WE ARE HERE

AN ATLAS OF AOTEAROA

CHRIS MCDOWALL & TIM DENEE

MASSEY UNIVERSITY PRESS

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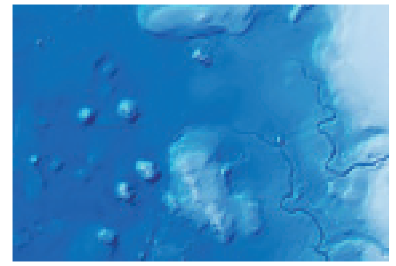
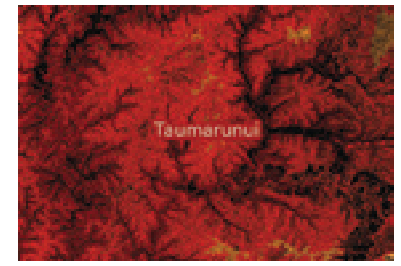
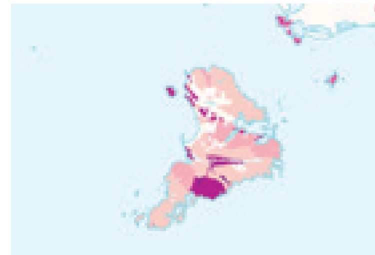
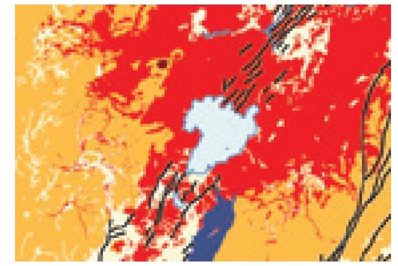
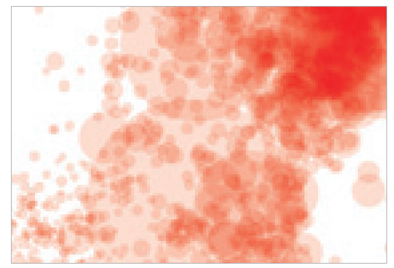
Te Whenua

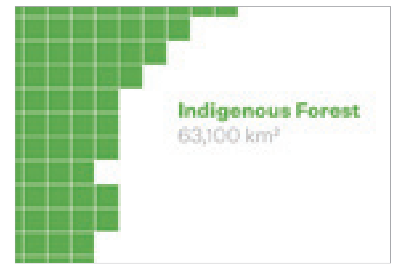












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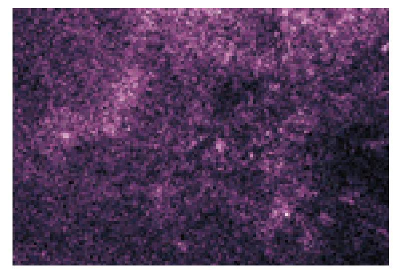
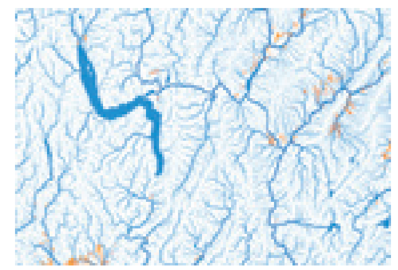
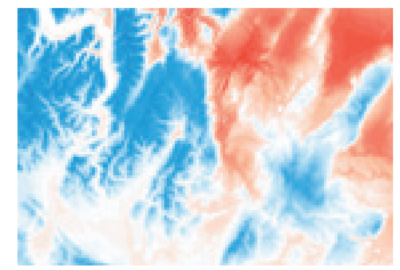
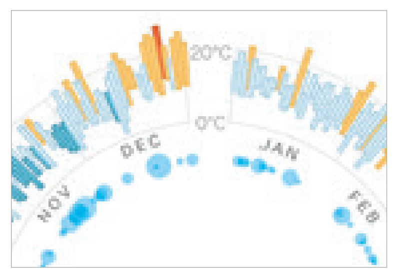
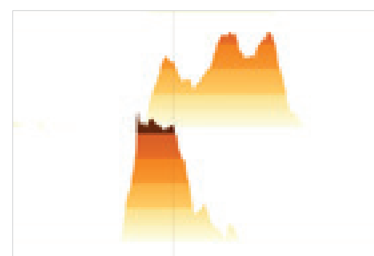
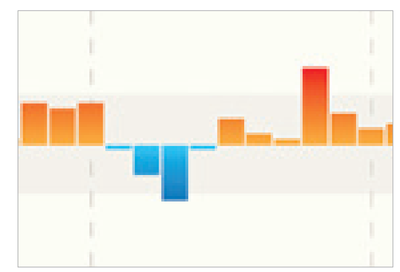












A Place for Maps

I miss paper maps. There is an intimacy to reading a map with hands and eyes that gets lost on a digital screen.

In 1972 my grandparents took a road trip from London to Lancashire and Ayrshire. As I write these words, the large folding travel map they used to plan their journey sits next to me — an 8-miles-to-the-inch duplex map of England and Southern Scotland.

It shows their three-week journey plotted in green felt-tip pen. Annotations mark places stayed and old friends visited. The more I study the map, the more I see. A day trip to Heysham. A tentative dotted path between Seatoller and Hawkshead. Bits scribbled out, suggesting routes abandoned. Did they ever make it to Ulverston?

To my grandparents the map was an evolving plan and a navigational aid. For me it is a glimpse into their lives. When I trace my fingers across those faded green paths, I touch family history.

In 2019 people use maps more than ever before. Geographic information systems and smart phones have revolutionised personal navigation. The experience of using Google or Apple maps on a phone is, by design, user-centric. You Are Here. This is the path to your destination. Here are the steps you will take to get there.

Yet despite people using maps more often, map literacy is falling. My grandparents' road trip combined map reading with wayfinding. The journey required them to study connections between places and estimate travel times. Planning a trip meant becoming intimate with the world of a map, even if only for a little while. Today map skills involve typing a destination into an autocomplete search-box and following an algorithm's instructions.

I appreciate and use these technological conveniences. But I am concerned about what we are also losing along the way. This atlas, *We Are Here*, is a response to You Are Here technology and mindsets. The book is a challenge to look up from our hyper-personalised bubbles and consider other perspectives and experiences.

Across eight chapters, this book explores many different aspects of Aotearoa. The first three chapters — 'Te Whenua', 'Water and Air' and 'Living Things' — examine New Zealand's landscapes, physical environments and the organisms that live here. 'Places' surveys patterns of settlement and urban form. 'People' explores different aspects of our lived experiences, from 'Where were you born?' to 'How we die'. 'Government' is about our governing institutions and their policies. 'Movement and Energy' examines flows of people, goods, energy and information. The final chapter, 'Heart and Memory', considers relationships between language, music, memory and landscape.

A different guest writer introduces each section. I am delighted and humbled by their contributions. Some of the essayists respond directly to the material within. Others share personal stories — humane jumping-off points into abstract maps and visualisations. In every case they set tone and challenge our thinking.

Some of the graphics in this atlas are unconventional. This stems from a personal worry I have that when people look at maps of Aoteaora, sometimes they hardly see anything at all. I watch people encounter terrain maps, for example, and their eyes glaze over. Shapes drawn in soothing greens, browns and whites are so commonplace that no interpretation happens.

In the opening chapter, elevation contour lines are drawn against darkness in high-contrast blood-red and flame-yellow. Fjords read as brain-like folds and wrinkles, plateaus as gauzy translucent sheets of skin. The landscape resembles a body. Sprinkled throughout the book there are other parallels to human anatomy. In the final chapter an intricate map of the Whanganui River's tributaries shows thousands of creeks and streams feeding into the great river, like blood capillaries flowing into larger veins. These bodily metaphors are reminders that Aotearoa is not a series of discrete places, but an interconnected whole.

In other maps we embrace sparseness, stripping everything back to just core thematic data. There are national population and transportation maps without coastlines. Another map consists of nothing but lightning strikes. These maps render the familiar in unfamiliar terms, challenging the reader to seek well-known landmarks through the data. My hope is that the act of finding oneself leads to deeper understanding. Interpretation begins with an anchor. When I show these spreads to readers, I know I'm on the right track if they trace fingers across a map and tell me a story.

We planned to include a series of maps and charts based on the 2018 census. Unfortunately, low participation rates resulted in significant delays for the release of results. When this book went to print in June 2019, the census data remained unavailable and so we abandoned some planned maps, replacing them with other graphics. One such late addition is the 'Counting People' graphic, which presents a history of the census. In other cases we included maps based on 2013 data. Where possible, updated digital versions of these maps are available at http://wearehere.nz/.

There are other gaps in this book. Some are because we could not keep working on the atlas indefinitely and needed to draw a line somewhere. In other cases the data we hoped to represent proved unavailable. For example, every government survey we reviewed deals only with biological sex. The question is simply phrased: 'Are you male/female?'. There were no questions on sexual orientation or gender identity. Government agencies offer many reasons why this is the case — particularly in regard to statistical integrity. The fact remains that LGBTQI people are invisible in the census and most other government statistics.

This book would not have been possible without open data and technologies. Open data is data that anyone can share or use. The New Zealand government has adopted an 'open by default' approach to data. Publicly funded non-personal data should be free for anyone to use and redistribute.

Subtle resistance remains in a few quarters, but the large majority of government agencies have embraced the policy. Statistics New Zealand and Land Information New Zealand deserve special mention for their open data initiatives and leadership. Nearly every map and chart in this book is based on open data. Curious readers can learn more about these sources in the appendices.

Although this book's title is *We Are Here*, many of its charts look back in time. This book touches on some bleak subjects, including habitat destruction, climate change, economic inequality and child poverty. We include timelines to offer historical context, but they do more than that; they also remind us that no matter how grim things seem, change is possible. Longitudinal data expresses facts but it also contains hope. If things are to improve, it will all come down to where we place our collective attention and our energies. The information is there; the question is how we then apply it. It is my sincere hope that this atlas contributes in some small way to those efforts.

I encourage you to locate yourself in these maps and charts. Then look for other people. I hope you experience feelings of connection while reading this book: connection to land, to place, to our shared histories and to one another.

—Chris McDowall

We moved around a lot when I was growing up; I went to school in Auckland, Wellington, Christchurch and Dunedin.

As the new kid from out of town, I felt like I was missing something that my friends knew — an understanding they had from living in one place their whole lives. I was one step apart.

I played video games growing up. In the game design concept 'emergent narrative', the story isn't designed but develops organically from the interactions between a player and the game system. The story is found, not made. Similarly, data visualisation involves finding emergent narratives all around us; sifting through dense datasets to find the story threads, the veins of meaning. It is like archaeology; carefully digging down, brushing away the dirt, exposing the precious items buried there. It is also like archaeology in that aspects of yourself inevitably seep into the interpretation.

A big part of making this book has been stripping things away. We wanted it to speak clearly and coherently, which meant a lengthy process of reduction. We also wanted it to be something gratifying to look at and hold. This is a book about a treasured place in the world and the people who live here, so it was important to us that the book had some grace.

We had so many conversations about every page. We discussed what colours felt surprisingly right, or surprisingly wrong (sometimes the surprisingly wrong colours are the best ones). We debated typefaces, iconography, illustration, hierarchy, juxtaposition. I hope all those conversations are invisible. I hope these maps and graphics speak for themselves.

What I didn't understand as a kid is that, on some level, most people have a sense of being one step apart. We only ever experience our own tiny slice out of the multiversity of experiences and perspectives around us. It is fulfilling to see a bit more widely, a bit more clearly. I hope this book can help others do the same.

—Tim Denee

Te Whenua

An examination of Aotearoa’s physical form and foundations. Landscapes moving in slow motion, with occasional sudden lurches.

Whatungarongaro he tangata, toitū he whenua
People pass on, but the land is permanent

Dan Hikuroa (Ngāti Maniapoto, Waikato-Tainui)

Aotearoa New Zealand — whenua comprising Te Ika-a-Māui (North Island), Te Waka-a-Māui (Te Waipounamu/South Island) and Te Punga o Te Waka-a-Māui (Stewart Island) — has been settled in many waves of migration, with our nation being built around two main bodies of knowledge: mātauranga and science.

'Whenua' has multiple meanings, built on two key components: land and placenta. For land it includes ground, is often used in the plural, and encompasses territory, domain, country, nation and state. 'Whenua ki te whenua,' the practice of burying the placenta, reflects the deep reverence and connection that Māori have with the land expressed in whakataukī (proverbs) such as 'Ko au te maunga, ko te maunga ko au' — I am the mountain, and the mountain is me.

One understanding of the origin of Aotearoa New Zealand stems from the exploits of Māui. His brothers refused to let him come fishing with them, so one morning he hid in their canoe. After Māui's brothers had paddled far out to sea to start fishing, he emerged from his hiding place, drew out his fishing line, which was imbued with strength through karakia and to which was attached the jawbone of Murirangawhenua, his grandmother. He hooked the home of Tonga-nui, grandson of Tangaroa, deity of the ocean, and began to pull in the huge fish. 'This is the fish that our grandmother, Murirangawhenua, said would be gifted to us,' Māui said. 'Guard our fish, and I'll soon return with our people.'

Māui left his brothers with strict instructions to neither eat nor cut up the fish until he returned. However, they disregarded these instructions, and began to hack into the fish and carve it up, as it writhed in pain. Thus, the smooth surface of Te Ika-a-Māui was transformed into one criss-crossed with knife-edged ridges, and it continues to respond to the pain.

Science provides another understanding of our whenua, our land. It is an inherently human condition to naturally focus our attention on the familiar — what is small and what is vast, what is brief and what is long are all relative to that which we know. Accordingly, our understanding of the age and breadth of landscapes, continents and geology is varied, as many of us have not spent much time considering, contemplating or drawing comparisons at relevant temporal and spatial scales.

Cosmic time refers to all of the time from the formation of the universe, around 14 billion years ago, whereas geological time refers to the time from when planet Earth formed about 4.6 billion years ago. Before the Big Bang, current thinking describes the universe as timeless, dimensionless, nothingness with infinite potential.

