Waikato Regional Council Technical Report 2024/27

Catchment riparian characteristics survey of the Matahuru catchment 2024/25

ISSN 2230-4363 (Online)
waikatoregion.govt.nz

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Publication date	July 2026
Document ID	30863042

	Name	Date
Peer Reviewer	Reece Hill	June 2026
Approving Manager	Michelle Begbie	August 2026

Disclaimer

Acknowledgement

We wish to acknowledge the contribution of the project team to the 2024/2025 Matahuru catchment riparian characteristics survey. Many thanks to: Mia Facer and Nathan Allison for arranging site visits and undertaking field data collection; Claire Kotze for assisting in the field data collection; Richard Glass for setting up the data capture forms and guidance in the use of the data capture devices; and Andrew Hoffman for assistance with GIS analysis. A big thanks to Jairus Wano for his support in coordinating landowner contacts and providing valuable site-specific information that greatly contributed to the success of the survey. We would especially like to thank all the landowners who granted us permission to access the sites on or via their property. The survey could not have been successfully completed without the assistance and co-operation of all those involved.

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Background

Riparian margins occur along the interface between land and water and provide several important ecosystem functions, including filtering of contaminants, stabilisation of stream/riverbanks, and biodiversity values. Across New Zealand, land use intensification has resulted in large scale clearance of riparian vegetation, impacting on both the hydrology and water quality of the receiving environment. The Waikato Regional Council (WRC) has actively promoted enhanced management of riparian margins through initiatives such as Project Watershed (2002 – current), the Clean Streams project (2002 – 2010) and through the development and implementation of catchment management plans such as the Waipā Catchment Plan (WCP) and Waikato and Waipā River Restoration Strategy (Neilson et al., 2018). To monitor the effectiveness of soil conservation work for improving water quality outcomes, WRC established the Catchment Environmental Monitoring (CEM) programme in 2003. An important part of the CEM programme is the monitoring of riparian margins across priority catchments to track changes in riparian characteristics over time and to assess the effectiveness of initiatives implemented by council, iwi, landowners, industry partners, and key co-funders such as the Waikato River Authority (WRA).

The Matahuru catchment is situated in the Lower Waikato Catchment Management Zone (CMZ) and has a catchment area of approximately 11,000 ha. The main waterway is the Matahuru stream which flows the length of the catchment before draining into Lake Waikare. The Waikato Regional Council identified the Matahuru catchment as a 'high priority' catchment, mainly due to water quality concerns related to phosphorus (P), *E. coli*, and sediment. Furthermore, the catchment was marked as a high priority for hill-country erosion control and river management under the collaborative Waikato and Waipā River Restoration Strategy. This strategy, led by WRC, WRA, DairyNZ, and iwi (Neilson et al., 2018), acknowledges the significant sediment contributions from the Matahuru and surrounding catchments to Lake Waikare and the Waikato River.

To assess the current state of riparian margins across the catchment, a riparian survey was undertaken during the summer of 2024/2025, involving field assessments at 50 representative sites. Examples of monitored riparian characteristics include extent of fencing, stock access, buffer width, vegetation type and extent, and streambank erosion. This report presents the findings from the most recent catchment-wide riparian characteristics survey in the Matahuru catchment, carried out during the summer of 2024/2025 (referred hereafter as the '2024 survey'). A previous catchment wide survey was undertaken in 2020/2021.

Methods

The Matahuru catchment riparian survey employed a stratified random design based on the proportion of stream length under different stream order and land use combinations. In total, 50 dairy and drystock sites were sampled across the catchment. The survey involved the observation of key riparian characteristics, including fencing, vegetation class, buffer width, and stream bank erosion. Data were collected along randomly selected 500 m segments of waterway using a Trimble DA2 receiver paired with an Apple iPad to record characteristics and the spatial location at which changes occurred. General site information (e.g. dominant land use, streambed type and valley system) was collected at the start of each sampling unit. Point characteristics are those characteristics that occur, or are best described, at a specific location along the length of a waterway and included (1) those observed at three designated locations (i.e., the start, middle and end points) at each sample site and

(2) those observed anywhere along the length of the sample site (co-incident with the occurrence of these features — i.e. occurrence-based). Occurrence-based attributes, including fencing, vegetation type, and erosion, were recorded by entering a GPS point at the location where a change was observed. Data were reported as ratios or percentages of the sampled bank length for respective strata. For example, the percentage of bank length with effective fencing or the percentage of effective fencing on drystock farms. Mean and confidence intervals for parameters were calculated using standard methods for calculating ratios and statistical analysis was undertaken in R statistical software.

Key results

- The predominant land use sampled at stream and river sites across the catchment in 2024 was beef farming (51%), followed by dairy farms (23%) and low intensity sheep and beef farms (21%).
- The proportion of sampled bank length on beef farms increased by 36% from 15% in 2020 to 51% in 2024 ($P < 0201$). This increase was largely offset by decreases in the sheep and beef (−19%) and dairy support (−13%) categories and may reflect reclassification between drystock land uses rather than a genuine shift to more intensive land use.
- Across the catchment, 47% of the surveyed bank length was effectively fenced, with significantly more bank length fenced for dairy land use (91%) compared to drystock (32%). No change in effective fencing was observed from 2020 to 2024.
- Excluding drains (stream order 0), there was a general increase in effective fencing with stream order, with 26% of bank length effectively fenced for first order streams compared to 85% and 77% for third and fourth order streams, respectively.
- In 2024, about 59% of surveyed bank length had evidence of current, recent, or past stock access, with current stock access affecting 25% of bank length across the catchment. Total stock access was significantly higher for drystock (75% of bank length) compared to dairy (11% of bank length).
- Most of the surveyed bank length across the catchment was occupied by non-woody vegetation (84%), which was predominantly grass and weeds (81%). In terms of woody vegetation, about 8% bank length was occupied by native species, and 7% by exotic species. From 2020 to 2024, woody vegetation cover declined by 11%. This decrease was primarily driven by a significant reduction in exotic species, such as willows, while the extent of native woody vegetation remained unchanged.
- On average, only 7% of surveyed bank length had buffer widths of 5 m or more (described as ‘wide’) while 40% of bank length had buffer widths of less than 5 m (described as ‘narrow’). The remainder of bank length across the catchment was unfenced (53%)
- About 3% of bank length in 2024 was classified as eroded with 1% showing signs of active erosion and 2% of recent erosion. About 8% of bank length was affected by pugging (classed as > 50% pugging disturbance within the riparian margin). While there was more bank length with total soil disturbance (erosion and pugging) for drystock (12.6%) compared to dairy (5.2%), the difference was not statistically significant.
- The amount of pugging along streambanks saw no change from 2020 to 2024. However, total soil disturbance (erosion and pugging) decreased by 12.1% ($P < 0.05$) from 22.8% in 2020 to 8.6% in 2024.

Recommendations

Based on the findings of this study, the following recommendations have been made for future work:

- Ensure that repeat surveys use the same core set of sites to ensure statistical robustness for detecting changes in riparian characteristics over time.
- For future surveys, sample numbers in some strata may need adjustment to ensure better representation of land use and stream order combinations.
- As part of the wider CEM programme, it is recommended that riparian condition data be correlated with other indicators such as instream sediment concentrations, *E. coli*, nitrogen, and phosphorus. Establishing these relationships will help determine whether improvements in riparian management are contributing to measurable improvements in the water quality of the Matahuru stream.
- It is recommended that outputs from the LiDAR derived SedNetNZ modelling be integrated with riparian survey results to develop a high-resolution prioritisation framework for the Matahuru catchment. This combined approach will support ICM in more effectively identifying and targeting future mitigation efforts within the catchment.

1 Introduction

Riparian margins support multiple ecosystem services and play a fundamental role in regulating flow and nutrient transport in waterways as well as providing a range of biodiversity values (Lind et al., 2019; Vigiak et al., 2016). Specific ecosystem functions include filtering of nutrients and sediment, shading to buffer water temperature, increased ecological connectivity, and flood protection. In New Zealand, land intensification has resulted in large-scale changes to the hydrology of streams and rivers, often to the detriment of riparian margins and the receiving environment (Lind et al., 2019). Hence, good riparian management is considered by central government, local authorities, and industry to be an essential tool for improving water quality at the national scale and for implementation of the National Policy Statement for Freshwater Management (MfE, 2025). An important first step in the restoration and protection of riparian margins is fencing to prevent stock access and the use of well-designed and controlled waterway crossing structures such as bridges and culverts (Ministry for the Environment, 2004). Effective fencing not only prevents direct input of contaminants into waterways but ensures riparian vegetation can establish, without which the functionality of riparian zones is greatly reduced (Norris et al., 2025).

With an increased emphasis on surface water quality over recent years, improved management of riparian margins has become a key focus for regional councils who are responsible for overseeing the integrated management of New Zealand's natural and physical resources under the Resource Management Act 1991. The Waikato Regional Council (WRC) has actively promoted fencing and planting of riparian margins via the Clean Streams project (2002 – 2010), Project Watershed (2002 – current), and other initiatives. Furthermore, a comprehensive set of guidelines has been produced to assist landowners with the management of their riparian margins by WRC. There have also been several industry-lead initiatives to support farmers in stock exclusion and riparian management/restoration, most notably the Dairying and Clean Streams Accord (2002 – 2012) (Fonterra et al., 2003) which later transitioned into the Sustainable Dairying Water Accord (2013 – 2018) (DairyNZ, 2018).

The Matahuru catchment is situated in the Lower Waikato Catchment Management Zone (CMZ) and has a catchment area of approximately 11,000 ha. The main waterway is the Matahuru stream which flows the length of the catchment before draining into Lake Waikare (Singleton, 2018). About 60% of the catchment has been characterised as moderately steep (21-25°) to very steep (>35°), with the remainder of the catchment occupied by rolling (8-20°) and flat (<7%) land. Pasture is the predominant land cover (89% of the catchment area), with indigenous forest occupying less than 6% of the catchment area, although locally significant pockets of indigenous forest occupy some areas of the upper catchment. Sheep and beef farming is the predominant land use within the catchment (58%), followed by dairy farming (30%) and forestry (~2%).

Between 2002 and 2021, WRC and its co-funders invested approximately $779,000 in soil conservation initiatives in the Matahuru catchment, primarily for fencing and planting. Over this period, soil conservation practices were implemented across about 509 ha, with a strong emphasis on riparian planting (266 ha), as well as fencing on 237 ha of land. In total, 52 km of fencing was established, mainly along streams and rivers. Since 2021, the Matahuru catchment saw a substantial increase in funding, with approximately $1.58 million being invested in soil conservation and fencing related works in the catchment through WRC-led programmes. Funding was provided by the Lower Waikato targeted rate, the Waikato River Authority (WRA), the Ministry of Business, Innovation and Employment (MBIE), and the Ministry for Primary Industries (MPI). Funded programmes included the One Billion Trees Programme, Hill Country Erosion Fund, and Shovel-ready projects.

To monitor the effectiveness of council and landowner implemented soil conservation and river management works across priority catchments, WRC established the CEM programme in 2003. The CEM programme combined land-based measurements (riparian monitoring and soil stability monitoring) with in-stream measurements (water temperature, suspended sediment, and instream ecology) to assess the effectiveness of soil conservation efforts at the catchment scale and to link on-land mitigations to changes in water quality. The riparian component of the CEM programme has been operative since 2003. The primary purpose of the riparian monitoring was to enable the repeatable, quantitative assessment of key riparian characteristics and to provide a catchment-wide picture of the state of riparian characteristics and the changes in some of these (i.e. fencing, vegetation, and streambank erosion) over time (Norris and Norris, 2021). In 2020, the catchment-scale riparian monitoring programme was re-designed to ensure consistency with the regional survey method and to ensure better representation of stream order and major land uses across monitoring catchments. Prior to 2020, riparian monitoring within the Matahuru catchment focussed on a small number of downstream sites, resulting in biased assessments because these lower-catchment locations are typically associated with well managed riparian margins along waterways on dairy farms. The revised catchment-scale survey design was developed to capture the full range of riparian conditions by applying a stratified sampling approach based on the length of waterway within different combinations of stream order and land use. The 2020 riparian survey in the Matahuru catchment represented the first catchment-wide survey using the improved approach. As such, the 2024 survey is the first repeat survey in the Matahuru since implementation of the improved survey approach.

In this report, we present findings from the most recent catchment-scale riparian characteristics survey, carried out during the summer period of 2024/2025 in the Matahuru catchment (henceforth referred to as the ‘2024 survey’). The objectives of the report are to:

- describe the state of key riparian characteristics (fencing, vegetation, buffer width, and stream-bank erosion) of pastoral waterways as observed during the 2024 survey of the Matahuru catchment;
- describe the changes in riparian fencing, vegetation, and stream-bank erosion over the previous 4-year period (using the 2020 and 2024 survey data);
- identity catchment-specific land management issues and their impact on riparian management and water quality; and
- provide a set of recommendations for future riparian monitoring surveys in the Matahuru catchment.

2 Methods and Materials

The 2024 Matahuru riparian characteristics survey involved the observation of key riparian characteristics including fencing, vegetation, buffer width, and stream bank erosion at 50 sites on pastoral land across the catchment. The overall survey approach (including field data collection processes) was largely the same as that used during the most recent regional riparian characteristics survey (Norris et al., 2025) where sections of waterway were visually assessed by WRC staff walking the length of the survey transect.

2.1 Survey design

2.1.1 Approach

The catchment-scale Matahuru survey employed a stratified random design to select a sample of sites, stratified by stream order and land use. Stream order, as a representation of stream size, was described using the Strahler system of ranking stream channels. The Strahler system ranks streams on a scale from 1 to 7 based on the number and size of tributaries contributing flow to a given stretch of waterway. The larger the stream order (Strahler) number, the larger the stream or river (Selby, 1985). Drains were differentiated from other waterways for the purposes of the survey by using a stream order designation of zero. The Matahuru catchment contains about 171 km of rivers, streams and drains in pastoral land with approximately 53% of stream order 1, 32% stream orders 2 to 4, and 15% in drains (Appendix 1).

To ensure consistency with the regional riparian characteristics survey (Norris et al., 2025), the Matahuru catchment survey focused on two pastoral land uses, dairy and drystock. During the site selection process, pastoral land use was defined using the AgriBase™ database. AgriBase™ is a database maintained by Asure Quality that records the land use activities on individual properties, based on information supplied voluntarily by landowners. Because these records reflect land use at a single point in time and may be out of date when the survey was undertaken, the AgriBase information was verified through follow-up contact with the relevant landowners.

2.1.2 Site selection

The previous 2020 Matahuru survey sampled 50 sites, combining existing lower-catchment monitoring locations with new sites across the wider catchment to meet the requirements of the improved sampling design. Each site comprised an approximately 500 m long stretch of waterway. Both banks along each 500 m site were assessed, giving a total monitored bank length of 1000 m for each sampling unit.

The total number of sampling units was based on prior analysis of riparian survey data from the Catchment Environmental Monitoring (CEM) programme which showed that a sample size of at least 30 units (for 500 m survey transects) would allow changes in key variables (e.g. effective fencing) to be detected to within ± 10% (Kimberley 2016). The number of units subsequently assigned to each land use stratum was based on the proportional length of watercourse within that stratum. For example, the proportion of first order streams under pastoral land use (defined using AgriBase) was 53%, resulting in the selection of 17 first order samples with 2 assigned to dairy (12% of first order stream land use) and 15 to drystock (88% of first order stream land use). Extra samples were included where the total stream order allocation was less than 6, this to improve representation within some land use classes, bringing the total number of sample sites to 50 (Table 1).

Exploratory analysis of the 2020 data indicated that some land use and stream order categories were under- or over-represented relative to the population. To address this, sample numbers in 2024 were adjusted within selected strata to better balance land use and stream order combinations and more closely reflect the underlying population. The final 2024 survey design included 50 sites: 38 resampled from 2020 and 12 new sites to improve representativeness. New sites were randomly selected from segments of the stream network (stratified by land use and stream order), generated by intersecting Agribase™ land-use data with the Topo 1:50k stream network layer (LINZ, 2026). All watercourses within pastoral land use in the catchment were segmented into 500 m lengths, and the required number of sampling units within each stream order and land use stratum were randomly selected from these lengths. Spatial analysis was undertaken in ArcGIS Pro 3.6.1, while site selection was carried out in Microsoft Excel by assigning random numbers to each stream segment.

Table 1. Number of sampling units selected for stream order and land use strata for the 2024 Matahuru riparian survey.

Stream order	Land use	Number of sampling units			
		2020	2024	Difference[1]	Predicted sample size[2]
0	Dairy	4	4	0	4
	Drystock	2	2	0	3
	All	6	6	0	7
1	Dairy	4	2	-2	5
	Drystock	12	15	3	22
	All	16	17	1	27
2	Dairy	1	1	0	2
	Drystock	5	5	0	5
	All	6	6	0	7
3	Dairy	2	2	0	1
	Drystock	4	2	-2	2
	All	6	4	-2	3
4	Dairy	10	5	-5	2
	Drystock	6	12	6	4
	All	16	17	1	6
Total		**50**	**50**	**0**	**50**

[1] Change in the number of sites from 2020 to 2024, where negative values indicate a decrease and positive values indicate an increase.
[2] Predicted sample size based on the proportional length of watercourse within each land use/stream order stratum.

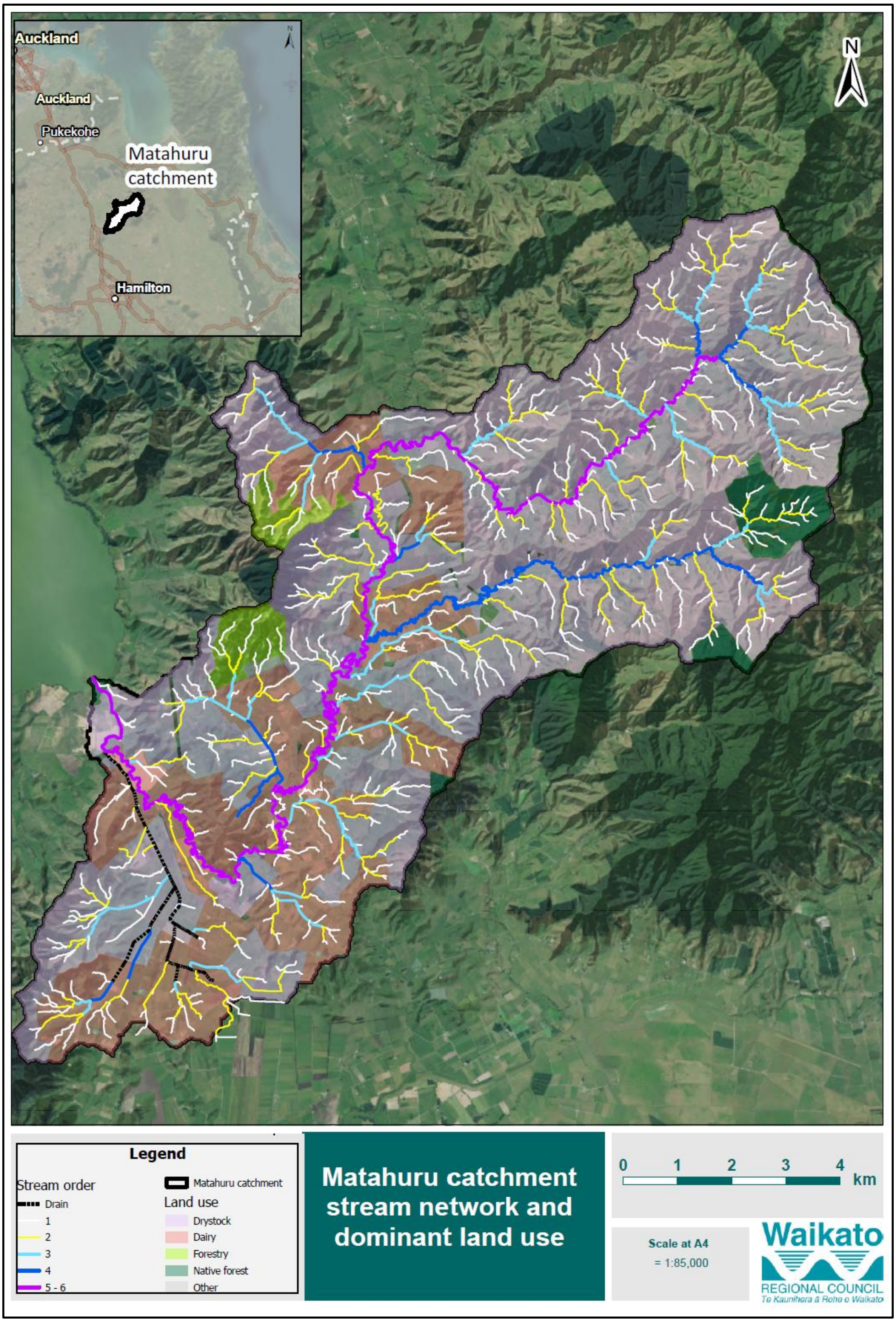

Figure 1. Map of the Matahuru catchment displaying the stream network (drains and stream orders 1 – 5) and major land uses (dairy, drystock, native forest, exotic forest and 'other').

2.1.3 Field data collection

The overall approach to field data collection for WRC riparian surveys has remained largely unchanged over the last 10 years and the reader is referred to Norris et al. (2025) for a detailed overview of the approach and the equipment used. In brief, the 50 sampling units were visited and assessed by field teams over the summer of 2024 – 2025 using an Apple iPad and Trimble DA2 GPS unit to record characteristics and the spatial location at which changes occurred. Compared to older Trimble devices (e.g. Trimble Juno®), the Apple iPad and Trimble DA2 receiver provided an improved user interface (touch screen) with a higher specification GPS to improve the efficiency and accuracy of data collection. Photographs were taken both upstream and downstream at the start, middle, and end point at each site to capture the waterway and the adjacent riparian margin. Any significant or unusual features observed (e.g. significant stream crossings, obstructions, etc.) were also photographed. Observed characteristics were grouped into three broad categories including (1) general site characteristics, (2) continuous characteristics, and (3) point characteristics.

