130
Selwyn (upper)/Waikirikiri	0	0	10	0	10	<10	20	<10	<10	40
Smite River	0	0	<10	10	30	<10	10	0	0	50
Swift River	0	0	10	0	20	<10	10	0	10	40
Swin Stream	0	0	0	20	<10	<10	20	0	<10	50
Tasman River	10	20	90	200	500	90	480	20	50	1,460
Tekapo River	0	<10	40	120	30	60	130	10	10	400
Tengawai River	0	0	<10	<10	0	20	10	<10	10	40
Twizel River	0	0	0	0	0	<10	10	10	10	30
Waiau River (lower)/Waiau Uwha	30	40	230	330	120	170	250	150	80	1,400
Waiau River (upper)/Waiau Uwha	20	<10	130	100	130	80	270	60	80	880
Waihao River	0	0	<10	<10	0	10	<10	<10	<10	20
Waimakariri River (above Bealey River bridge)	0	0	30	40	110	<10	110	10	40	340
Waimakariri River (lower)	70	90	160	320	140	90	180	90	110	1,240
Waimakariri River (upper)	0	0	50	50	80	<10	290	10	60	550
Waipara River	0	0	10	20	<10	50	30	20	<10	140
Waitaki River	30	10	330	40	<10	140	120	150	90	920
Wilberforce River/Waitawhiri	<10	0	60	90	460	30	320	10	50	1,010

Table A5-7: Cover class change matrix for 'moderate vegetation cover' for all rivers for 2024 and 2012.

River name	No data	Water 1 (deep water)	Water 2 (shallow water)	Raw riverbed	Older riverbed	Sparse vegetation cover	Moderate vegetation cover	High vegetation cover	Dense vegetation cover	2012 Moderate vegetation cover
Ahuriri River	<10	0	20	50	<10	450	430	60	10	1,030
Ashburton River (lower)/Hakatere	<10	0	10	30	10	20	20	30	10	120
Ashburton River (upper South Branch)/Hakatere	0	0	<10	30	20	30	110	10	10	210
Ashley River (lower)/Rakahuri	0	0	<10	20	0	10	10	<10	<10	40
Ashley River (upper)/Rakahuri	0	0	<10	<10	<10	<10	10	<10	<10	10
Avoca River	0	0	<10	<10	30	<10	70	0	10	120
Bealey, Mingha, Edwards Rivers	0	0	0	0	<10	0	<10	10	10	20
Cameron River	0	0	<10	<10	10	10	30	0	<10	50
Cass River	0	0	10	10	10	60	270	20	10	380
Clarence River (lower)/Waiau Toa	0	0	<10	10	<10	10	40	20	20	110
Clarence River (upper)/Waiau Toa	70	0	<10	<10	<10	50	60	10	10	200
Clyde River	0	0	<10	40	40	40	250	<10	10	390
Conway River/Piri tutae-putaputa	0	0	<10	<10	<10	<10	<10	<10	<10	20
Dobson River	0	0	<10	30	10	40	100	<10	10	200
Edward Stream	0	0	<10	40	<10	70	50	0	<10	170
Esk River	0	0	10	<10	10	<10	40	<10	10	70
Eyre River	0	0	0	<10	<10	<10	<10	<10	0	10
Fork Stream	0	0	<10	<10	<10	<10	30	0	0	40
Godley River	10	10	20	80	90	250	670	30	180	1,350
Hae Hae Te Moana River	0	0	<10	0	0	10	<10	10	<10	20
Hakataramea River	0	0	<10	<10	0	30	10	10	<10	60
Hapuku River	0	0	0	0	0	0	0	0	0	<10
Harper River	0	0	<10	<10	10	100	90	<10	20	230
Havlock River	0	0	10	50	30	40	150	10	30	300
Hawdon River	0	0	<10	<10	20	<10	30	<10	50	110
Hinds River/Hekeao	0	0	0	10	0	30	10	10	10	70
Hook River	0	0	0	0	0	<10	0	<10	0	<10
Hopkins River/Te Awa Aruhe	<10	0	10	40	10	90	90	10	10	270
Hurunui River (above Lake Sumner)	0	0	<10	0	<10	<10	10	<10	10	20
Hurunui River (lower)	<10	0	10	10	<10	20	10	20	10	90
Hurunui River (upper and South Branch)	0	0	<10	<10	<10	<10	20	<10	20	50
Kahutara River	0	0	0	0	0	<10	<10	<10	0	<10
Kowai River	0	0	0	0	0	<10	0	<10	0	<10
Kowhai River	0	0	0	0	0	0	0	<10	0	<10
Makikihi River	0	0	0	0	0	<10	0	0	0	<10
Mathias River	0	0	<10	10	40	50	110	20	40	280
Murchison River	0	0	0	10	<10	240	170	<10	10	430
Nell Stream	0	0	<10	0	<10	<10	<10	0	0	10
Ohau River (lower)	0	0	<10	<10	10	30	260	<10	20	320
Ohau River (upper)	0	0	<10	<10	<10	10	30	<10	<10	50
Okuku River/Rakahuri	0	0	0	0	0	<10	<10	0	<10	10
Opihi River (above Opuha River gorge)	0	0	0	0	<10	<10	10	<10	<10	20
Opihi River (lower)	20	0	10	10	0	40	10	10	<10	100
Opuha River	0	0	<10	0	0	<10	<10	<10	10	20
Orari River (lower)	0	0	<10	60	10	30	20	10	<10	120
Orari River (upper)	0	0	10	30	10	40	30	<10	10	130
Otaio River	0	0	0	0	0	<10	0	<10	<10	<10
Pareora River (lower)	0	0	0	0	0	<10	<10	<10	<10	10
Pareora River (upper)	0	0	0	0	0	<10	0	<10	<10	<10
Poulter River	0	0	10	<10	20	10	110	<10	30	180
Pukaki River	0	0	<10	<10	10	10	880	<10	10	910
Rakaia River (lower)	10	10	10	30	20	30	40	130	60	350
Rakaia River (upper tributaries)	0	<10	10	10	30	130	390	10	40	620
Rakaia River (upper)	10	<10	20	70	90	140	500	50	50	920
Rangitata River (lower)	20	<10	20	50	10	30	30	50	30	240
Rangitata River (tributaries)	0	0	10	40	90	20	320	<10	20	500
Rangitata River (upper)	10	<10	20	40	60	70	850	10	70	1,120
Ribbonwood Stream	0	0	0	0	0	0	<10	0	0	<10
Selwyn River (lower)/Waikirikiri	0	0	0	<10	<10	10	<10	<10	<10	20
Selwyn (upper)/Waikirikiri	0	0	0	0	0	<10	<10	<10	<10	10
Smite River	0	0	0	<10	10	10	40	0	<10	70
Swift River	0	0	<10	0	10	<10	10	<10	20	40
Swin Stream	0	0	0	10	<10	<10	40	<10	<10	60
Tasman River	20	10	10	110	40	460	800	20	80	1,550
Tekapo River	0	<10	30	160	20	290	1,430	50	60	2,040
Tengawai River	0	0	0	0	0	10	<10	<10	<10	10
Twizel River	0	0	0	0	0	<10	10	<10	<10	20
Waiau River (lower)/Waiau Uwha	<10	10	10	20	10	30	60	50	30	230
Waiau River (upper)/Waiau Uwha	0	0	10	10	<10	30	70	10	30	170
Waihao River	0	0	0	0	0	0	0	<10	0	<10
Waimakariri River (above Bealey River bridge)	0	0	10	20	30	20	90	<10	60	220
Waimakariri River (lower)	10	20	20	50	10	40	80	40	50	310
Waimakariri River (upper)	0	0	20	20	40	10	380	10	100	570
Waipara River	0	0	0	<10	<10	10	<10	<10	<10	20
Waitaki River	20	<10	50	10	0	60	50	100	40	320
Wilberforce River/Waitawhiri	0	0	20	30	120	150	720	10	100	1,150

