

KAREN DENYER & MONICA PETERS

Life in the Shallows

The wetlands of
Aotearoa New Zealand

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Foreword

WHEN I READ BOOKS like this one, I immediately lose a lot of time: hours, days or even more. I just can't help myself. Wetlands are places of endless fascination to me, and reading these stories instantly takes me on a virtual, dry-footed wetland tour. But this book isn't just for people who love nature and science, it's also for people who love people. It cleverly blends the weird and wonderful (and often hidden) features of our bogs, swamps and estuaries with stories about the very people who work to reveal their secrets.

When we hear the word 'scientist' it's easy to defer to the old stereotype — white lab coats and thick-rimmed glasses. This book will utterly dispel that image! You will read about people venturing into the wilderness in waders or kayaks, grappling with slippery apex predators or ornery giant herons, and coming up with clever ideas to make a fish feel at home. You will also read about researchers connecting with local hapū and community volunteers, pooling their knowledge and drawing on mātauranga Māori to learn about our wetlands and how to protect or restore them.

The scientists profiled here are a mere sample of New Zealand's scientific talent, but nonetheless impressive. The chapter themes weave and meander like a braided river, but blend together perfectly to accurately sketch the facets of 'a day in the life of a wetland scientist'. It paints the picture of a place where I can crawl on hands and knees, looking at life in all its glorious forms: orders, families, genera, species with associated ecosystem connections and jobs to do; organisms ranging in size from trees to microscopic and sometimes as small as e-DNA. (No wonder my 'field-trips' are usually no longer than 50 metres!)

When it comes to wetlands, New Zealand is not doing too well at all. In fact, just 10 per cent of our original wetlands are still hanging in there. Our European settlers, a product of their time, set out to cultivate the wild lands and to turn them into productive fields for pasture or crops. Thankfully we now appreciate that wetlands — those small springs, soaks, swamps, and the margins of rivers and streams and lakes — are nature's vital tools for maintaining water tables, filtering and recycling waste, pollutants, nutrients and sediment washed from the land. We also now know that functioning wetlands are right up there when it comes to sequestering carbon!

This book exposes the reason we have a National Wetland Trust in Aotearoa: modern-day *Homo sapiens* appear to have lost the operating manual for Planet Earth, and the passionate scientists of these wetland stories are doing their darndest to point us all in the direction of conservation, or better still, restoration of these life-sustaining habitats, and recognition of the traditional knowledge that can help us get there.



*Entomologist, media personality and passionate educator
Ruud Kleinpaste is the patron of the National Wetland Trust.*

This storytelling is of crucial importance to the way we teach young New Zealanders to understand that we live on a biological planet, which is run by aquatic life forms, botanical giants, fungi, birds and bats, grazers, predators, algae, snails, parasites and pathogens, lichens, barnacles, bogs and bugs.

Just think for a moment about all that life in a wetland. It started about 3.8 billion years ago and through evolution the resulting assemblies of organisms are our most senior, sacred, inspirational and perfectly adapted elders from which we can learn how to behave on this watery planet.

Let's listen to what they have to say!

Ruud Kleinpaste

Preface

Getting into Wetlands

MY ALL-TIME FAVOURITE MOVIE is Taika Waititi's *What We Do in the Shadows*. Not just because of its fabulous portrayal of our uniquely Kiwi sense of humour, but also because it almost perfectly encapsulates the livelihood of many of my colleagues featured in this book. *What We Do in the Shallows* was my personal working title for this book. Wading into amphibious ecosystems — sometimes wet, sometimes dry — or paddling around the shallow margins of lakes, ponds, rivers and estuaries is what wetland scientists do. But how many people know who they are or what their work entails?

New Zealanders are notoriously humble. It's almost a national crime to stick your head above the parapet and say, 'Look at me, look what I've done'. It's not part of the Kiwi psyche to blow your own trumpet, so to speak. Which is why most of the people featured in this book, irrespective of the incredibly significant contributions they have made to New Zealand science and wetland conservation, may be little known outside their science circle, family and friends. We certainly have scientists who are household names — Ashley Bloomfield, Nanogirl, Ernest Rutherford — but I challenge the average New Zealander to name one wetland scientist, living or passed on.

Perhaps science in general is underappreciated in Aotearoa New Zealand, or perhaps that's just true of wetlands, still shackled with negative connotations in Western society. Even in the cancel culture of the 2020s, there are still lingering images of the cartoon-like Creature from the Black Lagoon, enduring miserable European names for wetlands (Dismal Swamp, Boggy Lagoon), and Donald Trump vowing to 'drain the swamp'.

The National Wetland Trust, which championed this book, felt it was not only time to stop 'body shaming' wetlands but also to celebrate the humble, hard-working and incredibly dedicated scientists who are willing to pull on a pair of waders and head into the shallows. That is the purpose of this book: to bring wetlands, and wetland scientists, out of the shadows. It's a smorgasbord of science; a book that readers can dip in and out of and read in any order. Each chapter features a New Zealand scientist and one or more aspects of their work — new species they have discovered, novel applications of emerging technology, a better appreciation of the important role of wetlands in our landscape, and guidance on how to restore wetlands or protect their wildlife. Side boxes offer fascinating facts, and a featured wetland to visit brings the chapter to life by allowing the reader to experience some aspect of that person's research.



Karen Denyer has a life-time fascination with New Zealand's natural places. Wetlands are a particular passion of hers.

But who to include? Who to leave out? It was an incredibly hard decision, and Monica and I could fill another two books with those we left out. But, in reality, very few scientists in New Zealand work only on wetlands. Many are specialists in a particular field, and they apply that expertise variously to wetlands and other ecosystems. Dr Corinne Watts is an example; her expertise in invertebrate ecology is applied to forests, river margins, wetlands and other ecosystems. Many others, when approached with an invitation to appear in the book, hung back . . . ‘Well, I’m not really a *wetland* scientist.’