General site characteristics help to describe the nature of, and conditions at, the sample site. These included site metadata (site identification number, date observed, and observer), site status (e.g. new or re-sampled) and general land use (e.g. dairy or dry stock).

Continuous characteristics are those that have the potential to vary spatially along the length of a waterway and can be measured in terms of waterway segment length. Key continuous characteristics observed for both banks along the length of each sample site are listed in Table 2 and include land use, the nature and status of the riparian fencing, vegetation, and streambank erosion present at a site.

Point characteristics are those characteristics that occur, or are best described, at a specific location along the length of a waterway and included (1) those observed at three designated locations (i.e. the start, middle, and end points) at each sample site and (2) those observed anywhere along the length of the sample site (co-incident with the occurrence of these features — i.e. occurrence-based). Key point characteristics are listed in Table 3 (designated locations) and Table 4 (occurrence-based). Characteristics describing bank height, bank slope, stream channel type, channel width, aquatic vegetation, and stock access were observed at the start, middle, and end points at each site. Obstructions and stream crossings were observed where they were found to occur (i.e. occurrence-based).

Table 2. Key continuous characteristics observed during the 2024 Matahuru catchment-scale riparian survey.

Characteristic	Category	Description
Land use	Dairy	Dairy (platform)
	Drystock	Dairy support Beef Sheep Sheep & beef Deer Goats Horses Llamas/alpacas Pigs
	Forestry	Planted forestry
	Other	Poultry Manuka honey Other
Fence type	No fence	There is no fence present.
	Electric	Fence present has at least one wire that is electrified.
	Wire	Fence present is predominantly of wire construction.
	Wood	Fence present is predominantly of wood construction.
	Deer	Fence present is designed for deer (mesh and > 2 m in height).
	Mesh	Fence present is of mesh construction.
	Other	Fence present is of some other design, material, or construction.
Fence status	Effective, permanent	The fence is permanently in place, with large concrete or wooden posts. The fence is robust and will stop stock movement.
	Ineffective, permanent	The fence is permanently in place, with large concrete or wooden posts. The fence is not robust and stock will move through/across it.
	Effective, temporary	The fence is easily removed; posts may be waratahs, standards, or wooden stakes. The fence is robust and will stop stock movement.
	Ineffective, temporary	The fence is easily removed; posts may be waratahs, standards, or wooden stakes. The fence is not robust and stock will move through/across it.
Vegetation type	Woody native	Predominance of native trees/shrubs.
	Woody exotic willow	Predominance of willow (deciduous exotic) species.
	Woody exotic other (deciduous)	Predominance of deciduous exotic (non-native) tree and shrub species other than willow.
	Woody exotic other (evergreen)	Predominance of evergreen exotic (non-native) tree and shrub species.
	Woody mixed (native/exotic)	Mix of native woody and exotic species
	Grass and weeds	Predominance of low (< 1 m) pastoral grass and/or herbaceous weed species.
	Flax/sedge/rush	Predominance of (mainly indigenous) flax, sedge and rush species. Species often occur in wet or damp areas.
Vegetation structure	Forest	Tall dense vegetation, trees close together.
	Treeland	> 3 m high, widely spaced trees with grass in between.
	Scrub	Low stature vegetation (< 3 m) and close together.
	Shrubland	Low stature (< 3 m), widely spaced, grass in between.
	Grasses	Grass including small, low-lying weeds < 1 m in height.
	Wetland	Raupo/sedges.
Vegetation management	Planted & managed Planted & un-manged Planted & grazed Unplanted & managed Unplanted & un-manged Unplanted & grazed	Riparian vegetation has been intentionally planted and is being managed. Riparian vegetation has been intentionally planted but is not being managed. Riparian vegetation has been intentionally planted but is periodically grazed. Riparian vegetation has not been intentionally planted but is being managed. Riparian vegetation has not been intentionally planted and is not being managed. Riparian vegetation has not been intentionally planted and is periodically grazed.
Average width of riparian margin	< 2 m	Up to 2 m.
	2 – 5 m	Between 2 and 5 m.
	5 – 10 m	Between 5 and 10 m.
	> 10 m	Greater than 10 m.
Stream-bank erosion type	No erosion	No erosion present.
	Recent	Likely to add sediment to the waterway when in flood.
	Active	Adding sediment to the waterway at the present time.
	Bare soil (>50%)	Exposed soil not associated with livestock (e.g. under forest canopy)
	Pugging (> 50%)	Soil trampled by livestock across more than 50% of the stream-bank area.
	Pugging (< 50%)	Soil trampled by livestock across less than 50% of the stream-bank area.

Table 3. Key point characteristics observed at designated locations at each sample site during the 2024 survey.

Characteristic	Category	Description
Location	Start point	Locate the start-point of the survey.
	Middle point	Locate the middle-point of the survey.
	End point	Locate the end-point of the survey.
Bank slope	Slope value recorded (°)	Measure the slope of the streambank using a clinometer.
Bank height†	< 1 m	Bank height is less than 1 m.
	1 – 9 m	Bank height is between 1 and 9 m (selected to the nearest metre).
	> 9 m	Bank height is more than 9 m.
Stock access type	None	No evidence for livestock access to the waterway or riparian margin is observed.
	Past	Some evidence for livestock access to the waterway or riparian margin at some time in the past is observed (e.g. pugged soil, grazed/browsed vegetation, trampled/broken vegetation, animal tracks and dung).
	Recent	Evidence for recent livestock access to the waterway or riparian margin is clearly observed (e.g. recently pugged soil, grazed/browsed vegetation, trampled/broken vegetation; fresh animal tracks and dung).
	Current	Livestock are observed in the waterway or riparian margin at time of survey.

† Estimated height from stream bed to bank top.

Table 4. Key occurrence-based point characteristics observed during the 2024 survey.

Characteristic	Category	Description
Obstruction type†	Non-living debris	Dead wood, plastic, metal, fencing materials, etc in the stream flow.
	Willows	Willows in the stream flow.
	Other live vegetation	Living vegetation (other than willows) in the stream flow.
	Dams	Dam structures including small farm dams, concrete walls stopping flow, etc.
	Weir	A structure across the width of the waterway that alters the flow and level of the water.
	Side entry	Side entries are tributary streams, drains or pipes that flow into the mainstream course.
Stream crossing type	Culvert	Pipes channelling the stream water, usually associated with a stream crossing (e.g. road, track or constructed crossing).
	Constructed ford	Constructed area of controlled and regular animal or vehicle crossings through the water.
	Streambed ford	Area of regular animal or vehicle crossings through the water across the streambed.
	Bridge ≤ 10 m	Bridge 10 m or less in length.
	Bridge > 10 m	Bridge greater than 10 m in length.

† An obstruction was defined to be an object or structure that blocked 50% or more of the width of the waterway.

2.2 Data processing and analysis

2.2.1 Data extraction

Field data was collected using an Apple iPad paired to a Trimble DA2 receiver. Data was routinely downloaded to the WRC ArcGIS server over the course of the survey. Due to the accuracy of the Trimble DA2 GPS data (± 1 m), correction of locational data was not required. Upon completion of the fieldwork component of the project, data was processed using an automated R-based extraction script to calculate segment lengths for each observation. The final processed data was exported to an excel spreadsheet for statistical analyses (described in section 2.2.2 below).

2.2.2 Data analysis

In this study, parameters of interest were generally represented as ratios or percentages. For example, the percentage of bank length effectively fenced or the percentage of bank length with active erosion. Means and associated 95% confidence intervals for these parameters were derived using standard methods for estimating ratios (Särndal et al. 1993). The reader is referred to Norris et al. (2025) for a more detailed overview of this approach and its application to riparian survey data. All analyses were conducted using R Studio (V 1.3.1093) (R Core Team, 2024). Raw data tables are listed in Appendix 1 to Appendix 12. It is noted that in some cases the total number of samples analysed (as listed in the Appendices) for specific variables (e.g. 'fencing') doesn't equal 50, although in most cases it is very close to this number. This is because some sites were removed from analysis during the data cleaning process. For example, where a particular survey site occurred within permanently cropped areas.

3 Results

The following subsections present and discuss the riparian survey results in relation to land use, riparian fencing, stock access and exclusion, riparian vegetation, riparian buffer width, and streambank erosion. All results are expressed using estimates with 95% confidence intervals.

3.1 Land use

3.1.1 State

The predominant land use sampled at stream and river sites across the catchment in 2024 was beef (51%), followed by dairy (23%) and sheep and beef (21%) (Figure 2). Beef farms generally contain beef cattle only, while sheep and beef farms are a mixed enterprise, containing both beef cattle and sheep. Land use relating to the broader drystock category (beef, horses and sheep and beef) accounted for 74% of sampled bank length. Cropping (e.g. summer maize) occurred across dairy and drystock farms, and overall, accounted for 2.7% of sampled bank length. Dairy farms were located predominantly in the lower catchment along drains (stream order 0) as well as larger 3rd and 4th order streams (Figure 1, Appendix 1). Beef was the dominant land use in the upper catchment along 1st, 2nd and 3rd order streams, covering 54%, 61%, and 50% of sampled bank length, respectively.

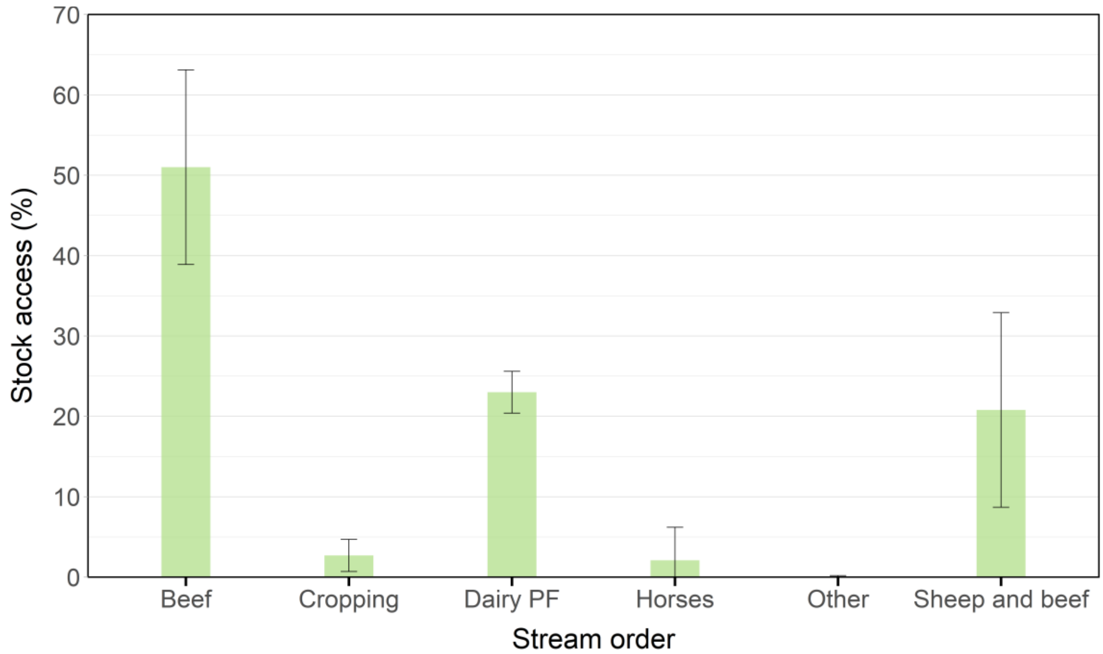

Figure 2. Percentage bank length by land use in the Matahuru catchment for surveyed transects. Estimated means and 95% confidence intervals are given for each land use type.

3.1.2 Change over time

The average proportion of bank length within beef farms saw a statistically significant increase ($P < 0.01$) from 15.3% in 2020 to 51% in 2024 (Figure 3, Table 5). The average proportion of bank length within low intensity sheep and beef farms decreased by 19.4% over the same 4-year period, although the change was not statistically significant. The proportion of bank length under dairy support decreased significantly ($P < 0.05$) by 13%, with no dairy support farms identified in 2024. It is plausible that some dairy support farms were incorrectly identified as beef farms in 2024 and to ensure consistent comparison between survey years, analysis was also undertaken on 'beef + dairy support'. Even under this broader grouping, there was still a significant increase in bank length over time (22%, $P < 0.05$), indicating a general shift away from lower-intensity sheep and beef farms towards more intensive, beef farms. Overall, the coverage of dairy farms remained relatively stable over the past four years, with only a marginal and non-significant increase of 4.5% between survey years.

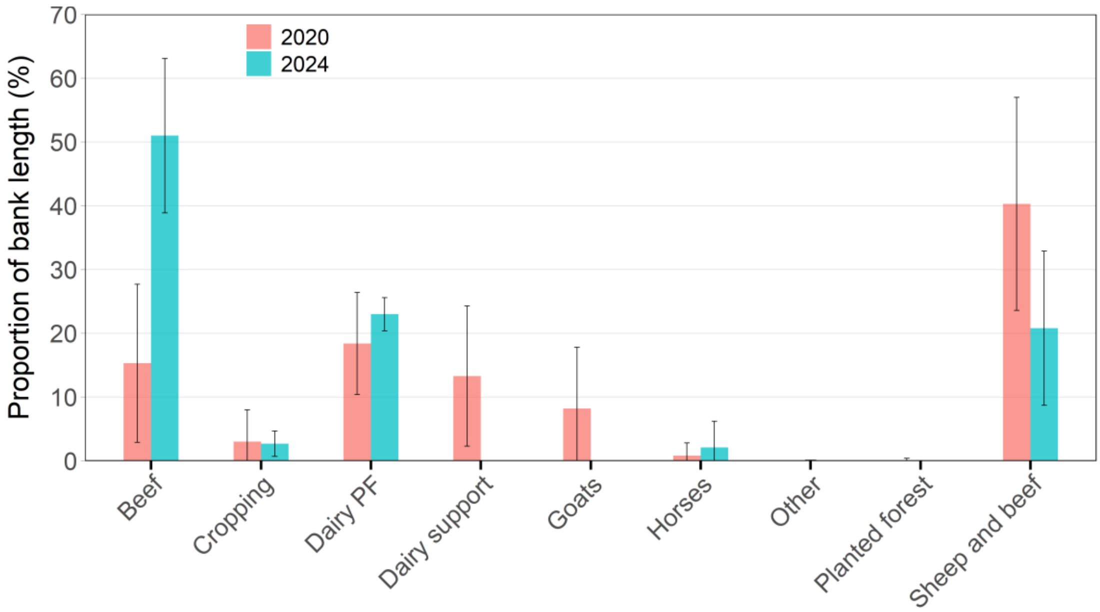

Figure 3. Average proportion of surveyed bank length under specific land uses within dairy or drystock for the 2020 and 2024 surveys in the Matahuru catchment. Estimated means and 95% confidence intervals are given for each land use.

Table 5. Average change in the proportion of bank length under different land use categories over the previous 4-year (2020 – 2024) period.

Specific land use category	2020		2024		Change	
	Estimate (pp†)	95%CI‡	Estimate (pp†)	95%CI‡	Estimate (pp†)	95%CI‡
Dairy platform	18.4	8.0	23.0	2.6	4.5 NS	9.3
Sheep and beef	40.3	16.7	20.8	12.1	-19.4 NS	20.1
Horses	0.8	2.0	2.1	4.1	1.3 NS	5.1
Beef	15.3	12.4	51.0	12.1	35.8**	21.1
Dairy support	13.3	11.0	0.0	0.0	-13.3*	11.4
Goats	8.2	9.6	0.0	0.0	-8.2 NS	9.8
Planted forest	0.1	0.3	0.0	0.0	-0.1 NS	0.2
Cropping[1]	3.0	5.0	2.7	2.0	-0.3 NS	5.1
Other[2]	0.6	1.7	0.3	0.6	-0.3 NS	1.1

[1] Cropping includes maize cropping and summer fodder crops
[2] Includes land uses such as lifestyle blocks, roads and reserves.
† Percentage point (% of bank length)
‡ 95% Confidence interval about the average.
** Significant at α = 0.01, * Significant at α = 0.05, NS Not significant.

3.2 Riparian fencing

3.2.1 State

Riparian fencing results are displayed in Figures 4a and 4b, with summarised data tabulated in Appendix 2. Across the catchment, 47% of the surveyed bank length was effectively fenced, preventing stock access to waterways, while the remaining 53% of bank length was not effectively fenced. Bank length not effectively fenced was recorded in instances where either no fencing was present along the surveyed waterway or where existing fencing failed to prevent stock access. In terms of fencing configuration, 39% of the surveyed stream length was effectively fenced on both sides, 16% along one bank only, and the remaining 45% along neither bank (Figure 4b).

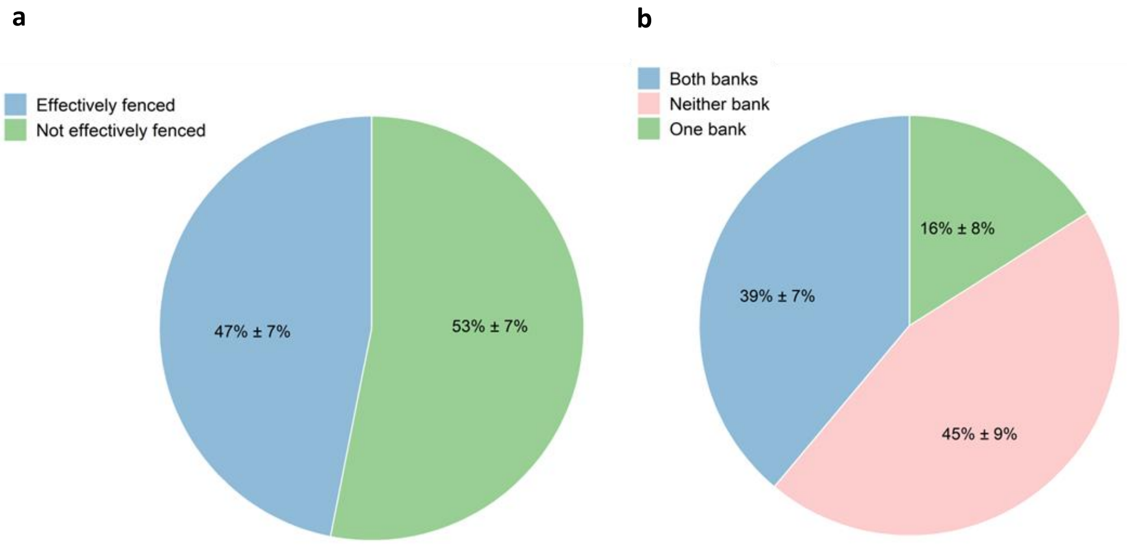

Figure 4. Average proportion of bank length effectively fenced and not effectively fenced (a), and average proportion of stream length effectively fenced on one bank, both banks, and neither bank (b) across the Matahuru catchment in 2024 (n = 49). Error terms represent the 95% confidence intervals about the mean.

There were clear differences in the amount and configuration of riparian fencing between dairy and drystock land uses (Figure 5), with an estimated 91% of total bank length effectively fenced for dairy compared to 32% for drystock ($P < 0.05$). With respect to fencing configuration, the proportion of stream length with effective fencing on both banks and one bank was significantly greater ($P < 0.05$) for dairy (84%) compared to drystock (24%), and the proportion of stream length with fencing on neither bank was higher for drystock (60%) than for dairy (3%) ($P < 0.05$). The proportion of stream length with fencing on one bank but not the other was similar between dairy and drystock land uses (13% and 17% respectively), with no statistically significant difference. The fencing results are consistent with the findings of the latest regional survey (Norris et al., 2025), which demonstrated a significantly higher proportion of fenced waterways on dairy farms compared to drystock farms. Dairy farms are generally located on flatter terrain, making fencing easier and less expensive compared to steeper hill-country areas managed under drystock. Additionally, the dairy industries active promotion of fencing through the Dairy and Clean Streams Accord (active from 2003 to 2012) and the relative financial strength of the dairy industry has contributed to these results. The Clean Streams Accord was superseded by the Dairying Water Accord (DairyNZ, 2018).

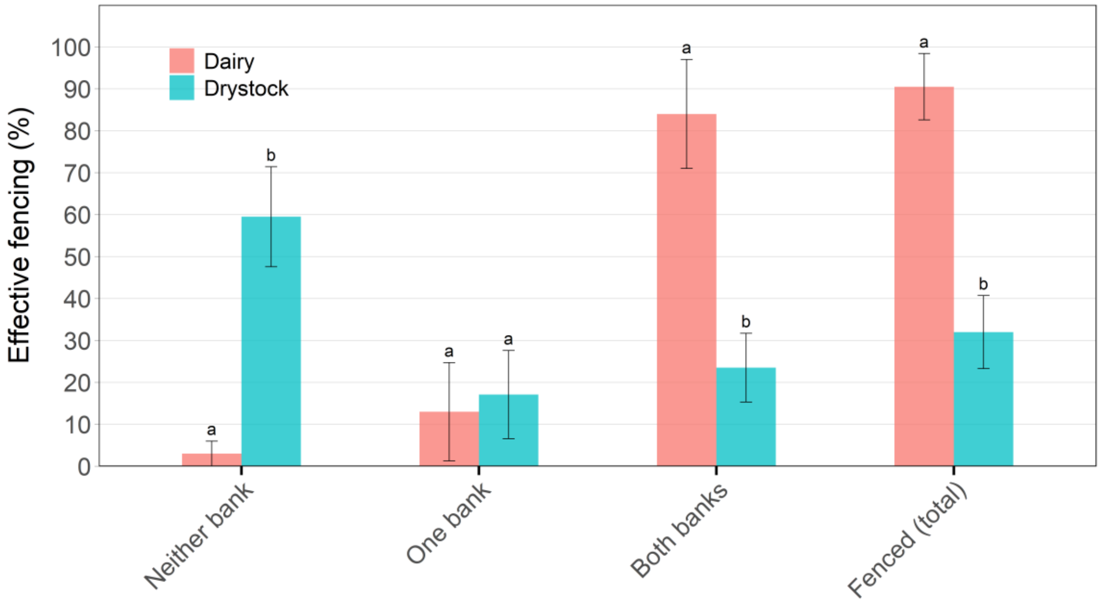

Figure 5. Average proportion of bank length fenced (total) and average proportion of stream length effectively fenced on one bank, both banks, or neither bank within land uses across the Matahuru catchment in 2024. Error bars represent the 95% confidence interval about the average.

