Changing land use and freshwater fish

Ka mua, ka muri | Fish Futures Policy Brief 03

Author information

Kiely McFarlane,[1] Marc Tadaki,[2] Ailsa Cain[3]

[1] Cawthron Institute
[2] Lincoln University
[3] Kauati Limited

Fish Futures

The Fish Futures research project aims to improve freshwater ecosystems in Aotearoa New Zealand and the lives of people who depend on them. The project seeks to foster local relationships, empower fishery managers, enhance the mana of kaitiaki and generate new approaches that integrate mātauranga Māori and Western science.

The research examines interactions between humans, fish and ecosystems by assessing the consequences of fish introductions and removals, identifying social barriers to restoring fish passage and co-developing fish management strategies with Māori, communities and other stakeholders.

Expected outcomes:

- improve understanding of the social–ecological factors that impact freshwater fish populations
- enhance capacity for sustainable freshwater and fisheries management
- increase collaboration between scientists, iwi and policymakers.

The project's findings will inform policy development and support community-based management and collaborative decision-making for healthier freshwater ecosystems and thriving fish populations.

Policy briefs in this series

01. Management of freshwater fish species
02. Identities of freshwater fishers
03. Changing land use and freshwater fish
04. Access to freshwater fishing
05. Harvesting and consuming freshwater fish
06. Markets for freshwater fish

Recommended citation
McFarlane K, Tadaki M, Cain A. Changing land use and freshwater fish. Fish Futures Policy Brief 03. Nelson: Cawthron Institute; 2026.

Cover photos: (Left) Whitebait. Photographer: D. Nicholson; October 1959. Source: Archives New Zealand; AAQT 6539 3537 57/A71885. (Centre) Drying tuna. Photographer: unknown; September 1934. Source: Auckland Libraries Heritage Collections; 1691-109. (Right) Lake Taupō. Photographer: E. Woollett; February 1954. Source: Archives New Zealand; AAQT 6539 3537 51/A33961.

Changing land use and freshwater fish

Fish ladder at Waitaki Dam. Photographer: unknown; c.1935; Source: Waitaki Archive [103406].

Key messages

- Land-use change is the key driver of decline for most freshwater fish and fisheries; modern landscapes limit freshwater fish populations through habitat loss, connectivity barriers and water quality degradation.
- Early Māori and European settlers modified landscapes to enhance fishery values, while later development prioritised economic productivity at the expense of freshwater fish and fishers.
- Land-use planning and freshwater management decisions today can either further degrade freshwater fish populations or intentionally support their restoration, including by managing modified environments for their ecological role.
- Recognising and incorporating freshwater fish in land-use planning is critical for sustaining fisheries and human–fish relationships.
- Diverse groups have shared interests in protecting and enhancing fish habitat.

Overview

Dramatic changes in land cover and use have occurred in Aotearoa New Zealand over the last 200 years. Forest clearance, drainage, agriculture, urbanisation and infrastructure development have transformed our landscapes, removing 75% of indigenous forest and 90% of wetlands. These changes have impacted freshwater habitats and habitat connectivity, water quality and food webs.[1] Today, almost two-thirds of monitored river sites show impaired ecological health, and three-quarters of monitored lakes are in poor or very poor condition. In some areas, freshwater habitats have disappeared entirely, and place names reflect freshwater environments that no longer exist.

Land-use change has driven declines in native freshwater fish and negatively impacted human–fish relationships. Habitat degradation influences which fish species inhabit our waterways, their population sizes and distribution. In New Zealand, 76% of native freshwater fish are now at risk or threatened with extinction, while salmon and some trout populations have declined.[1] Pest species flourish in these modified environments, contributing to further habitat and food-web modification.

These changes have had variable effects on human communities. Freshwater fish were an important, reliable source of food for Māori communities and a focus of settler acclimatisation efforts.[2] Early landscape modification by Māori and Pākehā sought to enhance freshwater fisheries by creating habitat and fishing infrastructure. However, later changes to establish settlements and primary industries disregarded outcomes for freshwater fish and negatively impacted native and non-native fisheries alike.[3] Land-use change has significantly reduced habitat availability for native and some introduced species, forcing trade-offs in areas where they co-occur and constraining species management programmes.

This brief examines the history of landscape modification to identify the major land-use changes that have affected freshwater fish and fisheries. We also explore why these changes were undertaken. By examining land-use change through the lens of freshwater fish, we draw attention to the fish values and management options that have been lost or promoted through landscape modification.

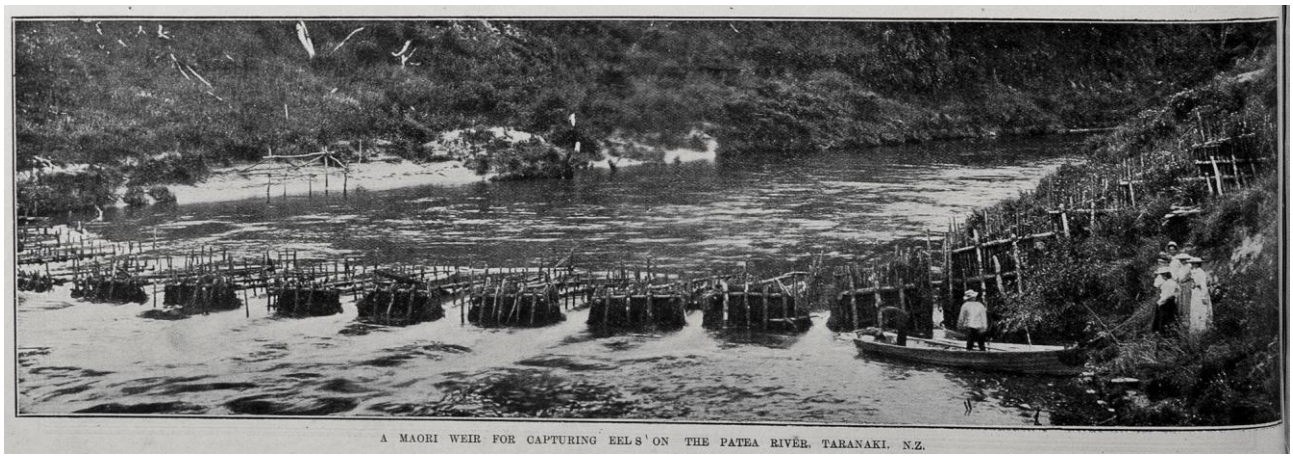
History of landscape modification

New Zealand's landscapes have been modified through processes ranging from forest clearance and draining of freshwater environments to the establishment and intensification of new land uses and infrastructure. This section summarises four themes in landscape modification, highlighting the varying purpose and drivers of modification over time and their different outcomes for freshwater fish.