It’s a fair point. What do we mean by wetland? Even for our aquatic scientists, the default tends to be: wetlands = bogs + swamps + fens; in other words, soggy but well-vegetated areas. The legal definition in New Zealand’s Resource Management Act 1991 and indeed the international definition under the Ramsar Convention are much broader. Wetlands are places where water sits long enough, and often enough, to alter the soil, vegetation and animal communities that live there. They include permanently or intermittently wet areas, shallow water and land–water margins that support a natural ecosystem of plants and animals adapted to wet conditions. They are diverse ecosystems,

with the different types determined by their water — amount, depth, permanence, temperature, the chemicals found there — and its source, whether groundwater, surface water, rainwater or a combination of these. The book reflects this wider definition by including scientists working on a wide range of wetland types: bogs, swamps, gumlands, estuaries, lakes, rivers and even semi-frozen pools. Each scientist has fascinating stories to tell, but often most intriguing was how they got into wetlands in the first place.

I FORGET HOW OLD I was when I had my first memorable encounter with a wetland. Probably around seven or eight. I didn't actually know it was a wetland at the time. It was just a muddy, mucky mangrove swamp that stood between me and a challenge.

With my childhood buddy and co-conspirator Michael — a fellow fearless adventurer — we slogged our way through the mangroves on the banks of the Whau River in West Auckland. Our goal? To swim to the other side. We didn't make it across, but we did survive to write about it.

I don't remember how we got out of the current, but I do recall slinking back home, covered in mud, legs bloodied from barnacle-sharpened mangrove roots, faces streaked with frightened and guilty tears, sneaking round to the outdoor hose at Michael's house to wash away the evidence. As far as I know, neither of us ever told our parents.

My Whau River adventure was the sort of experience that could scar a person for life (and not just from those sharp barnacles). Wetlands didn't really factor in my life again until high school science expeditions, back to the muddy mangrove forests, but with a better appreciation for their positive values. Even with an intense interest in ecology and conservation, wetlands still weren't really front of mind for me when I studied science at university. Marine biology, as ever, was totally cool, and definitely my career path, until the cold reality hit me — it's your *job*, you *have* to go scuba diving when the weather is rubbish, or when you're tired, or hungover, or in murky, uninviting water. Plan B was a career in something on slightly more solid ground. There was one paper on limnology (lakes) where I learnt the name *Vallisneria australis* on a field trip to Auckland's Lake Pupuke, but next to nothing about wetlands. I came out with a double major in botany and zoology, and went straight into forest ecology.

I got into wetlands, in both senses of the word, when I took a job at what was then called Environment Waikato (now the Waikato Regional Council). The Waikato is 'wetland central' for New Zealand. Just about every type of wetland can be found here, including geothermal and plutonic (underground) wetlands. It has three of our seven internationally recognised Ramsar wetlands, and one of the nation's largest proportions of remaining wetlands. Little wonder then that many wetland experts are based in the Waikato or have conducted research here, which is perhaps why it features a little heavily in this book.

This was where I was inducted into the world of wetlands. It was where I bought my first pair of waders, and where I first got lost in a wetland (with two other women, and thank goodness we had chocolate with us!). It was where I first met incredible Māori wetland scientists and learnt to think beyond biology. It was where I learnt that Aotearoa

New Zealand has fish that can breathe through their skin, plants that eat insects, aquatic micro-organisms that can withstand 120°C. It's also where I first heard the word 'repo', despite leaving high school with a Sixth Form Certificate in te reo Māori.

AT THE TIME OF PUBLICATION, New Zealand universities still don't have any dedicated degrees for would-be wetland scientists. You might graduate with a BSc in ecology, and a few aquatic papers under your belt; but while you can get a degree in marine biology, even today few New Zealand universities offer a wetland-centric undergraduate degree.

To encourage more students to consider researching wetlands for their Master's degree, the National Wetland Trust established the Golden Plover Wetland Research Award, a small financial incentive, recently doubled in value through a partnership with the New Zealand Freshwater Sciences Society. Despite being open to post-graduate researchers across the country, there are still some years with no applications.

Things are slowly changing. Wetlands were given strong legal protection in a new environmental law in 2020, and the University of Waikato is developing bilingual multimedia educational resources based on New Zealand wetland research. But there are still so many things we have yet to learn about our wetlands. Many wetland species are cryptic (rarely seen), or tiny. Few undamaged wetlands remain to tell us what they were once like, to guide restoration goals. Māori knowledge, built from centuries of interacting with, living in and collecting resources from wetlands, has the potential to radically improve wetland management in Aotearoa, but there is a lot of work to do to integrate mātauranga Māori into all restoration projects, while respecting intellectual property and cultural knowledge.

It is our hope that the stories so generously shared by the scientists featured in this book, including their personal insights, their highlights and even their 'oopsie' moments, will encourage a greater investment in wetland science at our universities. We also hope it will inspire a new generation of future scientists to get into their gumboots, muck in and carry on the quest for knowledge about New Zealand's wetlands.

Writing about people you know as peers, hearing their backstory, learning about their pathway into science and hoping to capture just a little bit of their personality as well as their science in each chapter, has been a thoroughly humbling and enjoyable process. We hope these stories will inspire everyday New Zealanders to explore the wetlands in their backyard, to experience what motivates our wetland scientists, and to learn more about the significant cultural, spiritual, recreational and ecological value of what the late Gordon Stephenson, founder of the National Wetland Trust, called our 'shy places'.

Karen Denyer

Preface

Engaging Communities

Ko Rangitoto te maunga te rū nei taku ngākau.
Ko Tāmaki te awa e mahea nei aku māharahara.
Nō Tāmaki Makaurau ahau.
E mihi ana ki ngā tohu o nehe, o Kirikiroa e noho nei au.
Ko Monica Peters ahau.