Table A5-8: **Cover class change matrix for 'high vegetation cover' for all rivers for 2024 and 2012.**

	Area (ha)									2012
					2024					
River name	No data	Water 1 (deep water)	Water 2 (shallow water)	Raw riverbed	Older riverbed	Sparse vegetation cover	Moderate vegetation cover	High vegetation cover	Dense vegetation cover	High vegetation cover
Ahuriri River	<10	0	30	40	<10	2,120	560	1,380	170	4,290
Ashburton River (lower)/Hakatere	10	0	30	50	30	130	80	1,990	90	2,410
Ashburton River (upper South Branch)/Hakatere	<10	0	<10	10	10	230	140	100	110	600
Ashley River (lower)/Rakahuri	10	<10	50	100	10	170	50	1,800	120	2,310
Ashley River (upper)/Rakahuri	<10	0	20	10	10	40	60	340	120	600
Avoca River	0	0	<10	0	<10	40	130	20	70	260
Bealey, Mingha, Edwards Rivers	0	0	<10	0	<10	0	<10	20	10	40
Cameron River	0	0	10	10	30	80	90	20	70	320
Cass River	<10	0	<10	<10	10	320	120	140	90	690
Clarence River (lower)/Waiau Toa	0	0	10	10	<10	40	10	110	70	240
Clarence River (upper)/Waiau Toa	20	0	<10	<10	10	60	10	140	30	270
Clyde River	0	0	10	20	20	170	160	40	150	570
Conway River/Piri tutae-putaputa	0	0	<10	<10	<10	20	10	160	10	200
Dobson River	<10	0	10	30	10	280	180	570	200	1,290
Edward Stream	0	0	0	30	0	310	60	10	10	420
Esk River	0	0	<10	<10	10	10	20	70	110	230
Eyre River	<10	0	<10	30	10	80	30	400	50	600
Fork Stream	0	0	0	<10	<10	120	130	<10	20	270
Godley River	<10	10	20	60	40	770	460	470	540	2,390
Hae Hae Te Moana River	0	0	<10	<10	0	50	20	490	20	580
Hakataramea River	<10	0	10	10	<10	1,360	50	500	140	2,060
Hapuku River	0	0	<10	0	<10	<10	<10	50	<10	70
Harper River	0	0	<10	<10	<10	140	80	20	50	300
Havlock River	0	<10	<10	50	20	100	40	40	70	330
Hawdon River	0	0	0	0	<10	<10	10	40	90	140
Hinds River/Hekeao	<10	0	0	10	0	80	20	590	30	730
Hook River	0	0	0	0	0	10	0	60	<10	70
Hopkins River/Te Awa Aruhe	<10	0	20	40	10	440	60	1,390	170	2,130
Hurunui River (above Lake Sumner)	<10	0	10	<10	10	10	20	590	30	680
Hurunui River (lower)	10	<10	30	20	10	210	50	1,560	120	2,020
Hurunui River (upper and South Branch)	<10	0	10	<10	10	30	40	260	110	450
Kahutara River	0	0	<10	<10	<10	20	20	130	10	180
Kowai River	<10	0	0	0	0	60	<10	200	10	270
Kowhai River	0	0	<10	0	10	<10	<10	70	<10	90
Makikihi River	0	0	0	0	0	10	0	20	<10	30
Mathias River	0	0	10	10	20	380	190	350	680	1,640
Murchison River	0	0	0	0	<10	130	40	40	10	220
Nell Stream	0	0	0	0	<10	20	10	10	20	50
Ohau River (lower)	0	0	0	0	0	60	50	40	20	170
Ohau River (upper)	0	0	0	0	0	10	10	<10	<10	20
Okuku River/Rakahuri	0	0	<10	<10	<10	20	10	80	10	130
Opihi River (above Opuha River gorge)	<10	0	0	<10	0	30	10	430	30	510
Opihi River (lower)	40	0	20	20	<10	100	30	650	50	910
Opuha River	0	0	<10	0	0	<10	<10	250	20	280
Orari River (lower)	<10	0	10	50	10	80	30	610	30	810
Orari River (upper)	<10	0	10	40	10	160	40	210	140	620
Otaio River	<10	0	0	<10	0	40	10	150	10	220
Pareora River (lower)	<10	0	<10	0	0	20	10	190	10	230
Pareora River (upper)	<10	0	<10	0	0	10	10	190	50	270
Poulter River	0	0	10	<10	10	20	60	280	300	680
Pukaki River	0	0	0	0	0	20	70	10	10	110
Rakaia River (lower)	60	30	30	130	50	440	280	3,620	990	5,650
Rakaia River (upper tributaries)	0	<10	<10	<10	10	220	70	140	340	790
Rakaia River (upper)	10	<10	20	30	40	400	270	810	880	2,460
Rangitata River (lower)	10	20	30	40	10	130	40	950	120	1,350
Rangitata River (tributaries)	0	0	<10	10	20	200	400	70	140	840
Rangitata River (upper)	30	<10	50	70	60	290	470	600	920	2,490
Ribbonwood Stream	0	0	0	0	0	<10	<10	<10	10	10
Selwyn River (lower)/Waikirikiri	<10	0	<10	50	20	220	90	720	200	1,310
Selwyn (upper)/Waikirikiri	<10	0	<10	0	<10	10	30	180	30	260
Smite River	0	0	0	0	<10	50	20	20	10	100
Swift River	0	0	<10	0	<10	<10	<10	<10	10	20
Swin Stream	0	0	0	<10	0	50	90	10	50	210
Tasman River	<10	10	10	50	10	680	390	140	390	1,690
Tekapo River	0	<10	10	70	<10	800	1,010	330	150	2,370
Tengawai River	0	0	<10	0	0	50	30	460	60	610
Twizel River	0	0	0	0	0	40	30	100	30	200
Waiau River (lower)/Waiau Uwha	10	10	30	40	20	330	210	1,930	190	2,770
Waiau River (upper)/Waiau Uwha	10	0	50	30	30	160	100	1,020	200	1,600
Waihao River	0	0	0	<10	0	30	<10	130	20	180
Waimakariri River (above Bealey River bridge)	0	0	<10	10	10	40	30	100	220	420
Waimakariri River (lower)	20	30	30	60	20	140	60	1,710	330	2,390
Waimakariri River (upper)	0	0	10	<10	10	30	120	80	160	400
Waipara River	0	0	<10	<10	<10	120	20	340	40	530
Waitaki River	620	<10	90	10	<10	370	70	3,190	110	4,460
Wilberforce River/Waitawhiri	0	0	10	<10	30	120	80	250	400	900