Cultivating waterways

Both Māori and early European settlers modified freshwater environments to propagate valued fisheries by introducing species, physically altering waterways and building fishing infrastructure.

Freshwater fish were an important food source for Māori communities, especially for inland and southern hapū.[2,3] Many early settlements were established alongside river mouths, which provided transport and access to freshwater resources. As Māori acquired knowledge of species' habitats and seasonal rhythms, they established sites further upstream to take advantage of seasonal food availability and the best fishing grounds.[3] They also used this knowledge to build specialised structures for harvesting species, from artificial refugia such as tau kōura (fern bundles) to large pā tuna and pā kanakana (eel and lamprey weirs) to catch migrating fish.[2] Fishing sites and infrastructure were governed by hapū or whānau, ensuring that harvesting was sustainable.[2]



'A Māori weir for capturing tuna on the Pātea River, Taranaki, N.Z'. Auckland Weekly News; 2 July 1908, p. 12. Source: Auckland Libraries Heritage Collections; AWNS-19080702-12-04.

Māori communities promoted fisheries through cultivation and translocation. Some hapū created new habitat (e.g. fish ponds), while others modified habitat to facilitate fish husbandry, which included connecting rivers to adjacent lagoons.[2,3] They worked with seasonal processes to cultivate species such as flax (to make fishing equipment) in regularly inundated river basins.[2] Māori also moved freshwater fish between waterways to establish and replenish mahinga kai, especially in the central North Island's volcanic lakes.[2] Commonly translocated species likely included kōura, tuna, kōaro, porohe (smelt) and kākahi. Some hapū created semi-captive fisheries by keeping lagoons and ponds stocked with tuna.[2]

Early European settlers also modified New Zealand's waterways to cultivate valued fisheries and fishing experiences. New Zealand was promoted as an egalitarian 'Britain of the South', but immigrants were disappointed to find its waterways rendered inaccessible by dense vegetation and lacking a 'single fish worth the angler's catching' (Hursthouse 1857, cited in Knight 2016, p. 90); therefore, they set about correcting what they perceived as nature's deficiencies.[3,4]

From the 1860s, acclimatisation societies and individuals introduced valued fish species to provide food and recreation for settlers, including trout, salmon and perch.[5] Societies shipped fish and ova from around the world and established hatcheries to raise and breed imported species, before translocating them to waterways around the country.[5] In waterways where natural reproduction was not possible, societies conducted regular restocking with hatchery-raised fish. They promoted abundant sport

fisheries by introducing supplementary food species (e.g. smelt) and culling their predators (e.g. tuna).[2] Recreational fishing later led to further species introductions through illegal translocations for coarse fishing (e.g. koi carp) and accidental introductions via boats and fishing equipment (e.g. catfish).[5,8]

European settlers also modified freshwater environments to facilitate access and create scenic landscapes for fishing. New Zealand's small, fast-flowing rivers were generally viewed unfavourably by settlers, and wetlands were seen as unproductive and unhealthy.[3] However, some lakes and meandering lowland rivers fulfilled expectations of benign and picturesque waterways.[3] Along their banks, settlers cleared vegetation, planted familiar species (e.g. willow) and built wharves and bridges. Fishery creation thus became intertwined with the cultivation of culturally valued landscapes.

Postcard from the 1910s showing the River Avon, Christchurch. Artist: unknown. Source: Christchurch City Libraries; CCL-PH14-110.

Early landscape modification practices had varied impacts on native fish. There is little evidence that Māori translocation, cultivation and harvesting had significant effects on fish or their ecosystems.[2] Hapū acquired in-depth knowledge of local species and ecosystems and used this to develop sustainable harvesting practices and promote fishery health.[2] For example, pā tuna trapped large eels while allowing juveniles to escape, and species introductions focused on naturally depopulated lakes.[3]

However, the acclimatisation of foreign species impacted native fish through competition and predation and modified freshwater ecosystems through their foraging behaviours, reproductive strategies and food webs. For example, perch can reduce water quality and exacerbate algal blooms in lakes through over-consumption of zooplankton.[6] Koi carp and catfish stir up the bottom of waterways as they feed, which dislodges aquatic plants and increases turbidity and nutrient cycling.[6] Introduced riparian and aquatic plant species also impact native fish by displacing native habitat (e.g. oxygen weed), transforming food webs (e.g. autumn leaves), and changing erosion and sedimentation (e.g. willows).

Creating productive landscapes

Settler colonisation was driven by the desire for land and resources. New Zealand offered the promise of land for settlers and food, timber and other resources to send back to Britain.[9] To 'break in' the land and render it suitable for productive use, vast areas were cleared of forests and drained, with devastating consequences for freshwater fish.[2]

Prior to human arrival, New Zealand was dominated by forests (82% land area) and wetlands (9%).[10,11] Both Māori and European settlers cleared large areas of forest, although the subsequent vegetation cover and effects differed markedly. Early Māori cleared coastal and lowland forests to establish settlements, cultivate food species, and enable travel and hunting. It is estimated that 6.7 million hectares of forest (approximately 30%) were cleared – predominantly through fire – in the 300 years following Māori arrival.[12] Forests were quickly replaced by fast-growing natives, including bracken fern, shrubs, tussock and raupō, which stabilised soils and provided valued food and fibre resources. In many areas, Māori maintained accessways and resources through small, controlled fires.[12,13]

The impact of this burning on waterbodies is thought to be relatively localised. While the loss of forest cover initially resulted in sedimentation and changes in algal and riparian communities, the rapid re-establishment of native vegetation helped to stabilise systems.[13] The growth of raupō around lake margins provided habitat for tuna, īnanga and other native fish.[2]

Forest clearance expanded with the arrival of European settlers. Many were labourers, tenant farmers and small landholders who were attracted to New Zealand by the promise of land ownership.[14] Realising this promise required further clearance of forests and wetlands, which settlers saw as unproductive 'wastelands', overlooking their high biodiversity and importance as mahinga kai.[2,4]

