Changing the Bog-Standard; repeatable solutions for Aotearoa's Peatlands

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2024 Nuffield Scholar

February 2025

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Executive Summary

Peatlands - wetland ecosystems formed over thousands of years - are one of Aotearoa New Zealand's most valuable yet underappreciated natural assets. These unique landscapes are known for their carbon-rich soils, their role in biodiversity and water regulation, and their cultural and ecological significance to Māori. They are also in crisis.

In Aotearoa, peatlands cover only around 1% of our land area, yet they store an estimated 20% of our soil carbon. That makes them disproportionately important in our response to climate change. But over 90% of our original wetlands (including peatlands) have been drained, developed, or degraded—mostly for agriculture and settlement. In their drained state, peatlands become a major source of greenhouse gas emissions, releasing CO_2 and nitrous oxide into the atmosphere as the peat oxidises. These emissions are often overlooked in national accounting, but they could represent up to 7% of our country's total footprint.

This report explores the challenge of how to care for and manage these peat-rich landscapes differently - without compromising the productivity, prosperity, and cultural connections that communities rely upon. It asks: what would it take to change the bog-standard approach?

The research draws on global literature and case studies from the United Kingdom, Germany, the Netherlands, Ireland, and Latvia, alongside New Zealand-based site visits and interviews. It explores both science-based and values-based approaches to peatland protection and restoration, with a focus on practical, repeatable solutions.

One major opportunity identified is the adoption of paludiculture—farming that works with wet conditions, rather than against them. Paludiculture involves cultivating wetland-tolerant species such as harakeke (flax), raupō (bulrush), and sphagnum moss, which can be harvested for bio-based products, building materials, or horticulture. These systems can be more climate-positive than conventional dryland farming, while opening new market and restoration opportunities. International examples show that, with the right support, wet farming can be commercially viable and ecologically regenerative.

But restoration is not just a technical exercise—it must also be a cultural and community-led process. Peatlands (*repo*) are taonga to many Māori. They have long been sources of food, fibre, medicine, and identity. Several iwi- and hapū-led projects are now leading the way in showing how wetland restoration can reconnect people to their whenua and whakapapa. These case studies demonstrate the power of combining mātauranga Māori with science, policy, and on-the-ground action.

The report identifies several key enablers needed to shift the dial:

- **Policy alignment**: clearer integration of peatlands into national climate, biodiversity, and freshwater policies, including the Emissions Trading Scheme (ETS).
- **Landowner incentives**: funding tools and long-term support for farmers and landowners transitioning to wetland-compatible systems.
- **Regional leadership**: councils and catchment groups need frameworks and support to enable wetland protection at scale.
- **Innovation investment**: research and development into new wetland-based land uses, products, and technologies.
- **Mātauranga Māori partnerships**: supporting iwi-led restoration and governance models that honour tikanga and mana whenua leadership.

The biggest challenge may be mindset. Peatlands have long been viewed as marginal land, or land that needs 'improving' through drainage and development. This report challenges that thinking. It calls on Aotearoa New Zealand to reframe peatlands as climate infrastructure, biodiversity strongholds, and cultural landscapes worth restoring.

If we want to achieve our emissions reduction goals, restore freshwater quality, and protect native species, peatlands must become a national priority. Their ability to sequester carbon, buffer floods, host taonga species, and hold cultural memory makes them one of the most strategic ecosystems we have.

This report concludes not with a single solution, but with a new starting point: What if we kept the ground wet on purpose?

That question might just change the future.

Chapter 1: Contents

Foreword

Wetlands and Peatlands have never been the easiest places to work. They're damp, complex, and often misunderstood. But through this Nuffield journey, I've come to see them not as difficult ground, but as sacred ground—both figuratively and literally.

New Zealand's peatlands are among the most significant natural assets we have. They are carbon vaults, biodiversity hotspots, and living taonga for Mana Whenua. Yet despite their value, they've been drained, developed, and largely forgotten in our policy, land use, and climate conversations.

This report reflects a journey across landscapes, both physical and intellectual—from the restiad bogs of the Waikato to the rewetted peat farms of Germany, and the cutting-edge research hubs of Europe and Aotearoa alike. It's been shaped by literature review and conversations with farmers who are rethinking how they use their land, scientists who are measuring carbon flux from bogs, and iwi who are leading the restoration of ancestral *repo*.

The views expressed throughout this report are my own and do not necessarily represent those of my current or past employers.

What I found was both urgent and hopeful. Urgent because the damage we're doing to peatlands is driving significant emissions and biodiversity loss. Hopeful because we already have the knowledge, tools, and will to do better.

This report does not offer a silver bullet, but a new way of looking at what we've long called marginal land. It suggests that peatlands, when managed well, can be part of our productivity, our identity, and our climate response—not in spite of their wetness, but because of it.

I am deeply grateful to Nuffield New Zealand, the NZRLT partners, my fellow scholars, and all those who gave their time, insight, and wisdom along the way. A special thank you to the farmers and kaitiaki who welcomed me into their whenua and shared their stories. Your leadership inspires this work.

This isn't the end of the peatland conversation. I hope it's just the start of something bolder, wetter, and wiser.

Acknowledgements

I'd like to express my heartfelt thanks to everyone who has walked alongside me on this journey into the deep, damp world of peat. The process was much like the job peat does – soaking, storing and surviving!

To Nuffield New Zealand and the New Zealand Rural Leadership Trust, thank you for believing in this kaupapa and for the opportunity to explore how a marginalised landscape could hold such outsized value - for climate, culture, and communities.
To the investing partners: Beef + Lamb New Zealand, DairyNZ, AGMARDT, Ravensdown, Ministry for Primary Industries, and Our Land and Water - thank you for your vision and support of leadership in the land-based sectors.

To my employers – Pouarua Farms, thank you for allowing me to take the time to delve into this subject and for your understanding of the importance this holds for your future business planning.

To the scientists, kaitiaki, farmers, landowners, and policy leaders across Aotearoa and around the world - thank you for sharing your time, your trials, and your truth. From the rewetted fens of Europe to the restiad bogs of Waikato, I have been humbled by the generosity with which you welcomed me and shared your mātauranga.

To the iwi and hapū who have held and continue to hold these *repo* as taonga—thank you for allowing me to learn, listen, and witness the intergenerational work of restoration, resilience, and reconnection.

A special thank you to my whānau. To my husband and children - thank you for your unwavering support and for giving me the space to dig into this topic, even when it took me away from home.

This opportunity and the people I have met from around the globe have solidified my opinion of peat – it is not marginal, it is essential – and we should treat it as such.

List of abbreviations

DOC – Department of Conservation New Zealand
ETS – Emissions Trading Scheme
GHG – Greenhouse Gas
MfE – Ministry for the Environment
MPI – Ministry for Primary Industries New Zealand
NGO – Non-Governmental Organisation
NPS-FM – National Policy Statement for Freshwater Management
NZ – New Zealand
RMA – Resource Management Act
UK – United Kingdom

Objectives

Research Objectives

1. **Characterise New Zealand's Peatlands**
   Document their distribution, key physical and ecological features, and current status.
2. **Evaluate Their Role in Carbon Storage and Climate Change Mitigation**
   Investigate how peatlands contribute to national carbon balances and their potential for emissions reduction.
3. **Identify Conservation Challenges and Threats**
   Examine anthropogenic pressures (e.g., drainage, conversion for agriculture) and natural stressors.
4. **Review Best Practices for Restoration and Sustainable Management**
   Assess successful techniques and emerging strategies, integrating insights from traditional Māori stewardship.
5. **Analyse Current Policy Framework**
   Assess existing governance and land-use policies, highlighting gaps and areas for improvement.
6. **Highlight Case Studies of Restoration and Conservation**
   Present practical examples that demonstrate successful outcomes and lessons learned.
7. **Develop Recommendations for Future Action**
   Propose strategies for policymakers, practitioners, and researchers to safeguard peatlands and enhance their ecosystem services.

Chapter 1: Introduction

Not all wetlands are peatlands – but all peatlands are wetlands…
Peatlands are wetland ecosystems characterised by the accumulation of peat – a dense, organic soil formed from partially decomposed plant material under waterlogged, anaerobic conditions. Despite covering only about 3% of the global land surface, peatlands hold a disproportionately large share of the planet's carbon. Globally, peat soils are estimated to store on the order of 550–600 gigatonnes of carbon, which is roughly twice the carbon stored in all of the world's forests combined.

This immense carbon reservoir has been built up over thousands of years, as plant material accumulates faster than it decomposes in these saturated environments. In intact peatlands, the water slows decay, leading to a net sequestration of carbon and the formation of peat layers that can be many metres thick. These ecosystems therefore function as significant long-term carbon sinks and play a critical role in regulating the global carbon cycle and climate system.

Peatlands are not only important for carbon storage but also for ecological stability and biodiversity. They are a subtype of wetlands and are among the world's most valuable and productive ecosystems, providing a range of ecosystem services. Wetlands (including peat-forming wetlands like bogs and fens) support a high concentration of wildlife species – often higher than any other native habitat – and provide essential services such as water purification, flood mitigation, and nutrient cycling.

Peat swamp forests and bogs serve as habitat for specialised flora and fauna; for example, many threatened bird species, amphibians, and invertebrates depend on peat swamp habitats. In addition, healthy peatlands help regulate hydrology by acting like sponges that absorb excess rainfall and release water slowly, thereby reducing flood peaks and maintaining baseflows during droughts.

Culturally, peatlands and wetlands have deep significance for indigenous communities around the world. In New Zealand, peat wetlands (repo) are considered taonga (treasures) by Māori, valued not only for the resources they provide (such as flax/harakeke for weaving, and wetland birds and fish for food) but also for their spiritual and ancestral importance.

New Zealand's peatlands present a microcosm of the global importance and challenges of these ecosystems. Although New Zealand is a relatively small country, it harbours a diverse array of peatland types, from restiad bogs in the North Island to blanket bogs in the southern rainforests. Historically, wetlands (including peatlands) were widespread across New Zealand's landscape, especially in lowland areas. However, since human settlement, and particularly over the past 150 years of European colonisation, New Zealand has lost an overwhelming majority of its wetlands. It is estimated that roughly 90% of the country's original wetlands have been destroyed through drainage and land development. This represents one of the highest rates of wetland loss of any country.

Most of this loss occurred in the 19th and 20th centuries, when extensive swamp lands were drained for agriculture and urban expansion. The Hauraki Plains, Canterbury Plains, and parts of Northland and Southland saw large-scale conversion of peat swamps and marshes into pasture. Today, only about 250,000 hectares of wetlands remain out of an estimated 2.47 million hectares pre-settlement.

Peatlands (wetlands on peat substrates) constitute a significant fraction of those remaining wetlands. While covering only ~1% of New Zealand's land area, peatlands are estimated to store approximately one-fifth of the country's total biomass carbon.

This underscores their outsized importance in the national carbon budget and the potential climate regulation services they offer. Conversely, the extensive draining of peat soils for

agriculture means that peat decomposition contributes substantially to New Zealand's greenhouse gas emissions.
Agriculture is the largest source of greenhouse gas emissions in New Zealand, accounting for nearly 50% of total emissions, primarily from methane (CH4) and nitrous oxide (N2O). Peatland degradation for agricultural purposes exacerbates this issue by releasing long-stored carbon into the atmosphere, further intensifying New Zeeland's agricultural emissions profile.
Restoring peatlands presents a viable solution for reducing agricultural emissions while maintaining productive land use. By exploring sustainable peatland management practices, New Zealand could look to balance economic growth with its commitment to national climate targets.