**Table A5-9:** **Cover class change matrix for 'dense vegetation cover' for all rivers for 2024 and 2012.**

	Area (ha)									
	2024									2012
River name	No data	Water 1 (deep water)	Water 2 (shallow water)	Raw riverbed	Older riverbed	Sparse vegetation cover	Moderate vegetation cover	High vegetation cover	Dense vegetation cover	Dense vegetation cover
Ahuriri River	0	<10	20	30	<10	150	100	140	60	500
Ashburton River (lower)/Hakatere	0	<10	40	70	70	80	140	960	230	1,600
Ashburton River (upper South Branch)/Hakatere	0	0	<10	<10	10	20	50	20	80	180
Ashley River (lower)/Rakahuri	10	<10	60	110	10	110	80	390	150	920
Ashley River (upper)/Rakahuri	<10	0	30	10	10	10	70	50	80	260
Avoca River	0	0	<10	0	10	<10	40	10	140	210
Bealey, Mingha, Edwards Rivers	0	0	<10	0	<10	<10	20	20	20	60
Cameron River	0	0	<10	0	<10	10	20	<10	50	90
Cass River	<10	0	<10	10	10	30	90	10	30	180
Clarence River (lower)/Waiau Toa	0	<10	20	10	10	20	40	70	110	280
Clarence River (upper)/Waiau Toa	140	0	50	20	10	210	200	240	260	1,110
Clyde River	0	0	<10	10	10	10	90	10	160	280
Conway River/Piri tutae-putaputa	<10	0	10	10	20	30	70	340	120	600
Dobson River	<10	<10	30	40	30	70	140	200	300	810
Edward Stream	0	0	0	10	0	10	<10	0	<10	30
Esk River	0	0	10	<10	10	<10	60	10	70	160
Eyre River	0	0	0	80	20	70	40	140	110	470
Fork Stream	0	0	0	<10	<10	10	30	0	10	60
Godley River	<10	10	30	60	50	120	280	50	330	930
Hae Hae Te Moana River	0	0	<10	<10	0	30	20	130	20	200
Hakataramea River	0	0	10	<10	0	130	40	90	70	340
Hapuku River	<10	0	20	<10	10	10	30	180	140	400
Harper River	0	0	<10	<10	<10	10	20	10	30	70
Havlock River	0	0	<10	10	10	20	40	10	110	210
Hawdon River	0	0	<10	0	<10	<10	10	10	40	60
Hinds River/Hekeao	<10	0	0	<10	0	40	30	280	90	440
Hook River	0	0	0	0	0	10	<10	100	10	130
Hopkins River/Te Awa Aruhe	10	<10	30	70	20	170	110	430	250	1,080
Hurunui River (above Lake Sumner)	<10	0	10	<10	10	<10	40	90	70	230
Hurunui River (lower)	20	<10	90	70	30	130	140	570	240	1,300
Hurunui River (upper and South Branch)	<10	0	20	<10	10	20	100	100	240	510
Kahutara River	<10	0	<10	10	20	30	60	240	180	530
Kowai River	0	0	0	<10	0	30	<10	30	10	80
Kowhai River	0	0	10	<10	50	10	40	260	210	590
Makikihi River	0	0	0	0	0	20	<10	30	20	70
Mathias River	0	0	20	10	60	30	320	50	840	1,320
Murchison River	0	0	0	<10	<10	10	20	10	30	70
Nell Stream	0	0	<10	0	<10	<10	10	0	10	30
Ohau River (lower)	0	0	<10	0	0	30	70	40	60	200
Ohau River (upper)	0	0	<10	<10	0	10	20	10	10	40
Okuku River/Rakahuri	<10	0	<10	<10	<10	10	20	20	20	70
Opihi River (above Opuha River gorge)	0	0	<10	0	<10	10	10	60	20	100
Opihi River (lower)	10	0	10	10	<10	30	10	170	30	280
Opuha River	0	0	<10	<10	0	10	10	60	30	110
Orari River (lower)	0	0	10	30	10	40	30	460	90	660
Orari River (upper)	<10	0	10	20	10	30	30	20	50	170
Otaio River	0	0	0	<10	0	40	20	80	30	180
Pareora River (lower)	0	0	<10	<10	0	50	20	60	30	170
Pareora River (upper)	0	0	0	0	0	10	10	40	30	80
Poulter River	0	0	20	<10	20	10	100	90	350	580
Pukaki River	0	0	<10	<10	0	<10	70	10	30	110
Rakaia River (lower)	120	60	60	240	100	110	220	830	1,520	3,260
Rakaia River (upper tributaries)	0	<10	10	10	20	10	70	20	380	520
Rakaia River (upper)	30	<10	50	50	90	110	390	360	750	1,830
Rangitata River (lower)	40	20	70	130	20	110	110	1,050	570	2,110
Rangitata River (tributaries)	0	0	<10	<10	20	10	70	20	110	230
Rangitata River (upper)	10	<10	30	20	30	30	80	70	180	440
Ribbonwood Stream	0	0	0	0	<10	0	10	0	40	50
Selwyn River (lower)/Waikirikiri	0	0	<10	30	10	60	60	90	110	360
Selwyn (upper)/Waikirikiri	0	0	10	0	<10	10	30	80	50	180
Smite River	0	0	0	<10	<10	<10	10	0	10	20
Swift River	0	0	<10	0	10	<10	<10	<10	<10	20
Swin Stream	0	0	0	<10	<10	<10	10	0	10	30
Tasman River	10	<10	10	50	20	50	170	60	210	570
Tekapo River	0	0	10	20	<10	90	160	160	120	570
Tengawai River	0	0	<10	0	0	20	20	80	30	150
Twizel River	0	0	0	0	0	10	10	90	60	180
Waiau River (lower)/Waiau Uwha	10	10	60	60	30	130	220	670	250	1,440
Waiau River (upper)/Waiau Uwha	20	0	110	50	90	160	500	720	710	2,360
Waihao River	0	0	<10	<10	0	40	20	80	30	170
Waimakariri River (above Bealey River bridge)	0	0	10	10	20	10	50	40	240	380
Waimakariri River (lower)	30	30	60	90	60	110	280	770	820	2,230
Waimakariri River (upper)	<10	0	20	20	20	<10	220	80	240	600
Waipara River	0	0	<10	<10	<10	40	20	70	30	180
Waitaki River	140	10	290	20	<10	230	230	1,150	560	2,620
Wilberforce River/Waitawhiri	<10	0	20	20	100	50	260	110	700	1,260

Appendix 6:   Examples of cover class changes between 2012 and 2024

- Water 1 (deep water)
- Water 2 (shallow water)
- Raw riverbed
- Older riverbed
- Sparse vegetation cover
- Moderate vegetation cover
- High vegetation cover
- Dense vegetation cover
- No Data
- River outline
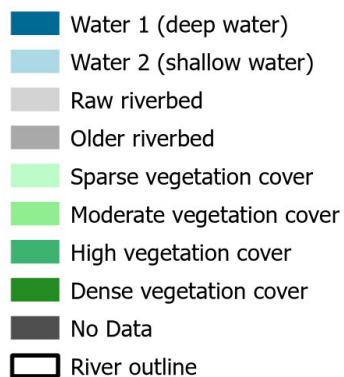
2012 SPOT 5 Image, top left
2012 Results, top right
2024 Sentinel-2 Image, bottom left
2024 Results, bottom right