> Damp and dripping forests, exhaling pestilent vapours from rank and rotten vegetation, fall before the axe; and light and air get in, and sunshine ripening goodly plants. Fen and marsh and swamp, the bittern's dank domain, fertile only in miasma, are drained; and the plough converts them into wholesome plains of fruit, and grain, and grass. (Hursthouse 1857, p. 69)[16]

Large-scale forest clearance took place from the 1870s and was mandated by the Crown, who sold, granted or leased land to settlers on the condition that they improve it for farming.[10] By the mid-1920s most lowland forests had been cleared by logging or burning and converted into pasture.[12,15] Further forest clearance took place following the world wars to provide timber for housing and land and work for returning soldiers.[10,15] While most land was converted to farms, some was replanted with exotic forests. Logging of native forests continued until prohibitions were introduced in the 1990s (public land) and 2000s (private land), by which time 71% of native forest had been lost.[10,15]

'North Auckland progress: the proposed drainage of the famous Kaitaia lake and swamp'. Photographer: A. Northwood. Supplement to the Auckland Weekly News; 6 July 1916, p. 46. Source: Auckland Libraries Heritage Collections; AWNS-19160706-46-05.

Wetland drainage was even more rapid and extensive. The government acquired, stopbanked and drained wetlands to convert them into productive farmland and settlements, and 'improved' wet soils for pasture and crop growth by lowering the water table with deep open drains.[17,18] Wetland extent reduced by 90% in the 150 years following European settlement.[11,13]

Māori opposition to wetland drainage was viewed as resistance to development; where the government could not persuade Māori to sell their wetlands, they introduced compulsory acquisition.[2,17]

> Year after year, from the late 1800s through into the 1950s and beyond, laws were passed that provided for the aquisition and development of extensive wetlands, with little or no consideration being given to the Māori values present… [leaving] the Māori owners of wetland complexes with virtually no rights. (McDowall 2011, p. 597)[2]

As forests and wetlands disappeared, concern about the ecological effects of landscape clearance grew. From the 1920s onwards, acclimatisation societies and conservationists joined iwi in raising the alarm about impacts on waterways and fisheries.[3,5] Acclimatisation societies highlighted that deforestation was causing sedimentation and flash flooding in streams, wiping out fish and insect life.[3] Furthermore the replacement of dense forests with pasture grasses was catastrophic for native species (e.g. banded kōkopu) and salmonids adapted to cool, clear waterways.[2] These impacts were exacerbated by the loss of wetlands, which provide critical fish habitat and spawning grounds, regulate water levels and improve water quality.[11] Where wetland drainage caused the water table to drop, nearby streams and lakes shrank in size and rapidly infilled.[2] These changes drove widespread declines in fish distribution and abundance.[2]

> The landscape has changed dramatically over the last 100 years. When we came inland after Hongi, I saw many native fish in the place which is now land. (Hauraki Māori Land Court Minute Book, cited in McDowall 2011, p. 585)[2]

> … the heavy bush cutting had turned some of the rivers into shingle beds. The Waipoua, twenty years ago one of the finest trout streams in NZ, was now nearly all shingle. (Report of the Eighteenth Conference of the New Zealand Acclimatisation Societies' Association 1929, cited in Knight 2016, p. 110)[3]

Facilitating expansion

As the colony grew so did the importance of water resources in facilitating population and economic expansion. Early settlements were often built alongside rivers to enable water supply and waste disposal, but growing settlements and new economies required greater access to water resources as well as protection from floods.[3] The late 19th century marked the beginning of a period of big infrastructure development to transport, store, divert, exclude and use water. These changes would significantly reshape New Zealand's rivers and freshwater fish habitat.[2,3]

The earliest water infrastructure was developed for water supply and waste disposal. By the 1860s, pipes, dams and wells were constructed to provide cities with a reliable town water supply, while water races, flumes and sluices were built to supply water to goldmining claims.[19,20] As cities grew, reservoirs became larger and more numerous.

Later, agricultural development in dry regions created demand for a reliable irrigation supply. Early irrigation involved the transfer of mining water rights to agricultural users to undertake flood irrigation. In the 1910s, the government began investing in irrigation to make farmland more productive, initially on a farm scale and then through the development of large irrigation schemes involving the development of river diversion races, storage dams, distribution channels and border dyke systems.[18]

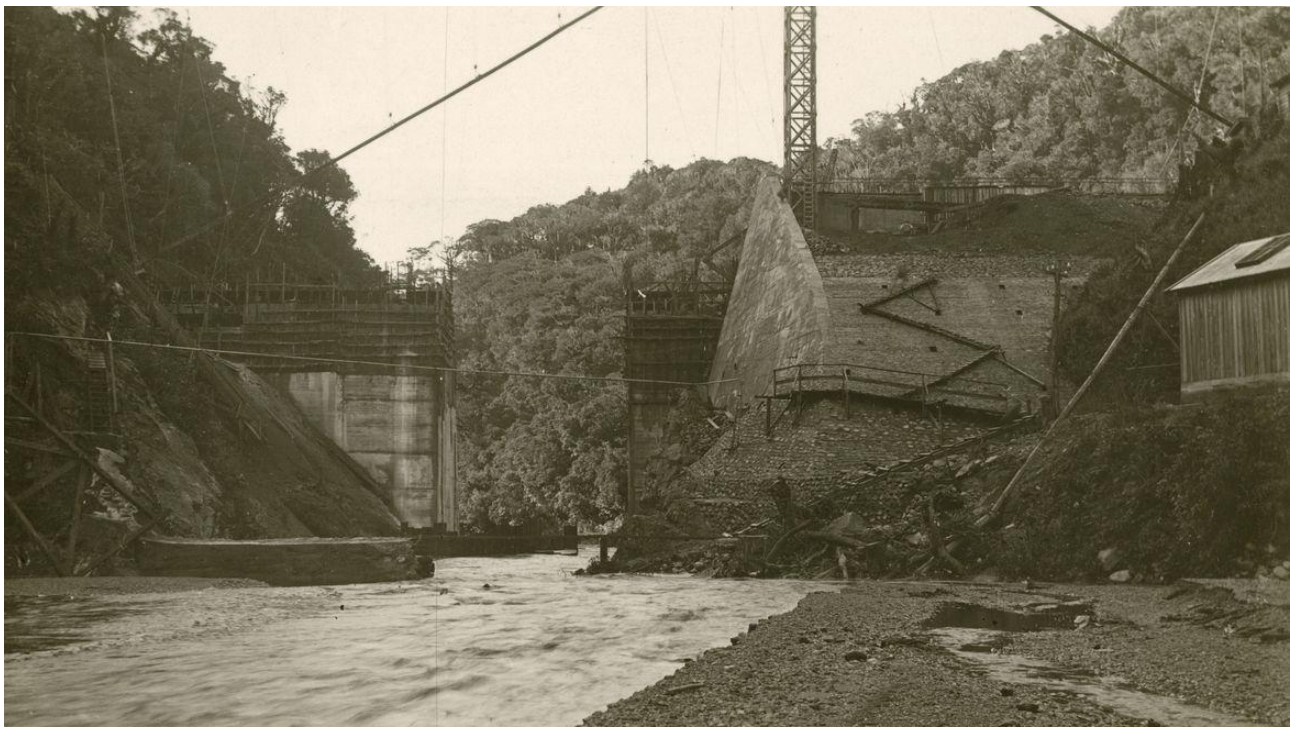
Rivers were also seen as the solution to waste disposal from cities and goldfields. Unlike Māori, who separated clean water (tapu) from used water (noa) by disposing of the latter on land, European settlers viewed rivers as having a self-renewing capacity to absorb waste.[3] Consequently, early wastewater networks piped untreated sewage directly into nearby rivers.[19] Mine tailings and industrial waste from sawmills, flaxmills, meat works, dairy factories and wool scours were also deposited untreated into rivers, which were legally classified as 'drains' and 'sludge channels' to enable this use.[3] Direct discharge into rivers continued until legislation that required discharge permits was enacted in the 1960s.[3]