Rangitoto is the mountain that speaks to my heart.
Tāmaki is the river that alleviates my worries.
I'm from Auckland.
I recognise the ancestral and spiritual landmarks of Hamilton where I live.
My name is Monica Peters.

MANY OF THE SCIENTISTS in this book honed their research skills and shaped their careers from a young age. My pathway has been much more eclectic, with years spent zigzagging between fine arts, conservation and international development. I eventually did study science, but not before volunteering in ever more remote places. From Te Hauturu-o-Toi Little Barrier Island to Raoul Island in the Kermadecs, to Malaysian Borneo and then Mongolia, my roles ranged from habitat-control volunteer to expedition artist. I've always seen art and science as different lenses through which to explore and understand the environment. I knew I wasn't cut out to specialise in one tiny area of either, but not because delving into detail isn't my thing. For science, in particular, I saw that to really make a difference it needs to be positioned within a sociocultural, economic and political setting. Unless it's relevant to society and decision-makers, science won't be picked up and applied. I also saw that an increasingly big part of doing science is how well it can be communicated to a broad and varied audience. And creativity is a big part of communication.

In my work — which sits at the interface between science, the public and conservation — the word 'community' crops up a lot. It's a convenient catch-all term that describes a group of people who have something in common. Community could easily be applied to the scientists in this book — they're united by a shared passion for learning about wetlands. Collectively, they're unpacking the mysteries and complexities of these extraordinarily diverse ecosystems: how wetlands work; the fascinating life within them; how we understand, value



Monica Peters applies her skills in conservation, research, international development and fine arts to understand our environment and our relationship to it.

and manage them; and how to right the wrongs of their past mismanagement. Most of the scientists profiled have worked together in one way or another. But perhaps what's not fully appreciated is how many of these scientists encourage, advise and support community groups all around Aotearoa New Zealand to restore their local wetlands and surrounds — and vice versa. How many of these scientists may have benefitted from community environmental groups with decades of hands-on wetland restoration experience?



Community groups and citizen scientists are adopting wetland monitoring techniques used by professionals to track the state of wetland health.

But it's not just scientists who study wetlands. Our understanding of these soggy sites and their inhabitants has been built on a much wider body of knowledge. This includes people with no formal science training but who are naturally curious, have a keen eye and appreciate the need to study, document and learn from nature. When people without formal science qualifications or who don't work in a science-based profession do science, they're commonly called citizen scientists. This includes backyard bird surveys, keen amateur botanists uploading their observations to iNaturalist,* and those who volunteer to regularly monitor stream water quality.

Citizen science, a particular passion of mine, is an umbrella term that covers community-based environmental monitoring. There are synergies between mātauranga Māori (traditional knowledge) and citizen science with data collection, analysis and the co-production of new knowledge commonly featuring in both. However, an important difference lies in provenance: mātauranga Māori is embedded in the Indigenous worldview of Te Ao Māori, while citizen science is built on the foundations of Western thinking. As both a social movement and a collaborative research method, citizen science often takes a more holistic approach to science-based studies, incorporating community engagement, education and outreach alongside data collection. It also complements the work of scientists: there simply aren't enough scientists to carry out the research needed to better understand and manage our environment.

We don't really know how many community groups are scattered throughout Aotearoa working to restore wetlands. We do know that it takes a phenomenal effort to haul degraded wetlands back from being unloved and uncared for, to being places that are a safe haven for our native species and amenable to visit. Sure, years of dedicated weeding, planting and controlling introduced predators (and sometimes putting the actual 'wet' back into the wetlands) typically produces a profound visual change — more water, cleaner water, lush native plants and secretive wetland birds slowly reappearing. But have the years of hard work resulted in a net gain in native species biodiversity? Nationally, the trend for our unique, quirky and remarkable indigenous species still shows a steady downward trajectory.

For my PhD I asked 296 community groups to describe their restoration objectives.¹ Many were very general — 'restore biodiversity', 'bring back native birds'. To better understand how they measured progress towards achieving their restoration objectives, I also asked them about their monitoring programmes. Did they use any science-based methods? If no, why not? If yes, did they measure the direct outcomes of their efforts, such as the numbers of predators trapped (rats, possums, stoats, cats, hedgehogs)? Or did they measure the indirect outcomes of their work, such as changes in birdlife or lizards resulting from their predator control? The difference is important: one paints a picture of what and how many introduced predators there are in the landscape; the other reveals whether reducing predator numbers is actually making a difference to our native species.

I'm still passionate about developing a more nuanced understanding of the institutional, bureaucratic and social barriers that hinder or block groups' monitoring efforts and

* See <https://inaturalist.nz>.

encouraging a culture where their data are valued more widely. Their data could, and should, be used to help flesh out how we, as a nation, are faring with respect to enhancing our indigenous biodiversity. Quantifying what community groups have achieved is important, because I (and many others working in the conservation sector) know through years of observation that their work is significant. Many of the wetlands we have left would be much worse off if it weren't for community groups and those organisations and individuals that support them: the National Wetland Trust and other environmental NGOs, funders and the science/technical advisors in councils, the Department of Conservation, universities and consultancies.

CREATING RESOURCES TO HELP COMMUNITY GROUPS manage wetlands means sweeping away desiccated formal language, jargon and tight stylistic conventions to create content that can be understood and then applied. I've had plenty of opportunities to put this philosophy into practice with my colleagues.

Working with Dr Beverly Clarkson (Manaaki Whenua — Landcare Research) to bring together *Wetland Restoration: A Handbook for New Zealand Freshwater Systems* (2010) was a matter of fortuitous timing.² We were already working on an experimental wetland restoration project translocating rare restiads (rushes) to new sites in the Waikato,³ when the opportunity arose to revamp a much earlier version of the handbook. The content was due for a major makeover to reflect new developments in the field and, importantly, to expand readership from technical experts to community wetland restoration practitioners.