The proportion of bank length observed as effectively fenced for each stream order is displayed in Figure 6. Excluding drains (stream order 0), there was a general increase in effective fencing with stream order, with 26% of bank length effectively fenced for first order streams compared to 85% and 77% for third and fourth order streams, respectively. Statistical analysis showed that the proportion of effectively fenced bank length was significantly greater for fourth order streams than for first and second order streams ($P < 0.05$, Figure 6). The proportion of effectively fenced bank length along third order streams was also greater than that of first order streams but was not significantly different to second order streams ($P > 0.05$). Drains had the highest proportion of bank length effectively fenced (92%), significantly greater than first and second order streams.

A study by McDowell et al. (2017) examined the impact of stream order and catchment characteristics on contaminant loads across 728 water quality monitoring sites across New Zealand. Contaminant loads from low order streams (< 1 m wide, 30 cm deep) exempt from potential national stock exclusion regulations accounted for an average of 73% for total nitrogen loads and 84% for total phosphorus. With 74% of first order and 64% of second order streambanks remaining unfenced, these steep headwater streams are likely to contribute substantially to catchment-wide contaminant loads (McDowell et al., 2017). Consequently, alternative mitigation approaches may be required where conventional methods of stock exclusion are impractical or not mandated under policy frameworks. One such approach is the use of virtual fencing to prevent cattle from accessing waterways. Although virtual fencing remains uncommon in steep hill-country, its adoption appears to be increasing as recent improvements to the technology have reduced costs and improved efficacy.

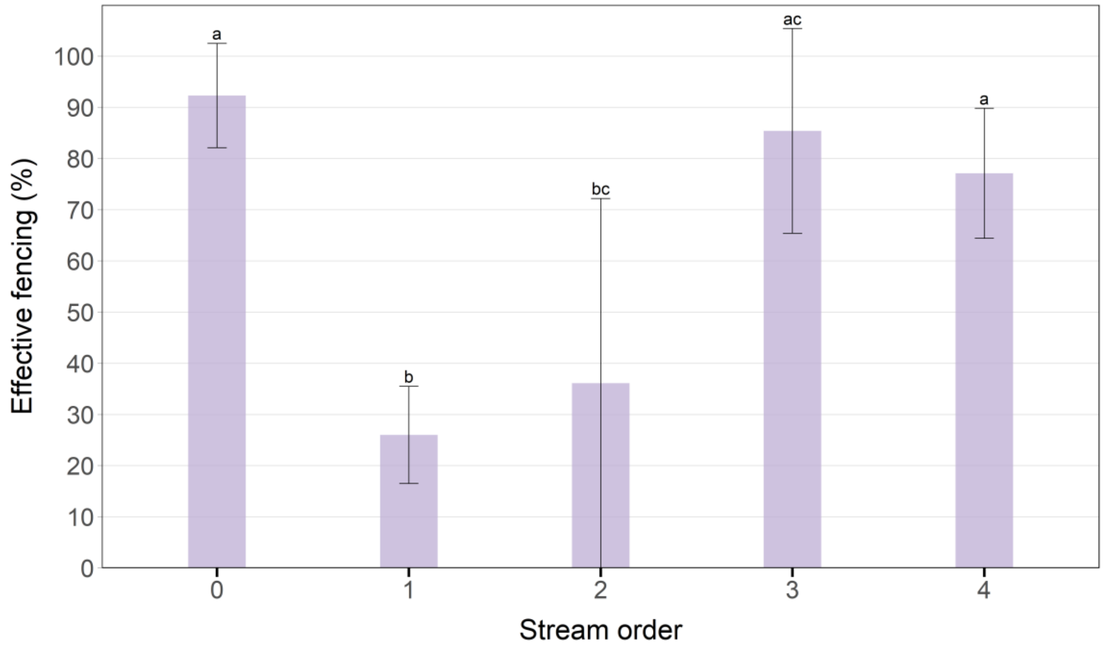

Figure 6. Average proportion of bank length effectively fenced within each stream order in 2024. Stream order 0 represents drains. Error bars represent the 95% confidence intervals about the average. Within each category, averages carrying the same letter are not significantly (P < 0.05) different.

Figure 7 shows the configuration of fencing along waterways, aggregated by stream order and land use. On dairy farms, only 1.4% of the sampled stream length along first order streams were unfenced on both banks, allowing stock to access the waterway. A further 8% were partially fenced, with one bank protected from stock but not the other. Along second order streams, no unfenced waterways were recorded; however, 25% of surveyed sites were partially fenced, with one bank protected from stock but not the other. When evaluating the total bank length (as denoted by the '+' symbols in Figure 7), 95% and 88% of the bank length was effectively fenced along first and second order streams, respectively. Given that Plan Change 1 (PC1) regulations require complete exclusion of dairy cattle from permanently flowing waterways, and assuming a combined bank length of 21 km for first and second-order streams, the required fencing along headwater reaches on dairy farms is estimated to be relatively small (~2 km). Third order streams were almost entirely fenced along both banks (97%), while 82% of fourth order streams were effectively fenced on both banks. This suggests that further work is required in the lower catchment to completely exclude dairy cattle from waterways.

On drystock farms, unfenced riparian margins were mostly associated with first and second-order streams, with 88% and 78% of the bank length unfenced, respectively. Across the catchment, first and second order streams located on drystock land comprise approximately 54% of the river network on all pastoral land. Using data from the 2024 survey, it is estimated that about 79 km of bank length along headwater streams (stream order 1 and 2) on pastoral drystock land remains unfenced. While PC1 regulations do not apply to all these waterways, fencing efforts should be focused on those streams subject to large stock units (i.e. cattle and deer), noting that more than half of streams on drystock land are managed as beef farms (Figure 3). Third and fourth-order streams had an average of 78% and 63% of effectively fenced bank length, respectively. A high proportion of third and fourth order streams within drystock land is effectively fenced (80% and 75%, respectively), reiterating that efforts should be focussed on smaller headwater streams in the upper catchment.

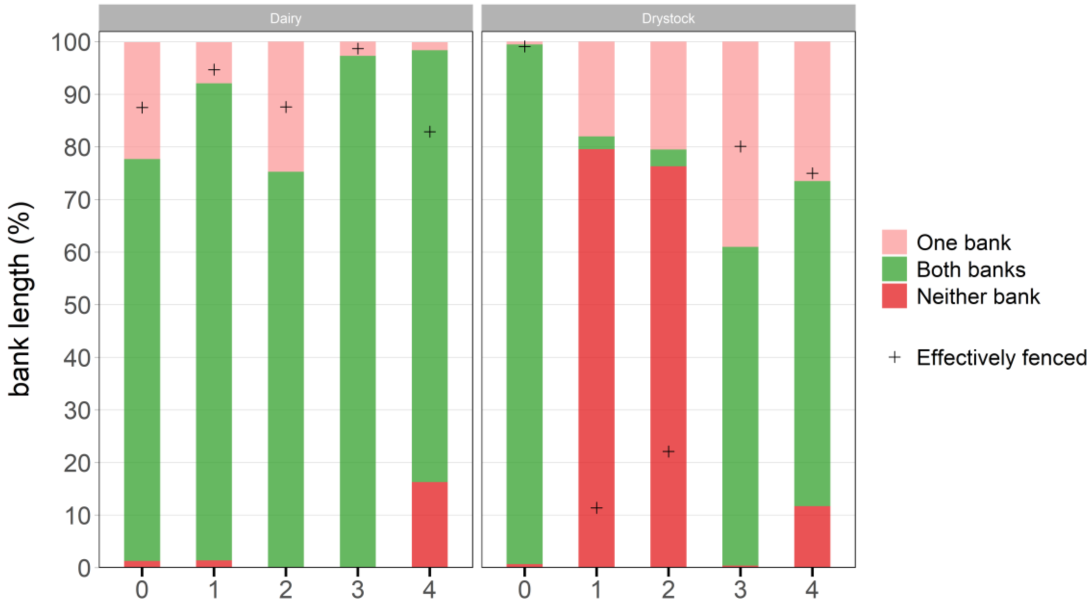

Figure 7. Average proportion of bank length effectively fenced (total, +) and and average proportion of stream length fenced on one bank, both banks, or neither bank, across stream orders on dairy and drystock land uses in the Matahuru catchment (2024). Bank length is calculated as the total distance of both banks along a waterway, while stream length reflects the length of the waterway itself, equivalent to half the total bank length.

3.2.2 Change over time

The average proportion of bank length fenced across the Matahuru catchment saw a very small but non-significant change over the past four years ($P > 0.05$) from 46.6% in 2020 to 46.9% in 2024 (Figure 8, Table 6). The configuration of fencing expressed as a proportion of stream length fenced over time is also shown in Table 7. Although streambanks fenced on both sides increased by 2.1% and those fenced on one side decreased by 3.6%, neither change was statistically significant, indicating no meaningful change over the four-year period.

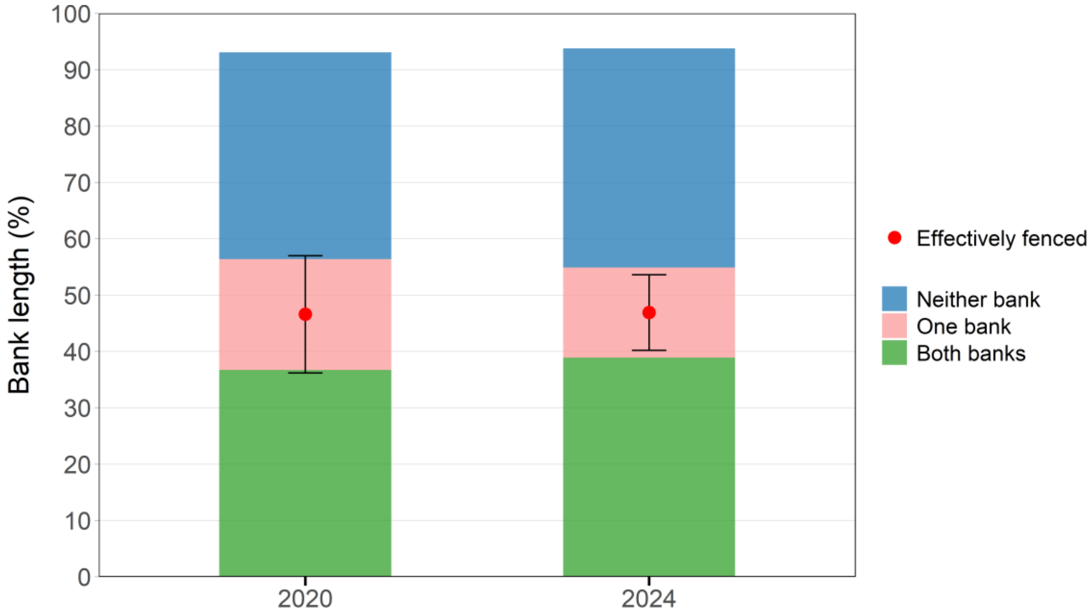

Figure 8. Average proportion of stream length (one bank, both banks, or neither bank) and average proportion of total bank length (represented by the red symbols) effectively fenced for each of the two survey years (2020 and 2024). Error bars represent the 95% confidence interval around the average proportion of effectively fenced bank length.

Table 6. Average change in the proportion of effective fencing for total bank length and stream length categories (one bank, both banks, or neither bank) over the previous 4-year (2020 – 2024) period.

Measure	Category	2020		2024		Change	
		Estimate (ppt†)	95%CI‡	Estimate (ppt†)	95%CI‡	Estimate (ppt†)	95%CI‡
Bank length	Total	46.6	10.4	46.9	6.7	0.3 NS	10
Stream length	Both banks	36.7	9.8	38.9	6.8	2.1 NS	11.2
	One bank	19.7	8.3	16	8.2	-3.6 NS	8.4
	Neither bank	43.6	12.4	45.1	8.8	1.5 NS	10.5

† Percentage point (% of bank length)
‡ 95% Confidence interval about the average.
** Significant at $\alpha = 0.01$, * Significant at $\alpha = 0.05$, NS Not significant.

Analysis of data by broad land use categories (dairy and drystock) revealed small but non-significant increases in total bank length fenced from 2020 to 2024 of 11.7% and 5.5%, respectively (Figure 9, Table 7). While not statistically significant, these results are encouraging and show that dairy cattle are almost completely excluded from waterways within the catchment. A further breakdown of the results by land use and stream order shows that for waterways on dairy farms, statistically significant increases in fencing occurred along first and second order streams (Appendix 5). For drystock farms, increases in the proportion of bank length fenced were constrained to second and third order streams (20% and 37%), although these increases were not statistically significant ($P > 0.05$). Importantly, no meaningful change (0.8 ± 19%) was observed in the proportion of bank length fenced along first order streams on drystock land, which accounts for 44% of the pastoral stream network in the catchment.

In terms of fencing configuration, a significant increase in the amount of fencing along both banks (24 ± 20%) on dairy streams was observed ($P < 0.05$). A corresponding decrease in the proportion of stream length fenced along one bank but not the other was also observed (-25.1 ± 18%). For streams on drystock farms, no statistically significant changes in fencing configuration were detected over time. Nevertheless, the observed increase in stream length fenced on only one bank suggests that fencing efforts over the past four years have generally targeted a single bank rather than fully fencing both sides.

Figure 9. Average proportion of bank length (total) and stream length (one bank, both banks, or neither bank) effectively fenced within land uses (dairy and drystock) at the two survey periods (2020 and 2024). The average proportion of bank length effectively fenced is represented by the black symbols. Error bars represent the 95% confidence interval around the mean.

Table 7. Average change in the proportion of bank length effectively fenced and stream length fenced on one bank, both banks, or neither bank within land uses over the previous 4-year (2020 – 2024) period.

	Land use	2020		2024		Change	
		Estimate (pp†)	95%CI‡	Estimate (pp†)	95%CI‡	Estimate (pp†)	95%CI‡
Fenced (total)	Dairy	78.8	10.5	90.5	7.9	11.7 NS	12.3
	Drystock	26.5	13.1	32	8.7	5.5 NS	15.6
Both banks	Dairy	59.7	16.7	84	13	24.3*	19.7
	Drystock	22.4	11.4	23.5	8.2	1 NS	15.7
One bank	Dairy	38.1	15.2	13	11.7	-25.1**	18
	Drystock	8.2	8.5	17.1	10.5	8.9 NS	12.2
Neither bank	Dairy	2.2	7.6	3	4.7	0.8 NS	8.8
	Drystock	69.4	15.8	59.5	11.9	-10 NS	17.8

† Percentage point (% of bank length)
‡ 95% Confidence interval about the average.
** Significant at α = 0.01, * Significant at α = 0.05, NS Not significant.

3.3 Stock access and exclusion

3.3.1 State

Stock access data is displayed in Figures 10 – 12 below, with raw data tabulated in Appendix 6. Across the catchment, stock were observed in the riparian margin along 25% of the sampled bank length (i.e. current access) (Figure 10). Current stock access refers to the presence of stock within the waterway or riparian margin at the time the survey was conducted. Approximately 28% of the sampled bank length had evidence of recent stock access (i.e. access within recent days), while 6% had evidence of past stock access. Overall, 59% of the sampled bank length displayed some evidence of stock access (sum of past, recent and current); while the remaining 41% of bank length displayed no evidence of stock access. Across the surveyed sites, there was a 6% difference between average bank length with no stock access (41%) and the proportion of bank length effectively fenced (47%). This suggests that there was a small percentage of bank length that was effectively fenced and accessed by stock (6%), likely due to fence breaches or intentional grazing of riparian margins.

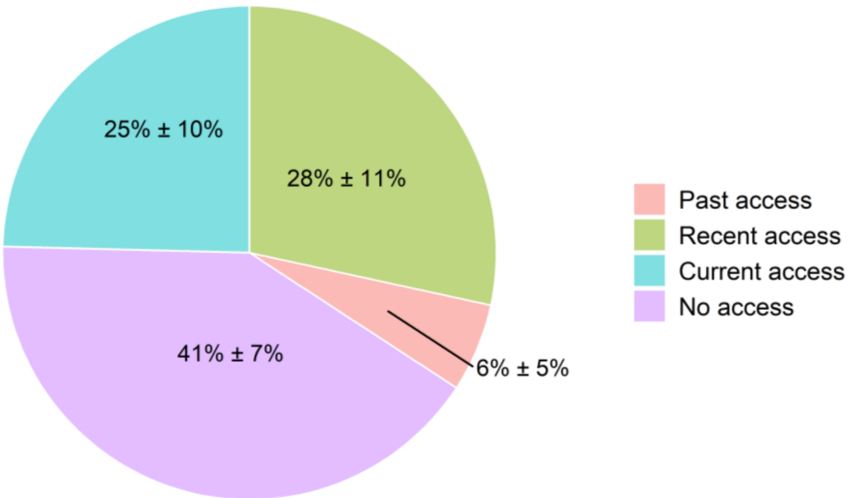

Figure 10. Average proportion of bank length with no stock access, and past, recent, or current stock access observed across the Matahuru catchment in 2024 (n = 49). Error terms represent the 95% confidence intervals about the mean.

Across the Matahuru catchment, the amount of total stock access was considerably less for dairy (11% of bank length) than for drystock (75% of bank length) (Figure 11). This was also the case for each individual stock access category, especially for the recent and current stock access categories (Figure 11). Recent stock access was observed along 8% of sampled bank length on dairy farms compared with 35% on drystock farms ($P < 0.05$), while current stock access was absent along waterways on dairy farms but present along 33% of sampled bank length on drystock farms ($P < 0.05$). Differences in stock access were driven primarily by the association of dairy land uses with flatter terrain, making fencing relatively less expensive than for steeper hill-country streams located on sheep and beef farms. Furthermore, initiatives such as the Sustainable Dairying: Water Accord (DairyNZ, 2018) have encouraged improved riparian management and the exclusion of stock from waterways on dairy farms.

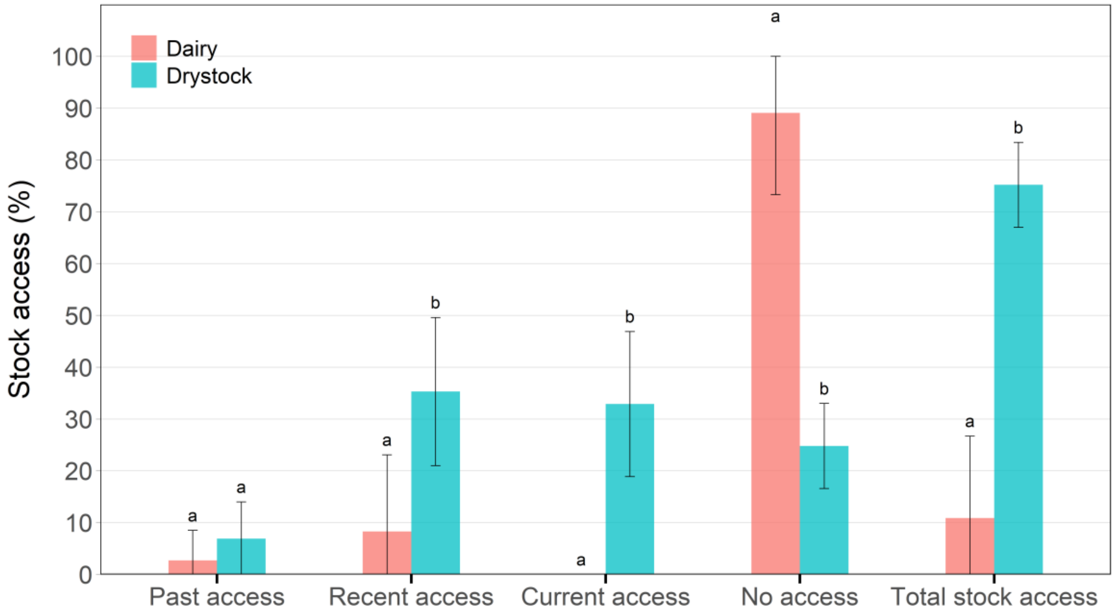

Figure 11. Average proportion of bank length with total stock access and past, recent, or current stock access within land uses (dairy and drystock) across the Matahuru catchment in 2024. Error bars represent the 95% confidence intervals about the average.

Consistent with fencing results, stock access generally decreased with increasing stream order, reflecting the low amount of fencing along headwater streams (Figure 12). First and second order streams exhibited the highest proportion of sampled bank length accessible to livestock, with values of 82% and 65%, respectively. In contrast, the proportion of sampled bank length along medium to large waterways (stream orders 3 and 4) accessible to stock was considerably lower ranging from 24% to 33% (Figure 12). These findings indicate that fencing and riparian restoration efforts should prioritise headwater streams to prevent access of cattle to waterways.

