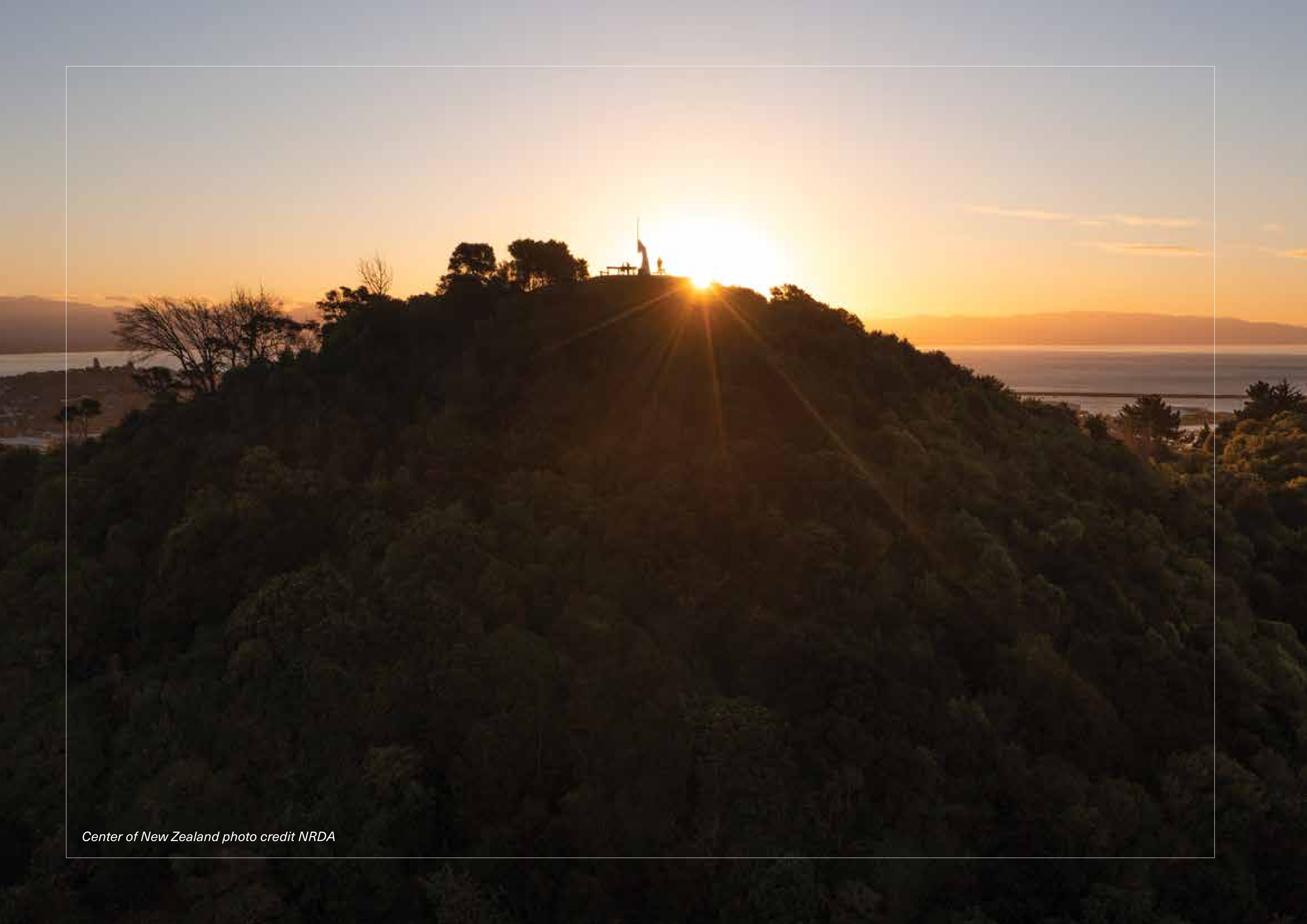
Nelson City Council State of the Environment Report 2019–2023

Nelson City Council | Te Kaunihera o Whakatū



Center of New Zealand photo credit NRDA

Contents

Figures

Tables

Graphs

Pictures

Foreword

This State of the Environment Report, collated by Nelson City Council's Science and Environment unit, presents the latest data concerning our local environment.

I have a strong interest in this work from my time as Minister when I led the development of New Zealand's Environment Reporting Act (2015). It is a practical application of the saying my management guru Peter Drucker used "What gets measured gets managed". There has always been a great deal of effort put into Council's measuring and reporting on its finances, but it is timely that we report on the state of our natural assets.

This report highlights not only the challenges we face but also the proactive measures we are taking to address them. The report's aim is to provide a comprehensive overview that not only informs but also motivates collective and individual efforts towards environmental stewardship. We trust that the insights shared here will inspire further action to nurture and protect the unique natural beauty of Nelson for generations to come.

Air Quality

There have been significant improvements in air quality since 2001, with a commendable reduction in particulate matter (PM10) by over 70%, thanks to community efforts in updating heating methods and regulating industrial emissions.

Despite this progress, challenges remain, particularly concerning finer particulate matter (PM2.5) and nitrogen dioxide levels, which are linked to vehicle emissions and have recognised health implications. The State of the Environment report indicates a need for ongoing monitoring to ensure these pollutants are within safe limits as per new international guidelines. This proactive approach underscores Nelson's commitment to environmental health and the wellbeing of its residents.

Indigenous Birds

The Nelson region has unique avian biodiversity, including the presence of species exclusive to Aotearoa, such as the South Island robin (Kakaruai), rifleman (Tītitipounamu), and yellow-crowned parakeet (Kākāriki). These endemic birds, once widespread, now retreat to isolated mature forests.

Comprehensive bird counts conducted over nine years within a selection of our Conservation and Landscape Reserves suggest an overall increase in bird numbers. However, this growth is predominantly seen in introduced species like blackbirds and house sparrows, which have adapted better to the presence of predatory animals and human-altered landscapes than their indigenous counterparts.

This report underscores a concerning trend: while bird numbers in surveyed high value ecological areas have risen since 2015, the species that are only found in New Zealand (endemic) remain confined to 'refugia' of untouched forest. This pattern signals the need for targeted conservation efforts to safeguard habitat for these endemic species, particularly in higher-altitude native forests. The report concludes that Nelson's biodiversity management programmes must prioritise these critical habitats to ensure the survival of Nelson's most vulnerable and unique bird species.

Indigenous Vegetation

The Maitai and Roding Conservation Reserves, located to the east of Nelson City are high in ecological value. The vegetation of the reserves is strongly influenced by the underlying geology including limestone outcrops, ultramafic (highly mineralised), and forested areas. The ecological values of the reserve are nationally important, notably the plant communities and habitats of the mineral belt and adjacent limestone substrates. One of the main threats to these areas is invasive plant and animal pests.

The introduction of non-native herbivorous animals like goats and deer poses a significant threat to the indigenous plant species in these areas. Periodic monitoring since 2013 has revealed a decline in the flora selectively eaten by these animals.

Through a combination of recreational and commercial hunting, efforts have been made to control the population of these animals to preserve the reserves' unique habitats. This report underscores the critical impact of selective feeding by goats and deer, which favours the growth of less palatable plant species and may eventually result in the loss of biodiversity and potential extinctions within these ecosystems. The report calls for ongoing vigilance and adaptive management strategies to safeguard the ecological integrity of these conservation areas.

Biosecurity

Biosecurity underscores the critical importance of pest control in both terrestrial and marine ecosystems. It celebrates the landmark achievement of eradicating the invasive Mediterranean fanworm, *Sabella*, from local waters—a species that posed a significant threat since its arrival in 2014.

Ongoing vigilance is required to prevent its re-establishment, highlighting the importance of the proactive measures taken by Council, including annual surveys of vessels and marina structures.

Additionally, collaborative efforts with Taihoro Nukurangi National Institute of Water and Atmospheric Research (NIWA) and Manatū Ahua Matua Ministry for Primary Industries (MPI) to conduct biannual surveys in Nelson Harbour, reinforce these actions as part of a broader national strategy to safeguard marine biodiversity against invasive species.

Land

The land section of the State of the Environment report emphasises the critical impact of land management on aquatic ecosystems. It highlights the vulnerability of land without permanent vegetation to erosion, which increases sediment in waterways, adversely affecting the habitat of aquatic life.

The report outlines proactive measures such as reforestation, sustainable forestry practices, and strategic planting along river margins to mitigate sediment flow into freshwater and coastal areas. Soil quality monitoring and erosion control are also key components, with significant investment in helping landowners implement these measures.

The environmental grants programme has supported the planting of approximately 140,000 plants since 2019, demonstrating a commitment to environmental restoration. The report includes updates on Wakapuaka Mouri and Project Mahitahi, where the Council collaborates with the community to restore native vegetation and manage pest populations, further contributing to the health of the region's land and water ecosystems. These initiatives reflect a comprehensive approach to preserving and enhancing the environment for future generations.

Freshwater Quality

Ongoing monitoring of freshwater quality and ecology at 28 sites across the Nelson region reveal significant degradation in urban streams due to increased levels of faecal bacteria and sedimentation.

These pollutants pose a long-term threat to the health of aquatic ecosystems. In rural areas, while nitrate levels remain relatively low, there is a concerning upward trend. Elevated nitrates contribute to summer algae blooms, further compromising stream health.

To combat these issues, Council is formulating Action Plans targeting the specific challenges within Nelson's catchments, including Wakapuaka, Whangamoa, Stoke Streams, and the Maitai. These plans will focus on interventions to reverse the negative trends identified in the report, with a strong emphasis on improving water quality and ecological integrity.

August 2022 Rainfall Event

In August 2022, over a span of three days, consistent rainfall led to moderate flooding and severe landslides, causing extensive damage to the landscape.

The aftermath of this event has left enduring marks on the environment, with the hillsides bearing scars of erosion and the water bodies burdened with increased sedimentation.

The immediate consequences, the ongoing environmental impact, and the sediment accumulation in rivers and estuaries, pose a continuing challenge to the ecological health and stability of the region. This report discusses the response measures taken and the strategies implemented for recovery and future resilience. It additionally aims to provide a comprehensive overview of the event's scale, the sustained effects on the natural terrain, and the implications for environmental management and policy.

Estuaries

Estuaries serve as crucial confluences where rivers meet the sea, creating vital habitats for juvenile fish, coastal birds, and migrating shorebirds. Despite their relative health, these ecosystems have been compromised by sedimentation, particularly following the floods of August 2022, which resulted in mud deposits that adversely affect seagrass beds and the species they support.

Ongoing monitoring of sediment levels and habitat health is planned for the Waimea Inlet, Nelson Haven, Delaware Inlet, and Kokorua Inlet. The introduction of a new modelling tool promises enhanced identification of problematic land uses in Nelson Haven. Additionally, collaborative efforts are underway to implement the Waimea Inlet Strategy and Action Plan, marking a proactive step towards the preservation and improvement of these essential natural resources.

Recreational Use of Rivers and Beaches

Swimming holes and beaches in the region are considered safe for recreational use for the majority of the time. However, it is advisable to avoid swimming during periods of windy or stormy weather due to the heightened risk of elevated bacteria levels and disturbed sediments, which can compromise water quality.

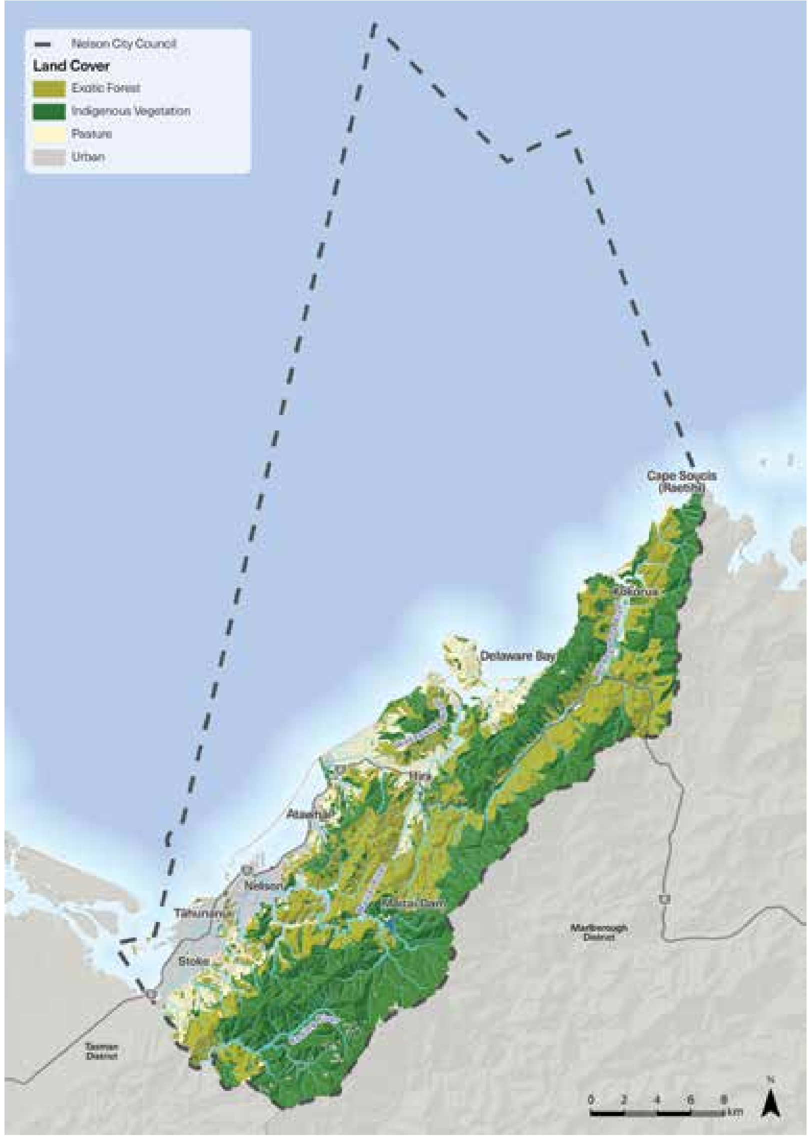
This report identifies Wakapuaka at Paremata Flats Reserve as having recurrent high *E. coli* levels, indicating a need for improved sustainable land management practices to align with public health standards and ensure the safety of these recreational waters.

Get in Touch

Nelson City Council's commitment to understanding and safeguarding our environment is a cornerstone of our work, as detailed in this report.

We welcome your insights and feedback on any aspect of our work. Should you wish to contribute your thoughts or engage in discussion, please reach out to our Science and Environment unit at science.environment@ncc.govt.nz.

Mayor, Nick Smith



Nelson City Council Region

Nelson at a glance

52,584
Population as of 2023 (3.3% Increase between 2018 – 2023)

Nelson $61,530
New Zealand $64,086
GDP per Capita at 2020

0.4%
Wetland (of total land area, 120 wetlands surveyed)

Land area

Urban 8,230 ha

Native Vegetation 16,600 ha

Exotic forestry 11,340 ha

Grassland 5,830 ha

Total **42,000 ha**

1
Marine reserve

8
Iwi in Nelson

1,000 mm
Mean annual rainfall

2,400hrs
Total annual sunshine hours

Top three industries by GDP ($m) at 2023

Health care & social assistance	$374.9m
Professional, scientific & technical services	$309.9m
Manufacturing	$305.8m

Air Quality

Photo credit NCC

What We Know – State and Trend

Breathing clean air is important for our health and wellbeing. Emissions from human and natural activities can degrade the quality of our air, impacting on our health and our quality of life. Poor air quality also affects the health of plants and animals. The main air contaminants in urban areas are particulate matter (particles suspended in the air) and gases such as nitrogen dioxide.

Health impacts can occur as a result of both short and long-term exposure to particulates. Long-term exposure to PM2.5 (the smallest particles) has the greatest health impacts as these tiny particles can penetrate deep into our lungs. Health impacts of particulate pollution can include people dying earlier than they otherwise would and being hospitalised with cardiovascular and respiratory problems. People with existing heart or lung diseases, as well as children and older adults, are the most likely to be affected by exposure to particle pollution.

Monitoring of PM_{10}, $PM_{2.5}$ and Gases

We have been regularly monitoring concentrations of PM10 (particles in the air which are less than 10 microns in diameter) for more than 20 years, and since 2018 we have been measuring PM2.5 (particles less than 2.5 microns in diameter, which is a subset of PM10). Monitoring data is collected from four 'airsheds' shown in Figure 1. We also monitor concentrations of gases such as nitrogen dioxide, but on a less frequent basis with the last survey of nitrogen dioxide in 2021.

We compare concentrations measured in Nelson to the National Environmental Standards for Air Quality (NESAQ). These are legally binding levels of air pollution that must not be exceeded. The NESAQ requirements for particulates are being revised, and this is likely to result in a new, stricter standard for PM2.5. It is also useful to compare Nelson's concentrations to the World Health Organisation (WHO, 2021) guidelines. These are international guidelines rather than requirements we must meet.

Air Quality Improvements

The good news is our PM10 concentrations comply with the NESAQ for PM10 and we no longer have 'polluted' airsheds, as shown in Picture 1. Since 2002 we have implemented our Nelson Air Quality Plan, which required a range of measures to be undertaken related to domestic heating and outdoor burning to improve air quality, as well as improvements in PM10 emissions from industrial activities. However, in some areas our PM2.5 concentrations are above the WHO (2021) guidelines, specifically in the Tāhunanui and Nelson South airsheds.

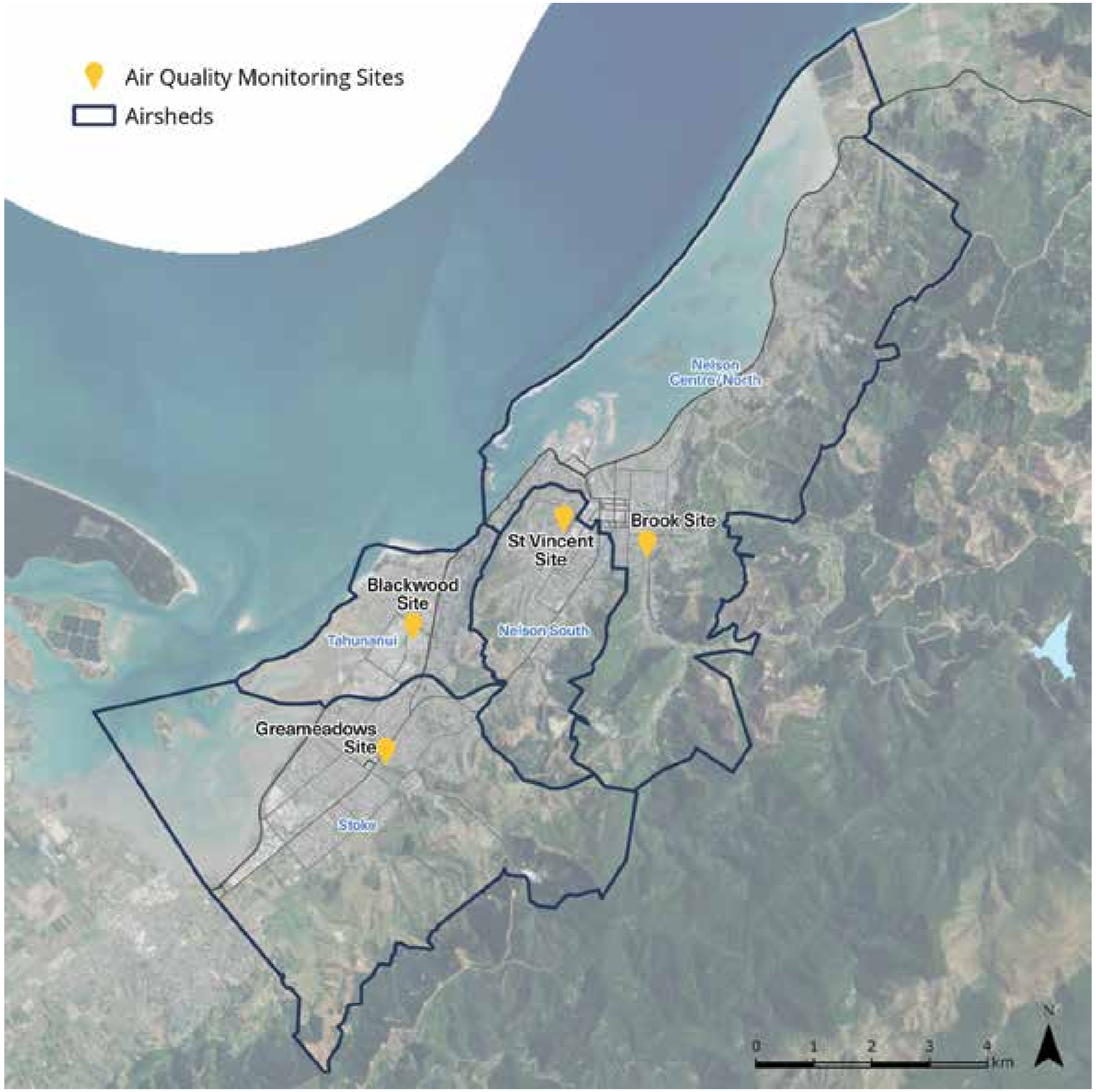


Figure 1: Map of Nelson's Airsheds

Picture 1: Photo of Typical 'Polluted' Winter Air Quality Emissions in Nelson (July 2024)

Photo credit K. Stephens

Concentrations of PM10 and PM2.5 have been improving in most areas of Nelson but this trend is unlikely to continue in the absence of further management measures, now that the changes required by the Air Quality Plan are in place.

In 2020 we assessed the sources contributing to PM10 and PM2.5 in Nelson. In all areas domestic heating is the main source of PM10 and PM2.5 although industry is equally significant in the Tāhunanui area.

Nitrogen Dioxide Monitoring

In the past we have monitored concentrations of nitrogen dioxide (NO2) during the winter months. These concentrations complied with the NESAQ standard for NO2 with no indication of any issues with this contaminant at that time. However, recent health studies conducted in New Zealand and overseas have shown that long term (annual) exposures to what were previously considered low concentrations of NO2 can have significant health impacts.

As a result, the WHO (2021) guidelines now include a new standard for annual average exposure of NO2 of 10 µg/m3 (1 microgram per cubic metre). We don't yet know if NO2 concentrations in Nelson comply with this guideline. Motor vehicles are the main source of NO2 in Nelson and also contribute to PM2.5. Tailpipe emissions of NO2 and PM2.5 from motor vehicles are estimated to decrease significantly over the next 25 years as a result of policy measures including fuel and emission standards implemented by central government.

What We're Doing

We measure both PM10 and PM2.5 in Nelson South (Airshed A) and in Tāhunanui (Airshed B1) because these are the areas that have the highest concentrations of particulates. We continue to monitor PM10 in Airsheds B2 and C. We are reviewing the air quality monitoring network and modernising our equipment to improve efficiency and ensure best use of monitoring resources. This is likely to result in a better understanding of PM2.5 by moving to continuous monitoring for Nelson South (Airshed A) and Tāhunanui (Airshed B1).

We continue to implement the Air Quality Plan to limit emissions from both domestic and industrial sources, and to ensure air quality is improving where this is necessary and is not degrading elsewhere. This includes ensuring only solid fuel burners that comply with regulations can be installed in our airsheds, and programmes such as the 'good wood' scheme continue to promote the use of quality firewood to reduce the particulates being discharged to air. We continue to require industries that discharge contaminants to air to obtain resource consents – which include conditions requiring action to be taken to improve the quality of these discharges.

Where We're Heading

We will continue to monitor key contaminants in the airsheds with the lowest air quality (Nelson South and Tāhunanui) and re-evaluate our air quality in relation to the revised National Environmental Standards for Air Quality (NESAQ) when these are released. This will tell us if our air quality is acceptable or if further improvements are required. We will then be able to evaluate our existing PM2.5 monitoring to determine whether Nelson complies with NESAQ and the WHO guidelines and to assess whether additional monitoring in other areas is needed or if changes to our approach are required.

Air quality monitoring equipment. Photo credit C. Appleton

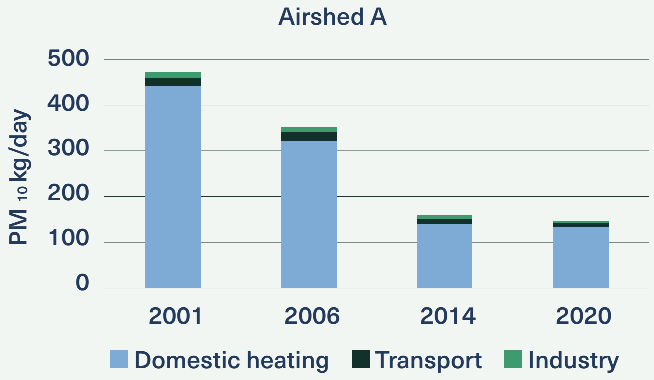
Air Quality – Case Study

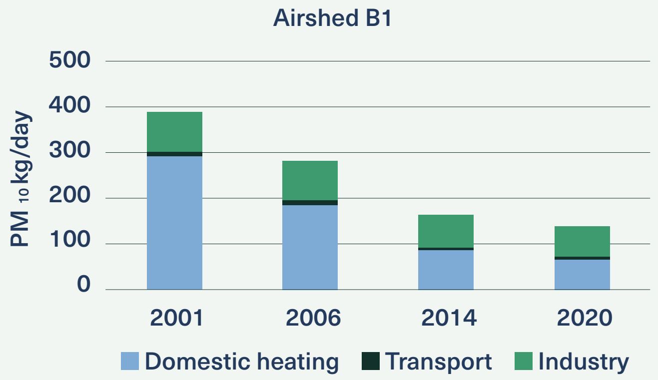
Improvements in Domestic Burning

Prior to the implementation of the Nelson Air Quality Plan, Nelson's air quality was amongst the worst in New Zealand. We were the 'pollution capital of New Zealand' for frequency of PM10 exceedances. This was based on data for 2001 when Nelson experienced the greatest number of days (81) ever measured in New Zealand when PM10 concentrations exceeded the 50 µg/m3 limit. The maximum daily PM10 during 2001 was 165 µg/m3; this is the highest ever recorded in Nelson and has rarely been exceeded elsewhere in New Zealand.

We undertook scientific studies to identify the causes and developed a strategy to reduce daily winter PM10 concentrations by around 70% in Nelson South (Airshed A) and 56% in Tāhunanui (Airshed B1) as shown in Graph 1. We also set a long-term air quality target of 32 µg/m3 for PM10 (66% of the NESAQ value). Domestic heating was identified as a key source of our daily winter PM10 and measures have been taken to improve this. Phasing out of open fires and older, more polluting, wood burners with clean heat or low emission alternatives has contributed significantly to improvements in our air quality. A 'Clean Heat Warm Homes' programme was established to assist low-income households with open fire and wood burner conversions. Banning outdoor rubbish burning and requiring industries to reduce their discharges has also helped to reduce PM10 concentrations in Nelson.

Graph 1: Shows the Improvement in Human Sources of PM10 Emissions by Source in Nelson South (Airshed A) and Tāhunanui (Airshed B1) from 2001 to 2020.



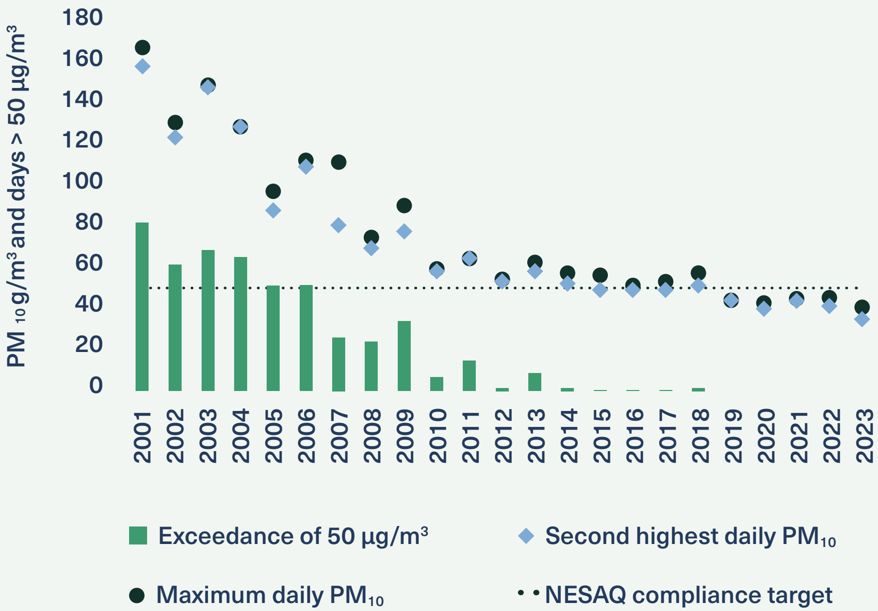


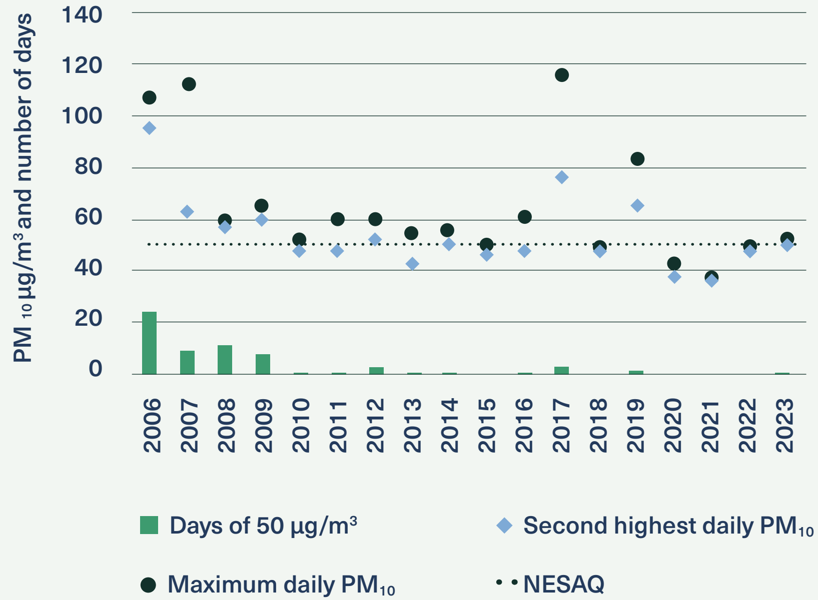
Our community has worked hard to achieve cleaner domestic burning. A 'good wood' scheme was established to promote the use of dry firewood and householders got on board by ensuring they had dry storage areas for their firewood. In 2018 we undertook additional work to improve emissions from smoky chimneys, helping people to identify the causes of excessive smoke from their household fires.

Our community's efforts in improving air quality in Nelson are nationally significant. We have achieved improvements in daily winter PM10 concentrations of more than 70%. We are the first town in New Zealand that needed to make a reduction in PM10 of this magnitude to no longer be 'polluted' under the NESAQ. This means that PM10 concentrations in Nelson have not breached the NESAQ for five consecutive years.

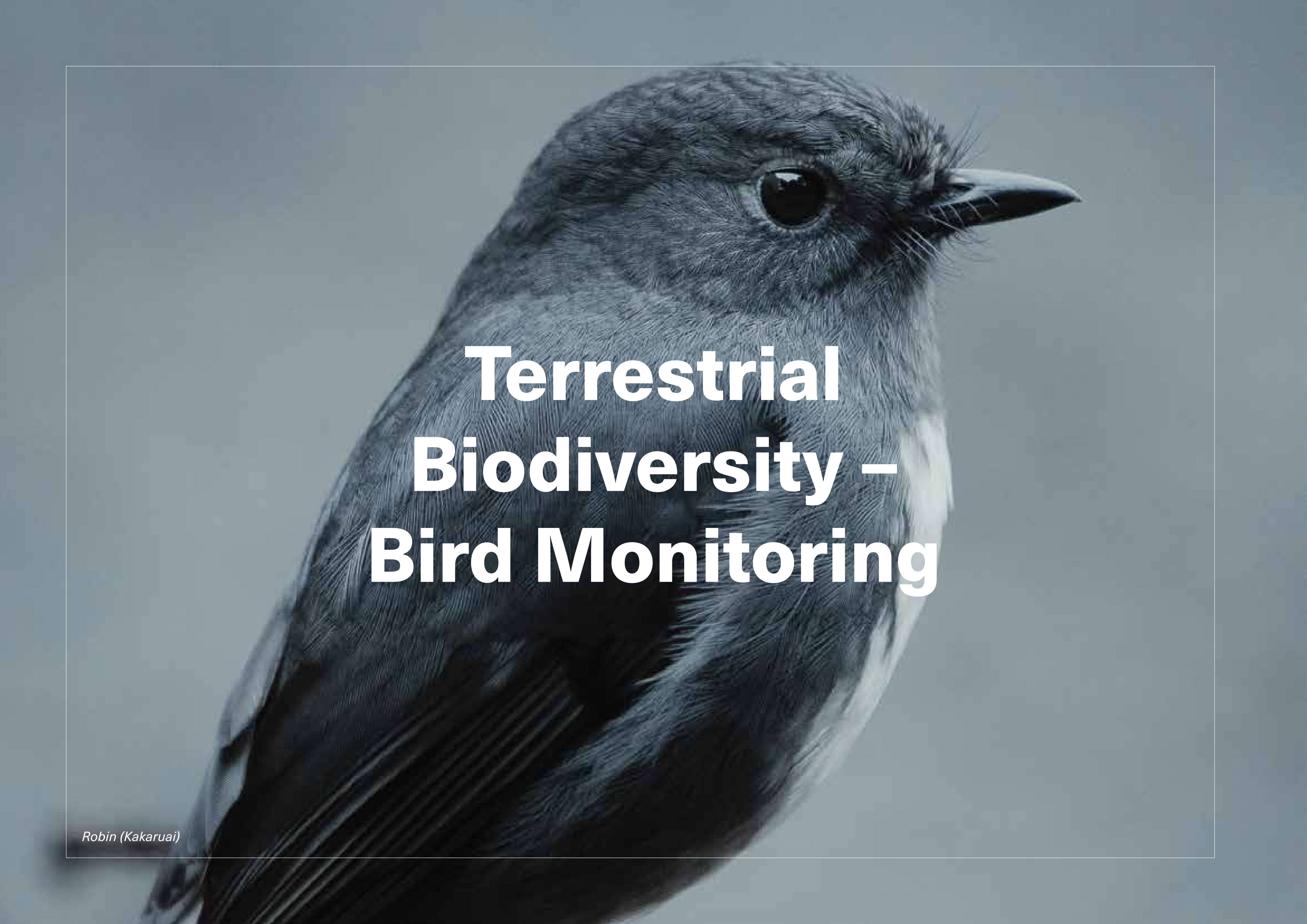
Graph 2 shows improvements in exceedance days, and the maximum and the second highest PM10 concentrations in Nelson South from 2001 to 2023. Monitoring of PM2.5 has not been carried out for this period, however, similar reductions in PM2.5 are expected.