The sheer immensity of geological time is a difficult concept to convey. An analogy using the 24-hour clock — with 24 hours representing all of geological time — is useful to gain a perspective of the vast scale of time. New Zealand's oldest rocks, which formed 510 million years ago, appeared just two and a half hours ago; the asteroid impact that led to the ultimate demise of the dinosaurs 65 million years ago occurred just 23 minutes ago; and the Polynesian peopling of the Pacific from about 3500 years ago occurred less than half a second ago.

Up until 450 million years ago our whenua lay in the northern hemisphere, and about 30 million years ago it very nearly drowned altogether. Currently the South Island is being rent asunder along the Alpine Fault — in the future it may be torn in two (but at current rates of movement not for millions of years).

Exploration of the sea floor has revealed that our whenua is far more extensive than it appears. Our long, narrow, mountainous landmass is just a glimpse of a large, mainly submerged continent called Zealandia, which is nearly 6 million square kilometres. The submarine landmass is some 20 times larger than the emergent land of Aotearoa New Zealand, and almost half the size of Australia. However, our neighbours across Te Tai-o-Rēhua — the Tasman Sea — live on a far more ancient landmass. Over 4 billion years old, Australia is the oldest continent on Earth.

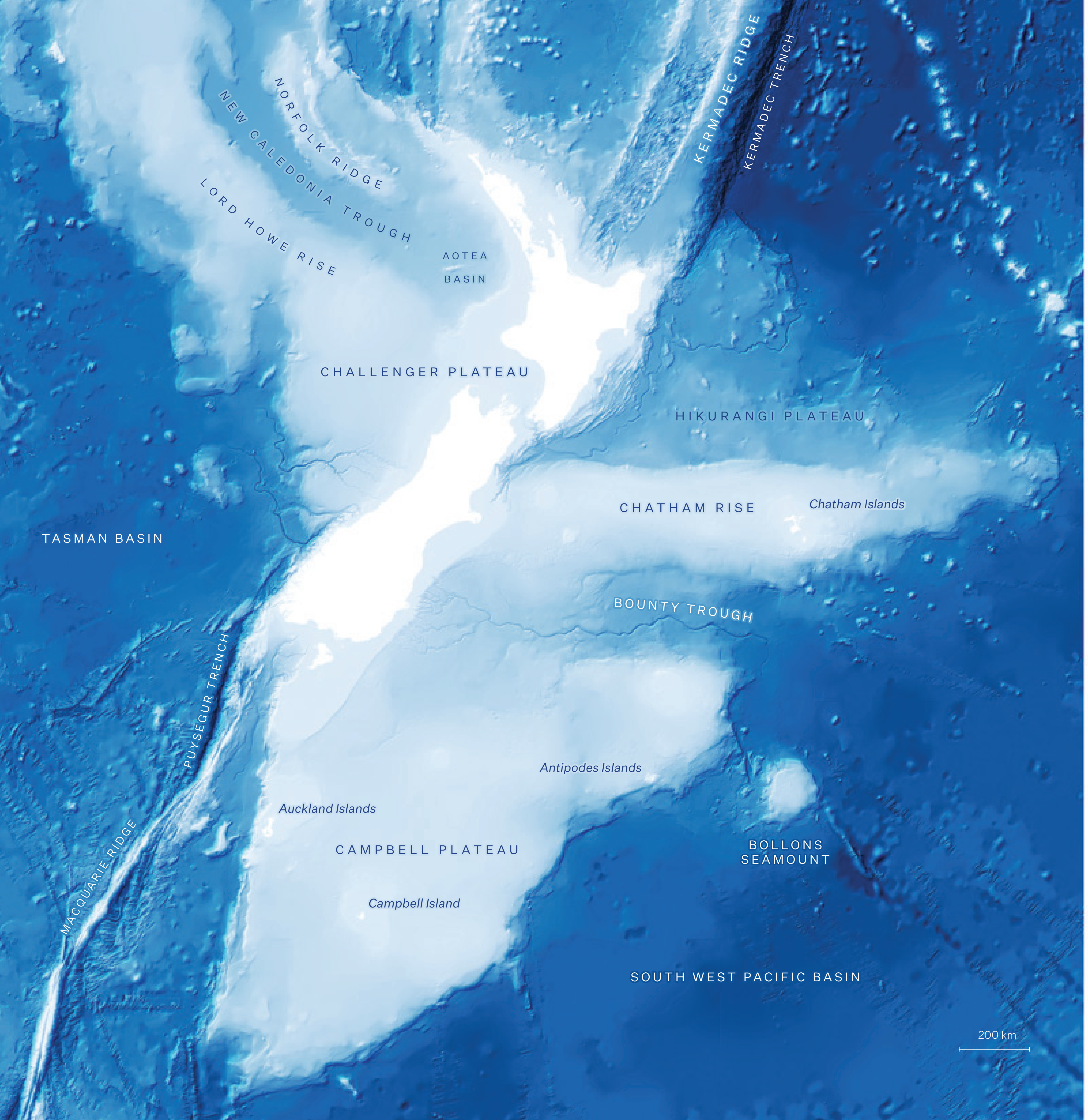
Back here, Zealandia lies across two moving tectonic plates, the Pacific and Australian, which are segments of the Earth's crust. As these plates collide, rocks are compressed and pushed up, creating the hills and mountains of the Southern Alps in Te Waipounamu and the Raukūmara, Ruahine, Kaweka, Kaimanawa and Tararua Ranges in Te Ika-a-Māui. Elsewhere, rocks are being subducted, melting and then erupting as volcanoes — Ruapehu, Tongariro, Ngāuruhoe, Tarawera, Whakaari, to name a few.

For the past 5 million years a huge tearing motion in Te Waipounamu has separated once continuous rocks by around 460 kilometres, forming the Alpine Fault — with strata in the Catlins matching with their once contiguous counterparts in north-west Nelson.

Thus, our whenua is old and vast in human terms, yet young and modest in planetary terms, and according to both knowledges, emerged from the sea.

Connection with te whenua is beautifully expressed in one of Patricia Grace's short stories. A young girl spends the last hours of a summer seaside holiday seeking a deeper communion with the place. 'Because how could you be really sure of coming there again next summer?' she thinks. 'And why should you come if you didn't let the place know you?'

So as well as getting to know our whenua better through this book, next time you are out experiencing it, try to let the place 'know you'.



Drowned Continent

Aotearoa's land area is modest by international standards. At 269,000 square kilometres, it is the world's seventy-seventh-largest country. Yet the country's sea area is huge. New Zealand's 4.2 million square kilometres of open waters is the world's fifth-largest exclusive economic zone, trailing only the United States, Australia, Indonesia and France. These waters hide vast geographical features and a tremendous diversity of life.

Draining the seas would reveal massive plateaus, dramatic cliffs, eroded mountains, deep trenches and active volcanoes. The Puysegur Trench, the Alpine Fault and the Kermadec Trench delineate boundaries between the Australian and Pacific tectonic plates. Earthquakes are common along these boundaries. North-east of New Zealand, undersea volcanoes regularly erupt in the waters around the Kermadec Ridge and Trench.

In 2017 a multinational team of 11 geologists concluded that New Zealand sits atop an eighth continent. The drowned continent of Zealandia stretches from tropical New Caledonia to sub-Antarctic waters thousands of kilometres south of Stewart Island. No official international body exists to recognise and name continents, as it had been assumed that they had all been discovered. Time will tell whether Zealandia gains currency with scientists and the general public.

Scientists have identified 15,000 marine species living in these waters. The number of undiscovered life forms is unknown. Some biologists estimate that there are as many as 50,000 more species yet to be described.

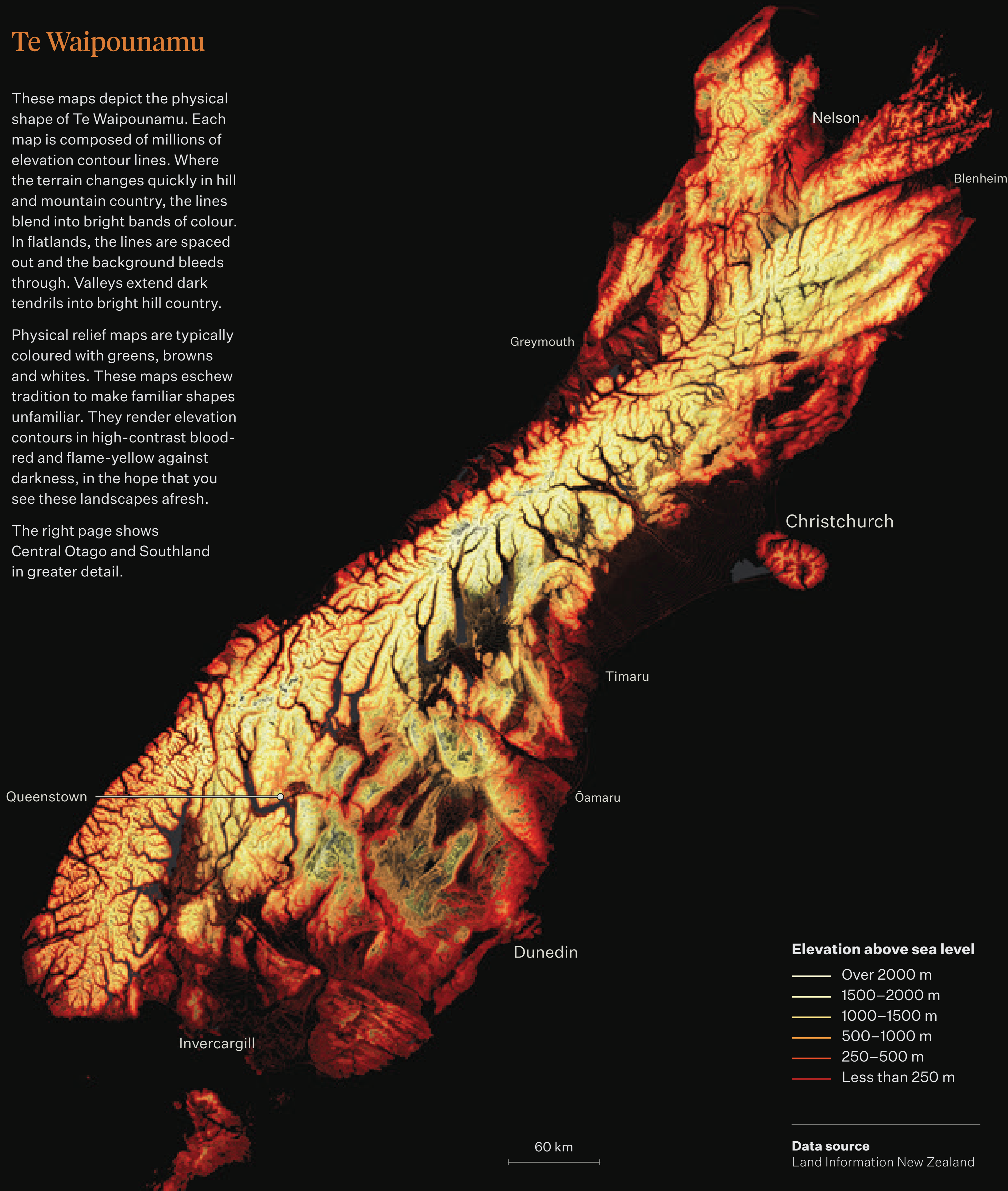
Data sources
NIWA
Land Information New Zealand

Te Waipounamu

These maps depict the physical shape of Te Waipounamu. Each map is composed of millions of elevation contour lines. Where the terrain changes quickly in hill and mountain country, the lines blend into bright bands of colour. In flatlands, the lines are spaced out and the background bleeds through. Valleys extend dark tendrils into bright hill country.

Physical relief maps are typically coloured with greens, browns and whites. These maps eschew tradition to make familiar shapes unfamiliar. They render elevation contours in high-contrast blood-red and flame-yellow against darkness, in the hope that you see these landscapes afresh.

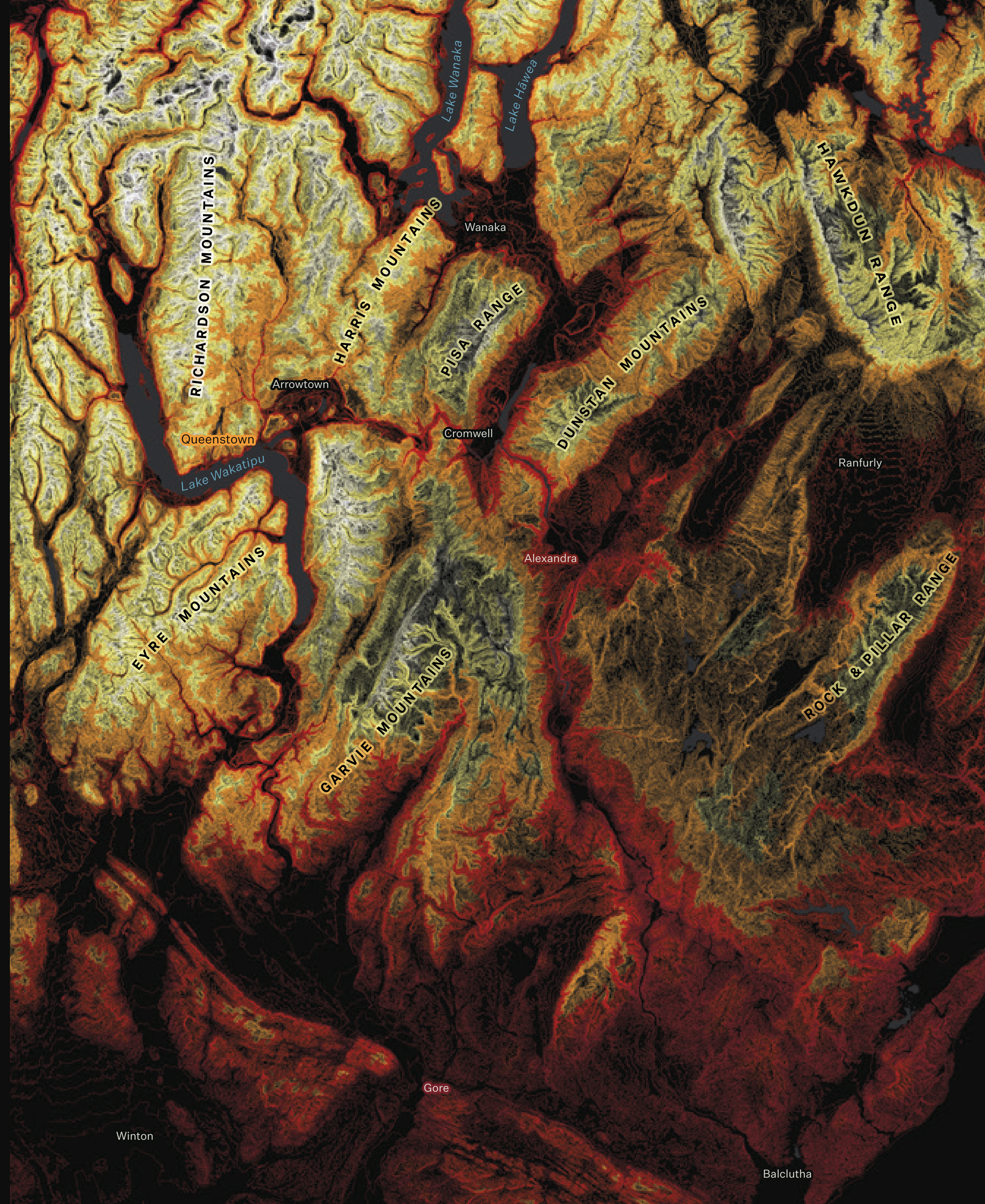
The right page shows Central Otago and Southland in greater detail.