In the updated version, experts each contributed a chapter on one aspect of wetland restoration, and each also included a case study of a community group's project(s) and achievements. A rich array of photos, diagrams and illustrations were also added. Several years later, colleagues at Manaaki Whenua used the design template of the handbook for two further publications, *Te Reo o Te Repo: The Voice of the Wetland* (2017)⁴ and *Te Reo o Te Repo: Kei Konei Tonu Au* (2021). Both are grounded in Māori culture and values, and expand on the mahi (work) of restoring wetlands.

I've previously joined forces with Karen Denyer on projects where we've turned techno-speak into everyday language. It started with the 2014 Wetland Monitoring and Assessment Kit (WETMAK).⁵ With more community groups restoring wetlands, an ecosystem-specific guide was desperately needed to help them measure change over time — both big picture (for example, carrying out a 'wetland warrant of fitness') and fine grain (such as surveying for weeds). Karen, as an ecologist skilled at working with communities, drove the science component of the project, developing modules written in everyday language. I wrangled funding and designed two 'how to' videos (vegetation plots and photopoints). We carried out WETMAK training for community groups around Aotearoa and taught groups' agency supporters how to use each module. In the meantime, technology has marched ahead, so the paper templates for data entry seem quaint. It's a project that's waiting to be modernised: an app to speed data entry and

instantly visualise and share results would be ideal. That's one we'd still love to tackle!

Broadening the citizen science theme, we again collaborated (this time with Peter Handford of Groundtruth*) to develop the grandly titled: *Auckland Community Ecological Monitoring Guide* (2018).⁶ It's a framework designed to help environmental restoration groups choose science-based monitoring protocols. Monitoring can be a complicated business for non-scientists: What do we monitor? Why? Which protocol should we use? Why this one and not that one? We researched these questions with groups as well as council staff who support community groups, and brought together 42 established environmental monitoring protocols. They cover all ecosystem types, but none need specialist expertise, expensive equipment or iron-clad health and safety plans. So, electrofishing didn't make the cut, but gauging fish diversity and abundance by spotlighting at night did. We developed a set of 11 criteria that groups and council staff could systematically work through to find the protocol that best matched their project objective, skill level, time commitment of group volunteers and, of course, budget.

Developing resources and sharing information are integral to broadening and strengthening the network of people who research, restore, manage and protect our remaining wetlands. But so is meeting face to face. The National Wetland Trust symposia have become a who's who of wetland restoration — the biannual event draws together not only scientists but also citizen scientists, mātauranga Māori specialists, landowners, policy makers and dedicated community group members.

I'd like to mihi (give thanks) to not only the scientists Karen and I are proud to have cajoled into sharing their career highlights, specialist knowledge and field anecdotes with us to create this book, but also those restoring their local wetlands and surroundings — the farmers, landowners, iwi, community groups, trusts, schools and others. As much as we need science to underpin the work on the ground, we need the people on the ground doing the hard yards — restoring wetlands takes persistence, dedication and experimentation. We need the research of both scientists and citizens, we need communities that are supported by scientists, and we need scientists who are willing to listen and to learn from communities.

Monica Peters

* See <https://trap.nz>.

Introduction

The Wetlands of Aotearoa New Zealand

LET'S BE HONEST, it rains a lot in Aotearoa New Zealand. According to NIWA (National Institute of Water and Atmospheric Research Taihoro Nukurangi), most areas of the country receive between 600 and 1600 millimetres of rainfall each year. That's an average. Te Tai Poutini, the West Coast of Te Waipounamu South Island, can have more than 4 metres of precipitation per year. All that rain needs somewhere to go. Much of it flows out to sea, but in low-lying areas, basins, and land blocked off by dunes or gravel bars, it forms freshwater or semi-salty wetlands.

Just how you define a wetland appears to depend on who you are talking to. The authors of the latest calculations of the amount of wetland area in New Zealand, who titled their paper 'Revised Extent of Wetlands in New Zealand', define them as 'terrestrial ecosystems that are permanently or intermittently wet' and exclude saline wetlands such as estuaries.¹

The International Convention on Wetlands* takes a broader view, defining wetlands as 'all lakes and rivers, underground aquifers, swamps and marshes, wet grasslands, peatlands, oases, estuaries, deltas and tidal flats, mangroves and other coastal areas, coral reefs, and all human-made sites such as fish ponds, rice paddies, reservoirs and salt pans'.

New Zealand law is relatively vague. The Resource Management Act 1991 defines wetlands as 'permanently or intermittently wet areas, shallow water, and land water margins that support a natural ecosystem of plants and animals that are adapted to wet conditions'. This definition could potentially apply to a poorly maintained gutter depending on how you define 'natural ecosystem', which the Act does not do.

A national wetland classification developed for New Zealand identifies nine hydrosystems (including saline) and nine wetland classes, differentiated by water source, substrate and nutrient status.² The compilers of the directory of New Zealand wetlands link these hydrosystems and classes to processes that formed them: 'rivers and bogs from

* The full name of the convention is the Ramsar Convention on Wetlands of International Importance Especially as Waterfowl Habitat. See www.ramsar.org.



From the mountains to the coast, Aotearoa has a diverse range of wetland types. The alpine tarns pictured here are at Key Summit, on the Routeburn Track in Fiordland National Park.

frequent rain; lakes from glaciation and volcanic actions; swamps from the deposition of erosion products by rivers and the sea; estuaries and lagoons from tidal flooding of old Pleistocene valleys'.³ Less common, or naturally rare, wetland types include ephemeral kettle holes formed on glacial moraines, and geothermal wetlands.