The importance of peatlands for carbon storage and ecological stability has increasingly been recognised by scientists, policymakers and markets. Globally, concern is rising that degradation of peatlands is turning these carbon sinks into significant sources of greenhouse gases. When peatlands are drained, the dried peat oxidizes and releases carbon dioxide (and often nitrous oxide), effectively reversing centuries of carbon sequestration. It is estimated that about 15% of the world's peatlands have been drained, and these drained peatlands contribute roughly 5% of global anthropogenic CO_2 emissions.
In fact, carbon emissions from drained and burned peatlands are comparable to 5–10% of all annual fossil fuel emissions. In New Zealand, the situation is similarly alarming. Improved national GHG accounting has revealed that a tiny proportion of New Zealand's land – the 1% occupied by drained peat soils – may be responsible for roughly 5–7% of the country's total greenhouse gas emissions.
This equates to around 4–5 million tonnes of CO_2 emitted per year from oxidizing peat, roughly double earlier estimates.
Clearly, protecting and restoring peatlands is not just an ecological imperative but also a critical climate change mitigation strategy. Healthy peatlands kept in a water-saturated state can continue to act as carbon sinks, whereas degraded peatlands will continue to exacerbate climate warming.

Research methodology: This study is based on a comprehensive literature review and synthesis of existing research, policy documents, and case studies. I have drawn on scientific studies of peatland ecology and carbon cycling, government and NGO reports on wetland/peatland status and management, as well as examples of on-the-ground restoration projects both in New Zealand and abroad. By integrating data from international assessments and local New Zealand-specific studies, the paper takes a comparative approach that situates New Zealand's peatland management challenges within the global context of peatland conservation. The case studies were selected to represent different regions and management approaches (e.g., large-scale wetland restoration vs. small community-led projects) and are informed by project reports and outcome evaluations. While no new field research was conducted for this paper, the synthesis of the available evidence allowed for me to identify best practices and gaps. The analysis also incorporates Mātauranga Māori (Māori traditional knowledge) perspectives from published sources to ensure indigenous viewpoints on wetlands and peatlands are represented. Overall, the methodology is a desk-based research and analysis, aimed at providing a rigorous and policy-relevant overview of peatland management for climate and ecological benefits. To back this literature review up, I visited and talked with many of the science institutions undertaking this research in Germany, The Netherlands, Ireland, Denmark and the UK, as well as here in New Zealand. I also draw on my own experience of peatland farming in the Waikato of New Zealand.

Chapter 2: Peatlands in Aotearoa New Zealand: Characteristics and Distribution

2.1 Characteristics of Peatlands

New Zealand's peatlands are diverse in type and reflect the country's varied climate and geology. In ecological terms, peatlands are areas where waterlogged conditions prevent full decomposition of organic matter, leading to peat accumulation. Several classes of wetlands in New Zealand can form peat and therefore be considered peatland ecosystems. These include bogs, fens, swamps, pakihi and gumlands, and some seepage wetlands.

It is useful to distinguish these types:

- **Bogs** are ombrotrophic mires that receive water only from rainfall (not from streams or groundwater) and are extremely nutrient-poor and acidic.
- **Fens** (minerotrophic mires) receive some groundwater or surface water inputs and have higher nutrient levels than bogs.
- **Swamps** are wetlands often fed by streams or rivers and usually have a higher nutrient status (often with a mix of peat and mineral soils).
- **Pakihi and Gumland** wetlands are special types found mainly in the West Coast and far north, characterised by leached, acidic peaty soils often maintained by frequent burning or low fertility; and
- **Seepage wetlands** occur on slopes where groundwater trickles to the surface, sometimes accumulating peat in patches.

These classes form a continuum from extremely nutrient-poor, rain-fed systems (bogs) to more nutrient-rich, groundwater-fed systems (swamps), and many large wetland complexes contain a mosaic of these types. New Zealand has nine recognised wetland classes, of which bogs, fens, swamps, pakihi/gumlands, and some seepages typically have peat substrates. Among these, bogs and fens are the classic peatlands in the global sense, and New Zealand's bogs are particularly distinctive in their ecology.

One unique feature of New Zealand's peat bogs is the dominance of restiad vegetation – peat-forming rushlike plants of the Southern Hemisphere family Restionaceae. In contrast to Northern Hemisphere peat bogs which are often dominated by Sphagnum mosses and ericaceous shrubs, many New Zealand bogs are dominated by restiad species such as *Empodisma minus* (wire rush) and *Sporadanthus ferrugineus* or *Sporadanthus traversii* (giant cane rush). These restiad bogs are a globally rare ecosystem, found mostly in New Zealand. *Empodisma minus* is widespread across the country and is a major peat-former, developing a dense mat of wiry stems and fibrous roots that accumulate peat. *Sporadanthus ferrugineus* survives in only a few bogs of the North Island (Waikato region), and *Sporadanthus traversii* is now restricted to peatlands on the Chatham Islands. These plants create a tightly woven peat that can build up into raised domes over thousands of years. A generalised trajectory in New Zealand is that a swamp (with open water and nutrient input) can gradually transition to a fen and then to a raised bog as peat depth increases and the wetland becomes more isolated from mineral soil inputs. This successional process has occurred in places like the Waikato, where entire wetland sequences from swamp to fen to dome bog once existed.

2.2 Geographical distribution

Historically, peatlands were extensive across many parts of New Zealand. In the North Island, peat-forming wetlands once covered large stretches of lowland areas, especially the Hauraki Plains (Waikato), central Northland, and parts of the Waikato and Manawatū floodplains.
In the South Island, significant peatland formations were found on the West Coast (encompassing swamps, fens and pakihi) and in Southland/Otago, most notably, in the Awarua Plains and the former wetlands of the Taieri Plains.
Peatlands also appear in higher, cooler regions – such as the North Island volcanic plateau, Fiordland and Rakira (Stewart Island) – where high rainfall and low temperatures have created blanket bogs on poorly drained highland surfaces. Additionally, the Chatham Islands (around 800 kilometres east of mainland New Zealand) are largely covered in peat soils, hosting extensive peat bogs dominated by restiads and sedges that have developed under the islands' cool, wet climate.

Today, the largest intact peatland in New Zealand is the Kopuatai Peat Dome on the Hauraki Plains, Waikato. Kopuatai is a raised bog covering approximately 10,200 hectares and is the only sizable domed bog in New Zealand that remains in a largely natural condition. It is dominated by *Sporadanthus ferrugineus* and *Empodisma* and has peat depths exceeding 10 metres in places. Kopuatai is recognised for its international ecological significance and has been designated a Ramsar Wetland of International Importance since 1989. It represents an increasingly rare ecosystem, as most other large lowland bogs have been heavily modified or destroyed. Another significant peatland area is the Whangamarino Wetland in the Waikato, a 5,900-hectare Ramsar site that includes swamps, fens, and bog remnants. Whangamarino, like Kopuatai, contains large areas of restiad peat bog.
In the South Island, the most significant peatland is the Awarua-Waituna Wetland in Southland. This complex, which includes Waituna Lagoon and surrounding bogs and fens, covers around 20,000 hectares (the Ramsar site boundary was extended to this size in 2008). The Waituna peatlands are a prime example of a coastal peat bog and lagoon system, supporting a mosaic of bog communities (with wire rush and restiad vegetation), interspersed with swamps and the brackish lagoon.
Other notable peatland areas include the West Coast pakihi bogs (extensive but shallow peatlands on terraces from Karamea to South Westland), the remnants of Rangitaiki Plains and Hauraki Plains swamps (mostly converted to farmland, leaving fragments such as Torehape and Moanatuatua bogs), and the Kaimaumau-Motutangi Wetland in Northland (a large peatland and dune wetland complex, portions of which remain despite drainage pressures). Even urban areas, host small peatlands – for example, peat swamps were once common around the Auckland region's lowlands (now almost entirely drained) however, peat still remains under some farmland and semi-urban areas.

However, the current distribution of peatlands in New Zealand is only a shadow of its former extent. The historical use and modification of these areas have dramatically reduced their area and altered their character. Drainage for agriculture has been the primary cause of peatland loss. For instance, the Hauraki Plains (formerly the extensive Thames Valley swamps) were drained with an extensive network of canals and stopbanks in the early 20th century to create dairy pasture, leaving only refuges like Kopuatai. Similarly, in the Waikato around Hamilton and Cambridge, vast bogs such as the Moanatuatua and Rukuhia bogs were largely drained and converted to farmland in the mid-1900s; today only a 140 ha scientific reserve at Moanatuatua remains as a remnant of a once 7,000+ ha bog. In Northland, gumland peat bogs and swamps were often burnt and dug over during the kauri gum extraction era in the late 19th century, and later converted to rough pasture or plantation forest, leaving fragmentary wetlands in some areas. On the West Coast, many pakihi wetlands were drained or repeatedly burned to create grazing land, although large tracts

still persist in conservation land.
Overall, New Zealand has lost 2.22 million hectares of wetlands since pre-human times, representing a 90% decline in wetland area. Peat-forming wetlands were particularly hard-hit: swamp wetlands declined by over 90%, and bogs by roughly 75% (from ~153,000 ha to ~40,000 ha by 2008). Those peatlands that do remain are often largely modified – water tables have been lowered at the margins, nutrient run-off from surrounding land has changed plant communities, and invasive species like willow (*Salix* spp.) have encroached on many swampy peat areas. In some regions, peat has been mined for horticultural uses (e.g., extraction of peat for potting mix was attempted on the margins of Waikato bogs in the past), although this use has been relatively minor compared to agricultural conversion.

2.3 Species diversity

Despite these pressures, the remaining peatlands in New Zealand are of significant importance ecologically. They provide habitat for a host of threatened species. For example, the Matuku-Hūrepo (Australasian bittern) an elusive wetlands bird, largely found in peat wetlands like Whangamarino – which holds the largest bittern population in New Zealand. The nationally critical swamp helmet orchid (Corybas carsei) survives only in Whangamarino and one other Waikato peatland. Peat lakes and swamps in Waikato host endangered fish such as the black mudfish (*Neochanna diversus*). In Southland's Waituna wetlands, a diverse plant community thrives, including rare cushion plants and charophyte algae in pristine peat pools.
These biodiversity values make peatlands key targets for conservation. Additionally, many peatlands have cultural and historical significance. Māori used peatlands and wetlands as sources of food (fish, eels, waterfowl), flax for weaving nets and clothing, and medicinal plants. Waituna's significance to Ngāi Tahu is formally recognised in the iwi's Treaty settlement, and many iwi are involved in current efforts to restore these ancestral wetlands.

Photo 1: Corybas carsei - swamp helmet orchid found at Whangamarino Wetland (photo credit DOC)

Chapter 3: The Role of Peatlands in Carbon Storage and Climate Change Mitigation

Peatlands are often described as the world's "carbon vaults" because of their remarkable ability to sequester and store carbon over long periods of time. In New Zealand, as well as globally, peatlands play a vital role in the carbon cycle. The basic process is that waterlogged conditions in peatlands slow down microbial decomposition of dead plant material. As a result, carbon that the plants absorbed from the atmosphere via photosynthesis is not fully returned to the atmosphere upon the plants' death; instead, a portion remains locked away in the accumulating peat. Over centuries and millennia, peatlands can accumulate massive amounts of carbon. Intact peatlands act as net carbon sinks, albeit usually accumulating carbon at a slow rate annually (often to the order of tens to a few hundreds of kilograms of carbon per hectare per year), but consistently over very long periods. The flipside is that degraded peatlands can become significant carbon sources, rapidly releasing carbon that was stored over millennial timescales back into the atmosphere as carbon dioxide (CO_2) or other greenhouse gases. Therefore, whether a peatland is wet and healthy or dry and degraded makes an enormous difference for climate change.