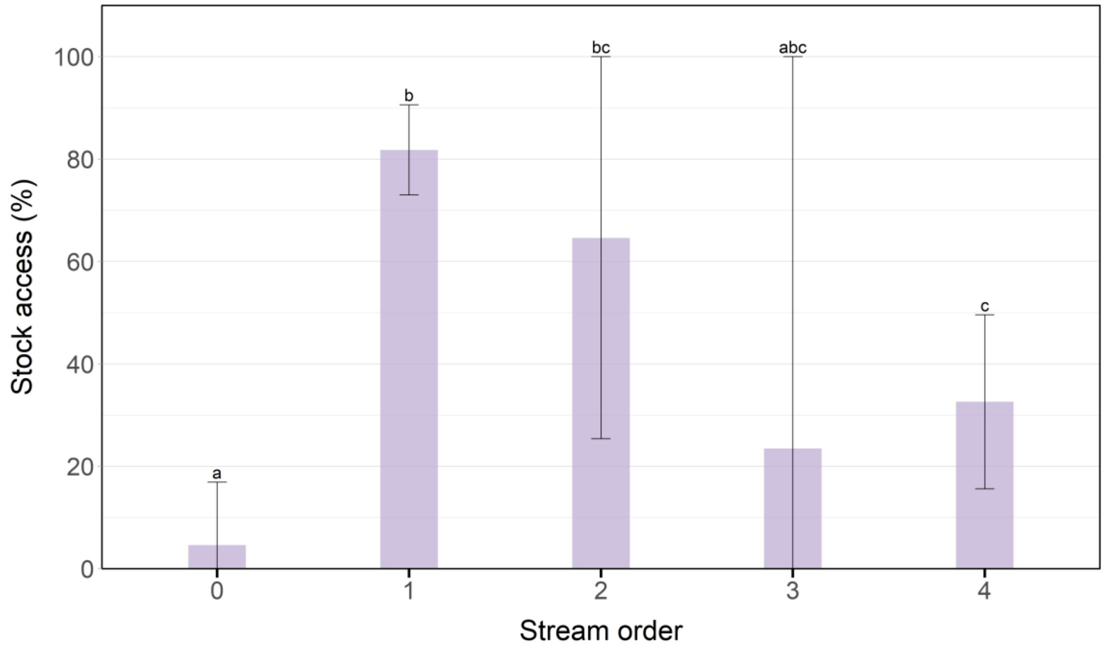

Figure 12. Stock access (none, past, recent, or current) along surveyed lengths of waterway during the 2024 Matahuru catchment riparian survey.

3.3.2 Change over time

Across the catchment, the average proportion of surveyed bank length showing evidence of stock access decreased by 2.9% between 2020 and 2024 but the change was not significant at the α = 0.05 level (Figure 13, Table 8). In terms of individual stock access categories, only past access saw a statistically significant change between survey years from 18.4% in 2020 to 5.8% in 2024 ($P < 0.05$). However, the decrease in past stock access was largely offset by small and non-significant increases in current (6.7%) and recent (3%) stock access (Table 8).

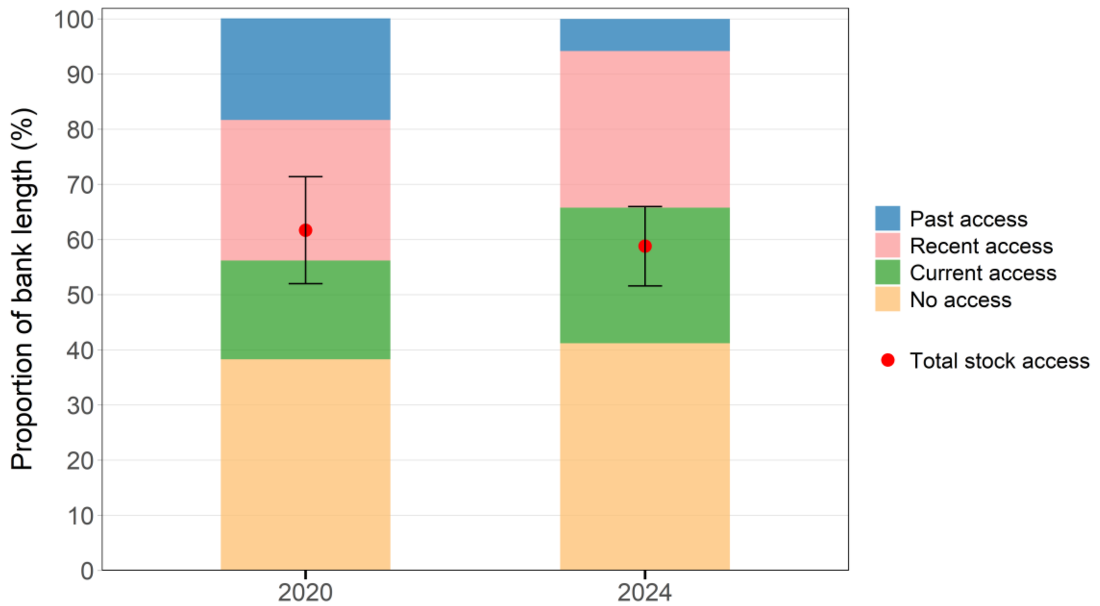

Figure 13. Average change in the proportion of bank length with no stock access and past, recent, or current stock access observed across the Matahuru catchment for the past two survey years (2020 and 2024). Red dots represent the average proportion of sampled bank length accessible to stock, while error bars represent the 95% confidence around the means.

Table 8. Average proportion of bank length subject to stock access (total access and individual stock access classes) during the 2020 and 2024 surveys and change over the previous 4-year (2020 – 2024) period.

	2020		2024		Change	
Stock access category	**Estimate (ppt†)**	**95%CI‡**	**Estimate (ppt†)**	**95%CI‡**	**Change (ppt†)**	**95%CI‡**
Past	18.4	10.3	5.8	5.4	-12.6*	10.3
Recent	25.5	11.6	28.4	11.3	3^{NS}	19
Current	17.9	10.3	24.6	10.3	6.7^{NS}	16.8
Total access	61.7	9.7	58.8	7.2	-2.9^{NS}	10

† Percentage point (% of bank length)
‡ 95% Confidence interval about the average.
** Significant at α = 0.01, * Significant at α = 0.05, NS Not significant.

When considering the broad land use categories (dairy and drystock), streambanks on dairy farms saw a large decrease in total stock access (19%) between 2020 and 2024 but the change was marginally non-significant at the α = 0.05 level (Figure14, Table 9). The largest decreases in stock access occurred along first and fourth order streams (-32% and -18% respectively, Appendix 6). Overall, stock accessed 11% of surveyed bank length on dairy farms in 2024, a marked improvement from 30% in 2020. Across drystock farms, there was a small and non-significant decrease of 6% in total stock access between 2020 and 2024 (P > 0.05, Table 9). While past access decreased by 14% on drystock farms between survey years, this was largely offset by small increases in current (6%) and recent (3%) stock access.

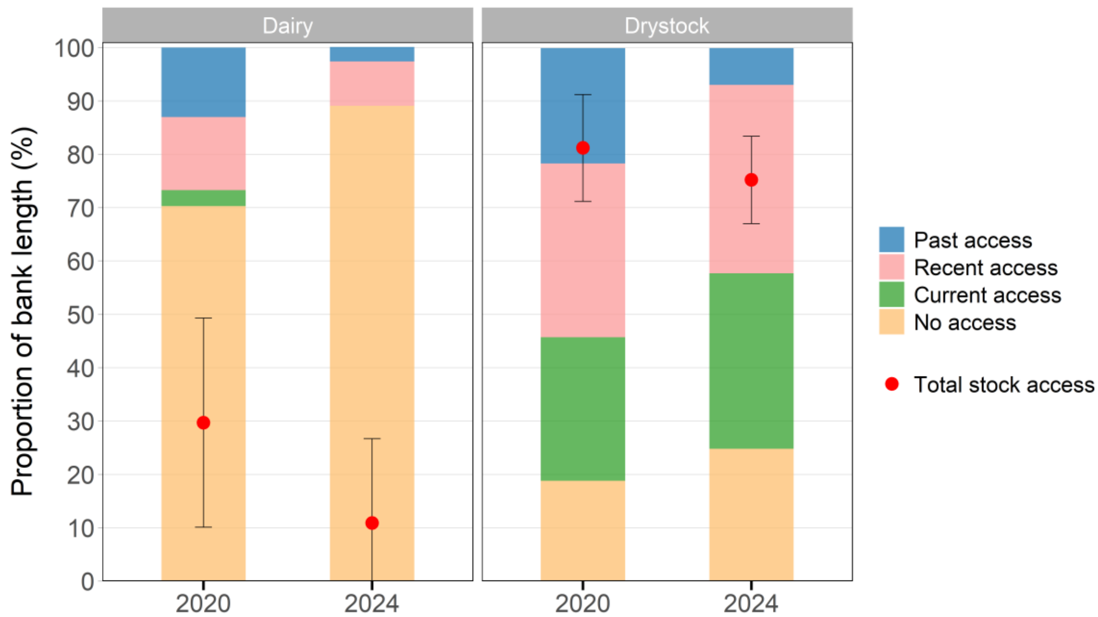

Figure 14. Average change in the proportion of bank length (total) with no stock access, and past, recent, or current stock access within land uses (dairy and drystock) in 2020 and 2024. Average proportion of bank length effectively fenced (total fencing) is indicated by the red symbols, with error bars representing the 95% confidence interval about the average.

Table 9. Average proportion of bank length with past, recent, or current, as well as total stock access observed across the Matahuru catchment within land use types at each of the two survey periods and average change over the previous 4-year (2020 – 2024) period.

Stock access category	Land use	2020		2024		Change	
		Estimate (pp†)	95%CI‡	Estimate (pp†)	95%CI‡	Estimate (pp†)	95%CI‡
Past	Dairy	13	9	2.7	5.8	-10.4*	9.7
	Drystock	21.6	16	6.9	7.1	-14.7	16.5
Recent	Dairy	13.7	17.8	8.3	14.8	-5.4	18.7
	Drystock	32.6	17	35.3	14.3	2.7	27.8
Current	Dairy	3.0	7.9	0.0	0.0	-3.0	8.9
	Drystock	26.9	15.6	32.9	14	6.0	24.7
Total access	Dairy	29.7	19.6	10.9	15.8	-18.8	19.1
	Drystock	81.2	10	75.2	8.2	-6.1	12.6

† Percentage point (% of bank length)
‡ 95% Confidence interval about the average.
** Significant at α = 0.01, * Significant at α = 0.05, NS Not significant.

3.4 Riparian vegetation

3.4.1 State

Key riparian vegetation data for 2024 is summarised in Figures 15 – 17 below, with raw data tabulated in Appendix 7 and 8. Across the surveyed sites, 84% of bank length was covered by non-woody vegetation (e.g. grasses and weeds) and 16% by woody vegetation (Figure 15a). Woody vegetation was broken down further into exotic (willow and 'other deciduous'), and native vegetation, while non-woody species were classified as either 'grass and weeds' or 'flax/sedge/rush'. The average proportion of sampled bank length occupied by individual vegetation classes are displayed in Figure 15b. Grass and weed species were the dominant vegetation type along waterways, occupying 81% of sampled bank length, followed by woody native species (8%), woody deciduous (5%), and flax/sedge/rush species (4%). The remaining bank length was covered by woody willow (2%).

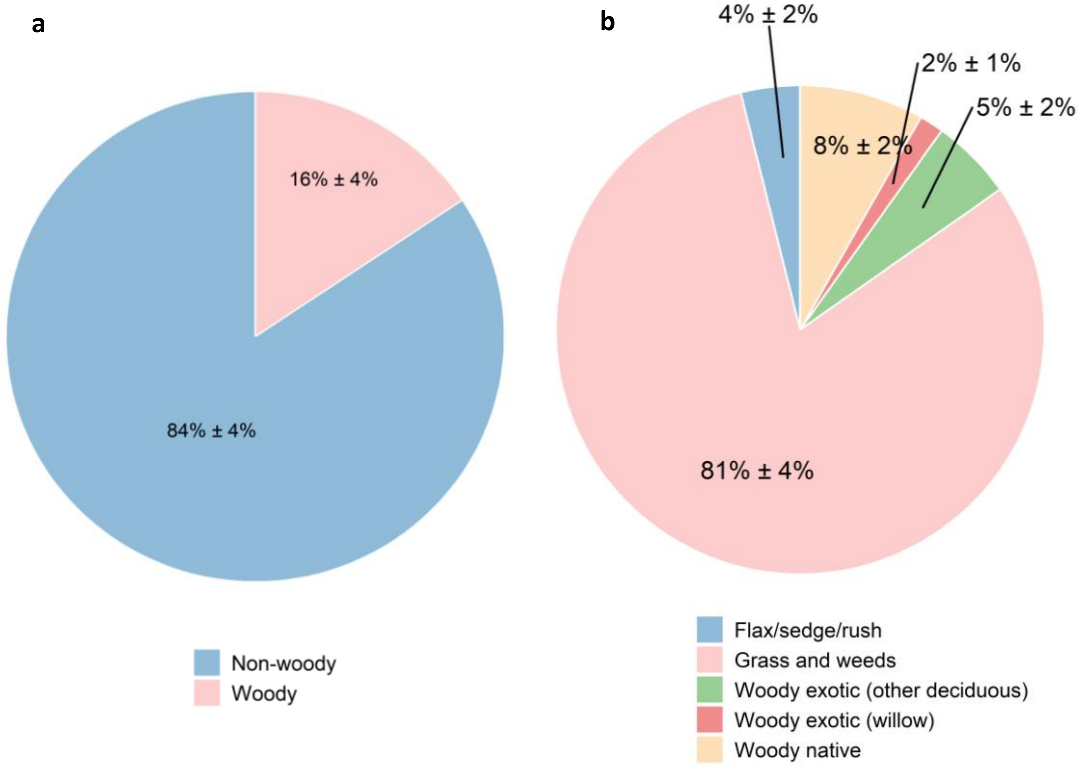

Figure 15. Average proportion of bank length with woody and non-woody vegetation (a) and individual vegetation types (b) across the Matahuru catchment in 2024 (n = 49). Error margins represent the 95% confidence intervals about the average.

Grass and weed species were the most dominant vegetation type along stream banks on both dairy and drystock farms (78% and 75%, respectively), with no statistically significant difference between land uses. There were similar proportions of bank length with woody native (8% – 9%), woody willow (1% – 2%), and flax/sedge/rush (2% – 5%). The vegetation class 'woody exotic (other)' includes deciduous and evergreen species and covered a greater proportion of bank length along streams on dairy farms (11%) than on drystock (4%) ($P < 0.05$). Overall, there was no statistically significant difference in the coverage of woody species along streams on dairy versus drystock farms ($P > 0.05$, Figure 16). Drains and first order streams contained the lowest proportion of woody vegetation (8% – 9% of bank length, Figure 17), followed by second and third order streams (13% – 19% of bank length). Fourth order streams in the lower catchment contained the highest proportions of woody vegetation (50% of bank length). Statistical analysis revealed no difference in the amount of woody vegetation between small to medium waterways (i.e. drains and 1st, 2nd and 3rd order streams), while fourth order waterways contained significantly ($P < 0.05$) more woody vegetation than all other stream orders.

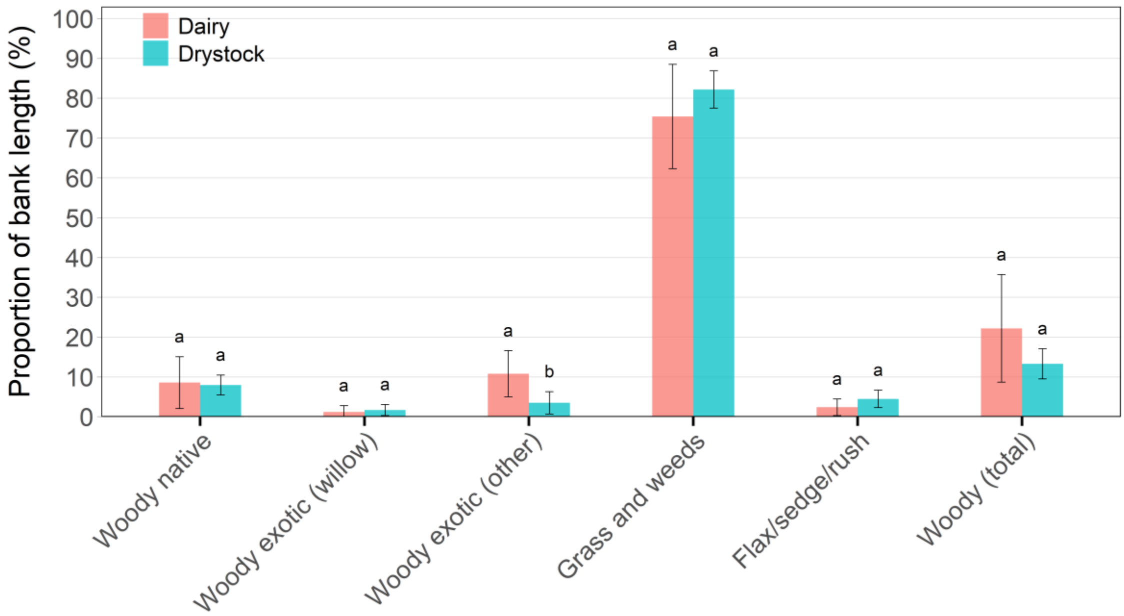

Figure 16. Average proportion of bank length occupied by individual vegetation types within land uses (dairy and drystock) across the Matahuru catchment in 2024. Error bars represent the 95% confidence intervals about the average.

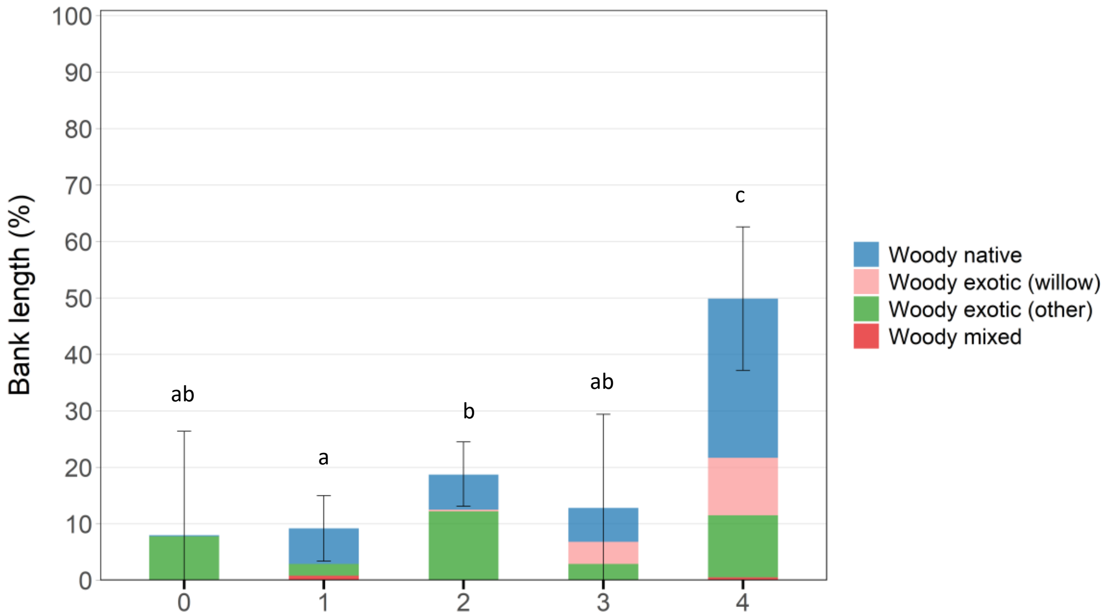

Figure 17. Average proportion of bank length associated with woody vegetation within each stream order in 2024. Error bars represent the 95% confidence bounds around the mean for total woody vegetation.

3.4.2 Change over time

Across the Matahuru catchment, there was a statistically significant decrease of 11% in the average proportion of bank length occupied by woody vegetation between 2020 and 2024 ($P < 0.01$) (Figure 18, Table 10). The overall reduction in woody vegetation was mainly due to a 4.5% decline in the proportion of bank length covered by "other" exotic woody species, which include both deciduous and evergreen exotic plants ($P < 0.05$, Table 10). This could be a result of clearance, either to make way for native species or to minimise obstruction of the river channel. While small changes were observed for other woody species (i.e. natives, willows, and mixed), these were non-significant and within the expected margin of error. A notable difference in the coverage of flax/sedge/rush and grass/weeds were observed between survey years (both significant at $\alpha = 0.05$). The increase in grass and weed cover, alongside the decline in coverage of flax/sedge/rush species, could be linked to differences in how these vegetation groups were classified during each survey. Catchment conditions at the time of the survey (e.g. soil moisture, level of grazing prior to the survey) can influence which dominant vegetation group is observed. For example, similar observations were reported in the regional riparian surveys conducted in 2007 and 2012, where pronounced differences in the cover of grasses/weeds and flax/sedge/rush between survey years were attributed to variation in how these categories were observed and recorded during each survey (Norris et al., 2025). However, in the case of the Matahuru catchment, the current survey approach only covers 2 points in time (2020 and 2024) and more long-term data Is required to determine whether the decrease in flax/sedge/rush between survey years was an anomaly or part of a long-term trend.