Graph 2: Trends in Daily PM10 Concentrations in Nelson South (Airshed A) and Tāhunanui (Airshed B1)– 2001 to 2023





Air Quality monitoring station at Greenmeadows Stoke, Photo credit R. Curtis



Terrestrial Biodiversity – Bird Monitoring

Robin (Kakaruai)

What We Know – State and Trend

Birds in the Nelson region can be classified into three main biogeographical designations based on where the species originated: endemic, native and introduced species (descriptions below). Note that the term ‘native’ often refers to native and endemic species. In this report, indigenous is used to refer to both.

It is important to understand the abundance and locations of birds, so that we can understand which species are present, population trends and compare numbers pre and post pest management. Grouping into endemic, native or introduced species helps us to detect changes amongst the groups. Endemic species, being more vulnerable to habitat loss and introduced predators, are generally more difficult to manage so are good indicators of management successes. See Table 1 for a list of species and status.

Endemic birds are unique to New Zealand, and not found in the wild anywhere else. Most of New Zealand’s endemic birds evolved in geographic isolation from land mammals, prior to the arrival of humans, and without the need to protect themselves from mammalian predators (such as rats, stoats, and cats); and without any competition from introduced birds. These New Zealand specialists are highly adapted to our natural, unmodified environments, and are very sensitive to environmental changes. Unfortunately, their unique characteristics can make them vulnerable to extinction. Examples of endemic birds include brown creeper (pīpipi) and robin (kakaruwai).

Native birds are self-introduced and naturally found in New Zealand but also live in other parts of the world. Generally, native bush birds end up in New Zealand by dispersal from Australia. The silvereye (tauhou) is an example of a native bird who arrived this way.

Introduced birds were brought to New Zealand by humans from other regions of the world. Introduced species can become ‘invasive’ if they outcompete indigenous organisms and disrupt the ecosystems they have colonised. Examples of introduced birds include house sparrows, blackbirds, and finches.

How We Count Birds

Transect Sampling

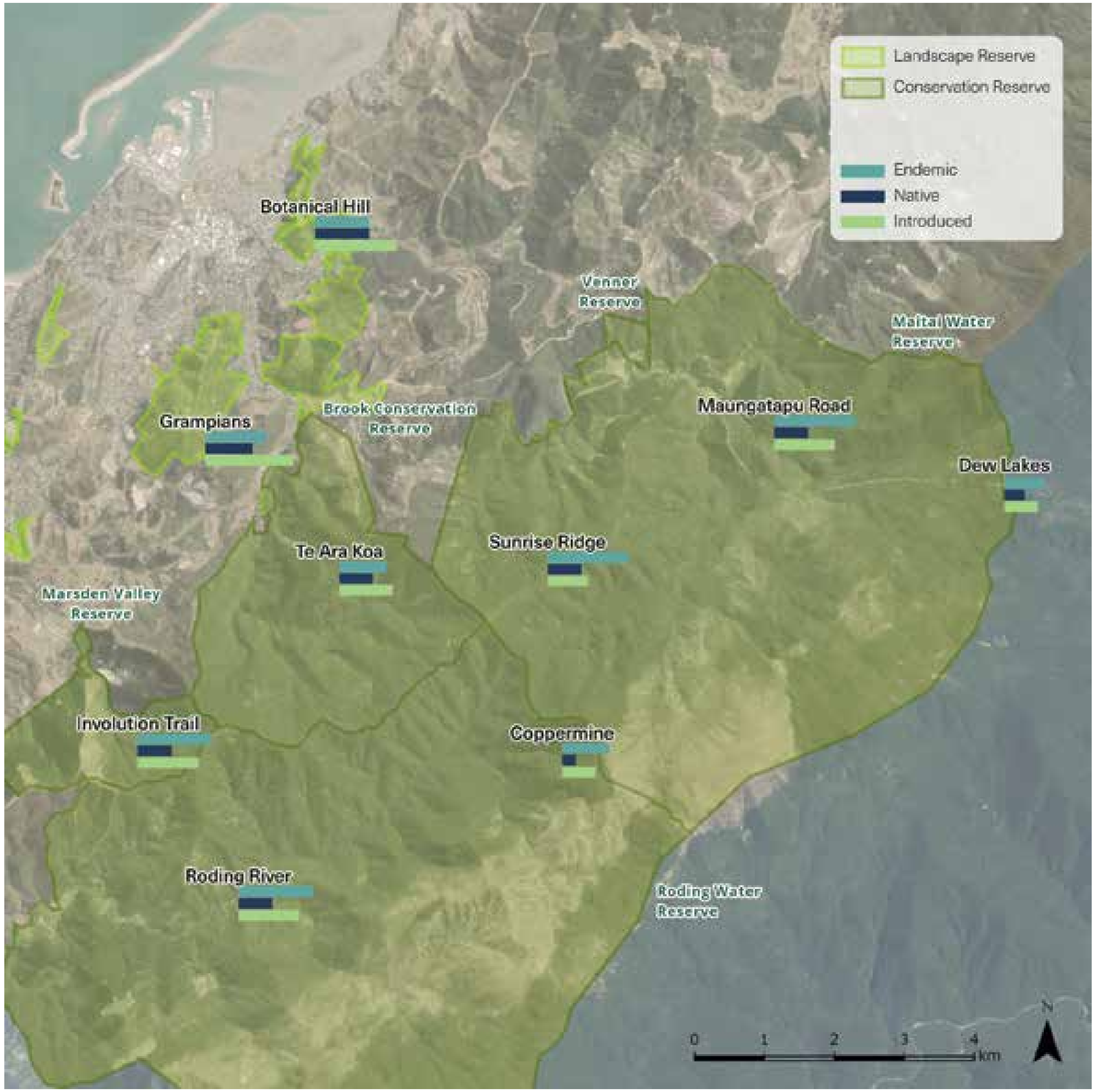
Our survey areas represent high value ecological areas in Nelson’s Conservation and Landscape Reserves (Figure 2). Bird counting happens four times per year at each site on separate days between late October and early December.

Transect sampling is a methodical, repeatable way to record the distribution and abundance of organisms in a defined area. A transect line is walked and bird counts are conducted at set points along that line. In our surveys, individual transect lines are between 6 and 13 counting stations, spaced approximately 200 m apart.

At each of these points, the observer spends five minutes recording all the birds they can see and hear during that time.

The locations of the nine transects show the proportions of introduced, native and endemic bird species at each site. The size of individual bars is scaled to represent the total number of individual bird detections.

Figure 2: Bird Monitoring Survey Locations



Results

We detected 35 different bird species between 2015 and 2023, which are listed in Table 1.

Table 1: Total Counts for each Bird Species, Latin and Te Reo Name and Threat Classification Between 2015 and 2023

Species	Scientific name	Te Reo name*	Biogeographic designation	Threat classification[0]	Count
Silvereye	*Zosterops lateralis lateralis*	Tauhou	native	Not threatened	9902
Chaffinch	*Fringilla coelebs*	Pahirini	introduced		4420
Eurasian blackbird	*Turdus merula*	Manu pango	introduced		3336
Grey warbler	*Gerygone igata*	Riroriro	endemic	Not threatened	2151
Bellbird	*Anthornis melanura melanura*	Korimako	endemic	Not threatened	1818
New Zealand fantail	*Rhipidura fuliginosa fuliginosa (SI)*	Pīwakawaka	endemic	Not threatened	1771
House sparrow	*Passer domesticus*	Tiu	introduced		1407
Tui	*Prosthemadera novaeseelandiae novaeseelandiae*	Tūī	endemic	Not threatened	1249
Song thrush	*Turdus philomelos*	Manu-kai-hua-rakau	introduced		768
Dunnock	*Prunella modularis*		introduced		716
South Island robin	*Petroica australis australis*	Kakaruai	endemic	At risk – declining	545
Sacred kingfisher	*Todiramphus sanctus vagans*	Kōtare	native	Not threatened	416
European goldfinch	*Carduelis carduelis*	Kōurarini	introduced		413
California quail	*Callipepla californica*	Tikaokao	introduced		399
Common starling	*Sturnus vulgaris*	Tāringi	introduced		390
Tomtit	*Petroica macrocephala macrocephalus* (SI)	Miromiro	endemic	Not threatened	311
Welcome swallow	*Hirundo neoxena neoxena*	Warou	native	Not threatened	228
Shining cuckoo	*Chrysococcyx lucidus lucidus*	Pīpīwharauroa	native	Not threatened	219

Species	Scientific name	Te Reo name*	Biogeographic designation	Threat classification⁰	Count
European greenfinch	*Carduelis chloris*	Kōurarini	introduced		195
Southern black-backed gull	*Larus dominicanus dominicanus*	Karoro	native	Not threatened	178
Kereru	*Hemiphaga novaeseelandiae*	Kererū	endemic	Not threatened	168
Yellowhammer	*Emberiza citrinella*	Hurukōwhai	introduced		138
Weka	*Gallirallus australis australis*	Weka	endemic	Not threatened	81
Paradise shelduck	*Tadorna variegata*	Pūtangitangi	endemic	Not threatened	74
Swamp harrier	*Circus approximans*	Kāhu	native	Not threatened	49
Common redpoll	*Carduelis flammea*		introduced		21
Rifleman	*Acanthisitta chloris chloris (SI)*	Tītitipounamu	endemic	Not threatened	18
Red-billed gull	*Larus novaehollandiae scopulinus*	Tarāpunga	native	At risk – declining	16
New Zealand falcon	*Falco novaeseelandiae ferox***	Kārearea	endemic	Nationally increasing	15
Brown creeper	*Mohoua novaeseelandiae*	Pīpipi	endemic	Not threatened	9
Common pheasant	*Phasianus colchicus*		introduced		5
Yellow-crowned parakeet	*Cyanoramphus auriceps*	Kākāriki	endemic	At risk – declining	4
Eurasian skylark	*Alauda arvensis*	Kairaka	introduced		2
Mallard	*Anas platyrhynchos*	Rakiraki	introduced		1
White-faced heron	*Egretta novaehollandiae*	Matuku moana	native	Not threatened	1

* New Zealand Birds online accessed 29/08/24

** Bush falcon subspecies

⁰Roberston et al (2021), Conservation status of birds in Aotearoa New Zealand, Department of Conservation.

By far, the most frequently observed species was the silvereye (tauhou) (9,902 detections; native), followed by the chaffinch (4,420 detections; introduced) and the Eurasian blackbird (3336 detections; introduced).

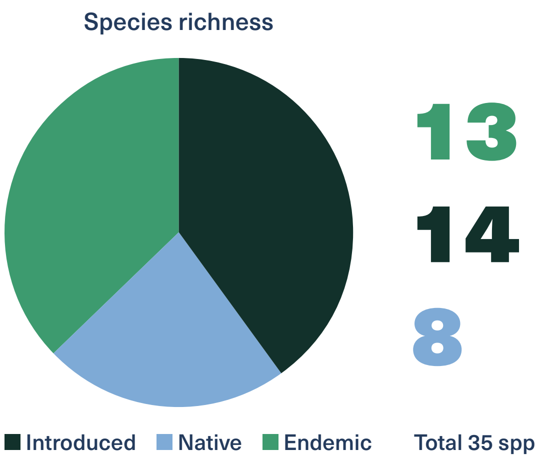
The most recorded endemic species were the grey warbler (riroriro) (2,151 detections), bellbird (korimako), (1,818 detections), fantail (pīwakawaka) (1,771 detections) and tūī (1,249 detections).

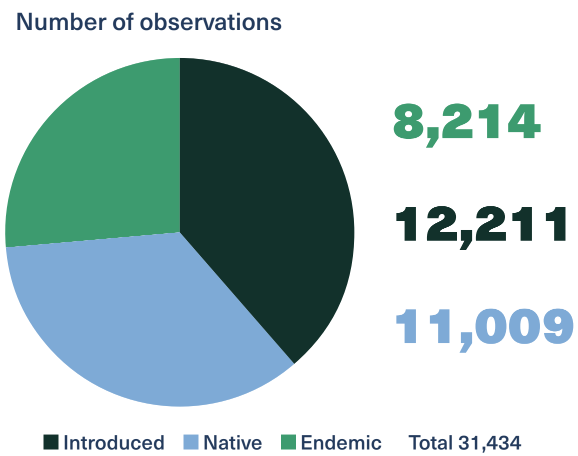
Other endemic and native species were much less commonly observed, including the brown creeper (pipipi) and the rifleman (titipounamu), as well as species which typically inhabit open-country or wetland areas, such as the swamp harrier (kāhu).

Of the 35 species observed in this study 13 were endemic, eight were native, and 14 were introduced (Graph 3).

Graph 3: Bird Species Richness and Number of Observations

Native Pigeon (Kererū)





Summary of Results:

- Introduced species were the most commonly present along the counted transects – both in terms of the highest number of species (species richness) and the highest number of individual birds (abundance).
- More endemic species than native species were present along the transects, but the total numbers of native birds in Nelson was higher than the numbers of endemic birds. A greater proportion of endemics live away from human modified habitats.

Endemic Species Were Found in Intact Indigenous Vegetation

Bird communities closer to suburban Nelson comprised more introduced and native species than endemic species. In these modified areas, the remaining tracts of native forest are fragmented, comparatively smaller in area, plants are younger, and forest is more heavily modified by human activity. More endemic species were present at mid-to-high elevations in larger expanses of mature indigenous forests. Their survival is supported by presumed few predators in higher altitude areas.

The numbers of endemic, native and introduced bird species heard or seen across the study area during the bird surveys varied considerably amongst the nine survey lines. The highest number of species (diversity) were observed in the Botanical Hill area (29 species) and southwest Grampians (28), and the lowest number of species were observed at the Coppermine and Dew Lakes (both 14).

- **Endemic birds** – species diversity was highest in the inland areas: Sunrise Ridge (12) the Involution Trail (11) and Roding River (11). The number of species was lowest at the Dew Lakes (6), Te Ara Koa (7) and the Coppermine (7) survey areas.
- **Native birds** – species diversity was highest at the Botanical Hill (8), the southwest Grampians (7), and lowest at the Coppermine (2).
- **Introduced birds** – species diversity was highest at the two survey areas closest to Nelson City. These are southwest Grampians (13) and Botanical Hill (12). The number of introduced species was lowest at the Coppermine (5) and Dew Lakes (5).

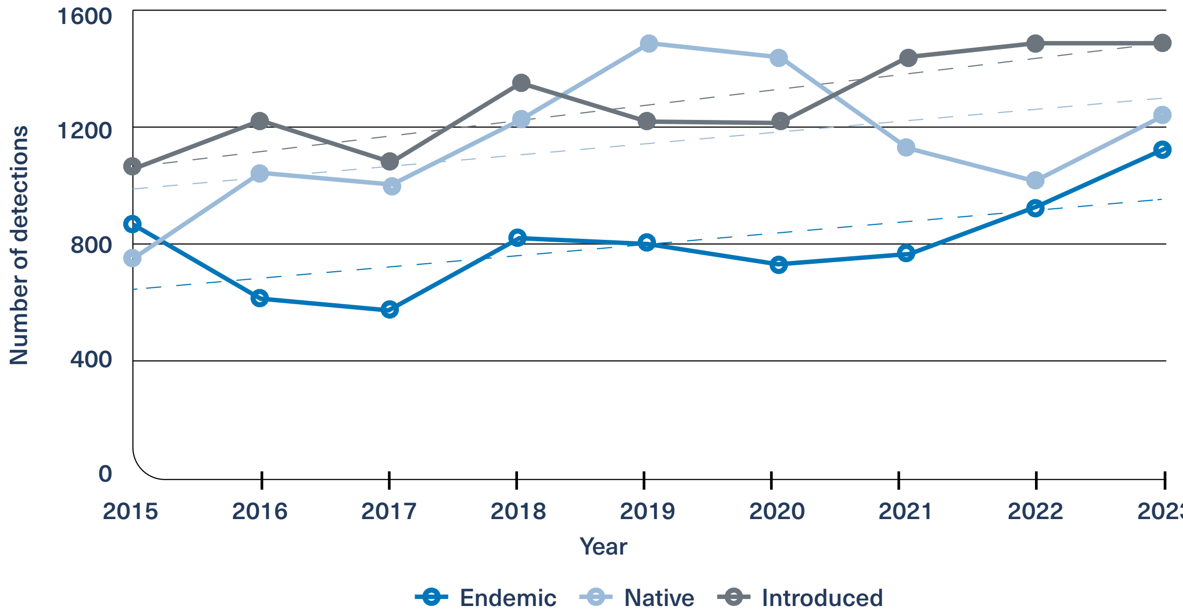
Temporal Trends in Indigenous verses Introduced Birds

From 2015 to 2023 the total number of birds counted in the survey areas increased the most for introduced species, but the rate of population increase has been higher for endemic species (the 2023 population is 1.5 times larger than it was in 2015).

The numbers of detections of endemic, native and introduced birds vary considerably between 2015 and 2023 (Graph 4).

- **Endemic birds** – detections initially decrease from 2015 to their lowest values in 2016 and 2017, then consistently increase from 2020 until the end of the monitoring period in 2023.
- **Native birds** – detection numbers increase very quickly from 2015 to 2019, then decrease rapidly until 2022, then rise again in 2023, with peak values in 2019 and 2020.
- **Introduced birds** – detection numbers vary from 2015 to 2021 but are more stable from 2021 until 2023.

Graph 4: Temporal Trends in the Numbers of Detections of Native, Endemic, and Introduced Bird Species at Monitoring Transects in Nelson's Conservation and Landscape Reserves, 2015 to 2023.



Endemic Birds are Less Numerous and have more Restricted Geographic Distributions than Native and Introduced Species

Nelson's endemic forest birds are found most frequently in cooler, higher-altitude 'refugia' with larger, connected stands of mature native forest, especially 600 metres and higher.

These locations include the sampling transects at Sunshine Ridge, Involution Trail, Roding River and Maungatapu Road. In these areas the greater diversity and abundances of endemic species means that sometimes they are more dominant than native or introduced species.

Endemic birds do well in high altitude, mature forest because:

- there may be fewer rats, stoats, and cats, which are major predators of New Zealand's indigenous birds;
- they provide habitats and food resources not available elsewhere, that many endemic species need to survive; and
- they are intact natural areas, relatively inaccessible and less impacted on by human activities.

These factors work together to provide more suitable, safer environments for endemic forest birds. Breeding populations of several endemic forest species were recorded in these areas, including South Island robin (kakaruai), and rifleman (titipounamu).

Endemic (and native) bird species that remain relatively common near Nelson's urban area tend to be:

- able to cope with significant alteration and fragmentation of forest habitats, as well as the presence of rats, stoats, and cats – species such as silvereyes (tauhou), grey warblers (riroriro) and fantails (piwakawa); or
- species that travel over open land, such as tūī and bellbird (koromiko), who regularly commute to these areas from larger tracts of nearby bush; or
- attracted to popular native flowering plants, such as kowhai, cabbage tree (tī kōuka) and flax (harakeke) in urban gardens and parks.

Weka

Bird Abundance in the Study Area has Increased from 2015 to 2023

One possible reason bird numbers in some of Nelson's reserves have increased over the last nine years is potential reduction in the numbers of rats, stoats, and weasels due to the efforts of community trapping. By reducing predator numbers, these projects may have improved nesting success rates, leading to population increases.

Introduced Bird Numbers are Increasing Fastest

While the increase in abundance of birds is certainly good news, we also need to realise that the number of introduced birds has increased the most, and these species can outcompete endemic and native species for food, nesting sites, and territory. Introduced species can also disrupt the natural balances in native ecosystems, leading to the decline of plant or insect species that are critical for the survival of native and endemic birds.

Populations of introduced species are generally more stable than those of indigenous species, as they are generalists – they are more adaptable, reproduce more quickly and are less affected by changes in the environment.

In contrast, endemic bird populations are more at risk of declining because they are specialists who have adapted over tens of thousands of years to the local conditions. They reproduce at lower rates, may put more parental effort into raising each chick, and are more sensitive to competition from other bird species, to introduced mammalian predators, and to changes in their environment.

This combination of factors leads to slower population growth rates of endemic species, making them more vulnerable to population decline than native and introduced species.

Not all Forest Bird Species Known to Inhabit the Study Area were Detected in our Monitoring

This includes kākā, morepork (ruru) and long-tailed cuckoo (koekoeā), which have been recorded through other monitoring programmes (including the Global Biodiversity Information Facility (GBIF), iNaturalist or eBird) which are available here: **gbif.org.nz**, **inaturalist.nz** or **ebird.org/home**

There are possible reasons why these 'missing' species were not observed. It could be that they were in low numbers and located away from the survey sites. Also, if they are secretive, nocturnal, and quiet then they would be difficult to spot.

Underestimating the locations and numbers of birds living in these selected reserves has important consequences for conservation programmes. Not reflecting the true diversity of ecosystems and how they function could lead to insufficient protection of threatened species and habitats. It could also mean we aren't aware of key areas where we should be taking action to protect habitats of endemic species, potentially resulting in the complete loss of threatened species from the region. Underestimating species richness can also affect policy-making decisions and resource allocation, leading to less effective strategies for environmental management and reduced funding for conservation initiatives.

Tūī. Photo credit P. Cochrane

What We're Doing

Council's Nelson Nature Halo programme coordinates and funds community trapping groups in three areas where bird counts were undertaken: Botanical Hill, Grampians, and Marsden Valley. These groups have been trapping pests during the bird count period. In addition, over the past three years, as part of Project Mahitahi and Jobs for Nature, a site near Te Ara Koa and an area in the Maitai Conservation Reserve have been trapped under contract. The majority of the area shown in Figure 2 lacks animal pest control, and few traps have been deployed outside of coordinated programmes.

Our bird monitoring was designed to capture an estimate of baseline counts and not to measure trapping success in the areas listed above. Summarising these data has provided a good estimate of the numbers and locations of birds in these areas in late spring. If Council, or community groups, undertake additional targeted pest control in these areas in future, our current estimates could be compared with future counts to measure success.

Where We're Heading

Our study shows that, while numbers of birds in this study area have increased from 2015 to 2023, remnant populations of rare endemic species are mostly restricted to high-altitude 'islands' of mature native forest.

The restriction of our endemic birds to remote, forested hill country and the rising numbers of introduced birds identified by our monitoring reflects a global pattern of biodiversity loss in which endemic 'specialist' birds are eradicated from their habitats at greater rates than non-endemic 'generalist' native or introduced species that have arrived comparatively recently.

An issue to be addressed is the shifts in species dominance from local endemics to non-endemic, or non-native species, creating ecosystems with less diversity and uniqueness at local and regional scales.

A key implication of this finding is that programmes to manage Nelson's biodiversity need to prioritise these sensitive areas to protect vulnerable endemic residents.

This can be achieved by increasing efforts to eradicate possums, hedgehogs, stoats, weasels, rats, and feral cats, but also consider controlling numbers of ungulates such as goats, deer, and pigs (see next section).

Managing indigenous species and ecosystems is complex and costly, and we acknowledge that current approaches are insufficient to support thriving endemic bird populations close to our urban centres. However, the national push for a predator-free NZ by 2050 has been a catalyst for innovation and it is hoped that new technologies will become cost effective on landscape scales and supported by our communities.

Council is considering the following management actions to safeguard rare, endemic bird species in Nelson:

- Conducting ecological research to better understand the needs of new and emerging threats to indigenous species and their habitats.
- Reviewing biodiversity monitoring.
- Communicating to the public and policy makers about the intrinsic values of indigenous species and the need for their conservation.
- Identifying and protecting ecological corridors linking fragmented habitats to facilitate movement of indigenous species amongst areas of high-quality habitat.
- Implementing strategies to address the likely impacts of climate change on indigenous species and ecosystems.
- Working with iwi in Te Tauihu to understand mātauranga and the cultural significance of protecting indigenous species in Nelson.


Silvereye (Tauhou)


Tomtit (Miromiro)

Photos credit P. Cochrane

Terrestrial Biodiversity – Vegetation Monitoring

What We Know – State and Trend

The Maitai, Brook and Roding Conservation Reserves are home to considerable natural assets (including globally unique biodiversity, and key national habitats and ecosystems) as well as scenic landscapes and important cultural sites.

The extensive forests in these reserves are also valuable for their ability to absorb carbon, to reduce downstream flooding and erosion, and to provide vital habitats for wildlife. They also offer diverse recreational opportunities and access to nature for residents and visitors, and the Maitai and Roding catchments supply drinking water to Nelson.

The natural vegetation types in these Council Reserves vary, for example due to the local soil types, including specialised or stunted plants on the highly mineralised ultramafic and limestone soils. Since 2013, Nelson City Council has been monitoring vegetation in these varied ecosystems.

Why Deer and Goats are a Problem in these Reserves

New Zealand's indigenous plants evolved in isolation from mammalian browsers, such as deer and goats (ungulates). Many of these plants lack defense mechanisms that protect them from these browsers (such as thorns on their stems or bitter tasting leaves).

Ungulates have been present in Nelson for many years and we assume they have been selectively eating vulnerable indigenous plant species since their introduction. To understand the state of indigenous vegetation in these reserves, given the presence of ungulates, we need to know to what extent the animals that consume them have impacted on the vegetation.

Plant species vary in their taste (palatability): some species are highly preferred and are frequently browsed, while others are less palatable and so are typically avoided by deer and goats. Even with very low numbers of deer or goats present, palatable plants are soon replaced by unpalatable plants, leading to localised extinctions and changes in community composition. This often results in forests having an understorey which is completely bare or comprised of low-palatable species (see Table 2 and Pictures 2–5). These preferences may also influence rates of seedling establishment and growth.

Table 2: Examples of Plant Palatability

Selected/Palatable	**Common Name**	**Te Reo Name**
Coprosma grandifolia	large-leaved coprosma	kanono
Griselinia littoralis	broadleaf	kāpuka
Hedycarya arborea	pigeonwood	porokaiwhiri
Melicytus ramiflorus	whitey wood	māhoe
Myrsine australis	red matipo	mapou
Non-selected		
Carpodetus serratus	marbleleaf	putaputawētā
Coprosma foetidissima	stinkwood	hūpiro
Coprosma propinqua	swamp mingimingi	mingimingi
Coprosma 'tayloriae'	x	x
Pseudopanax crassifolius	lancewood	horoeka
Avoided		
Leptecophylla juniperina juniperina	prickly mingimingi	x
Leucopogon fasciculatus	tall mingimingi	x
Fuscospora fusca	red beech	tawhairanui
Notofagus/Lophozonia menziessii	hard beech	x
Pseudowintera colorata	pepper tree	horopito

The primary desired outcome for ungulate management is long-term protection of forest understorey, shrubland and ultramafic vegetation, and to encourage regeneration of forest and shrubland canopy within the Maitai and Roding Reserves, including Dun Mountain.

Monitoring allows us to identify priority areas for protection and recovery of indigenous plants in Nelson's Conservation Reserves. This is essential if we are to maintain their ecological integrity and their ability to recover from the impacts of introduced animals.

Picture 2: Bare Understorey

Photo credit A. Wards

Pictures 3 and 4: Photographs show an Absence of Palatable Species near Maitai Caves

Photo credit P. Cochrane

Picture 5: Evidence of Pig Rooting and Ungulate Browsing

Photo credit P. Cochrane

How we Survey what Ungulates are Eating

Current best practice is to calculate the ratios of plants we know ungulates prefer to eat against those plant species we know ungulates avoid. This is called the Seedling Ratio Index (SRI), developed by Manaaki Whenua – Landcare Research. We measure this by recording plant species capable of growing at least 30 cm tall, that are present in what is called the browse tier, which is generally between the animal's knees and their mouths at full stretch. The SRI is a simple way to measure the proportions of tall-to-short seedlings in the forest understorey, with individual plant species being grouped into three palatability classes – preferred, not-selected and avoided.

We measure SRI along several lines (transects) in different vegetation types. Each 400 m long transect consists of 20 monitoring points located 20 m apart. At each of the 20 survey points we record:

- 'short' seedlings less than 30 cm high within a 0.49 m radius circular plot; and
- 'tall' seedlings between 30 cm and 2 m high which were within a 1.41 m radius circular plot.

Fifteen survey transects were measured in 2013 and 2015, with 14 of these on non-limestone substrates. We measured 12 new transects in 2018, nine of which were in limestone areas. Following recommendations provided by Manaaki Whenua – Landcare Research, 22 transects were remeasured in 2023 (Figure 3).

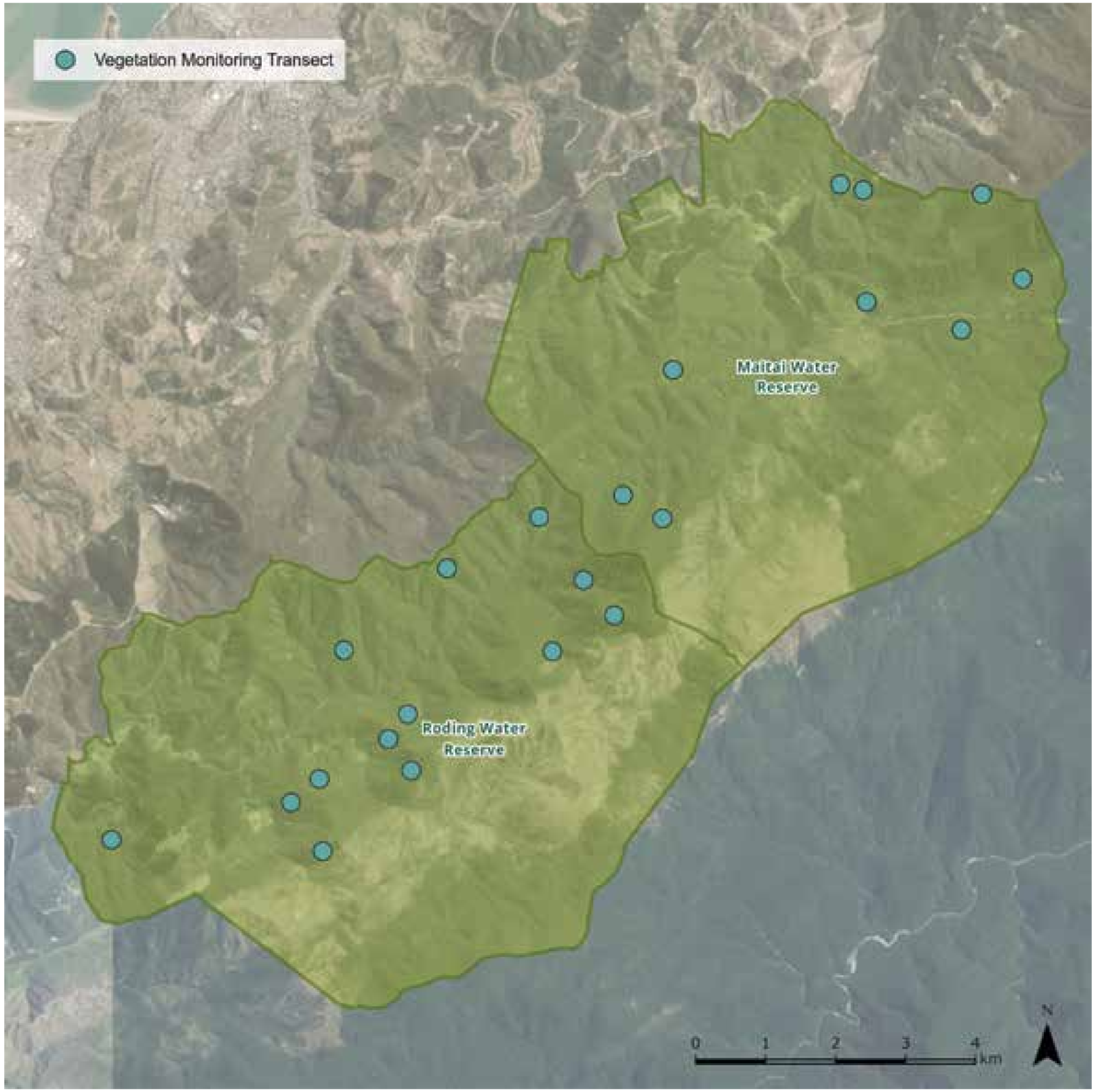


Figure 3: Vegetation Monitoring Transect Locations

Results

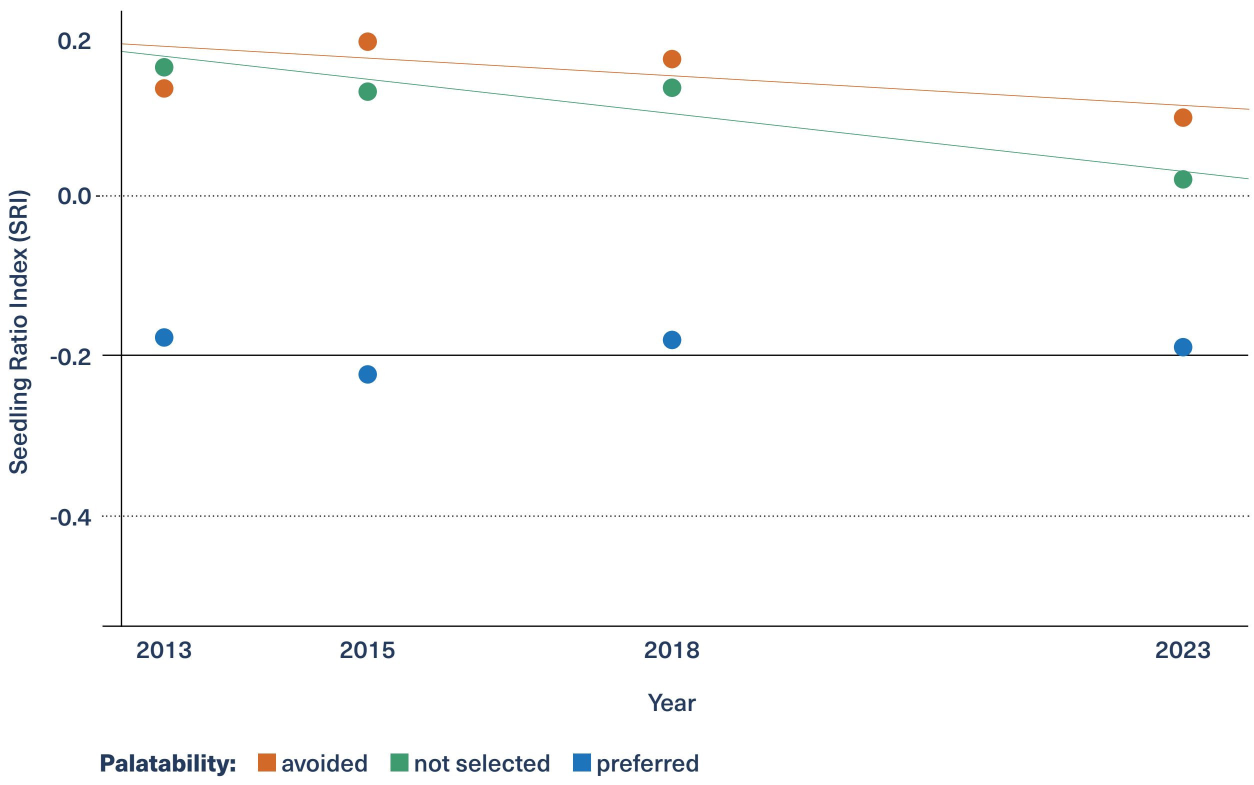
Natural Regeneration of Palatable Species has Decreased

The key results from this study demonstrate that the understorey of our forest ecosystems in our Conservation Reserves have already suffered noticeable damage from deer and goats in the 10 years since monitoring began. The extent of this damage has increased over time. Our monitoring also indicates that ungulates have reduced palatable vegetation to such low levels they now target less palatable vegetation (see Graph 5).