Elevation above sea level

- Over 2000 m
- 1500–2000 m
- 1000–1500 m
- 500–1000 m
- 250–500 m
- Less than 250 m

Data source
Land Information New Zealand



Te Ika-a-Māui

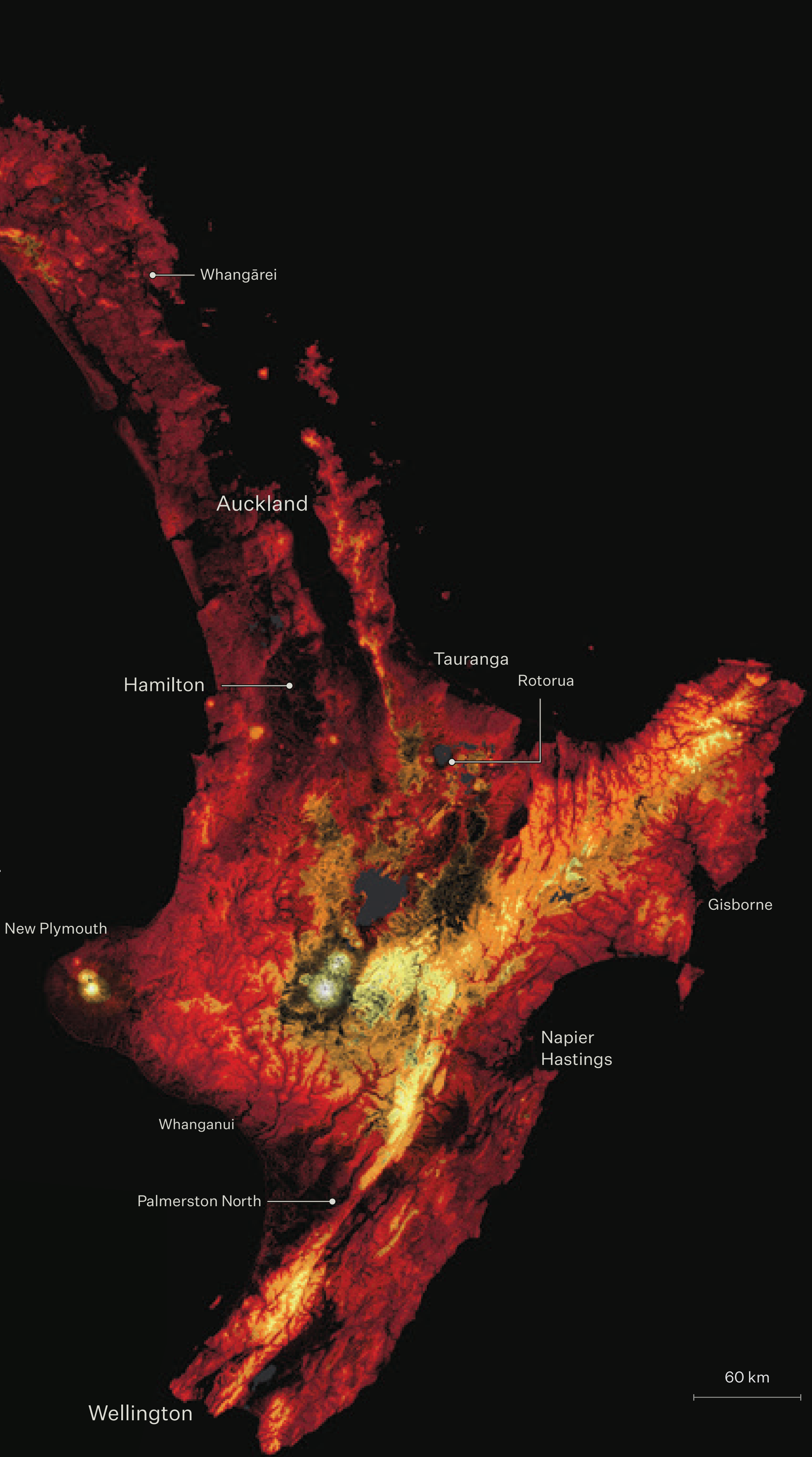
These maps are companions to those on the previous pages. Note how different Aotearoa's islands are. Te Waipounamu is dominated by a spine of steep mountains, south to north. The landscapes of Te Ika-a-Māui are less dramatic, but just as rich. Through learning to read the shape of the land, we can catch glimpses of its history.

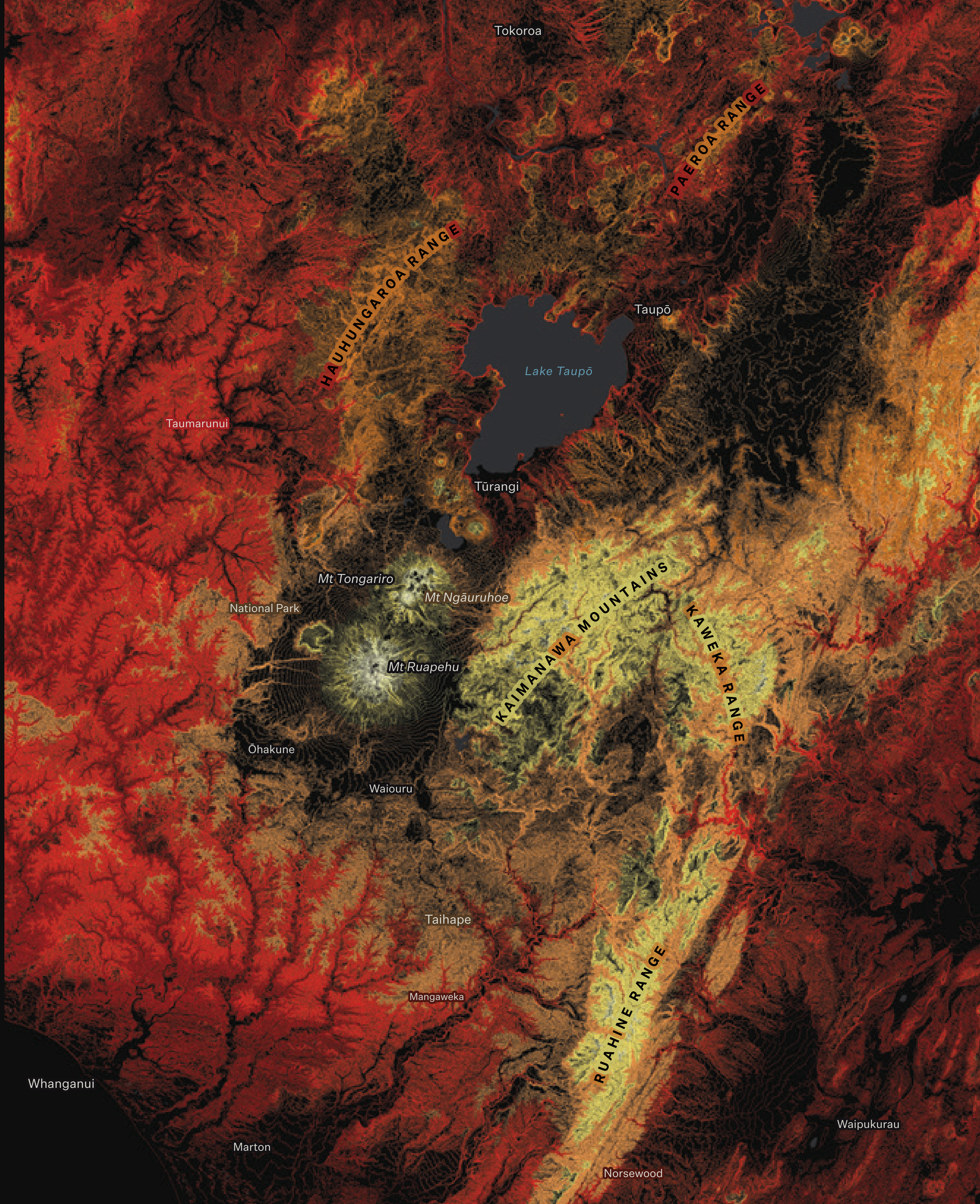
Dendritic tree-like patterns mark valleys carved by rivers over centuries. Smooth, sweeping bowls and basins are the hallmarks of glaciers' advances and retreats. Concentric cones and depressions are remnants of volcanic eruptions.

The right page zooms in on the heart of the Taupō Volcanic Zone.

Elevation above sea level

- Over 2000 m
- 1500–2000 m
- 1000–1500 m
- 500–1000 m
- 250–500 m
- Less than 250 m





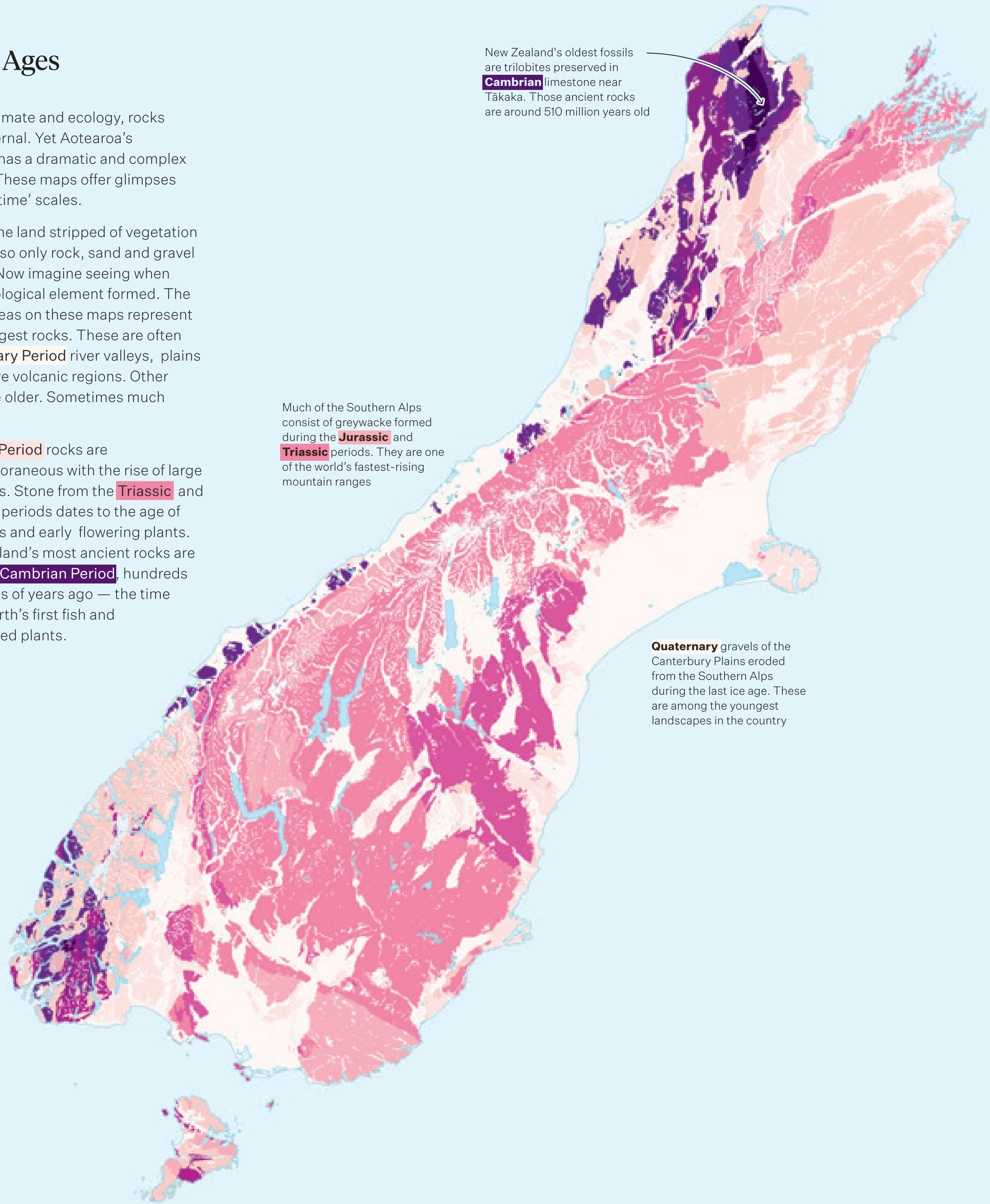
Data source
Land Information New Zealand