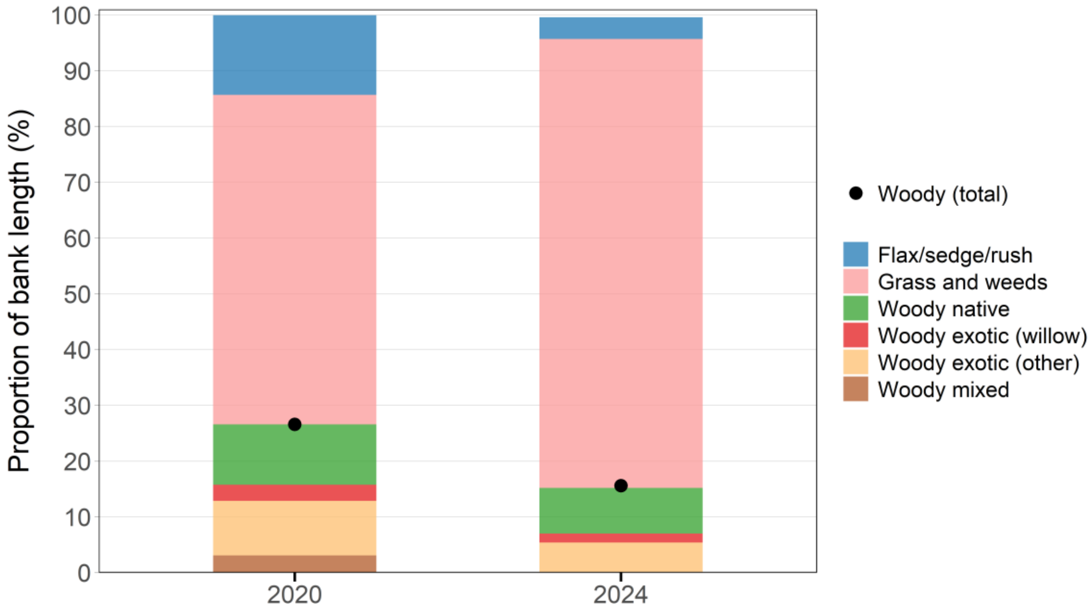

Figure 18. Average proportion of bank length occupied by woody vegetation (black symbols) and individual vegetation types at the two survey periods (2020 and 2024) across the Matahuru catchment.

Table 10. Average change in the proportion of bank length occupied by woody vegetation and individual vegetation types over the previous 4-year (2020 – 2024) monitoring period.

Vegetation class	2020		2024		Change	
	Estimate (pp†)	95%CI‡	Estimate (pp†)	95%CI‡	Estimate (pp†)	95%CI‡
Woody (willow)	2.9	5	1.6	1.1	-1.3	4.5
Woody exotic (other)	9.8	4.9	5.4	2.4	-4.5*	3.6
Woody (native)	10.8	5.9	8.2	2.2	-2.6	5.2
Woody (mixed)	3.1	3.7	0.5	0.8	-2.6	4.2
Flax/sedge/rush	14.3	7.3	3.9	1.7	-10.4**	7.7
Grass and weeds	59.1	10.5	80.5	4.2	21.4**	10.3
Woody (total)	26.6	8.7	15.6	3.8	-11**	7.5

† Percentage point (% of bank length)
‡ 95% Confidence interval about the average.
** Significant at α = 0.01, * Significant at α = 0.05, NS Not significant.

When considering land use effects, the pattern of change over time for individual vegetation types and woody vegetation was similar to that of the entire catchment (Figure 19). Most notable was the decrease in woody vegetation across both dairy and drystock farms (marginally non-significant at α = 0.05, Table 11). There is insufficient trend data to determine the drivers behind changes in the coverage of woody vegetation across the catchment, but it appears that the decline is attributed to clearance of exotic tree species rather than a decline in native species. Given the increased level of riparian restoration across the catchment in recent years, it is anticipated that the coverage of native vegetation will increase as plants become established within riparian margins.

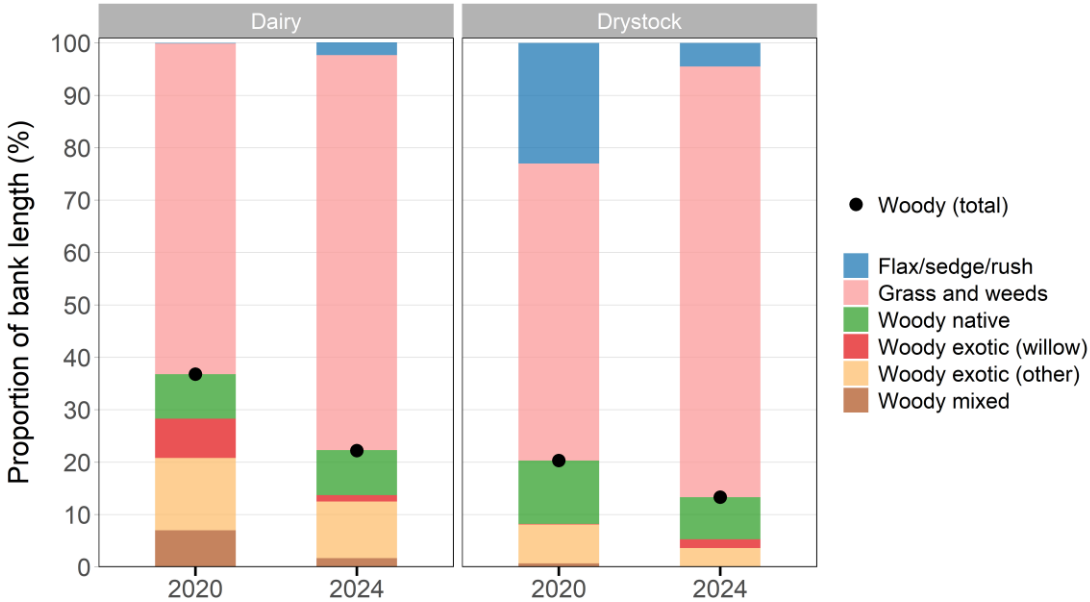

Figure 19. Average proportion of bank length occupied by woody vegetation and individual vegetation types within land uses (dairy and drystock) at the two survey periods (2020 and 2024). Total proportion of woody vegetation coverage is indicted by the black symbols.

Table 11. Average change in the proportion of bank length occupied by individual vegetation types and woody vegetation within land uses (dairy and drystock0 over the previous 4-year period (2020 – 2024).

Vegetation type	Land use	2020		2024		Change	
		Estimate (pp†)	95%CI‡	Estimate (pp†)	95%CI‡	Estimate (pp†)	95%CI‡
Woody (willow)	Dairy	7.5	12.9	1.2	1.6	-6.3	12.3
	Drystock	0.1	0.4	1.7	1.4	1.6	2.3
Woody exotic (other)	Dairy	13.8	7.3	10.8	5.8	-3	8.3
	Drystock	7.4	7	3.5	2.8	-3.9	5.4
Woody (native)	Dairy	8.5	8.8	8.6	6.5	0.1	7
	Drystock	12.1	8.7	8	2.5	-4.1	7.9
Woody (mixed)	Dairy	7	9.6	1.7	3.5	-5.3	10.9
	Drystock	0.7	0.8	0.1	0.1	-0.6	0.9
Flax/sedge/rush	Dairy	0.1	0.4	2.4	2.1	2.2**	1.2
	Drystock	23	11.1	4.5	2.2	-18.6**	11.8
Grass and weeds	Dairy	63.1	14.9	75.4	13.1	12.3	14.8
	Drystock	56.7	15.6	82.2	4.7	25.6**	16
Woody (total)	Dairy	36.8	15	22.2	13.5	-14.6	15
	Drystock	20.3	10.7	13.3	3.8	-7	9.7

† Percentage point (% of bank length)
‡ 95% Confidence interval about the average.
** Significant at α = 0.01, * Significant at α = 0.05, NS Not significant.

3.5 Vegetation buffer widths and management

Data relating to vegetation buffer width and management is summarised in Figures 20 – 24 below, with associated data tabulated in Appendix 9 to Appendix 10. Vegetation buffer width describes the width (m) of the riparian margin vegetation, which in some cases corresponds to the distance from the fence to the edge of the waterway. On average, 7% of the surveyed bank length had buffer widths of 5 m or more (described as 'wide'), while 40% of bank length had buffer widths of less than 5 m (described as 'narrow') (Figure 20a). The remainder of sampled bank length was unfenced, allowing stock to access the waterways. The individual buffer width categories are displayed in Figure 20b. Approximately 3% of the sampled bank length across the catchment had buffer widths exceeding 10 meters, predominantly associated with large waterways in the lower catchment (refer to Appendix 9). About 18% of surveyed bank length was identified as having buffer widths of < 2 m. Buffer widths of 2–5 m and 5–10 m accounted for 21% and 5% of the total bank length, respectively.

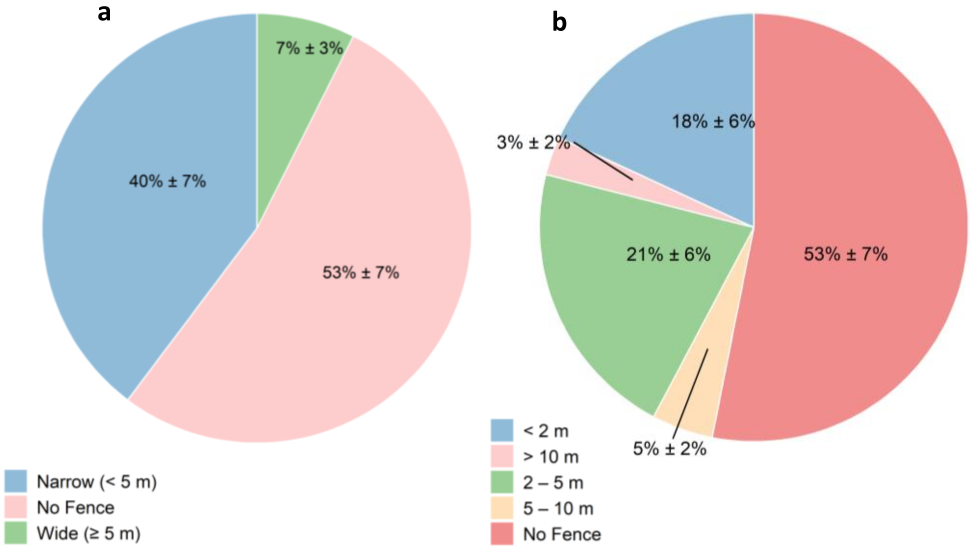

Figure 20. Average proportion of bank length with narrow (< 5 m) and wide (> 5 m) buffer widths (a) and individual buffer width categories (b) across the Matahuru catchment in 2024 (n = 49). The proportion of unfenced bank length is included for reference. Error terms represent the 95% confidence intervals about the average.

For dairy farms, 83% of bank length was associated with narrow buffer widths and 8% with wide buffer widths, with the remaining 9% of bank length being unfenced (Figure 21). For drystock, most of the sampled bank length was unfenced (68%) with about 25% and 7% associated with narrow and wide buffer widths respectively. In terms of land use effects, there was a significantly higher proportion of bank length associated with narrow buffers for dairy compared to drystock ($P < 0.01$), while drystock sites had a significantly higher proportion of unfenced bank length than dairy sites ($P < 0.01$, Figure 16).

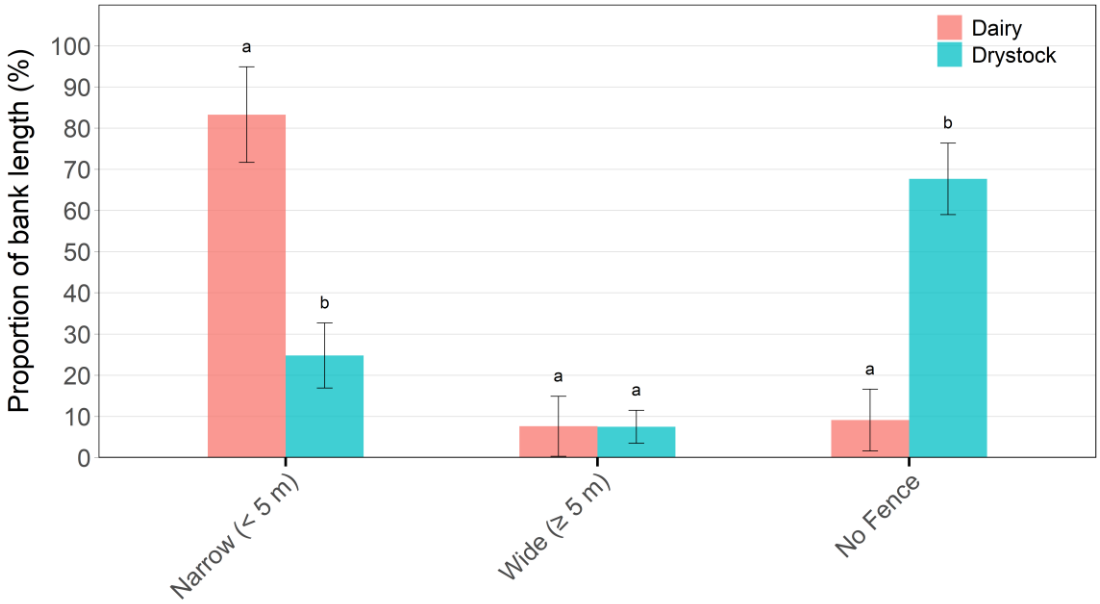

Figure 21. Average proportion of bank length with narrow (< 5 m) and wide (> 5 m) buffer widths within major land uses (dairy and drystock) across the Matahuru catchment in 2024. The proportion of unfenced bank length is included for reference.

Vegetation management was determined by assessing factors such as weed control, access of stock to the riparian margin, and active pest management. Overall, 57% of the surveyed riparian margins were grazed, with the remaining 43% being unmanaged (Figure 22a). Margins that were planted were almost entirely unmanaged, with 6% of surveyed margins being planted and unmanaged (Figure 22b). Those sites that were unplanted were either actively grazed (56% of sampled bank length) or excluded from stock but not actively managed (37% of bank length). A small proportion of bank length (0.6%) was unplanted and managed.

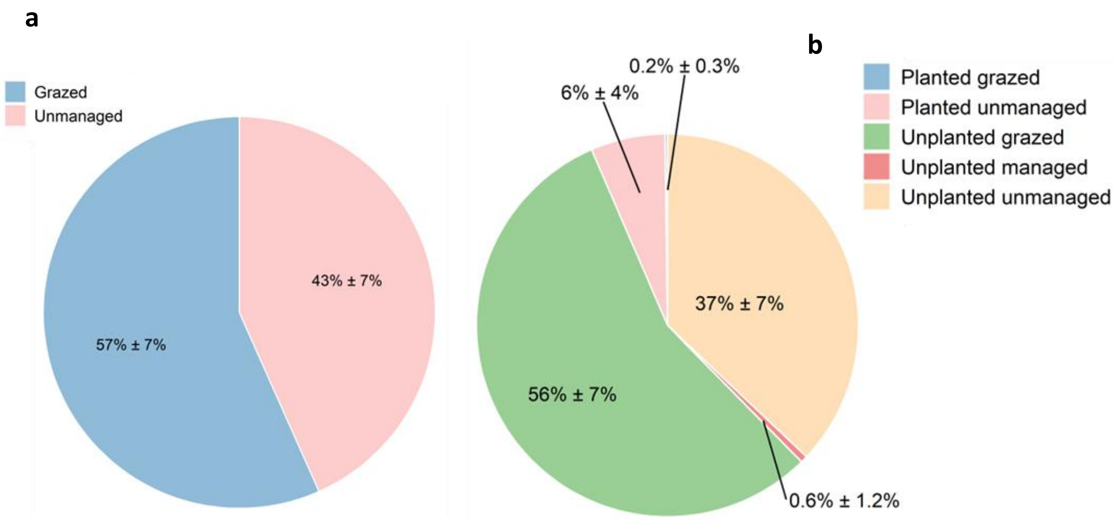

Figure 22. Average proportion of bank length with grazed, managed, and unmanaged riparian margins (a) and individual vegetation management categories (b) across the Matahuru catchment riparian survey sites in 2024 (n = 49). Error terms represent the 95% confidence interval about the average.

Examining the interaction between fencing and riparian management revealed that about 5% of surveyed bank length used for grazing was effectively fenced (Figure 23). These sections were located mainly on third and fourth order streams (Appendix 10). Most fenced bank length was unmanaged (41%), while most unfenced bank length was periodically grazed by stock (51%). A small proportion of bank length (2%) was unfenced and unmanaged. These sections typically occur adjacent to cropping or 'other' land use areas where livestock are not routinely present.

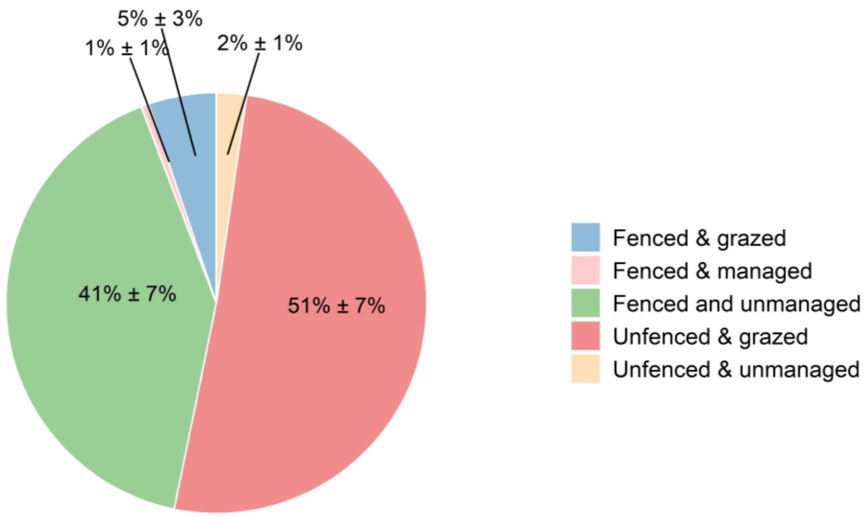

Figure 23. Interaction between effective fencing and vegetation management, observed along sampled bank length in the Matahuru catchment in 2024 (n = 50). Error terms represent the 95% confidence intervals about the average.

Figure 24 shows the interaction between fencing and riparian management within land uses (dairy and drystock) across the catchment. The proportion of bank length fenced and grazed was comparable between dairy and drystock (3% – 6%). For drystock, surveyed bank length was predominantly unfenced and grazed (67%) while for dairy, surveyed bank length was predominantly fenced and unmanaged (88%).

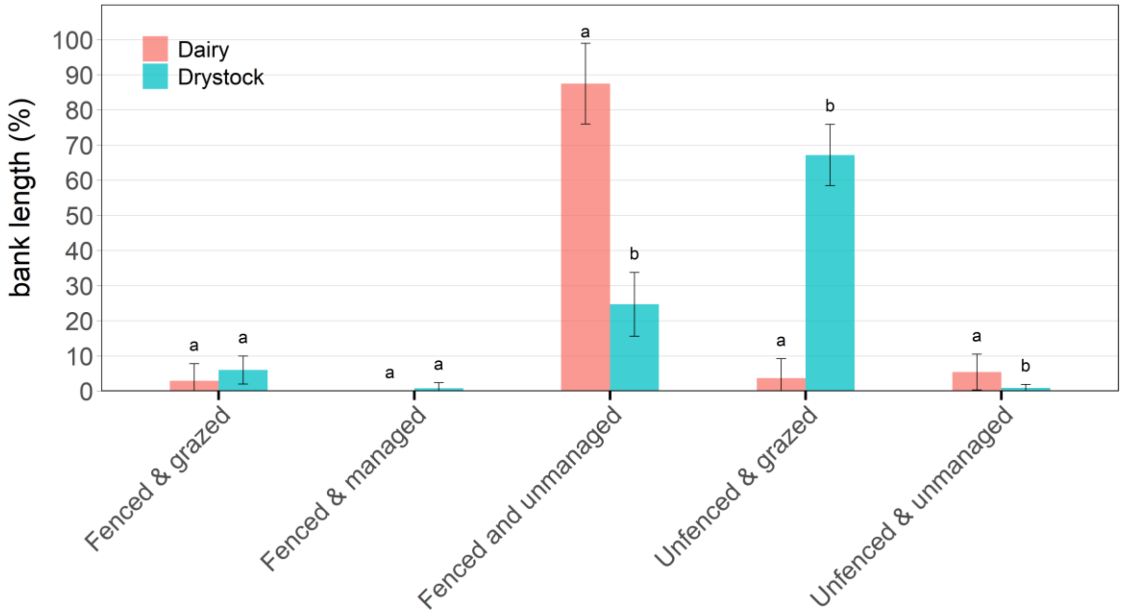

Figure 24. Interaction between fencing and vegetation management within land uses (dairy and drystock) across the Matahuru catchment in 2024. Error bars represent the 95% confidence interval about the average.

3.6 Stream-bank erosion

3.6.1 State

Key information relating to stream bank erosion is summarised in Figures 25 – 28 below, with raw data tabulated in Appendix 12 to Appendix 14. The majority (92%) of bank length across the catchment in 2024 was uneroded (Figure 25a). Approximately 1% of surveyed bank length was classified as 'unobserved' due to the presence of vegetation along the stream bank that obscured evidence of stream bank erosion. Of the 3% of bank length observed to be eroded, 1% showed signs of active erosion while 2% had recent erosion. Bare soil associated with vegetation cover (e.g. under Totara stands) accounted for 5% of bank length. Soil disturbance is the sum of total stream-bank erosion (active or recent erosion) and pugging disturbance (> 50% pugging disturbance within the riparian margin). Across the catchment, approximately 12% of the surveyed bank length showed signs of disturbance, with 8% displaying evidence of pugging (Figure 25b). The remaining 88% of bank length was classified as undisturbed.