Preliminary analyses of species presence data from SRI transects in the Maitai and Roding Reserves show that:

- Negative average SRI scores for palatable plant species in all four survey years confirm that palatable species are not regenerating to the expected levels. Such reduced regeneration results in altered understorey species compositions, which over time will lead to changes in forest type.
- Forest regeneration rates have slowed for recorded 'not-selected' and 'avoided' woody plants. However, the decrease in 'not-selected' plants is faster than that in 'avoided' species. These findings suggest that now palatable species are less common, ungulates now forage on less favoured vegetation.

Graph 5: Average Seedling Ratio Index scores (SRI) for Dominant Woody Plants of Different Ungulate Palatability Classes in the Maitai and Roding Conservation Reserves, 2013 to 2023



What We're Doing

Over 20 years, NCC has managed ungulate numbers in our reserves through recreational and contracted hunting. This work continues to seek the best outcomes given the available resources and relies on vegetation monitoring to measure success.

Deer and goats are the main threat to rare and vulnerable plant communities in these reserves; however, they are not alone. Possums are omnivores and preferentially consume plants in forested ecosystems and opportunistically devour snails, birds and whatever they encounter. Pigs forage on giant *Powelliphanta* snails and create significant disturbance by rooting in the soil. Rats, mice, hedgehogs, stoats, weasels and feral cats prey on indigenous birds, lizards and invertebrates. Currently, only a few of these species are targeted with pest control in localised areas of high ecological value.

Pest plants (weeds) including introduced vines (Old Man's Beard and banana passionfruit) and wilding conifers also threaten ecological values in these reserves and long-running programmes are tackling the worst of these pests.

Where We're Heading

The impacts on indigenous vegetation by ungulate browsing in our reserves are visible and confirmed by the monitoring and analyses conducted here. To protect vulnerable indigenous plant communities, including the palatable vegetation in our ultramafic, limestone and forest ecosystems, we must limit browse damage by limiting the number of introduced browsing animals.

Estimating the numbers of ungulates in a given area before control is necessary and complex. Current advice suggests that deer and goats must be held at almost undetectable levels to protect the most vulnerable plants from extinction.

NCC will continue to conduct this SRI monitoring at similar intervals, and could add small fenced areas to exclude ungulates as a visual contrast to browsed areas. The adjoining fenced Brook Waimārama Sanctuary already shows significant regeneration of palatable species since browsers (ungulates, rabbits/hares, and possums) were excluded in 2018 and is a perfect example of what our forests might look like if ungulates were absent or in very low numbers.

While currently outside the capacity of Council's biodiversity programmes, ecological values across Council Conservation and Landscape Reserves would benefit from landscape scale animal pest management.

Biosecurity

Fan Worm (Sabella spallanzanii) on a boat hull. Photo credit Hamish Lass (Bay of Plenty Regional Council)

What We Know – State and Trend

Regional councils and unitary authorities (like Nelson City Council and Tasman District Council) are mandated under the Biosecurity Act 1993 to provide regional leadership for biosecurity activities, primarily within their jurisdictional areas. The Council has a responsibility under the Biosecurity Act 1993 to prevent or manage risks from harmful pest plants and animals, and diseases, be they in the terrestrial, aquatic or marine environment.

Pest management influences, and is influenced by, the way land and water is used and managed. Developing and implementing regional pest management plans (as required by the Biosecurity Act 1993) provides the most efficient and coordinated way to reduce or prevent pest impacts on our region's economic, environmental, social, and cultural values. As pest management is a significant undertaking and requires coordination of effort and sharing of resources, the Council worked jointly with Tasman District Council to develop a combined Regional Pest Management Plan.

The Tasman–Nelson Regional Pest Management Plan was established in 2019 and identifies 84 terrestrial, aquatic and marine pests that can cause significant damage to both the Tasman and Nelson regions' natural environments and primary industries. Sixty of these identified pests are plants, 20 are animals and four are plant diseases. See pages 21 to 23 of the Tasman–Nelson Regional Pest Management Plan 2019 to 2029 for the full list. Council reports annually on the activities undertaken to implement the Plan.

What We're Doing

Council provides regional leadership for biosecurity activities by:

- developing and implementing a Regional Pest Management Plan;
- promoting alignment between organisations and adjoining regions;
- working with occupiers to identify and control pests;
- supporting public involvement in pest control and providing information on pest identification and control; and implementing a regional framework.

The Tasman–Nelson Regional Pest Management Plan (RPMP) provides a framework for the Tasman District and Nelson City Councils to work together to manage the 84 identified pest species across the Tasman and Nelson regions.

An objective has been set for each pest, which is one of these options: exclusion, eradication, progressive containment, sustained control, or 'site-led'. The Council reports annually on activities undertaken to implement the RPMP and progress towards meeting its objectives is shown in Table 3. We are largely on track to achieve the management objectives.

Table 3: Pest Management Objectives

Category	No. of Pests identified in RPMP (no.of Nelson City relevant pests in brackets)	Objective	Progress
Exclusion	12 (12)	Preventing establishment	On track
Eradication	24 (12)	Eradication	On track
Progressive Containment	7 (5)	Reducing geographic distribution	On track
Sustained Control	25 (8)	Slowing spread	On track
Site-led	16 (None in Nelson City)	Excluding, eradicating or progressively controlling, or containing in high-value sites (e.g. National Parks)	On track

Both Councils are currently undertaking a partial review of the RPMP, with new organisms proposed to be added and rule changes to other organisms already named as pests by the end of 2024. For Nelson blue passionflower, moth plant, water celery, Vietnamese parsley, feral cats, and wilding conifers will be added, and rule changes are planned for *Sabella* and boneseed.

Raising Community awareness. Photo credit M. McCay

Marine Biosecurity Partnership Regional Collaboration

The Council helped establish, and is an active partner in, the Top of the South (TOS) Marine Biosecurity Partnership across Te Tauihu with Marlborough District Council, Tasman District Council, and the Ministry for Primary Industries. The Partnership has reduced marine biosecurity risks in Nelson, Marlborough, and Tasman from 2009 to the present. It has also contributed to improving marine biosecurity for all of New Zealand, and in July 2023 was joined by Greater Wellington Regional Council.

Specifically the Partnership has:

- reduced biosecurity risks in the water by creating an effective incident response, recording that in a manual, and training all relevant parties in its application (which has reduced our response time from years to hours);
- inspected over 3,400 vessels for marine pests (206 in Nelson);
- produced and distributed public awareness materials both in the Top of the South and neighbouring regions (see marinebiosecurity.co.nz);
- contributed to the development of new tools and knowledge, including publishing technical reports, and running workshops and seminars (e.g. marine pest ID and anti-fouling workshops at Nelson Marina);
- led eradication of Mediterranean fanworm (*Sabella*) – all three Councils have established rules in their Regional Pest Management Plan for *Sabella* (see the following case study); and
- supported industry, including marine farming and marinas, in the development of standards and processes (e.g. supported Nelson Marina facility development to meet Port of First Arrival requirements, enabling overseas vessels to come directly to Nelson as a first port of call).

Emerging Plant Pests

In recent years we have carried out control programmes for highly invasive, emerging pest plants which are not listed in the RPMP. The objective has been to prevent them from establishing in the Tasman-Nelson region, especially water celery and Vietnamese parsley in aquatic environments, and the Moth plant and Blue passionflower (which grow on land).

Water celery *(Helosciadum nodiflorum)*, in Picture 6, is an aquatic herb that appears to be reliant on human activity to disperse fragments. It is widespread in the North Island, though rare in the South Island, and is in the early stages of naturalisation in Nelson City and Tasman District.

While the abundance of water celery is relatively low, current infestations are beyond the eradication stage and ability. There is a large invasion potential in regional waterways that are still free of the pest. Trials to control incursions have been successful at reducing the size of infestations but have not yet proven to be able to eliminate them completely. The proposed RPMP category for water celery is 'Sustained Control'.

Picture 6: Water Celery. Photo credits A. Kimber

Vietnamese parsley *(Oenanthe javanica)*, in Picture 7, is another aquatic herb and is cultivated as an ornamental and culinary herb species. It was first recorded as successfully establishing in the wild in 2014. It impacts on river fishing and swimming, drainage and aquatic biodiversity by clogging small streams and waterways.

Vietnamese parsley is in a very early establishment stage, with limited locations in Poorman Valley Stream. The proposed RPMP category for Vietnamese parsley is 'Sustained Control'.

Picture 7: Vietnamese Parsley. Photo credit T. James

Moth plant *(Araujia hortorum)*, in Picture 8, is a vigorous evergreen climbing vine with clusters of bell-shaped white flowers followed by a leathery pear-shaped pod. It has a toxic smelly milky sap that can cause skin irritation and dermatitis. It inhabits light gaps and forest edges, scrub, roadside margins, wastelands, hedges, and domestic gardens. It will readily spread into natural areas, smothering native plants and preventing establishment of native plant seedlings.

Moth plant has recently been detected as a pest in Nelson on a small number of urban sites with limited numbers of seedlings. However, it is highly invasive, so the proposed RPMP category is 'Eradication' before it becomes more widely established.

Picture 8: Moth Plant. Photo credit A. Nevin

Blue passionflower (*Passiflora caerulea)*, in Picture 9, is an evergreen climbing vine with hanging white-purple flowers. It can be distinguished from all other passionfruit by at least some of the leaves having five lobes. It also inhabits light gaps and forest edges, scrub, roadside margins, wastelands, hedges, and domestic gardens. It will readily spread into natural areas, smothering native plants, and preventing establishment of native plant seedlings. Its seeds are spread by birds and small mammals (e.g. rats and possums).

Blue passionflower has been in the region for 20–25 years, in a lag phase, from which it now seems to be expanding its range. Its estimated current extent is mainly in the Nelson urban areas, originating as garden escapees. The proposed RPMP category is 'Eradication'.

Picture 9: Blue Passionflower. Photo credit A. Nevin

Where We're Heading

As stated above, a partial review of the RPMP has been undertaken to add these emerging pests to the Plan (as well as other pests), and to revise some of the existing provisions. This includes introducing a biofouling standard for vessels entering the Nelson region to manage the risk of invasive marine pests becoming established (see the case study on *Sabella*).

We will continue surveying areas to establish the absence, presence, or extent of pests. We will also carry out investigations to check and prevent pests listed in the RPMP 'Exclusion' category from becoming established in the region and maintain our progress on meeting the RPMP objectives.

A complete review of the RPMP will be undertaken before it expires on 30 April 2029.

Biosecurity – Case Study

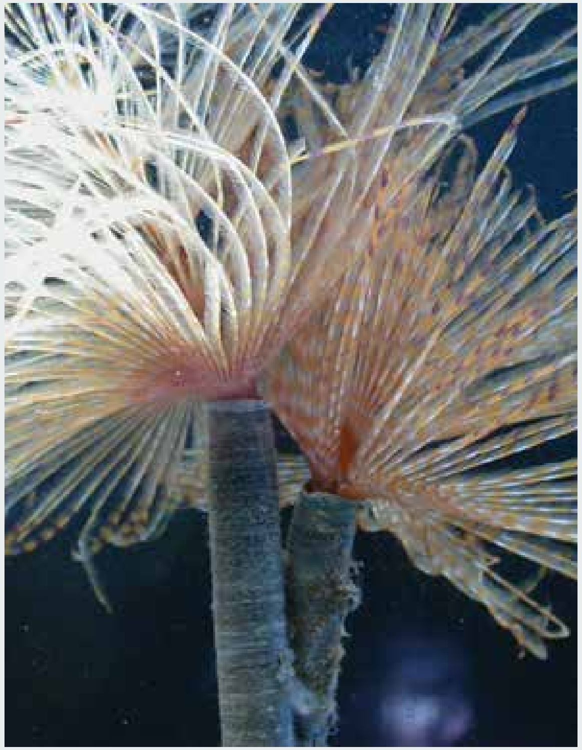
Eradicating *Sabella*

Mediterranean fanworm (*Sabella spallanzanii*), in Picture 10, is a large tube-dwelling worm in the marine environment – it is the largest fanworm in New Zealand, measuring up to 20 mm wide and 800 mm long. It is a significant marine pest because it:

- lives in most artificial and natural habitats in varying environmental conditions, including on wharves and boat hulls;
- grows rapidly, breeds prolifically and forms dense colonies of up to 1000 individuals per square metre;
- interferes with biological processes and out-competes other filter-feeding species – this includes both native and commercial species such as mussels and scallops; and
- has no known predators in New Zealand.

Since *Sabella* was first detected in Nelson Haven in 2013, Council has undertaken annual surveys of vessels, piles (posts pushed into the seabed to support building structures) and pontoons (jetties and floating bridges) at the Marina and other key sites (see Figure 4) to detect and control *Sabella* when found.

The National Institute for Water and Atmospheric Research (NIWA) and the Ministry for Primary Industries (MPI) also survey for *Sabella* in Nelson Harbour twice a year (winter and summer) as part of a National Marine High Risk Site Surveillance programme. The good news is the presence of *Sabella* has declined significantly since 2014 to the extent that none has been found since March 2022 (see Table 4), indicating successful eradication, especially from Nelson marina structures. The greatest risk in future will be from vessels bringing *Sabella* into the region attached to their hulls.



Picture 10: Sabella. Photo credit G. Read (NIWA)

Figure 4: Nelson Marina and Port Areas Surveyed for Sabella

Table 4: Sabella Detections, Nelson Harbour

Year	Number of *Sabella* found	Location
2013/14	30	Nelson Marina (28); vessel (2)
2014/15	5	Nelson Marina – pontoon
2015/16	3	Nelson Marina – pontoon
2016/17	2	Nelson Marina – pontoon
2017/18	0	
2018/19	3	Nelson Marina – pontoon (2); Port Nelson - vessel
2019/20	4	Nelson Marina – pontoon (2). Port Nelson – vessel (2)
2020/21	5	Nelson Marina – pontoon (3); vessel (2)
2021/22	1	Port Nelson – vessel
2022/23	0	
2023/24	0	

Sabella is an eradication pest in the Regional Pest Management Plan (RPMP) and sightings of it must be reported to Council for control. Proposed changes to the RPMP will require all vessels entering Tasman–Nelson waters to comply with stricter biofouling standards. Biofouling, or biological fouling, is the accumulation of microorganisms, plants, algae, or small animals on wet surfaces that have a mechanical function, causing structural or other damage. Under the new rules the level of fouling on a vessel's hull and niche areas cannot exceed Level 2 on the Cawthron Institute Level of Fouling (LoF) scale, unless specific exemptions apply.

Cawthron's Level of Fouling 2 is defined as: macrofouling (visible organisms that can be seen with the naked eye) is present in small patches, or a few isolated individuals or small colonies, and covers between 1–5% of the visible surface.

How Boat Owners Can Help

Boat owners can help prevent the spread of marine pests by:

- regularly cleaning the boat's hull – ideally keeping fouling growth to no more than a light slime layer;
- applying good thorough coatings of antifouling paint to the hull and keeping it in good condition;
- ensuring the boat's hull is clean and free of fouling before travelling to a new region;
- cleaning and drying any marine equipment (e.g. ropes, lines, pots) before using them in a new location;
- inspecting areas on the boat that retain water in case they're harbouring marine life; and
- checking anchors, trailers, and other equipment for tangled weeds.

Boats in Nelson Marina

Land

Todds Valley Stream riparian planting. Photo credit P. Fisher

What We Know – State and Trend

The Nelson region has 42,000 ha of land, with over 580 km of streams flowing from the back country into Tasman Bay. What happens on the land can directly impact our waterways, meaning we need to manage how we use our land within river and stream catchments.

This is why the region is split into five Freshwater Management Units (FMUs) – Wakapuaka, Whangamoa, Maitai, Stoke (urban streams) and the Roding. Land use varies between each FMU, with the Wakapuaka and Stoke containing the greatest areas of pasture relative to FMU size (20% and 23% of the FMU respectively), and the Whangamoa having the largest area of land currently in production forestry relative to FMU size (approximately 37% of the FMU). Urban land use represents a large proportion of the Stoke FMU (approximately 40%) and some of the Maitai FMU (approximately 12%) (LCDB V5 2021).

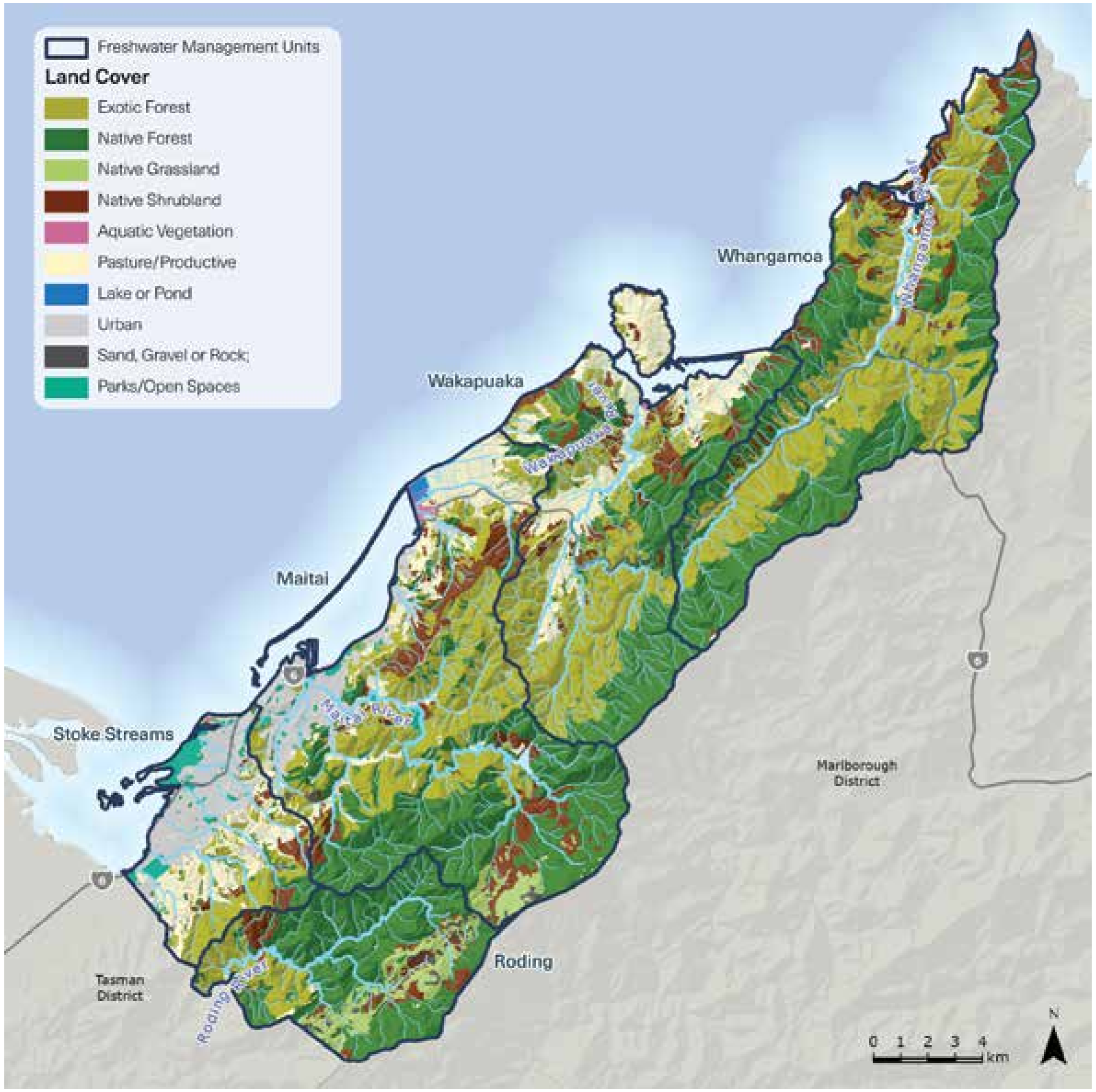
The primary type of land cover in Nelson is native and exotic forest (see Figure 5). The largest land cover is native vegetation including manuka/kanuka, which covers 39% of the region (approximately 16,600 ha), and exotic forest which covers 27% (approximately 11,340 ha). Grassland (pasture/productive) covers 14% (approximately 5,830 ha) and 8% of the land has other uses (such as urban zones and infrastructure) (LCDB V5 2021).

Understanding land cover in the region is important as the movement of water through the landscape and the stability of the land is influenced by the type and location of vegetation cover. Land cover mapping has not been updated since 2018, but changes in land cover in the Nelson region between 1996 and 2018 show an increase in urban/bare/lightly vegetated surfaces, exotic forest and indigenous scrub/shrubland, with a general decrease in exotic grassland and exotic scrub/shrubland (such as gorse) (LAWA). The increase in urban area and exotic forest generally matches the decrease in the area of exotic grassland and exotic scrub/shrubland (LAWA).

Population growth and an increased demand for housing has led to urban expansion in the region. This has mainly occurred in Atawhai and Stoke. Continued expansion of urban areas onto surrounding rural land can lead to habitat loss, an increase in hard surfaces (which don't absorb rainwater), increased rates of soil loss and a reduced area of versatile land (able to be used for agricultural and horticultural uses).

Nelson City Council currently owns around 700 ha of exotic forestry, predominantly in the Maitai FMU, some of which has been harvested in the last five years. A programme is underway to transition to native/mixed native and exotic forests. The reforestation of hillslopes at risk of erosion (e.g. steep land or fragile soils, or both) under grassland cover can be beneficial in terms of improving slope stability and reducing the incidence of soil erosion. Increasing indigenous scrub/shrubland (such as manuka and kanuka) is beneficial for the conservation of indigenous biodiversity, freshwater ecology, and land stability.

Figure 5: Land Cover for the Nelson Region, Based on the LCDB V5



Pressures

The Nelson region has seen a number of serious weather events in the last five years, notably ex-cyclone Fehi in 2018 and the severe flooding events of 2021 and 2022. These events led to an increase in slips and landslides, bank erosion, and gravel build-up in rivers and streams. In particular, the significant impacts in the Maitai catchment during the August 2022 weather event included widespread slips and landslides, and sedimentation of the river. Landslides caused major damage to infrastructure in the region, including to the main water supply pipe for Nelson. Disruptive storms and major flood events like these are predicted to become more common in the Nelson region due to climate change, which will increase pressure on land stability.

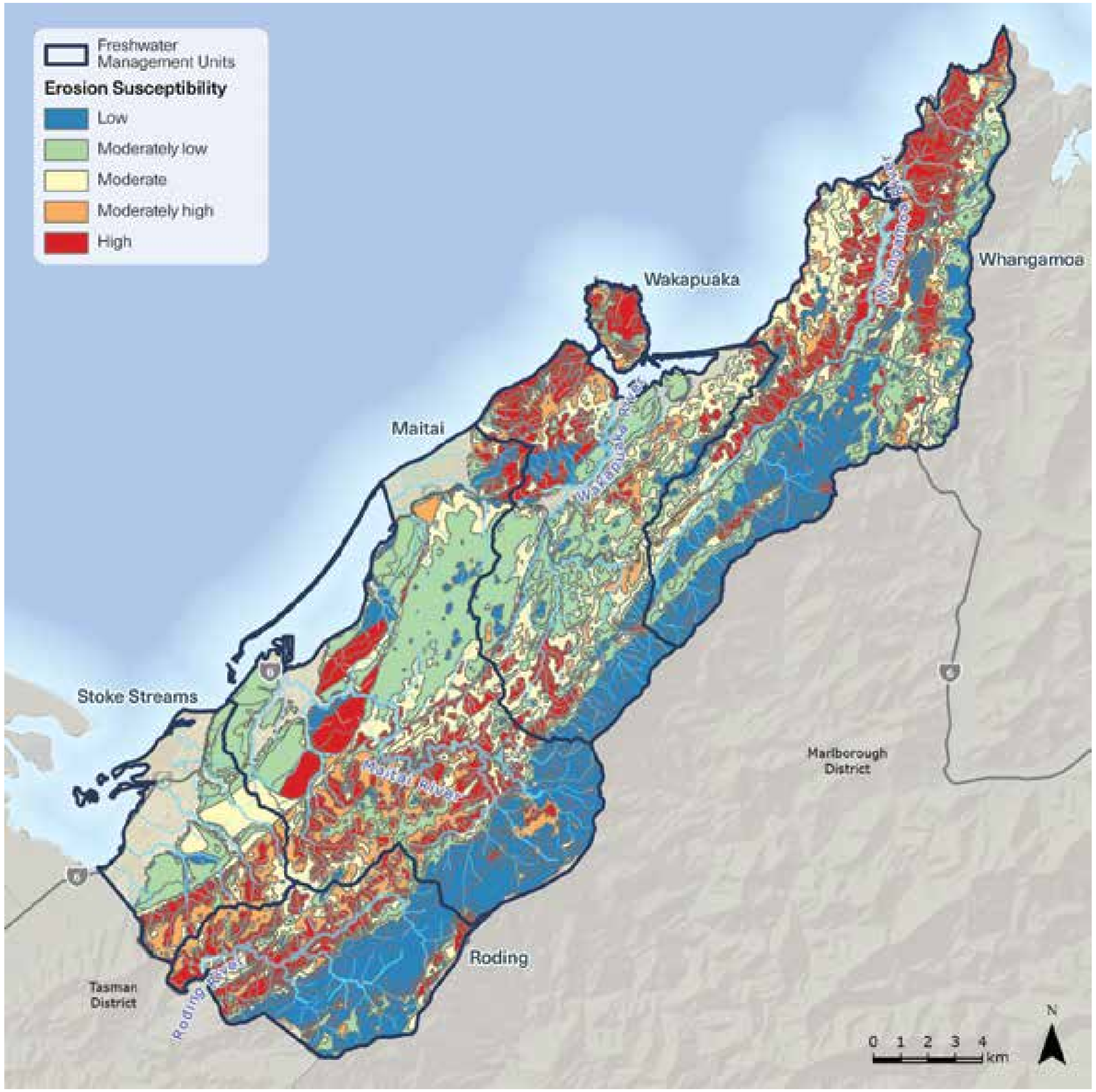
Land use changes, such as increases in production forestry, pasture and clearance of marginal land for agriculture, place pressures on land and water. Environmental pressures include reduced soil and water quality, increased susceptibility to erosion and sedimentation of watercourses.

Erosion of land is an issue in the Nelson region and can affect soil productivity and ecosystem services (such as sediment control, water regulation and biodiversity support), limiting the land's range of potential uses. Erosion and sediment can also reduce water quality in our streams, rivers, estuaries and in coastal areas. Increased fine sediment in water can decrease its clarity, degrade aquatic habitats and impact on recreation, fisheries, and domestic water supplies.

Steep land and/or weaker rocks and soil tends to be more at risk of erosion. Areas with lower slope gradients and more stable regolith (the region of unconsolidated rock and dust that sits between bedrock and soil) are usually less susceptible to erosion. A recent study (Land and Water Science, 2024), looked at the erosion susceptibility of the Nelson region (see Figure 6) and found:

- 21.8% of land has high susceptibility to erosion;
- 9.3% moderately high susceptibility to erosion;
- 21.3% moderate susceptibility to erosion;
- 25.2% moderately low susceptibility to erosion; and
- 22.4% low susceptibility to erosion.

Figure 6: Erosion Susceptibility for the Nelson Region



Of the land that is classified as having high susceptibility to erosion, approximately 13% is either in pasture or harvested forestry land and is likely to need land treatment to prevent erosion. Approximately 33% is covered in exotic forest and will need to be managed to reduce erosion risk during harvesting.

Land Use Capability

The Land Use Capability (LUC) system classifies the ability of the land to support various productive uses over time. It shows that:

- less than 7% is highly productive land (LUC 1 to 3);
- 24% is non-arable land, which means it cannot be used for crop production (LUC 6); and
- 65% has slight to severe limitations for productive land uses (LUC 7 and 8).

Slope

Slope gradient and land cover influence the erosion susceptibility of the land, increasing the potential for slips. Land is more susceptible to slips when permanent tree cover has been replaced with pasture. Approximately 30% of pastoral land (used for grazing livestock) across the region is suitable for intensive farming (this is land with less than a 15° slope), and much of this land is within the Wakapuaka and Maitai FMUs (LandVision 2017). Of the land in the region covered in pasture, (as per LCDB V5) approximately:

- 19% is flat (0–3°);
- 6% is undulating (4–7°);
- 5% is rolling (8–15°);
- 9% is rolling to strongly rolling (16–20°);
- 28% is moderately steep to steep hill country (21–25°); and
- 33% is steep to very steep hill country (26°+) (LandVision 2017).

More than 140,000 trees planted through the Environmental Grants scheme

Approximately 4,500 poplar and willow poles planted to treat erosion prone land

Our Freshwater Management Units

Wakapuaka

The Wakapuaka Freshwater Management Unit (FMU), is 9,276 ha and is located to the north of Nelson (Figure 7). The main tributaries of the Wakapuaka River are the Lud and Teal rivers, along with Packers Creek in the lower catchment and Swift Stream in the upper catchment. The Wakapuaka was once dominated by an extensive coastal flats ecosystem, still seen at Paremata Flats reserve at Delaware Bay, but this was modified in the recent past to create more productive land. Land uses include some pastoral activity (approximately 2100 ha) with a number of small lifestyle blocks, particularly in the lower Lud and Wakapuaka reaches, some native forest, and large areas of production forestry in the upper catchment.

Water quality in the FMU is generally good. However, monitoring of the catchment as a whole has identified some water quality issues, including high *E. coli* (faecal indicator bacteria) and periodically high sediment loads. Key sources of sediment could be landslides on steep land, trampling by stock on stream beds and drainage channels, and bank erosion (due to lack of vegetation on river margins). Harvesting production forestry in the upper catchment may also contribute to the increased sediment which occurs during high rainfall events.

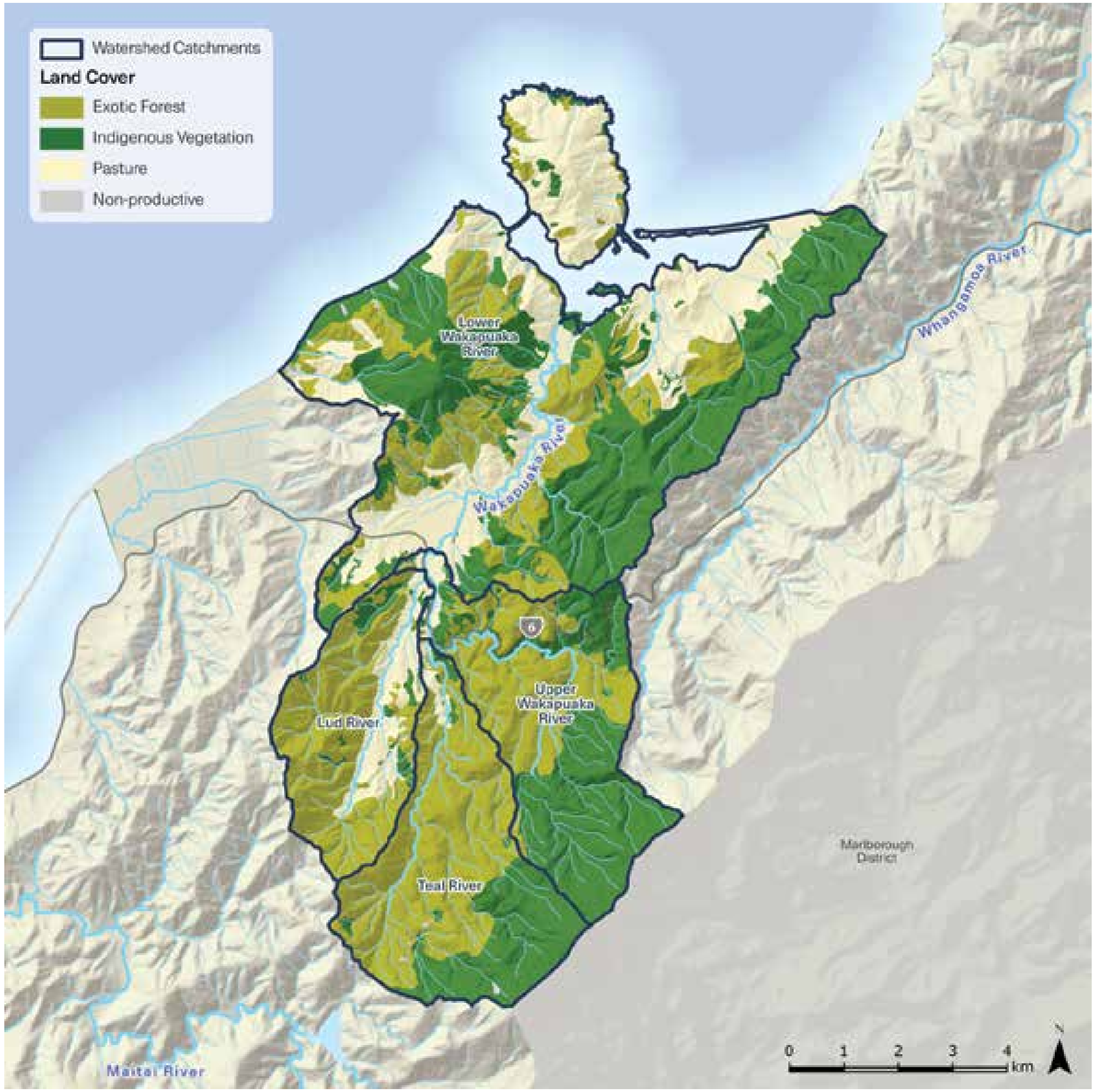


Figure 7: Wakapuaka Freshwater Management Unit

Whangamoa

The Whangamoa FMU is 11,224 ha in size (see Figure 8). The main land uses are native vegetation, production forestry and some pastoral land. A large proportion of the production forestry in the FMU is at harvestable age and is currently being harvested or is scheduled to be harvested in the near future.

Water quality in the catchment is generally good, but forestry harvesting is increasing the sediment issues in the catchment.