Most of the freshwater wetlands found in Aotearoa today formed at or after the end of the last glaciation, about 18,000 years ago.⁴ As the world warmed up, the glaciers melted, forming herbaceous fens.⁵ By the time humans arrived about 800 years ago, they had developed into either wooded swamps dominated by conifers including kahikatea (white pine, *Dacrycarpus dacrydioides*) and manoa (silver pine, *Manoa colensoi*), or extensive bogs dominated by rush-like restiads (*Sporadanthus* and *Empodisma* species) and *Sphagnum* mosses.

Prior to the arrival of humans, about 10 per cent of the landscape was freshwater wetlands.⁶ In addition, the nation has mapped 425,000 kilometres of rivers and streams,⁷ and more than 50,000 lakes. Today, wetlands occupy only a small part of New Zealand — less than 1 per cent of the total land area. Extensive and repeated burning of the woody vegetation drastically altered catchment hydrology, resulting in wetter, herbaceous wetlands of harakeke (flax, *Phormium tenax*), raupō (bulrush, *Typha orientalis*) and rush and sedge species (for example, *Carex*, *Juncus*, *Cyperus* and *Machaerina*). Drainage later caused the total loss or fragmentation of these wetlands, with many of the remnants invaded by introduced species, including tree willows (*Salix* species). The latest figure for the extent of freshwater wetlands with emergent vegetation (technically termed 'palustrine') in New Zealand is now calculated at 249,214 hectares, or 10 per cent of the pre-human extent.⁸ In addition, many of the lakes, lowland rivers and estuaries are affected by pollution, introduced plants or animals, channelisation, infilling, impounding or water diversion.



LEFT: *Kāmāna* (crested grebes) are a diving bird that inhabit South Island alpine and sub-alpine lakes. **RIGHT:** The red percher dragonfly, *Diplacodes bipunctata*, is the smallest of New Zealand's 14 species of dragonfly.

As to what animals live in New Zealand wetlands, it's mostly birds, invertebrates and fish. Long-tailed bats are known to forage along the edge of wetlands, and some skinks and geckos inhabit wooded wetland areas, but native frogs, mammals and reptiles are not generally considered wetland species in New Zealand.

Around 55 native bird species regularly inhabit or use freshwater or coastal wetlands.⁹ These include the Australasian crested grebe (*Podiceps cristatus australis*); matuku (Australasian bittern, *Botaurus poiciloptilus*); herons (*Ardeidae* species); royal spoonbill (*Platalea regia*); ducks, including pūtangitangi (paradise shelduck, *Tadorna variegata*) and *Anas* species; a rail — mioweka (banded rail, *Gallirallus philippensis assimilis*); crakes (*Porzana* species); and pūkeko (purple swamp hen, *Porphyrio melanotus*). Large numbers of migratory bird species, including Pacific golden plovers (*Pluvialis fulva*), red knots (*Calidris canutus*) and bar-tailed godwits (*Limosa lapponica*), seasonally visit New Zealand wetlands to feed on intertidal areas.

A similar number of freshwater fish (53, with others yet to be formally described)¹⁰ reside in lakes, rivers and swampy areas, and many also spend time in estuaries or the ocean as part of their migratory lifestyle. One group, waikaka (mudfish, *Neochanna* species), are adapted to living in dried-up pools and tributaries, and are capable of burrowing into mud for extended periods and 'breathing' through their scale-less skin.

The third major group to inhabit aquatic ecosystems is the invertebrates. In lowland wetlands, midges (Chironomidae), aquatic mites (Acarina), copepods, nematode worms and ostracods are abundant.¹¹ Other species commonly found include flies (Diptera), wasps, bees and ants (Hymenoptera), beetles (Coleoptera) and bugs (Hemiptera).¹² Many are new to science, including the stem-boring moth *Houdinia flexilissima*, which is host-specific to the nationally threatened giant cane rush *Sporadanthus ferrugineus*.

While healthy wetlands are undoubtedly important habitat for native species, they

SINKING CARBON

Wetlands play a crucial role in climate change. Globally, peatlands store around twice as much carbon as all the forests of the world.

In Aotearoa, Dr David Campbell (right, holding a peat core) and his students at the University of Waikato have been measuring carbon dioxide fluxes, to determine whether the 10,000-hectare Kōpuatai peatland in the Waikato region is a carbon sink or source. The research team found that for more than 10,000 years, plants have been continuously taking up carbon dioxide from the atmosphere and converting it into organic matter, stored away in perpetuity as peat.

Kōpuatai accumulates carbon at four to six times the rate of northern hemisphere bogs — in recent years, as much as 2 tonnes per hectare.¹³

While healthy Waikato bogs are net carbon sinks, drained peatlands are a significant carbon source. Campbell's team estimate that in a dry year, the total area of drained Waikato peatlands might emit around 2 megatonnes of carbon dioxide per year — equivalent to about 25 per cent of the region's agricultural emissions.¹⁴ It is expected that globally many peatlands will release carbon if the climate warms and dries.



perform many additional crucial roles in the landscape. The things they do for us free of charge is staggering — stripping nutrients and silt, storing floodwaters and recharging aquifers, to name a few. They are also, finally, now being recognised for their potential to act as carbon sinks. The dollar value of the 'ecosystem services' that wetlands provide is ten times more than either farmland or forest.¹⁵ Addressing the legacy of wetland loss in Aotearoa will require increased understanding of their ecosystem services and their cultural and ecological value, and novel approaches to reconnect people with aquatic habitats. Many of the wetland scientists featured in this book are doing just that, but it doesn't stop with the research. Applying their findings to proactive wetland protection and restoration, and investigating sustainable practices such as paludiculture, will become increasingly important to support the many iwi-, agency- and community-led initiatives aiming to restore and protect our vulnerable and valuable wetlands.



POLLUTE OR PALUDE?