In terms of carbon storage, New Zealand's peatlands, though limited in area, contain a substantial stock of carbon relative to the national context. One estimate indicates that New Zealand peatlands (covering ~1% of land) store about 20% of the country's total biomass carbon. This reflects the large peat depths and high carbon density of these soils. For example, the 10,000 ha Kopuatai Bog alone has been estimated to hold roughly 24 million tonnes of carbon in its peat. Comparisons to other carbon sequestration methods highlight peat's importance: on a per-hectare basis, peatlands can contain more carbon in their soil than a forest contains in its vegetation. Peat soils globally are thought to hold around 30% of all soil carbon on Earth, even though peatlands are only a few percent of land area. In New Zealand's case, much of the country's vegetation carbon is in forests (New Zealand has substantial forest carbon stocks), but the peatland soil carbon is disproportionately large relative to area. Conserving this stock is critical because if peatlands are destabilised, that carbon can be released as CO_2, contributing to atmospheric greenhouse gas concentrations.

Healthy peatlands not only store carbon but can also sequester carbon dioxide from the atmosphere year after year. When the water table is high, peatland vegetation (like restiad rushes or sphagnum mosses) takes up CO_2 through photosynthesis. Only a portion of that carbon returns to the air as plants respire or dead litter decays; the remainder becomes buried as peat. Intact bogs, for instance, typically have a slow but positive carbon accumulation rate, meaning they function as net sinks for CO_2. Importantly, peatlands also emit some methane (CH_4) because waterlogged, anoxic soils foster methane-producing microbes. Methane is a potent greenhouse gas, but it has a shorter atmospheric lifetime than CO_2. Research has shown that over long timescales, the climate cooling effect of CO_2 uptake and storage by peatlands outweighs the warming effect of the methane they emit – hence peatlands exert a net cooling influence on climate in their natural state. One study summarised that "peat wetlands have a net cooling effect in the long term" because they absorb huge amounts of carbon and permanently store it as peat. In New Zealand, continuous monitoring at Kopuatai Bog using eddy covariance towers has confirmed that this peatland is a net sink for carbon dioxide in most years, except perhaps during extreme drought periods.

Photo 2: Dr. Dave Campbell at the flux tower in Kopuatai Peat Dome, the largest raised bog in NZ. Instruments at this tower measure carbon dioxide exchange between the peatland and the atmosphere, providing data on carbon sequestration (photo credit: G. Glover-Clark)

The long-term preservation of such sinks should be of high value for New Zealand's efforts to mitigate climate change.

The concern, however, is that peatland degradation reverses the carbon sink function. When peatlands are drained, the water table drops, and oxygen penetrates the peat. Aerobic microbes then rapidly decompose the stored organic matter. This results in large releases of CO_2 (and often nitrous oxide, N_2O, if the drained peat is used for agriculture and fertilised). Essentially, centuries worth of carbon accumulation can be emitted in just a few decades of drainage. This is not only a theoretical concern; it is being observed in New Zealand's farmed peatlands. Drained peat soils in areas like the Hauraki and Waikato are subsiding as the peat carbon literally "vanishes" into the air as CO_2. According to a recent analysis, just 1% of New Zealand's soil (the portion that is drained peat) is emitting around 5–7% of New Zealand's greenhouse gas emissions. This startling statistic is due to the oxidation of peat in longstanding agricultural areas. Previous official inventories underestimated these emissions, but updated methods presented to the government now put peat soil emissions at 4–5 million tonnes CO_2 per year in New Zealand. To put that in perspective, these emissions from drained peat are roughly equivalent to the emissions from the entire New Zealand domestic aviation sector, or about 1 million extra cars on the road. Unlike industrial or transport emissions which can in theory be reduced with technological changes, peat soil emissions require land management changes – essentially, re-wetting or retiring peatlands from intensive use – to be abated. If nothing is done, drained peat will continue to emit CO_2 until the peat resource is largely exhausted (many Waikato peat areas have lost several metres of depth already, and eventually, as one regional council warns, "there will be no peat left" if current practices continue).

Another consequence of draining peat is the increased risk of peat fires, which can release massive surges of carbon. Peat fires are relatively uncommon in New Zealand compared to tropical peat regions, but the risk is rising, especially during hotter, drier summers. In a natural wet state, peat is more fire-resistant, but once dried it becomes extremely vulnerable. Recent events have shown this danger: in 2024, unusually low water tables contributed to the extent of a fire in the Whangamarino Wetland that burned over 1,000 hectares of peatland vegetation. Such fires not only destroy above-ground biomass but can also smoulder into the peat soil itself, combusting peat that may have accumulated over centuries. It was estimated that the peat soil in parts of Whangamarino could take hundreds of years to recover (i.e., regrow) after that fire. The immediate CO_2 emissions from peat combustion are significant, and the loss of peat depth means a permanent loss of some carbon storage capacity. Thus, climate change impacts (like increased droughts and heatwaves) can create feedback loops by making peatlands drier and more fire-prone, leading to carbon losses that further exacerbate climate change.

Recognising the climate regulation role of peatlands, there is a strong push internationally and within New Zealand to protect peatlands as a nature-based solution for climate change mitigation. The global policy context includes frameworks like the Ramsar Convention (which now emphasises peatland conservation due to their carbon value) and initiatives such as the "Global Peatlands Initiative" led by UN Environment, which calls for protecting peatlands as the "world's largest terrestrial organic carbon stock". Scientific bodies like the IPCC have also provided guidance (e.g., the 2013 Wetlands Supplement for national greenhouse gas inventories) to encourage countries to account for and reduce emissions from peatlands. In New Zealand, the policy context is evolving. Under the Paris Agreement, New Zealand has greenhouse gas reduction targets (NDCs) and a national framework via the Climate Change Response (Zero Carbon) Act 2019. Historically, New Zealand's emission inventories under-reported peat emissions, but there is movement to update this. In mid-2022, the Government explicitly discussed the need to address peatland emissions as part of meeting climate targets, with Cabinet papers noting the opportunity to reduce emissions from drained peatlands and potentially credit farmers who rewet peat soils. Indeed, the previous Climate Change Minister characterised reducing peat emissions as a domestic opportunity for climate action. While not yet fully realised, this suggests peatlands may be incorporated into New Zealand's formal climate strategy. Additionally, climate adaptation planning is considering peatlands: it has been argued that New Zealand's zero-carbon future will depend on restored peat and coastal wetlands, and that these nature-based solutions should feature in the National Adaptation Plan under the Zero Carbon Act. Conservation groups are calling for a national programme to protect and restore wetlands as a climate mitigation measure. The notion is that by re-wetting drained peatlands, New Zealand could avoid up to ~2 million tonnes of CO_2 emissions annually – a meaningful contribution to its climate goals.

Peatlands in New Zealand are both a huge carbon store and a current emissions source. Preserving intact peatlands avoids the release of their stored carbon and keeps them functioning as carbon sinks. Restoring degraded peatlands (raising water tables) can drastically cut ongoing CO_2 emissions and eventually allow a return to net carbon sequestration. If peatlands continue to be drained or are further impacted by climate change, they could release even more carbon, undermining other emission reduction efforts.

Chapter 4: Challenges to Peatland Management in New Zealand

Despite the clear benefits of conserving peatlands, there are numerous challenges and threats to peatland ecosystems in New Zealand. These challenges are historical and ongoing, stemming from human land-use pressures as well as emerging factors like climate change. Below I will outline the major issues: drainage and land conversion, farming impacts and nutrient runoff, climate change (warming, drought, and extreme events), fire risk, and other human-induced disturbances such as pollution and invasive species. Understanding these threats is crucial to devising effective management responses.

4.1 Drainage and land conversion:

The foremost threat to peatlands in New Zealand has long been drainage for agriculture, forestry, and development. As noted earlier, roughly 90% of the country's wetland area has been lost since European settlement, mostly due to deliberate drainage schemes to "reclaim" swamps for pasture. Peatlands were targeted because they often occupied flat, fertile plains attractive for farming once drained. The process of drainage typically involves digging ditches or installing tile drains to lower the water table and sometimes constructing stopbanks and pumping systems to keep water off the land. While this converts wetlands to arable or grazing land, it fundamentally alters the peat soil. When peat dries, it begins to decompose (oxidize), leading to soil subsidence (shrinking and sinking of the land) and the release of CO_2. Farmers then often deepen drains further to continue farming as the ground subsides, causing a vicious cycle of drying and subsidence. Over decades, peat soils can lose several metres of thickness. For example, on the Hauraki Plains, many areas that were once raised peat bog are now subsided farmland lying below river level, dependent on pumps for drainage. This situation is inherently unsustainable – eventually, the peat layer can be completely eroded. As a Waikato Regional Council guide bluntly states, under continuous drainage "*eventually there will be no peat left*". In addition to carbon emissions, subsidence from peat loss increases flood risk (land becomes lower and more flood-prone) and can damage infrastructure. Yet, drainage continues in some areas, including illegal or unauthorised draining of remaining wetlands by individuals seeking to expand agricultural land. Even small-scale drainage (like a farmer digging a trench at a wetland edge) can start drying out a peatland fragment, harming its ecology. Enforcement of regulations to prevent further wetland drainage has been inconsistent, and some peatlands that were theoretically protected have still suffered encroachment. For instance, in the Southland region, an estimated 10% of the remaining wetlands were lost between 2007 and 2015, largely due to ongoing drainage for pasture. Clearly, stopping drainage and maintaining sufficiently high water tables are fundamental challenges for peatland conservation on private lands.

4.2 Land conversion to different uses:

Land use change has also played a role. Beyond agriculture, peatlands have been affected by conversion to pine plantations (particularly some Northland gumlands and parts of Waikato), by urban expansion (e.g., the fringes of Auckland and Hamilton cities saw swamp drainage for housing/industry), and by infrastructure development (roads, flood control schemes, etc., that alter hydrology). A historical example is the Lower Waikato Flood Control Scheme in the 1960s, which lowered water levels in the Whangamarino Wetland to enable farming on its margins. While this scheme provided community benefits (flood control), it also dried part of the wetland until a compensatory weir was later installed. *Peat mining* has been a more minor but locally significant threat – for instance, proposals in the mid-20th century to mine peat from Kopuatai for fuel or horticultural use were fortunately never realised, but smaller scale extraction did occur in some Waikato peat bogs before environmental awareness increased. Overall, any activity that involves dewatering a peatland or removing peat soil is a major threat to that ecosystem's integrity.

4.3 Impacts of Farming and Nutrient runoff:

The vast majority of drained peatlands in New Zealand are under agriculture, often intensive dairy farming in regions like Waikato, Northland, and Southland. These land uses introduce several environmental pressures on peatland remnants. One issue is nutrient enrichment. Pristine peat bogs are nutrient-poor systems, but when surrounded by farmland, they are often exposed to runoff containing elevated levels of nitrogen (N) and phosphorus (P) from fertilisers and animal waste. Nutrient-rich water entering a bog or fen can change the plant community – for example, encouraging invasive weeds or generalist species that out-compete specialised bog plants adapted to low nutrients. As Forest & Bird notes, many remaining wetland fragments "can't cope with the huge amounts of nutrient and sediment-loaded runoff" from surrounding developed land. This leads to degradation of water quality in the wetland, algal growth in pools, and decline of sensitive species (such as the disappearance of certain peat mosses or carnivorous plants that thrive only in low-nutrient conditions). At Waituna Lagoon in Southland, nutrient runoff from intensive dairying in the catchment has been a major concern – it threatens to destabilise the lagoon's ecology by causing algal blooms that could smother the characteristic aquatic plants (Ruppia). Managing nutrient inputs is therefore a key challenge for peatland reserves embedded in agricultural landscapes.