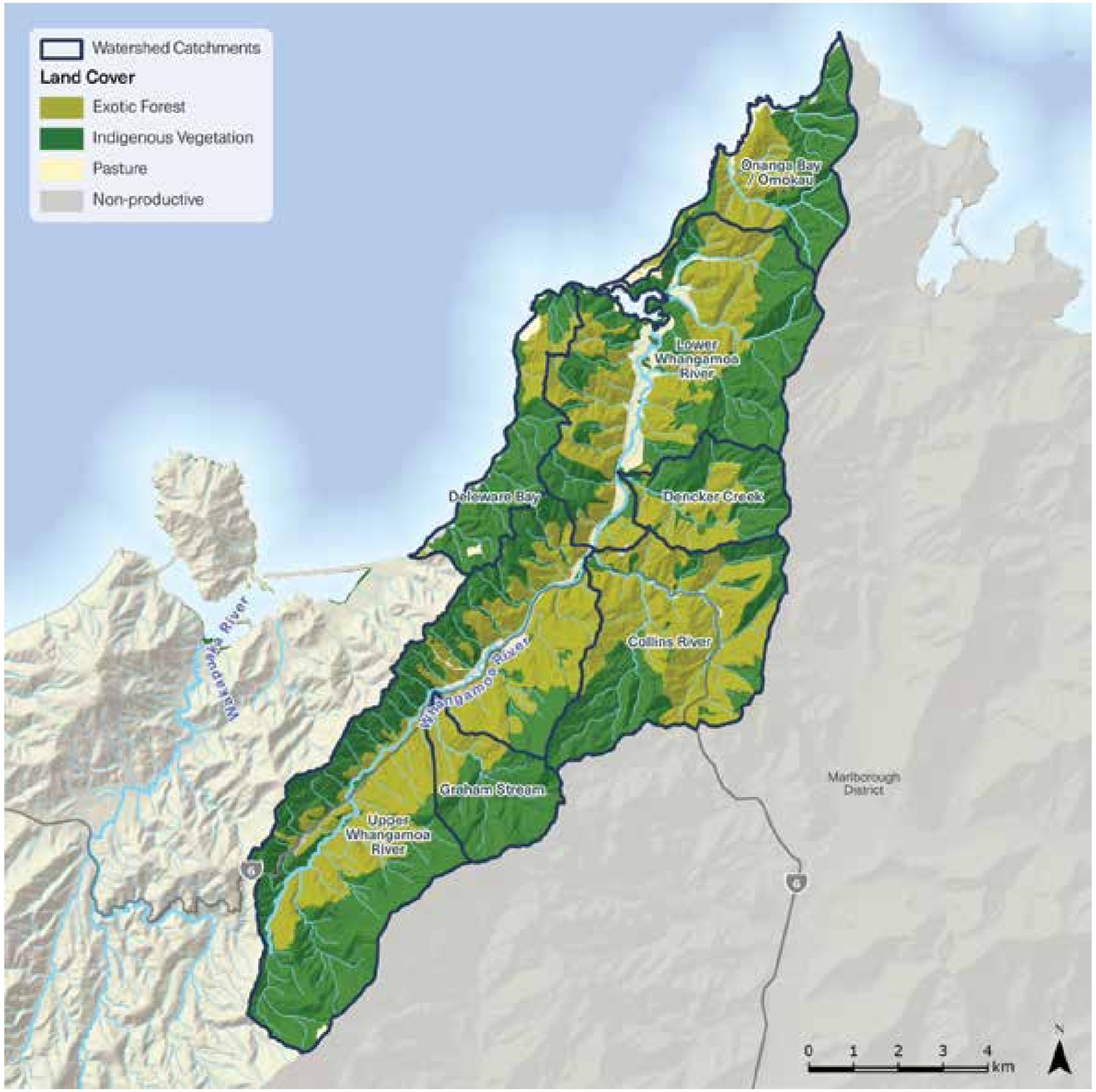


Figure 8: Whangamoa Freshwater Management Unit

Roding

The Roding River is in the Waimea catchment which flows through Tasman District into Waimea Inlet. The upper catchment is within Nelson City Council's jurisdictional area, and the majority of this land use is native forest, tussock grassland and production forestry (see Figure 9). The catchment is managed as one of the two sources of Nelson's water supply (along with the Maitai). The catchment generally has low land use pressure as a large proportion of the upper catchment is in native vegetation.

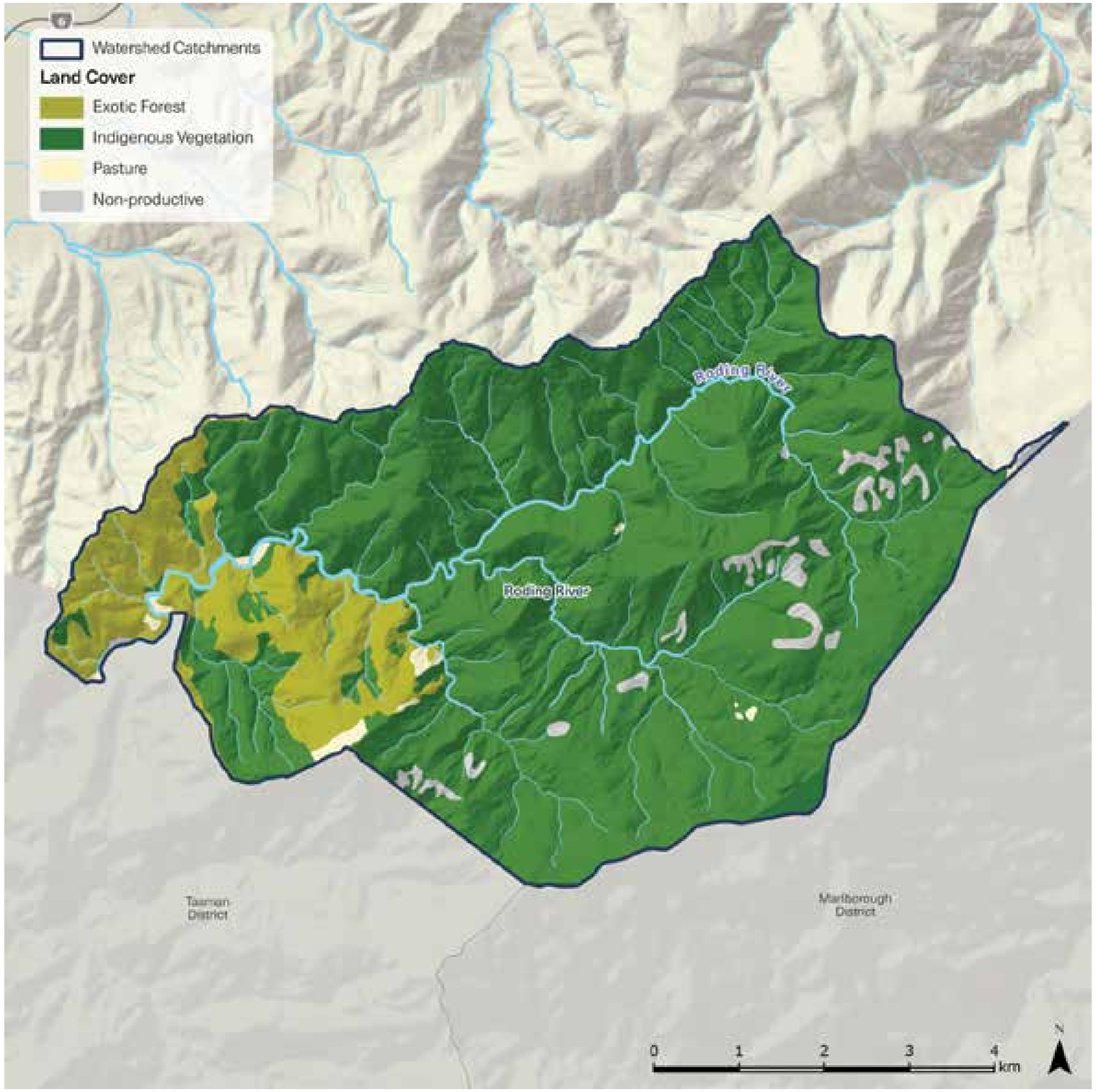


Figure 9: Roding Freshwater Management Unit

Maitai

The Maitahi/Mahitahi/Maitai FMU (13,038 ha), shown in Figure 10, is the largest catchment area in Nelson. Nelson's City Centre and surrounding residential areas are located in the lower catchment of the Maitai River, and the river is a central focus for the city. The river flows to the sea at Port Nelson, at the southern end of Nelson Haven.

The Maitai FMU consists of eleven sub-catchments, including approximately 1,400 ha of pastoral land (mainly on the coastal flats around Glenduan) and over 2,800 ha of exotic forestry land, with the remainder being in non-productive land uses, such as urban and industrial zones, and in native vegetation.

The Maitai catchment was significantly impacted by the August 2022 flood event, with a number of slips in the upper Maitai and upper Brook Stream.

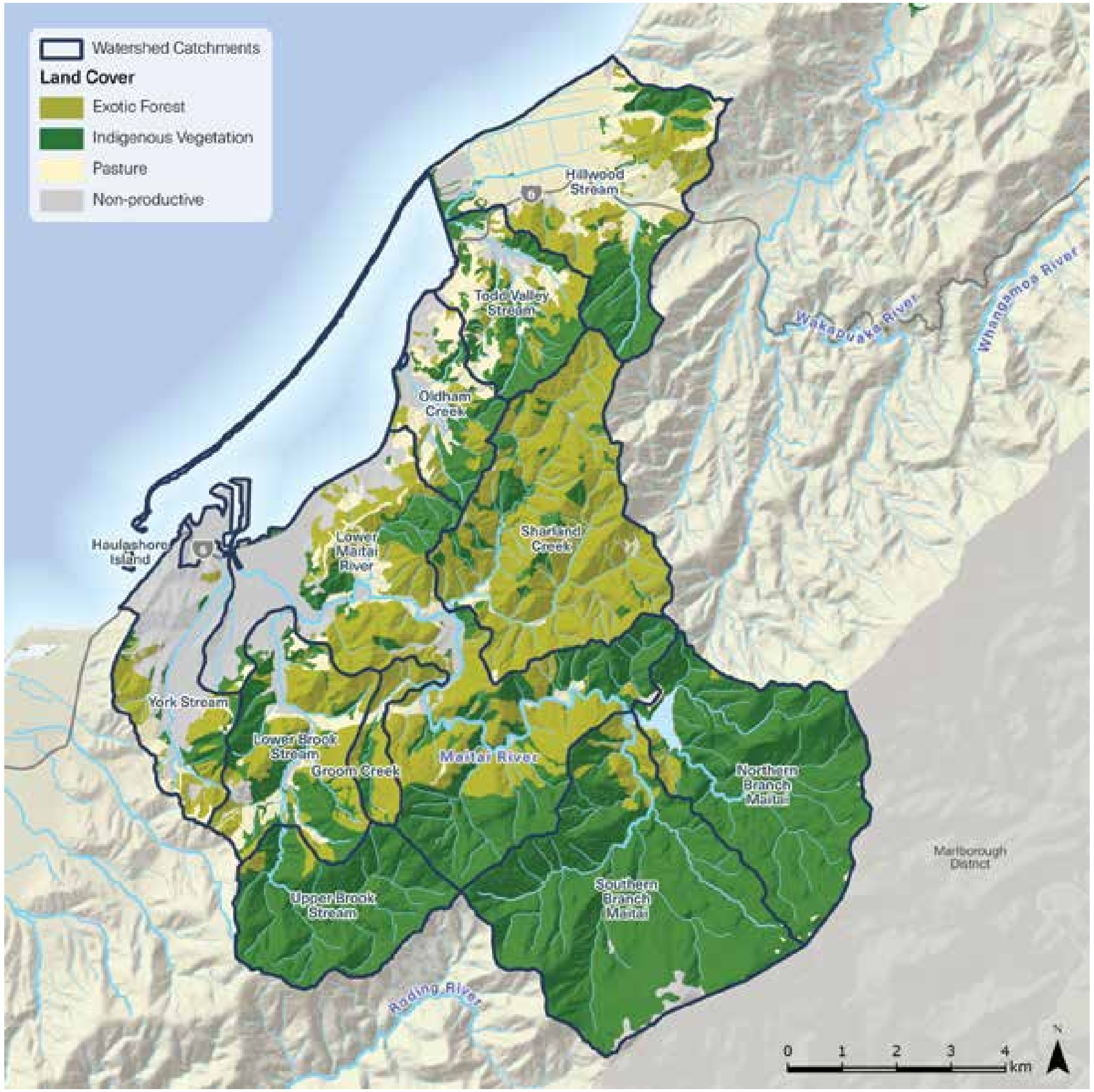


Figure 10: Maitai Freshwater Management Unit

Stoke

The Stoke FMU is approximately 3,757 ha, shown in Figure 11, with mainly urban land uses within the catchment. The Stoke FMU is made up of the small coastal streams to the south-west of Nelson City that flow into Waimea Inlet. Land uses in the lower reaches and nearer the coastline of this FMU are mostly urban (residential and industrial). There is some pastoral land use in the upper reaches, and a dairy farm in the Saxton catchment. There are some production forestry and native bush areas in the upper catchment.

Existing and ongoing urban development in the middle and lower catchments has led to stream modification and loss of habitats. Modified channels, reduced riparian margins, and increased impervious surfaces in the catchment have altered natural flow patterns.

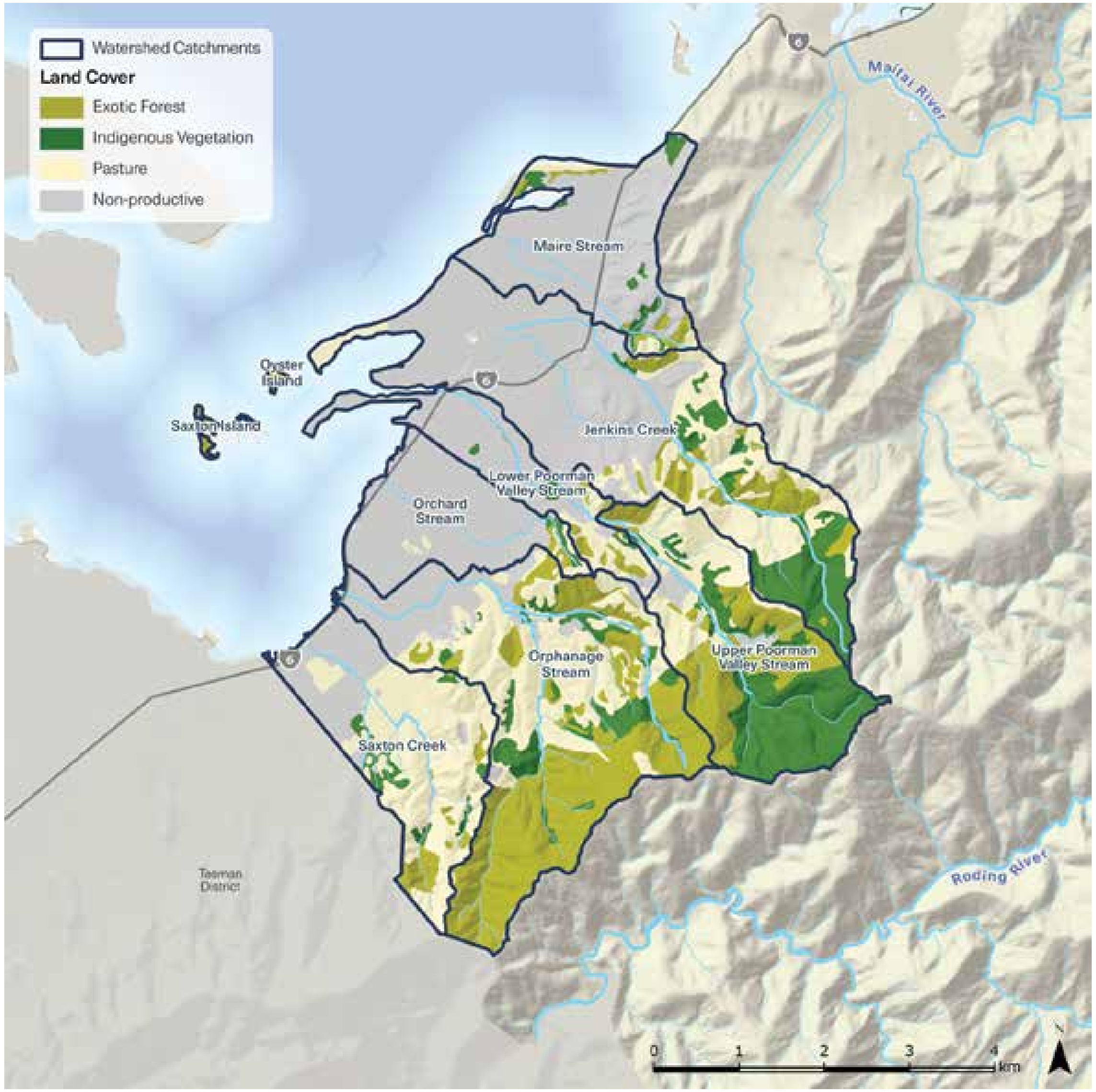


Figure 11: Stoke Streams Freshwater Management Unit

Soil Quality Monitoring

Soil quality and trace element monitoring has provided information on the effects of current land management practices on the soil and indicates whether soil management practices need to change to reduce the negative impacts on the surrounding environment.

In 2018 Nelson City Council undertook the first round of soil quality and trace element monitoring to contribute to reporting at both a regional State of the Environment (SoE) and national level. Fifteen monitoring sites were selected across the region covering dairy, dry stock, forestry, and native vegetation land uses (see Figure 12 and Table 5).

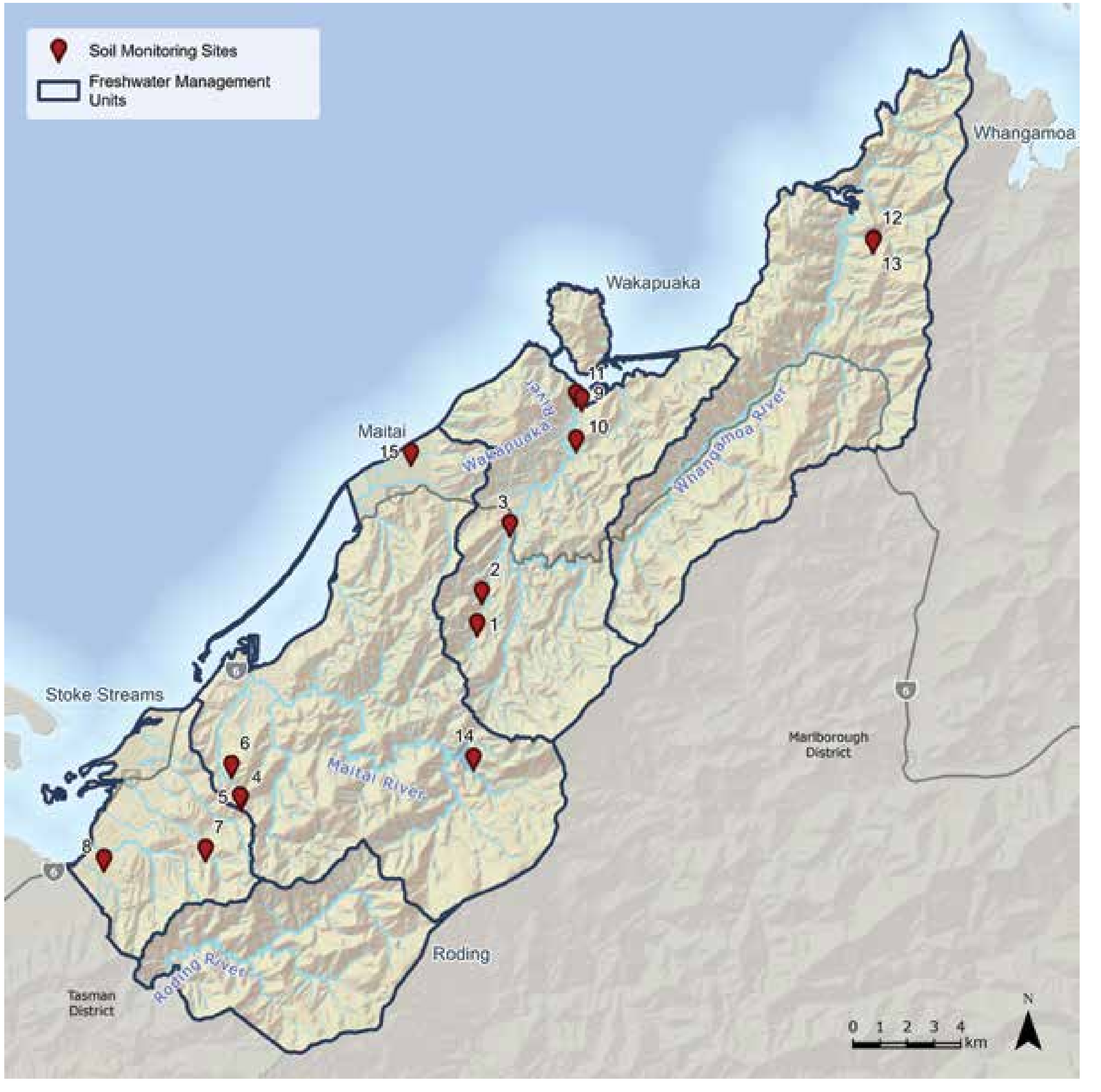


Figure 12: Soil Monitoring Sites

Methods

Soil quality was measured using seven geochemical indicators that describe the fertility, amount of organic matter, level of biological activity and physical condition of the soils across our monitoring sites (Table 5).

The Carbon to Nitrogen ratio is used as an indicator of soil health and fertility. It measures the balance of carbon and nitrogen in organic matter, which influences microbial activity, nutrient cycling and the decomposition of organic materials within the soil.

Hot Water Extractable Carbon (HWC) refers to the amount of carbon that can be extracted from soil using hot water. This is a useful indicator of soil biology because it measures the availability of organic carbon, that microorganisms need to survive. HWC is involved in the short-term cycling of nutrients, which contributes to nutrient availability for plants and gives insights into the early stages of organic matter decomposition and the soil's ability to sustain plant growth.

To determine levels of contamination, nine trace elements (arsenic, cadmium, chromium, copper, fluoride, lead, nickel, uranium, and zinc) were measured at each site.

These data were compared against nationally recommended target ranges for the different land uses and soils (Table 6).

Table 5: Soil Quality Measures

Soil quality characteristic	Measure	What it tells us	Why it's important
Fertility	Soil pH	Whether a soil is acid or alkaline	Some plants and animals will only live in soils at a particular pH.
	Olsen P (plant-available phosphate)	How much phosphate is available for plant growth	Phosphate (P) is an essential nutrient for plants and animals. Plants get their P from soil. Most New Zealand soils are low in phosphates and extra phosphate needs to be added for agricultural use.
Humus (organic matter)	Total C (carbon)	Organic matter content	Organic matter helps the soil store water and release it in a steady way. Organic matter also helps soil store nutrients and form a crumbly structure suitable for plant roots.
	Total N (nitrogen)	Organic N reserves in the soil	Nitrogen (N) is an essential nutrient for plants and animals. Nearly all the N in soil is in organic form (see anaerobic mineralisable N, discussed below).
Biological activity	Anaerobic Mineralisable N (AMN)	How much of the total N is available to plants through microbial activity	Mineralisable N is related to the amount and quality of organic matter and biological activity in soil. Soil life breaks down the total N in organic matter and converts it into forms plants can use.
Physical condition	Bulk density	Whether a soil is firm and compacted or loose and friable	Plant roots cannot grow through compacted soil. Compacted soils also become waterlogged quickly, starving roots of oxygen. If a soil is too loose, it dries out very quickly and may be easily eroded.
	Macropores	How many large pores there are in soil	Large pores (0.03–0.3 mm diameter) are needed for air to reach roots and for water drainage. The larger pores are the first to be damaged by compaction.
	Aggregate stability	How resistant soil aggregates are to breaking	A stable 'crumbly' texture lets water quickly soak into soil, doesn't dry out too quickly, and allows roots to spread easily. This measure is most useful for soils used for horticulture and cropping.

The target ranges (sometimes referred to as critical limits or guidelines) for soil quality indicators follow those provided in Hill and Sparling (2009) and updated in Mackay et al. (2013). Target ranges for soil quality indicators are shown in Table 6. For most soil quality indicators, the target range is defined by an upper and a lower limit, which can vary depending on the land use and soil (e.g. Olsen P). For some indicators there is only a lower limit (e.g. total carbon; the target range is above the lower limit), or limits do not apply (e.g. indigenous vegetation).

Table 6: Target Ranges for Soil Quality Indicators

Soil quality indicator or additional soil property	Unit	Land use			
		Dairy	Drystock	Forestry	Indigenous
Soil quality indicator					
PH	pH units	5.0 – 6.6		3.5 – 7.6	Not applicable
Olsen phosphorus	mg/kg[1]	20 – 40		5 – 30	Not applicable
Total carbon	%	Recent soils (2 – 12), other Soil Orders (2.5 – 1.2)			
Total nitrogen	%	0.25 – 0.70		0.10 – 0.70	Not applicable
Anerobic minealisable nitrogen	mg/kg	>50		>20	Not applicable
Dry fine buik density	g/cm³	Recent Soils (0.4 – 1.4), other Soil Orders (0.7 – 1.4)			Not applicable
Air-filled	%, v/v @ -10 kPa	10 – 30			Not applicable
Carbon/nitrogen ratio	-	Not applicable			Not applicable
Hot water carbon[3]	mg/kg	>1400			Not applicable

[1]mg/kg or mg/L corrected by volume weight
[2]Previoulsy referred to as macroporosity
[3]Provisional target range (cited in Drewry et al., 2017)

Results

- The number of soil quality indicators within the target range was 82% (and 18% were outside this range, see red values in Table 7).
- Based on the 15 soil quality sites established and sampled:
  - » 27% of sites met all the target ranges;
  - » 27% had one indicator outside the target range;
  - » 37% had two indicators outside the target range; and
  - » 9% of sites had three indicators outside the target range.
- The greatest number outside their target range were for the Olsen P and macroporosity soil quality indicators.
- Dry stock land use, followed by dairy then forestry had the most soil quality indicators not within the target range.
- The main soil quality issues identified were:
  - » high Olsen P on dairy sites;
  - » low Olsen P on dry stock and forestry sites; and
  - » high macroporosity on dairy and dry stock sites.

Table 7: Summary of Soil Quality Data from 15 Soil Quality Monitoring Sites in the Nelson Region (Red = Outside Target Range, Based on the Target Ranges in Table 6)

Site information				Soil quality indicators							Additional properties	
Site	Landuse	Soil Series[1]	Soil Order	Fine dry build density (g/cm[3])	Air-filled porosity (-10 kPa, %)	pH	Olsen P (mg/kg)[2]	ANM (mg/kg)	Total N (%)	Total C (%)	CN ratio	HWC (mg/kg)
NCC08	Dairy	Ranzau	Recent	1.09	**2**	6.2	**84**	203	0.63	7.0	11	3425
NCC15	Dairy	Richmond	Gley	1.02	**4**	6.0	**60**	126	0.56	5.8	10	2800
NCC01	Dry stock	Ronga	Recent	1.03	11	5.7	23	142	0.6	7.1	12	2616
NCC02	Dry stock	Whangamoa	Brown	0.88	10	5.8	35	163	0.48	5.3	11	2284
NCC03	Dry stock	Whangamoa	Brown	1.17	13	5.6	**9**	106	0.39	5.6	14	2231
NCC04	Dry stock	Wakatu	Brown	0.99	**7**	5.7	**7**	93	0.34	4.1	12	1582
NCC10	Dry stock	Ronga	Recent	0.87	22	5.4	36	268	0.69	7.4	11	3284
NCC11	Dry stock	Ronga	Recent	1.02	**5**	**7.3**	**14**	149	0.43	3.9	9	2551
NCC05	Forestry	Wakatu	Brown	0.79	28	4.9	7	84	0.38	4.9	13	2180
NCC07	Forestry	Lee	Recent	0.81	30	5.3	8	57	0.44	6.3	14	2388
NCC12	Forestry	Pelorous	Brown	0.95	24	5.0	**1**	**20**	0.13	2.9	22	**1144**
NCC06	Indigenous	Atawhai	Recent	0.94	15	5.9	9	90	0.40	5.3	13	1846
NCC09	Indigenous	Ronga	Recent	1.06	7	6.4	13	152	0.44	4.7	11	2922
NCC13	Indigenous	Pelorous	Brown	0.96	23	4.7	4	43	0.21	4.8	23	2653
NCC14	Indigenous	Whangamoa	Brown	0.97	20	5.3	7	145	0.33	7.1	22	2598

[1]From available map information. [2]Converted from mg/L to mg/kg using volume weight.

- Management interventions can improve soil quality:
  - For high N and P nutrients – adjust nutrient management (ideally based on farm scale soil testing) and maintain soil organic matter to maximise nutrient storage and availability.
  - For soil compaction – avoid overgrazing; and avoid grazing stock or using vehicles on wet soils.
- In general, soil trace elements are not a concern. However, ongoing use of fertiliser may increase levels outside the target ranges in the long term (for cadmium and fluoride). Matching fertiliser applications to production requirements would minimise the accumulation of these trace elements.
- A comparison of soil quality monitoring findings in the two adjacent regions (Marlborough and Tasman) showed similar soil quality issues for the same land uses as in the Nelson region.

What We're Doing

Our main priority is to reduce erosion, particularly hillslope and streambank erosion. Council runs several programmes to support sustainable land use. We only have a small number of commercial farming operations in the region, so the Integrated Catchments team is able to provide support to both commercial and private landowners via the Hill Country Erosion Fund and other environmental grants. Willow management and research are also an important part of our erosion management work.

Hill Country Erosion Fund

Two of Nelson's FMUs, the Wakapuaka and Whangamoa, are characterised by steep, erodible land, with narrow valleys and a dominant land use of forestry. Managing hillslope erosion is a priority concern for keeping productive land intact and minimising the amount of sediment entering waterways.

In 2019, Nelson City Council was awarded $1.2 million over four years from the Ministry of Primary Industries to deliver a series of projects within three main workstreams:

- Forestry Environment Planning relating to small forestry woodlots;
- planting of 50,000 trees per year on hill country land in both public and private ownership; and
- working collaboratively with iwi and councils in Te Tauihu to seek economic and environmental benefits for iwi owners of forestry land.

In 2023 Council was successful in gaining another four years of funding from the Ministry of Primary Industries.

Environmental Grants

Since 2019 Nelson City Council has offered environmental grants to private landowners needing support to improve environmental outcomes on their properties. Landowners can apply for things such as plants, fencing subsidies, traps, professional advice and restoration plans, and weed control. The main request has been for plants, and to date approximately 140,000 plants have been planted through the grants programme.

Willow Management

When planted appropriately, willow trees can help to stabilise stream banks and reduce erosion. However, many of the willow trees along Nelson's riverbanks are a weedy variety and have established from small pieces of the original tree. These willows can create river management issues and exacerbate streambank erosion if they establish within the river channel. Council has a willow management plan in place for the Maitai River to remove inappropriately located willow trees. Currently 1,100 willows have been removed from 12.5 km of the Maitai River as part of this programme. This work will continue, with the Wakapuaka catchment next in line for a willow management plan.

Data Collection and Trials

Council has improved its understanding of the land characteristics and land management practices that are contributing to declines in aspects of water quality. Recent studies have included an erosion susceptibility study based on the underlying rock types, reports into transitioning land from commercial pine forestry to natives, and catchment condition surveys after the flood events of August 2022. Two methods are being trialled (in an urban and a rural environment) to assess the use of softer engineering (more natural) approaches to streambank erosion.

Where We're Heading

Integrated Catchment Management Plans

Council is creating Integrated Catchment Management Plans which will combine work programmes across Council into a strategic plan for each catchment. These plans will allow Council teams to work together to fix complex issues, to prioritise projects to improve water quality, and to share information with iwi and the community more easily.

Action Plans

The National Policy Statement for Freshwater Management 2020 requires Council to prepare Action Plans where water quality is degraded. Action Plans will be developed for all catchments and will outline the specific actions required to improve the degraded aspects of water quality for each water body.

Soils Mapping and Monitoring

Starting in 2024 Nelson will engage with the S-map project run by Manaaki Whenua Landcare Research. With support from staff and landowners, scientists will collect a range of soil samples across the region and analyse these, creating updated maps for soils across the region. The Council will contribute funding and in-kind support, with significant additional funding provided by the Ministry for Primary Industries (MPI).

This will be the first time that soils in Nelson will have been classified to this level of detail. It will help us to better understand the soil characteristics of our productive land and assist with identifying any high-risk soil areas that may create challenges if the current land uses change.

Soil monitoring is also due to be undertaken in 2024, for the second time since soil monitoring was established in the Nelson region.

Land – Case Study

Wakapuaka Mouri

Wakapuaka Mouri is a five-year project supported by the Ministry for the Environment's Freshwater Improvement Fund, with co-funding from Nelson City Council and landowners. Wakapuaka Mouri has the aspirational goal of restoring mauri to the Wakapuaka River (Picture 11), by re-establishing native lowland forest on private land.

Picture 11: Wakapuaka River

Photo credits Liz Gavin and Sally Kidson

Over the past four years an area of over 13.8 ha has been fenced to exclude stock from the river and the river margins have been planted with over 75,000 native seedlings (Pictures 12 and 13). The landowners are undertaking regular water quality monitoring as well as cultural health monitoring, with advice from local iwi.

Picture 12: Volunteer Planting Day 2024

Picture 13: Original Wetland Plantings, Supported Through an Environmental Grant from NCC in 2019

In August 2022 the project site was severely flooded (Picture 14), with many of the planted areas underwater for more than a day. Gravel and other flood debris buried plants and damaged fencing. Once the flood waters cleared, Nelson Marlborough Institute of Technology (NMIT) trainee Conservation Rangers and FuturEcology staff (a local conservation business) carried out a significant amount of work recovering the buried plants.

Picture 14: Flooded Planting Site August 2022

Many plants that would have otherwise been lost to the flood were recovered and the project now boasts a survival rate for its plantings of more than 90%, despite the flood damage. Other notable achievements include the establishment of a community nursery that has successfully supplied the project with some of its eco-sourced native seedlings, and construction of an access track that has allowed public access to over 1.5 km of the river. A trapping network is being established to control predators at the project site and to protect native wildlife, which is checked by volunteers and landowners.

Council would like to thank the project partners: Ministry for the Environment, the landowners (the Kidsons and the Usshers), Ngāti Tama, Tasman Environmental Trust, FuturEcology, and all the volunteers and community members who have contributed to the success of this project.

Land – Case Study

Project Mahitahi

Project Mahitahi is a collaborative effort to restore the ecosystem and biodiversity of the Maitai/Mahitahi Valley (Figure 13). The vision is that the mauri (or life force) of the Mahitahi is restored – ki uta ki tai – so that native plants and wildlife can thrive, and people and communities are inspired to nurture and value the Mahitahi as a taonga for past, present, and future generations.

These efforts received a funding boost from the Department of Conservation and the Ministry for the Environment through the Jobs for Nature programme, between 2020 and 2025, with added support from Nelson City Council, the Ministry of Primary Industries and community volunteers. This project has enabled:

- planting of more than 140,000 native trees over 19 ha;
- 40 ha of weed control;
- Mahitahi wetland restoration;
- 128 ha of pest animal control with 2,000 pests trapped (possums, rats, mice, stoats, ferrets, weasels, and hedgehogs); and
- 4,000 ha of ungulate and targeted possum control.