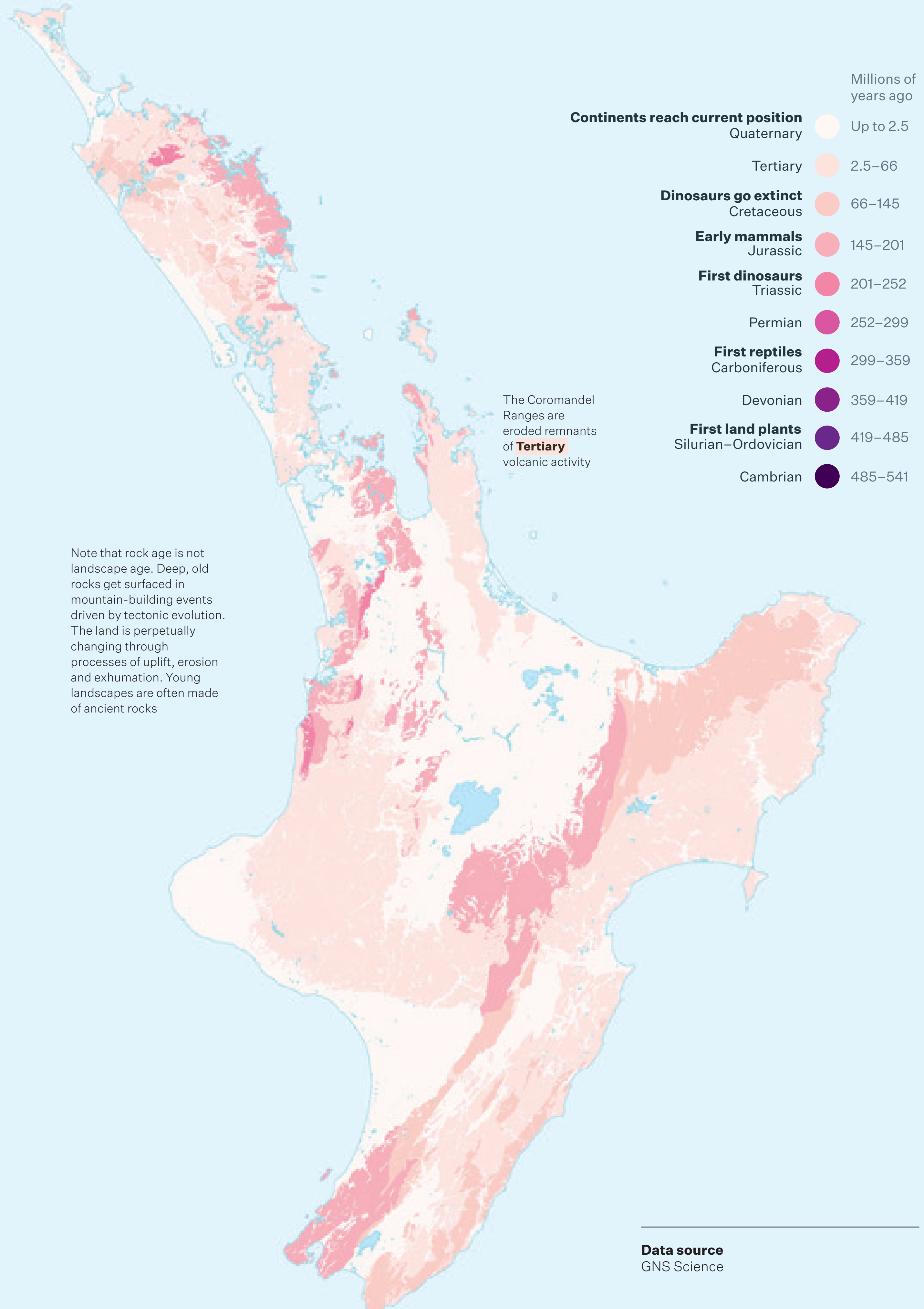
Rock Ages

Unlike climate and ecology, rocks seem eternal. Yet Aotearoa's geology has a dramatic and complex history. These maps offer glimpses of 'deep time' scales.

Picture the land stripped of vegetation and soil, so only rock, sand and gravel remain. Now imagine seeing when each geological element formed. The palest areas on these maps represent the youngest rocks. These are often Quaternary Period river valleys, plains and active volcanic regions. Other rocks are older. Sometimes much older.

Tertiary Period rocks are contemporaneous with the rise of large mammals. Stone from the Triassic and Jurassic periods dates to the age of dinosaurs and early flowering plants. New Zealand's most ancient rocks are from the Cambrian Period, hundreds of millions of years ago — the time of the Earth's first fish and land-based plants.





Data source
GNS Science

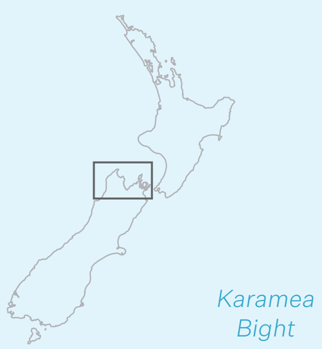
Most Ancient Rocks

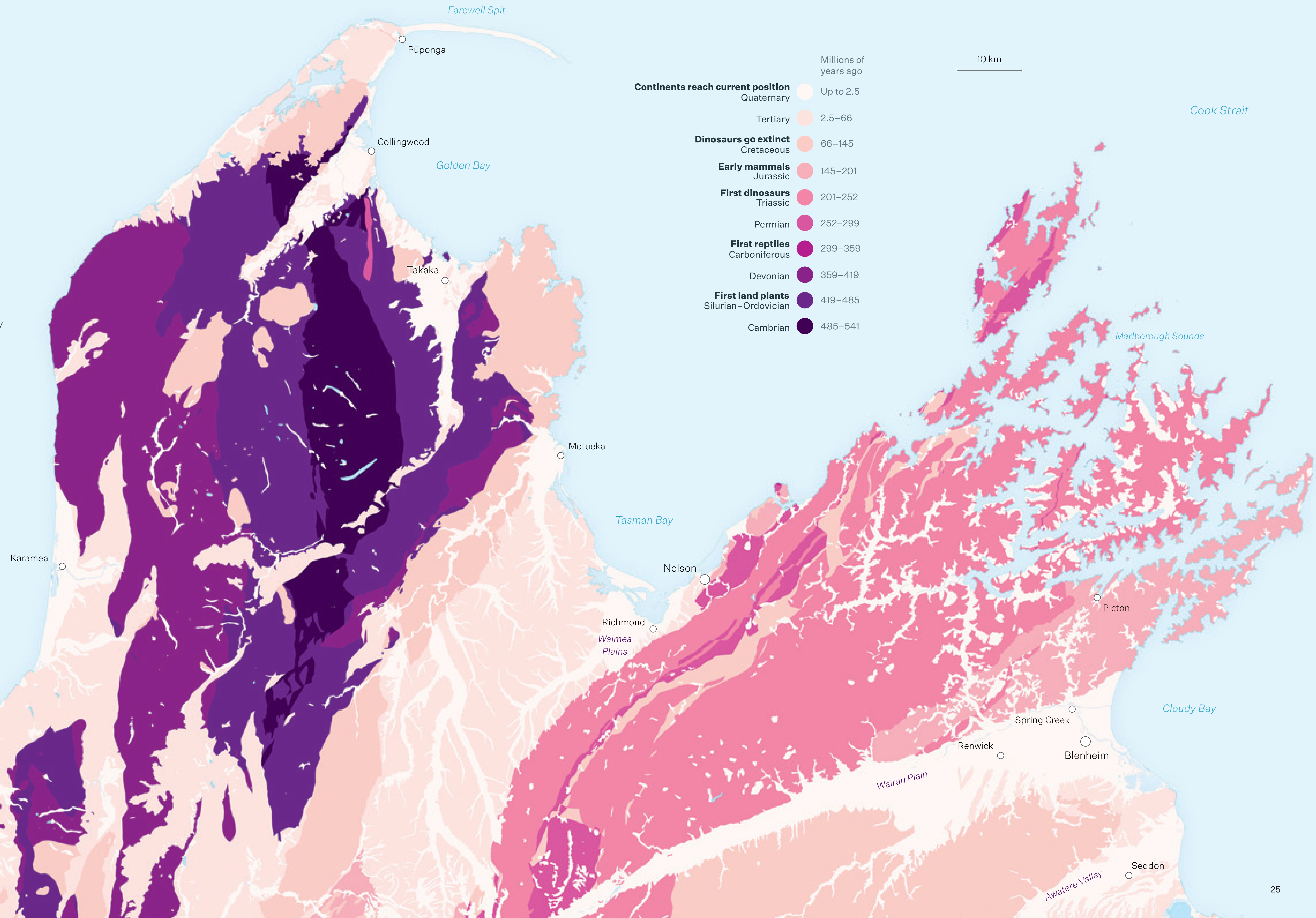
This map focuses on the top of the South Island, and shows some of Aotearoa's oldest and youngest rocks.

The Tasman region's hills and mountains contain the country's oldest geological features. Between Tākaka and Karamea lie ancient blocks of crooked mountains and valleys. These rocks formed during the Cambrian period, when life was restricted to the seas.

The youngest rocks are typically those found in coastal river valleys and floodplains. The Wairau and Awatere valleys are the most recently formed parts of Marlborough. Rivers have transported gravels down from the mountains and created substantial coastal floodplains. Along with a favourable climate, well-draining soils are the basis of the region's extensive vineyards.

How to read
The palest tones represent the youngest landscapes. The darker the colour, the older the bedrock.