Another farming impact is physical damage by stock and machinery. When wetlands are not fenced off, livestock (cattle or deer) can trample peat soils and wetland vegetation, pugging the ground and destroying delicate plant communities. Even on the periphery of peatlands, heavy farm machinery can compact peat soils. Additionally, farmers historically used fire to maintain open grazing on some wetlands, leading to recurring burns that altered peatland vegetation (e.g., creating manuka scrub or bracken-dominated pakihi on what were once sedge bogs). Invasive species often gain a foothold in disturbed or nutrient-enriched peatlands. Grey willow (*Salix cinerea*) is notorious for invading New Zealand swamps; it forms dense thickets that dry out wetlands and shade out native plants. Many Waikato peat swamps, such as parts of Whangamarino and the peat lakes, have required active willow control to prevent this transformation. Other weeds like gorse, reed canary grass, or royal fern can also invade. Farming has indirectly facilitated invasion by altering habitat conditions. The challenge is that even after a peatland is legally protected, the legacy of surrounding land use (nutrient inflows, altered hydrology, weed seeds) continues to threaten its health. Restoration efforts must often focus on buffering peatlands from these impacts.

4.4 Climate Change Threats:

Climate change poses a looming and multifaceted challenge for peatland conservation. One major concern is the effect of increasing temperatures and changing rainfall patterns on peatland hydrology. Many climate models project more frequent summer droughts for parts of New Zealand, especially the eastern and northern regions. Drought conditions can cause water tables in peatlands to drop, even in undrained sites. A normally wet bog surface may dry out, risking oxidation of the upper peat layers. During the severe summer drought of 2019–2020, even protected bogs experienced surface drying; in Whangamarino Wetland that year, the dried-out vegetation contributed to the ignition of the wildfire in October 2020. Hotter, drier summers increase fire risk in peatlands that historically would seldom burn. When the protective wetness is lost, above-ground plant matter becomes tinder. Peat fires are especially destructive (as discussed, they can destroy the peat itself) and dynamic to contain, as the burning moves underground. Managing this risk may require more proactive water management (ensuring wetlands have adequate water even in drought, perhaps through engineering solutions or by reversing drainage in the broader landscape) and specialised fire response capability in peatland regions.

Another aspect of climate change is extreme weather events – particularly heavy rainfall and floods. While peatlands generally buffer floods, extreme events can overwhelm systems. For example, more intense rainfall might cause greater runoff of sediment and nutrients from catchments into wetlands, exacerbating the nutrient loading issues. In coastal peatlands like Awarua-Waituna, rising sea levels and storm surges could lead to saltwater intrusion into freshwater peat ecosystems, altering their character. We can also expect changes in species distributions; warmer conditions might allow subtropical or invasive species to spread into peatlands (for instance, the potential incursion of tropical cattails or other invasive aquatics could be enabled by milder winters). Climate change is likely to *stress peatlands through increased drying, greater fire frequency, and possibly more nutrient fluxes*, unless mitigated by conscious management. The net effect could be accelerated loss of peat and biodiversity if no action is taken.

4.5 Fire and other human-induced disturbances:

I have touched on fire in the context of climate, but it's worth noting human-induced fires and disturbances as a separate challenge. Some peatland fires in New Zealand have been deliberately set (to clear vegetation for farming or by accident during land clearance). Even as far back as the 19th century, wetlands were sometimes burnt to improve access for gum digging or hunting. Each fire can reduce peat accumulation or even consume accumulated peat, so preventing uncontrolled burns is crucial. The 2022 fires in the Awarua and Kaimaumau-Moutangi wetlands (Southland and Northland) released an estimated 600,000 tonnes of carbon dioxide emissions. If these losses were to be paid for, on current carbon markets, that cost would equate to $32 million.

Beyond fire, other disturbances include peat excavation, pollution, and hydrological changes. For instance, drainage of surrounding lands can unintentionally drain a wetland due to subsurface connectivity. Cases have been observed where landowners deepen drains on farmland and unknowingly lower the water table of an adjacent reserve by several centimetres, harming the wetland (LiDAR studies have revealed how far drainage impacts can extend under peat soils). Pollution in the form of herbicides, effluents, or waste dumping in wetlands has occurred occasionally (wetlands sometimes being treated as wastelands historically). All these pressures require management intervention.

Photo 3: Awarua-Waituna fire, 980ha burnt and an estimated 515,000t of carbon dioxide released to the atmosphere (Photo – Fire and Emergency NZ / Stuff.co.nz)

4.6 Isolation

Another challenge is simply the small size and isolation of many remaining peatland fragments. With over 90% lost, those that remain are often disconnected from each other, like ecological "islands" in a sea of pasture. This isolation can lead to loss of species that require larger territories or multiple wetlands to sustain populations (for example, many wetland bird species need a network of wetlands to move between). It also makes each fragment more vulnerable to local extinction events. A single pollution spill or one fire could eliminate a species from that fragment with no easy re-colonisation source. Hence, fragmentation is a conservation challenge; one solution is to enlarge and reconnect wetlands where possible, but that is often difficult when surrounding lands are privately owned and economically valuable.

New Zealand's peatlands face a convergence of challenges: hydrological modification (drainage) remains the most significant threat, causing ongoing peat loss and emissions; intensive land use around wetlands leads to eutrophication and invasive species; climate change is compounding these issues by making wetlands drier and more fire-prone at times; and legacy impacts like altered flood regimes and isolation complicate conservation. Addressing these challenges is not easy – it requires coordinated efforts in land management, regulation, and restoration.

Chapter 5: Management Strategies for Peatland Conservation

Given the array of threats to peatlands, a suite of best practices and management strategies has emerged in New Zealand (and globally) to conserve and restore these ecosystems. Successful peatland management typically focuses on rehydrating drained peatlands (rewetting), restoring native vegetation and ecosystem function, promoting sustainable land-use practices (including novel uses like paludiculture), and integrating traditional knowledge and community stewardship. The following are key strategies being employed or recommended and provides examples of how they work in practice.

5.1 Re-wetting and restoration of hydrology

The cornerstone of peatland restoration is raising the water table to re-create waterlogged conditions. Since drainage is the primary cause of peatland degradation, reversing it (at least partially) is essential. Rewetting can be achieved through various techniques: blocking drainage ditches with peat or wooden dams, installing weirs or control gates on outflow streams to hold water in the wetland, disabling or removing drainage pumps, and infilling artificial channels. In agricultural peat soils, rewetting might involve operating drains at higher levels or "bunding" areas to retain rainfall. The goal is to keep the peat soil saturated for most of the year. By doing so, peat oxidation and subsidence are greatly reduced, and conditions for peat formation by plants (anaerobic, wet soil) are re-established. Rewetting also markedly cuts greenhouse gas emissions – a drained peatland can switch from being a significant CO_2 source back to a near-neutral or slight sink after rewetting, especially if vegetation recovers. According to Forest & Bird, if New Zealand were to re-wet its drained peatlands, it could potentially avoid or offset around 2 million tonnes of CO_2 emissions each year. This climate benefit is a strong motivation behind many restoration projects.

Best practice rewetting requires careful planning. One must consider the impact on neighbouring land (to avoid flooding someone else's paddock, for example) and the target water levels for ecosystem health. Often, an adaptive approach is taken structures like weirs are adjustable, so water levels can be tuned based on monitoring. An example is the Whangamarino Wetland where a weir was constructed on the wetland's outlet in 1994 to maintain a minimum water level in the peat bog core. The weir also slows water outflow, dampening rapid water level fluctuations. This is beneficial because gentle, stable hydrology favours peat accumulation, whereas rapid drawdowns can cause peat cracking and oxidation. Whangamarino's weir had to be repaired and upgraded in 2010 as part of best practice – ensuring infrastructure longevity is also key.

Another aspect of rewetting is dealing with the issue of subsidence: when deeply drained peatlands have sunk below surrounding drain or river levels, full rewetting might require pumping water in or allowing controlled inundation. In some cases, complete re-flooding is done to create a wetland lake in place of drained peat pasture (this has been tried in parts of the Netherlands, for example). In New Zealand, an alternative approach for heavily subsided peat soils is paludiculture (wet agriculture).

5.2 Restoration of native vegetation and peat-forming plant communities:

Hydrology is fundamental, but a peatland also needs the right vegetation to truly recover its function. Restoration practitioners often reintroduce or encourage native wetland plants once water levels are restored. In bogs, this could mean spreading spores or fragments of Sphagnum moss and planting restiad rushes if those species are not present to naturally regenerate. In some Waikato bog remnants, efforts have been made to transplant *Empodisma* and *Sporadanthus* into areas after removing invasive species. Wetland restoration guidelines suggest focusing on "ecosystem engineers" – species that create habitat structure and promote peat formation, such as wire rush in bogs or flax (*Phormium tenax*) in swamps.

Invasive species control is often a prerequisite to native revegetation. Best practice includes the removal of exotic trees like willow or pine that dry out peatlands. This can be done via mechanical means or controlled herbicide application (in the case of willow, ringbarking or applying glyphosate, which is approved for use over water). At Whangamarino, a large-scale willow control programme was implemented, resulting in the dieback of willows and regeneration of native scrub and flax in some areas. Removing grazing pressures (through fencing) is also critical so that palatable native seedlings can establish. For bogs, if the seed bank is depleted, fragments of peat from a donor site (containing seeds of bog plants and mosses) are sometimes spread over the site to aid recolonisation. Over time, if water conditions are right, native peatland flora can recover remarkably. For instance, after a peatland is rewetted, one might observe the return of bog plants like sundews, bladderworts, and restiads within a few growing seasons, as seen in sections of rehabilitated peat mines overseas.

Maintaining optimal water quality is another facet – controlling nutrient inputs by working with upstream land users. In peat lake restorations in Waikato, best practice involved creating sediment traps and riparian buffer zones to reduce nutrient-rich sediment entering the wetland. At Waituna in Southland, managers have set strict nutrient load limits for the lagoon and are establishing constructed wetlands to filter farm runoff. By keeping nutrient levels low, the native oligotrophic (low nutrient) peatland communities are favoured over weeds and algae.

Photo 4: Sphagnum moss propagation nursery - Lower Saxony Germany (own photo)

5.3 Sustainable land-use practices:

Completely retiring all peatland farmlands is unlikely to be feasible, so a key strategy is to make land use on peat more sustainable – essentially, to find a balance between utilisation and conservation. One emerging concept is paludiculture, which means "wet agriculture" – using wetlands productively while keeping them wet. This contrasts with conventional agriculture which requires drainage. In paludiculture, farmers would rewet the peat and then cultivate crops or resources adapted to waterlogged conditions. Examples include harvesting sphagnum moss as a horticultural product, or cultivating reed and sedge crops for biomass, or traditional materials like flax (*harakeke*) and *raupō* (bulrush) for fibre. In New Zealand, interest in paludiculture is growing. Raupō (Typha orientalis), for instance, can be used to produce construction materials or even biofuels, and it grows in shallow water. Harakeke (New Zealand flax) thrives in wetlands and has traditional and modern economic uses (e.g., for weaving, bio-based textiles). The National Wetland Trust's Karen Denyer points out that tangata whenua (Māori people) have a long history of sustainably harvesting from wetlands, which could guide modern paludiculture. She envisions scenarios where landowners "rewet a portion of [their] peatlands and grow species such as raupō or harakeke for high-end, eco-friendly products," creating a win-win for landowners and the climate. This approach would allow farmers to derive income while halting peat degradation. It is still at a trial stage in New Zealand, but overseas (in Germany, the Netherlands) some pilot paludiculture projects (like reed harvesting for construction materials and roof thatch on rewetted peatlands) have shown promise.