Figure A6-1: Cover class classification legend for examples of cover class changes between 2012 and 2024.
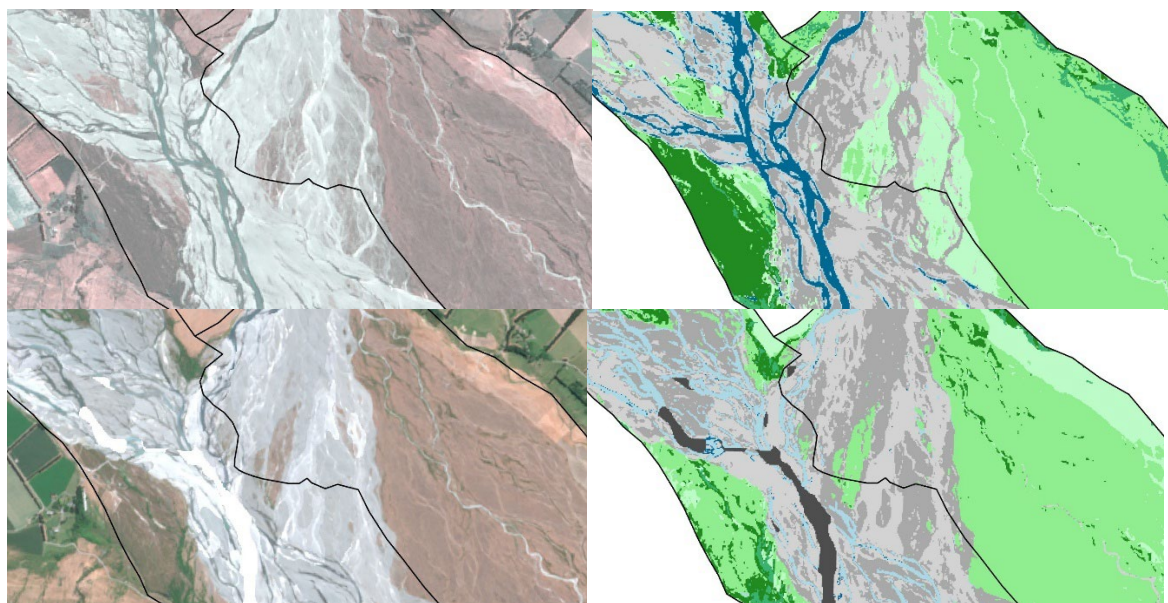
Figure A6-2: Upper Rakaia River and Wilberforce River (1:24,000) example of cover class changes between 2012 and 2024.