Data source
GNS Science

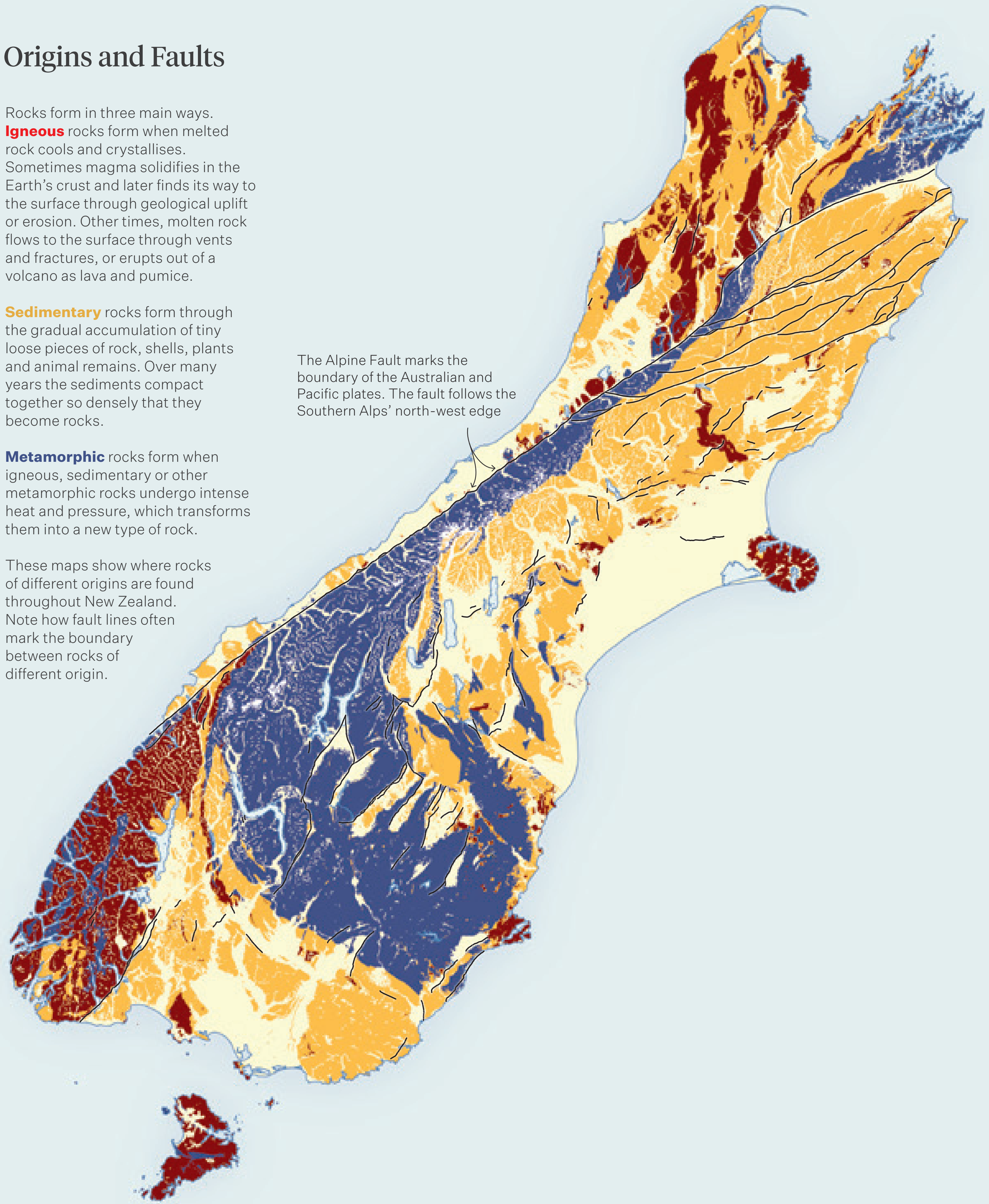
Origins and Faults

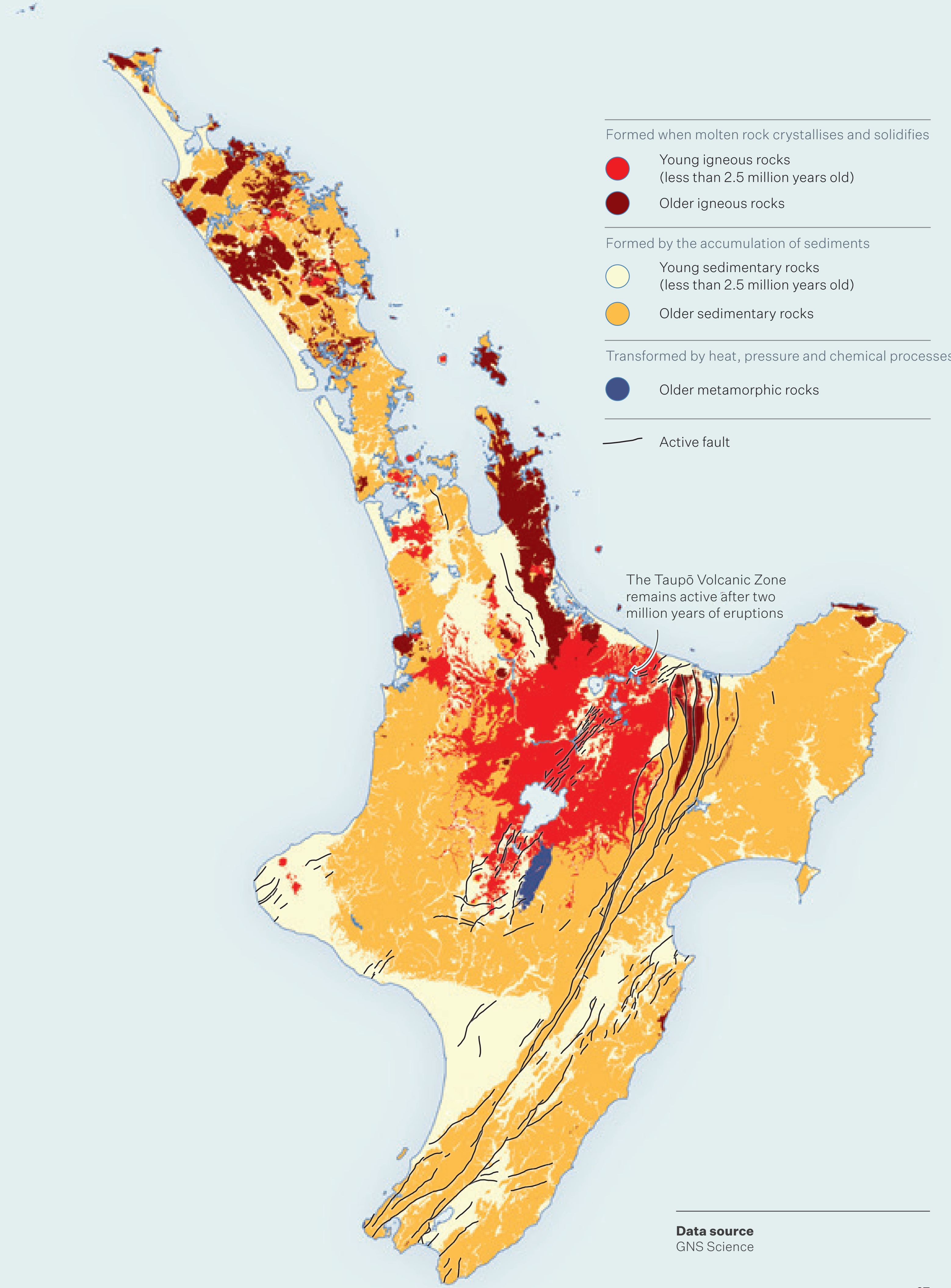
Rocks form in three main ways. **Igneous** rocks form when melted rock cools and crystallises. Sometimes magma solidifies in the Earth's crust and later finds its way to the surface through geological uplift or erosion. Other times, molten rock flows to the surface through vents and fractures, or erupts out of a volcano as lava and pumice.

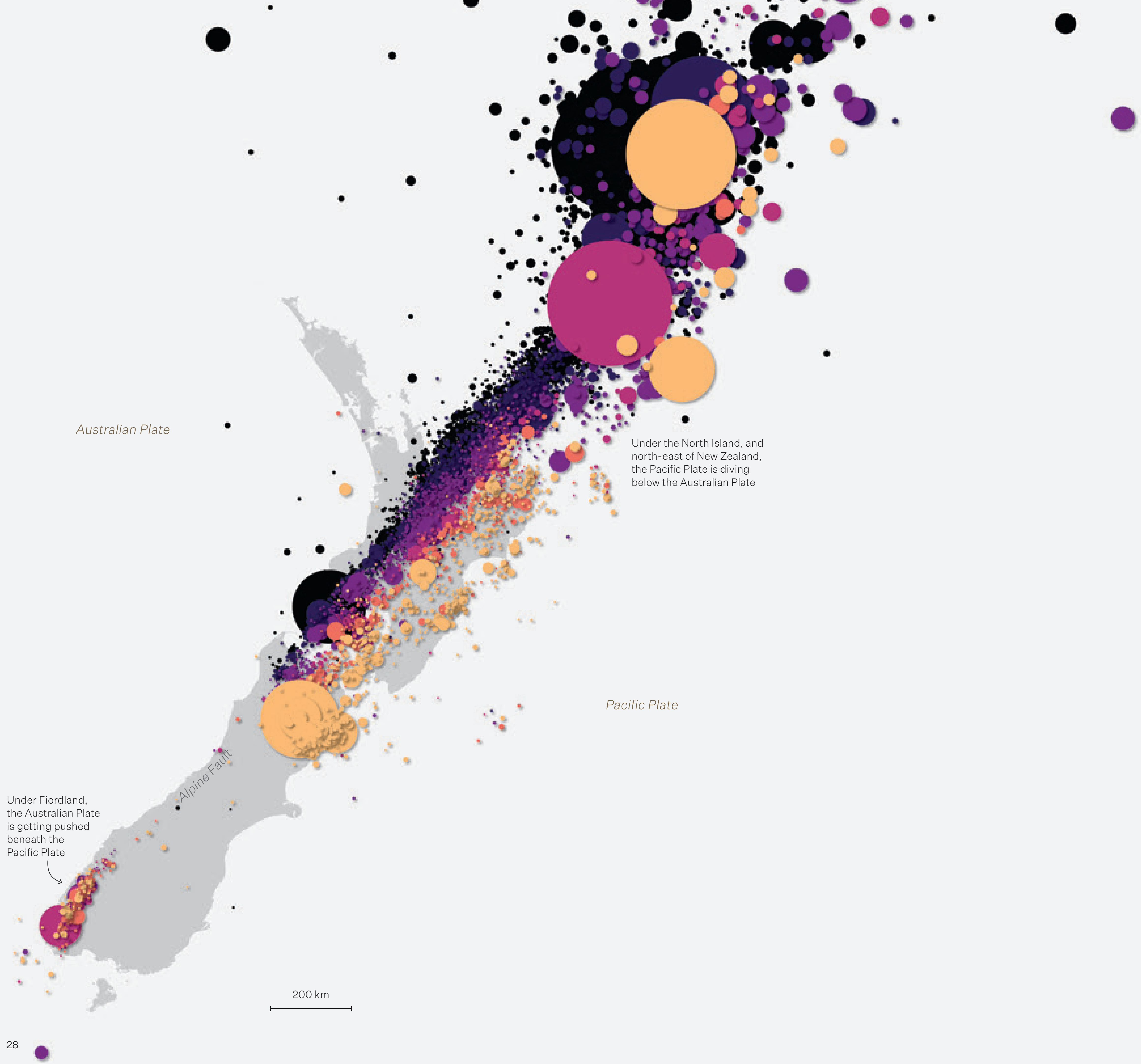
Sedimentary rocks form through the gradual accumulation of tiny loose pieces of rock, shells, plants and animal remains. Over many years the sediments compact together so densely that they become rocks.

Metamorphic rocks form when igneous, sedimentary or other metamorphic rocks undergo intense heat and pressure, which transforms them into a new type of rock.

These maps show where rocks of different origins are found throughout New Zealand. Note how fault lines often mark the boundary between rocks of different origin.







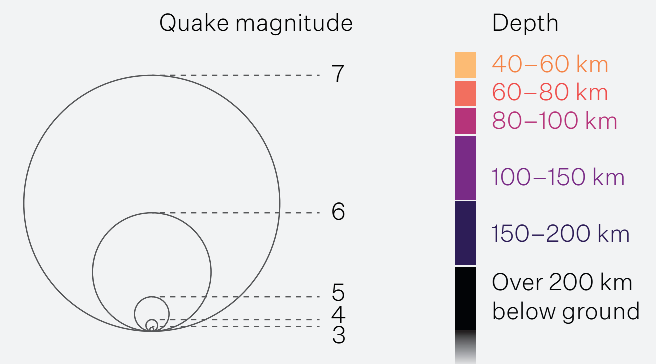
Deep Earthquakes

The surface of the Earth is made of a series of huge, slow-moving slabs of rock called tectonic plates. Aotearoa lies on the boundary between the Australian Plate and the Pacific Plate — two of the world's largest geological features.

The motions of these plates along their New Zealand boundary is complicated. In the North Island, the Pacific Plate is getting pushed beneath the Australian Plate. At the bottom of the South Island, the reverse is happening. Along the Alpine Fault, the Australian Plate is sliding horizontally as the Pacific Plate pushes up, forming the Southern Alps.

Along much of their boundary, the plates do not slide smoothly past one another. Instead they push together until the stress becomes too much, some part of the crust ruptures, and an earthquake occurs. This usually happens along a pre-existing fault.

How to read
This map shows 10 years of deep earthquakes between 2008 and 2018. Larger circles represent bigger earthquakes. The darker the circle, the deeper the earthquake. Note the bands of colour in the top half of the map, with deeper quakes in the west. This is due to the earthquakes following the slope of the plate boundary as it dips down into the subduction plate.



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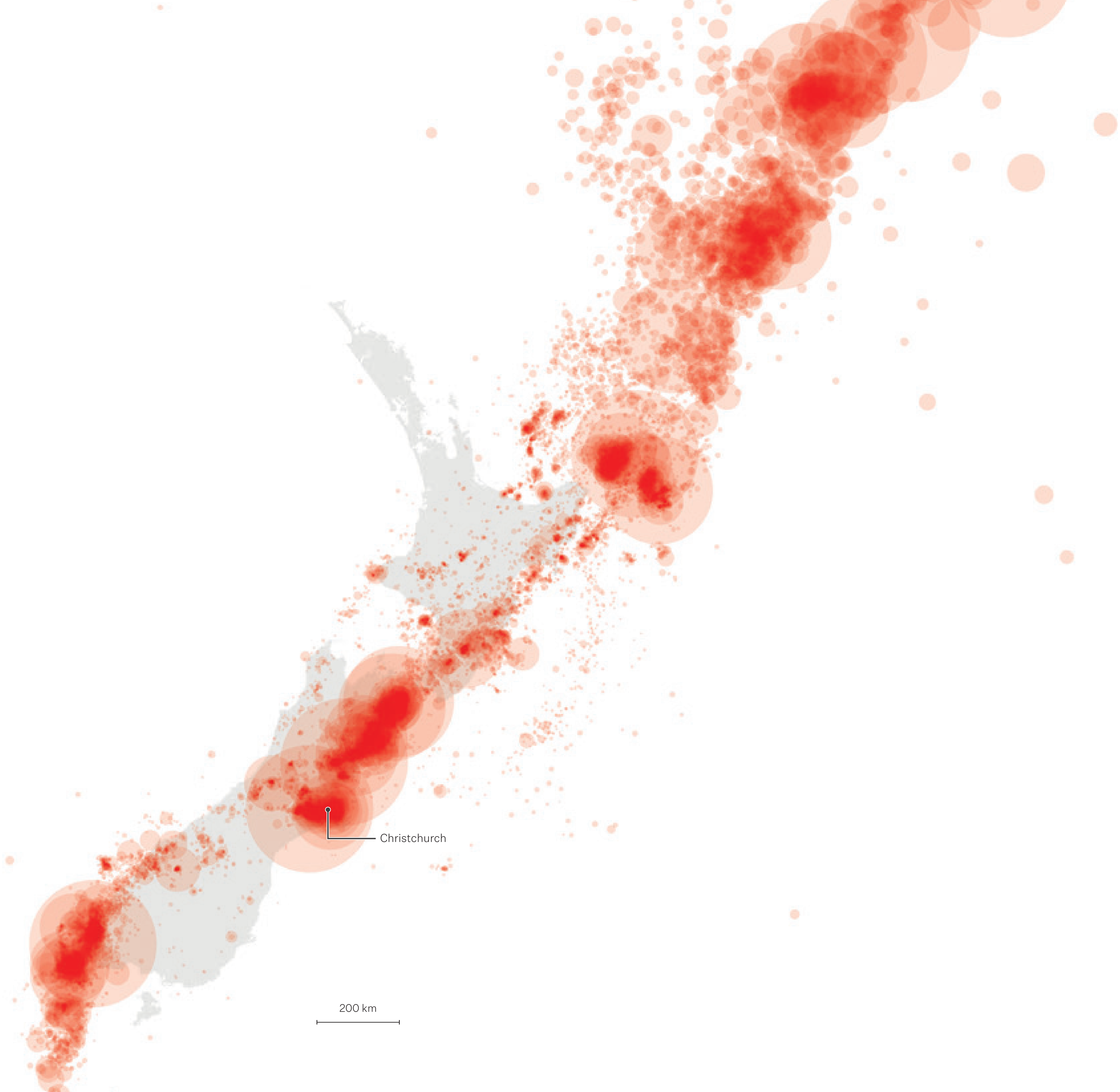


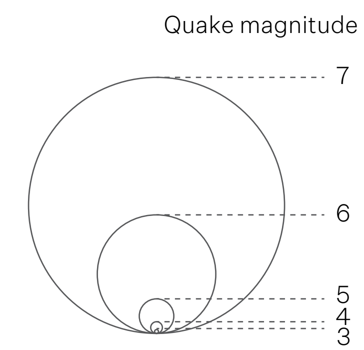
Shallow Earthquakes

The previous map shows 10 years of deep earthquakes. This map illustrates the more dangerous events that occurred within 40 kilometres of the surface between 2008 and 2018.