Even within conventional farming, there are best practices to farm peat "lighter and smarter." For example, avoiding deep ploughing or regular tillage on peat can slow its decomposition (ploughing aerates peat and accelerates breakdown). Instead, using no-till or low-impact cultivation methods is recommended. If pasture must be renewed, direct-drilling seed without fully reworking the soil is preferred. Maintaining a higher water table even under pasture (e.g., using weirs in farm drains to keep more water in the peat during summer) can significantly reduce peat shrinkage while still allowing grass growth. These methods require coordination, sometimes between neighbouring farms, because groundwater doesn't respect property lines. In the Waikato, farmers on peat have formed discussion groups to collectively manage water levels to an optimal compromise – high enough to slow subsidence, low enough to sustain pasture production. The regional council has published guidance with four key steps: avoid over-drainage, keep summer water tables higher, fence drains, and don't deepen drains further. Implementing these can extend the usable life of peat soils and maintain soil health, which indirectly benefits conservation by preventing extreme degradation that would otherwise demand intervention. This, however, is best practice and not common practice. Enforcement of these practices needs to be considered.

Rewetting retired peatland for carbon credits is another potential livelihood alternative. If New Zealand's Emissions Trading Scheme (ETS) or a future mechanism allows crediting the emissions avoided by rewetting peat, farmers could earn income by turning low-performing peat pastures back into wetlands. As of now, the ETS does not fully include wetlands. This could incentivise large-scale restoration on private land.

5.4 Mātauranga Māori in peatland management:

Māori have lived in New Zealand for centuries and have accumulated knowledge and practices for interacting with wetlands in a sustainable manner. Incorporating this knowledge can greatly enrich peatland management. A fundamental Māori view is that wetlands are a living entity with mauri (life force) and are part of a connected system of waterways from mountains to sea (ki uta ki tai). Wetlands were often viewed as valued mahinga kai (food gathering places) and were managed by hapū (sub-tribes) with rules (tikanga) to prevent over-exploitation. For instance, there were customary restrictions on harvesting flax during certain times to allow regrowth, or on taking young eels to ensure population sustainability

Māori also have techniques for wetland use that do not destroy the habitat: e.g., rather than draining a swamp to catch fish, they would build weirs or use spears and traps within the wetland. Such practices demonstrate how human benefit can be balanced with wetland conservation.

In modern restoration projects, Mātauranga Māori is increasingly being interwoven. One example is the Whakamana Te Waituna programme in Southland, where Ngāi Tahu are partners in designing restoration actions that respect cultural values. This includes planting species of cultural significance (like harakeke, used in weaving, and tī kōuka/cabbage tree, which has many uses) as part of restoration planting palettes, not just ecologically "cold" choices. Māori principles such as kaitiakitanga (guardianship) guide long-term thinking – seeing peatland restoration as a legacy for future generations rather than just immediate gains. Additionally, Māori narratives and language can help raise community appreciation of peatlands. For instance, using traditional wetland names and stories in interpretation can build a stronger connection. In the Waikato, local iwi have been involved in peat lake restoration projects, conducting rituals and blessings (karakia) at restoration sites, which underscores the spiritual value of these places and can galvanize community support.

Community engagement and education are universally regarded as best practice in wetland management. In New Zealand, community-led wetland restoration groups (often involving farmers, iwi, school groups, and NGOs) have made remarkable contributions. For example, at Lake Serpentine/Rotopiko (a peat lake in Waikato), the National Wetland Trust leads restoration and has built a predator-proof fence to create a wetland sanctuary and education centre, with input from both scientists and local Māori. Such projects show how blending scientific and traditional knowledge can yield robust outcomes – the fence protects endangered wildlife (like wetland birds and tuatara), while plantings and water management draw on historical knowledge of what the wetland was like and how species interact.

The best practices for peatland conservation in New Zealand revolve around keeping peatlands wet and healthy. Rewetting is non-negotiable for restoring peat formation and stopping emissions. Alongside that, controlling invasive species, re-establishing native peatland vegetation, and buffering wetlands from external nutrient and hydrological impacts are critical tasks. Where peatlands intersect with human land use, innovative strategies like paludiculture and sustainable farming can create win-win scenarios. Underpinning all these approaches is the recognition that local communities, including Māori as mana whenua (people of the land), must be partners in peatland management. Their knowledge, values, and active involvement ensure that restoration is not only scientifically sound but also culturally appropriate and socially supported.

Chapter 6: Policy Framework and Regulatory Approaches

Effective peatland management does not happen in isolation – it is supported (or undermined) by the policies, laws, and institutional arrangements in place. In New Zealand, wetlands and peatlands are addressed through a combination of environmental laws, national policy instruments, international commitments, and the efforts of government agencies and non-governmental organisations (NGOs). Outlined below are the current policy frameworks and regulatory approaches relevant to peatlands and how they contribute to peatland conservation. Key elements include the Resource Management Act and its successor legislation, the National Policy Statement for Freshwater Management, other national strategies, regional plans and council roles, the Ramsar Convention and international agreements, and the roles of various agencies and NGOs in implementing peatland protection.

6.1 National legislation – RMA and beyond:

For the past three decades, New Zealand's primary environmental law has been the Resource Management Act 1991 (RMA), which governs land, water, and resource use. The RMA explicitly recognises the protection of significant wetlands as a matter of national importance (Section 6c refers to "significant indigenous vegetation and significant habitats of indigenous fauna" which has been interpreted to include wetlands). Under the RMA, regional councils are responsible for water and soil management, and many have rules restricting drainage or modification of natural wetlands. In 2020, in response to continued wetland loss, the government strengthened protections via the National Policy Statement for Freshwater Management 2020 (NPS-FM) and associated regulations (National Environmental Standards for Freshwater). The NPS-FM includes specific provisions aimed at "no further loss" of natural wetlands. It requires councils to identify and map wetlands and prohibits drainage or development of natural wetlands except in very limited circumstances (for example, for certain infrastructure or if the activity has a significant benefit and effects are offset). Policy 6 of the NPS-FM directs that "there is no further loss of extent of natural inland wetlands, their values are protected, and their restoration is promoted".

In essence, this is a clear statement that remaining wetlands (including peatlands) must be safeguarded. Regional plans are being updated to reflect this, with rules that make it difficult to drain or clear wetlands. The NPS-FM also encourages restoration – it expects councils to not just protect but enhance wetland extent and condition over time. Some experts have advocated that each region set targets, for example, to restore wetland area to 20% of its original extent (a very ambitious goal, but indicative of the scale of restoration desired). The new Natural and Built Environments Act 2023, which is set to replace the RMA, similarly lists ecological integrity of wetlands and reducing greenhouse gas emissions as considerations, which should carry forward protections for peatlands, though details will depend on how new national planning frameworks are written.

6.2 Government Agencies

The Department of Conservation (DOC) is the central government agency charged with protecting indigenous biodiversity and managing public conservation lands, which include many wetlands. DOC manages several large peatland reserves (e.g., Kopuatai Peat Dome, Whangamarino Wetland, Awarua-Waituna Wetland) often in partnership with iwi and local councils. DOC's Arawai Kākāriki wetland restoration programme (2007–2016) put focus on three key wetlands (Whangamarino, Awarua-Waituna, and O Tu Wharekai/Ashburton lakes) to pilot restoration techniques and improve understanding – which has informed best practices nationwide. However, DOC's jurisdiction is mostly limited to wetlands on public conservation land; many peatlands are on private or council land. That's where regional councils come in. Regional councils (and unitary authorities) are responsible for implementing RMA/NPS-FM provisions on private lands, through their regional plans and consent processes. They monitor wetland extent and condition (e.g., through State of the Environment reporting) and can take enforcement action against illegal drainage. Some councils, like Waikato Regional Council, have developed specific peatland management strategies and provide guidance to landowners. They also sometimes facilitate restoration projects, for instance by offering environmental grants to fence wetlands or by coordinating catchment groups (Environment Southland's work at Waituna is an example of a council taking a lead in partnership with others).

A challenge in the policy framework has been ensuring compliance and enforcement. Despite nominal protections, wetland drainage continued in some areas due to lenient enforcement or lack of awareness. The strengthening of rules in 2020 is an attempt to curb that. Now, essentially, any earthworks or drainage in a mapped natural wetland can trigger penalties unless it fits a narrow exception. This is a positive development for peatlands. There are still contentions to navigate, such as farmers' concerns about what is classified as a wetland and regulatory burden, but overall, the trend is towards stricter protection.

6.3 Ramsar Convention and international commitments:

New Zealand became a signatory to the Ramsar Convention on Wetlands in 1976, signalling a commitment to wise use of wetlands. As part of this, New Zealand has designated six Ramsar Wetlands of International Importance:

- The Waituna/Awarua Wetland (Southland),
- Whangamarino Wetland (Waikato),
- Kopuatai Peat Dome (Waikato),
- Firth of Thames estuary (Waikato),
- Manawatu River estuary, (Manawatu/Whanganui)
- Farewell Spit (Nelson/Tasman)

Three of these – Waituna, Whangamarino, and Kopuatai – are peatland-rich sites. Ramsar status does not create binding domestic law, but it does oblige reporting and puts moral pressure to maintain the ecological character of these sites. DOC is the administrative authority for Ramsar sites, and ideally, Ramsar listing helps garner support and funding for these wetlands. However, there have been concerns that even Ramsar sites are not adequately protected on the ground. For instance, Whangamarino, despite Ramsar status, has suffered from nutrient influx and a major fire, leading an advocate to question "if an internationally recognised Ramsar wetland like Whangamarino is in such bad shape – what hope do our other wetlands have?". This indicates that while the policy framework is there, implementation can lag. Efforts are being made to improve Ramsar site management – e.g., DOC's restoration programmes and increased monitoring. Internationally, New Zealand also supports initiatives like the Global Peatlands Initiative and has made commitments under the Convention on Biological Diversity (CBD) that include ecosystem conservation (the new global biodiversity framework calls for restoration of 30% of degraded ecosystems by 2030, which would include wetlands). Additionally, under the Paris Agreement, as mentioned, New Zealand is contemplating integrating wetland emission reductions into its climate commitments. All these show that globally and locally, peatland conservation is being recognised within policy instruments, though tangible actions must follow.

6.4 Role of government agencies and NGOs:

Beyond DOC and councils, other government-associated bodies play roles. The Ministry for the Environment (MfE) sets national environmental policy and has been behind the NPS-FM wetland rules. The Ministry for Primary Industries (MPI) may get involved where peatland management intersects with agriculture and forestry (for example, MPI has funded projects under the Sustainable Land Management and Climate Change program looking at mitigation of peat emissions). On the NGO side, Forest & Bird (Royal Forest and Bird Protection Society) is a key advocate for wetland protection – they actively campaign, engage in policy submissions, and sometimes undertake restoration (they have branches that do wetland planting days, etc.). The National Wetland Trust of New Zealand is another important NGO dedicated specifically to wetlands; they focus on education (running Wetland Restoration Symposia, producing guides) and demonstration projects like the Rotopiko restoration. Fish & Game New Zealand, while primarily interested in game bird hunting and sports fishing, often becomes an ally for wetland conservation since ducks need wetlands; Fish & Game manages some wetland reserves and was instrumental in establishing some private wetlands through their wetland incentive schemes in the past.

6.5 Community and iwi involvement in governance:

Modern governance models increasingly involve co-governance with Māori for natural resources. The Waikato and Waipa rivers, for example, are co-governed by river authorities that include iwi representatives – their mandate extends to wetlands in those catchments. In the Waikato River Authority's strategies, wetland restoration (including peatlands) is a priority with funding allocated to it. Iwi management plans often highlight the restoration of traditional wetlands. As Treaty settlements continue, more iwi are gaining a say in how wetlands on Crown land are managed, and sometimes even ownership (some wetlands have been returned to iwi ownership with conditions to protect them). This is strengthening the policy framework by adding another layer of guardianship (kaitiakitanga) and accountability.