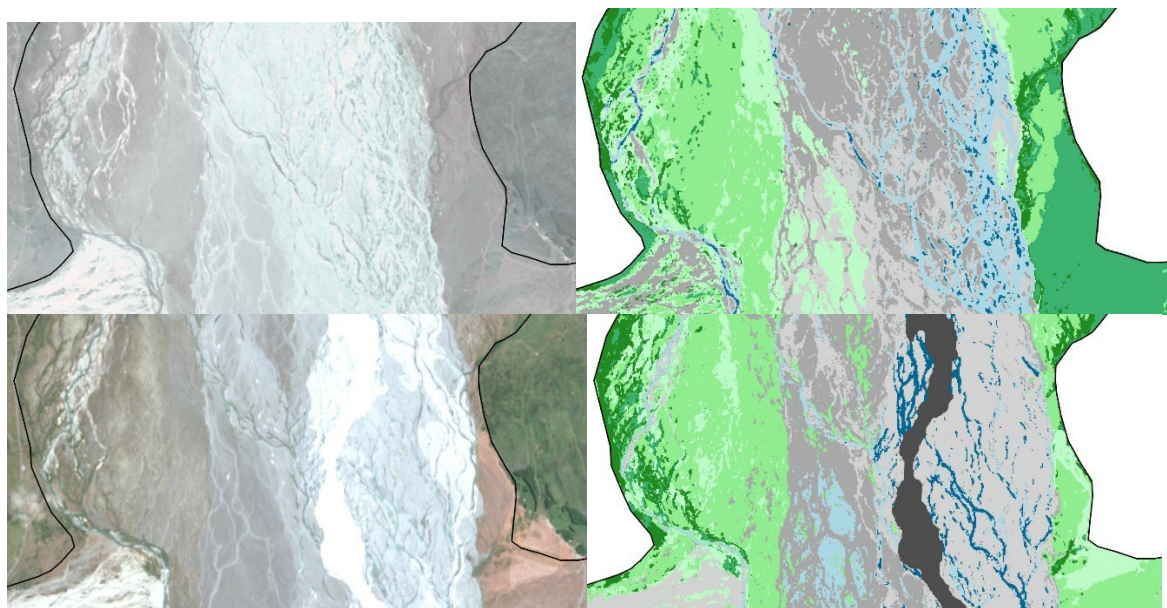
Figure A6-3: Tasman River (1:24,000) example of cover class changes between 2012 and 2024.
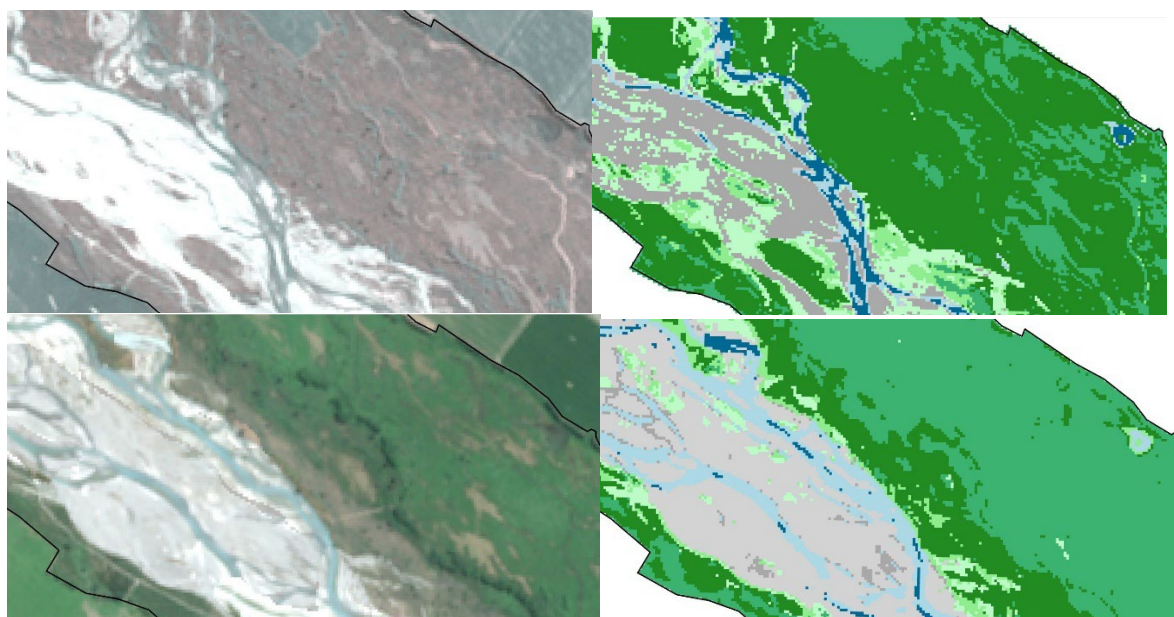
Figure A6-4: Rangitata River (lower) (1:10,000) example of cover class changes between 2012 and 2024.