There are over 21,000 earthquakes of magnitude 3 or higher represented on this page. The geographical pattern appears similar, but there are some important differences. Most notably, there are a large number of shallow events in the Canterbury area, but no deep quakes.

The 2010–16 Canterbury earthquake sequence was so destructive because the quakes were large, shallow, and in close proximity to New Zealand's second-largest urban centre. In the 22 February 2011 earthquake 185 people lost their lives and over 7000 were injured. Fifteen thousand families lost their homes, and 8000 were permanently displaced.

How to read
Circles represent shallow earthquakes within 40 kilometres of the surface. The larger the circle, the bigger the quake. The circles are transparent, so places where many quakes have occurred appear brighter red.



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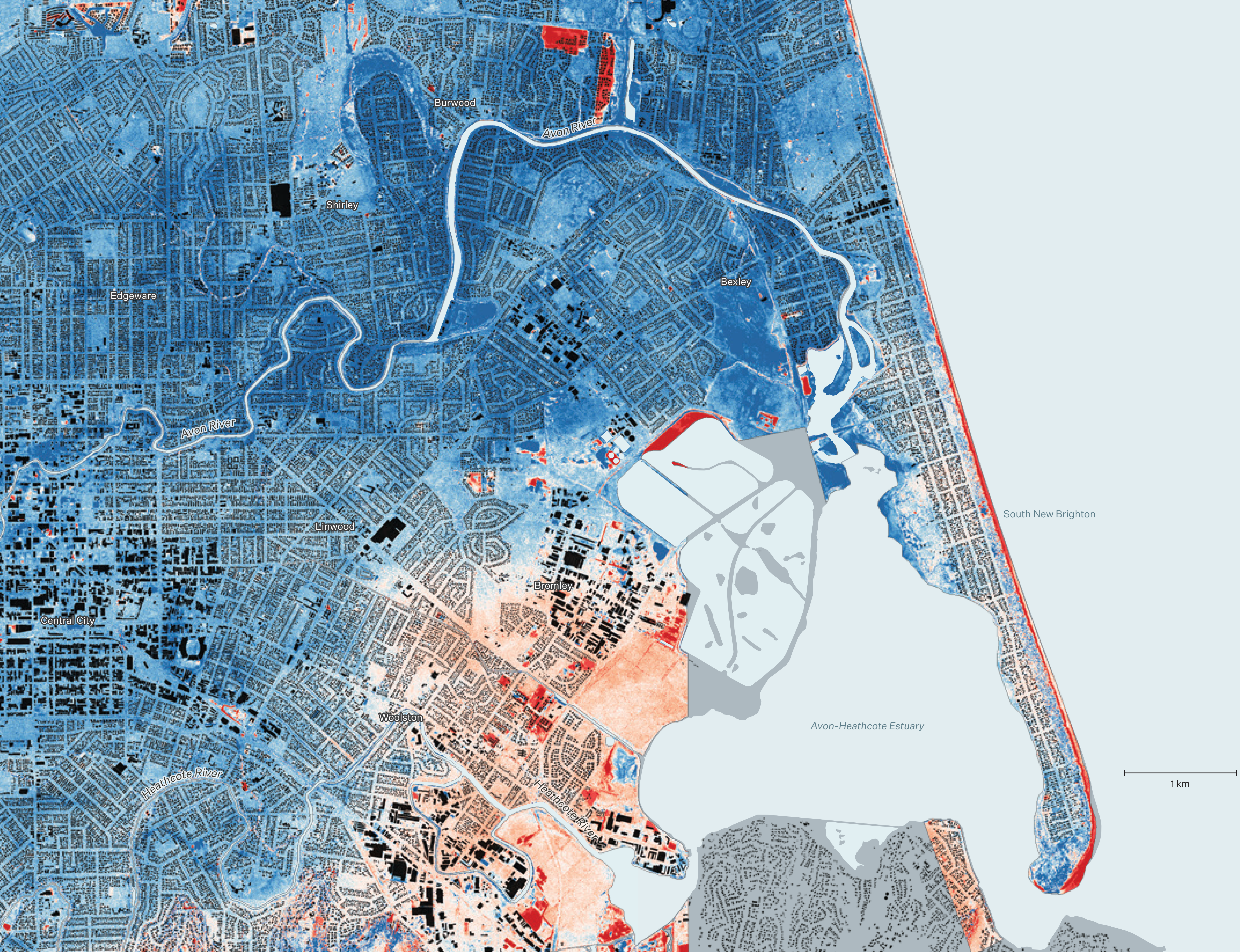


The Sinking City

The Canterbury earthquakes changed the shape of Christchurch. Much of the city is built on sand and silt, with shallow water tables and active faults. This combination meant the ground was ripe for liquefaction. Saturated soils responded to prolonged shaking by behaving like quicksand.

Waterlogged silt bubbled up from the ground to cover streets and gardens. Around 86 per cent of central and eastern Christchurch subsided. Most of this subsidence was caused by liquefaction. Some properties, especially along the Avon River, sank half a metre or more. Meanwhile, buried faults caused uplift in the Port Hills, the Avon-Heathcote Estuary and Woolston.

This map shows how the land's surface changed between a pair of surveys in 2003 and 2012. Most of the differences in elevation are due to the Canterbury earthquakes. Some uplift pockets, though, are the result of human activities, such as new housing developments and filling in salination ponds.

How to read
The blue parts of the map sank between 2003 and 2012. The red areas lifted up.

- **Lifted** +50 cm or more
- **Lifted** +10 to +50 cm
- Minimal change
- **Sank** −10 to −50 cm
- **Sank** −50 cm or more
- *Not surveyed*

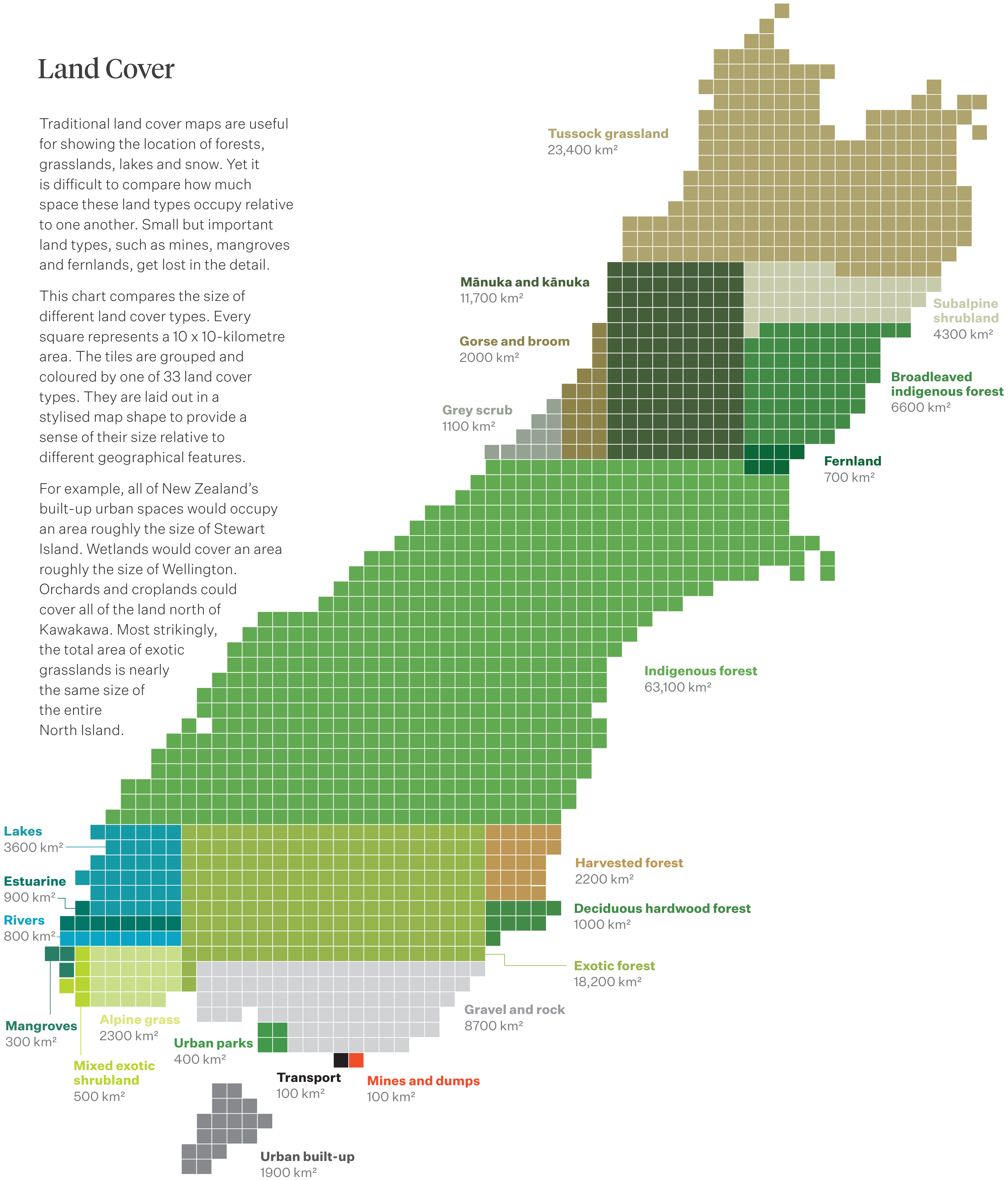
Data sources
Christchurch City Council
Canterbury Geotechnical Database

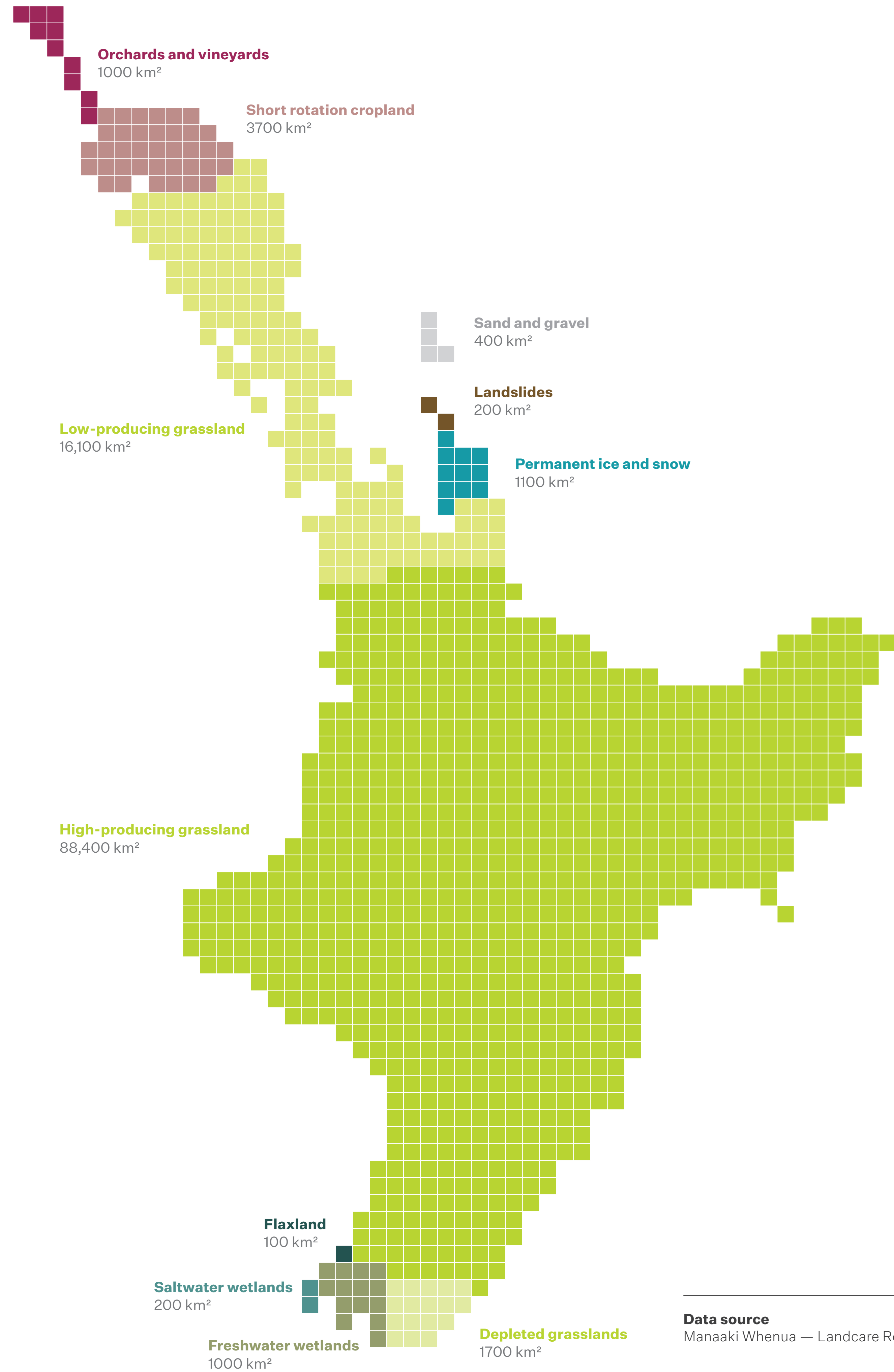
Land Cover

Traditional land cover maps are useful for showing the location of forests, grasslands, lakes and snow. Yet it is difficult to compare how much space these land types occupy relative to one another. Small but important land types, such as mines, mangroves and fernlands, get lost in the detail.

This chart compares the size of different land cover types. Every square represents a 10 x 10-kilometre area. The tiles are grouped and coloured by one of 33 land cover types. They are laid out in a stylised map shape to provide a sense of their size relative to different geographical features.

For example, all of New Zealand's built-up urban spaces would occupy an area roughly the size of Stewart Island. Wetlands would cover an area roughly the size of Wellington. Orchards and croplands could cover all of the land north of Kawakawa. Most strikingly, the total area of exotic grasslands is nearly the same size of the entire North Island.