> Half a mile below the freezing works the water [of the Oroua River] (at low flow) was very turbid and yellow coloured. There was a very strong smell and pieces of fat were seen on the water surface … The riverbed stones had a thick covering of sewage fungus. (Ministry of Works 1957, cited in Knight 2016, p. 82–83)[3]

Infrastructure was also developed to address flooding following significant events in the late 1800s.[3] Whereas Māori settlements were designed to accommodate intermittent flooding, European flood management focused on river and drainage works to channel floodwater away from developed land.[3] Rivers were dredged, cleared, straightened and channelised to increase flow efficiency, and stopbanks and

flood gates were constructed to contain high flows.[3] Open drains were dug to lower the water table and promote efficient drainage from farms, while streams in urban areas were piped and buried.[3,18] Pumps were later installed on stopbanks and in the stormwater network to expedite flood drainage.

Growing urban settlements also drove hydroelectricity development in the early 20th century. Following some small municipal schemes in the 1880s, the government took control of electricity generation and constructed hydroelectric schemes on several lakes and rivers.[3] Rapid growth of electricity demand resulted in shortfalls from the late 1920s to 1950s, driving the development of more and ever-larger hydroelectric schemes that involved the construction of dams, tunnels and canals, river diversions, flow changes, and the creation and raising of lakes.[21]



Dam under construction – Mangahao Electric Power Scheme. Photographer: unknown; July 1924. Source: Manawatū Heritage Public Photograph Collection; Mgh 82.

The extensive development of water infrastructure transformed New Zealand's waterways. The treatment of rivers as drains and sludge channels degraded water quality below fish tolerance levels and resulted in fish kill events. Mining sediments and other wastes created turbid streams and introduced pollutants including sulfuric acid, cyanide and large quantities of organic matter that depleted waterways of oxygen.[3]

Flood protection schemes, irrigation systems, reservoirs and diversions together resulted in the widespread dewatering of rivers.[3] In parts of Central Otago and Canterbury, irrigation allocations exceeded available flow.[18] With less water in rivers, fish habitat was greatly diminished and inundated by

fine silts, while flows slowed and warmed.[2] Flow changes rendered remaining instream habitat unsuitable for many species and vulnerable to pollution.[1]

> The [Waitangi] Tribunal … witnessed the obvious deterioration of the lower river and estuary area as a result of the diminution of the water flow. … there was slime and weed apparent and obviously no sign of the species of tuna and shellfish that were once there … (Waitangi Tribunal 1992, cited in McDowall 2011, p. 607)[2]

River development works also impacted fish habitat by clearing riparian vegetation and replacing riverbeds with pipes, canals and drains featuring uniform surfaces. This loss of habitat diversity impacted fish biodiversity, as only some species can survive in artificial waterways and flow regimes.[1]

Flood protection and hydroelectricity infrastructure created significant barriers to the movement of fish. These included physical barriers such as dams, weirs and stopbanks that prevent fish movement up / downstream and disconnect rivers from floodplain wetlands, as well as hydrological barriers such as dry channels and fast-flowing pipes.[1] Dam turbines and flood pumps pose additional threats, resulting in high mortality rates for large-bodied fish species (e.g. tuna). This loss of habitat connectivity caused population declines among migratory species, including salmon, tuna and kanakana, but protected some vulnerable non-migratory species from trout incursions.[2]

> Virtually all of the fish species that were of dietary importance to Māori migrate between fresh water and the sea. For many of them, the migrations are essential for the perpetuation of the life-cycle. (McDowall 2011, p. 607)[2]

Intensifying land use

The 1950s marked the start of intensifying land use to grow New Zealand's export economy. Post-war policies sought to improve primary productivity through government investment in infrastructure, commercial activities and support for farmers.[22] Pastoral farming, plantation forestry and horticulture expanded and intensified, while urban development accelerated.[9] These changes intensified demand for land, water and energy and increased diffuse pollution, exacerbating pressures on freshwater fish.[2]

Previous agricultural land use was dominated by extensive pastoral farming and small-scale dairying. Low soil moisture and fertility limited farming in much of the high and hill country and caused declines in productivity following initial deforestation.[23] However, innovations in fertiliser application (aerial topdressing) and irrigation (automation) in the 1950s enabled dramatic improvements in land productivity.[18] Rising agricultural product prices and government subsidies and infrastructure investments encouraged farmers to take up these innovations to bring steep, arid and infertile land into production and increase stocking density.[23] In some places, cleared land that had reverted to scrub was re-cleared for pastoral use.[23]

Irrigation infrastructure in Methven, Ashburton District, Canterbury. Photographer: Whites Aviation Ltd; May 1957. Source: Alexander Turnbull Library; WA-44230.