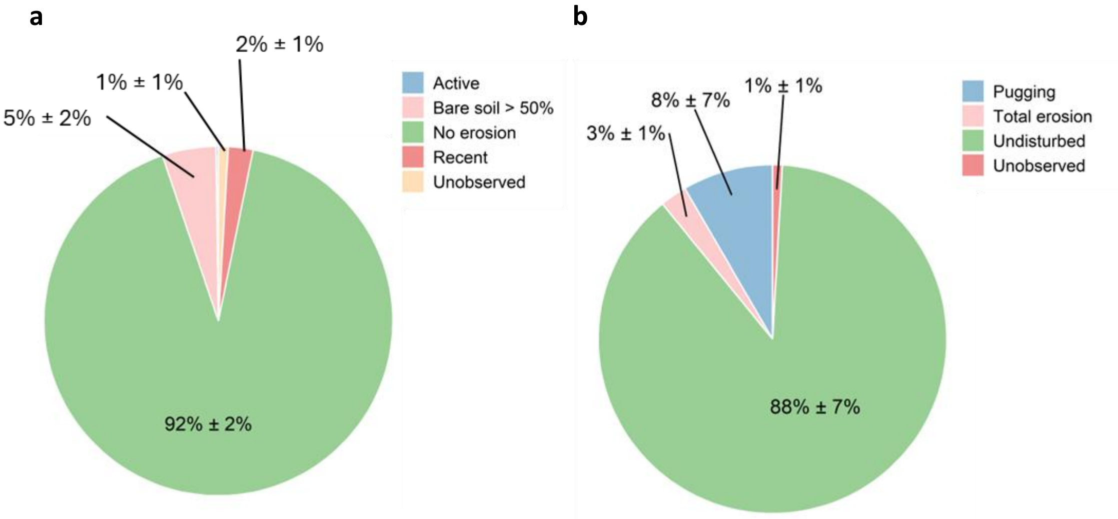

Figure 25. Average proportion of bank length (a) uneroded and with active or recent erosion or bare soil and (b) undisturbed and with erosion or pugging disturbance across the Matahuru catchment in 2024 (n = 49).

There was a greater proportion of bank length impacted by total erosion for drystock (3%) compared to dairy (1%) land use although differences weren't statistically significant at the α = 0.05 level (Figure 26). However, there was significantly more bank length with recent erosion for drystock (2.7%) compared to dairy (1.1%). While disturbance due to pugging was greater for drystock (10%) than for dairy (4%), the difference was not statistically significant. For drystock farms, 13% of bank length was classified as disturbed (pugging plus total erosion), compared with an estimated 5% on dairy farms—a difference that was not statistically significant at α = 0.05. Overall, these results are consistent with differences in stock exclusion (and effective fencing) between dairy and drystock (Figure 5 & Figure 7). That is, in drystock systems where levels of stock exclusion were lower on average, levels of soil disturbance were elevated.

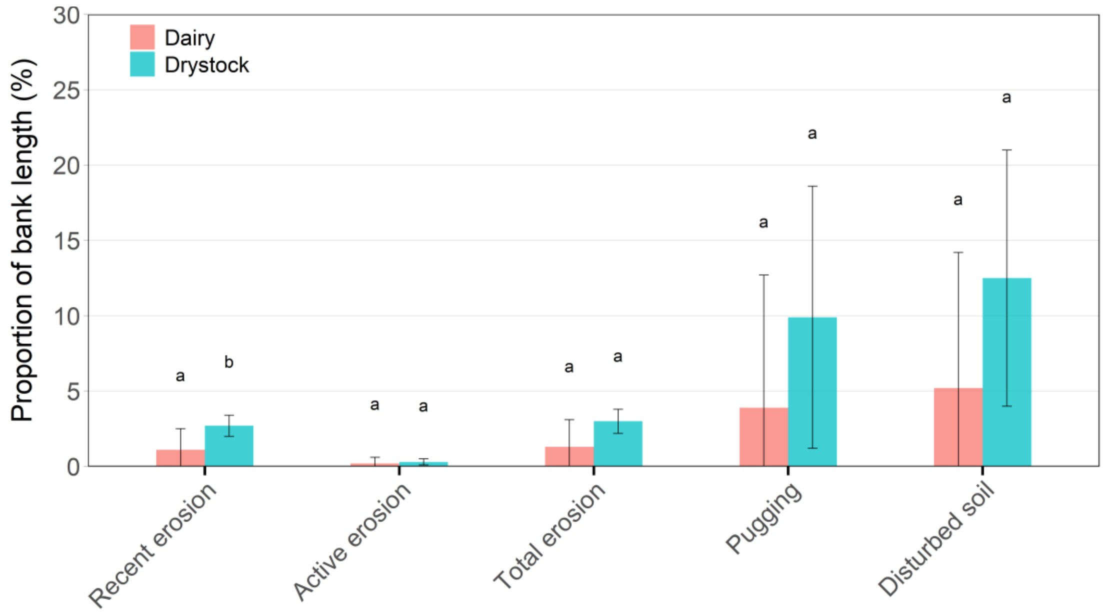

Figure 26. Average proportion of bank length eroded and bank length disturbed (with recent and active erosion components and pugging disturbance) within land uses (dairy and drystock) across the Matahuru catchment in 2024. Error bars represent the 95% confidence interval about the average.

Figure 27 displays the proportion of bank length subject to streambank erosion, broken down by stream order. There was a general increase in the proportion of surveyed bank length with observed streambank erosion with increasing stream size. Due to the large variance in streambank erosion observations (as indicated by the large confidence intervals), there was no statistically significant difference in the amount of streambank erosion between drains, and first to third order streams. However, the amount of streambank erosion was significantly greater along fourth order streams compared to drains, as well as first and second order streams. The Matahuru stream in the lower catchment is deeply incised in places and is particularly prone to streambank erosion along unprotected margins.

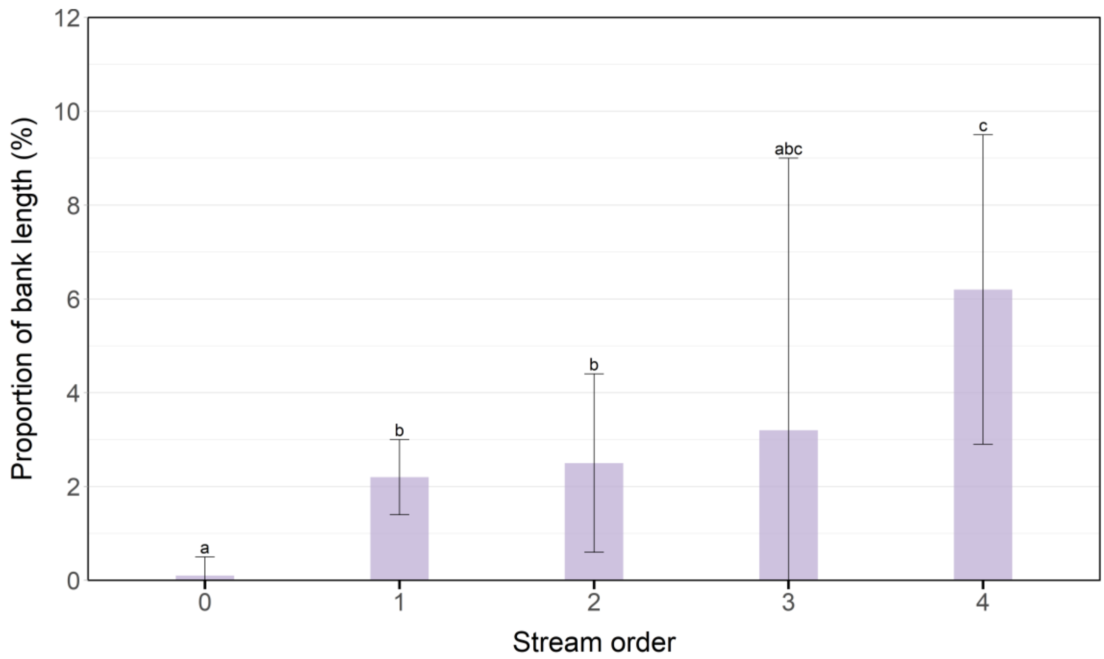

Figure 27. Average proportion of bank length with observed streambank erosion (recent or active) within each stream order in 2024.

When considering disturbance as whole, which is the proportion of bank length subject to streambank erosion or pugging, there were no statistically significant differences between stream orders (Figure 28). This is not surprising due to the highly variable nature of both pugging and streambank erosion as indicated by the large 95% confidence intervals. However, in general, the proportion of disturbed bank length was higher for first and second order streams (14% and 11%, respectively) compared to third and fourth order streams (3% and 6%, respectively). Pugging was the dominant disturbance type along drains, as well as first and second order streams with observed values of 7%, 12%, and 9%, respectively. It is noted that for drains, pugging occurred along a single, fully fenced drain. It is likely that the fence was breached by cattle prior to the survey, meaning the observed pugging may not represent typical disturbance along drains in the lower catchment. Along larger third and fourth order streams, no pugging was observed, reflecting the high proportion of effective fencing along waterways in the lower catchment.

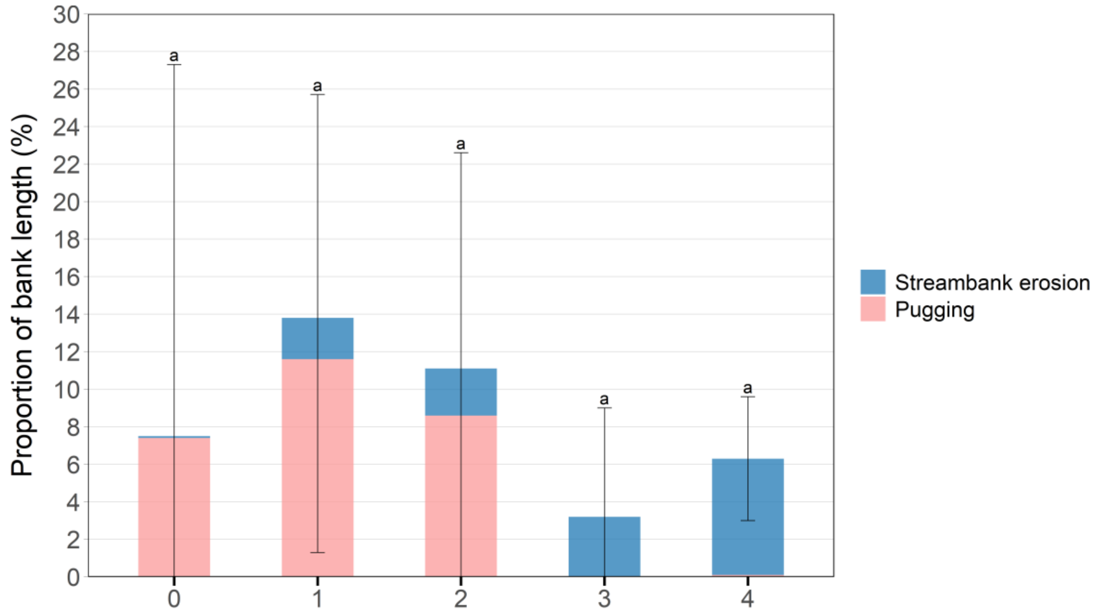

Figure 28. Average proportion of disturbed bank length (pugging + total erosion) within each stream order in 2024.

3.6.2 Change over time

A significant decrease in the average proportion of surveyed bank length eroded (i.e. sum of active and recent erosion) of about 10% occurred between 2020 and 2024 in the Matahuru catchment ($P < 0.05$, Table 12). When assessing the individual erosion components, there was a significant decrease of 8% of actively eroding bank length but no significant change in the amount of recent erosion. As noted in previous riparian survey reports (Norris et al.,2025, Norris et al., 2020), the amount of observed streambank erosion each year is highly variable and is dependent on several temporally variable factors such as antecedent storm events, flow conditions at the time of the survey and vegetation coverage that may obscure streambank erosion. Unlike more quantitative measures of riparian condition (for e.g. presence or absence of fencing or coverage of specific vegetation types), the occurrence of streambank erosion is not as easily quantifiable. It is therefore recognised that the riparian survey provides an indication of streambank erosion but not a definitive measure of presence or absence.

Disturbance of the riparian margin by pugging (defined here as >50% of the riparian margin affected by stock treading damage) saw no significant change between survey years (Table 12). However, total disturbance (sum of pugging and streambank erosion) decreased significantly over time due to the large observed decrease in streambank erosion (Table 12).

Table 12. Average change in the proportion of bank length eroded or disturbed (including erosion type and pugging components) over the previous 4-year (2020 – 2024) period.

Erosion class	2020		2024		Change	
	Estimate (pp†)	95%CI‡	Estimate (pp†)	95%CI‡	Estimate (pp†)	95%CI‡
Active erosion	7.9	5.6	0.2	0.1	**-7.6****	5.7
Recent erosion	4.5	3.1	2.3	0.6	-2.2	3.2
Total erosion	12.4	7.5	2.5	0.6	**-9.9***	7.4
Pugging	10.9	6.1	8.4	6.7	-2.6	10.2
Disturbed soil	22.8	7.8	10.7	6.6	**-12.1***	8.6

† Percentage point (% of bank length)
‡ 95% Confidence interval about the average.
** Significant at $\alpha = 0.01$, * Significant at $\alpha = 0.05$, NS Not significant.

4 General discussion and conclusions

4.1 Survey review

The Matahuru CEM catchment-scale riparian condition survey was undertaken over the summer of 2024/25 and provides robust estimates of a wide range of riparian characteristics for streams and rivers within the catchment. The survey employed a random stratified sampling design based on different combinations of dominant land uses (dairy and drystock) and stream order. The number of samples allocated to each stratum was based on the proportional allocation according to water course length. Consequently, estimates are considered more precise for catchment-based metrics such as land use (i.e. Dairy vs Drystock), but less precise for finer-scale metric such as stream order strata, where sample numbers were limited (e.g., the total number of sampling units for third order streams was limited to 4 sites).

Estimates for the 2024 Matahuru survey were calculated using the same statistical approach used for the regional survey (Norris et al., 2025). This is the first time that the regional statistical method has been applied to a catchment-scale survey. Previous catchment-scale assessments (e.g., Norris et al., 2021) relied on unweighted mean values, rather than weighting results by the proportional distribution of stream length across strata. For consistency and improved accuracy, continued use of the regional method is recommended for future catchment-scale surveys. A sample size of 50 satisfies the requirements of probabilistic sampling, and hence no additional sampling is required for future surveys. However, ad hoc analysis revealed that some strata (e.g. first order streams on drystock) were under-sampled, while others (e.g. 4th order streams on dairy) were over-sampled. Adjusting the allocation of samples to respective strata in future surveys is recommended to ensure better representation of stream order/land use combinations within the sampling framework.

4.2 Key findings

Key findings from the 2024 survey include:

- The predominant land use sampled at stream and river sites across the catchment in 2024 was beef farming(51%), followed by dairy (23%) and low intensity sheep and beef farms (21%).
- The proportion of bank length along beef farms increased by 36% from 15% in 2020 to 51% in 2024 (P < 0201). This increase was largely offset by decreases in the sheep and beef (−19%) and dairy support (−13%) categories, and may therefore reflect reclassification between drystock land uses rather than a genuine shift to more intensive land use.

- Across the catchment, 47% of the surveyed bank length was effectively fenced, preventing stock access to waterways, with significantly more bank length fenced for dairy land use (91%) compared to drystock (32%). No change in effective fencing was observed from 2020 to 2024.
- Excluding drains (stream order 0), there was a general increase in effective fencing with stream order, with 26% of bank length effectively fenced for first order streams compared to 85% and 77% for third and fourth order streams, respectively.
- In 2024, about 59% of surveyed bank length had evidence of current, recent or past stock access, with current stock access affecting 25% of bank length across the catchment. Total stock access was significantly higher for drystock (75% of bank length) compared to dairy (11% of bank length). First order streams had the highest level of total stock access at 82% of bank length. Consistent with the fencing results, total stock access saw no change from 2020 to 2024.
- Most of the surveyed bank length across the catchment was occupied by non-woody vegetation (84%), which was predominantly grass and weeds (81%). In terms of woody vegetation, about 8% of bank length was occupied by native species, and 7% by exotic species. From 2020 to 2024, woody vegetation cover declined by 11%. This reduction was driven by a significant decrease in exotic species, such as willows, while native woody vegetation remained unchanged.
- On average, only 7% of surveyed bank length had buffer widths of 5 m or more (described as 'wide') while 40% of bank length had buffer widths of less than 5 m (described as 'narrow'). The remainder of bank length across the catchment was unfenced. In terms of effectively fenced riparian zones, about 5% of these were used for grazing, 1% were actively managed, and 41% were unmanaged.
- About 3% of bank length in 2024 was classified as eroded with 1% showing signs of active erosion and 2% of recent erosion. About 8% of bank length was affected by pugging (classed as > 50% pugging disturbance within the riparian margin). While there was more bank length with total soil disturbance (erosion and pugging) for drystock (12.6%) compared to dairy (5.2%), the difference was not statistically significant.
- A significant decrease in the average proportion of surveyed bank length eroded (i.e. sum of active and recent erosion) of about 10% occurred between 2020 and 2024. The amount of observed streambank erosion each year is highly variable and is dependent on several temporally variable factors such as antecedent storm events, flow conditions at the time of the survey, and vegetation coverage that may obscure streambank erosion
- The amount of pugging along streambanks saw no change from 2020 to 2024. However, total soil disturbance (erosion and pugging) decreased by 12.1% ($P < 0.05$) from 22.8% in 2020 to 8.6% in 2024

4.3 Water quality related issues

One of the benefits of a field survey methodology is the ability to visually assess the landscape in relation to riparian margins and to assess potential diffuse contaminant pathways and processes. The following sections provide a brief overview of observed water quality issues in relation to the monitored riparian sites in 2024. The reader is referred to Singleton (2018) for a broader catchment scale overview of water quality risks and Vale et al. (2025) for an in-depth analysis of erosion risk across the catchment.

4.3.1 Issues related to natural processes

Across the catchment, water quality issues driven by natural processes were related primarily to sediment generation and transfer via stream bank erosion or mass movement such as shallow landslides or earthflows close to the riparian margin. Most bank erosion was observed in the lower catchment, particularly in areas where the Matahuru Stream is deeply incised. While stream bank erosion is difficult to eliminate in a highly mobile floodplain environment, there are stream margins that would benefit from the establishment of woody vegetation to improve bank stabilisation. In the upper catchment, a high proportion of sediment is sourced from hillslope erosion processes (Vale et al., 2025). Waikato Regional Council continues to promote pole planting to stabilise erodible land and reduce mass movement risk. In some highly erodible areas (e.g. steep gullies), it may be necessary to retire these areas in the future to mitigate wide-spread mass-movement. Singleton (2018) noted that about 27% of the catchment has a high risk from soil movement such as slips and would benefit from soil conservation work. Recent SedNetNZ modelling (Vale et al., 2025) incorporates high-resolution LiDAR-derived landslide susceptibility mapping to improve the prioritisation of high-risk areas and support erosion mitigation efforts aimed at reducing sediment transfer to waterways.

4.3.2 Issues related to land management

Across the survey sites, water quality issues driven by land management were related primarily to stock access to riparian margins. The survey results suggest a significant increase in the proportion of surveyed bank length with beef farming, most likely a consequence of intensification across the catchment (i.e. conversion of traditional, less intensive, sheep and beef grazing to more intensive beef grazing systems). It is well documented that cattle cause appreciably more damage to riparian areas than sheep due to their greater weight (i.e. higher hoof pressure) and affinity for riparian zones which they actively seek out for shelter and cooling as well as drinking water and forage (Davies-Colley and Parkyn 2001). This was particularly true in the upper catchment along headwater streams, where 16% of surveyed bank length on drystock land was disturbed due to pugging. Furthermore, 89% and 78% of first and second order streams classed as ‘drystock’ remained unfenced and accessible to stock. Recent research has shown that lower order streams often contribute the most to contaminant loads in agricultural catchments (McDowell et al., 2017), and hence it is important to explore alternative strategies for reducing these loads, especially in situations where fencing is impractical or not required under regulatory frameworks. While conventional fencing is often impractical in steep hill-country, recent developments in virtual fencing technologies offer new opportunities to restrict stock access to waterways in hill-country.

4.4 Future work programme

The Matahuru riparian characteristics survey was carried out as part of WRC’s CEM programme. Future catchment scale surveys will take place every four years with a view to evaluating trends in monitored attributes (e.g. effective fencing). The next survey is scheduled for the summer of 2028/29.

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Appendices

Appendix 1. Survey design statistics for the 2024 Matahuru riparian survey, including stream order lengths (total and within land uses), number of sampling units and sampling proportions (target and actual)

Stream order	Total Length (km)[1]	Land use	Intersect length (km)	Target proportion[2]	Number of sampling units	Actual proportion[3]
0	26	Dairy	14	0.08	4	0.08
		Drystock	12	0.07	2	0.04
		All	26	0.15	6	0.12
1	91	Dairy	16	0.09	2	0.04
		Drystock	76	0.44	15	0.3
		All	91	0.53	17	0.34
2	22	Dairy	5	0.03	1	0.02
		Drystock	16	0.10	5	0.1
		All	22	0.13	6	0.12
3	12	Dairy	3	0.02	2	0.04
		Drystock	8	0.05	2	0.04
		All	12	0.07	4	0.08
4	21	Dairy	7	0.04	5	0.1
		Drystock	13	0.08	12	0.24
		All	21	0.12	17	0.34
Total	172	Dairy	171	0.27	14	0.28
		Drystock	14	0.73	36	0.72
		All	12		50	

[1] Length of waterway within pastoral land only
[2] Intersect length/total intersect length
[3] Number of sampling units/total number of sampling units

Appendix 2. Average proportion of bank length (including 95% confidence interval) occupied by eight land use classes (for surveyed transects) within the Matahuru catchment across stream order and farm types.