Data source
Manaaki Whenua — Landcare Research

Water and Air

An exploration of water, wind, weather and climate.

Warming Air and Rising Seas

Veronika Meduna

When a southerly wind hits the 30-metre cliffs at Baring Head, south-east of Wellington, it is the first time it touches land after a long sweep across the Southern Ocean.

The air rushes over the cliff top, strumming guy ropes that fix a tall mast next to a small, whitewashed hut — the first building the breeze meets, even before the lighthouse. On top of that mast, a sample of air disappears down a stainless-steel tube.

Baring Head station is the longest-running air-sampling site in the southern hemisphere. It's a perfect spot. Here, southerlies are relatively frequent, unlike in other parts of New Zealand where the wind blows mostly from the west. Each southerly carries a clear chemical signature of the atmosphere above the southern hemisphere, unsullied by activities on land, and climate scientists have been coming here since 1972 to collect air samples in sealed gas bottles to track changing concentrations of heat-trapping greenhouse gases.

Today, the station is part of a global network, tracking several greenhouse gases, but back in 1972 it was the first to start monitoring carbon dioxide in the air south of the equator to complement an even longer northern-hemisphere series of air measurements taken atop the Hawaiian volcano Mauna Loa. US climate scientist Charles David Keeling started following carbon dioxide in the air flowing across Mauna Loa in 1958, motivated by a theory that Swedish scientist Svante Arrhenius had developed half a century earlier, suggesting that Earth's atmosphere acts like a greenhouse, and even small increases in atmospheric carbon dioxide would raise the temperature on Earth's surface.

Keeling had already established that carbon dioxide follows an annual cycle — Earth's slow rhythm of inhaling the greenhouse gas during spring and summer when the world's plants grow and photosynthesise, and exhaling it again when they rest during autumn and winter.

Within a few years, the data he had collected from the top of the volcano not only visualised Earth's seasonal breathing cycle, they also provided hard evidence that the background level of atmospheric carbon dioxide was rising. Since then, the Mauna Loa and, later, Baring Head stations have continued to track the ongoing rise in both hemispheres.

I first visited Baring Head station in 2012, some 40 years after it was identified as the best site by a young surf-loving New Zealand climate scientist by the name of Dave Lowe. By then, the measurements had also helped to pinpoint the source of the additional carbon dioxide as geologically old, organic in origin, and neither volcanic nor marine: unmistakably, it was coming from burned fossil fuels.

It was also clear that the concentration of carbon dioxide has been climbing at an unprecedented rate of around two parts per million per year since 2000. Parts per million, or ppm, may not sound much, until you realise that the starting point, when the first steam engines kicked off the Industrial Revolution some 250 years ago, was around 270 ppm. A year after my visit, in 2013, carbon dioxide concentrations in the atmosphere reached 400 ppm for the first time in human history.

More carbon dioxide in the atmosphere has two quantifiable and foreseeable consequences: warming air and rising seas. New Zealand has long-running records for both, often based on weather stations and tidal gauges that have been in place for some time before climate change was recognised as one of our biggest challenges. Temperature data come from weather stations between Kaitāia and Invercargill, with the oldest sites going back to 1908. They show that New Zealand has warmed by about 1°C over the past century. The height of the sea has been monitored by tidal gauges at four major city ports, going back to 1899 at Dunedin's harbour, and the data show a 20-centimetre rise in the past 100 years.

These are averaged values. The increases in both temperature and sea level are not universal across the country. Some areas are getting hotter faster, and in some parts of the country the sea has come up more than elsewhere. But with about two-thirds of us living within a few kilometres of the coast, and our major cities wrapped around harbours or floodplains, rising sea levels will affect everybody in some way.

The reality of climate change impacts on communities is complex, partly thanks to New Zealand's geography. The main islands straddle the prevailing westerly circulation belt that blows across the southern Pacific Ocean, and they span 14 degrees in latitude (from 34 degrees south to 48 degrees south). Mid-latitudes generally experience higher variability than the tropics. Year by year, New Zealand might feel the warmer air from the north, or icy winds and ocean currents coming straight from Antarctica.

On decadal rhythms, the country rides along with changes between El Niño and La Niña seasons, and a polar ring of climate variability known as the Southern Annular Mode, or SAM. Add to that the spine of mountains, which creates a stark weather divide, and it is clear that many factors shape our oceanic climate. Nevertheless, on top of all this variability, the trend of rising seas and temperatures is clear.

So far, the ocean has provided us with a climate buffer, taking up a third of global carbon dioxide emissions, and more than 90 per cent of the heat. The Southern Ocean, in particular, is the largest marine carbon sink, but its capacity to take up carbon dioxide is expected to slow as temperatures continue to climb.

As the world's oceans have warmed, sea levels have been rising, following a basic rule of physics that warmer water expands. Initially, this thermal expansion was the main driver of sea-level rise, but, more recently, warming seas have been hollowing out Antarctic ice from below, wasting some glaciers to the brink of the cryogenic equivalent of extinction. Any melting of continental ice in Antarctica adds to sea levels, and the potential magnitude of this is now uncomfortably familiar. If the smaller West Antarctic ice sheet were to melt, we can expect 6 metres of sea-level rise from that alone.

In an example of the global connectedness of both the atmosphere and the oceans, Antarctic ice loss raises seas in the opposite hemisphere, affecting highly populated coastlines along Europe and North America, and potentially slowing the ocean currents that make these coasts liveable.

The everyday impacts of climate change expected for New Zealand are both more mundane and more dramatic. Projections suggest a more intense version of the general weather patterns we already experience on either side of the mountain ranges. Wet regions become soggier, dry parts more parched, and for longer.

Already, a warmer atmosphere is changing the intensity of rain across New Zealand. Warm air holds more water and can turn a shower into a torrent, dumping a monthly average of rain in one day, overwhelming drainage infrastructure built for another era, or flooding desiccated soils.

Even though we are still counting the amount of sea-level rise in centimetres, it, too, has already become a hazard. When low-pressure systems travelling inshore coincide with spring tides, higher seas add to the impact of the storm surge by lifting it further inland, spilling into urban centres or reshaping estuaries.

Like invisible stress fractures weakening a bone, climate change will affect all aspects of life as we know it, and force us to take better care of the environment and the resources it provides. The future depends on decisions we make in the next few years.

Our chances of keeping the planet from warming by more than 2°C above pre-industrial temperatures are diminishing, even if we choose determined steps to throttle greenhouse gas emissions. That goal will require a comprehensive shift away from carbon-fuelled technologies — and, in that, climate change presents a huge opportunity for New Zealand and the world. With our abundance of wind, water and sunshine, we have a good chance of weaning ourselves off fossil fuels.

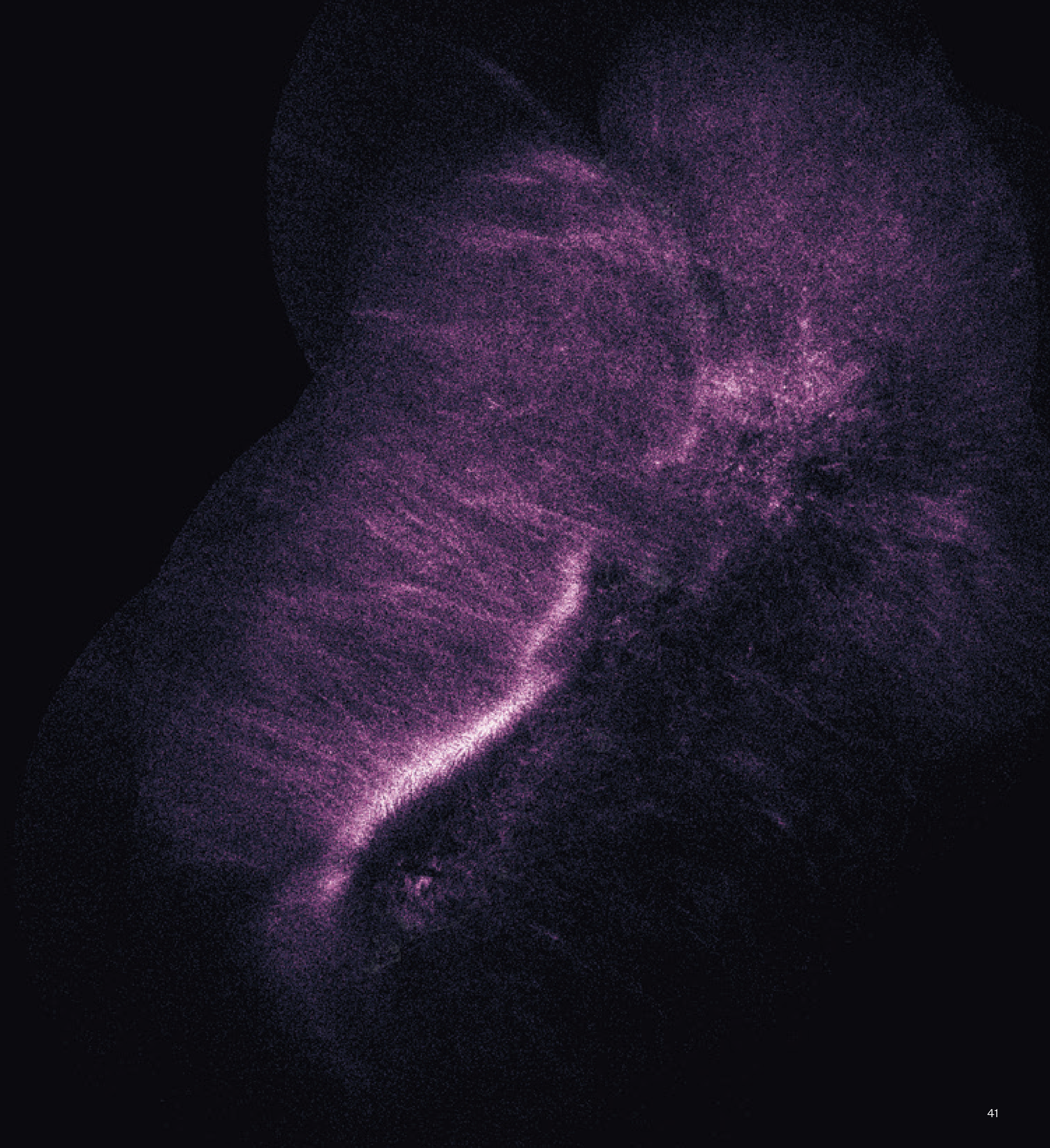
Lightning Strikes

New Zealand receives few lightning strikes by international standards. On average, the land and surrounding waters receive 'only' 190,000 strikes per year. This annual figure depends on how many storms the country is exposed to, and varies considerably. In 2012, there were only 100,000 strikes compared to 320,000 in 2013.

This map shows all 1.1 million lightning strikes recorded between May 2005 and November 2014. Each strike is represented by a tiny transparent dot. The more times a place was struck, the brighter it glows. Bright white regions are localities struck by lightning hundreds of times over the decade-long period.

Hotspots of activity stand out in mountains and hill country. Taranaki, Coromandel, the Central Plateau, Te Urewera and the East Coast are prominent in the North Island. The peaks of Mount Taranaki and Ruapehu glow brighter than their surrounds. A glowing white band stretches the length of the West Coast, the mountains forming a natural barrier to weather arriving from the west. Look closely and you can even see the ridges and major valleys of the Southern Alps.