Despite these frameworks, gaps and challenges remain. Enforcement of existing laws can be resource-intensive – councils need funding and political will to pursue wetland breaches. There can be conflicts with development interests – for instance, proposals for infrastructure (roads, subdivisions) still sometimes eye wetland areas as potential sites, requiring vigilance to ensure "avoid wetland" policies are upheld. The policy framework is also in flux with new environmental legislation being rolled out; it will be important that any new regime retains the strict protections introduced in recent years. Funding is another aspect: while Jobs for Nature (a recent government stimulus package) put millions into wetland restoration projects, long-term funding for ongoing management (weed control, water control structure maintenance, monitoring) must be secured. NGOs call for a dedicated national wetland restoration programme – akin to what exists for rivers – and indeed ask "where is the ambitious goal for our climate-protecting, life-saving wetlands?", indicating a desire for a more coordinated national strategy.

New Zealand's policy framework for peatlands has significantly improved, with strong legal protections on paper and multiple stakeholders involved in conservation efforts. The country's international commitments further reinforce the importance of doing so. Nonetheless, implementation is key: the true test is whether on-ground peatland loss has halted and whether restoration gains pace.

Chapter 7: Peatland restoration: Global Case Studies

7.1 UK Case Study – Restoring Agricultural Peatlands in the Fens.

Historical context & Degradation of Peatlands:

The East Anglian Fens of England once formed a vast wetland wilderness, but beginning in the 1600s–1700s they were extensively drained for agriculture. These lowland peat soils, formerly used for grazing and reed cutting, were converted to highly productive arable farmland. Over 99% of the original fen wetland habitat was lost as a result. Drained Fen peat proved extremely fertile and now supports intensive cropping – the Fens produce ~37% of England's vegetables on about 150,000 ha of peat soils. However, decades of drainage caused severe peat degradation. The ground surface subsided by several metres (notably recorded at Holme Fen in Cambridgeshire) as peat dried and oxidized. Much of the Fenland now lies below sea level, requiring constant pumping to manage water levels. The oxidation of drained peat emits significant greenhouse gases (GHGs), making peat loss in the Fens one of the largest single sources of CO_2 emissions from UK land use. By 2020, UK agriculture on peatlands was a major emitter, contributing to CO_2, methane, and nitrous oxide outputs disproportionate to its land area.

Restoration Efforts & Rewetting initiatives:

In response to this degradation, the UK has begun rewetting and restoring agricultural peatlands to curb emissions and preserve soil. A flagship effort is the Great Fen Project in Cambridgeshire – a 50-year partnership launched in 2001 to reconnect two small fen nature reserves by converting 3,700 ha (9,000 acres) of farmland back to wetland. Restoration here involves ceasing intensive farming, raising water tables, and re-establishing fen vegetation. Early steps included sowing former croplands with grass to stabilise peat and gradually "wetting up" the soil. The Great Fen's Water Works initiative is piloting paludiculture (wet farming) – growing crops like reeds, willow, or sphagnum moss on wet peat soils. This approach aims to provide alternative income for farmers (e.g. bioenergy, thatch reed, speciality foods) while keeping peat soils waterlogged and carbon rich. Monitoring by UKCEH scientists shows that raising water levels can drastically cut carbon losses compared to neighbouring drained farms. In places, net carbon emissions have approached zero once peat soils stayed wet year-round. Re-wetted fields have also seen a return of fen wildlife – wetlands now support breeding birds (lapwings, bitterns), water voles, and rich wildflower meadows, highlighting biodiversity co-benefits.

Policy frameworks are evolving to support such efforts. The UK Government's 25-Year Environment Plan (2018) set an objective to "create an ambitious framework for peat restoration" and end peat soil loss. Recognising that some fertile peatlands may not be fully re-wet in the near term, the plan calls for sustainable management of agricultural peat – keeping soils wetter to reduce GHG emissions even if not completely restored. The Climate Change Committee (CCC) likewise recommends restoring at least 25% of lowland peat fully to wetland and adopting wetter farming on the remaining peat fields as part of the UK's Net Zero strategy. Incentive programs are emerging, such as Agri-environment payments for raising water levels on farms and the voluntary Peatland Code for carbon credits from peat restoration. For example, projects like the Great Fen have tapped lottery funds and corporate sponsorship to finance land purchases and rewetting. By 2021, England's Peat Action Plan committed funding to restore 35,000 ha of peatlands by 2025, with a long-term goal of peat restoration at landscape scale.'

Photo 5: Drained lowland peat farmland in the Cambridgeshire Fens.

Lessons & Relevance to New Zealand:

The UK experience shows that rewetting agricultural peatlands is feasible and can deliver multiple benefits – carbon mitigation, biodiversity gains, and improved water management. A key lesson is the importance of developing alternative land uses (like paludiculture) that allow farmers to maintain livelihoods on wet peat. This has helped build local support, as farmers see opportunities (new wetland crops, payments for carbon or conservation) rather than simply losing productive land. New Zealand faces similar challenges in regions like the Waikato and Hauraki Plains, where peat bogs were drained for dairy farming and now suffer subsidence and high CO_2 emissions. The UK's approach suggests NZ could transition some peat farmland to wetter management or mosaic land uses – for example, converting marginal peat fields to wetlands or sphagnum farming while retaining productive use on drier parts. Policy support will be critical. Just as England developed a strategic plan and funding streams for peat restoration, New Zealand may consider integrating peatland restoration into its climate policies and farm subsidy schemes. The scientific data from the Fens (on GHG flux reductions, etc.) provides evidence that rewetting yields climate benefits within a few years. Additionally, the UK's community engagement – partnering with local councils, drainage boards, NGOs, and farmers – is a model for NZ to build stakeholder buy-in for peat conservation. Overall, the UK case underlines that saving peatlands in agricultural landscapes is not only an ecological imperative but can be compatible with rural economies if innovation and incentives align.

7.2 Germany Case Study: Peatland restoration for Climate Change Mitigation.

Peatlands, Carbon Storage & Emissions in Germany:

In Germany, peatlands are recognised as critical natural carbon sinks and their restoration has become a cornerstone of climate strategy. Although peatlands cover only ~1.9 million hectares (about 5% of Germany's land), they hold an outsized share of carbon – storing more carbon in soil than all German forests combined. Historically, over 90% of German peat bogs were drained (mostly for agriculture and forestry), converting them from carbon sinks into carbon sources. Drained peatlands in Germany emit an estimated 53 million tonnes of CO_2-equivalent per year, about 7–8% of the nation's total GHG emissions. This huge climate impact – largely from oxidizing peat in farmed bogs – has prompted Germany to view peatland rewetting as one of the most crucial climate mitigation measures in agriculture. Scientists calculated that to align with the Paris Agreement 1.5°C goal, about 1.3 million hectares of Germany's drained peat soils should be rewetted by 2050. Keeping peat "wet" ("*Moor muss nass*" as a local slogan puts it) is essential to halt ongoing carbon losses.

Restoration projects and National initiatives:

Ambitious national programmes have been launched to tackle this challenge. In late 2022, the German government adopted a National Peatland Strategy that explicitly links peatland conservation to achieving climate neutrality by 2045. This strategy sets out targets for rewetting and protecting peat soils, backed by significant funding. For instance, in 2023 the government created a €4 billion Natural Climate Buffers Program, earmarking €1 billion specifically to support farmers who rewet peatlands and develop sustainable wet-farming systems. A complementary National Water Strategy integrates peatland restoration with water security, since rewetting peat helps regulate floods and droughts.

On the ground, several high-profile projects demonstrate peatland restoration in action. In Schleswig-Holstein (northern Germany), a 400ha dairy farm was acquired to become "KlimaFarm," a pilot where water tables have been raised to near ground-level (0–10 cm below the surface) across former pasture. Over the next decade, this site will monitor farming under wet conditions – measuring changes in GHG emissions, peat condition, biodiversity, and farm economics. The goal is to cut ~20,000 tons of CO_2-equivalent emissions while testing viable wetland-adapted farming practices. Early observations indicate peat-forming vegetation is returning, and researchers are evaluating wet grazing and novel crops. In Mecklenburg-Western Pomerania, the state with some of the largest peatland areas, a PaludiPilot Farm (PaludiMV) covering 1,300 ha is experimenting with paludiculture (wet agriculture) on rewetted peat. Here, farmers and scientists have introduced crops like reed canary grass and cattails on saturated peat soils, using modified machinery (e.g. tracked harvesters) suited for wetlands. Products from these wet farms include construction materials (reeds for thatch, fibreboards), energy feedstocks (biogas from sedges), and peat-free growing substrates. Such initiatives illustrate how Germany is building new value chains around peatland restoration – effectively turning climate policy into rural development opportunities.

Economic incentives and Policy support:

A key aspect of Germany's approach is providing economic incentives to landowners for peatland conservation. Because rewetting often means reduced conventional yields or land-use change, the government and NGOs have created compensation schemes to reward the climate benefits. One example is the Klimafonds launched by the nature NGO NABU, which pays farmers €65 per ton of CO_2 emissions avoided through peat conservation. This fund is financed by citizens and private companies; notably, a major supermarket chain (REWE) contributed €25 million to support peatland farmers, recognising the carbon reductions as part of its supply chain sustainability. On a regional level, the state of Mecklenburg introduced MoorFutures – one of the world's first peatland carbon credit programs. MoorFutures credits represent verified GHG reductions from rewetting projects, allowing companies or individuals to invest in peatland restoration for carbon offsets. First launched in 2011, MoorFutures demonstrated a novel finance mechanism, although uptake was initially slow due to complex certification and some local scepticism. Nonetheless, it paved the way for integrating peatlands into carbon markets.

Germany's policies also encourage innovation on rewetted land. For instance, the government has moved to include wet peatlands in agri-environment schemes and is revising agricultural subsidy rules so that "productive" use of land can include paludiculture or carbon farming. Training and advisory services (often via the Greifswald Mire Centre, a leading peat research institute) help farmers transition to wetland management. The emphasis is on showing that farming "with water" can be economically viable. Already, entrepreneurial ventures have sprung up: a green energy cooperative produces "paludi-gas" (biogas from wetland biomass), and start-ups are manufacturing peat-free potting soil from rewetted peat moss. These efforts are boosted by public awareness campaigns highlighting that keeping peatlands wet serves public good – climate protection, water storage, and biodiversity. The broad lesson from Germany is that strong policy commitments, substantial funding, and market-based incentives together create an enabling environment for peatland restoration at scale.

Photo 6 & 7: Products from paludiculture farms in Germany - single use packaging and construction materials (own photo)

Lessons & Relevance for New Zealand:

Germany's experience showcases peatland restoration as a potent nature-based climate solution. Several insights can inform New Zealand's approach to peatlands and climate policy. First, quantifying the climate impact of drained peat helped build urgency – Germany's finding that 7% of its emissions came from peat soils prompted action. NZ could similarly strengthen its estimates and highlight emissions from its drained peatlands, such as the Waikato peat bogs used for dairy farming, to justify restoration efforts as part of meeting its emissions targets.

Second, Germany demonstrates the value of integrating peatlands into national climate strategies. New Zealand's Climate Change Response could incorporate peatland rewetting as an officially recognised mitigation measure (alongside forests), ensuring policies like the Emissions Trading Scheme or carbon funds provide credit for wetland restoration. The use of carbon finance and subsidies to support farmers is another parallel. German farmers are being paid for the ecosystem service of keeping peat soils wet. Likewise, NZ could explore payments for peatland stewardship – for example, expanding existing sustainable land use programs to include peat conservation, or developing a Kiwi equivalent of MoorFutures to generate carbon credits from restoring peat bogs.
Another lesson is the importance of research and pilot projects to adapt wetland farming to local conditions. Germany's paludiculture trials show that farming can continue on peatlands with modified techniques. In New Zealand, this could inspire trials of wet cropping in peat areas – perhaps cultivating flax/harakeke, sphagnum moss, or wet-tolerant pastures on rewetted Maori-owned peatlands, combining cultural values with innovation. By providing evidence that farmers can "farm carbon" or harvest alternative crops, resistance to rewetting could be overcome. Lastly, the German case underlines a collaborative approach: government agencies, scientists, conservation groups, and industry all coordinate on peatland initiatives. New Zealand can mirror this by engaging stakeholders early – working with iwi (who have kaitiakitanga over wetlands), farmers, and regional councils to develop peatland action plans. In summary, Germany treats peatlands as "hotspots" for climate action; if New Zealand does the same, it can address a currently under-recognised source of emissions while boosting biodiversity and resilience in peatland regions. The synergy of strong policy, financial incentives, and community buy-in seen in Germany provides a potential roadmap for NZ to restore its peatlands as a climate win-win.