Wartime and post-war policies similarly supported the expansion of horticulture and forestry. Whereas early market gardens supplied domestic markets, government directives to produce vegetables for overseas troops initiated the export of canned, dried and frozen vegetables.[24] As export markets grew so did the area used for vegetable production. The government also promoted forestry expansion to supply the post-war construction boom, including through stumpage fee and price controls and ambitious planting targets.[25,26]

Government investment, technological developments and international markets continued to drive land-use intensification in subsequent decades. The government sought to grow New Zealand's primary economy through research, subsidies and incentives, low-interest loans, minimum prices, trade agreements, infrastructure development and farm advisory services.[22,23] These policies facilitated dramatic growth in stock numbers, especially for sheep and beef cattle.[23]

However, deregulation in the mid-1980s removed most government assistance for pastoral farming, greatly reducing farm profits and land prices.[23] Dairying became the most profitable farming enterprise, benefiting from cheap pastoral land, reduced equipment costs and plentiful water for irrigation.[22,23] The industry expanded rapidly, especially in the South Island; within two decades the number of dairy cows had doubled and irrigated land area had tripled.[3] Dairy farms became much larger and more densely stocked (from 2.4 to 2.8 cows per hectare by 2007).[27] This growth was supported by increased use of

nitrogen-based fertilisers, supplementary feed, improved irrigation technology (e.g. pivot irrigators) and government funding for irrigation schemes.[3]

As primary production expanded and intensified so did concerns about effects on freshwater systems. Indigenous vegetation and wetlands continued to be converted into 'productive' land, while rivers shrank as further dams, canals and drains were built to supply water and energy for new land uses.[3] In the hill and high country, the expansion of pastoral farming caused widespread soil erosion, which together with ongoing land clearance and forestry operations contributed to increasing sedimentation of waterways.[3,23] The availability and suitability of habitat for freshwater fish therefore continued to contract, with some lowland rivers drying up each summer.[2] Species that require cool, fast-flowing rivers and gravel beds were particularly impacted (e.g. migrating salmon).[3]

Land-use intensification also generated increasing diffuse pollution from agricultural run-off.[23] Aerial topdressing facilitated widespread use of superphosphate fertiliser from the 1950s and later nitrogen-based fertilisers for dairy farming.[3] Dairy cattle increased nutrient pollution by compacting soils and producing large volumes of nitrogen-rich excrement.[1] Nutrients that were not absorbed leached into waterways, altering water chemistry and causing algal blooms. This was exacerbated by irrigation takes that left less water in rivers to dilute pollutants.[3] Impacts of agricultural run-off on waterways were detectable by the 1980s; these pressures increased exponentially as dairying expanded and intensified.[3] Many lakes and rivers now experience regular algal blooms, which decrease water clarity, release harmful toxins and cause oxygen depletion, impacting fish survival and ecosystem health.[1]

Urban land use also expanded and intensified over this period. The post-war baby boom and growth of manufacturing and service industries led to an increasing concentration of people in cities, while automobiles facilitated their outward expansion.[28] As demand for urban land rose, growth increasingly involved subdivision into smaller sections. More intensive urban development led to increases in surface water run-off, stormwater infrastructure and pollutants entering waterways.[1,19] Urban waterways became characterised by flashy flow regimes, low water quality and fragmented freshwater habitat, with large numbers of engineered structures (e.g. pipes, culverts) and invasive species (e.g. goldfish, weeds).[1]

Urban intensification and economic development increased demand for water and energy resources, impacting waterways further afield. Auckland's water supply, for example, shifted from small urban lakes to reservoirs in nearby mountain ranges, and then to the Waikato River.[19] The development of large, energy-intensive manufacturing facilities resulted in significant impacts on waterways, such as the diversion of 95% of the Waiau River's flow to supply energy to the aluminium smelter in Bluff.[3]

The manifold effects of land-use intensification on waterways and freshwater fish provoked a strong response. Since the 1970s, there have been nationwide protests, political campaigns and court cases, as well as new policies, governance bodies and plans to limit human impacts on waterways.[3,29] These efforts have highlighted the shared interests of iwi, acclimatisation societies and environmentalists in protecting and enhancing freshwater ecosystems and resulted in many successful collaborations.[5] However, land-use modification of waterways continues, and policy improvements have proven tenuous.[29] New Zealand's ongoing focus on maximising primary productivity has made managing agricultural run-off particularly intractable.

Changing relationships with freshwater fish

As land use changed and freshwater fish populations declined, they disappeared from the diets and cultural practices of many New Zealanders.

> Before European settlement, the Ōpihi River and its catchment supported a large Māori population. The whole catchment was one vast mahinga kai … Today the combined effects of farm-generated nutrient run-off, abstraction of water for irrigation, and the discharge of industrial effluent into the river, have reduced the waterways to waste removal channels and all but destroyed their mahinga kai value. (Tau et al. 1990, cited in McDowall 2011, p. 606)[2]

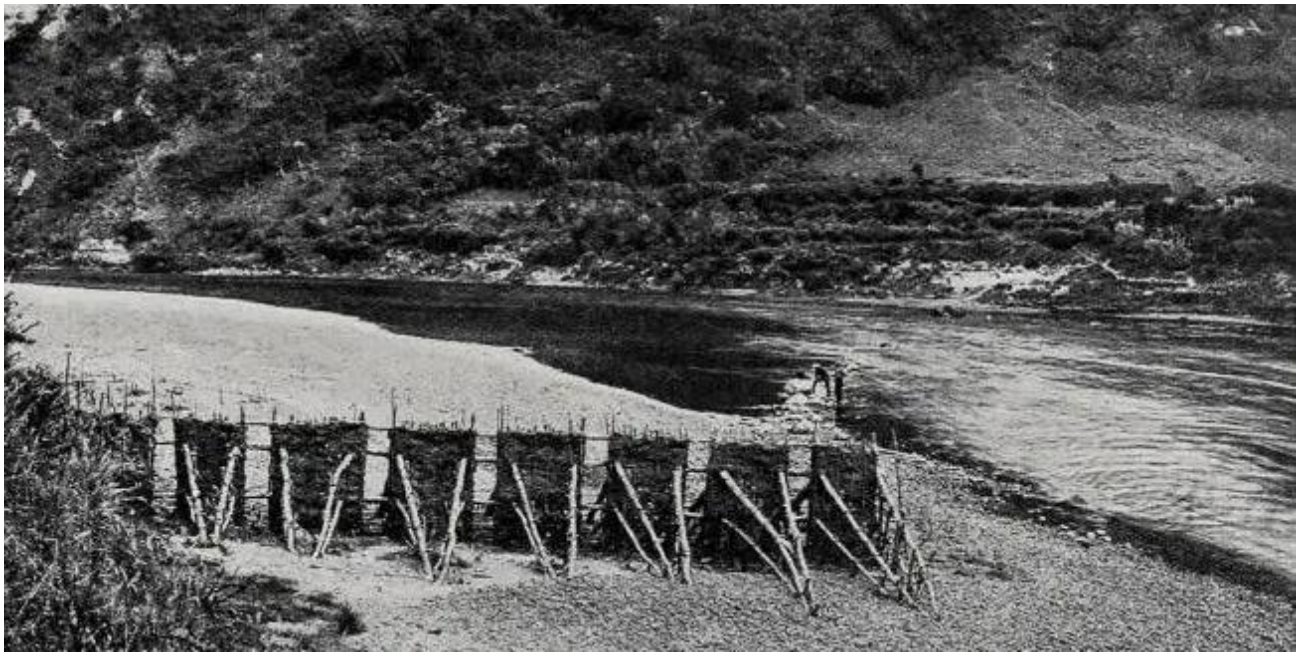
The impacts of land use and infrastructure development on freshwater fishing varied according to species' habitat, flow and ecosystem requirements. Valued fisheries that were particularly impacted by changes include:

- **kōwaro (mudfish) and īnanga**: wetland drainage and pastoral use reduce habitat and spawning areas
- **kanakana and salmon**: reduced flows, dams and other structures limit spawning migration
- **longfin tuna**: dams and flood pumps kill adults migrating downstream and limit upstream migration of juveniles
- **salmon, trout and whitebait species**: reduced flows and poor water quality limit habitat availability, while sedimentation impacts food availability and spawning habitat
- **kōaro**: deforestation diminished forest stream habitat and spawning habitat
- **kākahi**: sedimentation, poor water quality and the decline of host species impact survival.[2]

In addition, mass mortality events became common occurrences in waterways impacted by contaminant discharges, high nutrient or organic matter loads and reduced flows, killing thousands of fish.[1] Together, these changes meant that many species were no longer present in sufficient quantities for harvesting (e.g. kākahi), or that fishing became severely restricted (e.g. season limits for salmon).

Increasing pollution also impacted the quality and safety of freshwater fish for human consumption. Early disposal of untreated human and toxic wastes rendered receiving waterbodies unsafe for harvesting, while heavy metals in run-off and recurring algal blooms cause toxin accumulation in fish.[1,3] Disposal of treated wastewater into waterbodies (e.g. Lake Rotorua) is culturally offensive to Māori, limiting fisheries on cultural and spiritual grounds.[2] Declining water quality has also affected the flavour and quality of freshwater fish.

Land-use changes contributed to the loss of preferred fishing locations, structures and practices.[3] Māori and Pākehā fishing methods (e.g. flies, hīnaki) were developed to target preferred species and fish life stages in particular environments.[2,5] For example, pā kanakana were built across lowland streams to catch kanakana migrating upstream, while pā tuna were constructed further inland to trap tuna as they migrated downstream. Fishing sites also came to be valued for their family connections, and in Māori communities were sometimes tied to fishing rights.[2]



A tuna weir left exposed on the bed of the Whanganui River through changes in the river's course. Photographer: F.J. Denton. Published in Auckland Weekly News; 9 September 1909, p. 14. Source: Auckland Libraries Heritage Collections; AWNS-19090909-14-02.

Whitebaiting on the Avon River. Published in Christchurch Star; c.1940. Source: Christchurch City Libraries; CCL-StarP-04690A.

As landscapes were brought into production, many of these sites – deep pools, swamps, vegetated banks and fast-flowing channels – were lost, degraded or rendered inaccessible.[3] Acclimatisation societies and iwi repeatedly protested the loss of their mahinga kai and trout fishing streams, but these actions had little impact on land-use policies.[2,5] Indeed, policy changes prior to the 1980s tended to protect rights to pollute and clear or drain land, despite impacts on other property and rights holders.[3] Colonial attitudes towards waterways meant that Māori fishing locations were disproportionately impacted. Wetlands that were prized as mahinga kai were maligned and drained, while pā tuna and kanakana were demolished to make way for navigation or rendered useless by flow diversions.[3]

Without access to culturally valued fisheries, many fishers ceased fishing or shifted to other species, locations or catch and release. In some places, freshwater fisheries could no longer sustain families as a regular food source, and freshwater fishing became a pastime for recreational users and tourists.[30] Lowland fisheries were particularly impacted, causing a shift in fishing effort to the backcountry. These were significant changes in people's relationships with freshwater fish, household economies and ways of life that echo across generations. As human–fish interactions declined, culturally generated knowledge about species and fishing practices could not be passed on, and opportunities to observe changes in species declined.[30] These changes have impacted younger generations' appreciation and ability to care for culturally significant species. The loss of ecosystems and culture are thus intertwined and a significant source of pain for affected communities.[2,30]

> [Land-use changes had] succeeded in reducing the once proud Opihi and its estuary … into something unfit for humans and animals to swim in … I am glad that my tupuna cannot stand on the banks of the Opihi and see what I have stood back and allowed to happen to their river. (Kelvin Anglem 1992, cited in McDowall 2011, p. 606)[2]

However, not all fisheries and types of fishing were equally affected by land-use changes. Species with a higher tolerance for muddy sediments, low flows and poor water quality (e.g. shortfin tuna, perch) can survive and even thrive in urban and pastoral waterways. Infrastructure development also created novel freshwater environments that have been successfully colonised by several species; some have even become popular fishing locations. Hydro lakes, canals and other reservoirs provide ideal conditions for salmonid growth, with many becoming famous for their prolific trout and salmon fisheries. Irrigation races are also known to support trout and have created important habitat for native species (e.g. giant kōkopu, kōwaro, non-migratory galaxiids), although private property means that fisheries are not always accessible. In urban areas, infrastructure development has sometimes enabled public interactions with fish, such as riparian reserves and structures that enable residents to fish for whitebait or feed tuna.