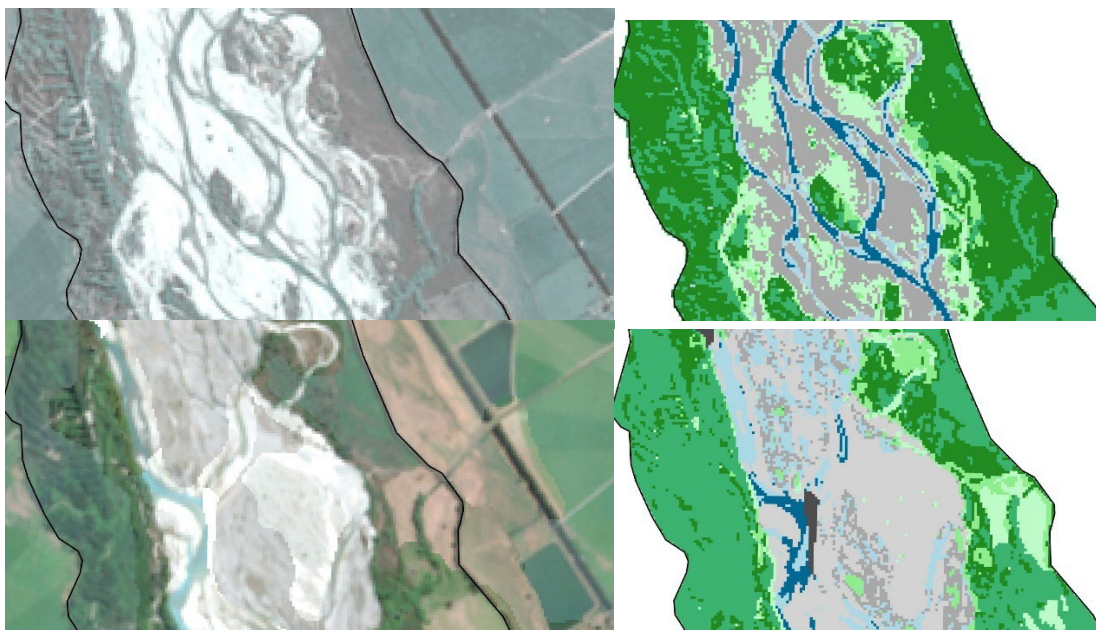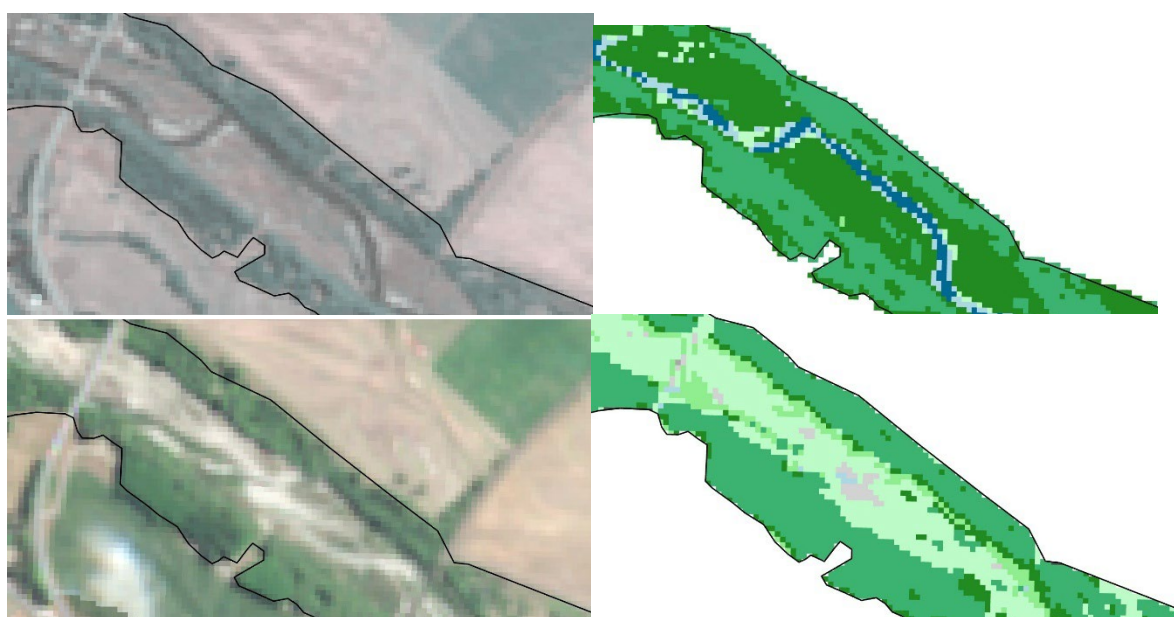
Figure A6-5: Rangitata River (lower) (1:10,000) example of cover class changes between 2012 and 2024.
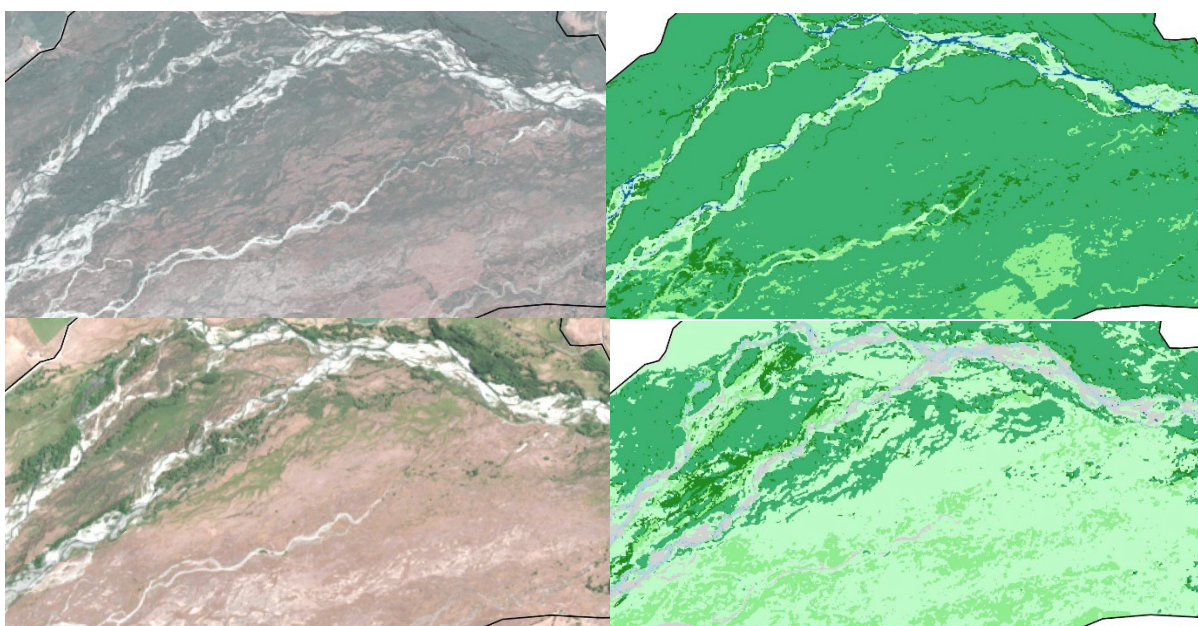
Figure A6-6: Ahuriri River (1:24,000) example of