Stream order	Farm type	n	Dairy (platform)	Dairy support	Sheep and Beef	Beef	Horses	Planted forest	Cropping	Other
0	Dairy	4	94.3% ± 16.6%	0	0	100% ± 0%	0	0	5.7% ± 16.6%	0
0	Drystock	2	0	0	0	0	0	0	0	0
0	All	6	65.9% ± 45.7%	0	0	30.1% ± 47.8%	0	0	4% ± 9.2%	0
1	Dairy	2	100% ± 0%	0	0	0	0	0	0	0
1	Drystock	15	0	0	33.7% ± 26.2%	61.4% ± 26.1%	4.8% ± 9.9%	0	0	0
1	All	17	11.9% ± 16.9%	0	29.7% ± 23.9%	54.1% ± 25.3%	4.2% ± 8.8%	0	0	0
2	Dairy	1	100% ± 0%	0	0	0	0	0	0	0
2	Drystock	5	0	0	24.3% ± 60.4%	71% ± 58.2%	0	0	4.7% ± 12.7%	0
2	All	6	14.6% ± 35.5%	0	20.7% ± 46.8%	60.7% ± 49.9%	0	0	4% ± 9.7%	0
3	Dairy	2	68.7% ± 212.4%	0	0	0	0	0	31.3% ± 212.4%	0
3	Drystock	2	0	0	0	100% ± 0%	0	0		0
3	All	4	34.2% ± 59.3%	0	0	50.2% ± 80.4%	0	0	15.6% ± 32.6%	0
4	Dairy	4	60.1% ± 92.5%	0	39.9% ± 92.5%	0	0	0		0
4	Drystock	12	0	0	24.7% ± 25.2%	64.2% ± 25.9%	0	0	11.1% ± 16.1%	0
4	All	16	12.6% ± 17.8%	0	30.5% ± 23.1%	44.7% ± 23.6%	0	0	9.4% ± 11.8%	2.8% ± 5.8%
All	Dairy	13	90.7% ± 8.8%	0	4.9% ± 7.6%	0	0	0	4.4% ± 5.1%	0
All	Drystock	36	0	0	26.4% ± 16.4%	68.7% ± 16.3%	2.9% ± 5.6%	0	1.9% ± 2.2%	0
All	All	49	23% ± 2.6%	0	20.8% ± 12.1%	51% ± 12.1%	2.1% ± 4.1%	0	2.7% ± 2%	0.3% ± 0.6%

Appendix 3. Average proportion of bank length (including 95% confidence interval) occupied by eight land use classes across the Matahuru catchment in 2020 and 2024.

	Year	n	Dairy (platform)	Dairy support	Sheep and Beef	Beef	Horses	Planted forest	Cropping	Goats	Other
Overall	2020		18.4% ± 8%	13.3% ± 11%	40.3% ± 16.7%	15.3% ± 12.4%	0.8% ± 2%	0.1% ± 0.3%	3% ± 5%	8.2% ± 9.6%	0.6% ± 1.7%
	2024		23% ± 2.6%	0	20.8% ± 12.1%	51% ± 12.1%	2.1% ± 4.1%	0	2.7% ± 2%	0	0.3% ± 0.6%
Dairy	2020		48.6% ± 18.3%	24.6% ± 21.3%	23% ± 7.4%	0	0	0	3.6% ± 10.3%	0	0.2% ± 1.1%
	2024		0	0	26.4% ± 16.4%	68.7% ± 16.3%	2.9% ± 5.6%	0	1.9% ± 2.2%	0	0% ± 0%
Drystock	2020		0	6.4% ± 10.9%	50.8% ± 26%	24.6% ± 20%	1.3% ± 3.3%	0.2% ± 0.5%	2.7% ± 5.7%	13.2% ± 15.5%	0.8% ± 2.7%
	2024		0	0	26.4% ± 16.4%	68.7% ± 16.3%	2.9% ± 5.6%	0	1.9% ± 2.2%	0	0

Appendix 4. Average proportion of bank length (including 95% confidence interval) effectively or not effectively fenced and average proportion of stream length effectively fenced on both banks, one bank, or neither bank across the Matahuru catchment in 2024. The number of samples (n) analysed within each population has been included for reference.

Stream order	Farm type	n	Bank length							Stream length		
			Effectively fenced	Not effectively fenced	Effective permanent	Effective Temporary	Ineffective Permanent	Ineffective Temporary	No fence	Both banks	Neither bank	One bank
0	Dairy	4	87.5% ± 19.8%	12.5% ± 19.8%	87.5% ± 19.8%	0.0% ± 0.0%	0.0% ± 0.0%	0.0% ± 0.0%	12.5% ± 19.8%	76.4% ± 39.6%	1.3% ± 2.3%	22.2% ± 39.7%
0	Drystock	2	99.1% ± 9.4%	0.9% ± 9.4%	99.1% ± 9.4%	0.0% ± 0.0%	0.0% ± 0.0%	0.0% ± 0.0%	0.9% ± 9.4%	98.8% ± 11.9%	0.7% ± 6.9%	0.5% ± 5%
0	All	6	92.3% ± 10.2%	7.7% ± 10.2%	92.3% ± 10.2%	0.0% ± 0.0%	0.0% ± 0.0%	0.0% ± 0.0%	7.7% ± 10.2%	85.7% ± 20.3%	1.1% ± 1.3%	13.2% ± 20.3%
1	Dairy	2	94.7% ± 66%	5.3% ± 57.7%	92.4% ± 95.7%	2.3% ± 29.6%	0.7% ± 9.0%	0.0% ± 0.0%	4.6% ± 57.0%	90.7% ± 116.3%	1.4% ± 15.7%	7.8% ± 100.6%
1	Drystock	15	11.4% ± 10.7%	88.6% ± 10.7%	11.4% ± 10.7%	0.0% ± 0.0%	0.0% ± 0.0%	0.0% ± 0.0%	88.6% ± 10.7%	2.4% ± 3.9%	79.6% ± 18.3%	18% ± 15.5%
1	All	17	26% ± 9.5%	74% ± 9.4%	25.6% ± 9.8%	0.4% ± 0.8%	0.1% ± 0.3%	0.0% ± 0.0%	73.9% ± 9.4%	17.9% ± 5.8%	65.9% ± 15.2%	16.2% ± 13.1%
2	Dairy	1	87.6% ± 0%	12.4% ± 0%	85.8% ± 0.0%	1.8% ± 0.0%	1.0% ± 0.0%	0.0% ± 0.0%	11.3% ± 0.0%	75.3% ± NA%	0% ± 0%	24.7% ± NA%
2	Drystock	5	22.1% ± 44.4%	77.9% ± 44.4%	21.9% ± 44.6%	0.3% ± 0.7%	0.0% ± 0.0%	0.0% ± 0.0%	77.9% ± 44.4%	20.5% ± 45.2%	76.3% ± 43.7%	3.2% ± 4.6%
2	All	6	36.1% ± 36.1%	63.9% ± 36.1%	35.6% ± 36.2%	0.6% ± 0.5%	0.2% ± 0.0%	0.0% ± 0.0%	63.6% ± 36.1%	32.2% ± 36.5%	60% ± 35.7%	7.8% ± 3.6%
3	Dairy	2	98.7% ± 15.7%	1.3% ± 15.7%	98.7% ± 15.7%	0.0% ± 0.0%	0.0% ± 0.0%	0.0% ± 0.0%	1.3% ± 15.7%	97.3% ± 31.4%	0% ± 0%	2.7% ± 31.4%
3	Drystock	2	80.1% ± 242.9%	19.9% ± 231.8%	80.1% ± 242.9%	0.0% ± 0.0%	0.9% ± 11.4%	0.0% ± 0.0%	19.0% ± 231.5%	60.6% ± 480.5%	0.4% ± 5.4%	39% ± 475.2%
3	All	4	85.4% ± 58.4%	14.6% ± 55.8%	85.4% ± 58.4%	0.0% ± 0.0%	0.7% ± 2.7%	0.0% ± 0.0%	13.9% ± 55.7%	71.2% ± 115.6%	0.3% ± 1.3%	28.5% ± 114.3%
4	Dairy	4	82.9% ± 59.3%	17.1% ± 59.3%	82.9% ± 59.3%	0.0% ± 0.0%	0.0% ± 0.0%	0.0% ± 0.0%	17.1% ± 59.3%	82.1% ± 61.9%	16.3% ± 56.6%	1.5% ± 5.3%
4	Drystock	12	75% ± 16.3%	25% ± 16.9%	73.5% ± 16.8%	1.6% ± 2.1%	2.2% ± 4.8%	0.0% ± 0.0%	22.8% ± 16.2%	61.8% ± 21.1%	11.7% ± 16.6%	26.5% ± 19.7%
4	All	16	77.1% ± 12.7%	22.9% ± 12.8%	76.0% ± 13.1%	1.1% ± 1.6%	1.6% ± 3.4%	0.0% ± 0.0%	21.3% ± 12.4%	67.1% ± 17.1%	12.9% ± 12.7%	19.9% ± 16.2%
All	Dairy	13	90.5% ± 7.9%	9.5% ± 7.6%	89.4% ± 9.2%	1.0% ± 2.0%	0.4% ± 0.6%	0.0% ± 0.0%	9.1% ± 7.5%	84% ± 13%	3% ± 4.7%	13% ± 11.7%
All	Drystock	36	32% ± 8.7%	68% ± 8.7%	31.8% ± 8.7%	0.2% ± 0.3%	0.3% ± 0.5%	0.0% ± 0.0%	67.7% ± 8.7%	23.5% ± 8.2%	59.5% ± 11.9%	17.1% ± 10.5%
All	All	49	46.9% ± 6.7%	53.1% ± 6.7%	46.4% ± 6.9%	0.4% ± 0.5%	0.3% ± 0.4%	0.0% ± 0.0%	52.8% ± 6.7%	38.9% ± 6.8%	45.1% ± 8.8%	16% ± 8.2%

Appendix 5. Average proportion of bank length (including 95% confidence interval) effectively fenced and average proportion of stream length effectively fenced on both banks, one bank, or neither bank across the Matahuru catchment in 2020 and 2024.

Stream order	Farm type	2020				2024			
		Bank length analysis (% bank length)	Stream length analysis (% stream length)			Bank length analysis (% bank length)	Stream length analysis (% stream length)		
		Total fenced	Both banks fenced	One bank fenced	Neither bank fenced	Total fenced	Both banks fenced	One bank fenced	Neither bank fenced
0	Dairy	100% ± 0%	100% ± 0%	0% ± 0%	0% ± 0%	87.5% ± 19.8%	76.4% ± 39.6%	22.2% ± 39.7%	1.3% ± 2.3%
0	Drystock	100% ± 0%	100% ± 0%	0% ± 0%	0% ± 0%	99.1% ± 9.4%	98.8% ± 11.9%	0.5% ± 5%	0.7% ± 6.9%
0	All	100% ± 0%	100% ± 0%	0% ± 0%	0% ± 0%	92.3% ± 10.2%	85.7% ± 20.3%	13.2% ± 20.3%	1.1% ± 1.3%
1	Dairy	71% ± 30%	41% ± 60%	59% ± 60%	0% ± 0%	94.7% ± 66%	90.7% ± 116.3%	7.8% ± 100.6%	1.4% ± 15.7%
1	Drystock	12% ± 18%	9% ± 15%	7% ± 12%	84% ± 22%	11.4% ± 10.7%	2.4% ± 3.9%	18% ± 15.5%	79.6% ± 18.3%
1	All	30% ± 18%	19% ± 16%	23% ± 14%	58% ± 22%	26% ± 9.5%	17.9% ± 5.8%	16.2% ± 13.1%	65.9% ± 15.2%
2	Dairy	65% ± 0%	33% ± 0%	64% ± 0%	3% ± 0%	87.6% ± 0%	75.3% ± 0%	24.7% ± 0%	0% ± 0%
2	Drystock	2% ± 7%	0% ± 0%	4% ± 14%	96% ± 14%	22.1% ± 44.4%	20.5% ± 45.2%	3.2% ± 4.6%	76.3% ± 43.7%
2	All	16% ± 7%	7% ± 2%	18% ± 12%	75% ± 13%	36.1% ± 36.1%	32.2% ± 36.5%	7.8% ± 3.6%	60% ± 35.7%
3	Dairy	72% ± 0%	44% ± 0%	56% ± 0%	0% ± 0%	98.7% ± 15.7%	97.3% ± 31.4%	2.7% ± 31.4%	0% ± 0%
3	Drystock	44% ± 138%	21% ± 110%	45% ± 150%	34% ± 193%	80.1% ± 242.9%	60.6% ± 480.5%	39% ± 475.2%	0.4% ± 5.4%
3	All	55% ± 75%	30% ± 79%	50% ± 75%	20% ± 89%	85.4% ± 58.4%	71.2% ± 115.6%	28.5% ± 114.3%	0.3% ± 1.3%
4	Dairy	81% ± 41%	71% ± 54%	21% ± 43%	9% ± 37%	82.9% ± 59.3%	82.1% ± 61.9%	1.5% ± 5.3%	16.3% ± 56.6%
4	Drystock	77% ± 98%	73% ± 98%	7% ± 29%	20% ± 101%	75% ± 16.3%	61.8% ± 21.1%	26.5% ± 19.7%	11.7% ± 16.6%
4	All	80% ± 32%	71% ± 39%	16% ± 30%	12% ± 31%	77.1% ± 12.7%	67.1% ± 17.1%	19.9% ± 16.2%	12.9% ± 12.7%
All	Dairy	79% ± 11%	60% ± 17%	38% ± 15%	2% ± 8%	90.5% ± 7.9%	84% ± 13%	13% ± 11.7%	3% ± 4.7%
All	Drystock	27% ± 13%	22% ± 11%	8% ± 9%	69% ± 16%	32% ± 8.7%	23.5% ± 8.2%	17.1% ± 10.5%	59.5% ± 11.9%
All	All	47% ± 10%	37% ± 10%	20% ± 8%	44% ± 12%	46.9% ± 6.7%	38.9% ± 6.8%	16% ± 8.2%	45.1% ± 8.8%

Appendix 6. Average proportion of bank length (including 95% confidence interval) with current, recent, past, and no evidence of stock access across the Matahuru catchment in 2020 and 2024. The number of samples (n) analysed within each population has been included for reference.

Stream order	Farm type	2020						2024					
		n	Current	Recent	Past	Total stock access[1]	No access	n	Current	Recent	Past	Total stock access	No access
0	Dairy	4	0% ± 0%	9% ± 31%	0% ± 0%	9% ± 31%	91% ± 31%	4	0% ± 0%	8% ± 24%	0% ± 0%	8% ± 24%	92% ± 24%
0	Drystock	2	0% ± 0%	0% ± 0%	0% ± 0%	0% ± 0%	100% ± 0%	2	0% ± 0%	0% ± 0%	0% ± 0%	0% ± 0%	100% ± 0%
0	All	6	0% ± 0%	5% ± 14%	0% ± 0%	5% ± 14%	95% ± 14%	6	0% ± 0%	5% ± 12%	0% ± 0%	5% ± 12%	95% ± 12%
1	Dairy	4	0% ± 0%	18% ± 57%	27% ± 38%	45% ± 64%	55% ± 64%	2	0% ± 0%	16% ± 205%	0% ± 0%	16% ± 205%	84% ± 205%
1	Drystock	12	28% ± 24%	50% ± 28%	20% ± 21%	97% ± 7%	3% ± 7%	15	47% ± 22%	43% ± 22%	6% ± 9%	96% ± 6%	4% ± 6%
1	All	16	19% ± 17%	40% ± 21%	22% ± 15%	81% ± 14%	19% ± 14%	17	39% ± 18%	38% ± 19%	5% ± 8%	82% ± 9%	18% ± 9%
2	Dairy	1	0% ± 0%	0% ± 0%	0% ± 0%	0% ± 0%	100% ± 0%	1	0% ± 0%	0% ± 0%	0% ± 0%	0% ± 0%	100% ± 0%
2	Drystock	5	46% ± 43%	8% ± 25%	34% ± 58%	87% ± 27%	13% ± 27%	5	35% ± 60%	41% ± 66%	6% ± 15%	82% ± 48%	18% ± 48%
2	All	6	35% ± 33%	6% ± 20%	26% ± 45%	68% ± 22%	32% ± 22%	6	28% ± 48%	32% ± 52%	4% ± 12%	65% ± 39%	35% ± 39%
3	Dairy	2	0% ± 0%	0% ± 0%	0% ± 0%	0% ± 0%	100% ± 0%	2	0% ± 0%	0% ± 0%	0% ± 0%	0% ± 0%	100% ± 0%
3	Drystock	3	21% ± 68%	32% ± 119%	38% ± 203%	91% ± 57%	9% ± 57%	2	0% ± 0%	0% ± 0%	33% ± 402%	33% ± 402%	67% ± 402%
3	All	5	13% ± 34%	20% ± 60%	24% ± 100%	56% ± 86%	44% ± 86%	4	0% ± 0%	0% ± 0%	24% ± 97%	24% ± 97%	77% ± 97%
4	Dairy	10	13% ± 38%	18% ± 54%	7% ± 22%	39% ± 57%	61% ± 57%	4	0% ± 0%	0% ± 0%	21% ± 72%	21% ± 72%	79% ± 72%
4	Drystock	5	19% ± 119%	0% ± 0%	25% ± 102%	44% ± 136%	56% ± 136%	12	2% ± 5%	34% ± 20%	0% ± 0%	37% ± 22%	63% ± 22%
4	All	15	15% ± 37%	12% ± 35%	13% ± 28%	41% ± 42%	60% ± 42%	16	2% ± 4%	25% ± 20%	6% ± 11%	33% ± 17%	67% ± 17%
All	Dairy	21	3% ± 8%	14% ± 18%	13% ± 9%	30% ± 20%	70% ± 20%	13	0% ± 0%	8% ± 15%	3% ± 6%	11% ± 16%	89% ± 16%
All	Drystock	27	27% ± 16%	33% ± 17%	22% ± 16%	81% ± 10%	19% ± 10%	36	33% ± 14%	35% ± 14%	7% ± 7%	75% ± 8%	25% ± 8%
All	All	48	18% ± 10%	26% ± 12%	18% ± 10%	62% ± 10%	38% ± 10%	49	25% ± 10%	28% ± 11%	6% ± 5%	59% ± 7%	41% ± 7%

[1]Total stock access is the sum of Current, Recent and Past categories.

Appendix 7. Average proportion of bank length (including 95% confidence interval) for individual vegetation types across the Matahuru catchment in 2020 and 2024. The number of samples (n) analysed within each population has been included for reference.

Stream order	Farm type	2020						2024					
		n	Woody (willow)	Woody exotic (other)	Woody (native)	Flax/sedge/rush	Grass/weeds	n	Woody (willow)	Woody exotic (other)	Woody (native)	Flax/sedge/rush	Grass/weeds
0	Dairy	4	0.4% ± 1.5%	0% ± 0%	0.5% ± 1.8%	0.8% ± 2.7%	98.3% ± 6%	4	0% ± 0%	0.1% ± 0.1%	0.4% ± 0.9%	2.6% ± 4.3%	97% ± 4.4%
0	Drystock	2	0% ± 0%	28.8% ± 312.9%	0% ± 0%	0% ± 0%	71.2% ± 312.9%	2	0% ± 0%	18.7% ± 180.6%	0% ± 0%	2.4% ± 24.6%	78.9% ± 205.2%
0	All	6	0.2% ± 0.7%	13.6% ± 35.5%	0.3% ± 0.8%	0.4% ± 1.3%	85.5% ± 35.4%	6	0% ± 0%	7.8% ± 18.4%	0.2% ± 0.5%	2.5% ± 3.1%	89.5% ± 20.7%
1	Dairy	4	12.9% ± 50.6%	15% ± 12.2%	3.9% ± 4.1%	0% ± 0%	57.4% ± 46.6%	2	0% ± 0%	8.2% ± 79.5%	3.9% ± 43.6%	0.7% ± 8.2%	83.1% ± 167.1%
1	Drystock	12	0% ± 0%	4.7% ± 4.3%	9.1% ± 8%	31.7% ± 18.2%	54.2% ± 23.6%	15	0% ± 0%	0.8% ± 0.9%	6.8% ± 3.4%	4.8% ± 3.5%	87.5% ± 5.3%
1	All	16	4% ± 9.2%	7.9% ± 4%	7.5% ± 5.6%	21.8% ± 13.6%	55.2% ± 17.3%	17	0% ± 0%	2.1% ± 2.3%	6.3% ± 3.1%	4.1% ± 2.9%	86.7% ± 6.5%
2	Dairy	1	0% ± 0%	49.4% ± 0%	7.9% ± 0%	0% ± 0%	41.6% ± 0%	1	0% ± 0%	52.6% ± 0%	11.6% ± 0%	0.8% ± 0%	35.1% ± 0%
2	Drystock	5	0% ± 0%	2.1% ± 1.7%	21.1% ± 38.9%	17.2% ± 22%	59.1% ± 36%	5	0.4% ± 1%	1.3% ± 2.3%	4.8% ± 4.1%	7.5% ± 6.6%	86% ± 9%
2	All	6	0% ± 0%	12.8% ± 2.5%	18.1% ± 30.2%	13.3% ± 17.6%	55.1% ± 27.7%	6	0.3% ± 0.8%	12.2% ± 3.3%	6.2% ± 3.4%	6.1% ± 5.2%	75.1% ± 8.4%
3	Dairy	2	0% ± 0%	1.6% ± 0%	8.2% ± 0%	0% ± 0%	90.2% ± 0%	2	13.5% ± 104.1%	9.2% ± 82.6%	6.5% ± 59.8%	0.7% ± 7.6%	70.1% ± 45.9%
3	Drystock	3	0% ± 0%	1.7% ± 5.6%	11.1% ± 26.2%	17.6% ± 79.3%	67.6% ± 111.6%	2	0% ± 0%	0.3% ± 4%	5.8% ± 70.2%	2.8% ± 34.7%	91.1% ± 101%
3	All	5	0% ± 0%	1.7% ± 2.8%	9.9% ± 13.1%	10.4% ± 37.9%	76.8% ± 50.9%	4	3.9% ± 10%	2.9% ± 8.2%	6% ± 17.9%	2.2% ± 8.4%	85% ± 25%
4	Dairy	10	8.3% ± 25.6%	13.3% ± 31.6%	24.3% ± 38.4%	0% ± 0%	44% ± 41.4%	4	0.6% ± 1.1%	8% ± 16.4%	40.6% ± 55%	9.1% ± 20.4%	40.2% ± 46.4%
4	Drystock	5	1.5% ± 8.2%	17.2% ± 50.7%	34.1% ± 103.1%	4.4% ± 21.8%	39.3% ± 78.5%	12	13.7% ± 11.2%	12% ± 9.3%	23.8% ± 12%	1.2% ± 1.1%	49.2% ± 14.2%
4	All	15	6.1% ± 16.5%	14.6% ± 22.4%	27.5% ± 34.2%	1.4% ± 5.6%	42.5% ± 32.1%	16	10.2% ± 9%	11% ± 7%	28.2% ± 11.4%	3.3% ± 3.5%	46.8% ± 11.8%
All	Dairy	21	7.5% ± 12.9%	7.5% ± 12.9%	8.5% ± 8.8%	0.1% ± 0.4%	63.1% ± 14.9%	13	1.2% ± 1.6%	10.8% ± 5.8%	8.6% ± 6.5%	2.4% ± 2.1%	75.4% ± 13.1%
All	Drystock	27	0.1% ± 0.4%	7.4% ± 7%	12.1% ± 8.7%	23% ± 11.1%	56.7% ± 15.6%	36	1.7% ± 1.4%	3.5% ± 2.8%	8% ± 2.5%	4.5% ± 2.2%	82.2% ± 4.7%
All	All	48	2.9% ± 5%	9.8% ± 4.9%	10.8% ± 5.9%	14.3% ± 7.3%	59.1% ± 10.5%	49	1.6% ± 1.1%	5.4% ± 2.4%	8.2% ± 2.2%	3.9% ± 1.7%	80.5% ± 4.2%

Appendix 8. Average proportion of bank length (including 95% confidence interval) with woody or non-woody vegetation across the Matahuru catchment in 2020 and 2024. The number of samples (n) analysed within each population has been included for reference.