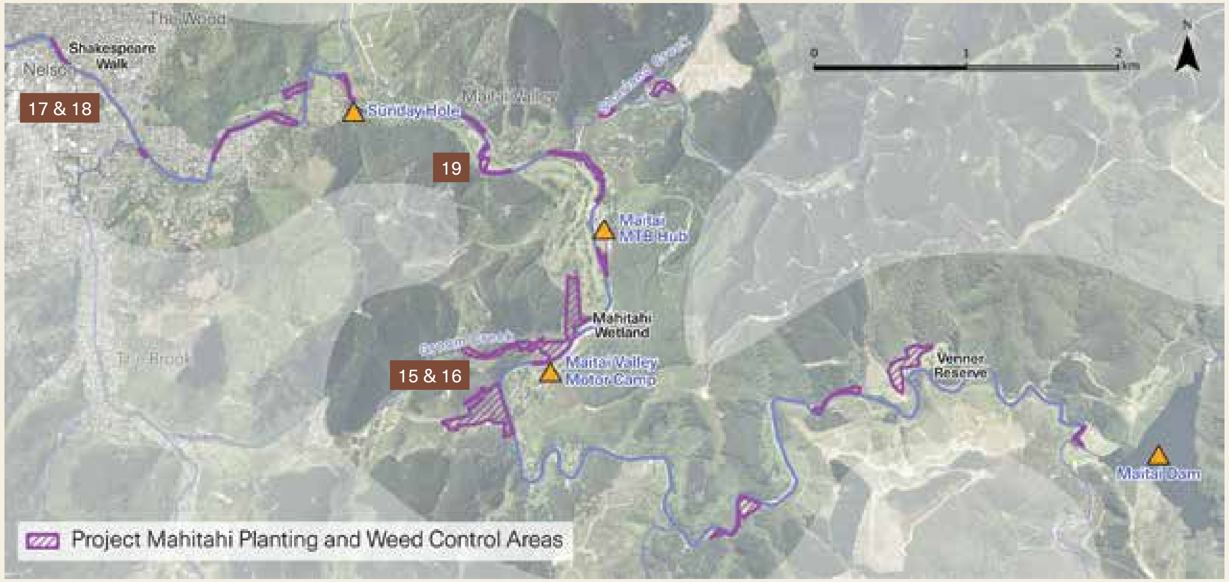
Tackling invasive weeds, like Old Man's Beard (Picture 15), and controlling predators (such as rats, possums, and stoats) supports native plants and wildlife populations in the valley to flourish (Picture 16).

Developing a continuous riparian margin, which is a planted corridor along each side of the river, provides habitat for the movement of native species, as well as shading and shelter for freshwater animals, including fish and insects. Once plants are established it also protects the banks from erosion and filters sediment run-off.

Project Mahitahi supported the clean-up and recovery from the August 2022 flood event (see Picture 17), which saw native plants bounce back after being covered by flood waters. The growth of the riparian plantings and the removal of crack willow from the riverbanks will build the river's resilience to future flood events.

The community has made a vital contribution to the wider restoration work by taking part in planting and education events (see Pictures 18 and 19). Our thanks also go to Kūmānu Environmental for delivering the project's field work and whose trainee ranger programme has upskilled many new conservation staff in the region. Find out more about Project Mahitahi on our website, explore the Project Mahitahi Storymap, and contact project.mahitahi@ncc.govt.nz to sign up to our mailing list.

Figure 13: Map of the Project Mahitahi Sites along the Maitai River



Numbers on map refer to following picture locations

Picture 15: Before – Groom Creek with Old Man's Beard Infestation

Photo credit Kūmānu

Picture 16: After – Native Plantings Beginning to Thrive

Photo credit M. McCay

Picture 17: Shakespeare Walk during August 2022 Flood Event

Photo credit NCC

Picture 18: Planting at Shakespeare Walk (photo credit Victory School)

Picture 19: Planting with Multicultural Nelson Tasman (photo credit NCC)

Project Mahitahi

Ngāti Rārua
Te Rūnanga o Ngāti Rārua

Ngāti Kuia

NGĀTI KOATA TRUST

TE ĀTIAWA
O TE WAKA-A-MĀUI

Kotahitanga mō te Taiao

Freshwater Quality

Roding River. Photo credit C. Appleton

Our Freshwater Catchments

Even though the streams in our upper catchments are typically less than one metre wide they provide important habitat and access to water for both land and water-based biodiversity, as well as drinking water for people and livestock in rural areas.

Our larger rivers in the lower catchments (such as the Maitai, Wakapuaka and Whangamoa Rivers) generally have greater capacity to recover from natural events or unnatural environmental impacts. These ecosystems are more resilient to stressors such as pollutants because the higher flows dilute and flush contaminants away.

Nelson's State of the Environment (SOE) water quality monitoring network was designed by the Cawthron Institute (2000–2002) and uses a range of ongoing monitoring sites to represent the geography of the region. The Freshwater Management Units include the five main watershed catchments for the Whangamoa, Wakapuaka, Maitai, Stoke (Figures 14 to 17) and Roding. We monitor relatively unmodified upstream sites as well as more impacted sites further downstream. The upstream sites are in catchments that are dominated by native forest (Maitai North Branch and Brook) or exotic forest (Wakapuaka and Whangamoa).

Figure 14: Map of Monitoring Sites in the Whangamoa Catchment

Figure 15: Monitoring Sites in the Wakapuaka Catchment

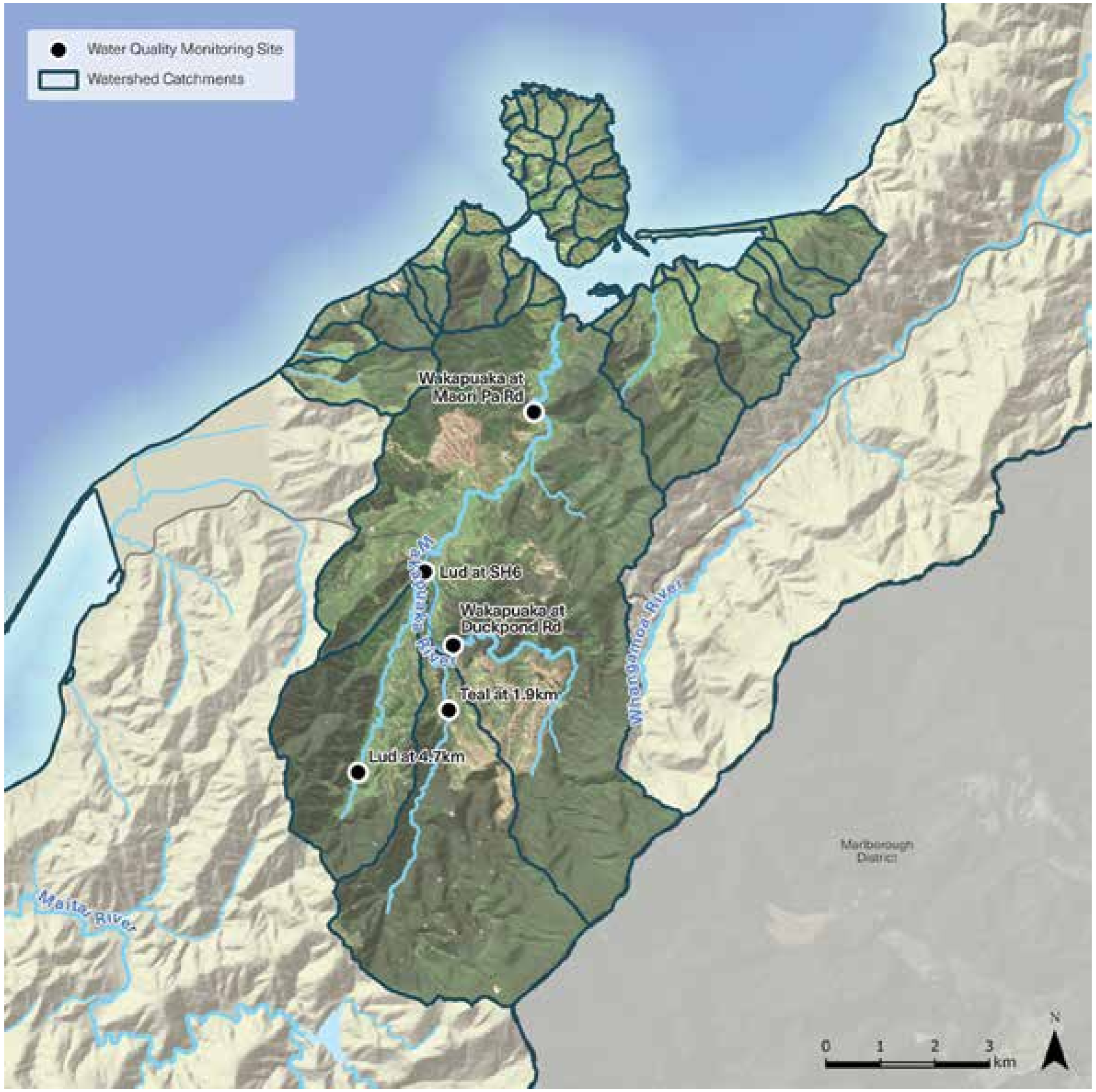
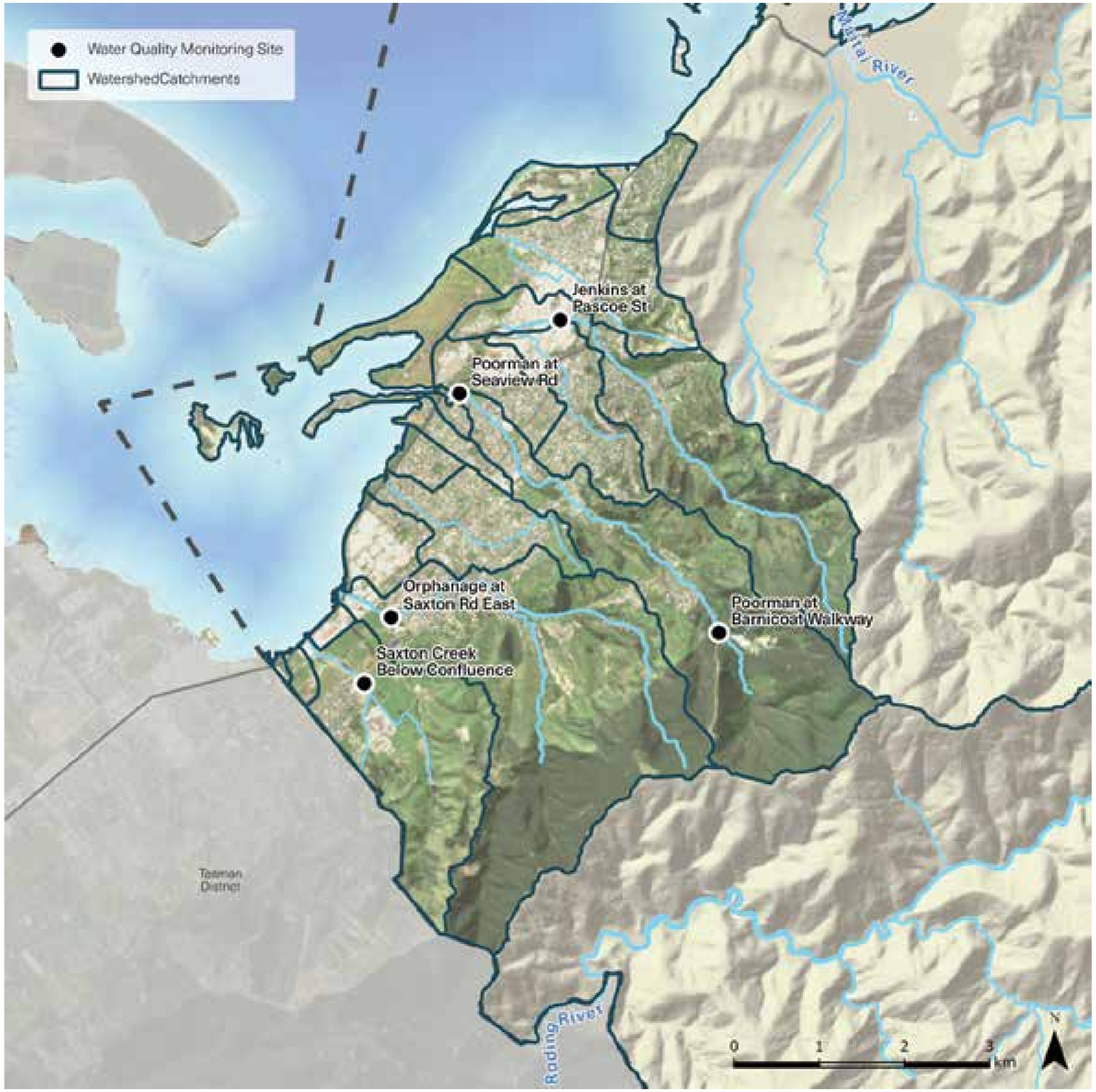


Figure 16: Monitoring Sites in the Maitai Catchment

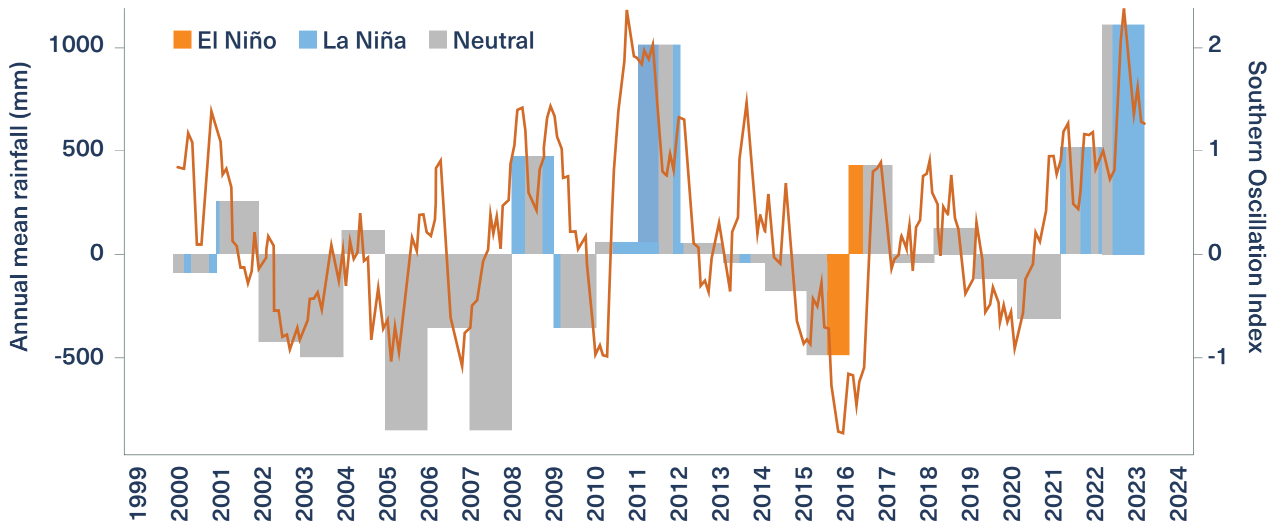
Figure 17: Monitoring Sites in the Stoke Catchment



Water allocation during drought periods needs to be managed where practicable to ensure that a 'minimum ecological flow' is maintained at all times. This is the flow level required to provide habitat for biodiversity and enough drinking water for domestic use, stock drinking and fire-fighting.

Climate and rainfall are key drivers for shaping our rivers and water quality, due to the close connection between weather patterns and annual rainfall. For example, Nelson usually gets more rain during La Niña years compared to neutral or El Niño years, and the last three years have been wetter than average as shown in Graph 6.

Graph 6: The Annual Average Rainfall for the Third House Rainfall Station (Brook FMU) shows how the Wet and Dry Weather Periods are Strongly Related to the Average Annual Rainfall and to the Southern Oscillation Index (La Niña, El Niño and Neutral Phases)

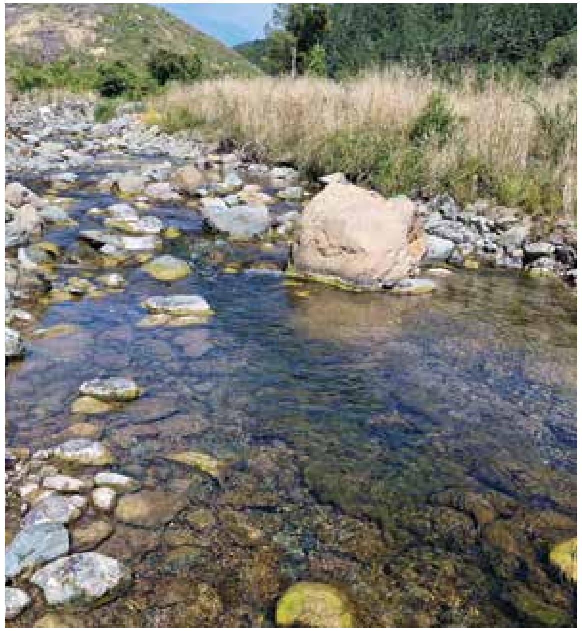


Peak loads of contaminants including faecal matter, nutrients, or fine sediment flow from the land into waterways when it rains. The type and duration of rain event will affect how much surface run-off with contaminants enters the river. Contaminant levels are highest during rain events and during the wetter, winter months of the year. Heavy rainfall also increases river flows, which at times can dilute the concentration of contaminants in the river.

In contrast, small streams with less water flowing through them are more likely to end up with high levels of dissolved nutrient concentrations for a longer period of time, which can lead to algae growth as shown in Picture 20). This impacts on stream health and ecology.

Movement of contaminants through catchments can be instantaneous if the source is close to the river or coast and the contaminants are quickly flushed downstream, or it can occur over months or years if it is gradually being released through groundwater and soils. Slower movements of contaminants (e.g. release of nitrates over several years after forestry harvest) can lead to an increase in benthic algae (which grow on riverbeds) and aquatic plants growing at faster rates.

Picture 20: The Streambed in Graham Stream, in the Whangamoa FMU, has an Extensive Cover of Green Filamentous Algae. Photo credit P Fisher



We monitor river flows at water quality sites to account for the natural variability in river flows over different seasons and weather patterns, to improve the consistency of our water quality assessments, and to gain a clear picture of the overall trends in water quality.

Monitoring Programme

The purpose of the State of the Environment (SOE) monitoring programme is to detect change in water quality over time. This includes the impacts from:

- natural environmental variation;
- climate change;
- changes in the type and intensity of land uses; and
- human-related activities.

This information helps us to identify whether our current approaches to freshwater management are effective, including our Resource Management Plan rules.

We measure nitrates, phosphates, faecal bacteria (*E. coli*), and suspended sediment/water clarity to describe the state of water quality. These indicators are linked directly to human activities and land uses that impact on freshwater ecosystem health. We also assess the types of aquatic macroinvertebrates (including insects, snails and worms) living at each site, as they provide an indication of the quality of the habitat. The macroinvertebrate index (MCI) score reflects the relative diversity of species based on their tolerance or sensitivity to nutrient enrichment. The tolerance scores for each species range from 0 to 10 with invertebrates such as snails, that can survive in a degraded enriched nutrient environment, scored low, compared to high scores for invertebrates such as caddisfly larvae (Picture 21), that require a more pristine stream environment. The overall MCI scores are used to describe the range of water quality from 'Probable severe pollution' MCI<90 (grade D) to 'Clean water' MCI>130 (grade A).

Picture 21: A Free Living Caddis Fly Larvae Sharing the Underside of a Boulder with a Cluster of Koaro Fish Eggs in Brook Stream

(Credit T. Kroos/NCC survey)

The core monitoring sites in Figures 13 to 16 have been maintained since 2002, and two extra monitoring sites were established in Saxton Creek and the Maitai North Branch water supply to the reservoir in 2018. Monthly trend analysis is carried out at these new sites in addition to the 25 'core' sites for which we have nine years of monthly monitoring (from Dec 2104 to Dec 2023) and more than 22 years of three-monthly (quarterly) monitoring, from 2002 to 2023.

Monitoring sites at the bottom of catchments (near the coast) cumulate the discharges of contaminants from the whole catchment as they receive all the upstream inputs, so these sites are more likely to have poor water quality.

All regional and unitary councils in New Zealand need to follow national guidance to sample monitoring sites on a monthly basis and to include all-weather sampling, which means monitoring during storm events, when contaminant loads are higher. 'Flow adjustment' techniques have been used in this analysis to account for high and low flows, which influence water quality observations.

To date, the Land, Air, Water Aotearoa (LAWA) water quality trend assessment methods do not include flow adjustment, which is used to improve the power of the statistical analysis. LAWA reports on national data sets over shorter periods (5 year monthly, 15 year quarterly) so the Nelson water quality trend directions, whilst generally similar to this report, are not directly comparable.

What We Know – State and Trend

Water Quality State

Under the amended (February 2023) National Policy Statement for Freshwater Management (NPS-FM), regional and unitary councils are required to monitor freshwater, and to identify rivers and streams that are degraded at or below the National Bottom Line and where trend analysis demonstrates a declining trend over time – and to address the issues. Sites that fall below the National Bottom Line values must be improved, unless there is a specific justification why that would not be achievable.

The NPSFM attributes for water clarity, nutrients (ammonia, nitrogen and phosphorus (DPR)), *E. coli* and macroinvertebrate communities, are indicators that are used to determine ecosystem health and human health risk from contact with water. Water quality attribute bands range from A (good) to D (poor), and are colour coded Green, Yellow, Amber and Red, with Amber and Red reflecting potential impacts on freshwater ecosystem health (see Tables 8 and 9). National Bottom Line values indicate thresholds when the attribute is likely to cause a significant adverse effect, and are in bold where they apply. The Human Contact Health value, using the *E. coli* attribute, has five bands from A to E to reflect the percentage risk of *Campylobacter* infection. A degraded site is one that is below the 'National Bottom Line' or is not achieving or not likely to achieve the desired target attribute state (i.e. with a very likely degrading trend) which is not due to natural causes.

Table 8: Water Quality Standards and Grades used to assess the Health of our Waterways. Source NPSFM (2020)

Ecosystem Health

			Attribute state			
Attribute	**Statistic**	**Units**	**A**	**B**	**C**	**D**
Water Clarity (suspend sediment class 3)	Median (monthly over 5 years)	m	≥2.95	<2.95 and ≥2.57	<2.57 and >2.22	>2.22
Ammonia-N	Annual median	g/m3	≤0.03	>0.03 and ≤0.24	>0.24 and ≤1.30	>1.30
	Annual maximum	g/m3	≤0.05	>0.05 and ≤0.40	>0.40 and ≤2.20	>2.20
Nitrate-N	Annual median	g/m3	≤1.0	>1.0 and ≤2.4	>2.4 and ≤6.9	>6.9
	Annual 95th percentile	g/m3	≤1.5	>1.5 and ≤3.5	>3.5 and ≤9.8	>9.8
Dissolved Reactive Phosphorous (DPR)	Median (monthly over 5 years)	g/m3	≤ 0.006	> 0.006 and ≤0.010	> 0.010 and ≤ 0.018	>0.018
	95th percentile	g/m3	≤ 0.021	> 0.021 and ≤0.030	> 0.030 and ≤ 0.054	>0.054
Macroinvertebrate Index	Median (annual over 5 years)	Indices score	≥130	≥110 and <130	≥90 and <110	<90

Human Contact Health

			Attribute state				
Attribute	**Statistic**	**Units**	**A**	**B**	**C**	**D**	**E**
E. coli	Annual median	CFU/100ml	≤130	≤130	≤130	≥130	≥260
	95th percentile	CFU/100ml	≤540	≤1000	≤1200	≥1200	≥1200

Table 9: State and Trend of Water Quality Attributes for Ecosystem Health and Human Contact Health for Monthly Monitoring over Nine Years, along with Macroinvertebrate Community Index (MCI)

Significant improving and declining water quality trends for attributes are shown by arrows indicating the direction of trend. Deposited sediment has not been reported here because of insufficient data.

Stoke FMU	Clarity	DRP	*E.coli*	Nitrate_N	Ammonia	MCI
Saxton upstream of Champion Rd	↑		•	↑		
Saxton Creek Below Confluence			•			
Orphanage at Saxton Rd East				↑	↑	
Poorman at Barnicoat Walkway				↑		↑
Poorman at Seaview Rd				↑		
Jenkins at Pascoe St				↑	↑	

Maitai FMU	Clarity	DRP	*E.coli*	Nitrate_N	Ammonia	MCI
Brook at Motor Camp	↑					
Brook at Burn Pl	↓		↓	↑		
Brook at Manuka St	↓		↓	↑		↑
Maitai North Branch above Dam						
Maitai South Branch at Intake						
Sharland at Maitai Confluence						
Maitai at Groom Rd				↓		
Maitai at Riverside						
York at Waimea Rd				↓	↑	
Todds at SH6				↑		
Hillwood at Glen Rd	↓			↓		

Wakapuaka FMU	Clarity	DRP	*E.coli*	Nitrate_N	Ammonia	MCI
Wakapuaka at Duckpond Rd				↓		↓
Wakapuaka at Hira	↓			↓		↓
Teal at 1.6km	↓			↓		
Lud at 4.7km						
Lud at SH6	↓					↓
Wakapuaka at Maori Pa Rd	↓			↓		

Whangamoa FMU	Clarity	DRP	*E.coli*	Nitrate_N	Ammonia	MCI
Whangamoa at Hippolite Rd				↓		
Graham at SH6	↓			↓		↓
Collins at SH6						↓
Dencker at Kokorua Rd	↓			↑		↓
Whangamoa at Kokorua Bridge						↓

Nitrate and phosphorus nutrient levels are at relatively low concentrations in our waterways, mostly within the A and B bands. (Phosphorus is naturally elevated in the Stoke FMU due to the erosion of weak bedrock in the upper catchment.)

However, the levels of nitrate and phosphorus are sufficient to promote growth of algae mats and filaments over summer when flows are low, with less dilution of contaminants, and daily water temperatures are higher than 20°C.

Ammonium nitrogen levels in all streams and rivers are within band A, so this is not having toxic effects on aquatic animals.

Faecal bacteria (*E. coli*) is at band E at 14% of monitored sites. The most polluted E band sites have dominant faecal sources from dairy/beef in rural streams and wastewater sources in urban streams.

Water clarity is at bands A and B for all sites. However, 14% of monitored sites have relatively poor water clarity due to elevated suspended sediment from erosion of stream banks and from land. This is caused by upstream land uses and natural storm-related land slips.

Oxygen and water temperatures – Almost a third of monitored streams in lowland urban and pastoral land are mostly unshaded and have unacceptably low dissolved oxygen levels and high-water temperatures. Dissolved oxygen and water temperature are both fundamental to the survival of aquatic life and overall ecosystem health.

Long Term Trends – At a Glance

Water Quality Attributes

Trend analysis was undertaken over two periods using the monthly and quarterly monitoring data spanning nine and 22 years respectively, to compare the relative proportion of improving and declining trends for each attribute across all sites (Figures 18 and 19).

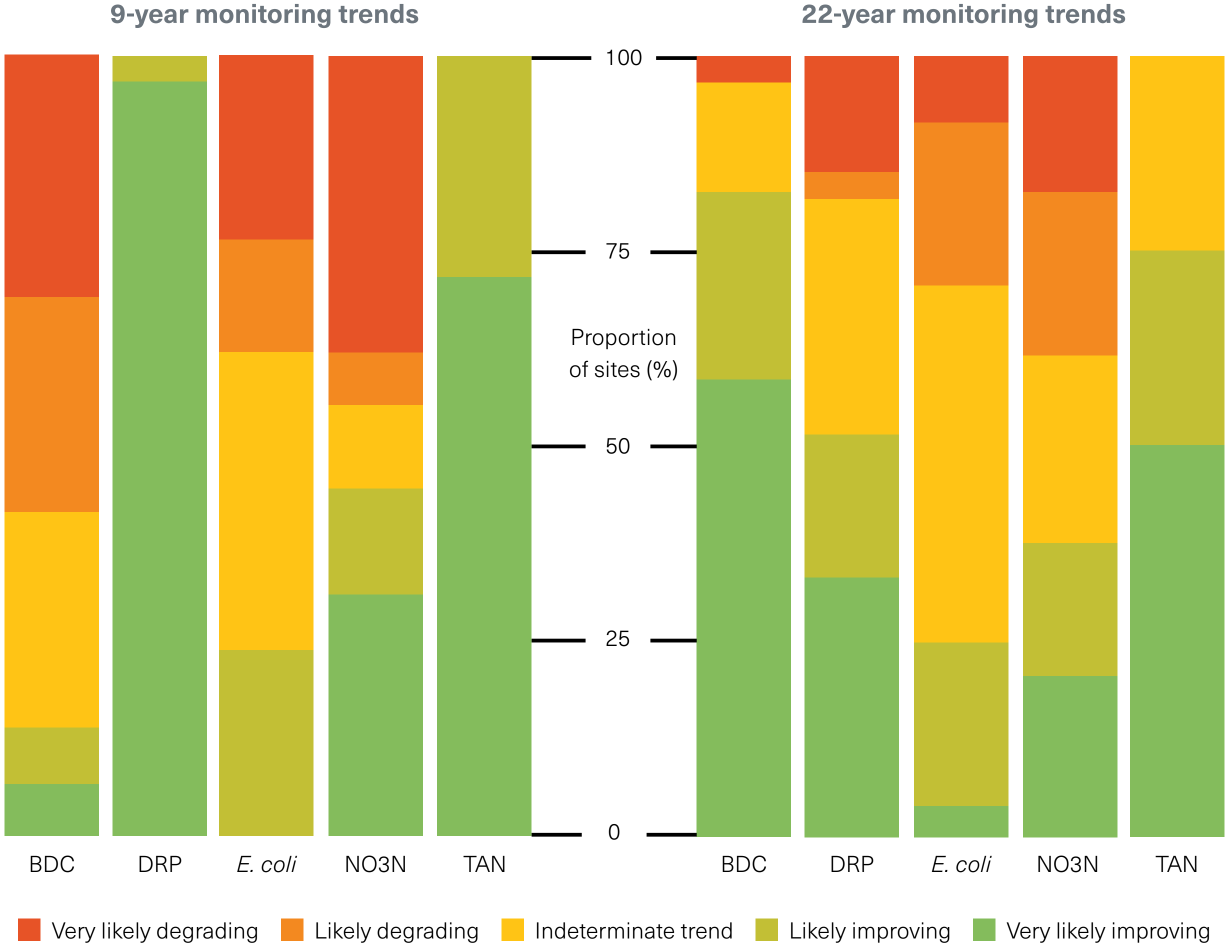
Sites with 'very likely declining trends' are expected to continue to decline with current activities and management, which could result in unacceptable degradation of water quality, significant loss of cultural, health, recreational and ecological values, and taonga.

Black disk clarity shows the greatest increase in the proportion of degrading sites over the last nine years.

Dissolved Reactive Phosphorus (DRP) and ammonia show improving trends over the last nine years (which require further investigation to confirm the relative contribution from natural sources of phosphorus).

Nitrate and *E. coli* had relatively similar trends over the monthly and quarterly periods, but the proportion of very likely degrading sites has increased for these two attributes over the last nine years.

Figures 18 and 19: Comparison of Water Quality Attribute Trends for 9-year Monthly (2014-2023) and 22-year Quarterly (2002–2023) Monitoring. Trends are Flow Adjusted



BDC - Black Disk Clarity; DRP - Dissolved Reactive Phosphorous; NO3N - Nitrate Nitrogen; TAN - Total Ammonium Nitrogen

Macroinvertebrate communities

Trends in annual macroinvertebrates communities scores were assessed over the 22-year period. The types of species present in a stream have different tolerances to eutrophication (excessive nutrients promoting algae growth) with higher macroinvertebrate community index (MCI) scores reflecting better quality freshwater environments. There was a wide range of MCI scores between years at each site, reflecting a high turnover of species and changes in habitat over time (see Table 9). The MCI sites at or below the National Bottom Line were all urban streams, whereas sites with grades at higher bands and 'very likely degrading' trends were in the larger waterways of rural catchments with a mix of forestry and pastoral farming land uses. Reference sites had declines in MCI scores, most likely reflecting disturbance to riverbeds, loss of habitat and fauna from flooding, and erosion effects from storm events.

What We're Doing

Freshwater Action Plans

Councils must investigate the causes of poor and declining water quality and develop Freshwater Action Plans to halt or reverse these trends. The Plans will include direct actions to improve stream habitats, community engagement to encourage actions to improve riparian margins and other land use changes to reduce contaminants, and may also place new limits on activities that are contributing to the degradation.

Action Plans will include what needs to be done to get from where we are now to achieving the desired outcomes, within a set time frame. The Action Plans will be reviewed every five years.

Both the 2018 and the 2023 State of the Environment Report (this one) have identified the key pressures contributing to degrading water quality, which mostly relate to *E. coli*, and to fine sediment reducing water clarity. Our fish spawning surveys have also identified fine sediment as a widespread issue in coastal streams, as it smothers instream habitats where fish lay eggs and macroinvertebrates live.

Council's Freshwater Action Plans will include actions to remove physical barriers that prevent fish from being able to swim up and downstream and improve the surrounding land uses in the catchments with degraded water quality attributes. Collaboration and engagement with tangata whenua and the wider community will be vital to raise awareness of the issues and to work together to improve our freshwater environments.

Action Plans will be developed for each Freshwater Management Unit (FMU), and these plans will prioritise actions for waterways with one or more attributes at or below the National Bottom Line. These Plans will also include investigations to determine contaminant sources for waterways with high quality attributes, which have been categorised as 'very likely degrading'.

Water Quality Attributes Requiring Improvement and Further Action

The high priority sites are those with the most degraded water quality attributes (band D or E; less than the National Bottom Line) listed in Table 8.

Macroinvertebrate Community Index (MCI)

The urban sites with very degraded MCI scores (less than the National Bottom Line) include:

- Maitai FMU – Brook at Manuka St, Maitai at Riverside, York at Waimea Rd, Todds at SH6 and Hillwood at Glen Rd.
- Stoke FMU – Saxton Creek below the Confluence, Orphanage at Saxton Rd East, Poorman at Seaview Rd and Jenkins at Pascoe St.

The rural sites with 'very likely degrading' trends include:

- Wakapuaka FMU – Wakapuaka at Duckpond Rd, Lud at SH6 and Wakapuaka at Hira.
- Whangamoa FMU – Graham at SH6, Collins at SH6, Dencker at Kokorua Rd and Whangamoa at Kokorua Bridge.

E. coli

The sites which are in the 'very degraded' band E for *E. coli* include:

- Maitai FMU – Brook at Manuka St, Brook at Burn Place, York at Waimea Rd, Todds at SH6 and Hillwood at Glen Rd.
- Stoke FMU – Saxton Creek below the Confluence.

Wakapuaka FMU – Wakapuaka River at Hira and Paremata Flats also need improvements in *E. coli* levels to support safe recreational use.

The following monitored sites with A or B bands have water quality trends that are 'very likely degrading' over the last nine years and will require further investigation to determine whether the trend is likely to continue, and whether action is required to avoid adverse environmental effects.

Black disk clarity

The sites with degrading water clarity include:

- Maitai FMU – Brook at Burn Place and Manuka Street and Hillwood at Glen Rd.
- Wakapuaka FMU – Teal at 1.6km, Lud at SH6, Wakapuaka at Hira and Wakapuaka at Maori Pa Rd.
- Whangamoa FMU – Dencker at Kokorua Rd and Graham at SH6.