Paludiculture is the practice of farming land that is wet — cultivating species that are adapted to a waterlogged environment. Thousands of hectares of peatland in Aotearoa have been drained for farmland, releasing large amounts of carbon, and polluting waterways with livestock effluent and fertiliser run-off. Instead of constantly pumping water from former peatland, Dr Brian Sorrell (Aarhus University, Denmark, formerly NIWA), shown in the field above, believes we should look at research and trials to re-wet New Zealand’s drained lowlands and transform them to sustainable paludiculture.

This isn’t fanciful. Māori have a long history of sustainably harvesting natural materials from wetlands, putting them to a wide array of uses, and commercial-scale paludiculture is already starting to happen overseas. Sorrell says the only way to stop massive loss of carbon from farmed peatland is to reflood it. The carbon dioxide released from drained farmland is not included in New Zealand’s greenhouse gas budget at the moment — but Sorrell thinks it should be, and says there will be more international and domestic pressure for this to happen. He says, ‘There’s a choice after flooding: the site could be returned “to nature” and [you can] compensate the farmers by buying their land — that’s the approach used in Denmark . . . but larger countries including Germany, Holland and Poland are going down the paludiculture track as well.’¹⁶

He believes there is great potential in areas like the Hauraki and Southland plains to re-wet drained peatlands that currently rely on expensive floodgates and pumps, or ever-deepened artificial drains, to support farmland. ‘Then we plant commercial crops of native wetland plants — raupō, purua grass, kuta — and sustainably harvest them. You can use them for a whole range of things . . . biofuels, particle board, paper . . . [There are] lots of possibilities to produce valuable biodegradable commodities to replace plastics, synthetic rubber and toxic insulation. Paludiculture would sit well with the Aotearoa clean green ethos.’

New Zealand Wetland Systems*

A national classification of New Zealand wetlands includes the full range of wetland types covered by the Ramsar Convention on Wetlands, and is presented in the book *Wetland Types in New Zealand* (2004).¹⁷ The classification is a family-tree in which hydrosystem, the broadest grouping sits at the top. New Zealand hydrosystems include palustrine (freshwater wetlands with emergent vegetation); lacustrine wetlands (lakes, tarns and their margins); riverine wetlands (rivers and streams); estuaries; geothermal wetlands; and plutonic (underground) wetlands.¹⁸

Palustrine wetlands

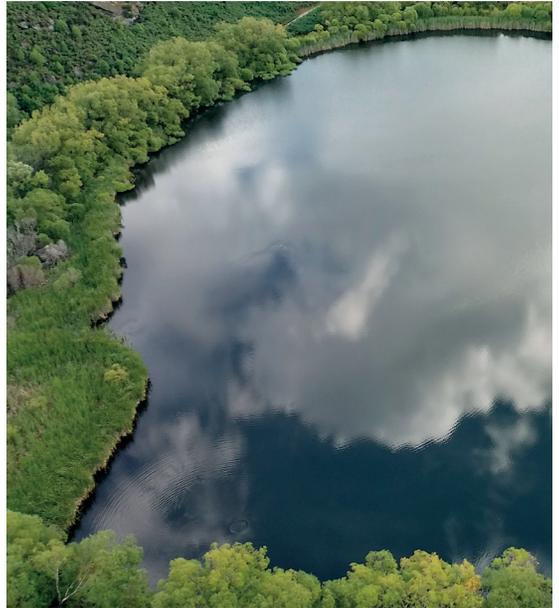
Bogs, fens, swamps and freshwater marshes are types of palustrine wetland. Bogs receive all their water from rain, so they are not enriched by nutrients from adjacent land or underlying mineral soils. Being almost constantly waterlogged, they are poorly aerated and usually acidic. They support a unique community of plants, including mosses, lichens, cushion plants, jointed rushes, wire rush, giant cane rush, orchids, sundews, pink pine and manoa (silver pine). They also host mātātā (fernbirds), native fish, and several unique species of moth. Fens also have a peaty substrate but being on slight slopes or at the edges of raised bogs, they receive groundwater and some nutrients from adjacent mineral soils and have a slightly higher nutrient status than bogs. Fen vegetation includes tangle fern, sedges, tall herbs, tussock grasses and mānuka.

Swamps are fertile wetlands that occupy basins, valley floors, deltas and plains. They are fed by both groundwater and abundant surface run-off, so receive a regular supply of nutrients and sediments from adjacent land. Typical plants include sedges, rushes, reeds, harakeke, tall herbs and mānuka, often intermingled, and also forest trees such as kahikatea, pukatea, maire tawake and tī kōuka. Freshwater marshes are better drained than swamps, and occur on valley margins and the edges of water bodies. They typically support rushes, grasses, sedges and herbs.

Lacustrine wetlands

Lacustrine wetlands are associated with lakes and ponds and their margins. Vegetation includes submerged macrophytes (large-leafed plants), suspended diatoms and algae, and floating ferns or herbs. Edge vegetation includes tall reedlike plants such as kūwāwā (lake clubrush, *Schoenoplectus tabernaemontani*), kuta (*Eleocharis sphacelata*), raupō and wīwī (jointed twig rush, *Machaerina articulata*). Lakes can be associated with peat (for example, Rotopiko in the Waikato), sand dunes (such as Lake Wainamu in West Auckland), lagoons (such as Te Waihora Lake Ellesmere in Canterbury), impounded rivers (including the Waikato hydroelectricity lakes), volcanoes (such as the Rotorua Lakes) or glaciers (such as Te Manahuna Mackenzie Basin and Nelson Lakes National Park).

* Derived with permission from the National Wetland Trust website, www.wetlandtrust.org.nz/what-we-do/resources/types-of-wetlands.



Wetland types in New Zealand. CLOCKWISE FROM TOP LEFT: Riverine scroll plain, palustrine swamp, lacustrine tarn, estuarine mangrove forest.