Enhancing landscapes for freshwater fish

Landscape modification has significantly curtailed habitat availability for native and some introduced species, forcing trade-offs in areas where they co-occur and constraining what can be achieved through species management today. Despite increased awareness of freshwater fish values, they continue to be incorporated in decision-making in limited ways, creating the potential for further and cumulative loss. Indeed, recent assessments found that wetland extent decreased by 537 hectares and indigenous land cover (e.g. forests, shrublands) by 8,652 hectares between 2018 and 2023.[31]

There have been significant regulatory efforts to protect freshwater fish values since the 1980s, although with limited or localised outcomes to date.[3] For example, a 1981 legislative amendment enabled the protection of outstanding waterway values, resulting in Water Conservation Orders for 16 waterways that prevent activities that would impact their flow, levels and (recently) water quality. Requirements for instream structures to provide for fish passage were introduced in 1983, leading to widespread use of fish ladders and screens.[3] These requirements were strengthened in 2020, alongside new mandates for councils to maintain or improve fish passage and restrict damaging activities within and around wetlands.

Following a failed attempt to set water quality standards in the 1980s, the National Policy Statement for Freshwater Management 2020 introduced national bottom lines for water quality and required decision-makers to prioritise the health and well-being of freshwater ecosystems. These policies have driven more integrated freshwater and land management as well as an increased focus on fish outcomes. However, recent proposals threaten to reverse these protections.

Regulations are only one mechanism for change. Given the scale of landscape modification and waterway degradation, widespread changes in land and water use will be required to secure freshwater fisheries. This will likely involve strategic land retirement, reforestation and wetland creation to manage issues such as soil erosion and eutrophication and secure vulnerable species. Significant investments will be required to retire old infrastructure that threatens fish survival (e.g. flood pumps).

However, there are also smaller scale changes that could help to enhance landscapes for freshwater fish. Land and water users, councils and other entities currently undertake a range of activities that adversely affect freshwater fish, including drain maintenance, pesticide use, willow removal and car washing.[1,3] Changing such practices to maximise fish values will require a shift in the way society views waterbodies; that is, to recognise the fish habitat potential of all natural, artificial and modified waterways. For example, irrigation races, drains and urban waterways have been shown to host diverse fish populations, while threatened mudfish have been found in boggy areas of paddocks. Greater awareness of the ecological value of these modified habitats is needed, as well as efforts to manage and enhance them as important components of freshwater ecosystems.

Recommendations for policy- and decision-makers

> At this time, the existence of suitable habitat is the single most important factor in maintaining populations of fish and wildlife … this policy includes every attempt to encourage and persuade other agenices whose activities affect habitat, to plan such activities in a manner that has a minimum of adverse effects on habitat and where possible plan such a way as to enhance habitat. (Annual report of Southland Acclimatisation Society 1982, cited by McDowall 1994, p. 165)[5]

The layers of historical land-use change that have led to the current degraded state of freshwater fisheries underscore the need for integrated land and water management and cross-agency cooperation to improve freshwater fish outcomes. Despite their differences, iwi, hapū, Fish & Game councils,

Department of Conservation and other environmental organisations all recognise the fundamental importance of protecting and enhancing freshwater fish habitat. This shared recognition has formed the basis of many collaborative projects to protect and restore waterways. These entities can be allies in ongoing efforts to enhance landscape outcomes for freshwater fish; they can also provide examples of how to achieve more integrated freshwater management.

What should policy- and decision-makers do with this information?

- Acknowledge that land-use change has caused and continues to drive declines in valued freshwater fish, and the ongoing material and cultural impacts of this loss.
- Critically examine the values and assumptions embedded in land-use policies, and how they impact freshwater fisheries and align with those of other agencies.
- Assess the environmental effects of land-use policies and plans from the perspective of what freshwater fish need to thrive.
- Acknowledge that land-use impacts have been uneven and expand protection and restoration of ecosystems that are critical for native fish and Māori fisheries.
- Identify opportunities for modified environments to enhance freshwater fish population and fisheries and review how their current management impacts fish.

How can policy- and decision-makers effect action and change?

- Collaborate with other governance agencies to secure the protection and enhancement of remaining freshwater fish habitat.
- Retain and strengthen legislation, policies and plans that protect the health and well-being of waterways and prevent further loss of freshwater fish habitat.
- Implement the recommendations of existing reports on reforms needed to give effect to Te Tiriti o Waitangi in freshwater management.
- Invest in freshwater habitat creation and enhancement, and increase resourcing for freshwater monitoring and policy implementation.
- Support and resource initiatives by tangata whenua and other groups to protect and restore freshwater ecosystems and fisheries, and showcase their benefits.
- Educate staff, farmers and the public on the impacts of land-use change on freshwater fish and how land-use practices can be modified to support healthy fish populations.

Selected glossary

Term	Definition
Hākari	Feast, celebration
Hau kāinga / hau kāika	Home people, local people of a marae
Hīnaki	Traditional woven basket-like fish traps
Īnanga / īnaka	Main whitebait species (*Galaxias maculatus*)
Kaihaukai	A Kāi Tahu tradition involving the reciprocal exchange, bartering or sharing of food among kinship groups
Kaitiaki	Guardian
Kākahi / kāeo / torewai	Three species of freshwater mussel (*Echyridella menziesii*, *E. aucklandica*, *E. onekaka*)
Kanakana / piharau	Lamprey (*Geotria australis*)
Kōaro	Climbing galaxiid (*Galaxias brevipinnis*), a whitebait species
Kōkopu	Three species of galaxiid, also whitebait: giant kōkopu (*Galaxias argenteus*), banded kōkopu (*G. fasciatus*), shortjaw kōkopu (*G. postvectis*)
Kōura / kēkēwai / kēwai	Native freshwater crayfish (*Paranephrops planifrons*)
Kōwaro / hauhau / waikaka	Five species of mudfish (*Neochanna burrowsius*, *N. heleios*, *N. apoda*, *N. diversus*, *N. rekohua*)
Mahinga kai / mahika kai	Food-gathering sites, traditions and methods
Manawhenua	Customary authority over a particular area and use of its resources
Maramataka	Māori lunar calendar
Mātauranga Māori	The body of knowledge originating from Māori ancestors
Nohoanga	Seasonal occupation sites used by Kāi Tahu
Pā kanakana / utu piharau	Lamprey weir, used to catch lamprey swimming upstream
Pā tuna	Traditional weir for catching tuna
Porohe	Common smelt (*Retropinna retropinna*)
Rāhui	A temporary ritual prohibition, closed season, ban, reserve
Raupō	Bullrush (*Typha orientalis*), a common wetland plant
Salmonids	Trout and salmon species
Tangata whenua / takata whenua	Local Indigenous peoples
Tiriti o Waitangi	Te reo Māori text of New Zealand's founding document
Treaty of Waitangi	English-language text of New Zealand's founding document
Tuna	Freshwater eels, including the longfin eel (*Anguilla dieffenbachii*) and shortfin eel (*A. australis*)
Upokororo	Grayling (*Prototroctes oxyrhynchus*), extinct