Stream order	Farm type	2020			2024		
		n	Woody	non-woody	n	Woody	non-woody
0	Dairy	4	0.9% ± 3.3%	99.1% ± 3.3%	4	0.4% ± 1.1%	99.6% ± 1.1%
0	Drystock	2	28.8% ± 312.9%	71.2% ± 312.9%	2	18.7% ± 180.6%	81.3% ± 180.6%
0	All	6	14.1% ± 35.4%	85.9% ± 35.4%	6	8% ± 18.4%	92% ± 18.4%
1	Dairy	4	42.6% ± 46.6%	57.4% ± 46.6%	2	16.2% ± 175.3%	83.8% ± 175.3%
1	Drystock	12	14.2% ± 8.6%	85.8% ± 8.6%	15	7.7% ± 3.5%	92.3% ± 3.5%
1	All	16	23% ± 12.5%	77% ± 12.5%	17	9.2% ± 5.8%	90.8% ± 5.8%
2	Dairy	1	58.4% ± 0%	41.6% ± 0%	1	64.1% ± 0%	35.9% ± 0%
2	Drystock	5	23.8% ± 40.4%	76.2% ± 40.4%	5	6.5% ± 4.8%	93.5% ± 4.8%
2	All	6	31.5% ± 31.5%	68.5% ± 31.5%	6	18.8% ± 5.7%	81.2% ± 5.7%
3	Dairy	2	9.8% ± 0%	90.2% ± 0%	2	29.2% ± 38.4%	70.8% ± 38.4%
3	Drystock	3	14.8% ± 37.5%	85.2% ± 37.5%	2	6.1% ± 66.3%	93.9% ± 66.3%
3	All	5	12.8% ± 17%	87.2% ± 17%	4	12.7% ± 16.7%	87.3% ± 16.7%
4	Dairy	10	56% ± 41.4%	44% ± 41.4%	4	50.8% ± 63.3%	49.2% ± 63.3%
4	Drystock	5	56.2% ± 75.8%	43.8% ± 75.8%	12	49.6% ± 14.2%	50.4% ± 14.2%
4	All	15	56.1% ± 30.9%	43.9% ± 30.9%	16	49.9% ± 12.7%	50.1% ± 12.7%
All	Dairy	21	36.8% ± 15%	63.2% ± 15%	13	22.2% ± 13.5%	77.8% ± 13.5%
All	Drystock	27	20.3% ± 10.7%	79.7% ± 10.7%	36	13.3% ± 3.8%	86.7% ± 3.8%
All	All	48	26.6% ± 8.7%	73.4% ± 8.7%	49	15.6% ± 3.8%	84.4% ± 3.8%

Appendix 9. Average proportion of bank length (including 95% confidence interval) with narrow (< 5m) and wide (≥ 5m) buffer widths and individual buffer width categories across the Matahuru catchment in 2024. The number of samples (n) analysed within each population has been included for reference. Buffer width was defined as the distance between the water way edge and an effective fence.

Stream order	Farm type	n	Narrow	Wide	<2 m	2-5 m	5-10 m	>10 m	Unfenced
0	Dairy	4	87.5% ± 19.9%	0.1% ± 0.2%	74.4% ± 28%	13.1% ± 35.3%	0% ± 0%	0.1% ± 0.2%	12.5% ± 19.8%
0	Drystock	2	99.1% ± 9.4%	0% ± 0%	55.2% ± 304.7%	43.9% ± 314.1%	0% ± 0%	0% ± 0%	0.9% ± 9.4%
0	All	6	92.3% ± 10.2%	0% ± 0.1%	66.4% ± 29.2%	25.8% ± 30.8%	0% ± 0%	0% ± 0.1%	7.7% ± 10.2%
1	Dairy	2	90.8% ± 100.6%	4.6% ± 43.6%	38.7% ± 86.5%	52.1% ± 187%	2.6% ± 18.1%	2% ± 25.5%	4.6% ± 57%
1	Drystock	15	7.4% ± 7.9%	4.1% ± 6.1%	0.5% ± 0.6%	6.9% ± 7.5%	2.9% ± 4%	1.2% ± 2.2%	88.6% ± 10.7%
1	All	17	21.9% ± 7.8%	4.1% ± 5.2%	7.2% ± 2.1%	14.8% ± 8.7%	2.8% ± 3.3%	1.3% ± 2%	73.9% ± 9.4%
2	Dairy	1	88.5% ± 0%	0.2% ± 0%	22.1% ± 0%	66.5% ± 0%	0.2% ± 0%	0% ± 0%	11.3% ± 0%
2	Drystock	5	21% ± 44.2%	1.2% ± 1.9%	11.6% ± 26.8%	9.4% ± 17.7%	0.6% ± 1.3%	0.5% ± 0.8%	77.9% ± 44.4%
2	All	6	35.4% ± 36%	0.9% ± 1.5%	13.8% ± 21.3%	21.6% ± 15.2%	0.5% ± 1%	0.4% ± 0.7%	63.6% ± 36.1%
3	Dairy	2	50.6% ± 446.8%	48% ± 431.1%	8.6% ± 97.3%	42.1% ± 349.5%	11.4% ± 5.2%	36.6% ± 426%	1.3% ± 15.7%
3	Drystock	2	72.6% ± 334.1%	8.4% ± 102.6%	51.9% ± 406.7%	20.7% ± 72.6%	6.1% ± 73.9%	2.4% ± 28.7%	19% ± 231.5%
3	All	4	66.3% ± 91.7%	19.8% ± 48.6%	39.5% ± 99%	26.8% ± 38.6%	7.6% ± 17.9%	12.2% ± 41.8%	13.9% ± 55.7%
4	Dairy	4	68.2% ± 48.6%	14.7% ± 12.6%	11.5% ± 18.3%	56.7% ± 37.6%	13.4% ± 12.3%	1.3% ± 3.2%	17.1% ± 59.3%
4	Drystock	12	41.2% ± 15.7%	36% ± 12.8%	7.6% ± 9.1%	33.5% ± 14.9%	22.9% ± 12.1%	13.1% ± 7.4%	22.8% ± 16.2%
4	All	16	48.3% ± 14.6%	30.4% ± 9.3%	8.7% ± 6.7%	39.6% ± 13%	20.4% ± 8.3%	10% ± 5.9%	21.3% ± 12.4%
All	Dairy	13	83.3% ± 11.6%	7.6% ± 7.3%	41.9% ± 9.9%	41.4% ± 16.7%	3.6% ± 2%	3.9% ± 6.7%	9.1% ± 7.5%
All	Drystock	36	24.8% ± 7.9%	7.5% ± 4%	10.6% ± 7.3%	14.2% ± 5.9%	5% ± 2.8%	2.5% ± 1.6%	67.7% ± 8.7%
All	All	49	39.7% ± 6.6%	7.5% ± 3.3%	18.6% ± 5.6%	21.1% ± 5.9%	4.6% ± 2.1%	2.9% ± 1.9%	52.8% ± 6.7%

Appendix 10. Average proportion of bank length (including 95% confidence interval) with grouped and individual vegetation management categories across the Matahuru catchment in 2024. The number of samples (n) analysed within each population has been included for reference.

Stream order	Farm type	n	Fenced & grazed	Fenced & unmanaged	Planted & grazed	Planted & managed	Planted & unmanaged	Unplanted & grazed	Unplanted & managed	Unplanted and unmanaged
0	Dairy	4	12.9% ± 39.7%	87.1% ± 39.7%	0% ± 0%	0% ± 0%	0% ± 0%	12.9% ± 39.7%	0% ± 0%	87.1% ± 39.7%
0	Drystock	2	0% ± 0%	100% ± 0%	0% ± 0%	0% ± 0%	29.3% ± 296.3%	0% ± 0%	0% ± 0%	70.7% ± 296.3%
0	All	6	7.6% ± 20.2%	92.4% ± 20.2%	0% ± 0%	0% ± 0%	12.1% ± 30%	7.6% ± 20.2%	0% ± 0%	80.3% ± 35.2%
1	Dairy	2	1.4% ± 17.5%	98.6% ± 17.5%	0% ± 0%	0% ± 0%	2% ± 26.2%	1.4% ± 17.5%	0% ± 0%	96.6% ± 43.7%
1	Drystock	15	94.6% ± 8.1%	5.4% ± 8.1%	0.3% ± 0.7%	0% ± 0%	0.8% ± 1.6%	92.9% ± 10%	1.4% ± 2.8%	4.6% ± 7.6%
1	All	17	78.3% ± 7.1%	21.7% ± 7.1%	0.3% ± 0.5%	0% ± 0%	1% ± 1.5%	76.9% ± 8.6%	1.1% ± 2.3%	20.7% ± 6.9%
2	Dairy	1	0% ± %	100% ± %	0% ± %	0% ± %	51.9% ± %	0% ± %	0% ± %	48.1% ± %
2	Drystock	5	79% ± 47.6%	21% ± 47.6%	0% ± 0%	0% ± 0%	0% ± 0%	79% ± 47.6%	0% ± 0%	21% ± 47.6%
2	All	6	62.1% ± 38.9%	37.9% ± 38.9%	0% ± 0%	0% ± 0%	11.1% ± 1.7%	62.1% ± 38.9%	0% ± 0%	26.8% ± 37.9%
3	Dairy	2	0% ± 0%	100% ± 0%	0% ± 0%	0% ± 0%	5.5% ± 61.8%	0% ± 0%	0% ± 0%	94.5% ± 61.8%
3	Drystock	2	33.5% ± 409%	66.5% ± 409%	0% ± 0%	0% ± 0%	0% ± 0%	33.5% ± 409%	0% ± 0%	66.5% ± 409%
3	All	4	23.9% ± 98.3%	76.1% ± 98.3%	0% ± 0%	0% ± 0%	1.6% ± 6.1%	23.9% ± 98.3%	0% ± 0%	74.5% ± 98.6%
4	Dairy	4	19% ± 65.1%	80.3% ± 64.4%	1.3% ± 4.5%	0% ± 0%	13.8% ± 20.9%	17.7% ± 60.7%	0% ± 0%	66.6% ± 57.3%
4	Drystock	4	35.2% ± 21.2%	64.8% ± 21.2%	0.4% ± 0.8%	0% ± 0.1%	22.9% ± 20.5%	34.8% ± 21.1%	0% ± 0%	41.9% ± 23.5%
4	All	17	29.3% ± 15.3%	70.5% ± 15.3%	0.6% ± 0.7%	0% ± 0%	21.9% ± 13.7%	28.7% ± 15.4%	0% ± 0%	48.6% ± 18.1%
All	Dairy	13	6.9% ± 10.4%	93% ± 10.4%	0.2% ± 0.3%	0% ± 0%	8.8% ± 2.8%	6.7% ± 10.2%	0% ± 0%	84.3% ± 11%
All	Drystock	36	74.1% ± 8.8%	25.9% ± 8.8%	0.2% ± 0.4%	0% ± 0%	5.3% ± 4.8%	73.1% ± 9.5%	0.8% ± 1.6%	20.6% ± 8.8%
All	All	50	56.6% ± 7%	43.3% ± 7%	0.2% ± 0.3%	0% ± 0%	6.5% ± 3.5%	55.8% ± 7.4%	0.6% ± 1.2%	36.9% ± 7.2%

Appendix 11. Average proportion of bank length (including 95% confidence intervals) with total erosion (recent + active) and no erosion in 2020 and 2024. The number of samples (n) analysed within each population has been included for reference.

			2020				2024				
Stream order	**Farm type**	**n**	**Recent**	**Active**	**Total erosion**	**No erosion**	**n**	**Recent**	**Active**	**Total erosion**	**No erosion**
0	Dairy	4	0% ± 0%	0% ± 0%	0% ± 0%	100% ± 0%	4	0% ± 0%	0% ± 0%	0% ± 0%	99.2% ± 2.3%
0	Drystock	2	0% ± 0%	0% ± 0%	0% ± 0%	100% ± 0%	2	0.3% ± 4.4%	0% ± 0%	0.3% ± 4.4%	99.7% ± 4.4%
0	All	6	0% ± 0%	0% ± 0%	0% ± 0%	100% ± 0%	6	0.1% ± 0.4%	0% ± 0%	0.1% ± 0.4%	99.4% ± 1.3%
1	Dairy	4	1.4% ± 5.5%	0.8% ± 3.2%	2.2% ± 8.6%	97.7% ± 9.2%	2	0.2% ± 2.5%	0% ± 0%	0.2% ± 2.5%	99.5% ± 1.9%
1	Drystock	12	8.3% ± 8.4%	16.7% ± 15.7%	25% ± 20.9%	75% ± 20.9%	15	2.5% ± 0.9%	0.2% ± 0.2%	2.7% ± 1%	89.8% ± 4.5%
1	All	16	6.1% ± 5.8%	11.8% ± 11%	17.9% ± 14.7%	82% ± 14.6%	17	2.1% ± 0.8%	0.2% ± 0.2%	2.2% ± 0.8%	91.5% ± 3.7%
2	Dairy	1	3.4% ± 0%	0% ± 0%	3.4% ± 0%	96.6% ± 0%	1	0% ± 0%	0% ± 0%	0% ± 0%	99.3% ± 0%
2	Drystock	5	2% ± 3.3%	3% ± 3.5%	5% ± 6.2%	95% ± 6.2%	5	2.6% ± 1.8%	0.6% ± 0.8%	3.1% ± 2.3%	91% ± 7.4%
2	All	6	2.3% ± 2.5%	2.3% ± 2.8%	4.7% ± 4.9%	95.3% ± 4.9%	6	2% ± 1.5%	0.4% ± 0.6%	2.5% ± 1.9%	92.8% ± 6.1%
3	Dairy	2	0.9% ± 0%	2.8% ± 0%	3.7% ± 0%	96.3% ± 0%	2	1.5% ± 3.9%	0% ± 0%	1.5% ± 3.9%	94.4% ± 36.4%
3	Drystock	5	6.1% ± 21.1%	10.5% ± 24.5%	16.6% ± 36.7%	83.3% ± 37.1%	2	3.9% ± 23.5%	0% ± 0.4%	3.9% ± 24%	89.4% ± 0.7%
3	All	7	4.1% ± 10.8%	7.5% ± 13.8%	11.6% ± 21.1%	88.3% ± 21.3%	4	3.2% ± 5.7%	0% ± 0.1%	3.2% ± 5.8%	90.8% ± 3.5%
4	Dairy	10	6.4% ± 10.6%	7.4% ± 10.8%	13.8% ± 13.3%	84.2% ± 12.6%	4	6.9% ± 16.9%	1.4% ± 5.3%	8.3% ± 22.2%	74.8% ± 42.5%
4	Drystock	5	3.2% ± 6.8%	5.5% ± 13.1%	8.8% ± 16.1%	88.7% ± 12.8%	12	5% ± 3.1%	0.4% ± 0.5%	5.4% ± 3%	85.5% ± 7.9%
4	All	15	5.4% ± 7.1%	6.8% ± 7.1%	12.1% ± 9.3%	85.7% ± 8.7%	16	5.5% ± 2.9%	0.7% ± 0.7%	6.2% ± 3.3%	82.7% ± 8.4%
All	Dairy	21	2.4% ± 2.7%	2.2% ± 2.5%	4.6% ± 3.7%	94.9% ± 3.7%	13	1.1% ± 1.4%	0.2% ± 0.4%	1.3% ± 1.8%	95.8% ± 4%
All	Drystock	27	5.8% ± 4.8%	11.3% ± 8.9%	17.1% ± 11.9%	82.7% ± 11.8%	36	2.7% ± 0.7%	0.3% ± 0.2%	3% ± 0.8%	90.2% ± 2.8%
All	All	48	4.5% ± 3.1%	7.9% ± 5.6%	12.4% ± 7.5%	87.3% ± 7.5%	49	2.3% ± 0.6%	0.2% ± 0.1%	2.5% ± 0.6%	91.6% ± 2.2%

Appendix 12. Average proportion of bank length (including 95% confidence intervals) with bare soil and disturbed soil (total erosion + pugging) and undisturbed soil across the Matahuru catchment in 2020 and 2024. The number of samples (n) analysed within each population has been included for reference.

		2020				2024			
Stream order	**Farm type**	n	Bare Soil (>50%)	Disturbed	Undisturbed	n	Bare Soil (>50%)	Disturbed	Undisturbed
0	Dairy	4	0% ± 0%	0% ± 0.1%	100% ± 0.1%	4	0.8% ± 2.3%	12.7% ± 38.8%	87.3% ± 38.8%
0	Drystock	2	0% ± 0%	0% ± 0%	100% ± 0%	2	0% ± 0%	0.3% ± 4.4%	99.7% ± 4.4%
0	All	6	0% ± 0%	0% ± 0%	100% ± 0%	6	0.5% ± 1.2%	7.5% ± 19.8%	92.5% ± 19.8%
1	Dairy	4	0.2% ± 0.6%	10.6% ± 25.6%	89.4% ± 25.6%	2	0.3% ± 0.6%	0.2% ± 2.5%	99.8% ± 2.5%
1	Drystock	12	0% ± 0%	44.3% ± 19.9%	55.7% ± 19.9%	15	7.5% ± 4.1%	16.3% ± 14.8%	83.7% ± 14.8%
1	All	16	0% ± 0.1%	33.9% ± 14.5%	66.1% ± 14.5%	17	6.3% ± 3.4%	13.5% ± 12.2%	86.5% ± 12.2%
2	Dairy	1	0% ± 0%	3.4% ± 0%	96.6% ± 0%	1	0.7% ± 0%	0% ± 0%	100% ± 0%
2	Drystock	5	0% ± 0%	18.2% ± 21.7%	81.8% ± 21.7%	5	5.8% ± 5.7%	13.5% ± 15.5%	86.5% ± 15.5%
2	All	6	0% ± 0%	14.9% ± 16.4%	85.1% ± 16.4%	6	4.7% ± 4.6%	10.6% ± 12%	89.4% ± 12%
3	Dairy	2	0% ± 0%	3.7% ± 0%	96.3% ± 0%	2	4.1% ± 40.3%	1.5% ± 3.9%	98.5% ± 3.9%
3	Drystock	5	0% ± 0%	20.7% ± 25.1%	79.2% ± 25.5%	2	6.7% ± 23.2%	3.9% ± 24%	96.1% ± 24%
3	All	7	0% ± 0%	14.1% ± 20.4%	85.8% ± 20.5%	4	5.9% ± 6.9%	3.2% ± 5.8%	96.8% ± 5.8%
4	Dairy	10	2% ± 4.5%	15.1% ± 15.1%	84.9% ± 15.1%	4	1.9% ± 3.3%	8.3% ± 22.2%	76.7% ± 40.7%
4	Drystock	5	2.5% ± 15.1%	14.4% ± 37.9%	85.6% ± 37.9%	12	4.6% ± 2.6%	5.5% ± 3.1%	90% ± 8.2%
4	All	15	2.2% ± 4.4%	14.8% ± 13.1%	85.2% ± 13.1%	16	3.9% ± 2.2%	6.3% ± 3.3%	86.5% ± 8.5%
All	Dairy	21	0.5% ± 1%	8.5% ± 6.8%	91.5% ± 6.8%	13	1% ± 0.9%	5.2% ± 9%	92.9% ± 9.5%
All	Drystock	27	0.2% ± 0.7%	31.5% ± 12.2%	68.5% ± 12.2%	36	6.3% ± 2.4%	12.6% ± 8.5%	86.9% ± 8.6%
All	All	48	0.3% ± 0.5%	22.8% ± 7.8%	77.2% ± 7.8%	49	5% ± 1.8%	10.7% ± 6.6%	88.4% ± 6.7%