Riverine wetlands

Riverine wetlands are associated with flowing water in rivers or streams. They include riverbeds that support algae and submerged aquatic plants; temporary wet areas of braided rivers, where kakī (black stilts, *Himantopus novaezelandiae*) feed; and swampy backwater wetlands behind river levees. The cool, clear water of the South Island's Te Waikoropupū Springs, which feed the river of the same name, support abundant submerged aquatic plants.

Estuaries

Estuaries are embayments where freshwater flows into intertidal areas, resulting in a mix of fresh, salt and brackish water. In northern New Zealand, a single species of mangrove (*Avicennia marina* subsp. *australasica*) is the dominant plant of this habitat, but where frost restricts its distribution wīwī (sea rush, *Juncus kraussii*) and oioi (jointed wire rush, *Apodasmia similis*) form extensive swards. At estuary edges, or within the influence of windborne salt spray, wave splash or groundwater intrusion, are salt meadows with tiny herbs, including shore primrose (*Samolus repens* var. *repens*), glasswort (*Salicornia quinqueflora*), remuremu (*Selliera radicans*), bachelor's button (*Cotula coronopifolia*) and the rare Māori musk (*Thyridia repens*), edged by taller mānuka, harakeke and marsh ribbonwood (*Plagianthus divaricatus*). Estuarine mudflats are vital habitat for thousands of migratory and resident wader birds.

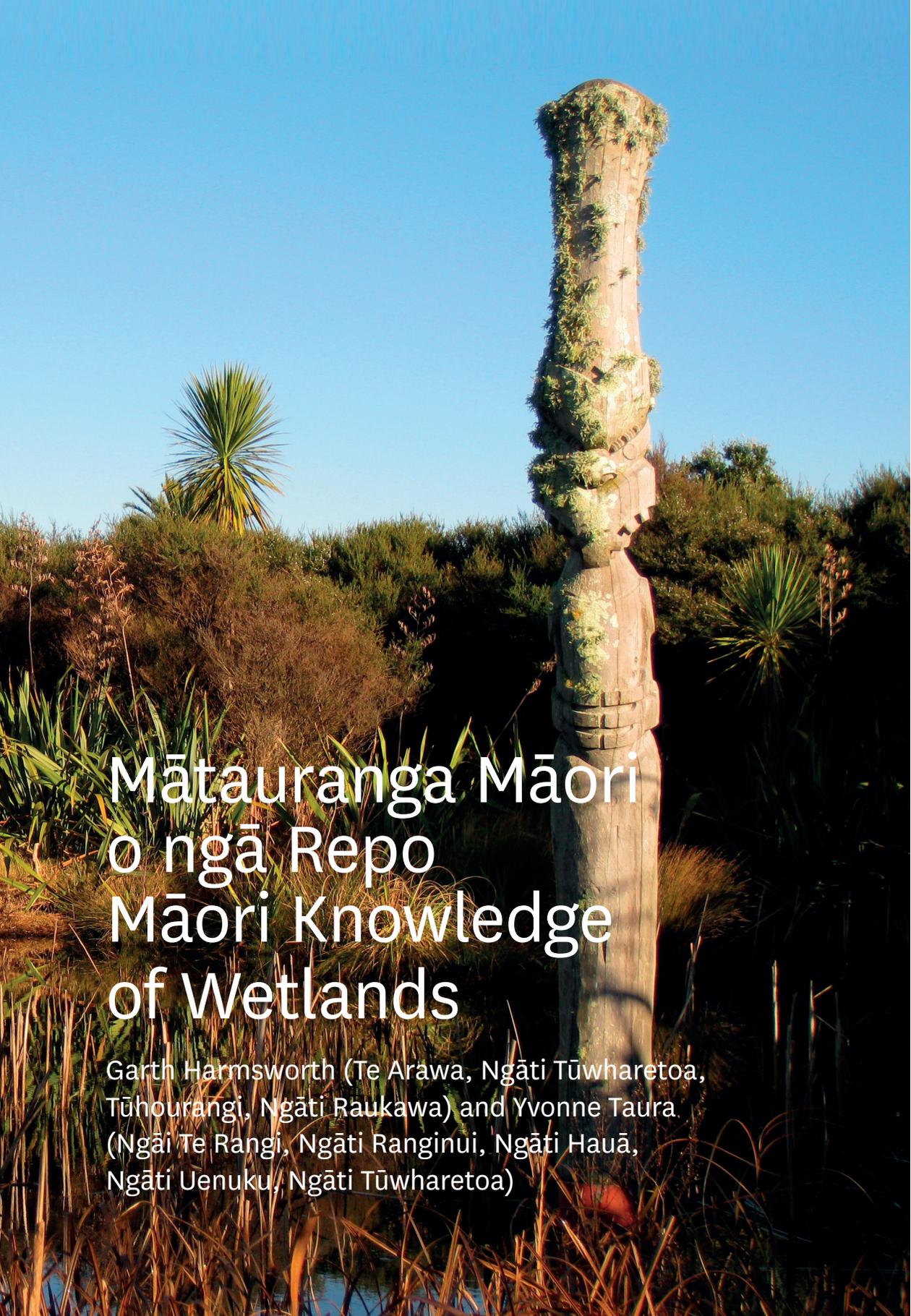
Geothermal wetlands

Geothermal wetlands are influenced by superheated water and/or mud, hot springs, thermal streams and geyser run-off sites. Two frost-tender fern species, *Cyclosorus interruptus* and *Thelypteris confluens*, survive in the warm, steamy environment of New Zealand's geothermal wetlands in the Waikato and Bay of Plenty regions.

Plutonic wetlands

Plutonic wetlands are underground waterways. Being too dark for plants to grow, they are inhabited by fungi, microbes, insect larvae and some fish species. They occur mainly as caves and underground streams in limestone country, but also as caves in lava tubes and as aquifers. Such wetlands are best viewed on guided cave tours such as in Waitomo and Tākaka.