Nitrate nitrogen

The sites with increasing nitrates include:

- Maitai FMU – Maitai at Groom Road, York at Waimea Road and Hillwood at Glen Rd.
- Wakapuaka FMU – Wakapuaka at Duckpond Road, Teal at 1.6km and Wakapuaka at Hira and Maori Pa Rd.
- Whangamoa FMU – Whangamoa at Hippolite and Graham at SH6.

Improvements in water quality for human and ecosystem health will be achieved by addressing issues through an integrated catchment approach working across Council teams, which includes investigating the major causes of poor water quality from pipe discharges and from run-off from land. Actions may include reducing *E. coli* at source through improvement programmes for wastewater and stormwater networks in urban areas and incentives for fencing waterways and riparian planting on land, and creating wetlands where appropriate to reduce cumulative effects.

We are carrying out additional nutrient and *E. coli* monitoring, for example, for the Hillwood and Todd Valley catchments, to characterise the contaminants from different land use types and prior to discharge to Nelson Haven. Additional assessments of bacteria in shellfish is also planned. Following the August 2022 flood event, the Todd Valley Stream channel was reinstated, and ongoing habitat creation is occurring, with more work planned to enhance flood resilience, biodiversity, and recreation values in this area.

Community events in the Stoke, Maitai and Wakapuaka FMUs have also been well supported. These events provide the foundation for respecting the community's values related to streams and rivers, as well as biodiversity values, and they encourage people to take responsibility for protecting our streams and rivers for future generations.

Where We're Heading

Integrated catchment approach

This programme of action will be guided by an integrated catchment approach to be developed with tangata whenua and the community. We will also collaborate with neighbouring councils and with other agencies, including the Department of Conservation.

Long-term riparian and wetland restoration

Improvements to freshwater quality will not be immediate and require a long-term outlook because of the time it takes to create and establish riparian margins and wetlands, and to make changes in current practices and policies to reflect sustainable land management practices and water sensitive design.

Research impacts of storm events

Climate will play a large part in shaping Nelson's future, in terms of avoiding further development and farming in flood and inundation risk areas and planning how infrastructure on the coast will be maintained, including wastewater treatment, industrial activities and transport routes. More studies are underway to describe the effects of sediment from storm events (as it ends up in estuaries) to develop stronger links between our monitoring programmes for climate, land and freshwater catchments, and estuaries. Council is investing in building on the existing hydrology network to provide more accurate and comprehensive coverage of real time river flows and rainfall for flood warning and to quantify the natural and minimum flows over time. This work is needed to plan for a more resilient community to protect our fresh water supply, environment and wellbeing for future generations.

Remote sensing and modelling

Remote sensing and modelling will increasingly be used to describe the state of our environment across the whole region in more detail than can be provided by a network of individual monitoring sites.

Modelling has previously been used to estimate fish habitat and water allocation, and the prevalence of cyanobacteria mats in the Maitai. Models are also being developed to estimate the macroinvertebrate community index scores across the Tasman-Nelson region. This baseline can be used to assess how impacted our waterways are. The hydrologic CREST model integrates remote sensing climate data, flood and coastal hydrology and land use characteristics that can be used to quantify contaminant inputs from land to rivers and estuaries. This water accounting model can then be used to prioritise and predict what remediation actions will make the biggest difference in meeting the desired water quality outcomes.

Fish diversity and spawning habitat

Fish biodiversity and spawning habitats are relatively well described for each of the Freshwater Management Units. Most of our freshwater fish species are diadromous (migratory between fresh and salt water during their lifecycle). This means whole catchments and estuaries need to be managed together, to protect the juvenile and adult life stages of these species, and to re-establish fish communities and other taonga by enhancing and creating habitat and water quality.

Environmental DNA

Environmental DNA (eDNA) (see the following case study) is increasingly being used as a tool to describe the range of different species present, and to assess ecosystem health. It can also be used to detect threatened and invasive species, and to identify the absence of common fish species (potentially due to fish passage barriers).

All these actions will have a positive impact on water quality.

Freshwater – Case Study

Environmental Detectives

Environmental DNA, or eDNA, is an emerging method of detecting biodiversity in our streams and catchments. This uses tiny traces of genetic material that are left behind by living things as they pass through terrestrial and aquatic environments. The eDNA method includes collecting eDNA material from river water on a filter, which is then used to identify different species by comparing the eDNA to reference databases.

During the 2020/2021 summer we collaborated with other regional and unitary councils, and Wilderlab, on a nationwide eDNA trial. The primary goals for this trial were to:

- explore the potential application of eDNA for monitoring fish and macroinvertebrate populations alongside regular survey methods; and
- determine the optimal number of samples and the volumes of water to collect for this type of monitoring.
- explore how eDNA can be used to gain a wider understanding of biological communities and how gradual whole-ecosystem changes can be used to provide a picture of the overall state and quality of an ecosystem.

The results from this pilot study have led to:

- national guidance on river eDNA sample methods for surveying fish and macroinvertebrates species; and
- development of the Taxonomy-Independent Community Index (TICI), which is a measure of biological diversity including all types of species, including species not currently recorded in the database (sometimes referred to as 'eDNA dark matter').

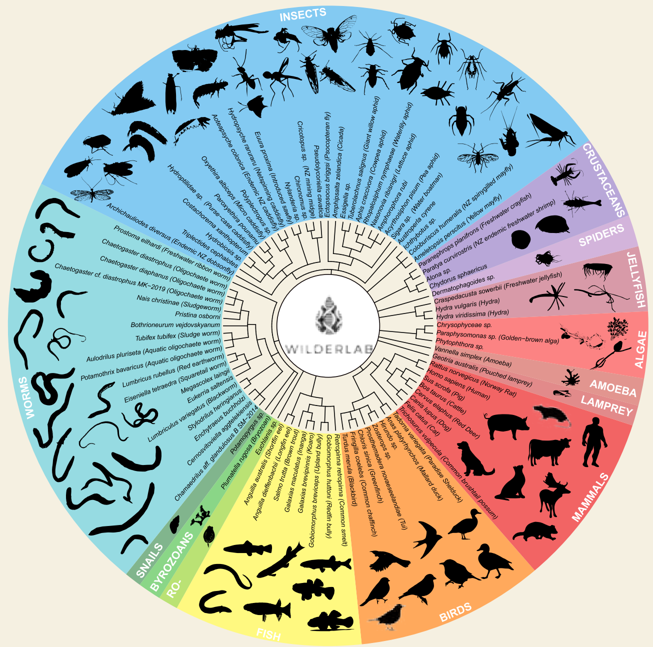
We are using eDNA to search for elusive threatened fish species such as the shortjaw kōkopu *(Galaxias postvectis)* and for national biosecurity surveillance of new pest species such as the freshwater gold clam *(Corbicula fluminea)*.

So far, we have detected new species in the region, such as the Australian longfin eel *(Anguilla reinhardtii)* which was recorded in the Brook Stream but is normally found on the east coast of Australia. The timing of the species' arrival to Aotearoa rivers is unknown, though it has potentially been in recent decades, due to changes in the oceanic currents that transport the passive eel larvae from the spawning grounds in the South Pacific.

The harmless freshwater jellyfish *(Craspedacusta sowerbii)* is one of the world's most successful invasive species and has now been recorded in Nelson as part of the eDNA survey. It is likely to have originated in China. Only male jellyfish have ever been recorded in New Zealand, as well as in many other parts of the world, which indicates no sexual reproduction via the free-living medusa stage. Dispersal of juvenile jellyfish is thought to be by accidental transport by humans attached to weed or boats. It may also have been wind-blown to New Zealand.

The eDNA project has brought science and communities together through Our Wai Tuwhera o te Taiao – Open Waters Aotearoa programme, an initiative by the Environmental Protection Authority. This programme supports connections with science, communities, and their local environments through eDNA exploration and discovery (see Figure 20). Stories and knowledge are shared through an interactive web portal which includes eDNA records and associated environmental projects.

Figure 20: eDNA Wheel of Life from the Wakapuaka River at Hira Illustrating the Range of Species Detected in March 2022



Freshwater – Case Study

Quantitative Microbial Risk Assessment

Indicators and pathogens in New Zealand rivers in 2020

The current Freshwater Recreational Guidelines and the NPS-FM 2020 requirements for protecting public health at recreational bathing sites are based on data collected over 20 years ago, which described an association between the bacteria *Campylobacter* and faecal indicator bacteria *Escherichia coli*.

There have been significant changes in land use and waste management practices in the 20 years since these frameworks were developed, leading to some uncertainty over the relevance of the relationships between pathogens and faecal bacteria indicators. The Institute of Environmental Science and Research (ESR) led a pilot study in 2020 with unitary and regional council monitoring teams to quantify the current prevalence of pathogens and their relevance to human health risk.

The risk to public health from pathogens is determined by several factors including their prevalence and persistence in the environment and likelihood of serious disease. *E. coli* and *Enterococci* bacteria are found in the gut of animals, so are commonly used as an indicator of animal faecal contamination, and potentially other associated organisms, including pathogens. The water quality standards are based on the estimated risk of *Campylobacter* bacteria infection for a range of occurrences, for 95% of the time (equivalent to 95% of samples).

Pilot Study

The purpose of the study was to sample sites that were likely to be contaminated with pathogens. If faecal bacteria contamination is present, indicated by high *E. coli* concentrations, it is likely that faecal pathogens will also be present. High *E. coli* concentrations was a criterion for selection of sites. The survey results are therefore not considered to be representative of freshwater quality in New Zealand. A selection of new analytical technologies for detecting microorganisms were trialled during the pilot, using samples collected since 2000. Due to the limited number of samples, the aims of the pilot did not include establishing the ‘current state’ of concentrations of pathogens and faecal indicators in the rivers sampled.

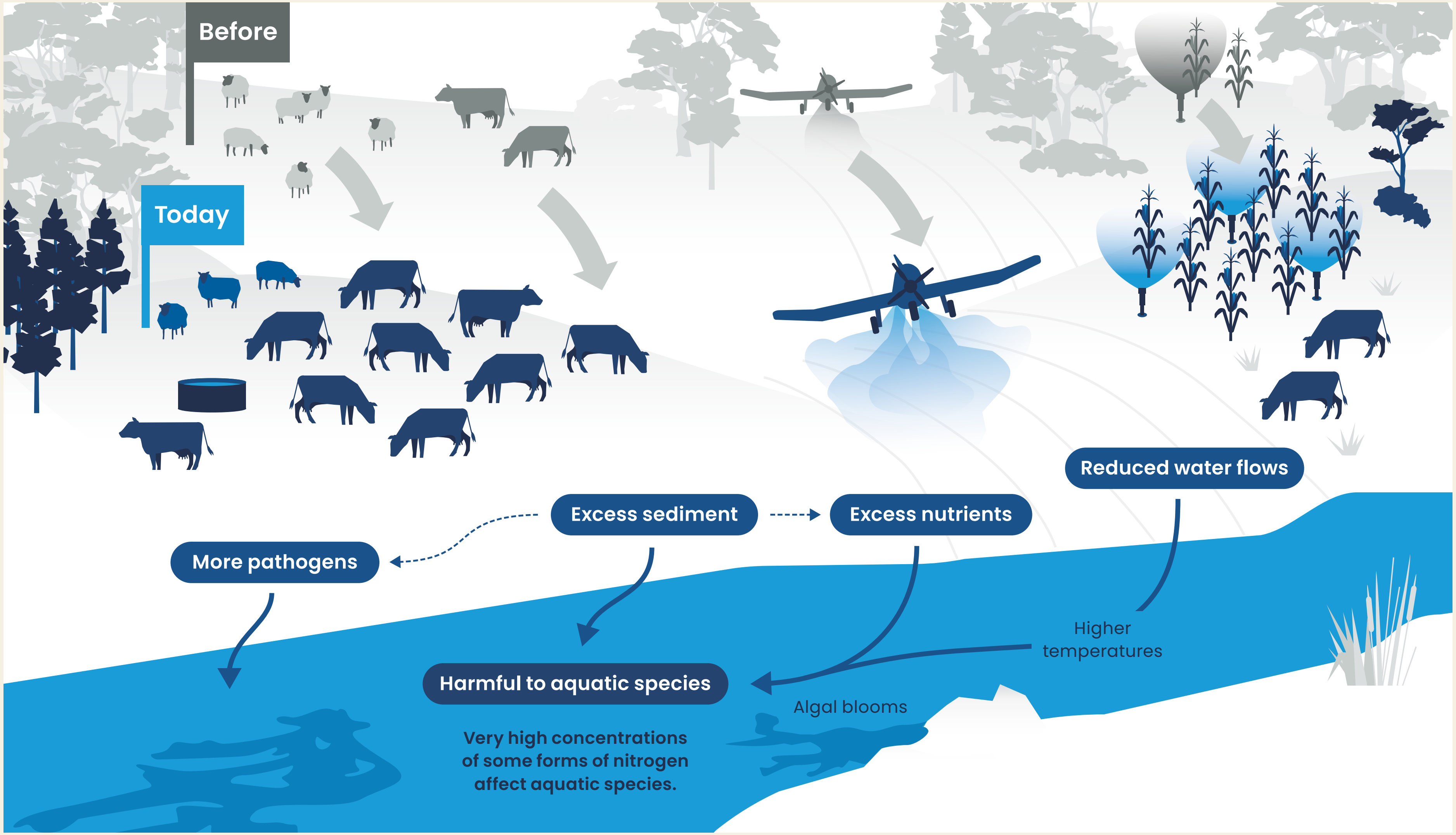
Between February and March 2020, 52 water samples were collected by unitary and regional councils from 16 rivers around New Zealand (initially characterised as six urban, five dairy farming and five sheep & beef farming land use areas). They were analysed for the levels of bacteria *E. coli, Enterococci, Campylobacter, Salmonella,* Shiga toxin-producing *E. coli* (STEC), norovirus, enterovirus, adenovirus and protozoa *Cryptosporidium* and *Giardia*, and a set of faecal source tracking markers (human, ruminant and wildfowl). The river sampling sites were selected because they regularly had elevated *E. coli* concentrations during previous monitoring by Council.

The Wakapuaka River was chosen for the Nelson site, which has a Long Term ‘Poor’ grade at the Paremata Flats Reserve bathing hole. This site represented low density stocking of beef and sheep. *E. coli* concentrations were relatively low (median = 288 *E. coli*/100mL) from the three sampling events compared to other sites around the country. *Campylobacter* was detected at a high concentration in one sample with high *E. coli* concentrations and at low concentrations or not present when *E. coli* was low. *Cryptosporidium* was only detected once at a very low concentration while very low concentrations of *Giardia* were in all three samples. Samples had strong ruminant, as well as wildfowl faecal source tracking markers. No human faecal markers or other pathogens were detected.

Key Findings

The Pilot Study concluded that land use has been shown to influence variations in pathogens and provides information on potential pathogen sources relative to current land management in urban and rural regions (Figure 21).

Figure 21: Land Use Change and Sources of Pollutants to Freshwater. Source MFE (2019)



Changes to our use of land in the past three decades

Less sheep more cows

Cattle numbers have increased, especially dairy cattle. Cows produce more urine with a higher nitrogen concentration than sheep.

More animals per hectare

High stocking rates and vehicles driven on the land cause soil compaction, increasing the likelihood of polluting run-off into streams.

More fertiliser

The amount of nitrogen applied in fertiliser has increased. Fertilisers such as nitrogen and phosphorus can pollute waterways.

More irrigated land

The amount of irrigated land has increased. Taking more water for irrigation reduces river flows and affects species and habitats.

Impacts on waterways

Algal blooms can reduce a river's dissolved oxygen, stop light entering the water, and change the composition of plant and animal species that live in the waterway.

Effects on cultural values

Changes in water quality can significantly affect the binding force between physical and spiritual elements and wairua (spirituality, connections to atua) of waterways, leading to the decline of iwi and hapū relationships with the environment.

Effects on human health

Pathogens in livestock faeces can enter waterways and cause rapid outbreaks of illness. Infection by *Campylobacter* is the most frequently noticed disease in New Zealand, and peaks in spring and summer.

This pilot study confirmed the frequent occurrence of more than one source of contamination, and that observed land use does not always match the sources of contamination. More sampling over time and in a range of weather conditions is required to provide representative pathogen data for freshwater and marine water quality standards. Future studies should include a multi-disciplinary approach of both visual confirmation of land use and faecal source tracking to fully assess catchment contaminant risks at recreation bathing sites.

Report source:

environment.govt.nz/publications/quantitative-microbial-assessment/

Freshwater Quantity

Water supply dam on the Roding River. Photo cedit C. Appleton

What We Know – State and Trend

Nelson City Council monitors rainfall and river flows for several important reasons:

1. Flood warning and management: Monitoring rainfall and river levels allows Council to predict and prepare for potential flooding events. This information is crucial for issuing timely warnings to residents and implementing flood mitigation measures.
2. Water resource management: Rainfall and river flow data help Council manage water resources effectively, including water supply for the city and environmental flow requirements for maintaining a healthy environment for ecosystems.
3. Environmental monitoring: Long-term records of rainfall and river flows are essential for assessing the effects of climate change and providing a comprehensive understanding of extreme weather events.

River Gauging on the Roding River. Photo credit M. Simpson

The Hydrology Network

Council operates a network of flow and rainfall monitoring sites that includes automatic gauges (Figure 22). These sites provide real-time data on river flows and rainfall levels and are updated frequently, typically every 30 minutes.

These sites provide near real-time data on what is happening in the catchments across the region. They provide data on droughts and floods, including how frequently these events occur and crucial near real-time alarms during floods.

To make sure we are getting accurate readings from this monitoring, we visit the monitoring sites each month to physically measure the river flows. These gaugings show us the current flow in litres per second (l/s) or in cubic metres per second (m3/s) which we can compare to our long-term flow record to make sure it matches.

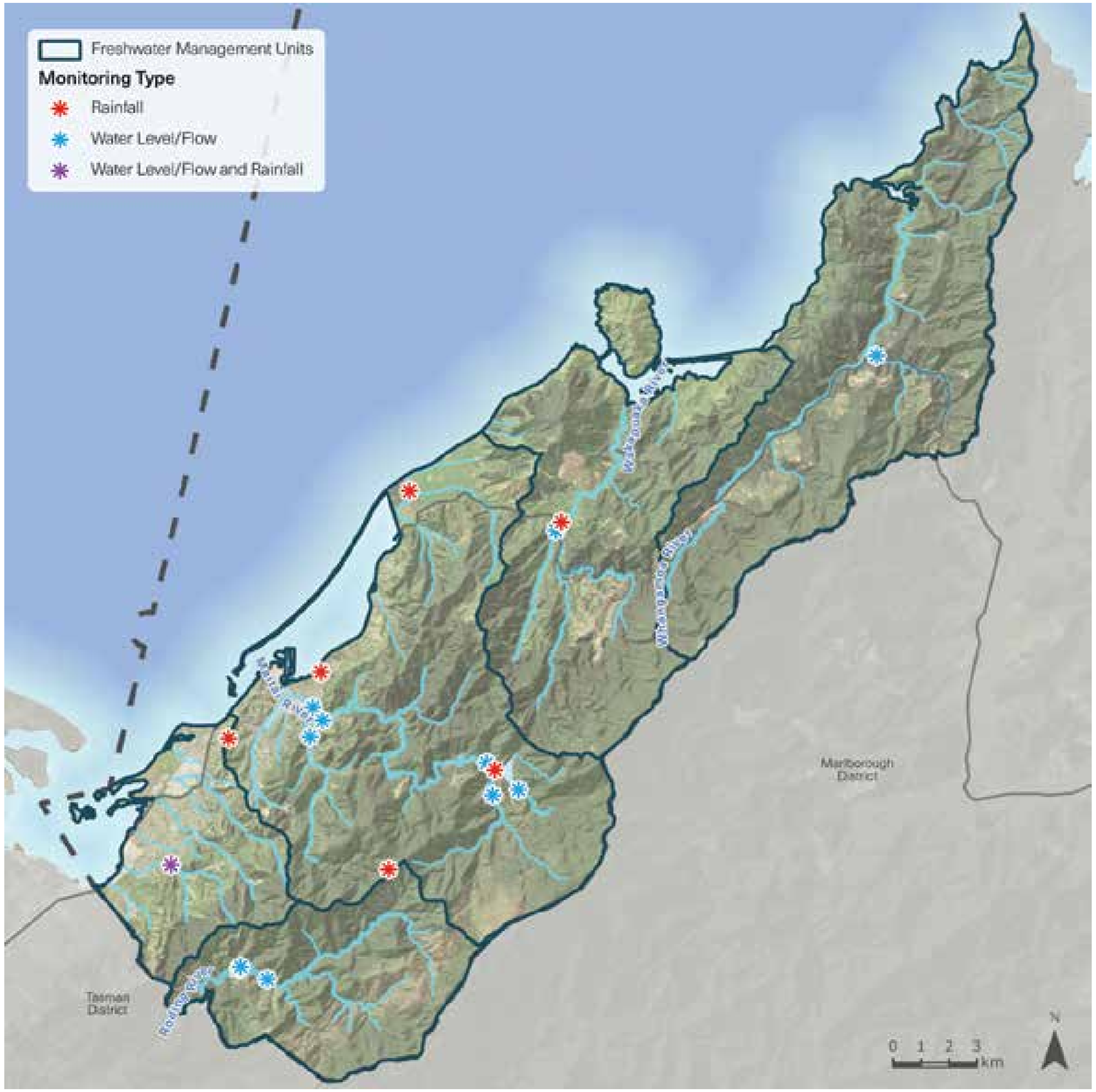


Figure 22: Hydrology Monitoring Sites Illustrating both Flow and Rainfall

Rainfall

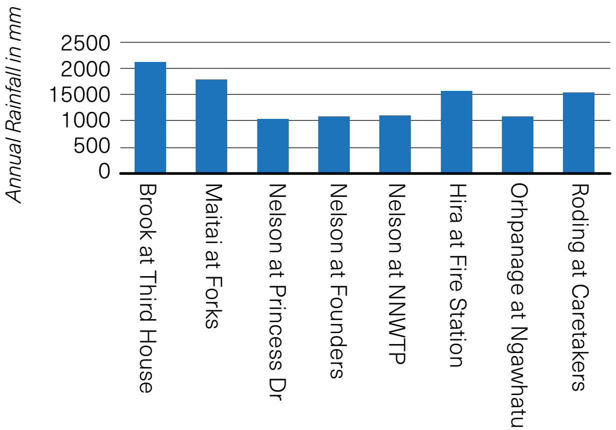
August 2022 a rainfall record breaker

On 17 August 2022 Nelson experienced an exceptionally large rainfall event lasting three days. It can be described as a 1 in 120-year rainfall event.

Brook at Third House recorded 275.6 mm in 24 hours and 806mm for the month of August. This is the largest and most extreme event based on available records.

The average annual rainfall across Nelson's eight monitored catchments is around 1,000 mm (1 metre) per year, with the wettest areas being the Maitai and the Brook valleys as shown in Graph 7.

Graph 7: Nelson's Average Annual Rainfall from 2018–2023



Recent Rainfall Variability

The Nelson region can experience significant variability in rainfall patterns from year to year with February and March typically being the driest months and October typically the wettest.

This pattern has been disrupted in recent years with large rainfall events outside of the normal wetter months. This natural variability, combined with potential impacts of climate change, could contribute to the perception of a 'mixed bag' in terms of rainfall.

The 2019–20 period saw below average rainfall for all but three months of 2019 across the whole region, with only 3.2 mm of rainfall recorded in January 2019. This was on the back of a dry 2018 too.

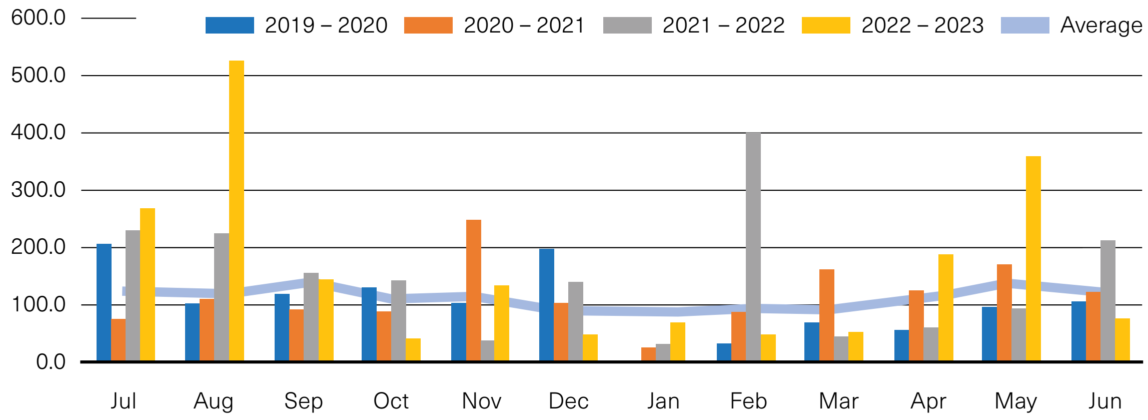
The 2021–22 period saw seven months out of 12 recording above the monthly average rainfall. February 2021 had a large rainfall, and a flood event in the Whangamoa and Collins catchments caused slips and road closures, then July 2021 had two days of heavy rain causing moderate flooding in the Maitai. Lastly, in August 2022, Nelson received heavy rain which lasted four and a half days with some areas receiving up to 742 mm over just a few days.

A year later, in May 2023, another sizable rainfall event occurred which caused more flooding and landslides in The Brook, Maitai and Wakapuaka catchments.

Notably, throughout 2020–2023 a La Niña phase was in place; described as a 'rare triple-dip'. The extended duration of La Niña is thought to have allowed for cumulative effects on weather patterns.

The impact of this phase can be seen in the following rainfall graph (Graph 8). A large rainfall event in February 2021 caused a lot of damage in the Whangamoa/Collins catchments and then in August 2022 we sustained three days of large rainfall totals causing moderate floods and devastating landslides across the Nelson region.

Graph 8: Total Rainfall for 2019 to 2023 Versus the Five-Year Average (Monthly Rainfall Totals all Sites Combined)



Note: these graphs are not in calendar years – instead, they show rainfall data from July of one year to June of the next. By starting the hydrological year in July, we can capture the full cycle of winter precipitation and its impacts on water resources.

The August 2022 rainfall total (yellow bar) stands out by far as the biggest, followed by the February 2021 (grey bar) and May 2023 (yellow bar) events.

The Brook at Third House rain gauge recorded 743 mm for five days and 806 mm for the whole month of August 2022. This is 238% of the average monthly total for August, which is 175 mm.

The Maitai at Forks rain gauge had similar totals for the month of August 2022, recording 695 mm for the five days and 749 mm for the month. That total is 249% of the monthly average for August (which is 170 mm).

River Flows

The Nelson region experienced multiple significant flood events between 2019 and 2023, with the August 2022 flood standing out in duration and impact.

On 5 February 2022, a flood caused notable damage in the Collins Catchment, and the highest flows were seen.

On 6 May 2023 the flood recorded in the Maitai South Branch was the largest seen in recent times. This flood event in the South Branch was larger than the flood in August 2022. Despite the rainfall intensity in the South Branch, the flood was not widespread across the Maitai catchment and only a medium size flood was observed downstream.

Table 10 summarises the mean annual flows for Council's flow sites across the region. The maximum recorded flows for the last five years are also shown, with return periods for those flows.

ARI definition: Is the average time period between events of a specific size or intensity.

Table 10: Mean Annual Flows for all Sites with Maximum Flows and Return Periods

Site	7 Day mean annual low flow (m3/s) MALF	Mean flow (m3/s)	Maximum recorded flow (m3/s)	2019–2023 Maximum recorded flow (m3/s)	2019–2023 Maximum recorded flow (Date)	2019–2023 Maximum recorded flow (ARI)	Length of record in years	Catchment size (km2)
Brook at Seymour Ave	0.055	0.356	40.20	40.20	20/08/2022	23	11	16
Collins at Drop Structure	0.062	0.556	123.40	123.40	5/02/2022	157	56	18
Maitai at Avon Tce	0.361	2.582	322.00	322.00	17/08/2022	42	19	90
Maitai at Forks	0.217	1.475	211.60	211.60	17/08/2022	35+	42	35.7
Maitai Sth at above Old Intake	0.168	0.857	91.50	73.00	6/05/2023	15	28	17.8
Maitai Nth at upper side of Lake	0.075	0.522	N/A	31.63	17/08/2022	N/A	8	8
Orphanage at Ngawhatu	0.0046	0.086	57.10	14.65	20/08/2022	5	17	7.75
Roding at Caretakers	Affected by water supply intake	1.718	404.00	154.50	20/08/2022	7.5	62	41.5
Roding at Skidsite	0.218	1.694	404.00	158.80	20/08/2022	7.5	28	38
Wakapuaka at Hira	0.304	1.374	204.30	185.0	18/08/2022	35+	46	41.9

16–20 August 2022 Flood

Most of the region's rivers experienced three different flood peaks during this flood event (See Table 11.)

These were the catchments most exposed to the northerly rain. The rainfall was steady over an extended period rather than intense over a short duration. In the Maitai, this event closely resembles the 1970 and 1986 events, based on water level alone (See Picture 22.)

In the Collins catchment, the August flood was the second largest with an ARI of 70+ years. This came on the back of the largest flood on record only six months earlier in February 2022 with an ARI of 157 years. In the Wakapuaka catchment, the August flow (35+ years) was slightly lower than the 1995 flood which is still the biggest to date.

The further south the catchments the lesser the impact was, as seen with Orphanage Creek showing only a five-year return period flood.

Table 11: River Flows with Statistics for each Flood Peak

River site	First Peak (flow m3/s)	Second Peak (flow m3/s)	Third Peak (flow m3/s)	Estimated average recurrence interval (ARI)
Collins at Drop Structure	38	101	64	70+
Maitai South at Above Old Intake	73	52	51	15
Maitai at Forks	210	150	152	35+
Maitai at Avon Tce	322	304	267	35+
Orphanage at Ngawhatu	7.3	10.9	14.6	5
Wakapuaka at Hira	148	185	138	35+

Picture 22: Maitai River in Flood During the August 2022 Storm Event

Photo credit NCC

Impacts on Nelson Catchments

The most visible impacts from the August 22 event were erosion of riverbanks and bed level change.

The Wakapuaka and Collins catchments sustained a huge amount of erosion to the catchments and both riverbeds have changed substantially.

At the Hira flow recorder, the riverbed level has increased by 800 mm (0.8 metres) due to sediment deposition.

Both recorder sites need to be repaired, if not replaced. (See Pictures 23 and 24.)

Picture 23: Wakapuaka at Hira After the August 2022 Flood. Photo credit NCC

Picture 24: Collins at Drop Structure After the August 2022 Flood. Photo credit NCC

Water quality monitoring in the Maitai River. Photo credit A. Kimber

Estuaries

Boulder Bank and Nelson Haven/Paruparuroa Estuary. *Photo credit C. Appleton*

What We Know – State and Trend

Estuaries are dynamic environments formed where the river meets the sea and are home to an abundance of species and unique habitats.

These habitats provide food and shelter for native fish, including the juvenile life stages of many important fisheries species, such as snapper (tāmure), mullet (kanae) and kahawai. Estuaries are also important sites for coastal native birds and migrating shorebirds, such as bar-tailed godwits (kūaka), royal spoonbills (kōtuku ngutupapa), and South Island pied oystercatchers (tōrea).

As the receiving environment at the end of our rivers, the health of our estuaries is affected by environmental pressures on land, including excess sedimentation, pollution, and development.

There are four estuaries along the coastline managed by Nelson City Council: Waimea Inlet, Nelson Haven/Paruparuroa, Delaware Inlet/Wakapuaka, and Kokorua Inlet (Figure 23).

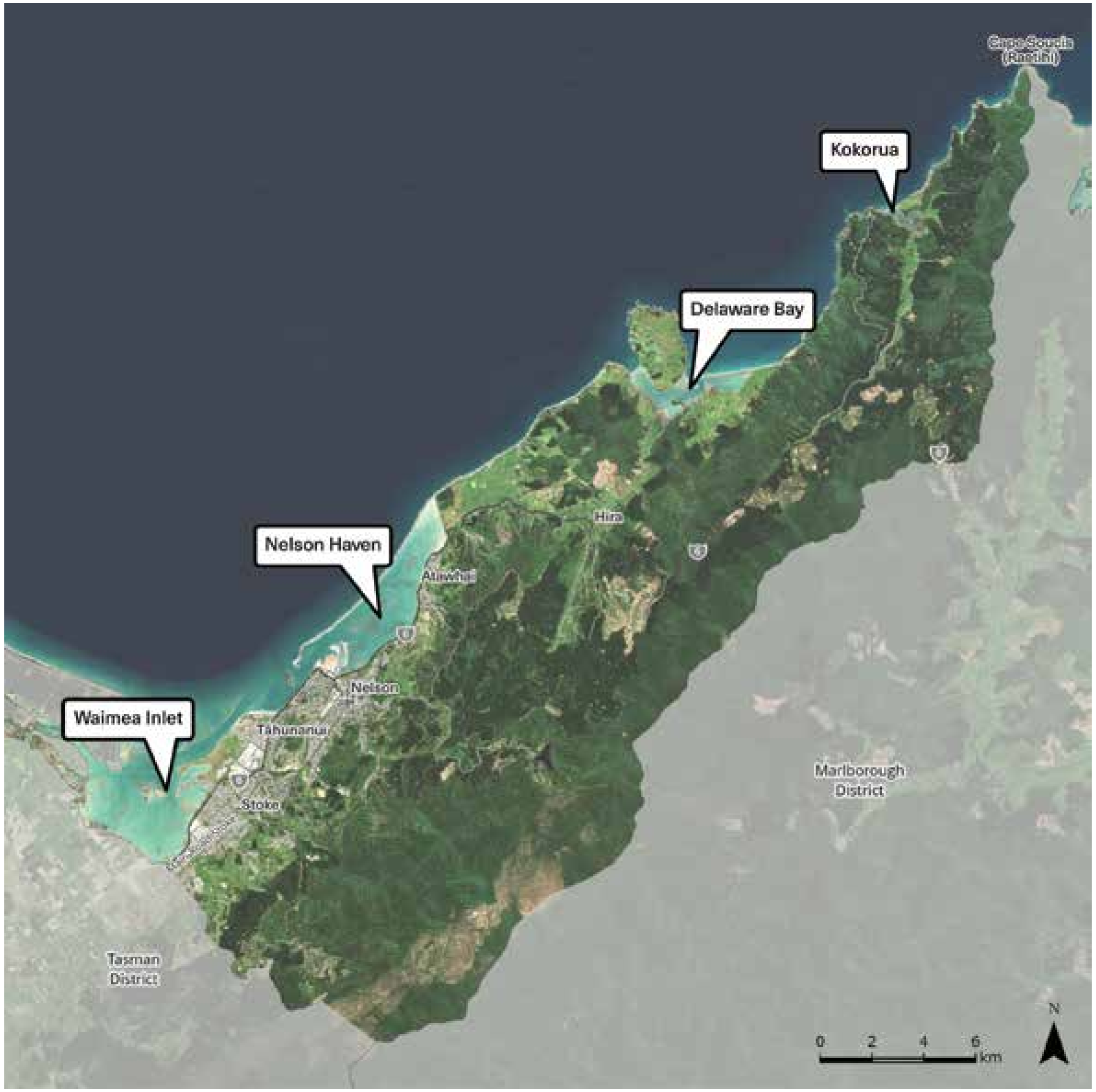


Figure 23: Map of Nelson Estuaries

Habitats and Species We Monitor

Salt marsh – Tidal habitat consisting of vegetation that is able to tolerate saltwater. This important habitat provides a natural filter for sediment and nutrients and protects the coastline from erosion (See Picture 25.)