References

1. Ministry for the Environment, Stats NZ. New Zealand's environmental reporting series: our Freshwater 2026. Wellington: Ministry for the Environment and Stats NZ; 2026. Available from: https://environment.govt.nz/assets/publications/Freshwater/our-freshwater-2026.pdf
2. McDowall RM. Ikawai: Freshwater fishes in Maori culture and economy. Christchurch: Canterbury University Press; 2011.
3. Knight C. New Zealand's rivers: an environmental history. Christchurch: Canterbury University Press; 2016.
4. Young D. Our islands, our selves: a history of conservation in New Zealand. Dunedin: Otago University Press; 2004.
5. McDowall RM. Gamekeepers for the nation: the story of New Zealand's acclimatisation societies, 1861–1990. Christchurch: Canterbury University Press; 1994.
6. Collier KJ, Grainger NPJ, editors. New Zealand invasive fish management handbook. Hamilton: Lake Ecosystem Restoration New Zealand, University of Waikato and Department of Conservation; 2015.
7. Holmes R, McFarlane K, Challies E, MacNeil C, Arnold J. The social–ecological fabric of freshwater fish management: accounting for feedback loops in human–fish interactions. Ecosphere. 2025;16(4):e70249. Available from: https://onlinelibrary.wiley.com/doi/abs/10.1002/ecs2.70249
8. Mitchell C. The liberator: how one man's 15,000 pest fish changed New Zealand's waterways. Stuff. 2020 Jan 26; Available from: https://www.stuff.co.nz/national/118845051/the-liberator-how-one-mans-15000-pest-fish-changed-new-zealands-waterways
9. Pawson E, Brooking T, editors. Making a new land: environmental histories of New Zealand. Dunedin: Otago University Press; 2013.
10. Ewers RM, Kliskey AD, Walker S, Rutledge D, Harding JS, Didham RK. Past and future trajectories of forest loss in New Zealand. Biological Conservation. 2006;133(3):312–25. Available from: https://www.sciencedirect.com/science/article/pii/S0006320706002886
11. Dymond J, Sabetizade M, Newsome PF, Harmsworth GR, Ausseil AG. Revised extent of wetlands in New Zealand. New Zealand Journal of Ecology. 2021;45(2):3444.
12. Dawson J. Conifer–broadleaf forests. Te Ara – the Encyclopedia of New Zealand. 2009 Mar 1. Available from: https://teara.govt.nz/en/conifer-broadleaf-forests
13. Wilmhurst J. Human effects on the environment. Te Ara – the Encyclopedia of New Zealand. 2009 Mar 2. Available from: https://teara.govt.nz/en/human-effects-on-the-environment
14. Wynn G. Conservation and society in late nineteenth-century New Zealand. New Zealand Journal of History. 1977;11(2):124–36.
15. Swarbrick N. Logging native forests. Te Ara – the Encyclopedia of New Zealand. 2009 Mar 2. Available from: https://teara.govt.nz/en/logging-native-forests
16. Hursthouse C. New Zealand, or Zealandia, the Britain of the South. London: Edward Stanford; 1857.

17. Park G. "Swamps which might doubtless easily be drained": swamp drainage and its impact on the indigenous. In: Pawson E, Brooking T, editors. Making a new land: environmental histories of New Zealand. Dunedin: Otago University Press; 2013.

18. Heiler T. Irrigation and drainage. Te Ara – the Encyclopedia of New Zealand. 2009 Mar 1. Available from: https://teara.govt.nz/en/irrigation-and-drainage

19. Dann C. Sewage, water and waste. Te Ara – the Encyclopedia of New Zealand. 2010 Apr 12. Available from: https://teara.govt.nz/en/sewage-water-and-waste

20. Walrond C. Gold and gold mining. Te Ara – the Encyclopedia of New Zealand. 2009 Mar 2. Available from: https://teara.govt.nz/en/gold-and-gold-mining

21. Martin JE. Hydroelectricity. Te Ara – the Encyclopedia of New Zealand. 2010 Apr 20. Available from: https://teara.govt.nz/en/hydroelectricity

22. Nightingale T. Government and agriculture. Te Ara – the Encyclopedia of New Zealand. 2009 Mar 1. Available from: https://teara.govt.nz/en/government-and-agriculture

23. Peden R. Farming in the economy. Te Ara – the Encyclopedia of New Zealand. 2009 Mar 1. Available from: https://teara.govt.nz/en/farming-in-the-economy

24. Wassilieff M. Market gardens and production nurseries. Te Ara – the Encyclopedia of New Zealand. 2009 Mar 1. Available from: https://teara.govt.nz/en/market-gardens-and-production-nurseries

25. Roche M. Exotic forestry. Te Ara – the Encyclopedia of New Zealand. 2009 Mar 1. Available from: https://teara.govt.nz/en/exotic-forestry

26. McGlone MS, Bellingham PJ, Richardson SJ. Science, policy, and sustainable indigenous forestry in New Zealand. New Zealand Journal of Forestry Science. 2022;52:8. Available from: https://doi.org/10.33494/nzjfs522022x182x

27. Stringleman H, Scrimgeour F. Dairying and dairy products. Te Ara – the Encyclopedia of New Zealand. 2009 Mar 1. Available from: https://teara.govt.nz/en/dairying-and-dairy-products

28. Pool I, Jackson N. Population change. Te Ara – the Encyclopedia of New Zealand. 2018 Aug 23. Available from: https://teara.govt.nz/en/population-change

29. Joy MK. The fight for freshwater. Wellington: Bridget Williams Books; 2024.

30. Holmes R, Kitson J, Tadaki M, McFarlane K. Diverse perspectives on the role of trout in Aotearoa New Zealand's biological heritage. Cawthron Report No. 3691. Nelson: Cawthron Institute; 2021.

31. Stats NZ. Indigenous land cover continues to decline. 2025 Nov 20. Available from: https://www.stats.govt.nz/news/indigenous-land-cover-continues-to-decline/

Fish Futures

CAWTHRON

Kauati

LINCOLN UNIVERSITY
TE WHARE WĀNAKA O AORAKI