cover class changes between 2012 and 2024.
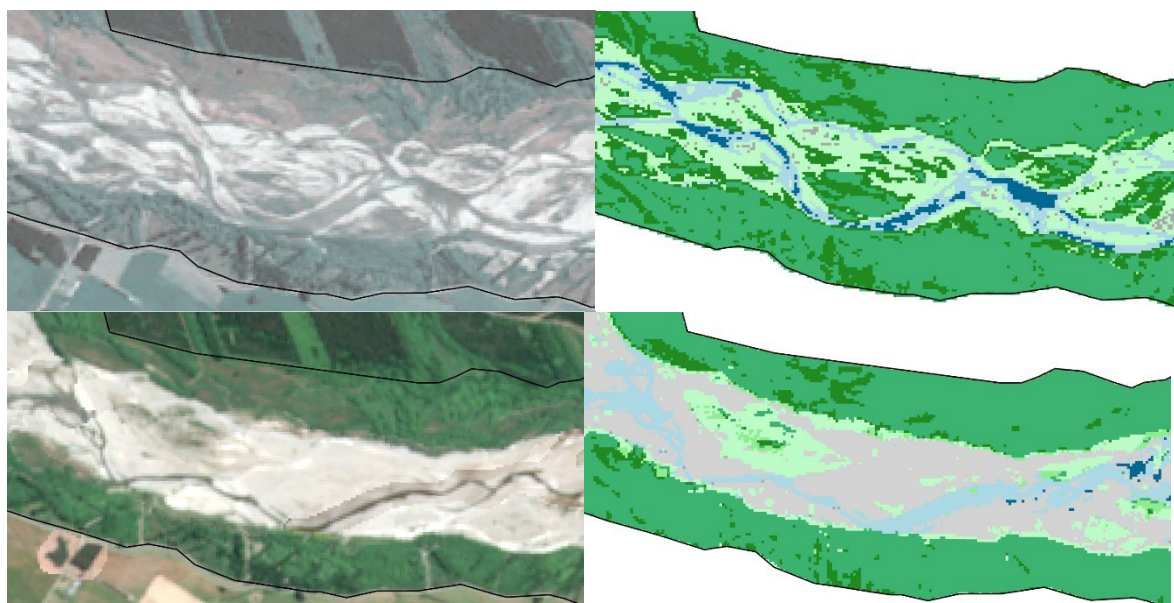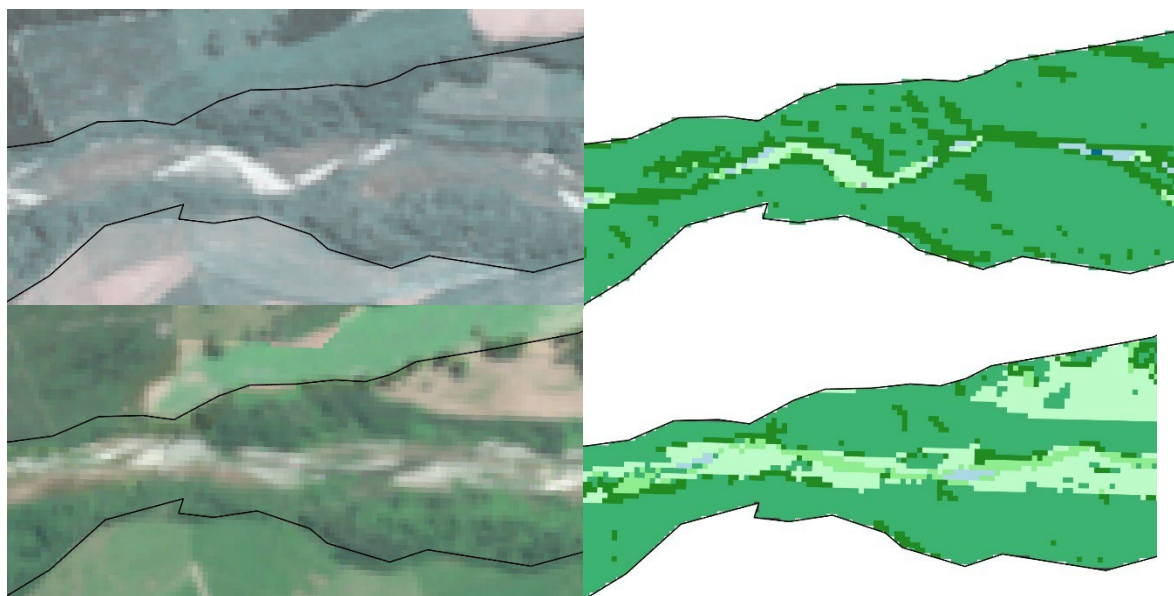
Figure A6-7: Ashley River (lower)/Rakahuri (1:10,000) example of cover class changes between 2012 and 2024.
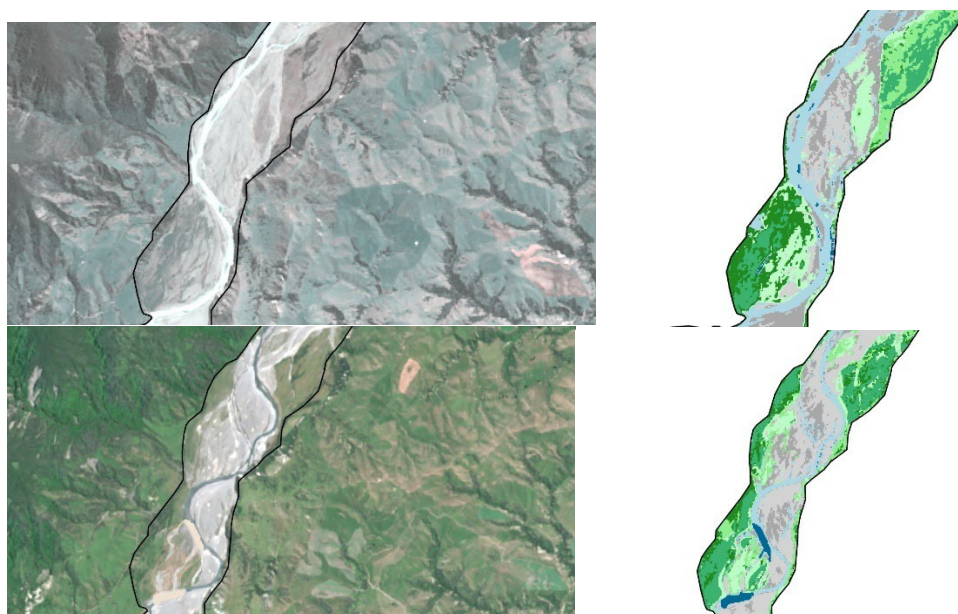