Data source
Transpower New Zealand

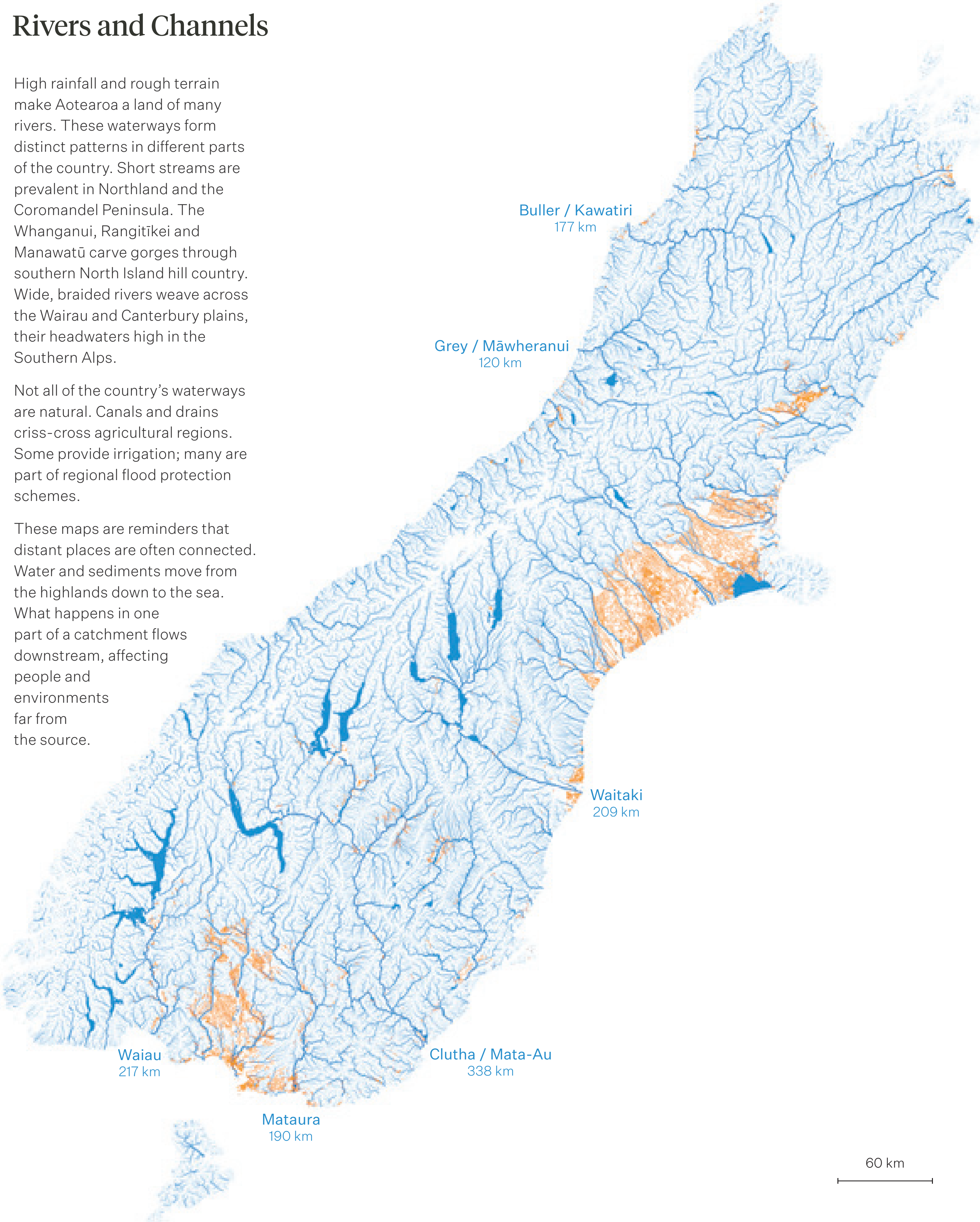


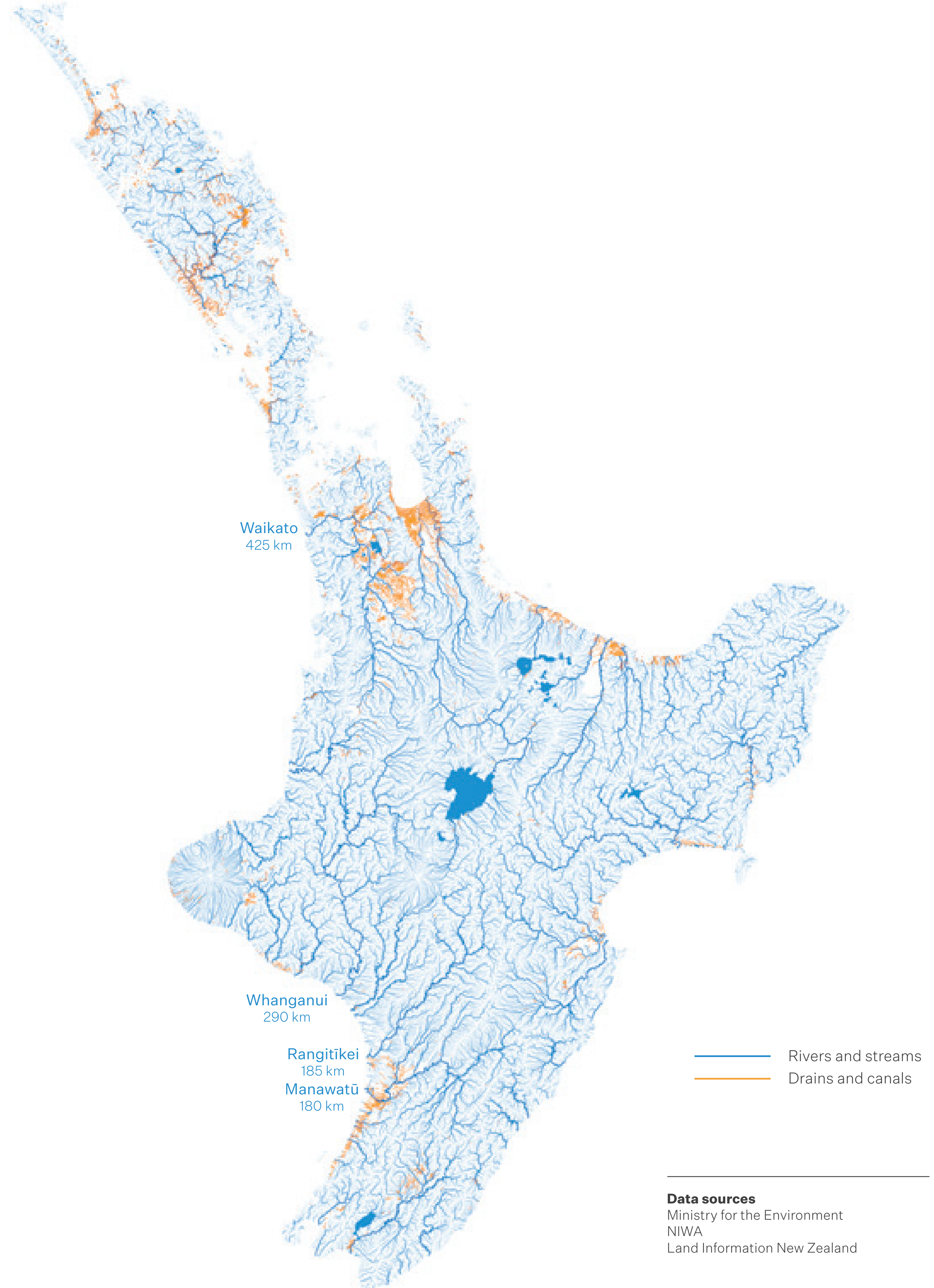
Rivers and Channels

High rainfall and rough terrain make Aotearoa a land of many rivers. These waterways form distinct patterns in different parts of the country. Short streams are prevalent in Northland and the Coromandel Peninsula. The Whanganui, Rangitīkei and Manawatū carve gorges through southern North Island hill country. Wide, braided rivers weave across the Wairau and Canterbury plains, their headwaters high in the Southern Alps.

Not all of the country's waterways are natural. Canals and drains criss-cross agricultural regions. Some provide irrigation; many are part of regional flood protection schemes.

These maps are reminders that distant places are often connected. Water and sediments move from the highlands down to the sea. What happens in one part of a catchment flows downstream, affecting people and environments far from the source.





Data sources
Ministry for the Environment
NIWA
Land Information New Zealand

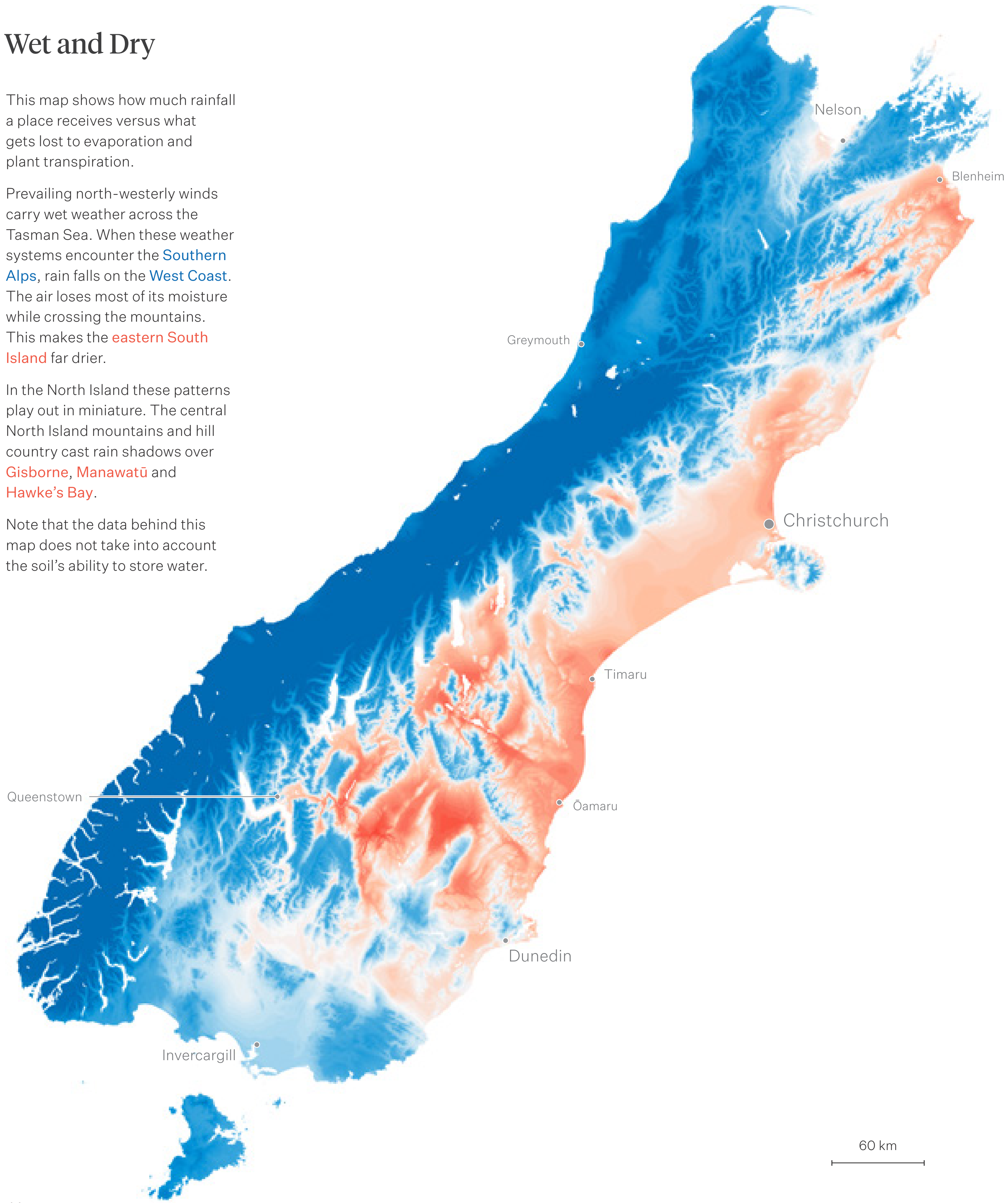
Wet and Dry

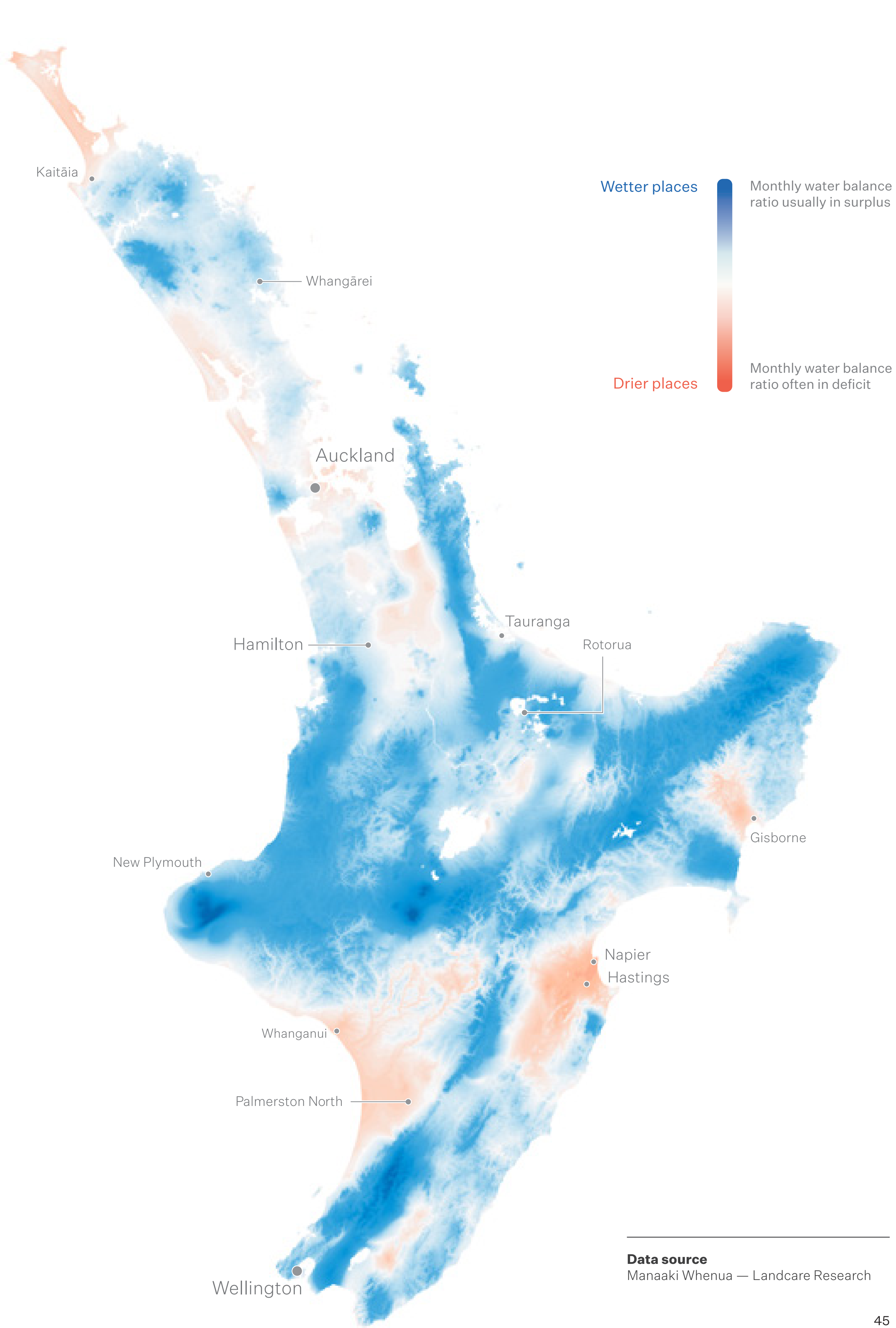
This map shows how much rainfall a place receives versus what gets lost to evaporation and plant transpiration.

Prevailing north-westerly winds carry wet weather across the Tasman Sea. When these weather systems encounter the Southern Alps, rain falls on the West Coast. The air loses most of its moisture while crossing the mountains. This makes the eastern South Island far drier.

In the North Island these patterns play out in miniature. The central North Island mountains and hill country cast rain shadows over Gisborne, Manawatū and Hawke's Bay.

Note that the data behind this map does not take into account the soil's ability to store water.





Data source
Manaaki Whenua — Landcare Research