There is also a range of smaller-scale specialised wetland types throughout New Zealand, including ephemeral (temporary) wetlands and nival (snow-derived wetlands).



Mātauranga Māori o ngā Repo Māori Knowledge of Wetlands

Garth Harmsworth (Te Arawa, Ngāti Tūwharetoa,
Tūhourangi, Ngāti Raukawa) and Yvonne Taura
(Ngāi Te Rangi, Ngāti Ranginui, Ngāti Hauā,
Ngāti Uenuku, Ngāti Tūwharetoa)

INDIGENOUS MĀORI HAVE BEEN observing and interacting with their environment for centuries. Te Ao Māori, the traditional Māori worldview and belief system, acknowledged a natural order to the universe, built around the living and the non-living, with the central belief that all parts of the environment were interrelated or interdependent through the domains of ngā atua or departmental gods. Traditionally, Māori believed that small shifts in the mauri or life force of any part of the environment — for example, through use or misuse — would cause shifts in the mauri of immediately related components, which could eventually affect the whole system.

All activities and relationships with the environment were governed by mythology, religion and Māori values. Within this framework spiritual qualities guided resource use through an elaborate system of ritenga or rules, with goals to regulate and sustain the well-being of people, communities and natural resources. Guiding values and concepts included kaitiakitanga (to care for, guardianship), tapu (sacred), mauri (life force), rāhui (temporary ban), mana (having status), noa (without restriction) and wairuatanga (the spiritual dimension).¹

Water is fundamental to all life on Earth. For Māori, water is the essence of life, well-being and identity: Ko wai ko au, ko au ko wai (I am water, water is me). This important whakataukī (proverb) asks not only who am I, but also who are my waters. It stresses an interconnection with water and the importance water gives to Māori cultural identity and survival. However, only about 2.5 per cent of the total water in the world is freshwater, and 99 per cent of all freshwater is frozen or underground.² This places in perspective the vital role wetlands play in our planet.

Besides life itself, freshwater wetlands provide significant ecosystem services, customary resources and biodiversity values.³ Wetlands are regarded by Māori as taonga (treasures), with historical, cultural, political, economic and spiritual significance. Many words are used to describe a wetland, one of the most common being repo. Repo are reservoirs of mātauranga Māori (Māori knowledge), well-being, resources and technology. They are sites of ceremonial activity (for example, wai tohi; see Table 1) and customary use, and support a range of activities, such as kaukau and kautāhoe (swimming and bathing), and waka ama (canoe regatta). As well as being mahinga kai (traditional food-gathering sites) used by local communities and marae, including whānau, hapū and iwi, they provide significant habitats for a large range of taonga plants and animals — fish, birds, reptiles, insects and micro-organisms. They therefore contain a variety of cultural resources for customary practice and technology, plants for rongoā (Māori medicines), implements and tools, and highly valued resources for raranga (weaving) and waihanga (building and construction).

In the past 150 years, more than 90 per cent of repo in Aotearoa New Zealand have been destroyed, and remaining repo are under threat from further land modification and other human activities. Māori have had to adjust to rapid changes in their cultural

landscape, and the effects of colonisation and oppression on their culture, and they now look to a future in which they can have a greater say in the management of precious, and degrading, resources.

This chapter introduces Te Ao Māori to give a glimpse into mātauranga Māori, providing examples of this knowledge and showing how it has been applied, particularly to environmental research and resource management in Aotearoa.

Mātauranga Māori

Mātau means ‘to know how’, ‘acquainted with’ or ‘to understand’. Mātauranga Māori or Māori knowledge systems are specific to Indigenous Māori, and the term encompasses knowledge and values that have been developed, retained and transferred through Māori for centuries — since at least 1300 CE in Aotearoa.⁴ This knowledge has developed within the natural environment, reflecting the interrelationship and interdependency between Māori and living ecosystems, and can be seen as dynamic and evolving. It therefore refers to the observations, experience, study and understanding of the world from an Indigenous cultural perspective, and is often equated with wisdom. It has its origins in Polynesian settlement, custom, activity and migration, and in Aotearoa was linked to hapū and iwi before important dialectal and specific elements became more generic, such as te reo Māori (the Māori language).

Mātauranga Māori has many definitions, covering traditional belief systems, cosmology, philosophy, custom, values, experience, observation and practice, all of which build an epistemology* that reflects ancient, traditional, historical and contemporary periods of time.⁵ It can be defined as the knowledge, comprehension or understanding of everything visible and invisible existing in the universe.⁶ It encompasses everything from the physical — such as values, including mahinga kai — through to the metaphysical — such as principles, including whakaaroaro (logic), tikanga (ethics), whakaponotanga (epistemology), kaitiakitanga (resource management) and wairuatanga (spirituality). Under te Titriti o Waitangi (Treaty of Waitangi) and government statutes, mātauranga Māori is recognised in legislation. The Wai 262 claim defined mātauranga Māori as ‘the unique Māori way of viewing the world, encompassing both traditional knowledge and culture’.⁷

A consistent theme from much of the literature is the multifaceted nature of mātauranga Māori. As with Western knowledge (knowledge brought to Aotearoa by the settler European cultures), mātauranga Māori has both qualitative aspects, including kōrero (narratives), pūrākau (ancient stories), observation, experience, interrelationships, learning, verbal data and evaluation, and quantitative aspects, such as measurement, assessment, metrics and numerical data.

* Epistemology is the branch of philosophy concerned with knowledge. Epistemologists ask such questions as ‘What is knowledge?’, ‘How is knowledge acquired?’, ‘What do people know?’ and ‘How do we know what we know?’



Waihora Lagoon in Pureora Forest Park is an ephemeral pool surrounded by podocarp forest. Mātauranga Māori, traditional Māori knowledge systems, are a vital part of the care and conservation of these special places.