Figure A6-8: Pareora River (lower) (1:5,000) example of cover class changes between 2012 and 2024.
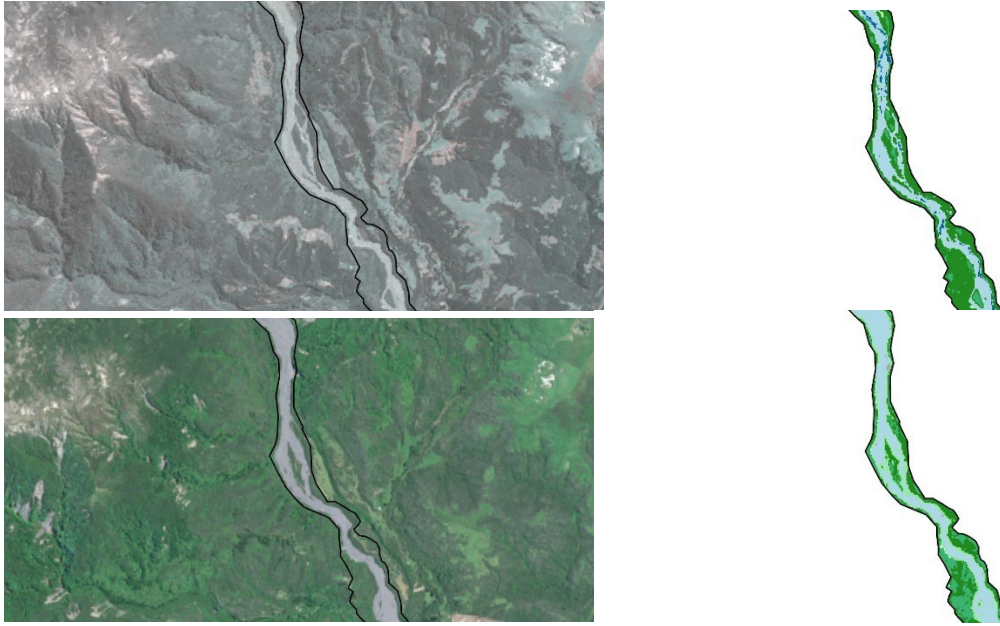
Figure A6-9: Tengawai River (1:5,000) example of cover class changes between 2012 and 2024.

Figure A6-10:   Clarence River (lower)/Waiau Toa Ahuriri River (1:24,000) example of cover class changes between 2012 and 2024.

Figure A6-11:   Hapuku River (1:24,000) example of cover class changes between 2012 and 2024.

(Airbus Defence and Space imagery 2005, *SPOT 5*. Copernicus Sentinel 2 data 2024, processed by ESA.)

![Environment Canterbury Regional Council — Kaunihera Taiao ki Waitaha]

Taking action together to shape a thriving and resilient Canterbury, now and for future generations.

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