Seagrass – *Zostera muelleri* is the one species of seagrass (rimurēhia) present in Aotearoa New Zealand. Seagrasses are not a macroalgae or seaweed but are a flowering plant. Just like grasses on land, seagrasses form underwater beds or meadows, which provide a valuable habitat to many species including juvenile fish. (See Picture 26.)

Nuisance macroalgae – Macroalgae is seaweed. Nuisance macroalgae (or opportunistic macroalgae) refers to species of *Agarophyton* and *Ulva* that grow in high densities in nutrient enriched estuaries. This state is a sign of poor estuary health, with the algae smothering the underlying sediment and leading to anoxic conditions (lacking oxygen).

Picture 25: Salt Marsh Habitat on Haulashore Island (photo from Salt Ecology)

Picture 26: Seagrass Bed in Nelson Haven/Paruparuroa (photo from Salt Ecology)

Monitoring Methods

Broad scale habitat surveys – These surveys are undertaken every five years and involve mapping sediment and habitat types across the estuary's intertidal area. This includes mapping areas of nuisance macroalgae and enriched sediment. These methods adapt the guidance of the National Estuary Monitoring Protocols.

Fine scale habitat surveys – After setting up a baseline for each estuary by surveying annually for a total of three years, fine scale surveys proceed every five years or following major environmental changes (e.g. an extreme weather event). Fine scale surveys focus on estuary health: sediment plate depths are measured, sediment samples are tested for contaminants and mud content, and sediment-dwelling invertebrates (macrofauna) are taxonomically classified.

Sediment plates – Small concrete pavers buried at a set depth in estuary monitoring sites. These are visited annually (and following any extreme weather events), and the depth of the paver is measured (Picture 27). Over time, the changing depth helps assess rates of sedimentation and/or erosion.

Picture 27: Measuring Sediment Plates in Kokorua Estuary. Photo credit P. Fisher

Waimea Inlet

Waimea Inlet is the second largest tidal estuary in the South Island (Picture 28), with an area of approximately 3,462 ha. Due to the estuary spanning the Nelson and Tasman Coastal Marine Areas, monitoring is split between Nelson City Council and Tasman District Council.

Waimea Inlet has high ecological value as it provides a nursery habitat for juvenile fish, including key fisheries species, as well as containing shellfish beds and internationally important feeding grounds for shorebirds. Among the Waimea Inlet's habitats are two sponge gardens, containing high densities of the estuary-tolerant sponge species *Mycale (Carmia) tasmani*. The main source of freshwater flowing into the estuary is the Waimea River, but nine other small streams also contribute.

The estuary's sediments are now mud-dominated, due in part to the development of orchards in the 1950–60s, leading to sediment runoff. This is a dramatic change from a historical substrate of sand, shell, and gravel full of large shellfish – which was discovered by taking core samples from deep in the sediment. This process of sedimentation is putting pressure on the estuary due to ongoing runoff from agricultural land and exotic forestry harvesting.

Picture 28: Waimea Inlet. Photo credit V. Ambrose

Habitat (From the 2020 broad scale survey results)

Waimea Inlet has seen extensive modification, with significant historic losses of seagrass and salt marsh habitats via drainage and land reclamation. Ongoing pressures include hard engineering of the coastline and elevated sedimentation.

9.9% of estuary area covered by salt marsh

62.8% decrease in seagrass cover from 1990 baseline

Sediment (From the 2021 fine scale survey results and sediment plate monitoring)

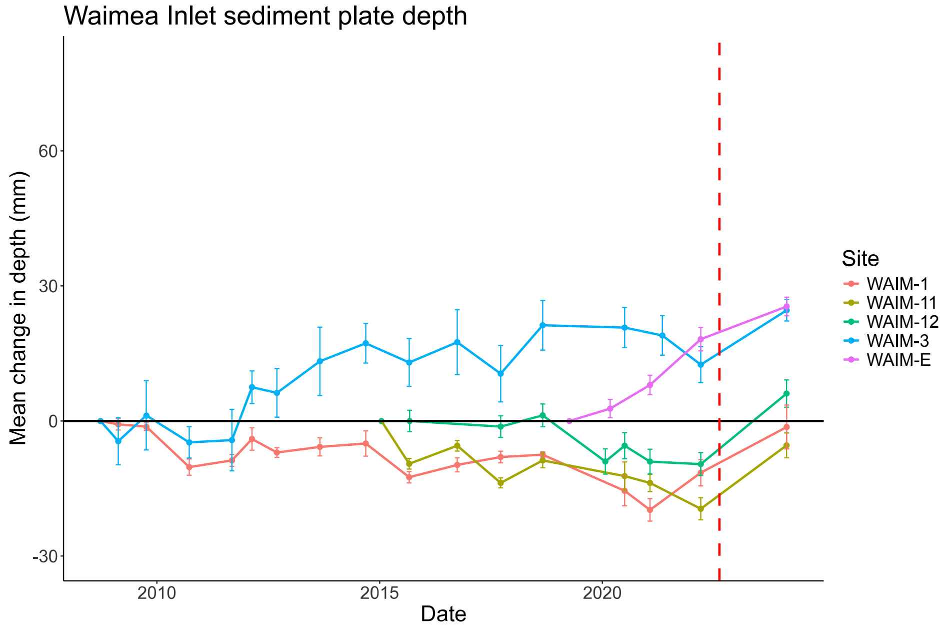
Trends

There has been a net increase of approximately 30 ha in the total area of mud-dominated sediment from 1990–2020. The patterns of deposition, erosion, and redistribution of new sediment around the Waimea area has been highly variable (Graph 9), particularly when considering the dramatic long-term movements of sand at the western Tāhunanui and Back Beach areas.

High nutrient enrichment conditions (which lead to macrophyte weed growth) covered just 0.6% of the estuary area (20.3 ha) in 2020, a decrease of approximately eight hectares from 2014 surveys.

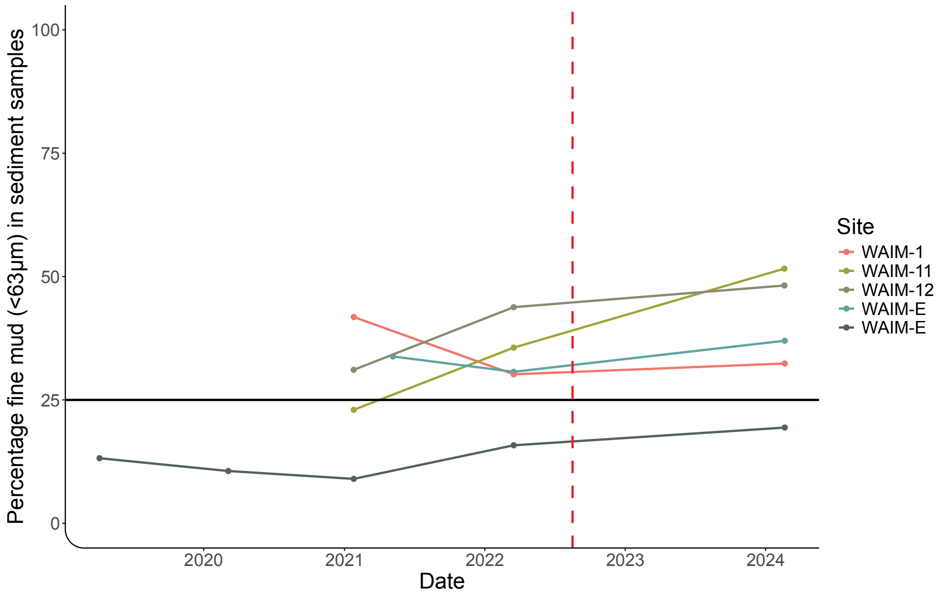
The main tidal flats are in a relatively healthy state, but the steady increase in sediment mud content at most sites poses a gradual but growing risk to estuary health. Monitoring of the Waimea Inlet sediment plates in 2024 revealed an increase in sediment depth and a slight increase in mud content at all sites, which was made worse by the sediment inputs during the August 2022 floods (Graphs 9 and 10).

Graph 9: Changes to Sediment Depth at the Waimea Inlet Sediment Plate Monitoring Sites



Negative changes to sediment depth indicate erosion of sediment has occurred. The vertical dashed red line marks the August 2022 flood event.

Graph 10: Changes to the Proportion of Mud in Sediment Samples from the Waimea Inlet Sediment Plate Monitoring Sites.



The vertical dashed red line marks the August 2022 flood event. The horizontal dotted blue line marks the guideline for estuary sediment health to be considered 'poor' due to high mud content (≥25% mud content).

Contaminants

The 2020 fine scale surveys revealed that Kokorua Inlet sediments held very low concentrations of trace contaminants when compared to default guideline values in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018), except for consistently elevated concentrations of nickel and chromium, as well as mercury, with concentrations recorded at Site A in 2020 rated 'fair' against the ANZG guideline value. All of these trace metal concentrations are attributable to the geology of the catchment.

Invertebrate Communities

There were no notable areas of nutrient-enriched or anoxic sediments (lacking oxygen), and most sites contained a rich array of macrofauna including cockles/ Tuangi and wedge shells/Hanikura, which are an important part of the diet of fish, wading birds, and stingrays.

Nelson Haven/Paruparuroa

Nelson Haven/Paruparuroa is a relatively large estuary (approximately 1,250 ha) that extends along the Nelson City coast and is enclosed by the 13 km Boulder Bank/Te Taero a Kereopa (see Picture 29). The Maitai River is the main freshwater input, but many smaller streams and stormwater outfalls along the coast also enter Nelson Haven.

Picture 29: Nelson Haven/Paruparuroa
Photo credit H. Allard

The estuary and its margins have been heavily modified since European settlement of the region, with over 500 ha (or 30%) of the estuary area lost since 1840 due to extensive land reclamation via the drainage of salt marsh and wetlands. Some of the most dramatic changes to the estuary include the construction of a causeway cutting the northeastern estuary off from the Wakapuaka Sandflats, an area of salt marsh and estuarine vegetation now largely separated from tidal influence, and the construction of SH6, which involved the hardening of the estuary's eastern edge with a rip-rap wall.

Habitat (From the 2024 broad scale survey results)

Although there have been minimal reductions in overall estuary extent since 1980, the scale of the historic habitat changes is dramatic, with an estimated 126 ha (62%) loss of seagrass meadows and 285 ha (98%) decline in salt marsh extent from the natural state (see Figures 24 and 25).

Due to the hardening of the foreshore and the presence of the causeway to the northeast, neither the seagrass or the salt marsh habitat has capacity to migrate inland in response to sea level rise. Despite this threat, seagrass remains relatively widespread (168ha or 18.5% of the estuary's intertidal area) and this cover even increased by 17 ha between 2009 and 2019. However, density of the existing beds declined dramatically between 2019 and 2024, with evidence of recent stress and diebacks.

Following the August 2022 floods, mud was deposited in a thin layer (approximately 2–5 mm deep) across Nelson Haven. This smothering and resuspension of mud, along with new sediment deposited in the estuary, are likely major contributors to the recent decline in seagrass health.

Figure 24: Map of Seagrass Distribution in Nelson Haven/Paruparuroa for 2019

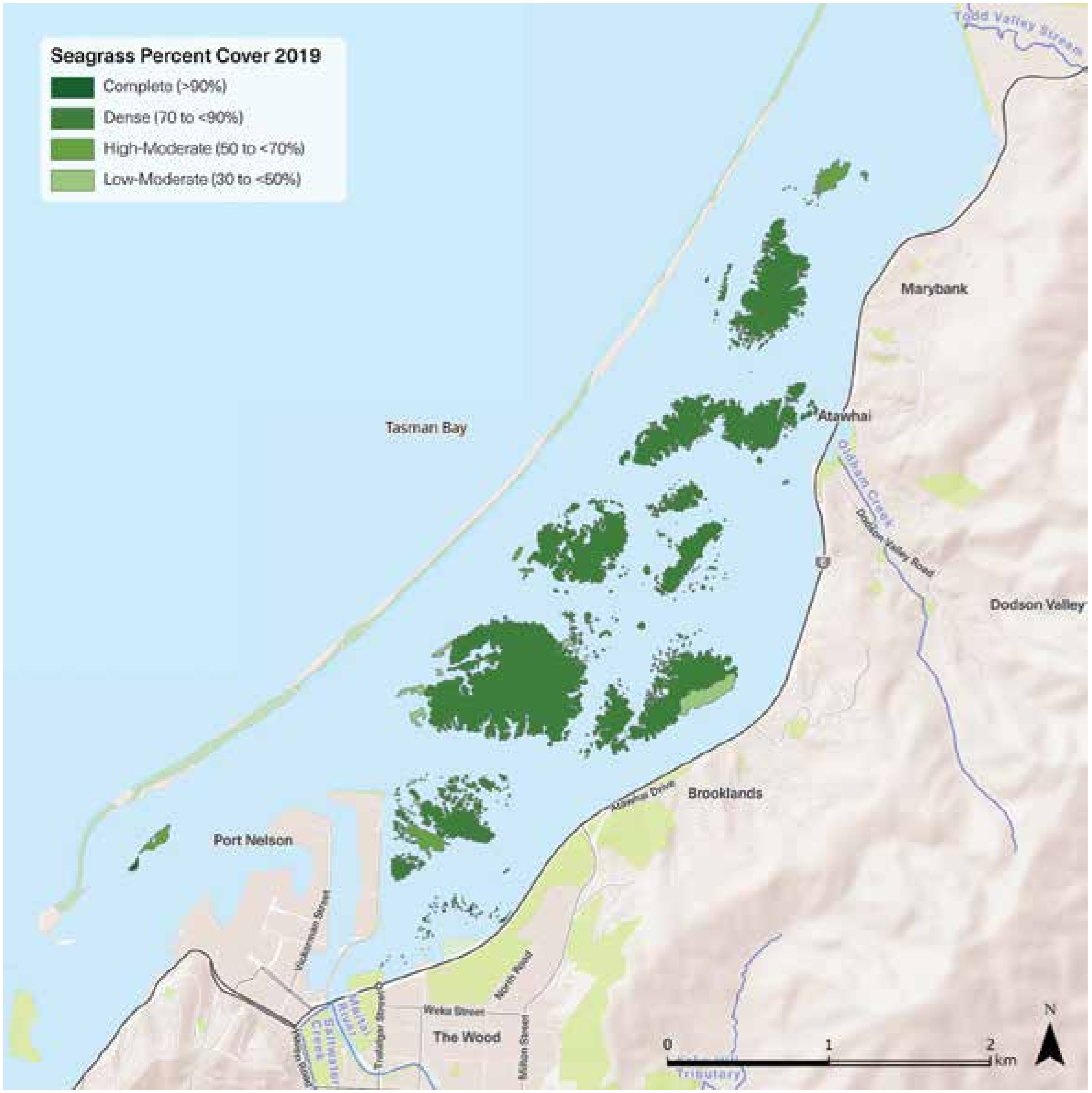
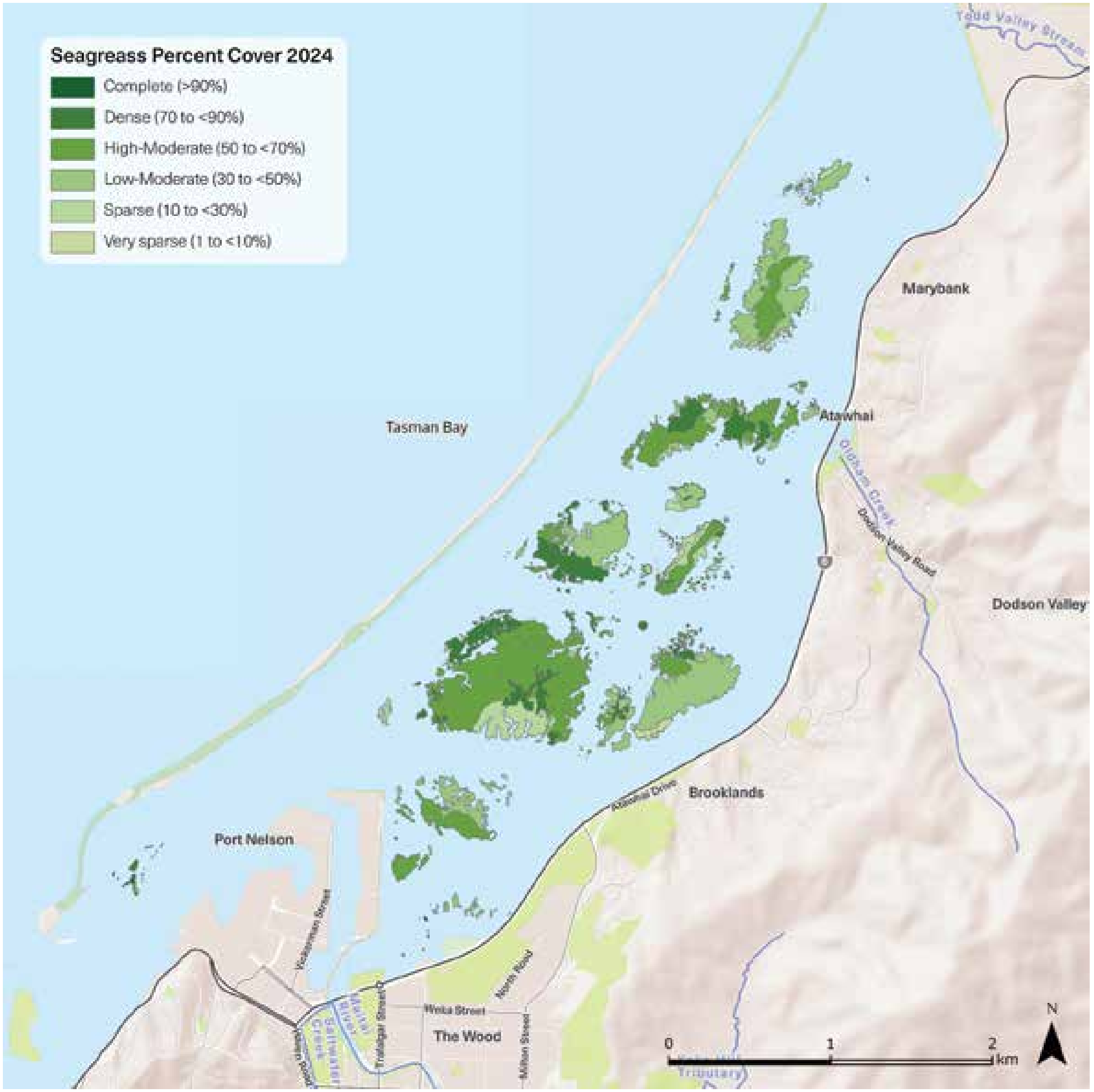
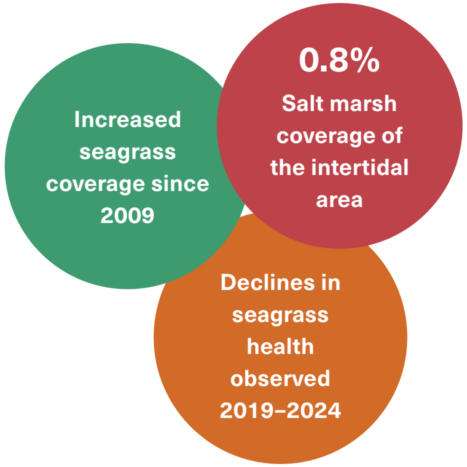


Figure 25: Map of Seagrass Distribution in Nelson Haven/Paruparuroa for 2024



In April 2022, some high biomass patches of the opportunistic macroalgae *Agarophyton* were found growing in muddy sediments around stormwater outfalls, which is likely to be a response to nutrients in the stormwater.

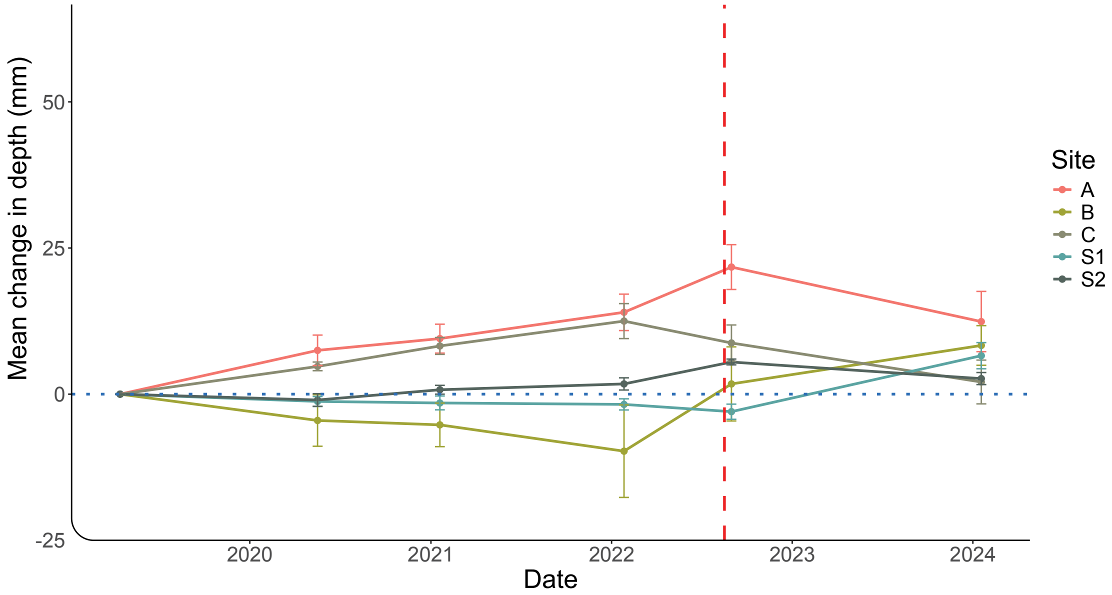


Sediment (From the 2023 fine scale survey results and sediment plate monitoring)

Trends

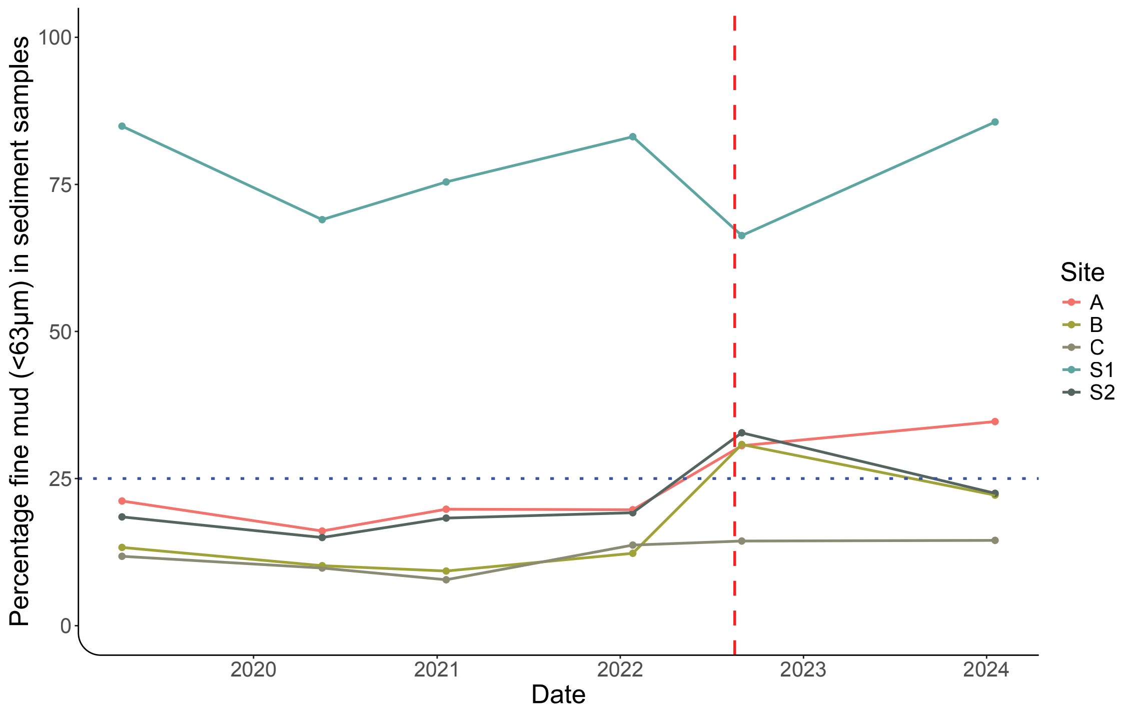
Mud deposition from the August 2022 floods resulted in some loss of seagrass and surface-dwelling macrofauna at the usual monitoring sites due to smothering – and while newly deposited sediment has been eroded from most sites (Graph 11), sediment mud content was still elevated in the mid and upper estuary in January 2024 (Graph 12).

Graph 11: Changes to the Proportion of Mud in Sediment Samples from the Waimea Inlet Sediment Plate Monitoring Sites



The vertical dashed red line marks the August 2022 flood event. Please note that large standard error bars usually indicate sites that experienced erosion at some sediment plates and sediment accumulation at others.

Graph 12: Changes to the Proportion of Mud in Sediment Samples from the Nelson Haven Sediment Plate Monitoring Sites



The vertical dashed red line marks the August 2022 flood event. The horizontal dotted blue line marks the guideline for estuary sediment health to be considered 'poor' due to high mud content (≥25% mud content).

Contaminants

Sediment quality at the three main monitoring sites was relatively healthy. Excluding the naturally elevated Nickel levels, concentrations of trace contaminants were rated as 'very good' – a rating corresponding to concentrations less than half of the default guideline value in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018)).

Invertebrates

Sediment macrofauna species richness and abundance were higher in 2023 than 2022 at all sites, with all sites classified 'good'. However, the total absence of the filter-feeding estuarine barnacle *(Austrominius modestus)* may be due to smothering of the sites with mud post-flood.

Wakapuaka/Delaware Inlet

Background (From the 2023 broad scale survey results)

Wakapuaka/Delaware Inlet (in Picture 30) is a 355 ha estuary to the northeast of Nelson City. Its main freshwater input is the Wakapuaka River delta, which enters at the estuary's southern flats. The estuary is well-flushed and seawater-dominated, via its single tidal opening to the east of Pepin Island. Two intertidal arms stretch to the east and west of the tidal opening: east towards Delaware Bay, and west from Pepin Island to Cable Bay.

The estuary margin has been modified via reclamation, drainage, and hardening due to road construction. While the surrounding catchment is not urbanised, it has been extensively modified, with 34.8% of the land cover consisting of exotic plantation forestry, and 18.5% in pastoral land uses.

In a preliminary assessment in 2009, Wakapuaka Inlet was described as relatively pristine, and it has largely maintained its natural functional qualities. However, ongoing monitoring does indicate that fine sediment runoff from the surrounding catchment is a major issue for estuary health.

Picture 30: Wakapuaka. Photo credit H. Allard

Habitat (From the 2023 and 2024 broad scale survey results)

Salt Marsh

In the present monitoring period (1983–2023), the extent of salt marsh has been relatively stable. Minor losses have occurred due to pasture development, burial by silt during storm events, and erosion during floods.

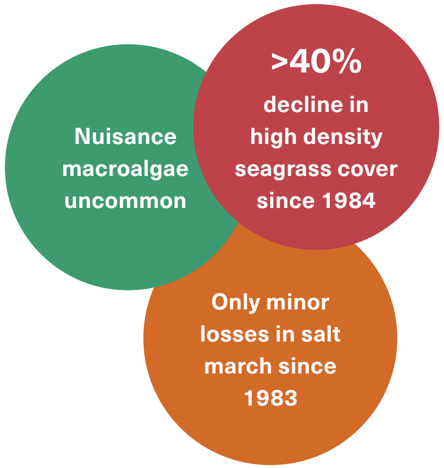
Salt marsh presently covers 8.3% of the available intertidal area (27.5 ha), but future habitat migration is limited by both artificial hardening and the natural steepness of the estuary margin.

Seagrass

Losses in seagrass cover have occurred due to sedimentation. Sedimentation smothers and scours seagrass beds, and the murky water limits the amount of light reaching the plants. Driving vehicles into the estuary to launch boats also damages seagrass.

A 2023 survey identified a 1.8 ha decrease in seagrass cover since 2018, with a further 3.4 ha reduction between 2023 and 2024, indicating an ongoing decline in seagrass condition following the August 2022 floods. All existing seagrass is growing in firm, sandy sediments (less than 25% mud content), and is exposed to natural variability due to the movement of the sands in addition to the negative impacts of increased mud content.

Areas of poor quality, oxygen-depleted sediments with associated nuisance macroalgae *(Agarophyton spp.)* are rare, comprising just 0.02% of the estuary area. However, these small areas of high biomass nuisance macroalgae have grown over time, and all are associated with high mud content (areas with more than 50% mud).

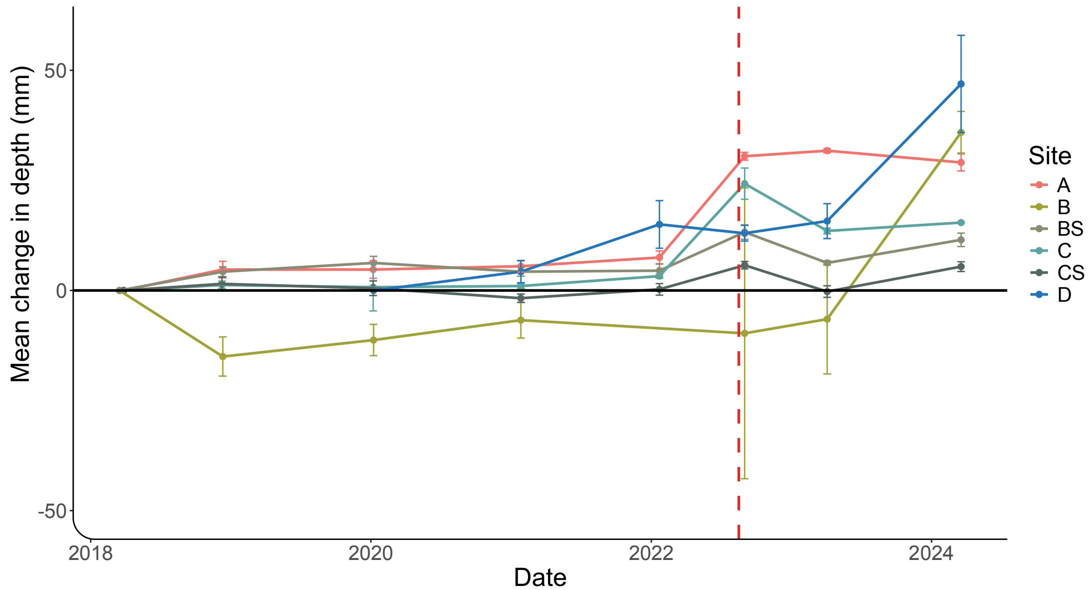


Sediment (From the 2023 fine scale survey results and sediment plate monitoring)

Trends

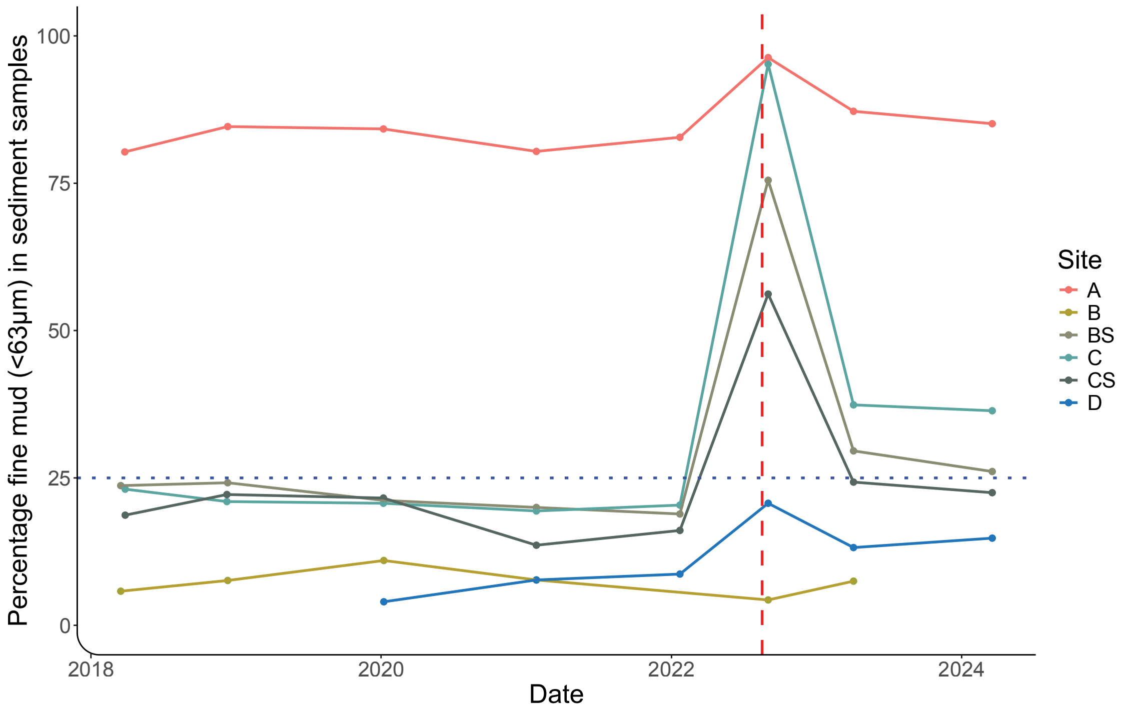
The extent of muddy sediments (at least 25% mud content) increased 400% from 2009–2023. Significant mud deposition occurred during the August 2022 floods. While much of the newly deposited fine sediment had been flushed into Tasman Bay by April 2023, sediment mud content at most sites remained elevated (at least 25% mud) in 2024 (Graphs 13 and 14). Wakapuaka is estimated to retain 89% of deposited sediment, and the sedimentation rates recorded at all monitoring sites exceed the guideline value of 2.1 mm/yr. These attributes highlight the vulnerability of this estuary to excess sedimentation.

Graph 13: Changes to Sediment Depth at the Wakapuaka/Delaware Inlet Sediment Plate Monitoring Sites



Negative changes to sediment depth indicate erosion of sediment has occurred. The vertical dashed red line marks the August 2022 flood event. Please note that large standard error bars usually indicate sites that experienced erosion at some sediment plates and sediment accumulation at others.

Graph 14: Changes to the Proportion of Mud in Sediment Samples from the Wakapuaka/Delaware Inlet Sediment Plate Monitoring Sites



The vertical dashed red line marks the August 2022 flood event. The horizontal dotted blue line marks the guideline for estuary sediment health to be considered 'poor' due to high mud content (≥25% mud content)

Contaminants

Most trace elements were rated 'very good', reflecting concentrations less than half those specified as default guideline values in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018). The only exceptions were Nickel (rated 'fair') and Chromium (rated 'good'), which again relates to natural sources in the geology of Nelson catchments.