Chapter 8: Peatland restoration: New Zealand Case Studies

8.1 Whangamarino Wetland (Waikato) *Protecting and restoring a large peat swamp and bog complex in an agricultural landscape.*

Whangamarino Wetland, located in the lower Waikato River basin, is one of New Zealand's largest remaining wetland complexes, covering ~7,000 hectares. It comprises extensive swamp areas (reedlands and scrub), fens, open water, and a raised peat bog in its central and southern parts. Whangamarino is internationally recognised for its ecological values, including the country's largest population of the endangered Matuku-hūrepo (Australasian bittern) and the only known site of the critically endangered swamp helmet orchid. The wetland also holds cultural significance for Waikato-Tainui and is valued for recreation (duck hunting). However, Whangamarino has faced multiple threats: historical drainage schemes lowered water levels, invasive willows spread in the swamp areas, and nutrient and sediment runoff from surrounding dairy farms degraded parts of the wetland. By the 1980s, much of the peat bog was drying in summer, causing manuka shrub encroachment and peat subsidence. In response, a concerted restoration and management programme was initiated, especially under DOC's Arawai Kākāriki programme (from 2007 onward).
A central action at Whangamarino has been hydrological restoration via the Whangamarino Weir. As part of the Lower Waikato Flood Control Scheme in the 1960s, the water levels had been artificially held low to provide flood storage, inadvertently over-drying the wetland. In 1989, after years of advocacy, a resource consent was granted to construct a weir on the

Whangamarino outlet to raise the minimum water level. Completed by 1994 and operational by 2000, this adjustable weir now maintains water in the wetland during dry periods. Summer water levels are prevented from dropping too far (the weir crest is ~3.2 m above sea level), which has been crucial in protecting the integrity of the peat bog. Monitoring showed that after the weir installation, peat subsidence slowed and conditions for bog species improved. However, a side-effect was that holding water longer led to more frequent inundation of swamp areas, depositing nutrient-rich silt and encouraging the spread of manuka scrub into areas that were previously open bog. This illustrates a key lesson: hydrological restoration can involve trade-offs (bog vs. swamp dynamics in this case), and adaptive management is needed. The weir was repaired and upgraded in 2010 to ensure its effectiveness, and water levels are continuously managed in balance with flood control needs.

Alongside hydrology, vegetation and species management has been significant. A major willow eradication effort was carried out, with DOC and Waikato Regional Council partnering to spray and physically remove willows over hundreds of hectares. By killing the invasive willows, large portions of the wetland have been returned to open water or native marsh vegetation (albeit leaving behind standing dead trunks that will decay over time). The removal of willows has re-opened habitat for waterbirds and allowed native plants like flax, sedges, and ferns to regenerate. The project also established a predator control network, as Whangamarino is habitat for ground-nesting birds (bittern, rails) and native fish (mudfish) that are vulnerable to predators like rats, stoats, and feral cats. Trapping and baiting have helped improve breeding success for some bird species. One notable success indicator is the status of the matuku (Australasian bittern): Whangamarino is regarded as a stronghold, and while exact numbers are hard to pin down due to the bittern's secretive nature, regular call-count monitoring suggests stable or increasing occupancy of territories in the wetland post-restoration. This is encouraging, as bittern are an indicator of wetland health. Also, the swamp helmet orchid (an extremely rare plant) has had its habitat safeguarded by fencing off its locations and managing the disturbance regime (DOC even trialled controlled burns in small patches to mimic the natural disturbance the orchid needs for regeneration).

The Whangamarino restoration efforts illustrate the importance of multi-objective management: the site is part of a flood control scheme, a wildlife habitat, and culturally significant land. Through negotiation and adaptive measures like the weir, these objectives have been balanced to a degree. The project also highlights the need for ongoing management; for example, willow regrowth needs periodic checking, the weir requires operation, and predator control must be sustained. Community and iwi engagement has been fostered via the establishment of a local Wetland Care group and inclusion of Whangamarino in the Waikato-Tainui River Trust's discussions. A lesson learned is that large peatland systems can be resilient if key processes (like water regime) are restored – parts of Whangamarino's bog that were close to collapse have shown signs of rejuvenation (e.g., increased prevalence of *Empodisma* rushes again) after rewetting. However, the combination of nutrient runoff and altered flooding patterns (due to the river control) continues to drive *mānuka* expansion in some areas, which may require intervention (perhaps periodic mowing or controlled burning) to maintain open bog vegetation.

8.2 Awarua-Waituna Wetland (Southland) *Collaborative catchment restoration to save a peatland-lagoon complex.*

The Awarua-Waituna Wetland in Southland, at the far south of the South Island, is a vast expanse (~20,000 ha) of peat bog, swamp, lagoon, and coastal marsh that has been recognised as a Wetland of International Importance under Ramsar since 1976. At its heart lies Waituna Lagoon, one of the best-preserved coastal lagoons in New Zealand, which is intermittently open to the sea. Historically, the lagoon was surrounded by extensive peat bogs – the Waituna bogs – which gave the water its characteristic clear brown "tea" colour from peat tannins. This wetland supports an array of wildlife: migratory wading birds, waterfowl, rare aquatic plants (notably *Ruppia* or horse's mane weed in the lagoon), and endemic fish. It is culturally significant to Ngāi Tahu, who know it as a rich source of mahinga kai. Awarua-Waituna is largely in public ownership (managed by DOC), but it does sit downstream of an intensively farmed catchment (~20,000 ha). Over the past few decades, land use intensification (mainly dairy farming) in the Waituna catchment led to increased nutrient and sediment runoff, putting the lagoon at risk of eutrophication. By the 2000s, scientists warned that unless nutrient inputs were curbed, Waituna Lagoon could "flip" to an algae-dominated state, losing its ecological character. Additionally, parts of the bog were drained on the edges and converted to pasture in earlier times, shrinking the peatland extent.

In response, a major collaborative initiative called "Whakamana Te Waituna" was launched, involving Environment Southland (regional council), DOC, Te Rūnanga o Ngāi Tahu and local rūnanga (Awarua), Fonterra (through its Living Water partnership with DOC), and local landowners. This partnership approach recognises that protecting the wetland requires working across the whole landscape – from farm drains to the lagoon outlet. Significant funding was secured (including government grants of several million dollars) to implement measures. Key strategies have included:

- **Nutrient management in the catchment:** Farmers have been supported and sometimes financially incentivised to implement better practices – fencing off streams and wetland remnants, planting riparian buffer strips, upgrading effluent management systems, and reducing fertiliser applications where possible. A voluntary farm environmental plan program was rolled out, with many farmers participating (by 2020, a majority of farms had nutrient plans).
- **Installation of sediment traps and constructed wetlands:** To intercept run-off, features like sediment retention basins and two-stage drainage channels were added to farm streams. One notable project is the Waituna Creek Restoration Trial, where parts of the creek were re-shaped to reintroduce meanders and floodplains, large wood (log) structures and bundles of mānuka branches were installed in the stream to improve habitat complexity, and riparian zones were revegetated. This not only helps in trapping sediment and nutrients but also enhanced habitat for fish (monitoring showed increases in native fish diversity and biomass in sections of the creek with the added wood structures. According to progress reports, *native fish populations (including longfin eel and giant kōkopu) have noticeably improved in restored reaches*, demonstrating early ecological gains.
- **Lagoon water level management:** Historically, Waituna Lagoon was opened to the sea by mechanically breaching the gravel barrier to prevent flooding of farmland – a practice that can also flush out nutrients. However, inappropriate opening timing could harm the lagoon's ecology (for instance, opening too frequently can lower water levels and reduce the habitat for *Ruppia* weed). Under the restoration programme, guidelines for lagoon opening were revised to better balance ecological and land drainage needs. The aim is to keep the lagoon closed longer to allow *Ruppia* to grow (it needs stable water levels) yet open it if water quality declines too much. This adaptive hydrological management is ongoing, aided by scientific monitoring of water quality and plant health.
- **Direct peatland restoration:** Parts of the peat bog that had degraded are being actively restored. This includes re-blocking some old drains on the peatland margins to re-wet bog areas. Hundreds of hectares of scrub and rank pasture on former bog have been retired from grazing. Planting of bog species (such as wire rush/tangle fern communities) is tricky on a broad scale, so the strategy relies on natural regeneration once water is back. Early results show that areas where drains were blocked have wetter soils and some re-colonisation by sphagnum moss and restiad rushes.
- **Governance and community:** A core strength of this case is the collaborative governance. Ngāi Tahu (via Te Rūnanga o Awarua) has been deeply involved,

ensuring cultural values are part of the decision-making. Local farmers are not just regulated but are *partners* in many projects, which has built trust. For instance, demonstration farms show how changes can be made without losing profitability. The local council and DOC coordinate closely, aligning their goals (which historically might have been siloed – here they present a united front). As noted by officials, this "multi-agency effort…involves local farmers, residents and landcare groups" and relies on "good science" to guide actions. The community has been kept informed through events and signage (for example, interpretation panels explaining the importance of the bog and lagoon).

The outcomes at Waituna are still unfolding, but already water quality has shown some improvements – phosphorus levels have stabilised and there have been fewer signs of imminent "flips" in the lagoon since the interventions began. The wetland's ecological integrity remains intact; *Ruppia* cover has been maintained above critical thresholds. A big lesson here is the power of collaboration and holistic catchment management. By addressing the root causes (runoff from farms) in tandem with direct wetland remediation (drain blocking, etc.), the project tackles the issue from both ends. It's also a showcase of integrating climate change into wetland restoration: by improving peatland condition, they are not only protecting biodiversity but also ensuring the peat bog continues to store carbon and not become a source.

Another lesson is that socio-economic factors cannot be ignored. The project provided resources (and some compensation or incentive) for farmers to change practices, which eased potential economic concerns. And cultural leadership (Ngāi Tahu) helped articulate a long-term vision that resonates with many stakeholders: to leave a legacy of a healthy Waituna for future generations.

8.3 Moanatuatua Bog (Waikato) – *A remnant bog restoration experiment.*

While large-scale projects give broad lessons, small remnant-focused efforts provide insights into restoration techniques. Moanatuatua Bog, near Cambridge, is a 140 ha fragment (Scientific Reserve) of what was once a 7,000 ha raised bog. It is essentially an island of peatland in a sea of dairy farms. By the late 20th century, the bog fragment was drying out at the edges and being invaded by scrub since drains around its perimeter were steadily lowering its water table. A restoration attempt led by researchers from the University of Waikato and DOC involved constructing a plastic membrane wall or bund around part of the bog to trap rainwater and raise the internal water level. They also removed pine trees and brush from the bog margins. Early monitoring indicated that within the trial area, water table height increased, and peat moisture improved. Sphagnum moss and restiad cover showed slight increases, suggesting peat accumulation could restart. However, the restoration is challenging: the fragment is so small that edge effects are strong, and the surrounding land continues to drain water away. The project highlights both the possibilities and limits of bog restoration in isolation. It underscores that protecting large, contiguous peatlands (like Kopuatai or Whangamarino) in the first place is far easier than rescuing tiny remnants later. Nevertheless, Moanatuatua has served as an outdoor laboratory – it's one of the best-studied peatlands in the country, and findings from there (on peat chemistry, hydrology, and vegetation response) have informed the practices used at bigger sites.

These case studies demonstrate that peatland restoration is achievable in New Zealand, yielding tangible benefits, but it requires long-term commitment, scientific guidance, and often a collaborative approach. Whangamarino showed that even a heavily managed wetland can have its natural functions partially restored (water and habitat) with infrastructure like a weir and removal of invasive species. Waituna showed that an entire catchment's behaviour can change when stakeholders rally around a wetland's health, preventing ecological collapse. And smaller projects like Moanatuatua contribute to our understanding of peat dynamics and test interventions that might be scaled up. Each case emphasises monitoring and adaptability: things like water levels, nutrient concentrations, species populations were tracked, and management was adjusted accordingly (adaptive management is key since wetlands are dynamic). Importantly, these cases also highlight the role of people – without advocates, volunteers, farmers, iwi, scientists, and officials working together, none of these successes would be possible. The lessons learned inform our recommendations for future peatland management, which we turn to in the final section.

Chapter 9: Future Directions and Recommendations

The overarching goal is to ensure that peatlands are protected as critical carbon sinks and ecological assets, while also integrating them into New Zealand's climate change response and sustainable land-use planning. The recommendations are grouped into policy measures, management and restoration actions, research needs, and community engagement strategies.

9.1 Enhance research and fill knowledge gaps:

While a lot is known about peatlands, certain gaps remain that future research should address to inform management. One key area is greenhouse gas (GHG) flux measurements from New Zealand peatlands. Continued research (like the eddy covariance tower at Kopuatai) is needed to refine estimates of carbon sequestration and emissions under different conditions. This will help prioritise which drained peatlands, if rewetted, would yield the biggest climate benefits, and how quickly restored sites turn from carbon sources to sinks. Another research need is exploring paludiculture options under New Zealand conditions – trials to determine which wetland crops (e.g., sphagnum farming, flax plantations, etc.) can be viable here, including their economics. As noted, overseas examples exist, but local trials will build confidence for farmers to adopt these practices. There is also scope for more hydrological modeling of peatland catchments to predict outcomes of interventions (like modelling how high a water table can be restored without affecting neighbouring properties – this can aid consent processes by addressing farmer concerns with data). Research into biodiversity responses to restoration (e.g., how do peatland bird or insect populations recover after rewetting?) would help quantify the ecological benefits beyond vegetation changes. Additionally, monitoring techniques could be improved – remote sensing (like satellite or drone imagery) to detect peat moisture levels or vegetation health offers a cost-effective way to keep tabs on large, inaccessible peatlands, and investing in these technologies can complement on-ground monitoring. New Zealand could also contribute to global peatland science by studying its unique restiad bog systems; for example, understanding how Empodisma and Sporadanthus species contribute to peat accumulation and how they respond to climate variables extends knowledge that might be relevant as the climate warms. All this research should be made accessible to decision-makers and land managers – possibly via an online "peatland hub" that collates guidelines, case studies, and data (somewhat akin to how the NZ Landcare Trust disseminates restoration handbooks).

9.2 Strengthen and enforce protective policy measure:

New Zealand should continue to strengthen its legal and policy framework to prevent any further loss of peatland extent. The current provisions under the NPS-FM (no net loss of natural wetlands) need rigorous implementation. Regional councils must be resourced and willing to enforce rules against illegal drainage or infilling of peatlands. This could involve increased surveillance of at-risk areas and prompt action when breaches occur. On the flip side, the policy framework should encourage positive actions. For example, the government could establish a dedicated Wetland Restoration Fund to support landowners in rewetting and restoring peatlands, similar to how there are funds for planting forests. Incorporating peatland emission reductions into the Emissions Trading Scheme (ETS) or another incentive system by 2030 would align economic signals with conservation – farmers could earn carbon credits for raising water tables on peat soils, making restoration financially attractive. Policymakers should also integrate peatlands into climate adaptation plans, recognising their role in flood mitigation and drought resilience. At a strategic level, setting a national target for wetland restoration (for instance, restore 50,000 hectares of wetlands by 2030, as a contribution to global biodiversity goals) would provide focus and accountability. Some experts have called for each region to aim to restore wetlands to at least 10–20% of their original extent.

While that level is ambitious, having concrete targets can inspire action and funding. Finally, ensuring that new legislation (like the Natural and Built Environments Act) maintains or strengthens wetland protections is crucial during this transition period in environmental law. There should be no weakening of the current safeguards – if anything, peatlands might be explicitly recognised for their climate regulation function, which could offer an additional lever for protection under climate law.

9.3 Expand restoration and rewetting efforts (scale up!):

The success stories at places like Whangamarino and Waituna should be replicated and scaled up in other regions. Many peatland areas that remain degraded (for example, portions of the Kaimaumau wetland in Northland, or partially drained peat swamps in the Waikato and Manawatu) would benefit from similar hydrological restoration measures. Rewetting drained peatlands should be a priority. A practical recommendation is to conduct a national inventory of drained peat soils (this is being partially done by councils like Waikato updating peat maps) and identify hotspots where rewetting would yield the greatest climate and biodiversity gains. Then, implement demonstration projects in each major peatland region (Northland, Waikato, East Coast, West Coast, Otago/Southland). Government and regional councils can work with local landowners to construct weirs or ditch-blocks, much like what has been done in Whangamarino, on smaller scales initially. The Living Water partnership model (Fonterra and DOC) could also be expanded to other dairying regions with peat soils – engaging the agriculture sector in funding and expertise for wetland creation on farms. Restoration should not only aim to stop harm but actively increase peatland area where feasible. For instance, there are areas of marginal farmland on peat that could be returned to wetland. Encouraging farmers to retire such areas (through buyouts, land swaps, or stewardship payments) would allow wetlands to regenerate or be reconstructed.

Furthermore, maintenance of restored sites needs long-term commitment. It is recommended that every significant peat restoration site has a management plan for at least 10 years post-restoration that covers water level management, invasive species control, and monitoring. The case studies taught us that initial efforts can be undone without follow-up (e.g., willows can regrow, infrastructure can fail). Thus, funding models should include maintenance, not just one-off capital works. Expanding predator control in and around peatlands is also advised, especially to protect vulnerable bird and fish species – this could tie into New Zealand's broader Predator Free 2050 initiative, ensuring wetlands are part of the landscape-scale predator control areas.

9.4 Incorporate Mātauranga Māori and co-governance in peatland management:

Future peatland management should deepen the involvement of Māori as kaitiaki (guardians). Co-governance arrangements (like at Whangamarino via the river settlement, or Waituna via the partnership group) are a good template. It's recommended to formalise such arrangements for all major peatland complexes, meaning local iwi/hapū should have a decision-making role alongside councils and DOC for those areas. This will help ensure that management approaches respect cultural values – for example, the use of traditional harvest timings to manage certain species, or the protection of sacred sites (urupā or historical sites) within wetlands. Mātauranga Māori can also guide restoration techniques. For instance, Māori knowledge of certain plant traits might inform which species to plant where; or traditional burning practices might inform how to create small disturbances needed for some plants without causing a large fire. Cultural health indices for wetlands could be developed and used alongside scientific monitoring, as has been done for rivers in some areas, to track the holistic health of peatlands (including spiritual and cultural aspects). Supporting iwi-led restoration projects on Maori-owned land is another avenue – there are Māori land blocks that include degraded wetlands (particularly in Northland and the central North Island) where owners may wish to restore them. Government agencies could provide targeted support for those projects, marrying traditional techniques with modern science.

9.5 Foster community engagement, education and stewardship:

Ultimately, the fate of many peatlands, especially those on private land, lies in the attitudes and actions of local communities. Therefore, a strong recommendation is to ramp up education and outreach focusing on wetlands/peatlands. This can range from school programs in regions with peat soils (teaching the next generation the value of these ecosystems) to field days for farmers demonstrating wetland-friendly practices. The National Wetland Trust's proposed wetland education centre at Rotopiko is a great initiative – more such centres or interpretive sites near peatlands (even a simple boardwalk and signage at a publicly accessible bog) can raise public appreciation. Every World Wetlands Day (Feb 2), New Zealand could showcase a peatland project in media to keep public interest.

Encouraging citizen science is another way to engage people. Local volunteers can help with monitoring water levels, doing bird counts, or planting days. For example, a community group could "adopt a wetland" and take on tasks like regular bird surveys or weed watch, contributing data to DOC/regional councils. This not only reduces monitoring costs but builds a sense of ownership. In areas like the Waikato and Southland where there are many drains, community drain management schemes could be set up – where landowners collectively agree to maintain certain water levels in shared drains for mutual benefit, effectively acting as stewards for the peat's health.

Stakeholder collaboration should continue to be a theme: the successes in Waituna's multi-stakeholder approach can be replicated. It might be valuable to establish a National Peatlands Steering Group or Forum that meets periodically, bringing together representatives from councils, iwi, DOC, farmers, NGOs, and scientists. This forum could oversee the implementation of a national peatland strategy, troubleshoot issues, share success stories, and ensure continued high-level attention.

In conclusion, the future of New Zealand's peatlands can be optimistic if these recommended directions are pursued. The scientific understanding, policy tools, and community will are coalescing around saving these vital ecosystems. By solidifying protective policies, investing in restoration, integrating indigenous knowledge, advancing research, and cementing public support, New Zealand can position itself as a leader in peatland conservation. This would yield multiple co-benefits – particularly helping meet climate targets through natural climate solutions, conserving unique biodiversity, safeguarding water resources, and upholding cultural and recreational values associated with wetlands. Perhaps most importantly, it will ensure that the remarkable carbon-rich peatlands – those quiet giants of climate regulation – remain a stable cornerstone of ecological resilience in New Zealand's landscape for generations to come. The time to act is now, while there is still peat left to save. As one conservationist aptly put it, "*Wetlands must be wet for them to do their magic*" – the challenge and opportunity ahead is to restore that magic across Aotearoa's peatlands.

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Plain English Compendium Summary

Project Title: Changing the Bog-Standard: Repeatable Solutions for Aotearoa's Peatlands
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Objectives

- Understand the current state and significance of New Zealand's peatlands.
- Assess the climate, ecological, and cultural value of peat soils.
- Explore opportunities for sustainable peatland restoration and management.
- Investigate land-use models (like wet farming) that balance environmental and economic outcomes.
- Develop repeatable strategies for local and national implementation.

Background

Peatlands are wetland areas where plant material breaks down slowly in waterlogged conditions, forming deep carbon-rich soils. Although they make up only 1% of New Zealand's land, they store around 20% of our soil carbon - playing a vital role in climate regulation. But drainage for farming and development has led to the loss of over 90% of our wetlands. The remaining peatlands are degrading rapidly and becoming a major source of greenhouse gas emissions. This project builds on domestic and international research into peatland restoration and wetland-based land use.

Research

This report draws on domestic and global literature and case studies (Germany, Netherlands, UK, Ireland), field visits, and discussions with farmers, researchers, iwi (Māori tribal groups), and policy experts. The work investigates both technical and cultural aspects of peatland restoration. The study also explores paludiculture - wetland-compatible agriculture - as a viable future land use for drained peat areas.

Outcomes

- A detailed report and global review of peatland restoration, climate impact, and emerging farming solutions.
- Real-world examples of rewetting and land-use change from overseas and within New Zealand.
- Recommendations for policy, landowner engagement, and community co-leadership in restoration efforts.
- Strong alignment with indigenous knowledge systems (Mātauranga Māori) and values-led decision-making.

Implications

New Zealand has a major climate and biodiversity opportunity in its peatlands. By rewetting, protecting, and managing these landscapes differently, the country can avoid up to 2 million tonnes of CO_2 emissions annually, improve water quality, protect cultural heritage, and diversify farming. The report calls for urgent investment in peatland management and recommends treating wetlands and peatlands as national climate infrastructure - not marginal land.