Invertebrates

The ongoing issue of increasingly muddy sediments is demonstrated by an increase in the numbers of species which are associated with disturbed sediment conditions. However, the overall condition of sediment-dwelling macrofauna declined only slightly. Key species like cockles are still common at their existing sites.

Kokorua Inlet

Background

Location and Size

Kokorua Inlet (in Picture 31) is Nelson's smallest estuary, located 28 km north of Nelson City, towards the Marlborough region. The main freshwater source flowing into the estuary is Whangamoa River, with other, minor contributions from several small streams.

Due to restricted access, the area has high ecological value, with rare features such as remnant native forest immediately adjacent to the estuary and the presence of native dune flora near the tidal entrance. Much of this value is due to long-term restoration and regeneration, considering that in 1943 most of the surrounding catchment consisted of pasture.

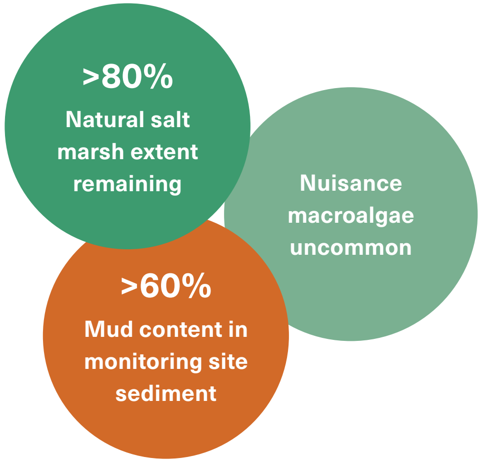
The area within 200 m of the estuary margin is now 71.4% densely vegetated, primarily consisting of regenerating native forest. The steep catchment behind this area is 96.3% densely forested but is modified, with 39.3% exotic forestry. Despite its relatively pristine nature, the estuary receives a high rate of fine sediment input, posing an ongoing risk to its ecological values.

Habitat (From the 2022 broad scale survey results)

Salt marsh habitat covers 20.1 ha or 35.1% of the estuary area and is most common in the upper estuary, consisting of extensive rushlands, and herbfields. Seagrass is uncommon in Kokorua Inlet, covering just 0.6% of the estuary area across two sites in the southeastern estuary.

Picture 31: Kokorua Inlet. Photo credit H. Allard

Nuisance macroalgae including *Agarophyton* and *Ulva* are uncommon, and affects just 1.6% of the estuary area, but localised areas of *Ulva* smothering seagrass beds have been recorded.



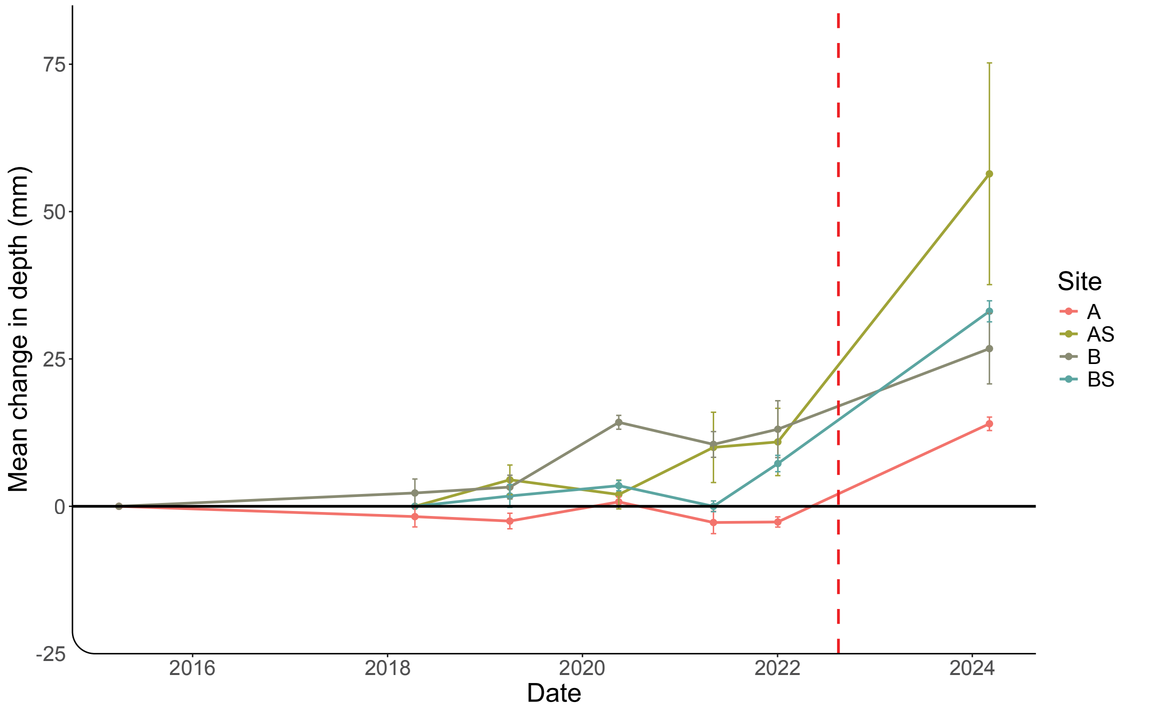
Sediment (From the 2020 fine scale monitoring and sediment plate monitoring)

Trends

Sediment levels are highest in the eastern arm of the inlet, with mud content in this location making up more than 60% of the sediment composition in 2018, 2019, and 2020 surveys, resulting in a rating of 'poor' in 2020. The eastern side of the estuary also has much lower abundances of sediment-dwelling invertebrates.

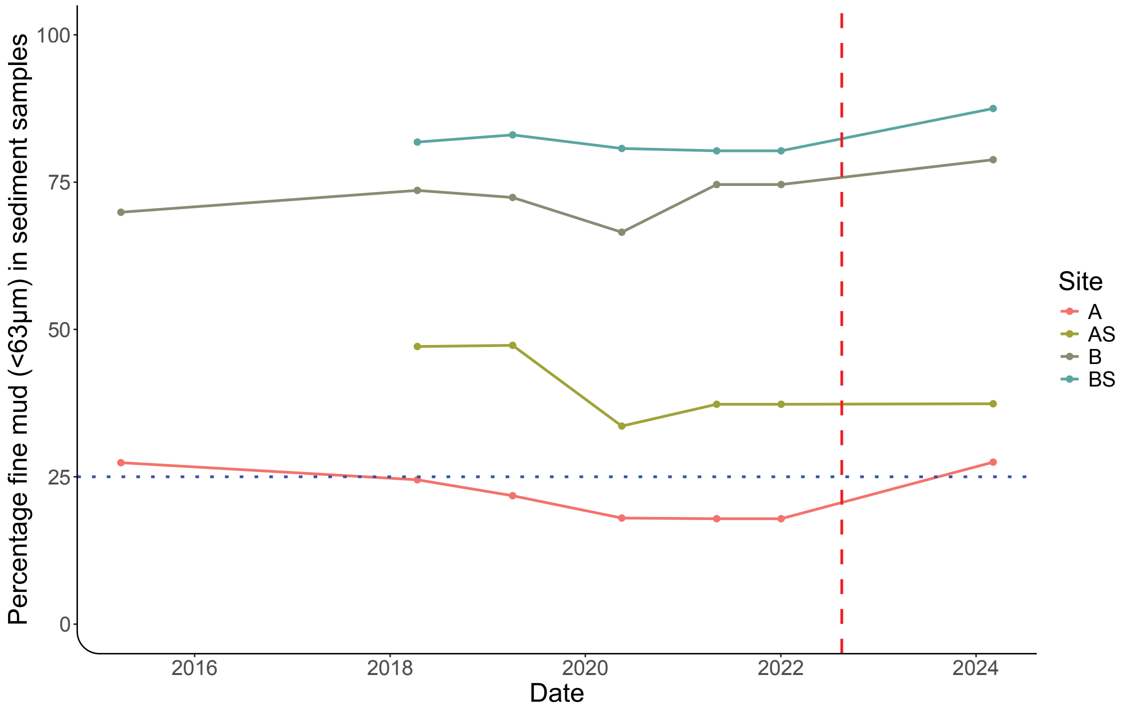
There was a dramatic increase in sediment depth on all sediment plate sites surveyed in 2024, which is due in part to the 2022 floods (Graph 15), and all monitoring sites now contain excessively muddy sediments (>25% mud content, Graph 16).

Graph 15: Changes to Sediment Depth at the Kokorua Sediment Plate Monitoring Sites



Negative changes to sediment depth indicate erosion of sediment has occurred. The vertical dashed red line marks the August 2022 flood event. Please note that large standard error bars usually indicate sites that experienced erosion at some sediment plates and sediment accumulation at others.

Graph 16: Changes to the Proportion of Mud in Sediment Samples from the Kokorua Inlet Sediment Plate Monitoring Sites



The vertical dashed red line marks the August 2022 flood event. The horizontal dotted blue line marks the guideline for estuary sediment health to be considered 'poor' due to high mud content (≥25% mud content).

Contaminants

Most trace elements were rated 'very good', reflecting concentrations less than half those specified as default guideline values in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018). The only exceptions were Nickel (rated 'fair') and Chromium (rated 'good'), which again relates to natural sources in the geology of Nelson catchments.

Invertebrates

The easternmost monitoring site, with the highest mud content (Graph 15), had much lower abundances of sediment-dwelling invertebrates than any other site. Among these invertebrates, the proportion of species which are more tolerant to mud has increased over time, and the species which are most sensitive to mud are not present, highlighting the long-term impacts of mud deposition on species diversity.

What We're Doing

Estuary Monitoring

Future estuary monitoring will continue according to the existing timetable:

- both habitat monitoring and fine-scale sediment quality monitoring will be conducted every five years; and
- sediment plate monitoring will be carried out annually.

In addition to this schedule, targeted surveys or investigations will be carried out, if necessary, usually to understand ecosystem responses to unexpected events, or to better understand the influences of land use activities on the estuary environment. Prior examples of these targeted surveys include additional mapping to track seagrass recovery after the August 2022 floods, stormwater outfall sediment monitoring, and mapping any changes to the presence of patches of nuisance macroalgae.

Our monitoring data shows clearly that excess sedimentation and the deposition of mud is the main driver of environmental decline in Nelson's estuaries. To pinpoint the sources and lessen their impacts will require close collaboration with the river monitoring and catchment teams and their ongoing work programmes, with a focus on native planting and wetland regeneration. Our future monitoring strategy is built around better spatial resolution of the pressures facing our estuaries, to ensure our efforts on land are fit for purpose.

In addition, in 2024 Nelson City Council adopted the new Waimea Inlet Strategy and Action Plan. The goal is to ensure the future health of Waimea Inlet via the efforts of all partnering agencies. It is overseen by the multi-stakeholder Waimea Inlet Coordination Group.

Where We're Heading

The Impacts of Land Uses on the Haven

To better understand the connectivity between Nelson Haven estuary and the surrounding catchment, we are developing a modelling tool that shows the transport of sediment and other river pollutants within the estuary's intertidal area. By linking catchment land use data and river load data to impacts in the estuary we can better predict how changes on land might impact our most vulnerable estuary habitats (Picture 32).

We will use this tool to design effective monitoring of the coastal impacts from new land uses and extreme weather events, and better understand the sources of pollutants recorded in our monitoring.

Additionally, the use of smart monitoring buoys for targeted deployments in our estuaries will enable us to record peaks in sediment deposition in real time, helping us to identify the likely contributors and inform any future model developments with high quality data.

Picture 32: Collecting Tidal Water Movement Data to Build the Nelson Haven Sediment Deposition Model

Online Reports

Other changes include the development of online 'web report' platforms for each of Nelson's estuaries, providing anyone with the ability to better understand our existing monitoring data via interactive tools and figures. These include historical data sources and are the most complete record of the long-term changes to Nelson's estuaries available. The first of these, for Wakapuaka/ Delaware Inlet and Nelson Haven/ Paruparuroa, can be found on NCC's 'Estuarine Health' page.

Linking Rivers, Estuaries, and Tasman Bay Water Quality

A new coastal and marine water quality programme will kick off in 2024–2025, aiming to establish closer linkages with the existing river water quality programme, and to begin building a long-term dataset of Tasman Bay background water quality.

Photo credit H. Allard

Recreational Use of Rivers and Beaches

Tāhunanui Beach

What We Know – State and Trend

Nelson's swimming holes and beaches are iconic and are regularly used by locals and visitors year-round for recreation (see Picture 33).

The good news is they are safe for swimming most of the time. Bacteria levels are monitored at our recreational bathing water sites over summer with immediate action taken if the bacteria levels exceed the water quality standards. We do this to minimise the risk of illness from harmful bacteria and viruses that may be present in the water.

Picture 33: Tāhunanui Back Beach. Photo credit NRDA

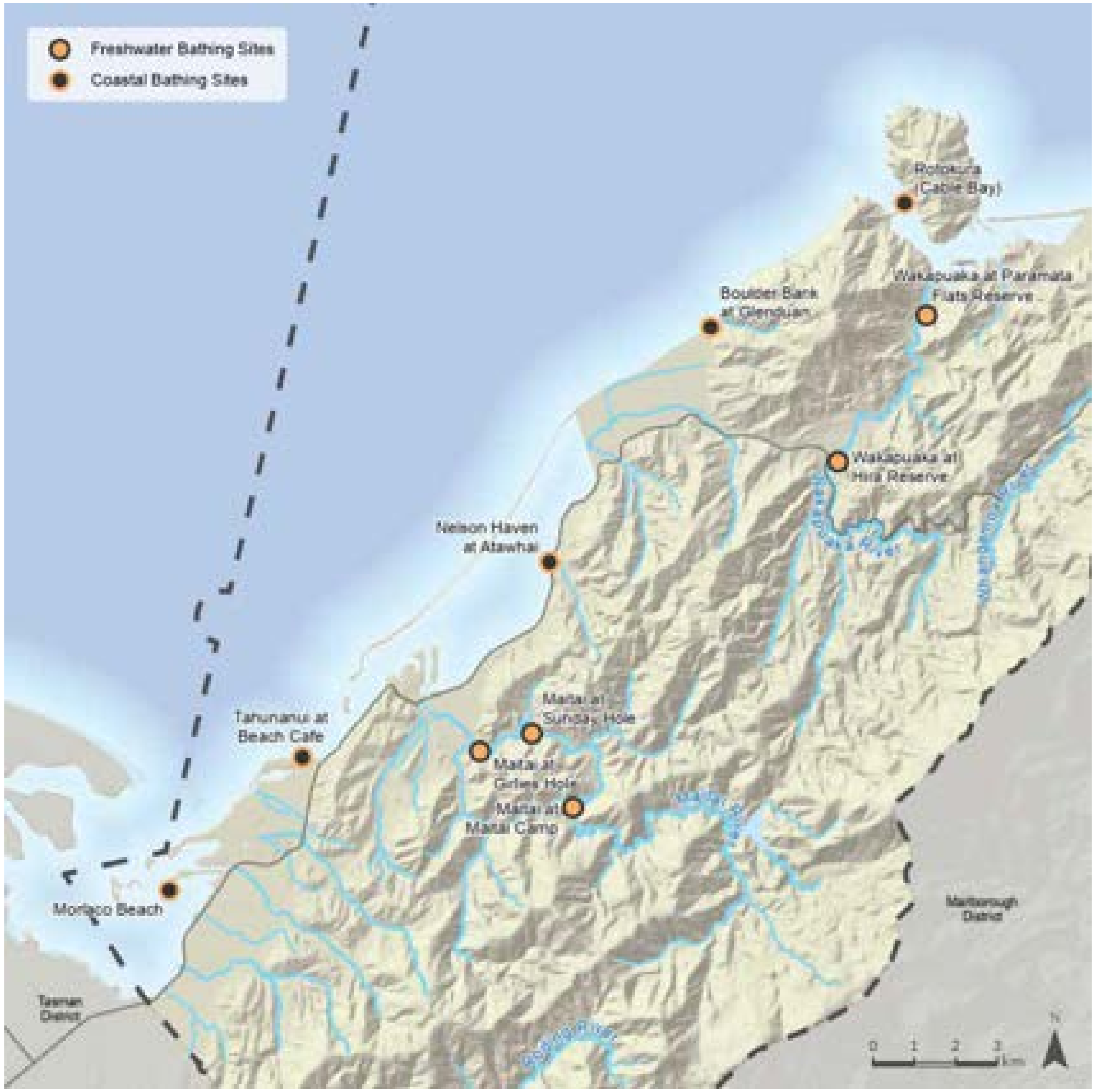
Recreational water quality is monitored over the summer months with live reporting to Land, Air, Water Aotearoa (LAWA). We use *E. coli* and *Enterococci* bacteria as indicators for the presence of other pathogens, including *Cryptosporidium* which is a commonly occurring protozoa (unicellular parasite).

Bacteria are naturally killed by exposure to the sun's UV light but can persist for days in murky water and sediment. That means spikes in bacteria occur during storm events from both direct discharges from stormwater pipes and as part of rainwater runoff from land. This also happens on windy days when the waves churn up sediment in shallow water and in beach litter, including woody debris and flotsam.

Naturalised bacteria (not from any animal source) are found in the environment and can survive indefinitely, persisting in sediments and under algae mats. A relatively new technique for source tracking of *E. coli* has shown that some of the bacteria contributing to our results are likely to be naturalised bacteria of unknown source. Investigations to track *E. coli* sources in the Maitai and Brook have also used methods to detect whitening agents from cleaning products, indicating wastewater contamination, and ageing the bacteria community to determine if it is from a recent source or is long-lived persistent bacteria. (See the QMRA case study that discusses our contribution to a national study to characterise *E. coli* and pathogens as a first step towards developing new guidelines for New Zealand.)

We have carried out recreational bathing monitoring since 1998, presently with five designated freshwater and marine primary contact recreation sites, as shown in Figure 26. (These areas are well-used for swimming and other activities where people may swallow water.) Monitoring near the Collingwood Street bridge on the Maitahi/Mahitahi/Maitai River has also been carried out due to concerns about stormwater and wastewater discharges in this area. However, the site's water samples have a high level of variance because the area is tidal, with freshwater mixing with incoming sea water.

Figure 26: Recreational Bathing Monitoring Sites Across Nelson Region



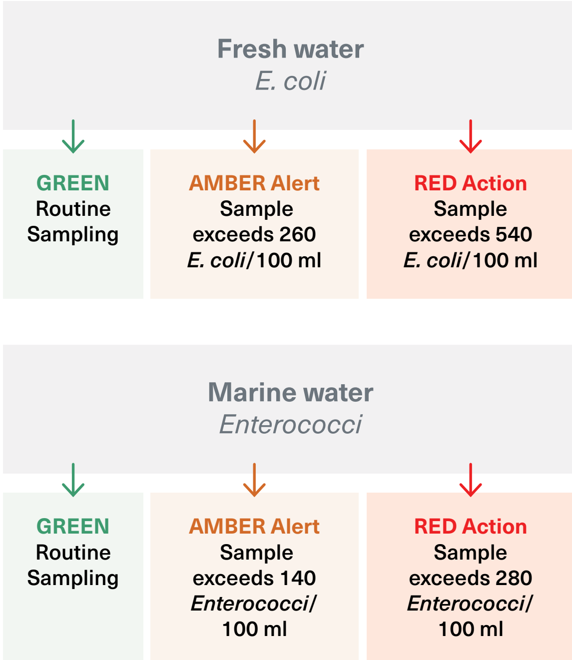
Te Whatu Ora Nelson Marlborough Health Protection Team is responsible for regulating public health water quality and signage. Any water quality exceedance is discussed with the Health Protection Team to explain the source (if known) and any required actions are completed. This can include an immediate re-sample, signage, and a media release to alert the public to the risks. The Health Protection Team also liaises with Council's wastewater team when leaks occur and may use Council's recreational bathing surveillance data to assist with assessing the public risk.

The assessments of our coastal sites are informed by the MfE/MoH Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas (MfE 2003); and freshwater sites are guided by the National Objectives Framework (NOF) in the National Policy Statement for Freshwater Management (2020).

The standards for marine waters are lower than for freshwater because more dilution occurs in the larger bodies of water. The water quality management framework follows a traffic light system (Figure 27):

- For coastal waters 140 MPN/100 mL is an amber and 280 MPN/100 mL is a red action alert.
- For freshwater 260 Most Probable Number (MPN)/100 mL is an amber and 540 MPN/100 mL is a red action alert.

Figure 27: Traffic Light System for Recreational Bathing Alerts and Actions Based on Bacteria Concentration Thresholds



Red alerts require re-sampling until bacteria levels return to safe levels for public recreation and may require investigations to determine the source of the elevated *E. coli* or *Enteroccoci* if not known, appropriate signage and communication to warn the public of the potential health risk.

An amber alert triggers a review with the Health Protection Team and a red alert requires re-sampling and signage until satisfactory bacteria levels are reported.

Water Quality Reporting

Each year we report on the annual water quality and assign a Long Term grade based on five years of monitoring so that we account for the natural high variability in *E. coli* numbers at each site (see Tables 12 and 13). Scheduled bathing water samples include wet and dry weather conditions to align with national level reporting standards and to better describe the risk profile for a range of environmental conditions (i.e. whether it is safe to swim in different weather conditions). Twenty water quality samples are collected over the summer (December to March) and the results can be viewed within 24 hours on the Land, Air, Water Aotearoa (LAWA) website – lawa.org.nz/explore-data/nelson-region.

Table 12: Long Term Grade Descriptions – Coastal

95th percentile value of *Enterococci*/100 ml (rounded values)	Basis of derivation	Estimated risk
A: ≤40	This value is below the NOAEL in most epidemiological studies.	<1% GI illness risk, <0.3% AFRI risk. This relates to an excess illness of less than one incidence in every 100 exposures. The AFRI burden would be negligible.
B: 41-200	The 200/100 ml value is above the threshold of illness transmission reported in most epidemiological studies that have attempted to define a NOAEL or LOAEL for GI illness and AFRI.	1–5% GI illness risk, 0.3-1.9% AFRI illness risk. The upper 95th percentile value of 200 relates to an average probability of one case of gastroenteritis in 20 exposures. The AFRI illness rate at this water quality would be 19 per 1000 exposures, or approximately 1 in 50 exposures.
C: 201-500	This level represents a substantial elevation in the probability of all adverse health outcomes for which dose-response data is available.	5-10% GI illness risk, 1.9-3.9% AFRI illness risk. This range of 95th percentiles represents a probability of 1 in 10 to 1 in 20 of gastroenteritis for a single exposure. Exposures in this category also suggest a risk of AFRI in the range of 19–39 per 1000 exposures, or a range of approximately 1 in 50 to 1 in 25 exposures.
D: >500	Above this level there may be a significant risk of high levels of minor illness transmission.	>10% GI illness risk, >3.9% AFRI illness risk. There is a greater than 10% chance of illness per single exposure. The AFRI illness rate at the 95th percentile of *Enterococci* per 100 ml would be 39 per 100 exposures, or approximately 1 in 25 exposures.

1. AFRI = acute febrile respiratory illness; GI = gastrointestinal; LOAEL = lowest observed-adverse-effect level; OAEL = no-observed-adverse-effect level.

Reference: MfE/MoH Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas (2003).

Table 13: Long Term Grade Descriptions – Freshwater

Value	Human contact	
Freshwater body type	Primary contact sites in lakes and rivers (during the bathing season)	
Attribute unit	95th percentile of *E. coli*/100 ml (number of *E. coli* per hundred millilitres)	
Attribute band	**Numeric attribute state**	**Narrative description**
Excellent	≤130	Estimated risk of *Campylobacter* infection has a <0.1% occurrence, 95% of the time[1]
Good	>130 and ≤260	Estimated risk of *Campylobacter* infection has a 0.1–1.0% occurrence, 95% of the time
Fair	>260 and ≤540	Estimated risk of *Campylobacter* infection has a 1–5% occurrence, 95% of the time
National bottom line	540	
Poor	>540	Estimated risk of *Campylobacter* infection has a >5% occurrence, at least 5% of the time

[1] The narrative attribute state description assumes '% of time' equals '% of samples'.

Reference: National Policy Statement for Freshwater Management (2020).

Water Quality Results

All the river bathing sites had 100% compliance for the 2023/24 summer recreation bathing season, with no bacteria exceedances over 540 MPN/100 mL and NPS-FM grades of Fair to Good (see Table 14). For the five-year long-term grade, all sites were Fair to Good except Wakapuaka at Paremata Flats Reserve. This site has a Poor grade due to historical exceedances. The Wakapuaka catchment has a mix of pastoral farming, lifestyle blocks and forestry. Faecal Source Tracking in 2020 identified ruminant (sheep and beef) *E. coli* as the dominant source and wildfowl *E. coli* are also present, though other sources, including introduced mammals, are likely to contribute at other times.

All the marine sites, save the Glenduan, have shallow beaches and are within semi-enclosed bays. This means they are susceptible to re-suspension of sediment and elevated bacteria during windy or stormy weather, with four of the five sites graded C or D because of storm-related samples above 500 MPN/100 ml (see Table 14). The water quality at these sites remains good, with the four main swimming beaches – Cable Bay, The Glenduan, Tāhunanui and Monaco – having a long-term Grade B and Nelson Haven estuary having a Grade C, with storm-related exceedances caused by occasional spikes in *Enterococci* bacteria. More detailed analysis of the bacteria levels with respect to rainfall are provided in the Council's Recreational Water Quality web report – https://ncc-environmental-reporting.gitlab.io/recreational-water-quality-2023-24/faecal-indicator-bacteria.html

Table 14: Water Quality Results

All units are MPN/100 ml and n refers to the number of samples. The range of the 95th % for each grade are included in brackets after the grade, and % yy refers to the length of the data period in years. Some 19/20 grades are not available (N/A) when n is too low to calculate Hazen percentiles.

			2019/24 (5y)				2023/24 (1y)			
Site	**Indicator**	**Weather**	**Grade**	**95th%/ 100 ml**	**n**	**% compliant**	**Grade**	**95th%/ 100 ml**	**n**	**% compliant**
Maitai at Girlies Hole	*E. coli*	All	Fair (260–540)	319	123	96.7	Good (130–260)	212	22	100
Maitai at Maitai Camp	*E. coli*	All	Good (130–260)	171	120	97.5	Good (130–260)	164	22	100
Maitai at Sunday Hole	*E. coli*	All	Good (130-260)	228	123	97.6	Good (130–260)	181	22	100
Wakapuaka at Hira Reserve	*E. coli*	All	Fair (260-540)	512	77	96.1	N/A	N/A	N/A	N/A
Wakapuaka at Paremata Flats Reserve	*E. coli*	All	Poor (>540)	560	124	92.7	Fair (260–540)	285	22	100
Nelson Haven at Atawhai	*Enterococci*	All	C (200–500)	438	121	93.4	D (>500)	1182	21	95.2
Tasman Bay at Glenduan	*Enterococci*	All	B (40–200)	44	118	98.3	A (≤40)	20	20	100
Tasman Bay at Rotokura (Cable Bay)	*Enterococci*	All	B (40–200)	130	127	96.9	D (>500)	504	21	95.2
Tasman Bay at Tāhunanui	*Enterococci*	All	B (40–200)	77	126	99.2	C (200–500)	241	20	95
Waimea Inlet at Monaco Pier	*Enterococci*	All	B (40–200)	75	122	98.4	D (>500)	666	20	95

All units are Most Probable Number (MPN)/100 ml and n refers to the number of samples. The range of the 95th% for each grade are included in brackets after the grade, and 5 year vs 1 year refers to the length of the data period in years. Some 1 year grades are not available (N/A) when n is too low to calculate Hazen percentiles.

Compliant samples: The percentage of samples over each period that are below the marine *Enterococci* (≤280/100 ml) & freshwater *E. coli* (≤540/100 ml) action thresholds.

Notes:

1. Collingwood Bridge monitoring has been discontinued due to strong tidal influences and sediment resuspension impacting reliability of sampling to identify sources of contamination. *E. coli* is routinely monitored in the Anatoki River and Waitapu monitoring sites.

2. Wakapuaka at Hira Reserve monitoring was not undertaken because the August 2022 storm event filled the bathing hole with gravel.

What We're Doing

Action Plans

Improvements in water quality to support human and ecosystem health will be achieved by addressing issues through an integrated catchment approach, working across Council teams. This will include investigating the major causes of poor water quality and producing action plans for each Freshwater Management Unit. These plans will prioritise actions for waterways and catchments in a degraded state or with 'very likely degrading' trends.

Actions to reduce *E. coli* at source include improvement programmes for wastewater and stormwater networks in urban areas and providing incentives for fencing waterways and riparian planting on rural land. Another action to consider is to create wetlands in rural areas to treat the cumulative effects of land uses.

Site investigations may be required at specific bathing sites, e.g. for source tracking to rule out human waste. However, most rural *E. coli* bacteria is from livestock sources from catchment-wide land use activities so require a more holistic approach by raising awareness of public health issues, fencing livestock out of waterways, and land management improvements to reduce flow paths of *E. coli* from land and contamination of drinking water supplies and recreation areas.

Contribution to a Nationwide Study

We are contributing to a Quantitative Microbial Risk Assessment study led by the Institute for Environmental Research (ESR) and funded by the Ministry for the Environment. Our role has been to carry out additional monitoring at the Maitai and Wakapuaka River sampling sites to quantify pathogens. We are doing this to identify the risk factors for areas with different surrounding land uses and bacteria sources (see the following case study for more details).

The second phase of this study includes funding for local iwi participation to increase our environmental monitoring capacity; and focusing on specific contaminant sources within catchments. The results from the ESR study will require further analysis and review of the management response, and it will inform new water quality standards in the coming years.

Ongoing Surveillance

We continue to liaise with the Public Health Protection Team, Council's wastewater and stormwater staff, and neighbouring councils to provide comprehensive surveillance and ways to improve coordinated responses to local exceedances and to region-wide Civil Defence responses to extreme weather events.

Contribution to *E. coli* Research

We have also contributed to a research project by AgResearch and ESR which is funded by a Smart Idea grant from MBIE. The purpose of this project is to identify methods for discriminating between *E. coli* from faeces that is present in waterways, and those naturalised *E. coli*-like organisms that may also be present in water. These *E. coli*-like organisms are also counted by the current water testing methods such as 'Colilert' but are not thought to be indicative of faecal sources.

Reporting

We have developed annual web reports that include links to key monitoring information and supporting information, including the policy that underpins the methods and standards. Our main web platform for live environmental reporting will continue to be LAWA – **lawa.org.nz/explore-data/swimming.**

Where We're Heading

We will continue to monitor recreational bathing sites using water sampling and explore opportunities to utilise predictive modelling to forecast exceedances based on rainfall and other environmental information, including existing surface flow dispersion models for Nelson Haven and Tasman Bay.

We have extended our State of the Environment marine and coastal monitoring programme to include sampling nearshore from bathing sites to monitor ki uta ki tai, from the mountains to the sea.

The ban on shellfish collection in the Haven and Waimea nearshore waters needs to continue due to stormwater contamination. Alongside dedicated Council programmes to reduce stormwater and wastewater inundation and ongoing investment and upgrades to the utilities network, we will also reinstate assessments of bacteria levels in shellfish to monitor the effectiveness from these improvements, with the aim of reducing contaminants being assimilated in the receiving environment.

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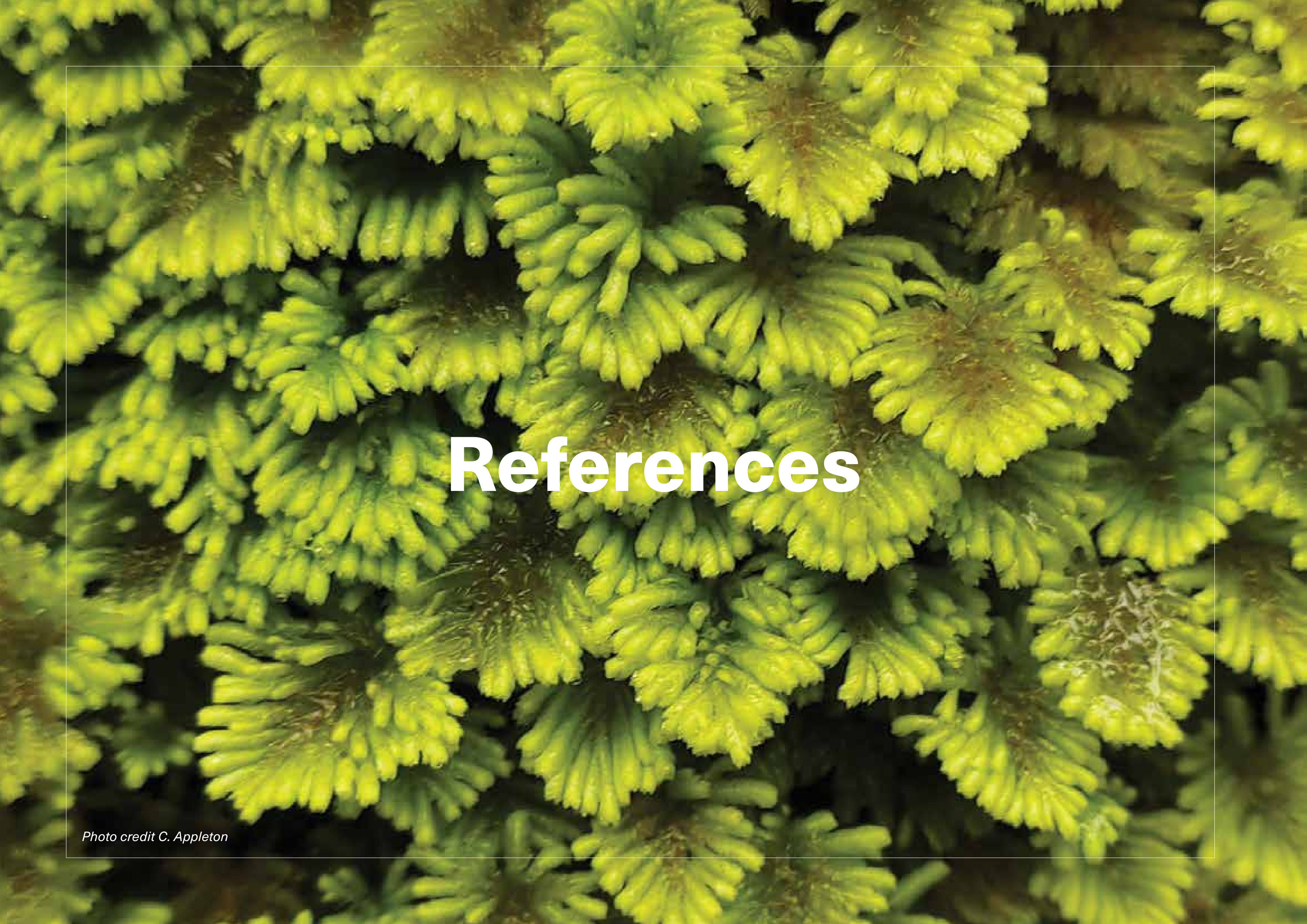

Photo credit C. Appleton

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